VALIDATION OF THE MERIS ATMOSPHERIC CORRECTION OVER OCEAN USING AERONET

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INTRODUCTION

Validating the atmospheric correction mainly over coastal water areas requests an '*atmospheric*' approach. Both the atmosphere and the water body present very complex and variable optical properties. By looking at water surfaces in a cloud-free scene acquired with an optical sensor such as MERIS, we observe more likely the pattern of the ocean colour rather than the spatial variability of the aerosols. Therefore, why not to use the atmospheric optical measurements rather than the marine optics?

It is clear that the atmospheric correction cannot be validated only with through in-situ measurements of the aerosol optical thicknesses (AOTs). Validation of the atmospheric correction passes also by a well estimate of the atmospheric scattering components. The diffuse atmospheric transmittance can be directly provided by the sky radiance measurements. The aerosol reflectance at top of the atmosphere (TOA) can be estimated with the acquisition of the sky radiance at the same scattering angle as for the sensor/view geometry, in order to well predict the primary scattering. The introduction of the multiple scattering requires more, with the aerosol phase function (APF) and the AOT. The full protocol of the validation scheme for the atmospheric correction over ocean is described hereafter.

Both in-situ measurements and MERIS level-2 data extracted from MERMAID over the AAOT site (Acqua Alta Oceanographic Tower, Venice - Italy) is employed to illustrate the methodology in a direct comparison between marine reflectances derived from the MERIS ESA Ground-Segment (MEGS) processor and extracted with an atmospheric correction based on the characterization of the inherent optical properties (IOPs) of the aerosols at the time of MERIS overpass.

THE STANDARD APPROACH

The MERMAID database focuses on the retrieval of the water reflectance. Nevertheless, the spatio-temporal variability of the water colour in coastal areas makes difficult this approach. Complementary to this, the retrieval of the AOT is an indicator of the potential performance of the atmospheric correction. In MERMAID, the comparison was initially brought on the AOT in the near-infrared (NIR) region. More recently, MERMAID included the visible part of the spectrum. The comparison on the AOT at 779 and 870 nm stresses, first an important bias, and second a large dispersion (Figure-1). The latter results from the large dispersion observed in the APF (P_a) as reported in [1].

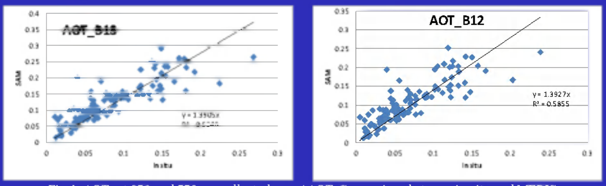
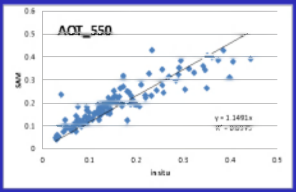


Fig. 1: AOTs at 870 and 779 nm collected over AAOT. Comparison between in-situ and MERIS.



The AOT at 550 nm is extracted from the MERIS L2 product. AERONET provides the AOT at 440 and 675 nm from which we interpolate at 550 nm.

The AOT describes the extinction which gives the attenuation of the light propagation in the atmosphere on the direct to direct path. The atmospheric correction involves the scattering functions which are not measured. Consequently we use the sky radiance measurements.

A NEW APPROACH FOR VALIDATION

We do not validate here, neither the gaseous correction and nor the Sun glint correction. Therefore, we use the TOA reflectance after gas and glint correction as provided in MERMAID.

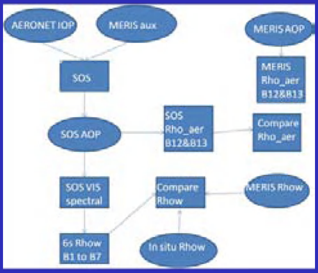
The 5S formalism $\rho_{TOA} = \rho_{atm} + \rho_w T(\theta_s)T(\theta_v)$ is used to perform the atmospheric correction. ρ_{TOA}, ρ_{atm} and ρ_w are respectively, the reflectance of water target at TOA, the intrinsic atmospheric reflectance and the in-situ water reflectance, and $T(\theta_s)$, the total (direct + diffuse) downward atmospheric transmittance corresponding to the ratio of the BOA to TOA irradiances for the solar zenith angle (θ_s) measured over a dark water body including the *Fresnel* reflection. $T(\theta_v)$, the total upward atmospheric transmittance, represents (following the principle of reciprocity) the ratio of the BOA to TOA irradiances for the view zenith angle (θ_v) measured over a dark water body ignoring the *Fresnel* reflection.

AERONET provides at 440 nm (B2), 675 nm (B7) and 870 nm (B13) the AOT and P_a. The barometric pressure and the wind-speed are auxiliary data for MERIS. Using these inputs, the successive order of scattering (SO) code is used, first to compute ρ_{atm} and $T(\theta_s)$, and second to calculate $T(\theta_v)$ in the 3 reference bands. These runs are also completed for the pure *Rayleigh* case with ρ_R, $T_R(\theta_s)$ and $T_R(\theta_v)$. Combining these 2 sets of computations, we get ρ_{aer}, $T_{aer}(\theta_s)$ and $T_{aer}(\theta_v)$ in the 3 CIMEL bands. A spectral interpolation in *Log-Log* is then achieved to get ρ_{aer}, $T_{aer}(\theta_s)$ and $T_{aer}(\theta_v)$ in all the MERIS bands.

