Comparisons of Top-of-atmosphere Radiation Budget from Multiple Data Sets: GEWEX Radiative Flux Assessment Results

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GEWEX RFA TOA Radiation Overview

- GEWEX Radiative Flux Assessment (RFA) is a community based activity (first of its kind for TOA and surface radiative flux) commissioned by GEWEX Radiation Panel
- Assess our current understanding and capability to derive TOA radiative fluxes from analysis of satellite observations
- Identify uncertainties and outstanding issues in flux estimation (including satellite calibration, input data sources, spatial and temporal gap filling, and other assumptions)
- The final report will be an useful reference for developing future climate data requirements for radiative fluxes as well as for understanding current data limitation and uncertainty for future IPCC report

GEWEX RFA TOA Radiation Datasets

Data Source	Satellite Source	Spatial Coverage	Temporal Coverage
CERES*	Terra, Aqua	Global	03-2000 to 10-2005
ISCCP-FD	Geo + Polar	Global	07-1983 to 12-2004
GEWEX SRB	Geo + Polar	Global	07-1983 to 06-2005
FORTH	Geo + Polar	Global	01-1984 to 12-2004
UMD SRB/SW**	Geo + Polar	Global	07-1983 to 12-2004
UMD HIRS/OLR**	NOAA Polar	Global	01-1979 to 09-2003
ERBE Scanner	ERBS, N9, N10	Global	02-1985 to 05-1989
ERBE NonScanner	ERBS	60N to 60S	1985 to 1999
ScaRaB Scanner***	Meteor, Resurs	Global	1994-95, 1998-99

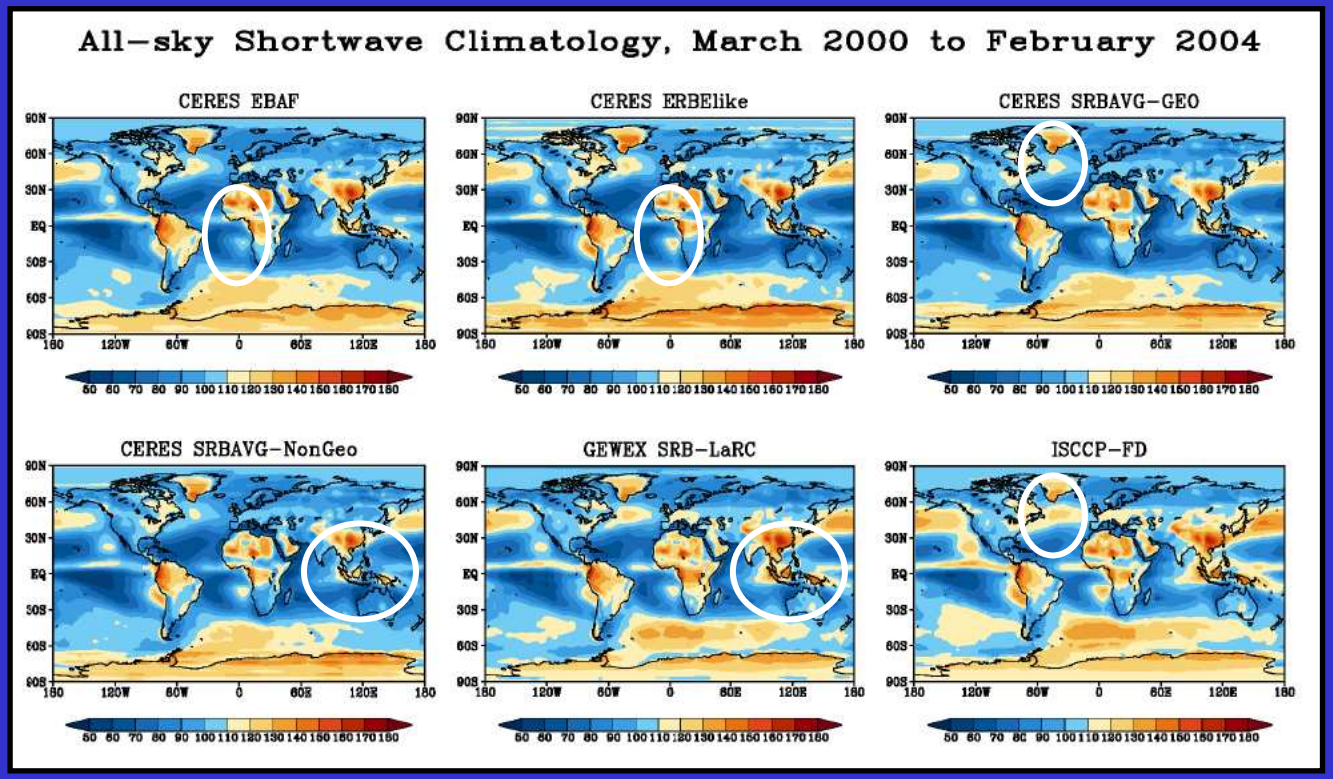
* CERES: SRBAVG-GEO, SRBAVG-nonGEO, ERBE-like, and EBAF; ** UMD SRB/SW, UMD HIRS/OLR: single component data; *** ScaRaB: only few months available from each mission

Outlines

- Examine the consistencies and the differences of TOA Radiation data sets in GEWEX RFA Archive for the CERES/Terra period (March 2000 to February 2004)
  - Focus on baseline climatology (absolute values) and deseasonalized anomaly (variability) comparisons
  - CERES (four sets), ISCCP-FD, and LaRC GEWEX SRB
  - Longwave, Shortwave, Net (all-sky and clear-sky)
  - Regional, zonal, tropical (20N to 20S), global (90N to 90S)
  - Truth: CERES SRBAVG-GEO (regional) and Ensemble mean (zonal, tropical, and global)
- Tropical mean Longwave time series comparison (1979 to 2005)

