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Proposed Set of Climate Change State and Impact Indicators in Europe

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Summary

This report provides a preliminary list of climate change state and impact indicators that have been developed by the European Topic Centre on Air and Climate Change (ETC/ACC), as part of its work programme for the EEA, and with input from several other ETCs. The report starts with a summary of the objectives of the work, followed by a short background on different types of climate change indicators. Then the methods and approaches used for the initial selection process are presented.

Based on an initial proposed list of indicators prepared by ETC/ACC and the outcome of an expert meeting at the EEA by the end of 2001 a preliminary list of potential indicators was compiled which is presented in this report. These preliminary selected indicators are thought to be suitable to describe the main currently occurring and in some cases expected future trends in climate change and its impacts on ecosystems, human health and socio-economic sectors. In addition “Indicator Description Sheets” are presented that contain more detailed information on the preliminary selected indicators, including background information, sources of data and a detailed assessment of the suitability of the indicator for policy making processes, based on EEA and OECD criteria.

The report provides a picture of the current situation on climate change state and impact indicators but also gives an impression of the efforts which have to be taken in the near future to compile and develop a set of useful indicators for monitoring climate change and its impacts. The preliminary list of potential climate change indicators will be distributed for comments to climate change contact points in EEA member countries, experts in the scientific community and others interested, to enable a final selection of indicators for EEA reporting in the coming years.

1 Introduction

1.1 Objectives of the ETC/ACC work on climate change indicators

The EU has identified climate change as one of the key environmental issues. Because of this interest, the EEA work programme and the EEA Scientific Committee have recognised the need for more work by EEA on the identification and development of climate change indicators. Climate change indicators should reflect, among other things, trends in greenhouse gas (GHG) emissions ('pressures') and climate change 'state and impact' such as GHG concentrations, temperature increase and effects on biodiversity, human health and socio-economic sectors. The indicators should show the progress made in meeting climate change policy targets and should identify requirements for adaptation and mitigation measures. The indicators will be presented in EEA reports, e.g. the Environmental Signals series or a specific EEA report on climate change. The indicators will be used in the DPSIR (socio-economic Driving Forces, Pressures (emissions), State, Impact and policy Responses) assessment framework of the EEA, and can be used to present and evaluate the link between various parts of the DPSIR elements, for example between climate change (state) and the hydrological cycle.

EEA and ETC/ACC already have extensive experience with indicators of climate change pressures (emissions) and policy responses (emission projections and emission intensity), in particular in support of the EU Greenhouse Gas Monitoring Mechanism. Detailed information about these indicators can be found in other reports (e.g. Topic Report 'EC and MS greenhouse gas trends', EEA, 2001) and these types of pressure and policy response indicators will therefore not be addressed in this report.

However until now EEA has not performed much work on climate change state and impact indicators. This report is the first EEA report on this subject and it summarises the results of the initial work on climate change state and impact indicators by ETC/ACC. Firstly, the objective of the report is to propose a list of such indicators for monitoring and reporting on climate change. A second aim is to identify gaps in knowledge and to analyse the time frames in which underlying data could become available in future. Finally, the report shows the underlying data sources that are available at a number of national and international institutes and research organisations in Europe, including WMO, UNFCCC/IPCC, WHO, EUMETNET, JRC and AMAP.

1.2 Background on climate change indicators

Climate change is an issue of major environmental concern. Temperatures (globally but also in Europe) have increased to a level higher than temperature increases to which our civilization has adapted in the past. In addition, the rate of temperature increase exceeds historically observed rates, and is possibly faster than the adaptation capacity of natural, social and economic systems. Apart from temperature other climate changes occur, such as changes in precipitation. There is more and more evidence that these changes in climate are, at least partly, driven by anthropogenic greenhouse gas emissions (IPCC, 2001).

The multiple linkages between causes and impacts of climate change are, in many cases, not completely understood. Indicators can help to present and explore these complex relationships to support policy making, by demonstrating the impacts of climate change on different environmental and socio-economic sectors. To limit climate change and its potential impacts, countries agreed in 1997 to supplement the United Nations Framework Convention of Climate Change (UNFCCC) with quantitative limits for emissions of greenhouse gases from industrial countries aimed at a reduction by 5% in 2008 - 2012 from

1990 levels. Furthermore, the EU defined an indicative target for potentially 'sustainable' climate changes including a tolerable global temperature increase of not more than 2 Kelvin above pre-industrial values.

Policy makers need indicators to measure progress towards achieving these objectives, which means indicators that can be used to measure quantitatively greenhouse gas emissions and to evaluate the effectiveness of policies aimed at reducing these emissions. In addition, indicators should also monitor the actual trends in climate change (by 'state indicators') and its impacts.

Monitoring both mean values and extreme events is necessary for analysing what happens under a changing climate in complex natural and social systems. Indicators for climate change impacts are important because public concern is mostly directed at these impacts and adaptation measures will be increasingly needed the coming years and decades. Furthermore, these state and impact indicators could provide early warning signals to policy makers and subsequently deliver arguments for further emission reductions, in particular immediately after 2012.

Policy makers are also interested in impacts of climate change over longer time periods, e.g. up to 2050 and 2100, in order to develop the potentially required additional policies or societal changes needed now to achieve 'sustainable' targets for climate change (yet to be defined) and sustainable development in general. The selected indicators should therefore also be applicable in integrated assessment models to evaluate the link between observed and possible future changes in climate, changes in natural systems and developments and changes in society and economy.

2 Methods used for selection of indicators

2.1 Initial indicator assessment

Climate change state and impact indicators have been presented in many reports in the last decades, in particular in the recent third assessment report of IPCC (IPCC, 2001), the European-wide climate change assessment ACACIA (Parry et al. 2000) and in national and regional case studies (e.g. Cannell et al., 1999). Therefore this project started with a European-wide evaluation of available information on indicators related to climate change. The evaluation was based on a literature survey and a questionnaire, developed by ETC/ACC specifically for this purpose (Annex A-1). The aim of the questionnaire was to acquire information on the existence and availability of the relevant indicators and data sets in different categories.

ETC/ACC sent the questionnaire to about 200 scientists throughout Europe. In addition, the EEA sent out a letter to the National Focal Points and National Reference Centres on Climate Change (Annex A-2), with the same questionnaire, to inform the EEA member countries on the work by the ETC. ETC/ACC team used the replies in combination with further information from literature, meta-data bases about research projects (e.g. CORDIS) and interviews with experts to define an initial broad set of potential climate change state and impact indicators suitable for the EEA reporting and integrated assessment framework.

Indicators were selected for the broad set using criteria taken from the EEA (see chapter 2.4 for more explanations). The most important criteria are the data availability and the relevance to policy makers. Other criteria are, for example, the spatial representation (e.g. for the whole of Europe or for certain regions only), transparency (i.e. can they be understood by policy makers, scientists and stakeholders?), analytical soundness and measurability and potential inclusion in integrated assessment tools. The latter

resulted in the acceptance of some indicators for which sufficient data are not yet available, but which are potentially very relevant for climate policy.

