Reporting on uncertainties in ETC/ACC reports.
A practical proposal

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W Tuinstra, T Petroula, R Swart

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Reporting on uncertainties in ETC/ACC reports. A practical proposal.

Willemijn Tuinstra, Dora Petroula, Rob Swart, RIVM[1].
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1. Introduction

1.1 Why is reporting uncertainties important for the ETC/ACC and EEA?

The EEA ETC/ACC provides information on air pollution and climate change issues for different users through several channels, including different categories of reports, fact sheets, databases and web-based information. Part of the knowledge and information provided by the EEA ETC/ACC is constituted by information about the quality of the available knowledge and methods used and about the robustness of the policy-relevant conclusions. The audience of the ETC products, including policy makers, their advisors, technical and scientific experts in academia and the private sector, the general public and other societal actors, must be able to responsibly deal with the sometimes large uncertainties, which are inherent in problems related to the environment, nature and sustainability, such as air pollution and climate change.
It is therefore important to be transparent about uncertainties related to the data and assessment results reported. Until recently however, how to deal with uncertainties in analysis and reporting has not got much explicit attention in practice in the work of the EEA and its Topic Centres. At the same time, however, reporting on uncertainties is becoming an issue in the policy arena and requested as part of conventions and protocols (e.g. UNFCCC, national greenhouse gas emission inventories, IPCC assessments). Also, with the emergence of emissions trading schemes for GHGs and possibly also air pollutants (e.g., NO_x in the Netherlands), uncertainties in emissions and emissions factors represent (possibly significant amounts of) money.

Of late, the EEA has addressed the issue of dealing with ignorance, uncertainties and risks in the publication *Late lessons from Early Warnings* (Harremoes *et al.*, 2002).
The EEA is aware of the need of more transparency on uncertainty and recently started work on developing guidance for the EEA and its partners on how to acknowledge and respond to ignorance, as well as uncertainty and risk, in environmental reporting. An EEA Scientific Committee workshop was organised around this issue in October 2003, at which elements of the current note were presented by ETC/ACC.

1.2 Scope of this note- improving reporting on uncertainties in ETC/ACC work

ETC/ACC takes the issue seriously and aims to think together with EEA how to address communication about uncertainties in a more systematic way. While ideally uncertainties should be "managed" throughout the processes that eventually culminate in the ETC reports (research, measurements, usage of statistics and technology information, aggregation, assessment, reporting), as a start we propose to improve the attention to uncertainties in the final ETC products (the reports and fact sheets). This note is meant to get a quick view of the ETC/ACC's current practice for its regular (groups of) reports, taking a few reports as example. The objective is to provide a quick glance, not to do an exhaustive analysis of the treatment of uncertainties in these reports and its source materials. The note aims to signal needs for improvement and to give suggestions for practical first steps. To a certain extend

[1] We would like to thank Tinus Pulles, Ed Buijsman, Frank de Leeuw and Kati Huttunen for their thoughtful comments on an earlier version of this note. For reactions, please contact willemijn.tuinstra@rivm.nl

ETC/ACC can make use here of experiences at RIVM (Petersen et al. 2003; Janssen et al., 2003) as a basis to produce suitable EEA and ETC/ACC guidance and practices.

In section 2 we introduce shortly the various ways in which the concept of uncertainty plays a role in the various activities of EEA/ETC. In section 3 we discuss a few recent ETC/ACC reports with regard to the way they have addressed uncertainties. Also, we give suggestions for improvements. In the final section we introduce the *RIVM Guidance for Uncertainty Assessment and Communication* and give short term and long term recommendations for ETC/ACC work.

2. The concept of "uncertainty" in various ETC/ACC activities

2.1 Introduction

Broadly, in the day to day work of ETC/ACC, three main groups of activities can be discerned. 1) *Measurements and monitoring* (Data collection on GHG emissions, Air Pollution emissions, Air Quality, Climate Change); 2) *Modelling and assessment* and *3) Reporting* (including fact sheets).

In each of those activities uncertainties are of a different nature, the audience for the uncertainty information varies and the responsibility to provide this information also lies with different actors. In this note we focus especially on reporting, but as the reporting builds further and is dependent on the work done and information provided in the course of the two other main activities, we present in this section all three groups of activities and the various ways the concept of uncertainty plays a role in those activities.

2.2 Measuring and monitoring[2]

The concept of uncertainty in providing information on environmental issues is closely linked to the concept of data and model quality. The appreciation of data quality on its turn is dependent on the final application and use of the data. The intended use is relevant for any analysis of this concept with respect to environmental data and models. Two major fields of application of emission inventory data can be discerned (Pulles and Builtjes, 1998):

- for policy purposes:
  - monitoring of progress of environmental policy;
  - compliance checking, both of individual polluters with respect to permits and emission standards and of countries in relation to international treaties and protocols;
- for scientific purposes, including the assessment of the effectiveness of abatement strategies.

