Annex D Indicator description sheets

Category 1: Climate and Atmosphere

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC[1]
Indicator title: **Temperature**	
Definition*:* Temperature is the long-wave energy (sensible heat) at frequencies between 10^{-6} and 10^{-4} m. In this case it is the temperature measured in the lower atmosphere about 2m above ground level.	
Policy question: Surface temperatures are needed to assess trends in average temperatures. These trends and accompanying changes in frequency and intensity of extreme events such as heat waves may lead to severe impacts on natural, social and economic systems. For this reason changes in temperature are the key issue in UNFCCC negotiations. There is very high perception of changes in average temperature amongst the public. Climate change is mainly defined by trends in temperature.	
Derived from policy instrument/documents The global trends in surface temperatures are the key issue in the UNFCCC negotiations (COP 1-7 including COP3, the Kyoto Protocol)	
Description/rationale of the indicator Temperature is the most important parameter used in indicating climate change and therefore of high relevance for policy makers. It is measured in a standardized way according to WMO rules. A network of meteorological stations with relatively high density is available for measuring temperature. Data bases are updated annually and can be easily interpreted on monthly average level. Data can be interpolated on high resolution grids, even in complex terrain with a high level of significance. A number of indices based on fixed thresholds such as number of days with temperatures higher than 25°C or calculated as percentiles can be used to describe trends in temperature and changes in the intensity and frequency of extreme events. Current trends can be related to long term time series derived from ice cores and sediments and can be interpreted in relation to historic climate conditions. ***State of knowledge: Well established***	

[1] Responsibility for further development within the EEA framework by the relevant ETC

Sources:
Source of the indicator
Temperatures are measured and updated by weather services on a national level using worldwide standards.
Station density and data availability are dependent on the organisation of the weather services at national level. Only certain parts of measured data are delivered to WMO and available for European-wide trend analyses.
Standardized data sets of monthly temperatures on fixed resolution are available, e.g. CRU climatological data set, and can be used for trend analyses. These data will be updated at irregular periods.

The expected source(s) of data
- CRU, Climate Research Unit (Uni. East Anglia, Norwich) (L)
- Vent-Schmidt (DWD) (L)
- Klein Tank (KNMI) (L)
- Bergström, Alexanderson, Räisänen (SMHI) (Q)
- GRIP and VOSTOK ice core

The expected source of assessment
- Klein Tank (KNMI) (L)
- Gerstengarbe (PIK) (P)

Evaluate the data situation:
- Collect and update existing data sets
- Perform trend analysis, calculate thresholds or percentiles
- Compare new data with reference periods or historic records

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 5

Data reliability (1: low to 5: high): 5

Geographical coverage
Global and European wide data sets; Irregular station data with daily values or monthly values of interpolated regular grid data

Time series length
Grid data are available from 1901 onwards. Station data have been available since 19th century (17th century in UK). Data are available and updated annually. Regular analyses are performed by several institutions.

Further work required
See data situation

Time schedule for indicator development
Short term (0-2 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	e.g. climatological period 1931-1960
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC

Indicator title:

Precipitation

Definition*:*

Precipitation is the amount of water in liquid or solid phase (rainfall, snow, hail) reaching the surface of the earth (fallout from atmosphere) and measured with different methods, mostly 2m above ground

Policy question:

Changes in precipitation have severe impacts on natural and economic systems, affecting the number and intensity of droughts and floods, supply of drinking water, water for irrigation in agriculture and for industrial production.

Derived from policy instrument/documents

Water related issues are treated in a number of international organisations such as Global Water Partnership, World Water Forum, IWMI, IRI, WCP Water, World Climate Program, IPCC, DWC, UNEP.

Description/rationale of the indicator

Precipitation is measured world-wide according to WMO standards. European-wide data sets are available at different institutions. Changes in rainfall amount and intensity and seasonal snowfall have severe consequences on different ecological and economical sectors. Droughts and floods can cause severe damage. Therefore stakeholders are highly aware of changes in rainfall patterns, snowfall and droughts. A number of indicators based on fixed thresholds or percentiles can be derived from daily and monthly precipitation data to analyse changes in the number and intensity of extreme events. Changes in precipitation can be expressed in different ways, depending on the purpose. Changes in annual totals, for example, are useful to show the overall development while changes in the daily maximum are more useful as an indicator for extreme events.

State of knowledge: Well established

Sources:

Source of the indicator

Precipitation is measured and updated by weather services on national level using worldwide standards. Station density and data availability are dependent on the organisation of the weather services at national level. Only certain parts of measured data are delivered to WMO and are available for European-wide trend analyses.

Standardized data sets of monthly precipitation at a fixed resolution are available, e.g. CRU climatological data set, and can be used for trend analyses. These data are updated at irregular intervals. Daily or even hourly data should be available for analysing trends in extreme events. In some countries, data availability for this purpose is not sufficient yet.

The expected source(s) of data

- CRU, Climate Research Unit (Uni. East Anglia, Norwich) (L)
- Vent-Schmidt (DWD) (L)
- Klein Tank (KNMI) (L)
- Bergström, Alexanderson (SMHI) (Räisänen (Q)
- Günther (DWD, IfH) (P, L)
- Grieser, (GPCC, DWD Offenbach) (C, L)

- Groisman et al. (1999) (L)

The expected source of assessment
- Gerstengarbe (PIK) (P)
- Klein Tank (KNMI) (L)
- Rudolf, (DWD Offenbach) (C, L)

Evaluate the data situation:
- Collect and uupdate existing data sets
- Perform trend analysis, calculate thresholds or percentiles
- Compare new data with reference periods or historic records

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage
Station density and data availability are dependent on the organisation of the weather services at national level. Only certain parts of measured data are delivered to WMO and are available for European-wide trend analyses. Variations in rainfall are much higher than in temperature, especially in areas with high amounts of convective rainfall.
Monthly values of precipitation in regular spatial resolution are available
Data sets will be updated annually. Regular analyses are performed by several institutions.

Time series length
Irregular station data have been available since the 19th century. Gridded data since 1901

Further work required
See data situation

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	Climatological normal periods e.g. 1931-1960
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	Economic models sensitive to water related issues
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC

Indicator title:

Climate Indices

Definition*:*

Climate indices are calculated using combinations of different climate parameters, such as temperature, precipitation, humidity, pressure, radiation or circulation patterns of the atmosphere. They can be predefined or derived from multivariate statistical analysis.

Indicators are available describing periodic large scale changes in the atmospheric circulation. Well known indicators include the El Niñio Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO).

Multivariate statistics allow an overall estimate of trends in the climate and weather system. Climate indices are sensitive to seasonal changes in weather conditions. Such changes can cause severe damage to natural and economic systems.

Policy question:

Number and intensity of periodic changes in seasonal weather conditions are important for economic sectors, especially for agriculture and fishery. Stakeholders, including policy makers, are becoming more and more concerned about this issue.

Derived from policy instrument/documents

Climate indices are used as indicators for climate change (see IPCC 3rd report).

Description/rationale of the indicator

Climate indices can deliver comprehensive information about changes in climate conditions. They can be used to analyse changes in total energy fluxes (sensible and latent heat flux). Therefore they should be a more sensitive indicator for changes in climate and weather conditions than one particular parameter alone, such as temperature or precipitation. Climate indices are tools to describe the changes in the complex interactions in the different components of the climate system. This is important to estimate potential impacts of climate change which in many cases might not be an effect of trends in one parameter alone.

In some cases climate indices are well known and highly accepted as indicators for trends in climate conditions, e.g. NAO (North Atlantic Oscillation) Index.

Indices might be complex, sometimes not very easy to understand and therefore difficult to mediate to the public. Interpretation of the results might also be difficult.

State of knowledge: Competing explanations

Sources:
Source of the indicator
A number of indicators, such as the NAO index, is derived from weather data. Statistical tools are available to perform multivariate analysis of climate data in high spatial resolution

The expected source(s) of data
- Gerstengarbe/Österle (PIK, Potsdam) (P)
- Schönwiese (L)
- Klein Tank (KNMI) (L)
- Institute for Meteorology, University Cologne

The expected source of assessment
- Gerstengarbe/Österle (PIK, Potsdam) (P)
- Schönwiese (P, L)

Evaluate the data situation:
Some indicators are available and data sets are regularly updated, e.g. the NAO Index.
Further efforts are necessary to analyse available data sets of climate and weather data to detect changes in climate conditions.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 5

Geographical coverage
Europe for NAO index, Europe in 0.5 x 0.5° spatial resolution for statistical analysis of climate data

Time series length
NAO since 1950, multivariate statistics since 1901

Further work required
Statistical analysis of available data is necessary in order to establish trends in European climate. More investigations are necessary to analyse trends in circulation patterns. It is also important to analyse trends in storm events and intensity. Weather data instead of climate data are needed for this. These are not available to the public.

Time schedule for indicator development
Short term (0 - 2 years) for NAO index
Medium term (3 - 5 years) for high resolution indicators based on multivariate statistical analysis

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	Sometimes not easy to mediate
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	Results are being discussed by experts
□ Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	If models are sensitive to climate
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC
Indicator title: **Atmospheric CO_2 and other Greenhouse Gas Concentrations**	
Definition*:* Atmospheric CO_2 and other greenhouse gas concentrations in the troposphere	
Policy question: Atmospheric CO_2 and other greenhouse gas (methane, nitrous oxide and fluorinated compounds) concentrations are the key indicator for international negotiations on emission reduction. Increase in greenhouse gas concentration levels are considered to be one of the most important causes of global warming. Increases in GHG concentration levels are due to emissions from human activities.	
Derived from policy instrument/documents The relationship between atmospheric CO_2 concentration and climate change is documented in the IPCC 3rd report and the COP 1 – 6 documents, especially in COP 3, the "Kyoto Protocol"	
Description/rationale of the indicator An increase in greenhouse gas concentrations can be observed within the last decades due to anthropogenic emissions. Long-term historic records are available from ice-core projects (e.g. GRIPS) and marine sediment. Data are representative on global level. Changes in emission in European countries can not be related to average CO_2 and other greenhouse gas concentrations. ***State of knowledge: Well established***	

Sources:
Source of the indicator
Continuous measurements of atmospheric CO_2 concentrations are performed at a number of sites (e.g. Mauna Loa, Hawaii, Antarctica). In Europe, measurements are carried out at different spatial and temporal scales, especially by the CarboeEurope research cluster. Measurements of other greenhouse gases are performed as well.

The expected source(s) of data
- Keeling and Whorf. 2001, SCRIPPS (L)
- CDIAC (L)
- CarboEurope
- GRIPS and Vostok ice core programme
- MPI Jena

The expected source of assessment
There is no need for further assessments. Data can be used directly.

Evaluate the data situation:
Data are available via internet and will be updated annually.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 5

Data reliability (1: low to 5: high): 5

Geographical coverage
Measurements at sites are representative for the global average concentration.

Time series length
Measured monthly data since 1958 (Mauna Loa)
Date derived from ice cores and sediments >400.000 years

Further work required
No further work required

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	if models are sensitive to CO_2 concentration
Measurability. Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC
Indicator title: **Storms**	
Definition*:* Changes in frequency, intensity and tracks of storms due to changing climate conditions.	
Policy question: Frequency and intensity of storms have major impacts on economic sectors, forests and infrastructure. Changes in storm tracks may necessitate adaptations, especially in coastal areas. There is high public awareness about trends in storms.	
Derived from policy instrument/documents IPCC 3rd report WG I	
Description/rationale of the indicator Under certain conditions storms can cause severe damage to ecosystems, especially to forests and infrastructure. There have been a number of severe incidents in the past decade causing great damage and consequently high public awareness. "Changes in tropical and extra-tropical storm intensity and frequency are dominated by inter-decadal to multi-decadal variations, with no significant trends over the 20th century evident. Conflicting analyses make it difficult to draw definitive conclusions about changes in storm activity, especially in the extra-tropics. No systematic changes in the frequency of tornadoes, thunder days, or hail events are evident in the limited areas analysed" (IPCC, 2000). There may be trends on regional level. Because of the high perception amongst the public, trends in storm frequency and intensity should be observed. ***State of knowledge: Speculative***	

Sources:
Source of the indicator
Wind speed is measured on weather stations. Data with high temporal resolution is necessary to analyse extreme events. Large scale storm frequency and intensity can be derived from air pressure fields. Data are available from weather services and research institutes. Changes in pressure fields have to be analysed to investigate long-term trends in storm frequency and intensity.

The expected source(s) of data
- MPI and University, Hamburg (P)
- Institute for Tropospheric Research, Leipzug (P)
- Pew Center on Global Climate Change (L)
- Tyndall Center, Norwich UK (P)
- National weather services

The expected source of assessment
- MPI and University, Hamburg (P)
- Institute for Tropospheric Research, Leipzug (P)
- Tyndall Center, Norwich UK (P)
- National weather services

Evaluate the data situation:
Circulation patterns have to be analysed. This is different from processing climate data.
There is a high risk of failure in detecting sensitivity of wind to climate change.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
Several decades

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?		**Uncertain**
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?		**Uncertain**
Is the indicator based on international standards and international consensus about its validity?		**Uncertain**
Could the indicator be linked to economic models, forecasting and information systems?		**Uncertain**
Measurability. Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?		**Uncertain**
Adequately documented and of known quality?	**No**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	**Uncertain**

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC
Indicator title **Lightning Frequency**	
Definition*:* Number of bolts per time unit in the atmosphere.	
Policy question: Increase in lightning frequency may be used as an indicator for an increase in energy, especially in latent heat in the atmosphere. This indicator is easy to understand, may be more "visible" than an increase in temperature and therefore easy to mediate to the public.	
Derived from policy instrument/documents None	
Description/rationale of the indicator: Frequency of lightning should depend on the overall energy content in the atmosphere. Assuming that a stable amount of the latent and sensible heat flow in the atmosphere is converted into lightning, an increase in the frequency of lightning means an increasing amount of transported energy. Assuming further a stable percentage of latent and sensible energy in the overall content of energy in the atmosphere, this increasing frequency of lightning could be used as an indicator for an increased energy content in the troposphere driven by an accelerated greenhouse effect caused by growing concentrations of greenhouse gases. However, changes in lightning frequency may also be due to changes in actual weather conditions. To identify trends in climate by analysing changes in lightning frequency, large areas should be monitored over a longer period of time. ***State of Knowledge: Speculative***	

Sources:
Source of the indicator:
A causality between the atmospheric content of energy and the number of bolts has already been presumed in the scientific community for a while. Existing and newly developed lightning detection networks of national weather services are now used in various programmes to evaluate the suitability of lightning frequency as a climate change indicator.

The expected source(s) of data:

- Various weather services and companies in Europe run networks to detect lightning frequency (e.g. UK, France, Netherlands, Belgium, Hungary, Germany).

The expected source of assessment:

- T. Hauf and U. Finke, Uni. Hannover (P)
- Global Hydrology Resource Center GHRC (L)
- Kern ; Siemens; Karlsruhe (L)

Evaluate the data situation:
Data are collected via remote sensing and ground observations. Further efforts are necessary to interpret data.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Global

Time series length
Several decades; update daily

Further work required
Establish contacts to the networks in European countries.
Gathering of data if available

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?		Uncertain
Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
Is the indicator responsive to changes in the environment and related human activities?		Uncertain
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Climate and Atmosphere Responsibility: ETC/ACC
Indicator title: **Cooling and Shrinking of Strato-, Meso- and Thermosphere**	
Definition*:* Changes in the average temperature of the stratosphere and of the altitude of characteristic layers.	
Policy question: Changes in the upper layers of the atmosphere are a clear indicator for global climate change and therefore important for stakeholders.	
Derived from policy instrument/documents IPCC 3rd report	
Description/rationale of the indicator Cooling of the upper regions of the atmosphere (strato-, meso- and thermosphere) is closely related to temperature increase in the troposphere caused by the "Greenhouse Effect " and is therefore very sensitive to climate change. A cooling of these regions should be accompanied by a shrinking and therefore by a decrease of characteristic layers (D, E, F1 and F2 layer). Long-term experiments are being carried out by ionoprobe observations, by RADAR PMSE (Polar Mesospheric Summer Echo) observation and by LIDAR absorption. The trends in the E layer and the F1 layer are in general agreement with model predictions, assuming an increasing atmospheric greenhouse effect. ***State of knowledge: Established but incomplete***	

Sources:
Source of the indicator:
Various meteorological stations (e.g. in Germany, France and Sweden) have been running experiments for atmospheric observations for about 50 years.
These long-term ionospheric data series have been used to derive trends in the E, F1 and F2 region by involvement of newly developed different methodical approaches.
Furthermore, some experiments for the exploration of the upper atmosphere and its suitability as an indicator for climate change were carried out during the CRISTA experiment (**Cr**yogene **I**nfrared **S**pectrometer and **T**elescope for **A**tmosphere) involved in Space Shuttle missions undertaken by 'Atlantis'(14.11.1994) and 'Discovery'(16.08.1997).
Because of their very limited range in time, these experiments are not able to show any trends in temperature.
More information might be available from the NASA experiment UARS/HALO which has been running since 1989.

The expected source(s) of data:
- Leibniz-Institut für Atmosphärenphysik
- Service d' Aeronomie, Verrieres-le-Buisson
- Universität Wuppertal (CRISTA-Exp.)

The expected source of assessment:
- Bremer; Leibnitz-Institut Kühlungsborn (P, L)
- P. Keckhut, A. Hauchecorne, M.L. Chanin (L)
- Offermann (Uni Wuppertal)

Evaluate the data situation:
There are several long-term data sets (more than 40 years) available in e.g. France, Germany, Sweden and UK. Evaluated information has to be requested.

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe (Northern, Western and Central Europe)

Time series length
Several long-term data sets (40-50 years) from Ionoprobes; some others (about 20 years from LIDAR and RADAR)
Update: weekly or monthly

Further work required
Gathering of already evaluated information provided by different stations in Europe (DE, FR, SE, UK)

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Category 2 Cryosphere

Indicator set: ***Climate Change***	Issue: Cryosphere Responsibility: ETC/ACC
Indicator title: **Snow Cover**	
Definition: The indicator describes the climate driven long-term changes in the snow-covered land surface [km^2; %] by using remote sensing and ground truth data Background Information: Duration and thickness of snow cover	
Policy question: Extent and duration of the snow cover has economic and political impacts because of its influence on agriculture, water balance and human infrastructure.	
Derived from policy instrument/documents UNFCCC; Art.2	
Description/rationale of the indicator The extent, duration and thickness of a temporary existing snow cover are driven by current weather conditions such as temperature and precipitation. A significant change over longer periods of time should prove suitable as a sensitive indicator of climate change. It seems very likely that changes in seasonal extent and thickness of snow cover have been very inhomogeneous in Europe during the past decades. Although even if spring and summer SCE decreases, there seems to be an increase in other seasons in some areas. Further information is necessary. Satellite records indicate that annual snow cover extent (SCE) in the northern hemisphere has decreased by about 10% since 1966, largely due to decreases in spring and summer since the mid 1980s. There is a highly significant inter-annual and multi-decadal correlation between spring land temperature and spring SCE. Longer regional time series based on station records and reconstructions suggest that northern hemisphere spring and summer SCEs during the past decade have been at their lowest in the past 100 years. There is a common thread in scientific literature about an overall reduction in spring snow cover in the latter half of the 20th century. There has been a general decrease in snow depth in Canada since 1946 corresponding to decreases in SCE. However, more information about long-term trends of SCE or snow depths in Europe is necessary. ***State of Knowledge: Established but incomplete***	

Sources:
Source of the indicator
Snow cover monitoring by satellites was started in the 1960s.
Systematic observations of yearly changes in snow cover have existed since the mid 1960s on a regional level.

