Fine aerosols and the performance of a dust correction algorithm in the Mediterranean

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1. The Spectral Matching Algorithm

The presence of dust aerosols can interfere with ocean color satellite data retrieval. To compensate for dust aerosols, the spectral matching approach was developed (Gordon et al., 1997). SMA simultaneously computes for in-water and aerosol properties. The current implementation selects from a suite of 18 candidate Saharan dust models (a combination of 3 size distributions by 3 dust column heights by 2 absorpton indices) using a "best fit" test (Moulin et al., 2001 b). SMA has been shown to significantly reduce spatial and temporal gaps in SeaWIFS images off the North African Atlantic coast and in the Arabian Sea (Moulin et al., 2001a; Banzon et al., 2004). On dusty days, SMA yields results that are statisitically similar to STD values under non-dusty conditions. But it has been difficult to find sufficient situ data to make a more thorough evaluation of when the SMA error is smaller than the of standard processing (STD).

2. Objective of study

Our objective was to assess the effectiveness ofSMA in retrieving water-leaving radiances in SeaWIFS imagery during dust events in the Mediterranean using data from the BOUSSOLE project. We also wanted to determine what atmospheric parameters could be used as criteria for selecting which pixels SMA processing would be appropriate.

3. The BOUSSOLE project and the AOPEX cruise

The ESA-CNES-NASA-funded BOUSSOLE project aims to collect a long time series of in situ data for ocean color cal/val. Under the framework of the BOUSSOLE project, bio-optical measurements have been collected almost continuously from 2003 at a fixed buoy location (Fig. 1 a). Ship-based measurements are also made during quasi- monthly cruises. One such cruise hosted the Advanced Optical Properties Experiment (AOPEX). This dataset presents an opportunity to examine SMA application over a window in time when water properties were relatively constant. Moreover, AERONET data is collected in Villefranche, along the coast near the buoy site (Fig, 1a).

The AOPEX cruise (July 30-Aug 16, 2004) focused on 2 sites:

1) the BOUSSOLE site (or briefly, Sta. B) is where the fixed buoy is located (Fig. 1 a). The ship was in Sta. B from July 30-Aug. 4, and Aug. 10-16.

2) the Tyrhennian Sea (or in short, Sta. T) where only SPMR data was collected from Aug. 5-9 (Fig. 2 a).

Two dust events with rather different characteristics occurred during AOPEX (Fig. 3).

4. AERONET DATA

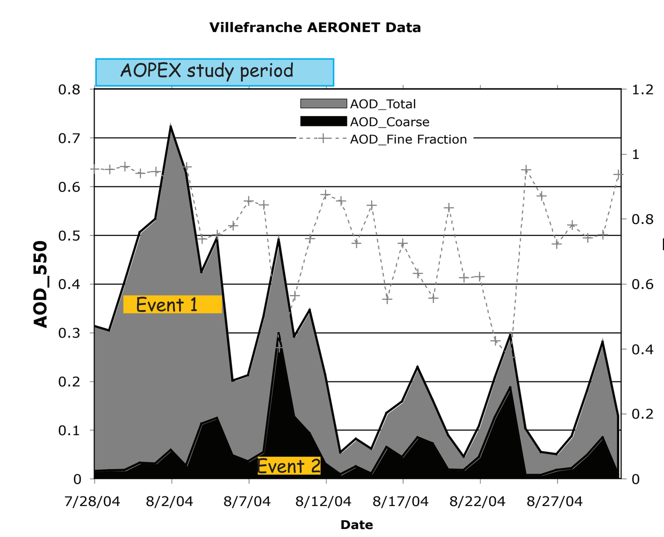


Figure 3. AERONET total and coarse aerosol optical depth (AOD) referenced to 550 nm. During AOPEX, the total AOD was high during the two dust events but coarse (dust) particles dominated only on one day (Aug. 9). Post AOPEX, coarse aerosol dominance was also rare and brief in duration.