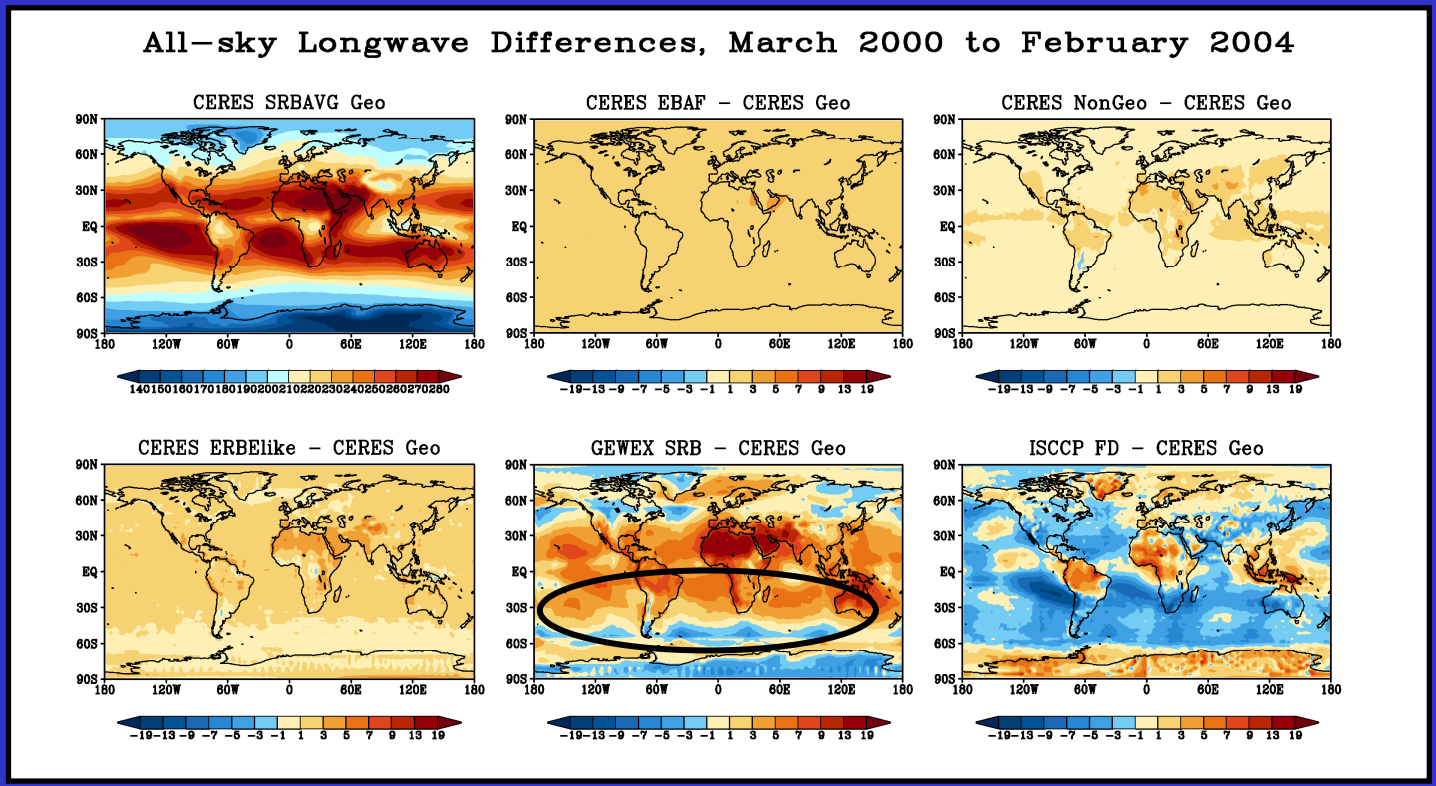
Baseline Climatology Comparisons

Regional Climatology: Shortwave Radiation



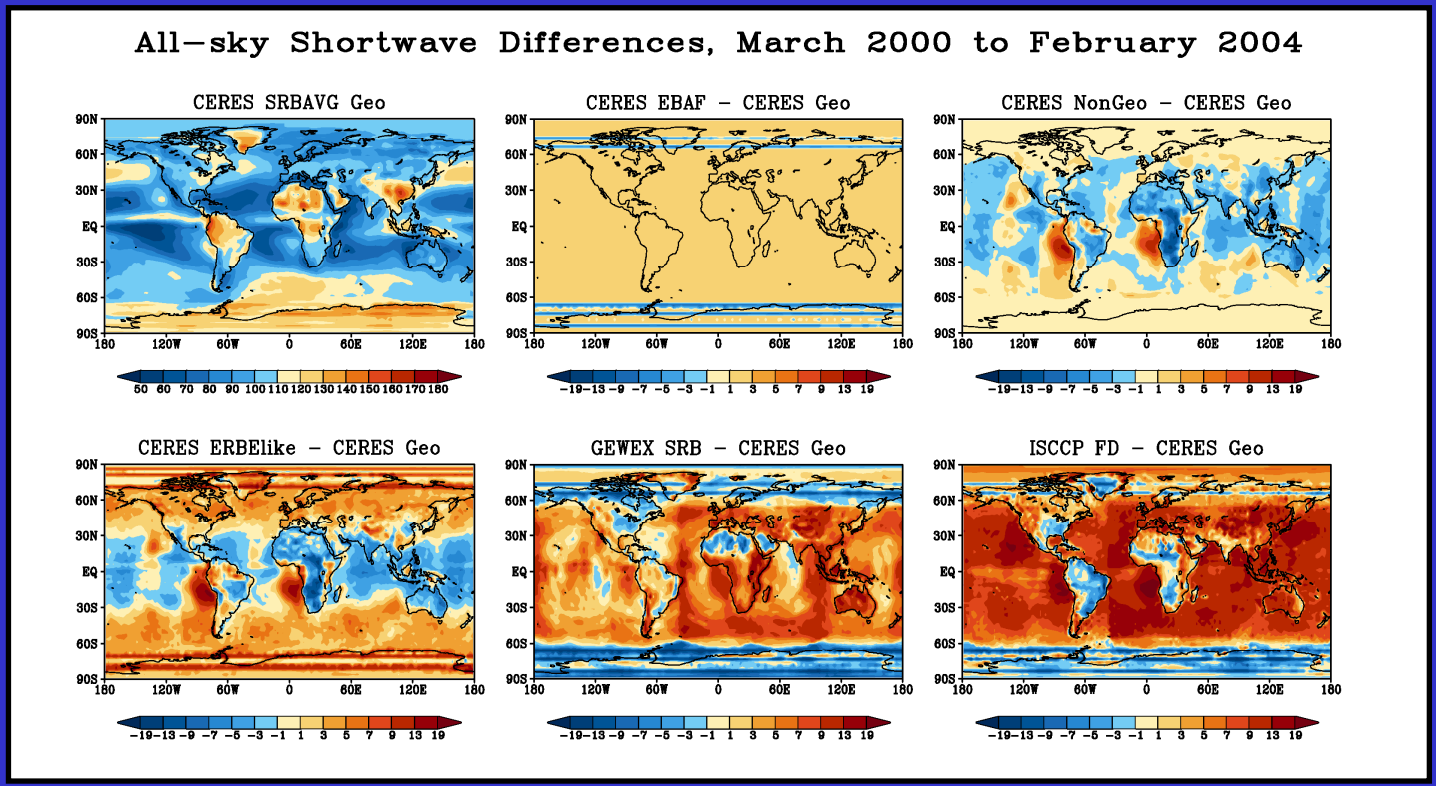
- Major regional shortwave patterns are similar for all six datasets
- Differences in mid-latitude storm track areas (both hemisphere), stratus regions off the west coast of major continents, regions over ITCZ and the western Pacific

