Update on

RADAGAST

Radiative Atmospheric Divergence using Arm mobile facility Gerb and Amma STations

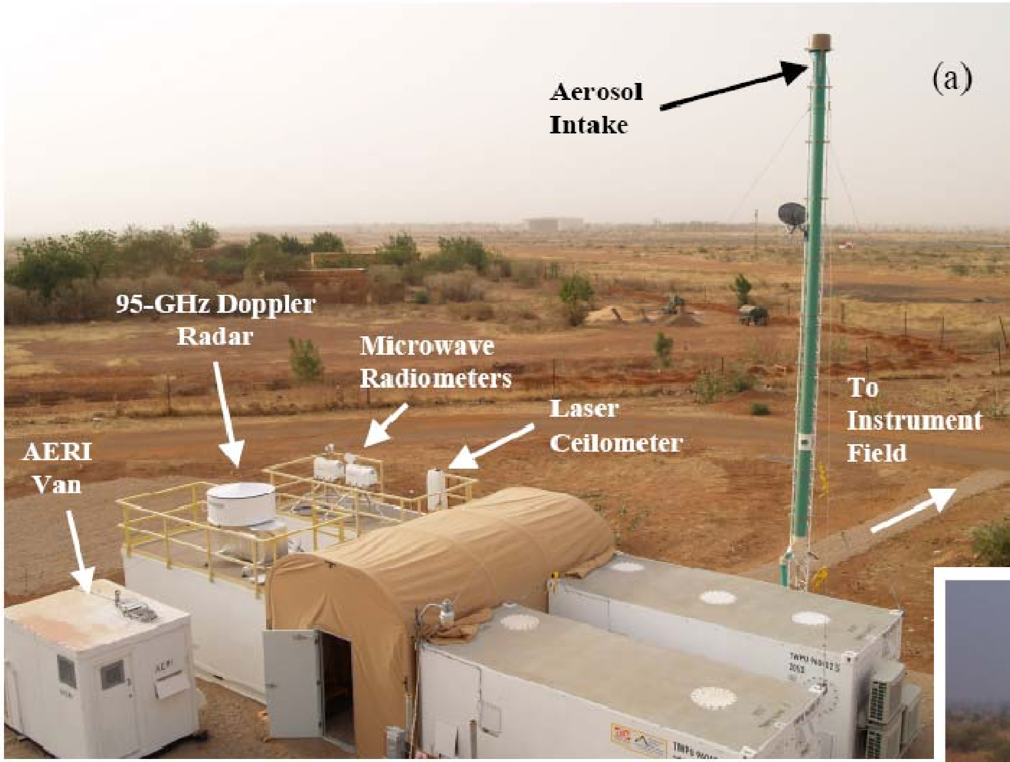
- ARM Mobile Facility deployment in Niamey
- Sampling of initial results
- Published and planned papers

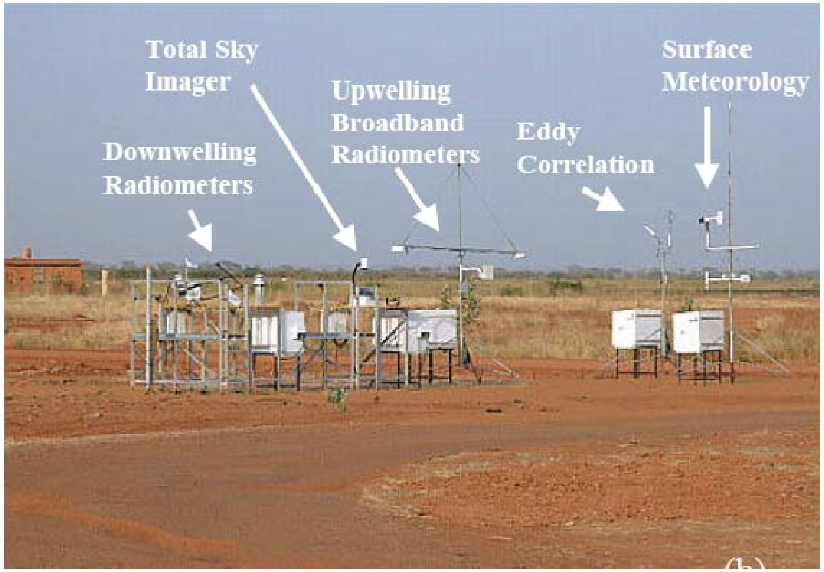
The RADAGAST project

- Radiative Atmospheric Divergence using ARM Mobile Facility, GERB data and AMMA stations
  - led by Tony Slingo, ESSC, Reading University, UK
- Links the **ARM Mobile Facility** with **GERB** (Geostationary Earth Radiation Budget instrument on Meteosat) & **AMMA**
- The objective is to derive the divergence of radiation across the atmosphere:
  - combine the AMF measurements of the surface radiative fluxes and vertical structure of the atmosphere with GERB data from the top of the atmosphere and AMMA observations
  - study the radiative properties of aerosols (desert dust, biomass), water vapour and clouds
  - provide comprehensive observations for testing radiation codes and NWP and climate models

Overview of geography

Overview of the main site at Niamey airport. The “instrument field” (right) is located about 100m from the main facility (left)





Ancillary site at Banizoumbou; radiometers and surface met only

Recent Accomplishments

- AMF and RADAGAST background paper, Miller and Slingo, BAMS, August 2007
- RADAGAST project meeting, ESSC (U. of Reading), July 2007
- Set of papers planned for submission in October

THE ARM MOBILE FACILITY AND ITS FIRST INTERNATIONAL DEPLOYMENT

Measuring Radiative Flux Divergence in West Africa

BY MARK. A. MILLER AND ANTHONY SLINGO

The ARM Mobile Facility is a transportable community climate research platform containing sophisticated sensors that are used to study radiation transfer and other atmospheric processes.

A primary goal of the U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) Program (Stokes and Schwartz 1994; Ackerman et al. 2003) is to collect and analyze data that can be used to improve the representation of clouds and radiation in global climate models (GCMs). The ARM program currently operates five fixed sites: three sites in the tropical western Pacific, an Arctic site on the north slope of Alaska, and a midcontinent site in the southern Great Plains of the United States (Oklahoma). To complement these fixed sites, the ARM Program has developed the ARM Mobile Facility (AMF) to enable data collection in additional regions of interest to the general atmospheric science community. The AMF is designed to operate continuously for periods of 6–12 months and includes a core suite of active remote sensors that are similar to those at the fixed sites. Deployments are determined through an international proposal competition and data are freely distributed through the ARM archive (www.arm.gov), typically in near–real time.

The purpose of this paper is to describe the AMF instrumentation and its charter as a Department of Energy Facility, and to demonstrate the use of the AMF in its first international field deployment in Niamey, Niger. This deployment is associated with two large international campaigns: the African Monsoon Multidisciplinary Analysis (AMMA; Lebel et al. 2003) and the Geostationary Earth Radiation Budget (GERB; Harries et al. 2005; Allan et al. 2005) experiment. The proposal to the ARM program leading to this deployment was titled "Radiative Atmospheric Divergence Using the AMF, GERB Data, and AMMA Stations (RADAGAST)." It represents an international effort to measure continuously the radiative fluxes at the surface and top of the atmosphere through the seasonal progression of the West African Monsoon, which is strongly impacted by Saharan dust, biomass burning, and the devel-

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The abstract for this article can be found in this issue, following the table of contents.

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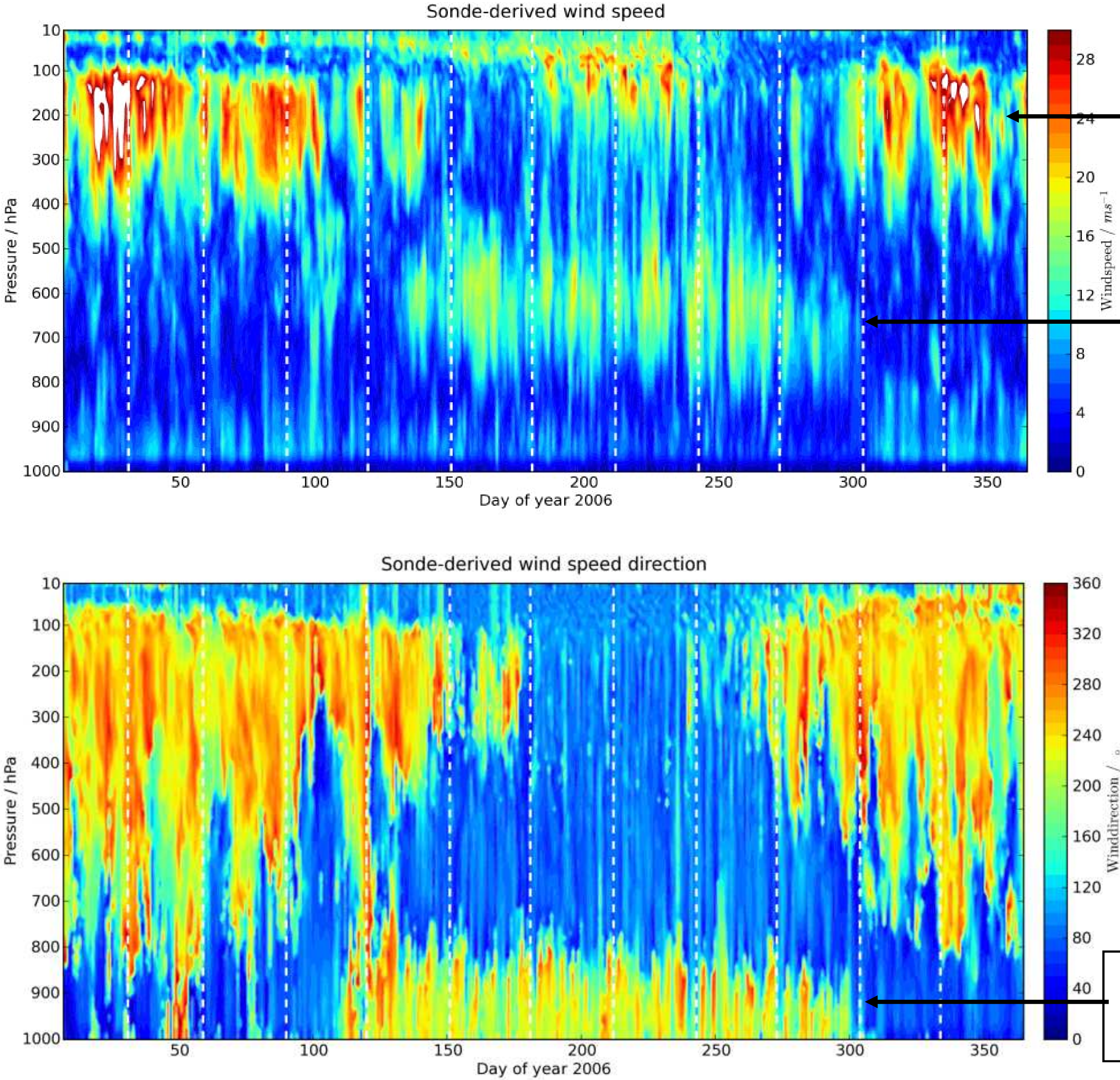
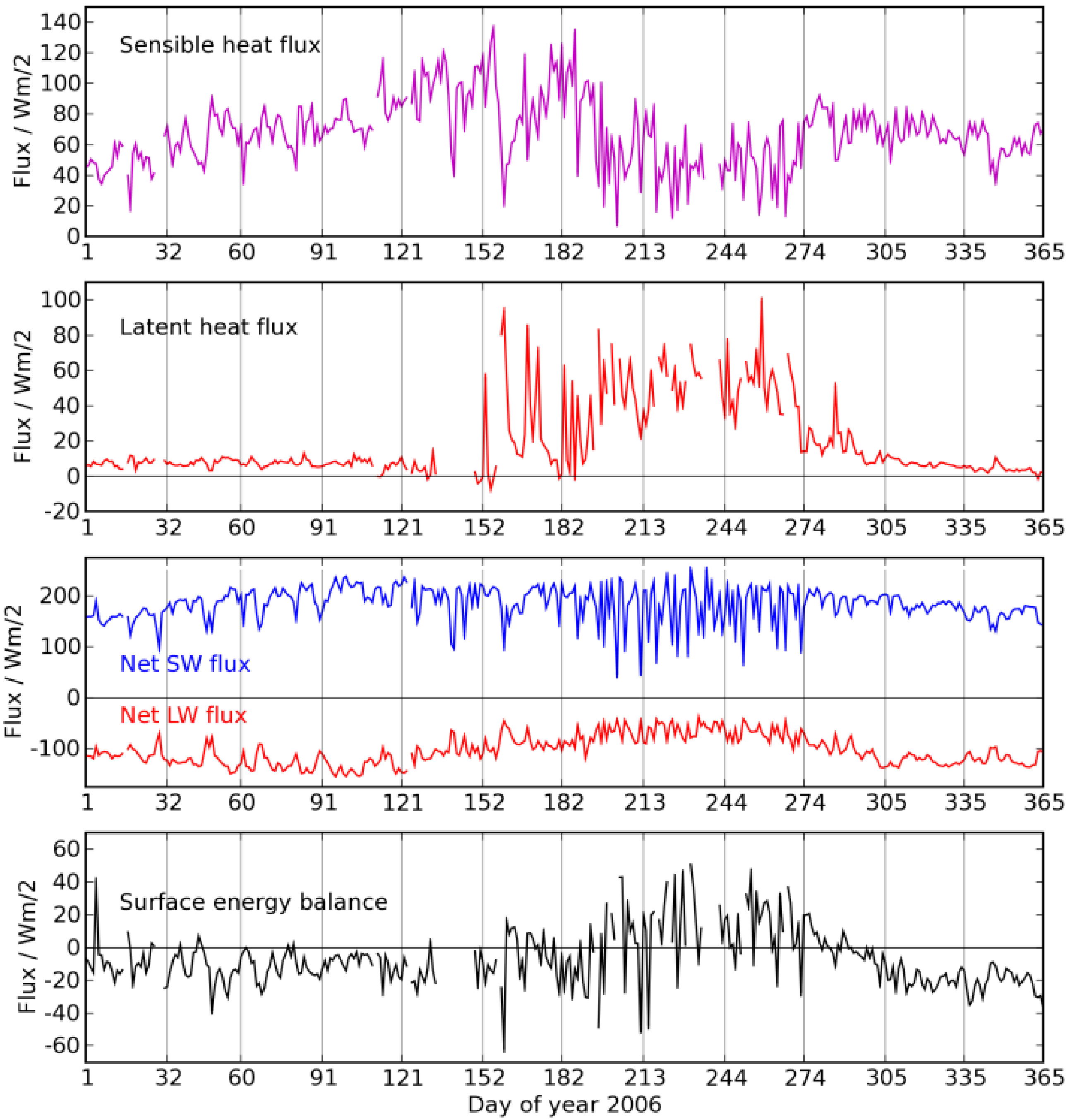
In final form 25 January 2007

