8-year climatology of dust properties from HIRS observations.

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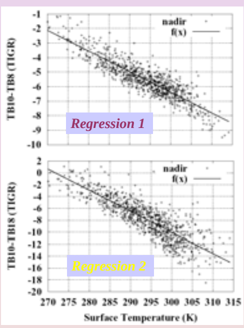
Introduction: The last report from the Intergovernmental Panel on Climate Change (IPCC, 2001) pointed out that aerosols are one of the major sources of uncertainty in the climate system. Since then, many studies have been conducted, most of them focusing on the solar spectrum. Yet, the closure of the Earth radiative balance also needs knowledge of the aerosol effect on terrestrial and atmospheric infrared radiation. This is why we focus here on remote sensing of aerosol at infrared wavelengths. The infrared vertical sounder HIRS has provided observations for almost 25 years, this is why it is of particular interest for climatological studies. In a first step, we use HIRS observations onboard NOAA10 and NOAA12 satellites during the period 1987-1995.

1. Methodology

Dust Index (DI) and Dust Index 2 (DI2)

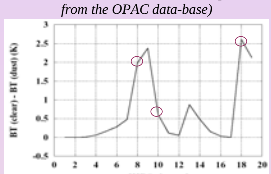
Channels 8, 9, 18, 19 are sensitive to dust but channel 9 is contaminated by ozone
Channel 10 : transmittance close to channels 8 and 18 but no sensitivity to dust (minimum in dust absorption)

→ **Selection of channels 8 (11.1 µm), 10 (8.3 µm), and 18 (4.0 µm)**



Linear Regression 1 and 2, established over 872 tropical atmospheric clear sky situations (TIGR data-set)

Signature of dust on HIRS channels
(dust aerosol model : Mineral Transported from the OPAC data-base)



• Differences between channel 10 and 8 (resp. 18) brightness temperatures (BTs) are strongly correlated with the surface temperature (T_{surf}).

• Idea of the **regression** : trying to predict the BT difference with the surface temperature.

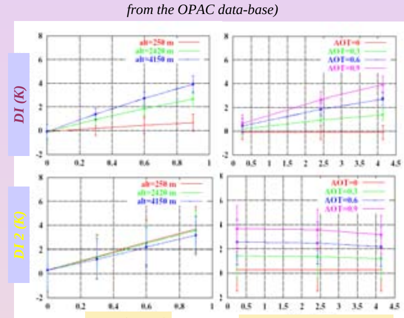
• The **Dust Index** is the difference between the observed BT difference and the predicted BT difference.

$$DI = (BT8-BT10)-(a\ T_{surf} + b)$$

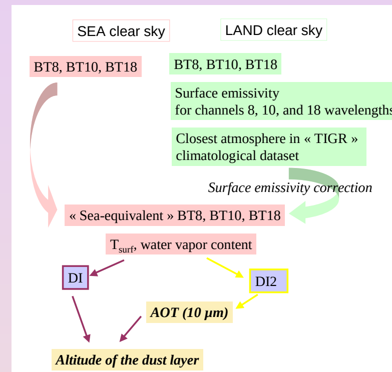
$$DI2 = (BT18-BT10)-(a_2\ T_{surf} + b_2)$$

Retrieval of dust Aerosol Optical Thickness (AOT) and altitude

Radiative transfer simulations
(dust aerosol model : Mineral Transported from the OPAC data-base)



