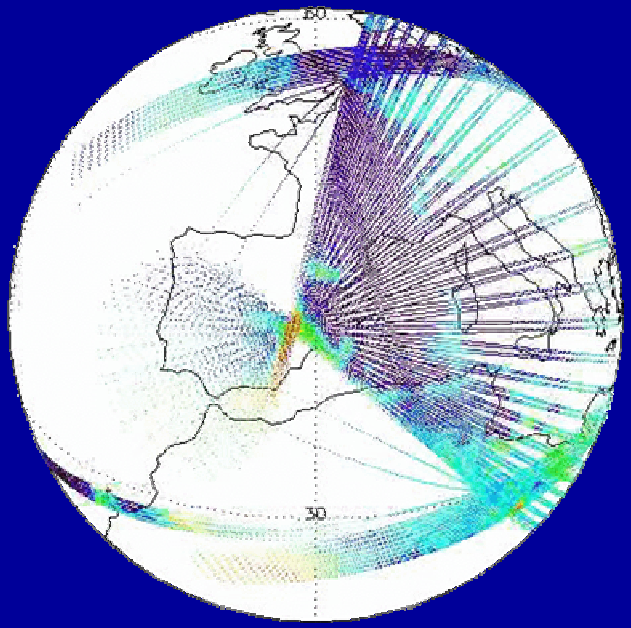
Use of *CERES* data at *Valencia Anchor Station*



4th CERES-II Science Team Meeting
Radisson, Hampton VA
Nov 1-3, 2005

Contents

1. Summary
2. Introduction
3. Methodology
4. Application of the methodology to CERES data
5. Conclusions and future work

1. Summary

The purpose of this work is to develop a suitable methodology to compare measured TOA radiances and fluxes to independent radiative transfer (RT) simulations.

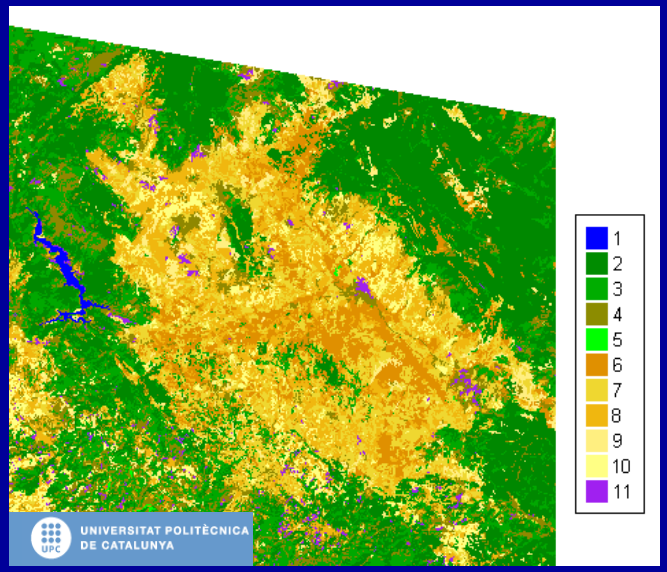
The RT simulations have been performed using surface and atmospheric measured parameters gathered during the *GERB Surface Ground Validation Campaign* at the *Valencia Anchor Station* (VAS) area in February 2004.

2. Introduction

The methodology developed is being tested for the NASA *Clouds and the Earth's Radiant Energy System* (CERES) instrument in the framework of the SCALES project (*SEVIRI and GERB Cal/val Area for Large scale field ExperimentS)*, and it will be eventually used to validate GERB much lower spatial resolution data over the VAS area.

The study includes the selection of atmospheric profiles from on-purpose radiosonde and GPS data, a BRDF (*Bidirectional Reflectance Distribution Function*) estimation for the large-scale study area and *Streamer* RT simulations of TOA SW and LW radiances and fluxes.

Study area (I)



Land Use Classification

1: water
2: pine trees
3: low density pine trees and shrubs
4: shrubs
5: irrigated crops
6: vineyards
7: low density vineyards
8: very low density vineyards
9: herbal crops
10: bare soil
11: urban areas

In winter

(20x20 km² pixel)

76.6%: bare soil

23.4%: pine trees and shrubs

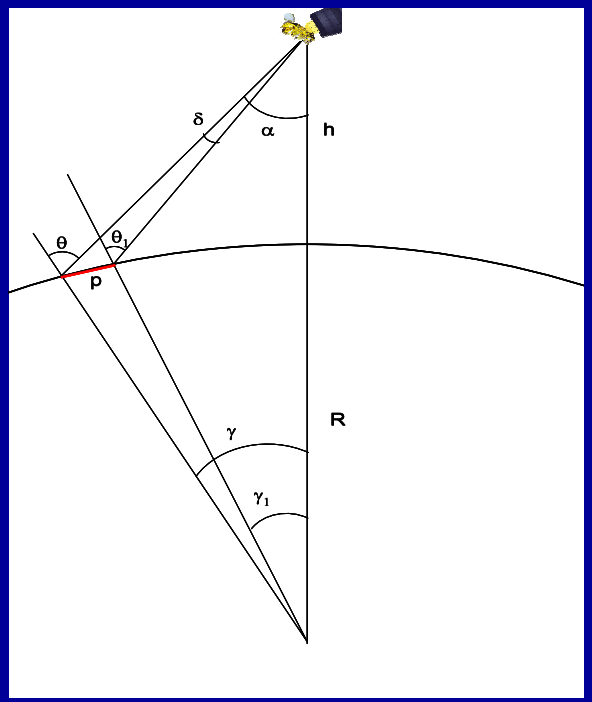
Study area (II)

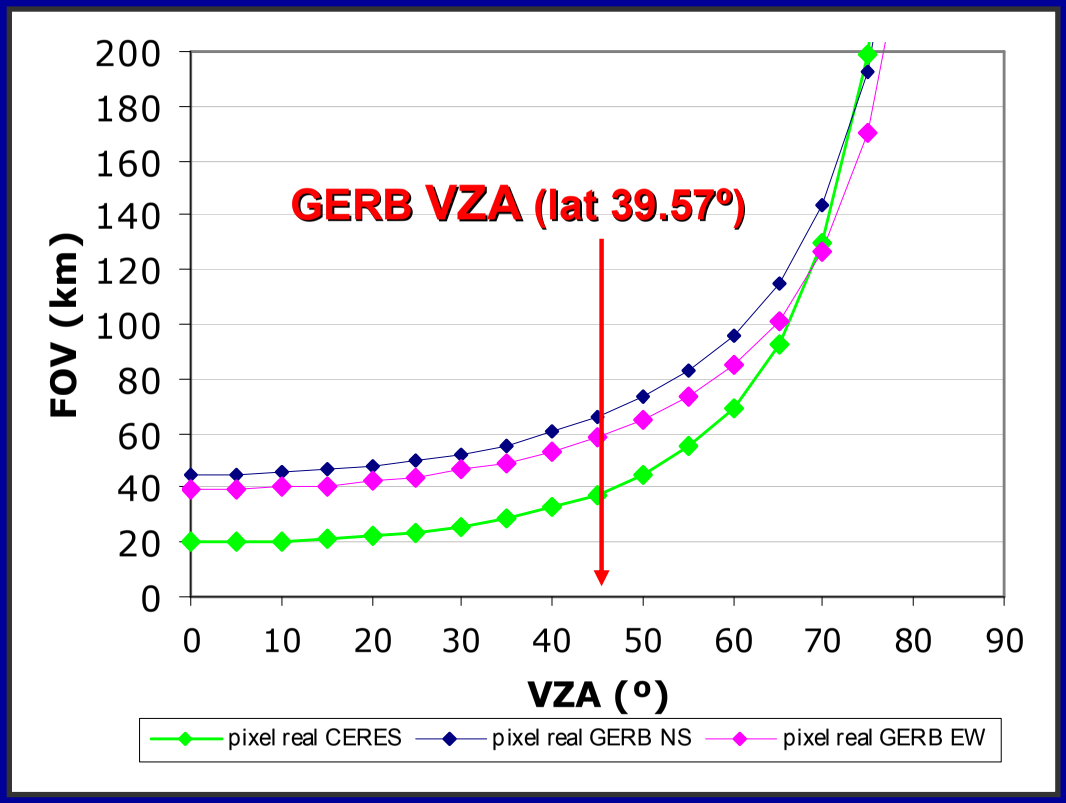
Ground Validation Campaign
February 2004

June 2003

Footprint size

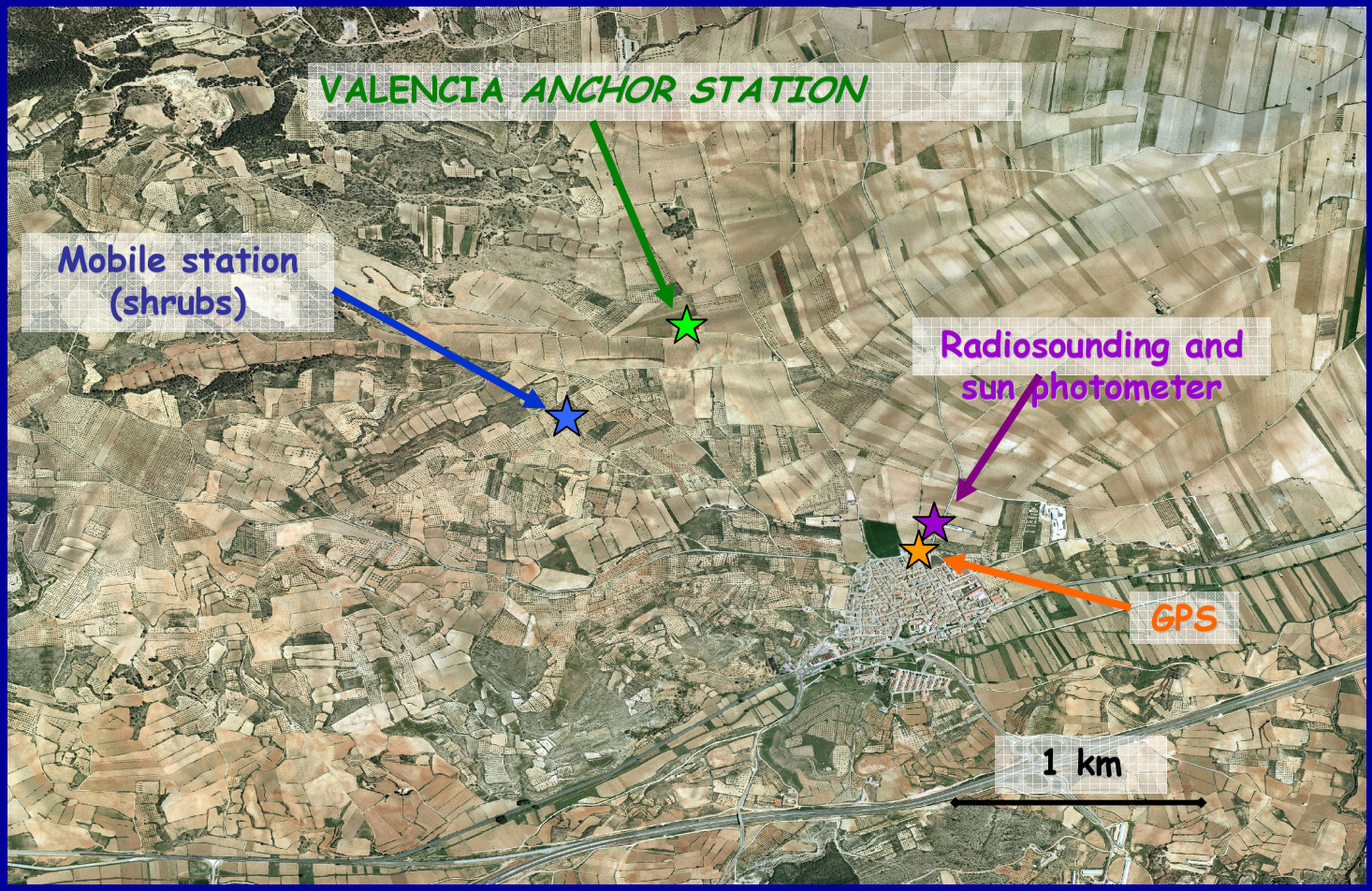
GERB and CERES pixel size vs VZA



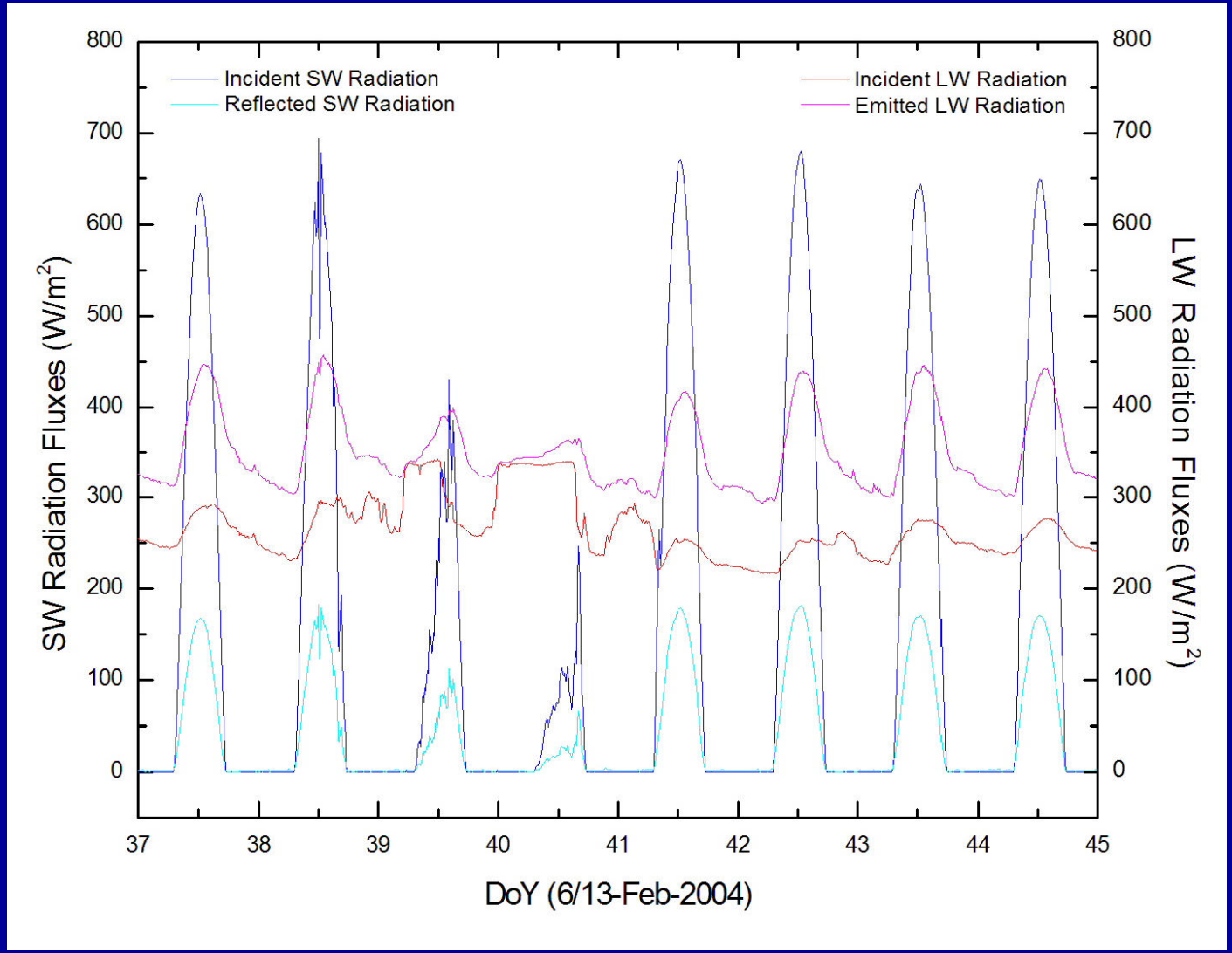


$$P \approx 2 \cdot p = R \cdot (\gamma - \gamma_1) = 2 \cdot R \cdot (\theta - \theta_1 - \delta) = 2 \cdot R \left(\cdot\theta - sen^{-1} \left(\frac{R+h}{R} \cdot sen(\alpha - \delta) \right) - \delta \right)$$

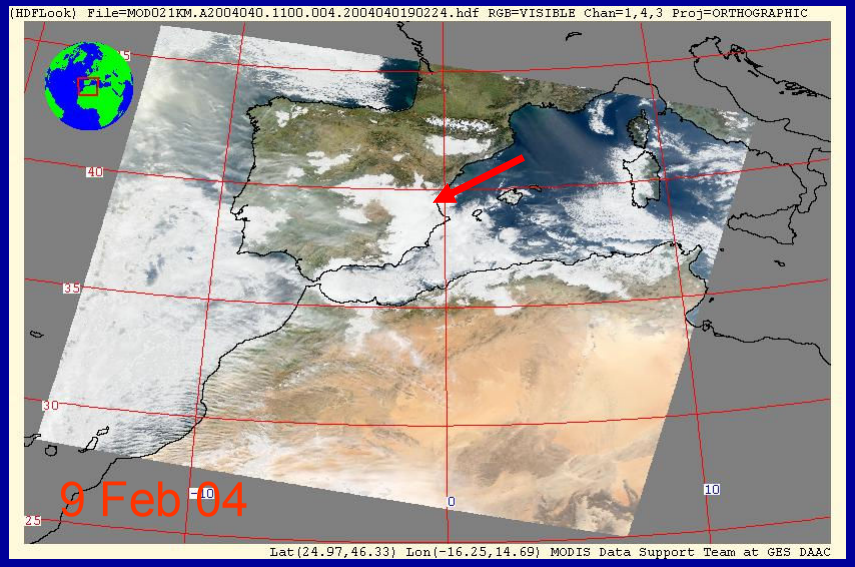
February 2004 Ground Validation Campaign outcome

