

Part III

Uncertainties of Atmospheric Correction in Complex Environments



Uncertainties in Ocean Colour Remote Sensing

**Key findings
of the IOCCG Working Group**

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Working Group Terms of Reference:

- *analyse factors which determine uncertainties for various water types;*
- *analyse the problem of uncertainties for different product types;*
- *analyse the problem of uncertainty propagation in L3 and merged products;*
- *review, analyze and document methods, which allow to determine out-of-scope conditions and uncertainties including flagging;*
- *recommend procedures to be implemented in ground processors and formats to present errors / uncertainties in data products;*
- *summarize the results and recommendations in the form of an IOCCG report.*

<http://ioccg.org/group/uncertainties/>



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Outline

- 1. Introduction**
- 2. Terminology and Main Principles**
- 3. Sources of Uncertainties**
- 4. Uncertainty Estimates**
- 5. Representation and Distribution of Uncertainties**
- 6. Requirements from Different Applications**
- 7. Recommendations**



DEFINITIONS

Measurement error:

Measured quantity value minus the true value / a reference value

Measurement uncertainty :

Non-negative parameter characterizing the dispersion of the quantity values being attributed to a measurand

BIPM: Bureau International des Poids et Mesures
International Bureau for Weights and Measures

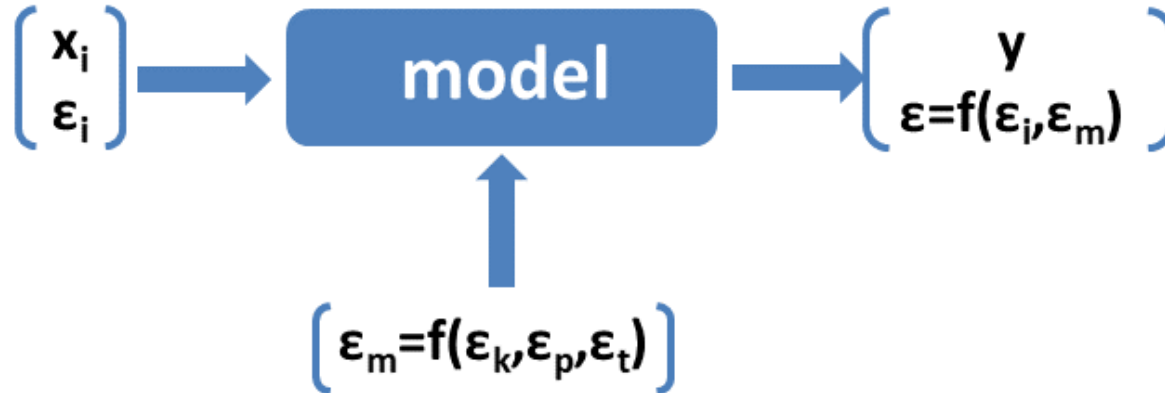
<https://www.bipm.org>

GUM: Guide to the expression of Uncertainty in Measurements
(not for EO)

VIM: Vocabulaire International de Métrologie
International Vocabulary of Metrology



