International Ocean Colour Science Meeting 2019 | Advancing Global Ocean Colour Observations

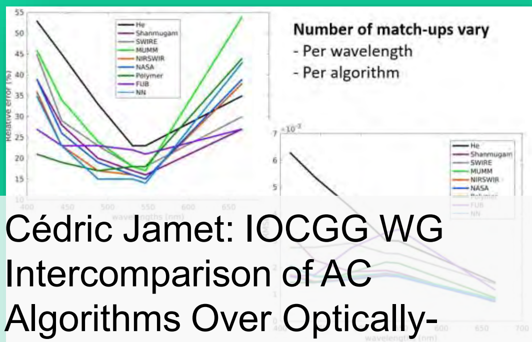
Report of Breakout Workshop #9:

Atmospheric Correction under Complex/Extreme Environments

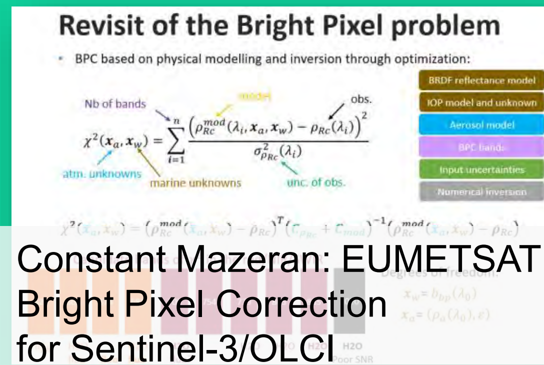
Co-chairs: Constant Mazeran, Amir Ibrahim, Robert Frouin
Speakers: Cédric Jamet, Nima Pahlevan, Maria Tzortziou, Frédéric Mélin
With support from Julien Chimot and François Steinmetz

Overview of the session: three parts

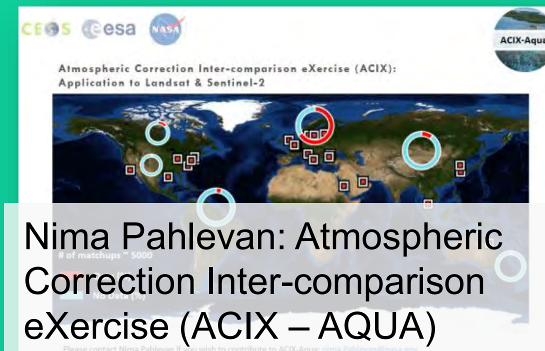
1. Atmospheric correction over complex waters



Cédric Jamet: IOCGG WG Intercomparison of AC Algorithms Over Optically-Complex Waters

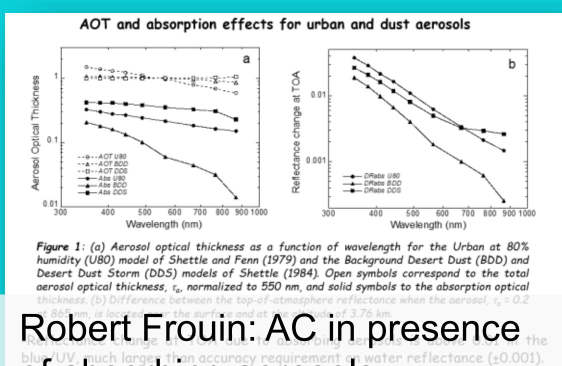


Constant Mazeran: EUMETSAT Bright Pixel Correction for Sentinel-3/OLCI

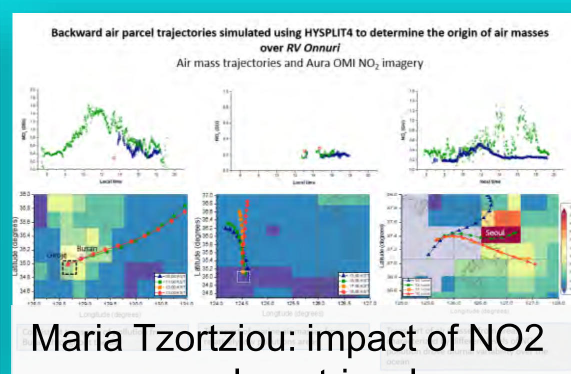


Nima Pahlevan: Atmospheric Correction Inter-comparison eXercise (ACIX – AQUA)
→ Nima.Pahlevan@nasa.gov