The expected source(s) of data
- NORUT Ltd. ; Norway
- SLF; Davos; Switzerland
- ZAMG; Vienna; Austria
- DWD; Offenbach/Berlin; Germany
- NVE; Norwegian Water Resources and Energy Directorate

The expected source of assessment
- M. Laternser; SLF; Davos; Switzerland
- M. Schneebelli; SLF; Davos; Switzerland
- P. Föhn; SLF; Davos; Switzerland
- T. Guenther; Berlin; Germany
- K.Gabl.; Innsbruck; Austria

Evaluate the data situation:
Satellite-based data records for more than 30 years should be available in various data centres of space agencies or national research units.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage
Northern and central Europe

Time series length
30 to 40 years (yearly)

Further work required
Identification of data sets and gathering of information

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Cryosphere Responsibility: ETC/ACC

Indicator title:

Mountain Glaciers

Definition*:*

A mountain glacier is a mass of land ice flowing downhill (by internal deformation and sliding at the base) and constrained by the surrounding topography.

Two types of data from glaciers contain climatic information:

(I) mass balance

(II) glacier length

Policy question:

Changes in length and mass balance of mountain glaciers have political and economical relevance due to the impacts on ecosystems, water balance and tourism.

Derived from policy instrument/documents :

UNFCCC, Art.2; Alpine Convention; Convention on Biodiversity

Description/rationale of the indicator

Glacier retreat on a century time-scale is widespread, notably in Alaska, Franz-Josef Land, Asia, the Alps, Indonesia, Africa and South America. In the European Alps, after a loss of 50% of glacier volume since 1850, current glacier recession is reaching levels not seen for perhaps several thousand years.

Although a considerable number of glaciers are currently advancing in a few regions (western Norway, New Zealand), it is very likely due to climate change and in particular to regional increases in precipitation.

Glaciers are generally not in equilibrium with the prevailing climatic conditions.

Analysis done so far by models indicates that the response times of glacier lengths are in the 10 to 70 year range. Therefore, the timing of glacier retreat implies that a significant global warming is likely to have started no later than the mid 19th century. This conflicts with the global land instrumental temperature data and the combined hemispheric and global land and marine data, where clear warming is not seen until the beginning of the 20th century.

These discrepancies are currently unexplained.

On the global scale, air temperature is considered to be the most important factor reflecting glacier retreat.

Changes in length as well as in the mass balance of nearly all of the observed glaciers show significant trends for loss of substance.

State of Knowledge: Well established

Sources:
Source of the indicator
First data sets of glaciers in the (sub)-arctic and the alpine region have been available since the mid 19th century. Significantly more data of a reasonable quality have been recorded during the past 50 years.

The expected source(s) of data
- World Glacier Centre (Zürich; Switzerland)
- University of Innsbruck (Austria)
- Bavarian Academy of Sciences (Germany)
- Norwegian Water Resources and Energy Directorate (Norway)

The expected source of assessment
- Ludwig N. Braun; Bav. Acad. of Sciences; München; Germany (P);
- Michael Kuhn; Uni Innsbruck; Austria (P);
- Wilfried Häberli, Uni Zürich; Switzerland;
- Andrea Mochet; CTN-CON at ARPA Val dÀosta; Italy(Q);
- Olaf Orheim; Norw. Polar Institute, Tromsoe, Norway ;
- Jon Ove Hagen; University of Oslo, Norway;
- J. Oerlemans, IMAU, Uni. of Utrecht, the Netherlands
- H. Blatter; ETH Zurich; Switzerland
- P. Burlando; ETH Zurich; Switzerland
- M. Funk; ETH Zuerich, Switzerland
- U. Strasser; ETH Zuerich; Switzerland
- A. Kaeaeb; Uni Zuerich; Switzerland
- R. Frauenfelder; Univ. Zuerich; Switzerland

Evaluate the data situation:
For the European Alps, data of glacier length exist for about 150 years for a few glaciers. Many more datasets of a number of well-observed alpine and (sub)arctic glaciers have been available since the middle of last century.
For the last two or three decades many glacier records have been made available, most of them documented at the World Glacier Monitoring Service in Zürich, Switzerland.
However, not all data are readily available.

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage
Mountain regions of northern and central Europe

Time series length
On average about 50 years (up to 150 years in some special cases); yearly

Further work required
Contacts to experts and request information in order to have an overview of glacier reaction in Europe

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	**Notes**
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Cryosphere Responsibility: ETC/ACC

***Indicator title**:*

Arctic Sea Ice (ASI) / Extent and Duration

***Definition**:*

The indicator describes the climate driven long-term changes at the ice-covered surface of the Arctic Ocean and the Northern Seas [km^2; %]

The indicactor includes:

- Thickness of ASI
- Freeze-up and break-up dates of coastal ice formation
- Distances of arctic ice edges to coast lines
- Width of bottom fast ice zone

Policy question:

Changes in the ice cover of the seas in northern Europe have economic and political impacts because of their influence on the northern seaways. Furthermore they disturb existing ecosystems (polar bears; seals).

Derived from policy instrument/documents

UNFCCC; Art.: 2

Description/rationale of the indicator

Arctic sea ice extent, thickness and duration is expected to become an indicator of a warming climate, because it reacts very sensitively to changing air-temperatures, irradiation and temperatures of water-masses, although only recently have long records become available in the Arctic,. Comparable reactions should be shown by coastal ice formations.

The shrinking of arctic sea ice is regionally very inhomogeneous due to competing thermodynamic and dynamic effects and the available data of ice thickness were almost all produced during sporadic submarine expeditions.

Sea ice extent and duration was observed from space from 1973 to 1978 by various satellite-based SMR (Scanning Microwave Radiometer) and then continuously from 1978up to the present time by SSM/I (Special Sensor Microwave/Imager) to obtain consistent monthly estimates of sea ice extent for both hemispheres.

During this time the arctic sea ice extent decreased by approximately 3% per decade and the duration of season decreased by approximately 5 days per decade.

The knowledge of sea ice thickness in the Arctic comes largely from upward sonar profiling by USA and British submarines since 1958 and 1971 respectively.

Comparing mid-September values from the 1990s with data from cruises in the 1960s, a significant decline was observed for all regions with a mean reduction in ice thickness of 42 % from 3.1m to 1.8m.

More continuous and area-wide information will be available after the launching of the Cryosat-mission in 2004.

State of Knowledge: Established but Incomplete

Sources:
Source of the indicator:
Monitoring and scientific evaluation of climate driven changes in ASI using remote sensing data from satellites as well as data from military submarines should be available for several decades.

The expected source(s) of data:
- Euroclim Project (Scott-Institute; Univ. of Cambridge).
- ACD-Programme by IASC
- Alfred Wegener Institute Foundation for Polar and Marine Research; Bremerhaven (AWI)
- Federal Maritime and Hydrographic Agency of Germany; Hamburg (BSH)
- Arctic and Antarctic Research Institute; St. Petersburg; Russia

The expected source of assessment:
- Konstantin Y. Vinnikov ; Uni -Maryland; U.S.A..
- F.B. Mitchell ; Hadley Centre; Met. Office; Bracknell; UK
- Peter Wadhams; University of Cambridge, UK
- Felix E. Are; Petersburg State University; Russia
- Christian Haas ; AWI; Bremerhaven; Germany
- Peter. Lembke; AWI Bremerhaven; Germany

Evaluate the data situation:
Datasets for ASI are available for several decades at various institutions and will be further recorded and evaluated in the Euroclim project. They almost show trends already and will be discussed with potential partners.
The indicators related to coastal ice formation are proposed as a subject of investigation in the programme of Arctic Coastal Dynamics (ACD) by the International Arctic Science Committee (IASC).
Data sets for coastal ice formation processes might not yet exist, but will be available later as the result of a (possible) ACD programme.
Contacts are necessary to partners who deal with ASI. Furthermore information should be requested from the ACD programme.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage
North Atlantic; Greenland Sea; Norwegian Coasts

Time series length
Several decades (satellites; daily)

Further work required
Gathering and evaluation of information from different partners (Euroclim; ACD)

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?		Uncertain
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Cryosphere Responsibility: ETC/ACC

Indicator title:

Permafrost / Profiles of Temperature

Definition:

The indicator describes changes in permanently frozen ground (especially in higher latitudes and higher mountains) driven by climate change. The focus is on changing temperatures being measured during longer time periods at different depths [°C].
Regions: Sierra Nevada; Alps; Scandinavia; Spitzbergen; Greenland
Additional background information:

- Changes in extent and duration of permafrost
- Changes in the thickness of the active layer (seasonal freezing)

Policy question:

Degradation of permanently frozen ground by climate warming endangers existing ecosystems and human infrastructure (e.g. stability of buildings, highways). As mentioned in the UNFCCC, these impacts should be avoided.

Derived from policy instrument/documents

UNFCCC; Art.: 2

Description/rationale of the indicator

Permafrost (permanently frozen ground) covers about 25% of land mass in our hemisphere (in the northern part) and is common in the higher mountains. To a great extent, permafrost depends on climate, because over half of it is at temperatures a few degrees below 0°C.
Temperature variations in near-surface permafrost (20 to 200m depth) can be used as a sensitive indicator of the inter-annual and decade-to-century climatic variability and long-term changes in the surface energy balance. Very small changes in surface climate can produce significant changes in permafrost temperatures.
An international permafrost thermal monitoring network has been established recently (2000). This means that data availability is still very limited (Murtel-Corvatsch Glacier, Switzerland, since 1987).
Thermal profiles in permafrost at a certain depth (about 15 m) are mainly not influenced by impacts other than surface warming.
The thickness and southern extent of the active layer is significantly influenced by current seasonal weather conditions, especially by snow cover.
If the other conditions remain constant, the thickness of the active layer (subject to seasonal freezing and thawing) could also be expected to increase in response to a warming of the climate.
There is also evidence of change in the southern extent of the discontinuous permafrost zone in the last century.
The disturbing influence of current seasonal weather conditions is not quite clear. More information is necessary.

State of Knowledge: Established but Incomplete

Sources:
Source of the indicator:
Long-term monitoring of shallow permafrost has begun in earnest during the past few decades.
First steps towards the observation of mountain permafrost were done at the Murtel glacier in Switzerland in 1987 (Häberli et al.).
Recent analyses indicate that permafrost in many regions of the earth is currently warming.
A new international permafrost thermal monitoring network with a well established European branch has been developed recently (**PACE, P**ermafrost **A**nd **C**limate in **E**urope).

The expected source(s) of data
- PACE-Project (Coordinator: Dr. Charles Harris)
- Norwegian Meteorological Institute; Oclo; Norway
- Univ. of Oslo; Dept. of Physical Geography; Norway

The expected source of assessment
- Jerry Brown (Woods Hole-Uni) (P);U.S.A.
- Kuhry (Uni-Lapland) (Q),FIN
- Lorenz King; Uni Gießen (P),D
- W.Häberli (Uni Zürich),CH
- B.H.Jacobsen (Uni Copenhagen)(P),DK

Evaluate the data situation:
Contacts to the European partners of the PACE project should be used to gather information about changes in permafrost temperatures.
Suitable information from temperature profile data sets of the PACE project should be available in about 10 years.
Information about changing extent of permafrost and thickness of the active layer is probably available at partner organisations in Scandinavia (e.g. Universities of Copenhagen and Oslo) as well as in the Alps (Universities of Zürich, Innsbruck and Munich).

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 5

Geographical coverage
Permafrost zone of Europe (northern latitudes and higher mountains)

Time series length
T profiles for about 10 years (daily)
Extent of permafrost and thickness of active layer not longer than several decades (selective)

Further work required
Contacts to the management of the PACE project and to relevant Universities in order to gather suitable information.

Time schedule for indicator development
Long term (6 - 10 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness	**Yes**	
Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability. Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Cryosphere Responsibility: ETC/ACC
Indicator title *:* **Lake and River Ice**	
Definition *:* The indicator describes the long-term changes in freezing and break-up dates of northern lakes and rivers [days, weeks].	
Policy question: Freezing of northern lakes and rivers might have economic impacts (transport, fishery) and impacts on ecosystems.	
Derived from policy instrument/documents : UNFCCC; Art.: 2	
Description/rationale of the indicator Icing of lakes and rivers is directly connected to weather-conditions, especially to temperature and snow cover. Changes in long term averages of the beginning and ending of ice-cover on northern lakes and rivers should be an important index of climate variability and change. Limitation results from time dependent biases such as changes in observers and protocols related to the identification of “ice-on” and ”ice-off” conditions. Larger lakes are often located near human settlements. This can affect the homogeneity of records by “heat- island” effects or water discharge. Numerous studies suggest the importance of lake and river ice break-up as an index for climate variability and change. A recent analysis of trends in northern hemisphere lake and river ice records over a 150-year period (1846-1995) showed clear trends. Ice break-up in spring occurs on average 9 days earlier. Autumn freeze-up occurs 10 days later. More than 350 years observation of the Tornio river in Finland also shows a clear trend for the past decades. However the limitations have to be taken in consideration and the datasets are not available yet. ***State of knowledge: Established but incomplete***	

Sources:
Source of the indicator
First observations, in a very limited number of areas, already started about 300 years ago. A more systematic monitoring was established, especially in Scandinavian countries, about 150 years later.

The expected source(s) of data
- Dr. Esko Kuusisto; Helsinki; Finland
- Data-sets in national centers in Scandinavian and other Nordic Countries

The expected source of assessment
- Magnusson J.J. et.al. (Science 289, 1743-1746.)

Evaluate the data situation:
Northern hemisphere lake and river ice records over a 150-year period (1846-1995) should be available already.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Northern and central Europe

Time series length
Longer term (up to 300 years), yearly update

Further work required
- Identification of available data sets
- Gathering of information from several partners

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC
Indicator title *:* **Baltic Sea Ice (BSI)**	
Definition *:* Extent, duration and thickness of the ice-covered surface of the Baltic Sea [km^2; %]	
Policy question: Freezing of the Baltic Sea might have an impact on transport, coastal fishery and ecosystems. Changes in the frequency of freezing might have an impact on public awareness.	
Derived from policy instrument/documents : UNFCCC; Art.2	
Description/rationale of the indicator Baltic Sea ice extent, thickness and duration is expected to become an indicator of a warming climate, because it seems to react very sensitively to changing air temperatures, irradiation and temperature of water masses. The temperature of water masses and the extension of sea ice are influenced predominantly by seasonal and actual distribution of sunshine and air temperature, as well as by the actual storminess and salinity. The situation in the southern part of the Baltic Sea is characterized in wintertime by water temperatures close to the freezing point and therefore instable for icing. Freezing, extent, duration and thickness of sea ice in the Baltic Sea are related, but not in a simple way, to climate change. The correlation between climate change and Baltic Sea ice has to be clarified in more detail. ***State of Knowledge: Speculative***	

Sources:
Source of the indicator:
Datasets of Baltic Sea ice from many stations covering descriptions for some centuries or measurements for many decades are available in various countries (e.g. Germany, Sweden and Russia).
Datasets are being collected in the Baltic Sea Ice Climate project
However, available datasets have to be discussed with experts.

The expected source(s) of data:
- Federal Maritime and Hydrographic Agency; Hamburg; Germany
- AARI; St. Petersburg; Russia
- Estonian Met. and Hydr. Inst; Tallinn
- State Res. Centre of the Russian Federation; St. Petersburg; Russia
- Latvian Hydromet. Agency, Riga, Latvia
- Univ. of Helsinki; Finland
- Inst of Met. and Water Management; Gdynia; Poland

The expected source of assessment:
- Schmelzer/ Strübing; Federal Maritime and Hydrographic Agency; Hamburg; Germany
- AARI; St. Petersburg; Russia
- S. Jevrejeva; Tallinn; Estonia
- V.V. Drabkin, A.A. Lebedjev, Ye.M.U. Mironov; St. Petersburg; Russia
- J. Kostjukov; Riga; Latvia
- M. Leppäranta; Helsinki; Finland
- M. Sztobryn; Gdynia; Poland

Evaluate the data situation:
Processed datasets should be available in the archives of the Baltic Sea Ice Climate Project, at AARI (Russia), the German Maritime and Hydrologic Agency and the Universities of Stockholm (Sweden) and Helsinki (Finland).

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage
Baltic Sea and Substructures

Time series length
Daily terrestrial data from coastal-stations are available for some centuries.
Datasets from remote-sensing satellites exist for several decades.

Further work required
Gathering suitable information from relevant projects (Baltic Sea Ice Climate Project; Euroclim) and from European Focal Points of Baltic Sea Ice data sets (e.g. AARI)

Time schedule for indicator development
Medium term (3 - 5 years)

- Checking of available information in the different data centres and projects (July 2002)
- Completion of the indicator description sheet (Dec.2002)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?		Uncertain
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Uncertain
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Category 3 Soils and Land Resources

Indicator set: ***Climate Change***	Issue: Forestry and Agriculture Responsibility: ETC/TE
Indicator title: **Soil Moisture Availability**	
Definition: The indicator tracks the amount of moisture available in the soil which is necessary for plant growth (in mm or number of days above a threshold).	
Policy question: Sufficient soil moisture is essential for natural ecosystems, agriculture, ground water recharge and water availability in other sectors, e.g. supply of drinking water.	
Derived from policy instrument/documents These systems are included in various policy plans, such as the UN FCCC, the UN CBD, and various European and national policy plans. Thus, although no policy targets exist for soil moisture, there is link to various plans.	
Description/rationale of the indicator Soil moisture conditions are very sensitive to the balance between rainfall and evapo-transpiration (which, in turn depends on factors like temperature, radiation, wind, etc.). Thus soil moisture integrates various components of the climate systems and is as such a suitable indicator for climate change. Soil moisture availability can function as an indicator in itself (in mm). Alternatively, the duration of dry and wet soils can be used as indicators (in number of days). Experiences with this indicator exist, among others, in the UK. Based on such studies, it became clear that the period when soils are wet defines the opportunity for ground water to recharge, but it is also a major driving factor for flood risk. The duration that a soil is (very) dry determines drought risks and the potential threat to agricultural production (or at least the need for irrigation). Despite the attractiveness of such thresholds, there are a few difficulties. These difficulties are related to the large spatial variation of soil moisture conditions. Soil moisture varies between soil types (some soil types are often dry, while others are always close to saturation), and depends on climate (which makes a use in a European context difficult), vegetation cover, and land uses. A proposed solution is the definition of comparable sites throughout Europe. This will, however, still be difficult because of the large variation in the European climate and its effects on soil moisture. The tendency towards a warmer climate will probably result in an increase of the duration of dry soils and lead to a reduction of the number of wet soil days. The net result will depend in particular on the changes in precipitation. In areas in which precipitation decreases the mentioned effect will be enhanced (i.e. more dry soil days and less wet soil days), whereas increasing (winter) rainfall could produce a counterbalancing effect. ***State of knowledge: Competing explanations***	

Sources:
Source of the indicator
Soil moisture is dealt with by monitoring networks and included in simulation models. Various sources for historic, current and future figures are available. A major problem will, however, be the comparability between regions. Soils in southern Europe are often already dry. Climate change will have a minor effect on these soils. Similar soils in other parts of Europe might be more affected, even when subject to less changes in the climate.