AERONET data at Villefranche shows that coarse (dust) particles were rarely dominant at the buoy site, even during the two dust events observed during AOPEX (Fig. 3). These size distributions do not match those used in SMA, which instead have a larger coarse-particle fraction. Only the size distribution of Aug. 9 (Day 222) is similar to that of the Saharan dust models in SMA.

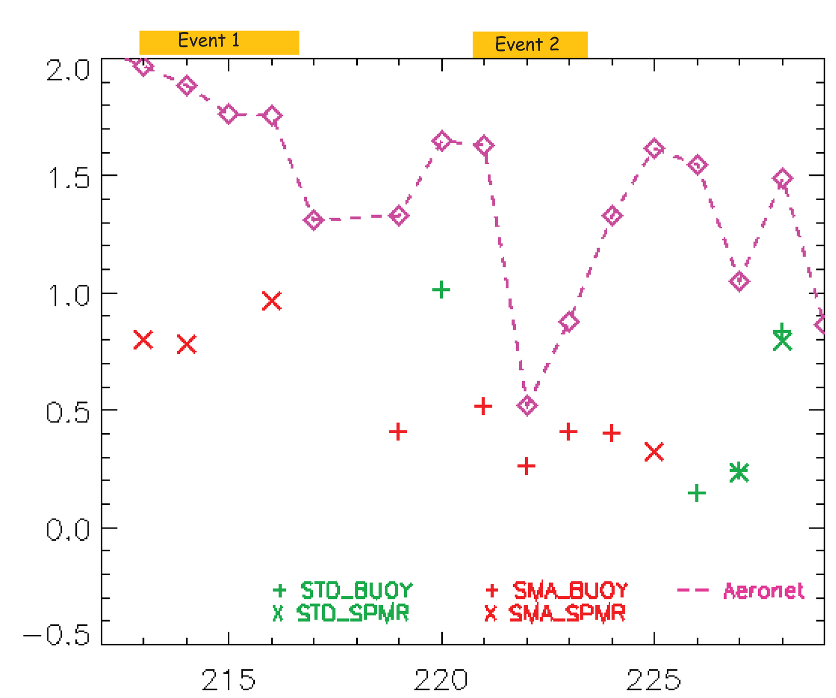


Figure 4. Daily mean Angstrom exponent (500_870 nm) at the AERONET station, and the SeaWIFS angstrom exponent (510 nm) in Sta. B at the buoy and ship locations. Lower values are associated with coarse aerosol size (and thus, dust).

The angstrom exponent (Fig. 4) is a good indicator of the mean aerosol size, but it is computed from the ratio of aerosol optical thickness at two wavelengths, and is thus subject to the error in estimating those quantities. AERONET measures AOT from the ground while the downward-looking SeaWIFS value is derived by assuming an aerosol model. Thus, one might expect a smaller error in the ground-based estimate.