Based on the initial broad set of indicators, a preliminary set of state and impact indicators was developed (see Chapter 2.3). Both lists have been discussed with experts during a meeting held at EEA on 22 and 23 November 2001 (see chapter 2.5). The results of the expert meeting have been used to modify the set of indicators. The updated set is presented in chapter 3 of this report.

2.2 Input from countries and international organisations

Data availability is one of the key issues for a European-wide indicator system. Data required for climate change indicators are currently often collected for purposes other than specifically climate change.

Global data (e.g. WMO, WHO, WRI, WCMC, UNEP, data sets from European and national organisations (Eurostat, JRC, EUMETNET, AMAP, national weather services), and results from EU (Parry et al., 2000; Valentini et al., 2000) and national research projects have, as far as feasible within this project, been checked for estimating the expected time frame for implementing the indicators. To what extent possibly new or additional data collection from countries would be needed to compile climate change indicators has not yet been fully investigated by the ETC/ACC, because the primary aim of this report was to identify a preliminary set of indicators.

The implementation of specific data collection and indicator compilation needs to be coordinated between ETC/ACC and ETC/Terrestrial Environment, ETC/Nature Protection and Biodiversity and ETC/Water (see chapter 3).

2.3 Criteria for selection

Ten criteria have been used for the preparation of the preliminary list of indicators. Criteria 1 – 8 are according to the EEA Indicator Fact Sheet Model. The following questions have not been considered in this approach, because they could not be answered with ‘yes’ or ‘no’: ‘What are the causes behind the development (trends) of the indicator?’ and ‘What is the shortest time period required to show change?’. ETC/ACC added two additional criteria (9 – 10) to the list because of the, quite often, long response time of the different systems, which is very specific for climate change.

The criteria for selecting an indicator therefore were:

1. Is the indicator attractive to the eye (accessible)?
2. Is the indicator easy to interpret correctly? Does it match the interest of the target audience?
3. Is the indicator representative for the issue or area being considered?
4. Is the indicator based on data, which are updated at regular intervals?
5. Is there a reference value for comparing changes over time? What is this value?
6. Do the data (raw data or indicator data) allow international comparability? What would make the data non-comparable (differences in national definitions, changes over time to the definition and methodologies, etc.)?
7. Scientifically, is the work well done? Is the indicator well founded and of good quality (data & methodology)?
8. Is there agreement on the data validity: data collection methods, statistical methods, etc.?

Additional criteria introduced by ETC/ACC:

9. Are there appropriate data sets (length of time series) in relation to the response time of the indicator?
10. Is there an appropriate level of sensitivity to climate change?

Using the criteria and by grouping the indicators resulted in 6 main types of climate change state and impact indicators:

I Indicator (short-term)
All criteria are already fulfilled or will be fulfilled within a short-term perspective (within 0-2 years).

II Indicator (medium-term)
Many criteria are fulfilled within a medium-term perspective. Some analysis or data mining will however be needed (within 3-5 years).

III Indicator (long-term)
Many criteria are fulfilled within only a long-term perspective (6 to 10 years). Both model evaluation and data collection and processing are needed for these indicators.

IV Potential indicator
Indicators that are potentially interesting within a medium/long-term perspective, but need more analysis (e.g. because of links to other environmental issues). Further, it is unclear whether data exist and are available and/or models exist to evaluate future conditions.

V Soft indicator
Attractive indicators that are, however, not sensitive enough to climate change and/or for which not sufficient data are available.

VI Not suitable as indicator
According to the information available, this indicator is not feasible for observing climate change.

The types V and VI have, on the one hand, been listed to exclude potential indicators for ETC/ACC assessment and, on the other hand, to deliver a comprehensive set of potential indicators to allow for changes in the ranking after re-assessments by experts in the expert meeting described below.

2.4 Categories of climate change state and impact indicators used in this report

ETC/ACC has defined 9 main categories for climate change state and impact indicators (Table 1, Annex B). In this section these categories are briefly described. For each of the categories a number of indicators had been initially selected. The total (initial) list (Annex B) was used as input to an expert meeting at EEA (see Chapter 2.5). This meeting led to an update of the indicator list, which is described in Chapter 3. For some categories, especially category 4 - agriculture and forestry, the first assessment was severely modified due to the results of the expert meeting. The nine categories are described below, see also table 1.

Table 1 - Overview of categories of climate change state and impact indicators

	Category	Brief description of indicator category
1	Climate and Atmosphere	Changes in climate at the earth's surface and in the stratosphere, atmospheric CO_2 and other greenhouse gas concentrations.
2	Cryosphere	Changes in glaciers, arctic sea ice, permafrost, lake/river ice and snow cover
3	Soils and Land Resources	Changes in carbon sequestration in vegetation and soils. Use of carbon sequestration as measure to meet Kyoto protocol commitments.
4	Agriculture and Forestry	Changes in yields of key crops; pests and diseases; forest growth, shifting of tree lines.
5	Ecosystems and Biodiversity	Changes in growing season, behaviour of birds and insects, composition of ecosystems
6	Hydrology / Water Resources	Changes in water shortage; irrigation; lake and river temperatures; extreme events/floods and average discharge.
7	Marine Environment and Costal Zones	Changes in sea level rise, sea surface temperature, storm surges, thermohaline (North Atlantic) circulation, retreat of shorelines due to erosion.
8	Economy and Infrastructure	Changes in insurance; electricity, gas and water consumption; tourism; industry and transport
9	Human Health	Changes in mortality due to heat-waves; hospital admissions (allergies disease, hay fever); distribution of vector-borne diseases (e.g. malaria); food-/water-borne diseases

1. Climate and atmosphere

Climate and atmospheric variables such as temperature change and trends in precipitation are obvious parts of assessments, which study climate change impacts. Such variables are described in a number of studies (IPCC, 2001; Parry et al. 2000; Klein Tank & Wijngaard, 2001). Emphasis up to now has often been on changes in absolute trends. Extreme events and changes in seasonality have also been investigated. Statistical analysis of climate data can be used to describe the interrelationships in changes in the different climate parameters (Gerstengarbe & Werner 1999) but might not be as understandable to policy makers and the public as temperature or precipitation. Significant changes in rainfall pattern can be observed, especially in Western Europe, but there are still uncertainties concerning the underlying causes (Schmith, 2001; Werner et al., 2000). There may be feasible indicators based on processes in the stratosphere, but this data cannot be used for impact assessments. Atmospheric CO_2 and other greenhouse gas concentrations are the key indicator for international negotiations on emission reduction.

Increases 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.