Regional Differences: Longwave Radiation



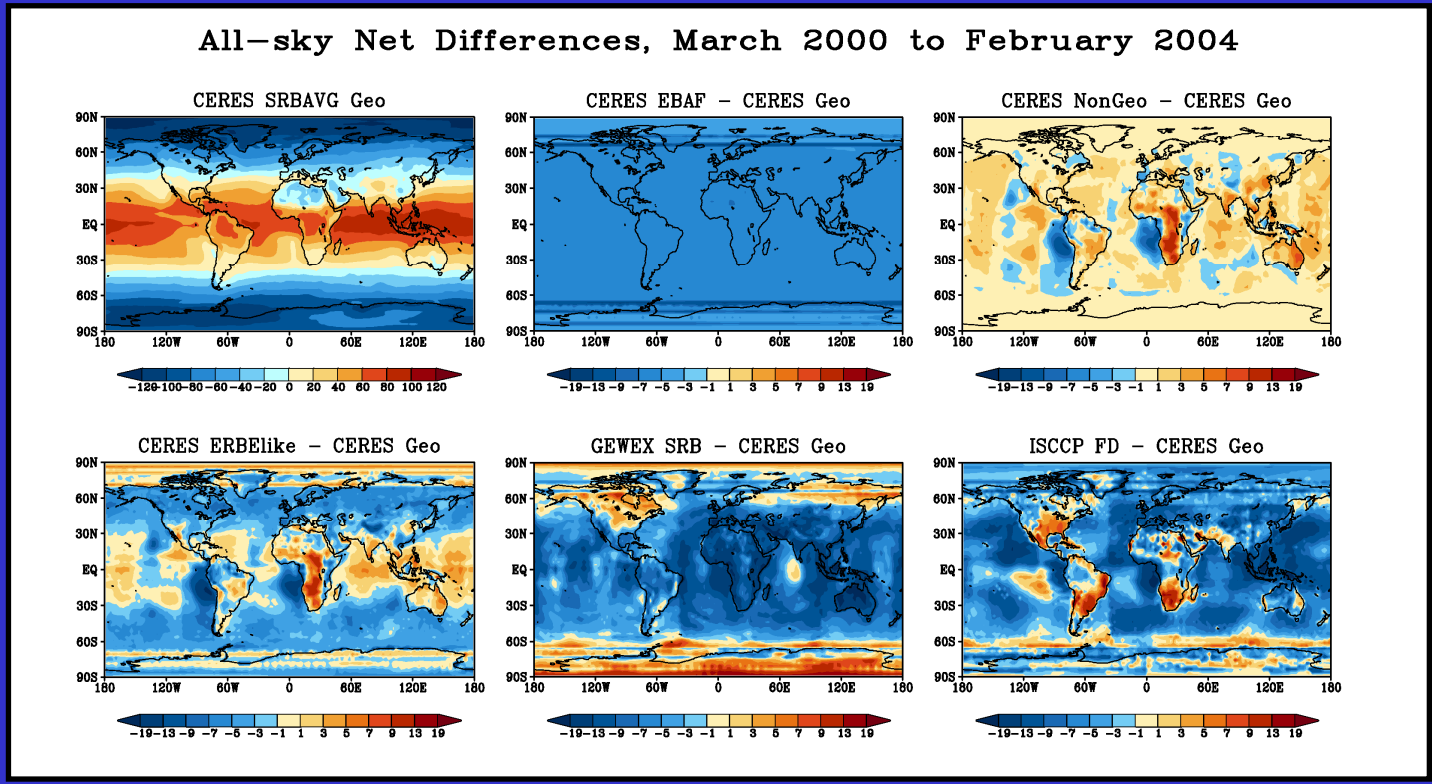
- Regional longwave differences are small for CERES-based products; but larger for ISCCP-based product
- Geostationary artifacts are noticeable for both GEWEX SRB and ISCCP FD product

Regional Differences: Shortwave Radiation



- Much larger differences than longwave; geostationary artifacts in most shortwave products
- Horizontal lines over the polar regions are artifacts for missing shortwave data

