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Remote sensing of atmospheric aerosols in South America in the context of weather and climatic models

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1. Introduction

Atmospheric aerosol particles (Fig. 1) can influence the climate either by directly interacting with sunlight acting as scatterers or absorbers in the atmosphere, or indirectly by acting upon clouds and thus influencing hydrological cycles. Aerosol lifetime is about a few days, and it is distributed with a high degree of spatial heterogeneity.

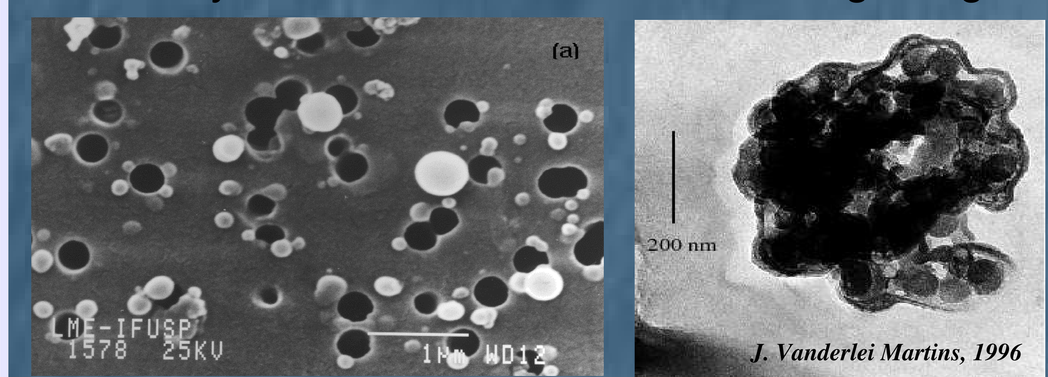


Figure 1. Biomass burning aerosol particles collected on filters.

Because of these characteristics, aerosols constitute one of the major scientific issues necessary to be addressed in order to reduce the uncertainties in chemical/weather and climatic models.

One way of studying aerosols is by remote sensing from satellite sensors like MODIS aboard Terra and Aqua spacecrafts. A system to derive timely aerosol products after each satellite overpass is being built at DSA-CPTEC/INPE, based on NASA/GSFC algorithms. This will allow for the prompt assimilation of aerosol loadings into chemical weather forecast models (*e.g.* CATT-BRAMS, Freitas *et al.*, 2005), covering large areas in Brazil and parts of South America. For longer-term studies, a database will be built with aerosol retrievals from archived overpasses since the launch of Terra (1999) and Aqua (2003). In the future, new developments will be incorporated into the aerosol algorithm, like specific dynamic aerosol models for Brazil and South America, and/or finer resolution aerosol products, following proper validation by experimental measurements.

2. Operational remote sensing of aerosols

INPE maintains an EOS reception system in Cuiaba, located in a central position in South America. Upon each satellite overpass, MODIS data are collected and locally processed to calibrated radiances and level 2 products. Fig. 2 shows the reception site location, the control center in Cachoeira Paulista and the approximate cover range for the antenna. MODIS aerosol retrievals are based on 3 empirical principles derived from worldwide satellite observations:

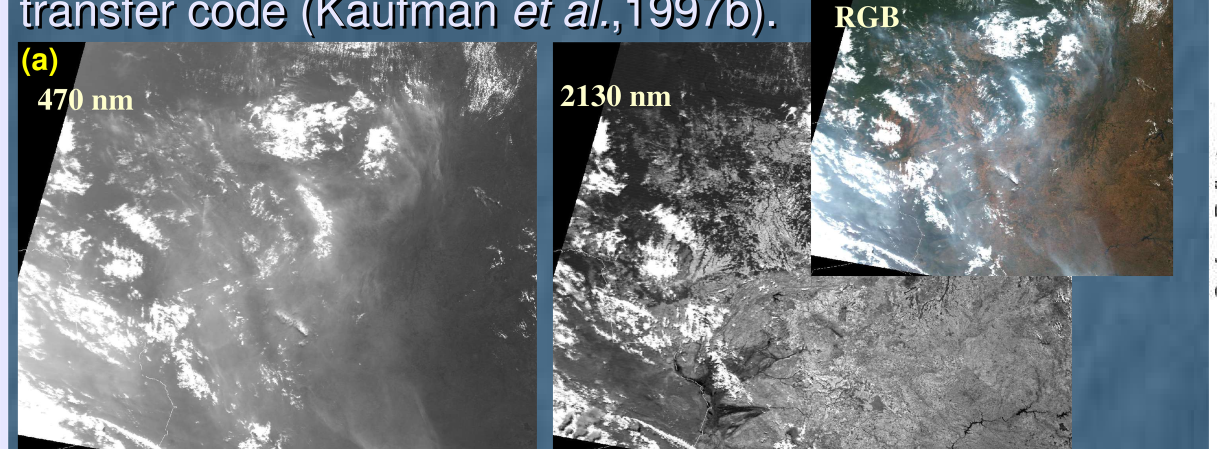
a) the interaction between solar radiation and aerosols decrease as λ^{1} to λ^{2} (Kaufman, 1993);

b) over dark surfaces, the prevailing net aerosol efect is scattering of solar radiation (Kaufman and Tanré, 1998).