5. Dust layers and sources

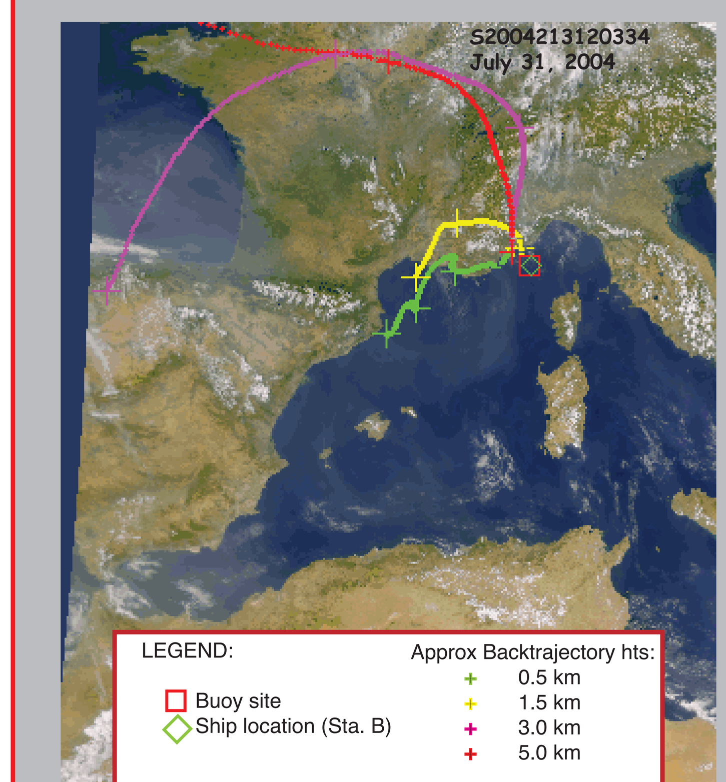


Figure 1. a) SeaWIFS truecolor image representing the first dusty period during AOPEX. Crosses show daily position at 1200 GMT of backtrajectories from the Villefranche AERONET station.

The first event was apparent as a thin haze in the SeaWIFS truecolor images (Fig. 1 a). LIDAR data (Fig. 1 b) and backtrajectories derived from AERONET (Fig. 1 a) indicated that the lower aerosol layer came from local aerosol sources while the upper layer was traced to the North Atlantic within the past 4 days, an ultimately back to the African coast after an additional 2-3 days. In subsequent days, highly backscattering layers also appeared to have African origins but clouds were also present.

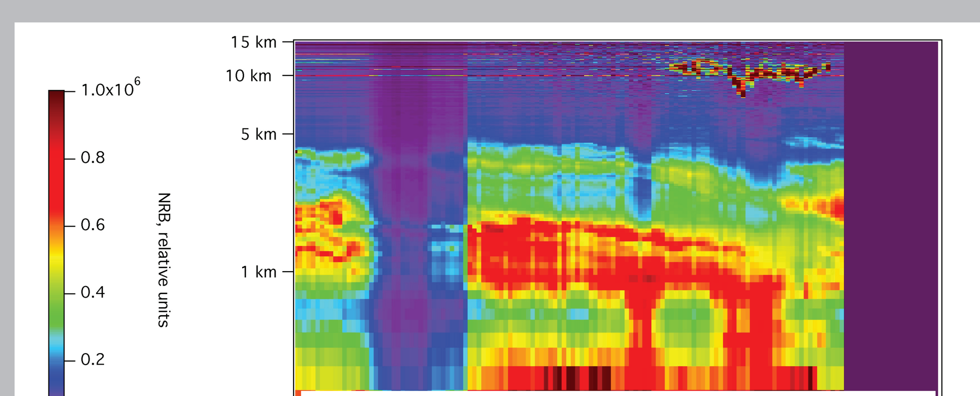


Figure 1. b) LIDAR backscatter shows a distinct aerosol layer at 4 km and other layers between 1-3 km height