The expected source(s) of data
- Carter, Finnish Environmental Institute, FI (Q, P)
- Döll, Uni. Kassel, DE (Q, P)
- ETC terrestrial and ETC-Water(P)
- FAO (e.g. for various soil and land use data)
- Marsh, CEH, UK (L)

The expected source of assessment
- Arnell, Uni. Southhampton, UK (L)
- Döll, Uni. Kassel, DE (Q, P)
- ETC terrestrial and ETC-Water

Evaluate the data situation:
- Define information that is needed to quantify soil moisture and understand observations (e.g. soil types, land use maps; ETC Water, ETC Terrestrial Environment, FAO, Marsh).
- Identify and contact various sources in which soil moisture conditions are available (e.g. Marsh; ETC Water, ETC Terrestrial Environment)
- Define method to enable an European comparison
- Identify and contact modelling groups
- Discuss the presentation of the information (e.g. map, country-by-country graph, European graph, etc.).
- Evaluate possible future changes in soil moisture.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
1960 – 2000,2020, 2030, 2050, 2100

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Local
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	A threshold might be needed as a quantifier of the indicator. But no threshold for the relation to climate change
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?		May be based on an arbitrary threshold
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	.
• Could the indicator be linked to economic models, forecasting and information systems?		Unclear
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?		Unclear
• Adequately documented and of known quality?		Unclear
• Updated at regular intervals in accordance with reliable procedures?		Unclear

Indicator set: ***Climate Change***	Issue: Soils and Land Resources Responsibility: ETC/ACC
Indicator title: **Net Carbon Uptake**	
Definition The indicator quantifies the net carbon (C) flux between the atmosphere and terrestrial biosphere, i.e. the accumulation or loss of additional carbon through biospheric activities (in t ha^{-1}).	
Policy question The net carbon uptake of the terrestrial biosphere is important for various policy-related issues. Firstly, the behaviour of the biosphere (i.e. whether a net uptake or release of carbon occurs) determines, among others, the effort needed to reduce greenhouse gas emissions (aiming at a stabilisation of the atmospheric concentration as formulated in the UNFCCC). If the current biospheric sink declines and even becomes a source of carbon itself (e.g. because temperature increase results in significant increase of soil respiration), additional reductions of energy related emissions or additional land-use related sequestration ('sinks') are needed to achieve stabilisation. Information about the trend in net carbon uptake is therefore important. Secondly, the information is needed as an indication of the sink potential of the terrestrial biosphere, as mentioned in the Kyoto Protocol. Although there is no one-to-one relationship between the biospheric uptake and human-induced sink, the former can provide some indication. Finally, biospheric uptake and changes in it provide information about the vitality of the different ecosystems in the biosphere. There is a link to the UNFCCC and the Convention of Biological Diversity, stating that adaptation to changes in climate should be possible.	
Derived from policy instrument/documents The behaviour of the terrestrial biosphere in the global carbon (C) cycle is an important indicator for the status of the biospheric ecosystem. This is important with regard to the UNFCCC and the Kyoto Protocol.	

Description/rationale of the indicator

The net carbon release or uptake of ecosystems is called net ecosystem production (NEP). If NEP is positive, it means that carbon accumulates in the terrestrial biosphere. In a given ecosystem, NEP is often positive for most years (sometimes at a low level). These years are alternated with years having a negative NEP, caused by major disturbances, death etc. (resulting in a release of carbon). Both the normal NEP sequence and the frequency and extent of disturbances are sensitive to changes in the climate and atmospheric CO_2. Climate change may, for example, increase NEP (i.e. the carbon accumulation), followed by a more dramatic release (e.g. due to forest fires).

Methodologies have only recently been developed to quantify the NEP (i.e. biospheric C storage) on a large scale. To begin with, a vast monitoring network has been set up (e.g. using flux towers). Information from these sites can be scaled up by the use of remote sensing information. However, the long-term usefulness of the network has to be analysed, for example with regard to disturbances. The monitoring network has been proposed within the EU to not only measure the C fluxes in general, but also to quantify the carbon sinks/source of forest and agricultural ecosystems as part of the Kyoto protocol. Secondly, large-scale NEP fluxes can be quantified through the use of simulation models. Activities to harmonise these models (e.g. through a comparison) have been initiated. Although agreement about standard methods (e.g. as part of IPCC) has still to be established, a general picture is that NEP will continue to grow for a couple of decades, followed by a steep decline (probably even becoming negative, i.e. C release).

Net carbon uptake of the terrestrial biosphere is (mostly) understood, internationally accepted and seen as an important measure. However, some agreement on the methods to quantify the uptake is still needed.

In addition to NEP, the C dynamics of specific ecosystems is important in relation to the Kyoto protocol. These ecosystems include the forests that have been planted or disappeared and, more generally, ecosystems in which the management has been changed since 1990 or will change towards 2008-2012.

State of knowledge: Established but incomplete

Sources:
Source of the indicator
Large-scale quantification of the net C uptake of the biosphere has only recently been started. As such long-term historical data sets are rare. It can both be observed as well as computed by simulation models (e.g. to project future changes). One problem might be the link to the climate and atmospheric CO_2. Although both factors have an important influence, other factors also exist (e.g. N deposition, land use). Again, simulation models can be applied to distinguish between the different impact factors.

The expected source(s) of data
- Beier, RISO National Laboratory, Dk (Q)
- EuroCarbon (L, P)
- Raes, JRC, IT (P, L)

The expected source of assessment
- Cramer, Potsdam Institute for climate impact Research, DE (P)
- CarboEurope (L, P)
- Leemans, RIVM, NL (P)
- Schimel/Freibauer, MPI-Jena, D (P)
- Smith, University of Aberdeen, UK (Q)
- Woodward, University of Sheffield, UK(L)

Evaluate the data situation:
- Gather knowledge about the current C fluxes in European ecosystems (based on observations and model experiments). Compare the various assessments.
- Contact groups involved in the monitoring network throughout Europe (e.g EuroCarbon)
- Determine appropriate tools (and persons) to assess the past, current and future (potential) C uptake fluxes
- Define baseline for projections.
- Assess the potential C uptake fluxes under the defined baseline. Possibly repeat the exercise for different 'what-if' scenarios.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 2 (although for recent years the data availability is better)

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
1995 – 2000, 2020, 2030, 2050, 2100
.

Further work required
See data situation

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Various projections exist with respect to crop suitability under climate change.
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Both for observations (remote sensing) and modeling
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	Although for models the standards are under discussion.
• Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:	**No**	If wanted, it can be based on models alone.
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	Observations are expensive, but often funded through other projects
• Adequately documented and of known quality?	**Yes**	Used in various climate change assessments
• Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly observations. Some work still needs to be done. Models are updated every 3 - 5 years.

Category 4: Agriculture and Forestry

Indicator set: ***Climate Change***	Issue: Agriculture and Forestry Responsibility: ETC/ACC
Indicator title: **Crop Suitability**	
Definition The indicator describes the possibility of growing crop types in an area/country, based on climate driven variables (and soil properties). A set of the currently important crops within the European Countries will be chosen (in km^2) as a basis.	
Policy question Considerable changes in agricultural production and ultimately crop suitability are explicitly mentioned in the UNFCCC and Sixth Environmental Action Programme as climate change impacts that should be avoided. The issue is important, among others, because changes in production and suitability may affect food security within a country (or at least require certain types of adaptation).	
Derived from policy instrument/documents The suitability of currently important crops can be used as indicator to assess the threat of climate change on the agricultural production potential within a country. Agriculture is an important sector in Europe. As such, climate change impacts on agriculture have been identified as important (e.g. see Sixth Environmental Action Programme, page 24).	
Description/rationale of the indicator Agriculture is an important sector within Europe, both from the financial perspective as well as in relation to its products (food security). Agriculture depends, among others, on climate and atmospheric CO_2. Changes in climate and CO_2 increase have impacts on the potential for growing new crop types, whereas the suitability of other existing crops may decrease (e.g. due to too high temperatures or lack of moisture) (high confidence[2]). The latter can be quantified by considering the suitability of currently important crops in different countries and evaluating their response to the observed and future changes in the climate (and CO_2). Studies have already shown that the suitability could become critical in unfavourable climatic conditions in those parts of Europe where agriculture is most affected by temperature (northern part) and moisture (parts of eastern and southern Europe) (High confidence[1]). If such changes indeed occur within a time frame where adaptation becomes difficult, self-sufficiency with respect to food production might become threatened (something that should be avoided according the UNFCCC). Agricultural production (in $t*ha^{-1}$) is also often used as an indicator for climate change impacts. There might be problems to assess climate change impacts on agriculture in Europe , due to the strong influence of agricultural management and dominance of the EU's Common Agricultural Policy (CAP) on the agricultural system. Because of the stronger link to climate, the potential suitability of currently important crops has been chosen. Since we evaluate the potential of crops and changes caused by climate change, the indicator is especially suitable as an indicator for future changes (e.g. up to the year 2100). ***State of knowledge: Well-established***	

[2] According IPCC levels

Sources:
Source of the indicator
Agricultural production in all European countries is monitored frequently. This, however, concerns the actual production. Potential production and suitability are computed by simulation models and partly compared with existing data sets. As such, data sets (i) will be directly used if they contain results of modelling studies; (ii) will be used for validation purposes if they contain measurement data on a local scale;

The expected source(s) of data
- Eurostat
- JRC, Ispra, (IT) Project MARS (L)
- Downing, Uni. Oxford, UK (L)
- Parry, University of Norwich, UK (L, P)
- Ramankutty and Foley, UK (L)

The expected source of assessment
- Carter, Finnish Environmental Institute (Q, P)
- Cramer, Potsdam Institute for Climate Impact Research, DE (P)
- JRC, Ispra, (IT) Project MARS (L)
- Easterling, Pennsylvania State Univ., USA (L)
- Downing, Uni. Oxford, UK (L)
- Fischer, IIASA (P)
- Leemans, RIVM, NL (P)
- Olesen, Res. Centre Foulum, DK (Q)
- Parry, University of Norwich, UK (L, P)

Evaluate the data situation:
- Gather knowledge about the currently important crops in European countries (e.g. link to ETC/Terrestrial Environment)
- Determine appropriate tools to assess the suitability of currently important crops in Europe (needs discussion among experts)
- Assess the potential suitability of these crops under present-day climate conditions (they might grow in areas where they are currently not grown due to various reasons)
- Evaluate the fluctuation of the crop suitability during the past decades.
- Evaluate possible future changes in suitability, using different climate change scenarios

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
2020, 2030, 2050, 2100
.

Further work required See data situation
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/ No	**Notes**
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Indicator shows esp. relation to environment, less to response
• Is the indicator simple, easy to interpret and able to show trends over time?		Yes for long-term trends, less suitable for yearly fluctuations
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Various projections exist with respect to crop suitability under climate change.
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?		Many models exist, most applicable tool should be discussed
• Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	Very useful for that
Measurability Are the data required to support the indicator:	**Yes**	Especially initial state as a basis for projections.
• Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
• Adequately documented and of known quality?	**Yes**	Used in various climate change assessments
• Updated at regular intervals in accordance with reliable procedures?	**Yes**	In 3 - 5 years new models will become available. These could be used for new evaluations

Indicator set: **Climate Change**	Issue: Forestry and Agriculture Responsibility: ETC/NPB
Indicator title: **Forest Suitability**	
Definition The indicator quantifies the changes in tree species distribution in Europe due to changes in climate (in km^2).	
Policy question Forest ecosystems consist of many different species, of which tree species are dominant. The potential of growing these tree species is related to various policy questions, e.g. the UNFCCC. Many studies have shown that climate (temperature, precipitation, atmospheric CO_2) is an important factor in determining the distribution of tree species. The rate of climate change has to be restricted to limit the overall effects on the distribution of forests. Healthy forests are also important for sustaining biodiversity. European forests belong to an important economic sector (timber, recreation, water conservation). Policy action plans have argued for a sustainable management of forests. Climate change might affect these plans, because it affects the productivity (see forest production indicator) and distribution of forests.	
Derived from policy instrument/documents The UNFCCC explicitly mentions that ecosystems (including forests) should have the opportunity to adapt naturally to climate change. A key issue of the Convention on Biological Diversity is sustainable forest conditions.	

Description/rationale of the indicator

About 30% of Europe is covered by forests. Thus forests are an important land cover type. These forests are managed for several purposes, such as timber, water resources and recreation.

Climate, soil moisture availability and atmospheric CO_2 limit the natural structure and distribution of European tree species. Other factors that play a role are nutrient availability and a natural disturbance regime. Despite these other factors, studies project that climate change (incl. enhanced CO_2) may result in large shifts in tree distribution throughout Europe (see below). Whether or not these changes in tree distribution will indeed occur, depends on the rate of climate change. It must be noted that the projected rate of climate change is more rapid than most tree species have seen in the past and the migration rates are bound to be larger than historically observed. The problem is whether local growing conditions (e.g. soils) can change as well to allow for such high migration rates. A further complicating factor in projecting changes in forest composition is the uncertainty of how the risk of disturbances and forest management will change in the future. The uncertainty with respect to disturbances is caused by the complex interaction between disturbances and climate. The management issue is important because many forests in Europe currently consist of tree species that are different from those that would occur naturally. As such, studying climate change impacts on forest distribution in Europe should consider also forest management. Another complicating factor is the often broad 'environmental amplitude' of many forests, i.e. it will take considerable climate changes to have an effect on the composition of forests.

Despite these potentials and restrictions, many studies have shown potentially large impacts of climate change on forest structure and composition throughout Europe. For example, studies reported in the latest IPCC report project that under warmer conditions boreal tree species may invade large parts of the current tundra area, whereas boreal species themselves may be replaced by a northward movement of more temperate deciduous tree species. In southern Europe, where most forests consist of specific, drought adapted species, the possible impacts are uncertain. Projected decreasing precipitation rates may limit the distribution of forests, because of increasing drought stress and more forest fires. On the other hand, enhanced CO_2 levels allow for compensating for the additional water losses. In most mountainous regions an upward movement of forest species is projected due to higher temperatures. In many European regions this effect might be limited due to the large influence of forest management.

Because of the mentioned complicating factors, the long life span and the broad environmental amplitude of most tree species, forest suitability is especially a projection indicator, i.e. to be assessed through modelling. Various models developed in the last decade can simulate changes in forest suitability. However, the models seldom consider (i) climate variability (inter-annual and intra-annual); (ii) disturbances such as forest fires and changes in it. For an appropriate assessment of the consequences of climate change, these factors might be important.

State of knowledge: Competing explanation

Sources:
Source of the indicator
The impact of climate change on forest distribution is a slow process. This is caused by the fact that most forests have a broad environmental amplitude, a long life span and have a potential to adapt to a range of climate changes. Further, other factors such as forest management (e.g. causing many forests in Europe to consist currently of tree species that are different from those which would occur naturally) complicate the relationship between climate and forest distribution. As such, the indicator is less observable, but particularly suitable to be assessed by simulation models (e.g. to project future changes). Many simulation models have been developed and applied for assessing possible consequences of climate change on forests. Data are needed for validation purposes.
Biodiversity aspects will be added in a later stage (by ETC/NPB.

The expected source(s) of data
- FAO Forest resource assessment (L)
- Karalainen, T. (L, P) EFI
- Nabuurs, G.J., Alterra Institute for Green World Research, NL, (P, Q)
- Lexer, University of Vienna (Q)
- Raes, JRC, IT (P)
- Svidenko, IIASA, AU (P)

The expected source of assessment
- Cramer, PIK, DE (P)
- Karalainen, T. (L, P) EFI
- Nabuurs, G.J., Alterra Institute for Green World Research, NL, (P, Q)
- Prentice, I.C., MPI-Jena, GE (P, L)

Evaluate the data situation:
- Gather knowledge on the current distribution of European forests and their growth trends (e.g. EFI, JRC).
- Identify appropriate tools and persons for determining the forest distribution trends in Europe (e.g. Alterra, EFI, PIC)
- Discuss the presentation of the information (e.g. map, country-by-country graph, European graph, etc.).
- Evaluate possible future changes in forest growth, using one baseline and different 'what-if' scenarios.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length 1990-2000, 2020, 2030, 2050, 2100 (for the starting period only simulation results are available for a European picture of forest growth trends. Many simulation studies exist that evaluate the more historic link between climate and forest distribution. The usefulness of these studies has to be evaluated in relation to the processes that are important in this decade or even century (depends on target year of an assessment).
Further work required See data situation
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Especially relation between climate and indicator, less about responses
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes/No**	Yes, simple to understand, no trends in short-term
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	Regional Especially modeling
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	Although many non-climate related factors play a role
• Is the indicator based on international standards and international consensus about its validity?		Uncertain
• Could the indicator be linked to economic models, forecasting and information systems?	**No**	But it is easy to link to other models, e.g. climate models
Measurability Are the data required to support the indicator:		Untertain
• Readily available or made available at a reasonable cost/benefit ratio?	**No**	
• Adequately documented and of known quality?	**Yes**	Used in various climate change assessments

• Updated at regular intervals in accordance with reliable procedures?	**Yes**	Models are updated every 3-5 years.

Indicator set: **Climate Change**	Issue: Forestry and Agriculture Responsibility: ETC/ACC

Indicator title:

Forest Growth

Definition

The indicator quantifies the net biomass increase of forests in Europe (in t ha^{-1}).

Policy question

Forest growth is an indicator that is related to various policy questions. Firstly, climate (temperature, precipitation, atmospheric CO_2) is one crucial factor that determines forest growth. As such, the Climate Convention explicitly mentions that ecosystems (including forests) should have the opportunity to adapt naturally. Forest growth (and total biomass) provides an indicator on the status of forest ecosystems. Related to the climate issue, temperate and boreal forests (in Europe and Northern America) absorb considerable amounts of carbon (and compensate for emissions in tropical areas). Secondly, sustainable wood production (which is similar to forest growth) and other uses of natural resources are key issues of the Convention on Biological Diversity. Finally, European forests belong to an important economic sector (timber, recreation, water conservation, nature). For this reason, policy action plans have been formulated for a sustainable management of forests. Climate change might affect these plans.