If data are being used in (inter)national policy making, users will be mainly interested in the acceptance of the data by the different institutions involved in a specific policy process. Users in scientific applications will be very eager to know the quality of the data in terms of the "true values". From this we might derive three different perspectives on the concept of data quality in e.g. emission inventories. Table 1 presents these perspectives.

Table 1. Perspectives on data quality depends on the intended user of the data

	Perspective	*High quality if …*
"Scientist"	Scientific debate: search for weaknesses and errors; falsification	… it produces predictions that are confirmed
"Policy maker"	Political debate: search for consensus and agreement; compromise	… everybody involved agrees

[2] This section is for a major part taken from Pulles and Heslinga (2003)

"Lawyer"	Judicial debate: search for proof or doubt; persuasion	… it convinces a judge or jury

- The *scientist* is looking for the truth by trying to find weak spots in theory and data and by falsification. The data quality will be high if the data or predictions based on them are confirmed by independent estimates. If falsification occurs, the scientist will work on it until he or she understands the reasons and has derived better data or a better theory.
- A *policy maker* is looking for agreement and will therefore be more inclined towards reaching consensus and compromise. In many cases a policy maker does not have enough time to wait until all scientific problems are solved: a company might have asked for a permit for a new activity and regulations prescribe a decision to be made within a given period of time; or a country has to report its emissions according to a protocol before a certain fixed data. The policy maker will have to decide, although a number of uncertainties are still present and a number of phenomena might not be fully understood.
- The *lawyer* has again a different perspective. He or she might be involved in compliance checking and will regard data to have high quality if the data are convincing.

These perspectives on data quality will also influence the perspective on "truth" and "quality" and hence on the uncertainty aspects of the data and models.

In this respect a clear distinction is to be made between the concepts of "Verification" and "Validation"[3] :

- *Verification* refers to the truthfulness of the data. Verifying an emission inventory database is aimed at assessing whether the inventory contains "true" values. *Verification* will focus on attributes as "precision", "accuracy", "uncertainty", "reproducibility" and so on. Methods used will comprise error analysis, comparing with independent estimates and comparison with measurements but might also include inter-country comparisons of inventories. *Verification* might be regarded as the establishment of the *scientific quality* of the data.
- *Validation* assesses the way the data have been collected and compiled. It is more related to the procedures that are followed and whether or not requirements are met. Concepts that relate to *Validation* are: "confidence", "reliability", "quality assurance", "quality control" and similar. *Validation* must be regarded as the evaluation of the *procedural quality* of the data.

In the monitoring work of ETC/ACC and EEA both quality aspects and consequent uncertainty assessments occur.

Emission Inventories

Especially in the compilation of emission inventories a strong emphasis is put on the procedural quality: have the appropriate guidelines and guidance documents been correctly applied? The question whether or not a correct application of the guidelines will indeed yield "scientifically correct" data is object of the *development procedure* of the particular guidelines used for the compilation of the inventory. Once these guidelines exist, this question is no longer relevant in policy application sense.

Uncertainties for national *GHG inventories*, as reported under international conventions, obey to the guidance given by IPCC/TFEIP and requested by UNFCCC.

For emissions of *air pollutants*, similar guidelines are under development in the context of UN-ECE/LRTAP/EMEP. The goal of estimating uncertainties here is not primarily the knowledge on the uncertainties themselves, but on inventory improvement. The uncertainty

[3] We use here these concepts as defined in the IPCC Good Practice Guidance and Uncertainty Management report (Penman, J. et al., 2000).

analyses are designed to identify the weakest spots in an inventory and as such suggest priorities for improvement.

Air quality
The situation with respect to *air quality* data is less clear. Here European directives request certain measurement procedures and documentation for data reported to the EU and EEA. However, at the European level, air quality data reported by countries under the Exchange of Information Decision do not include uncertainty information. The scientific uncertainties in this case are related to such issues as measurement errors and representativity (see also discussion in section 3.2 and 3.3).

In general a major question with regard to data collection and data management is: who is responsible for the quality of the data and the uncertainty information provided. Is this the responsibility for the member states (MS), who deliver the data, or of the ETC/ACC, which manages the data and makes them available trough data bates like AIRBASE[4] and CORINAIR[5] (see also discussion in section 4).

