ASSESSMENT OF THE UNCERTAINTY OF ATMOSPHERIC SCATTERING FUNCTIONS USED IN MERIS ATMOSPHERIC CORRECTION OVER WATER

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Motivations

- Contribute to the MERIS validation of L2 optical parameters
- Consolidate the validation of the aerosol product
- Propose an atmospheric alternative for the validation of the marine reflectance:
  - Clear waters: Check consistency with Vicarious Calibration (VCAL)
  - Coastal waters: Spatial & temporal stability of atmosphere is higher than that of marine signal
Context

- Aerosol optical thicknesses (AOTs) are used to validate the MERIS L2 aerosol product.
- AOTs from AERONET Ocean Colour are proposed in MERIS Matchup In situ Database (MERMAID).
- MERIS water reflectances ($\rho_w$) result from the atmospheric correction (AC).
- AC relies on the knowledge of the aerosol inherent optical properties (IOPs).
Methodology

• Aerosol IOPs: AOT(\(\lambda\)) + SSA(\(\lambda\)) + Paer(\(\Theta,\lambda\)) at 440, 675 & 870 nm
• IOPs are provided by AERONET inversions
• Compute the required atmospheric scattering functions with these IOPs for the AC in the MERIS conditions
• Compare the aerosol reflectance (\(\rho_{aer}\)) in NIR for validating BPAC + Sun glint correction
• Use the 5S formalism of the TOA reflectance for extracting \(\rho_w\) and to compare it with the MERIS derived one
Flow Chart of the Methodology to Validate MERIS Atmospheric Scattering Functions

1. AERONET IOPs
2. MERIS auxiliary data
   - RTC/SO
   - Computed AOPs
     - Computed $\rho_a$ in B12 & B13
     - Computed AOPs in VIS
       - 5S formalism
       - Computed $\rho_w$ in B01,...,B07
3. MERIS atm. AOPs
   - Comparison
   - Extracted $\rho_a$ in B12 & B13
4. MERIS marine L2 Product
   - Extracted $\rho_w$ in B01,...,B07
5. AERONET-OC In-Situ Meas.
   - Comparison
   - Measured $\rho_w$ in B01,...,B07
RTC/SO

- Vector code (polarization)
- Vertical discretization: 100 sub-layers
- Black water body
- Fresnel reflection (Cox & Munk model)
- Angular integration: Gauss quadrature (24 angles)
- RTE solved using the *Fourier* series expansion (Is) of radiance
  - + *Transmittances*: nadir view and Is = 0
    (Principle of reciprocity)
  - + *Radiances*: Is = 80 terms
Aerosols (MERIS-3RP)

- **Heritage**: 12 SAMs (Fern & Shettle)
  - Maritime, Coastal & Rural (RH=50, 70, 90, 99%)

- **Additional models**:
  - Model #0 (Whiter than white)
  - 3 IOPA blue aerosols (including a spectral dependence extracted from an approach combining micro-physical properties of small particles with IOP’s derived from CIMEL measurements)

- **Exotic models**:
  - 18 absorbing DUSTs (Moulin et al., 2001)
AOT: MERIS vs AERONET

AOTs at 560, 665 and 865 nm over the AAOT site (Venice, Italy).
Comparison between the MERIS retrievals and the AERONET extractions.
AERONET - Aerosol Phase Function

\[ \omega_0(\lambda) \cdot P_a(\Theta, \lambda) \]

Aerosol phase function times single scattering albedo, \( \omega_0(\lambda) \cdot P_a(\Theta, \lambda) \)
Aerosol reflectances ($\rho_a$) in MERIS B02 (442.5 nm), B07 (665 nm) and B13 (865 nm). Comparison between the MERIS extractions and the RTC/SO computations.
Conclusions on $\rho_{aer}$

• Not so bad:
  
  ✓ MERIS Calibration in the NIR is OK!
  ✓ BPAC as well

• MERIS APF ($P_a$) is underestimated
  $\Leftrightarrow$ MERIS AOT overestimated!

Retrieval of Water Reflectance

• 5S formalism: \( \rho_w = \frac{\rho_{ng} - \rho_{atm}}{T(\mu_s) \cdot T(\mu_v)} \)

• AOT and \( P_a \) are interpolated in all the MERIS spectral bands from the 3 AERONET bands

• \( \rho_{atm} \) and \( T \) are from MERMAID break-points

• Validation of \( \rho_{atm} \) through \( \rho_{aer} \)
\[ \rho_{\text{aer}} : \text{From MERIS } B_{13} \text{ to } B_{02} \]

**Spectral dependence factor of the aerosol reflectance** \( \epsilon \)

*computed between \( B_{02} \) and \( B_{13} \): MERIS versus AERONET*
Atmospheric transmittances \( T_{\text{atm}} \) in \( B_{02} (442.5 \text{ nm}) \), \( B_{07} (665 \text{ nm}) \) and \( B_{13} (865 \text{ nm}) \). Comparison between MERIS extractions and RTC/SO computations.
Evaluation of Marine Reflectance

Marine reflectances ($\rho_w$) in $B_{03}$ (490 nm), $B_{04}$ (510 nm) and $B_{05}$ (560 nm).
Comparison between MERIS retrievals and RTC/SO simulations.
Illustration of an alternative approach to validate AC

Not an evaluation of the MERIS L2 product

- Only one site: AAOT
- Only 110 matchups

AERONET Sites

• Alta Acqua Oceanographic Tower (AAOT, Venice’s offshore platform) in the Adriatic Sea (coastal waters + coastal atmosphere)

• Forth Crete (station located on the coastline in the North of Crete) (oligotrophic waters + clear atmosphere)

• Marine Optical BuoY (MOBY, Lanaii) in the Pacific Ocean (oligotrophic waters + very clear atmosphere)
Atmospheric Reflectance (443nm)

\[
\begin{align*}
\rho_{\text{path}}(443) \text{ MERIS} & \approx 0.86 \cdot \rho_{\text{path}}(443) \text{ AERONET} + 0.022 \\
\rho_{\text{path}}(443) \text{ AERONET} & \approx 0.94 \cdot \rho_{\text{path}}(443) \text{ MERIS} + 0.011 \\
\rho_{\text{path}}(443) \text{ AERONET} & \approx 0.97 \cdot \rho_{\text{path}}(443) \text{ MERIS} + 0.007
\end{align*}
\]
Atmospheric Reflectance (865nm)
Atmospheric Transmittance (443nm)

![Graph showing atmospheric transmittance at 443nm for different locations with regression lines and statistics.](image)

- **AAOT**: N=231, slope=0.89, intercept=0.061, r²=0.87
- **FORTH_CRET**: N=139, slope=1.16, intercept=-0.130, r²=0.77
- **MOBY**: N=24, slope=1.01, intercept=-0.019, r²=0.83
Atmospheric Transmittance (865nm)
Preliminary Conclusions-2

- Uncertainty around 3% on the atmospheric reflectance at 443nm
- Uncertainty around 1% on the atmospheric transmittance at 443nm
- This contributes to about 3% uncertainty on the vicarious calibration gains in the blue region
Perspectives

- MERIS-4RP (NASA/GSFC Climatology)

- Add 2 other AERONET sites
  - Gustav-Dalen Tower (Baltic Sea) + Gloria (Black Sea)

- Use L2 quality flags in the statistical analysis
  - PCD19, PCD1_13, ...

- Assess the temporal variability of aerosols using the AERONET data bracketing the time of MERIS overpass

- Assess the spatial variability of aerosols by inspecting MERIS data over few kilometers around the site
Thank You!