2. Cryosphere

Many studies have shown that different components of the cryosphere are very sensitive to climate change. Some examples of these studies are long-term glacier observations in alpine regions, the significant loss of arctic sea-ice and the retreat of snow cover in Europe. One example of a new study is the PACE project (http://www.cf.ac.uk/uwc/earth/pace) which measures the temperatures in different depths of permafrost at a number of places round the world.

3. Soils and land resources

The storage capacity of carbon in vegetation and soils has a high policy relevance because of the link to the Kyoto protocol and the Marrakech Accords (UNFCCC, 2001) that allow countries to make use of carbon sequestration in agricultural soils and forestry to meet their commitments. Furthermore, carbon storage is an indicator for various processes, e.g. the response of soil organic matter decomposition to climate change. In addition land use and land degradation is influenced by climate change. There are still gaps in data availability especially on soil carbon dynamics but many efforts have been made to simulate carbon dynamics under climate forcing (Cramer & Field 1999, Valentini et al. 2000). The observed trend in carbon storage can only be partly explained by climate change. Especially in Europe, other factors might be (more) important (e.g. management of ecosystems).

4. Agriculture and forestry

Agriculture and forestry are two important land uses in Europe, providing various resources (e.g. food, fodder, timber). Although economic factors are important for changes in both activities (e.g. subsidies from the European Union), climate is still a basic underlying factor. Changes in climate can have severe impacts on both agricultural productivity and forest management in Europe, as shown by many studies (e.g. Hulme, et al., 1999, Lindner, 1999, Parry et al., 2000). Three relevant climate change impact indicators have been defined: the yield trend of important crops in Europe (e.g. wheat and grapes), growth trends of forests and the tree line in mountainous regions. The first two indicators are applicable for the whole of Europe, while the latter indicator is a more regional one. All three indicators are monitored intensively over entire Europe. The tree line in mountainous regions has also been monitored for a number of decades, especially in the Alps and Norway.

5. Ecosystems and biodiversity

Climate change impacts on ecosystems and biodiversity are regarded as very important because of the low adaptation potential of most ecosystems. The Framework Convention on Climate Change explicitly stresses that climate change should be limited to a level at which ecosystems can adapt. Likewise, the Convention on Biological Diversity explicitly mentions the risk of significant changes in climate. Because of the high relevance, ecosystems and biodiversity have been included in many studies, varying from the local to the global scale. Further efforts are necessary to identify key species, suitable for monitoring climate change on European level. An existing, useful network is the European Phenology Network (EPN). This network shows that phenology of plants can be well monitored throughout Europe. Phenological gardens and satellite data are potentially useful sources for data about vegetation changes.

Further, models can be used to calculate carbon fluxes and sequestration using phenology and satellite data.

6. Hydrology and water resources

Many studies exist which show that climate and land use affects various water-related indicators in Europe (IPCC, 2001). One of the indicators that have been studied frequently is the water discharge in large rivers. In many European countries, catchment scale studies have been established to evaluate the effects of climate change on river discharge. Data are available for many major rivers such as the Rhine, Danube, Rhone and Po. Climate and its variability are key underlying factors for changes in discharges, although management factors such as land-use changes, construction of dykes and dams and extraction of water are important too.. A second water-related indicator is the water demand for irrigation. Irrigation is the most important use of water. Potential impacts of climate change are a direct change in demand, but also a reduced reliability of reservoir systems (IPCC, 2001).

Flood risk is a third indicator. This indicator is a complex aggregation of various underlying factors. For example, flood risk depends on the duration of high intensity rainfalls and snow melt in major basins (esp. in mountainous regions). Because of the complexity, data about flood risks are only rarely available.

Fourthly, trends in water resources can be evaluated using water scarcity as an indicator. This indicator is very interesting because it integrates water availability with water demand. This advantage makes it, in turn, also difficult to understand because it integrates even more factors than flood risk or river discharge. Up to now, data required for compiling this indicator have not been identified in this study, although it may be possible to base the indicator on existing studies (Lehner et al. 2001)).

Finally, lake and river temperature can be used to illustrate the relationship between water and the hydrological cycle. The moment of thawing is particularly interesting. Observations have been made in various rivers, especially in Northern Europe, showing a clear trend. This indicator may also be coupled to assessment models in order to project changes in the future. Changes in river and lake ice may affect transportation and water availability throughout the year (similar to snow melt, see category 2, cryosphere).

7. Marine environment and coastal zones

Climate change is influencing coastal zones and marine environment. Increasing temperatures, changing precipitation patterns and storm tracks could lead to higher sea surface temperatures, a rising of sea-level, an increase of storm surges and increased shoreline retreat caused by stronger erosion of beaches.

Melting sea-ice and arctic inland glaciers, in connection with changing patterns of precipitation, could reduce the salinity in the North Atlantic. These factors can deplete the down welling of water into the deep layer of the ocean and consequently weaken the conveyer belt transporting large amounts of warm water across the ocean to Europe.

8. Economy and infrastructure

The direct impact of climate change on economy and infrastructure is difficult to assess. Energy consumption and damage compensations due to natural disasters (insurances) are the most important sectors with significant direct effects of climate change. A number of potential economic indicators are already mentioned in the other sections (e.g. forest and agricultural products). Climate impacts are mostly

related to micro-economic processes and extreme weather events, e.g. seasonal changes in agricultural yields, energy consumption per capita due to heat waves or extremely cold periods.

9. Human health

Indicators to describe the impact of climate change on human health are still limited due to lack of data, but these are politically important. Climate change can exacerbate heat waves resulting in higher rates of morbidity and mortality. Furthermore, higher temperatures could lead to an increase of water and food-related diseases. New distribution patterns of certain vectors could induce malaria or other tropical diseases in Southern Europe. The identification and evaluation of indicators for climate change impacts on human health is one of the activities of WHO (WHO, 2001) and as soon as results are available these will be used.

2.5 EEA expert meeting on indicators

On the 22 and 23 of November 2001, an expert meeting was held to discuss climate change state and impact indicators (Annex C-1). The main objectives of the meeting were (i) to investigate the applicability of the indicator concept with a group of experts from the EEA, other ETCs and scientists from various disciplines (Annex C-2); (ii) to discuss a first (preliminary) set of indicators. The expert meeting consisted of various presentations on indicators and projects on climate change, the ETC/ACC preliminary overview of indicators and several discussions in groups. In the groups the proposed indicators were discussed in detail, the ranking was modified where necessary and new indicators were introduced, using the predefined list of criteria for the evaluation of the indicators. The expert meeting closed with a plenary discussion about the outcomes of the sub-sessions, leading to an assessment of indicators differing in some aspects from the preliminary set proposed by ETC/ACC.