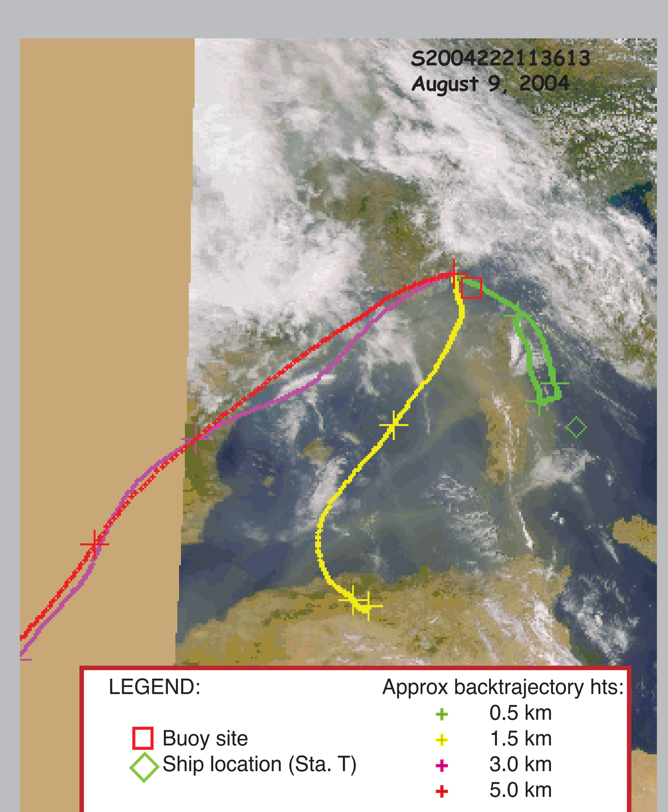


Figure 2. a) SeaWIFS truecolor image showing peak of second dust event. Crosses mark daily position at 1200 GMT for backtrajectories from the Villefranche AERONET station

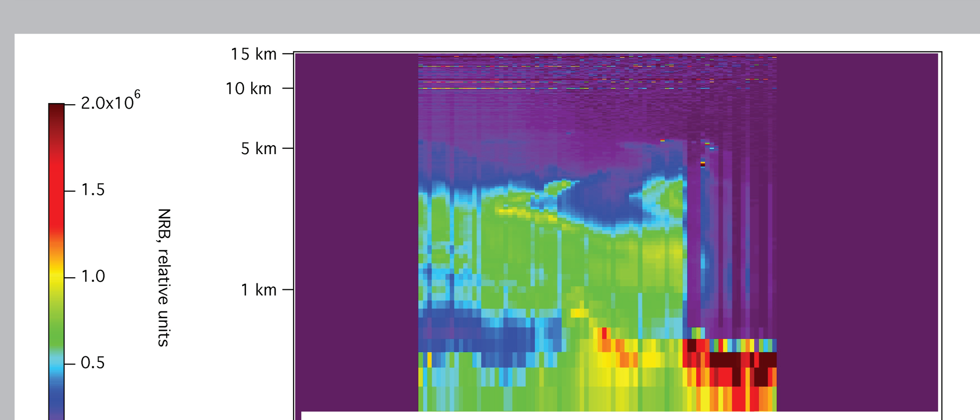


Figure 2. b) LIDAR backscatter indicates high aerosol concentrations at around1-4 km altitude. Note color scale diference with respect to Fig. 1 b.

The second event was characterized by a more turbid atmosphere and distinct brown haze in the truecolor images (Fig. 2 a). Backscatter was quite high at 1-3 km altitude (Fig. 2 b). AERONET backscatter trajectories indicate aerosols above 1 km originated from Tunisia and Morocco within the past 2 days (Fig. 2 a).

6. Matchups

At the BOUSSOLE site, the STD retrievals generally provided good matches to the in situ data (buoy and SPMR) though positive biases did occur during the dust events. SMA produced a reasonable matchup at the peak of the second dust event on Aug. 9 when the STD method did not produce a result(Fig. 5 a). The rest of the time SMA had greater biases.

Since the atmospheric data indicated a significant fine component (Fig. 3 and 4), the spectral optimization algorithm (SOA; Chomko and Gordon, 1998), which can correct for the presence of industrial type aerosols, was applied on selected days. SOA was found to generally perform much better than SMA and STD (Fig. 5 a).

At Sta. T, SPMR measurements were made on only 5 days so a satellite-derived time series was used added as reference, i.e., the STD retrievals at a fixed location (Fig. 5 b). Like in site B, SMA produced retrievals within a standard deviation of the in situ mean only at the maximum of the second dust event.