2.3 Modelling and assessment

ETC/ACC presents results of models or performs model calculations for example to do assessments and provide information on air quality, air pollution impacts or climate change impacts. Uncertainty information in outcomes of modelling work and scenario analysis relies partly on uncertainty information in available data. For example air pollution dispersion and air chemistry models can be linked to emission data. Next to this uncertainties in model structure and model parameters play a role.

Similar observations as made for measuring and monitoring can furthermore be made for modelling and assessment work. With regard to *prospective studies* ("integrated assessments", scenario studies) a few additional aspects come up:

- First of all "verification" as defined above can't really be done. Nobody knows how the future will develop. A useful definition of uncertainties here then cannot mean the difference between the estimate and the real value.
- "Validation" of prospective numbers can be performed, provided that guidelines or guidance documents are available.
- Uncertainties here will in most cases be interpreted as "robustness", which in principle can be assessed by sensitivity analyses.
- Another aspect of the uncertainties in this case will be related to the sensitivity of the assessment methods to various policy options. This is more or less the converse of the former point: if you want to study the effects of policy options, these policy options must be implemented in the method in such a way that the resulting air pollution effects are visible.
- Scenario-analysis is in itself a method to deal with an uncertain future.

At an EFIEA meeting at EEA in 1999, suggestions were made to incorporate uncertainty analysis more explicitly in different steps of the prospective and integrated assessment work of the EEA. In the report *Environment in the European Union at the turn of the century of 2000* the EEA noted with regard to prospective reporting methodology, that "The uncertainty analysis … has been limited to a series of comparisons with actual measurements. Clearly future work in this area will be a priority for state of the environment reporting" (EEA, 1999, p16).

[4] http://etc-acc.eionet.eu.int/databases/airbase.html
[5] http://air-climate.eionet.eu.int/databases/#emisdocdata

Important for ETC/ACC would be to provide insight into how the different uncertainties add up in the models and scenarios and to be transparent about the assumptions and structure of the models and scenarios. Information of this kind is in principle available in model documentation of the individual models used, but not directly available for the integrated assessment framework as a whole as applied by ETC/ACC, nor for the scenario analysis performed with this framework.

2.4 Reporting

Fact sheets.
Fact sheets produced by the ETC/ACC contain space to fill in so-called "meta-data" with technical information on data resources, methodology and frequency of data collection and data manipulation. The meta data also include so-called "quality information" existing of a section with "strengths and weaknesses" and a section on reliability, accuracy, robustness and uncertainty at data level. However this sections are note always completed.

Reports.
Reports produced by ETC/ACC are generally based on evaluation of data trends (emissions, air quality) and results of projections from modelling analysis. There is not yet a transparent and systematic way to report on uncertainties in ETC/ACC reports. Even while dealing with uncertainties is part of the ETC/ACC 's daily work (as we saw in this section), this is not done in any systematic manner, and is not reflected in the output. One possible reason for this is that it is assumed that people interested in uncertainties might find the information needed on the level of the databases, fact sheets and models, or other underlying reports to which references are made. However this deeper level is not always easily accessible, or also has insufficient treatment of uncertainties. For example, though fact-sheet templates include space for relevant uncertainty information, the space is not always used and thus the information is not as easy available to editors as could be hoped for. Or, a problem of an even more fundamental nature, data as provided by countries sometimes don't include information on uncertainties consequently this information can't be provided by ETC/ACC either.

There are also the practical questions what kind of information on uncertainties is really needed, whether the extra (time) effort really is worthwhile, and how the information will be used (or misused). As the various ETC/ACC reports have different purposes and different audiences, these questions have to be looked into for each kind of report separately.

For the rest of this note we will focus especially on issue of *reporting* on uncertainties in ETC/ACC publications (elaborated in this note only for reports on emissions and air quality) and how this could be improved in practice. Not because we assume that uncertainty management is dealt with in a satisfactory way in the data management, fact sheet production and modelling work already, but because we want to focus on the communication of uncertainties and an obvious first step is to look how this is dealt with in the publications.

3. Current practice of uncertainty management and reporting in different ETC-ACC documents: two examples

3.1 Introduction

In this section we will discuss two different kinds of reports of ETC/ACC separately, in order to get an idea what the current practice of reporting on uncertainties is. We discuss reports on (1) GHG emissions and (2) air pollutant emissions and air quality. For each field we analyse for specific reports to what extend uncertainties were addressed. Each sub-section we will finish with some suggestions for improvements.

3.2 Greenhouse gas emissions

3.2.1. Introduction

Greenhouse gas emissions in Europe are reported annually by MS in the context of the GHG Monitoring Mechanism. Based on national inventories and other data sources the ETC develops an EC inventory as the basis for the formal EC submissions to the UNFCCC. In addition, the ETC develops Technical Reports on GHG trends and projections and a more policy-oriented Environmental Issue report.