The most important conclusions of the expert meeting were:

- There was broad agreement about the need for climate change state and impact indicators. Climate change has to be monitored in order to evaluate the impacts and consequences of a changing climate on ecosystems, on human health and on socio-economic sectors. It is important that resources are allocated at national and international level to maintain monitoring networks.
- A number of data sets are already available at national and international organisations that can be used to compile climate change indicators. Often the data has been collected for other purposes than for the development of indicators. In various cases additional work is necessary for the purpose of compiling indicators.
- Several climate change indicators are already available (e.g. IPCC,ACACIA, UKCIP climate change report). However these indicators need in most cases further work, for example due to the need for up-scaling from national or sub-national level or down-scaling from global level to the European level.
- There should be explicit distinction between indicators for past and current trends (climate change already occurring now) and for future, projected, trends based on scenarios and models.
- Some of the indicators may overlap with indicators being developed by other ETCs. Some indicators have to be formulated more explicitly. For example for the indicator ‘precipitation’ it should be made clearer what is meant: total amount or number of rainy days or rainfall intensity.

As a result of the expert meeting, the ETC/ACC compiled an update of the list of climate change state and impact indicators that can be used by EEA (see below).

3 Preliminary (proposed) list of climate change indicators

Based on the method described in chapter 2 (questionnaire, literature review, expert meeting), a preliminary list of climate change indicators was compiled (Table 2).

Table 2 - Preliminary (proposed) list of climate change indicators

	Category	**Indicators**	**Responsibility within EEA framework (ETC)**	**Time for development (Short/Medium/Long-term)**
1	Climate and Atmosphere	- Temperature		**S**
		- Precipitation		**S**
		- Atmospheric CO_2 and other greenhouse gas concentrations	**ETC/ACC**	**S**
		- Climate Indices (temperature, precipitation, humidity)		**M**
		- Storms		**M**
		- Lightning Frequency		**M**
		- Cooling and Shrinking of Strato-, Meso- and Thermosphere		**M**
2	Cryosphere	- Mountain Glaciers		**S**
		- Arctic Sea Ice		**S**
		- Snow Cover	**ETC/ACC**	**M**
		- Lake- and River Ice		**M**
		- Baltic Sea ice		**M**
		- Permafrost		**L**
3	Soils and Land Resources	- Net Carbon Uptake	ETC/ACC	**S**
		- Soil Moisture Availability	ETC/TE	**M**
4	Agriculture and Forestry	- Crop Suitability	ETC/NPB	**M**
		- Forest Suitability	ETC/NPB	**M**
		- Forest Growth	ETC/ACC	**M**
		- Shifts in the Tree Line	ETC/NPB	**M**
		- Pests and Diseases	ETC/ACC	**L**

5	Ecosystems and Biodiversity	- Growing Season - Plant Phenology - Changes in Species Behavioural Patterns - Storm Events - Changes in Ecosystem Composition / Biodiversity - Ecosystem Fires - Marine Ecosystems and Biodiversity	**ETC/NPB** (ETC/TE)	**S** **M** **M** **M** **M** **M** **M**
6	Hydrology and Water Resources	- Global and Regional Annual River Discharges - Lake Temperatures - River Discharge from Small Undisturbed Watersheds - Frequency of Low and High River Flows - Fresh Water Availability	**ETC/WTR**	**S** **M** **M** **M** **M**
7	Marine Environment and Coastal Zones	- Sea Surface Temperatures (SST) - Sea Level Rise - Characteristics of Storm Surges - Thermohaline Circulation - Temperature of the Intermediate Layer (Baltic Sea) - Coastal Erosion / Coastal Retreat	**ETC/ACC** ETC/TE	**S** **S** **M** **M** **M** **M**
8	Economy and Infra-structure	- Energy Consumption for Space Heating in Winter - Number of Weather Related Catastrophic Events / Insurance - Disruption of Transport Services - Tourism / Number of Skiing Tourists - Sales of Seasonal Products	**ETC/ACC**	**M** **M** **L** **L** **L**
9	Human Health	- Seasonality of Hay-fever - Vector Distribution - Distribution of Vector-Borne Diseases - Catastrophic Weather Related Events - Death Attributable to Heat - Seasonal Peak of Food-/Water-Borne Diseases	**ETC/ACC**	**M** **M** **M** **M** **M** **M**

For each of these indicators detailed description sheets (Annex D) were produced. The sheets contain information about:

- the name of the indicator and the category,
- its definition (including the unit) and description (e.g. the rationale)
- its relevance to policy (e.g. by making links to policy documents) ,
- the data availability and reliability now and in future (using the EEA categories 0-2 years (S), 3-5 years (M) and 6-10 years (L)). Possible sources of information and data are also mentioned.
- The satisfaction of different criteria (showing why an indicator is suitable)

For each category the main indicators and the main reasons for identifying the indicator as available in the short or medium term are briefly presented below. In chapter 2 the general description of the indicators is presented, while here a summary is given of the results of the discussions at the expert meeting leading to changes in the list of indicators

Climate and atmosphere

Trends in temperature and precipitation are considered to be available within the short-term (S). 'Climate indices' are more complex but may be very sensitive to climate change. Processes in the stratosphere are sensitive to climate change but not suitable to be related to other processes on the earth's surface. Cloud cover was estimated not to be useful as a climate change indicator. Trends in greenhouse gas concentrations, especially atmospheric CO_2 and other greenhouse gas concentrations, are important indicators that are available in the short term.

Cryosphere

The indicators 'changes in the extent of glaciers' 'mass-balance of glaciers' and (possibly) 'arctic sea ice' were assessed to be available in the short term. Other indicators will be available and more useful in the mid term, except the indicator 'temperature profile in permafrost', which is only expected to be available in the long term.

Soils and land resources

Two indicators have been identified to show the effect of climate change on soils and land resources. Data for one indicator ('net carbon uptake of the biosphere') might be available in the short-term (e.g. through the Carbo Europe project). Whether the indicator would be directly useful needs further investigation. 'Soil moisture' will only be available in the mid term.

Agriculture and forestry

In line with the initial preliminary set of indicators, in total 5 indicators for agriculture and forestry are proposed, all expected to be available in the mid-term. However, one change has been made during the expert meeting. The participants identified crop yield as a less suitable indicator. Instead, crop suitability became important, because of its strong link to climate.

Ecosystems and biodiversity

The category 'ecosystems and biodiversity' was the category with the largest number of possibly useful impact indicators. 'Trends in growing seasons' is the only indicator that will become available in the short term. The other 5 indicators are expected to be available in the mid term, although much work is needed to improve the data availability and modelling. The participants made a clear distinction between 'growing season' and 'plant phenology'. The former indicator has a relative simple relationship with the climate

system, whereas for plant phenology also other factors (e.g. plant species) are important. The proposed list of indicators considered terrestrial ecosystems only. After the expert meeting, this list was extended to marine ecosystems. Results should be available in mid term time scale.

