COMPARISON OF TOP-OF-ATMOSPHERE LONGWAVE RADIATIVE FLUX ESTIMATES FROM EMPIRICAL AND THEORETICAL ANGULAR DISTRIBUTION MODELS APPLIED TO CERES RADIANCE MEASUREMENTS

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IAMAS 2001, Innsbruck, Austria

• Introduction

- ◇ CERES on TRMM
- ◇ TRMM data status

• Longwave (LW) Flux Anisotropy

- ◇ Empirical approach, R_{EMP}
- ◇ ERBE-like and new BETA-II LW fluxes
- ◇ Theoretical model parameterization, R_M, ***C.J. Stubenrauch et al, JAM 1993***

• LW Flux for Clear, Overcast and All-Sky Ocean Scenes

- ◇ Comparison of the R_{EMP} and R_M
- ◇ Comparison of the empirical and model LW fluxes
- ◇ Longitude Flux error average and STD

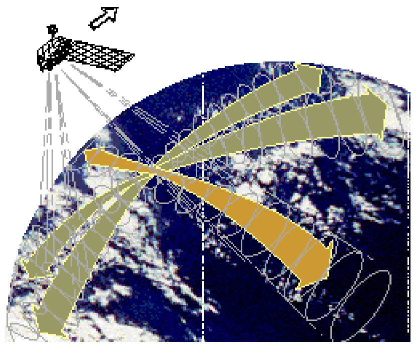
• Viewing Zenith Angle Bias

- ◇ As Function of Precipitable water
- ◇ As Function of Brightness Temperature

• Summary

TRMM DATA STATUS

- Tropical Rainfall Measuring Mission (TRMM), launched in Nov. 1997
- Data collected for January - August 1998, March 2000
- Geometry: precessing orbit, from 40° North to 40° South latitude.
- Multiangular measurements combined with high spatial resolution.



INSTRUMENTATION

CERES - Clouds and the Earth's Radiant Energy System
VIRS - Visible/InfraRed Scanner

SSF *BETA-II* DATA PRODUCT

Summer, 2001

- Time and Position: Sun, satellite, footprint
- Viewing geometry
- Surface information
- Scene identification
- Radiometric data: total, shortwave, window
- Unfiltered radiances: shortwave, longwave, window
- Top-of-Atmosphere (TOA) and surface fluxes
- Full footprint area parameters: imager coverage, wind, temperature, humidity, extrapolation
- Clear area parameters: clear amount, aerosol
- Cloud area parameters for up to 2 layers: cloud amount, height, temperature, pressure, optical depth, emissivity, water path and particle size for both water phases
- Imager Radiance Statistics: full footprint, clear, cloudy, layers

EMPIRICAL APPROACH

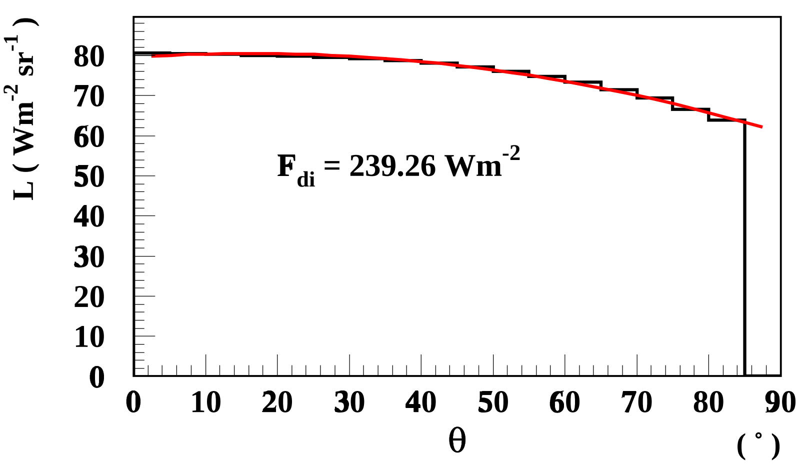
(*see poster at Symposia 4.4, N. Manalo-Smith*)

