Tinus Pulles

Uncertainty management

TNO Environment, Energy and
Process Innovation

Q/QC Workshop assessment of air quality and emission measurements under the European Commission's directives

JRC – Ispra – Italy
25th September 2002 27th September 2002

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

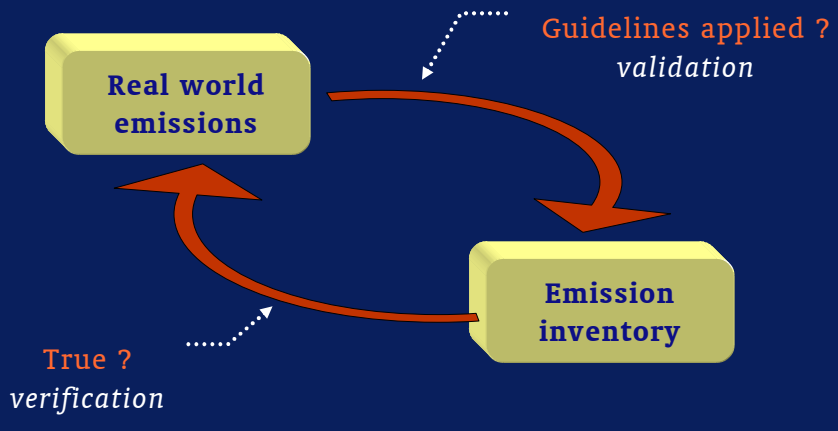
	Perspective	Quality high if …
Scientist	***Scientific debate***: search for weaknesses and errors; falsification	predictions that
Policy maker	***Political debate***: search for consensus and agreement; compromise	body involved agrees
Lawyer	***Judicial debate***: search for proof or doubt; persuasion	convinces a judge or jury

True ?

Accepted ?

Convinced ?

Verification Validation



Verification

- indicates truth, reliability and credibility of the data reported.
- external checking

Validation

- the establishment of sound approach and foundation
- internal checking

Verification

methods:

- Error propagation
- Independent checks
- Measurements and models

objectives:

- ✓ Accuracy (no systematic error)
- ✓ Precision (no random error)

Validation

methods:

- quality control
- auditing
- country comparisons
- feed back

objectives:

- ✓ Transparency
- ✓ Comparability
- ✓ 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**

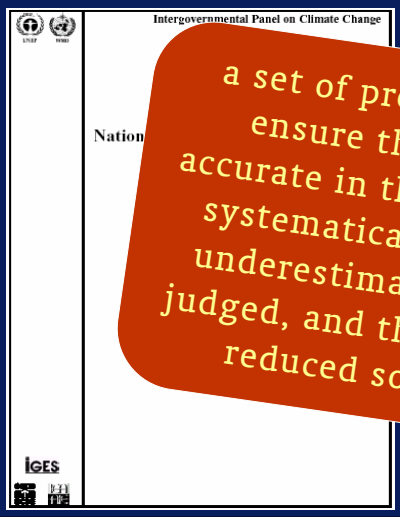
Why manage uncertainties ?

- **"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

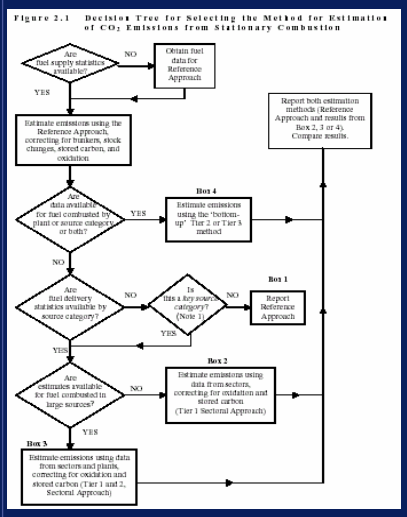
Good practice guidelines



- Prepared by IPCC
- ted 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.

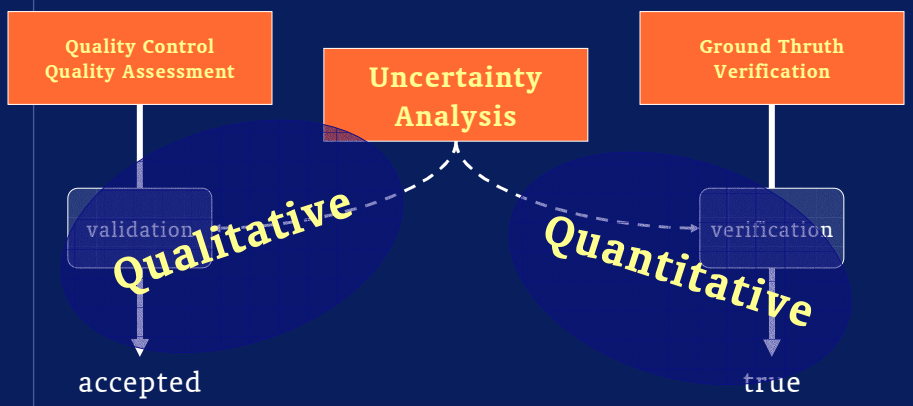
Decision tree



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



Qualitative Uncertainty Analysis

UNFCCC (TCCCA)

