# Towards Global Transferability of Inference Schemes for Radiative Forcing Functions under CEOP

**R. T. Pinker**

**M. M. Wonsick, H. Wang, and H. Liu**

**Department of Atmospheric and Oceanic Science**
**University of Maryland, College Park, MD**

**5th CEOP**
**Implementation Planning**
**UNESCO, Paris France**
**26 Feb-1 March, 2006**

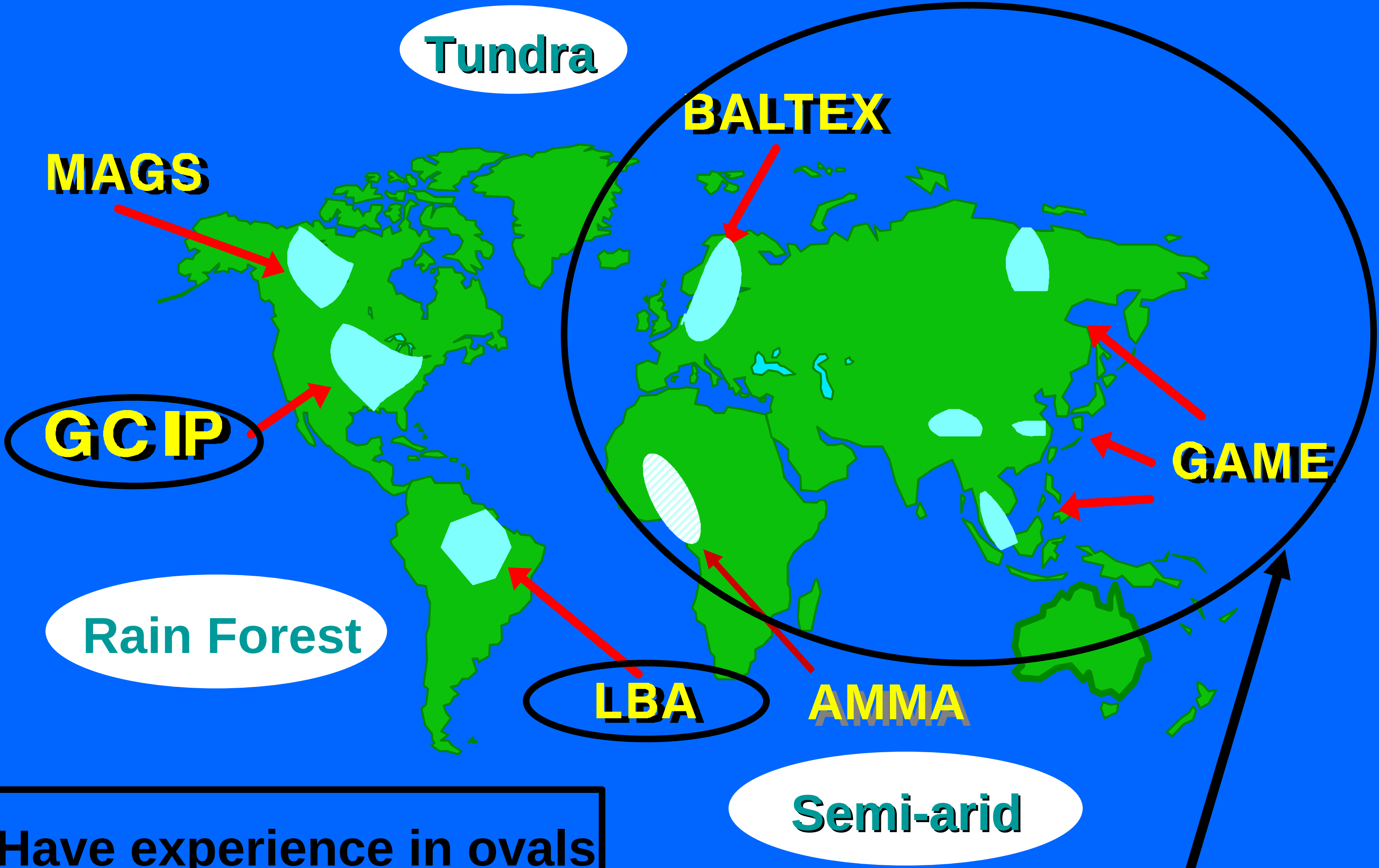
## Objective

- Develop capabilities to obtain radiative fluxes to support hydrological modeling and LDAS type activities in key CEOP regions that meet temporal and spatial scale requirements of CEOP.

- Implement global scale satellite methodologies with new sensors (MODIS) to serve as common denominator/calibrators of the regional products.

- **Involves:** Differences in satellite observing systems; Uniqueness of various climatic regions; Human impacts on radiative balance

# CEOP CSEs

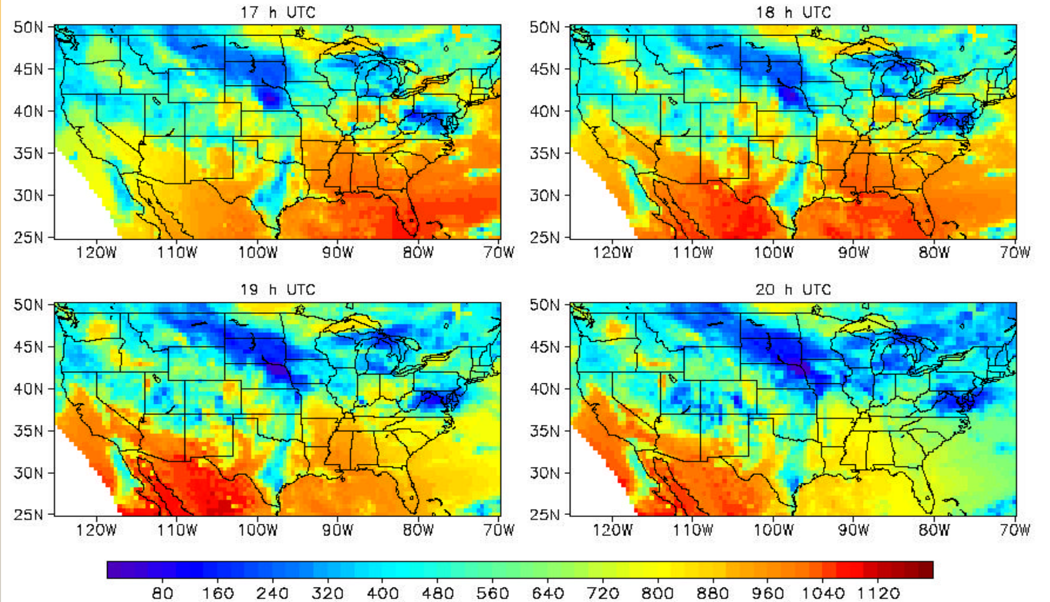



Have experience in ovals

Requires METEOSAT, GMS and

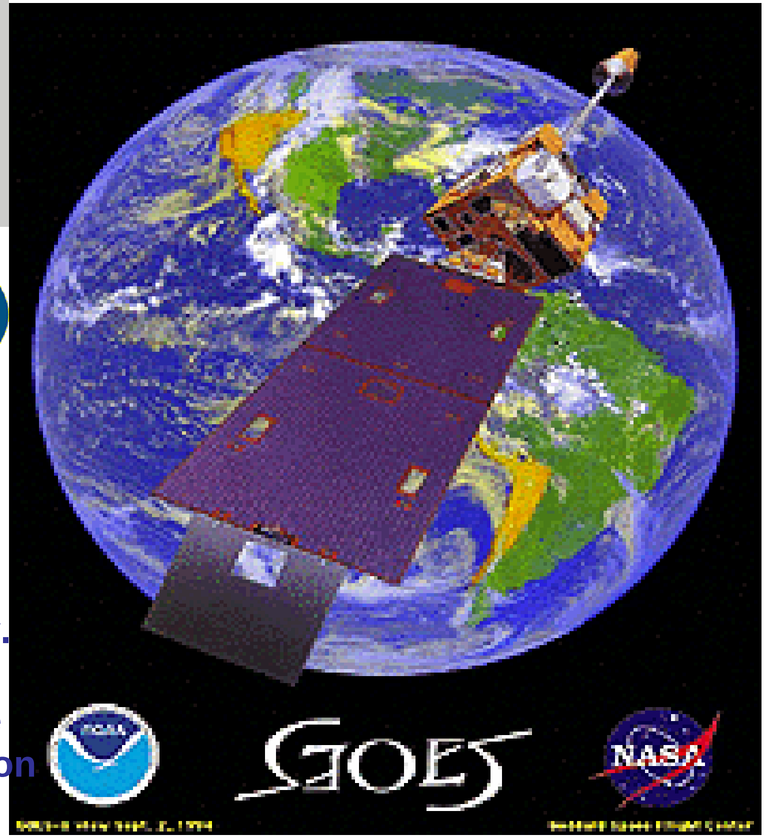
GEWEX Continental Scale International Project (GCIP)
and GEWEX Americas Prediction Project (GAPP):
Surface Radiation Budget (SRB) Data

# Transfer Experience from GCIP/GAPP to other geostationary satellites




Produced at real time at NOAA at 0.5 deg; distributed by the U of MD at

Parameters provided: surface short-wave and PAR (global and diffuse); TOP net; cloud amount; cloud optical depth; surface skin temp

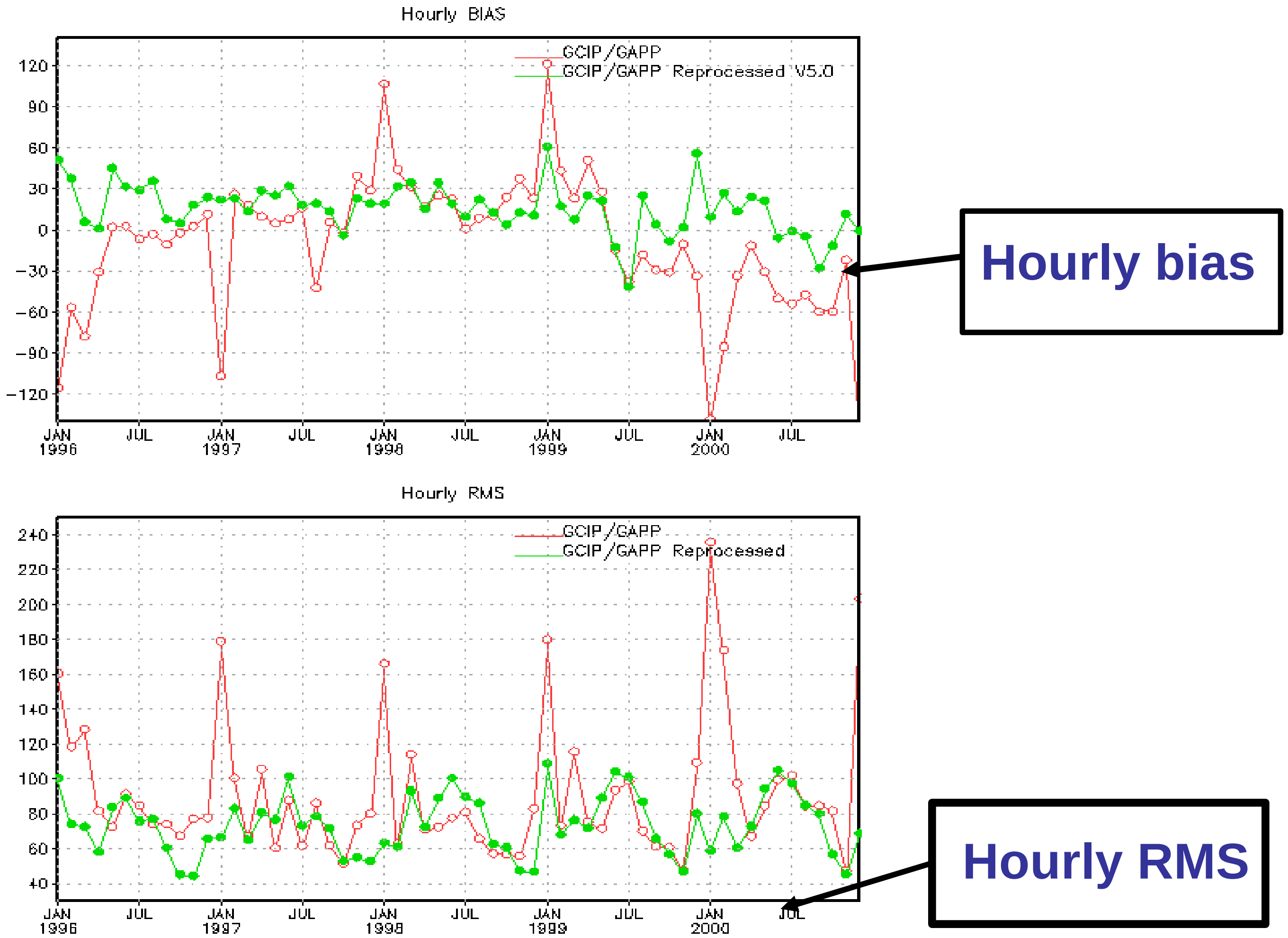



**FOCUS ON CLOUDS OVER SNOW ISSUES**

X.Li*, R. T. Pinker, M. M. Wonsick, and Y. Ma, 2006. **Towards improved satellite estimates of short-wave radiative fluxes: Focus on cloud detection over snow Part I: Methodology.**

R. T. Pinker, X. Li* and W. Meng, 2006. **Towards improved satellite estimates of short-wave radiative fluxes: Focus on cloud detection over snow Part II: Results. JGR, in revision.**

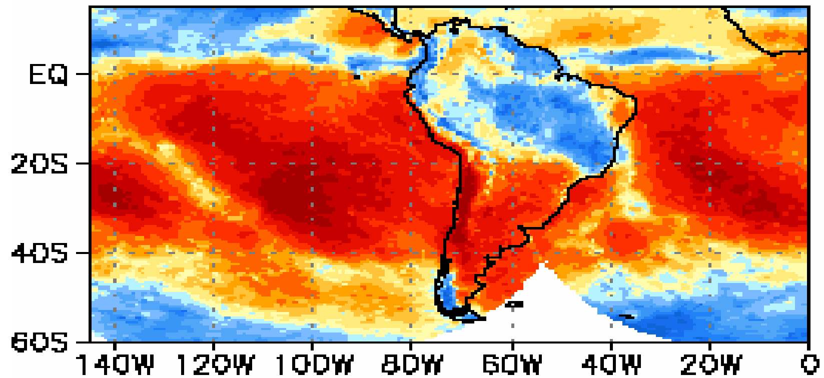
# Period 1996-2000 was reprocessed: improved for snow conditions

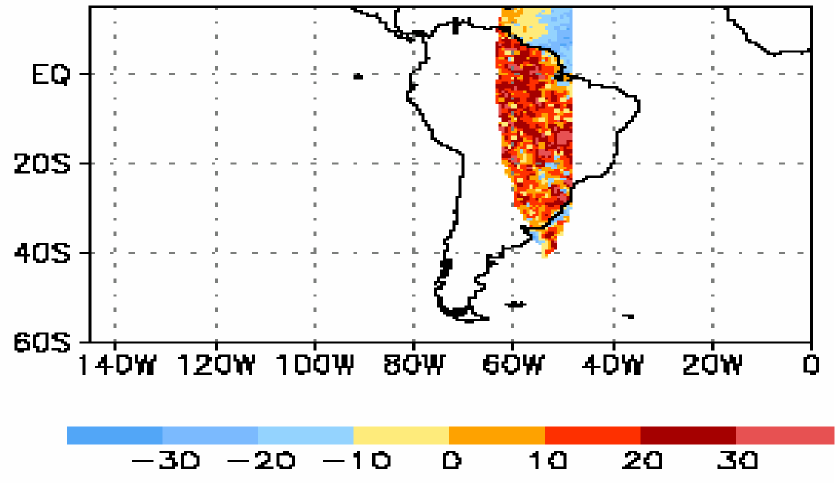



**FOCUS ON CLOUDS OVER SNOW ISSUES**

**X.Li*, R. T. Pinker, M. M. Wonsick, and Y. Ma, 2006.**
**R. T. Pinker, X. Li* and W. Meng, 2006. JGR, in revision.**

# Area of overlap between METEOSAT and GOES Differ
# EOF Analysis used for optimal merging




**Regional scale products from ISCCP DX METEOSAT/GOES/AVHRR at 0.50**

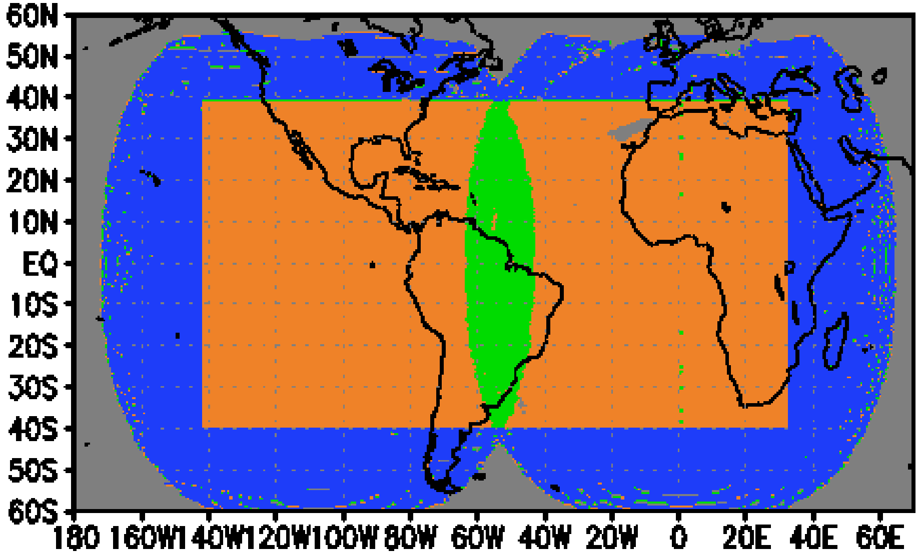
LBA

EXPERIMENTO DE GRANDE ESCALA DA BIOSFERA-ATMOSFERA NA AMAZÔNIA - LBA

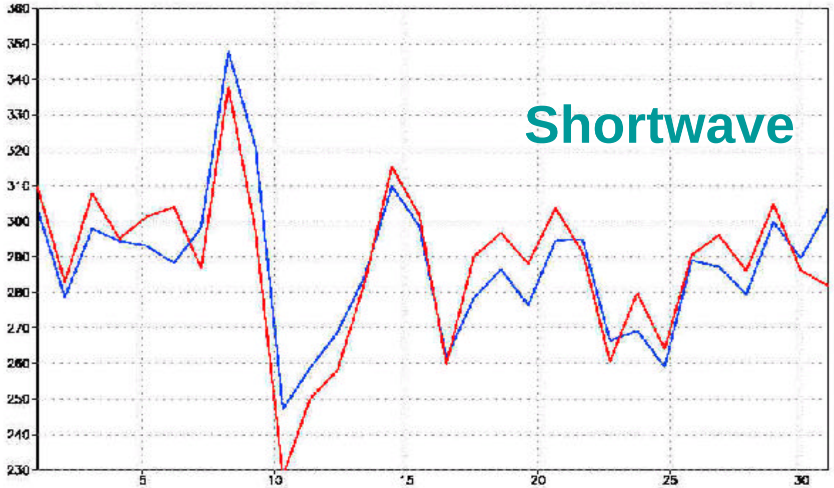
**UNDER LBA:**

**Issue:** **data gaps, degraded spatial resolution near boundary of geostationary satellites, and different viewing geometries in areas of overlap;**