Uncertainties in emission inventories are caused by uncertainties in activity statistics and uncertainties in emissions factors (dependent on technologies, process, abatement measures) and the algorithms used to calculate the final emissions. In addition, uncertainties in trends can be quite different (smaller) than uncertainties in absolute values. This is especially relevant when policy targets are set in relative values ("stabilisation a 1990 values", "reduction by 6% relative to 1990 values" as in the Climate Convention).

Below we discuss the treatment of uncertainties in the annual EC GHG inventory report (EEA, 2003a) as compiled by ETC/ACC, the Technical Report 'Detailed analysis of greenhouse gas emission trends and projections in Europe' (EEA, 2003b) and the EEA Environmental Issue report 'Greenhouse gas emission trends and projections in Europe' (EEA, 2002a) respectively.

3.2.2 Reporting on uncertainties in greenhouse gas emissions-related EEA ETC/ACC reports

3.2.2.1 Annual European Community Greenhouse Gas Inventory and Inventory Report

The European Community (EC) GHG inventory is compiled annually on the basis of the inventories of the 15 EC Member States (MS). The inventory report is the EC's yearly official submission (as one of the parties) to the UNFCCC. The inventory is in fact the direct sum of the 15 national inventories. Exeptions are the CO_2 emissions estimates from fossil fuels which are taken from Eurostat for the EC as a whole, based on Eurostat energy balance data and following the reference approach developed by the Intergovernmental Panel on Climate Change (IPCC). The inventory report is supposed to include all necessary background information for the inventory, including uncertainty. The main audience of the report is the UNFCCC and its review team. Important issues for the UNFCCC are transparency, completeness correctness, comparability and accuracy of the inventory, which should also be reflected in the way uncertainty is estimated and described.

There are a few points in the inventory report, which can be clearly distinguished, as explicitly referring to uncertainties:

Like the member state inventories, the annual EC inventory follows as much as possible the IPCC "Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories" (Penman et al., 2000), which are consistent with the "Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories" (Houghton et al., 1997).

The overview of information provided by MS on uncertainty estimates in their latest available National Inventory Reports, is presented in a table. The table summarises results of these estimates, but does not derive any uncertainty estimates at the EC level. The overview table provides general information on uncertainty estimates of the MS and quantified uncertainty estimates at total gas level, if available.

An overview of the $CO_{2\text{-eq}}$ emissions estimates per sector is given, in which qualitative estimates of uncertainty are provided.

At the same time, there are a few other points, related to uncertainties which are not explicitly mentioned as such but rather presented in the context of the quality and completeness of data reporting:

- There are differences between the estimates of Eurostat and the MS for the EC CO_2 emissions from fossil fuels. For example the addition of the MS emissions would miss out the emissions from European international (air) travel. However, the usage of European-wide emissions factors may miss some special national emission factors. One may consider this as a data quality issue, which also affects the level of uncertainty of the final European numbers.

- Different methodologies and background data (including different levels of activity and emission factors) are used by the MS for the compilation of their national inventories. These methodologies are described in the inventory report in an annex.

- Quality Assurance and Quality Control (QA/QC) procedures differ at MS level. An overview of these procedures is also included in the report.

- Not all countries report on all greenhouse gases, or for all required sectors. A gap filling procedure is then followed by the ETC/ACC. An explanation of the gap filling methodology and for which specific data it is applied is included in the report.

- Recalculations of estimates made by some MS, could be responsible for the differences between the estimates of the submissions by the MS over the years.

3.2.2.2 Technical report 'Analysis of greenhouse gas emission trends and projections in Europe'

Each year the ETC/ACC prepares the Technical report 'Analysis of greenhouse gas emission trends and projections in Europe' (TP report). This report presents an assessment of the actual (from 1990 to two years before the actual year) and projected progress (by 2010) of the European Community (EC) and its MS and of acceding countries towards fulfilling their commitments under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. The main data sources are the EC GHG inventories as compiled under the EC monitoring mechanism and submitted to the UNFCCC, data from Eurostat and National Communications submitted to UNFCCC.

The TP report uses the EC GHG inventory report and other technical reports and guidebooks as references. The latter documents give explanations and descriptions on the methodologies and the background data used, but the TP report itself includes very few details about this type of information. For example, the overview table with information provided by MS on uncertainty estimates in their latest available National Inventory Reports, which could be found in the EC inventory report, is not included in the TP report.