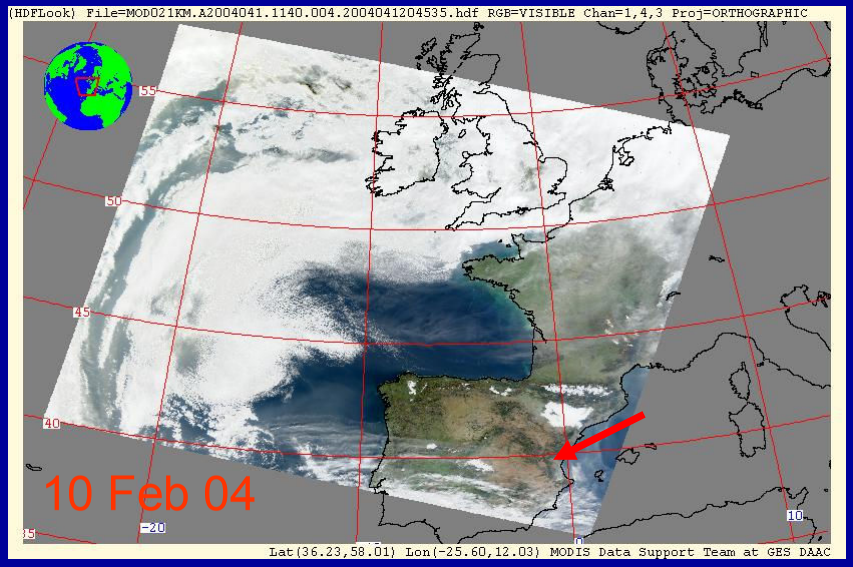


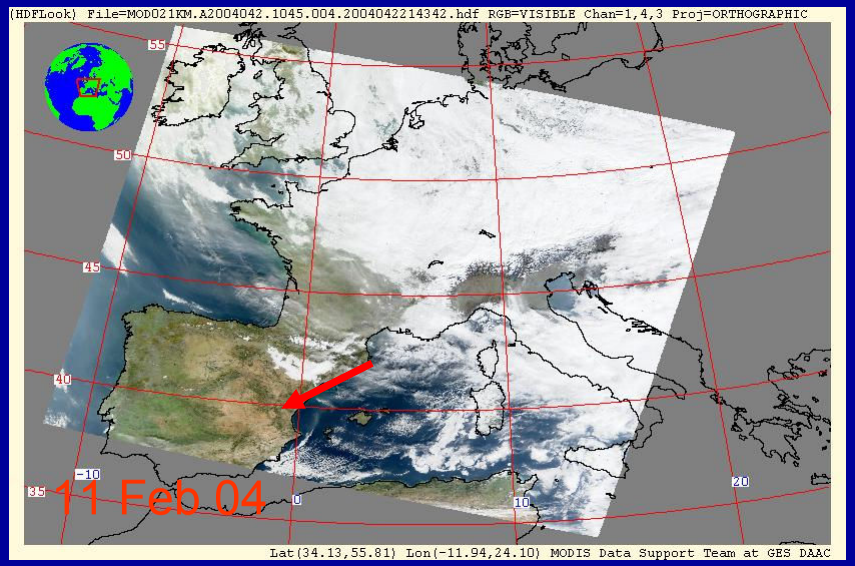
Surface radiation fluxes measured at the VAS

