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Estimating aerosol altitude from reflectance measurements in the O_2 A-band

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INTRODUCTION

The vertical distribution of absorbing aerosols affects the reflectance of the ocean-atmosphere system. Previous studies have shown the impact of the aerosol vertical structure on performance of standard atmospheric correction algorithm in ocean-color studies (Gordon et al., 1997). A methodology is presented to estimate aerosol altitude from reflectance ratio measurements in the O_2 absorption A-band, i.e., in spectral bands centered around 760 nm.

The methodology is applied to MERIS imagery acquired in July-August 2004 over the western Mediterranean Sea during the AOPEX experiment (Antoine et al., in preparation). Estimates of aerosol altitude are compared with lidar profiles of backscattering coefficient.

I- DATA AND MODEL

Radiative transfer modeling: GAME code

O_2 gaseous absorption: line-by-line calculations (Dubuisson et al., 1996), at high spectral resolution (Figure 1), using the HITRAN 2004 spectroscopic database.

Multiple scattering: Adding Doubling Method (De Haan et al., 1988)

Atmosphere: Verticaly inhomogeneous atmosphere stratified into plane and homogeneous layers; Rayleigh and aerosol scattering

Interaction Surface / Atmosphere: Specular reflection, sea surface roughness (Duforêt et al., 2004)

BOUSSOLE-AOPEX 2004 Measurements

Lidar in situ measurements: profiles of backscattering coefficient (Voss et al., 2001)

Surface pressure measurements

MERIS reflectances and products

Aerosol Optical Thickness (AOT): available from MERIS products and sun photometer measurements

II- ESTIMATE OF AEROSOL ALTITUDE

In the spectral range of the oxygen A-band (759 to 770 nm), the reflected solar radiation measured at the top of the atmosphere depends on oxygen absorption, surface reflectance and vertical distribution of scatterers. Atmospheric absorption can be estimated from a reflectance ratio, defined as the ratio of the reflectance in a first spectral band at 761 nm, strongly attenuated by O_2 absorption, to the reflectance in a second spectral band at 753 nm, minimally attenuated. The MERIS instrument has adequate spectral properties in the spectral range of the oxygen A-band (Figure 1) (Dubuisson et al., 2001).

Simulations have shown a relation between the altitude of an aerosol layer and the reflectance ratio in the oxygen absorption spectral range (Figure 2). For a moderately loaded atmosphere (aerosol optical thickness of 0.3 at 550 nm), the expected accuracy on aerosol altitude is about 0.25 km with MERIS data. Accuracy is better when multiple scattering is less effective, i.e., in the presence of absorbing aerosols.

Look-up tables that relate reflectance ratio to aerosol altitude have been generated with the GAME code for a wide range of solar and viewing angles. The methodology is applied to MERIS imagery.

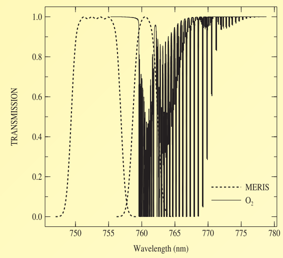


Figure 1: Transmission in the oxygen A-band calculated with a line-by-line model (solid line); MERIS spectral response (dashed line) .

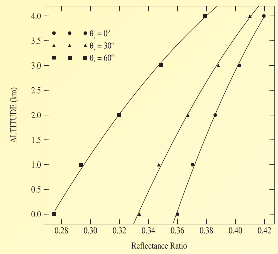


Figure 2: Altitude of an aerosol layer as a function of the reflectance ratio (761 nm / 753 nm) simulated for the MERIS instrument.

IV- *In situ* COMPARISONS

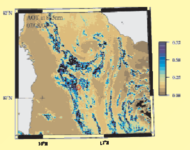
Four situations have been selected to evaluate the method. Retrieved aerosol altitude and *in situ* Lidar profiles of backscattering coefficient are presented. These data have been acquired during the BOUSSOLE-AOPEX 2004 experiment, in July-August 2004 over the western Mediterranean Sea.