Hydrology and water resources
River discharge has been identified as a climate change indicator, which is available in the short term. Various studies and data set exist that provide discharge data. In contrast, river discharge from small undisturbed watersheds and lake temperature are expected to be only available in the medium term. Further investigations are necessary to test the sensitivity of potential indicators, such as the number and intensity of floods and droughts or total water availability (medium term).

Marine environment and coastal zones
Data on changes in surface temperatures can be used as a climate change indicator within a short time scale (‘S’). Long time series of data on sea level rise are available, but due to the inertia and natural variability of the system these often don’t show a clear trend of accelerated increase yet. Caused by the need of further analysis it should be a medium term indicator. A number of other indicators will be available in future (mid term). Indicators for marine ecosystems could be useful climate change indicators (see indicators in category ecosystems and biodiversity).

Economy and infrastructure
There are two major problems in using economic data as indicators for climate change. In many cases other factors are also influencing trends and data sets are often available only on a regional level. Seven indicators have been identified that are expected to be available on a regional level only in the near to long term. One of these, ‘energy consumption for space heating in winter’, might be available for larger parts of Europe.

Human health
Indicators showing impact on human health, like the distribution of vectors or extreme weather events, are expected o be available in the medium term.

4 Conclusions

A list of state and impact indicators has been proposed and presented in this report. The list is based on a European-wide questionnaire, a literature review and interviews by ETC/ACC and results from an expert meeting in which experts from the EEA, ETCs and scientists participated. There was agreement about the need for climate change state and impact indicators. The indicators should reflect the current and future projected state and impacts of a changing climate on natural and socio-economic systems in order to raise awareness with policy makers and the public.

The identified climate change state and impact indicators are categorized in 3 levels of availability (short, medium, long-term), taking also a number of other criteria into account, such as transparency and policy relevance. The ranking of the indicators undertaken by ETC/ACC was strongly influenced by the question of data availability. The following indicators have been classified as policy relevant and available in the short term (within 2 years):

- 'State' indicators (categories 'Climate and Atmosphere'; 'Cryosphere'; 'Hydrology and Water Resources' and 'Marine Environment and Coastal Zones'): Atmospheric CO_2 and other greenhouse gas concentration; temperature and precipitation; sea surface temperature; river discharges; extent and mass-balance of glaciers; arctic sea ice.
- 'Impact' indicators (categories 'Ecosystems and biodiversity' and 'Soils and land resources'): net carbon uptake and growing season length.

These indicators have been identified as very relevant for policy makers and the public and the data should be available within the short term (less than 2 years). For most of these and other potentially useful impact indicators in these categories some additional efforts are necessary to derive useful indicators for regular reporting.

For the indicators that show impacts on human health and on economic sectors no suitable indicators were identified that could be available in the short term. However several indicators are expected to be available in the medium term, in these categories.

The preliminary (proposed) list of potential climate change indicators will be distributed for comments to climate change contact points in EEA member countries, experts in the scientific community and others interested, to enable a final selection of indicators for EEA reporting the coming years.

ETC/ACC will analyse and incorporate comments and, possibly resulting in a re-classification of some of the proposed indicators or addition of some indicators. Additional resources might be needed to get access to the data needed for the actual compilation of the indicators. In some other cases suitable data sets may be derived by using models. Finally, for some of the sectors (especially in economy and infrastructure) further research is necessary to generate suitable indicators that can be used on a European and regional level.

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6 Annexes

Annex A-1 Questionnaire to experts

Annex A-2 Letter to NFPs and NRCs

Annex B Initial overview of climate change state and impact indicator categories

Annex C-1 Expert meeting summary

Annex C-2 List of participants in expert meeting

Annex D Indicator description sheets

Annex A-1 Questionnaire to experts

EUROPEAN TOPIC CENTRE

ON

AIR AND CLIMATE CHANGE

UNDER CONTRACT TO

THE EUROPEAN

ENVIRONMENT AGENCY

RIVM UBA-B UBAVIE IIASA NILU AEAT AUTh CHMI DNMI NTUA ÖKO SHMU TNO

Dear Madam/Sir,

We are kindly asking your help in identifying relevant ***state and impact indicators*** of climate change in Europe. You have been contacted on the basis of your expertise in fields that are highly relevant to our project and/or your contribution in the climate change policy arena. We would be very grateful if you would answer a short **expert questionnaire** relating to potential indicators of climate change. The national focal points in EEA countries (NFPs) have also been informed of this project.

Why indicators?

Climate change has been identified as a key environmental theme, because of its potential impacts. Objectives have been set for greenhouse gas emissions, global average temperature increase and the carbon dioxide concentration in the atmosphere. Policy makers need indicators that enable them to measure progress towards achieving these objectives, which means indicators that can be used to set quantitative benchmarks for climate change and for evaluating the effectiveness of that policy question is, for. The indicators have to reflect the actual climate change trends for variables that are giving rise to public concern. In addition, the indicators should provide early warning signals to policymakers. Environmental indicators have become indispensable to policy-makers and environmental managers.

What we are asking for?

Until recently the EEA effort was mainly focused on pressure (greenhouse gas emission) indicators (to monitor progress to the EU Kyoto Protocol target). A common agreed set of ***state and impact*** indicators is still not available.

***State* indicators** give a quantitative and qualitative description of the actual changes occurring in the climate (in our case). State indicators may, for instance, describe temperature increases in Europe, shifts in average temperature or seasonal rainfall.

***Impact* indicators** are used to describe the impacts of the above climate changes on ecological, social and economic functions and human health. This includes impacts on biodiversity, availability of water resources, number of people infected by vector diseases….

For more detailed information, especially on the general EEA indicator assessment framework (***D***riving-force ***P***ressure ***S***tate ***I***mpact ***R***esponse), please see the main regular EEA indicator-based report Signals2001 (http://reports.eea.eu.int/signals-2001).

The ETC wishes to collect readily available results, which can be used to compile such climate change indicators to be used in EEA reports. Based on the available information, indicators will need to be selected on criteria such as relevance (for climate policy), spatial representation (e.g. for the whole of Europe or for certain regions only), transparency (i.e. can they be understood by policy makers, scientists and stakeholders?), analytical soundness and measurability.

Who are we?

We are members of the recently established European Topic Centre on Air and Climate Change (ETC-ACC), under contract to the European Environment Agency (EEA) in Copenhagen, Denmark. The Federal Environmental Agency (UBA) in Berlin, Germany, and the National Institute of Public Health and the Environment (RIVM) in Bilthoven, The Netherlands, are responsible for the task concerned, to perform a feasibility study and prepare for a report on Climate Change State- / Impact-Indicators in Europe. One of the results of our study will be a list of state and impact indicators of climate change. The final list will be decided based on the aforementioned criteria.