Overview of meteorology and thermodynamics during Niamey AMF deployment

Tony Slingo, Ali Bharmal, Pete Lamb, et al.

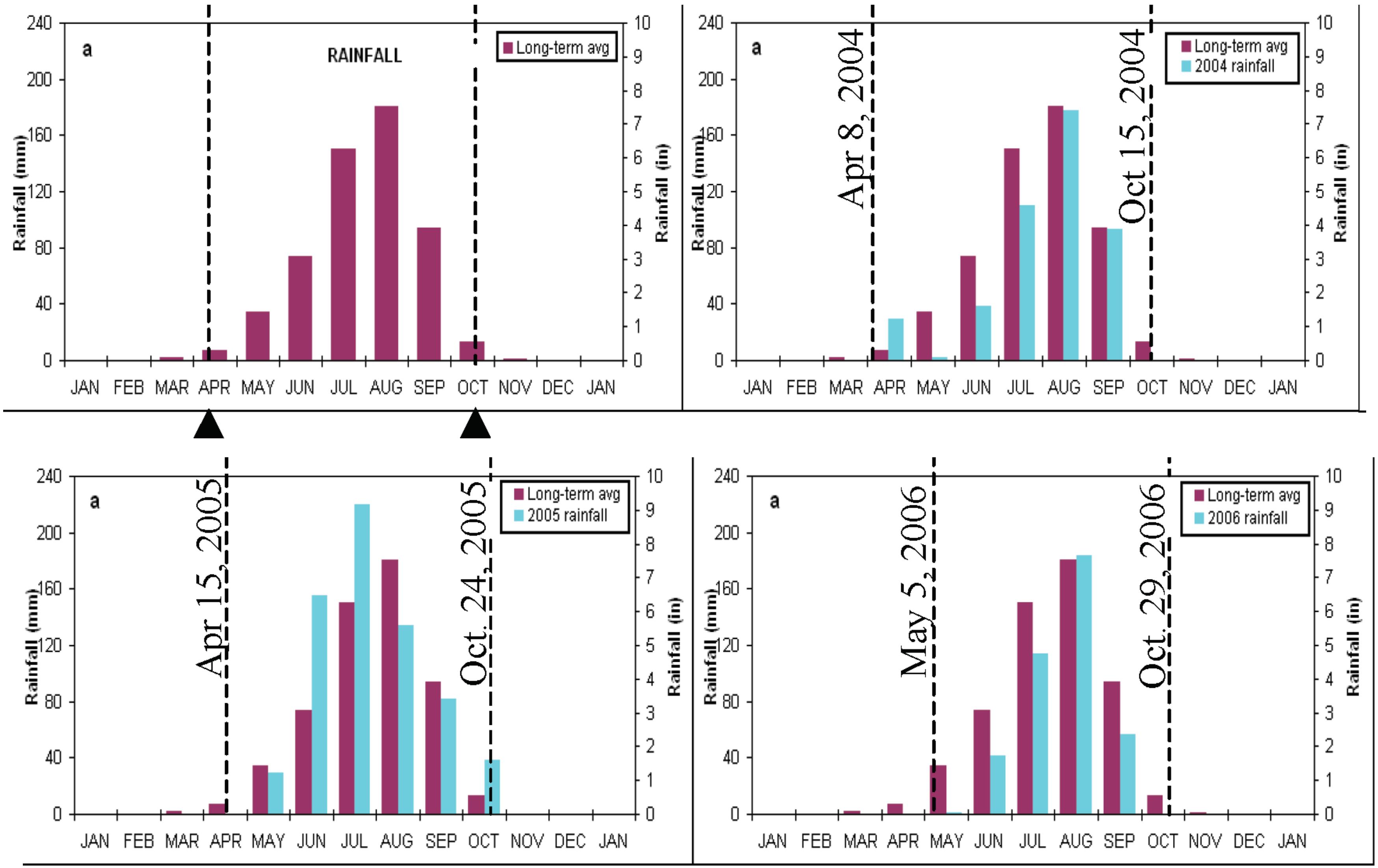


Vertical cross section of zonal wind, from radiosondes launched from the Niamey airport site.



Surface energy balance at the Niamey airport site.

Madison, WI



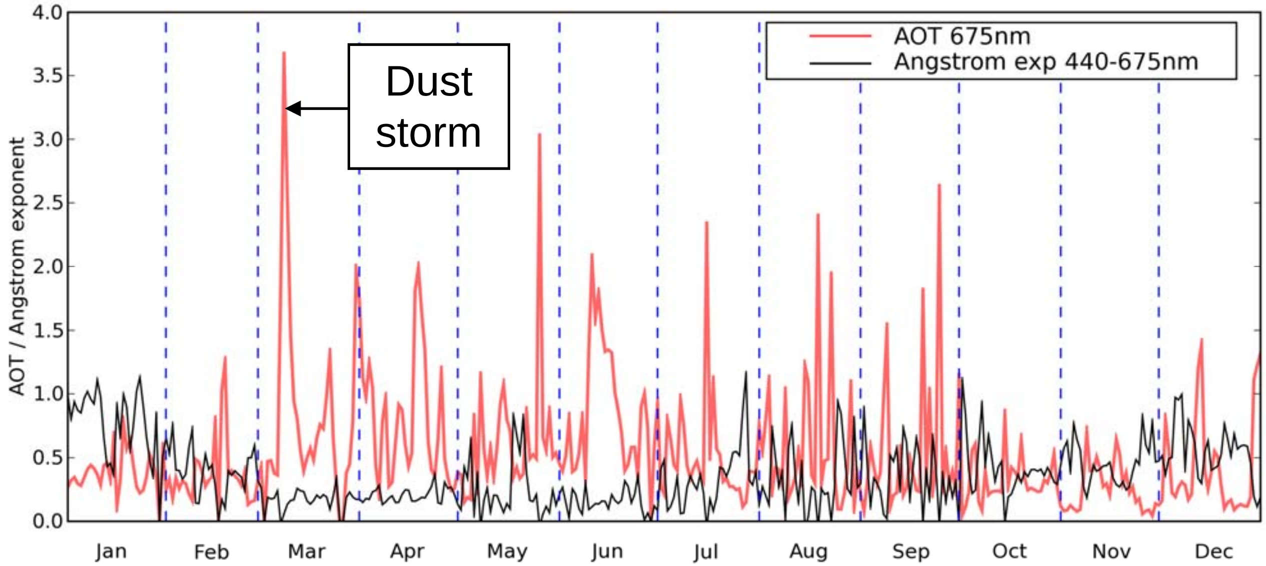
P. Lamb and I. Lele

Overview of radiative fluxes during AMF Niamey deployment

Tony Slingo, N. Bharmal, et al.

Red: Aerosol Optical Thickness at 675nm from the AERONET site at Banizoumbou

Black: Angstrom exponent

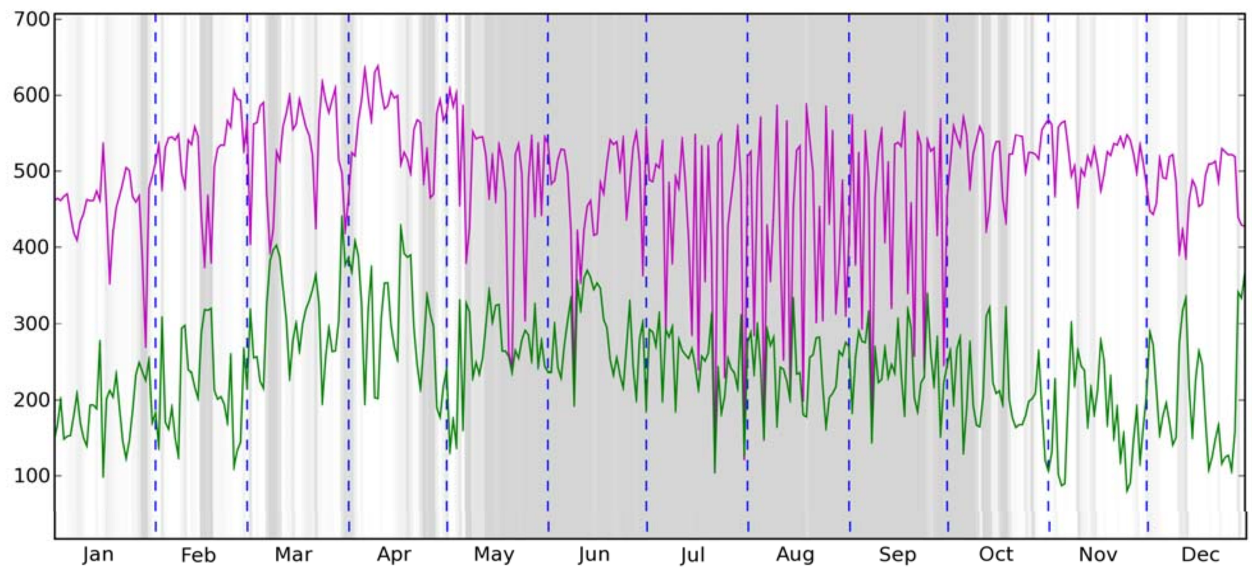


Downward Solar flux (daily averages Wm^{-2})