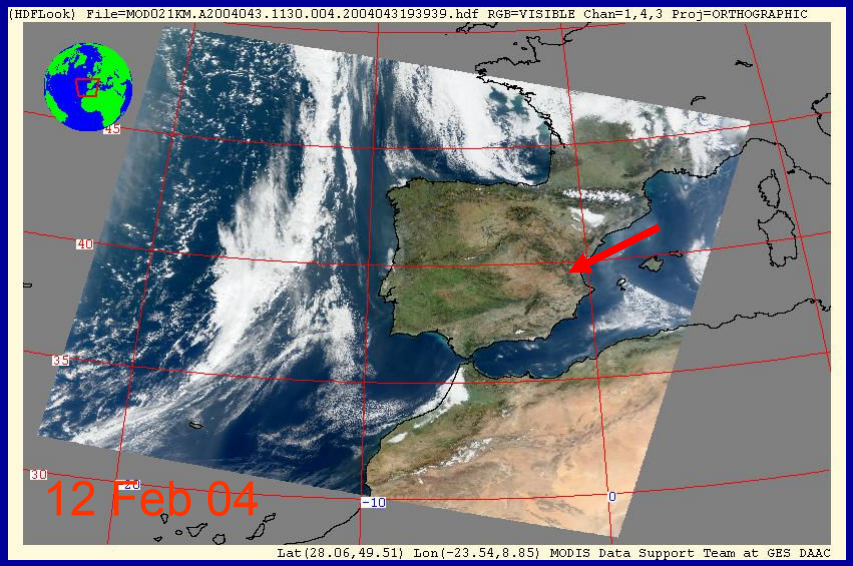


HDFLook of SSF data



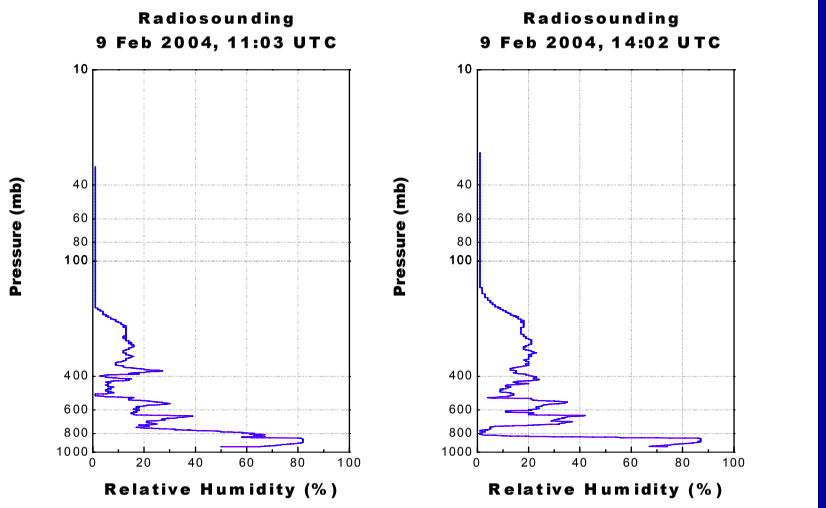


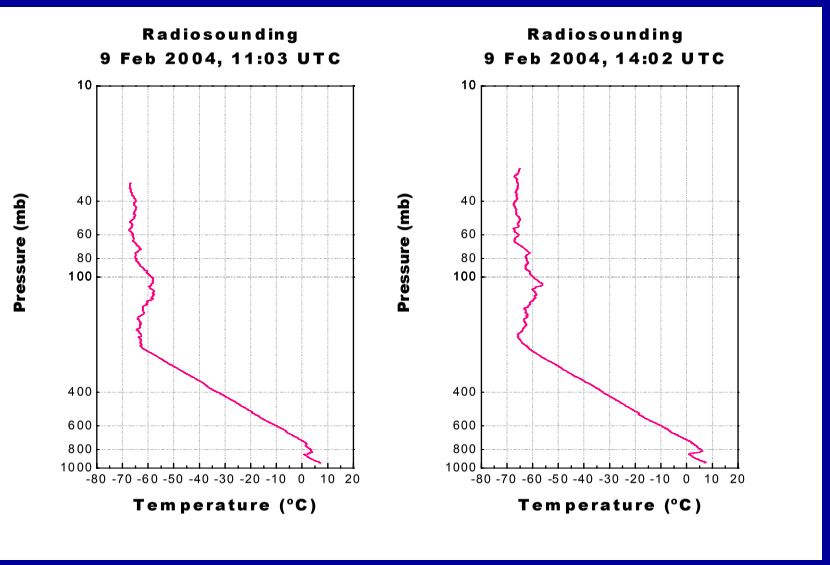




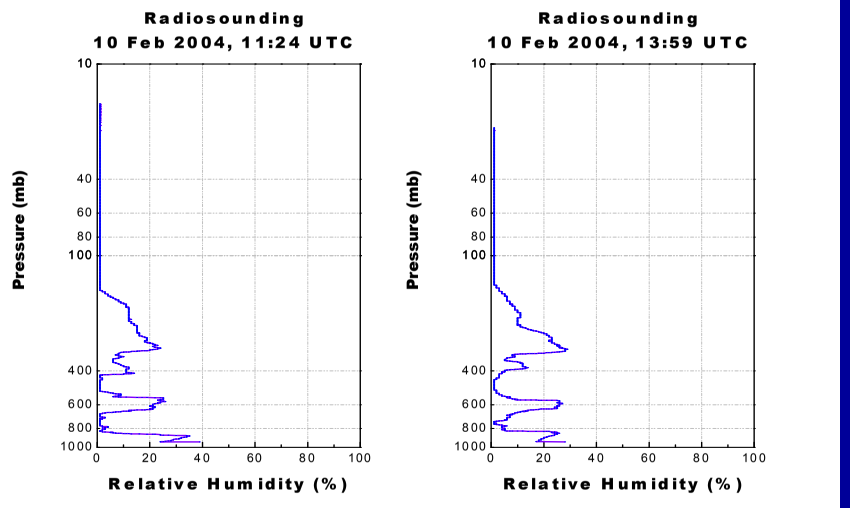
Radiosounding data

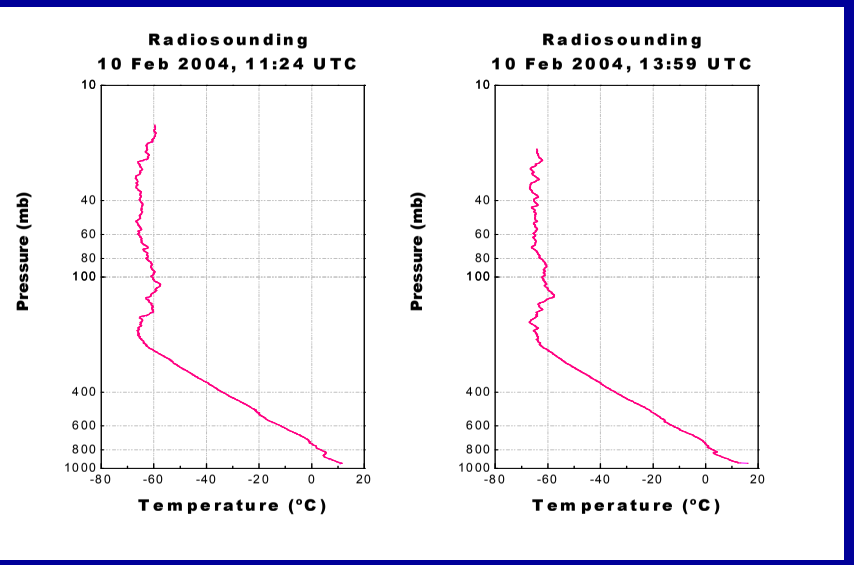
9 FEB 2004





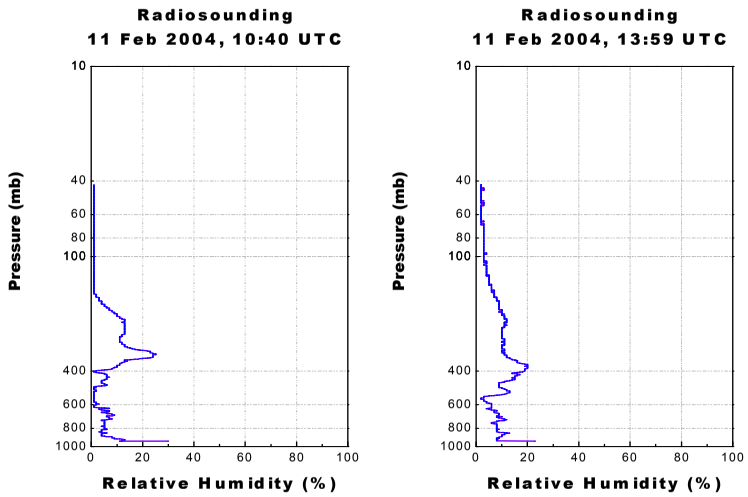
10 FEB 2004

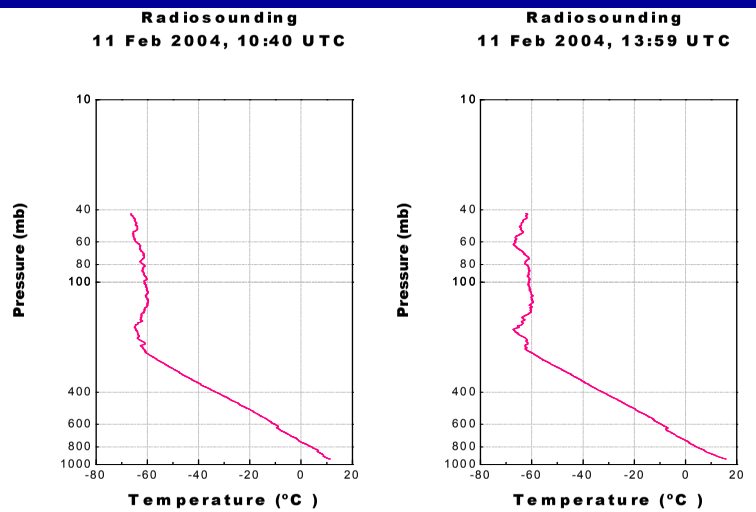




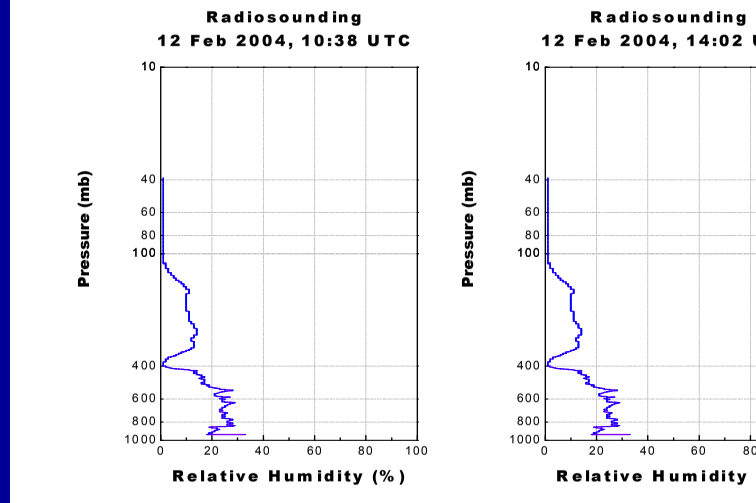
Radiosounding data

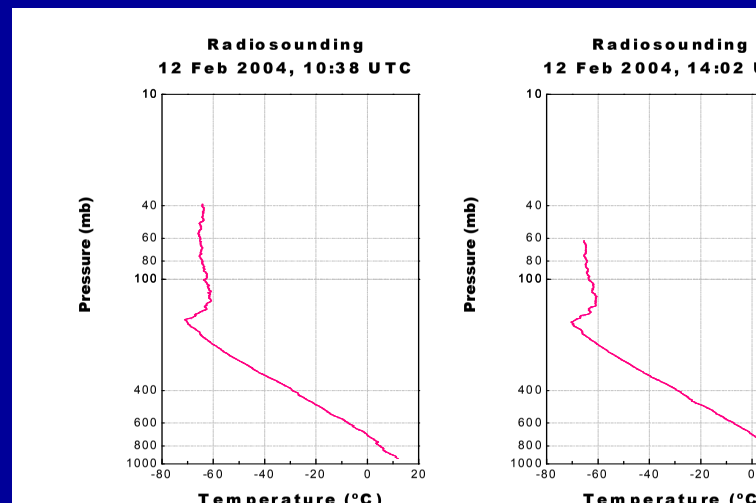
11 FEB 2004





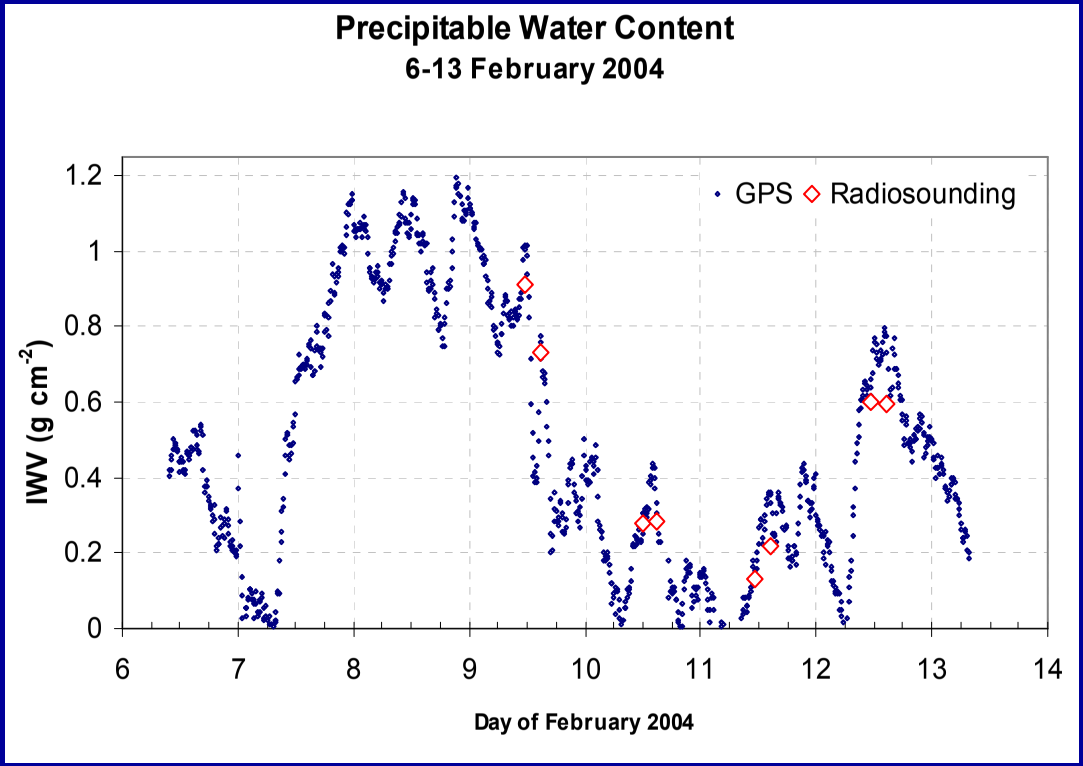
12 FEB 2004





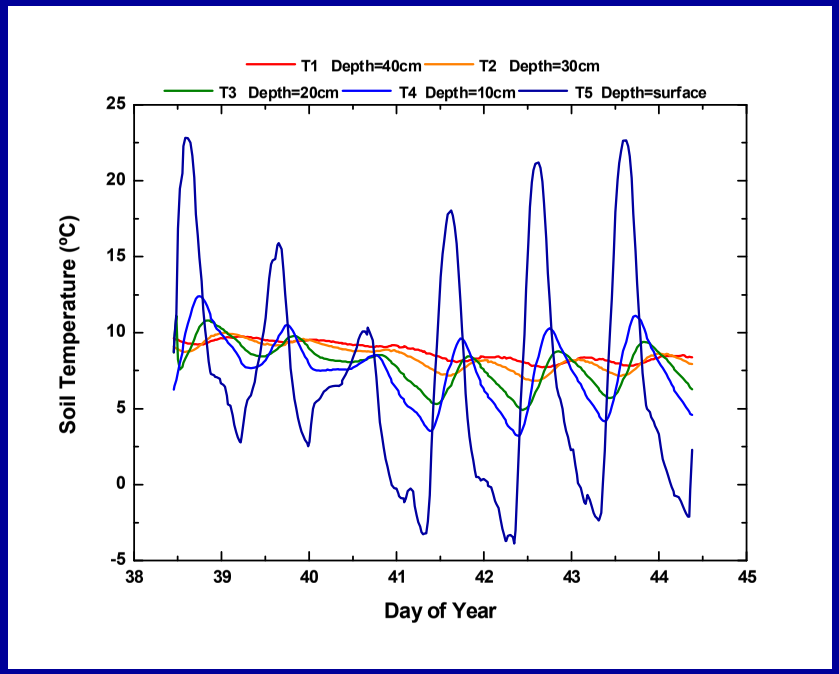
Integrated water vapour

Related to Zenith Tropospheric Delay of the signal received



GPS Antenna

Soil temperature

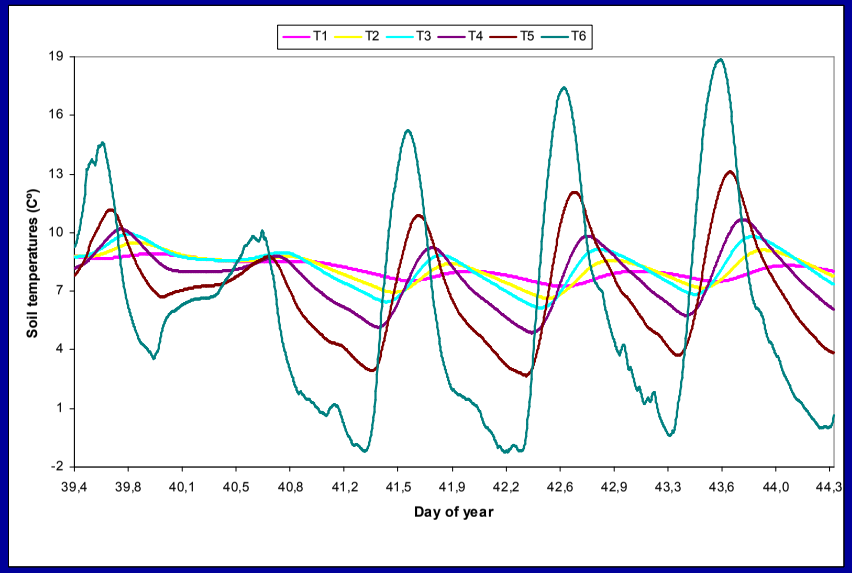


Valencia Anchor Station

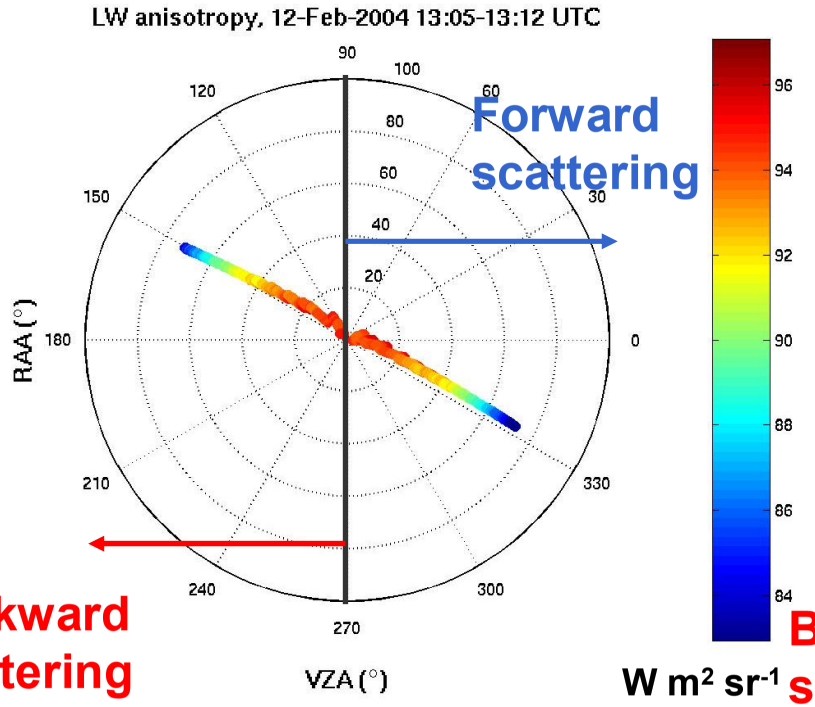
- T1: 40 cm depth
- T2: 30 cm depth
- T3: 20 cm depth
- T4: 10 cm depth
- T5: surface

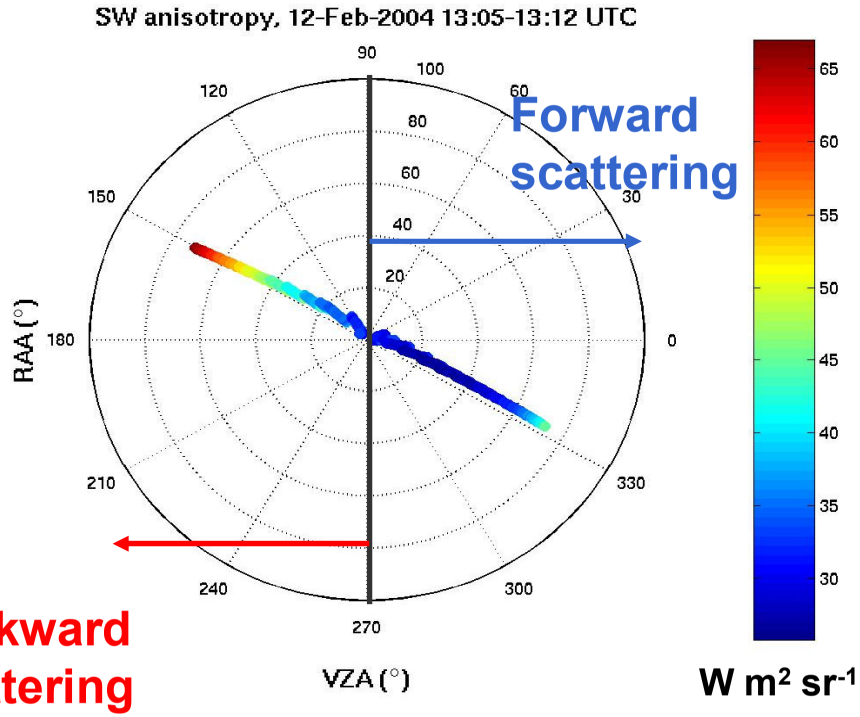
Mobile station

- T1: 30 cm depth
- T2: 20 cm depth
- T3: 15 cm depth
- T4: 10 cm depth
- T5: 5 cm depth
- T6: surface



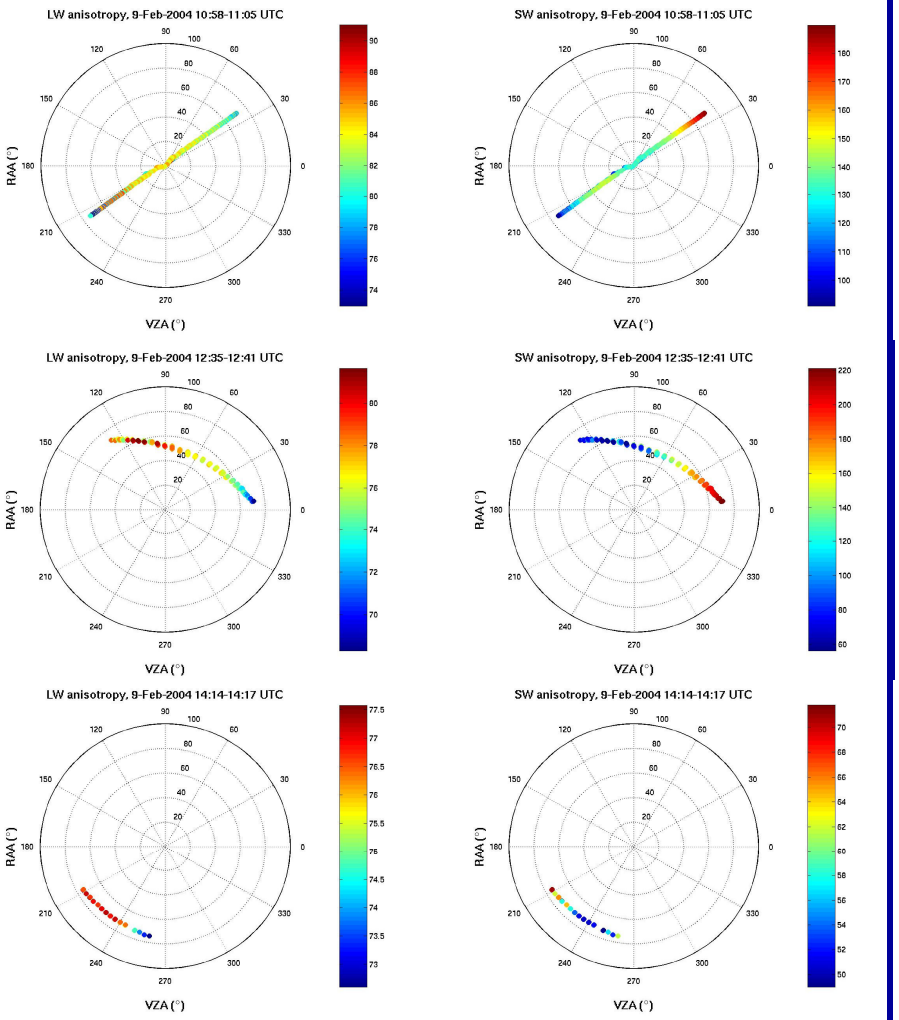
CERES TOA radiances over the study area (I)



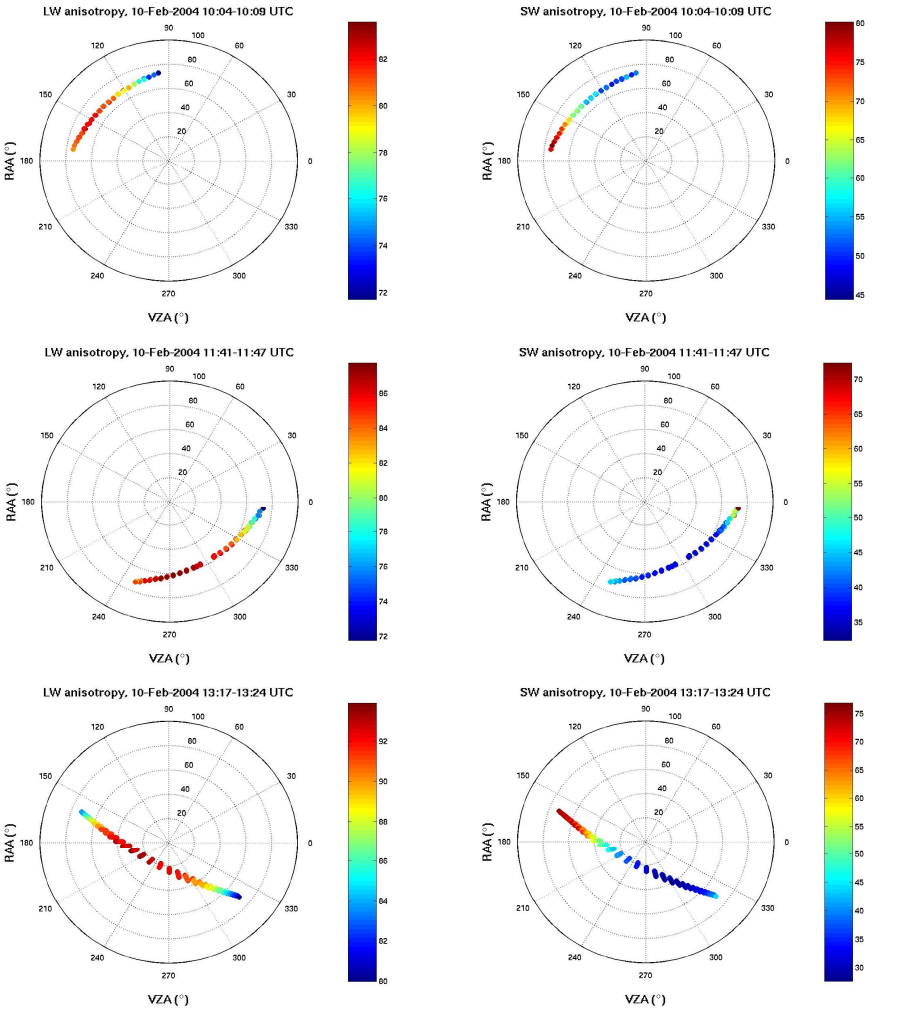


CERES TOA radiances over the study area (II)

9 FEB 2004

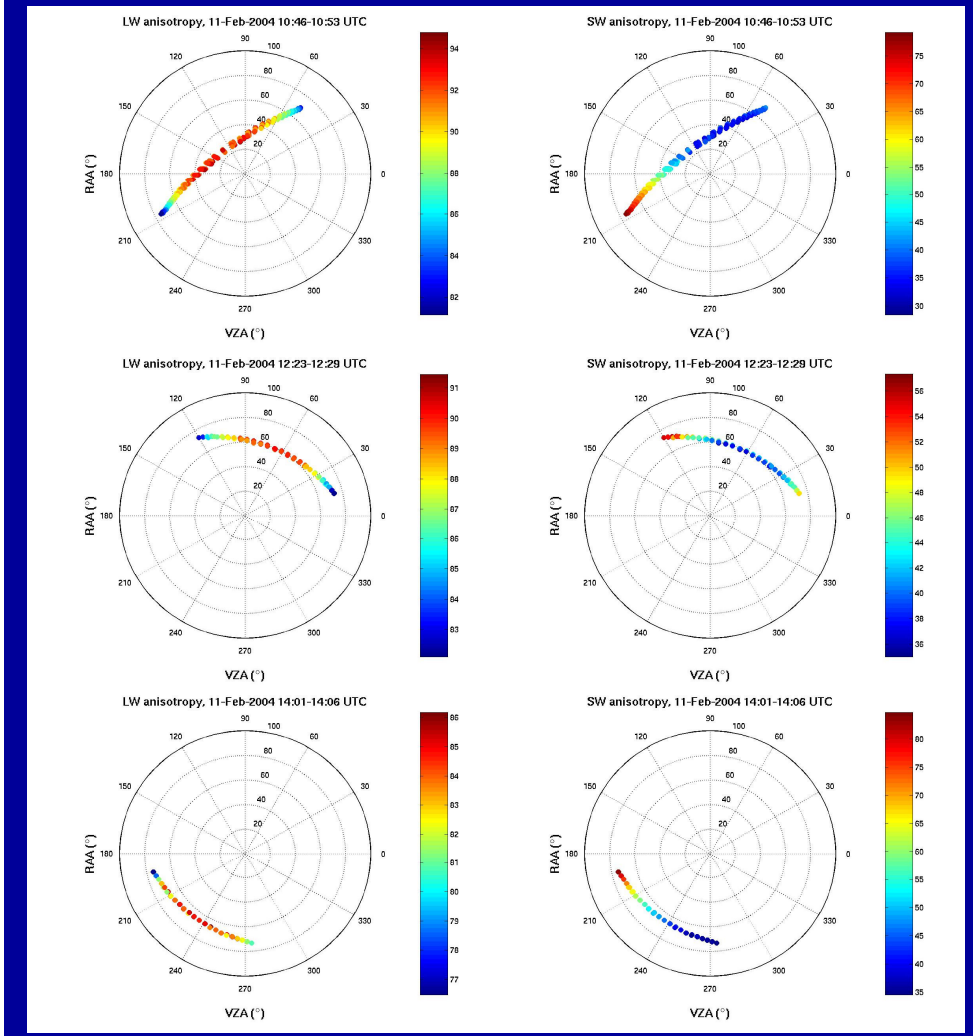


10 FEB 2004

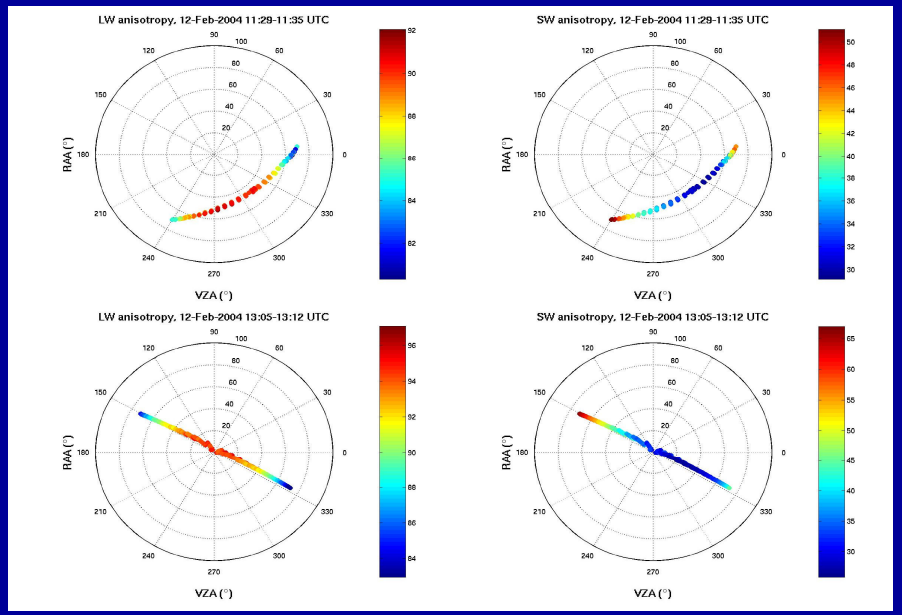


CERES TOA radiances over the study area (III)

11 FEB 2004



12 FEB 2004



3. Methodology

Parameter selection

Atmospheric profiles

a) **Water vapour, pressure and temperature**

Radiosounding water vapour scaled to the GPS IWV.

b) **Ozone profile**

Streamer MLW profile scaled to TOMS *(Total Ozone Mapping Spectrometer) value*

c) **Aerosols profile**

Streamer MLW profile + sun photometer measurements + assume background tropospheric aerosols and background stratospheric aerosols.

