Radiative Forcing of Saharan Dust Aerosol at Niamey

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Introduction and Motivation

- Vertical distribution of radiative heating within the atmosphere is an important driver of atmospheric circulations
- Knowledge of the amount of absorption of shortwave and longwave radiation and its vertical distribution within a column is lacking, especially for aerosol
- ARM Mobile Facility (AMF) deployment in Niger, Niamey as part of RADAGAST (Miller and Slingo, 2007) allows unprecedented observation of the atmospheric column from the ground and from space (with GERB and SEVIRI sensors on Meteosat-8 geostationary satellite)
- Objective is to retrieve profiles of aerosol vertical distribution, calculate radiative heating rates, and examine radiative forcing of Saharan dust aerosol at Niamey

Location of Niamey, Niger

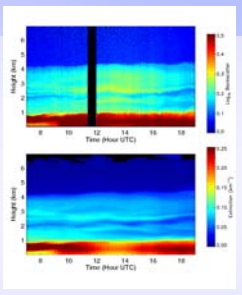
AMF deployed at Niamey airport

Summary

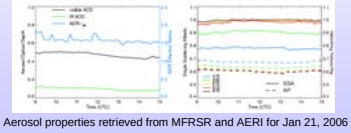
- AMF instruments allow retrieval of aerosol optical properties and vertical distribution of aerosol extinction
- For non-cloudy conditions, radiative calculations show reasonable agreement with surface fluxes.
- Dust aerosol increases SW heating and LW warming within the column by up to 10%.
- Average daily (24 hour) radiative effect of aerosol at Niamey on the downwelling flux at the surface is -36 W/m^2 in total SW; -124 W/m^2 in direct SW; +88 W/m^2 in diffuse SW; and +27 W/m^2 in total LW

Aerosol Properties

- Aerosol optical depth (AOD), single-scatter albedo (SSA), and asymmetry parameter (AP) retrieved from MFRSR during clear skies following Kassianov et al. (2005)
- Longwave optical properties retrieved from the AERI (see S. Bedka poster), assuming kaolinite
- Vertical profiles of extinction retrieved from the MPL by iterating extinction-backscatter ratio until MPL AOD matches MFRSR AOD for non-cloudy periods.
- Cloudy periods identified by automated cloud-screening of AOD and MPL backscatter; Aerosol properties interpolated over missing/cloudy periods



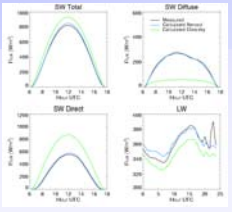
Vertical profile of corrected backscatter (top panel) and retrieved extinction (bottom panel) for Jan 21, 2006.



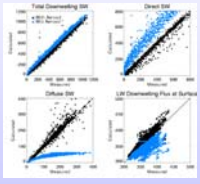
Aerosol properties retrieved from MFRSR and AERI for Jan 21, 2006

Radiative Transfer Calculations

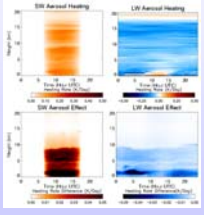
- Atmospheric merged sounding profiles derived from radiosondes, surface meteorology and column water vapor
- Spectral surface albedo of dry sand scaled to observed broadband albedo
- 15 min average profiles of aerosol properties
- SHDOM radiative transfer model (1D mode) with RRTM k-distribution
- Clear-sky calculations run with same atmosphere/surface albedo but no aerosol



Calculated and measured fluxes for Jan 21 case.

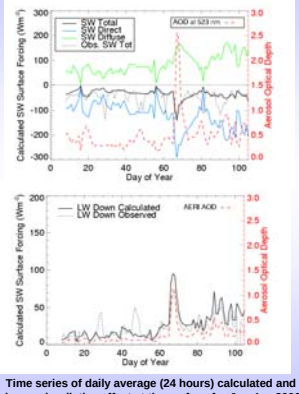


Fluxes for 15-minute periods identified as clear by automatic cloud-screening

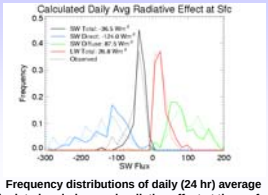


Calculated heating rates and aerosol effect on heating rates (w/ aerosol – w/o aerosol) for Jan 21

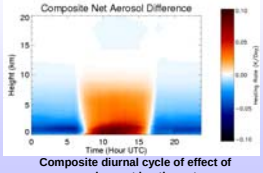
Calculated Aerosol Radiative Effect at Niamey



Time series of daily average (24 hours) calculated and observed radiative effect at the surface for Jan-Apr 2006. Calculations assume aerosol only (no clouds).



Frequency distributions of daily (24 hr) average calculated and observed radiative effect at the surface. Calculations assume aerosol only (no clouds).



Composite diurnal cycle of effect of aerosol on net heating rates.

Future Work

- Further work on calibration of MPL, cloud-screening, and retrieval of extinction profiles
- Relative role of desert dust and biomass burning aerosol (work with DABEX aircraft measurements)
- Collaboration with U. of Reading group to combine top-of-atmosphere and surface estimates of radiative forcing in a consistent manner
- Examination of surface radiation budget at Niamey in CAM and MMF models

Acknowledgements:

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References:

Kassianov et al. 2005: Retrieval of aerosol microphysical properties by using surface MFRSR data; Modeling and observations. *J. Geophys. Res.*, 110, D09201.

Miller M. and A. Slingo, 2006: The AMF and its first international deployment: Measuring radiative flux divergence in West Africa. *Submitted to B. Amer. Meteorol. Soc.*

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