Derived from policy instrument/documents (*provide quote or page reference*)

Forest growth related issues are documented in the CBD and are part of COP negotiations

Description/rationale of the indicator

About 30% of Europe is covered by forests, making forests an important land cover type. These forests deliver a number of products, of which timber is (economically) the most important one. Among others, climate factors such as precipitation and temperature, as well as atmospheric CO_2 are important driving factors of forest growth.

Forest growth has increased during the past decades in northern forests and many other places in Europe. Various factors such as climate change, increased atmospheric CO_2, nitrogen deposition and changes in forest management (leading to ageing of forests) have been identified as being behind the increase. The contribution of all these single factors is still uncertain. The impacts of climate change and atmospheric CO_2 are shown by experiments and model calculations. They show different trends for different parts of Europe. Positive growth trends are projected for northern and central Europe (up to 12-15% additional growth per 1° C warming in forest tundra and northern boreal forests, Parry et al, 2001). Decreasing growth trends are projected for southern and parts of eastern Europe, due to projected limited moisture availability (resulting from increasing temperatures and possibly reduced summer rainfall). Increasing CO_2 levels in the atmosphere might partly compensate for the losses, but the net growth is still likely to decline.

A complicating factor in projecting forest growth trends is the uncertainty of how the risk of disturbances will change in the future. The uncertainty is caused by the complex interaction between disturbances and climate.

State of knowledge: Well established.

Sources:
Source of the indicator
Net C uptake of the biosphere can both be observed as well as computed by simulation models (e.g. to project future changes). One problem might be the link to the climate and atmospheric CO_2. Although both factors have an important influence, other factors also exist (e.g. N deposition, land use).

The expected source(s) of data
- FAO Forest resource assessment (L)
- Karalainen, T. (L, P) EFI
- Maier, Uni. Bonn, GE (Q)
- Nabuurs, G.J., Alterra Institute for Green World Research, NL, (P, Q)
- Raes, JRC, IT (P)
- Sparks, CEH, UK (Q)
- Svidenko, IIASA, AU (P)

The expected source of assessment
- Carter, Finnish Environmental Institute, FI (Q, P)
- Cramer, Potsdam Institute for climate impact Research, DE (P)
- Karalainen, T. (L, P) EFI
- Nabuurs, Alterra Institute for Green World Research, NL, (P, Q)

Evaluate the data situation:
- Gather knowledge on the current distribution of European forests and their growth trends (e.g. EFI, JRC).
- Evaluate the fluctuation of forest growth during the past decades.
- Identify appropriate tools and persons for determining the forest growth trends in Europe (e.g. Alterra, EFI, PIC)
- Discuss the presentation of the information (e.g. map, country-by-country graph, European graph, etc.).
- Evaluate possible future changes in forest growth, using one baseline and different 'what-if' scenarios.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage
Europe

Time series length
1950 – 2000, 2020, 2030, 2050, 2100 (during the starting period only simulation results are available for a European picture of forest growth trends. Observations are represented by site information across Europe. Closer to 1990, satellite images provide information about observed EU wide forest growth trends.

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	Regional Both for observations, remote sensing and modeling
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	Although for models the standards are under discussion.
• Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
• Adequately documented and of known quality?	**Yes**	Used in various climate change assessments
• Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly observations. Some work still needs to be done. Models are updated every 3-5 years.

Indicator set: ***Climate Change***	Issue: Forestry and Agriculture Responsibility: ETC/ACC
Indicator title: **Pests and Diseases**	
Definition Pests and diseases indicate the frequency with which pests and diseases affect agricultural and forest production. However, it is still unclear whether all (major) pests and diseases will be used or whether specific types will be selected as examples (unit: frequency per decade).	
Policy question The occurrence of pests and diseases is a normal phenomenon in agriculture and forestry. However, if the frequency of the occurrence changes due to environmental changes such as climate change, this becomes significant because: • It may affect the fertility of ecosystems and, as such, the potential to adapt naturally to climate change • Pests and diseases can significantly reduce agricultural and forestry production. As such, it may becomes an economic threat as agriculture and forestry are important economic sectors in Europe. Various policy action plans have argued for a sustainable management of forests and agriculture. This might, for example, become affected by changes in the occurrence of pests and diseases.	
Derived from policy instrument/documents Natural adaptation to climate change is one of the key issues of the UNFCCC	

Description/rationale of the indicator

Most pests and diseases that affect plant behaviour are very sensitive to environmental conditions and so can be expected to be affected in a number of ways by, for example, changes in the climate. The changes may be negative, neutral or positive, with regard to the impact on agriculture and forestry. If negative impacts occur, this may have various ecological and economic implications. Especially if new pests and diseases appear, this may lead to considerable effects because ecological and human adaptation potentials are limited.

Assessments of how pests and diseases are affected by climate change show a complex interaction resulting in a high level of uncertainty.. On one hand the occurrence of pests and diseases is a relevant indicator for climate change because the timing of the occurrence is strongly related to climate (e.g. climate defines whether insects are able to reach the stage of adult). Warm and dry weather generally results in faster development and lower mortality. If, however, the conditions become too dry, it becomes hard to make generalisations. Droughts may, on the one hand, lead to limited impacts (e.g. because of reduced distribution of some fungi), although there are also exceptions. On the other hand, droughts also reduce the vitality of many plant species, making them vulnerable. Furthermore, the interaction between pests and diseases on the one hand and climate on the other hand is complex because not only is the climate at a certain moment in time important (e.g. temperature in January), but also the course in the past. The course determines, for example, the synchronisation between hosts and insects. A warmer climate may lead to a dis-synchronisation, leading, for example to many insects in desiccated food supplies.

Despite these uncertainties, various studies have shown a correlation between the occurrence of pests and diseases and climate. The studies show, for example, that more insects can be expected, especially in central and northern Europe, taking the projected changes in climate into account. In the UK, for example, studies suggest a doubling/tripling of the population of some specific insect species if the temperature increases by $1^{o}C$.

It is still unclear whether the total frequency of pests and diseases can be used or whether specific types should be chosen as an indicator. Existing studies mainly focus on single species. However, with regard to the ecological and economic impacts, it would be more important to assess the correlation between climate change and the total occurrence of pests and diseases.

State of knowledge: Speculative

Sources:
Source of the indicator
The impact of climate change on pests and diseases in forestry and agriculture is complex. For example, not only is the climate at a certain moment in time important but also in the past. Further, although climate is an important factor, other factors (e.g. management) also play a role. Despite these difficulties, theoretical understanding has started to emerge and the development of simulation models has been initiated. In particular the IGBP-GCTE programme on 'Global Change impacts on pests, diseases and weeds' may be helpful in reducing some of the uncertainties.

The expected source(s) of data
- Cannell, CEH, UK (P, L)
- Harrington, Rothamsted Institute, UK (Q, L.)
- Scherm, University of Georgia, USA (L)
- Bob Sutherst, John Ingram, IGBP/GCTE, (L)

The expected source of assessment
- Bob Sutherst, John Ingram, IGBP/GCTE, (L)

Evaluate the data situation:
- Detailed description of the indicator (e.g. which species, which regions, which climate variables)
- Contact IGBP/GCTE network and others for historic and present situation (e.g. Rothamsted Institute).
- Determine potentially suitable tools and persons for projecting future changes (e.g. IGBP/GCTE network?)
- Discuss the results and presentation of the results

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 2

Geographical coverage
Europe, eventually sub-European

Time series length
1960-2000 (e.g. available in UK), 2020, 2030, 2050, 2100

Further work required
See data situation

Time schedule for indicator development
Long term (6 - 10 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes/No**	Interaction is complex. Clear correlation has to be identified
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	Climate is only one of the factors
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Regional Especially modeling
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	Although many open issues remain
• Is the indicator based on international standards and international consensus about its validity?		Uncertain
• Could the indicator be linked to economic models, forecasting and information systems?		Pests and diseases have a considerable impact on agricultural production. As such, can be coupled to economic models.
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?	**No**	
• Adequately documented and of known quality?	**No**	
• Updated at regular intervals in accordance with reliable procedures?	**No**	Activities only recently started .

Indicator set: **Climate Change**	Issue: Forestry and Agriculture Responsibility: ETC/NPB
Indicator title: **Shifts in the Tree Line**	
Definition The indicator shows the upward movement of forests due to climate warming (in m).	
Policy question The potential distribution of forests is mainly determined by climate. The northward and upward movement of ecosystems is often used to illustrate climate change. The tree line in mountainous regions is a clear example.	
Derived from policy instrument/documents The Climate Change Convention (UNFCCC) explicitly mentions that climate change impacts should be limited to a level and to a rate to which ecosystems (including forests) can adapt naturally. One of the possible adaptations to climate change is the movement towards new suitable areas. One example which can be observed is the upward movement of trees in mountainous regions. Thus, the tree line can help to indicate whether the climate is changing and, if so, whether the forests are able to adapt naturally.	
Description/rationale of the indicator About 30% of Europe is covered by forests. Many of these forests are located in mountainous regions. Climate is one of the main driving forces determining the potential distribution of these forests. In the Pyrenees, for example, studies have shown that upward and downward movements of the tree line are related to climate conditions. Changes in tree lines can therefore be used as an indicator of climate change. One problem, however, is the strong human influence in these areas. Many tree lines in Europe are currently more determined by management rather than climate. To conclude, the tree line may be a useful indicator. However, work needs to be done to identify areas where human influences are limited. ***State of knowledge: Established but incomplete***	

Sources:
Source of the indicator
Tree lines are documented by observations and partly included in simulation models. Various sources for historic, present and future figures are available. One problem, however, is how to distinguish between actual (observations) and potential (modelling) distribution of forests (tree line) andthe determining effect of management. Biodiversity aspects will be added in a later stage (by ETC/NPB.

The expected source(s) of data
- FAO Forest resource assessment (L)
- Lexer, Uni. of Vienna, AU (Q)
- Svidenko, IIASA, AU (P)
- EU Project GLORIA (L)

The expected source of assessment
- Bugman, Swiss Fed. Inst. for Technol., CH (P, L)
- Carter, Finnish Environmental Institute, FI (Q, P)
- Cramer, Potsdam Institute for climate impact Research, DE (P)
- Körner, University of Basel, CH (L)
- Krauchli, Swiss Fed. Inst. Forestry, CH (L)
- Bugmann, ETH Zürich, CH (P)

Evaluate the data situation:
- Contact possible data sources of tree lines in Europe
- Identify human and climate signals in data, if possible. Evaluate availability of data in which the climate signal dominates.
- Discuss comparability between data.
- Discuss the possibility for a European picture of historic and present tree lines.
- Contact modelling groups.
- Discuss availability and comparability of modelling results.
- Evaluate possible future changes in tree lines, using one baseline and different 'what-if' scenarios.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
? – 2000, 2020, 2030, 2050, 2100 (during the starting period both observations and modelling results are available for a European picture.

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**?**	Possibly. Climate is a determining factor. But may be overruled by human influences in Europe
Is the indicator simple, easy to interpret and able to show trends over time?	**Y**	
Is the indicator responsive to changes in the environment and related human activities?	**Y**	The potential tree line is responsive
Does the indicator provide a basis for international comparisons?	Y	Both for observations and modelling tools
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	Regional	For observations, remote sensing and modelling
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	N	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**?**	
Is the indicator based on international standards and international consensus about its validity?	**Y**	
Could the indicator be linked to economic models, forecasting and information systems?	**N**	
Measurability. Are the data required to support the indicator:	**N**	
Readily available or made available at a reasonable cost/benefit ratio?	**?**	6-10 years
Adequately documented and of known quality?	**Y**	Used in various climate change assessments
Updated at regular intervals in accordance with reliable procedures?	**Y**	Observations exist for some regions. Remote sensing can help as well.

Category 5: Ecosystems and Biodiversity

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/ACC
Indicator title: **Growing Season**	
Definition*:* Seasonal changes in photosynthetic activity and in vegetation cover (greening, de-greening) due to changes in leaf area of annual and deciduous plants. Growing season is also defined by thresholds calculated from climate or weather data, e.g. number of consecutive days with temperatures above 5°C.	
Policy question: Changes in the growing season can affect vegetation structure and function. Certain fruits need a number of days with temperatures below 0°C. Crops such as winter rape can grow up to early in late autumn and can not cultivated any longer if average temperatures increase. Adaptation might be necessary, affecting the agricultural production in areas with increasing temperatures.	
Derived from policy instrument/documents Changes in growing season is described in IPCC 3rd report.	
Description/rationale of the indicator In areas where plant growth is limited by temperatures, certain thresholds are very important for the productivity of the vegetation. In particular the number of consecutive days with temperatures higher than 0° C or 5° C are used to describe the length of the vegetation period. Long-term changes in the length of the vegetation period can also lead to changes in species distribution and consequently may change ecosystem structure and function. ***State of knowledge: Well established***	

Sources:
Source of the indicator
Remote sensing techniques, especially the Normalized Differential Vegetation Index (NDVI), are used to analyse vegetation dynamics in high spatial resolution.
The growing season is easy to calculate but can be difficult to interpret due to the different thresholds of the various plant species.
Calculating NDVI from remote sensing data is a highly widespread method, but data processing, especially geo-referencing and atmospheric correction of the data needs much work and computer capacity. Observing changes in the growing season needs remote sensing data with high temporal and therefore less spatial resolution (e.g. NOAA-AVHHR). This can not be interpreted easily in areas with small scale fractioning of the landscape.

The expected source(s) of data
- Anette Menzel, TU München Freising (C, L)
- Alberte Bondeau (PIK, Potsdam) (P)
- Frank Veroustraete (VITO, Belgium) (P)

The expected source of assessment
- Anette Menzel, TU München Freising (C, L)
- Alberte Bondeau (PIK, Potsdam) (P)

Evaluate the data situation:
Length of growing season can easily be derived from climate and weather data. There is no systematic monitoring of NDVI data over Europe yet.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 5

Geographical coverage
Most parts of Europe in high spatial resolution; Some NDVI data might be missing at high latitudes; Weather data are available from stations in irregular spatial resolution.

Time series length
Climate data are available from 1901
NVDI data are available from 1973, data in good quality since 1985

Further work required
NDVI data have to be evaluated and analysed for Europe

Time schedule for indicator development
Short term (0 - 2 years) for growing season derived from climate data
Medium term (3 - 5 years) for NDVI data

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly NDVI data irregularly

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/NPB
Indicator title: **Plant Phenology**	
Definition*:* Observed states in plant growth over the year like sprouting, bud bursting, blooming, appearance of first leaves, leaf senescence.	
Policy question: Climate change induces changes in the dates of the different phenological states of plant growth. There is high public awareness about trends in phenology. Early growing can have negative effects on crop growth. Certain species (e.g. winter rape) will possibly not be cultivated any longer in areas with increasing temperatures because of early blooming in early winter time instead of spring time with the consequence of total loss of yield.	
Derived from policy instrument/documents Mentioned in IPCC 3rd report.	
Description/rationale of the indicator A number of data sets are collected in phenological gardens all over Europe. In some countries, weather services have organized regular monitoring systems run by volunteers. The observation system is more sensitive than the calculation of growing seasons from climate or remote sensing data. Data can be analysed for certain species or plant functional types. Observations can be combined with climate and remote sensing data for validation. There are distinct relations between leaf development and weather conditions at the beginning of the growing season. Processes controlling leaf senescence are still not completely understood. ***State of knowledge: Well established***	

Sources:
Source of the indicator
Data are collected by a number of organisations such as national weather services. Biodiversity aspects will be added in a later stage (by ETC/NPB).

The expected source(s) of data
- Chmielewski (Humboldt Uni. Berlin)
- Van Vliet De Groot (L)
- Collinson (Woodland Trust UK) and otheres (Q)
- DWD, German Weather Service (P)
- EPN European Phenological Network (L)

The expected source of assessment
- Anette Menzel, TU München Freising (C, L)
- Jörg Schaber PIK, Potsdam (P)

Evaluate the data situation:
The main problem is the access to existing data. Data availability depends on the institution and sometimes on single persons. Data are not equally distributed over Europe and might not be interpreted easily for the whole continent or for vegetation in total.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 5

Geographical coverage
Most parts of Europe in irregular spatial resolution

Time series length
Several decades of annual data

Further work required
Analysing and harmonising data is the most important issue

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/NPB

Indicator title:

Change in species behavioural patterns

Definition*:*
Specific seasonal patterns in the behaviour of animals, which depends on weather conditions.

Policy question:
Seasonal patterns in animal behaviour can change due to changes in weather conditions. Changes may be detected in term of modifications of migration routes (birds, butterflies, fish). For Birds; areas of wintering, breeding or migration may be modified due to climate change.
Stakeholders, especially in the sector of nature protection, are concerned about changes in animal behaviour. Planning of protected areas has to be adapted to animal behaviour.
Changes in the behaviour of insects may affect agriculture and forestry.

Derived from policy instrument/documents
FHH, Millenium Ecosystem Assessment, Ramsar Convention, Convention on Biodiversity (CBD), Convention on Migratory Species, Diversitas (UNESCO; IGBP/GCTE and others)

Description/rationale of the indicator
A number of animals, mainly insects, birds and also some fish species, show a distinct seasonal behaviour which is influenced by weather conditions. Long-term records over a number of decades can be used to analyse changes and shifts in the behaviour of certain species. These have to be specified beforehand. There is high perception of the public to some of these issues. In addition to research programmes, observations and data collecting are performed by volunteers.

State of knowledge: Established but incomplete

Sources:
Source of the indicator
There are lots of data on national and local levels in a number of countries, but not on European level. Only a few species are common in whole Europe, but local and regional trends in arrival dates can be used as an indicator. Further efforts are necessary to collect and process the available data. It might be difficult to extract European-wide indicators out of the existing data. Biodiversity aspects will be added in a later stage (by ETC/NPB).

The expected source(s) of data
- Unep-WCMC, Cambridge (C)
- Lavorel (CEFE, France) (C)
- Neff (Uni. Mannheim) (Q)
- Environment and Climate Programme of the European Commission (L)
- UKCIP Climate Change Indicator Programme (L)
- Parmesan (2001) (L)
- Hill et al. (2001) (L)
- Hodkinson et al. (1998) (L)
- Tryjanowski, Adam Mickiewicz Uni., Poznan (Q)
- Juillard (CRBPO, Paris) (Q)
- Domenico Gaudioso (INEA, Rom) (Q)
- Kinzelbach et al. (1997) (L)
- Crick (BTO, Norfolk, UK) (Q)
- IOW Warnemünde, Uni. Rostock, Uni. Kiel, Uni. Greifswald (C)

The expected source of assessment
- Unep-WCMC, Cambridge (C)
- Lavorel (CEFE, France) (C)

Evaluate the data situation:
Many records are collected, but data access has to be organized. For this reason indicators are not available within short time perspectives.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 5

Geographical coverage
National and regional level (e.g. UK)

Time series length
Several decades

Further work required
Data mining and processing is necessary to extract information for larger parts of Europe.