We believe this list should be supported by making use of your expertise. We have, therefore, formulated an expert questionnaire to enable us to make use of your expertise (please see the Annex). We would very much appreciate it if you could support our work by answering these few questions. You may return your completed survey to us by email, fax or regular mail. We encourage you to contact us if you like to discuss certain issues with us. We would be very grateful if you would return your comments before **15 October**.

What are our next steps?

- The ETC will prepare a draft technical report with the objectives, methods used, results of the data collection, draft criteria for indicator selection, broad list of potential indicators by early November.
- EEA/ETC will organise a small workshop to discuss the broad list of indicators and to reach consensus on a provisional set of indicators (e.g. 10-15 indicators), at EEA (22-23 November).
- ETC will finalise the draft report by end of 2001, based on the outcome of the workshop, and send this for review to national focal points in EEA countries and other interested institutions and finalise the technical report early 2002.
- EEA/ETC will, based on the outcome of the technical report, decide on the content of a (potential) report Climate change indicators in Europe, to be prepared in 2002 (and published in 2003).

Thank you very much for your efforts.

Yours faithfully,

Thomas Voigt

Please send your answers and comments to the following address:

Dr. Thomas Voigt

Federal Environmental Agency, FG II 6.4

Bismarckplatz 1

D-14193 Berlin

Germany

(Phone: +49 30 8903 2093; Fax: +49 30 8903 2282;
e-Mail: thomas.voigt@uba.de)

Annex: Questionnaire - Climate Change Indicators ETC/ACC

General information

Name:

Institution:

Questions

(1) In the first phase of the project we defined nine main categories for which we are looking for indicators: Climate and atmosphere, cryosphere, soils and land resources, agriculture and forestry, ecosystems and biodiversity, hydrology and water resources, marine environment and coastal zones, economy and infrastructure and human health. Which suitable/relevant state and impact indicators of climate change for these categories (or other, if applicable) can you propose, based on the fields your research activities are covering?

(2) Are these indicators already the subject of your research?
(Please write a short statement about the measurability and availability of data, the start date of relevant measurements and the planned extent of the activities)

(3) Please characterise the indicators in a few words. Are they, for example, representative of climate change on a more general scale (European) or more regional scale (e.g. Mediterranean)? And how transparent are they for non-scientists? Are they analytically sound? Can they be used in integrated studies or in models? What do you think about the policy relevance of the indicator?

(4) Do you have contacts with other scientists or institutions with whom we could also discuss the issue of climate change state and impact indicators?
(Please add here relevant contact details, email addresses, etc…)

(5) Further remarks and personal comments related to this issue. Please also provide copies and/or references of relevant reports prepared by your organisation that provide additional information on your indicator work.

Annex A-2 Letter to NRCs and NFPs

Dear colleague,

Collection of information for climate change indicators by ETC/ACC

I am writing would like to ask you to assist the European Topic Centre on Air and Climate Change (ETC/ACC) in its task to develop climate change state and impact indicators as part of its work for EEA.

What is the need for climate change indicators?

The EU has identified climate change as one of the key environmental themes. Indicators reflect trends in the state of the environment and monitor the progress made in meeting environmental policy targets. The EEA work programme and the EEA Scientific Committee recognise the need for more work on climate change state indicators (such as temperature increase, shifts in precipitation) and impact/effect indicators (on ecosystems, biodiversity, health, forests, water and other resources, agriculture), as part of the general EEA DPSIR assessment framework (Driving forces (socio-economic), Pressures, State, Impact, policy Responses). Such indicators are designed to assist the policy process by highlighting trends and underlying causes and where adaptation and mitigation measures may be required.

What is the ETC asking for?

The ETC wishes to collect readily available information, which can be used to compile such climate change indicators to be used in EEA reports. The underlying data to build such indicators is available at a number of national institutes and research organisations in Europe and in addition at EU/international organisations such as JRC, WMO, UNFCCC/IPCC, EUMETNET and AMAP.

Based on the available data, indicators will need to be selected on criteria such as relevance (for climate policy), spatial representation (e.g. for the whole of Europe or for certain regions only), transparency (i.e. can they be understood by policy makers, scientists and stakeholders?), analytical soundness and measurability.

The ETC has prepared the attached, short questionnaire (annex 1) for consideration by you, as NRC Climate change, by the international organisations mentioned above and by the institutes separately identified (annex 2).

How can you help the ETC?

I would like to ask you to assist the ETC/ACC in the following way, **by 30 October**:

- Supply the requested information if you are able to do so;
- If not, please inform the ETC if you know another organisation in your country that could do so (which is not already included in Annex 2);
- Provide additional information if you consider this would help.

Next Steps

- The ETC will prepare a draft technical report with the objectives; methods used; results of the data collection; draft criteria for indicator selection; broad list of potential indicators by early November.
- EEA/ETC will organise a small workshop to discuss the broad list of indicators and to reach consensus on a provisional set of indicators (e.g. 10-15 indicators), at EEA (22-23 November).
- ETC will finalise the draft report by end of 2001, based on the outcome of the workshop, and send this for review to NFP/EIONET and others interested and finalise the technical report early 2002.
- EEA/ETC (in consultation with NFP/EIONET) will, based on the outcome of the technical report, decide on the content of a (potential) report Climate change indicators in Europe, to be prepared in 2002 (and published in 2003).

Please send your answers and comments to the following ETC/ACC partner organisation **by 30 October 2001** (with copies to the EEA project manager André Jol, andre.jol@eea.eu.int):

Dr.Thomas Voigt

UBA, FG II 6.2

Bismarckplatz 1

D-14193

Germany

(Phone: 0049 30 8903 2093; Fax: 0049 30 8903 2282; e-Mail: thomas.voigt@uba.de)

Thanking you in advance for your cooperation.

Best regards,

Gordon McInnes

Programme Manager

Reporting and Networking Coordination

Cc: K. Alfsen, E. Buttle, D. Asimakopoulos (EEA Scientific Committee); U. Pinborg, C. Steenmans, N. Thyssen, A. Künitzer, R. van Aalst, A. Barkman (EEA); K. Wieringa (ETC/ACC); T. Lack (ETC/WTR); E. Evrard (ETC/TE); C. Romão (ETC/NPB); B. Munck-Kampmann (ETC/WMF); F. Raes (JRC)

Annex B Initial overview of climate change state and impact indicator categories

	Category	Initially proposed indicators	Type
1	Climate and Atmosphere	- Trends in temperature	I
		- Trends in precipitation	I
		- Climate indices	II
		- Snow cover	III
		- Lightning frequency	IV
		- Cooling in and shrinking of stratosphere	IV
		- Trends in cloud cover	V
		- Luminous night clouds/Stratosphere	V
2	Cryosphere	- Changes in extend and mass-balance of glaciers	II
		- Changes in volume and extend of arctic sea ice	II
		- Temperature - profiles in permafrost	III
		- Freeze-up and break-up dates of arctic coastal ice	IV
		- Distances of arctic ice edges to coastlines	IV
		- Width of the bottom fast ice-zone	IV
		- Dynamics of permafrost	V
		- Ice breakup date of Tornio river (Fin)	V
		- Frequency and intensity of avalanches in the Swiss Alps	VI
3	Soils and Land Resources	- Carbon sequestration in vegetation and soils	II
		- Land cover	VI
4	Agriculture and Forestry	- Yield-trends of important key-crops	II
		- Pests and diseases	IV
		- Trends in forest growth	IV
		- Shifting of tree lines	IV