**Developed methodology for optimal merging based on EOF Analysis. First applied to ISCCP DX.**
**Evaluation of the scheme conducted by artificially removing data in a region without missing data, and comparing estimated fluxes from EOF iteration scheme with the actual data.**




**Time series for January 90**
**(0.25N, 117.75 W)**
**Test-Blue ; Control –red**



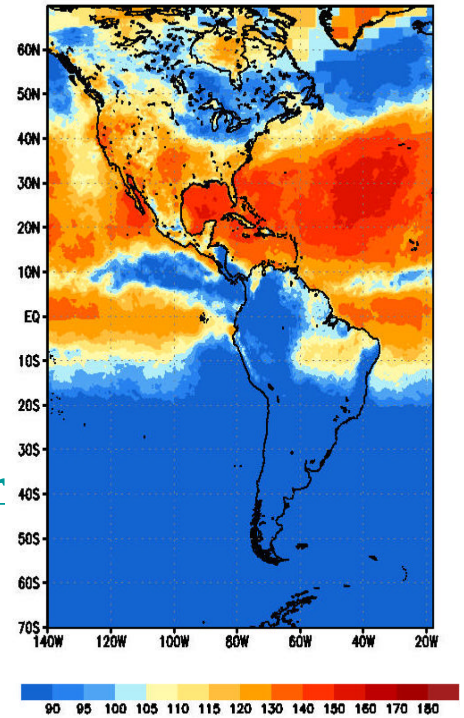

**Zhang, Pinker, Stackhouse ( 2006)**

**QUERY:**

# Beija-flor
## Search Engine for the LBA Project

**Current Database: LBA**

| | |
|---|---|
| **Title:** | **Daily 0.5 degree Shortwave Radiative Fluxes (Jan. 1989-Dec. 2000)** |
| **Project(s):** | **LBA (Large-Scale Biosphere-Atmosphere Experiment in the Amazon)** |
| **Activity Identifier:** | **LBA-HydroMeteorology** |
| **LBA Science Component:** | **Physical Climate** |
| **LBA Investigation Team ID:** | **PC-02 (Pinker / Ceballos)** |
| **Investigator(s):** | **Pinker, Rachel T Email: pinker@atmos.umd.edu**<br>**Ceballos, Juan Carlos Email: ceballos@cptec.inpe.br**<br>**Angelis, Carlos Frederico Email: angelis@cptec.inpe.br**<br>**Bottino, Marcus Jorge Email: bottino@cptec.inpe.br**<br>**Bush, Mark B Email: mbush@fit.edu**<br>**Pereira, Enio Bueno Email: enio@dge.inpe.br** |
| **Contact(s):** | **Pinker, Rachel T Email: pinker@atmos.umd.edu** |
| **Status:** | **Final** |



# Motivation for selection of new regions

Monsoon regions are of particular interest to scientific objectives of CEOP

The Indian monsoon is the dominant one

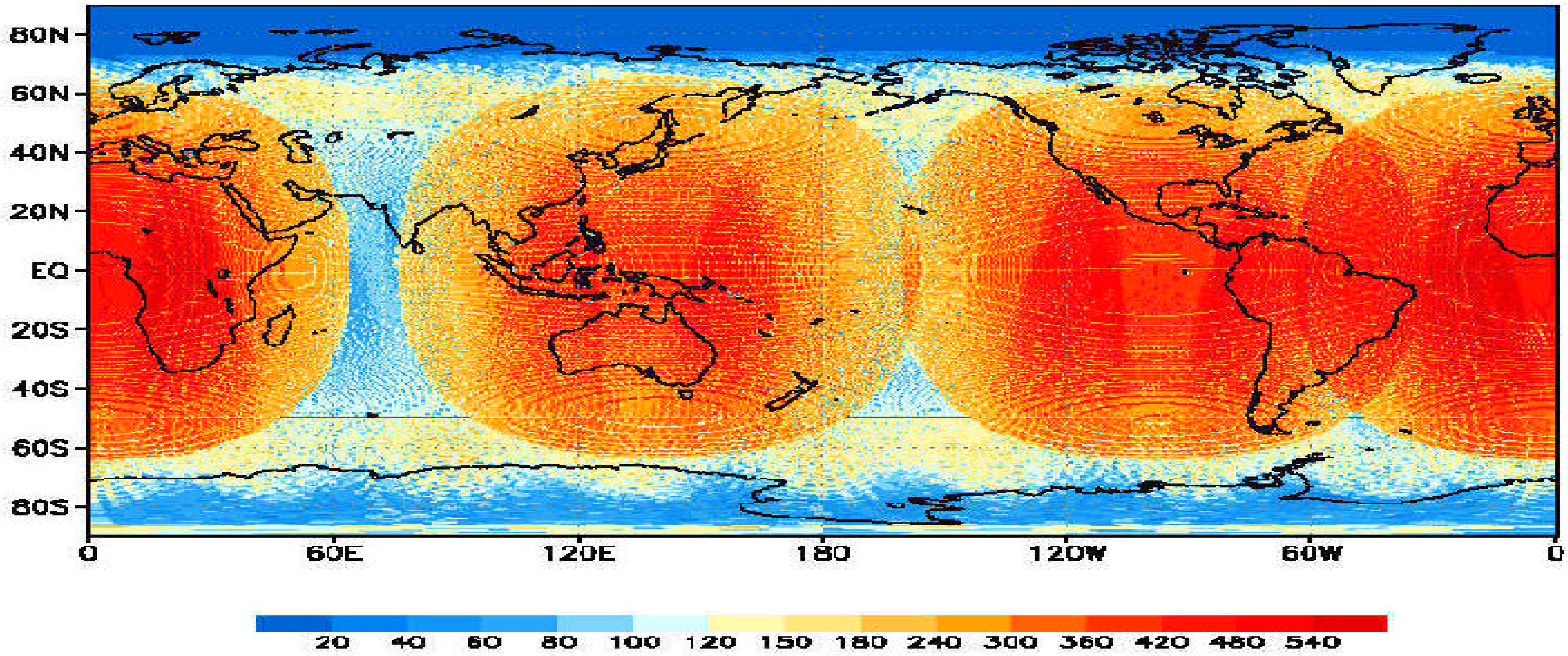
Information on radiative fluxes from available satellite data such as ISCCP, lack coverage in that region (known as the "Indian Ocean Gap")

Indian continent is a source region of anthropogenic aerosols for prolonged periods of the year (as documented during the Indian Ocean Experiment (INDOEX)

**At Issue with existing global data sets: methodologies based on low spatil sampling and normalization to polar orbiting satellites**

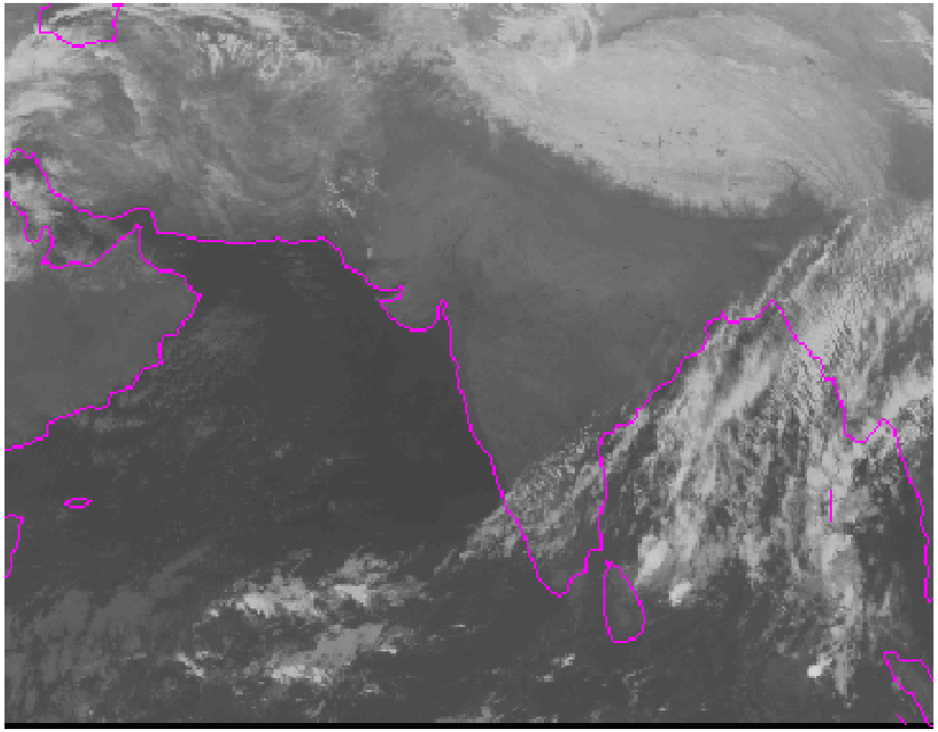
**Unequal coverage; data gaps, degraded spatial resolution near boundary, and different viewing geometries in areas of overlap**

**Number of ISCCP D1 AVHRR and Geostationary observations**

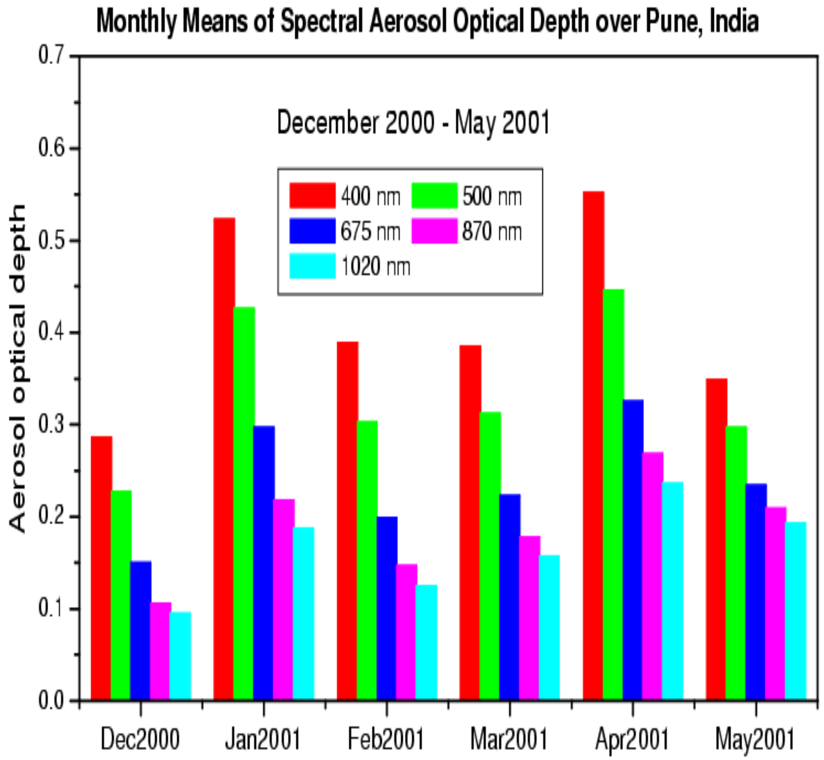


# Feasibility

- Meteosat-5 has been moved over India during INDOEX
- Aerosol climatology and model modification developed under independent activity
- Existing collaboration with the Indian Institute of Tropical Meteorology for validation



Meteosat-5 over India   1 Jan 2002  01Z

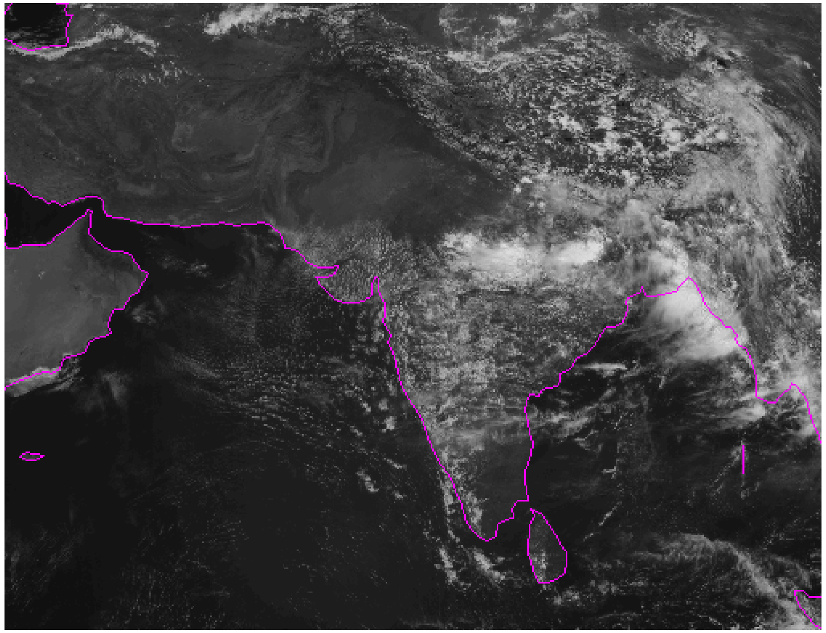


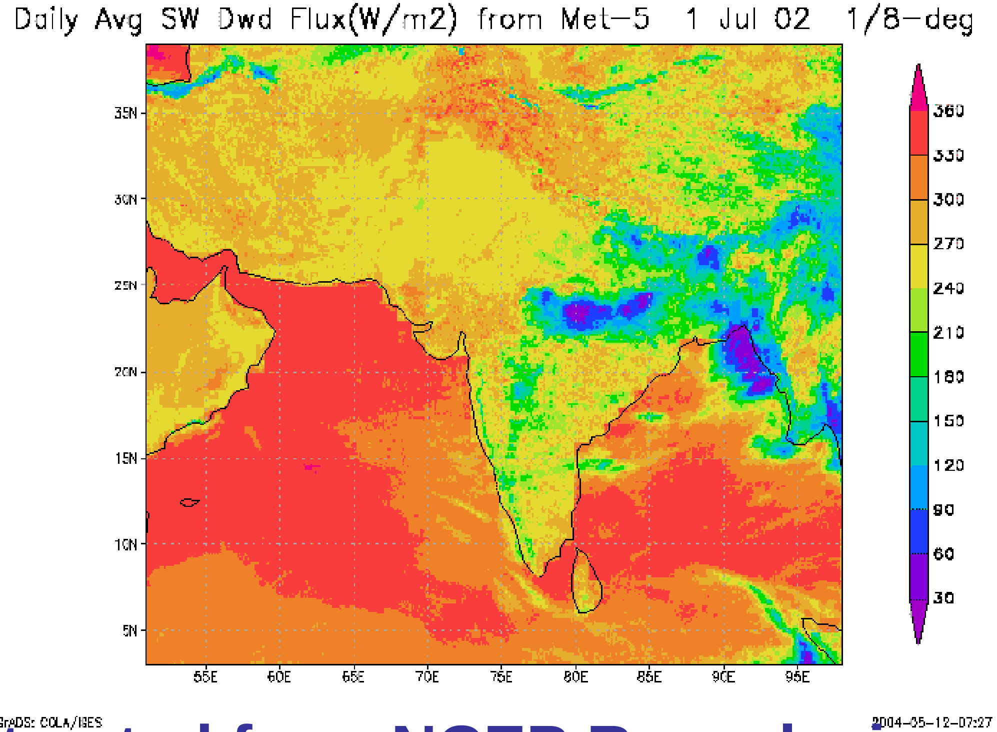
# Meteosat-5 Shortwave Flux

- Developed a cloud screening  for METEOSAT 5 at pixel level

- Developed capabilities to derive high resolution surface radiative fluxes  from METEOSAT 5.

