# A Climatological Comparison of the TOA Radiation Budget Data from the GEWEX Radiative Flux Assessment Archive during the CERES Period: An Update

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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
  - sources include satellite calibration, input data sources, spatial and temporal gap filling, and other assumptions
- GEWEX RFA report may be an useful reference for development of future climate system observation requirements for radiative fluxes as well as for understanding current data limitation and uncertainty for future IPCC report

# GEWEX RFA TOA Radiation Datasets

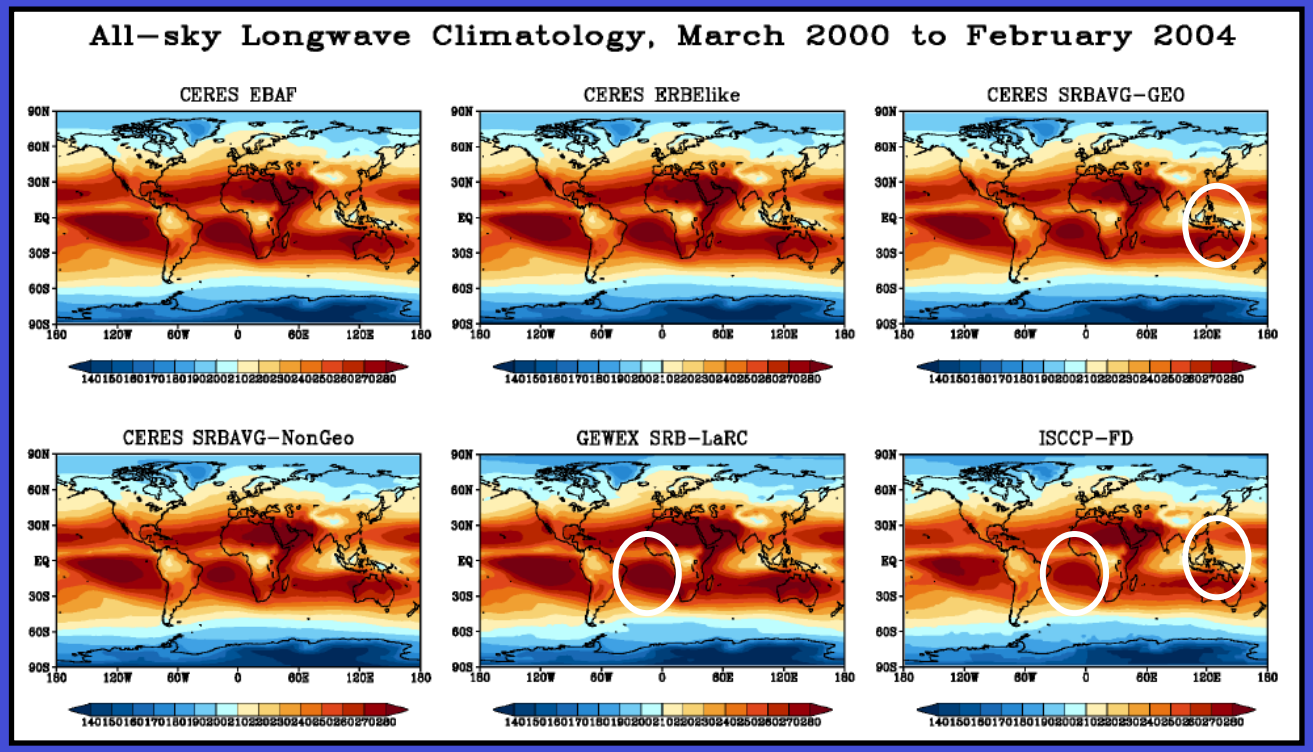
| Data Source | Satellite Source | Spatial Coverage | Temporal Coverage |
|---|---|---|---|
| CERES* | Terra, Aqua | Global | 03-2000 to 10-2005 |
| ISCCP-FD | Geo + Polar | Global | 07-1983 to 12-2004 |
| LaRC GEWEX SRB | Geo + Polar | Global | 07-1983 to 06-2005 |
| FORTH | Geo + Polar | Global | 01-1984 to 12-2004 |
| UM GEWEX SRB/SW** | Geo + Polar | Global | 07-1983 to 12-2004 |
| UM 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; ** UM GEWEX SRB/SW, UM HIRS/OLR: single component data; *** ScaRaB: few months within these two periods