DI is sensitive to dust AOT and altitude
DI2 is only sensitive to dust AOT

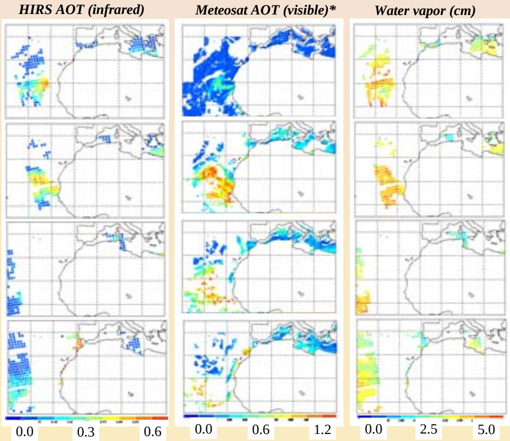


Principle of the Retrieval algorithm

Retrieval of aerosol properties over both sea *and* land:
1) cloud detection (adapted from 3I inversion, *more strict on clear sky*)
2) use $\mathbf{T_{surf}}$ and **water vapor content** from co-located TOVS Path-B data [*Scott et al, 1999*] and monthly mean **land surface emissivity** maps [*Chedin et al*, 2004, *Péquignot et al*, 2005 subm. to JGR])

2. Daily results

Case study: dust event over the Atlantic Ocean : from June 20, to June 23, 1989

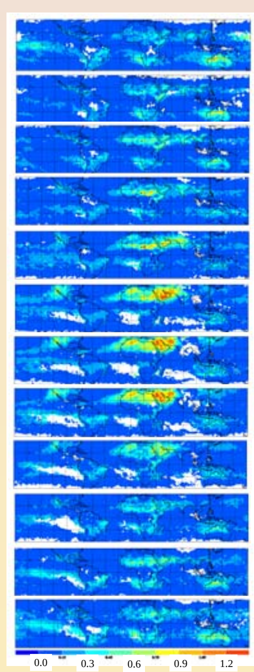


Good comparison between HIRS and Meteosat products
Note : Meteosat is 12.00 pm GMT, HIRS is 7.30 pm local time at the Equator, explaining the slight difference for the first day of the event.

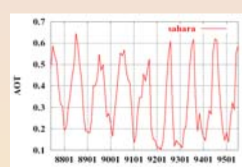
Whereas a dust event should be associated to dry air coming from the Sahara, the retrieved water vapor content looks rather high. This suggests a **contamination of water vapor retrieval by dust**. As a consequence, dust aerosols should be taken into account in retrieving atmospheric parameters for meteorogological forecast.

** Meteosat data are from Moulin,1997*

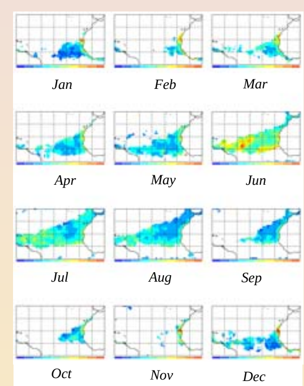
3. Monthly results



Global climatology of dust infrared AOT from HIRS onboard NOAA10-NOAA12 (1987-1995) . From top to bottom : January to December.



Seasonal variation of dust AOT over the Sahara (zone 15N-35 N, 10W-30E)



Seasonal variation of Sahara dust altitude over the Atlantic (1987-1995)

Results:
• the Sahara, the Sahelian zone, and the Arabic peninsula are the main sources of dust. Secondary sources are observed in Australia and North America.
• dust over the Sahara desert shows a strong seasonal cycle, with a maximum activity in summer.
• from spring to summer, there is a translation of dust sources activity from lower to higher latitudes. Link with moonson?
• over the Atlantic Ocean, dust transport occurs at higher altitudes in summer than winter.

Possible sources of error and improvements:
• only one type of dust is considered (Sahara dust) for the whole globe. It is possible that Arabic dust, Australian and North American dust have other refractive indices. The linear relation between dust index and dust AOT should depend on the place (or kind of dust) considered.
• the contamination of the retrieval by low altitude clouds over the Pacific Ocean is not yet totally removed.

Conclusions: Provided the preliminary retrievals of surface temperature, water vapor content, and continental surface emissivities, HIRS is able to retrieve the infrared optical thickness of dust aerosol on a global scale. The first results obtained here show the main expected features: the Sahara and Arabic deserts as first dust sources, a seasonal cycle with maximum optical thickness in summer. The temporal variations are also in agreement with what is previously known from other satellite observations: for example, the very high optical thickness over the Atlantic ocean for the summer 1988 (not shown).
Perspectives: The retrieved products have not yet been fully analyzed. A unique product for both land and sea should be of great interest in climate studies.