Purple: Total

Green: Diffuse

Grey bands: clouds

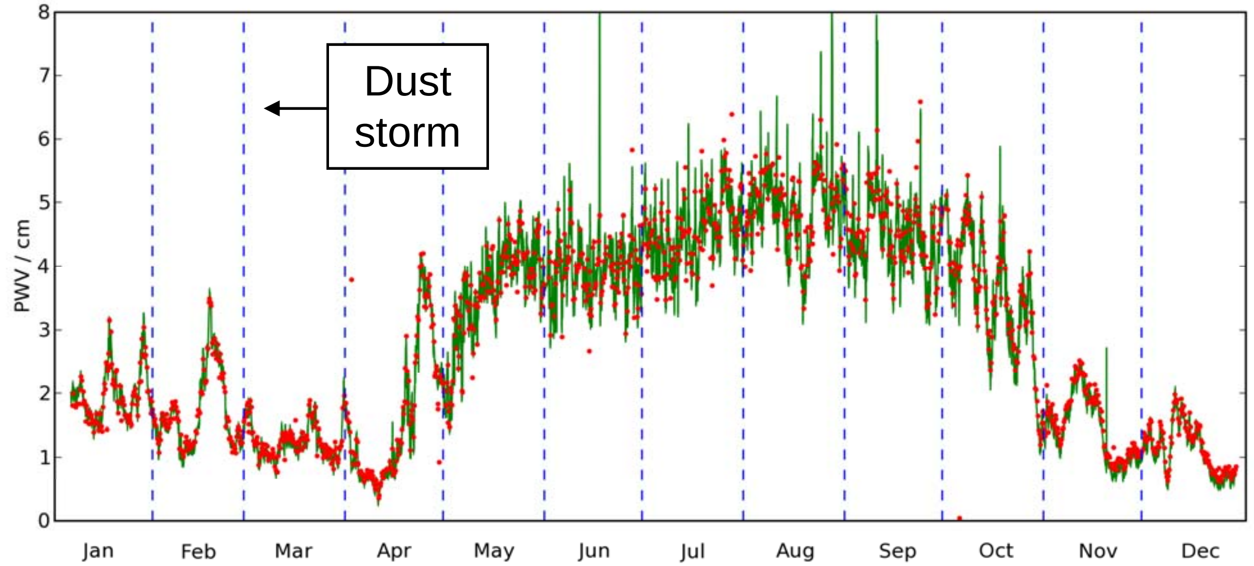


Downward solar fluxes are controlled by clouds and by aerosols

Column water vapour (cm)

Green: Radiometer

Red: Sonde

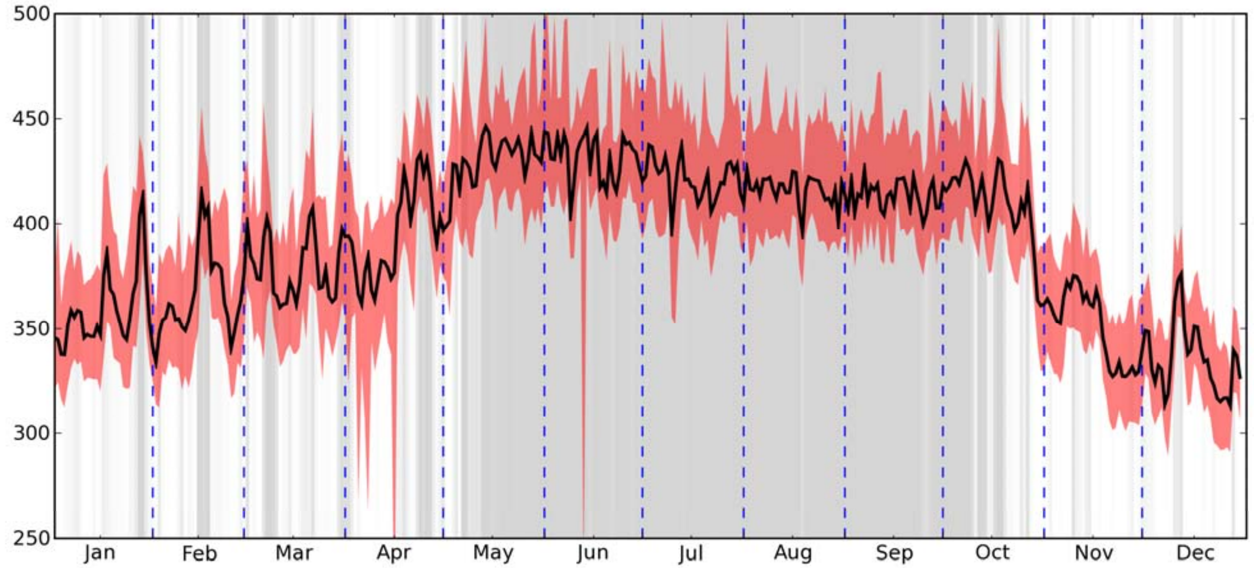


Downward Thermal flux Wm^{-2}

Black: Daily average

Red: variability

Grey bands: clouds

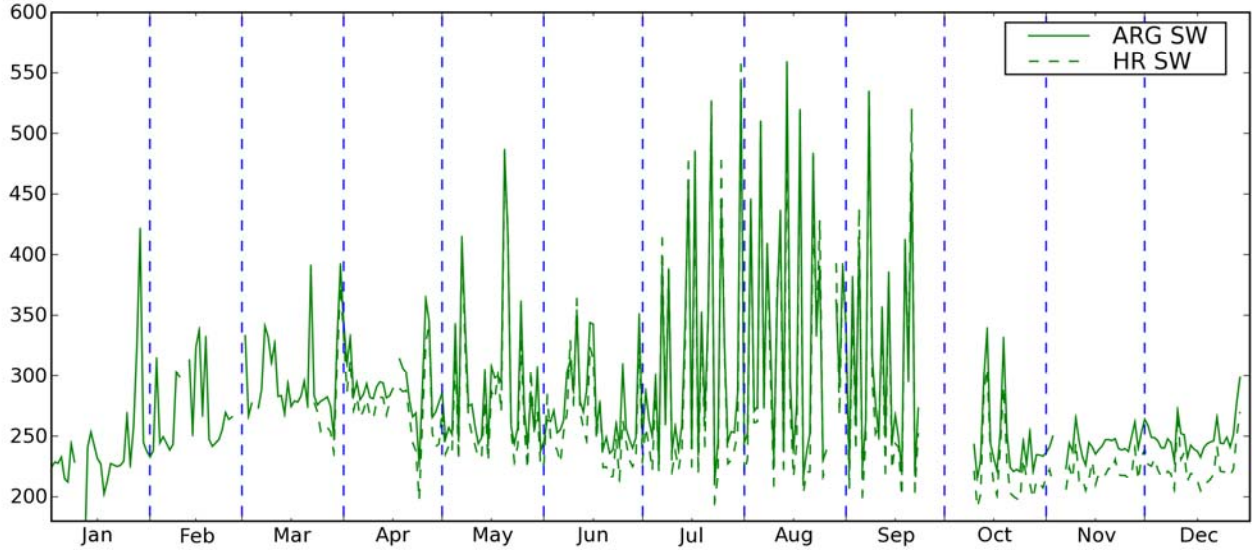


Downward thermal fluxes are controlled by clouds, column water vapor, atmospheric temperatures *and aerosols*

GERB reflected solar Wm^{-2}

ARG: Standard product (50km resolution)

HR: High Resolution hybrid product using SEVIRI imager data (10km resolution)

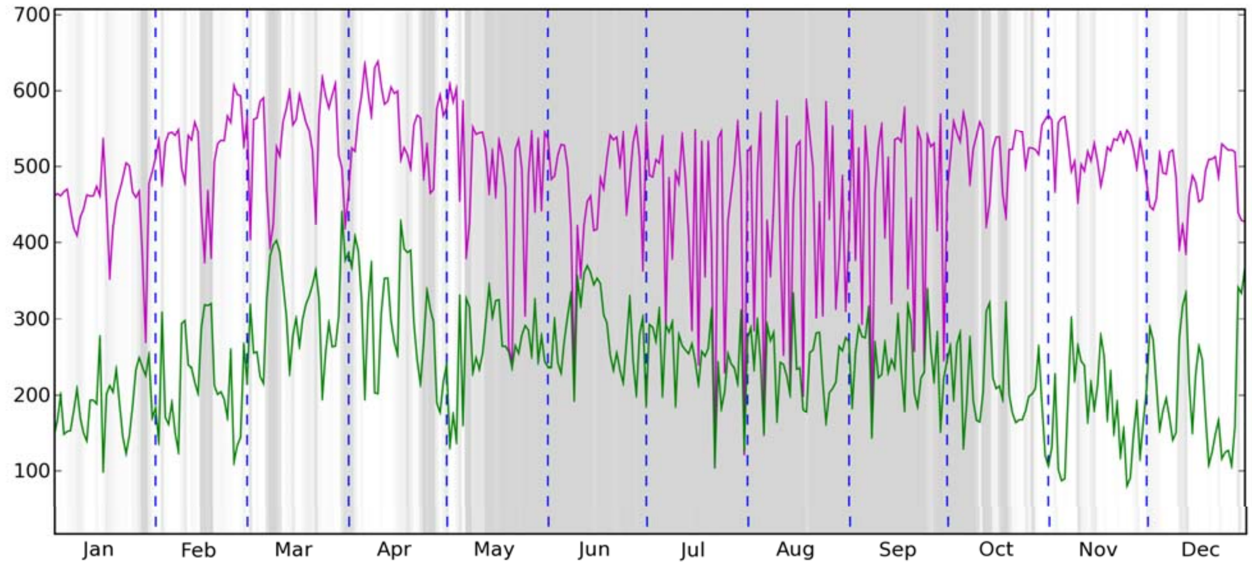


Downward Solar flux (daily averages Wm^{-2})