Surface emissivity

From CERES/SARB data

Surface temperature

Measured temperatures at the VAS and the mobile station

BRDF *(Bidirectional Reflectance Distribution Function)*

TOA radiances are sensitive to the anisotropy of the surface reflectivity and its diurnal changes.

It is necessary to know the spectral albedo and the bidirectional reflectivity

From the land use clasification: 76.6 % is bare soil

23.4 % vegetation

- **Ahmad y Deering bare soil BRDF:**

Bidirectional reflectances: every 10º in SZA and VZA and every 30º in RAA

2 spectral bands: red (0.662 μm) and near infrared (0.826 μm)

- **Spectral albedo from Aster Spectral Library (JHU, John Hopkins University)**
- **Broadband albedo: weighted from the measured broadband albedo in the stations.**

Study area BRDF

It is obtained from the broadband albedo measured at the VAS and the mobile station (a_0^{BB}), JHU spectral albedo (a_l^{JHU}) and the bidirectional reflectance from Ahmad y Deering for bare soil ($\rho_\lambda(\theta_0, \theta, \phi)$)

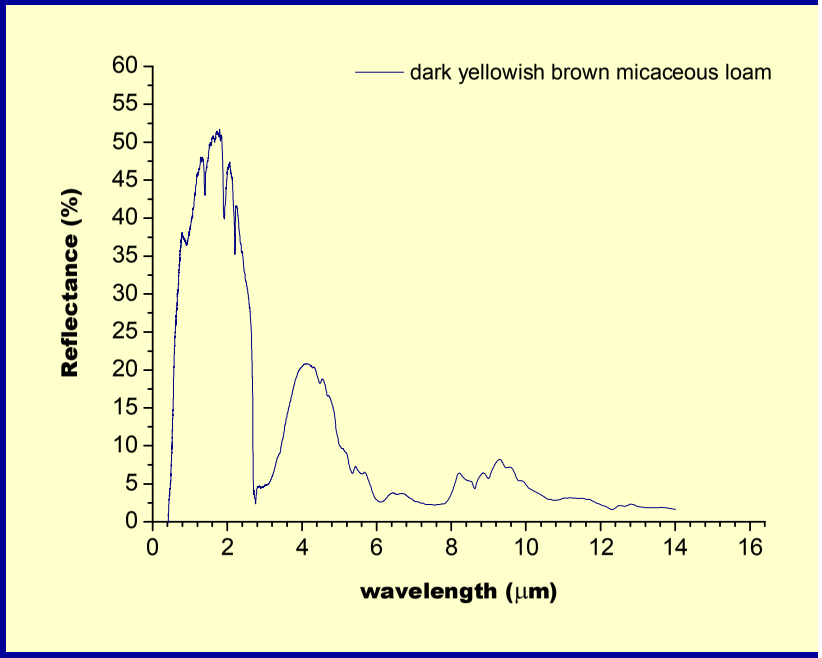
- **1. scale the JHU spectral albedo**

$$a'_\lambda = \frac{a_\lambda^{JHU}}{\int_{\lambda_2}^{\lambda_1} a_\lambda^{JHU} d\lambda} a_{BB}^0$$

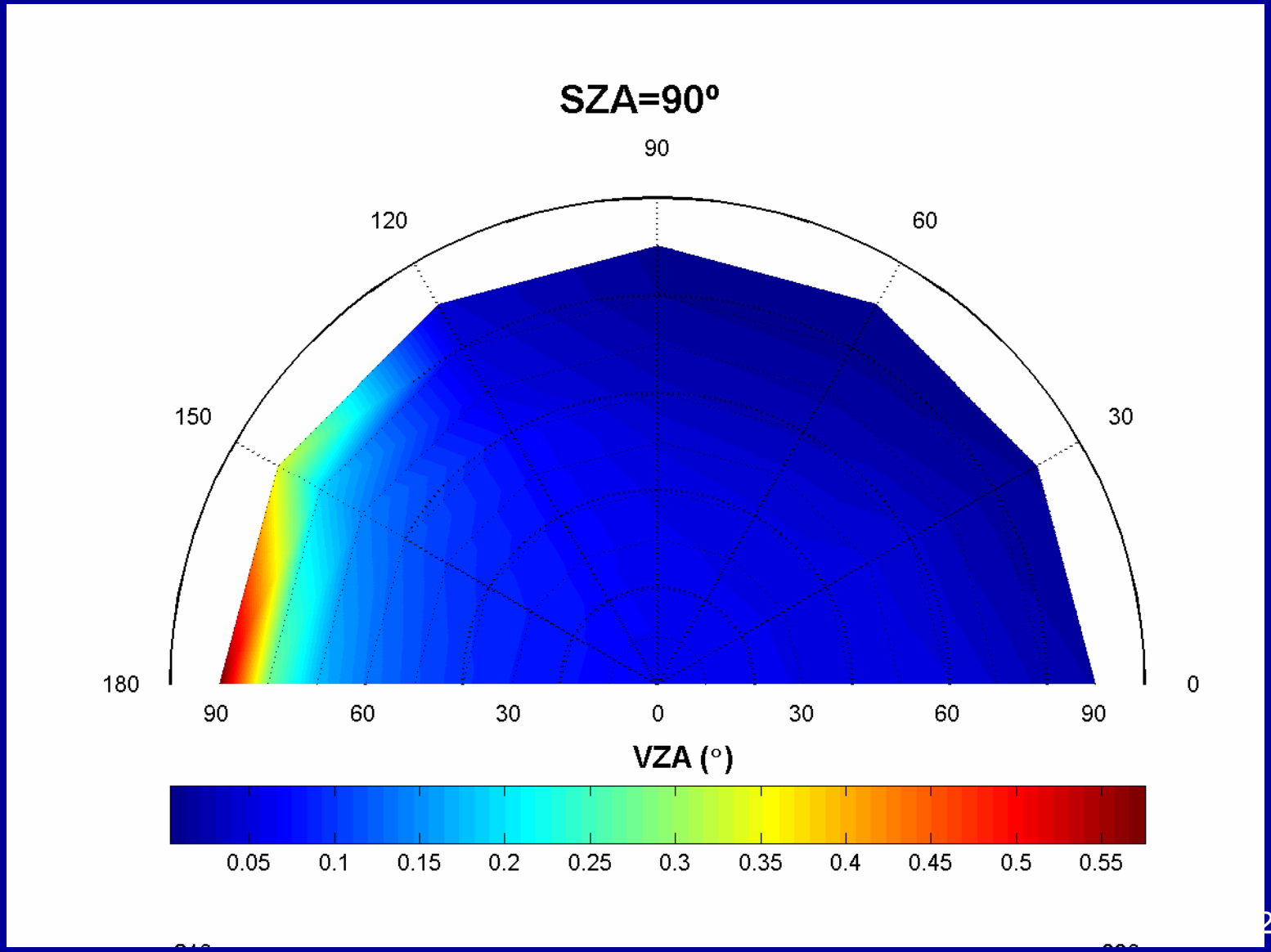
- **2. scale the bidirectional reflectances from the model**

$$s_{red} = \frac{a'_{\lambda red}}{\frac{1}{\pi}\int_0^{2\pi}\int_0^1 \rho_\lambda(\theta_0,\theta,\phi)\mu \cdot d\mu \cdot d\phi} = \frac{a'_{\lambda red}}{\rho_\lambda(\theta_0)}$$

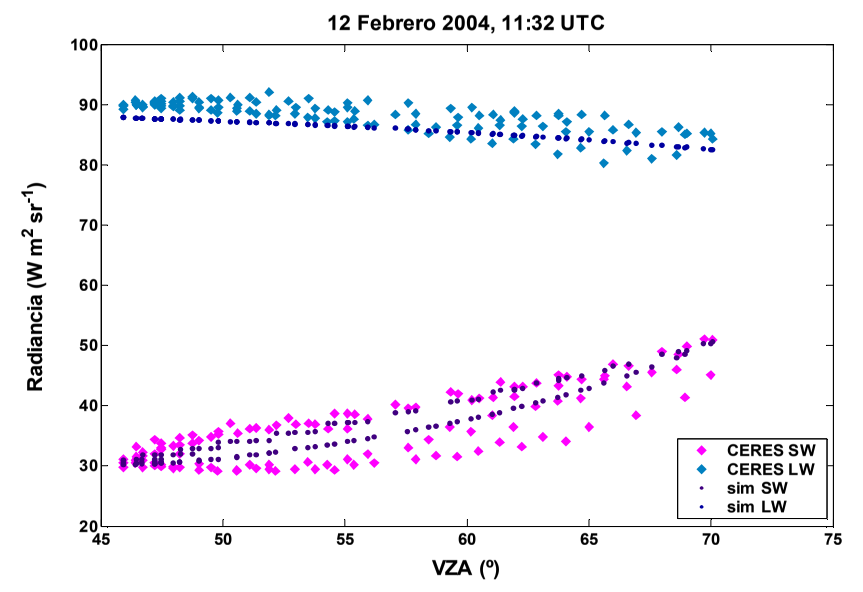
$$s_{NIR} = \frac{a'_{\lambda NIR}}{\frac{1}{\pi}\int_0^{2\pi}\int_0^1 \rho_\lambda(\theta_0,\theta,\phi)\mu \cdot d\mu \cdot d\phi} = \frac{a'_{\lambda NIR}}{\rho_{\lambda NIR}(\theta_0)}$$

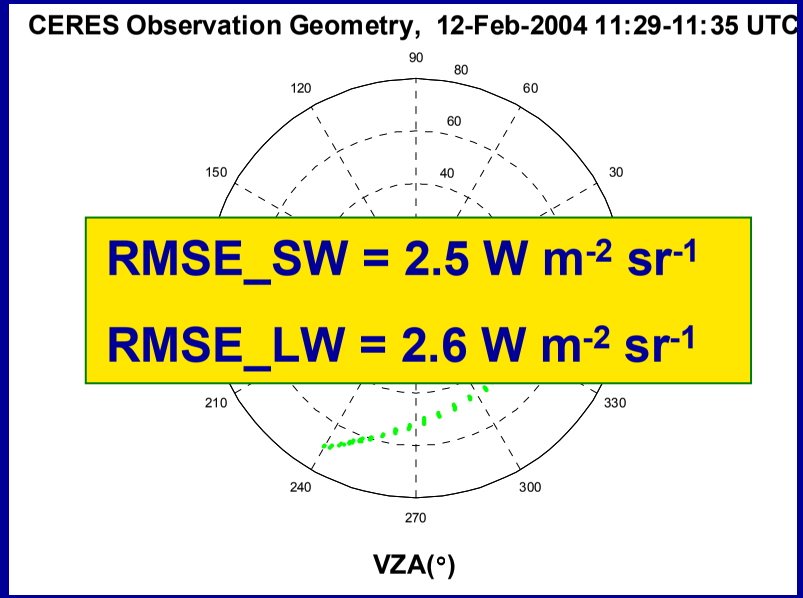


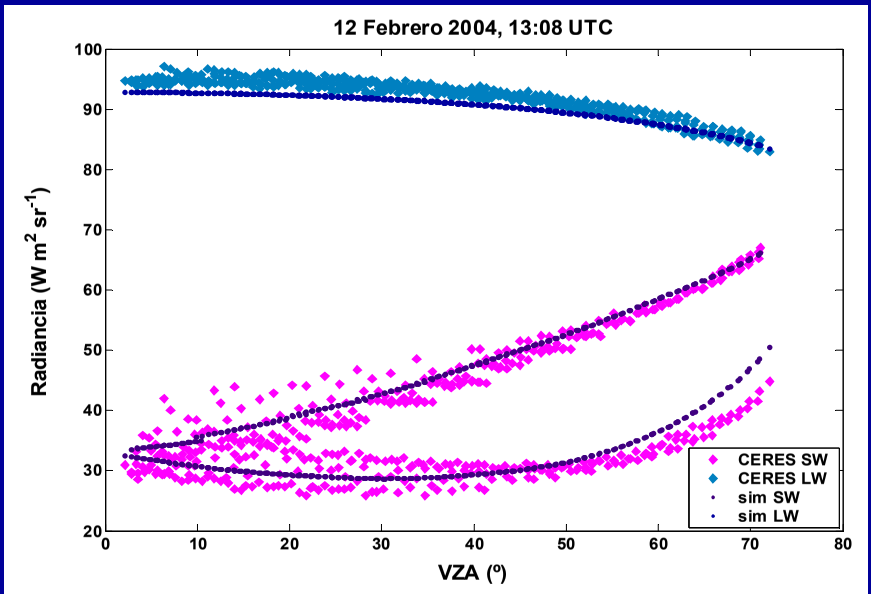
Bidirectional reflectivity

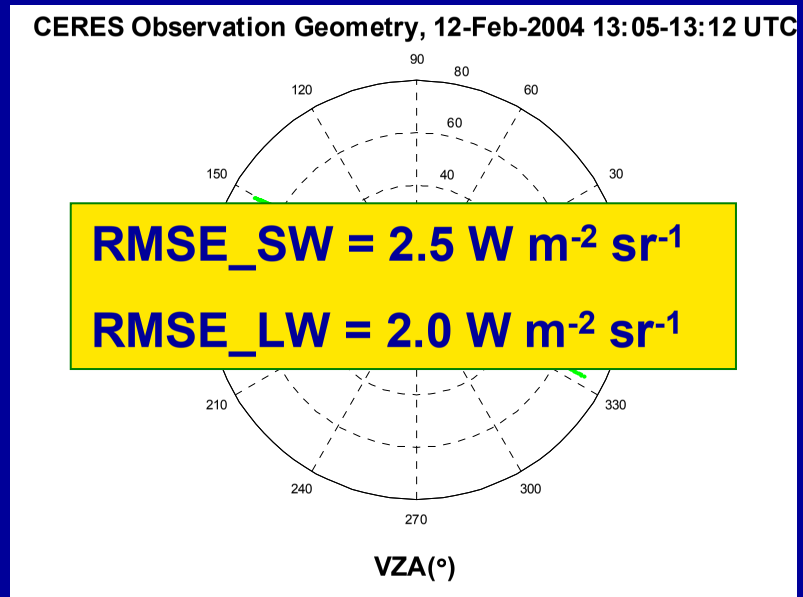


4. Application of the methodology to CERES data

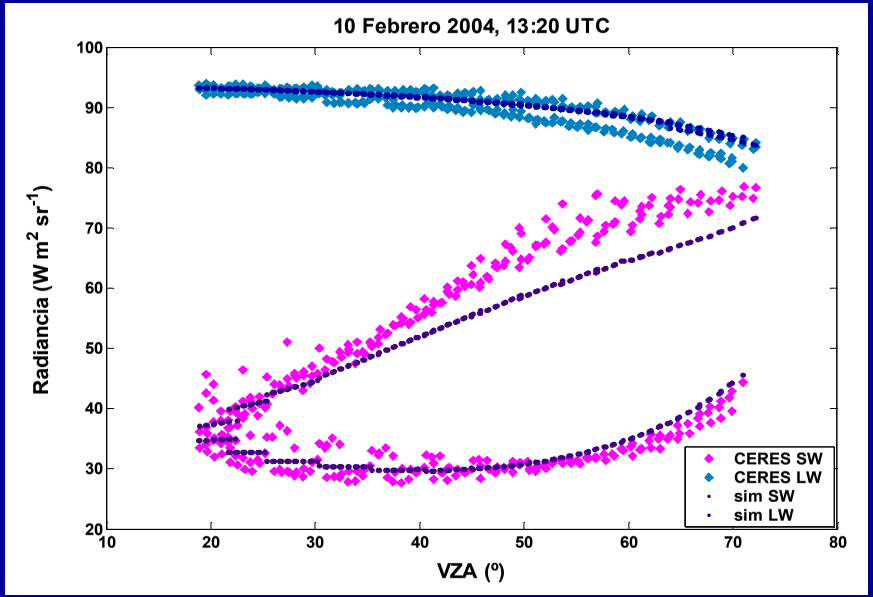


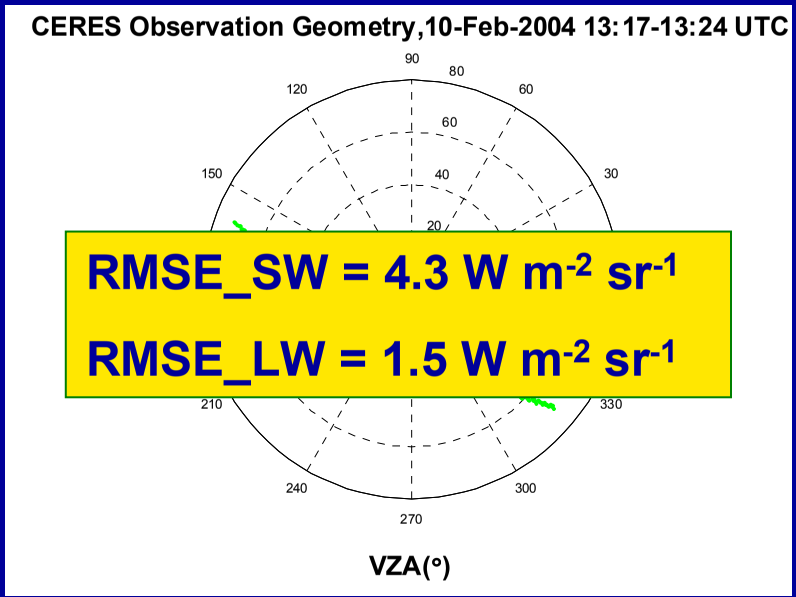






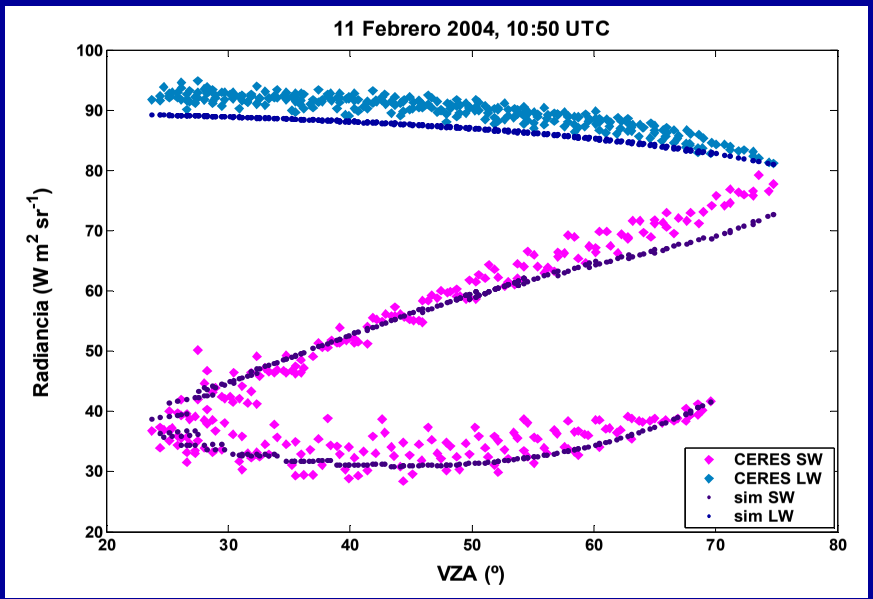
Results (II):