# Objective

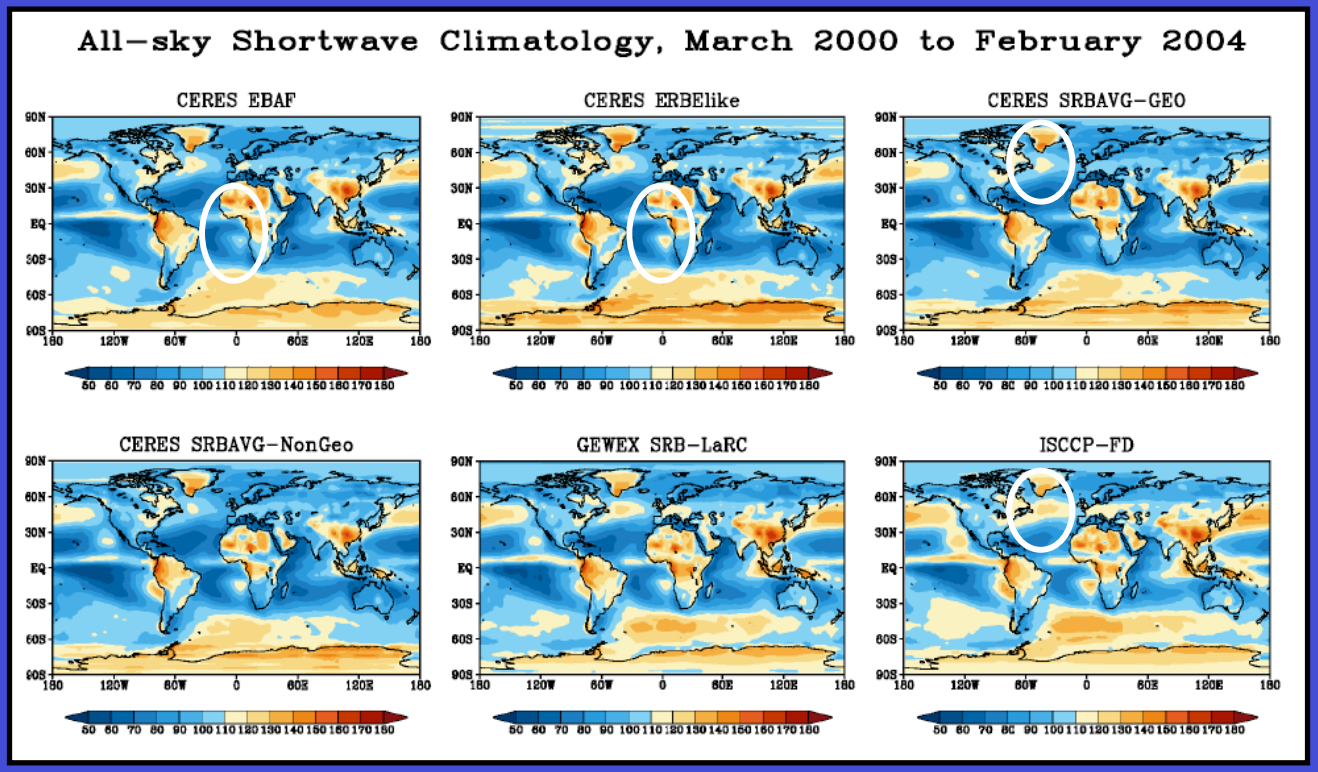
- Examine the consistencies and the differences of TOA Radiation data sets in GEWEX RFA Archive for the CERES/Terra period (March 2000 to February 2004).
  - Focus on baseline climatology comparisons (absolute values)
  - Longwave, Shortwave, Net (all-sky and clear-sky)
  - Regional, zonal, tropical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