Time schedule for indicator development
Medium (2 - 5years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	**Notes**
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/ACC

Indicator title:

Storm Events

Definition*:*
Area with vegetation cover where the structure has been severely damaged by single storm events. In most cases damage to forests by strong gusts of wind is the most important impact.

Policy question:
Amount and intensity of storms have major impacts on economic sectors, especially on forests and infrastructure. For this reason there is major concern of various stakeholders about trends in storms.

Derived from policy instrument/documents
IPCC 3rd report

Description/rationale of the indicator
Under certain conditions storms can cause severe damage to ecosystems, especially to forests. There have been a number of severe incidents in the past decade causing great damage and consequently high public awareness.
Extent of damage is not only dependent on wind speed but also on other factors, such as soil/water content, physiological status of the trees and structure of forest ecosystems. Data have to be re-analysed for assessing the importance of the various factors in describing the effect of wind and trends in wind speed.

State of knowledge: Speculative

Sources:
Source of the indicator
Damages are recorded by organisations in the forest sector.

The expected source(s) of data
- EFI, Finnland (C)
- National, regional and local forest institutions

The expected source of assessment
- EFI, Finnland (C)

Evaluate the data situation:
Information about storm events is available, but only on a regional level. Further work is necessary to separate the impact of various environmental factors and management from wind speed impacts.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage Parts of Europe
Time series length Decades
Further work required See data situation
Time schedule for indicator development Medium term (3 - 5years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	**Notes**
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/NPB
Indicator title: **Changes in Ecosystem Composition / Biodiversity**	
Definition*:* Changes in species and ecosystem composition and abundance due to changes in climatic conditions. Species' functional characteristics can be used to describe changes due to rise in temperature, precipitation, CO_2-concentration and extreme events. These functional characteristics may also be used to discriminate between climate-related changes and other human-induced changes. Changes in ecosystem structure and function may be used as well.	
Policy question: Climate change may lead to changes in ecosystem structure, function and biodiversity. Ecosystem services such as recreation, supply of wood, food and fibre may be affected by climate change. There might be negative impacts on economic sectors (agriculture, forestry, fishery) as well as on natural protected areas. Planning a sustainable future is affected by changes in ecosystem structure and function. Biodiversity is one of the central environmental values and functions. The focus here is on the intrinsic values of ecosystems, species and genes, the natural values. This indicator can be used to assess the evolution of the problem, the contributions of different sectors, the distance to target goals and the effectiveness of policy measures.	
Derived from policy instrument/documents Ecosystem function is strongly related to international initiatives and conventions such as FHH, Millenium Ecosystem Assessment, Ramsar Convention, Convention on Biodiversity (CBD), Convention on Desertification (CCD) and described in IPCC 3rd report.	

Description/rationale of the indicator

Species distribution, ecosystem structure and animal behaviour are strongly influenced by climatic conditions. But most of European ecosystems are affected by actual and historic human management. Species distribution and abundance is controlled by a number of different factors which are not all climate related. It might be difficult, though possible, to separate climate induced changes from changes in site conditions e.g. nitrogen deposition and management.

Several climate related indicators can be discerned:

- Presence of psychrophilic (drought-tolerant) and thermophilic (heat-tolerant) species
- Presence of atlantic and continental species
- Presence of adapted species (like C4-plant species, hibernation types, butterflies etc.)
- Distribution, quantity and quality of ecosystems
- Establishment of new (exotic or invasive) species, which is also very important in marine ecosystems (see indicator sheet "marine ecosystems").

Some of these indicators are very suitable for early warning indicators, e.g. lichens and mosses. The proper use of these indicators in integrated assessment or scenario analysis is one of the key bottlenecks, but some applications have been developed already (e.g. EUROMOVE).

Special focus have to be on unmanaged ecosystems, like rivers, lakes and mountain ecosystems. Mountainous ecosystems are very sensitive to environmental changes and are characterised by the relatively low anthropogenic influence. The combination of different factors such as the distribution of mountainous ranges over Europe, data availability and the public awareness about nature conservation especially in areas with high importance for recreation makes it suitable to derive climate change indicators for reporting.

State of knowledge: Established but incomplete

Sources:
Source of the indicator
There are numerous studies on ecosystem structure, function and biodiversity being undertaken at universities and research institutes in Europe. The best access to data can be obtained via EU projects. Biodiversity aspects will be added in a later stage (by ETC/NPB).

The expected source(s) of data
- EU-project GLORIA (L)
- A. Menzel (TU Munich) (P)
- E. Koch (Vienna) (L)
- Wil Tanis (CML, Uni Leiden) (P)
- Bugmann (ETH Zürich) (C)
- Kupfer et al. (1996) (L)
- Wielgolaski (Uni. Oslo) (L)
- Van Oene et al. 2000, 2001 (NOP)
- M. Harley (English Nature, UK) (C)

The expected source of assessment
- Grabherr, Vienna university (Q)
- Bugmann (ETH Zürich) (C)
- Sandra Lavorel (CEFE, CNRS) (P)
- Wil Tanis (CML, Uni Leiden) (P)
- GBIF – Global Biodiversity Information Facility
- National institutions with information on distribution of plants and animals (NGOs, herbaria, universities, governmental institutions)

Evaluate the data situation:
Further efforts are necessary to evaluate available information and to analyse existing data in order to develop suitable indicators which are sensitive to climate change. There is still ongoing and European-wide research about mountainous ecosystem dynamics. Results will be available within the next few years, e.g. EU project GLORIA.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage
Regional and national level, e.g. Northwestern Europe, mountainous regions, natural and/or protected areas.

Time series length
Most data are present from about 1950 onwards; regional and national data could be evaluated on a decadal basis. Some data from monitoring programms is produced every year till every four years. Availability of data partly depends on research initiatives and projects.

Further work required Investigations have to be performed to evaluate data and separate climate change effects form other impacts
Time schedule for indicator development Medium (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**No**	
□ Could the indicator be linked to economic models, forecasting and information systems?	**No**	To be developed
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	Depending on country and organisation
□ Updated at regular intervals in accordance with reliable procedures?	**No**	Depending on country and organisation

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/NPB
Indicator title: **Ecosystem Fires**	
Definition*:* Number and/or intensity of fires in ecosystems	
Policy question: Every year fires, especially forest fires, lead to a great amount of damage, especially in the Mediterranean area. An increase in drought periods will also increase the number of fires. There is major concern about fires, especially in the forest sector, but also in local and regional planning.	
Derived from policy instrument/documents IPCC 3rd report	
Description/rationale of the indicator Fire is one of the most important factors controlling ecosystem structure and dynamics, especially in the Mediterranean and continental mid-European climate area. The number and intensity of fires depends on weather conditions as well as on anthropogenic impacts. To separate both effects the probability of fires due to climate and weather conditions can be used as indicator. ***State of knowledge: Competing explanations***	

Sources:
Source of the indicator
Number and intensity of fires in ecosystems is documented by various public and research organisations.

The expected source(s) of data
- MPI, Jena, University Lund, PIK, and others (C)
- Goldammer (Uni. Freiburg i. Br.) (L)
- IES/JRC, Ispra, IT (L)
- European Forest Institute (EFI) (C)
- EU-Project ACACIA

The expected source of assessment
- European Forest Institute
- MPI, Jena, DE (C)
- PIK, Potsdam, DE (P)

Evaluate the data situation:
Data availability varies within different parts of Europe. Further efforts are necessary to evaluate data and to analyse the effects on fires driven by changing climatic conditions.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 5

Geographical coverage
Parts of Europe

Time series length
Decades

Further work required
Further investigations are necessary to evaluate and interpret available data. Separating anthropogenic effects from climate induced fires is one of the major challenges.

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Ecosystems and Biodiversity Responsibility: ETC/NPB
Indicator title: **Marine Ecosystems and Biodiversity**	
Definition*:* Changes in seasonal behaviour and biodiversity of plants and animals (e.g. fish stocks, phyto- and zooplankton) due to changes in water temperature and/or salinity.	
Policy question: Climate induced changes in water temperature and salinity can severely affect the behaviour of species and the composition of marine ecosystems. Commercial deep sea fishing can be negatively influenced by shifts in appearance and migration of fish stock and the appearance of new species. Fishing quota (TACs) are strictly regulated within the EU. Natural and climate induced changes in fish stock have to be taken into consideration in order to keep the fishery sector sustainable.	
Derived from policy instrument/documents FHH, Millenium Ecosystem Assessment, Convention on Biodiversity (CBD), EU Commission, common fisheries policy	
Description/rationale of the indicator Plankton and many commercially important fish species show a distinct seasonal behaviour, which is influenced by water temperature and salinity. Long-term records over a number of decades can be used to analyse changes and shifts in the distribution and behaviour of certain species. In the case of commercially exploited fish species, changes influence fishery and EU policies.	

Sources:
Source of the indicator
There are data sets on national and European levels in countries with commercial fishery and/or marine research institutions. Efforts are necessary to collect and process available data. Biodiversity aspects will be added in a later stage (by ETC/NPB).

The expected source(s) of data
- ICES , Copenhagen (L)
- SAHFOS, continuous plankton recorder (CPR) (L)
- Unep-WCMC, Cambridge (C)
- IOW Warnemünde, Uni. Rostock, Uni. Kiel, Uni. Greifswald (C)
- ACIA, Fairbanks, Alaska (L)

The expected source of assessment
- Patterson, Univ. Ottawa (L)
- ACIA, Fairbanks, Alaska (L)
- ICES , Copenhagen (L)

Evaluate the data situation:
Many records are collected, but data access has to be organized. Separating climate change effects from other impacts may be difficult. For this reason indicators are not available within short time perspectives.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 5

Geographical coverage
European and national level

Time series length
Several decades

Further work required
Data access has to be organized. Climate impacts have to be analysed and separated from other impacts on marine ecosystems and biodiversity.

Time schedule for indicator development
Medium term (3 - 5years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability. Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?		Uncertain in the case of climate change
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Category 6: Hydrology and Water Resources

Indicator set: ***Climate Change***	Issue: Hydrology and Water Resources Responsibility: ETC/WTR

Indicator title:

Global and Regional Annual River Discharge

Definition

The indicator quantifies the annual discharge of large watersheds around the world and in Europe (in $m^3 yr^{-1}$).

Policy question

The indicator 'global and regional annual river discharge' assesses the annual water discharge of large water bodies round the world with a special focus on Europe. The indicator is often used to assess (potential) impacts of climate change on flood risk. Flood risk has become an issue in Europe, because of a sequence of floods in the last years, which has lead to changes in water management in many countries. The need for appropriate indicators to assess potential impacts of projected changes in climate on flood risk has been defined. This may in turn define the need for further changes in management.

In addition, river discharge can be used to mimic water availability in a region. Sufficient water is essential for sustainable food production.

Derived from policy instrument/documents

Water supply is one of the objectives of the UN Convention on Climate Change (UNFCCC). The issue is included in the UNFCCC because of the obvious relationship between climate change and water availability. Likewise, water availability is a key issue in the UN Convention to Combat Desertification (UNCCD). In this respect, the Convention text refers frequently to the interaction between climate change (and other sustainability issues) and desertification. The UNCCD therefore emphasises the need to co-ordinate the research efforts and response strategies inspired by the different concerns. Appropriate tools and indicators are essential to this.

Because of these two issues, the World Water Commission on Water for the 21st Century has been established to prepare recommendations for the development of water resources. To come up with these recommendations the commission needs information about the availability of fresh water on a local, regional and global scale.

Description/rationale of the indicator

River discharge is an indicator both for water availability and flood risk. Both are sensitive to climate and to changes in it. Many observations showed a strong year-to-year signal in the amount of river discharge due to weather fluctuations. In addition, projections show a response to the projected long-term changes in climate (especially precipitation) in different parts of the worlds. Because of the strong relationship between climate and river discharge, a strong regional differentiation in the response has been observed and projected. On a European scale, for example, river discharge is projected to increase, especially in northern and western Europe, caused by the increased precipitation rates in the winter season. In contrast, southern Europe may experience a reduction in discharge, caused by the projected decrease in precipitation combined with higher temperatures.

The previous paragraph shows that climate (change) may have a considerable effect on river discharge. Water management activities also play a role. To limit the effect of water management (i.e. to increase the correlation between river discharge and climate), only annual figures for large water bodies will be used.

State of knowledge: Competing explanations

Sources:

Source of the indicator

River discharge fluctuates on a daily but also annual basis. Main driving forces are climatic conditions and water management measures. To limit the latter, we selected the annual discharge rates as being most appropriate. The annual discharge of large river basins in Europe is frequently measured. It is also included in various simulation models, which have been applied to assess the consequences of projected changes in climate. Contacts with both data sources and modelling teams have been established. The focus of both data and simulation models will be on the large (e.g. European) scale. Data are mostly available on a small scale (e.g. for one watershed or a subset), however. Using this information would imply the development of approaches to compare the data. However, the data might be very useful to fill gaps in the large-scale datasets.

The expected source(s) of data

- Arnell, Uni. Southhampton, UK (L)
- Döll, Uni. Kassel, DE (Q, P)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)
- Sparks & Marsh, CEH, UK (Q)
- European Water Network
- GRDC group

The expected source of assessment

- Arnell, Uni Southhampton, UK (L)
- Becker, PIK, DE (P)
- Döll, Uni. Kassel, DE (Q, P)

Evaluate the data situation:

- Select representative number of river basins in Europe
- Contact data sources for past and current annual discharge rates for the selected river basins (Nixon, Döll, GRDC)
- Contact modelling groups for assessing future discharge rates (Arnell, Döll)
- Discuss requirements and select modelling tools
- Select climate change scenarios
- Assess discharge rates for 2000, 2005 and 2010 (and possibly 2050 and 2100)

DAFIA diagram not available yet

Rank

Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage

Europe

Time series length

1950-2000, 2005, 2010, 2020, (&beyond)

Further work required See data situation
Time schedule for indicator development Short term (0 - 2 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Especially relation between climate and indicator, less about responses
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	Simple to understand,
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	Especially climate
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Regional Watersheds
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Is, among others, related to flood risk. Some thresholds might be possible
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	
• Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
• Adequately documented and of known quality?	**Yes**	Used in various climate change assessments
• Updated at regular intervals in accordance with reliable procedures?	**Yes**	Models are updated every 3 years.

Indicator set: ***Climate Change***	Issue: Hydrology and Water Resources Responsibility: ETC/WTR
Indicator title: **Lake Temperatures**	
Definition The indicator quantifies the changes in water temperatures of certain inland lakes in Europe (in $^{\circ}$C).	
Policy question 'Lake temperature' is an important determinant of the water quality of lakes . Sustainable water quality has been prioritised in various policy plans at local, national, regional and global scale.	
Derived from policy instrument/documents Mention in IPCC 3rd report as a system affected by climate change	
Description/rationale of the indicator The temperature of lakes is an important determinant of the biological and chemical processes within lakes. For example, temperature determines the possible oxygen content of the water and as such also the biological activity. Lake temperature is affected by changes in precipitation and especially air temperature. As such, lake temperature is a relevant indicator for the relationship between climate change and water quality. Nnote that despite the significance of the indicator, the correlation between air and lake temperature is not straightforward. This is especially caused by the thermal stratification of lakes which determines the response of lakes to climate (change). ***State of knowledge: Established but incomplete***	

Sources:
Source of the indicator
Lake temperature is measured in various local and regional programmes. Most of these programmes are, however, carried out in the US. Thus data for Europe are limited with the exception of the European Water Network.

The expected source(s) of data
- European Water Network
- Meyer, US (L)
- NRRI, University of Minnesota (L)

The expected source of assessment
- Hosteler, US (L)
- Meyer, US (L)
- Livingstone, CH, (P)

Evaluate the data situation:
- Select representative number of inland lakes in Europe (European water network, internet)
- Contact data sources for past and current figures for lake temperatures of the selected lakes (European water network)
- Contact modelling groups for assessing changes in lake temperature (e.g. NRRI)

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 2 (activities have recently been started)

Data reliability (1: low to 5: high): 4

Geographical coverage
Europe, sub-regions within Europe

Time series length
1990-2000, 2005, 2010, 2020, (& beyond)

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Especially relation between climate and indicator, less about responses
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	Simple to understand,
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	Especially climate
• Does the indicator provide a basis for international comparisons?	**Yes**	Although a comparison of lakes is complicated due to different characteristics of lakes
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	Regional/ local
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Lake temperature is important for many processes. It is unclear whether threshold exists
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	
• Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		Uncertain
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
• Adequately documented and of known quality?		Various assessments, however, mainly locally
• Updated at regular intervals in accordance with reliable procedures?		Various activities have recently been initiated.

Indicator set: ***Climate Change***	Issue: Hydrology and Water Resources Responsibility: ETC/WTR

Indicator title:

River Discharge from Small, Undisturbed Watersheds

Definition

The indictor describes the discharge from small, undisturbed watersheds (unit m^3/day^{-1})

Policy question

The indicator 'river discharge from small, undisturbed watersheds' assesses the discharge of certain water bodies throughout Europe. The water bodies will be selected on the basis of a limited influence of water management. In this case, discharge measurements can be used to indicate climate and changes in it.

Although the suitable rivers are often relatively small, they are important for quantifying the water availability in a region. Sufficient water is essential for sustainable food production, which is one of the objectives of the UN Convention on Climate Change (UNFCCC).

Derived from policy instrument/documents

The issue is included in the UNFCCC because of the obvious relationship between climate change and water availability (which is especially the case with these small rivers). Likewise, water availability is a key issue in the UN Convention to Combat Desertification (UNCCD). In this respect, the Convention text refers frequently to the interaction between climate change (and other sustainability issues) and desertification. The UNCCD therefore emphasises the need to co-ordinate research efforts and response strategies inspired by the different stakeholders. Appropriate tools and indicators are essential to this.

Description/rationale of the indicator

River discharge is the amount of water that flows through a river at a certain location. As such the indicator integrates spatial information of an entire watershed. River discharge can be measured on a daily up to an annual basis. The advantage of using a short time scale is the usefulness of the indicator not only for changes in precipitation over a region but also as an indicator for changes in seasonality. Since flood risk largely depends on the amount of discharge in a relatively short time period (e.g. number of days)river discharge can also be used to assess flood risks.

One problem related to the usefulness of this indicator for climate change is the strong effect of human management on discharges in many rivers in Europe. This is especially the case for discharges on relatively short time scales (e.g. measures are taken to increase the discharge in periods with heavy rainfalls). Because of this constraint, only a limited number of rivers are suitable. These suitable rivers are often relatively small.

