Observations of the Earth’s Radiation Budget from Geostationary Orbit and from the Surface

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• Results from Meteosat-8
  – diurnal cycle of the OLR observed by GERB

• Combining GERB data with observations from the ARM Mobile Facility in Niamey, the capital of Niger
  – the RADAGAST project
Meteosat-8

- Geostationary Earth Radiation Budget instrument (broadband radiometer)
- SEVIRI high-resolution imager
- Two pairs of instruments currently in orbit:
  - Meteosat-8 (launched in August 2002)
  - Meteosat-9 (launched in December 2005)
  - switchover between satellites in late 2006
  - Niamey near centre of field of view
GERB

• GERB has two broadband channels:
  – shortwave and total: 0.32-4μm and 0.32-30μm
  – subtraction results in longwave: 4-30μm
  – sub-satellite resolution is ~45km

• SEVIRI measures in 12 narrow channels:
  – covering solar (4 vis/NIR) and thermal (8 IR) regions
  – sub-satellite resolution ~1km / ~3km

• Data have 15 minute resolution
GERB observations of the diurnal cycle of the Outgoing Longwave Radiation

Ruth Comer, PhD student

• We use GERB data for July 2006, with 15-minute temporal resolution
• Composite the data to produce an average diurnal cycle, according to local solar time
• Analyse using Principal Component (PC) Analysis
• Results:
  – PC1 shows the diurnal cycle of surface temperature
  – PC2 shows the diurnal cycle of convective clouds, which are triggered by topography
The RADAGAST project

- **Radiative Atmospheric Divergence using ARM Mobile Facility, GERB data and AMMA stations**
  - collaboration between ARM program, ESSC, PNNL and other partners
  - led by Tony Slingo, ESSC

- **Links the ARM Mobile Facility (Niamey) with GERB and AMMA (African Monsoon Multidisciplinary Analysis)**

- **Derive the divergence of radiation across the atmosphere:**
  - first comprehensive surface measurements of atmospheric radiation and structure in Africa
  - study the radiative properties of aerosols (desert dust, biomass), water vapour and clouds
  - opportunity to resolve disagreements between radiation codes and data
ARM Mobile Facility

- **AMF in Niger from late 2005 to end 2006**
- **Two sites:**
  - main site at Niamey airport
  - subsidiary site at Banizoumbou, 60km distant
- **Wide range of instruments available:**
  - radiometers, Lidar, Radar, aerosol sampling, infrared spectrometer *and* radiosondes
Overview of geography
Surface fluxes measured with AMF sites

Top of atmosphere fluxes measured with GERB and SEVIRI instruments on Meteosat

GERB resolution of 50km, but the ARCH product has a resolution of ~10km, whereas the AMF sites measure over ~0.01km
Why is RADAGAST based in Niamey?

Long-term average annual cycles of climate parameters at Niamey, Niger

- **Temperature**
- **Humidity**
- **Dew Point Temperature**
- **Visibility**
- **Vapor Pressure**
- **Rainfall**

*Graphs showing the average annual cycles of climate parameters at Niamey, Niger.*
AMF observations in 2006

Daily averaged column water vapour over Niamey
Sonde humidity profiles in 2006
RADAGAST
Radiative Atmospheric Divergence using Arm mobile facility Gerb and Amma Stations

Objectives
RADAGAST aims to improve our understanding of the radiative balance of the atmosphere by combining simultaneous measurements of radiation at the surface and the top of the atmosphere.

This unique project is using data from multiple instruments of the US ARM Mobile Facility located in Niger, Africa during 2006 and the SEVIRI and GERB imaging sensors on the Meteosat Second Generation satellites.

Participating Programs & Institutions

USA:
- Atmospheric Radiation Measurement Program
- National Centers for Environmental Prediction

UK:
- Environmental Systems Science Centre
- Imperial College London
- Met Office

Europe and International:
- GERB International Science Team
- European Centre for Medium range Weather Forecasts
- Satellite Application Facility for Climate Monitoring at the Deutscher Wetterdienst

Features

Region of Interest:
- Approximately 25°W to 25°E, 5°S to 30°N
- RADAGAST placemark (km) file for Google Earth™

Data (near-real time and archived):
- Full resolution images, every 15 minutes, of all 12 SEVIRI bands over the RADAGAST region of interest
- Daily time series of the above over Niamey and Banizoumbou AMF sites

Derived Products (near-real time and archived):
- Half resolution dust and pseudo-natural visible image products, based on Eumetsat algorithms, every 15 minutes
- Animations of interesting meteorological and other events

Meta-data:
- Daily log of meteorological conditions and other events, compiled by Tony Slingo

Contact Points

Principal Investigator: Prof. Tony Slingo, ESSC

Web site, SEVIRI processing: Dr Gary Robinson, ESSC
Observations of the impact of a major Saharan dust storm on the Earth’s radiation balance

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submitted to GRL

Animation of Meteosat dust product
Dust product (upper) and GERB OLR (lower) for 1200UT on 8 March 2006

Cloud

Dust

Lake Chad
Onset of storm at 09h30, 2006/3/7
...and the next day, 2006/3/8
…webcam for 2006/3/8
…and dust settles, 2006/3/10
...webcam for 2006/3/12
Radio-sonde ascent, 2006/3/8 (during storm)
Dust storm: summary

Solar fluxes

• Increase in flux scattered back to space
• Larger reduction in the downward flux at surface
  – direct flux reduced virtually to zero ($\tau_{\text{aerosol}} \sim 3$)
  – all the remaining downward flux is diffuse (as under thick cloud)
• Implies significant atmospheric absorption
  – absorption underestimated by the models, despite using dust that is more absorbing than in other studies
  – so we may have a real problem in modelling the absorption

Thermal fluxes

• Significant effect of “cold”, dry air
• More thermal radiation emitted to the surface (dust)
• Less OLR emitted to space
• Increased atmospheric cooling

Solar effect is larger: net effect of aerosol is heating
Summary and future work

• We continue to receive excellent data from the Mobile Facility and from GERB and SEVIRI
  – the mobile facility will remain in Niamey for the RADAGAST project until the end of 2006.
• Major dust event in March 2006
  – paper submitted to GRL
• Monsoon conditions
• Future work at ESSC includes:
  – continue to monitor events and to identify test cases
  – exploit the data from the second site at Banizoumbou
  – develop the methodology to derive area-average surface fluxes
  – start work on deriving and simulating the vertical profiles of radiative fluxes and heating rates for a range of conditions
  – e.g. clear skies with as wide a range of water vapour loading as possible, aerosol, cloud cases