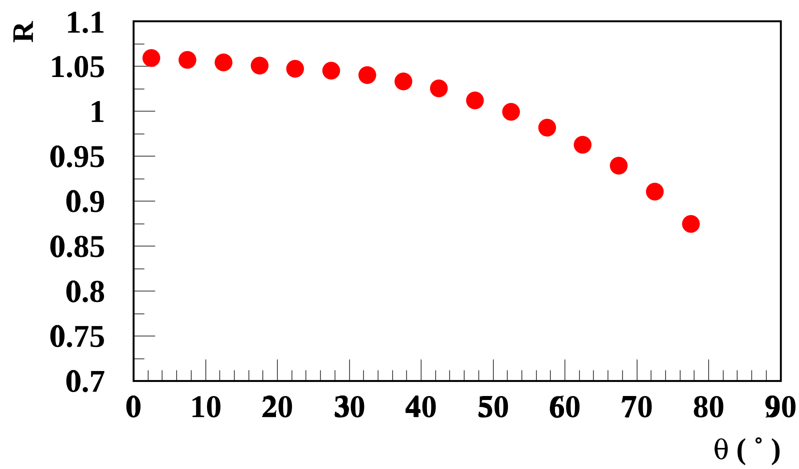
Longwave Flux: $$F = \int L(\theta)\, cos\theta\, d\Omega = 2\pi \int_0^{\pi/2} L(\theta)\, cos\,\theta\, sin\,\theta\, d\,\theta$$

Anisotropic Emission Factor: $$R(\theta) = \frac{\pi\, L(\theta)}{F}$$

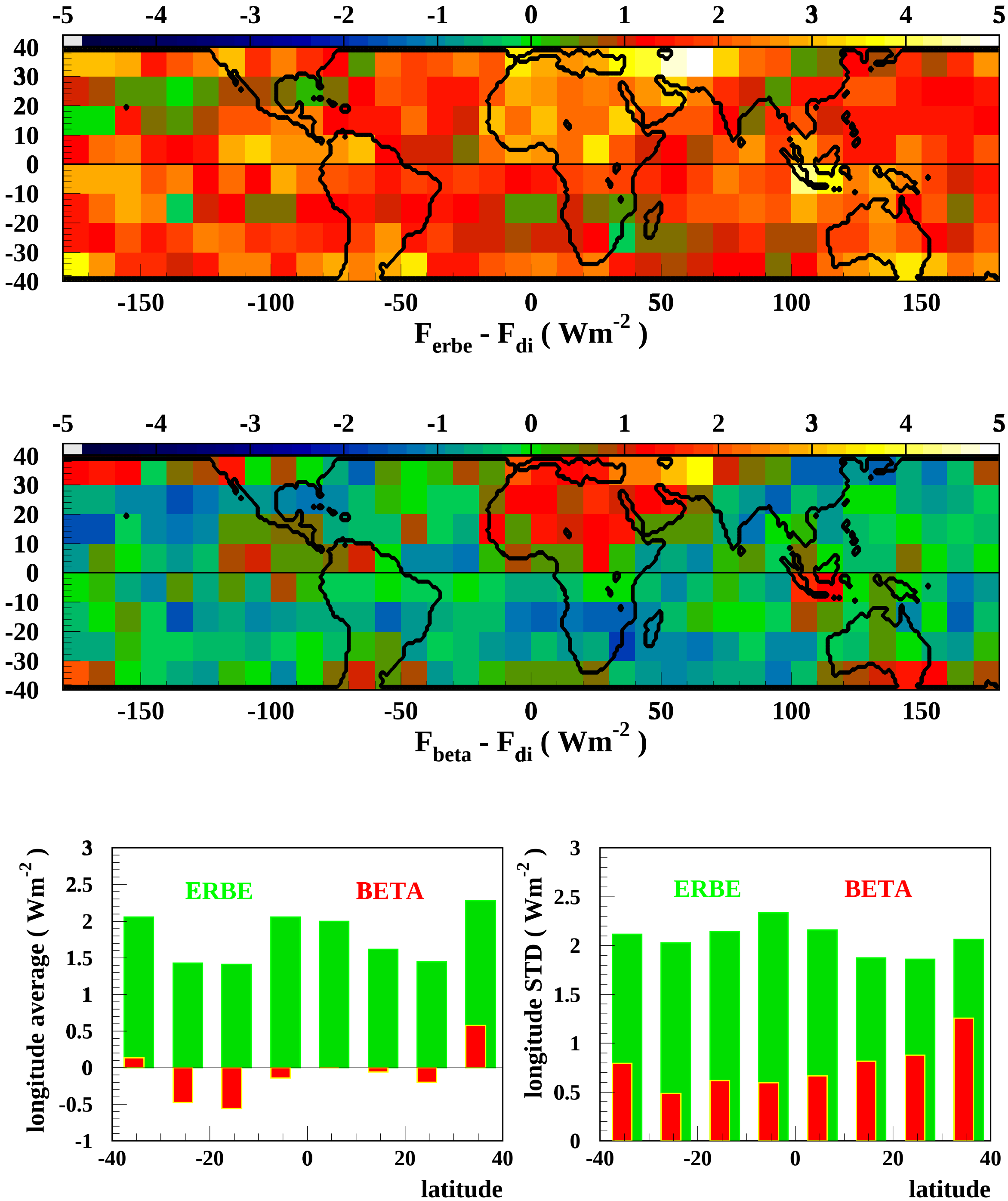
$R\,(\theta)$ empirically defined as function of

- Surface Type
- Cloud Fraction
- Cloud Emissivity
- Precipitable Water
- Vertical Temperature Change





ERBE-like & *BETA-II* FLUXES



MODEL PARAMETERIZATION

C.J. Stubenrauch *et al*, Journal of Applied Meteorology, 848 (1993).