State of knowledge: Established but incomplete

Sources:
Source of the indicator
River discharge fluctuates on a daily but also an annual basis. The main driving forces are climatic conditions and water management measures. To limit the latter and still have the intention to develop an indicator with a short temporal scale (e.g. because of the connection to flood risks) limits the number of appropriate rivers in Europe. The rivers have still to be identified and a substantial amount of work is needed to distinguish the role of the different driving factors. Furthermore, some models exist for particular river basins. Work is needed to harmonise the different approaches.

The expected source(s) of data
- Arnell, Uni. Southampton, UK (L)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)
- Sparks & Marsh, CEH, UK (Q)
- European Water Network

The expected source of assessment
- Arnell, Uni Southampton, UK (L)
- Nixon, ETC-Water, UK, (P)

Evaluate the data situation:
- Select number of representative river basins in Europe (e.g. contact ETC Water)
- Contact data sources for past and current annual discharge rates for the selected river basins (Nixon, GRDC)
- Contact modelling groups for assessing future discharge rates (Nixon, Arnell,)
- Discuss requirements and select modelling tools
- Select climate change scenarios
- Assess discharge rates for 2000, 2005 and 2010 (and possibly 2050 and 2100)

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
1950 (?)-2000, 2005, 2010, 2020, (& beyond)

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	At least for a set of river basins
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	Especially climate
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modeling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Local catchment areas
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	
• Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?		Data sources are currently unknown
• Adequately documented and of known quality?		Not yet
• Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Hydrology and Water Resources Responsibility: ETC/WTR

Indicator title:

Fresh water availability

Definition

The indicator describes the amount of water available in rivers and groundwater for various purposes such as agriculture, industrial production and drinking water supply (unit m^3).

Policy question

The indicator 'fresh water availability' shows the availability of water for various purposes throughout Europe. Sufficient fresh water is essential for various activities. Sustainable food production, in particular, depends on the availability of water, since agriculture is by far the largest consumer of water. Fresh water availability is a suitable indicator because of its strong relationship with climate.

Derived from policy instrument/documents

Water supply is one of the issues of the UN Convention on Climate Change (UNFCCC), because of the obvious relationship between climate (change) and water availability. Likewise, water availability is a key issue in the UN Convention to Combat Desertification (UNCCD). In this respect, the Convention text refers frequently to the interaction between climate change (and other sustainability issues) and desertification. The UNCCD therefore emphasises the need to co-ordinate the research efforts and response strategies inspired by the various concerns. Appropriate tools and indicators are essential to this.

Because of these two issues, the World Water Commission for the 21st Century has been established to prepare recommendations for the development of water resources. To come up with these recommendations the commission needs information about the availability of fresh water on a local, regional and global scale.

Description/rationale of the indicator

The amount of water available in rivers and groundwater layers depends on land management , but it is more strongly related to climate. Obviously, the availability is low in dry periods when the demand (e.g. for agriculture) is high. Various studies have shown a clear inverse relationship between precipitation and the demand for, for example, irrigation. Many of these studies have also shown a significant increase in demand over the last decades in Europe. One problem in identifying a clear climate signal is the autonomous increase in demand, for example, due to increasing irrigation capacity. It is therefore important to determine the influences of management. Despite the problems, the studies project significant geographical differences in changes in water availability. Water loss due to increased evapotranspiration (in response to higher temperatures) is projected for most areas in Europe. The loss could possibly be counterbalanced by increasing precipitation rates, projected especially for Northern Europe. However, increasing rates are only projected for some areas. Still, the net result is unclear. In other areas (mainly in the Mediterranean region) the negative trend in water availability may be exacerbated (especially in the summer), due to the projected decreasing trend in precipitation.

State of knowledge: Established but incomplete

Sources:

Source of the indicator

Fresh water availability fluctuates on a daily but also on an interannual basis. Main driving forces are climate conditions and water management measures. To limit the latter, we selected the annual discharge rates as being most appropriate. Water availability and water use are frequently measured. Therefore we focus on large-scale assessments. Water availability and water use are also included in various simulation models, which have been applied to assess the consequences of projected changes in climate. Contacts with data sources and modelling teams have been established.

The expected source(s) of data

- Arnell, Uni. Southhampton, UK (L)
- Döll, Uni. Kassel, DE (Q, P)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)
- Palutikof, University of East Anglia, UK (P, L)
- Sparks & Marsh, CEH, UK (Q)
- European Water Network
- GRDC group

The expected source of assessment

- Arnell, Uni Southhampton, UK (L)
- Becker, PIK, DE (P)
- Döll, Uni. Kassel, DE (Q, P)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)

Evaluate the data situation:

- Decide on the precise definition of indicator (e.g. total water availability or just availability for agriculture as the largest user of irrigation water).
- Contact data sources for past and current annual trends in water availability
- Contact modelling groups for assessing future discharge rates
- Discuss requirements and select modelling tools
- Select climate change scenarios
- Assess discharge rates for 2000, 2005 and 2010 (and possibly 2050 and 2100)

DAFIA diagram not available yet

Rank

Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage

Europe

Time series length

?-2000, 2005, 2010, 2020, (& beyond)

Further work required See data situation
Time schedule for indicator development Medium term (6 - 10 years). Data are available but need harmonisation

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Especially relationship between climate and indicator, less about responses
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	Depends on definition. If related to agriculture, it is more simple than the total water availability
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modelling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		?
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**Yes**	
• Could the indicator be linked to economic models, forecasting and information systems?		Water has a value in many regions. As such, the availability can be linked to economic models
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	In some regions
• Adequately documented and of known quality?	**Yes**	Used in various assessments
• Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Hydrology and Water Resources Responsibility: ETC/WTR

Indicator title:

Frequency of Low and High River Flows

Definition

This indicator describes extremes in the discharge of rivers in Europe. The definition of the indicator is the number of days per year when the discharge is below and above a certain threshold (unit days per year).

Policy question

The indicator 'frequency of low and high river flows' indicates the frequency of floods and drought. The results are socially, economically and ecologically important if the change occurs under changed climate conditions. Low flows may threaten the water availability (in turn, affecting various activities such as agriculture), whereas high flows present a risk of flooding in a specific area. Flood risk has become an issue in Europe because of a sequence of floods in the last years. This has lead to changes in water management in many countries. The need for appropriate indicators to assess potential impacts of projected changes in climate on flood risk has been identified. This may in turn define the need for further changes in management.

Various studies exist that assess the implications of climate change for different places in Europe.

Derived from policy instrument/documents

Water supply is one of the objectives of the UN Convention on Climate Change (UNFCCC) and the UN Convention to Combat Desertification (UNCCD). Water supply in a region depends, among others, on the frequency of low and high river flows.

Because of these two issues, the World Water Commission for the 21st century has been established to prepare recommendations for the development of water resources. To come up with these recommendations, the Commission needs information on the availability of fresh water on a local, regional and global scale.

Description/rationale of the indicator

The amount of water available in rivers and groundwater layers and the frequency of low and high flows partly depends on the management of the land. However, the flows are also highly dependent on the climate system, especially precipitation. Temperature also plays a role, since evapotranspiration generally increases under higher temperature values.

More frequent low flows are projected to occur in many regions throughout Europe, especially in southern Europe. The cause is the projected decrease in precipitation and increasing temperatures. At the same time, some areas could be exposed to more high flows and thus an increased flood risk. The number of floods may increase due to the increased number of intense rain periods and due to rapid snow thawing (southern Europe is a region with a great water resource problem). In many other regions, climate change is likely to increase the frequency of high flows due to increasing precipitation rates, especially in central and northern Europe.

The section above shows that an interesting aspect of this indicator is its integration of flood and drought phenomena. One region can suffer both in one year . At one moment, short, intense rainfall can cause floods, while in the next moment the same region can suffer from water shortage. Both will be registered.

State of knowledge: Well established

Sources:
Source of the indicator
River flows data are available for many watersheds. The problem is to deal with the human management separately. To achieve the latter certain rivers (e.g. small, undisturbed rivers) need to be selected. However, are data available for these rivers? River flow is also included in various simulation models which have been applied to assess the consequences of projected changes in climate. Contacts with data sources and modelling teams have been established.

The expected source(s) of data
- Arnell, Uni. Southampton, UK (L)
- Döll, Uni. Kassel, DE (Q, P)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)
- Palutikof, University of East Anglia, UK (P, L)
- Sparks & Marsh, CEH, UK (Q)
- European Water Network
- GRDC group

The expected source of assessment
- Arnell, Uni Southampton, UK (L)
- Becker, PIK, DE (P)
- Döll, Uni. Kassel, DE (Q, P)
- Marsh, CEH, UK (Q)
- Nixon, ETC-Water, UK, (P)

Evaluate the data situation:
- Decide on precise definition of indicator and select representative rivers..
- Contact data sources for past and current annual trends in water availability
- Contact modelling groups for assessing future discharge rates
- Discuss requirements and select modelling tools
- Select climate change scenarios
- Assess discharge rates for 2000, 2005 and 2010 (and possibly 2050 and 2100)

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
?-2000, 2005, 2010, 2020, (& beyond)

Further work required
See data situation

Time schedule for indicator development
Medium term (3 - 5 years).

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
• Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	Especially relationship between climate and indicator, less about responses
• Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
• Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
• Does the indicator provide a basis for international comparisons?	**Yes**	Both for observations and modelling tools
• Is the indicator either national in scope or applicable to regional environmental issues of national significance?		?
• Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
• Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
• Is the indicator based on international standards and international consensus about its validity?	**No**	
• Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
• Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	In some regions
• Adequately documented and of known quality?	**Yes**	Used in various assessments
• Updated at regular intervals in accordance with reliable procedures?	**?**	

Category 7: Marine Environment and Coastal Zones

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC
Indicator title: **Sea Surface Temperature (SST)**	
Definition **:** SST, based on terrestrial hydrographical observations, describes the bulk temperature in the first few metres below the surface of the sea. SST, based on satellite observations, describes the surface temperature of the ocean.	
Policy question: It does not only indicate climatic changes, but influences other physical (salinity, CO_2 solubility, storm generation in the tropics), chemical (internal chemical reactions) and biological (algae activity) parameters as well as the commercial and cultural (fishery, tourism) use of the area. Therefore a widespread interest in the observation of SST exists.	
Derived from policy instrument/documents UNFCCC, Art. 2; HELCOM and PARCOM Conventions	
Description/rationale of the indicator: Long term noticeable changes in sea surface temperatures (SST) should indicate changes in regional or global climate. It provides evidence of changes of climate related parameters such as solar irradiance, air temperature close to the surface or maritime currents. ***State of Knowledge: Established but incomplete***	

Sources:
Source of the indicator:
Sporadic measurements undertaken by SST vessels or boats started at the beginning of the last century. Scientific programmes and routine measurements of SST on a more national level started after World War II. International systematic observations, including the continuous monitoring of SST, began in the 1970s, covered by programmes of the HELCOM and PARCOM Conventionsand supported by advanced remote sensing technologies.

The expected source(s) of data:
- Deutsches Ozeanographisches Datenzentrum (DOD), Hamburg; D
- International Council for Exploration of the Sea (ICES), Copenhagen; DK
- IFREMER; Brest; F

The expected source of assessment
- Wilhelms/Schulz/Dr. Löwe; Federal Maritime and Hydrographic Agency; Hamburg; D
- H. Dooley; ICES; Copenhagen; DK
- F. Wulff; Stockholms University; S
- Claude Millot; COM; F
- M. Fichaut, C. Maillard; IFREMER; F
- L. Fenoglio-Marc; Univ. Of Darmstadt; D

Evaluate the data situation:
Research related measurements of SST are made by scientifically trained staff using high quality bucket samples. Data are archived, for example, at the *Deutsches Ozeanographisches Datenzentrum* (DOD) in Hamburg or the International Council for Exploration of the Sea (ICES) in Stockholm. Their quality is relatively high but their quantity is not sufficient.
On the other hand, there are SST data produced in high frequency by monitoring undertaken several time a day by research vessels, merchant ships, military ships, fishing vessels, fixed platforms, coastal stations and polar orbiting NOAA satellites.
Scientific statistical tests have shown that digitised and prepared data obtained in this way are suitable for statistical analyses and are sufficiently accurate and stable for scientific applications.
There is a high level of consistency between changes in SST and near surface land-air temperatures across the land-ocean boundary over the 20th century.
During the past decades, many SST data sets of the European seas have been produced and analysed. First results are available.
However, more information is needed and clear trends have to be detected.

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage
Baltic Sea, North Sea, Mediterranean Sea

Time series length
Weekly, monthly

Further work required
Gathering and evaluation of information from various (be to identified) data centres

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC

Indicator title

Characteristics of Storm Surges

Definition:
Storm surges result from storm events and are described by the difference between the actual tide and the average tide (5 years means).
Long term significant changes in characteristic parameters, such as

- intensity
- duration
- frequency

of storm surges should indicate changing climate conditions.

Policy question *:*
Storm surges have a serious impact on coastal zones as they endanger human infrastructure and ecosystems.

Derived from policy instrument/documents
UNFCCC, Art.2

Description/rationale of the indicator
To describe the climate impact on storm tides and their alteration, storm tide descriptions such as 'oscillations of the water level in coastal or inland water body, resulting from forcing from the atmospheric weather system' are not sufficient, because the crest of a storm tide only represents the influence on the water body during high tide.
To analyse changes of the whole storm surge climate, it is necessary to take into account the influence of the wind on the whole event, described by the surge curve.
This curve directly shows the course of wind duration, wind direction and wind speed during the whole tide.
It is likely that a changing climate will have an impact on the characteristics and frequency of coastal flooding.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator
Damage caused by storm tides is increasing on a global scale. Big insurance companies and various government agencies hold data sets of storm-tides in various maritime data centres, some of them are transformed to storm surge data sets already.

The expected source(s) of data
- Amt für Strom- und Hafenbau; Hamburg; Germany
- Federal Maritime and Hydrographic Agency; Hamburg; Germany
- University of Cambridge; CCRU; UK

The expected source of assessment
- Gabriele Gönnert ; Hamburg; Germany
-
- James Brown; Univ. Of Cambridge; UK

Evaluate the data situation:
There are long term data sets of storm-surges available (since 1900) from the area of the German Bight. These data sets have already been analysed and the results show trends.
To make evidence more significant, some more data sets recorded in other coastal areas should be involved in the investigation.

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 3

Geographical coverage
Coastal areas of the North Sea and the Baltic Sea

Time series length
More than 100 years (yearly updated)

Further work required
Identification of other relevant information describing the characteristics of storm surges.

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC

Indicator title *:*

Thermohaline Circulation (THC) of the North Atlantic Ocean

Definition*:*

The THC is a global-scale turn over of water in the ocean driven by density differences arising from temperature and salinity effects. It is responsible for the major part of the meridional heat transport in the Atlantic Ocean.

It includes:

- Changes in salinity and temperature of vertical layers
- Changes in convective mixing
- Geographical switching of the 'Sub-polar Front'

Policy question:

The THC-driven maritime transport of energy has a clear influence on the regional climate in the surrounding areas (e.g. Gulf stream impact on climate in north-western Europe).

Cooling effects caused by weakened ocean flows might have an impact on economy, policy and living conditions (e.g. agriculture, transport, tourism, health).

Derived from policy instrument/documents :

UNFCCC; Art. 2

Description/rationale of the indicator

In the Atlantic, heat is transported by warm surface waters flowing northwards and cold saline waters from the North Atlantic returning at depth. Reorganisations in the Atlantic THC can be triggered by perturbations in the surface buoyancy, which is influenced by precipitation, evaporation, continental runoff, sea ice formation and the exchange of heat.

Very large regions might be influenced by changing circulation patterns. However, only sporadically measured data sets of limited regional extension are usually available.

Some important global and regional climate processes are influencing THC, thus significant changes should indicate climatic changes in the region.

The interplay between the large-scale atmospheric forcing, with warming and evaporation in low latitudes and cooling and increased precipitation at high latitudes, forms the basis of potential instability of the present Atlantic THC. ENSO may also influence this THC by altering the fresh water balance of the tropical Atlantic.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator
During experiments of some climate research programmes such as WOCE (World Ocean Circulation Experiment) and CLIVAR (Climate Variability and Predictability)
measurements have been done to gain information about the intensity of the THC in the North Atlantic.

The expected source(s) of data:
Data centres of institutions involved in the maritime area of WMO climate research programmes

The expected source of assessment
- Bersch, Holfort; Inst. f. Meereskunde; Uni Hamburg; D
- Stramma; Inst.f. Meereskunde, Uni Kiel, D
- Hansen; Faroese Fisheries Laboratory; DK

Evaluate the data situation:
Data sets have been registered during some projects involved in oceanographic programmes such as WOCE and CLIVAR. Some data sets indicating changes in the mixing layer, water salinity or water temperature are available (e.g. Universities of Hamburg and Kiel).
More continuous work is necessary but is expensive.
Remote sensing data should be suitable for observations of a shifting of the 'Sub-polar Front'.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
North Atlantic and coastal regions of the U.K., Ireland and Norway

Time series length
Not more than 10 years. Update depends on the frequency of campaigns.

Further work required
Discussion with experts and gathering of information

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
□ Adequately documented and of known quality?		Uncertain
□ Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC

Indicator title

Sea Level Rise

Definition*:*

The average sea level at the coast is defined as the height of the sea with respect to a local benchmark, averaged over a period of time long enough for fluctuations caused by waves and tides to be largely removed.

'Eustatic sea level change' is caused by alteration to the volume of water in the world's oceans.

Policy question:

Rising sea levels have certain impacts on coastal areas causing an increasing number and intensity of storm surges and coastal flooding. This endangers industrial and residential areas and may cause migration by destroying small, flat islands as well as flat coastal areas.

Derived from policy instrument/documents :

UNFCCC; Art.2

Description/rationale of the indicator

Eustatic sea level change results from changes to the density or to the total mass of water. Density is reduced by thermal expansion occurring when the ocean warms. The mass of water will be altered by exchanges with water stored on land, e.g. by reduction of glaciers and ice caps caused by increased melting and evaporation. Another source will be the change in terrestrial storage of water (e.g. exhaustion of groundwater).

Thermal expansion of oceans is expected to contribute the largest component to sea level rise over the next hundred years. Because of the large heat capacity of the ocean, this process is very slow and could continue for many centuries. A clear accelerated increase in the sea level due to thermal expansion will only be noticeable after decades, because of the large natural variations in sea level. Both reasons for sea level rise are related to climate. However, because of the natural variability and inertia of the ocean system, there is no noticeable evidence of accelerated trends in sea level rise yet. It might take some years or several decades before a clear signal is detectable.

State of Knowledge: Well established

Sources:
Source of the indicator
The use of sea level rise as an indicator for climate change is already mentioned in the First Assessment Report of the IPCC.

The expected source(s) of data
- Maritime data centers in various European countries
- Permanent Service of Mean Sea Level (PSMSL); Birkenhead; UK
- European Sea Level Service (ESEAS); Hornefoss; N

The expected source of assessment:
- G. Liebsch; Technical University of Dresden; D
- R. Dietrich; Technical Univ. of Dresden;D
- H.-P. Plag; NMA; Hornefoss; N
- L. Fenoglio-Marc; University of Darmstadt; D

Evaluate the data situation:
For more than 200 years datasets of sea level gauge have existed in Europe. Many of them are available in well analysed standards already.