# Regional Climatology: Longwave Radiation



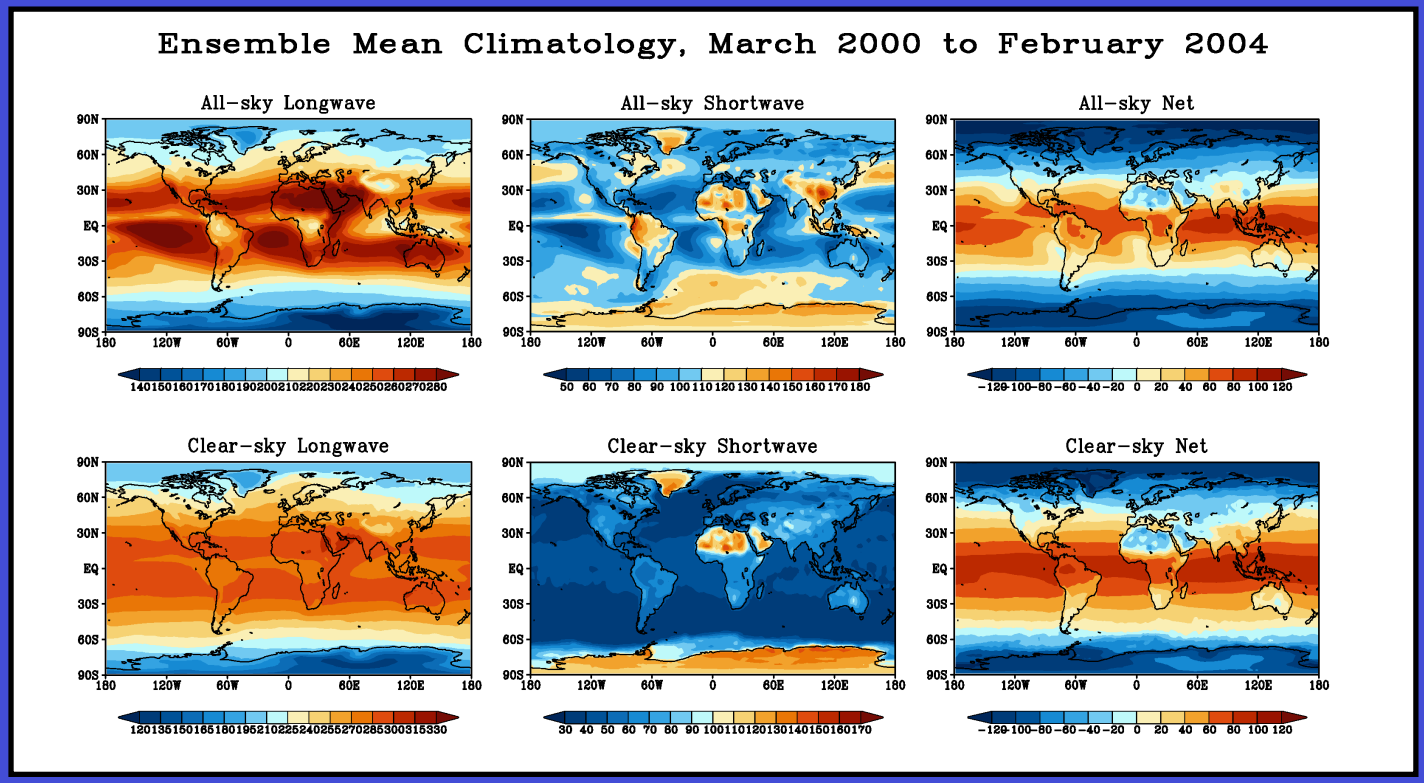

- Major regional longwave patterns are similar for all six datasets
- Subtle, but noticeable differences are found in (1) the subsidence regions over the ocean and desert and (2) the deep convective regions over land and ocean

# Regional Climatology: Shortwave Radiation




- Significant differences in shortwave, i.e., mid-latitude storm track areas (both hemisphere), stratus regions off the west coast of major continents, regions over ITCZ and the western Pacific
- Some polar shortwave differences are artifacts of missing data

