# The First Decade of CERES/Terra Radiation Budget Data

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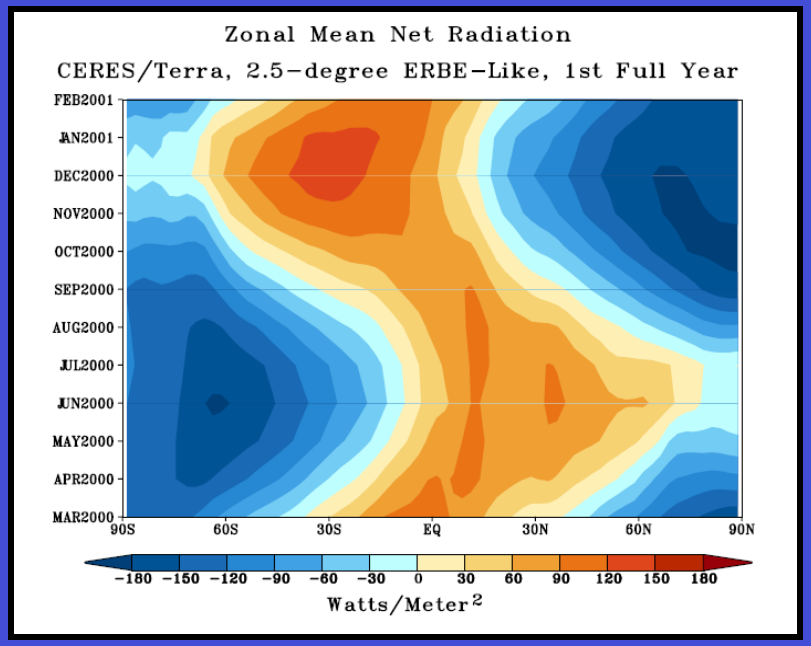
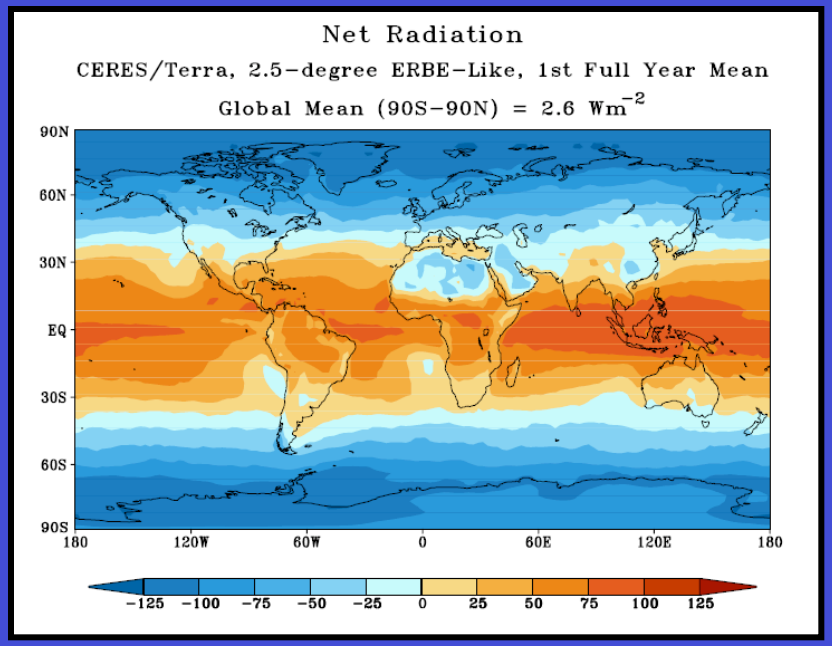
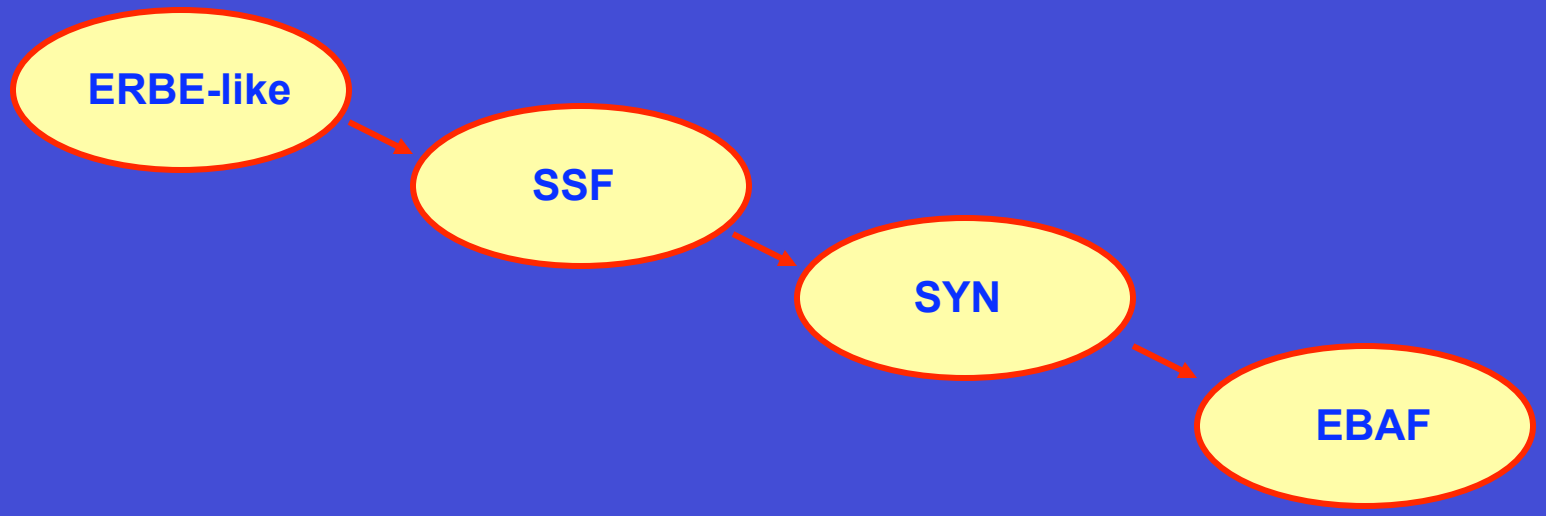
# Past (10-year Ago, 2001 Spring Meeting)