Meteosat-5  1 Jul 02  07Z



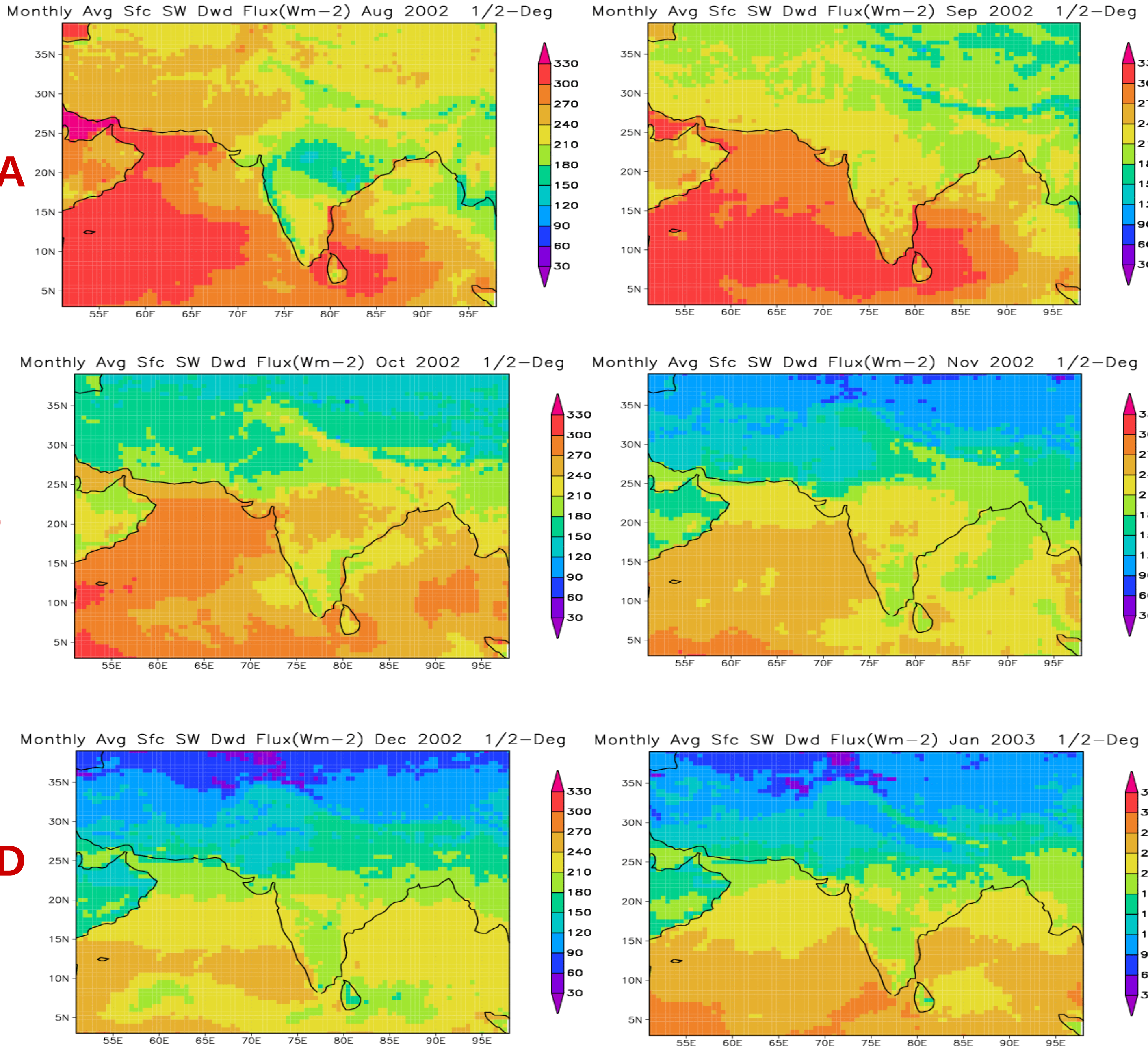



## Atmospheric inputs were extracted from NCEP Reanalysis

Thanks are due to the staff at EUMETSAT Archive and Retrieval Facility for providing the Meteosat-5 observations  and to Yves Govaerts  for his help.

# Examples of monthly surface SW fluxes at 0.5 degree for 2002-03

**Covers EOP 1**




A

S

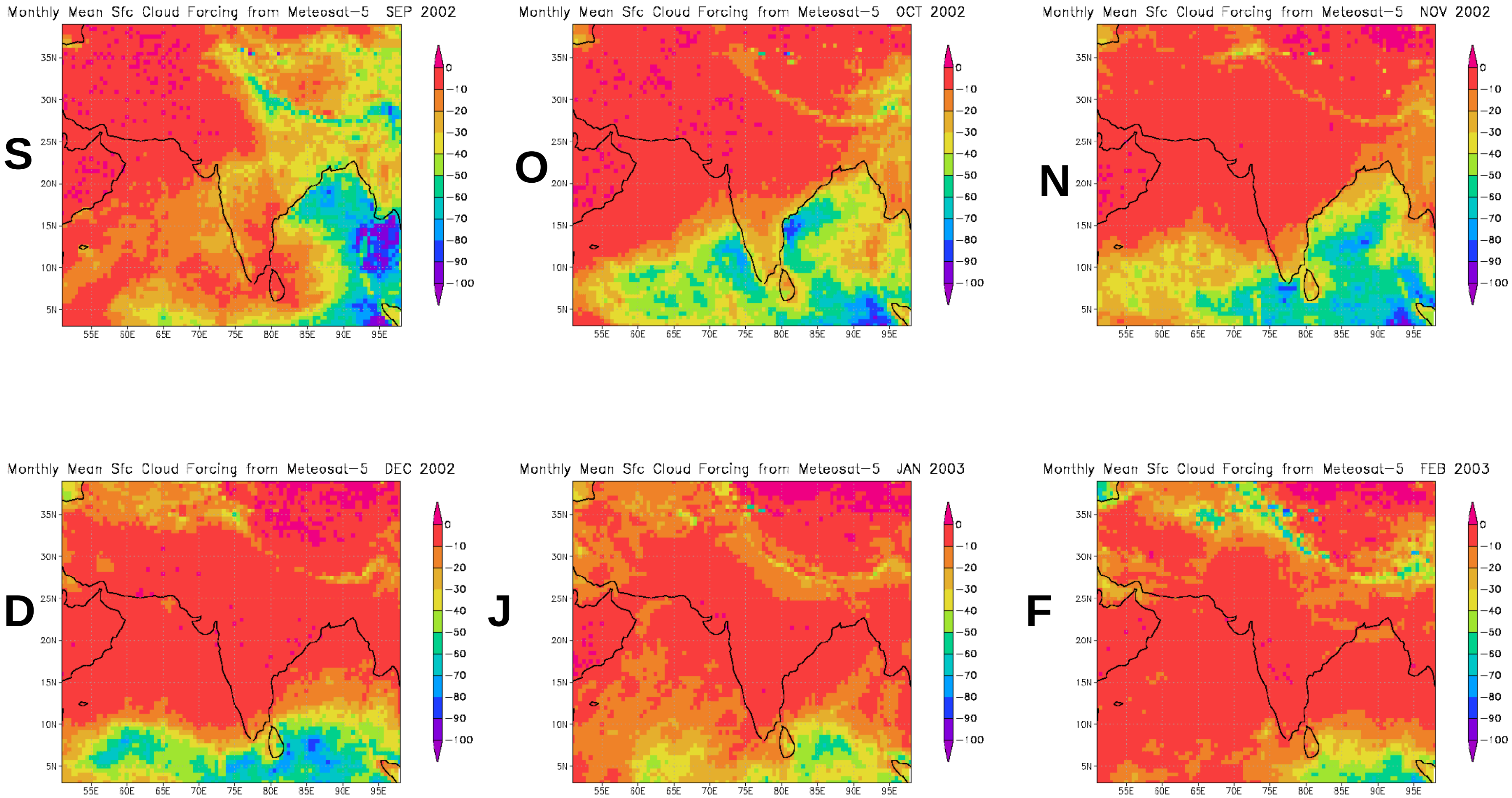
O

N

D

J

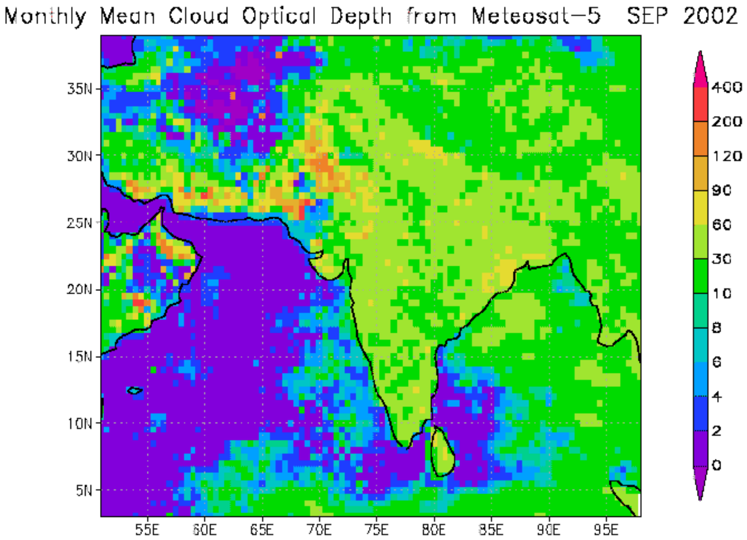
# Monthly Mean Surface Cloud Forcing
## September 2002 – February 2003

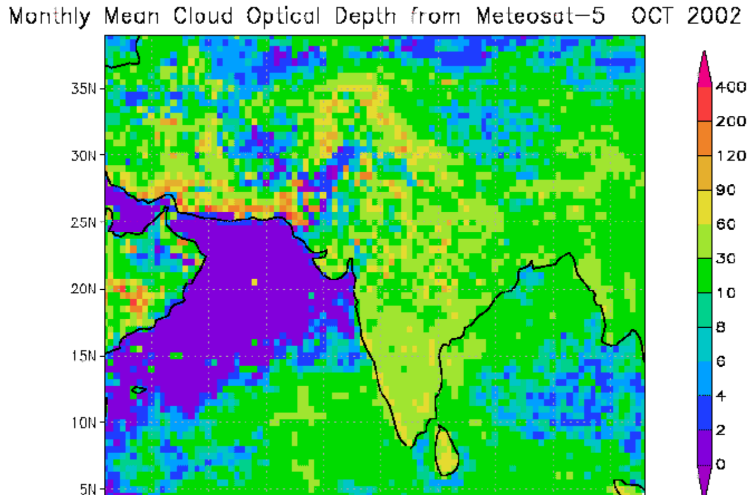


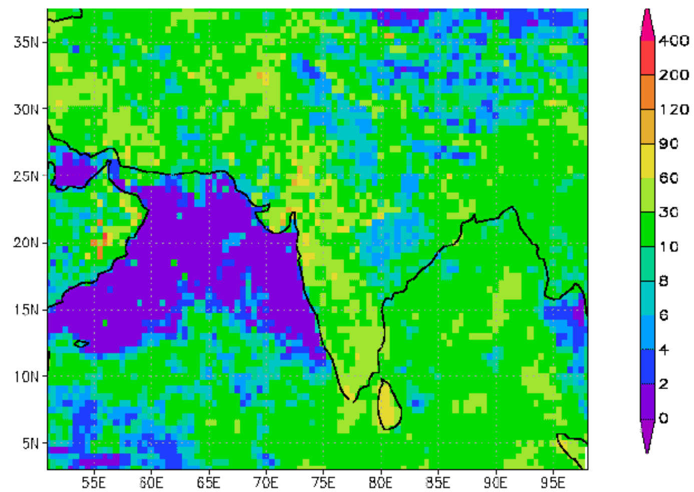

**Cloud Forcing = Fas – Fcs; Fas = All-sky net flux = Fas- - Fas+**

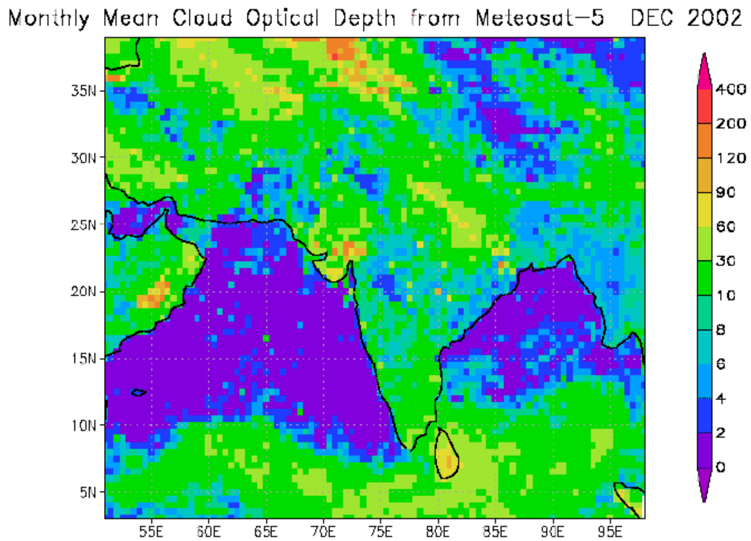
**Fcs = Clear-sky net flux = Fcs- - Fcs+**

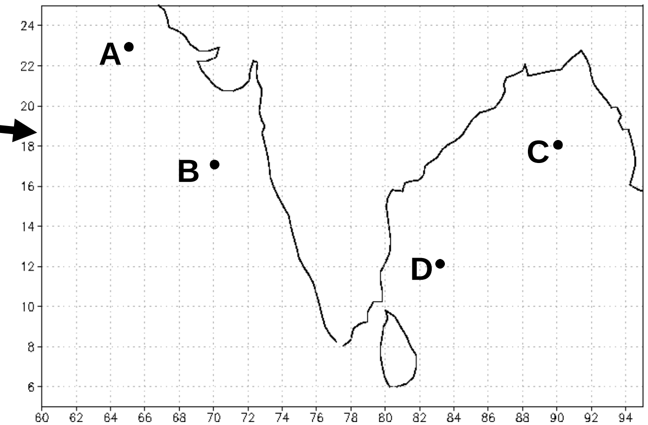
# Monthly Mean Cloud Optical Depth
## September 2002 – December 2002