c) the surface reflectance is correlated to some degree along the solar spectrum (Kaufman et al., *1997a).*

Figure 2. EOS reception site in Cuiaba, control center in Cachoeira Paulista and approximate cover range.

Fig. 3 shows how these principles relate to MODIS imagery to derive aerosol loadings. Fig. 3a shows an RGB composition, the blue and infrared channels from a MODIS scene over Brazil under severe biomass burning conditions. The blue channel is strongly affected by clouds and aerosols, while in the infrared channel the aerosol layer is transparent. Fig. 3b shows the correlation between infrared surface reflectance and visible channels. The strategy is to correct the image for gaseous absorption, then derive the surface reflectance in the blue and red channels from the infrared measurements, and then compare them with the actual reflectances in each visible channel. The "difference" is related to the total aerosol loading using a look-up table produced by a radiative transfer code (Kaufman *et al.*,1997b).



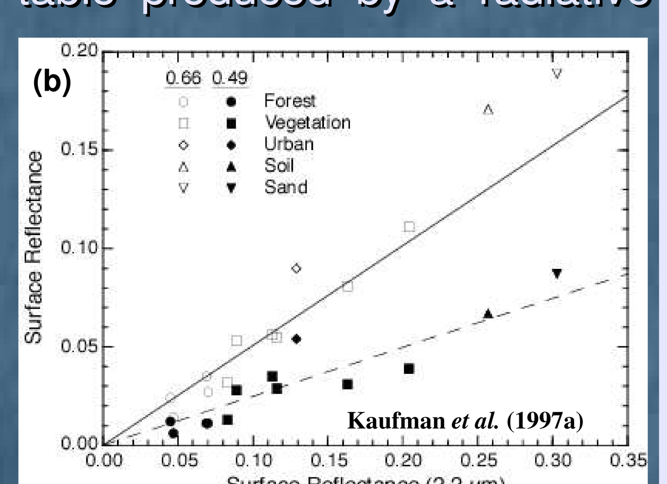
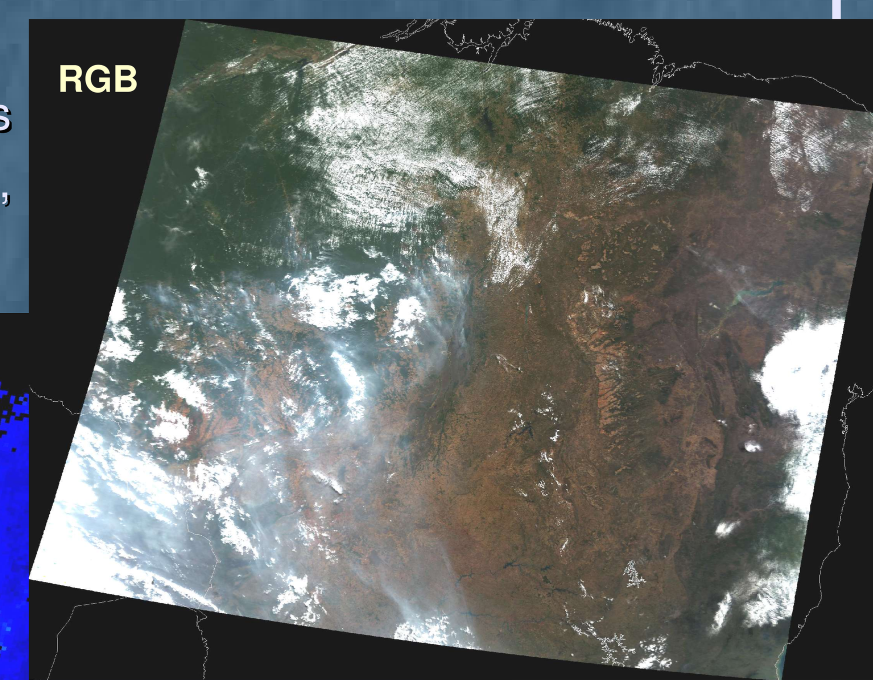