Purple: Total

Green: Diffuse

Grey bands: clouds

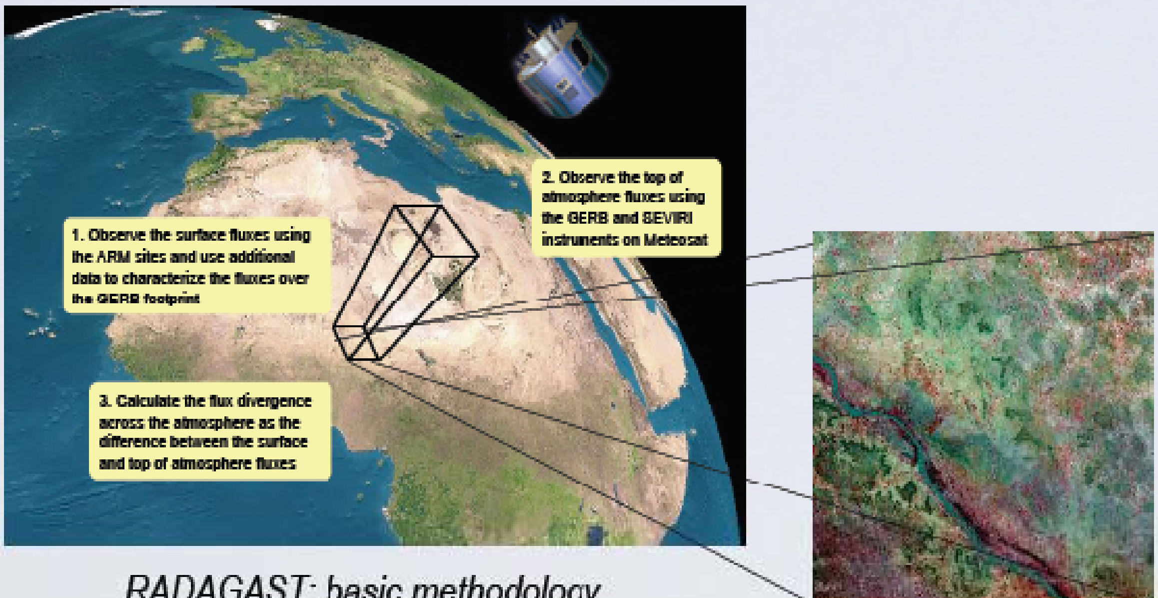


GERB and AMF fluxes will be combined to calculate atmospheric divergence

Surface Albedo Heterogeneity

Jeff Settle, ESSC

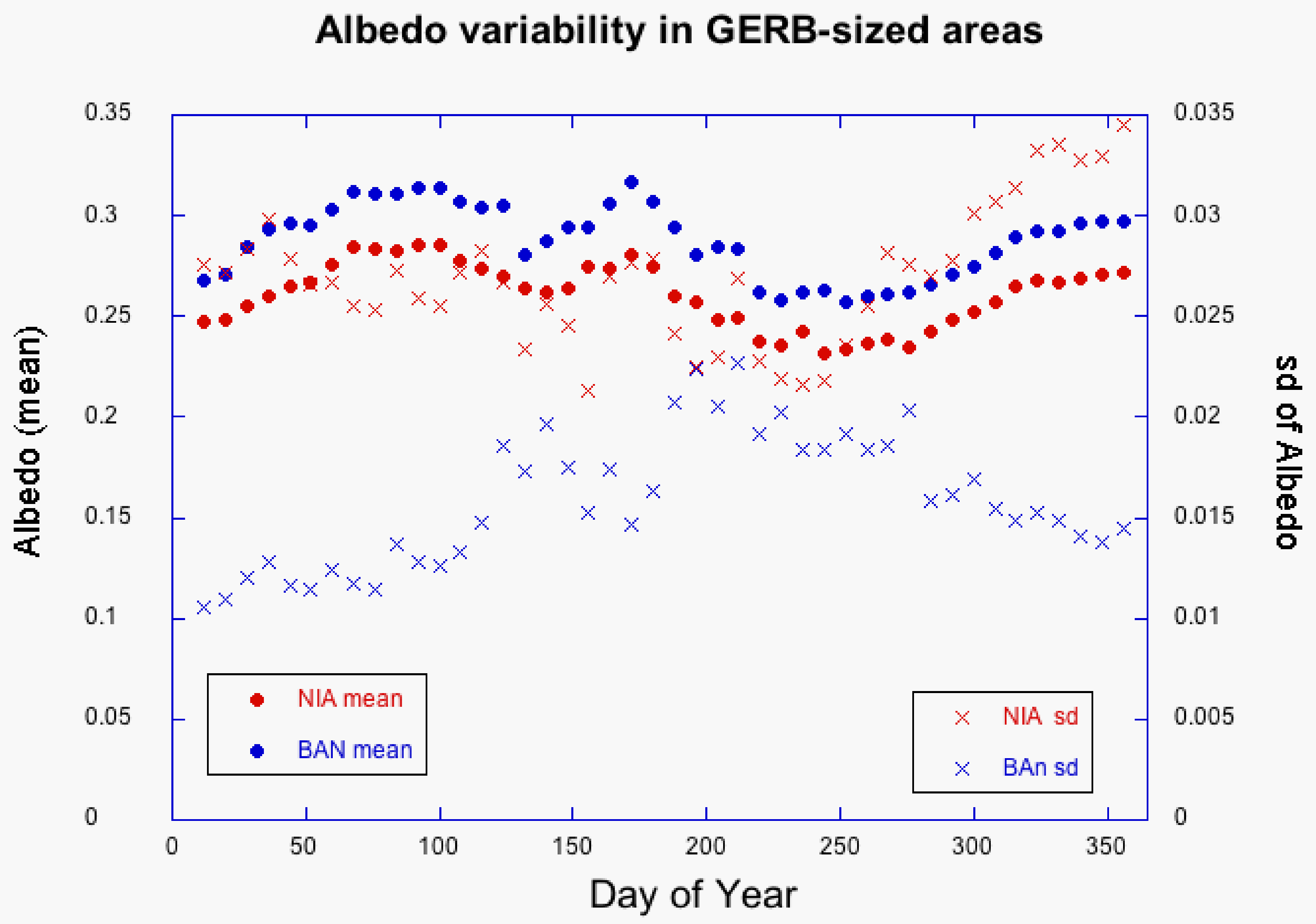
The principal aim of RADAGAST is to characterize the radiative flux divergence across the atmosphere. At the top of atmosphere the data are provided by the GERB instrument on Meteosat 8, with a footprint at the surface of ~40km. At the surface, the fluxes are measured continuously at a point by the AMF instruments.



RADAGAST: basic methodology

The land surface can be very heterogeneous at the scale of a GERB footprint (~50km). How well do fluxes measured at a point represent the spatial average across the GERB footprint? How well does a time average at a fixed point represent the same time average over the larger area?

To address these questions we are using flux measurements from AMF radiation instruments deployed at the main site at Niamey airport (NIA) and at a rural site 50km further East at Banizoumbou (BAN).


Albedo variability in GERB-sized areas
Albedo (mean)
sd of Albedo
Day of Year
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.005
0.01
0.015
0.02
0.025
0.03
0.035
50
100
150
200
250
300
350
NIA mean
BAN mean
NIA sd
BAn sd

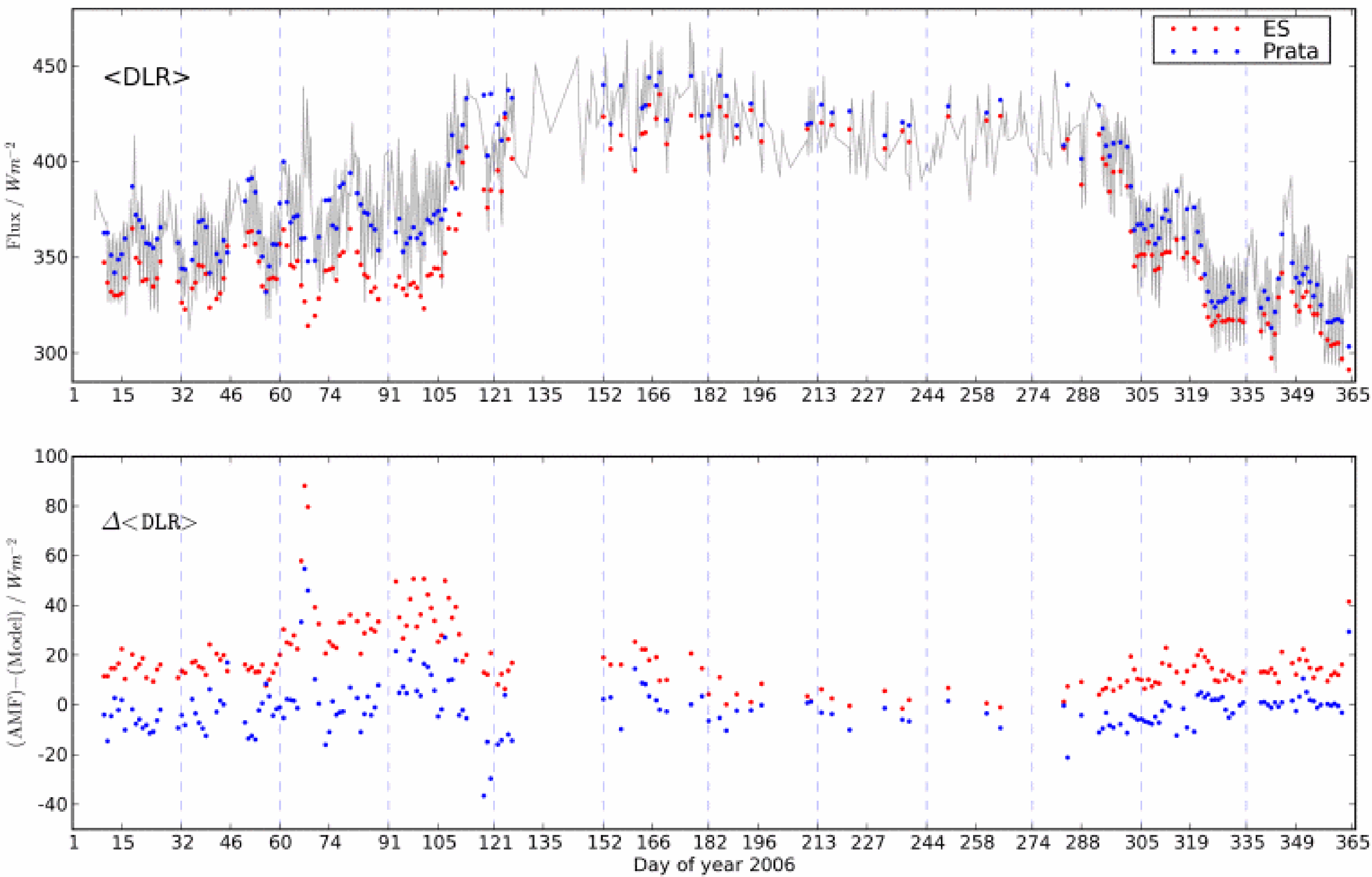
Comparison of fluxes with radiative transfer models

Nazim Bharmal
ESSC, University of Reading

DLR modelling

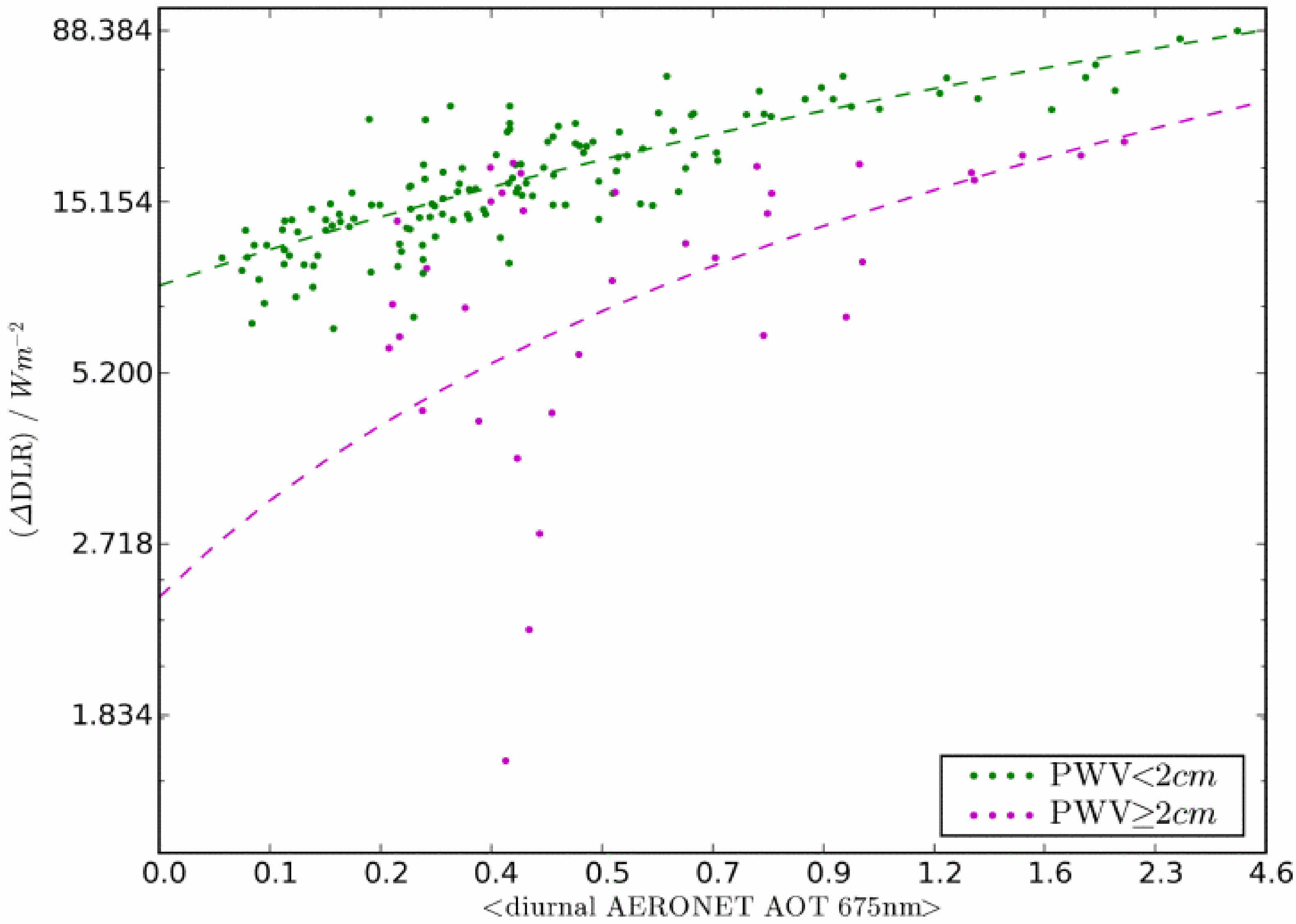
Downward Longwave Radiation (DLR)

- DLR from Prata formula and ES (pristine sky)