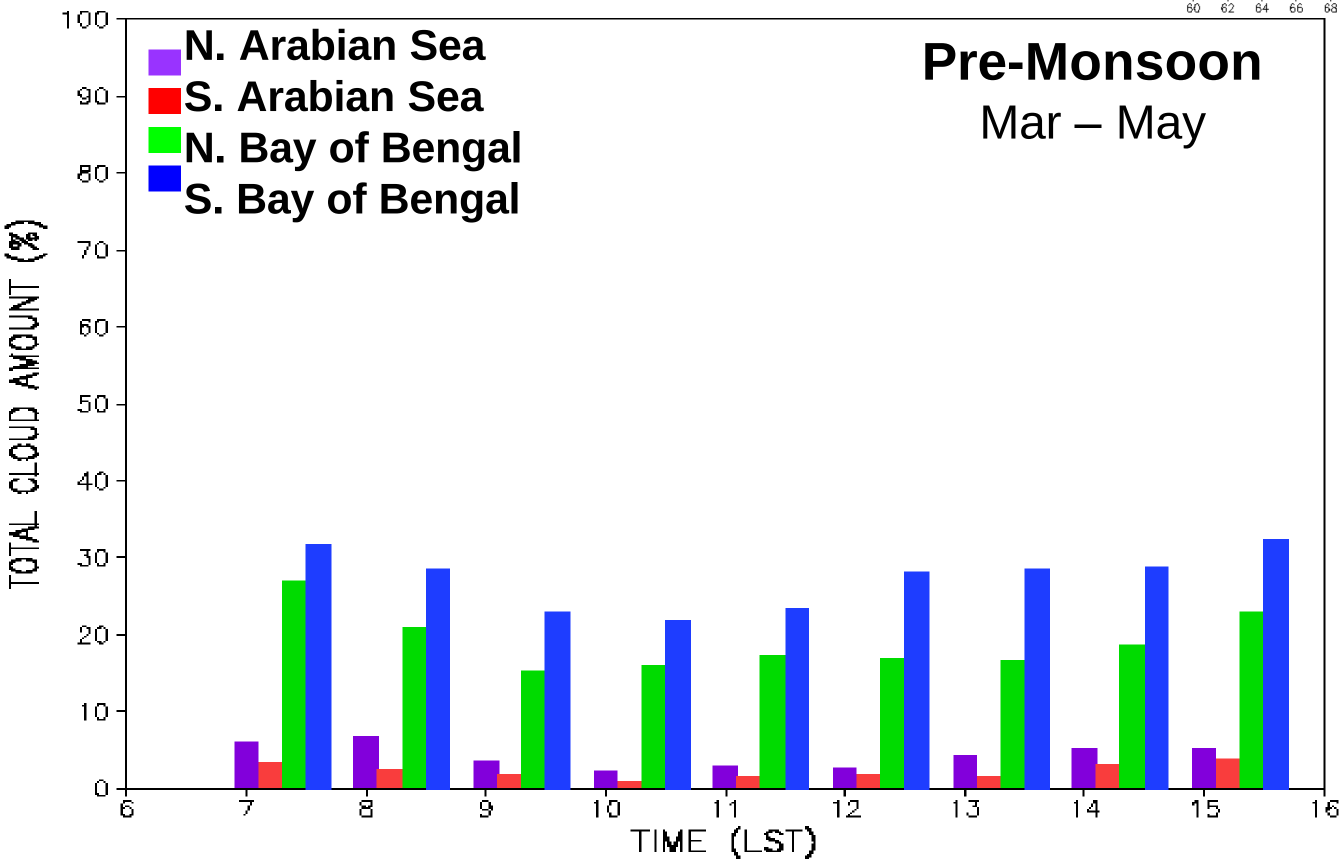


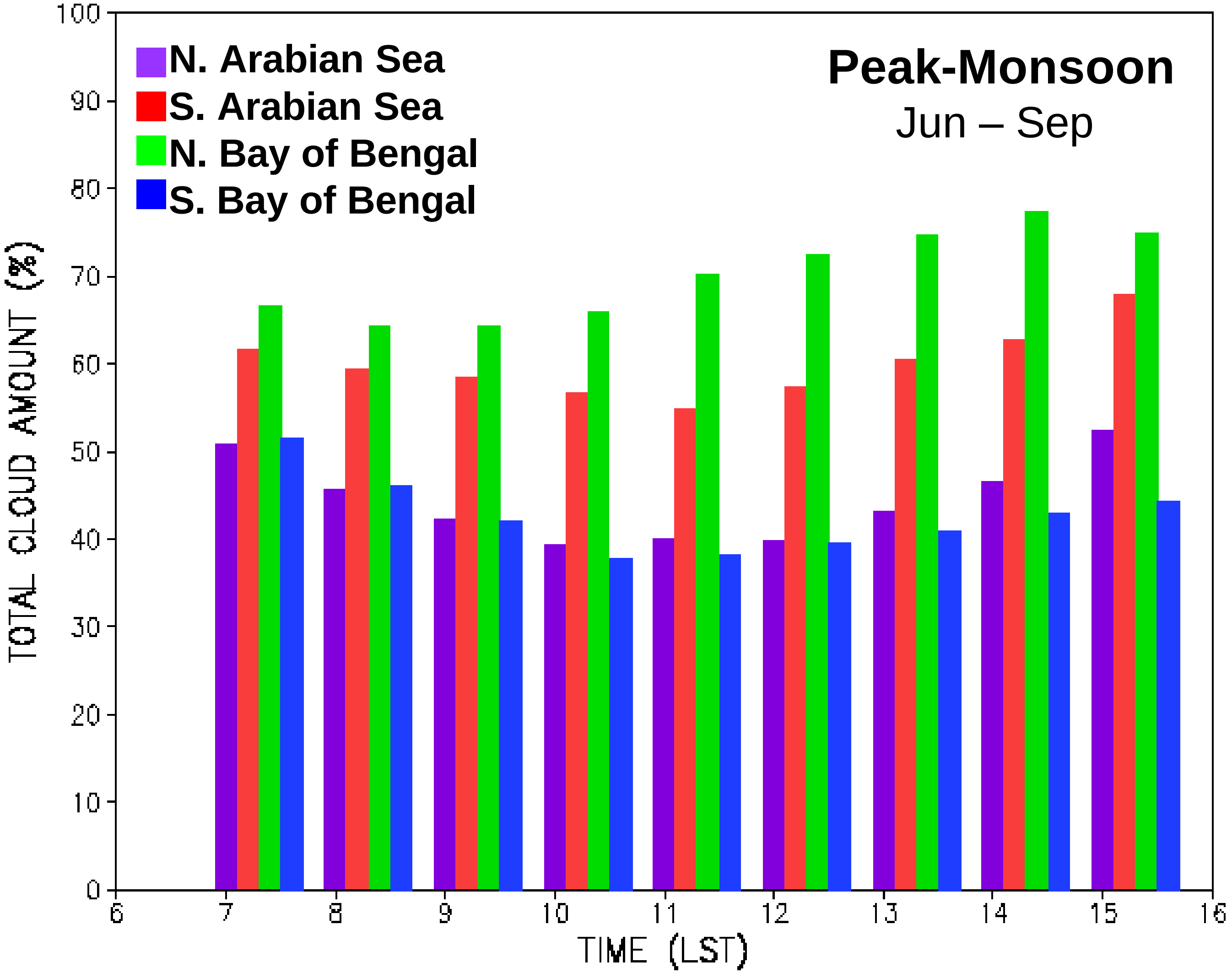



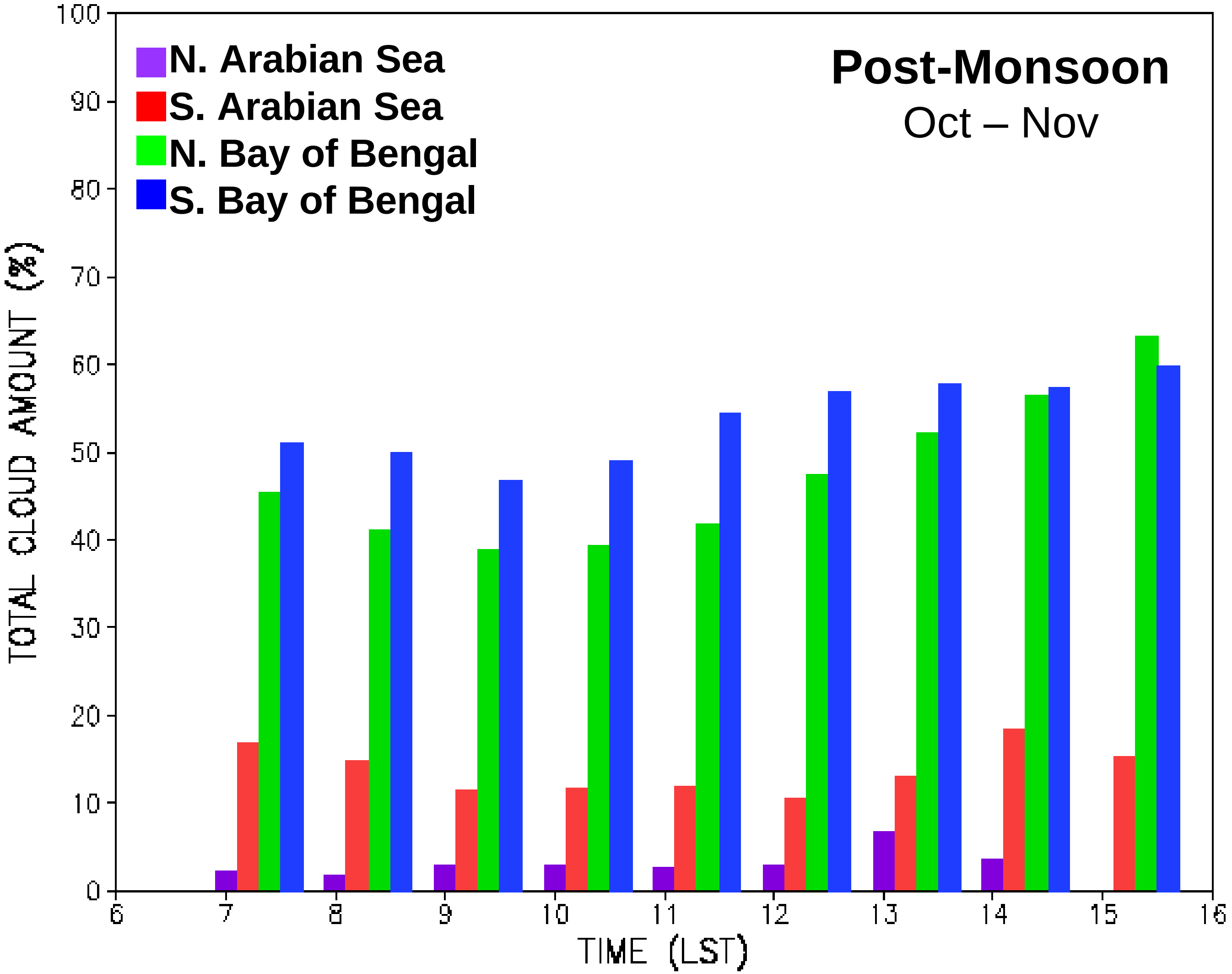


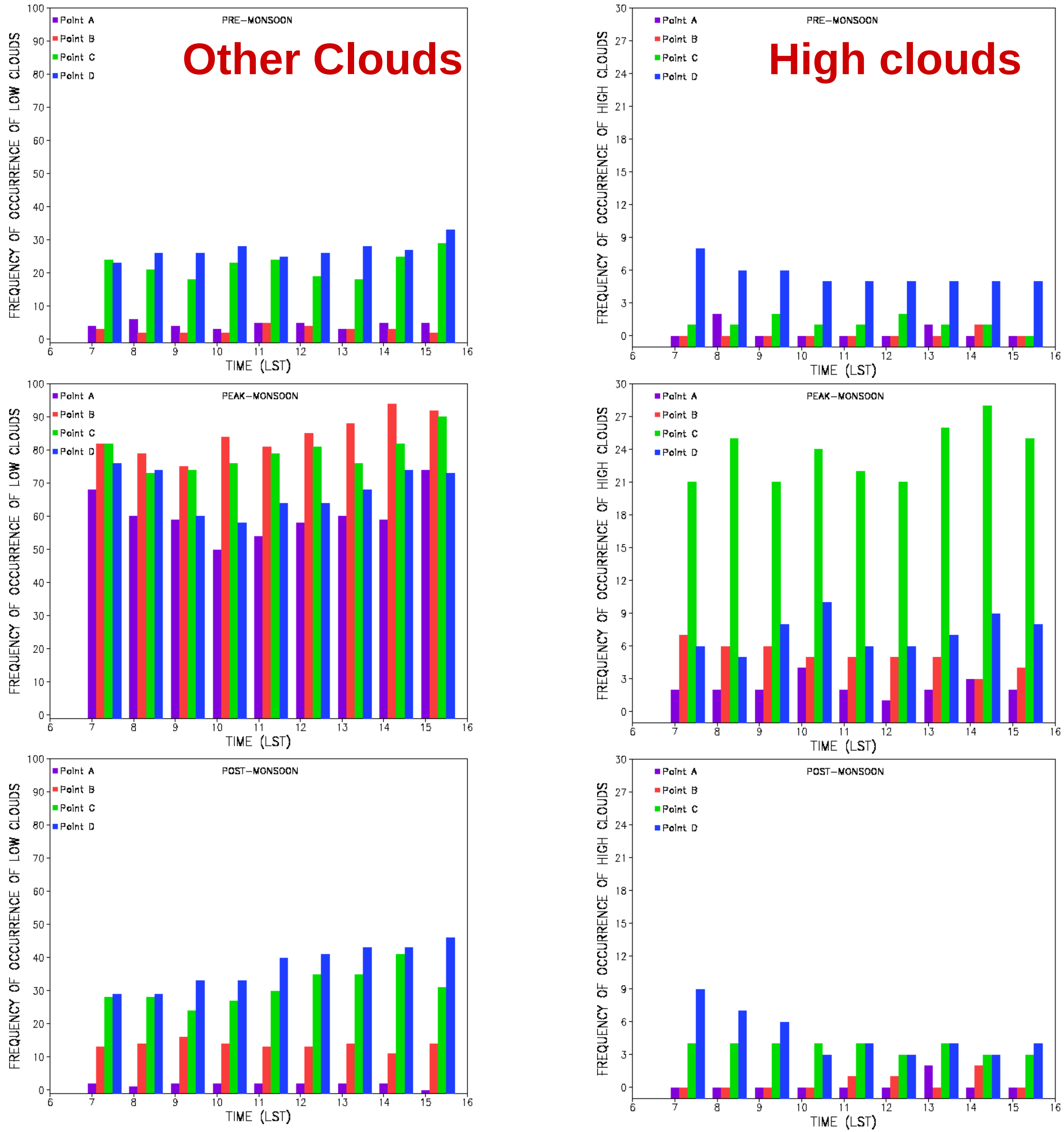

## Diurnal variation of total cloud amount




# Diurnal variation of cloud amount




**Diurnal variation of totalcloud amount**




**Frequency of occurrence for:**

**pre-monsoon (top)**

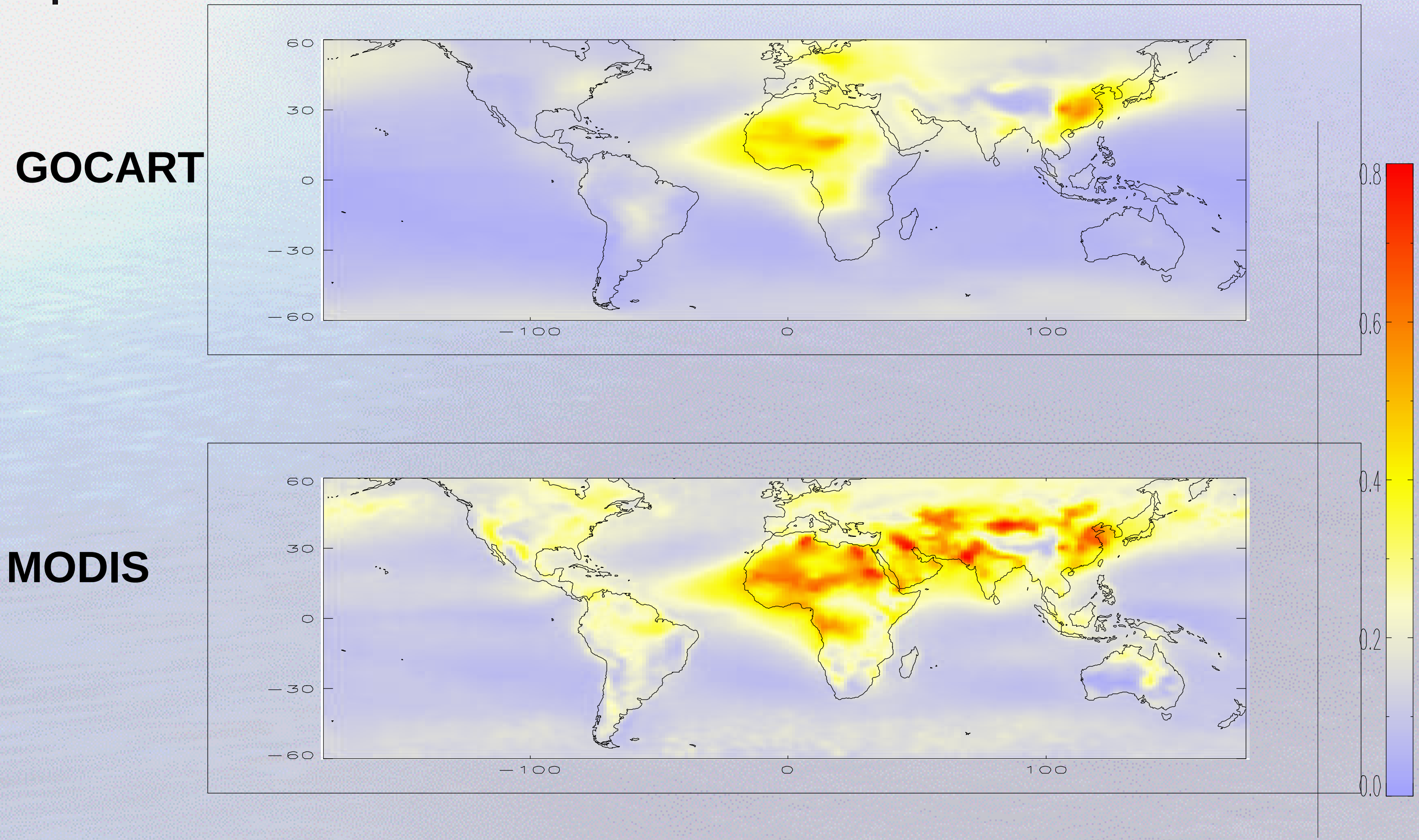
**peak-monsoon (middle)**

**post-monsoon (bottom)**

**High clouds have have an IR brightness temperature less than 220K**

# Aerosol Issues

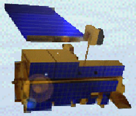
# *2-year mean AOD*



# *Aerosol Data* *March 2000 – February 2002*

**GOCART model simulations**

$2.5^{\circ} \times 2^{\circ}$ monthly mean AOD at 550nm

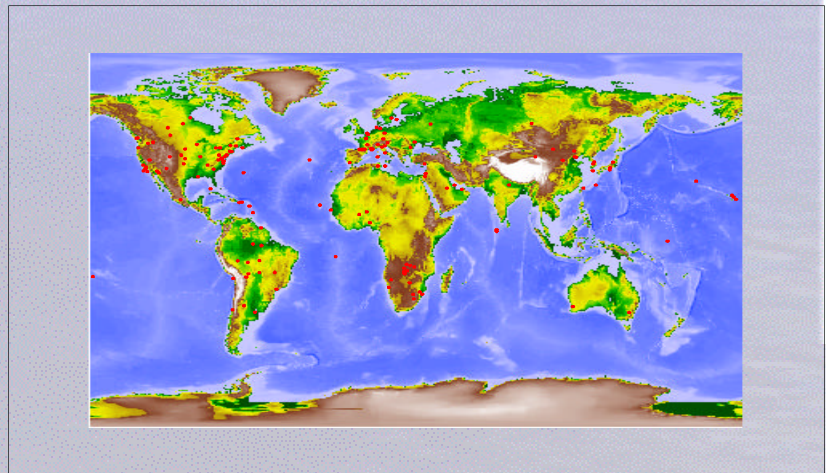


**MODIS retrievals**

Level-3 $1^{\circ} \times 1^{\circ}$

**AERONET measurements**

monthly mean AOD at 550nm

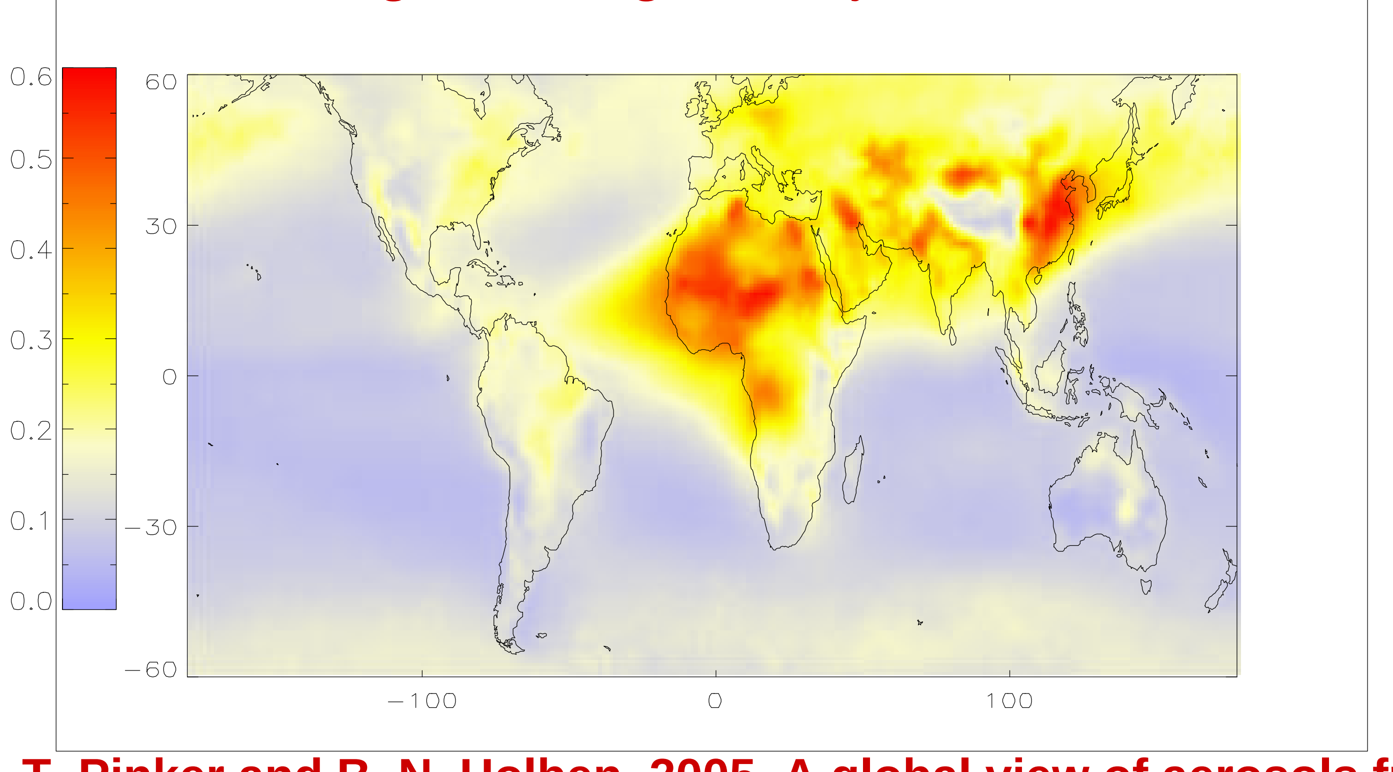


**Fit leading EOFs (significant spatial variation patterns) to AERONET in a least square sense to propagate local information to large scale.**

