Uncertainty management

TNO Environment, Energy and Process Innovation

Workshop assessment of air quality and emission measurements under the European Commission’s directives

JRC – Ispra – Italy
25th September 200

Issues in this presentation

• The concept of “data quality”
• Quality criteria: reliability & accuracy
• Why manage uncertainties?
• How to manage uncertainties
• How to report uncertainties
**Perspectives on data Quality**

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Quality hi...</th>
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<tbody>
<tr>
<td>Scientist</td>
<td>Scientific debate:</td>
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<tr>
<td></td>
<td>search for weaknesses</td>
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<td></td>
<td>and errors; falsification</td>
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<td>Predictions that...</td>
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<td>Policy maker</td>
<td>Political debate:</td>
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<td>search for consensus</td>
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<td></td>
<td>and agreement;</td>
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<td></td>
<td>compromise</td>
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<td>Accepted?</td>
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<td>Lawyer</td>
<td>Judicial debate:</td>
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<td>search for proof or</td>
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<td></td>
<td>doubt; persuasion</td>
</tr>
<tr>
<td></td>
<td>Convinced?</td>
</tr>
</tbody>
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**Verification**

- Real world emissions
- Guidelines applied? validation
- True? verification

**Validation**

- Emission inventory
Verification
• indicates truth, reliability and credibility of the data reported.
• external checking

Validation
• the establishment of sound approach and foundation
• internal checking

True?
Agree?

Verification
methods:
• Error propagation
• Independent checks
• Measurements and models

Validation
methods:
• quality control
• auditing
• country comparisons
• feed back

objectives:
✓ Accuracy
  (no systematic error)
✓ Precision
  (no random error)

objectives:
✓ Transparency
✓ Completeness
✓ Consistency
✓ Accuracy
## Sources of unreliability

**Unreliability**

| T | Transparency | ✓ Insufficient documentation |
| C | Consistency  | ✓ Different methods for different years  
   |             | ✓ Inconsistent activity data |
| C | Comparability| ✓ Deviations of sector split and fuel defs  
   |             | ✓ Deviations in sector grouping  
   |             | ✓ Incomplete reporting |
| C | Completeness | ✓ Omissions of sources and/or pollutants |
| A | Accuracy     | ✓ See below |

## Sources of inaccuracy

**Inaccuracy**

| Structural               | ✓ Aggregation error  
|                         | ✓ Unknown sources  
|                         | ✓ Mathematical formulation error |
| Input value              | ✓ Extrapolation error  
|                         | ✓ Measurement error  
|                         | ✓ Unknown developments  
|                         | ✓ Reporting error |
Why manage uncertainties?

- "Good practice" in scientific work
  - It simply needs to be done!
- To identify weak spots in the inventory
  - Improvement of inventory
- Requested by conventions and protocols
  - Report uncertainties
  - Convince expert review teams

How to manage uncertainties

- Good practice
  - Follow guidelines
  - Key source analysis
  - Selection of methods: decision trees
  - Documentation
  - QA/QC
- Estimate uncertainties
  - Data need:
    - Input uncertainties (EFs, ARs)
    - Probability distributions
  - Combining input uncertainties
    - Tier 1: simple spreadsheet calculation
    - Tier 2: Monte Carlo simulation
Good practice guidelines

- Prepared by IPCC
- Endorsed by UNFCCC

A set of procedures intended to ensure that inventories are accurate in the sense that they are systematically neither over nor underestimates so far as can be judged, and that uncertainties are reduced so far as possible.

Decision tree

Example Energy
- Guides user step by step through the procedure
- Supports methodology choice (Tier 1 or Tier 2)
- Proposes data to be looked for
Uncertainty analysis

- Quality Control
  - Quality Assessment
- Uncertainty Analysis
- Ground Truth Verification

Qualitative
- accepted

Quantitative
- true

Qualitative Uncertainty Analysis

UNFCCC (TCCCA)
- “Synthesis and Assessment Report”
  - Review national submissions:
    - Earlier submissions of the country
    - Implied emission factors between countries
    - Activity rates with international statistics
- Expert review teams
  - Ask questions to national exp.

UNECE / CLRTAP
- Still under development
- chapter in Guidebook consistent with IPCC!
Quantitative Uncertainty Analysis

\[ Emission_{\text{pollutant}} = \sum_{\text{activities}} \text{Activity Rate}_{\text{activity}} \times \text{Emission Factor}_{\text{activity,pollutant}} \]

Uncertainty estimates for input data
- Activity data
- Statistics office?
- Emission factors
  - Literature
  - Databases
  - Expert judgement

Combine uncertainties into one over all uncertainty estimate:
- Tier 1: relatively simple spreadsheet method
- Tier 2: Monte Carlo simulation

Tier 1 Uncertainty Analysis
- Simple approach using a "squared uncertainty multiplication" technique
- Is statistically sound
- Can be expanded
- This is perhaps
- Tier 1 is a statistical
  - How?
Tier 2 Uncertainty Analysis

Monte Carlo simulation
- (Re)build inventory model in a spreadsheet
- Choose probability density functions (PDF) for all ARs and EFs
- Run a Monte Carlo add in
  - @Risk
  - Crystal Ball

How to report uncertainties

- 95 percent confidence intervals
- IPCC Good Practice and Uncertainty Management report proposes a table. CRF will have one.
- It might be similar for other conventions!
Use of uncertainties in Adjustments

- "Conservative Estimate"
- 25- (base year) and 75-percentiles (commitment period) of possible values
- Table of “Conservative factors”

Conclusions:
Issues in this presentation

- The concept of “data quality"
  - Complex issue, depends on (perspective of) user
  - We are interested in the policy perspective
  - Qualitative and quantitative aspects
  - Good practice
- Quality criteria: reliability & accuracy
- Why manage uncertainties?
- How to manage uncertainties
- How to report uncertainties
Conclusions: Issues in this presentation

- The concept of “data quality”
- Quality criteria: reliability & accuracy
  - Accuracy: mainly scientific understanding
    - Are data good?
  - Reliability: mainly application oriented understanding:
    - Are data good enough?
- Why manage uncertainties?
- How to manage uncertainties
- How to report uncertainties
Conclusions: Issues in this presentation

- The concept of “data quality”
- Quality criteria: reliability & accuracy
- Why manage uncertainties?
- How to manage uncertainties
  - Apply the IPCC Guidelines and Good Practice Guidance
  - Key source analysis & Decision trees
  - Estimate uncertainties
  - QA/QC: adequate documentation
- How to report uncertainties

Conclusions: Issues in this presentation

- The concept of “data quality”
- Quality criteria: reliability & accuracy
- Why manage uncertainties?
- How to manage uncertainties
- How to report uncertainties
  - Estimate using Tier 1 or Tier 2
  - In a predefined table as defined in CRF
  - Additional information in National Inventory Report
  - Get it accepted by the expert review team
Thank you