ES correlation

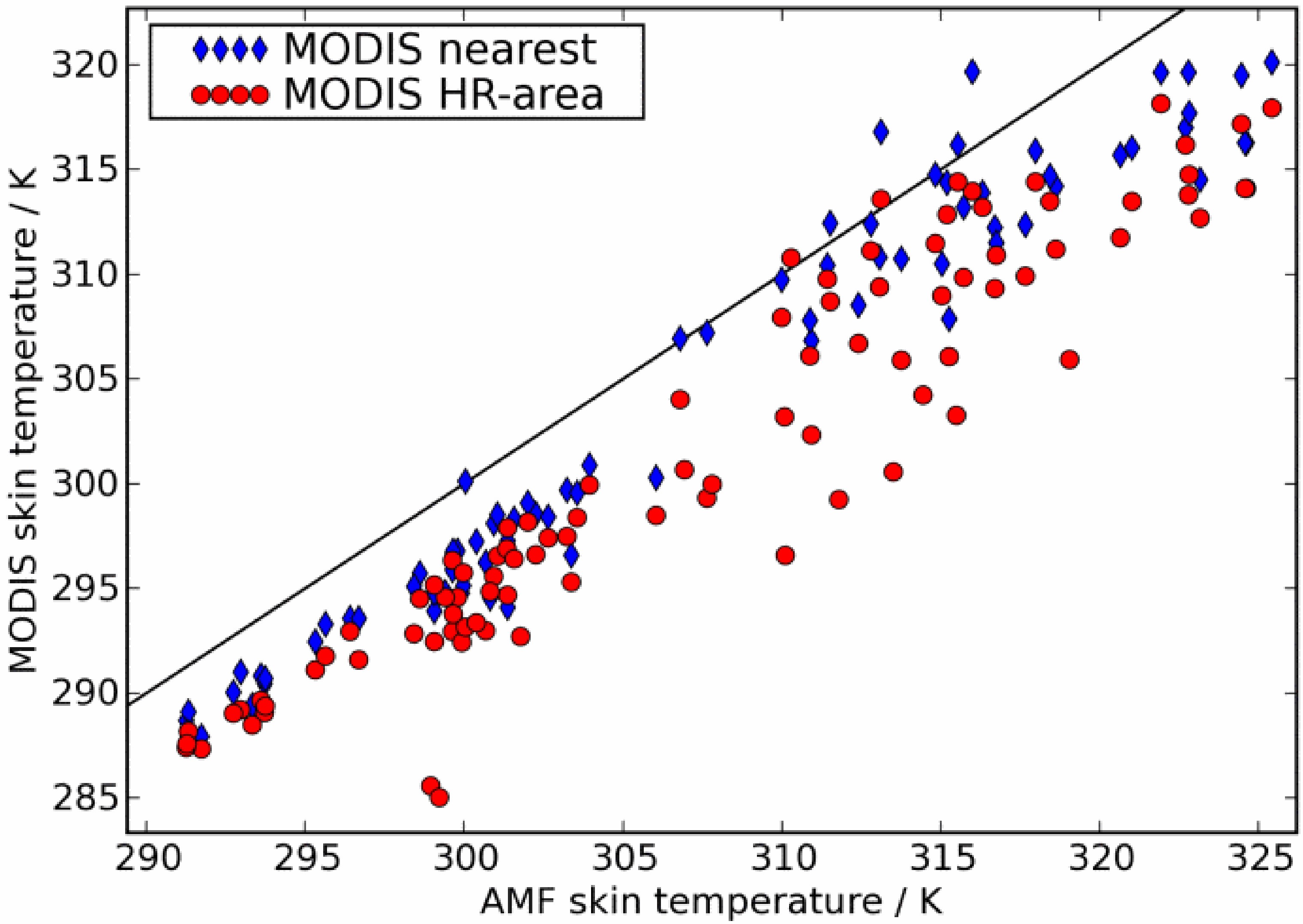
- Correlation of DLR with AERONET derived AOT is also significant.



S

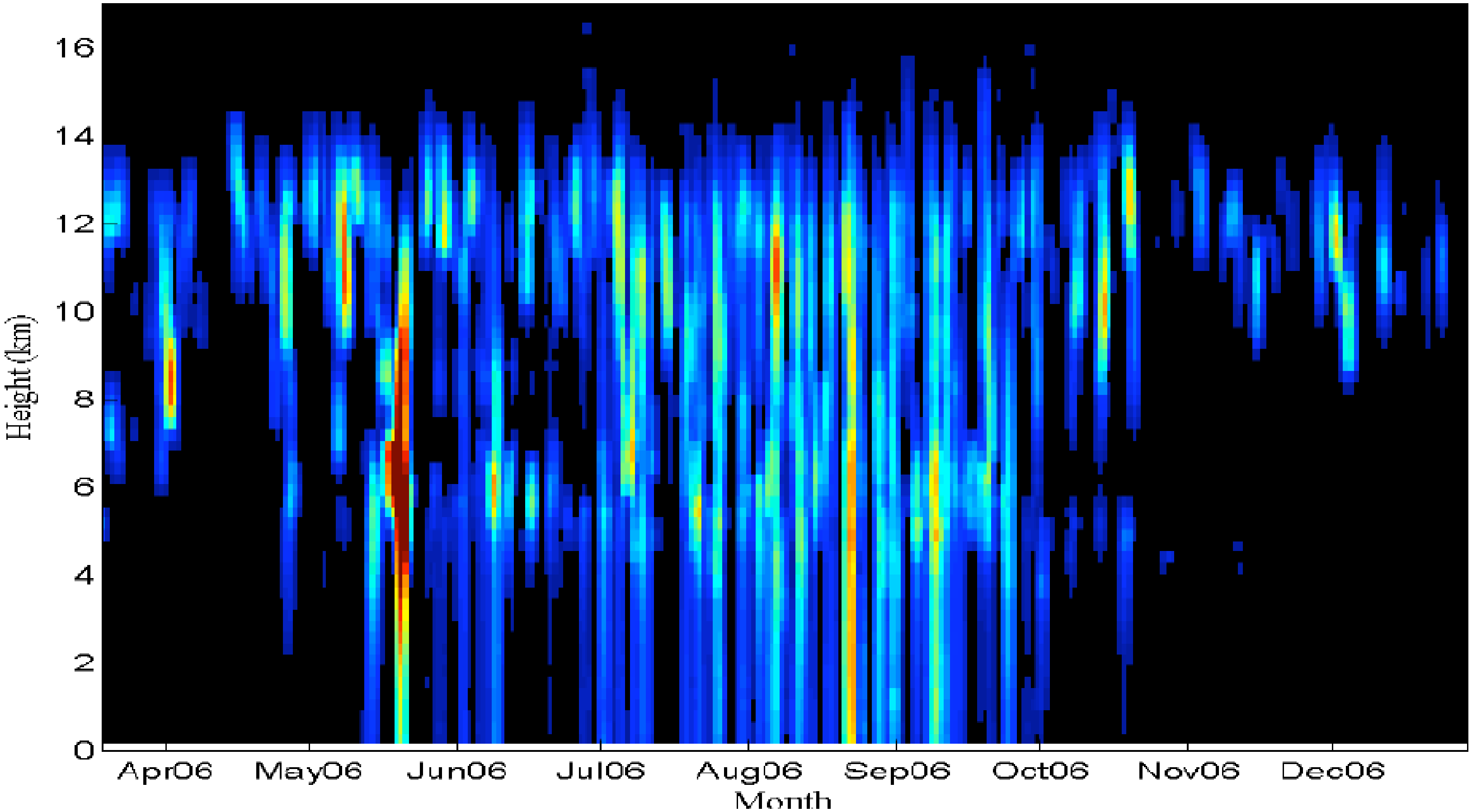
MODIS skin temperature comparison

- Use MODIS to derive a GERB-area skin temperature from AMF data.



Clouds observed by the W-band radar at Niamey

P. Kollias and M. Miller



Height (km)
16
14
12
10
8
6
4
2
0
Apr06
May06
Jun06
Jul06
Aug06
Sep06
Oct06
Nov06
Dec06
Month

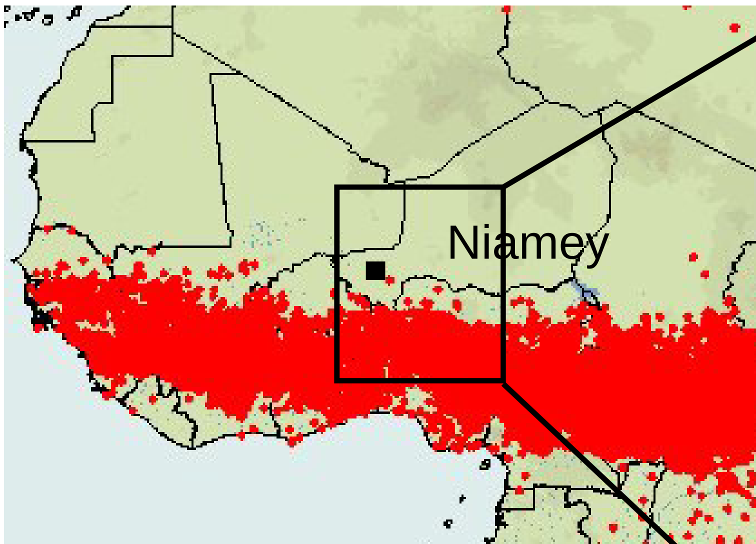
Aircraft observations of mineral dust, biomass-burning aerosol over west Africa