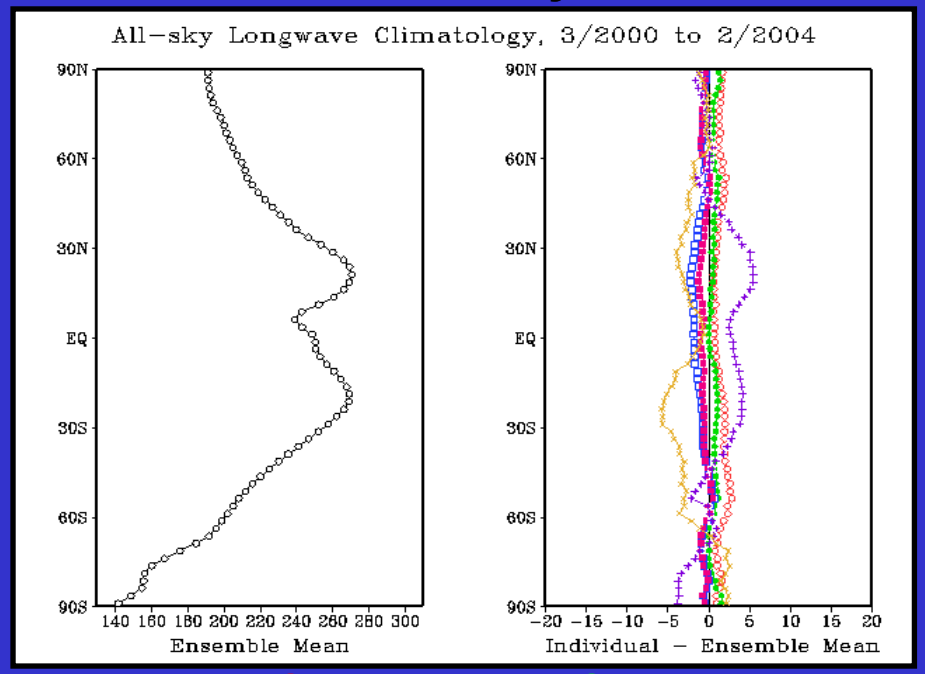
Regional Differences: Net Radiation



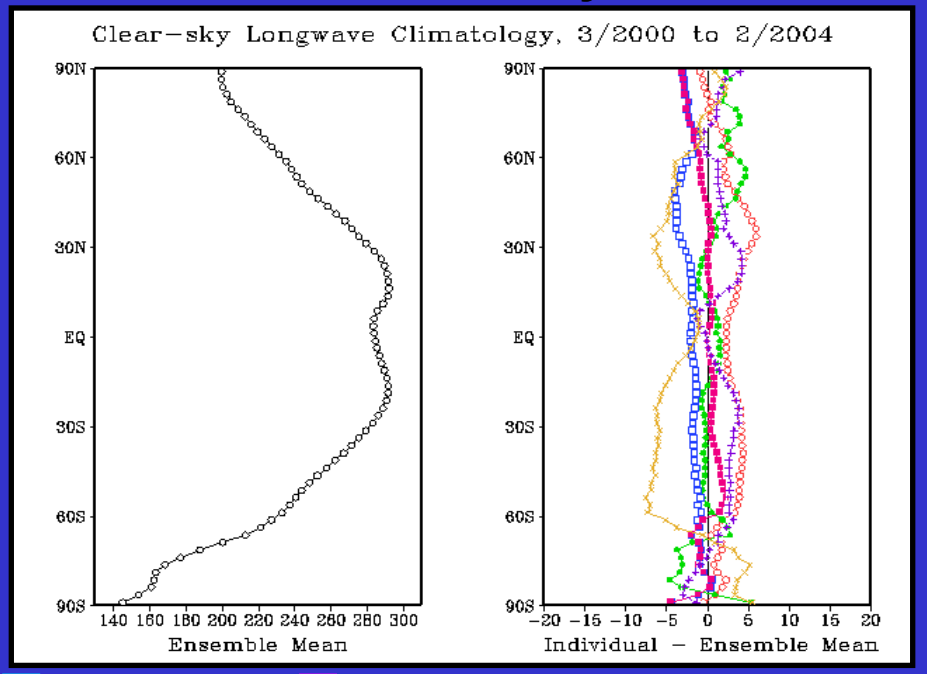
- Complicated patterns due to combined longwave and shortwave effects; shortwave differences dominate the net differences
- Improving shortwave should lead to better agreement in Net

