Rapid review of the main features of the MERIS Atmospheric corrections over Case 1 waters

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This presentation aims at summarizing the most significant features of the MERIS atmospheric corrections, as well as its overall performance and capabilities, before some more detailed & technical presentations are provided in this session, including the results of the ACRI-ESA-LOV collocations. Further details are to be found in the references provided at the end of this slide show.
What atmospheric correction of ocean color observations are supposed to do?

→ provide the water-leaving reflectance in the blue with a 5% accuracy for an oligotrophic ocean (e.g., Gordon 1997) (i.e., when the marine signal is maximum in this spectral domain)

To reach this goal, it has been shown that multiple scattering effects have to be accounted for in some way (Gordon, 1997)

So: the central difficulty is to determine these effects in the visible, based only on the measurements that are performed in the near infrared, because we have no contribution from water in this part of the spectrum.
The MERIS algorithms are using the same basic principles than other algorithms, i.e.,

- Using 2 near infrared bands (where there is no marine signal) to determine an aerosol model and the AOT

- Use this model to extrapolate the signal to the visible and then perform the correction of the visible bands. This is just one practical way to account for the multiple scattering effects.

These algorithms have however some specific features, i.e.,

- They use of the \([\rho_{\text{path}} / \rho_r]\) ratio instead of the \([\rho_{\text{path}} - \rho_r]\) difference.

- They include a capability to cope with absorbing aerosols

**Note:** the Case 1 waters algorithms are used above Case 2 waters, after the “bright pixel atmospheric correction” (BPAC) has removed the marine contribution in the near IR bands (performance not guaranteed at the end).
A preliminary study, based on Monte Carlo simulations of the radiative transfer, was performed (Antoine & Morel, 1998, Applied Optics).

It included a detailed study of the aerosol-Rayleigh coupling term, and an assessment of the correctness of the usual signal decomposition.

Using the $[\rho_{\text{path}} / \rho_r]$ ratio instead of the $[\rho_{\text{path}} - \rho_r]$ difference was considered more physically meaningful.

In addition, it would be less sensitive to calibration errors.
MERIS Atmospheric corrections over Case 1 waters:
Basic scheme for the identification of the aerosol model

These relationships are stored in LUTs, under the form of 2nd order polynomials. One polynomial for each ensemble: wavelength, geometry, aerosol model.
The LOV “breadboard” : code developed at LOV and used for initial test and sensitivity studies, as well as for comparison with the two other implementations:

MEGS : the “prototype”, produce by ACRI-st, from the breadboard LOV and the “detailed processing model” (DPM) document. Latest version is 7.4.1.

IPF : the “instrument Processing Facility”, i.e., the operational ground segment. Produced from the “detailed processing model” (DPM) document. Latest version is 5.0.1.
Latest implementation of the aerosol look up tables (MEGS 7.4.1 & IPF 5.01)

34 Aerosol models:

- 13 “SeaWiFS-like”, i.e., Shettle & Fenn 1979 models:
  - 5 maritime models (one being a very “flat” model)
  - 4 coastal models (RH 50%, 70%, 90%, 99%)
  - 4 rural models (RH 50%, 70%, 90%, 99%)

- 3 “blue aerosols” (i.e., jünge distributions with steep spectral slopes for the scattering)

- 18 Dust models, as proposed by Moulin et al., 2001 (only used after a specific test has indicated the possible presence of absorbing aerosols)
Comparison with algorithms of the other major ocean color missions (IOCCG working group; Menghua Wang, chairman). Based on simulated data.