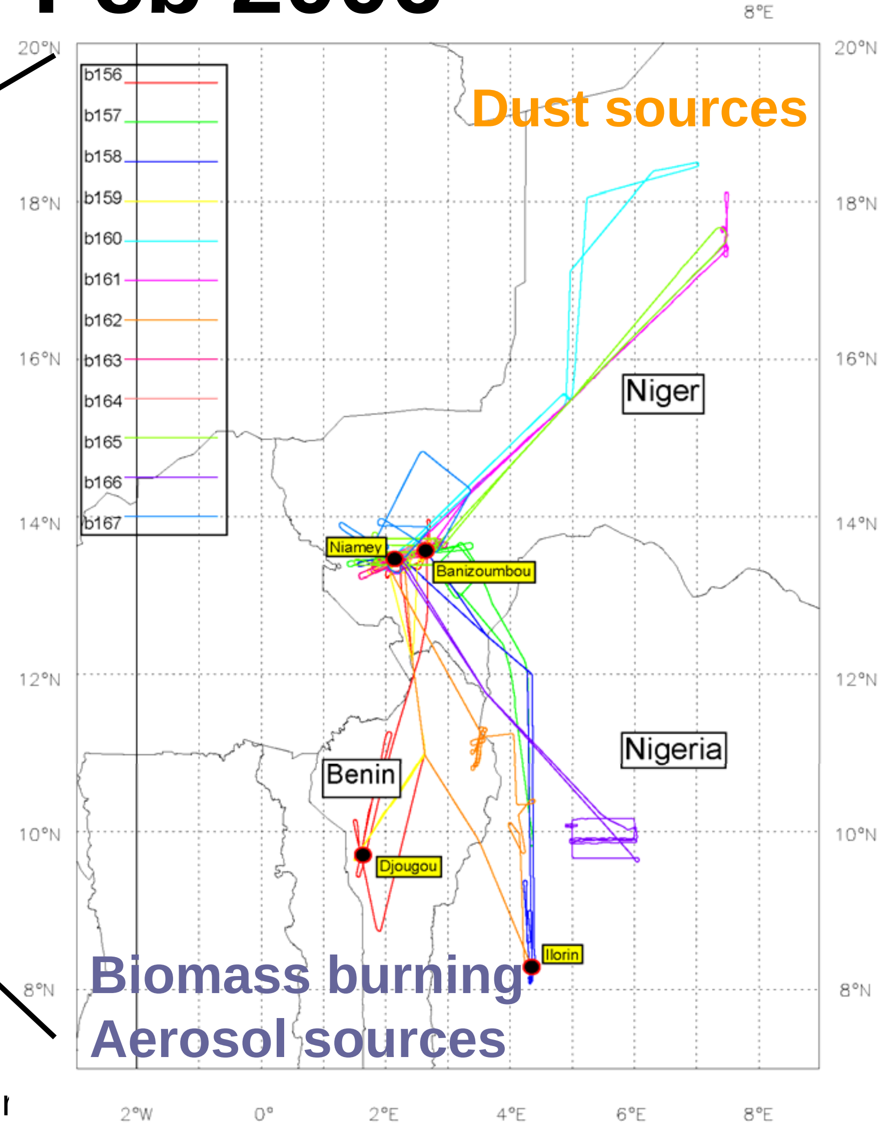
Ben Johnson, UK Met Office

Jim Haywood, Simon Osborne, Glenn Greed, Nicholas Bellouin, Andy Jones

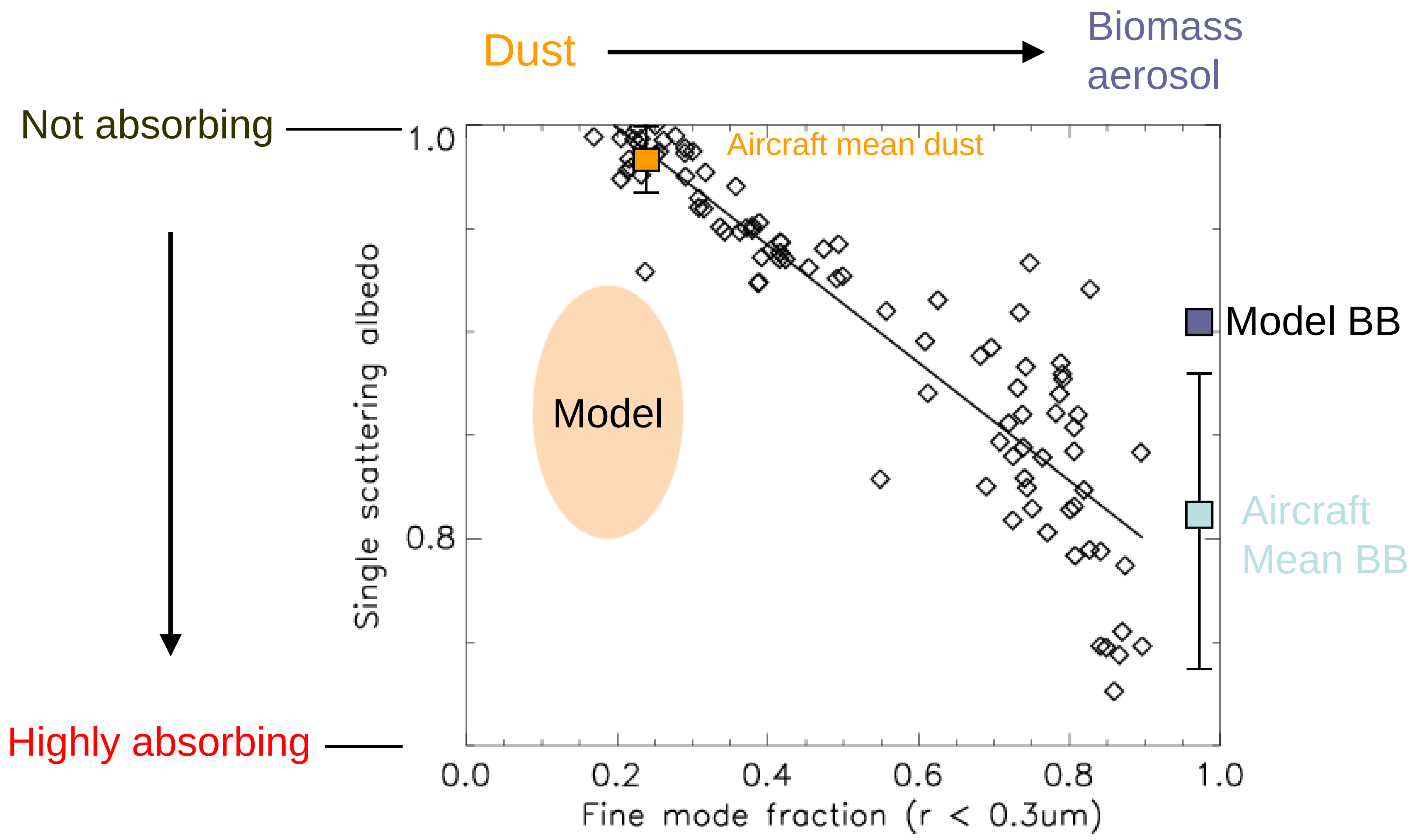
Dust and Biomass Experiment (DABEX), Jan-Feb 2006

MODIS fire counts 15-19th Jan 06





Absorption of solar radiation

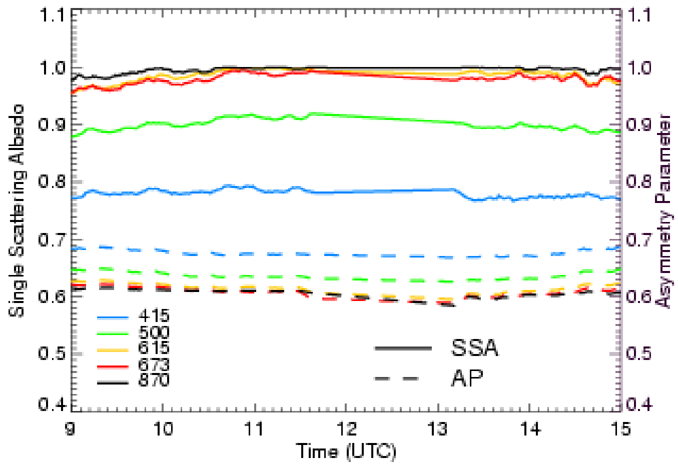


MFRSR/MPL Aerosol Retrievals and Surface Radiative Forcing

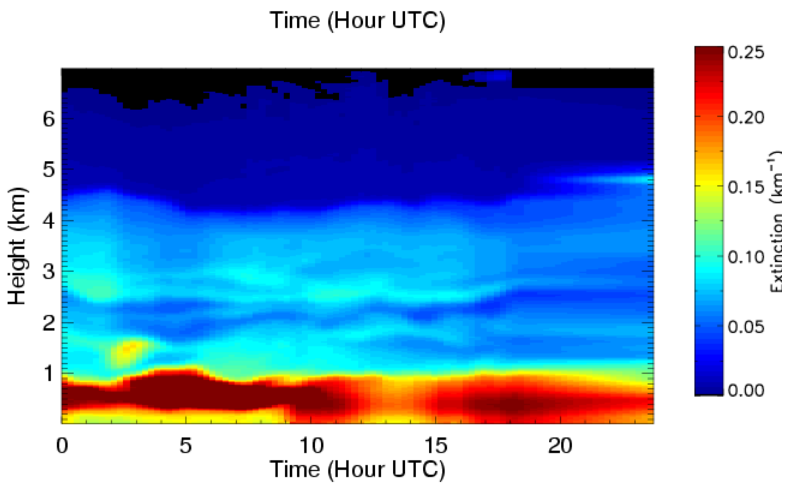
McFarlane, Kassianov, Barnard, Flynn

(PNNL)

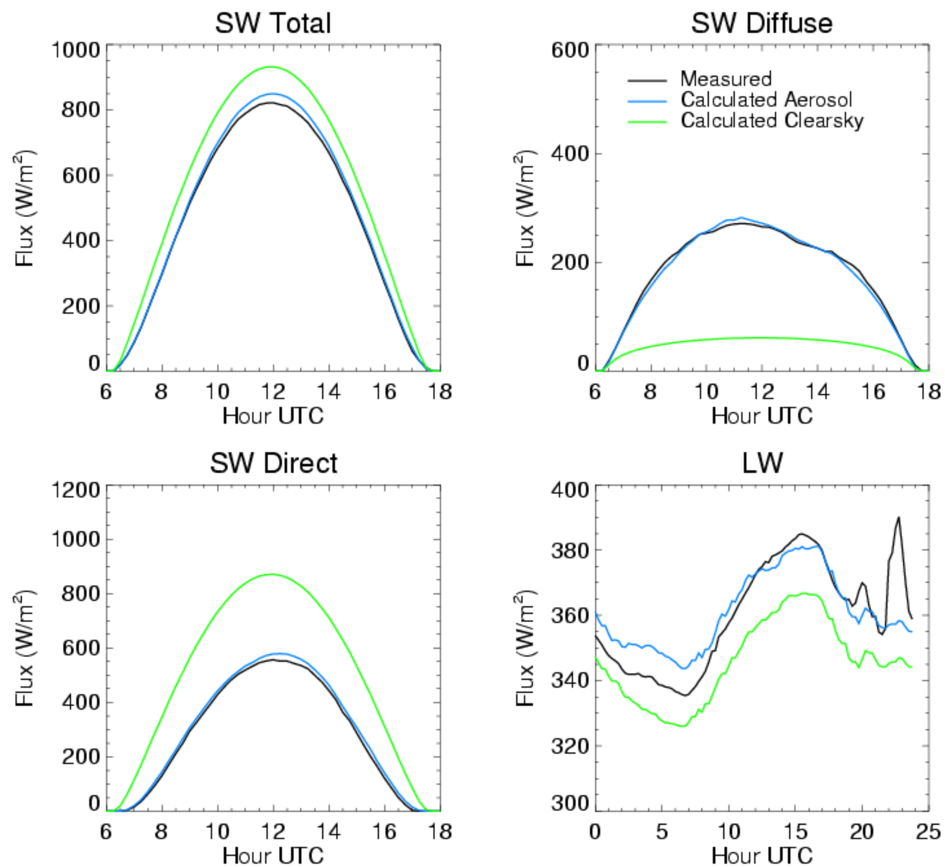
Jan 21 (dust only case)