Atmospheric Pseudoabsorption:

$$A = 1 - \frac{L(\theta)}{\int_{5\mu m}^{100\mu m} B\,(\,T_B, \lambda\,)\; d\lambda} = 1 - \frac{L(\theta)}{(\sigma/\pi)\;\; T_B^4}$$

Brightness Temperature:

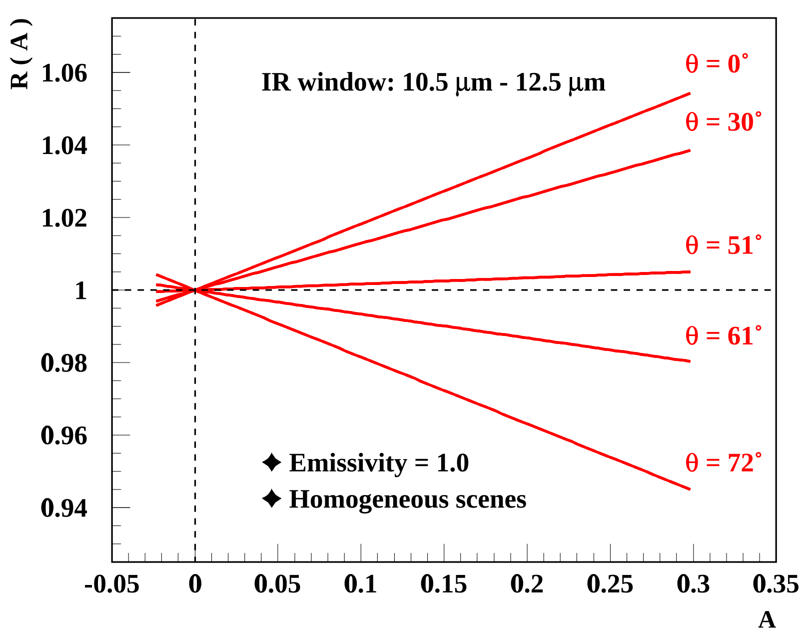
$$T_B(\lambda) = \frac{hc}{k\lambda\;\ln\,(\,2hc^2/\lambda^5 I_\lambda + 1\,)}$$

Anisotropic Emission Factor:

$$R = 1 + c\,(\theta)\;A$$

$$c\,(\theta) = 0.55 - exp\,(-cos\;\theta)$$

$$R = 1 + [\,0.55 - exp\,(-cos\;\theta)\,]\;A$$

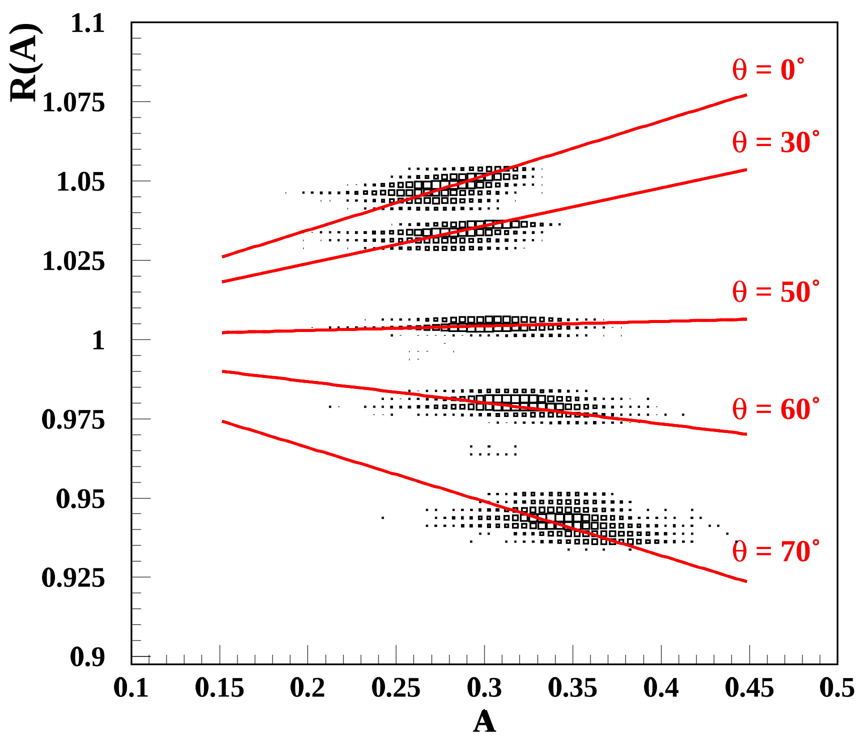


CLEAR OCEAN SCENES

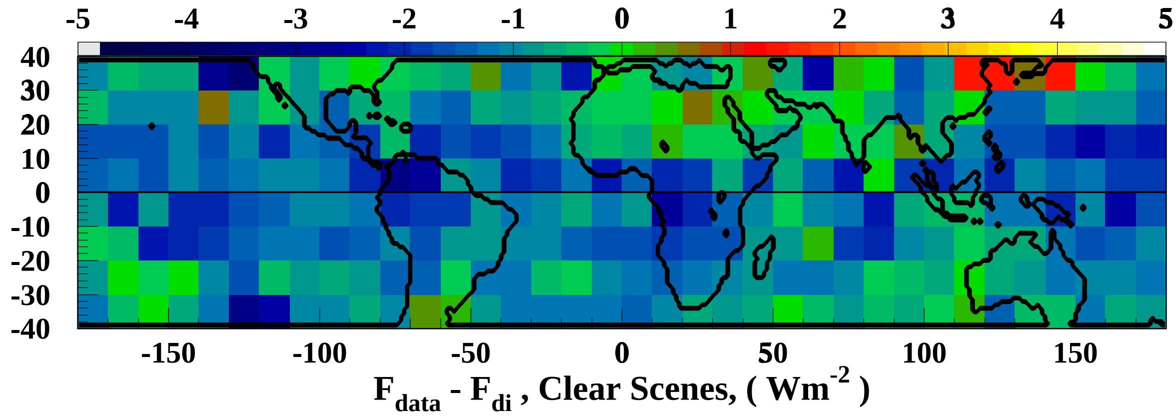
DATA

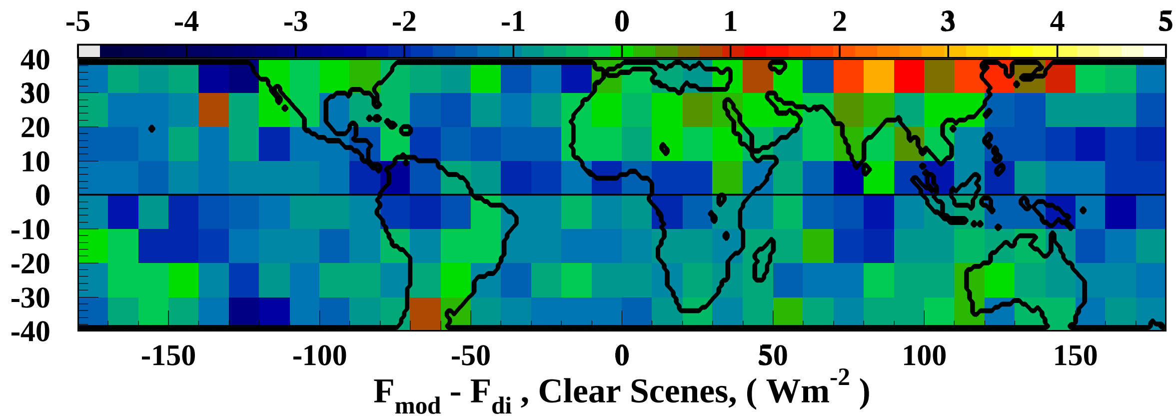
- ◇ VIRS channel #4 IR window = $10.8 \pm 1.5\ \mu m$
- ◇ clear ocean scenes
- ◇ emissivity = 0.98
- ◇ θ bin width = 1°

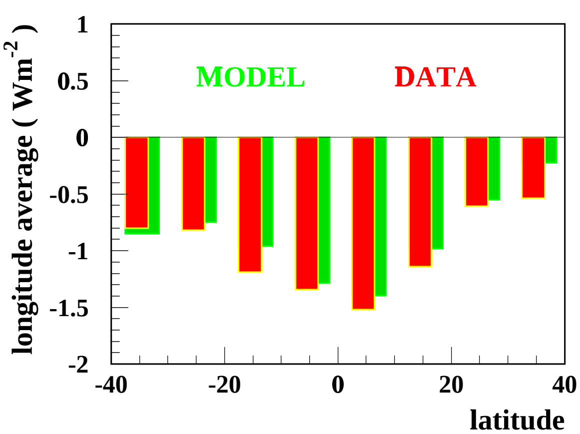
$$R_M(\theta, A) = 1 + [\,0.54 - exp\,(-cos\,\theta)\,]\;A$$