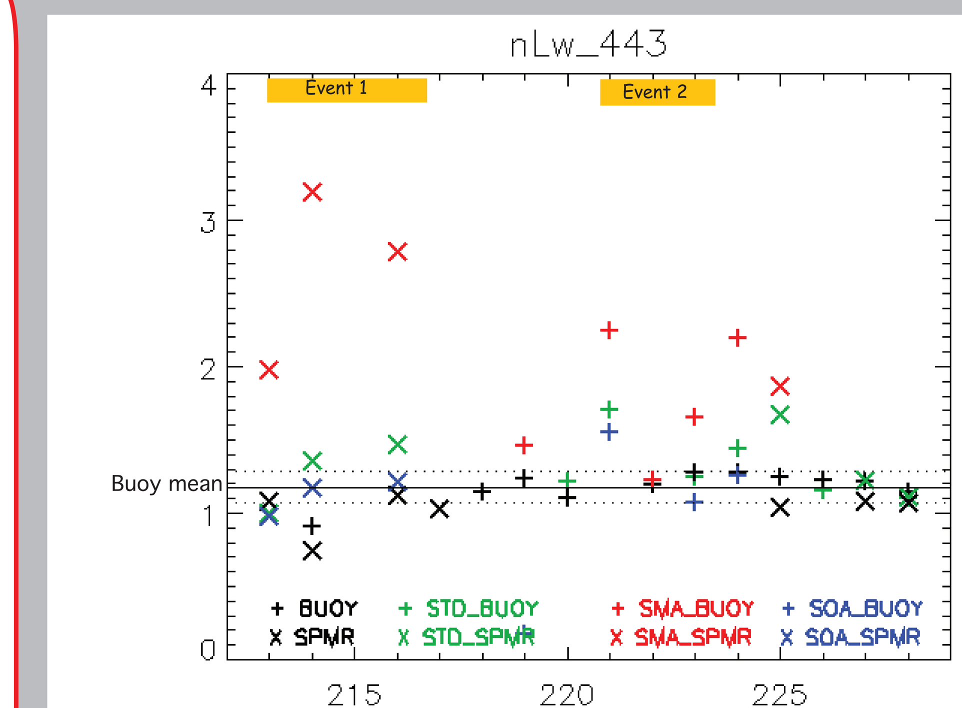


Figure 5 a). SeaWIFS matchups at Sta. B. SMA is the dust-correction algorithm, while SOA can compensate for pollution-type aerosols.

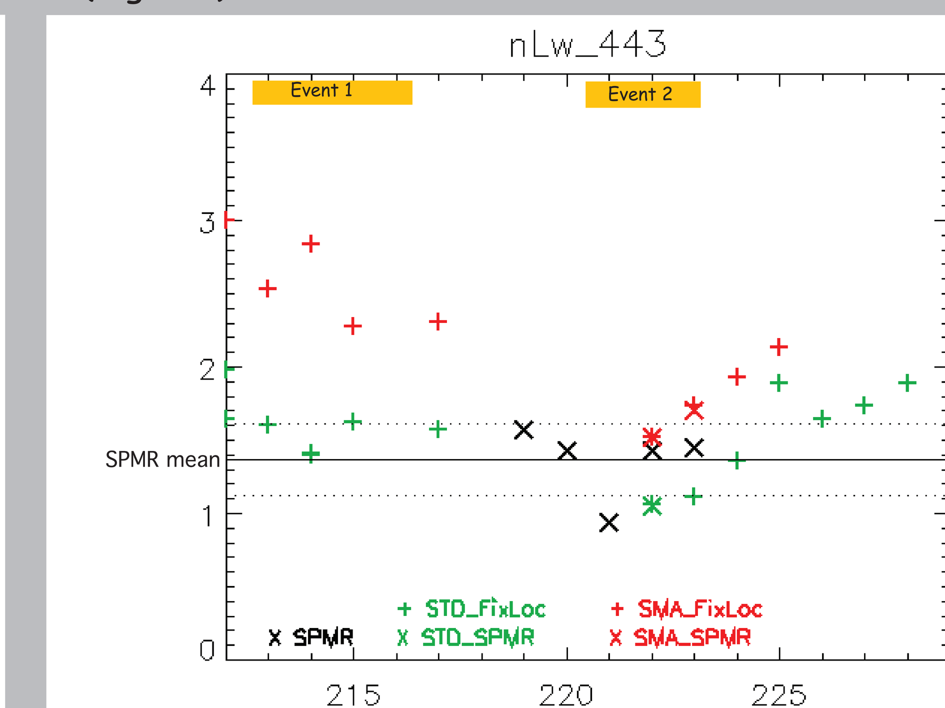


Figure 5 b). SeaWIFS matchups at Sta. T.