# Two-Year Mean AOD: Weighted Average

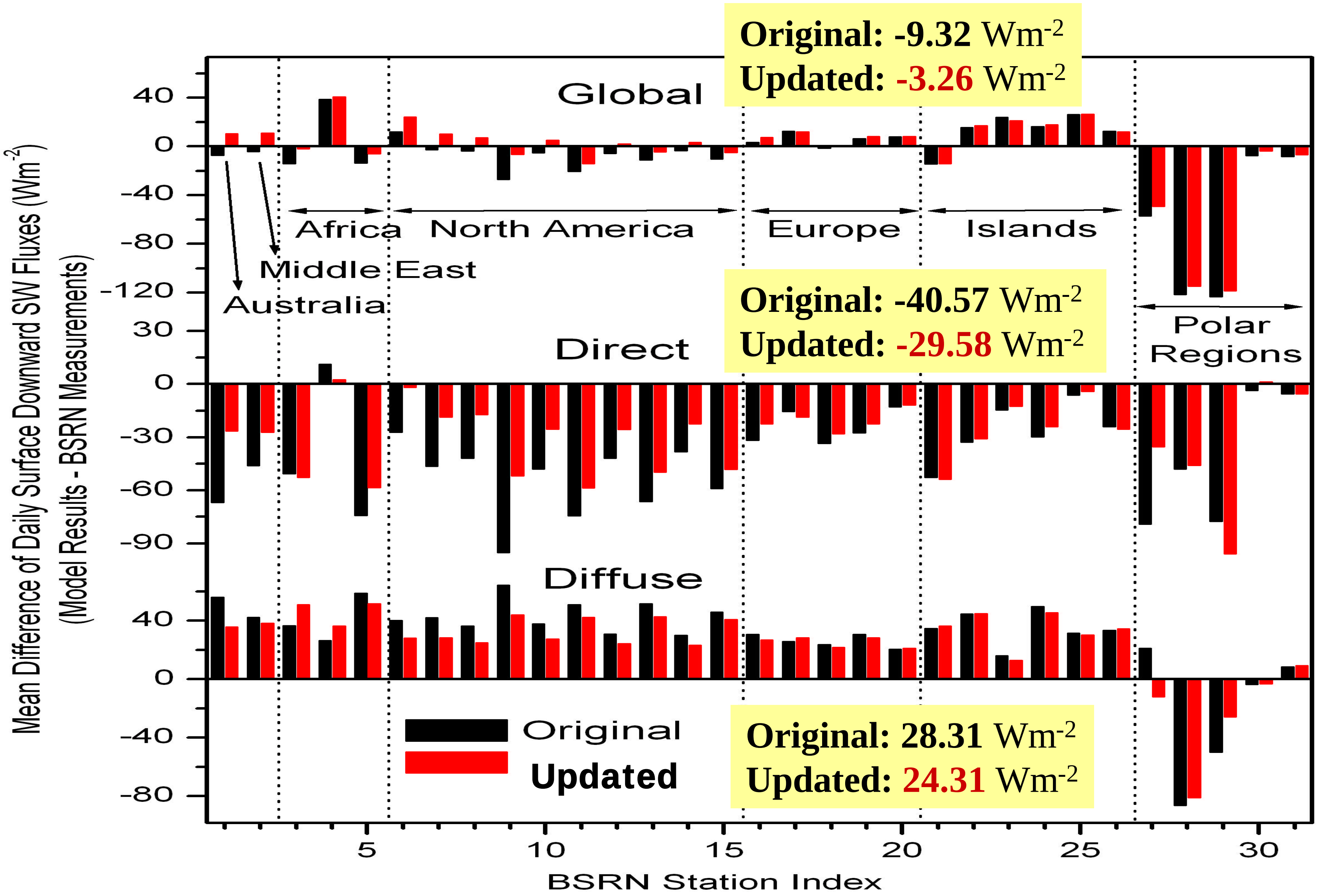
- ➢MODIS and GOCART two-year means are first weight-averaged.
- ➢Weights are inversely proportional to the error variances:

Weighted Average of Two-year Mean AOD

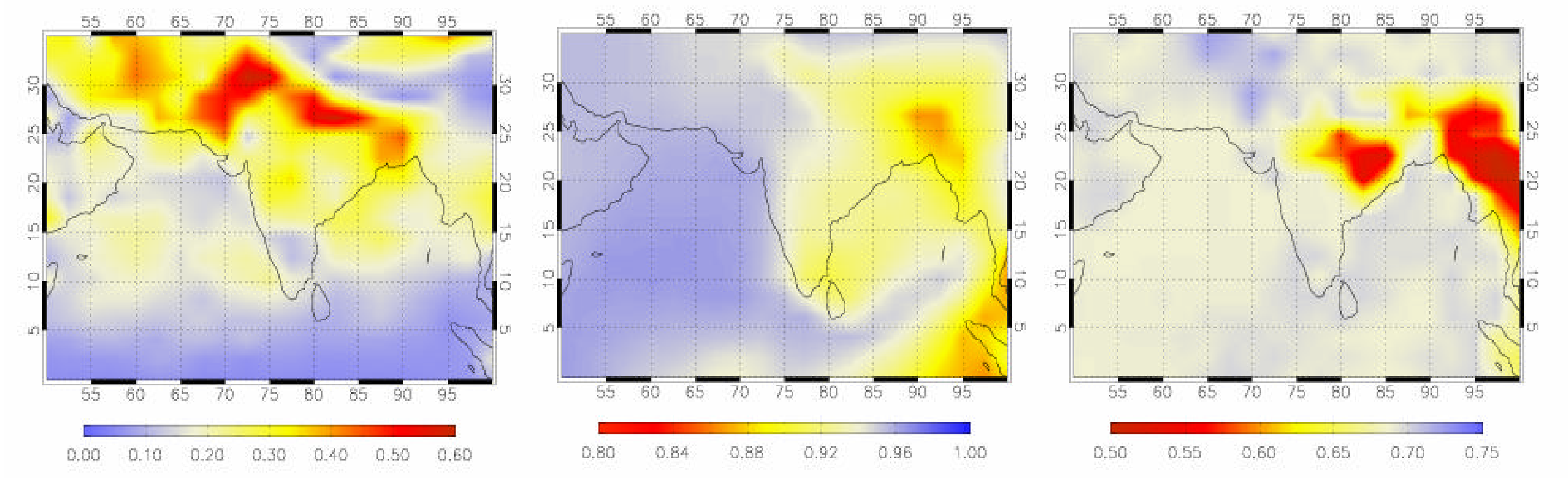


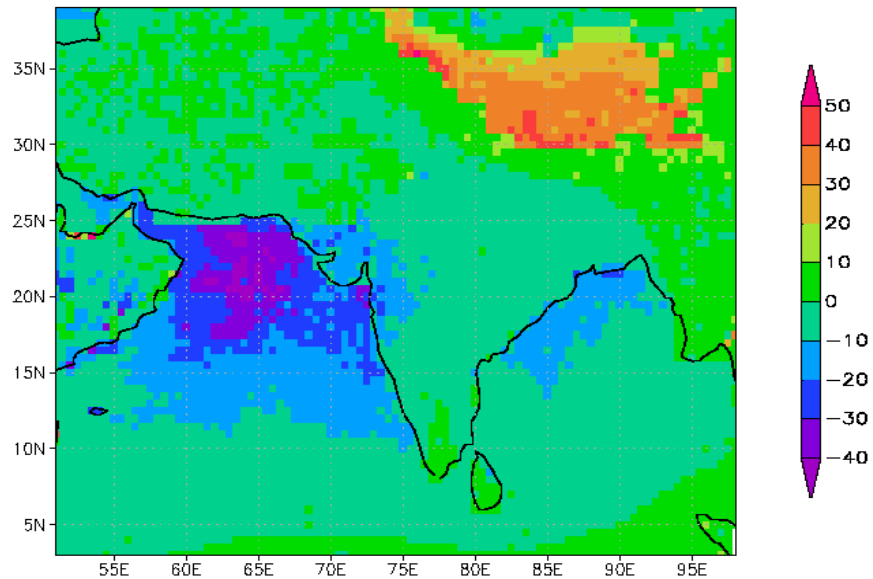

Liu, H., R. T. Pinker and B. N. Holben, 2005. A global view of aerosols from merged transport models, satellite, and ground observation. JOURNAL OF GEOPHYSICAL RESEARCH, VOL. 110, doi:10.1029/2004JD004695 (Special Issue-Aerosol Systems)

# Surface Irradiance : Compare with BSRN (2001)

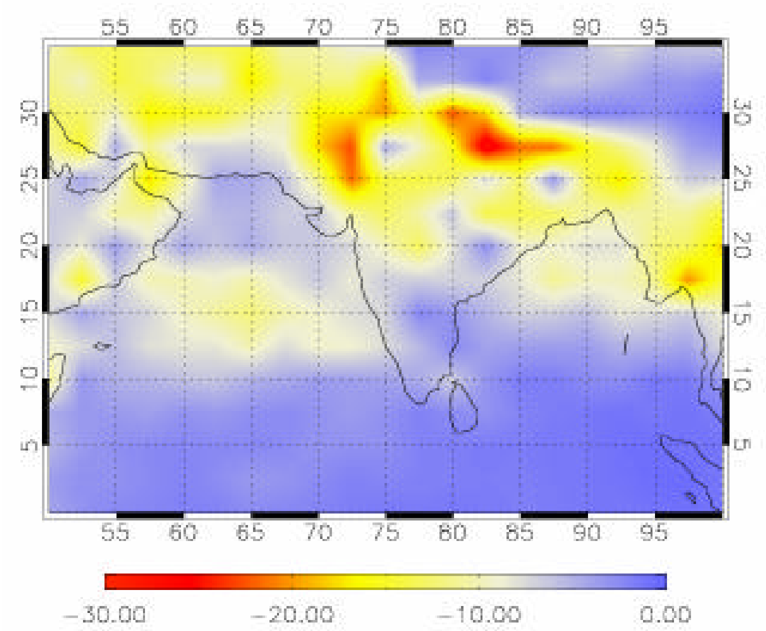


**AOD at 550nm** **SSA at 550nm** **ASYM at 550nm**




**Reduction in monthly mean SW flux (Wm-2) with aerosol climatology vs.default case for all-sky conditions, August 02, at 1/8th**



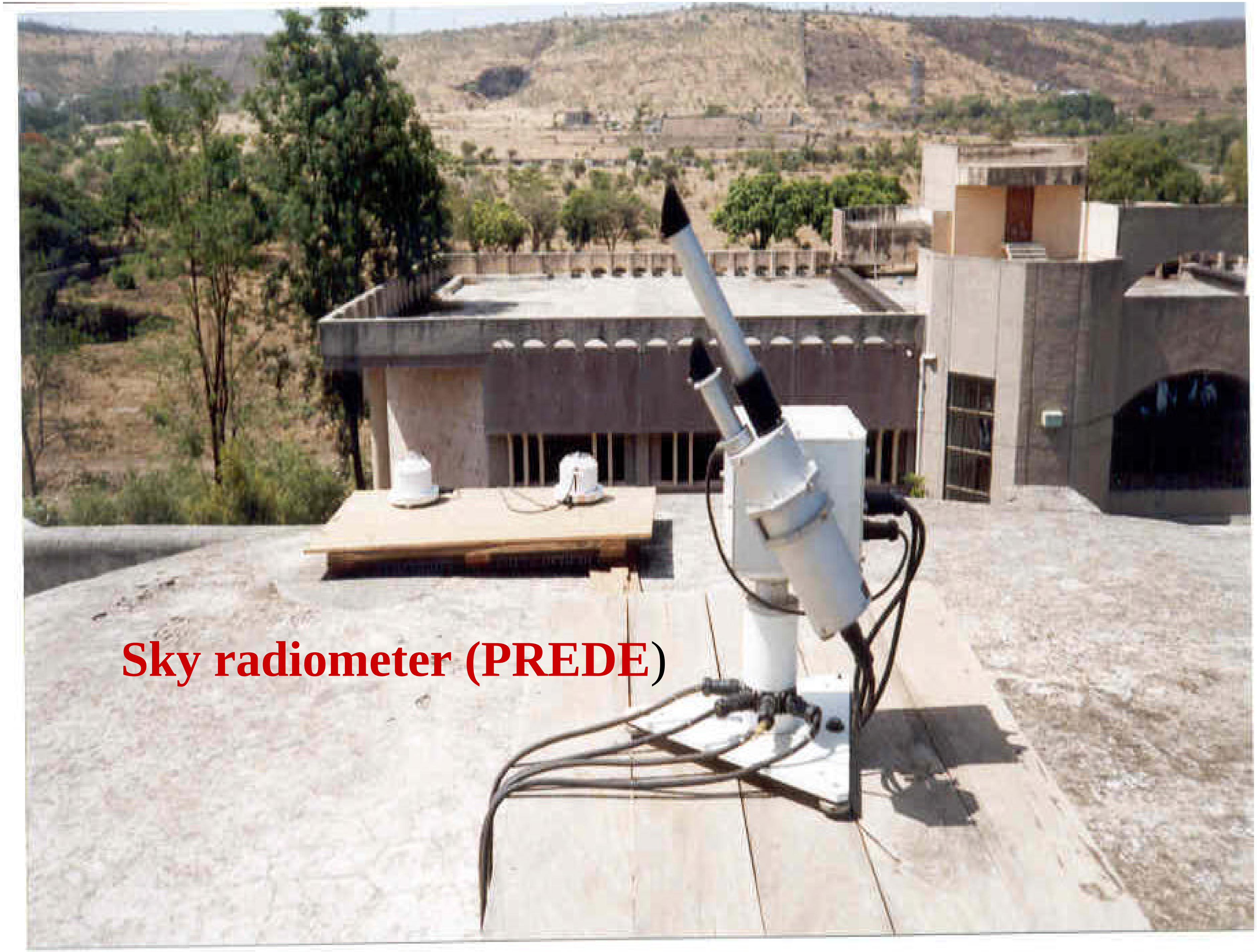

**Reduction in monthly mean SW flux under clear-sky, May 02 at 2.5 degree.**

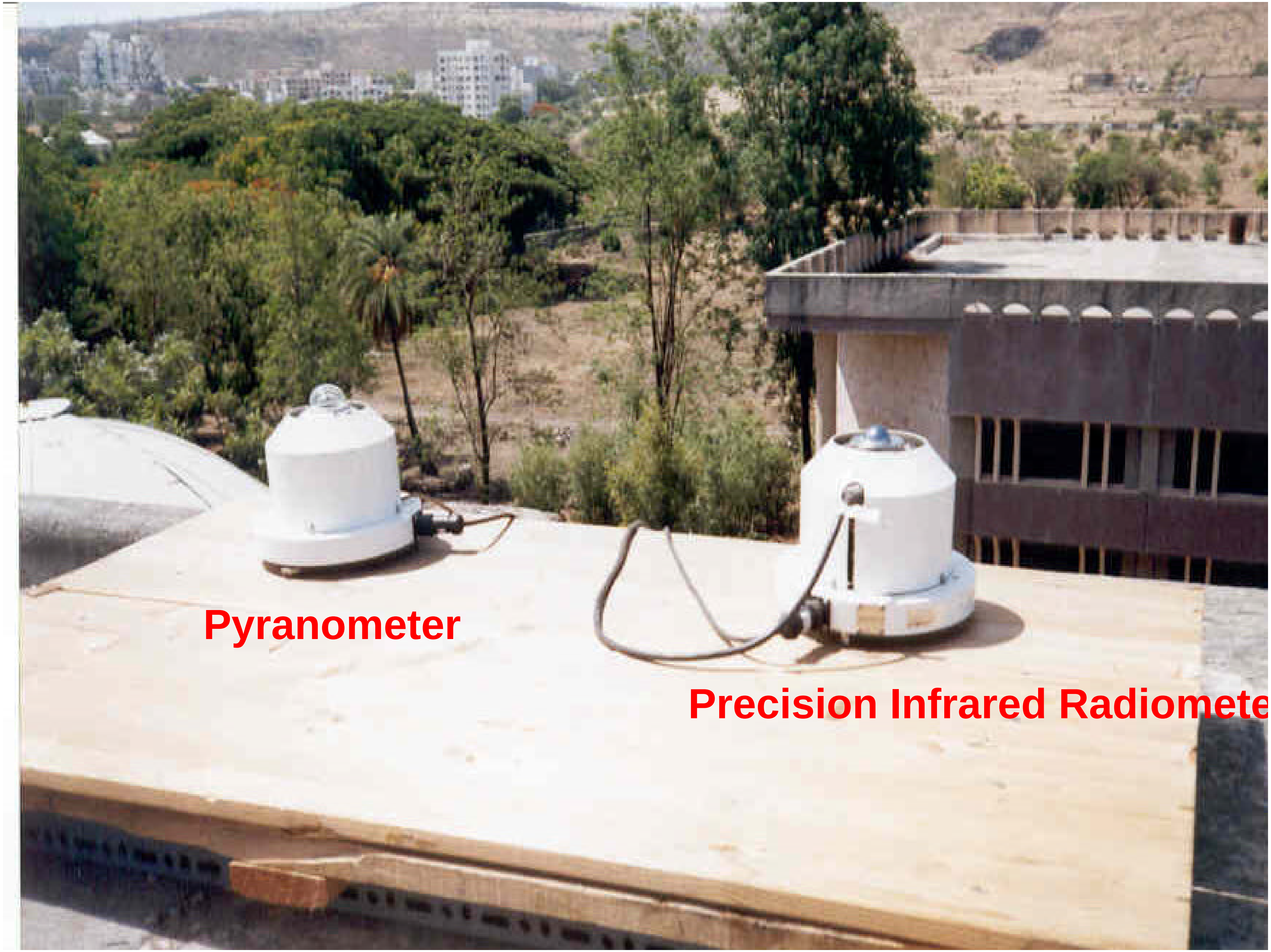
# Climatic uniqueness:

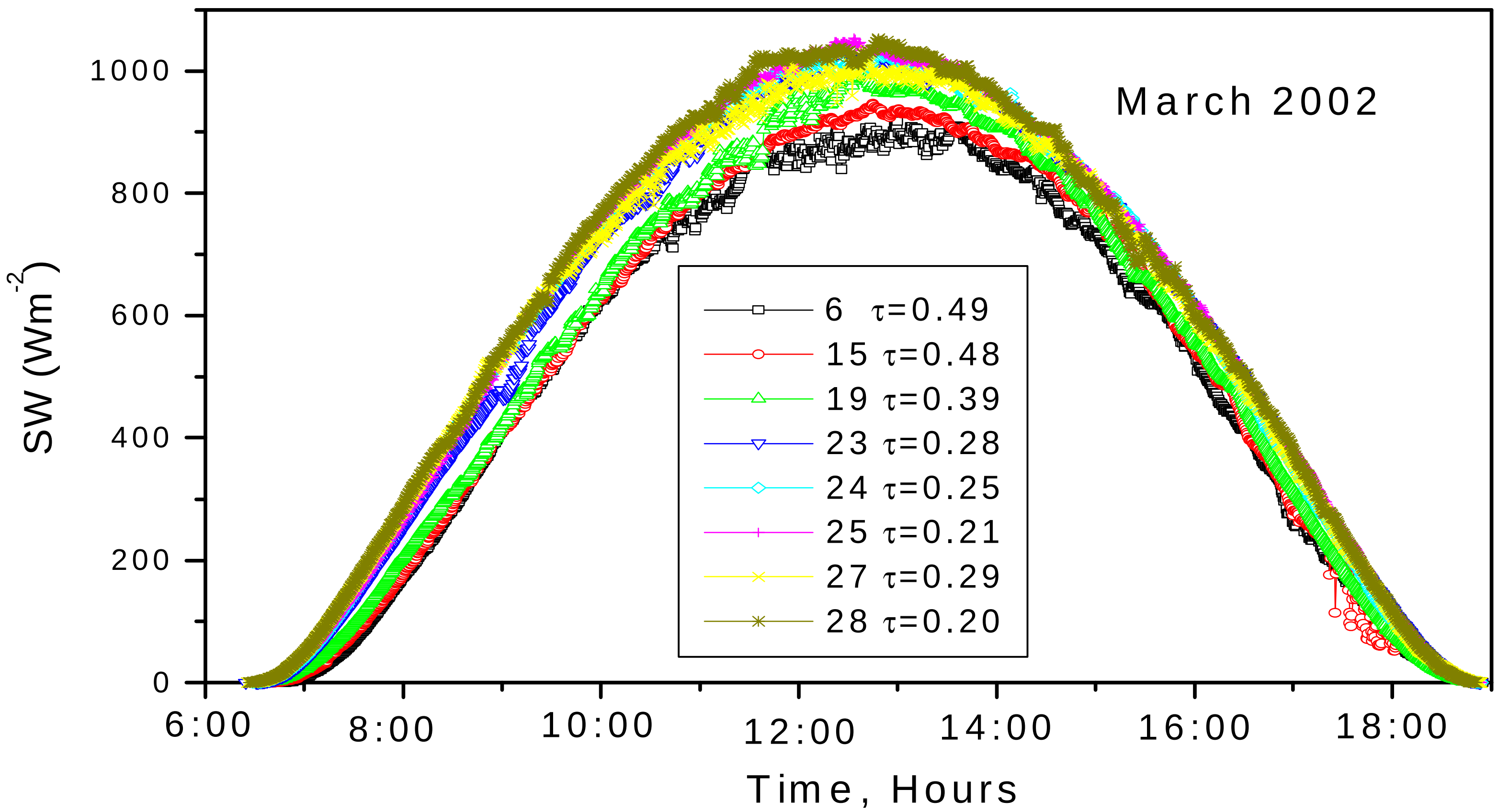
## Aerial view of the observational site during clear and hazy conditions


**CEOP goal:**

**To understand what are the causes of water cycle variations at global and regional scales and to what extent is this variation induced by human activity.**


Sky radiometer (PREDE)

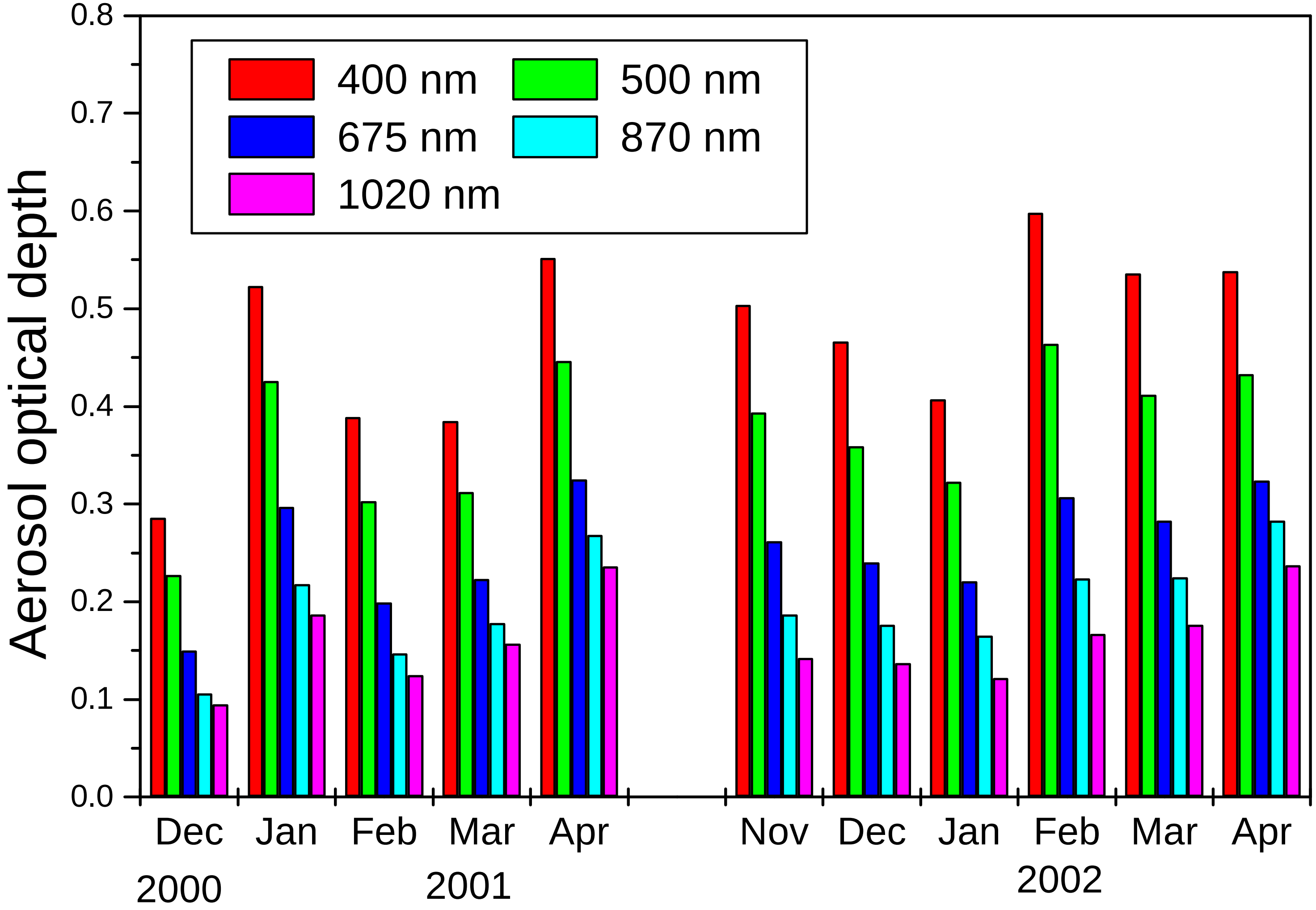

Pyranometer
Precision Infrared Radiomete



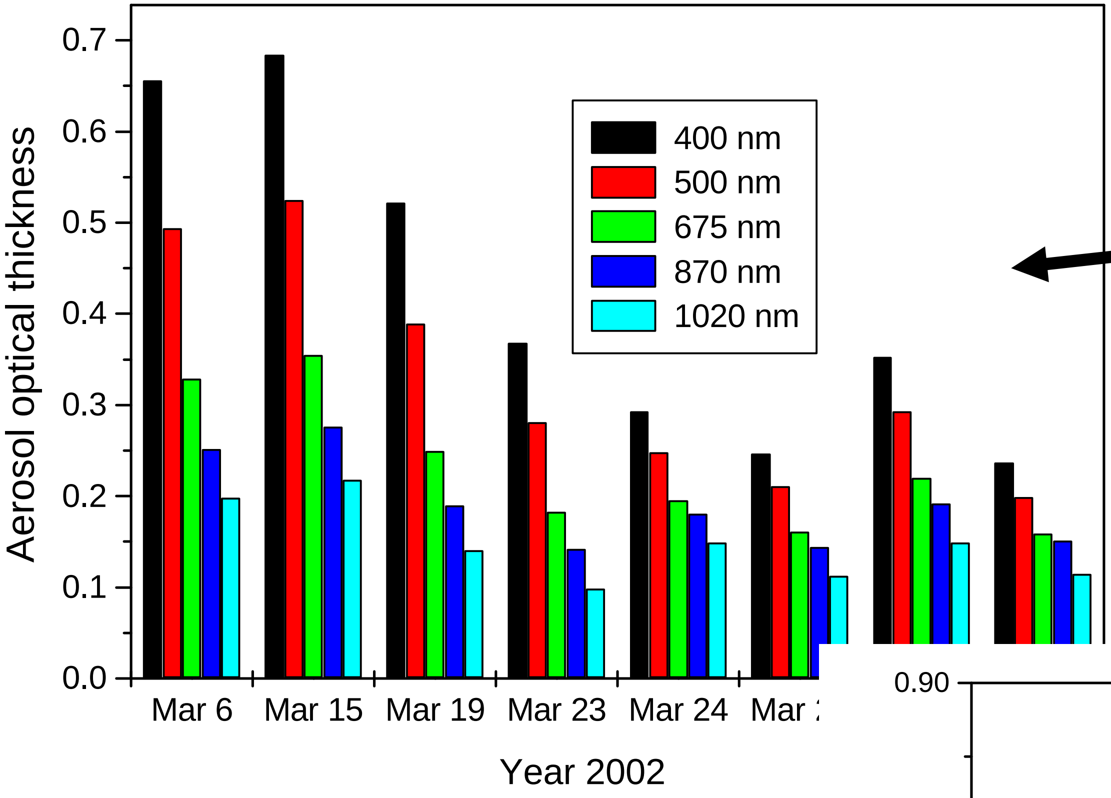

**Diurnal variation of SW down for different aerosol loading days**

**Pandithurai G., R. T. Pinker, T. Takamura and P. C. S. Devara, 2004. Aerosol Radiative Forcing over a Tropical Urban Site in India. GRL (2005)**

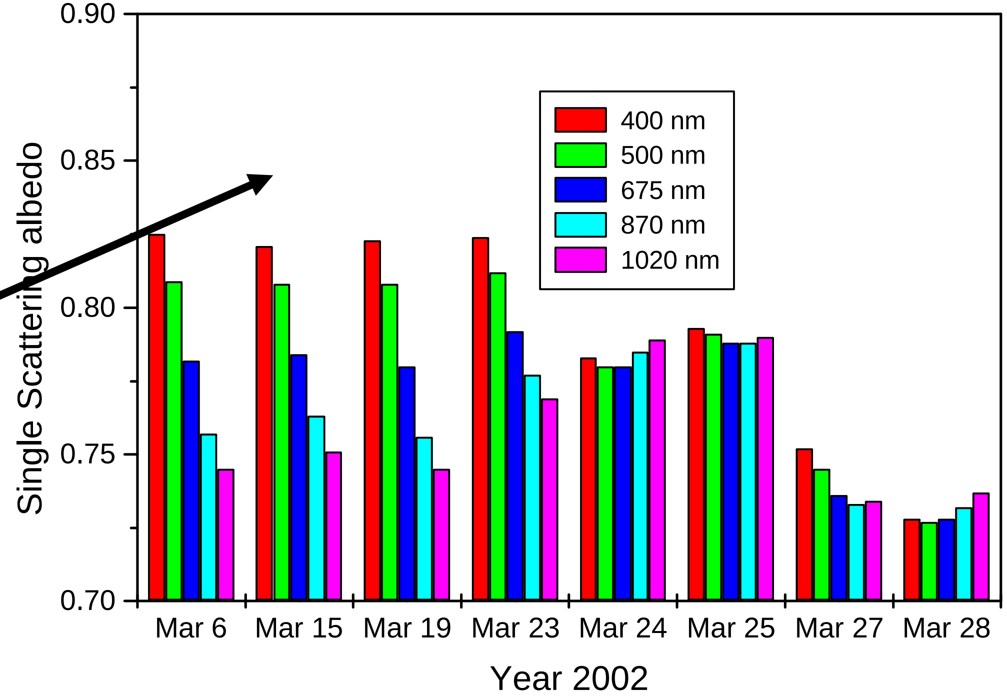
## Month-to-month Variation in Spectral Aerosol Optical Depth observed over Pune



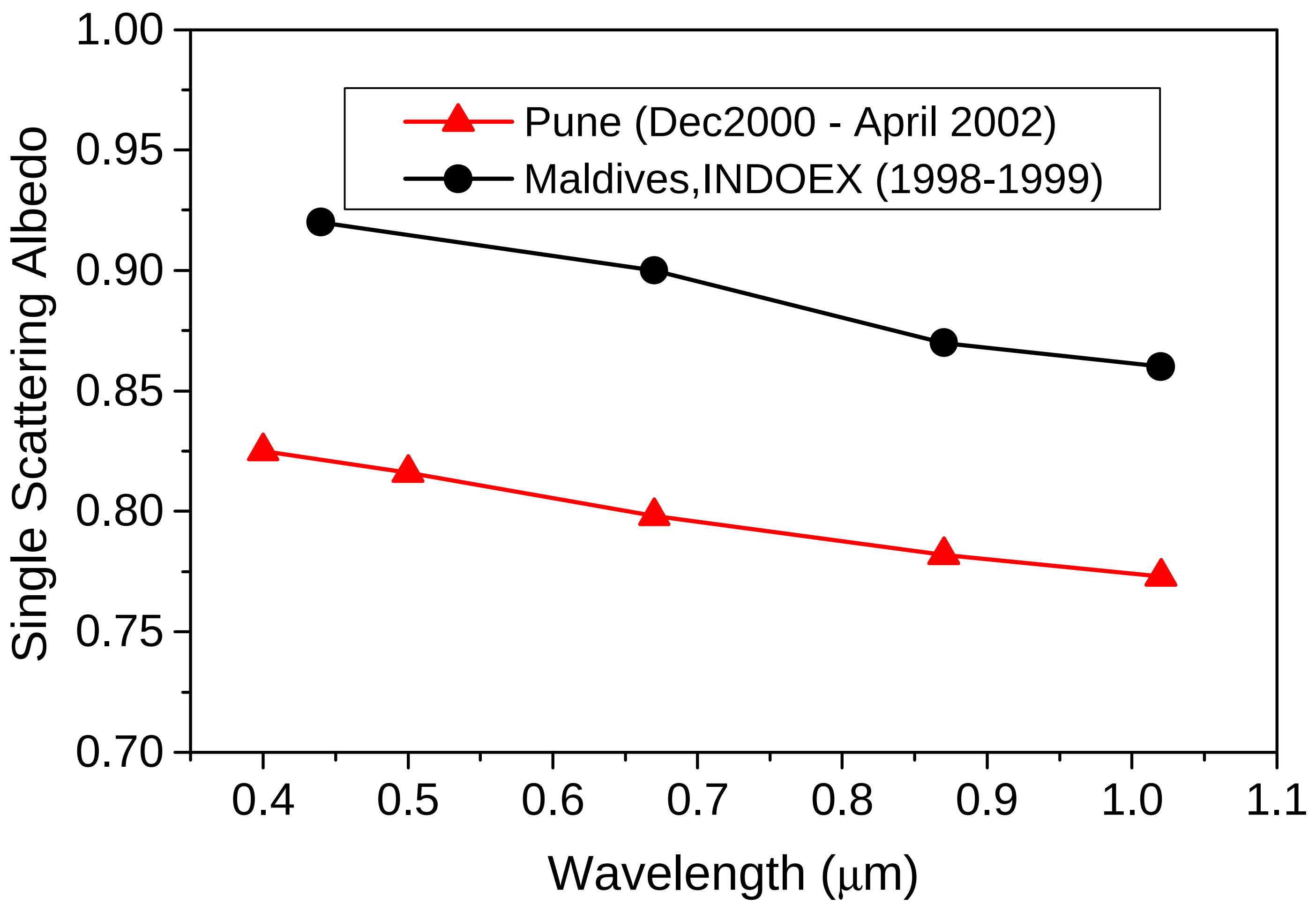
**Day to day variation of Aerosol Optical depth**