- First year of CERES/Terra Global Fluxes from the CERES/Terra ERBE-like Edition1 data product in HDF format
- No other CERES/Terra monthly mean data products were available at the time
- There was a Net imbalance in the CERES ERBE-like data

# Present (2011 Spring Meeting)

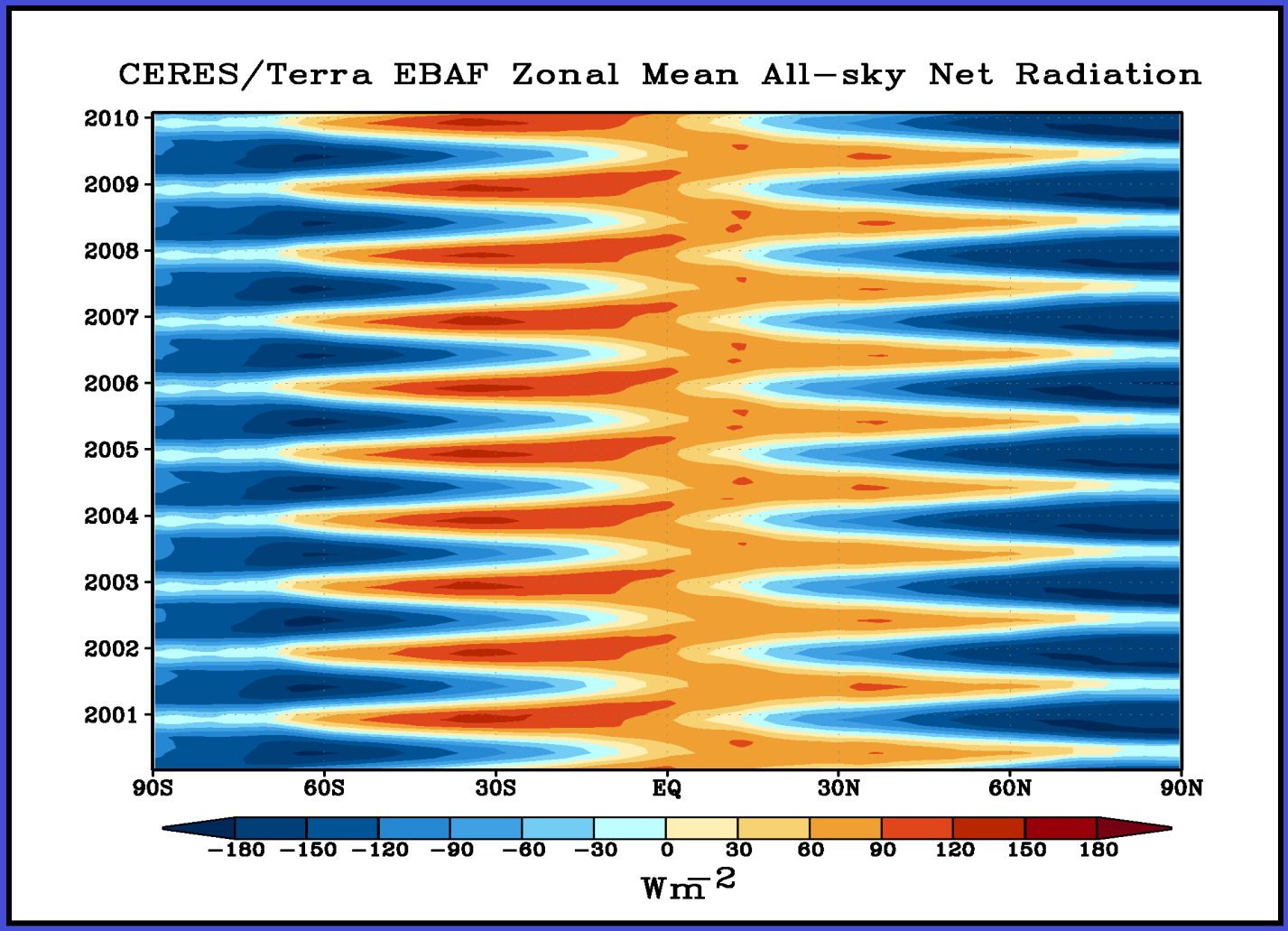



- More than 10-year of CERES/Terra data in the archive
- Many monthly data products with different levels of complexity
- Available in HDF, NetCDF, and ASCII Format
- Gone through at least one reprocessing to improve accuracy