Sources of Uncertainties



$$\varepsilon = f(\varepsilon_i, \varepsilon_k, \varepsilon_p, \varepsilon_t)$$

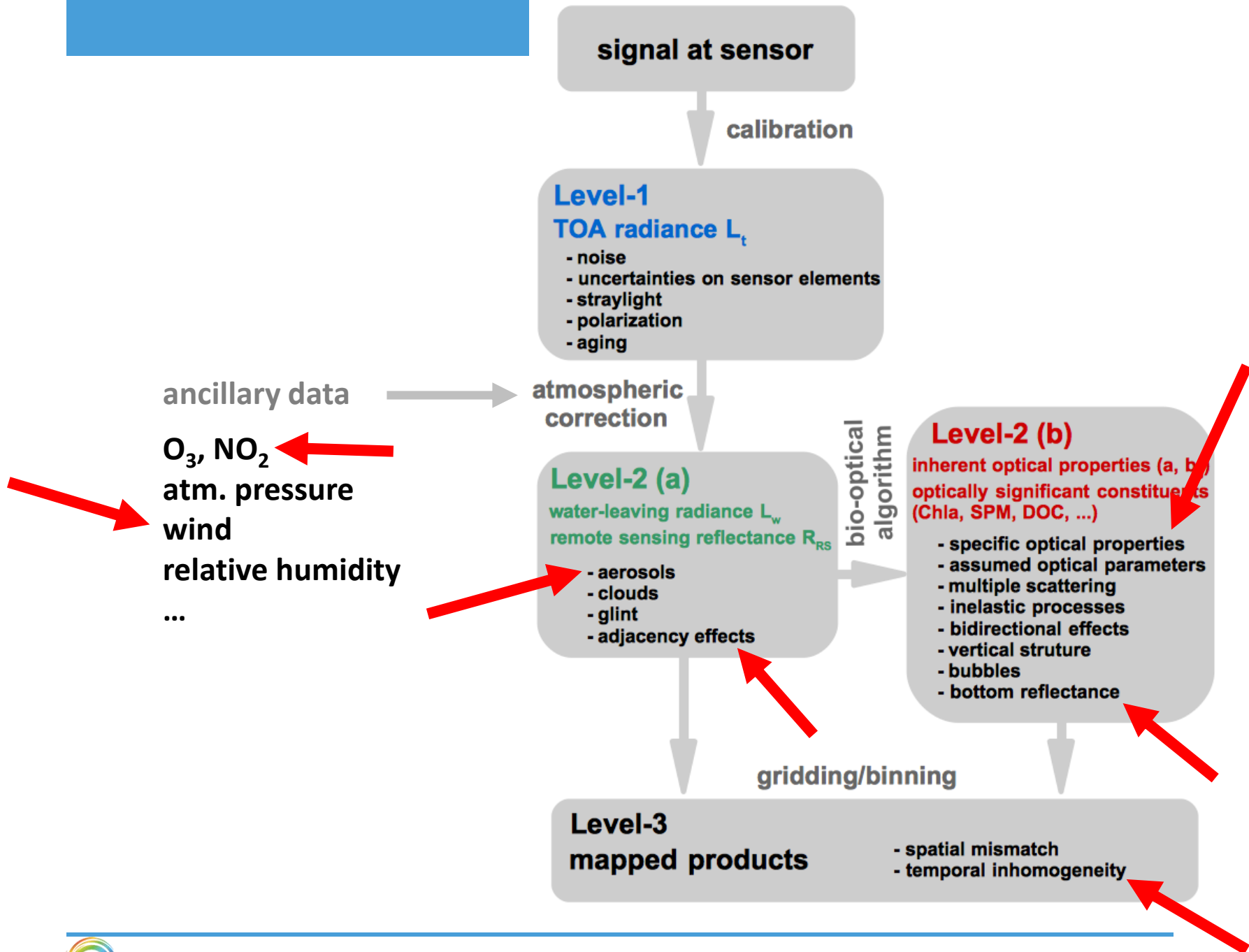
$$+ \varepsilon_e$$

editing

inherent/
stochastic

model model technical/
 structure parameters numerical
 structural/epistemic





Methods for identifying out-of-scope conditions and estimating uncertainties

- Identification of out-of-scope conditions
- Assessment from algorithm construction
- Use of simulated data
- Clear-water approach
- Approach based on optical water types
- Outputs on non-linear inversion methods
- Uncertainty propagation using expansion-based methods
- Uncertainty propagation using Monte-Carlo approaches
- Bayesian approach
- Use of Cramer-Rao bounds
- Comparison of satellite products
- Co-location techniques
- Role of biogeochemical models

None of the methods presented includes a full uncertainty budget !!



What about validation?

(i.e., comparison between satellite and field data)

Issues:

- ❖ **Definitional uncertainty**
- ❖ **Spatial representativeness**
- ❖ **Uncertainties of the field data**

Nonetheless, most of what we know about uncertainties historically come from validation statistics



Validation results for atmospheric corrections:

Residuals distributions:

- vary by site/atmospheric/water type
(when expressed both in relative and absolute terms)

For a site:

- are fairly Gaussian
- show spectral correlation
- are fairly consistent across missions
- show cross-mission correlation
(when processed with the same code)



Discussion: recommendation about uncertainties in complex environments



How should requirements be formulated?

Given in radiometric units? What about error covariance?



How is the role of field data to be (re-)considered?

What about their uncertainties? What about the issue of representativeness (scale)? Role as the main independent source of verification of uncertainties estimates?



Are there favored approaches to obtain and present comprehensive, traceable, uncertainty estimates?

Comprehensive uncertainty propagation? Role of class/pattern recognition for detection of out-of-scope conditions and for easier calculation of uncertainty estimates? Comparison of outputs from different methods?



Part IV

Final discussion