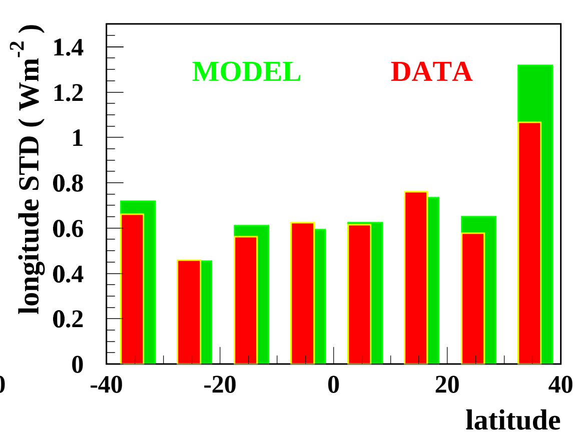


CLEAR SCENES REGIONAL FLUXES

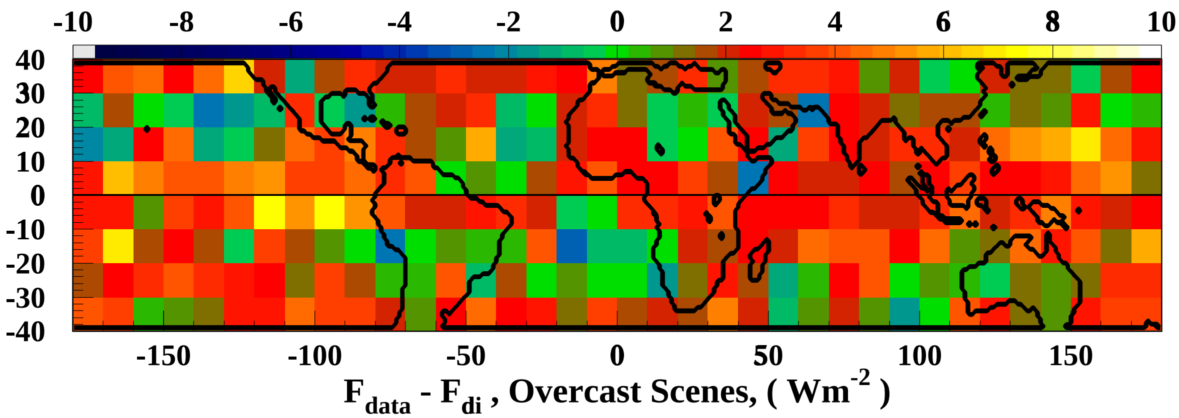


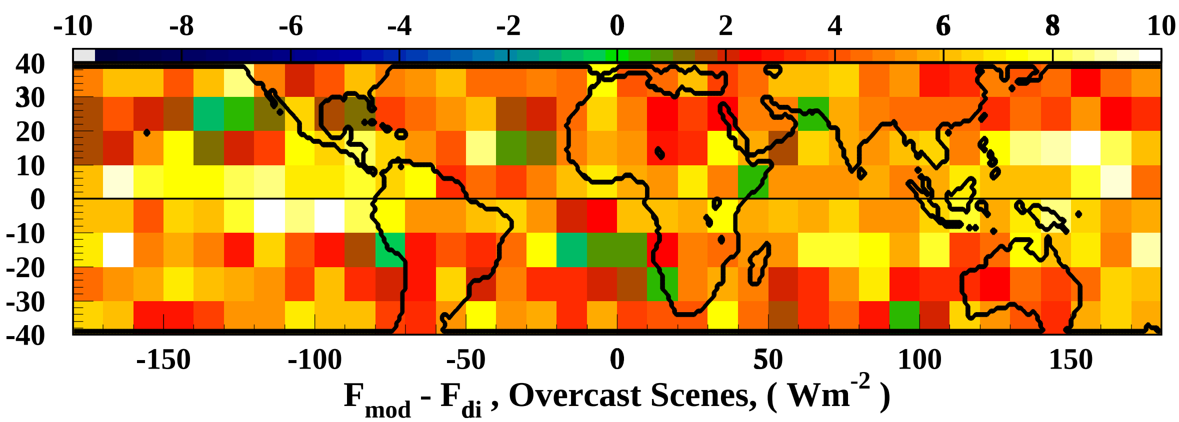


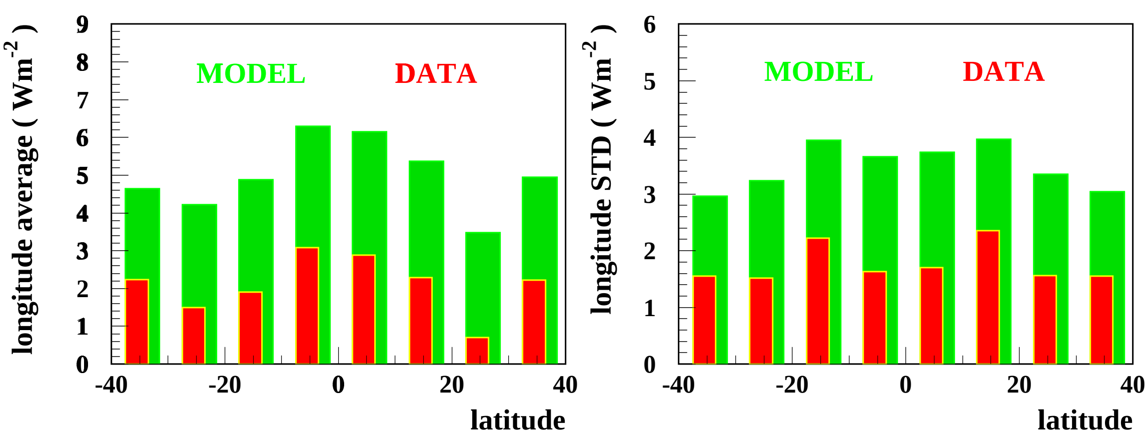




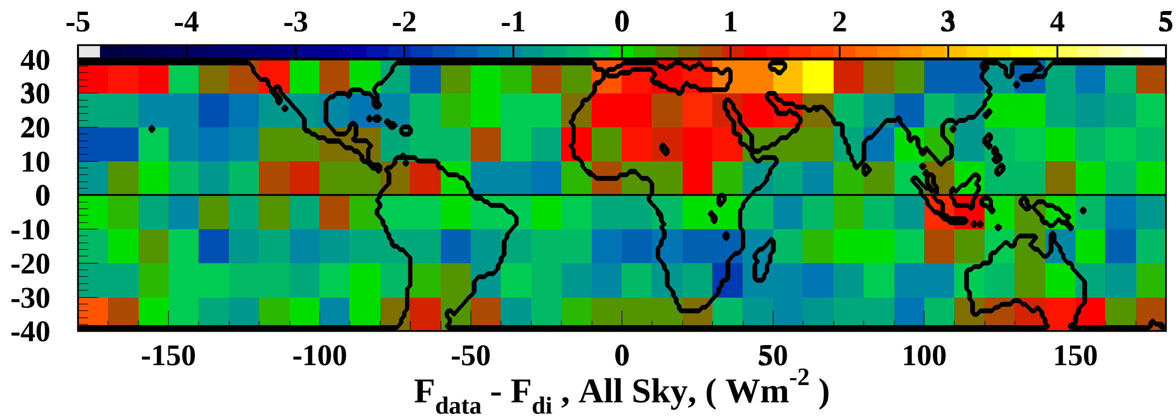
OVERCAST SCENES REGIONAL FLUXES

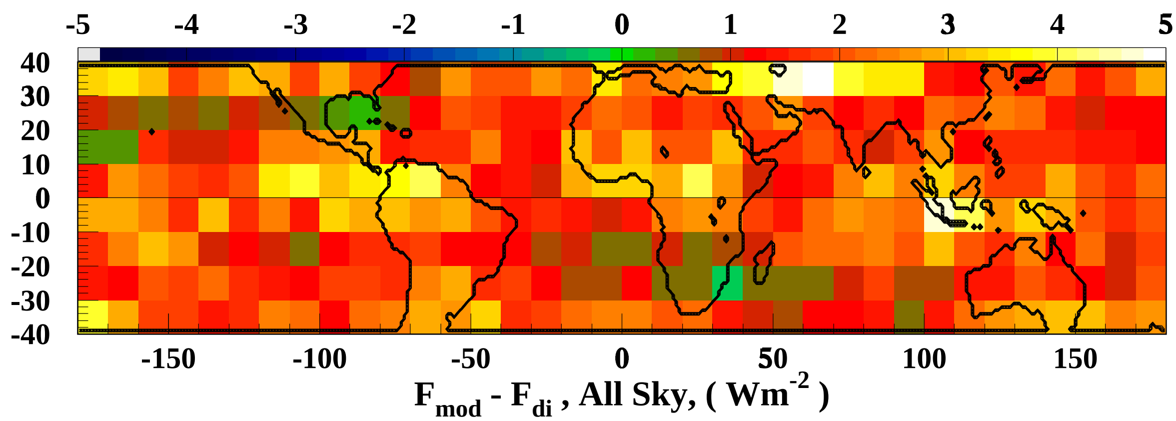


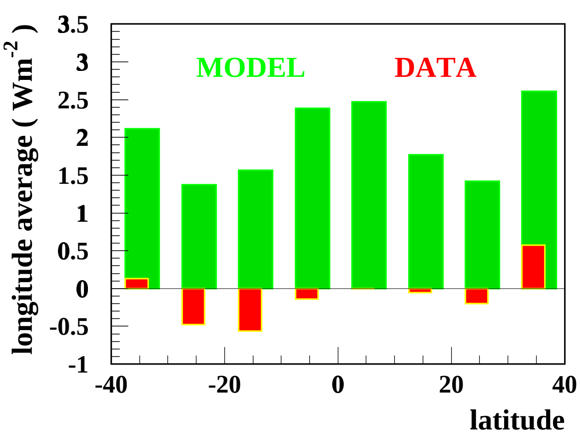


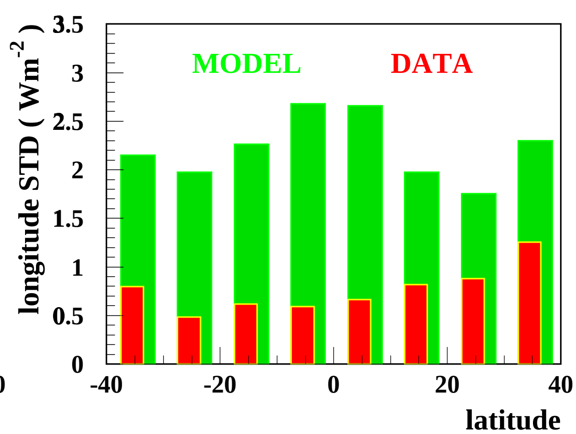


ALL - SKY REGIONAL FLUXES



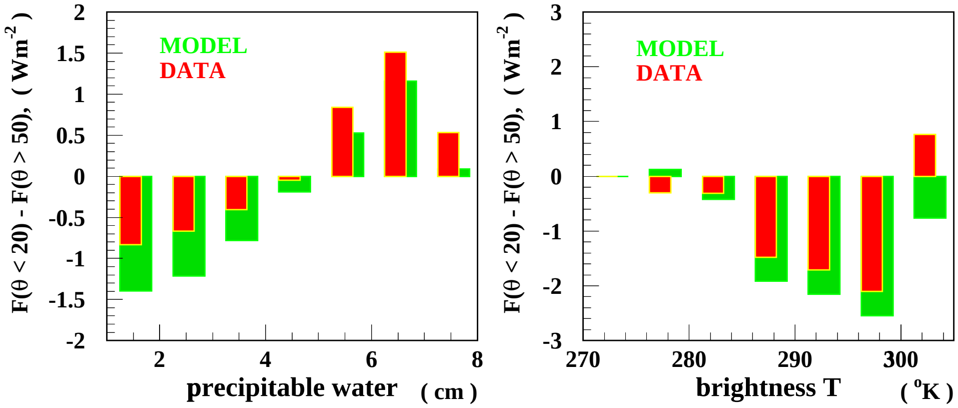