MFRSR-derived optical properties

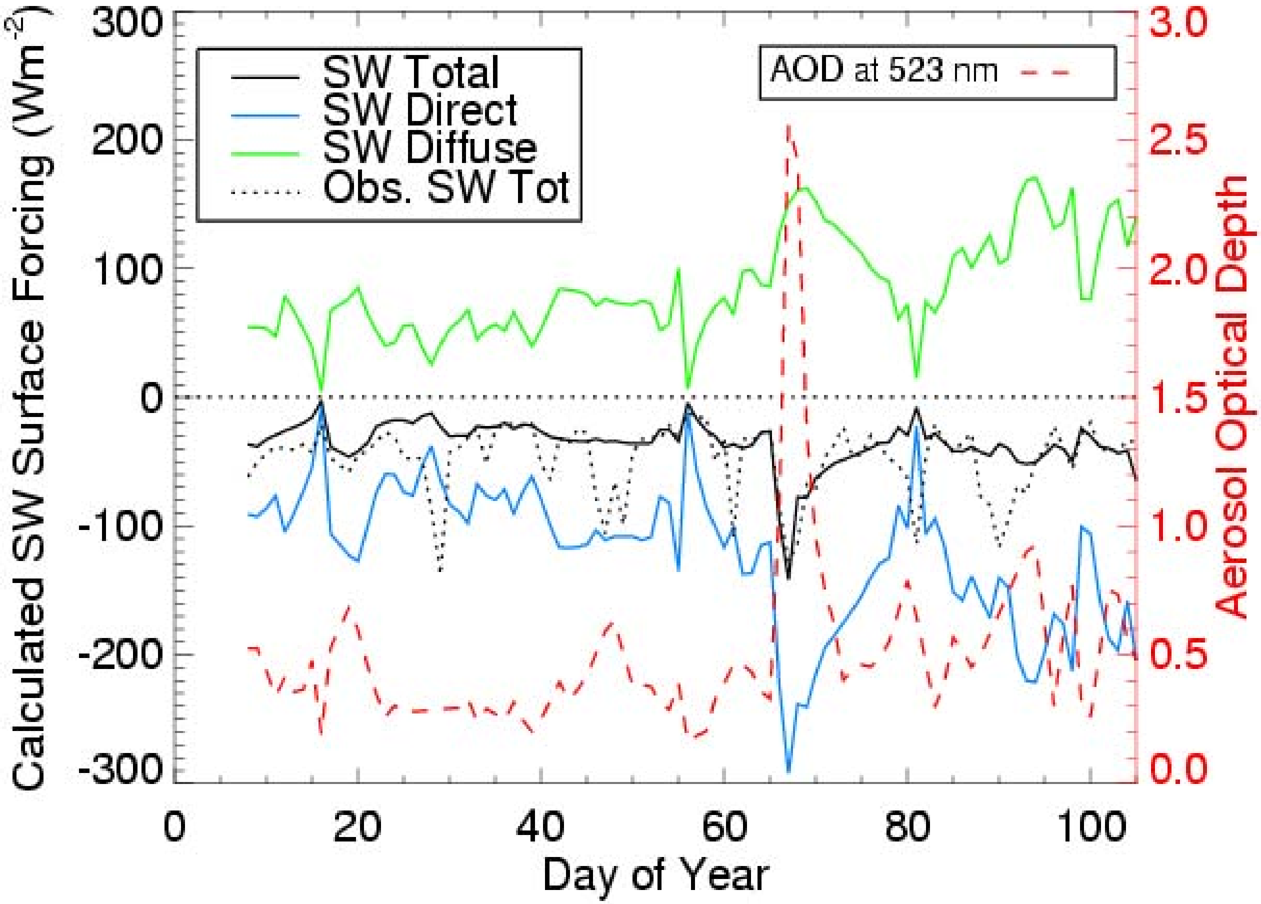


MPL-derived extinction profile



Calculated/measured surface fluxes

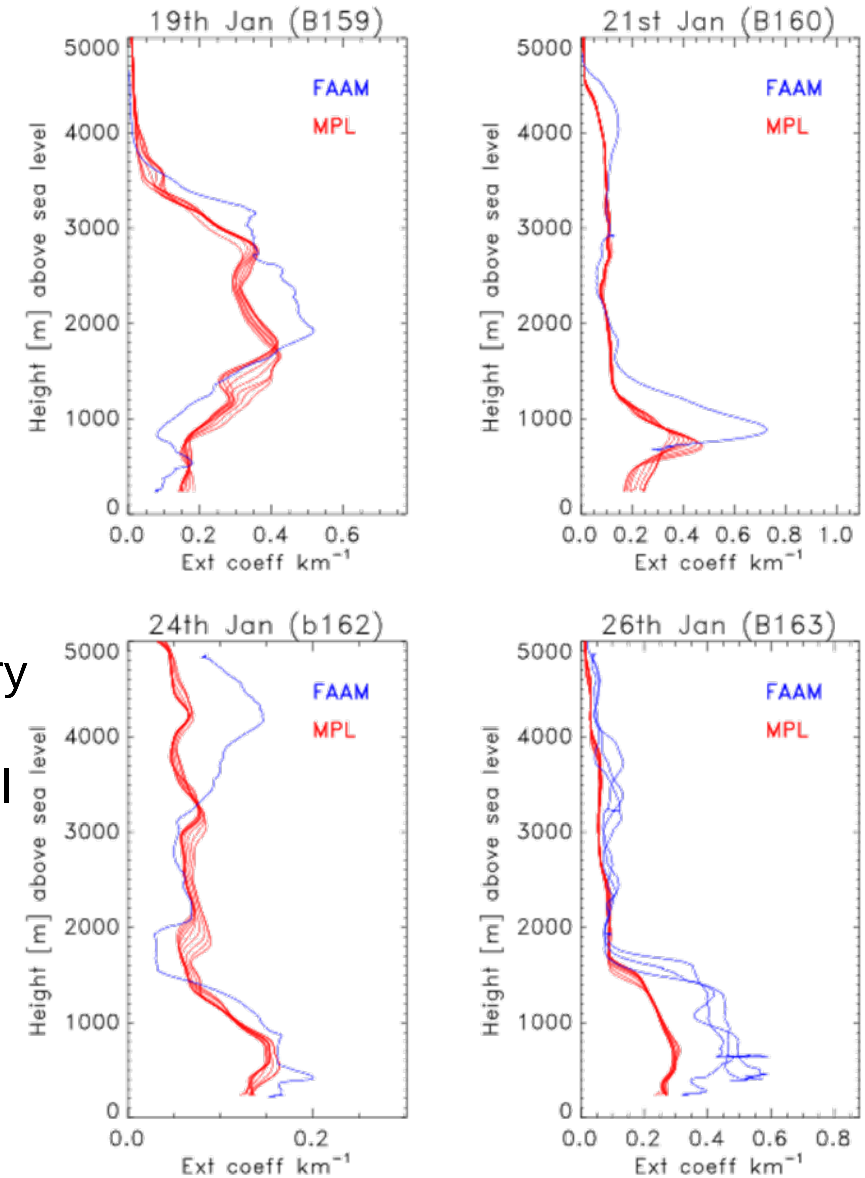
Calculated Daily Avg SW Radiative Effect at Surface due to Aerosol Only (Jan-Apr 2006)



Initial comparisons of vertical extinction profiles from MPL and aircraft (FAAM) during DABEX

Very thick elevated biomass burning aerosol layer

Very dusty boundary layer



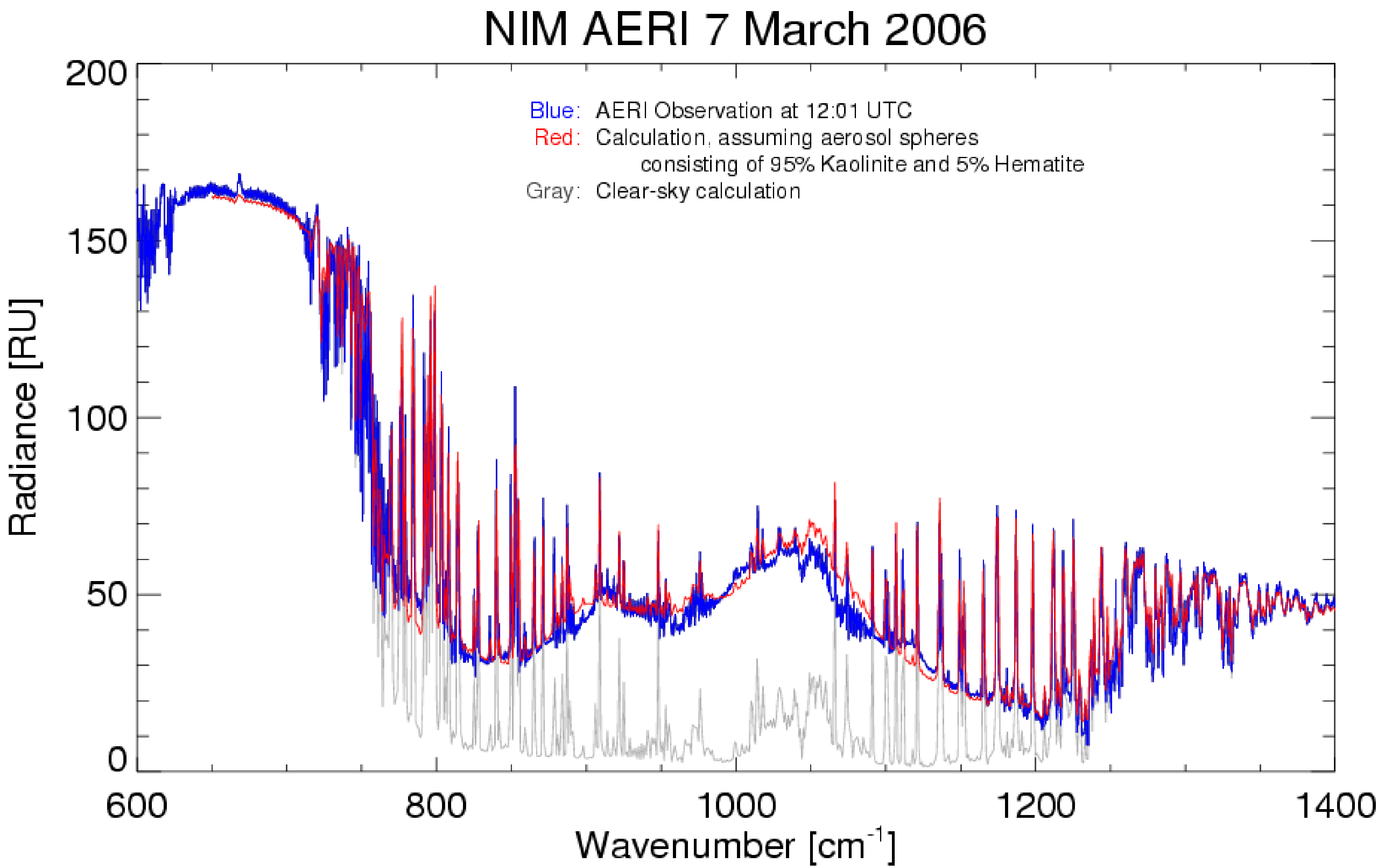
Dust in boundary layer; biomass burning aerosol above

Dusty, well mixed boundary layer

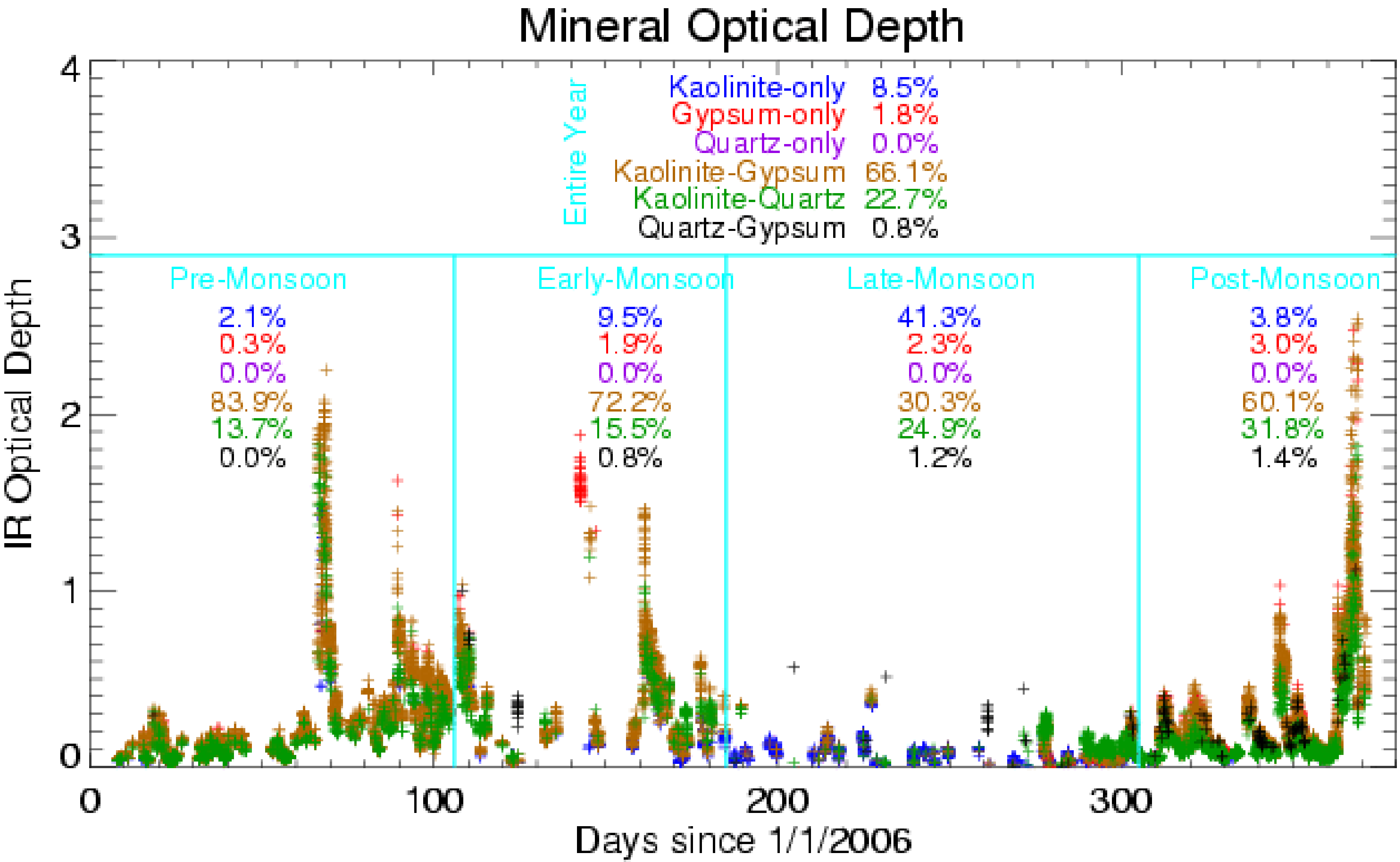
Dust Properties Retrieved from AERI Observations