In addition, the direct Sun glint component is also computed with the attenuation on the direct to direct path, as provided by the CIMEL extinction measurements.

MERMAID also provides in all these MERIS bands ρ_R, ρ_{aer}, $T(\theta_s)$ and $T(\theta_v)$ for the comparison.

Moreover, by using the 5S formalism and the CIMEL atmospheric functions, the water reflectance can be also predicted as $\rho_{TOA} - \rho_{ray} - \rho_w T(\theta_s)T(\theta_v)$ It will be compared to the MERIS one.



Upper left: The AERONET aerosol IOP and the barometric pressure and wind-speed are used to compute the atmospheric functions in the 3 reference spectral bands.

Lower left: The SO derived aerosol optical properties (AOPs) are interpolated at the MERIS nominal wavelengths. Then, by using the 5S formalism, the water reflectance is computed and compared both with the MERIS L2 product and the in-situ data reported in MERMAID.

Upper right: The MERIS derived AOPs are used to compute ρ_{aer} for comparison with the SO predicted value.

Acknowlegments

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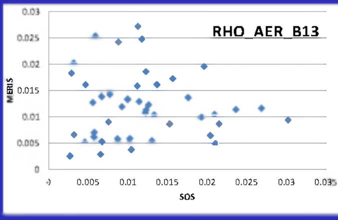
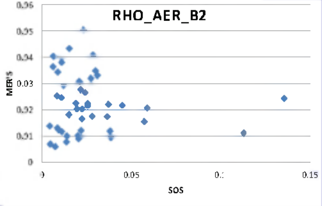
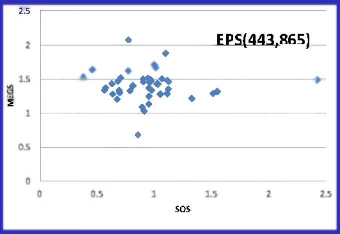
COMPARISON ON THE ATMOSPHERIC REFLECTANCE

The SO aerosol reflectances values are computed using as inputs the AERONET AOTs and aerosol phase functions at 440, 675 and 870 nm. We can directly compared them with the MERIS ones in B2, B7 and B13. Results displayed in Figure-2 stress that the MERIS aerosol reflectances in B13 can be retrieved but with a large dispersion associated with the natural large dispersion of the aerosol, as it was noticed in [1]. Obviously, the same dispersion also also appears in MERIS B2 but MERIS seems to overestimate the aerosol reflectance at TOA.

At AAOT, we are mainly in the case-2 waters for which the bright pixel atmospheric correction (BPAC) is applied before to proceed by the analysis of the atmospheric reflectance. A bad retrieval of the water reflectance in the NIR region clearly impacts on the aerosol model retrieval.







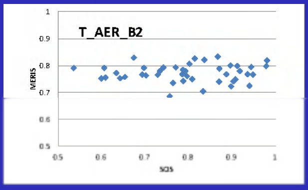
In terms of atmospheric correction, the key issue is to be able to predict the aerosol reflectance in the visible part of the spectrum from its NIR determination. The spectral dependence in *Log-Log* of the aerosol reflectance is described by the ε coefficient.

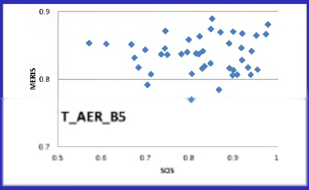
Clearly, MEGS overestimates the evaluation of the aerosol reflectance in the blue region. It was reported as well in [1] based on the aerosol IOPs and on the single scattering approximation.

COMPARISON ON THE ATMOSPHERIC TRANSMITTANCE

The atmospheric transmittance in the visible domain is mostly attributed to the *Rayleigh* scattering. We isolated the aerosol transmittance from our comparison between the MERIS and SO estimates based on the AERONET measurements.

It clearly appear that our prediction of the attenuation by the aerosols is by far stronger than what MERIS predicts.

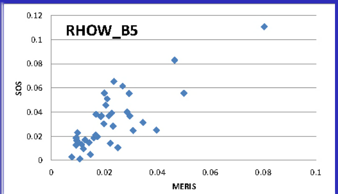




COMPARISON ON THE WATER REFLECTANCE

The 5S formalism is used to perform the atmospheric correction. The MERIS input is the MERMAID TOA reflectance after correction for the Sun glint and for the gaseous absorption. The atmosphericfuntions are computed as described above.

The comparison in MERIS B5 suggests that MEGS slightly over-corrects.



CONCLUSION

We proposed here a new approach to validate the atmospheric correction over water. This method is firstly based on the experimental determination of the aerosol IOPs thank to AERONET. Secondly, we use the SO radiative transfer code to predict at the time of MERIS overpass all the atmospheric functions required in the MEGS atmospheric correction procedure.

This protocol is applied here to the validation but it can be used as well for the vicarious calibration.

The results reported here, are more an illustration of the methodology than a quality assessment on the MERIS atmospheric correction. This protocol should be validated and extended to the other AERONET Ocean Colour stations in order to make a significative analysis which separates the type of aerosols and the ranges of the scattering angle.

As indicated in a companion poster, we have in mind to test the new aerosol models, and this approach of the validation can be used to evaluate the performances of the atmospheric correction.

References

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