- Net imbalance is driven largely by instrument's absolute uncertainty → lead to the creation of the EBAF product which anchors the TOA net flux to the ocean heat storage value

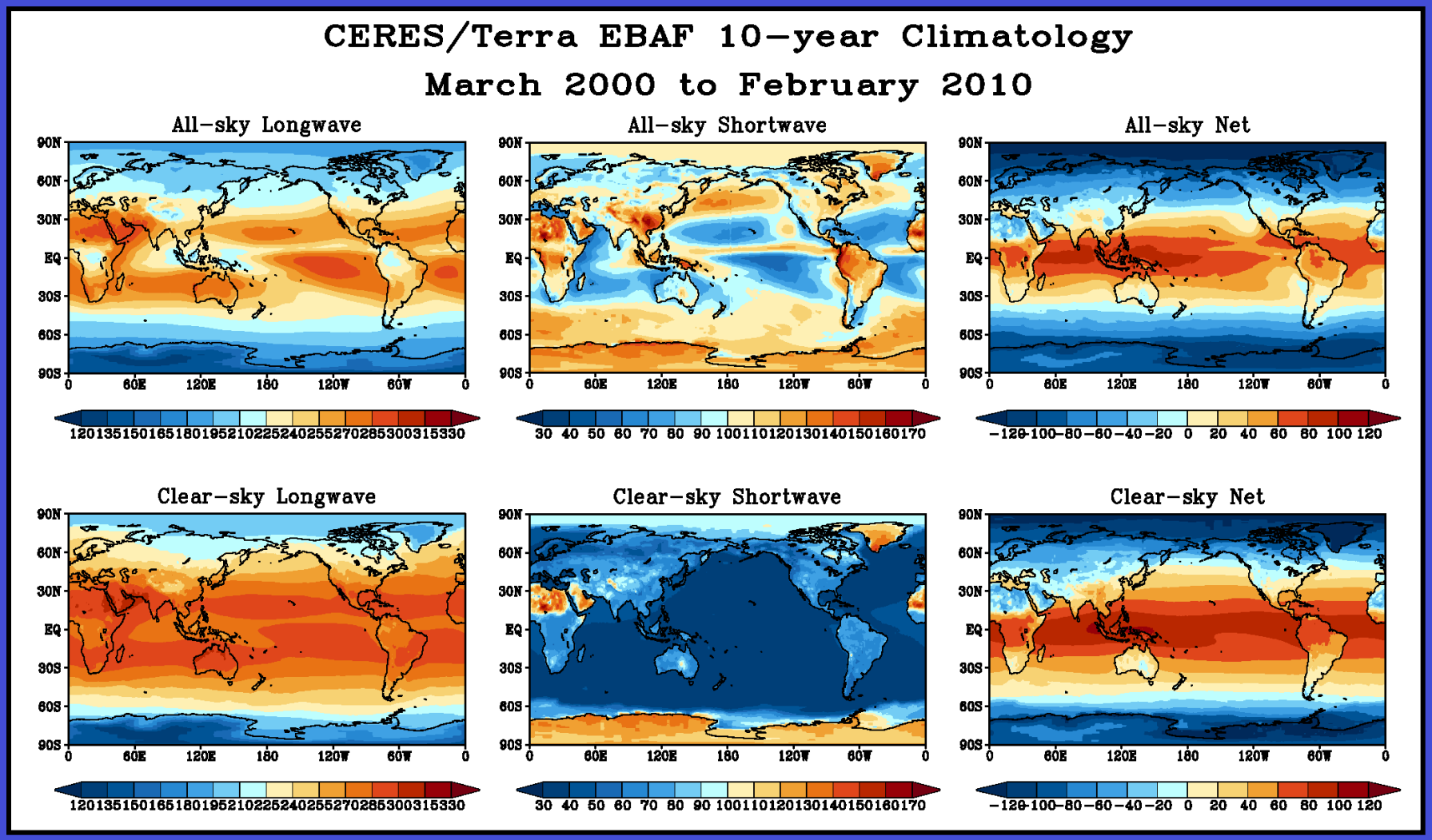
# Objective

- Examine the first decade of CERES/Terra TOA radiation budget data (March 2000 to February 2010)
  - Focus on the CERES EBAF data product
  - Longwave, shortwave, net (all-sky and clear-sky)
  - Regional, zonal, tropical (20N to 20S), global (90N to 90S)
  - 10-year climatology (average)
  - Interannual variability (1-sigma)
  - Exploratory regional trend analysis