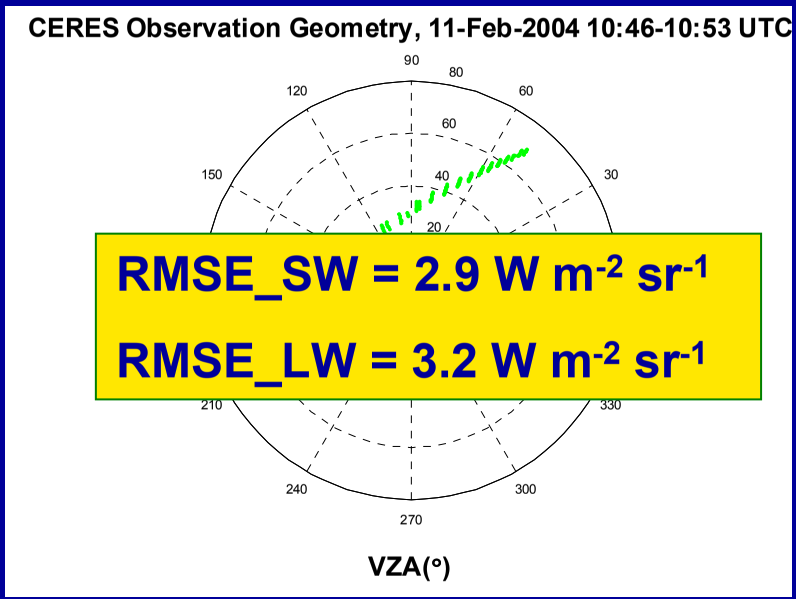




RMSE_SW = 4.3 W m^{-2} sr^{-1}

RMSE_LW = 1.5 W m^{-2} sr^{-1}

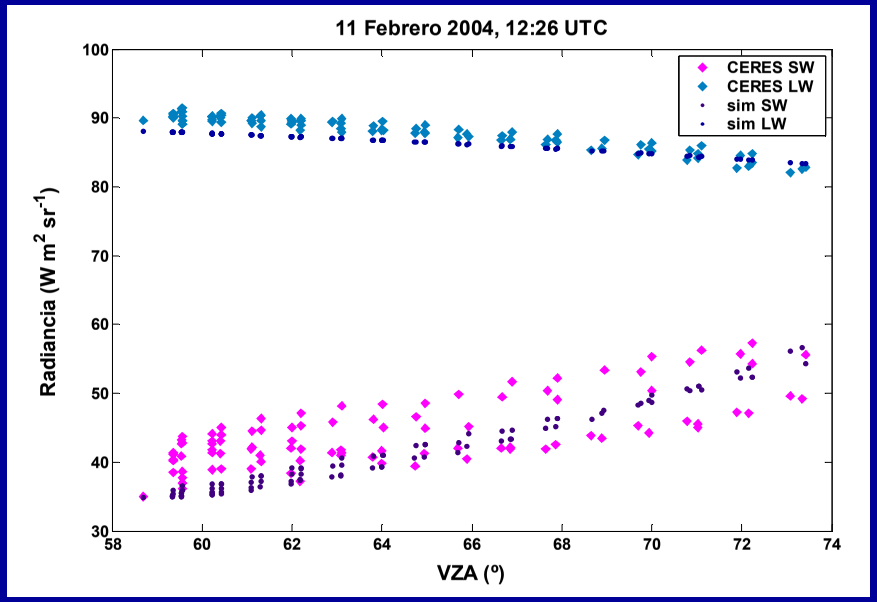


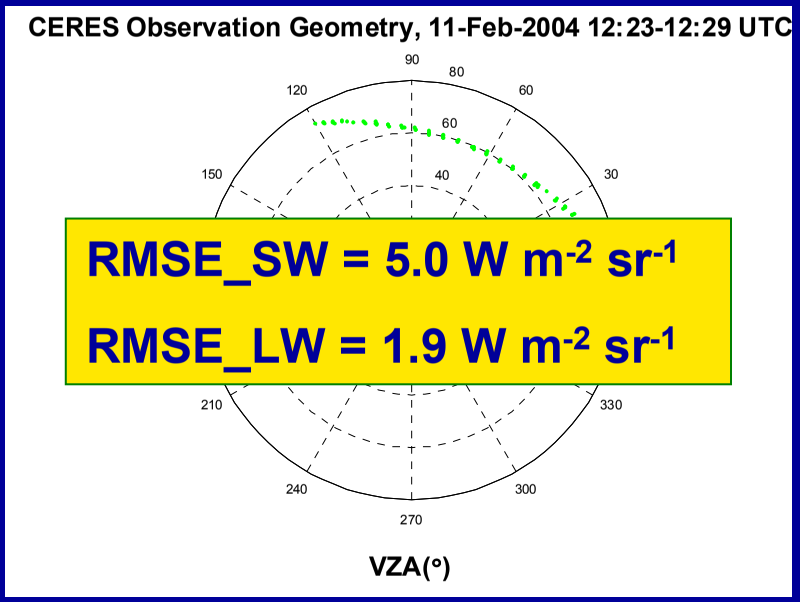


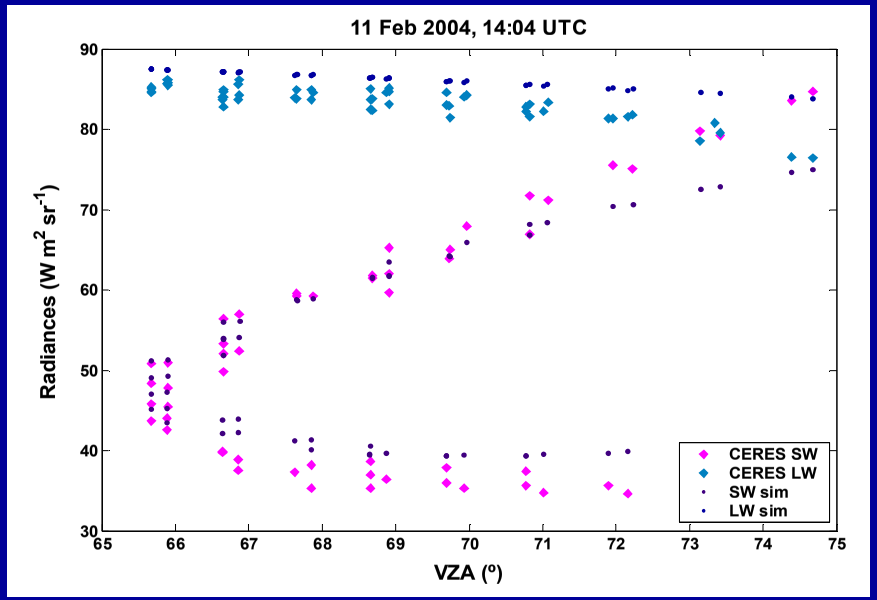
RMSE_SW = 2.9 W m^{-2} sr^{-1}

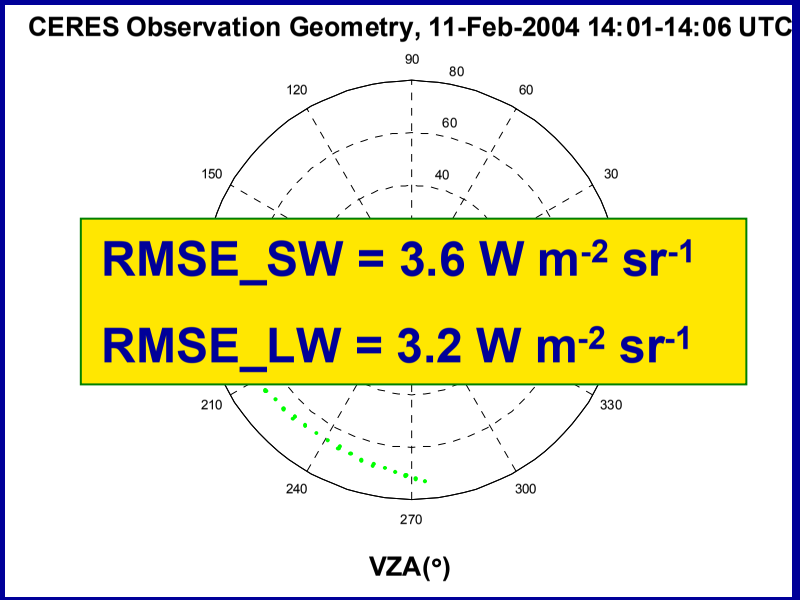
RMSE_LW = 3.2 W m^{-2} sr^{-1}

Results (III):

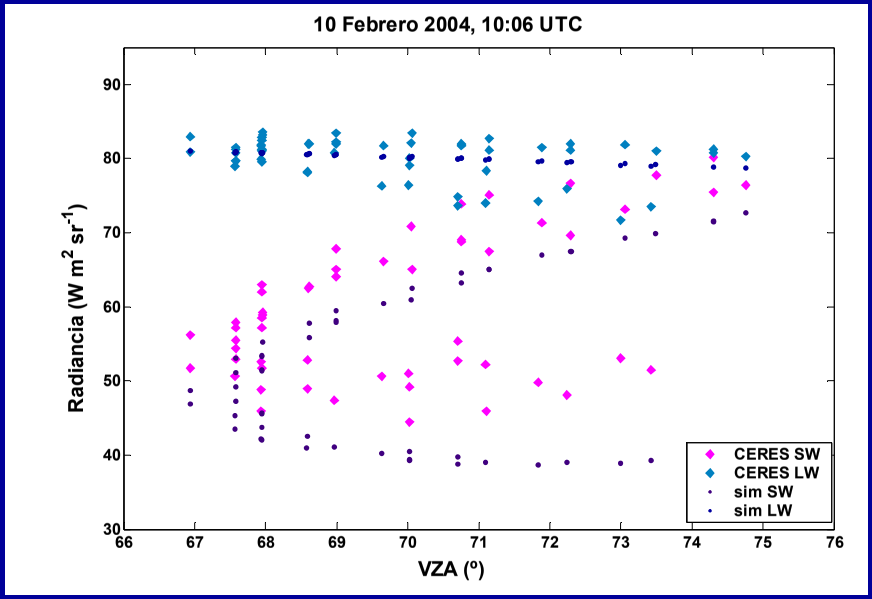

11 Febrero 2004, 12:26 UTC
CERES SW
CERES LW
sim SW
sim LW
Radiancia (W m^{2} sr^{-1})
VZA (°)

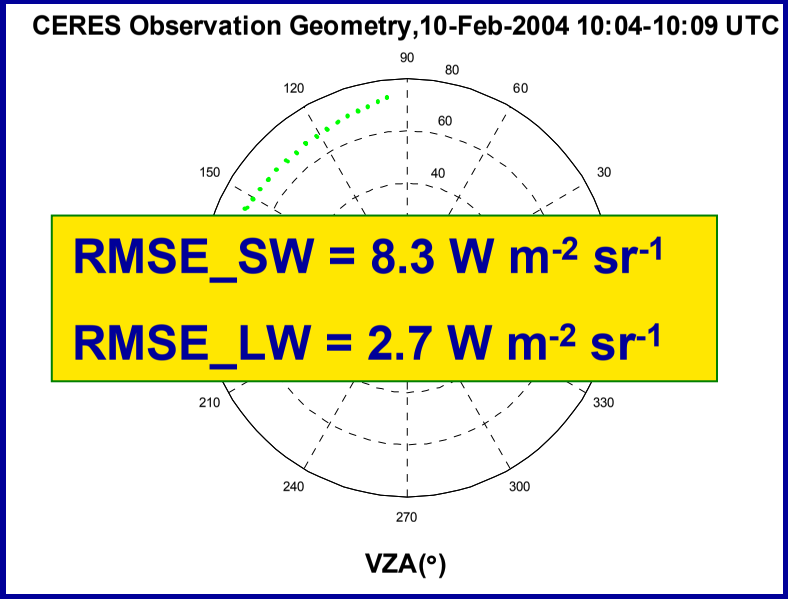

CERES Observation Geometry, 11-Feb-2004 12:23-12:29 UTC
RMSE_SW = 5.0 W m^{-2} sr^{-1}
RMSE_LW = 1.9 W m^{-2} sr^{-1}
VZA(°)

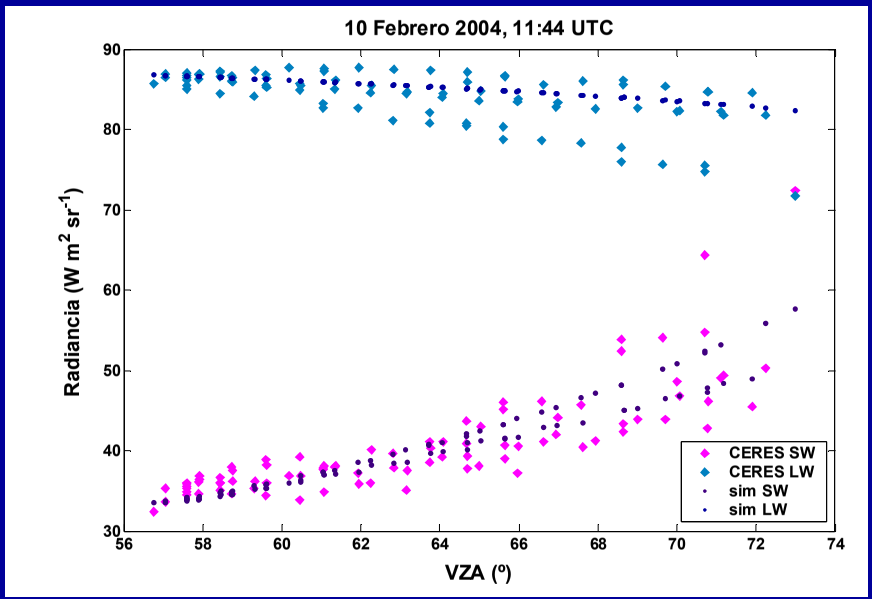

11 Feb 2004, 14:04 UTC
CERES SW
CERES LW
SW sim
LW sim
Radiances (W m^{2} sr^{-1})
VZA (°)

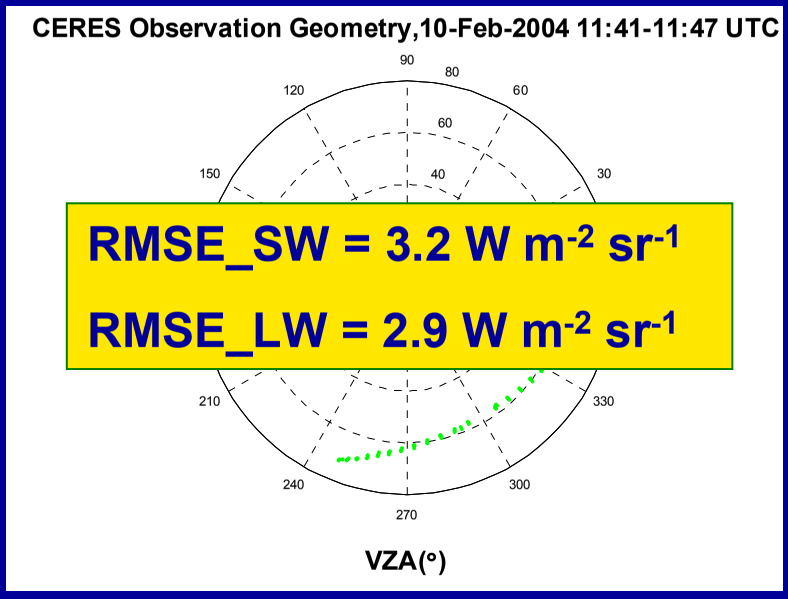

CERES Observation Geometry, 11-Feb-2004 14:01-14:06 UTC
RMSE_SW = 3.6 W m^{-2} sr^{-1}
RMSE_LW = 3.2 W m^{-2} sr^{-1}
VZA(°)

Results (IV):

