DETECTION OF SAHARAN DUST BY SPATIAL/SPECTRAL SIGNATURES IN VIS-TIR SATELLITE RADIANCES

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1. INTRODUCTION

Several techniques have been proposed until now in order to characterize dust clouds from satellite observations. They are more or less successful depending on observation conditions (day/night, land/sea, etc.) and specific aerosol properties (mainly size distribution and complex refractive index). In the visible part of solar spectrum dust clouds appear clearly brighter over dark and uniform backgrounds so it is generally easier to describe them over surfaces having low/known visible reflectance, as sea and inland water basins or large vegetated areas [1, 2, 3, 4, 5].

Over poorly vegetated land areas, spatial heterogeneity of optical surface properties, higher values of visible reflectances, have brought to consider thermal infrared sounding more appropriate not only for night-time observations.

In fact, during the day, dust haze attenuates both the upward Earth radiative flux and the incoming solar radiation producing an apparent local cooling effect which can be observed by thermal infrared soundings in the 10-12 μm atmospheric window [5, 6].

During the night only the first term remains producing a local warming effect which can be observed by comparison with reference fields built for the same area in clear-sky conditions [5, 6].

In alternative, blurring effects on visible imagery have been considered in order to characterize dust haze [5, 7] in presence of well contrasting surface features (as river or mountains) and lineaments.

In order to overcome problems related to unknown, highly spatially variable, surface radiative properties, usually a low day-to-day (year-to-year) variability is assumed and reference fields in clear-sky (i.e. no dust, no meteorological clouds) conditions are built to which satellite observations at hand can be compared to quantify atmospheric turbidity variations due to the presence of tropospheric aerosols (e.g.[8]).

Legrand et al. ([3, 9]) using IR METEOSAT observations, proposed to discriminate dust from meteorological clouds on the base of their differences in horizontal structure and spatial homogeneity.

Compared with a reference IR field (built from similar observations in clear-sky conditions) they found that dust clouds show lower spatial variability than do water/ice clouds when image portions of about 100·100 km^2 [9] or 70·70 km^2 [3] are considered. Nevertheless the definition of suitable thresholds (in terms of spatial signal variability) proved to be not easy in the case of midday observations over naturally contrasted soils [3].

Saharan dust has been particularly studied for its relevant climatological implications and for damage mitigation purposes. Due to dust-clouds optical properties - which are very similar to those exhibited by low/thin meteorological clouds, as well as by clouds fringes - their identification during the day is still the main problem which is made more intricate because of the fairly high visible reflectance of Saharan background. For damage mitigation purposes an early detection, as close as possible to dust sources over deserts and semi-desert regions, would be required which is made difficult by the relatively similar mineral composition (and spectral signatures) of airborne and surface dust [10].

2. METHODS AND RESULTS

In this paper the problem of identifying Saharan dust clouds, distinguishing them from small, low or thin, meteorological clouds, is faced by combining spatial and spectral signatures in the visible and thermal infrared AVHRR remotely sensed radiances. Spatial structure analysis, performed on AVHRR (Advanced Very High Resolution Radiometer) imagery, for different typologies of meteorological and dust clouds over Saharan desert background, permitted to explain why discrimination strategies based on sounders, as METEOSAT-IR, having spatial resolution lower than 5 km, become effective only at larger scale (with better results beyond 60 km). In the main time a more marked spatial signature, at a scale shorter than 5 km, has been recognized which suggests that an early detection of sandstorm sources could be possible, in daytime, by using sounders having at least 1 km spatial resolution in the visible spectral range. A new algorithm is proposed which mainly relies on a preliminary variogram analysis of the peculiar texture exhibited, in the daytime, by low height dust clouds and their shadows over the desert background. Reference fields computed following the general RAT (Robust AVHRR Technique, [11]) approach - now named RST (Robust Satellite Technique, [12]) – have been used in order to automatically identify *llocal* (i.e. depending on the location and on the time of observation, [11]) thresholds to be applied in the detection phases both to visible and thermal infrared radiances.

Global coverage, low-cost and high repetition rate offered by NOAA satellites, together with spectral and spatial resolution offered by AVHRR sounder, have been considered for possible implementations in an operational monitoring context.

Looking to the results so far achieved by using AVHRR data (the case of dust-storms events that hit North Africa will be described with some detail) it seems that the proposed technique, combining spatial and spectral signatures in the visible and thermal infrared bands, is actually able to distinguish between small, low or thin, meteorological clouds and dust clouds. The potential of the application of the proposed method to the new generation of geo-stationary satellite sounders (and particularly on SEVIRI aboard Metesosat Second Generation centered on African continent) with improved time-resolution and spectral capabilities will be moreover considered.

3. REFERENCES

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