# Ensemble Mean TOA Radiation Climatology

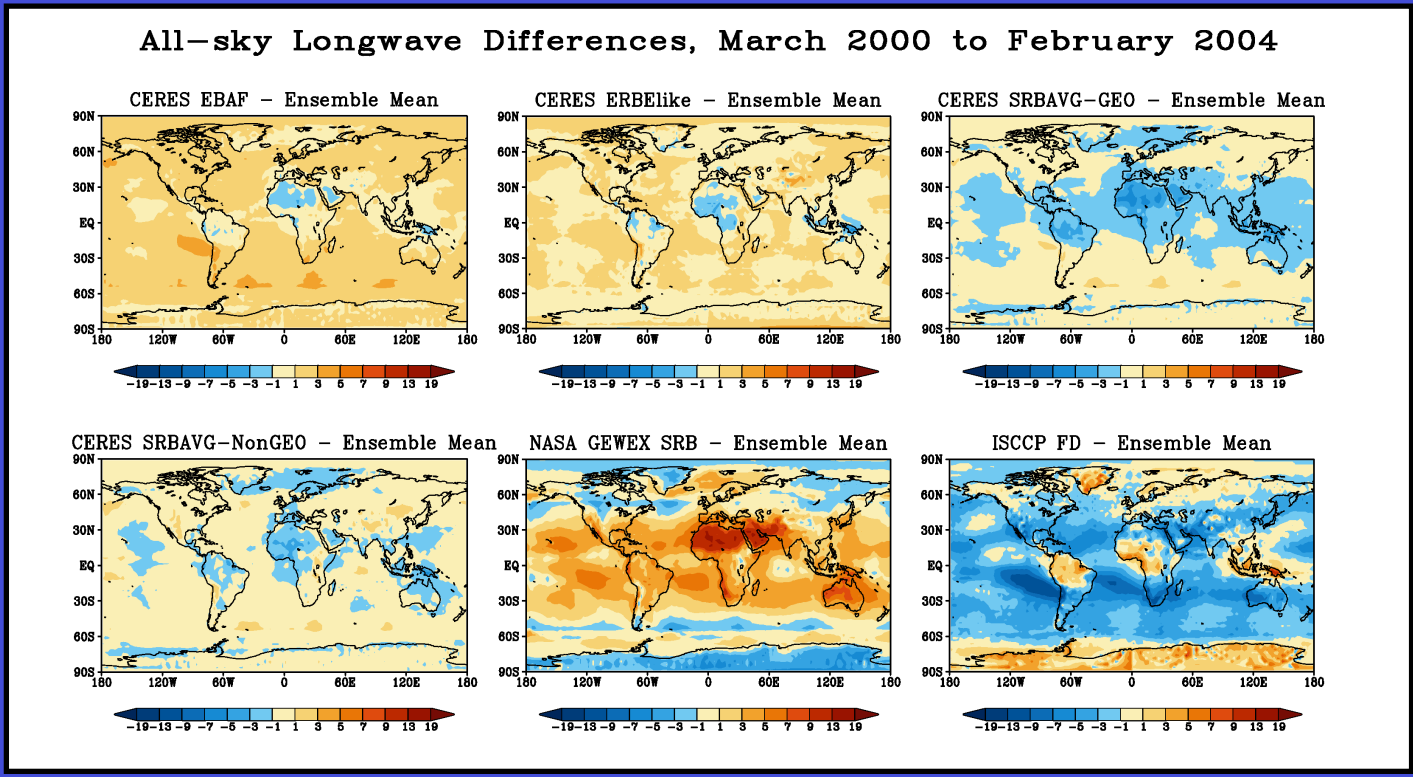



- Ensemble mean climatology are constructed from six datasets and used as un-bias estimates for comparison purposes
- These ensemble means show the typical regional patterns of TOA radiation fields over the globe

# Ensemble Mean: Good and Bad

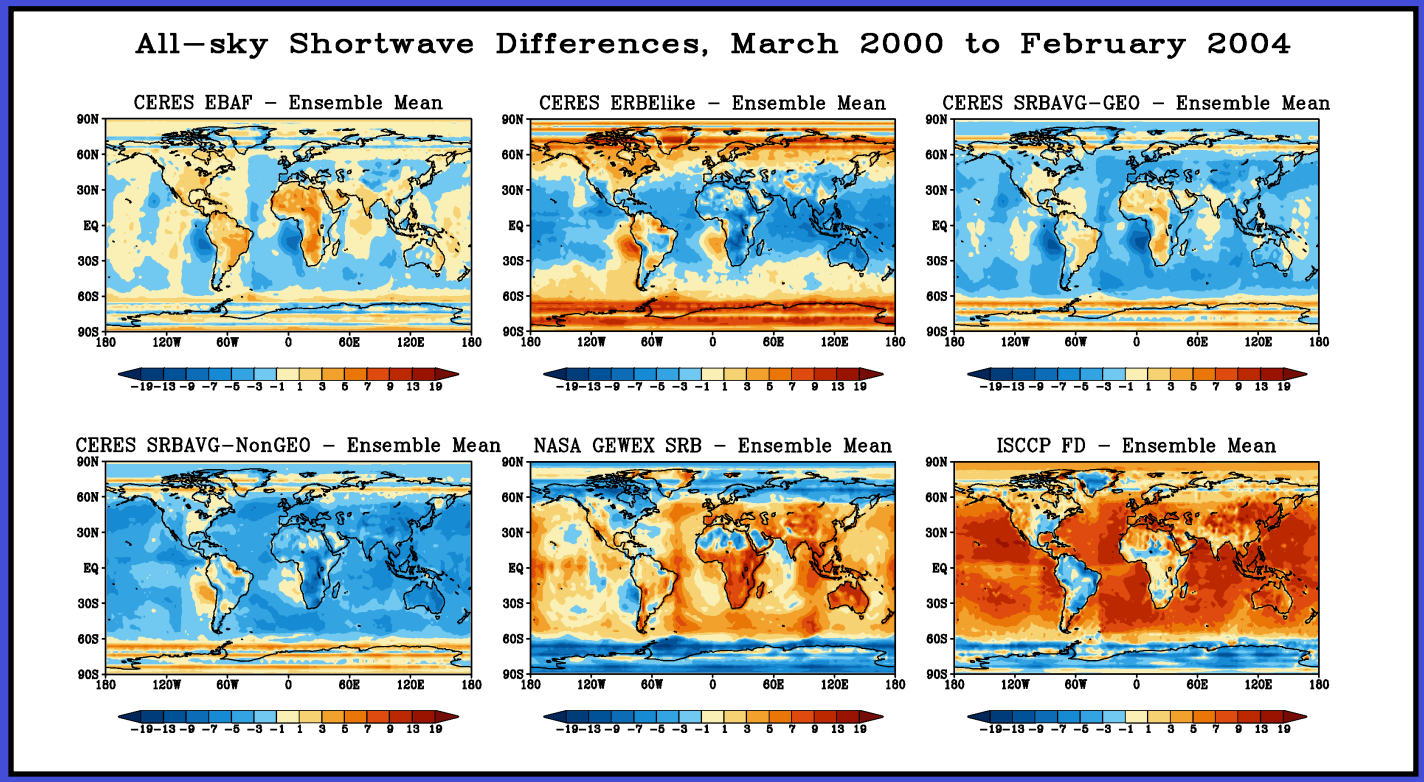
- Advantages:
  - Not picking one favor data set over another
  - Easy to implement
  - Efficiently summarize multi-data results (i.e., zonal, large area averages)
- Disadvantages:
  - contain muted artifacts from all data sets
  - May not be the best choice if there is a clear winner
  - May be harder to understand regional differences