7. Criteria for algorithm selection

The satellite-insitu difference was plotted against a number of atmospheric variables. The best relation was with the AERONET angstrom exponent (Fig. 6). SMA bias was minimal at when the Angstrom exponent was below 0.5. Such low values are typical at the AERONET Cape Verde station off Africa in summer during the dusty season. STD bias was consistently within 10% of the in situ value at the Angstrom exponent range of 0.8-1.4. The potential for using this parameter is evident if one compares the angstrom_510 distributions on July 31 and Aug. 9, 2004 (Fig. 7).

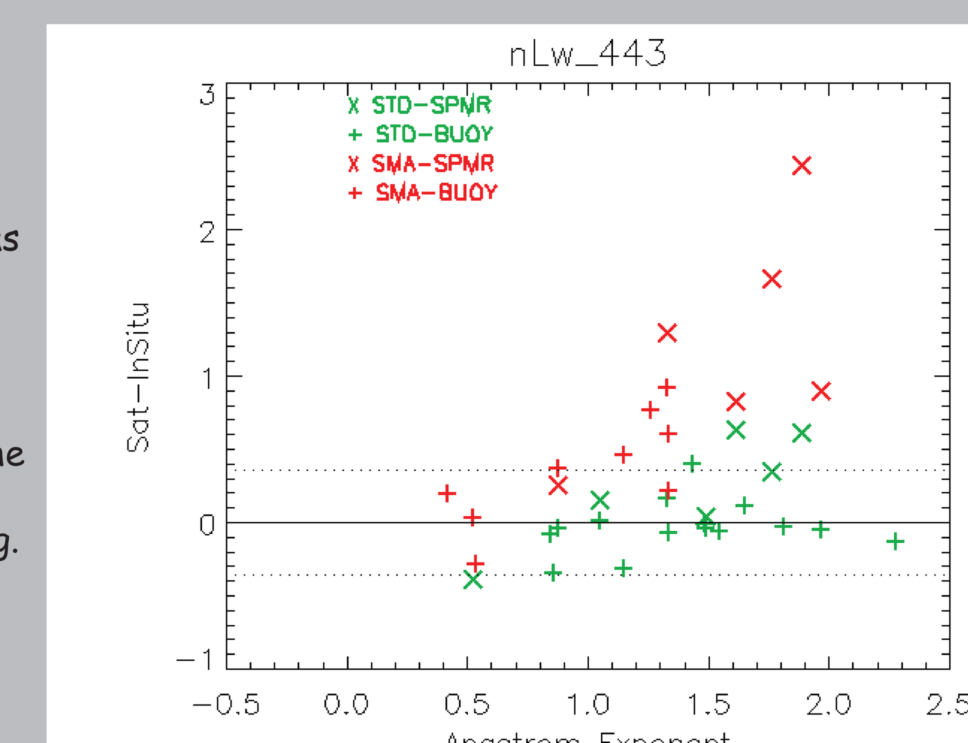


Figure 6. Relation of SMA and STD processing error to the AERONET Angstrom exponent. Data shown includes matchups for all ofAugust 2004.