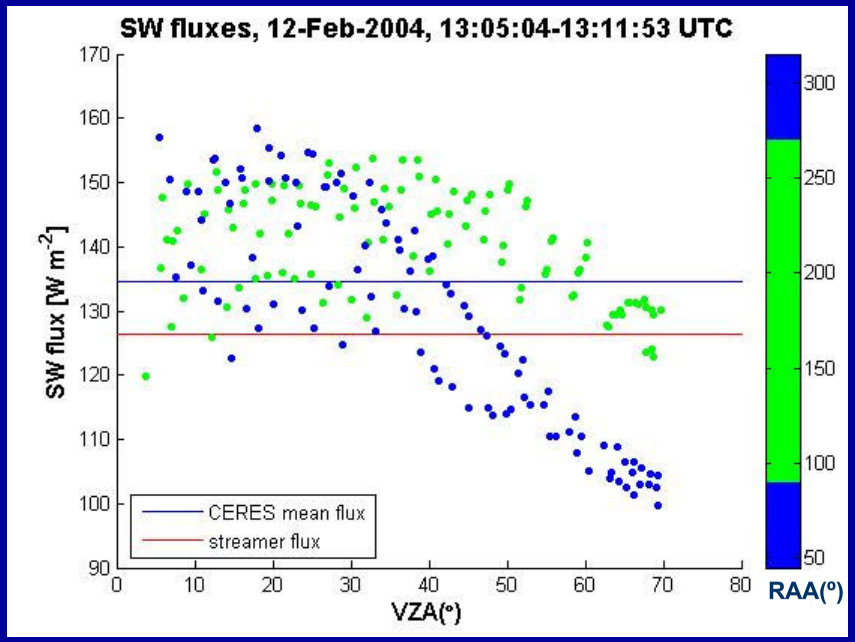

10 Febrero 2004, 10:06 UTC
Radiancia (W m^2 sr^{-1})
VZA (º)
CERES SW
CERES LW
sim SW
sim LW

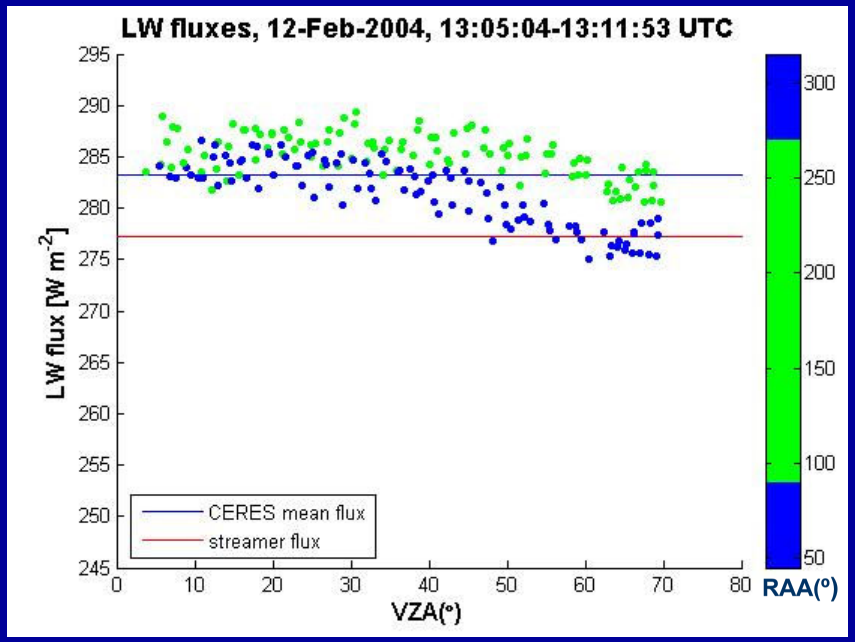

CERES Observation Geometry,10-Feb-2004 10:04-10:09 UTC
VZA(°)
RMSE_SW = 8.3 W m^{-2} sr^{-1}
RMSE_LW = 2.7 W m^{-2} sr^{-1}

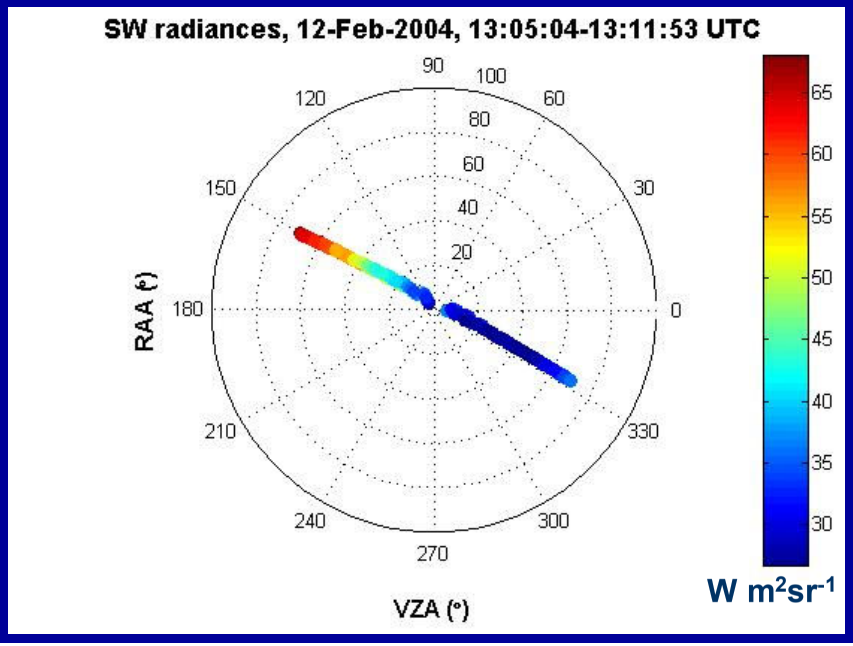

10 Febrero 2004, 11:44 UTC
Radiancia (W m^2 sr^{-1})
VZA (º)
CERES SW
CERES LW
sim SW
sim LW

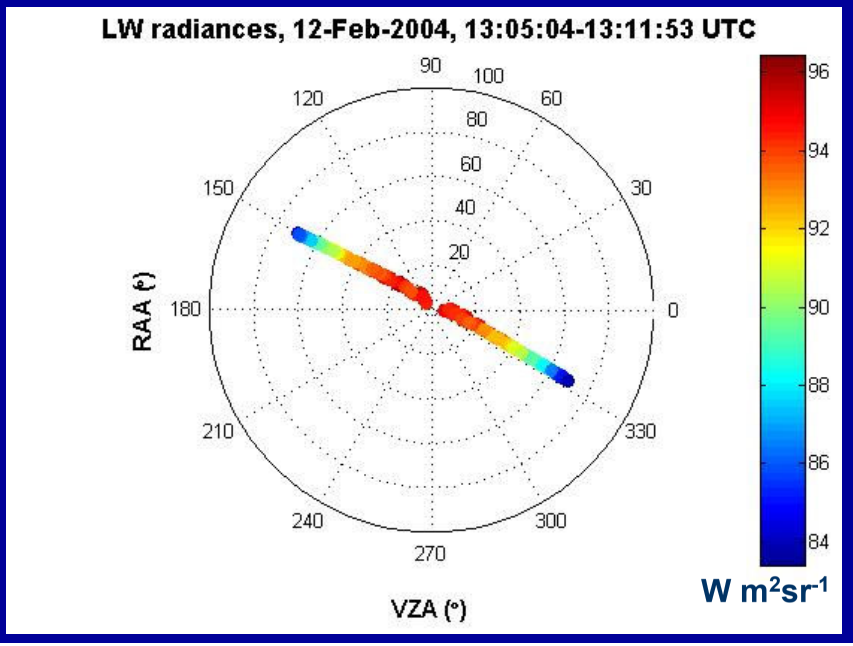

CERES Observation Geometry,10-Feb-2004 11:41-11:47 UTC
VZA(°)
RMSE_SW = 3.2 W m^{-2} sr^{-1}
RMSE_LW = 2.9 W m^{-2} sr^{-1}

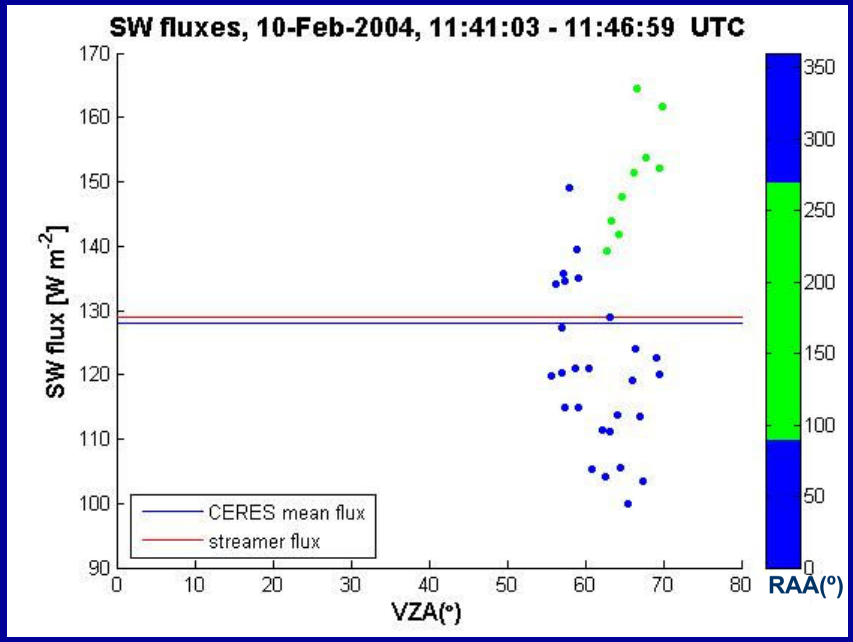
Fluxes comparisons

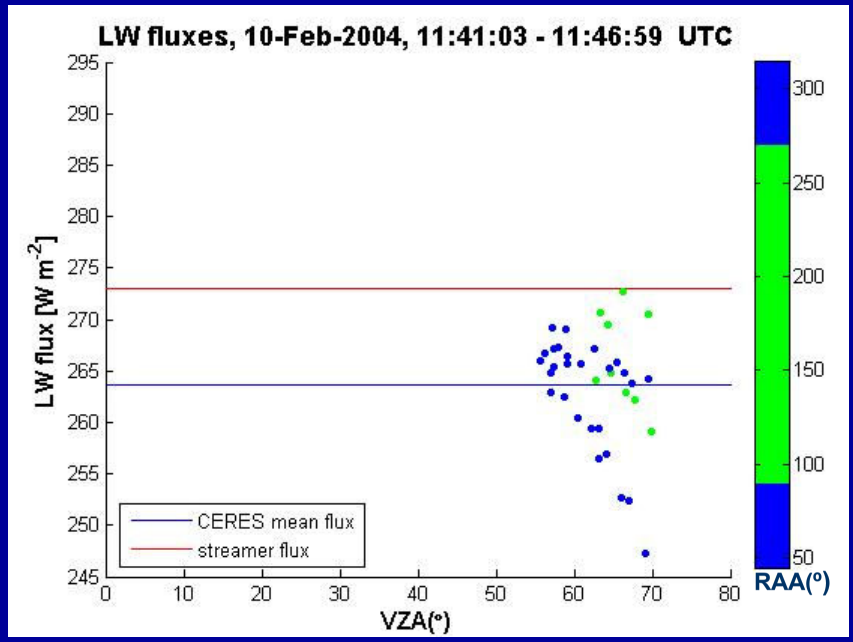


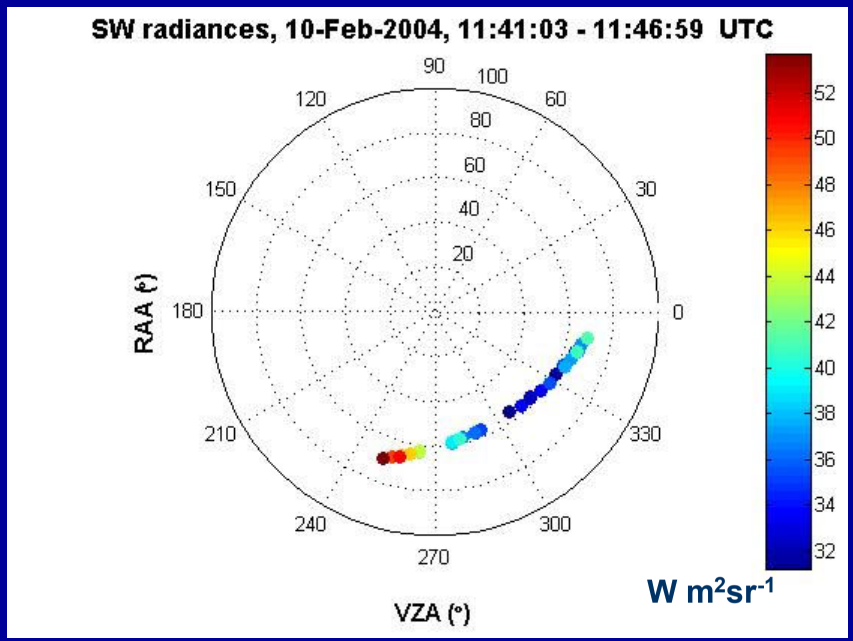


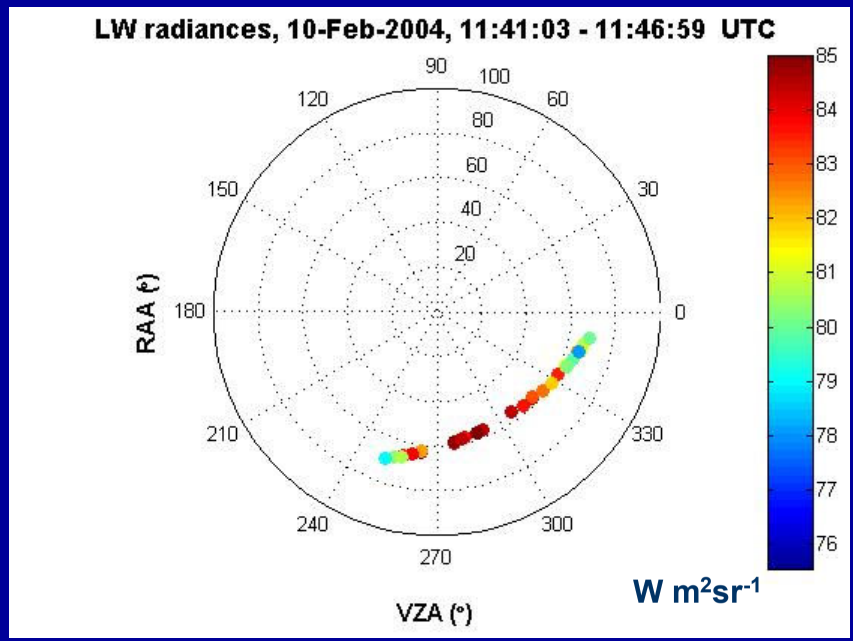


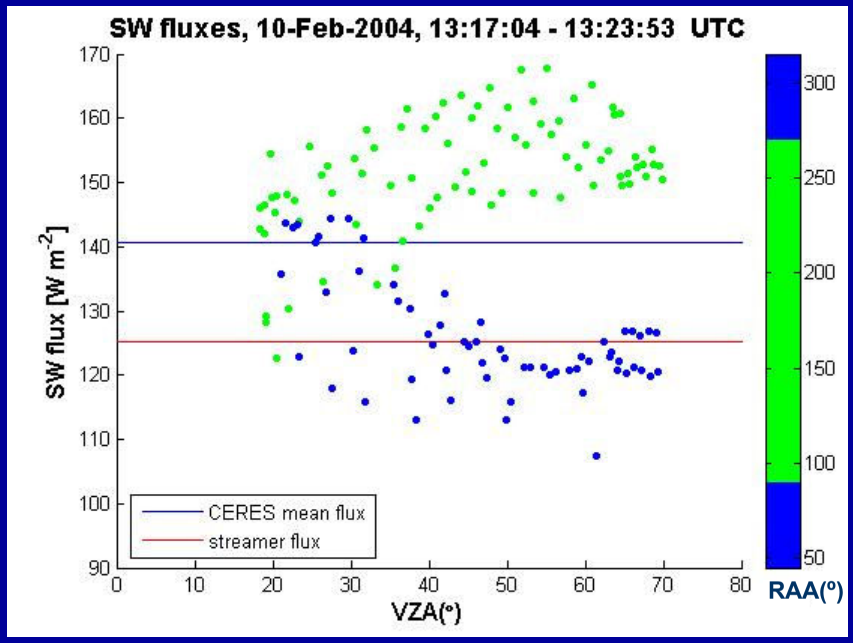


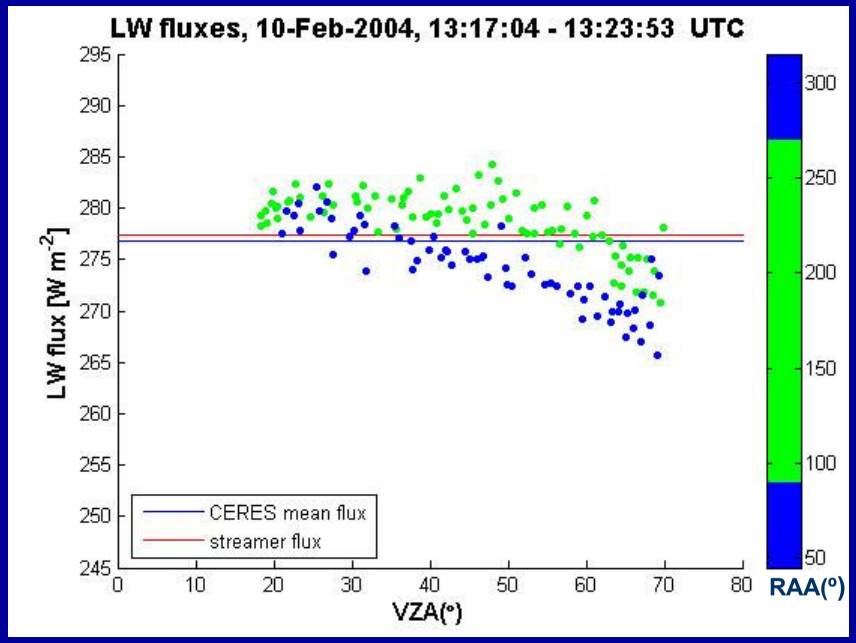

SW fluxes, 10-Feb-2004, 11:41:03 - 11:46:59 UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

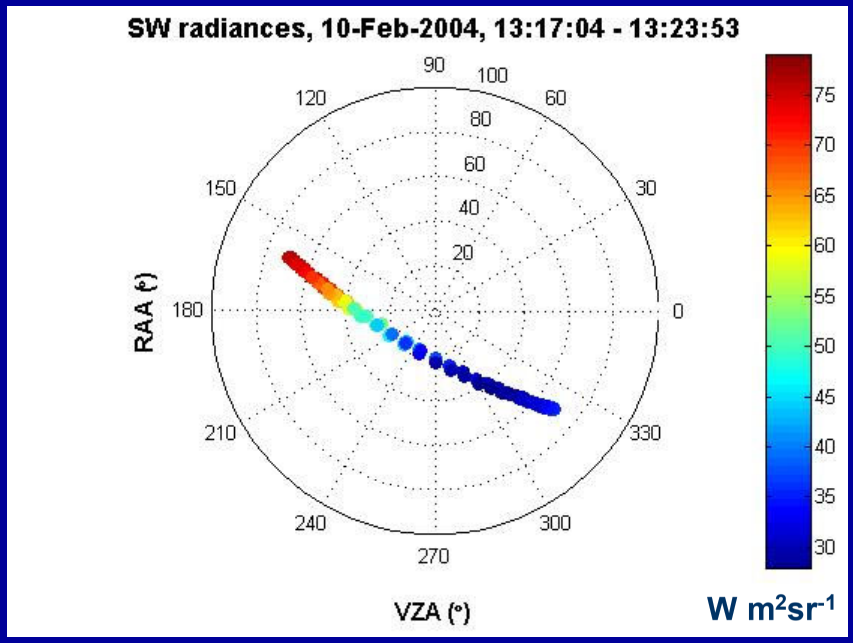

LW fluxes, 10-Feb-2004, 11:41:03 - 11:46:59 UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