2. Atmospheric correction over complex atmosphere

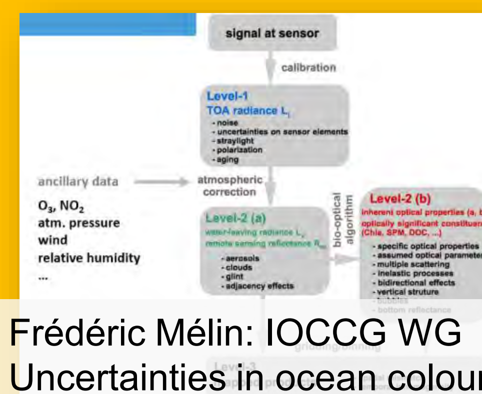


Robert Frouin: AC in presence of absorbing aerosols



Maria Tzortziou: impact of NO2 on ocean color retrievals

3. Uncertainties



Frédéric Mélin: IOCCG WG Uncertainties in ocean colour remote sensing

Recommendation: understanding performance

Many algorithms exist: there is a need to *better understand their performance* - and then improve them

→ Importance of international validation/comparison exercises (IOCCG WG, ACIX...): provide guidance and recommendations

→ Go beyond simple ranking:

- Why do algorithms work or fail?
- What are their fundamental hypothesis?
- Are there compensations in the errors?

ACIX example: address the root cause of differences

Recommendation: methods

For complex environments, focus should be put on AC using *the full spectral information (e.g. spectral matching algorithm)*, instead of the heritage NIR-based approach - Important to get the proper spectral shape in the blue-green bands over complex waters

→ Coupled approaches require a representative marine reflectance model: improve physical modelling (e.g. better knowledge of IOPs) or go to statistical approach

→ Pay attention to pre-corrections and accuracy of ρ_{Rc} :

- Effect of surface reflection (sun glint and sky glint), in particular for pushbroom Landsat and S-2 technology
- Gaseous corrections (e.g. H2O for OLCI in the NIR; NO2)
- White-caps

Recommendation: open code & open data

The source code of algorithms must be *publicly available*

- ✓ **SeaDAS, POLYMER, ACOLITE …**
- ✗ **OLCI Level-2 processor …**

Simulated datasets should also be shared in the community (open data)

- In particular in complex/extreme environments, where there are little or non-optimal situ measurements; e.g. simulations of absorbing aerosol events

Recommendations: validation datasets

Existing datasets (e.g. AERONET, AERONET-OC) are probably under exploited: need to investigate them in more details to understand the sources of failure (physical analyses, aerosol phase function, etc.)

Capacity building: In situ validation should be extended to **operational water agencies/authorities**, which benefit from satellite data products