# Regional Differences: Longwave Radiation



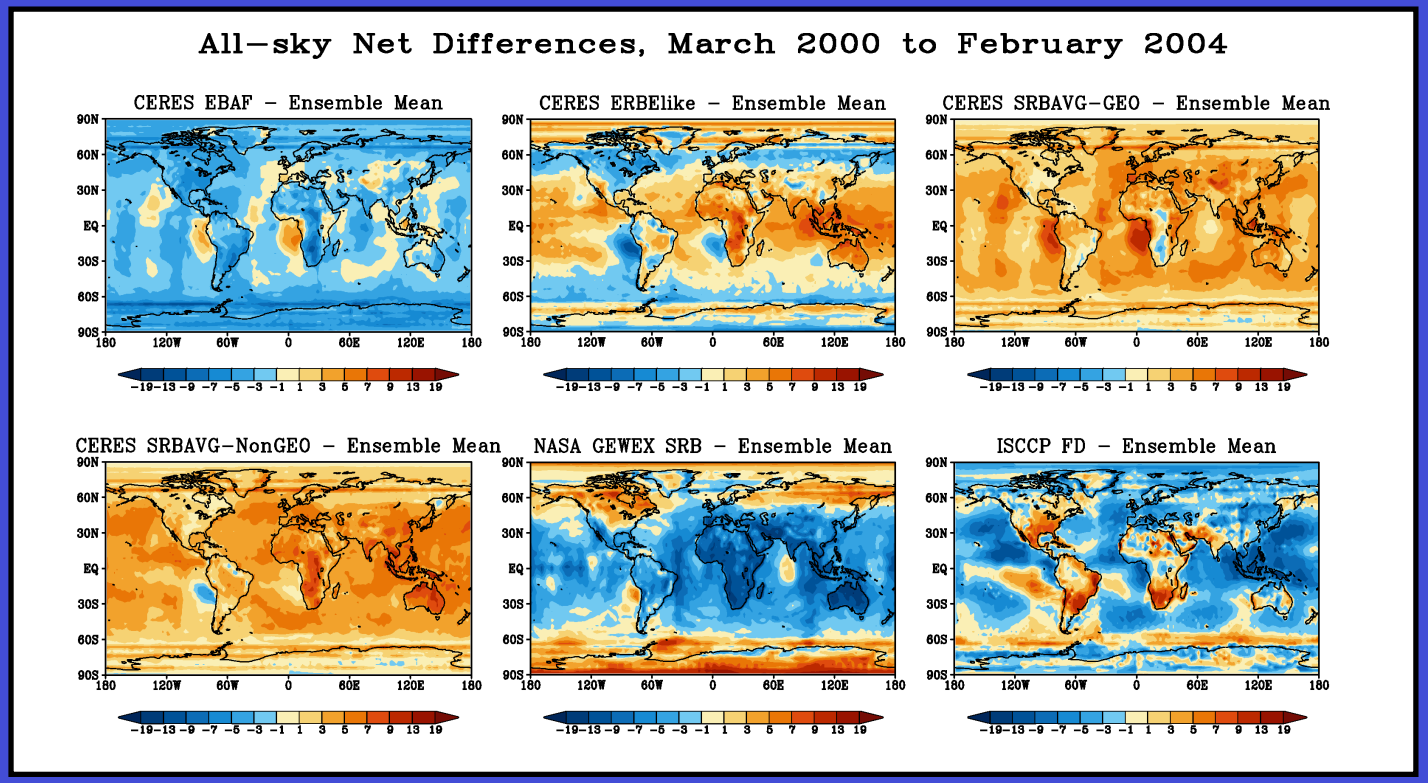

- Regional differences are small for CERES-based products; but large for ISCCP-based product
- ISCCP artifacts (ISCCP-FD and GEWEX SRB) are noticeable over S.H.

# Regional Differences: Shortwave Radiation




- Orbital patterns are visible; ensemble mean shortwave contaminated with ISCCP artifacts
- CERES-based products have mostly negative differences and ISCCP-based products have mostly positive differences.