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage:
Baltic Sea; North Sea; Mediterranean Sea

Time series length
Up to more than 300 years in some cases. More than 100 years.Updated yearly.

Further work required
Gathering of information from different sources in Europe

Time schedule for indicator development
Short term (0 - 2 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/ACC

Indicator title *:*

Temperature of the Intermediate Layer (Baltic Sea)

Definition*:*
Changes in the average temperature, measured in late spring/early summer, at certain points in the Baltic Sea in a water depth between 30m and 70m.

Policy question:
The content of energy in the intermediate layer has an impact on the aquatic ecosystem of the Baltic Sea.

Derived from policy instrument/documents
UNFCCC, Art.2; HELCOM

Description/rationale of the indicator
The late spring/early summer temperature of the intermediate layer in the Baltic Sea is a signal that indicates the integrated development of the water temperature during the previous winter season, because it is not influenced by the wind-driven overturning of the upper layers nor by the input of deep water from the North Sea.
The temperature of this layer is influenced by the climatic conditions of the respective winter season and should be suitable as an indicator describing climate change in the medium and longer terms.

State of knowledge: Competing explanations

Sources:
Source of the indicator
The role of the intermediate layer of the Baltic Sea as a storage of water, the temperature of which is definitely influenced by the previous winter climate, has been defined some decades ago.

The expected source(s) of data
- Federal Maritime and Hydrographic Agency; Hamburg; Germany

The expected source of assessment
- W. Matthäus; Baltic Sea Research Institute Warnemünde

Evaluate the data situation:
Sporadic data are available from the 1930s to the 1950s. More systematic recording of data started at the beginning of the 1960s.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 4

Geographical coverage
Baltic Sea

Time series length Systematically recorded data are available for about 40 years.
Further work required Gathering and evaluation of information from different data centres.
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Uncertain
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
□ Is the indicator based on international standards and international consensus about its validity?	**Yes**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?		Uncertain
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Marine Environment and Coastal Zones Responsibility: ETC/TE

Indicator title :

Coastal Erosion / Coastal Retreat

Definition*:*

Retreat of coast lines compared to an average value (caused by erosion due to sea level rise and changes in extreme events (e.g. storm surges, cyclones).

Policy question *:*

Approximately 20% of the world's population lives within 30 km of the sea and about 600 million people will occupy coastal floodplain land below the 1000 year flood level by 2100.
A huge amount of commercial interests (e.g. harbours, industries) and complex ecosystems (e.g. salt marshes) are concentrated in coastal areas.
Increasing coastal erosion caused by a growing number and intensity of storms and flooding as well as sea level rise will cause economical, political and social problems.

Derived from policy instrument/documents :

UNFCCC, Art.2

Description/rationale of the indicator

Coast lines, the boundary between land and sea, are one of the most dynamic interfaces on Earth. With global warming and sea level rise many coast lines will experience accelerated coastal erosion.
Mid-latitude temperate coasts in Europe often consist of coastal plains and barriers and soft sedimentary cliffs and bluffs which are highly vulnerable to erosion.
High-latitude coast lines are also susceptible. A combination of accelerated sea level rise, increased melting of ground ice, decreasing sea ice cover and more energetic waves will have a severe impact on coast lines.
Coast lines are overall vulnerable, thus any analysis of climate change impact on the coastal zone should include beaches and barriers.
Over the past century, about 70% of the world's sandy shorelines have retreated, about 20-30% have remained stable, and less then 10% have advanced.
There is evidence that, with global warming and sea level rise, there will be a tendency for currently eroding shorelines to erode further, stable shorelines to begin to erode and accumulating shorelines to stabilize or retreat.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator
In some coastal regions of Europe (e.g. The Netherlands, Germany, Denmark, U.K.), regional and local authorities which are responsible for coastal protection have already started to archive data of coastal erosion and destruction many years ago (almost always concentrating on single catastrophic events).
In more recent times many government agencies of various European countries have been responsible for the continuous observation of coastal erosion.

The expected source(s) of data:
- Data centres of government agencies in various European countries which are responsible for coastal protection or universities running relevant projects.

The expected source of assessment:
- Pruszak; Gdansk; Poland
- Schwarzer; Kiel; Germany

Evaluate the data situation:
In some European countries (e.g. Poland, Denmark, Germany) datasets exist describing coast line retreat.

Rank
Data availability (1: low to 5: high): **4**

Data reliability (1: low to 5: high): **4**

Geographical coverage
European coast lines

Time series length
Varies regionally (Some up to more than 100 years)

Further work required
Identification, evaluation and gathering of available information

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?		Uncertain

Category 8 Economy and Infrastructure

Indicator set: ***Climate Change***	Issue: Economy and Infrastructure Responsibility: ETC/ACC
Indicator title: **Energy Consumption for Space Heating in Winter**	
Definition*:* Domestic energy consumption by space heating in winter	
Policy question: Energy consumption can be used as an indicator for detecting climate change impacts in the economic sector. This may affect the planning of infrastructures on the long term time scale.	
Derived from policy instrument/documents None	
Description/rationale of the indicator Domestic energy consumption is dominated by space heating in winter and therefore very sensitive to weather conditions. The effect of weather conditions can be assessed by analysing data on a seasonal level. Data are available for a number of countries but not on a European level. Data in relatively high temporal resolution is needed for the assessment. In a number of countries energy consumption for heating might not be supplied by public services and for this reason might be difficult to assess. ***State of knowledge: Competing explanations***	

Sources:
Source of the indicator
Energy consumption has been used as an indicator for climate trends in a number of studies (EU project WISE, UKCIP climate change indicator report).

The expected source(s) of data
- Eurostat
- National administrations, especially bureaus of statistics
- DIW (German institute for economic research, Berlin), DE (C)

The expected source of assessment
- Gehrlinger (PIK) (C)
- Palutikov (CRU-UEA, Norwich, UK) (L)
- Lisoe, NBI, Oslo (Q)

Evaluate the data situation:
Data availability has to be checked and trends in energy consumption for heating have to be separated from overall trends in total energy consumption and from consumer behaviour.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Regional and national level

Time series length
Decades

Further work required
Data availability should be checked on European level

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?		has to be investigated
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?	**Yes**	
Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	
Measurability. Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?		has to be investigated
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Economy and Infrastructure Responsibility: ETC/ACC

Indicator title:

Number of Weather Related Catastrophic Events / Insurance

Definition*:*
The amount of money paid for compensating damages caused by extreme weather events such as floods, droughts and storm damages.

Policy question:
There is high public awareness about the number and intensity of catastrophic events mainly because of the high impact of natural disasters on economy and infrastructure.

Derived from policy instrument/documents
United Nations International Strategy for Disaster Reduction (ISDR)

Description/rationale of the indicator
It is difficult to separate climate trends from changes in the values covered by insurance companies. Therefore, trends in the amount of money paid for compensation have to be checked against the trends in values of insurance policies.

State of knowledge: Established but incomplete

Sources:
Source of the indicator
There is regular annual reporting on compensations paid for damages caused by natural disasters. Reporting is performed by reinsurance companies. There might be data available at statistical offices in some countries.

The expected source(s) of data
- G.Berz; Fr.Wirtz (Münchner Rückversicherung) D (C)

The expected source of assessment
- Palutikov (CRU-UEA, Norwich, UK) (L)

Evaluate the data situation:
Data sets are available at reinsurance companies. Availability at national and international organisation has to be checked.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length decades
Further work required Investigations should be performed to check data availability and check the suitability of data for detecting trends in climate.
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		has to be investigated
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		has to be investigated
□ Is the indicator based on international standards and international consensus about its validity?		has to be investigated
□ Could the indicator be linked to economic models, forecasting and information systems?	**Yes**	
Measurability. Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		has to be investigated
□ Adequately documented and of known quality?	**Yes**	
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Economy and Infrastructure Responsibility: ETC/ACC

Indicator title:

Disruption of Transport Services

Definition*:*
Number and period of disruptions to transport services (ferries, airports, trains) and car traffic due to weather conditions (snow fall, ice on streets, tracks and channels) on a regional level.

Policy question:
Trends in climate may affect infrastructure and lead to changes in the disruption of transport services. The public is highly aware of extreme weather events with negative impacts on traffic, because many people are personally affected.

Derived from policy instrument/documents
None

Description/rationale of the indicator
Heavy snow fall and rapid ice formation has a strong negative effect on traffic during the winter period. Public services are prepared to handle such events. Staff and equipment are available due to many years of experience. Therefore, changes in the number and/or duration of disruptions to transport are an indication of changes in the amount and the intensity of extreme weather events.

State of knowledge: Speculative

Sources:
Source of the indicator
Data should be available at national statistical offices

The expected source(s) of data
- National statistical offices

The expected source of assessment
- Palutikov (CRU-UEA, Norwich, UK) (L)

Evaluate the data situation:
Data sets should be available on a national and sub-national level in some parts of Europe.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage
Countries (National)

Time series length unknown
Further work required Information is only available on a regional level. It might not be easy to evaluate a general trend in climate conditions from the number and/or the duration of events. Extreme events are not necessarily linked to trends in climate. The analysis of the climate impact on these events is the major challenge
Time schedule for indicator development Long term (6 - 10 years) Medium term (3 - 5 years) for regional case studies

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Has to be investigated
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Has to be investigated
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**No**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?	**No**	
□ Is the indicator based on international standards and international consensus about its validity?	**No**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Has to be investigated
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Has to be investigated
□ Adequately documented and of known quality?		Has to be investigated
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Economy and Infrastructure Responsibility: ETC/ACC

Indicator title:

Tourism / Number of Skiing Tourists in Winter

Definition*:*
Number of tourists visiting ski resorts in winter.

Policy question:
Tourism is of high importance for the economy in some areas, especially in mountainous regions. Climate change may lead to negative impacts on this sector, especially in winter.

Derived from policy instrument/documents
Alpine Convention

Description/rationale of the indicator
The number of tourist visiting the ski resorts and the number of overnight stays are indicators for the snow conditions in mountainous areas.

State of knowledge: Speculative

Sources:
Source of the indicator
Figures are regularly collected and reported in many ski resorts in the alpine area and Scandinavia

The expected source(s) of data
- National and regional statistical offices
- Regional and local tourist offices

The expected source of assessment
- Palutikov (CRU-UEA, Norwich, UK) (L)
- Gyalistras (Uni. Bern) (C)
- Gehrlinger (PIK) (C)

Evaluate the data situation:
Data are available for some areas only. It might be difficult to compare the data from different regions.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Regional and local level

Time series length
Several decades

Further work required Number of skiing tourists might be controlled by overall economic trends. Data availability and quality has to be checked to assess how comparable and suitable the information is for describing trends in climate.
Time schedule for indicator development Long term (6 - 10 years) for Europe, Medium term (3 - 5 years) for regional case studies

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?		Has to be investigated
□ Is the indicator simple, easy to interpret and able to show trends over time?		Has to be investigated
□ Is the indicator responsive to changes in the environment and related human activities?		Has to be investigated
□ Does the indicator provide a basis for international comparisons?		Has to be investigated
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Has to be investigated
□ Is the indicator based on international standards and international consensus about its validity?		Has to be investigated
□ Could the indicator be linked to economic models, forecasting and information systems?	**No**	
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
□ Adequately documented and of known quality?		Has to be investigated
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	Yearly

Indicator set: ***Climate Change***	Issue: Economy and Infrastructure Responsibility: ETC/ACC

Indicator title:

Sales of Seasonal Products

Definition*:*
End of season sales (winter or summer clothes) and amount of products, such as hot or cold food and drinks, sold within the season.

Policy question:
Consumption of a number of products may depend on weather conditions of the season. Economic impact and consequently public awareness can be presumed in this case.

Derived from policy instrument/documents
None

Description/rationale of the indicator
End of season sales or amount of products sold during the season are sensitive to weather conditions. Consumption of numerous products, such as cold and hot drinks and ice-cream, are also dependent on seasonal weather conditions. A long-term trend in climate changes the average seasonal weather conditions with consequences for the volumes of sales of a number of products.

State of knowledge: Speculative

Sources:
Source of the indicator
Data might be collected by several organisations on local, regional, national and international levels.

The expected source(s) of data
- Eurostat
- National statistical offices
- Regional, national and international chambers of commerce

The expected source of assessment
- Gehrlinger (PIK) (C)
- Palutikov (CRU-UEA, Norwich, UK) (L)

Evaluate the data situation:
The concept seems to be promising, but it is not clear which data sets are available.
Sensitivity to trends in seasonal weather has to be investigated carefully.

DAFIA diagram not available yet

Rank
Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage Countries
Time series length Decades
Further work required Availability of data has to be checked as well as the quality of the relationships between the volumes of sales and weather conditions. End of season sales might be influenced by trends in economical growth and consumer behaviour and marketing. Regulations for sales are still different in European countries. Therefore it might be difficult to compare the data of European countries.
Time schedule for indicator development Long term (6 - 10 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	**Notes**
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?		Has to be investigated
□ Is the indicator simple, easy to interpret and able to show trends over time?		Has to be investigated
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Has to be investigated
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	Has to be investigated
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?	**Yes**	
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Has to be investigated
□ Is the indicator based on international standards and international consensus about its validity?	**No**	
□ Could the indicator be linked to economic models, forecasting and information systems?		Has to be investigated
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Has to be investigated
□ Adequately documented and of known quality?		Has to be investigated
□ Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Category 9: Human Health

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC
Indicator title *:* **Seasonality of Hay fever (Pollen and Allergic Disorders)**	
Definition *:* Changes in seasonality of hay fever and other pollen related disorders.	
Policy question: Climate change/health monitoring should be directed towards the following aims: • To detect health impacts of climate change at an early stage • To improve quantitative analysis of the relationships between climate and health • To improve analysis of vulnerability to climate change • To assist in prediction of future health impacts of climate change, and validation of predictions • To assess effectiveness of adaptation strategies • To promote better research • To inform policy makers and the public	
Derived from policy instrument/documents : Third Ministerial Conference for Environment and Health (London, June 1999): "It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heat wave related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)". "Support the identification, development, standardisation, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be coordinated with global monitoring activities" IPCC WG2 –SPM (2001). "Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems - including physical infrastructure, housing, local food production, and infectious disease occurrence - have been adversely affected by the increasing frequency of floods and droughts over the past several decades." WHO-European Centre for Environment and Health: Workshop on Monitoring Health Impacts of Climate Change in Europe, Meeting report; London, UK ; 29-30 March 2001. Proposal: • Pollen seasonality - onset and duration of important local pollens • Use/sale of antihistamine drugs as an indicator of allergic rhinitis and other allergic conditions related to pollen exposure	

Description/rationale of the indicator

The timing of onset and duration of pollen seasons are related to weather factors.

Data from Hungary indicate that the pollen season stars 2 weeks earlier, on average, and is of longer duration, than a decade ago (the onset of the season is defined as >10 grains per cubic metre).

There are 30 different types of allergenic pollen, and 11 are considered to be very allergenic [in central Europe]. The most allergenic also vary between countries. Ragweed is an imported plant and considered to be a strong allergen producer. There is a very high spatial variability in the distribution of pollen. Trends in abundance of pollen are thought to be more closely linked to changes in agricultural practices. Episodes of very high pollen concentrations have been attributed to thunderstorms (very extreme events) and extreme hot and dry seasons.

An environment-based indicator could be developed on the following aspects of seasonality for a particular pollen or combination of pollens:

- Timing of onset of season – brought forward?
- Duration of season – extended?
- Change in distribution of pollen producing species – e.g. expansion northward?
- Contemporaneous circulation of more than one allergen (increases health impact).

A health-based indicator could also be developed based on the following types of data:

- Primary care consultations (GP consultations) available for UK only?
- Hospital visits (accident and emergency)
- Hospital admissions (asthma)
- Use of drugs (allergic rhinitis, asthma, other)? Data are available for Italy.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator
IPCC, WHO (ECEH), LSHTM and other actively involved organisations have identified possible indicators on climate change impact on human health in various workshops and meetings (e.g. London-meeting, March 2001), among others, indicators on pollen-induced diseases.

The expected source(s) of data:
- European Pollen Monitoring Programmes and Networks (e.g. UK, F, E, I, D)
- European Aeroallergen Network / Pollen Database (Europe-wide)

The expected source of assessment:
- S. Jaeger; Univ. Vienna; A
- J. Chuine; Univ. Montpellier; F
- J. Belmonte; Univ. Barcelona; E
- J. Emberlin; Univ. Worcester; UK

Evaluate the data situation:
The monitoring of pollens is done by selected centres in Europe. There are both national networks (e.g. Italy, UK, Germany) and a European Aeroallergen Network which runs a pollen database . Unfortunately the coverage of pollen data is not very good. There are only a few centres. Data are not easily available.
There is a need for a pilot study to test the hypothesis "an increase in incidence of allergic episodes is associated with a change in the pollen season or distribution".
Within F5 (Framework programme 5 of the EU) there is a Key Action on Allergies and Allergy-related diseases which focuses on the causes of atopic diseases (i.e. initiation of asthma). It was suggested that this key action could be expanded to include studies on the environmental triggers of asthma episodes.

Rank
Data availability (1: low to 5: high): 3

Data reliability (1: low to 5: high): 3

Geographical coverage
Europe

Time series length
Unknown

Further work required
- Identification and evaluation of existing information
- Checking of suitability of possible indicators

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
Does the indicator provide a basis for international comparisons?	**Yes**	
Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability. Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC
Indicator title: **Vector Distribution**	
Definition*:* Changes in spatial and seasonal distribution of vectors	
Policy question: Climate change/health monitoring should be directed towards the following aims: • To detect health impacts of climate change at an early stage • To improve quantitative analysis of the relationships between climate and health • To improve analysis of vulnerability to climate change • To assist in prediction of future health impacts of climate change, and validation of predictions • To assess effectiveness of adaptation strategies • To promote better research • To inform policy makers and the public	
Derived from policy instrument/documents : Third Ministerial Conference for Environment and Health (London, June 1999): "It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heat wave-related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)". "Support the identification, development, standardization, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be coordinated with global monitoring activities" IPCC WG2 –SPM (2001). "Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems - including physical infrastructure, housing, local food production, and infectious disease occurrence - have been adversely affected by the increasing frequency of floods and droughts over the past several decades." WHO-European Center for Environment and Health: Workshop on Monitoring Health Impacts of Climate Change in Europe, Meeting Report; London, UK; 29-30 March 2001 Proposal: Distribution of known vectors of malaria, sand flies and ticks	

Description/rationale of the indicator
Vector-borne diseases may be relatively sensitive indicators, since transmission involves intermediate organisms, such as mosquitoes, open to environmental influences.
In the WHO European region the following classes of health impacts have been identified as high priorities for monitoring in relation to climate change:

- Geographic, temporal and ecological changes of vector organisms, might lead to altered transmission frequency of vector-borne diseases, principally leishmaniasis, lyme disease, tick-borne encephalitis and malaria, possibly also dengue and Toscana virus.
- Changes in the distribution of rodent-borne diseases, including hantavirus and leptospirosis.