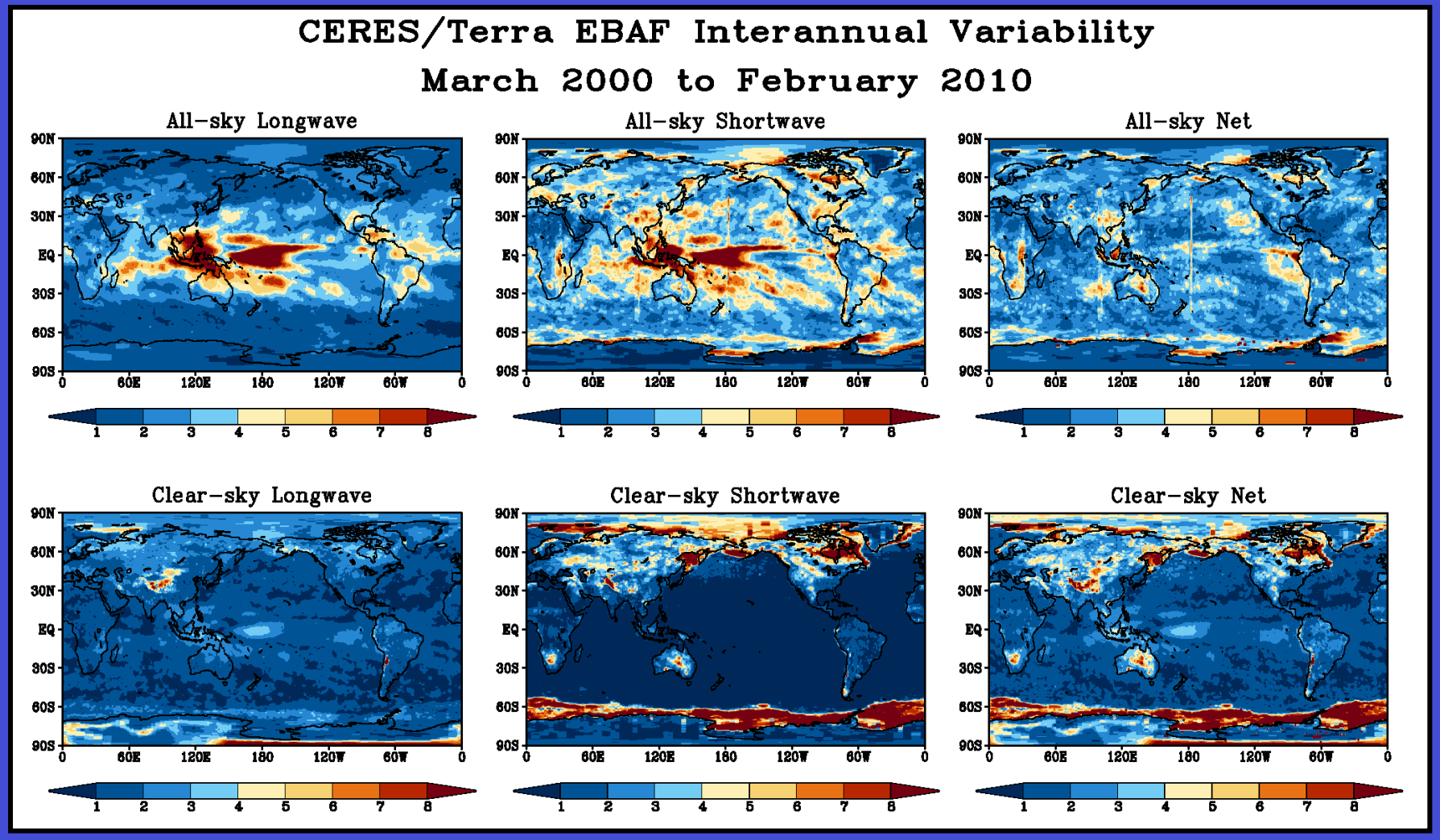
# 10-year of Zonal Mean All-sky Net Radiation



