Characterization of Dust Type and Properties at Niamey, Niger Using Downwelling Infrared Radiance Data

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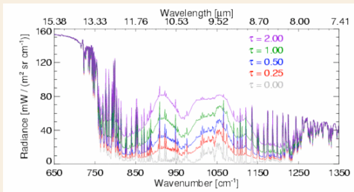
1) Introduction

The ARM Mobile Facility was deployed to the western Sahel region of Africa from Jan 2006 to Jan 2007. Dust is common in the Sahel boundary layer, and plays an important role in the radiative balance of the region. We retrieved aerosol optical depth, effective radius, and mineral type from Atmospheric Emitted Radiance Interferometer (AERI) data using the Mixed-phase Cloud Retrieval Algorithm (MIXCRA) during the cloud-free sky periods.

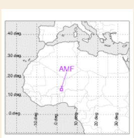
2) Retrieving Aerosol Properties using AERI

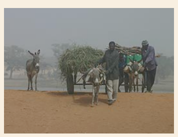
- MIXCRA was originally designed to retrieve mixed-phase cloud properties [Turner, JAM 2005]
- Requires that each "phase" has different absorption features in the thermal infrared
- Optimal estimation used to retrieve τ and r_{eff} for each "phase" (also provides uncertainty estimates)
- Used 19 microwindows between 8-13 µm
- Valid for all PWV
- Maximum τ is approx 6
- Error in r_{eff} grows when τ approaches 0 or 6



Simulated IR radiance for a kaolinite dust layer with r_{eff} = 2 µm for a range of infrared optical depths. The dust particles were modeled as spheres.

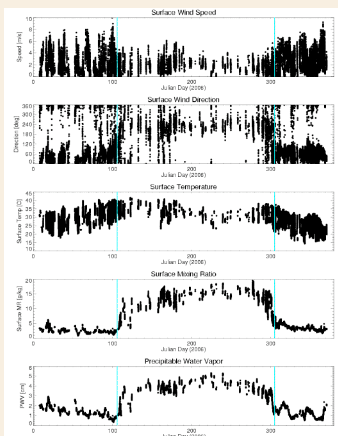
3) Site Location and Climatology



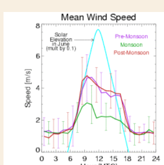


The monsoon season in Niamey is identifiable by trends in surface moisture and wind. The authors have approximated the 2006 monsoon period as being from Apr 16 to Nov 1, based on the following observations:

- Shift in the average wind direction from NE to SW
- Increase in the surface mixing ratio and PWV
- Decrease in the average daytime surface wind speed.



Cyan lines indicate the beginning (April 16) and end (Nov 1) of the monsoon season, as defined in this study.



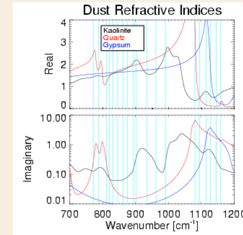
The 3 periods have significant diurnal variations in surface wind speed. The daytime winds speeds are much slower during the monsoon period.

We want to look at the correlation of the aerosol properties with other meteorological variables or season.

4) Aerosol Retrieval Results

Retrievals were made for 6 combinations of 3 minerals:

- Kaolinite-only
- Quartz-only
- Gypsum-only
- Kaolinite+Quartz
- Kaolinite+Gypsum
- Quartz+Gypsum



Primary absorption features:

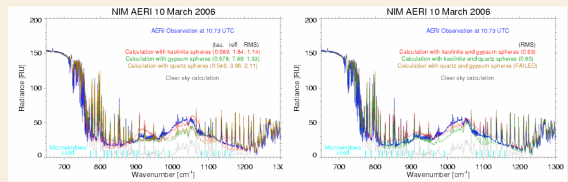
Kaolinite: 920 and 1050 cm^{-1}

Quartz: 780 and 1080 cm^{-1}

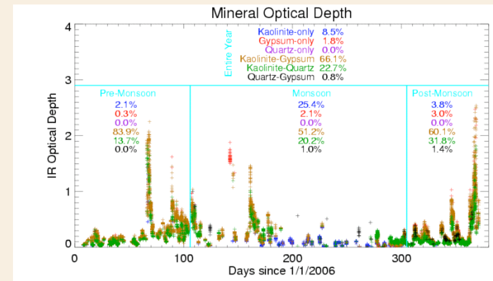
Gypsum: 1130 cm^{-1}

Microwindows used in retrieval are in cyan

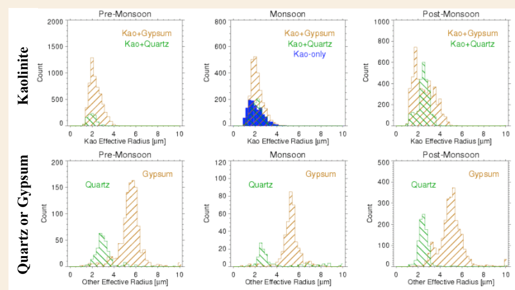
Single vs. dual mineral retrievals



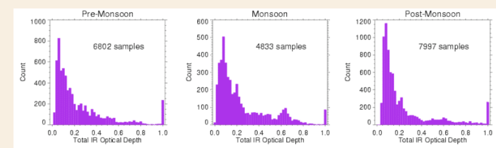
AERI observed vs. computed radiance spectra, where the computations used single-mineral retrievals (left) or dual-mineral retrievals (right). For this example, the dual-mineral retrievals provided better fits to the observation, with kaolinite+gypsum yielding the best fit.



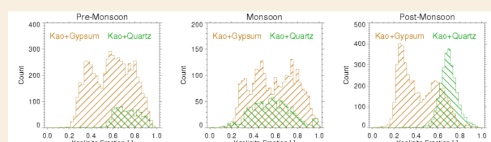
Retrieved τ_{IR} and best-fit mineral composition before, during, and after the monsoon. Dual-mineral retrievals were considered the best fit only if the improvement over the single-mineral retrieval was statistically significant (F-test). There are significant differences in the retrieved composition for each period.



Distribution of the retrieved effective radius for the dominant mineral components during the three periods. Note that the kaolinite r_{eff} was often smaller than the second mineral, especially for the kaolinite+gypsum retrievals.



Distribution of the retrieved total τ_{IR} for the best fit mineral type for the three periods. All three periods show a fair number cases with large optical depth (τ_{IR} > 0.5).



The distribution of kaolinite fraction for the dual-mineral retrievals in the three periods. There is a markedly different distribution in the post-monsoon period relative to the other periods.

	Wind Speed	Wind Direction	WV Mixing Ratio
Pre-monsoon	0.25	0.00	-0.26
Monsoon	0.24	0.21	0.28
Post-monsoon	0.25	-0.05	-0.12

Correlation between kaolinite optical depth and atmospheric conditions (wind, moisture) during the 3 periods. No diurnal correlation was found between aerosol properties and wind or water vapor..

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