In general, the TP report refers to the issue of the uncertainties directly only once by giving some examples of sensitivity runs concerning the projections, which were reported by individual countries. The number of runs is limited and the level of detail given for these sensitivity runs varies for each country depending on how much information the countries themselves have provided.

On the other hand, the TP report indicates that the robustness of the assessment made could be limited due to the fact that the report is based on data and information, which are reported

by the countries themselves. A separate section is dedicated to present briefly the current practise for reporting on projections and policies and measures by the MS and to explain qualitatively the limitations that the incomplete data impose to the assessment. Sometimes individual countries use different approaches as a base for their projections. Also mentioned is the difference between the projections of the PRIMES model used by the Commission and the projections by the MS.

3.2.2.3 EEA Environmental Issue report 'Greenhouse gas emission trends and projections in Europe'

The EEA Environmental Issue report 'Greenhouse gas emission trends and projections in Europe', is designed mostly for policy-makers and is based on the TP report as discussed above. The TP report provides the detailed background data and indicators to the Environmental Issue report.

Compared to the TP report, there is not much additional information on uncertainties in the Environmental Issue report. On the contrary, as it is addressed mostly to policy makers, it is less detailed and less technical.

3.2.3 Discussion and suggestions

In conclusion, while the MS GHG inventories generally do contain information about the uncertainties of the emissions for different gases (following the IPCC Good Practice Guidance), this kind of information is not aggregated/evaluated by the ETC/ACC in the EC inventory report, and is subsequently lost in the trends and environmental issues reports. In compiling the EC inventory, in the context of QA/QC the ETC is performing tasks such as identification (and filling) of gaps and identification of dips and jumps in data. The extent to which gaps have to be filled and dips and jumps identified is important information. If for example the inventory data of a major country would have lots of gaps, dips and jumps, this would affect the level of uncertainty of the EC inventory much more than if a small country would have such problems. It would be useful (and feasible) to include some information about this in the report. Similarly, on the basis of the assessment of uncertainties (ranges, percentages) by individual countries, it should be possible to derive some information about uncertainties at the EC level. Again, if the uncertainty ranges provided by major countries would be quite large, this would affect the confidence in the EC inventory more than if this would be the case for a small country.

As to the uncertainties in projections, the main way these are addressed is by reporting sensitivity runs from countries, and a comparison with PRIMES Europe-wide modelling results. Taking the uncertainties in the inventory data, the projections add new uncertainties based on assumptions for main driving forces and the choice of methodology. Since the main finding of the TP report is an assessment of the "distance to target" with respect to the Kyoto Protocol goals, it is important to give the reader an impression of how certain some findings are. For example, the recent revised projection for Germany has a major impact on the findings at the EC level. Recent developments suggest that while EC CO_2 emissions do not develop positively towards contributing to the Kyoto targets, this is at least partially compensated by developments for the non-CO_2 GHGs. It may be valuable information to policymakers that non-CO_2 GHG emissions are much less certain than CO_2 emissions.
Thus, for the improvement of uncertainty information in the GHG emissions inventory reports the following preliminary recommendation could be given:

Communication:

- Include an uncertainty chapter in each report, and design this chapter based on the needs of the audience. E.g. in the TP reports the language of the uncertainty chapter should be comprehensive to an audience with basic knowledge on GHG inventories and at the same

time provide accurate and professional information for inventory experts. The wording used could be checked by the ETC-ACC's internal review (Öko-Institut, Berlin).
- Assess the level of confidence in the formulations of the key messages.
- The reporting content will depend on the assessment method and the resources available. As to the methods used, a decision has to be made on the actual method of estimating uncertainties (both quantitatively and qualitatively). The most ideal situation would be a combination of both a quantitative and qualitative estimation, with a thorough assessment of the inventory uncertainty. It should in any case meet the requirements of the UNFCCC reviews.

Content:
- Consider including information on relative uncertainties (e.g., between gases) in graphs.
- Use the uncertainty information from the EC GHG inventory report for the TP reports.
- Qualitative work could describe uncertainty in each source and summarise this information.
- Important uncertainty issues to mention are differences between the estimates, MS methodologies, MS QA/QC procedures, dips and jumps in data and ETC-ACC's gap filling procedure.
- Assess the consequences of incomplete or suspicious data at the member state level for the aggregate EC numbers (gaps, dips and jumps).
- Assess to what extent uncertainties in a large country affect the total uncertainty of the EC inventory compared to that of a small country.
- Evaluate the Europe-wide consequences of the ranges of uncertainty given by member states per gas, also taking into account literature information on these uncertainties.
- In ETC-MS contacts stimulate countries which do not report uncertainties in inventories and projections, to do this for both types of activities (*strictly spoken not a reporting issue but a data issue*).