Situations are described in the following table:

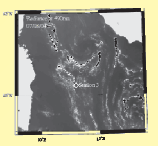
Date	MERIS AOT	LIDAR AOT	
7 August 2004	0.11 at 9H45	0.33 at 9H35	|
		0.17 at 9H45	|
		0.12 at 9H55	|
10 August 2004	0.3 at 9H45	0.21 at 9H35	|
		0.22 at 9H45	| Clear atmosphere
		0.28 at 9H55	| with aerosols
16 August 2004	0.2 at 9H45	0.26 at 9H35	|
		0.35 at 9H45	|
		0.31 at 9H55	|
31 July 2004	Not available	Not available	> Cirrus clouds

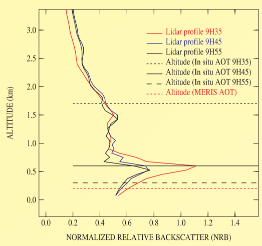
07 August 2004

Aerosol Optical Thickness



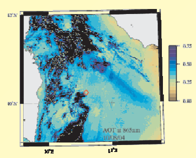
Reflectance at TOA



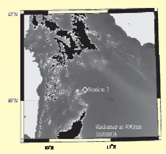


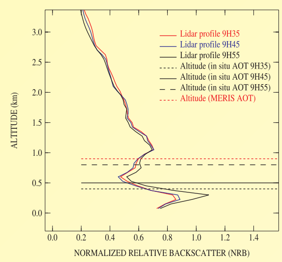
10 August 2004

Aerosol Optical Thickness



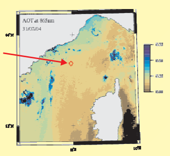
Reflectance at TOA



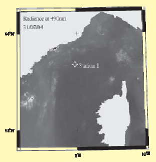


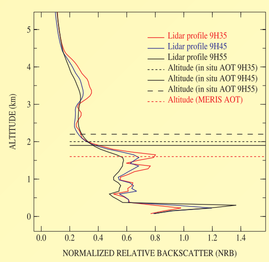
31 July 2004

Aerosol Optical Thickness



Reflectance at TOA





Comments:

Aerosol Optical Thickness (AOT) at 865 nm and reflectance measured with MERIS at 490 nm are presented for the selected dates.

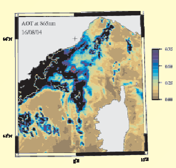
Lidar profiles of backscattering coefficient are reported with the aerosol altitude retrieved from the O_2 reflectance ratio.

Coherent altitudes are obtained for the four situations. The retrieved method is sensitive to the vertical distribution of scatterers.

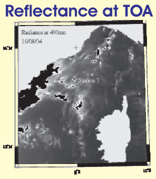
Important influence of the AOT on the method is observed. Cirrus clouds have a strong impact on the retrieval.

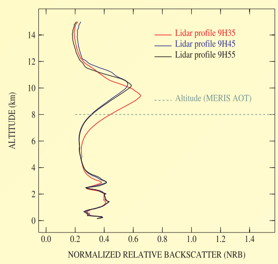
16 August 2004

Aerosol Optical Thickness



Reflectance at TOA





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CONCLUSION

The results demonstrate the potential of the differential absorption methodology for obtaining information on aerosol vertical distribution. Using this information in atmospheric correction algorithms may improve the retrieval of marine reflectance in the presence of aerosols (Duforêt et al., in press).

Additional evaluations are needed with concurrent measurements of Lidar profiles and near-infrared imagery. In this context, the data of the A-train will provide such evaluation. Indeed, the POLDER sensor, aboard PARASOL, has adequate spectral properties in the oxygen absorption band. In addition, the CALIOP lidar, aboard CALIPSO, allows backscattering profile measurements.