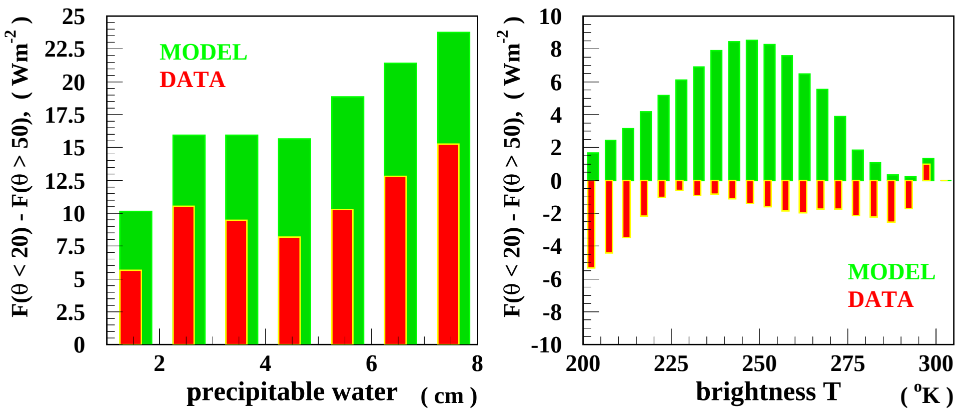


VIEWING ZENITH ANGLE BIASES

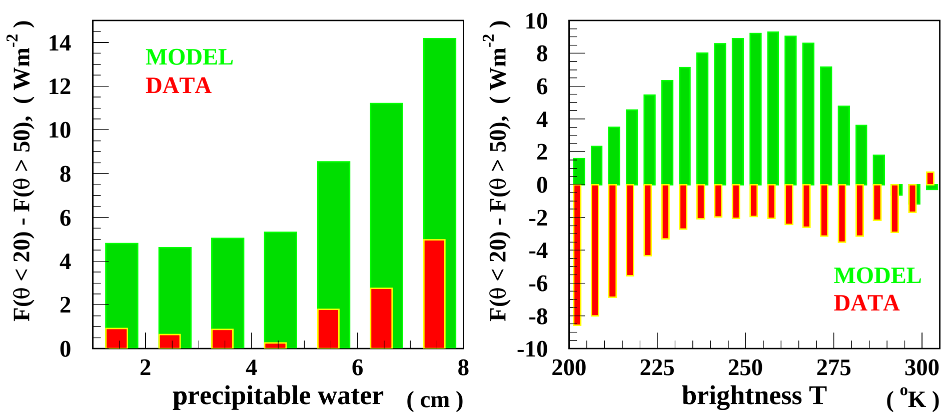
Clear Ocean Scenes



Overcast Ocean Scenes w/ Emissivity > 0.9



All-Sky Ocean Scenes



SUMMARY

- **The longwave flux errors of the new edition, Beta-II, of the TRMM data are considerably improved in comparison with the ERBE-like longwave flux errors. The regional relative differences with the directly integrated fluxes are within 0.2% ($\leq$ 0.5 W/m^2).**

