Symposium

Uncertainty of ozone retrieval

The European Metrology Research Programme (EMRP) is jointly funded by the EMRP participating countries within EURAMET and the European Union.
Symposium Introduction

In **metrology** uncertainties are generally generated by uncertainty of **physical measurements** depending on the instrument:

- mechanics of the instrument
- electronics of the instrument
- design of the instrument
- sensitivity of the detectors
- stability of the instrument
- temperature (Humidity) dependence of the instrument
- calibration of the instrument
Symposium Introduction

E.g. Measurement of global **UV Radiation** (Array Spectroradiometer):

- linearity of the detector (correction)
- wavelength scale calibration
- uncertainty of calibration lamp (ageing, distance etc.)
- effect of different integration time
- dark signal handling
- cosine response
- spectral resolution (sampling depending on slit function)
- sensitivity of the detector (NEI=Noise Equivalent Irradiance)

- stray light (correction) -> uncertainty of stray light matrix generation and correction algorithm.
Ozone Retrieval

Measurement → Retrieval Method «Model» → O₃ Value
Ozone Retrieval

Measurement ➔ Retrieval Method «Model» ➔ $O_3$ Value

Uncertainty of measurement: $+$ Uncertainty of model: $\equiv$ Uncertainty of $O_3$ value
Ozone Retrieval

Measurement \rightarrow \text{Retrieval Method «Model»} \rightarrow O_3 \text{ Value}

Uncertainty of \text{measurement:} + \text{Uncertainty of model:} = \text{Uncertainty of } O_3 \text{ value}

Metrology (Physics)
Ozone Retrieval

Measurement → Retrieval Method «Model» → $O_3$ Value

Uncertainty of measurement: $\text{Metrology (Physics)}$

Uncertainty of model: $\text{Physics: Beer-Lambert law}$

$I_\lambda = I_\lambda^0 e^{-\tau_\lambda m}$

$\log I_\lambda = \log I_\lambda^0 - \tau_\lambda^R m_R - \tau_\lambda^{O_3} m_{O_3} - \tau_\lambda^{SO_2} m_{SO_2} - \tau_\lambda^{aod} m_{aod}$
Ozone Retrieval

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Uncertainty of measurement: + Uncertainty of model: = Uncertainty of O₃ value

Metrology (Physics)

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- sensitivity of the detector (NEI)
- stray light (correction)
Ozone Retrieval

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Metrology (Physics)

Uncertainty of model:
- selected wavelength
- selected cross-section
- selected atmospheric temperature
- selected atmospheric layers
- aerosol estimation
- trace gas estimation
- post processing of data for the model
- computational uncertainty (used functions)
- Extraterrestrial spectrum

Physics: Beer-Lambert law

Uncertainty of $O_3$ value

Metrology (Physics): Beer-Lambert law
Ozone Retrieval

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Uncertainty of $O_3$ value

Brewer / Dobson
Full spectrum (range)
Ozone Retrieval

- Measurement

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  Brewer / Dobson Full spectrum (range)

  Physics: Beer-Lambert law

  Pass & Baur
  Brion
  New: Uni Bremen
Ozone Retrieval

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New: Uni Bremen

Pass & Baur
Brewer / Dobson
Full spectrum (range)
Modelling of the atmosphere
Ozone Retrieval

- Measurement
- Retrieval Method «Model»
- \( O_3 \) Value

Uncertainty of model:

- Extraterrestrial spectrum
- Physics: Beer-Lambert law
- Brewer / Dobson Full spectrum (range)
- Modelling of the atmosphere

Uncertainty of \( O_3 \) value:

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- Sensitivity on these parameters
- New: Uni Bremen
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Ozone Retrieval

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Extraterrestrial spectrum = Uncertainty of O₃ value

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Brion
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Sensitivity on these parameters

Brewer / Dobson
Full spectrum (range)

Modelling of the atmosphere

«Tricks» of preparing the data
Ozone Retrieval

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Physics: Beer-Lambert law

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Sensitivity on these parameters

Random best fit methods / algorithm
Ozone Retrieval

Measurement → Retrieval Method «Model» → O\textsubscript{3} Value

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Uncertainty of O\textsubscript{3} value
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- «Tricks» of preparing the data

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New: Uni Bremen

Sensitivity on these parameters

Random best fit methods / algorithm

Several available
New: in this JRP

Physics: Beer-Lambert law
Ozone Retrieval

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Uncertainty of measurement: + Uncertainty of model: = Uncertainty of $O_3$ value

Conclusion:
The uncertainty of $O_3$ depends on:
- Instrument (physical measurement and corresponding model)
- Conditions for the model (atmosphere, cross-section, ET, aerosols etc.)

Challenge / Questions:
- What conditions for the model are the «right» assumptions?
- What is the overall uncertainty using all instruments with their corresponding models with all feasible conditions (assumptions).
- How are model uncertainty depending on measurement uncertainty?
- What does traceability means when retrieval models are included?
I am curious about the following presentations
Proposal for Uncertainty of Ozone Retrieval

Measurement → Retrieval Method «Model» → $O_3$ Value

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Mathematical uncertainty analysis
Proposal for Uncertainty of Ozone Retrieval

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«True» Spectra
- Measured
- Modelled (with variation of uncertainties)

All retrieval methods applying all Conditions

Benchmark of uncertainty of \( O_3 \)