Zonal Mean: Longwave Radiation

All-sky



Clear-sky

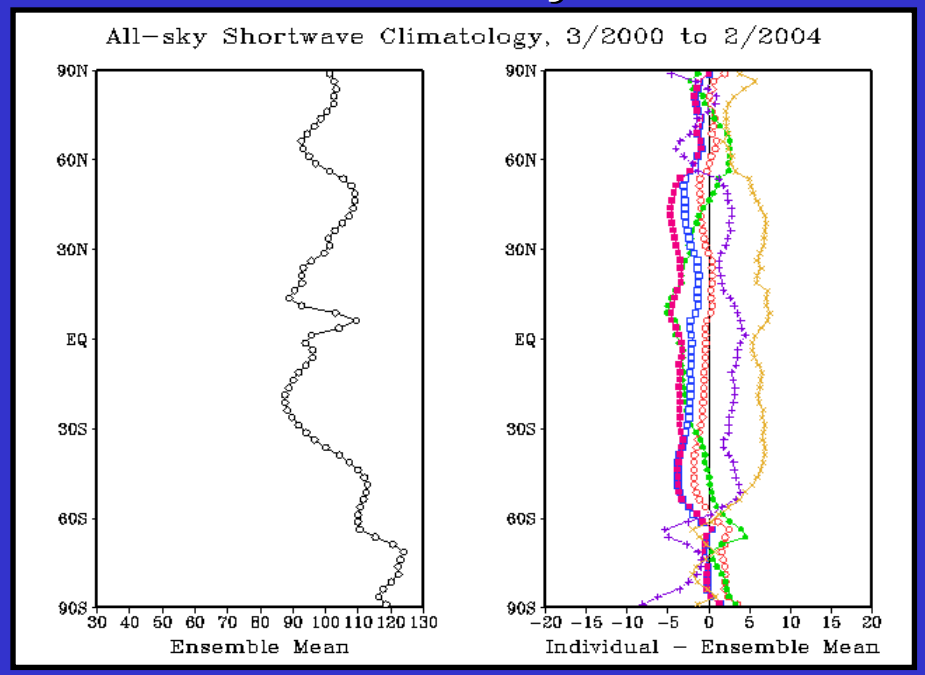


Legend: = CERES EBAF, = CERES ERBE-like, = CERES GEO, = CERES nonGEO, + = LaRC GEWEX SRB, X = ISCCP-FD

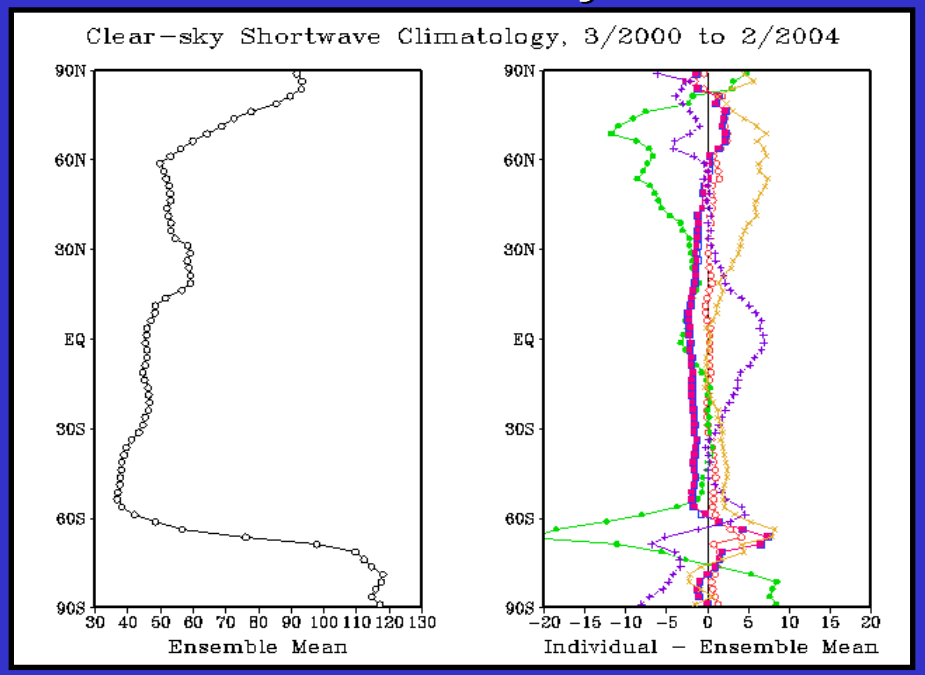
- All-sky: very good agreements over N.H. high latitudes
- Clear-sky: larger differences than all-sky through all latitude zones

Zonal Mean: Shortwave Radiation

All-sky



Clear-sky



Legend: = CERES EBAF, = CERES ERBE-like, = CERES GEO, = CERES nonGEO, + = LaRC GEWEX SRB, X = ISCCP-FD

- All-sky: Clear separation between CERES-based and ISCCP-based products
- Clear-sky: Large differences for CERES ERBE-like data in high latitudes (ERBE clear-sky scene ID issue)

Annual Global Mean TOA Radiation Budget

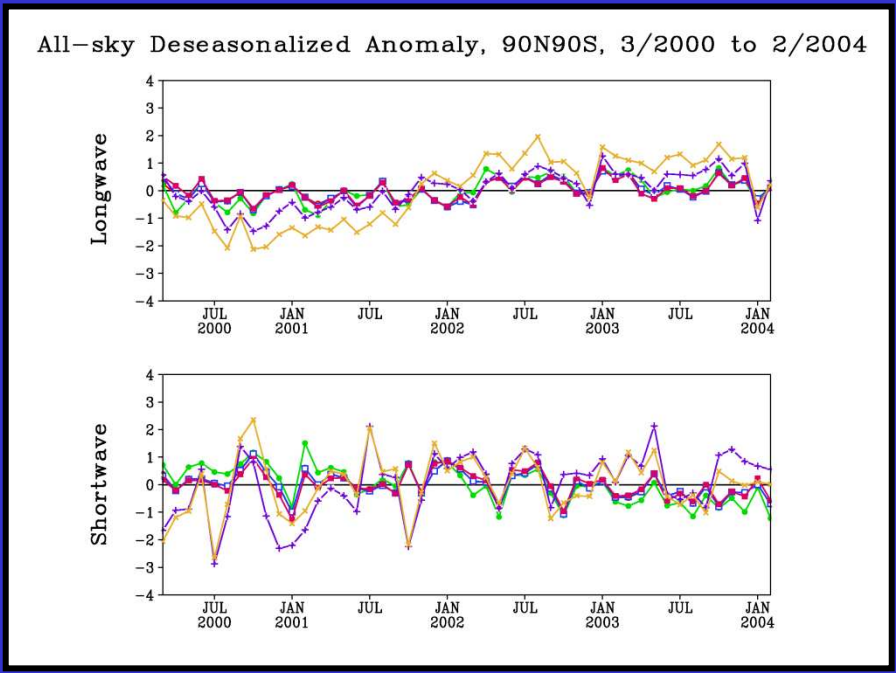
Parameters (Wm^{-2})	Ensemble Mean	Abs. SD (1-sigma)	Rel. SD (1-sigma)	Range (Min, Max)
Solar Incoming	341.3	0.7	0.2%	340.0, 341.8
Longwave	238.3	1.8	0.8%	235.6, 240.5
Shortwave	99.9	3.2	3.2%	96.6, 105.2
Net	3.2	3.2	100.0%	-0.4, 7.0
Clear Longwave	266.1	2.7	1.0%	262.0, 268.0
Clear Shortwave	52.0	1.9	3.6%	49.2, 54.5
Clear Net	23.1	3.3	14.3%	18.1, 26.2

- Agreement: LW within 1%, SW within 3.6% of the ensemble mean
- Disagreement: Largest relative SD for Net due to small Net value; smallest for solar incoming