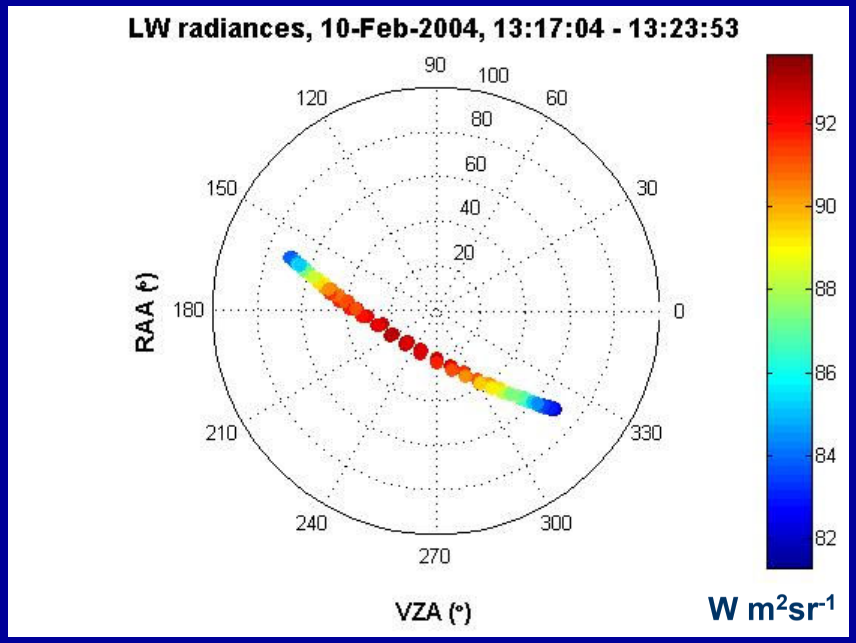

SW radiances, 10-Feb-2004, 11:41:03 - 11:46:59 UTC
RAA (°)
VZA (°)
W m2sr-1

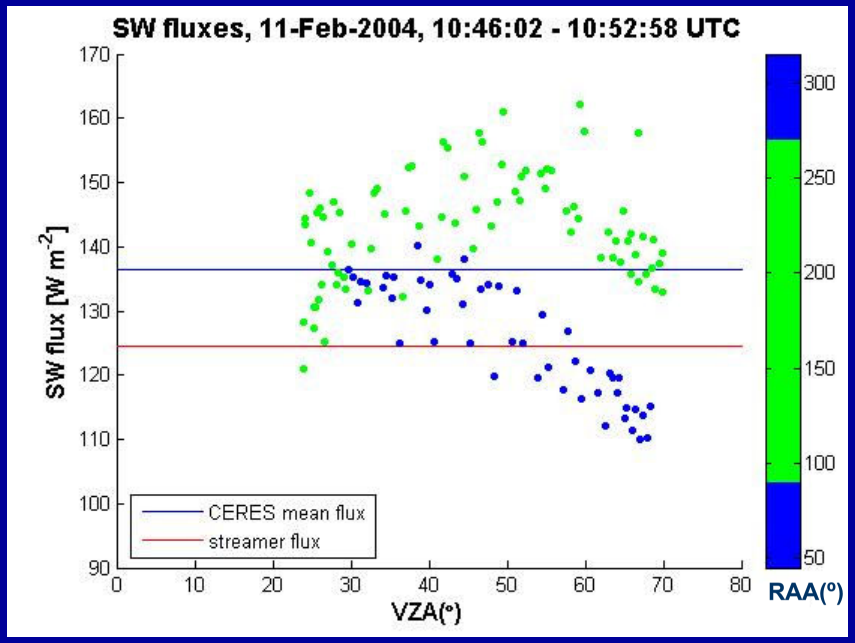

LW radiances, 10-Feb-2004, 11:41:03 - 11:46:59 UTC
RAA (°)
VZA (°)
W m2sr-1

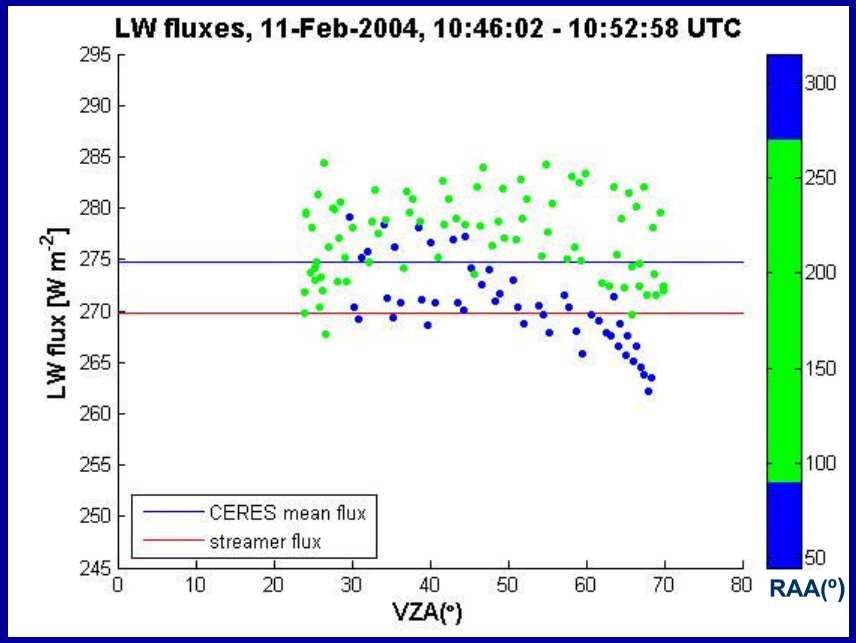

SW fluxes, 10-Feb-2004, 13:17:04 - 13:23:53 UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

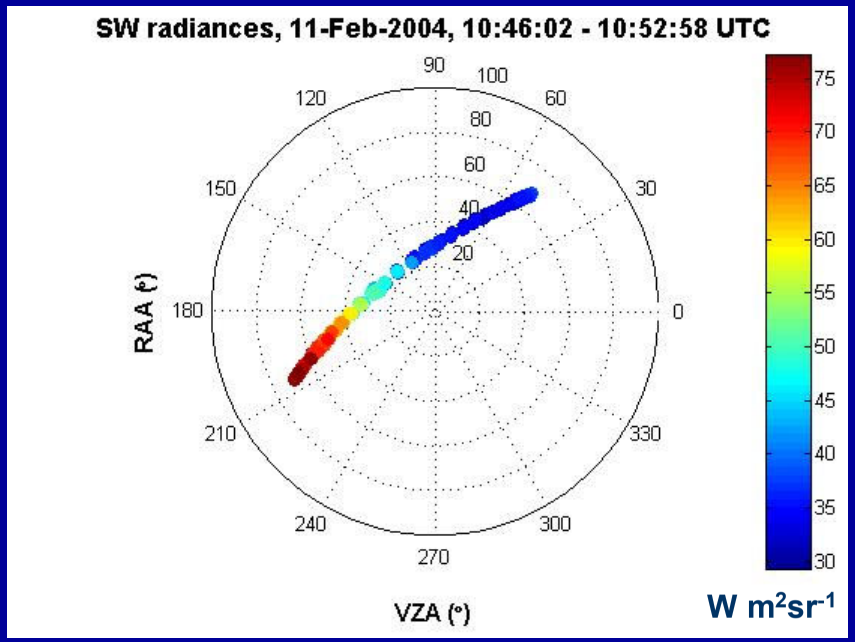

LW fluxes, 10-Feb-2004, 13:17:04 - 13:23:53 UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

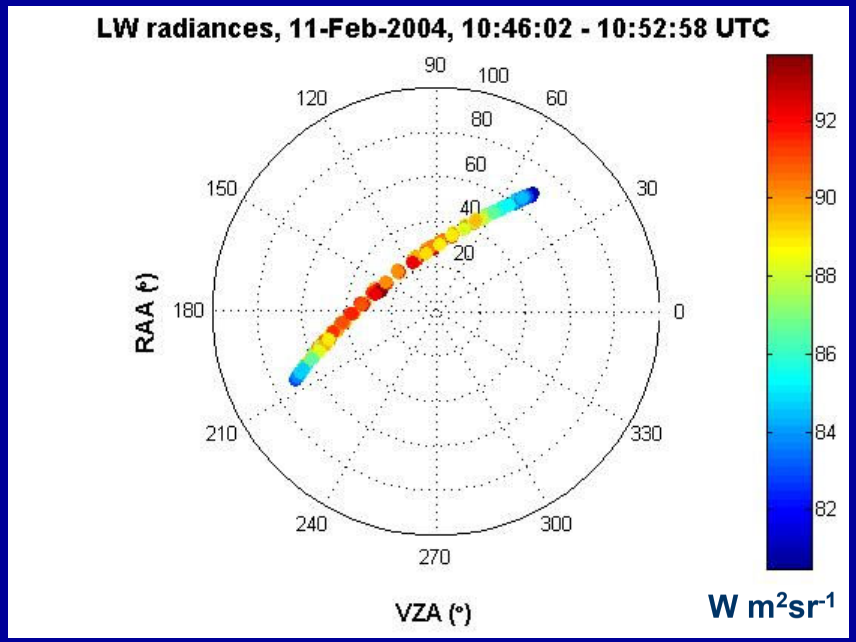

SW radiances, 10-Feb-2004, 13:17:04 - 13:23:53
RAA (°)
VZA (°)
W m2sr-1

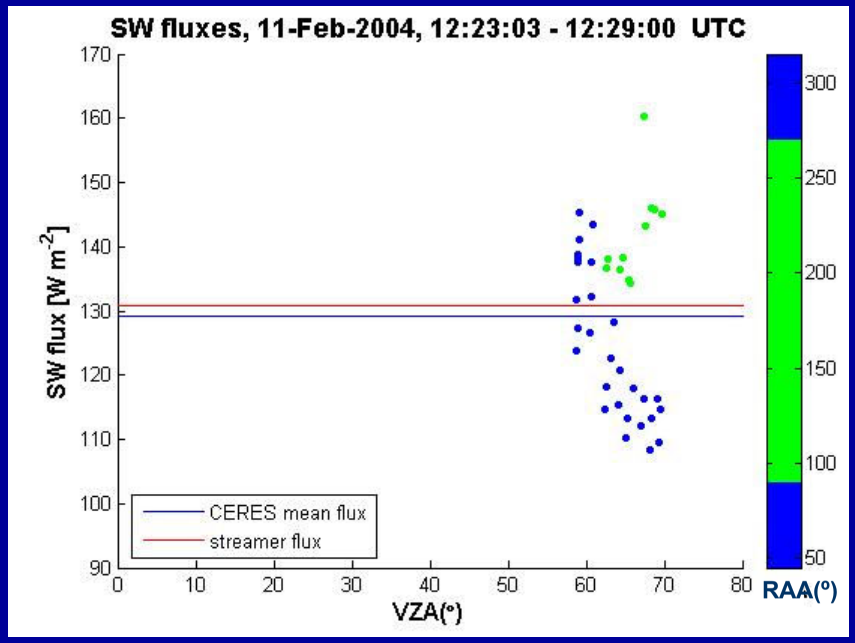

LW radiances, 10-Feb-2004, 13:17:04 - 13:23:53
RAA (°)
VZA (°)
W m2sr-1

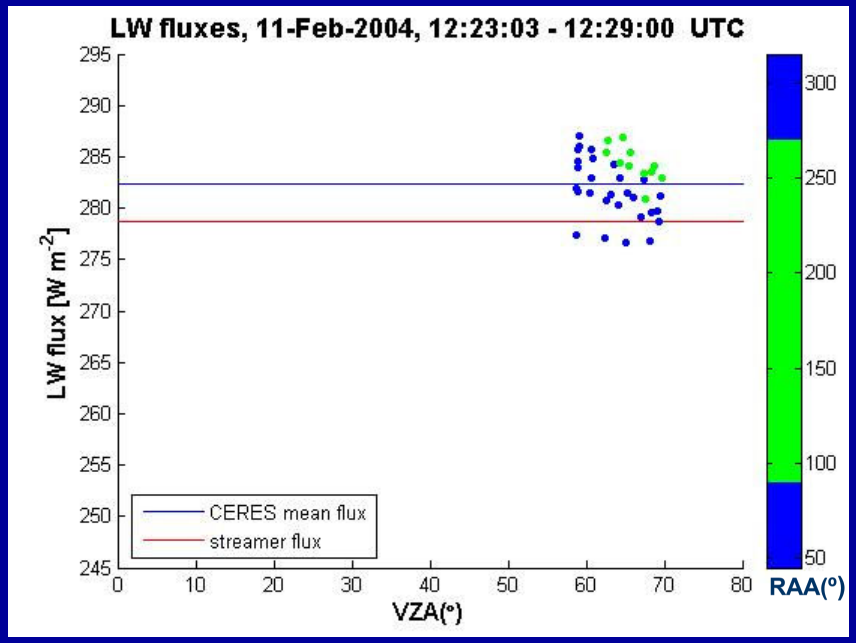

SW fluxes, 11-Feb-2004, 10:46:02 - 10:52:58 UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

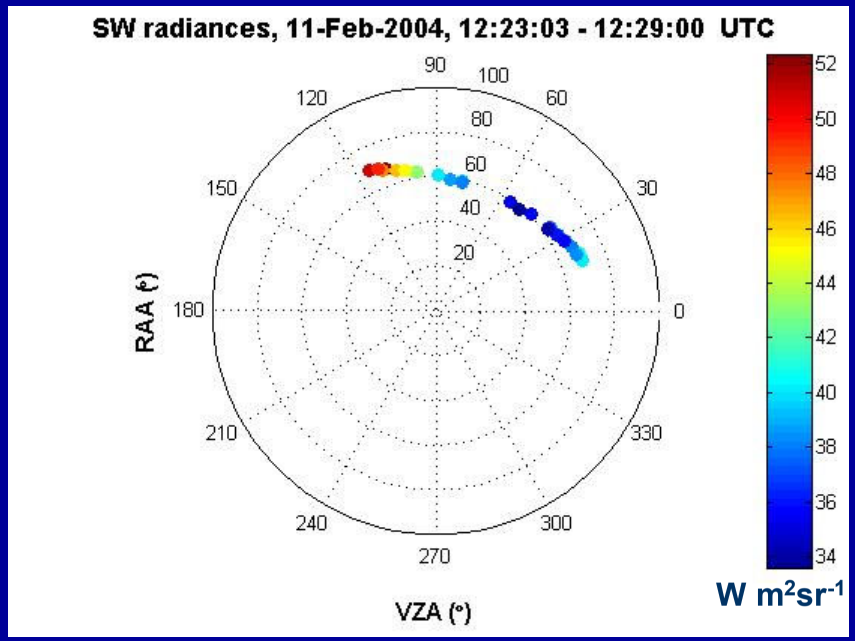

LW fluxes, 11-Feb-2004, 10:46:02 - 10:52:58 UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

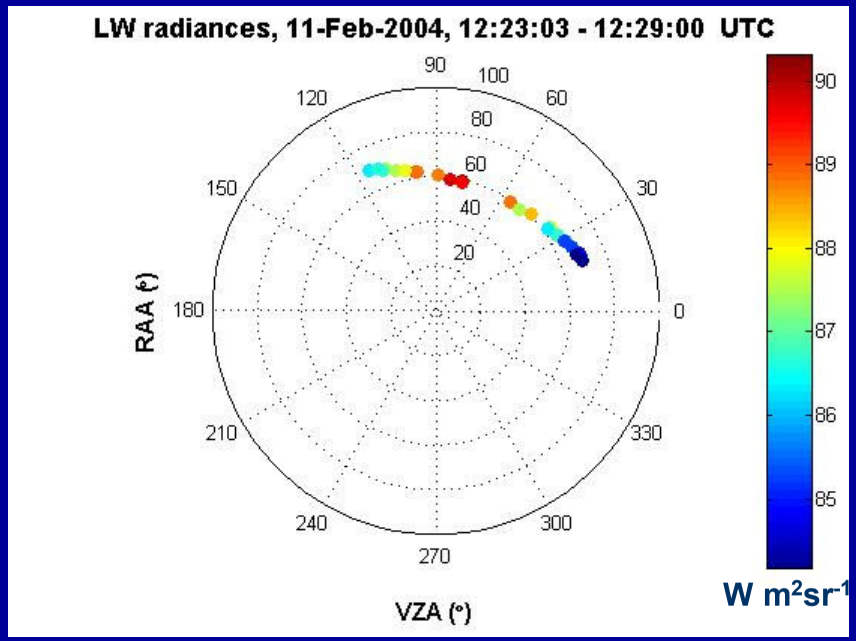

SW radiances, 11-Feb-2004, 10:46:02 - 10:52:58 UTC
RAA (°)
VZA (°)
W m2sr-1

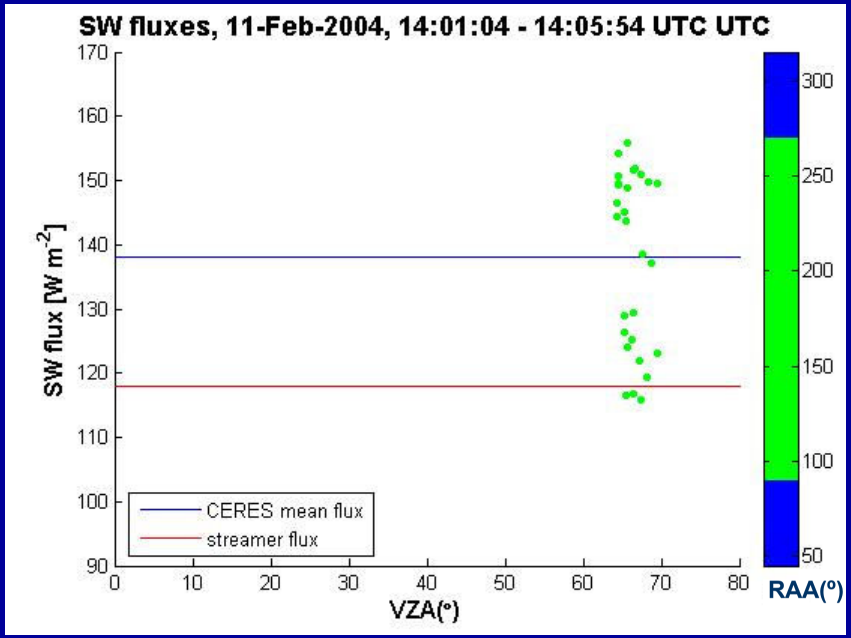

LW radiances, 11-Feb-2004, 10:46:02 - 10:52:58 UTC
RAA (°)
VZA (°)
W m2sr-1

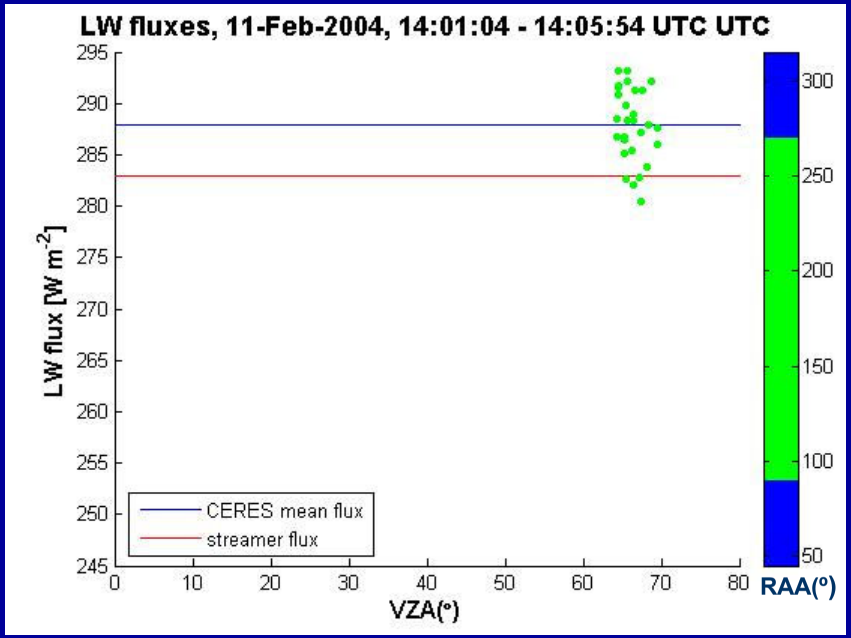

SW fluxes, 11-Feb-2004, 12:23:03 - 12:29:00 UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