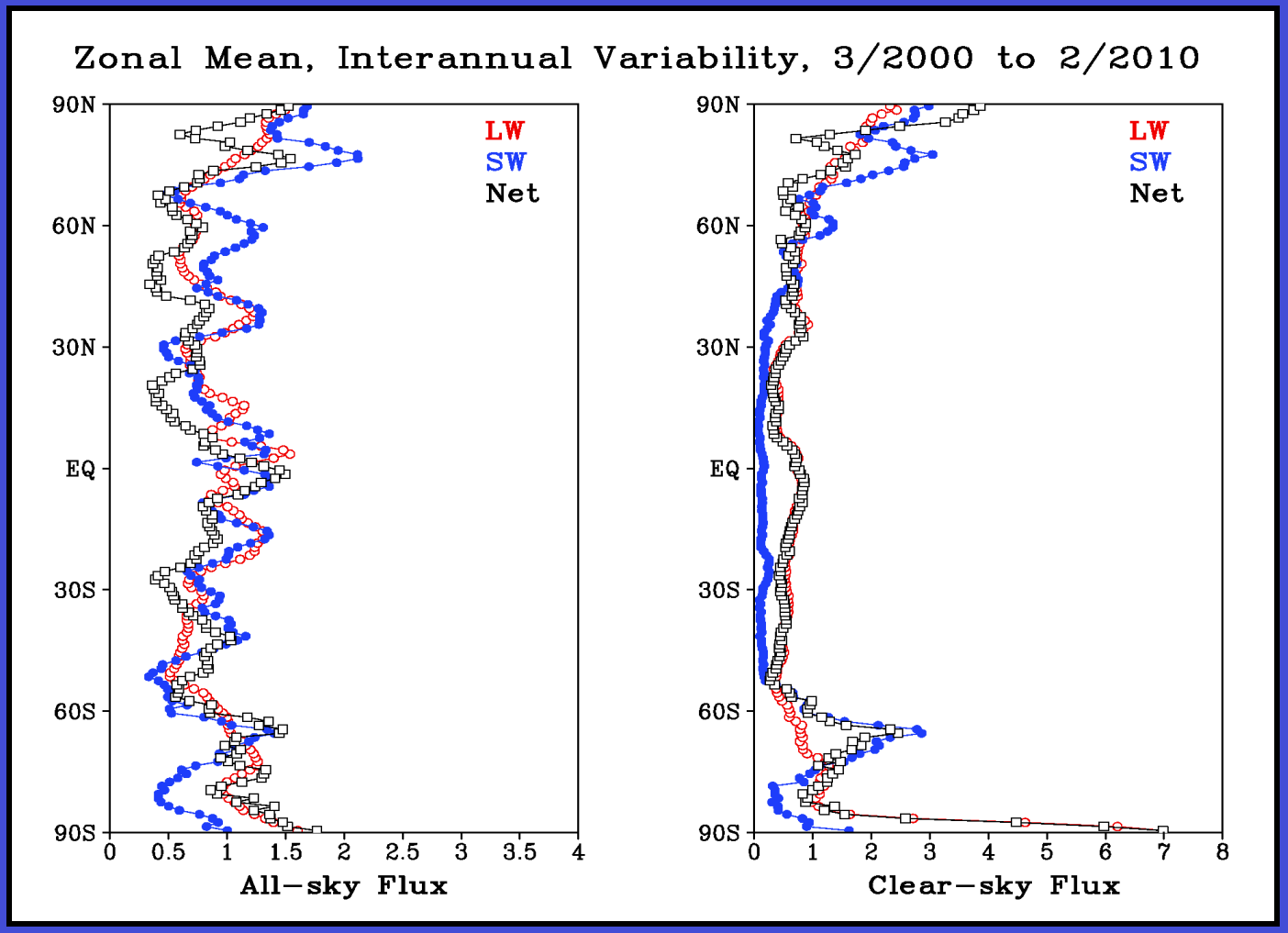
# Regional TOA Climatology



# Regional TOA Interannual Variability



# Zonal TOA Interannual Variability



# Global (90NS) Mean and Interannual Variability

| Parameters ($Wm^{-2}$) | 10-year Mean | Abs. SD (1-sigma) | Rel. SD (1-sigma) | Range (Min, Max) |
|---|---|---|---|---|
| Solar Incoming | 340.1 | 0.18 | 0.05% | 340.0, 340.3 |
| Longwave | 239.6 | 0.26 | 0.11% | 239.2, 239.9 |
| Shortwave | 99.5 | 0.34 | 0.34% | 98.9, 100.0 |
| Net | 1.0 | 0.31 | 31.0% | 0.7, 1.9 |
| Clear Longwave | 266.0 | 0.29 | 0.11% | 265.4, 266.3 |
| Clear Shortwave | 52.4 | 0.11 | 0.21% | 52.3, 52.7 |
| Clear Net | 21.6 | 0.22 | 1.02% | 21.4, 22.1 |

- Global mean interannual variability < 0.35 $Wm^{-2}$ (1-sigma)
- Shortwave flux has the largest absolute SD ~ 0.34 $Wm^{-2}$
- Clear shortwave flux has the smallest absolute SD ~ 0.11 $Wm^{-2}$