→ Inter-agency effort to coordinate data merging

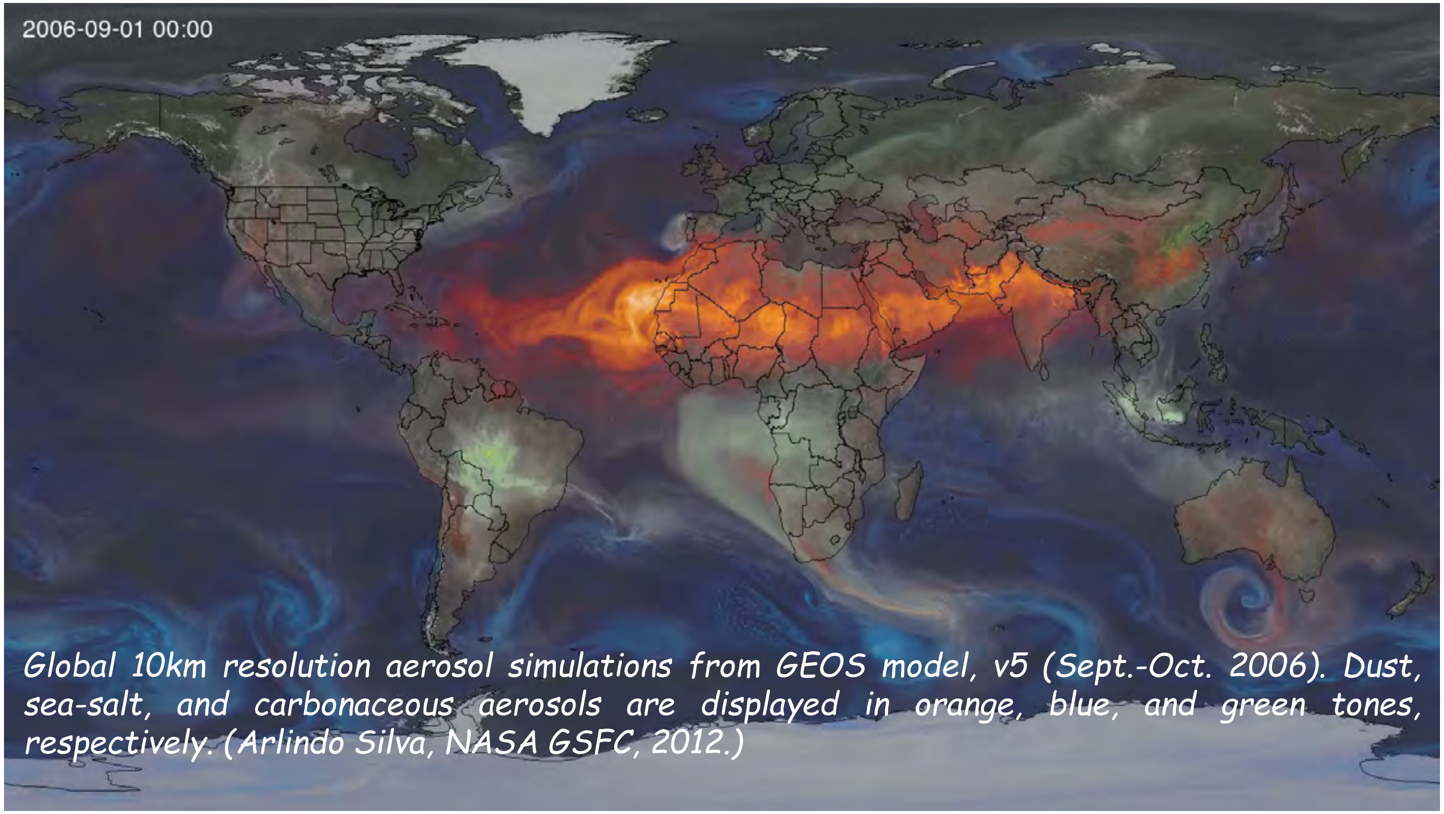
→ Care to the protocols and representativity of the data

- Need to gather data set **representative of situations expected to be encountered**; UV measurements lacking
- Inter-agency coordination for **open data**

AC & absorbing aerosols

Absorbing aerosols cannot be neglected

- Present over vast oceanic regions
- Impact is 10 times larger than acceptable errors
- AC based on NIR-SWIR only cannot handle the issue



Global 10km resolution aerosol simulations from GEOS model, v5 (Sept.-Oct. 2006). Dust, sea-salt, and carbonaceous aerosols are displayed in orange, blue, and green tones, respectively. (Arlindo Silva, NASA GSFC, 2012.)