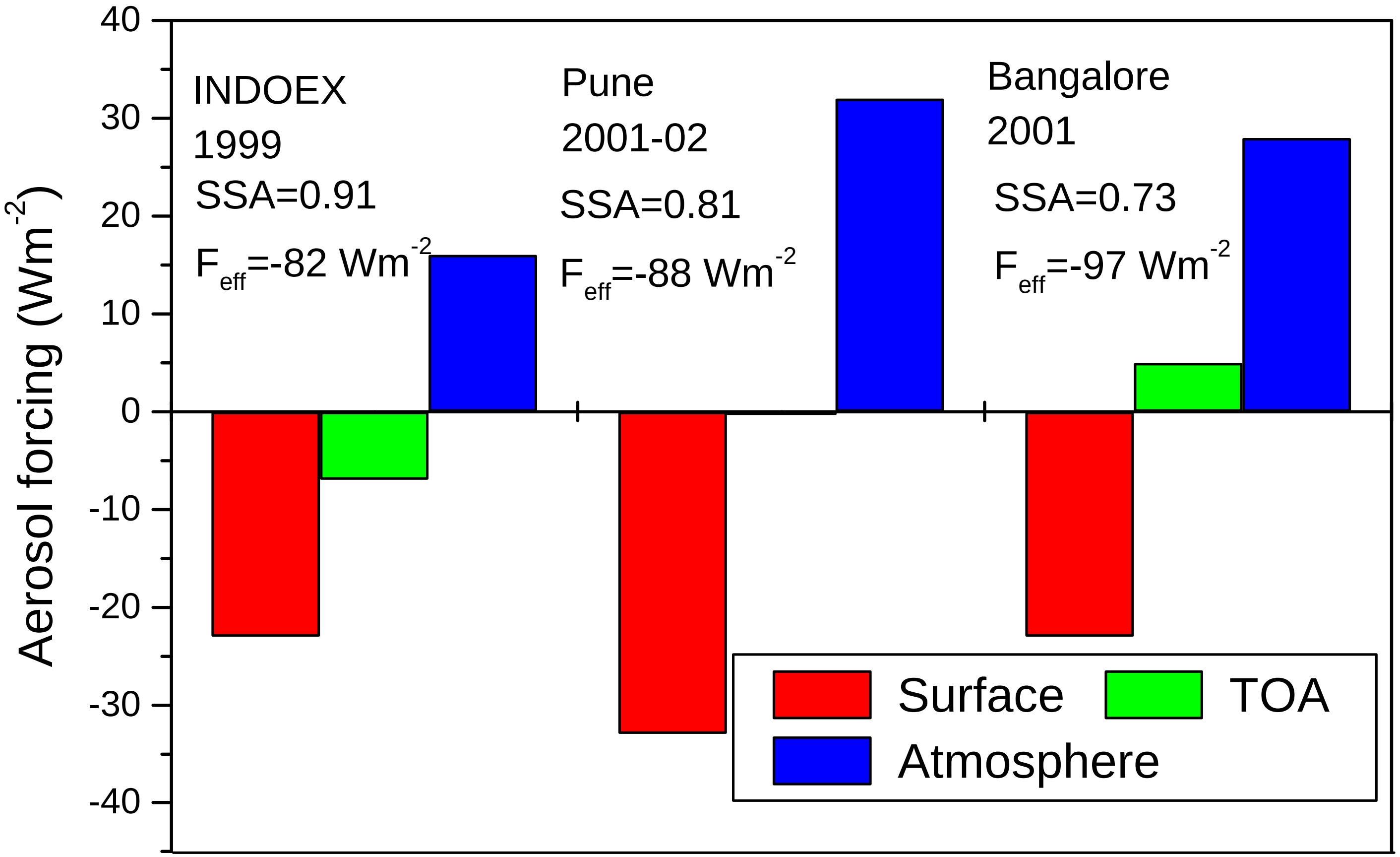

**Day to day variation in single scattering albedo**



# Comparison of single scattering albedo over Pune with Maldives INDOEX (AERONET) measurements



# Example on the spatial variability in aerosol absorption




**Aerosol radiative forcing at the surface, TOA and atmosphere and their comparison with previous investigations over India.**

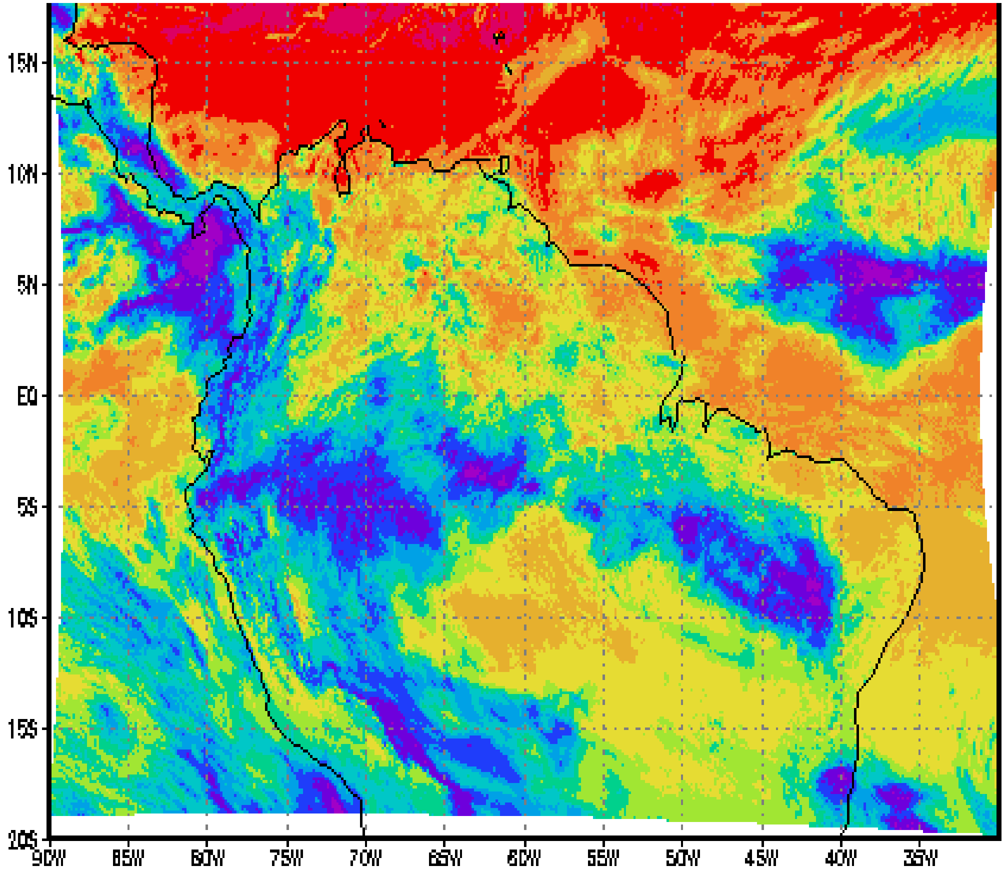
# Status of radiative fluxes in support of CEOP

## 1. GCIP/GAPP

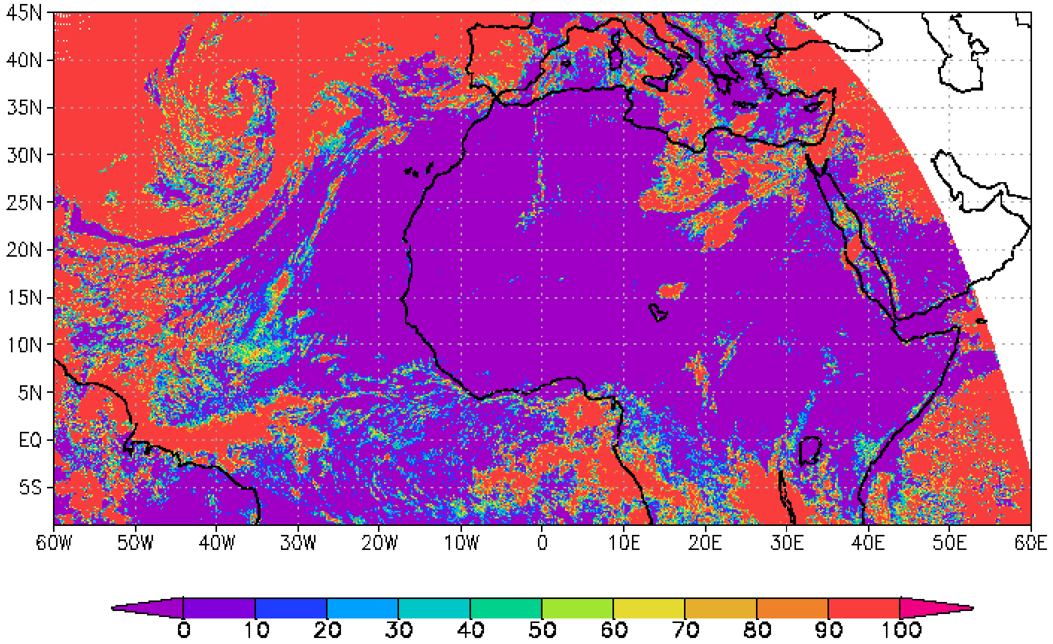
- Improved methodologies available; were implemented between 1996-2000.
- CEOP period no covered with improved methodology.
- CEOP period covered with operational product.

# 2. L BA

- 3-years of data at 1/8th degree processed for 1998-2000 in support of LBA.  As yet not released, pending joint evaluation with INPE and INPE/CPTEC groups.
- Model ready for implementation with corrections for aerosols at 1/8$^{th}$ degree; require satellite observations.
- Optimal approach- collaborative effort with Brazilian groups in synthesizing methods.

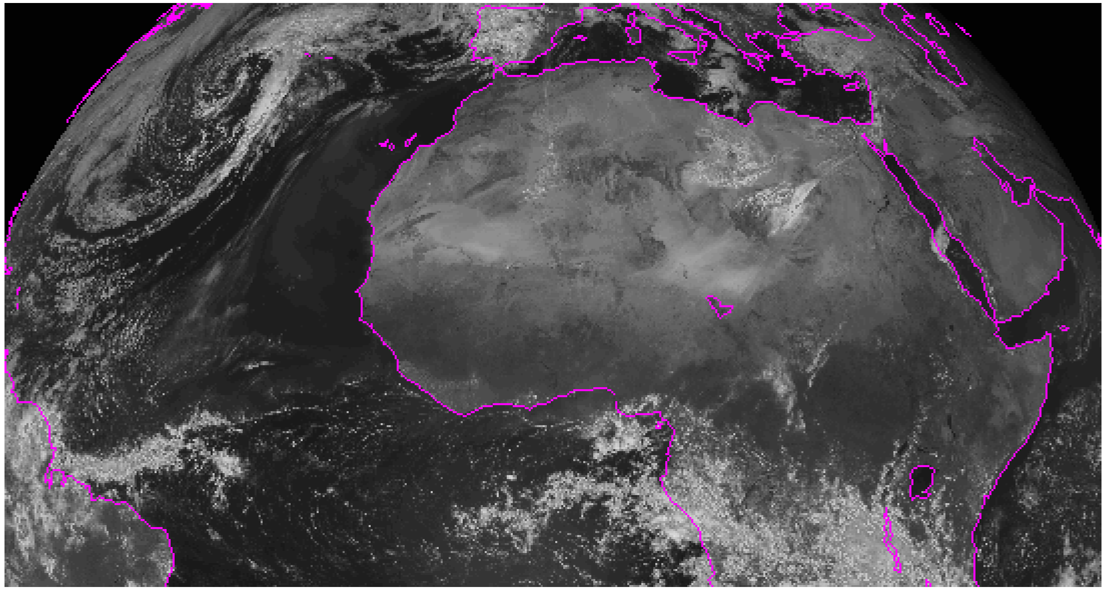


# 3. AFRICA and AMMA region




Methodology developed for METEOSAT 7 and

Tested with improved aerosols.



**Will be implemented for CEOP EOP-1.**

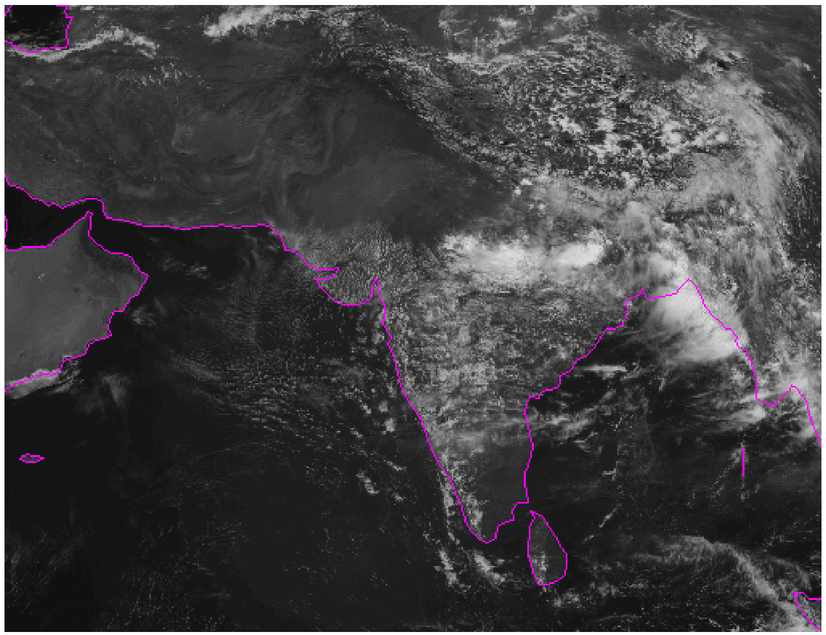
## At issue over Africa

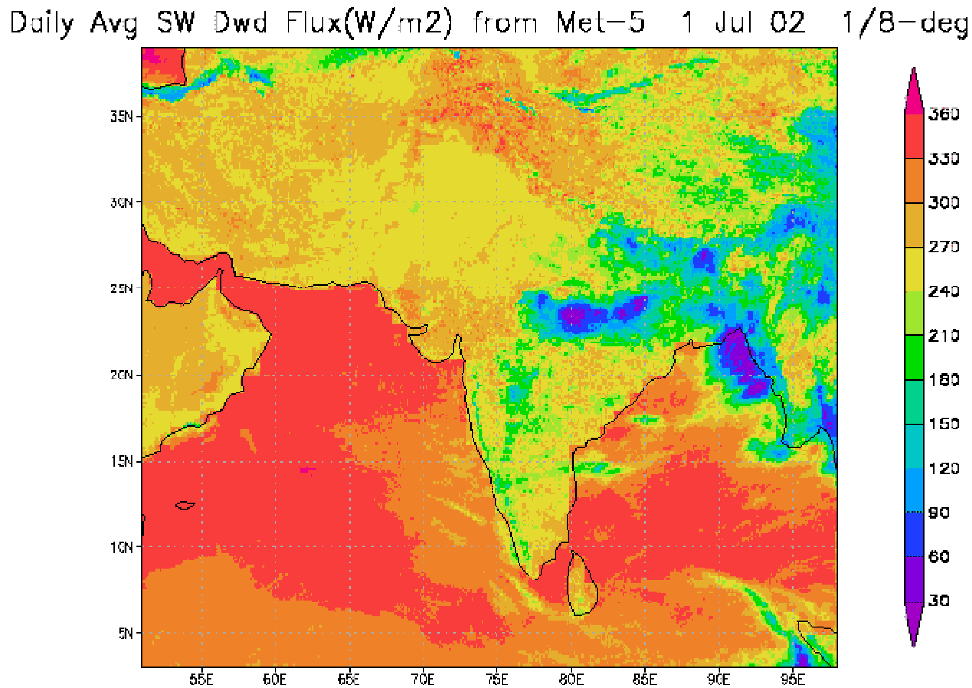
- Preliminary tests indicate that AERONET retrievals of aerosol absorbing properties when dust and biomass burning occur at the same time, most likely not accurate. Separation of dust and biomass burning needs to be resolved.

- For later phases of CEOP, need adjustments for METEOSAT 8.