# Tropical (20NS) Mean and Interannual Variability

| Parameters ($Wm^{-2}$) | 10-year Mean | Abs. SD (1-sigma) | Rel. SD (1-sigma) | Range (Min, Max) |
|---|---|---|---|---|
| Solar Incoming | 407.9 | 0.22 | 0.05% | 407.8, 408.1 |
| Longwave | 256.6 | 0.58 | 0.23% | 255.6, 257.4 |
| Shortwave | 94.4 | 0.49 | 0.52% | 93.6, 95.4 |
| Net | 56.9 | 0.60 | 1.05% | 56.5, 58.6 |
| Clear Longwave | 286.8 | 0.48 | 0.17% | 285.6, 287.4 |
| Clear Shortwave | 47.6 | 0.07 | 0.15% | 47.5, 47.8 |
| Clear Net | 73.5 | 0.46 | 0.62% | 73.0, 74.4 |

- Tropical variability is slightly larger than Global Mean's
- Net has the largest absolute SD ~0.6 $Wm^{-2}$
- Clear shortwave has the smallest absolute SD ~ 0.07 $Wm^{-2}$

# Polar (60-90NS) Mean and Interannual Variability

| Parameters ($Wm^{-2}$) | Ensemble Mean | Abs. SD (1-sigma) | Rel. SD (1-sigma) | Range (Min, Max) |
|---|---|---|---|---|
| Solar Incoming | 203.6 | 0.08 | 0.04% | 203.5, 203.7 |
| Longwave | 192.0 | 0.69 | 0.36% | 191.0, 193.3 |
| Shortwave | 107.8 | 0.38 | 0.35% | 107.2, 108.6 |
| Net | -96.2 | 0.54 | 0.56% | -97.5, -95.6 |
| Clear Longwave | 208.9 | 0.61 | 0.29% | 208.0, 210.0 |
| Clear Shortwave | 78.7 | 0.63 | 0.80% | 77.8, 79.9 |
| Clear Net | -84.0 | 0.34 | 0.40% | -84.5, -83.4 |

- Polar interannual variability can be large; especially for clear-sky fluxes which are comparable to those of all-sky fluxes.