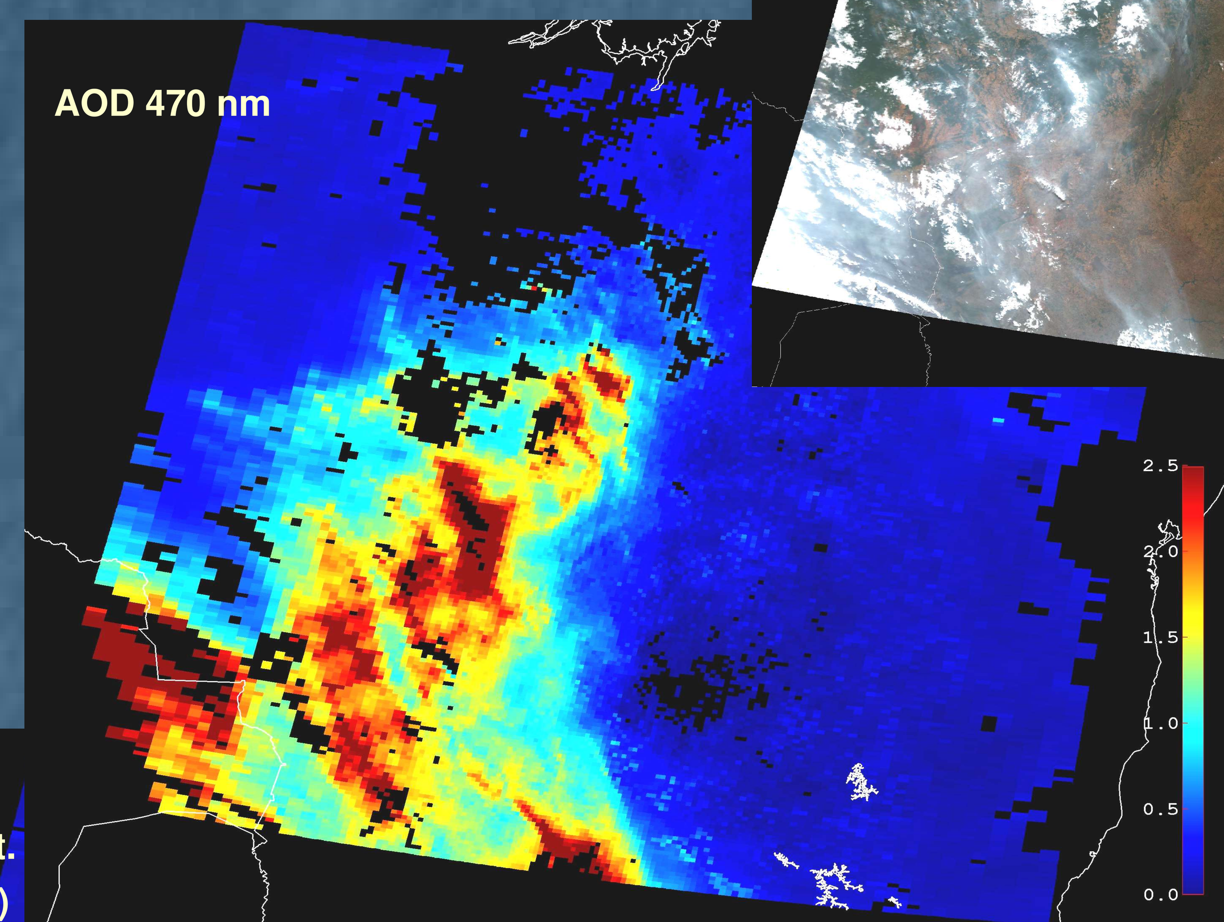
Figure 3. (a) MODIS Terra images over Brazil in 30 Aug 2005 13:40 UTC: RGB composition, blue (470 nm) and infrared (2130 nm) channels. (b) Correlation between infrared (2200 nm), and red (660 nm) and blue (490 nm) surface reflectances for several surface cover types around the globe. Note that red to infrared reflectance ratio is about 0.50 and blue to infrared reflectance ratio is about 0.25.