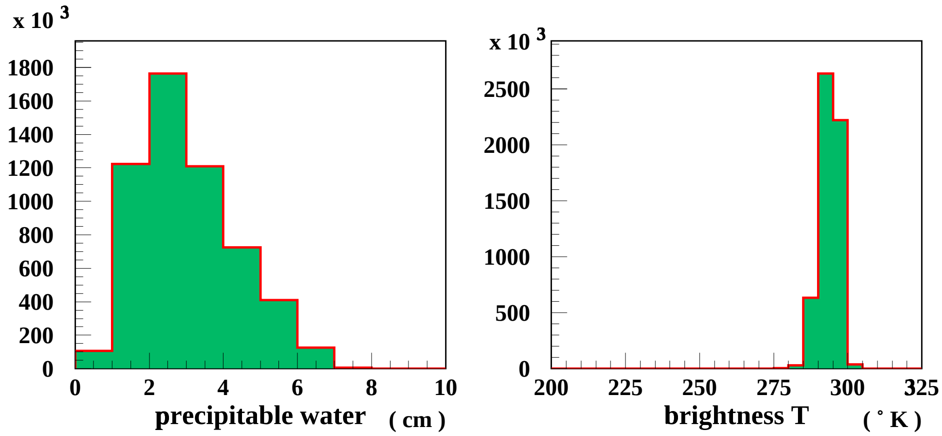
- **Longwave fluxes are successfully reproduced by a model for clear scenes with large emissivity (ocean, dark desert). The difference with directly integrated fluxes smaller than 0.5 W/m^2 (0.2%).**

- **The model fluxes for overcast scenes with large emissivity have relative errors close to 1% (the difference with DI fluxes $\approx$ 2 W/m^2), mostly due to inhomogeneity in clouds cover.**