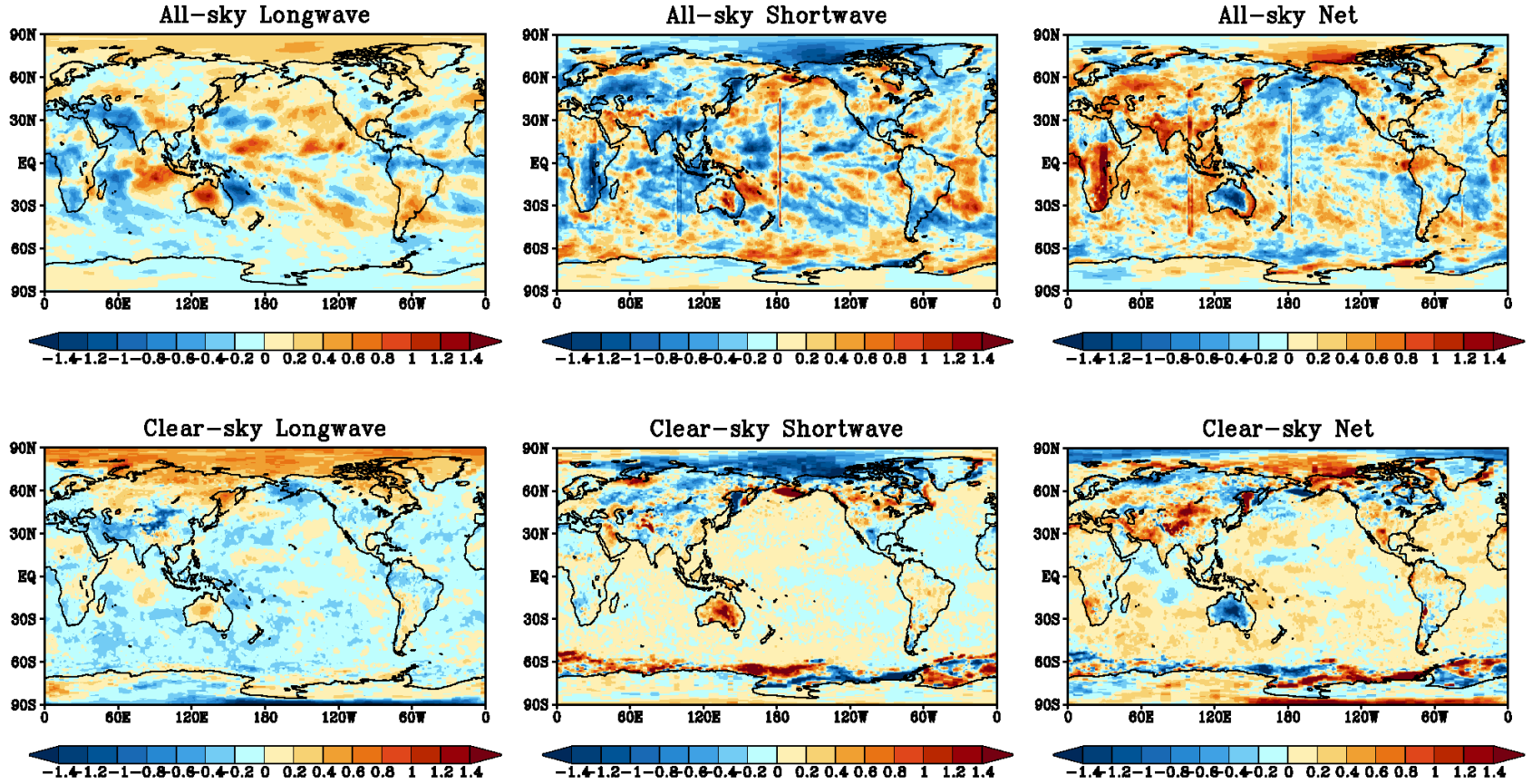
# Exploratory Trend Analysis

- Identify regions of interests for further data exploration
- Linear regression analysis using deseasonalized monthly time series (120 months) on all 1-degree EBAF regions
  - Longwave, shortwave, net (all-sky and clear-sky)
  - Global maps of trend
  - Global maps of trend uncertainty (2-sigma)
  - Global maps of significant trend (showing only regions that passed the 2-sigma test)

