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DETECTION AND QUANTIFICATION OF SAHARAN DUST OUTBREAKS USING OBSERVATIONS FROM SEVIRI ON METEOSAT-8

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ABSTRACT

The current operational algorithm used to retrieve aerosol optical depth and Ångström exponent over ocean from the solar reflectance bands of the Advanced Very High Resolution Radiometer (AVHRR) on the NOAA polar orbiting satellites has been adapted to the corresponding channels of the Spinning Enhanced Visible and Infra-Red Imager (SEVIRI) on the Meteosat-8 geostationary platform. The algorithm was applied to a large Saharan dust event which occurred through 3-5 March 2004 and a detailed description of the dust loading through the diurnal cycle was obtained. Snapshot comparisons with spatially resolved retrievals from the MODerate resolution Imaging Spectrometer (MODIS) instruments on the *Terra* and *Aqua* polar platforms show qualitative agreement with the SEVIRI retrievals. The sensitivity of these retrievals to the assumed aerosol model was tested by replacing the generic model used in the operational algorithm with three specific desert dust representations, and a model derived for non-spherical particles. Comparisons of the diurnal variation seen in the SEVIRI retrievals with available ground based Aerosol Robotic Network (AERONET) observations from the Cape Verde coastal station suggests that the phase functions associated with the three dust representations and, to a lesser extent, the non-spherical model result in unrealistic time dependent behaviour. This tendency is removed when the more generic aerosol representation used in the NOAA/NESDIS algorithm is employed.

RETRIEVAL METHODOLOGY

Acquire SEVIRI images for 0.6, 0.8, 1.6, 7.3, 8.7, 9.7, 10.8 and 12 μm channels along with corresponding geometry and cloud flag information

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Convert visible and near-ir channels to reflectances, mid-ir channels to brightness temperatures and spatially average to 3 x 3 SEVIRI pixels (~ 10 x 10 km^2)

↓

Perform mid-ir dust detection[1] and estimate 0.55 μm optical depth

↓

Add dusty points to nominally clear points identified by MPEF cloud flag[2]

↓

Identify regions of sun-glint and points with solar zenith angles > 60° within 'clear' points and remove

↓

Retrieve visible and near-ir channel optical depths for given solar/view geometry using pre-defined, aerosol specific look up tables (LUTs). Derive Ångström coefficient and scale retrieved values to required wavelengths for comparisons if required.

AEROSOL MODELS

LUT Label	Aerosol model employed
3gen	Monomodal, log-normal size distribution, purely scattering aerosol[3] Used as standard in 3rd generation AVHRR aerosol retrievals
Opac0	OPAC desert model at 0 % relative humidity[4]
Opac99	OPAC desert model at 99 % relative humidity[4]
Des	'Desert-like' aerosol model[5]
Dubovik	Optical properties derived using AERONET retrieval of desert dust size distribution and refractive indices[6] and assuming particles to be randomly orientated spheroids[7]

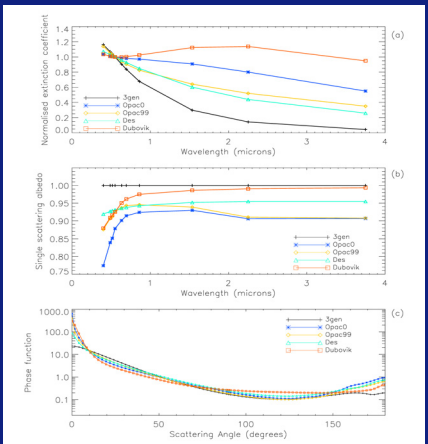

FIGURE 1

Optical properties associated with the aerosol models tested here:

(a) Spectral dependence of normalized extinction coefficient for 3gen, Opac0, Opac99, Des and Dubovik aerosol models.

(b) As (a) for the single-scattering albedo.

(c) Dependence of phase function (normalised at 2π) on scattering angle at a wavelength of 0.63 μm for the five aerosol models.