Error in the water-leaving radiance at 443 nm, for a standard maritime atmosphere (maritime model for RH=80%), optical thickness=0.1. ±5%
MERIS validation at the MOBY site
(LOV breadboard results)

$y = 1.0412x + 2E-05$

$R^2 = 0.9861$

All points for the wavelengths 620, 665, 681 and 708 nm
These light blue bars represent an error of about +/- 2 \(10^{-4}\) in terms of reflectance, centred onto the 1:1 line.
An example of validation (BIOSOPE cruise in the southeast Pacific gyre)
Using Level-2 products from the prototype MEGS 7.4.1

Irradiance reflectance
(R=E_u/E_d) ~15%!
Specific implementation to cope with the absorbing aerosol issue:

Basic concept is simple:

1- Perform a first-step atmospheric correction using the set of 16 non-absorbing aerosols (maritime + coastal + rural + blue)

2 — Determine an error budget at 510 nm, based on the computed path reflectance and an average (or a climatological value) of the reflectance at 510 nm (hinge point of the reflectance spectrum, where the reflectance is the less varying, whatever the chlorophyll concentration)

3 — If the test shows a significant overcorrection (i.e., error budget < threshold), it is supposed to indicate the presence of absorbing aerosols.

4 — The 18 dust models (Moulin et al., 2001) are then scanned.
Examples of dust detection
(From Nobileau & Antoine, 2005)

SeaWiFS

SeaWiFS

MERIS

True color classification AOT(865 nm)

Dust
Clouds (ICE_HAZE flag)
Maritime
Examples of absorbing aerosols Detection, including dust, smoke and volcanic ash (From Nobileau & Antoine, 2005)

SeaWiFS data

True color classification

- Dust
- Clouds (ICE_HAZE flag)
- Maritime
Application to 7 years of SeaWiFS data over the Mediterranean (Antoine & Nobileau, 2006, JGR-Atmosphere, in press)

Frequency (%) of dust detection on a seasonal basis, from 1998 to 2004.
Results are encouraging, yet the MERIS revisit, combined to the glint problem, makes the study of rapidly varying phenomena a bit problematic...
Conclusions

- The MERIS atmospheric correction algorithm is of the same “family” than other algorithms previously developed for other missions (SeaWiFS, MODIS, POLDER...). It has some peculiarities, however (e.g., absorbing aerosols).

- It has been peer-reviewed, and is published in the open literature.

- It has been compared to the algorithms developed for SeaWiFS, OCTS, MODIS & POLDER, showing the same performance.

- The breadboard implementation at LOV is validated and shows excellent validation results (especially considering the fact that MERIS is not vicariously calibrated). Degraded performances are essentially observed in conditions that are not those for which it has been developed, i.e., in coastal waters where the so-called “bright pixel atmospheric correction” (BPAC) might sometimes fail.

- Some problems have been recently identified in the prototype implementation (therefore as well in the IPF), for instance in the aerosol lookup tables. These problems are likely explaining most of the discrepancies that are presently observed between prototype or IPF products and in situ measurements (cf. validation presentation on Thursday morning).
Conclusions, continued..

Two main directions to follow:

1 – Identify and correct the problems in the implementation.

2 — Improve the “algorithm environment” and some aspects of its implementation. Indeed, the performance of the MERIS atmospheric corrections are meeting the requirements in most cases, yet they could be further improved:

- Better glint correction
- White caps correction.
- Transmittance calculations can be improved (no approximation: using RT LUTS)
- Extrapolation from the near IR to the visible (better aerosol models ? Spectral change of the “mixing ratio”? Use of a third band — 753 or 709 - to confirm the selection of the aerosol model that is based on the 779-865 couple ? etc. ....)
- Improved aerosol data bases for the specific case of absorbing aerosols (different types of absorbing aerosols as a function of the sources regions)
- Improved climatology for the average reflectance at 510 nm
- Including polarization into the aerosol lookup tables as well (for the moment, it is only accounted for in the Rayleigh LUT).

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References

Peer-reviewed ATBD:
Antoine, D., and A. Morel, 1997, Atmospheric correction over the ocean (Case 1 waters), MERIS ATBD 2.7, ESA/ESTEC contract N° 11878/96/NL/GS, november 1997, 110 pp. Revised in Dec 2005

Papers in the open literature:


- Antoine D. and D. Nobileau, 2006, Recent increase of the dust load over the Mediterranean Sea, as revealed from 6 years of ocean color satellite (SeaWiFS) observations, *Journal of Geophysical Research, Atmosphere*. In press.
Thank you...