# 4. Indian Monsoon region

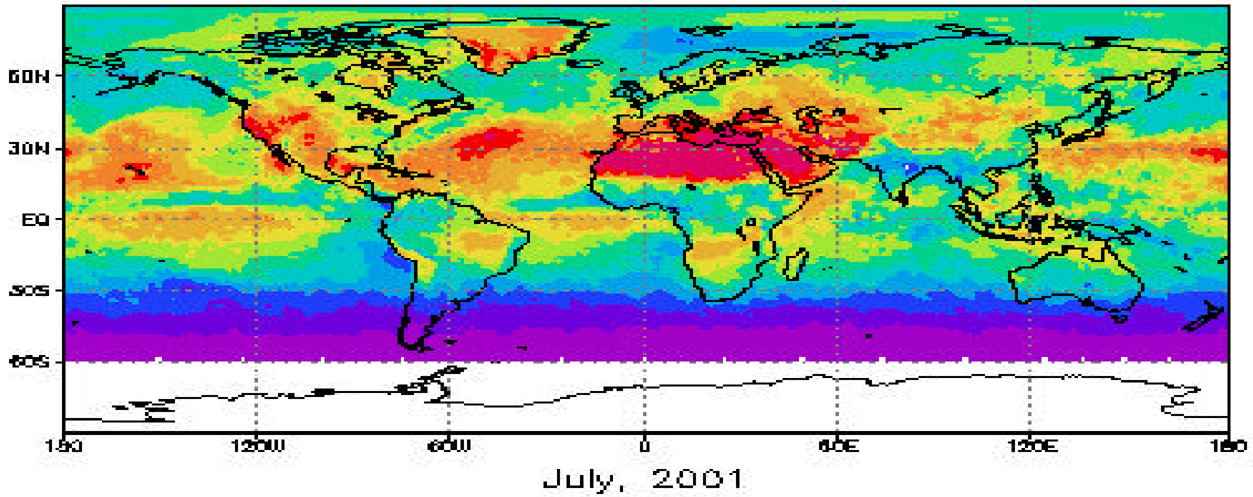
- ❑ **Plan to implement during all CEOP EOPs.**
- ❑ **Desirable, to expand region.**
- ❑ **Requirements: METEOSAT 5 data.**





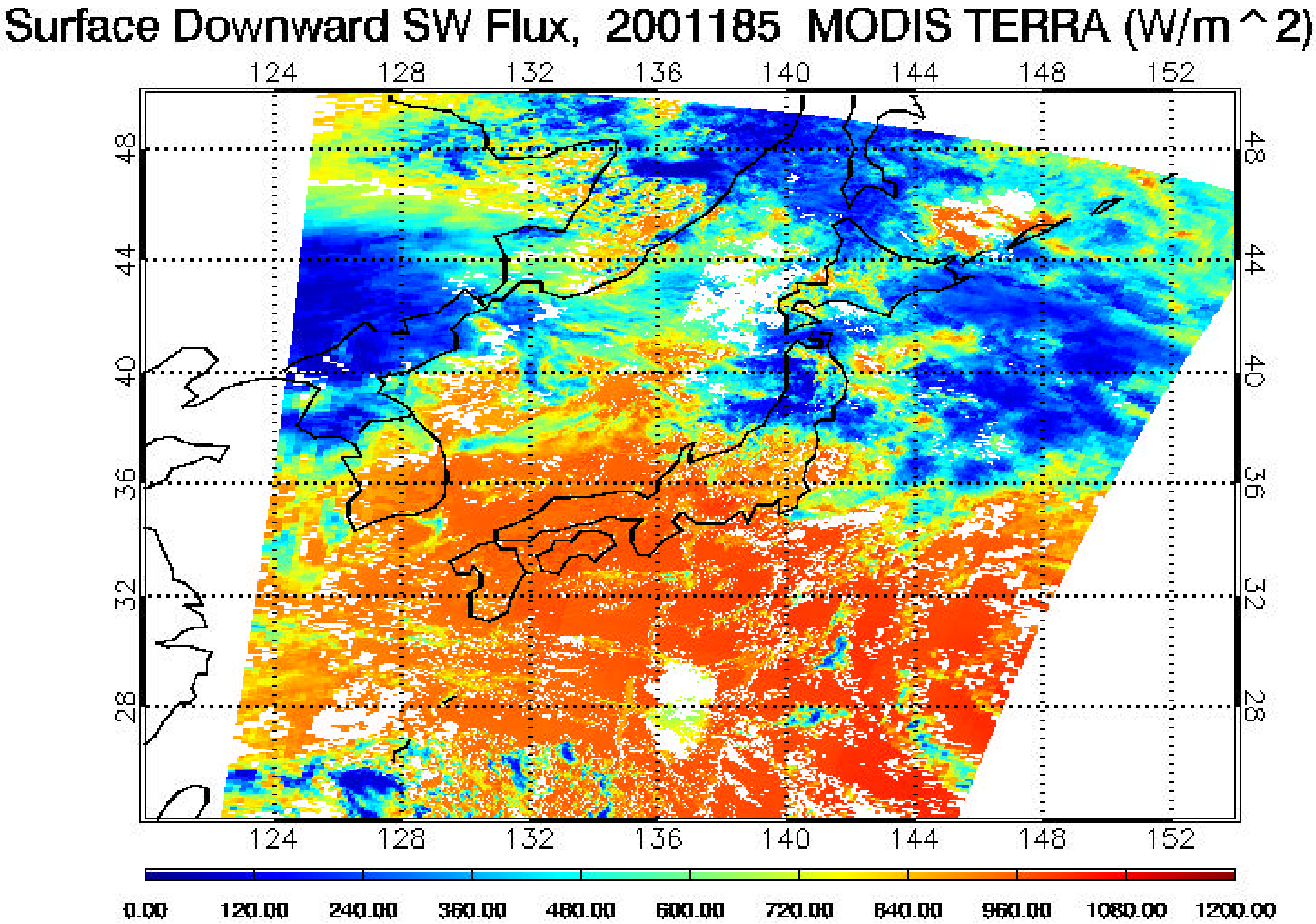
# 5. MODIS data

- Available at 1-deg resolution for 3 years(2001- 03). Will be completed for all CEOP EOPs at that resolution.
- Feasibility demonstrated to implement MODIS at 5-km resolution. Not included under CEOP activity




**Monthly mean SW surface down flux (W/m**2), 2001**
**MODIS V004: Modified SRB**

# Pixel level shortwave surface fluxes over Japan



## Summary

- Steps were taken that will facilitate:

- Testing of hydrological models in special climatic regions

- Transferability and sharing of satellite inference schemes

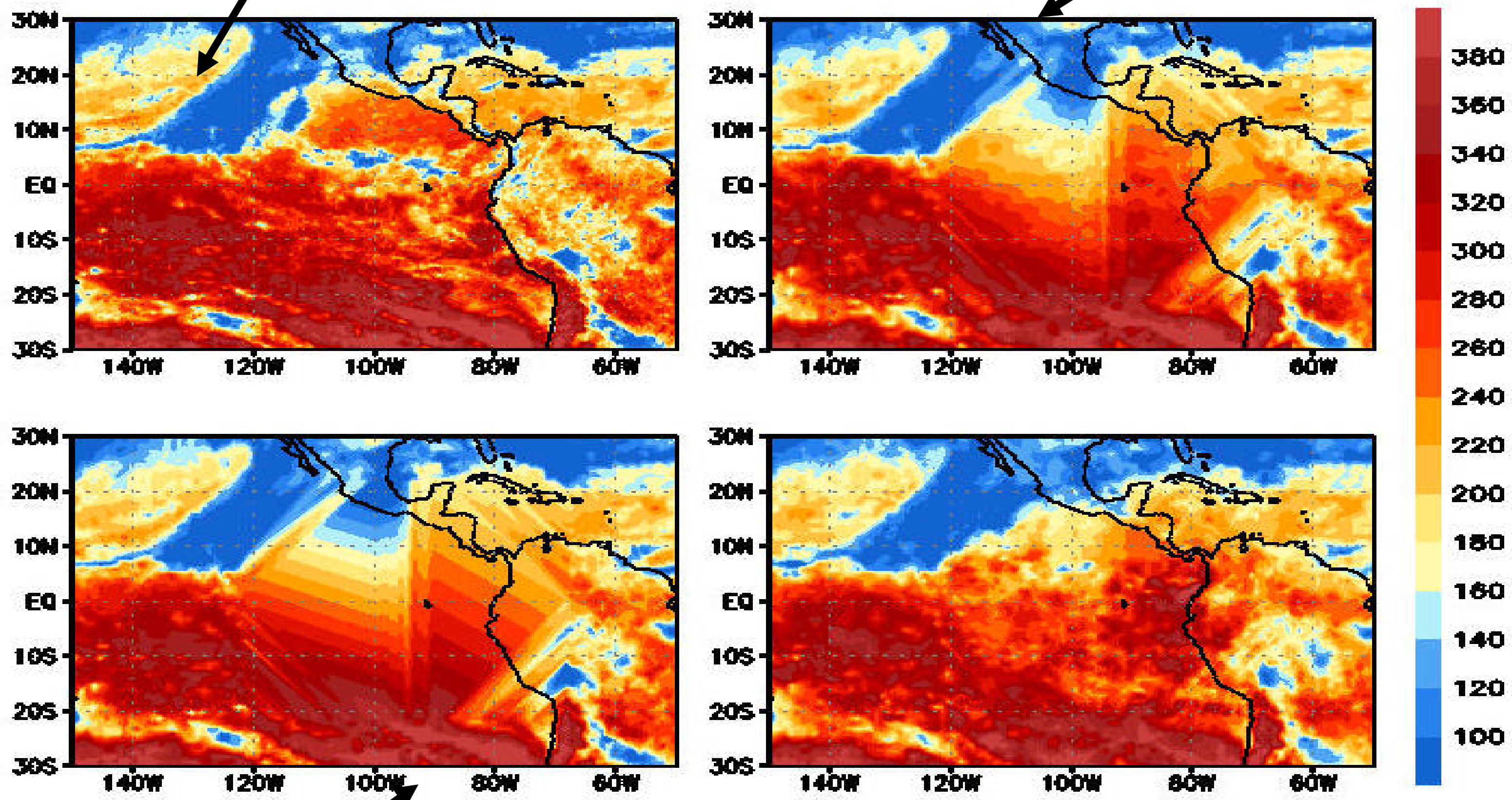
- Linkage to global scale transferability

- Connection to long term information

- Facilitation of testing coherence in long term trends of climatic parameters.

Observed

Reynolds EOF

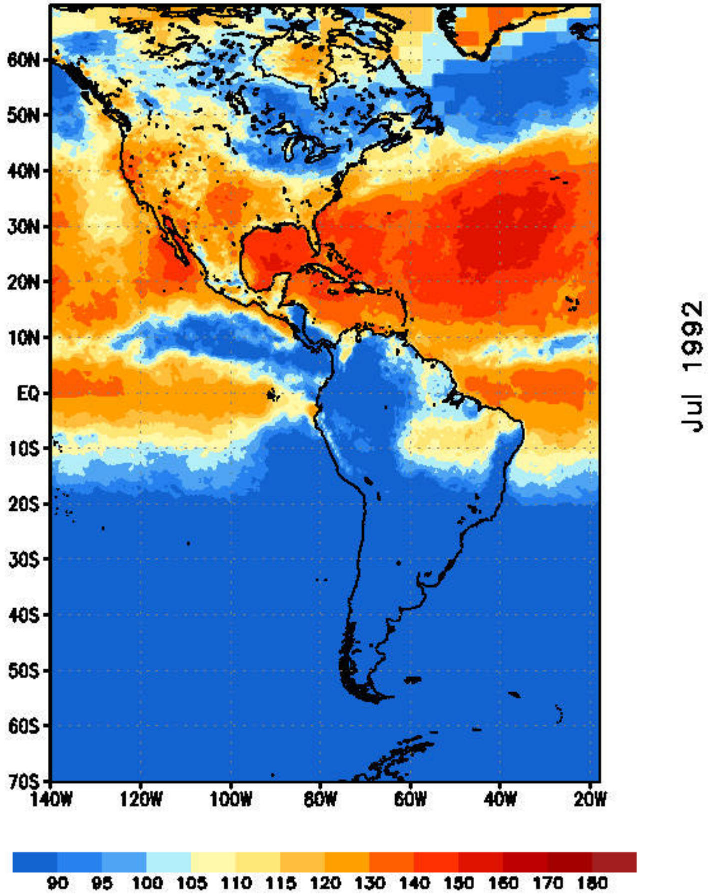



Renka Interpolation

**UMD Iterative EOF**

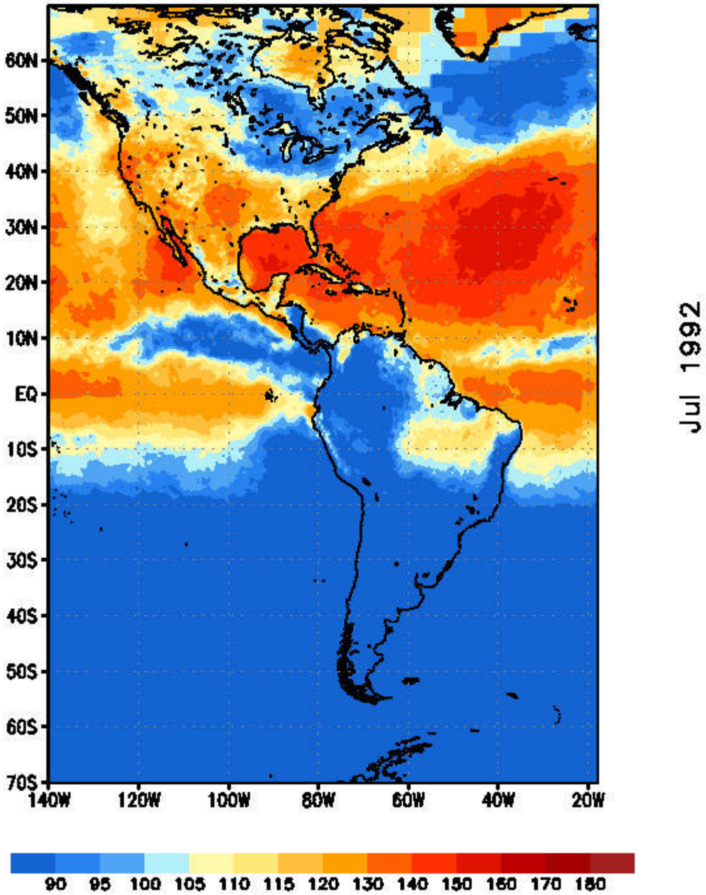
## Control tests

Monthly mean PAR surface downwelling
flux (w/m**2) gridded to 0.5 Deg
merged from ISCCP DX GOES/METEOSAT/AVHRR data




University of Maryland

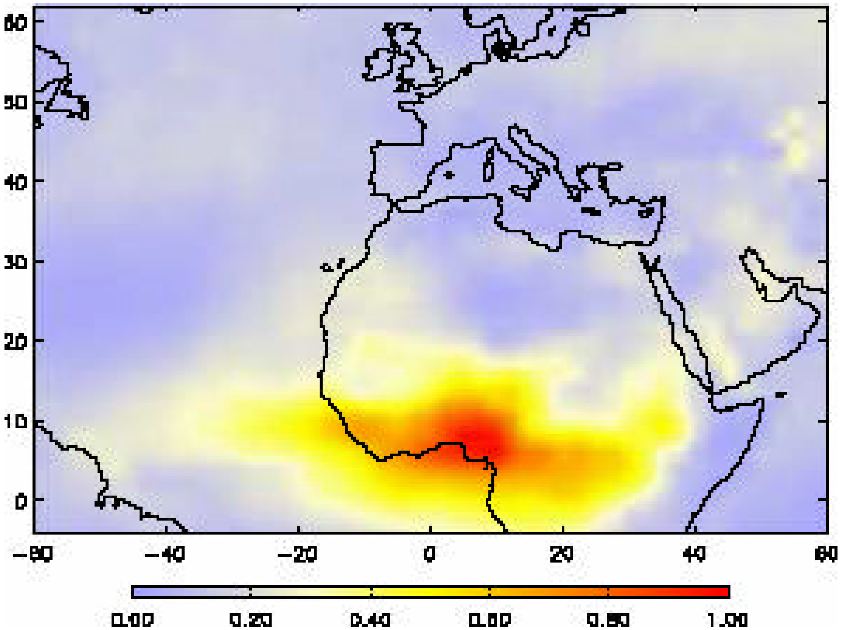
Monthly mean PAR surface downwelling
flux (w/m**2) gridded to 0.5 Deg
merged from ISCCP DX GOES/METEOSAT/AVHRR data

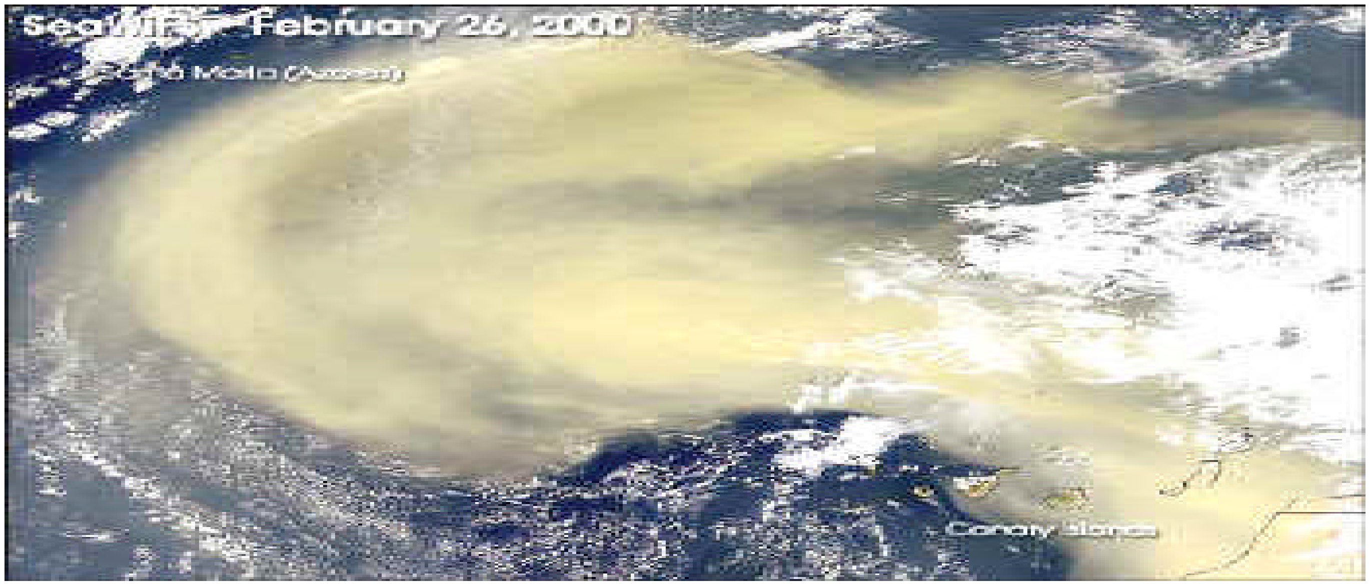



iiversity of Maryland

# Motivation for Africa

- ❖ **Climatically vulnerable**
- ❖ **Dust and biomass burning**
- ❖ **Human dimension**
- ❖ **Famine prediction**
- ❖ **AMMA**




**Courtesy: Norman Kuring, SeaWIFS project.**