AC & absorbing aerosols

Absorbing aerosols cannot be neglected

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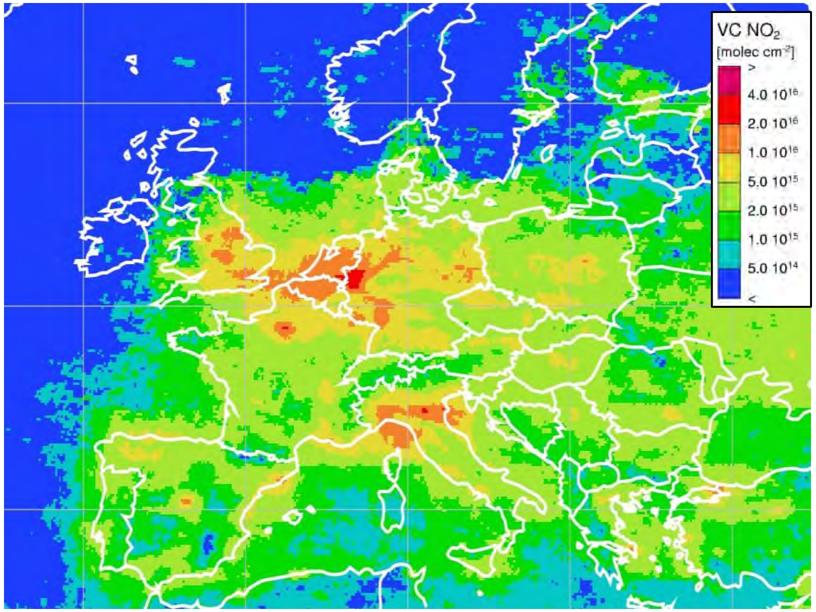
Solutions exist, for instance:

1) **Estimate the relevant properties** (e.g., using multi-angle photo-polarimetry) - but accuracy may not be sufficient
2) **Use all the wavelengths** with deterministic/statistical schemes, **in particular bands sensitive to aerosol absorption, i.e., UV**
3) **Using multi-angle information** (allows one to avoid determining separately the relevant variables) – Feasibility for PACE (SPEX, HARP)?
4) **Detect** the presence of absorbing aerosols and, **shift to a set of absorbing models** in the standard AC algorithm

Recommendation: NO2 correction

Small scale variability in TCNO2 needs to be taken into consideration for coastal imagery:

- Effect as large as 50, 100 or 200% on Rrs in the blue depending on Sun zenith angle
- Diurnal variability impacts not only the amplitude of Rrs but also its spectral shape



Need for **high-spatial and temporal resolution of atmospheric NO2** instead of current climatology

- From shipboard platforms and integration of these measurements to atmospheric correction approaches
- From satellite observations of atmospheric NO2 (e.g., TEMPO, TROPOMI, GEMS, Sentinel-4, Sentinel-5)

Recommendations for new algorithms and platforms

Encourage interdisciplinary collaboration between the modelling, atmospheric and the OC communities: constrain the inversion with global assimilated aerosol transport models

- This solution could be implemented to past sensors to ensure continuity & to sensors from which we could not obtain a reliable AC

Using UV: need to study what would be the radiometric requirement

- Depends on the AC method (physic-based, spectral matching…)
- Start from laboratory capability + existing UV sensors

Potential of **hyperspectral inversion should be studied**:

- **Oxygen band**: vertical distribution of the aerosol. PACE: 0.6 nm resolution could be used to program O2 band
- **Hyperspectral bands in the blue (400-450 nm)** to correct for NO2: challenging but should be tried (PACE)

Using lidar for better describing the aerosol vertical column profile should be encouraged: select aerosols in a subset of models

Recommendation: uncertainties of AC

Deriving uncertainties should be a requirement when developing algorithm, especially in complex environments: rigorous approach to understand performance & sources of errors (calibration, absorbing gas, sea state, aerosols…)

Radiometric requirements in complex environment need to go beyond the historical "5% over open ocean":

- Use radiometric unit; ideally error covariance
- Distinguish the water types
- For very low signal: negative reflectance should be kept in the distribution (up to a given level) to not bias statistics

There is a strong need to **characterize the input L1b uncertainties** following metrology principles:

- Pre-launch
- Post-launch
- Full uncertainty structure: random & systematic, temporal…