The potential effect of climate change on vector-borne diseases should take into account the transmission system as a whole and combine climate data with corresponding measurements of the vector capacity and infection rate of vectors, abundance and infection rate of reservoir hosts (if any), and the infection rate and possible health impacts on humans.
However, information on the effects of climate on vectors is often collected separately from disease data.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator

IPCC, WHO (ECEH), LSHTM and other actively involved organisations have identified possible indicators on climate change impact on human health in various workshops and meetings (e.g. London meeting, March 2001), among others, indicators on seasonal and spatial changes of vector distribution.

The expected source(s) of data:

- International Consortium on Ticks and Tick-borne Diseases (ICTTD)
- Tropical Vegetation Monitoring Unit, ECJRC, Ispra, I
- Research group ' Medical Arachno-Entomolgy' (MAEZo), Univ. of Bonn, D

The expected source of assessment:

- E. Lindgren, Univ. Stockholm, Sweden
- W. Maier, Univ. Bonn, Germany
- Elsa Casimiro, SIAM, Lisbon, P
- P.H. Martin and M.G. Lefebure; ECJRC, Ispra, I

Evaluate the data situation:
It is already known how to monitor changes in vector borne diseases. The problem is the lack of time series data on incidence and distribution and vector abundance and distribution. Data that are needed to investigate early effects of climate change include:

- *Anopheles messae* in Ekaterinburg in the Urals region of Russia
- Malaria in Italy (imported vs local cases)
- Sand flies and canine leishmaniasis in Italy
- Seasonal transmission of TBE in the Czech Republic and Sweden.

Rank
Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage Several regions in Europe
Time series length Up to 20 years
Further work required • Identification and evaluation of existing information • Checking of suitability of possible indicators
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Uncertain
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
□ Adequately documented and of known quality?		Uncertain
□ Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC

Indicator title *:*

Distribution of Vector - Borne Diseases

Definition*:*

Changes in seasonal and regional pattern of cases of vector-borne diseases in Europe

Policy question:

Climate change/health monitoring should be directed towards the following aims:

- To detect early health impacts of climate change
- To improve quantitative analysis of the relationships between climate and health
- To improve analysis of vulnerability to climate change
- To assist in prediction of future health impacts of climate change, and validation of predictions
- To assess effectiveness of adaptation strategies
- To promote better research
- To inform policy makers and the public

Derived from policy instrument/documents :

Third Ministerial Conference for Environment and Health (London, June 1999):

"It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heat wave-related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)."

"Support the identification, development, standardization, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be coordinated with global monitoring activities" IPCC WG2 –SPM (2001).

"Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems – including physical infrastructure, housing, local food production, and infectious disease occurrence have been adversely affected by the increasing frequency of floods and droughts over the past several decades." WHO-European Center for Environment and Health: Workshop on Monitoring Health Impacts of Climate Change in Europe, Meeting Report; London, UK; 29-30 March 2001.

Proposal:

- Distribution of TBE and leishmaniasis (with and without HIV co-infection)
- Cases of malaria, particularly those due to local transmission

Description/rationale of the indicator

Vector-borne diseases may be relatively sensitive indicators, since transmission involves intermediate organisms, such as mosquitoes, open to environmental influences.

Geographic, temporal and ecological changes of vector organisms might lead to altered transmission frequency of vector-borne disease, principally leishmaniasis, Lyme disease, tick-borne encephalitis and malaria, possibly also dengue and Toscana virus.

For infectious diseases, detailed knowledge of transmission cycles is essential in selecting priority diseases. Climate change effects are likely to be most profound for diseases caused by organisms which reproduce outside of human hosts (where they will be subject to ambient conditions), and will be less important and/or difficult to detect for those where human to human transmission is common.

The potential effect of climate change on vector-borne disease should take into account the transmission system as a whole and combine climate data with measurements of the vector capacity and infection rate of vectors, abundance and infection rate of reservoir hosts (if any), and the infection rate and eventual health impacts on humans. However, information on the climate effects on vectors are often collected separately from disease data.

It should be emphasized that malaria differs from the other vector-borne diseases in Europe in that, because human cases are treated, this minimizes the reservoir of parasites which could infect vectors. Thus, even if the vector capacity of the *Anopheles* populations were greatly increased, it seems unlikely that transmission of malaria would reestablish itself in Western Europe if the current health services are maintained.

The animal reservoirs of the pathogens which infect the tick vectors of TBE (tick-borne encephalitis) and lyme disease are not treatable. Therefore the incidence of these diseases in humans is likely to depend more directly on the vector capacities of the tick populations. Over the past two decades marked increases have been reported in the abundance of ticks and in the incidence of tick-borne disease in Europe. There is some evidence that the northern limit of the distribution of the tick vector *(Ixodes ricinu*s) and tick density has increased in Sweden between 1980 and 1994 concurrent with an increased frequency of milder winters.

The very strong association of leishmaniasis with HIV in Europe suggests that changes in HIV prevalence would constitute a serious confounding factor if one tried to detect effects of climate change on the incidence of human leishmaniasis.

State of Knowledge: Established but incomplete

Sources:
Source of the indicator:
IPCC, WHO (ECEH), LSHTM and other active organisations identified possible indicators on Climate Change impact on Human Health in various workshops and meetings (e.g. London meeting, March 2001), among others indicators on vector-borne diseases.

The expected source(s) of data:
- Datasets on malaria and TBE (**T**ick **B**orne **E**ncephalitis) exist in some European countries.
- A surveillance network for leishmaniasis has recently been developed. This includes 28 institutions from 13 countries, mainly based in Europe.
- WHO HQ Geneva (CSR department) is coordinating a new initiative to improve the collection of surveillance data.
- WHO Euro Infection Disease Department is also improving surveillance for vector-borne diseases in Europe (CIDIS).

The expected source of assessment:
- E. Lindgren (Univ. Stockholm;S) TBE
- B. Kriz (Nat. Inst. of Public Health, Prague; CS)
- A.Githeko (Kenya Medical Research Institute, Kisumu, Kenya)
- P. Martens (Univ. of Maastrich; NL)
- S.Kovats (LSHTM, London, UK)
- J.Patz (Programme Health Effects of CC, Baltimore, USA)

Evaluate the data situation:
Knowledge to monitor changes in vector-borne disease already exists. The problem is the lack of time series data on incidence and distribution and vector abundance and distribution. Data that are needed to investigate early effects of climate change include:
- *Anopheles messae* in Ekaterinburg in the Urals Region of Russia
- Malaria in Italy (imported vs local cases)
- Sand flies and canine leishmaniasis in Italy
- Seasonal transmission of TBE in the Czech Republic and Sweden.

The following monitoring systems should be improved and extended:
- Malaria notification in south east Europe and central Asia.
- Distribution and abundance of malaria vector species – prioritize existing monitoring sites (e.g. Ekaterinburg, others to be identified.)
- Tick borne encephalitis and tick vectors in existing sites in Sweden and the Czech Republic.
- Sand fly populations, canine leishmaniasis (noting HIV association).
- Emerging diseases such as West Nile Fever, and vectors such as *Aedes albopictus* (a vector of dengue in Asia).

Rank
Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage
Several regions in Europe, but increasing

Time series length Up to 20 years
Further work required Identification and evaluation of existing information Checking of suitability of possible indicators
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
□ Adequately documented and of known quality?		Uncertain
□ Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC

Indicator title *:*

Catastrophic Weather Related Events (floods, storms)

Definition *:*

Number of victims of catastrophic weather related events (floods, storms) per year.

Policy question:

Climate change/health monitoring should be directed towards the following aims:

- To detect health impacts of climate change at an early stage
- To improve quantitative analysis of the relationships between climate and health
- To improve analysis of vulnerability to climate change
- To assist in prediction of future health impacts of climate change, and validation of predictions
- To assess effectiveness of adaptation strategies
- To promote better research
- To inform policy makers and the public

Derived from policy instrument/documents :

Third Ministerial Conference for Environment and Health (London, June 1999):
"It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heat wave related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)".
"Support the identification, development, standardisation, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be co-ordinated with global monitoring activities" IPCC WG2 - SPM (2001).
"Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems - including physical infrastructure, housing, local food production, and infectious disease occurrence - have been adversely affected by the increasing frequency of floods and droughts over the past several decades".

Description/rationale of the indicator

Exposures to extreme weather events (floods, high winds, etc) might lead to cardiac arrest, drowning, injuries, respiratory diseases, diarrhoeal diseases and others.
Deaths, injuries and illnesses caused by extreme events (such as floods and storms) satisfy the condition of "few competing explanations", but in many populations it may be difficult to distinguish the climate change signal from much stronger mitigating effects of social and economic development.

State of Knowledge: Competing Explanations

Sources:
Source of the indicator:
IPCC, WHO (ECEH), LSHTM and other actively involved organisations identified possible indicators on Climate Change impact on Human Health in various workshops and meetings (e.g. London meeting, March 2001), among others indicators on
victims and damages by catastrophic weather events.

The expected source(s) of data:
- Re-insurance and insurance companies such as Munich-Re or Swiss-Re.

The expected source of assessment:
- G.Berz and A.Wirtz Munich-Re ; Munich, Germany

Evaluate the data situation:
Big re-insurance companies, such as Munich-Re or Swiss-Re, have statistical overviews of victims and damages of catastrophic weather events covering about 50 years (large catastrophic events) and about 20 years (smaller events).

Rank
Data availability (1: low to 5: high): 4

Data reliability (1: low to 5: high): 4

Geographical coverage
Europe

Time series length
50 years (large catastrophic events)
20 years (smaller events)

Further work required
- Identification and evaluation of existing information
- Checking of suitability of possible indicators

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
Is the indicator responsive to changes in the environment and related human activities?		Uncertain
Does the indicator provide a basis for international comparisons?		Uncertain
Is the indicator either national in scope or applicable to regional environmental issues of national significance?	**Yes**	
Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
Is the indicator theoretically well founded in technical and scientific terms?	**Yes**	
Is the indicator based on international standards and international consensus about its validity?		Uncertain
Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
Readily available or made available at a reasonable cost/benefit ratio?	**Yes**	
Adequately documented and of known quality?	**Yes**	
Updated at regular intervals in accordance with reliable procedures?	**Yes**	

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC
Indicator title *:* **Death Attributable to Heat**	
Definition *:*Rate of daily mortality caused by heat waves	
Policy question: Climate change/health monitoring should be directed towards the following aims: • To detect early health impacts of climate change • To improve quantitative analysis of the relationships between climate and health • To improve analysis of vulnerability to climate change • To assist in prediction of future health impacts of climate change, and validation of predictions • To assess effectiveness of adaptation strategies • To promote better research • To inform policy makers and the public	
Derived from policy instrument/documents : Third Ministerial Conference for Environment and Health (London, June 1999): "It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heatwave-related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)." "Support the identification, development, standardisation, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be co-ordinated with global monitoring activities" IPCC WG2 - SPM (2001). "Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems - including physical infrastructure, housing, local food production, and infectious disease occurrence - have been adversely affected by the increasing frequency of floods and droughts over the past several decades." WHO - European Center for Environment and Health: Workshop on monitoring health impacts of climate change in Europe, Meeting report; London, UK; 29-30 March 2001. Proposal: Daily mortality could be an indicator of heat wave related mortality	

Description/rationale of the indicator

The relationship between mortality and temperature is well characterized. Time series analysis of daily mortality data for just a few (4-10) years provides an estimate of the mortality attributable to low and high temperatures. Long series of daily meteorological data are easily available. Combined with models of temperature-mortality relationships, such data can be used to provide quantitative estimates of the impact on heat-attributable mortality of a change in the frequency of "hot" days.
However, long term monitoring is still required to provide early evidence of climate change effects. This would also provide data with which to validate and refine predictive models.
It is not possible to directly observe heat-related deaths because:

- heat-related deaths are defined from a statistical model as “attributable deaths”. However, this does depend on important assumptions about the relationship between daily temperatures and mortality.
- Long data series of daily mortality >30 years are not available for many countries.

At European level the WHO identified a high priority to monitor exposures to extremes in high temperature, as they might lead to cardiovascular and renal diseases or fatalities.
A US study of 179 climate stations found that “high heat stress days” are twice as frequent now compared to 1950s.

State of Knowledge: Established but incomplete

Sources:

Source of the indicator

The Working group on climate and health of the Commission on Climatology (CCI) within the WMO concluded that the development of climate change/health indices is to be regarded as the highest priority of the working group for the next two years. A first step would be to develop an indicator on thermal stress/ heat waves. One approach is to develop the UTCI-Universal Thermal Climate Index.

The expected source(s) of data:

- APHEAII-Project (Air pollution and Health: An European approach 2)
- LSHTM (London School of Hygiene and Tropical Medicine)

The expected source of assessment:

- P. Wilkinson, S. Kovats (LSHTM); London, UK
- K. Katousuannyi, Univ. Athens, GR
- G. Mc Gregor, Univ. Birmingham, UK
- G. Jendritzky, Deutscher Wetterdienst; Stuttgart, D
- B. Menne, WHO/ECEH, Roma, I

Evaluate the data situation:

Long term series of meteorological data are easily available. More problematic are data sets of heat impacts to human health.
Only a few sets are already available, such as the 20 year data set on heat related mortality by Wilkinson/ Kovats (LSHTM) and the 30 year data set of climate change/ health indices by Jendritzky (Deutscher Wetterdienst)

Rank

Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage Few European countries and regions (e.g. U.K., Germany)
Time series length Up to 30 years
Further work required • -Identification and evaluation of relevant data sets. • -Checking of suitability of possible indicators
Time schedule for indicator development Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators

The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?	**Yes**	
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?		Uncertain
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
□ Does the indicator have a threshold/target or reference value against which to compare it, so that users can assess the significance of the values associated with it?		Uncertain
Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
□ Is the indicator based on international standards and international consensus about its validity?		Uncertain
□ Could the indicator be linked to economic models, forecasting and information systems?		Uncertain
Measurability Are the data required to support the indicator:		
□ Readily available or made available at a reasonable cost/benefit ratio?		Uncertain
□ Adequately documented and of known quality?		Uncertain
□ Updated at regular intervals in accordance with reliable procedures?		Uncertain

Indicator set: ***Climate Change***	Issue: Human Health Responsibility: ETC/ACC

Indicator title *:*

Seasonal Peak of Food - / Water - Borne Diseases

Definition *:*

Seasonal variation and distribution of cases of Salmonellosis, Campylobacteriosis, Cryptospridiosis and Ecoli.

Policy question:

Climate change/health monitoring should be directed towards the following aims:

- To detect health impacts of climate change at an early stage
- To improve quantitative analysis of the relationships between climate and health
- To improve analysis of vulnerability to climate change
- To assist in prediction of future health impacts of climate change, and validation of predictions
- To assess effectiveness of adaptation strategies
- To promote better research
- To inform policy makers and the public

Derived from policy instrument/documents :

Third Ministerial Conference for Environment and Health (London, June 1999):
"It is anticipated that climate change will have a range of health impacts. Some will result from direct effects (e.g. heat-wave-related); others will result from disturbances to complex physical and ecological processes (e.g. changes in patterns of infectious disease)."
"Support the identification, development, standardization, evaluation and broad use of systems for monitoring and assessing changes in environmental indicators, bio-indicators of health risk and impacts on health as well as indicators of population health status across Europe. These systems must be coordinated with global monitoring activities" IPCC WG2 - SPM (2001).
"Human social and economic systems are somewhat buffered against early impacts of climate change. Nevertheless, evidence suggests that some of these systems - including physical infrastructure, housing, local food production, and infectious disease occurrence - have been adversely affected by the increasing frequency of floods and droughts over the past several decades." WHO-European Center for Environment and Health: Workshop on Montoring Health Impacts of Climate Change in Europe, Meeting report; London, UK ; 29-30 March 2001.
Proposal: cases of salmonellosis, campylobacteriosis and cryptospridiosis

Description/rationale of the indicator

Intestinal infections (food poisoning) show very strong seasonal patterns (suggesting a powerful effect of climate variability) and have been routinely reported for many years (although the data are known to be incomplete).
Microbiologically contaminated food and water can lead to diarrhoeal disease and serious illness.

Best candidates for indicators of climate change effects are:

- Salmonella, all types (however, overall rates of salmonella are declining)
- Campylobacter
- Cryptosporidiosis – but unfortunately this is only well reported in the UK
- Ecoli
- Campylobacter (food-borne) and Cryptosporidiosis (water-borne) have been identified by WHO as high priority infections in Europe and are under climate change surveillance.

The best approach is to detect a shift in the seasonal pattern of infections.
A potential indicator, using a weekly time series for a single region or country, would address the following:

1. A change in the base of seasonal peak - is it wider?
2. A change in timing of onset of seasonal peak - is it earlier?.
3. A change in spatial and temporal distribution?

However, there are some important problems to be faced, such as:

- Comparability between countries
- Capacity of laboratories
- Person to person transmissions (not influenced by food or water)
- Insufficient recording of data
- Problematic identification of sample locations
- Lack of information on important confounders

State of Knowledge: Established but incomplete

Sources:
Source of the indicator:
IPCC, WHO (ECEH), LSHTM and other actively involved organisations have identified possible indicators on climate change impact on human health in different workshops and meetings (e.g. London meeting, March 2001), among others indicators on food-/water-borne diseases.

The expected source(s) of data:
- European network ENTERNET for Salmonella and Ecoli already exists.
- Mc Michael, Edwards (LSHTM) 1981-now (Food-borne diseasis)

The expected source of assessment
- T. Mc Michael (LSHTM)
- S. Kovats (LSTHM)

Evaluate the data situation:
Some data sets for Salmonella and Ecoli exist in the European network ENTERNET.
Because of their high priority under climate change surveillance, some data sets of Campylobacter and Cryptospridiosis infections might exist.

Rank
Data availability (1: low to 5: high): 2

Data reliability (1: low to 5: high): 3

Geographical coverage
Few countries only

Time series length
Up to 20 years

Further work required
Identification and evaluation of existing information

Time schedule for indicator development
Medium term (3 - 5 years)

OECD criteria for selecting environmental indicators
The criteria describe the "ideal" indicator; not all of them will be met in practice.

	Yes/No	Notes
Policy relevance		
□ Does the indicator provide a representative picture of environmental conditions, pressures on the environment or society's responses?	**Yes**	
□ Is the indicator simple, easy to interpret and able to show trends over time?		Uncertain
□ Is the indicator responsive to changes in the environment and related human activities?	**Yes**	
□ Does the indicator provide a basis for international comparisons?	**Yes**	
□ Is the indicator either national in scope or applicable to regional environmental issues of national significance?		Uncertain
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Analytical soundness		
□ Is the indicator theoretically well founded in technical and scientific terms?		Uncertain
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