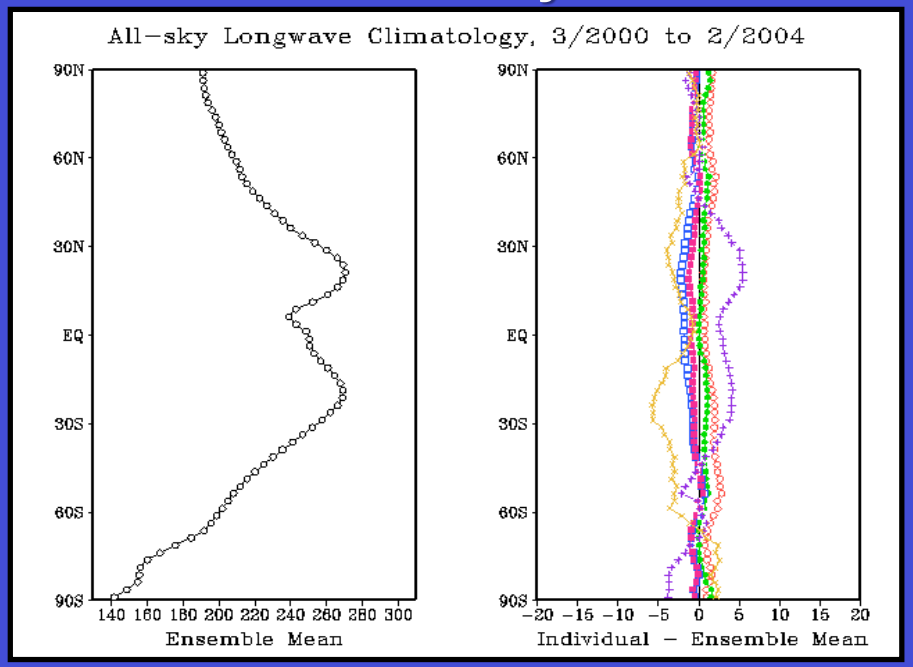
# Regional Differences: Net Radiation



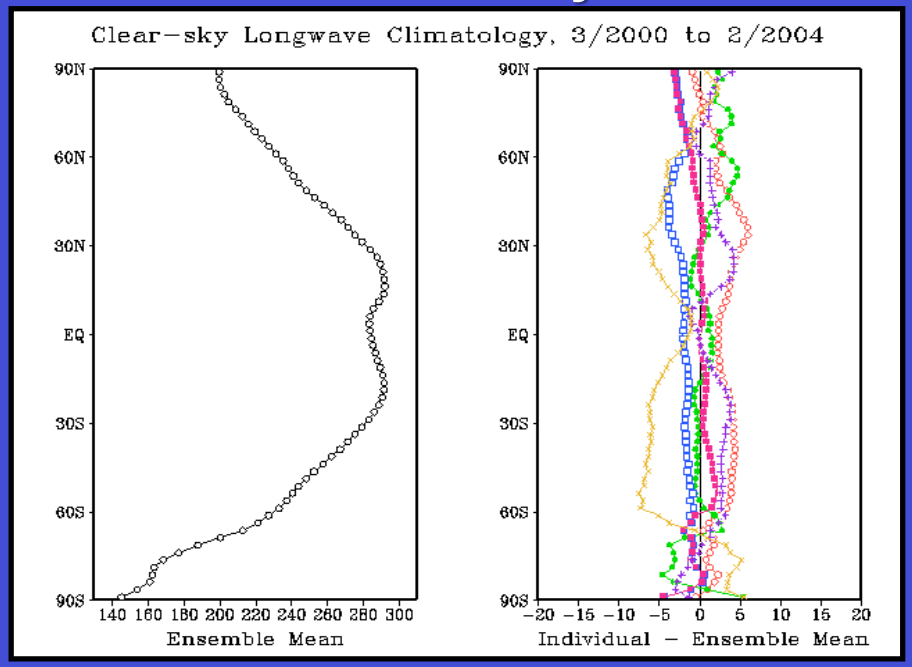

- Complicated patterns from combined longwave and shortwave differences
- Some data products show mostly negative differences; others show mostly positive differences