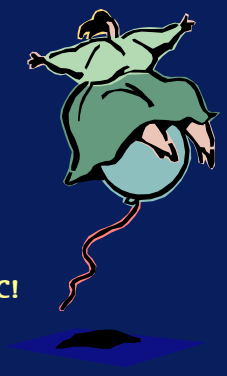
- **"Synthesis and Assessment Report"**
  Review national submissions:
  - Earlier submissions of the country
  - Implied emission factors between countries
  - Activity rates with international statistics
- **Expert review teams**
  Ask questions to national exp

Adjustments

UNECE / CLRTAP

Still under development

chapter in Guidebook consistent with IPCC!



Quantitative Uncertainty Analysis

$$Emission_{pollutant} = \sum_{activitiess} Activity\ Rate_{activity} \times Emission\ Factor_{activity,pollutant}$$

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 "squa
- Is sta
  - Star
  - All
- This i

Therefo

- Tier 1 a stat
- How

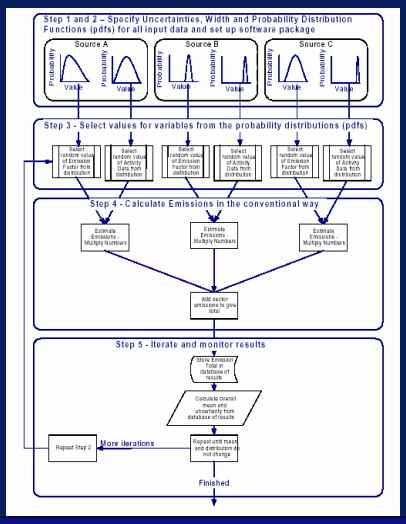
Tier 1 Uncertainty Calculation and Reporting

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
NRF sector	Pollutant	Base year emissions	Year t emissions	Activity data uncertainty	Emission factor uncertainty	Combined uncertainty	Combined uncertainty as % of total national emissions in year t	Type A sensitivity	Type B sensitivity	Uncertainty in trend in national emissions introduced by emission factor uncertainty	Uncertainty in trend in national emissions introduced by activity data uncertainty	Uncertainty introduced into the trend in total national emissions	Emission factor quality indicator	Activity data quality indicator	Expert judgement reference numbers	Footnote reference number
		Input data	Input data	Input data	Input data	$\sqrt{E^2+F^2}$	$\frac{G \bullet D}{\sum D}$	Note B	$\frac{D}{\sum C}$	I • F Note C	J • E • $\sqrt{2}$ Note D	$\sqrt{K^2+L^2}$	Note E	Note E		
		Mg	Mg	%	%	%	%	%	%	%	%	%				
1a																
1b																
…																
Etc.	…															
		$\sum C$	$\sum D$				$\sqrt{\sum H^2}$					$\sqrt{\sum M^2}$				
Total																

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
  - Cristal 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!**

TABLE 6.2
TIER 2 UNCERTAINTY REPORTING

A	B	C	D	E	F	G	H	I	J
IPCC Source category	Gas	Base year emissions	Year t emissions	Uncertainty in year t emissions as % of emissions in the category		Uncertainty introduced on national total in year t	% change in emissions between year t and base year	Range of likely % change between year t and base year	
		(Gg CO_2 equivalent)	(Gg CO_2 equivalent)	% below (2.5 percentile)	% above (97.5 percentile)	(%)	(%)	Lower % (2.5 percentile)	Upper % (97.5 percentile)
e.g. 1.A.1 Energy Industries Fuel 1	CO_2								
e.g. 1.A.2 Energy Industries Fuel 2	CO_2								
Etc…	…								
Total									

Use of uncertainties in Adjustments

- "Conservative Estimate"
- 25- (base year) and 75-percentiles (commitment period) of possible values
- Table of "Consrvative 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?**
  - Because it is good practice
  - Because the client requires it
  - To find weak spots in the inventory
  - To improve the quality of the inentory
- 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