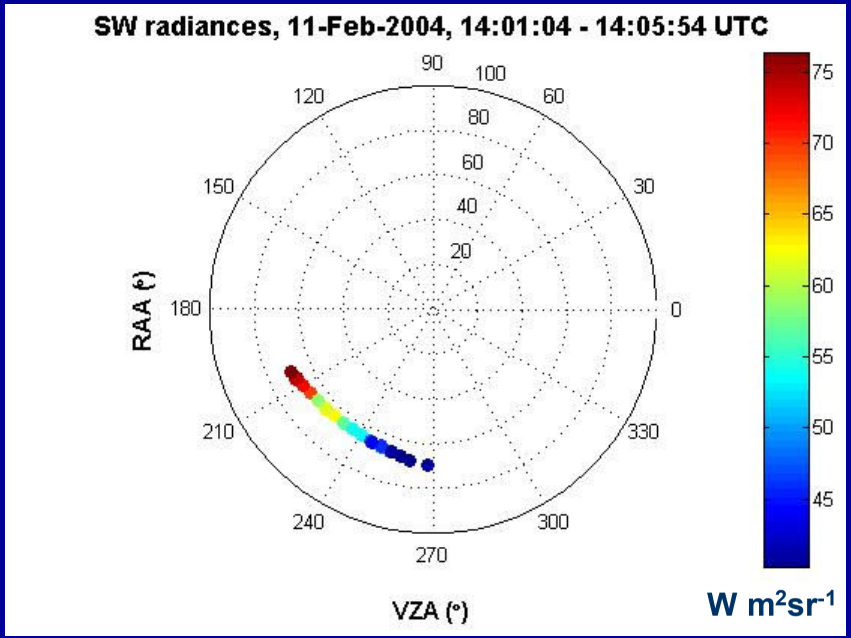

LW fluxes, 11-Feb-2004, 12:23:03 - 12:29:00 UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

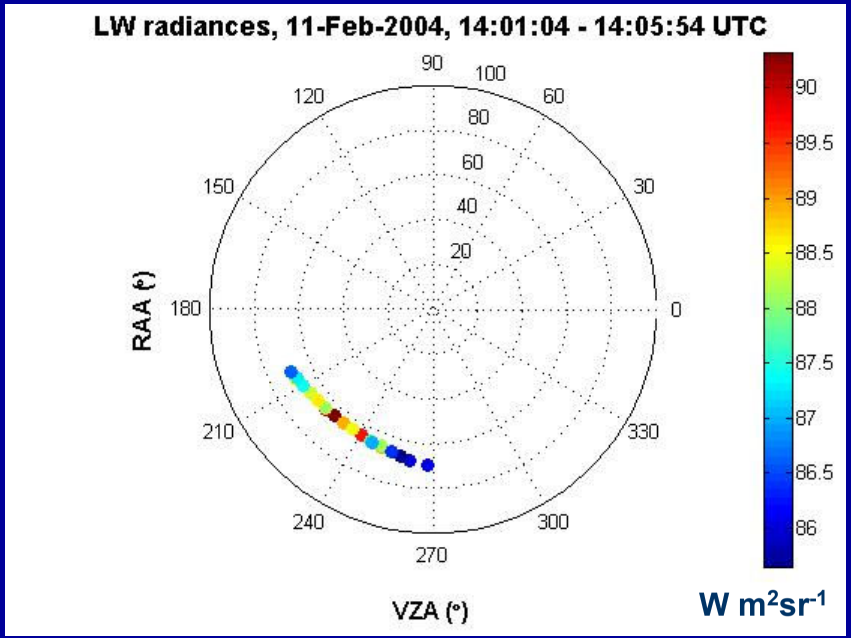

SW radiances, 11-Feb-2004, 12:23:03 - 12:29:00 UTC
RAA (°)
VZA (°)
W m2sr-1

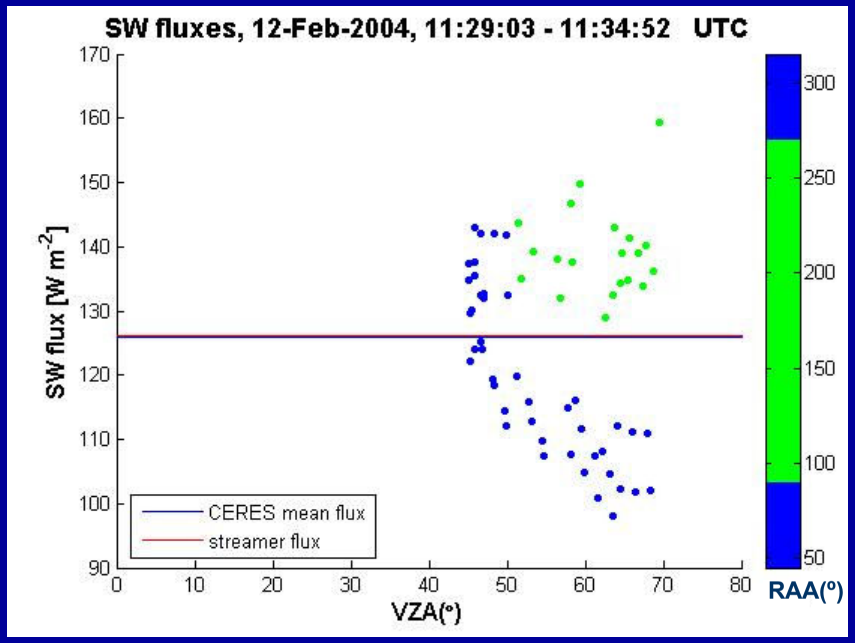

LW radiances, 11-Feb-2004, 12:23:03 - 12:29:00 UTC
RAA (°)
VZA (°)
W m2sr-1

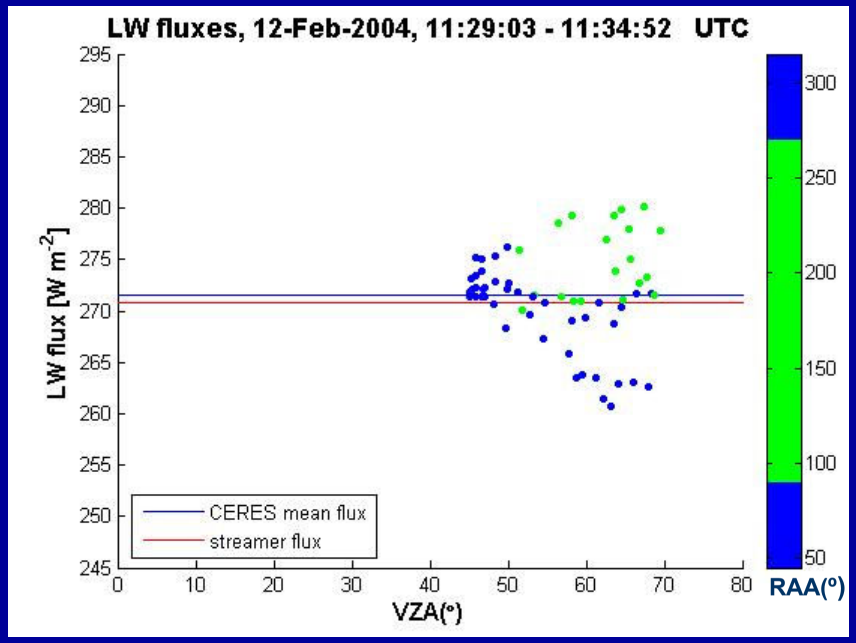

SW fluxes, 11-Feb-2004, 14:01:04 - 14:05:54 UTC UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

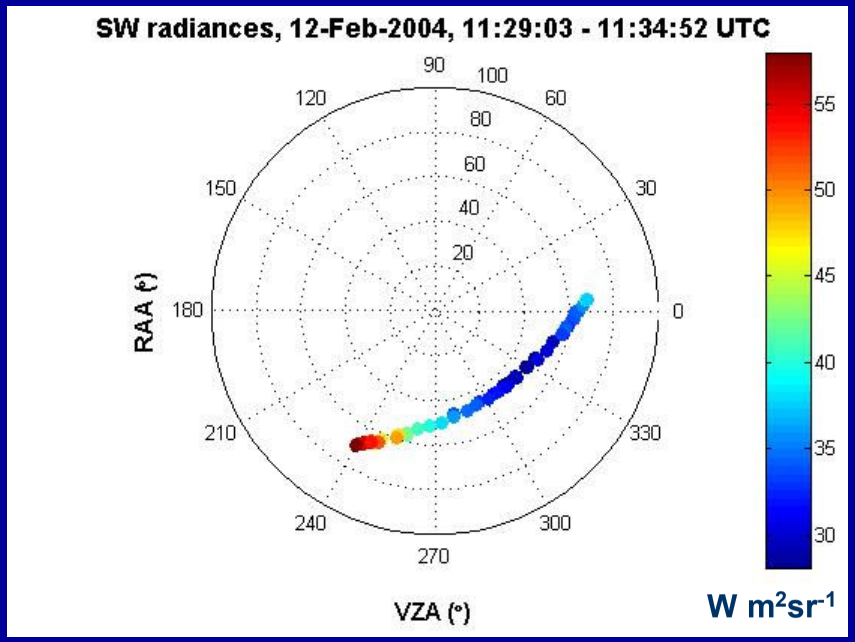

LW fluxes, 11-Feb-2004, 14:01:04 - 14:05:54 UTC UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux

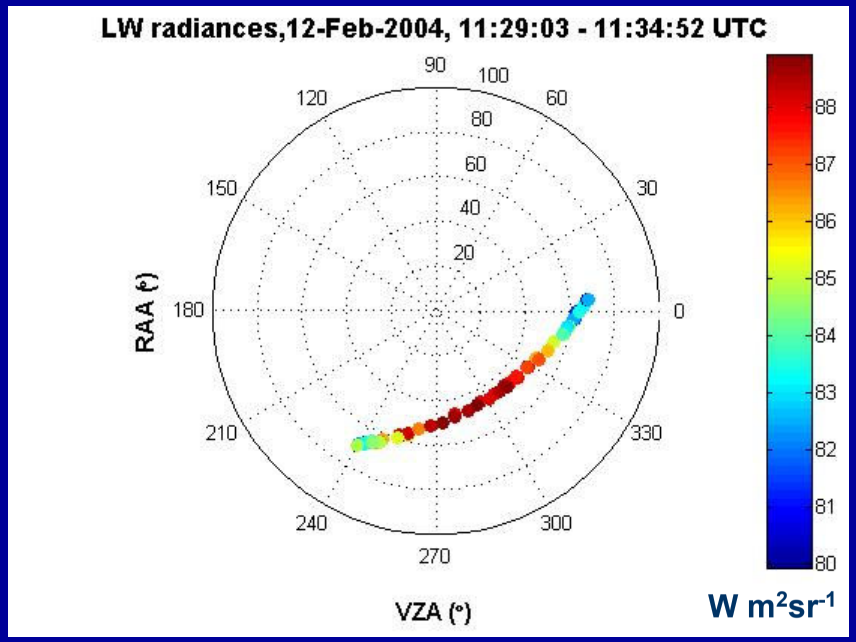

SW radiances, 11-Feb-2004, 14:01:04 - 14:05:54 UTC
RAA (°)
VZA (°)
W m2sr-1


LW radiances, 11-Feb-2004, 14:01:04 - 14:05:54 UTC
RAA (°)
VZA (°)
W m2sr-1


SW fluxes, 12-Feb-2004, 11:29:03 - 11:34:52 UTC
SW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux


LW fluxes, 12-Feb-2004, 11:29:03 - 11:34:52 UTC
LW flux [W m-2]
VZA(°)
RAA(°)
CERES mean flux
streamer flux


SW radiances, 12-Feb-2004, 11:29:03 - 11:34:52 UTC
RAA (°)
VZA (°)
W m2sr-1


LW radiances,12-Feb-2004, 11:29:03 - 11:34:52 UTC
RAA (°)
VZA (°)
W m2sr-1

5. Conclusions and future work

- Conclusions:
  - Suitable methodology to simulate TOA CERES radiances
  - The analysis has been carried out under clear sky conditions
  - In winter we can assume that the study area is mainly composed of bare soil and vegetation
  - A representative BRDF for our study area has been developed
- Future plans:
  - Improve aerosol characterization
  - Include cloudy days in the simulations
  - Study limb darkening process in the LW
  - Use of MM5 as an interpolation tool
  - Use of BRDF measured from satellite or in situ BRDF
  - Extend the results to the last validation campaign carried out in September 2005

Study area BRDF

It is obtained from the broadband albedo measured at the VAS and the mobile station (a_0^{BB}), JHU spectral albedo (a_l^{JHU}) and the bidirectional reflectance from Ahmad y Deering for bare soil ($\rho_\lambda(\theta_0, \theta, \phi)$)

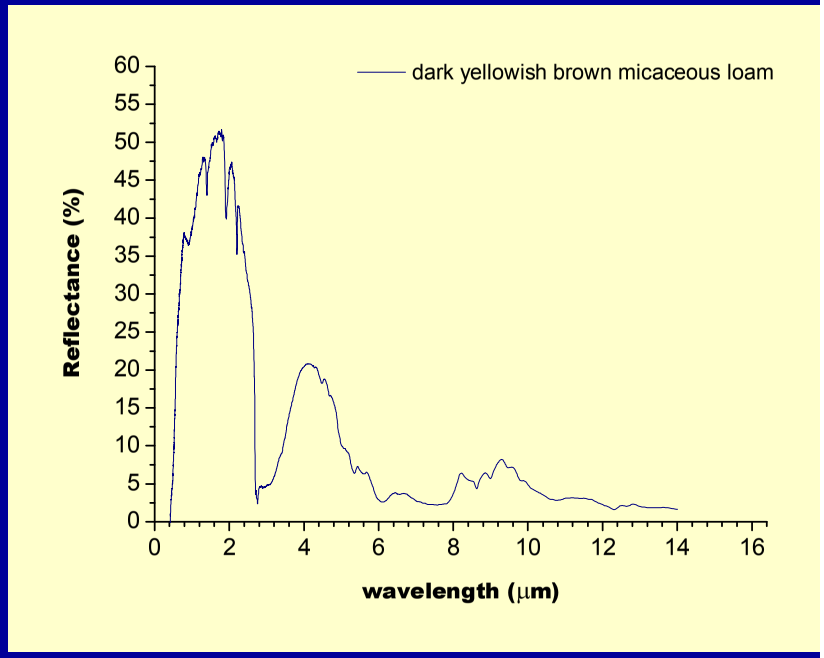
- **1. scale the JHU spectral albedo**

$$a'_\lambda = \frac{a_\lambda^{JHU}}{\int_{\lambda_2}^{\lambda_1} a_\lambda^{JHU} d\lambda} a_{BB}^0$$

- **2. scale the bidirectional reflectances from the model**

$$s_{red} = \frac{a'_{\lambda red}}{\frac{1}{\pi}\int_0^{2\pi}\int_0^1 \rho_\lambda(\theta_0,\theta,\phi)\mu \cdot d\mu \cdot d\phi} = \frac{a'_{\lambda red}}{\rho_\lambda(\theta_0)}$$

$$s_{NIR} = \frac{a'_{\lambda NIR}}{\frac{1}{\pi}\int_0^{2\pi}\int_0^1 \rho_\lambda(\theta_0,\theta,\phi)\mu \cdot d\mu \cdot d\phi} = \frac{a'_{\lambda NIR}}{\rho_{\lambda NIR}(\theta_0)}$$

Finite number of angles

$$\rho_i = \sum_{k=1}(\phi_{k+1} - \phi_k)\sum_{j=1}\overline{\rho_i} \cdot (\sin^2\theta_{j+1} - \sin^2\theta_j)$$