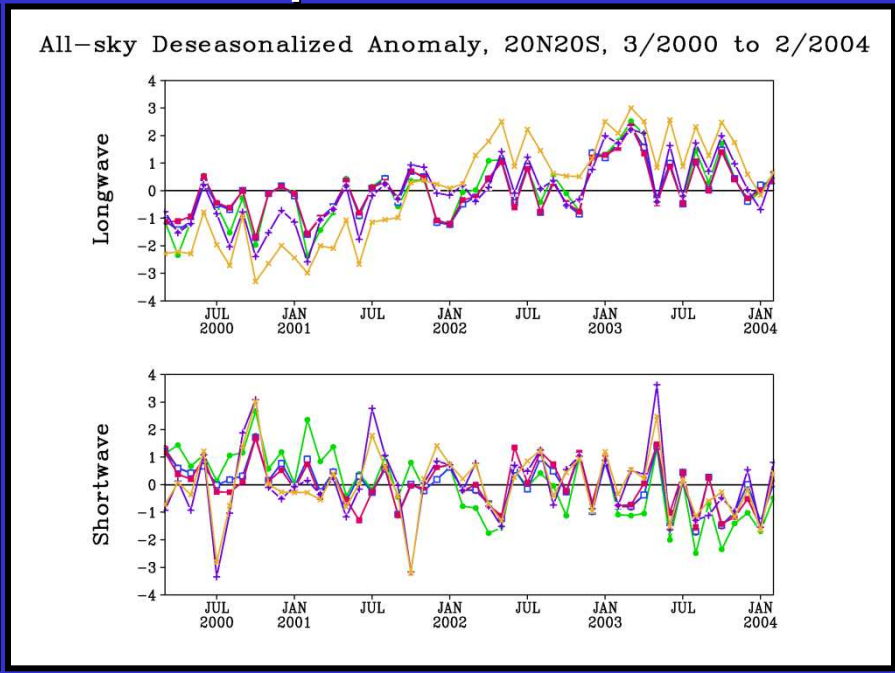
Deseasonalized Anomaly Comparisons

All-sky Longwave and Shortwave Anomaly

Globe: 90N to 90S



Tropics: 20N to 20S

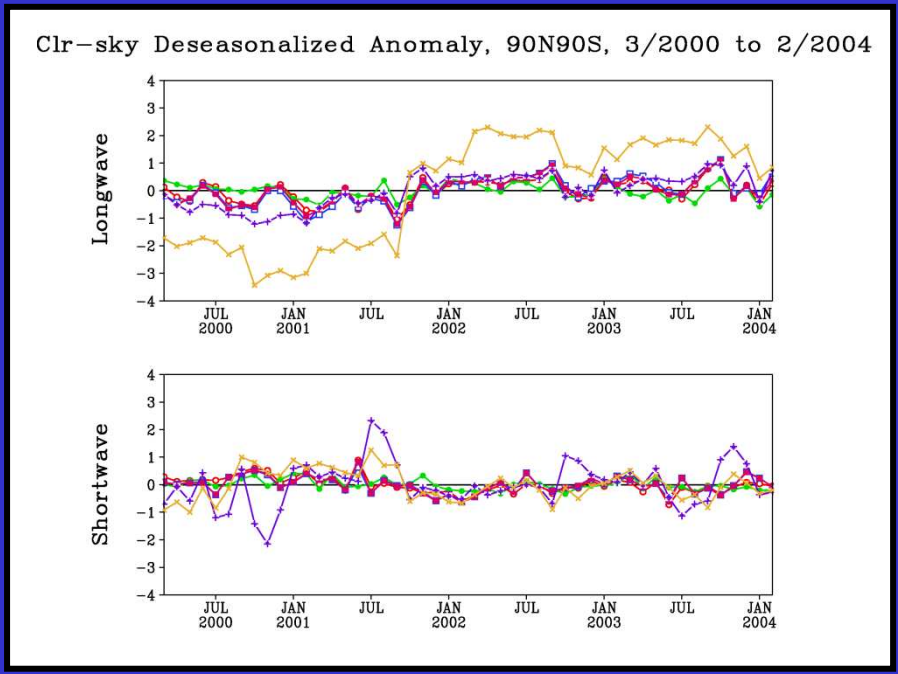


Legend: ○ = CERES EBAF, ● = CERES ERBE-like, □ = CERES GEO, ■ = CERES nonGEO, + = LaRC GEWEX SRB, X = ISCCP-FD

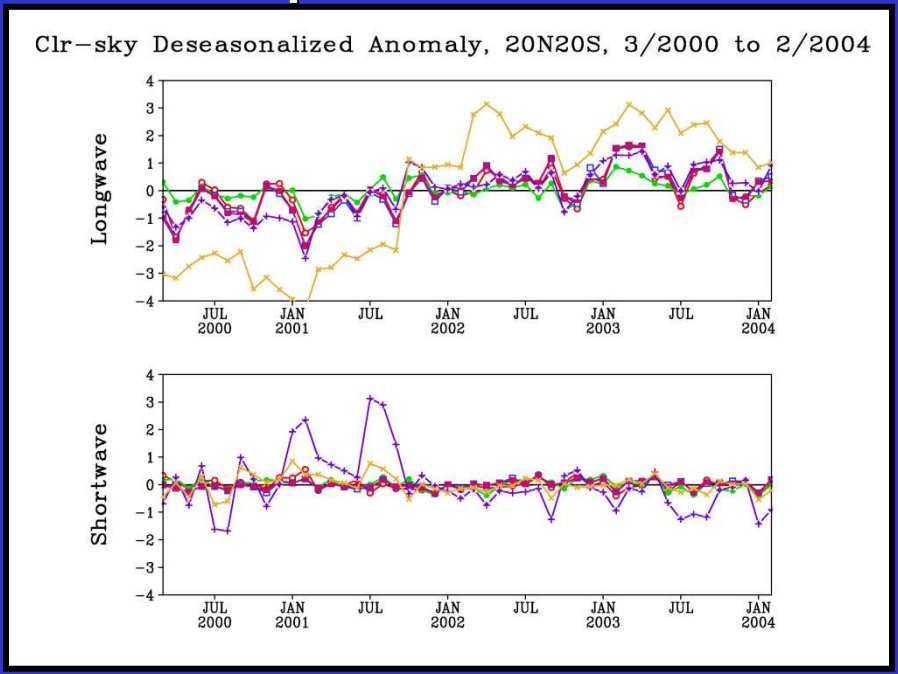
- CERES-based data have smaller variability than ISCCP-based data
- SW variability > LW variability; Tropical variability > Global variability