Dave Turner, U. Wisconsin

Example: 8-13 μm Band Fit



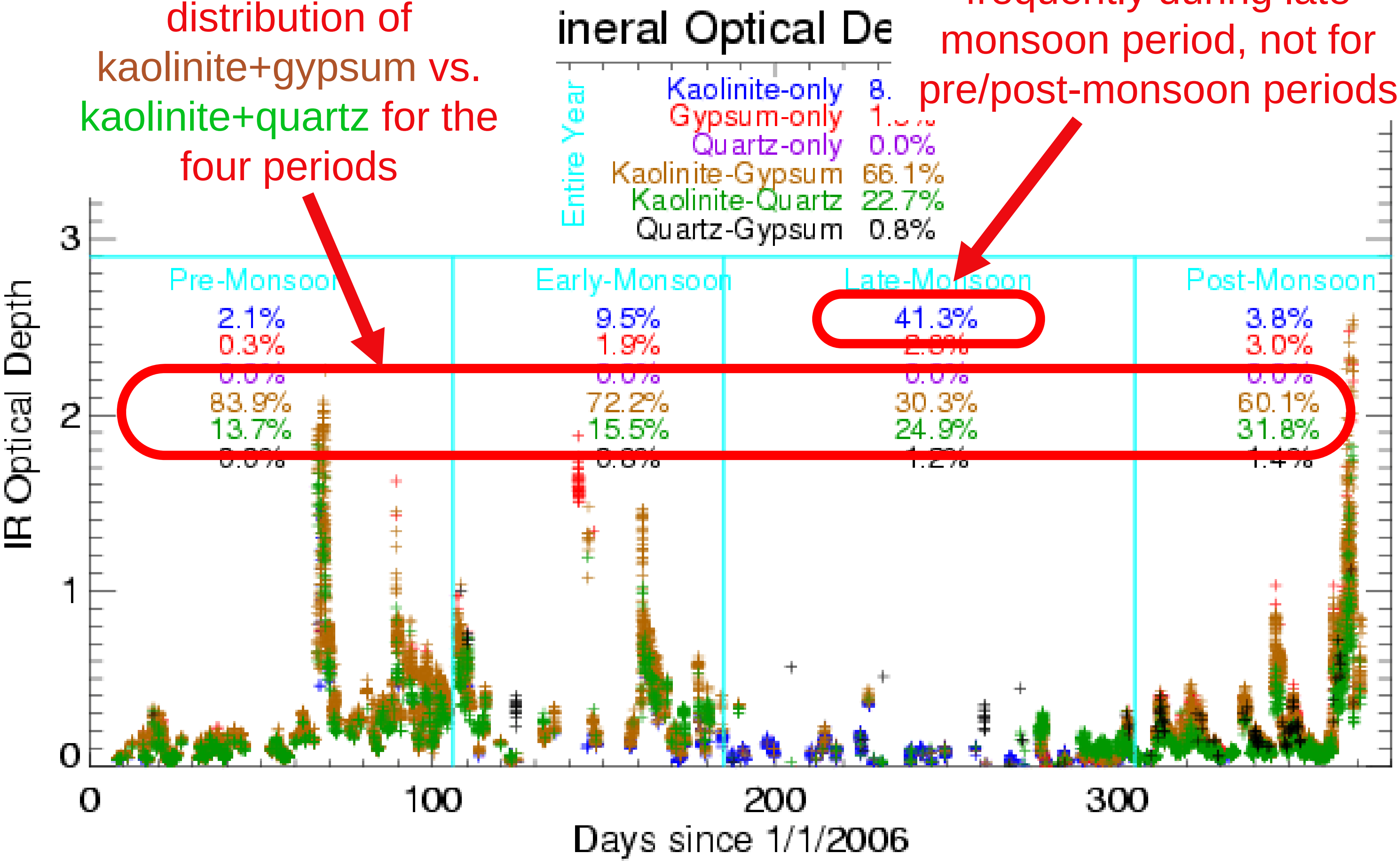
Dust Optical Depth and Composition Distribution



Dust Optical Depth and Composition Dist

Significantly different distribution of kaolinite+gypsum vs. kaolinite+quartz for the four periods

Kaolinite-only was best fit frequently during late monsoon period, not for pre/post-monsoon periods



Evaluating Radiative & Energy Balance in Met Office NWP Models over Africa.

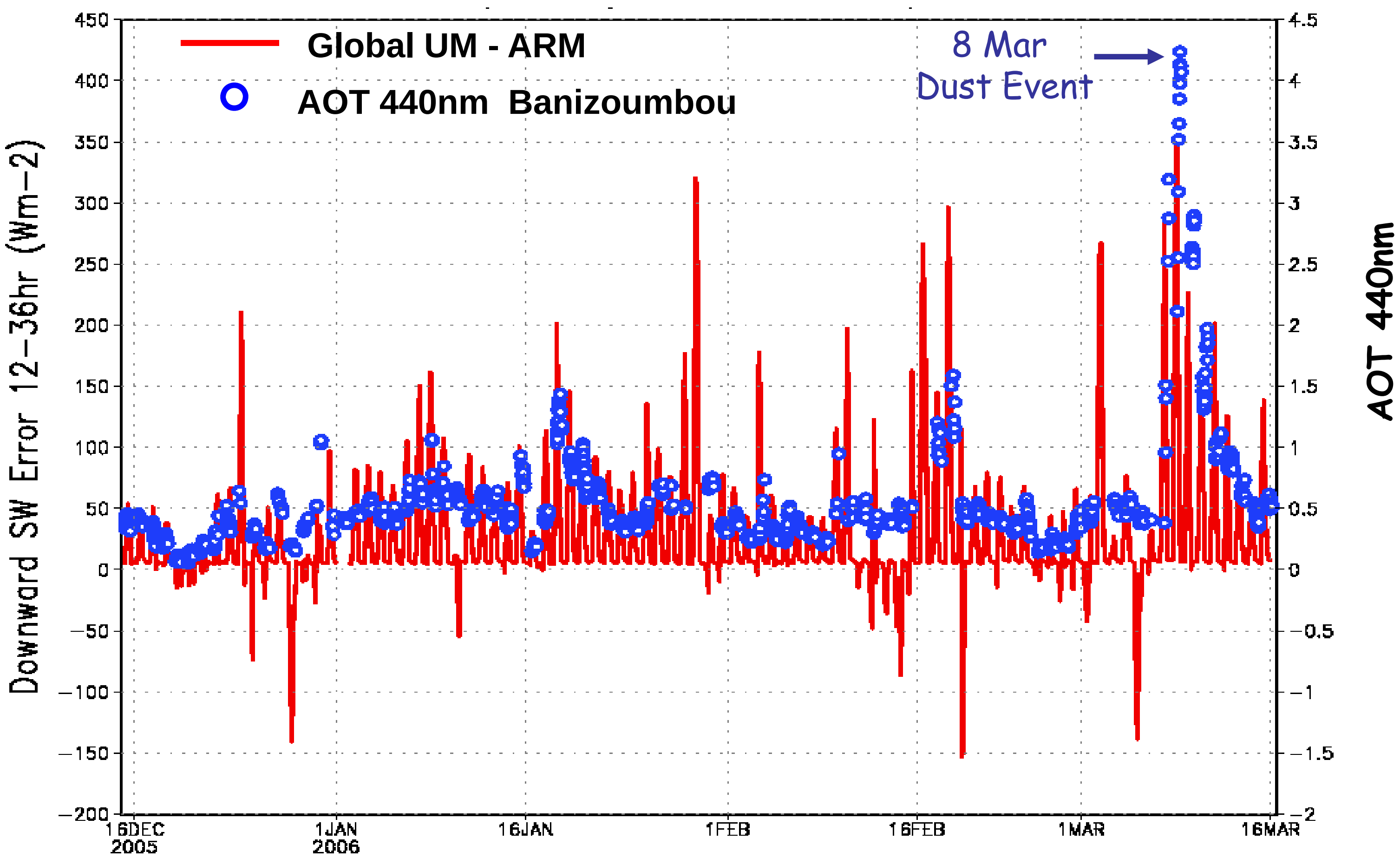
Sean Milton, Glenn Greed, Malcolm Brooks, J.Haywood, R.Allan* & A. Slingo*

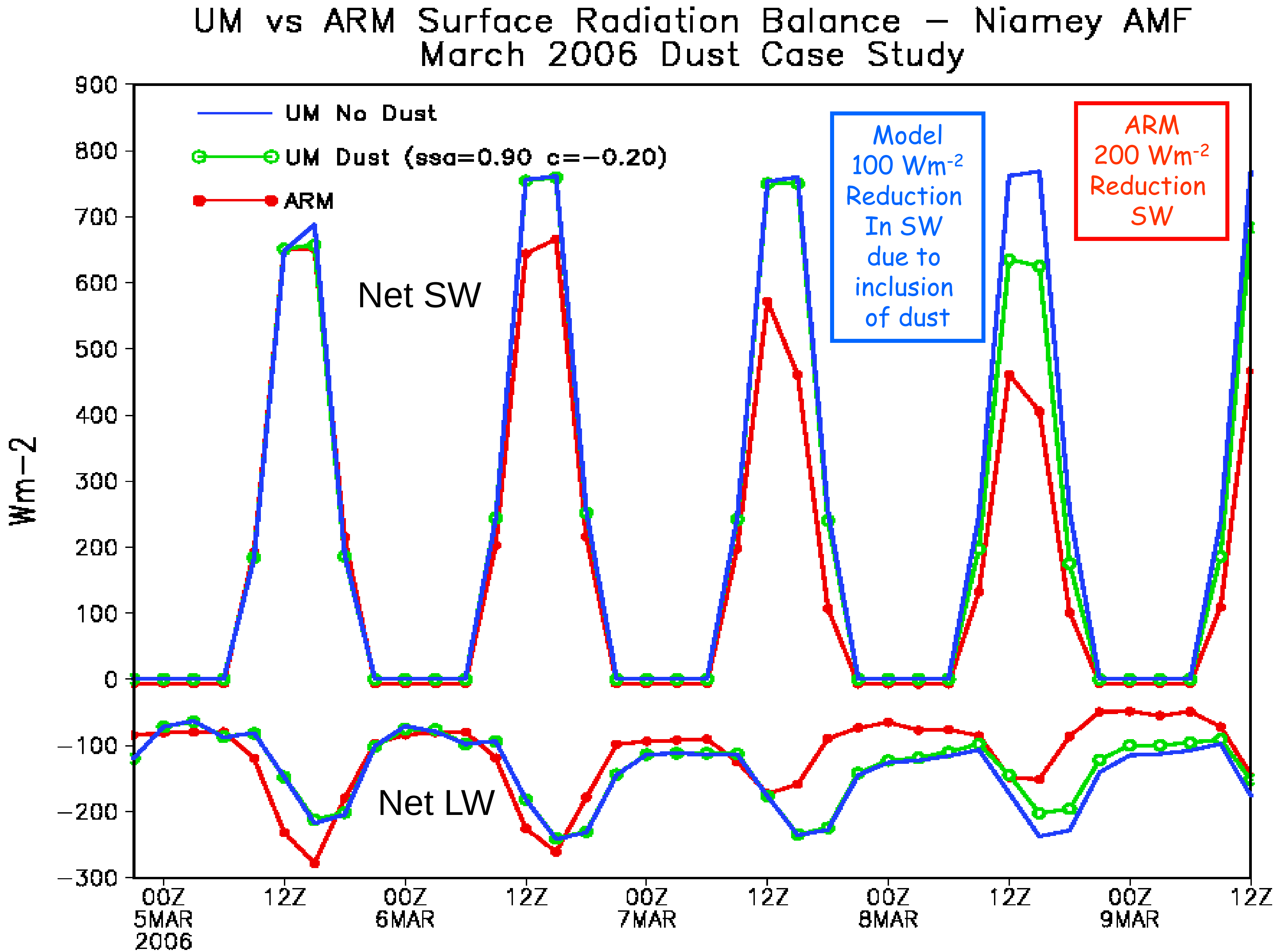
Met Office, Exeter, UK

*ESSC, Reading University

RADAGAST Meeting 19 July 2007

Importance of Aerosols for NWP




UM vs ARM Surface Radiation Balance – Niamey AMF
March 2006 Dust Case Study
UM No Dust
UM Dust (ssa=0.90 c=-0.20)
ARM
Net SW
Net LW
Model
100 Wm-2
Reduction
In SW
due to
inclusion
of dust
ARM
200 Wm-2
Reduction
SW
Wm-2
900
800
700
600
500
400
300
200
100
0
-100
-200
-300
00Z
5MAR
2006
12Z
00Z
6MAR
12Z
00Z
7MAR
12Z
00Z
8MAR
12Z
00Z
9MAR
12Z

Tentative list of planned RADAGAST papers

- Submitted or published:
  - Major dust storm; Slingo et al., *Geophys. Res. Lett.*, 30 December 2006
  - AMF and RADAGAST background; Miller and Slingo, *Bull. Amer. Meteorol. Soc.* (August 2007)
  - Clouds at Niamey; Kollias and Miller, *Geophys. Res. Lett.,* submitted
- In preparation:
  - Overview: meteorology and related AMF data (Slingo, Lamb et al.)
  - Overview: radiative fluxes and related data (Slingo, Bharmal, et al.)
  - Comparisons of fluxes with models (Bharmal et al.)
  - Comparisons with NWP model (Milton et al.) in DABEX issue
  - Dust properties retrieved from AERI (Turner)
  - MFRSR aerosol retrievals and radiative forcing (McFarlane, Kassianov, et al.)
  - Heterogeneity and surface fluxes (Settle)
  - Satellite detection of aerosols and clouds (Robinson)

Aerosol vertical distribution