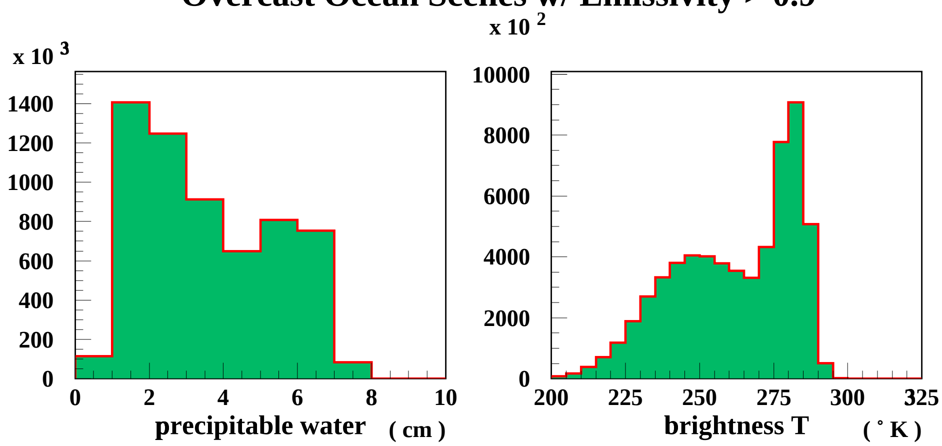
- **The viewing zenith angle biases as function of precipitable water and brightness temperature are small and consistent for both model and empirical methods over clear ocean scenes. However, for overcast and all-sky ocean scenes the bias and the difference between two methods became large.**

FREQUENCY DISTRIBUTIONS

Clear Ocean Scenes



Overcast Ocean Scenes w/ Emissivity > 0.9



All-Sky Ocean Scenes