In general in its reporting ETC/ACC should pay attention to the question what the uncertainties mean: what are the implications? An important audience for the emission inventory reports are policy makers.

3.3 Air Pollution

3.3.1 Introduction

In the year 2003 the ETC/ACC prepared a report, which for the first time contained both information on emissions of air pollutants and air quality at the same time) (EEA, 2003c). This reports “Air Pollution in Europe. State and Trends 1990-2000" (AP2000) provides an overview and analysis of the air pollution situation in Europe, in the year 2000 and the preceding decade, based on indicators for underlying sectoral driving forces, emissions, air quality, deposition and the effectiveness of policies and measures. It covers the 31 EEA member countries and Switzerland.

The report is aimed at policy-makers and policy implementers in EU and national level, and is expected to be also of use for air pollution managers at the local level as well as the interested and informed public.

The AP2000 report uses different sources of the data (e.g. UNECE/CLRTAP, UNFCCC Auto-Oil II programme and AIRBASE), which are presented as references wherever necessary. Most of the information concerning the data and methodologies used to compile the emission statistics, including information about uncertainties, is concentrated in an Appendix of the report.

3.3.2 Reporting on uncertainties with regard to Emissions of Air Pollutants in the AP2000 report

The basis for the emissions assessment in the AP2000 report are the emission data which are submitted by countries to various international reporting obligations and which are compiled into a central database maintained by ETC/ACC called CORINAIR. Unlike the emissions inventories for GHGs, which routinely should include information about uncertainty in emission estimates according to the IPCC Good Practice Guidance (see below), emission inventories for air pollutants do not have such requirements.

In the AP2000 report quantitative estimates of uncertainty for the main gases are presented as percentages, based on the paper *Inventory Uncertainty and Inventory Quality* (Eggleston, 1998) though without getting into detail about their basis. References are made to the air pollutant emission fact sheets at the EEA website as well as to the CORINAIR database for more information. It is also stated that uncertainties in trends are smaller than uncertainties in absolute numbers.

3.3.3 Reporting on uncertainties with regard to Air Quality in the AP2000 report

Uncertainties in air quality data reported in ETC/ACC reports are dependent, amongst other factors, on measurement methodologies and aggregation procedures. Possibly even more important than uncertainties in actual monitoring data are uncertainties in assessments, caused by varying representativeness of monitoring stations.

Air quality data used in the report are the official data on air quality and information on monitoring networks and stations submitted by countries according to the Exchange of Information Decision (EoI) (European Council, 1997). The data have been compiled in the European air quality database AIRBASE to which a reference is made in the report.

Possible sources of uncertainties are identified in the report though quantitative estimates for uncertainties in the air quality data are not given. One way uncertainties in trends are visualised in the report is through graphs with the interannual variations of ozone, NO_2 and PM_{10} in 10^{th} and 90^{th} percentiles for the different types of stations. The larger the interannual variations, the more uncertain the interpretation of trends would be.

Examples of the sources of uncertainties mentioned are:

- The coverage, in spatial terms, of the data (received through the EoI and stored in AIRBASE) is by no means uniform or consistent across Europe. The monitoring strategies may differ between countries, and such differences will influence the air quality "picture" that is given by each individual country and reflected in the report.

- Factors which contribute to uncertainty in comparing concentration tendencies with emission trends are the influence of year-to-year variation of meteorological conditions (not analysed yet) and the spatial representativeness of these data for Europe as a whole, in terms of population exposure (difficult to assess).

- At the urban scale, the representativeness of the reported concentrations depends upon the number and types of stations in each city, and their representativeness of population exposure. Even if the accuracy of the concentration data would be 100 %, there would still be uncertainty in terms of exposure of the population.

Uncertainties resulting from modelling, applied to calculate Europe-wide deposition levels, are not reported. The EMEP model is mentioned as the source for data on deposition and additional air quality data, but no information of the uncertainties introduced by using the

model is given. The report includes a disclaimer that current calculation routines in EMEP are under further development and should be taken as only indicative of the actual situation.

Uncertainties with regard to impacts (e.g. percentage of ecosystems protected from acidification) are reported neither. Maps are presented with the source (MNP/CCE) included, but no details are given about the methodology used.

In general, the report focuses more on the quality and the transparency of the air quality data than on explicitly discussing the size and source of uncertainties. It states that the quality of the data in AIRBASE is the responsibility of the data suppliers and describes briefly the QA/QC procedures, which are followed by ETC/ACC and EMEP to further validate the data.