# Zonal Mean: Longwave Radiation

## All-sky




## Clear-sky

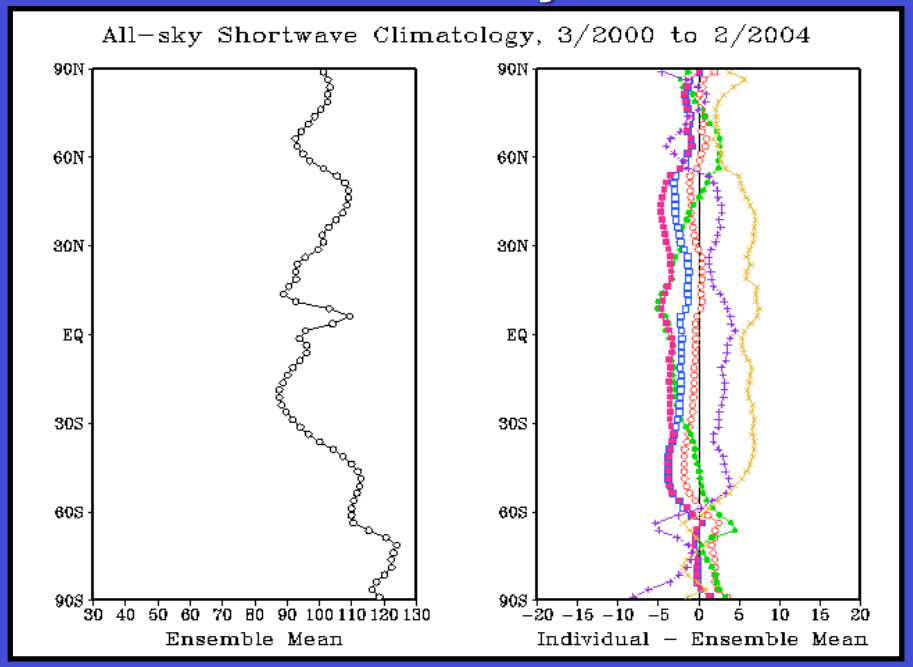



Legend: Opn. Cir.=CERES EBAF, Clo. Cir.=CERES ERBE-like, Opn. Sqr.=CERES GEO, Clo. Sqr.=CERES nonGEO, +=LaRC GEWEX SRB, X=ISCCP-FD

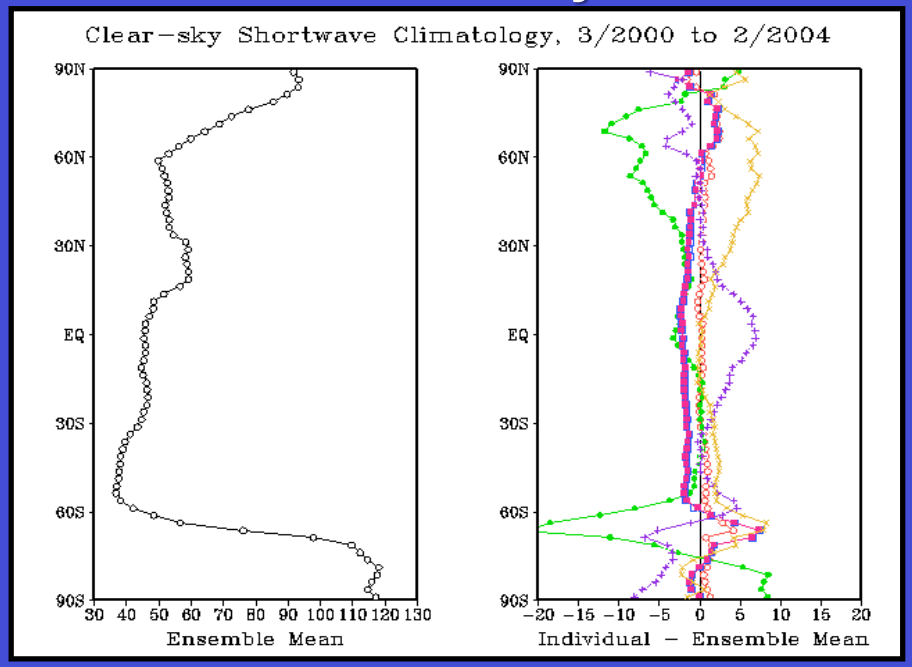
- All-sky: good agreements over N.H. high latitudes; larger differences occurred between 45 N and 45 S and over South Pole
- Clear-sky: noticeable differences through all latitude zones

# Zonal Mean: Shortwave Radiation

## All-sky




## Clear-sky

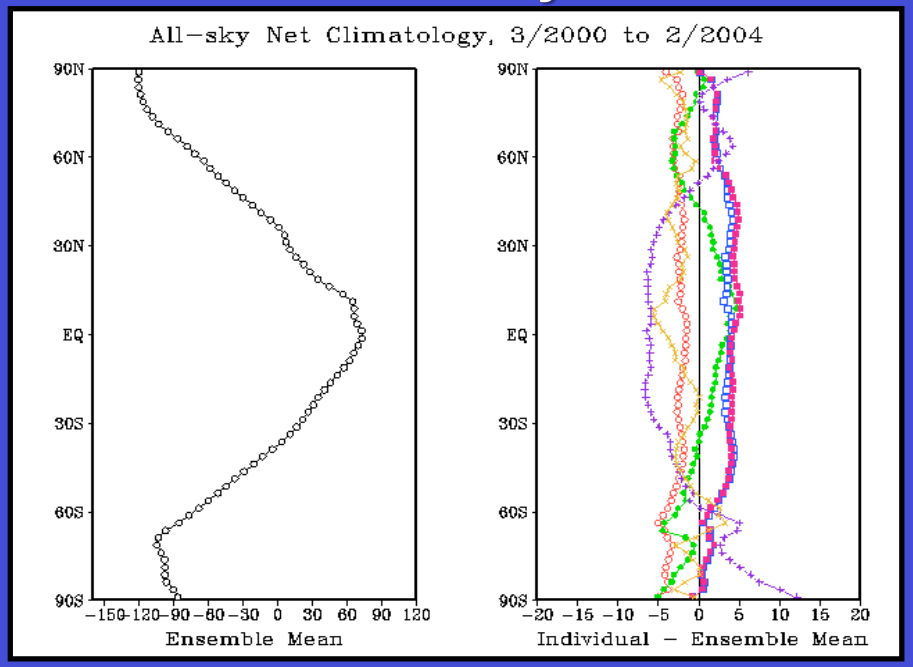



Legend: Opn. Cir.=CERES EBAF, Clo. Cir.=CERES ERBE-like, Opn. Sqr.=CERES GEO, Clo. Sqr.=CERES nonGEO, +=LaRC GEWEX SRB, X=ISCCP-FD