5	Ecosystems and Biodiversity	- Phenology / Changes in the Growing Season - Arrival Date of Birds - Egg-laying Date of Birds - Mountains and subarctic environments - Changes in the composition of ecosystems - Extreme events (fires, storm events) - Dates of insect appearance and activity, insect abundance - Bioindicators - Freshwater and marine biodiversity	I II II III IV IV IV V V
6	Hydrology / Water Resources	- Changes in Demand of Irrigation - Lake and river temperatures - Extreme events / floods and changes in average discharge - Changes in the structure of stable layers / temp.-profiles; Changes of extend, duration and thickness of the ice-cover of inland-lakes - Changes in water shortage / scarcity	III III IV IV IV
7	Marine Environment and Costal Zones	- Changes in SST and other characteristic, temperatures - Changes in the characteristics of storm surges (Frequency, duration and intensity) - Changes in thermohaline circulation - Sea level rise - Seasonal extend and duration of sea- ice on the Baltic Sea - Changes in the retreat of shorelines due to erosion - Fisheries and aquaculture productivity	II II III III IV IV VI
8	Economy and Infrastructure	- Insurance - Electricity, gas and water consumption - Tourism	II IV IV

		- Construction - Industry and Transport	V VI
9	Human Health	- Daily mortality (heat-waves) - Daily hospital admissions (allergies disease) - Sale of antihistamine drugs (pollen exposure) - Tropospheric ozone concentration - Cases of malaria or other tropical diseases (due to local transmission) - Changes in the distribution of vectors (mosquitos, sand flies and ticks) - Climate Extremes - Disease implications of floods	IV IV IV IV IV IV V VI

Annex C-1 Expert meeting summary

Expert meeting - Summary

Climate Change State and Impact Indicators (EEA-ETC/ACC)

European Environment Agency, Copenhagen, 22-23 November 2001

Jelle van Minnen, Thomas Voigt, Markus Erhard (ETC/ACC), André Jol (EEA)

Participants

Markus Erhard, Jelle van Minnen, Thomas Voigt (all ETC/ACC), Roel van Aalst, Andreas Barkman, Peter Bosch, Gordon Mc Innes, Andre Jol, Anita Künitzer, Jan-Erik Petersen, Ulla Pinborg, Hans Vos (all EEA), Francoise Breton (ETC/TE), Steve Nixon (ETC/WTR) ,Melvin Cannell (CEH,UK), Tim Carter (Fin. Env. Inst.,Finland), Wolfgang Cramer (PIK, Germany), Petra Doell (Kassel Uni.,Germany), Annette Freibauer (MPI Jena, Germany), Alex Haxeltine (Tyndall Centre, UK), Sari Kovats (London School of Hygiene and tropical Medicine, UK), Rik Leemans (RIVM, NL), Zbigniew Pruszak (Inst. Of Hydrology, Gdansk, Poland), Frank Raes (JRC, Italy), Lars-Olaf Reiersen (AMAP, Norway), Janet Wijngaard (KNMI, NL)

Objectives of the expert meeting

The main objective of the expert meeting was to discuss potential climate change state and impact indicators with a group of experts and to reach initial agreement on a preliminary set of such indicators to be used within the EEA framework. The indicators to be selected in the EEA set of indicators should be in line with the EEA criteria for indicators, which include:

- Policy relevance (are they linked to environmental targets or reference values?);
- Transparency (are they easily understandable by policy makers?);
- Analytical and scientific soundness (is the methodology scientifically sound and have the data been validated?);
- Comparability (can the indicator be used for comparisons across countries or regions? is the indicator only valid for specific regions?);
- Data availability (are the data available now or in a foreseeable future? Especially for climate change there is a need for data sets with the appropriate length of time series in relation to the often long response time of the indicator)

The resulting set of indicators should be used for the following purposes:
(i) a selection of the set should be suitable for the regular annual reporting scheme of the EEA (Environmental Signals reports);
(ii) be applicable in the Integrated Environmental Assessment (IEA) framework of the ETC/ACC, which is needed for next EEA State of the Environment and Outlook report due in 2004,

(iii) be suitable to describe climate change state and impacts in Europe in a complete and transparent way in a special report of the EEA (to be published in 2003).

Additional information is provided in the main background paper that was used as input to the meeting: Background note on Climate Change Indicators for EEA/ETC-ACC expert meeting on 22 and 23 November (ETC/ACC, November 2001).

The first day of the meeting consisted of a number of very useful plenary presentations given by the invited experts about climate change related indicators in different categories and about their experience from related projects (see attachment 1), while parallel meetings and a plenary session on main outcomes and conclusions were held the second day. All presentations and background information are available from the ETC/ACC web site at http://etc-acc.eionet.eu.int/.

Main results of the expert meeting

At the end of the first day, the ETC team presented a first preliminary broad list of indicators. The indicators were ranked into 6 different ranking types, according to a number of criteria, generally used by EEA for evaluating indicator and which are summarized in attachment 2. The following ranking types were used:

I Indicator

All criteria are fulfilled now or within a short term perspective (few months).

II Indicator

All criteria are fulfilled within a medium term perspective if some analysis or data mining will be performed (next two years).

III Indicator

All criteria are fulfilled within a long term perspective (5 to 10 years), if current projects are finished and / or data is processed.

IV Potential indicator

May be feasible for indicating climate change within a medium/long term perspective, if data is available and/or some additional analysis are performed.

V Soft indicator

Indicator may not sensible enough to climate change due to other impacts and/ or there is not enough data available.

VI Not suitable as indicator

According to the available information this indicator is not feasible for detecting climate change.

The initial preliminary list prepared by the ETC was used as input for detailed discussions in three parallel sub-sessions at the second day. Consequently the list was modified regarding the definition and description of the indicators as well as the proposed ranking. For convenience the indicators were grouped into 2 broad types:

- Indicator (ranking I to III). This approach implies that indicators that fulfil most criteria, except full availability at the short term are still considered to be important. In practice this means that only the indicator ranked I are available immediately (for the EEA Environmental Signals 2002 and/or for the foreseen EEA Report Climate Change in Europe), while those ranked II or III are very promising, but only available in medium or long term.

- Potential indicator (ranked IV). These indicators may be feasible for use, provided specific data collection programs are set up, which currently do not (yet) exist.