3.3.4. Discussions and recommendations

3.3.4.1 Air pollutant emissions

In general, including treatment of uncertainties is less developed for inventories of air pollutant emissions than for GHGs. This has consequences for assessments and related reporting based on these inventories.

With regard to the improvement of uncertainty treatment in inventories there are several recent evelopments. A system for emissions data checking (REPDAB) has been developed within EMEP, and in collaboration with the ETC/ACC an in depth review of the inventories has been completed. It is intended to institutionalise this review, improving the quality of the emissions data and providing information on uncertainties. Also here it is important to be clear about what ETC/ACCs responsibilities are and what not. For both emissions data and air quality data verification and quality of the data is responsibility of the MS who have to follow guidelines (verification). However it is not known if the countries really comply to this and this aspect should be made transparent by ETC/ACC in its report. Furthermore in the future ETC/ACC could assist MS in improving their estimates of uncertainties in emissions reporting. Also ETC/ACC should check in the data flows on completeness gap filling, outliers, and consistency (validation).

Thus for the improvement of uncertainty information in the reporting on air pollutant emissions the following preliminary recommendations can be given:

- Move information from the Annex to an uncertainty chapter in each report, and design this chapter based on the needs of the audience.
- In formulating key findings, determine confidence levels (qualitatively).
- Make transparent in the report the consequences of the extent to which MS follow guidelines in their inventories.
- Include information on relative uncertainties of air pollutants emissions more explicitly in inventory and trends reporting, learning from experiences in the area of GHG emissions, and making use of the review of emissions inventories by MSc-West and ETC/ACC.
- For readers it would be interesting to know about relative uncertainties for different types of gases, and how certain it would be that emissions are developing in a way that would, or would not, lead to meeting the targets of the National Emissions Ceilings Directives.

3.3.4.2 Air Quality

The high variability of air quality (dependent on variable emissions of short-lived gases, on meteorology) makes assessment of uncertainties even more difficult for air quality than for emissons. A quantitative analysis of uncertainties appears to be far away However, what is possible is a qualitative description of the main sources of uncertainties. For key findings,

more robust variables could be selected. For trend analysis, the analysis could focus on averages rather than on maximum values, which are extremely sensitive to meteorological fluctuations.

The same counts for the assessment of uncertainties for the impacts of air pollution. For example, for an assessment of exposure of population to air pollution, there is a series of sources of uncertainties:

- Uncertainties of measurements, dependent on methods and techniques used (according to the EoI the responsibility of the MS, not reported to the Commission or EEA/ETC): in its European assessments, the ETC/ACC implicitly has to assume that the data from different countries are comparable;
- Uncertainties about the representativeness of the data (concentrations to which people are exposed - spatial representativeness): are station classifications adequate?
- Uncertainties with respect to the exposed population in terms of numbers and sensitivity.

Also here a qualitative description of the main sources of uncertainties could still be given in the report together with an indication what the uncertainties mean.

With regard to impacts on ecosystems at least insight should be given in the methods and models (and their inherent uncertainties) applied to do the assessment.

4. General discussion and suggestions

The former chapter gives a limited insight based on a quick scan of just a few reports of the way ETC/ACC addresses uncertainties in its reports. Still, based on this we conclude that implicitly, ETC/ACC staff has taken uncertainties into account in their appraisal of the knowledge base, but this did not result in any systematic mapping and assessment of uncertainties, nor in systematic reporting in this area. Improved management and reporting of uncertainties will improve the relevance of the ETC products for support to policy development.

Improved management and reporting of uncertainties should be an inherent part of QA/QC procedures. Several efforts are underway in the area of QA/QC - such as the review of the CLRTAP inventories and improvements of the GHG MM – which provide information on uncertainties of reported data and assessment findings.

In the coming years, the ETC information will have to (continue to) answer questions such as: is the EC on the right track in meeting it's Kyoto (or NEC) commitments and how certain are we of this? Are the European air quality standards being met? In order to answer such questions in a scientifically credible way, uncertainty management needs to be improved stepwise in our view.

Rather than promote the introduction of rigorous, time-consuming quantitative uncertainty analyses, we suggest that a qualitative evaluation of the uncertainties derived from the knowledge basis should be routinely included in the development of both ETC/ACC data and assessment reports. For reporting on GHG emissions, uncertainty information is mandatory, for other ETC work it is important as part of the regular QA/QC procedures. It should be acknowledged that scientists have an understanding of the importance of uncertainties different from that of policy makers. While for the former, scientific credibility of findings is important, for policymakers, robustness of policy-relevant findings is important. Furthermore it is important to discuss in texts what the uncertainties *mean*.