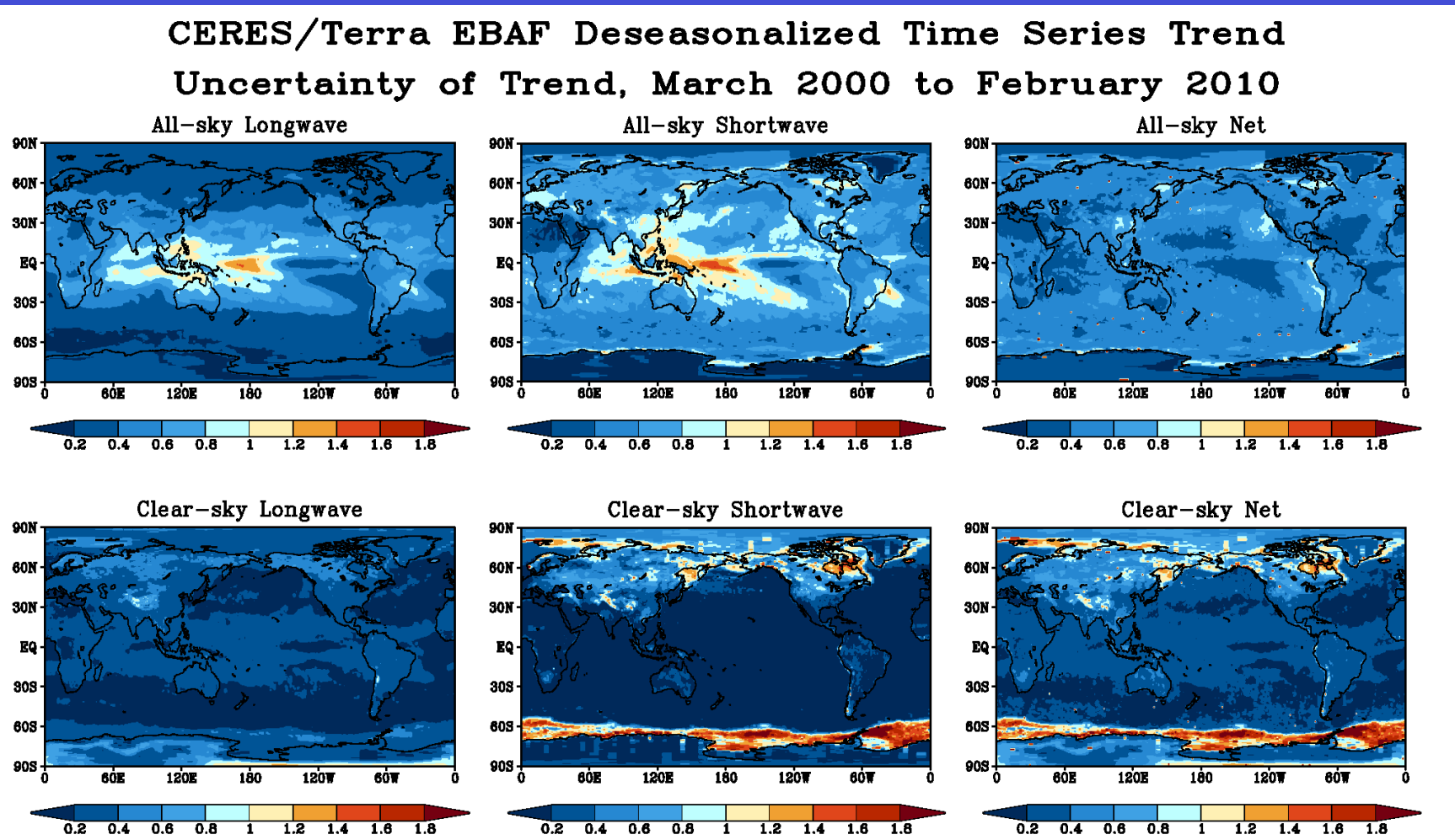
# Regional Trend

CERES/Terra EBAF Deseasonalized Time Series Trend

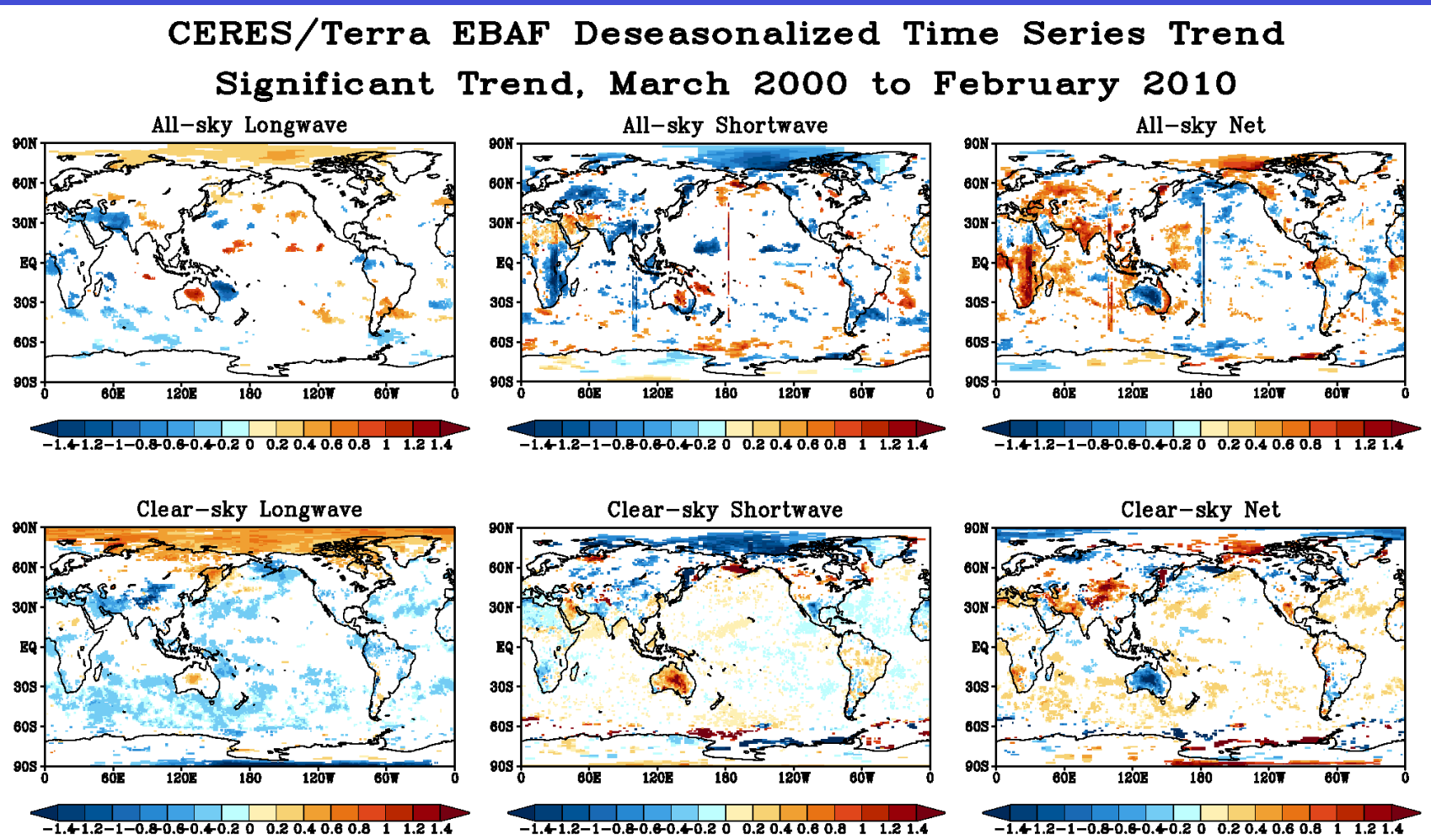
Trend, March 2000 to February 2010



# Regional Trend Uncertainty



# Regional Significant Trend



# Summary

- 10-year of EBAF data shows climatology that are consistent with ERBE and other Radiation budget datasets
- Interannual variability of all-sky LW and SW shows large regional patterns relating to ENSO event
- Large clear-sky SW variability over the southern oceans. Clear-sky Longwave shows large variability over elevated terrains
- No interannual ENSO signal in all-sky Net due to large cancellation between SW and LW; All-sky Net does show strong interannual variability over low cloud regions
- Zonal mean clear-sky net variability between 45N – 45S is dominated by clear-sky longwave variability
- Exploratory trend analysis shows significant changes in the Arctic and over Australia
- Geo artifacts in EBAF data should be removed in order to improve data analysis over the tropics