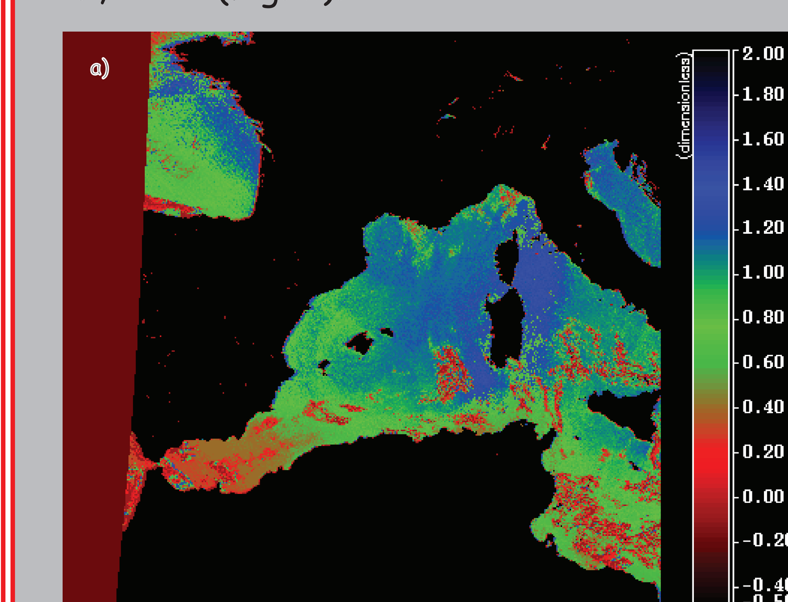
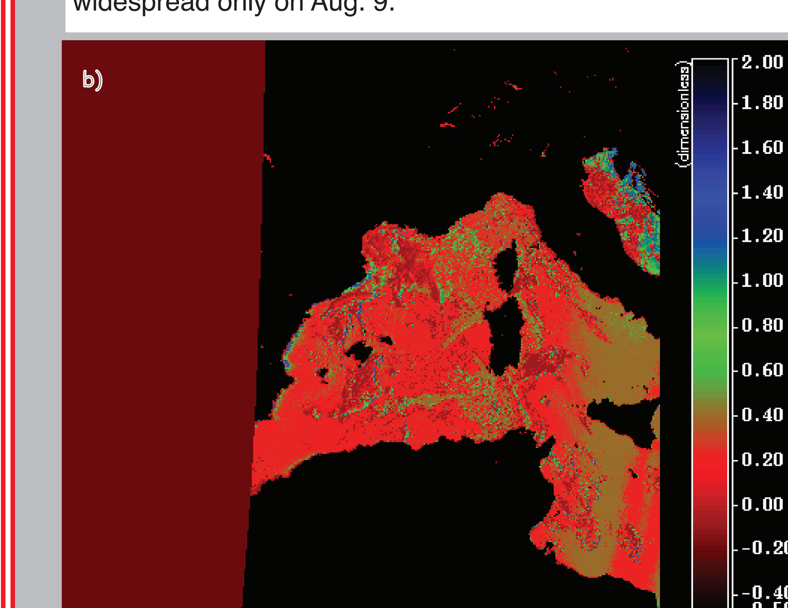


Figure 7 SeaWIFS Angstrom exponent (510 nm) for a) July 31, 2004 and b) August 9, 2004. Values are below 0.4 are widespread only on Aug. 9.



8. Summary and Conclusions

Although dust events are common in the Mediterranean Sea, the aerosol size distribution integrated over the atmospheric column may not be similar to that typical of pure Saharan dust plumes due to the presence of fine aerosols from more local sources. During the AOPEX study period, SMA results were reasonable only when the AERONET Angstrom exponent was below 0.5. This parameter could be used as a criteria for selecting when to apply the absorbing aerosol algorithms like SMA, but an iterative approach would be required since the initial aerosol model assumptions used in estimating it may not be valid.

Acknowledgements

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References

Banzon et al. (2004) Deep Sea Res. II, 51: 189-208.
Chomko and Gordon (1998) Applied Optics 37 (24): 5560-5572.
Gordon et al. (1997) Applied Optics 36 (33): 8670-8684.
Moulin et al. (2001 a) Geophys. Res. Lett. 28(1): 5-8.
Moulin et al (2001 b) J. Geophys. Res. 106 (D16): 18239-18250.