The expert meeting closed with a plenary discussion about the outcomes of the sub-sessions, some comments about future work, possibilities for further co-operation and a summary of the entire expert meeting.

Use by EEA of the proposed set of indicators

Regarding the use by EEA of the proposed set of indicators, for the three main purposes as mentioned above, the following comments were made during the meeting:

- For the Signals 2002report of the EEA data of 'I' indicators should be available within a few weeks. Currently the only climate change indicator in Signals 2002 is trends in global and European mean temperature. It was concluded that it might be impossible for some of the most interesting impact indicators to collect the necessary data in a short time. Therefore it was proposed to add a box in the Signals 2002 report, chapter on climate change, where the development of climate change state and impact indicators will be discussed, and where a few state/impact indicators could be included as example.
- For the foreseen EEA report on Climate Change Indicators in Europe there is more time available during 2002 to further analyze the available data for those indicators ranked as I or possibly also for those ranked as II.
- For the third objective, use of the indicator within integrated assessment including also scenarios (e.g. specifically for Europe), the draft set of indicators should be further analyzed. In the list there should be a more explicit distinction between indicators demonstrating ongoing trends *(CC is already going on)* and indicators included in scenarios (e.g. up to 2050 or 2100), showing potential future impacts of climate change.
- Some of the indicators might not be specific enough for describing impacts due to climate change, because several other factors are also important (for example pressure on ecosystems and biodiversity is determined by many other factors, a similar situation occurs for impacts on human health). Additional discussion is needed to find the most meaningful solution for use of such indicators.
- Efforts to collect indicator-relevant underlying data might require additional resources for the ETC/ACC, for other ETCs or for other organizations. Additional resources might also be needed to establish a possibly needed additional European-wide monitoring system for the required underlying data for the proposed indicators. The need for such additional monitoring should be further explored by the EEA/ETCs in close collaboration with other organizations to ensure making best use of available information and avoiding duplication of efforts.

Summary of the main outcome of the meeting

- A proposal for a set of climate change state and impact indicators in Europe
- An improved understanding which data are currently available and from which organizations, including other ETCs.
- A (draft) list of next steps to cover the objectives of the EEA/ETC-ACC work.

Next steps for EEA/ETC-ACC

- Preparation of a draft technical report by the ETC on climate change state and impact indicators, to be used as a feasibility study for a (possible) EEA-report of climate change state and impact indicators (February2002);
- EEA will consult the Commission, member countries and relevant international organizations by sending the draft technical report for review (February/March 2002);
- Delivery of an updated list of indicators by the ETC to EEA (May 2002);
- Preparation of a (draft) report on climate change state and impact indicators in Europe by the ETC (December 2002).

Attachment 1: Agenda of indicator expert meeting 22-23 November in Copenhagen

22 November 2001 (day 1):

Block 1: Introduction and Client Needs

10:00	Welcome (EEA and ETC Air and Climate Change)	**G.MCINNES/A.JOL**
10:10	EEA environmental reporting and indicators (EEA)	*P. Bosch/ A.Jol*
10:25	DG Environment views on climate change indicators	
10:40	Introduction to work on climate change state/impact indicators (ETC/ACC)	*T.Voigt*
11:15	*Coffee break*	

Block 2: Current knowledge on Climate Change State and Impact Indicators

11:45	Climate change indicators in the IPCC Third Assessment Report (IPCC)	*W. Cramer*
12:05	ACACIA (Assessment of Potential Effects and Adaptations for Climate Change in Europe) (Jackson Env. Inst.)	*T. Carter*
12:25	Arctic Climate Impact Assessment (ACIA) (Arctic Monitoring and Assessment Programme, AMAP)	*L.-O. Reiersen*
12:45	*Lunch break*	
14:15	Climate change indicators in the UK (CEH)	*T. Cannell*
14:35	CarboEurope	*A. Freibauer*
14:55	Carbon sink indicators (JRC)	*F. Raes*
15:15	European Climate Assessment (EUMETNET)	*J. Wijngaard*
15:35	Biodiversity and climate change (ETC/NPB)	*U. Pinborg*
15:55	*Coffee break*	
16:25	Water resources/hydrology/marine/coastal zones and climate change (ETC/WTR)	*S. Nixon*
16:45	Preliminary broad list of climate change indicators for EEA and selection criteria for choice of smaller set of indicators (ETC/ACC)	*J . van Minnen*
17:15	Plenary discussion	*All*
18:00	Close of first day	

23 November 2001 (day 2):

Block 3: Categories of CC indicators

Plenary

09:00	Break-out in 3 groups to discuss preliminary broad indicator list (discussion e.g. on feasibility/availability in short/medium/long term), aimed at identifying a smaller set of indicators	*ETC / ACC*
09:05	Short Introduction to Group Work	*ETC / ACC*

Group Work (introduction by experts mentioned and discussion, see below)

Group A Chair: *Rapporteur: T.Voigt*	**Group B** Chair: U. Pinborg *Rapporteur: J.van Minnen*	**Group C** Chair : A. Künitzer *Rapporteur: M.Erhard*
Economy and Infrastructure *A.Haxeltine*	Soils and Land Resources *F. Breton/J.Fons*	Climate and Atmosphere *J.Wijngaard*
Human Health *S.Kovats*	Agriculture and Forestry *W.Cramer*	Cryosphere *L.-O. Reiersen*
	Ecosystems and Biodiversity *R. Leemans*	Hydrology and Water Resources *P.Doell*
		Marine Environment and Coastal Zones *Z.Pruszak*

Timetable for Group Work

09:10	Introduction to Indicator Categories	*Experts above*
09:40	Group Discussion	*all in group*
11:00	*Coffee break*	

Plenary

11:30	Reports from the 3 groups	*Group rapporteurs*
12:30	*Lunch break*	

Block 4: Final Discussion, Future Work

14:00	Plenary discussion of outcome/proposals of groups	*All*
15:00	Needs for further research	*All*
15:30	*Coffee break*	
16:00	Preliminary Set; next steps for EEA/ETC	*A. Jol*
17:00	Close of second day	

Attachment 2: EEA criteria for climate change state and impact indicators

EEA – Criteria

1. Is the indicator attractive to the eye (accessible) ?
2. Is the indicator easy to interpret correctly ? Does it match the interest of the target audience ?
3. Is this indicator representative to the issue or area being considered?
4. Is the indicator based on data that are updated at regular intervals?
5. Is there a reference value for comparing changes over time? What is this value?
6. Do the data (raw data or indicator data) allow international comparability ? What would make the data non-comparable (differences in national definitions, changes over time to the definition and methodologies, etc.)?
7. Is the work Scientifically sound ? Is the indicator well founded and good quality (data and methodology)
8. Is there consensus on the data validity: data collection methods, statistical methods, etc.?

Annex C-2 List of participants

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