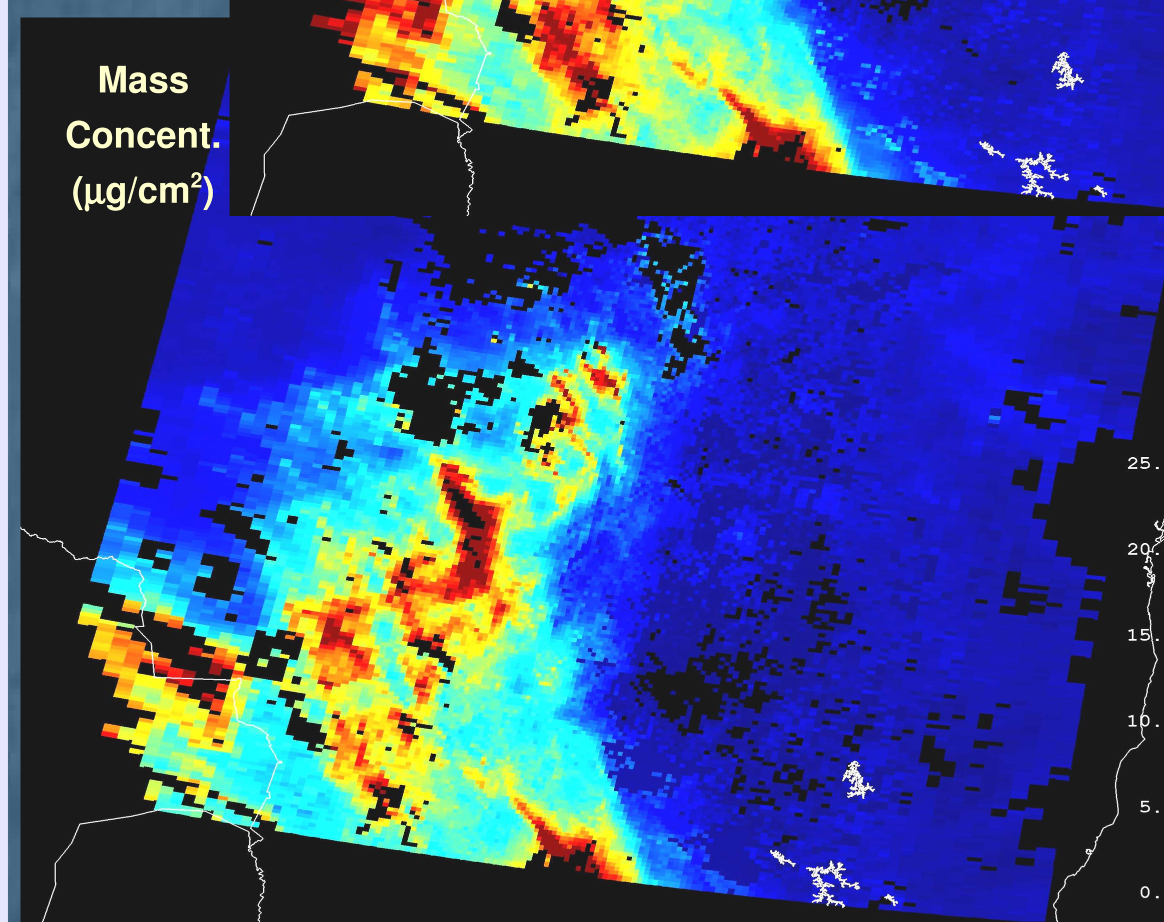
3. Aerosol products

Fig. 4 shows two examples of results for 30 Aug 2005. Aerosol data like these will be available for input into chemical weather models shortly after each MODIS overpass at 13:30 UTC and 16:30 UTC. Atmospheric correction for gaseous absorption will be performed using forecast results by CPTEC, or climatological data. The algorithms will be re-run to build an aerosol database when definitive analysis data is available, typically a few days after each overpass.

In the RGB composition in Fig. 4 one notices smoke plumes over a large area over Brazil, typical for the biomass burning season.







Aerosol optical depths (AOD) in the blue channel (470 nm) in excess of 2.0 are observed in Fig. 4, meaning that about 86% of sunlight in that wavelength does not reach ground level due solely to the occurrence of dense smoke plumes. Mass concentration is defined as function of AOD in the red channel.

Figure 4. RGB composition and aerosol products for 30 Aug 2005 13:40 UTC. No retrievals are made over cloudy conditions indicated by black pixels. Aerosol optical depth at 470 nm is a product validated by field experiments. Mass concentration is a derived parameter.

4. Concluding remarks

Operational remote sensing data of atmospheric aerosols over Brazil and parts of South America will be input into a chemical weather model at CPTEC-INPE, with the assimilation of timely aerosol products after each MODIS overpass. A database of archived MODIS aerosol data will be built for longer timescale studies. Future developments will seek to improve the retrieval algorithms by including specific dynamic aerosol models for South America and deriving finer resolution aerosol products. This same technology can be deployed to other EOS reception sites, in order to help improving the understanding of aerosol spatial distribution and atmospheric loading on a continental scale.

Acknowledgments

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