RESULTS I: SPATIAL CONSISTENCY WITH MODIS

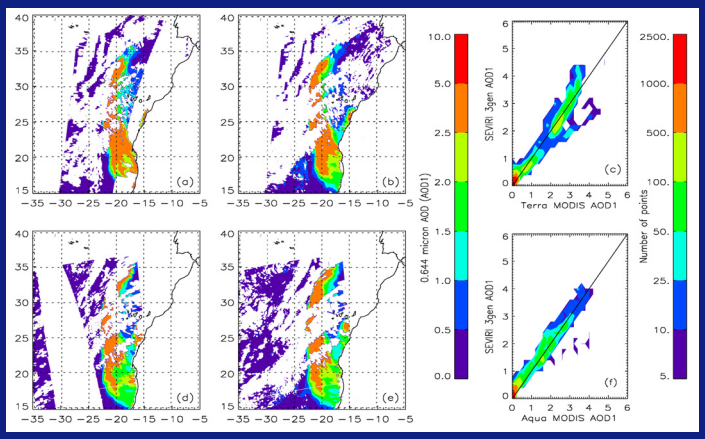

FIGURE 2

Top Row: (a) Aerosol optical depth at 0.644 μm (AOD1) retrieved from 11:50 and 11:55 UTC MODIS (*Terra*) observations on 4th March 2004. (b) AOD1 retrieved from co-temporal and co-spatial SEVIRI observations using 3gen aerosol model. (c) 2-D histogram of the two AOD1 distributions. One-to-one line is shown for comparison.

Bottom Row: As top row, but comparing MODIS (*Aqua*) AOD1 with matched SEVIRI retrievals between 14:50 and 15:00 UTC on 4th March 2004.

RESULTS II: DIURNAL CONSISTENCY WITH AERONET

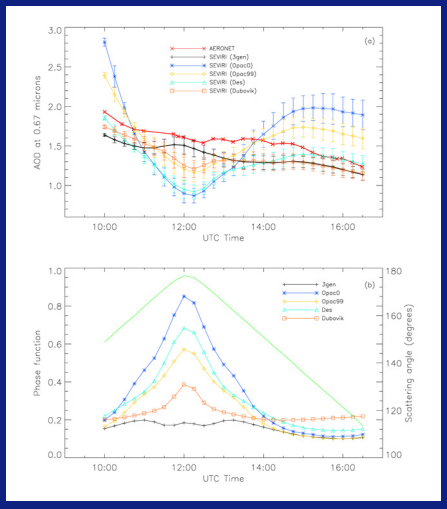

FIGURE 3

(a) Comparison of the temporal evolution of AOD seen at Cape Verde during March 5th 2004 between ground based AERONET measurements and retrievals from SEVIRI using the five aerosol models. Best agreement with the AERONET measurements is seen when the 3gen model is employed.

(b) Dependence of the scattering angle of SEVIRI observations with time (green line). Values of the phase function at the given scattering angle are also shown. The AOD retrievals essentially mirror the phase function behaviour and suggest that the dependence of the phase function on scattering angle in the back-scatter region is too pronounced in the dust specific and non-spherical models.

CONCLUSIONS

• 'AVHRR-like' aerosol retrieval algorithm is now in place and ready for routine use on SEVIRI visible and near-ir channel observations

• Tests on specific dust case studies show the impact of the assumed aerosol model on the retrieval quality. Of the five models considered here, the 3rd generation AVHRR aerosol representation provides the best match to independent observations of the AOD.

• For this model, snapshot comparisons with MODIS retrievals show a mean agreement in AOD of ~ 0.1 at 0.644 μm, although the spatially resolved differences can be substantial (> |2.0|) in optically thick regions (AOD > 4.0). Analysis of the time evolution of the AOD over coastal AERONET sites indicates close agreement between the temporal behaviour of the ground based observations and the SEVIRI retrievals. Absolute values of the ground based and SEVIRI derived AODs also show reasonable agreement although the satellite retrievals show a low bias relative to the AERONET measurements. The level of the former could easily be adjusted through the incorporation of a small absorbing component in the aerosol model, a modification consistent with suggestions in the literature.

• The dedicated desert-like dust models tested here do not capture the temporal behaviour of the AOD, principally due to the strong dependence of their Mie-calculated phase functions on scattering angle in the back-scatter region. A similar, albeit reduced effect is seen when a non-spherical model is used.

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