Clear-sky Longwave and Shortwave Anomaly

Globe: 90N to 90S



Tropics: 20N to 20S

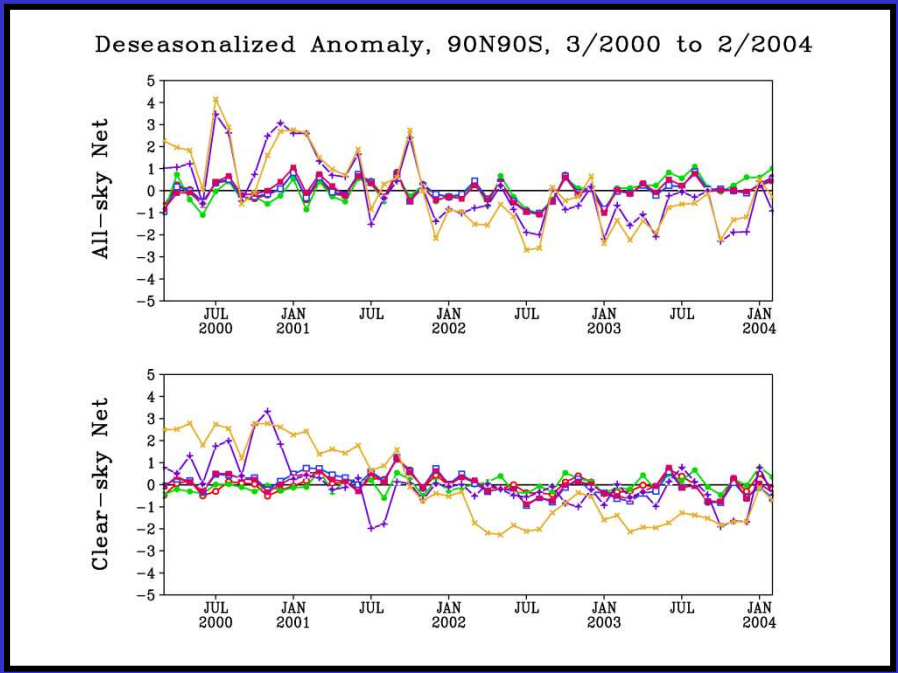


Legend: ○ = CERES EBAF, ● = CERES ERBE-like, □ = CERES GEO, ■ = CERES nonGEO, + = LaRC GEWEX SRB, X = ISCCP-FD

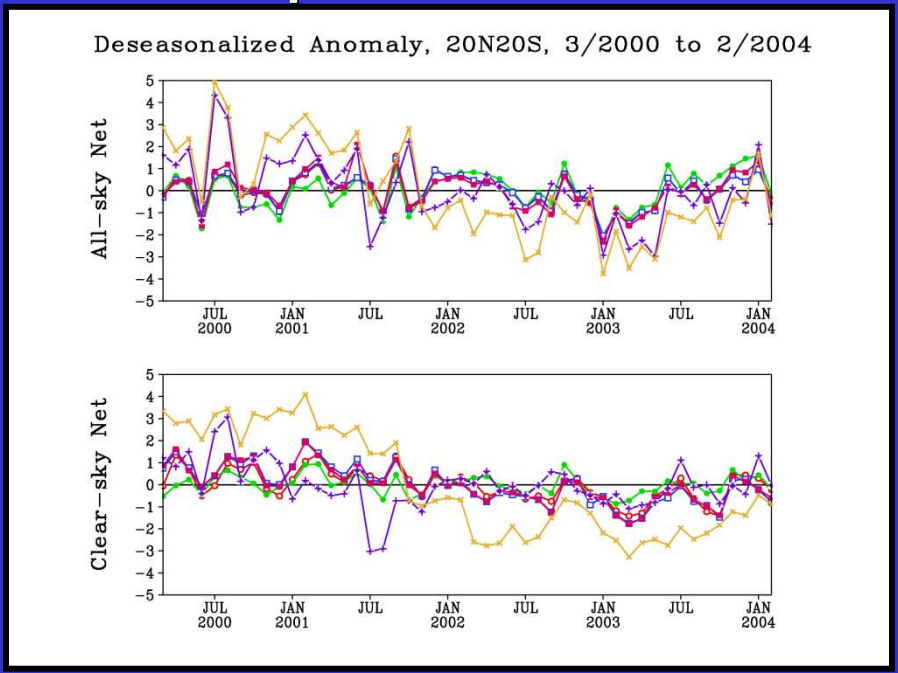
- Clear-sky results are similar to all-sky results
- Jump in clear-sky longwave ISCCP time-series due to changes in TOVS sounder

All-sky and Clear-sky Net Anomaly

Globe: 90N to 90S



Tropics: 20N to 20S



Legend: = CERES EBAF, = CERES ERBE-like, = CERES GEO, = CERES nonGEO, + = LaRC GEWEX SRB, X = ISCCP-FD

- ISCCP-based global net time series show large negative trend
- CERES-based global net time series are very stable with time

Global Mean Variability: TOA Radiation Budget

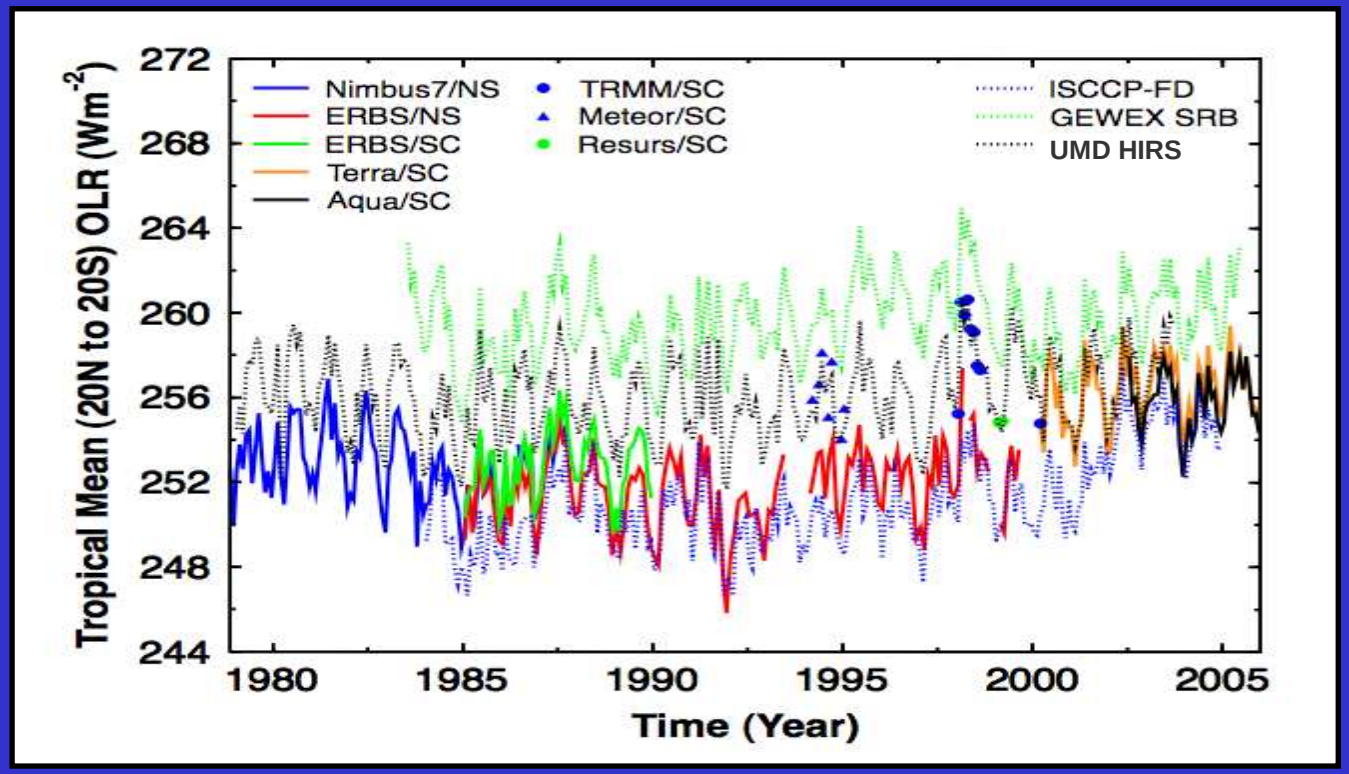
Parameters (Wm^{-2})*	EBAF	ERBE-like	SRBAVG-GEO	SRBAVG-NonGeo	GEWEX SRB	ISCCP-FD
Longwave	0.4	0.5	0.4	0.4	0.7	1.2
Shortwave	0.5	0.7	0.5	0.5	1.2	1.1
Net	0.5	0.6	0.5	0.5	1.5	1.7
Clear Longwave	0.4	0.3	0.5	0.5	0.6	1.9
Clear Shortwave	0.3	0.2	0.3	0.3	0.8	0.6
Clear Net	0.4	0.4	0.5	0.5	1.1	1.8