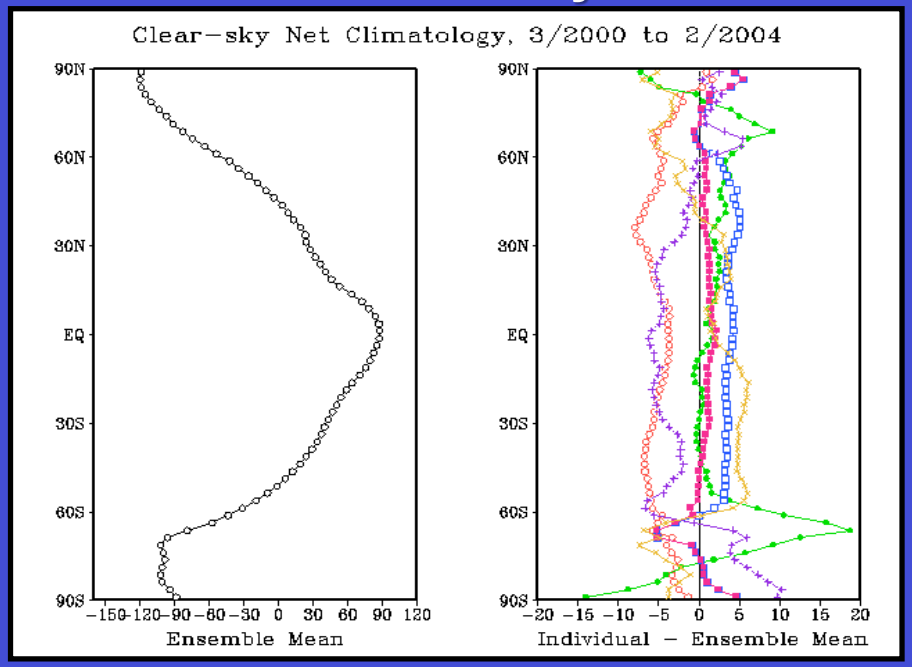
- All-sky: Clear separation between CERES-based and ISCCP-based products
- Clear-sky: Large differences for CERES ERBE-like data in high latitudes (ERBE clear-sky scene ID, ERBE MLE algorithm issue)

# Zonal Mean: Net Radiation

## All-sky




## Clear-sky




Legend: Opn. Cir.=CERES EBAF, Clo. Cir.=CERES ERBE-like, Opn. Sqr.=CERES GEO, Clo. Sqr.=CERES nonGEO, +=LaRC GEWEX SRB, X=ISCCP-FD

- All-sky: large differences in Net radiation throughout all zones
- Clear-sky: similar to all-sky's with larger differences over the polar regions for ERBE-like data.

# 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

# Annual Tropical Mean TOA Radiation Budget

| Parameters ($Wm^{-2}$) | Ensemble Mean | Abs. SD (1-sigma) | Rel. SD (1-sigma) | Range (Min, Max) |
|---|---|---|---|---|
| Solar Incoming | 409.4 | 0.7 | 0.2% | 408.1, 410.0 |
| Longwave | 255.7 | 2.2 | 0.8% | 253.3, 259.3 |
| Shortwave | 94.8 | 4.1 | 4.3% | 91.0, 101.1 |
| Net | 58.9 | 4.4 | 7.5% | 52.7, 63.4 |
| Clear Longwave | 287.9 | 2.1 | 0.7% | 284.8, 290.6 |
| Clear Shortwave | 47.8 | 2.7 | 5.6% | 45.7, 52.8 |
| Clear Net | 23.1 | 3.7 | 5.1% | 68.4, 76.8 |

- Agreement: LW within 0.8%, SW within 5.6%, Net within 7.5% of the ensemble mean
- Disagreement: Largest for Net and smallest for Solar Incoming

# Summary

- Longwave data sets agree better than shortwave and Net datasets
- Regional differences are noticeable over major climate locations; such as convective regions over the warm pool, major deserts, and subsidence regions
- 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 (ERBE Scene ID and ERBE MLE issues)
- 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
- Tropical results are similar; agreement within 0.8% (1-sigma) for LW, 5.6% for SW, and 7.5% for Net, relative to ensemble mean
- Improving shortwave fluxes can bring these data sets closer together