ETC/ACC can make use of experiences at RIVM (Petersen et al., 2003; Janssen et al., 2003) as a basis to produce suitable EEA and ETC/ACC guidance and practices. The *RIVM Guidance for Uncertainty Assessment and Communication* aims to support dealing with uncertainties in a broad sense (that is, broader than only applying ready-made tools for uncertainty analysis and communication), for in all parts of environmental assessments choices are made which have a bearing on the way uncertainties are dealt with. The RIVM Guidance therefore pays special attention to (1) problem framing; (2) involvement of stakeholders; (3) selection of indicators; (4) appraisal of knowledge base; (5) mapping and assessment of relevant uncertainties and (6) reporting of uncertainty information (see also Box 1 for more detail about 6, the focus of this note). A directed effort to analyse and communicate uncertainty is usually made in (5) and (6). However, the choices and judgements, which are made in (1) to (4), are also of high importance for ascertaining the most relevant uncertainties and for communicating about them. The *RIVM Guidance* is intended to stimulate reflection on choices, which are made in different parts of environmental assessments. This can lead to more conscious choices and a better way of dealing with uncertainties.

In our understanding, the first three steps are not so important for the two types of reports, which we have looked at. But they are important in the integrated assessment work for the SoEOR2005 report and in the preparation of fact sheets.

Box 1

The *RIVM Guidance for Uncertainty Assessment and Communication* aims to support dealing with uncertainties in a broad sense. This includes mapping and assessment of relevant uncertainties and reporting of uncertainty information. Communicating and reporting uncertainty entails a number of issues that should be taken into consideration. The RIVM Guidance discerns (1) context of communication of uncertainty; (2) target audiences; (3) language; (4) methods; (5) format and (6) content.

With regard to *context* authors have to ask themselves why the uncertainty is being reported (e.g. political purpose, scientific purposes, required by legislation, requested by stakeholders). This will influence the scope of the reporting.

Target audiences may correspond to the stakeholders identified for the problem of concern. It might not correspond to the whole set of stakeholders but it is surely a subset of those. The type of audience will determine amongst other things the 'language' of the communication/report and its content.

The *language* used in the communication and reporting of uncertainty is one of the most important issues. Careful design of communication and reporting should be done in order to avoid information divide, misunderstandings, and misinterpretations. The communication of uncertainty should be understandable by the audience. There should be clear guidelines to facilitate clear and consistent use of terms provided. Values should be made explicit in the reporting process. Potential ambiguity in the wording of the report or in use of metaphors should be avoided.

The *method* used to manage uncertainty (uncertainty analysis, QA/QC, qualitative assessment) and hence, the type of information generated, is a crucial aspect of communicating and reporting uncertainty and should be described. Uncertainty methods can operate in the foreground when applied explicitly to produce information on uncertainty (e.g. written material, graphs), or in the background as when run behind a model and results are embedded in the output (e.g. model outputs, scenarios).

A variety of different reporting *formats* and media can be used (numbers, words, narratives, graphs, pictures, multimedia, internet). No one format is more valid than others. The choice of format depends on communication settings, type of audience, and uncertainty management methods.

With regard to *content* one could think of stating areas of ignorance as far as relevant to results, background of results and insights from other studies. Also in the case of reporting on integrated assessment the implications of uncertainties for policy and for social context and uncertainty could be included as well as relations with risk (namely consequences for different risk management strategies).

Source: Janssen et al. 2003

In general, we suggest the following:

- apply already existing guidelines, such as really completing all fields on uncertainty assessment in fact sheets
- be explicit about uncertainties in underlying data (e.g. emissions, using the understanding of uncertainties emerging from review activities, and for pollutants concentrations) and methodologies used (e.g. for gap filling, for aggregations, for projections), e.g. by special report chapters/sections
- explain to the audience what the uncertainty information means: what are the consequences?
- determine confidence levels of key statements in assessment reports and develop clear and transparent terminology
- include information about which factors are contributing most to uncertainty in reporting and address robustness of findings (which is different from confidence)
- consider uncertainties in the design of main graphics in ETC reports
- for assessments, explore a variety of information not limited to formal MS reports, e.g. multiple model comparisons and a number of expert opinions and include this information in the reports
- include uncertainty reporting in QA/QC guidance manuals (distinct between validation and verification)
- be clear about the role of ETC/ACC: what are ETC/ACC's responsibilities and what MS
- help MS in improving uncertainty reporting in their submissions to the Commission

First concrete actions

- develop tasks to improve uncertainty management in IP2004 as part of QA/QC
- develop a one page guide for uncertainty reporting in official EEA reports and apply this in the year 2004 and evaluate.

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