*** 1-sigma value based on 4 years of data**

- Globally, ISCCP-based products have 1.2 to 4 times more variability than CERES-based datasets

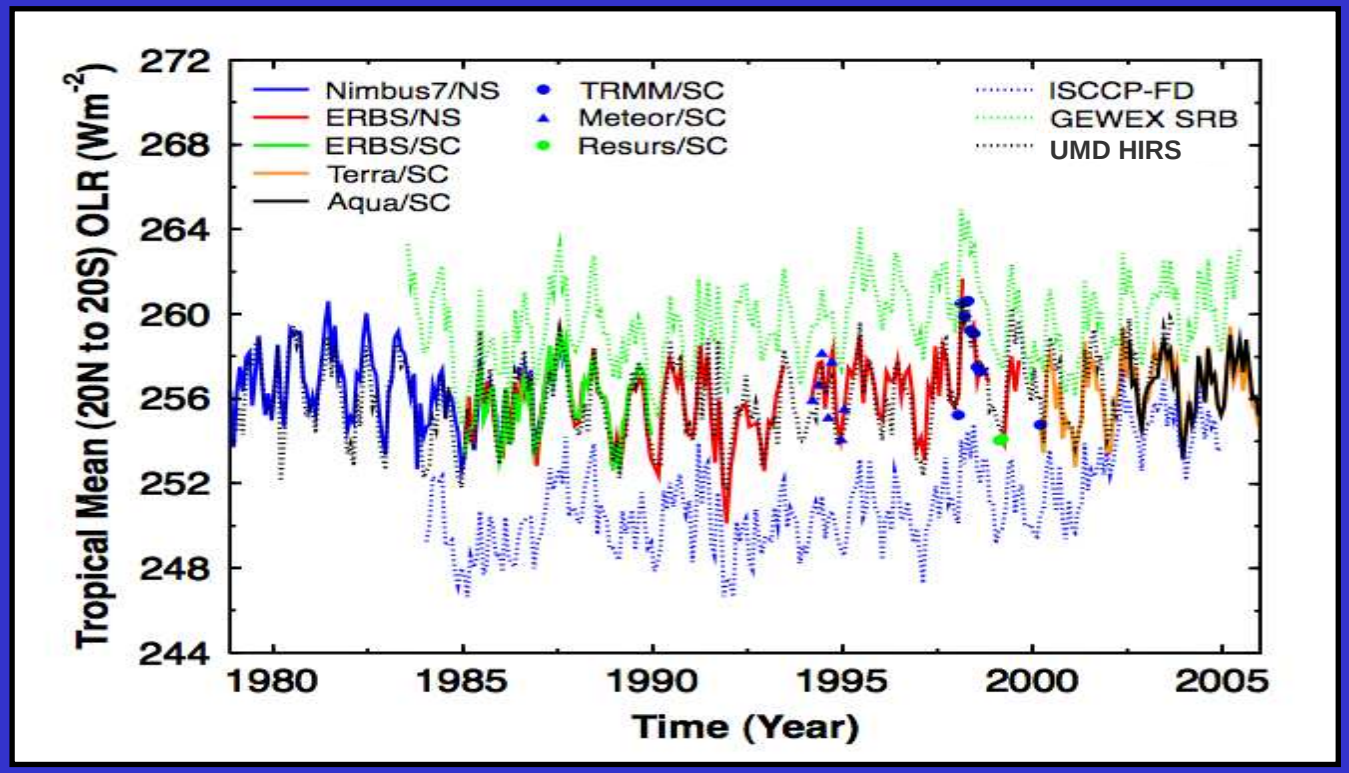
Tropical Mean Time Series Comparisons

Tropical (20N to 20S) OLR Comparison



- The two ISSCP-based products (GEWEX SRB and ISSCP FD) provide the upper and the lower range of these datasets
- Instrument calibration difference between ERBE and CERES

Tropical (20N to 20S) OLR Comparison (Cont.)



- ERBE and CERES differences (~4 Wm^{-2}) can be removed using overlapping data period
- Adjusted broadband longwave time series agrees well with narrowband UMD HIRS

Summary

- Regional differences are complicated; due to differences in processing algorithm, data sampling, instrument calibration, and missing data ; LW comparisons are better than SW's or Net's
- Zonal mean differences, relative to ensemble mean, show distinct separation between CERES-based and ISCCP-based data products for shortwave radiation; large differences in ERBE-like clear-sky shortwave flux in the polar regions (ERBE clear-sky Scene ID issue)
- Globally, agreement with ensemble mean is within 1% (1-sigma) for LW, 3.6% for SW; all-sky Net agrees to within 3.2 Wm^{-2} (1-sigma) of the ensemble mean; similar results for tropical mean
- Improving shortwave fluxes can bring these data sets closer together
- CERES-based products have smaller variability than ISCCP-based datasets (1.2 to 4 times smaller for global mean)
- Large tropical mean longwave calibration difference (~4 Wm^{-2}) between CERES and ERBE instruments can be removed using overlapping data period