ERBE/ERBS WFOV Nonscanner Data Update

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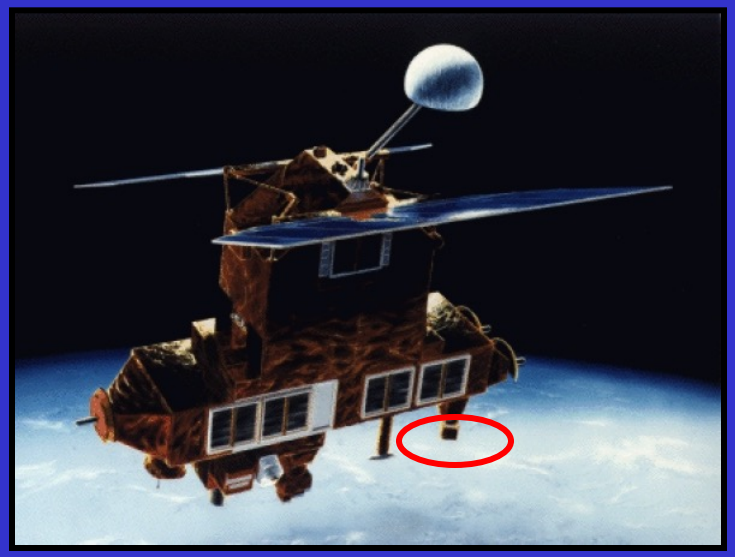
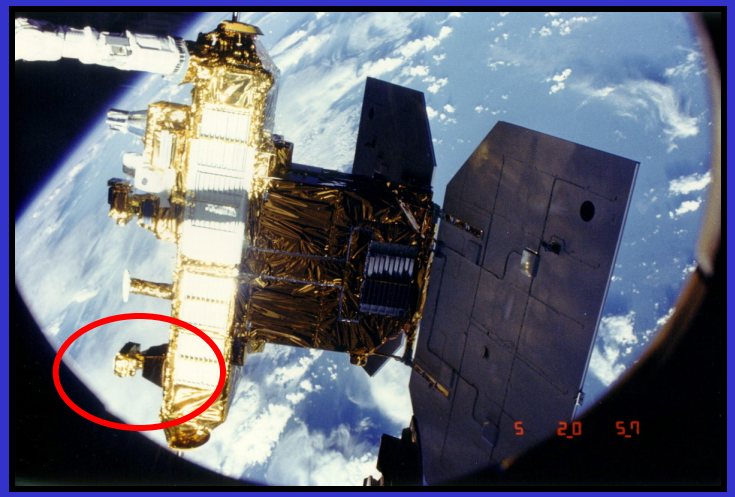
Outline

- Earth Radiation Budget Satellite (ERBS)
- ERBE Nonscanner instrument package
- History of ERBE/ERB WFOV Nonscanner data editions
- Edition4.1 dataset and changes
- Long term time-series comparisons (ERB and OHC)

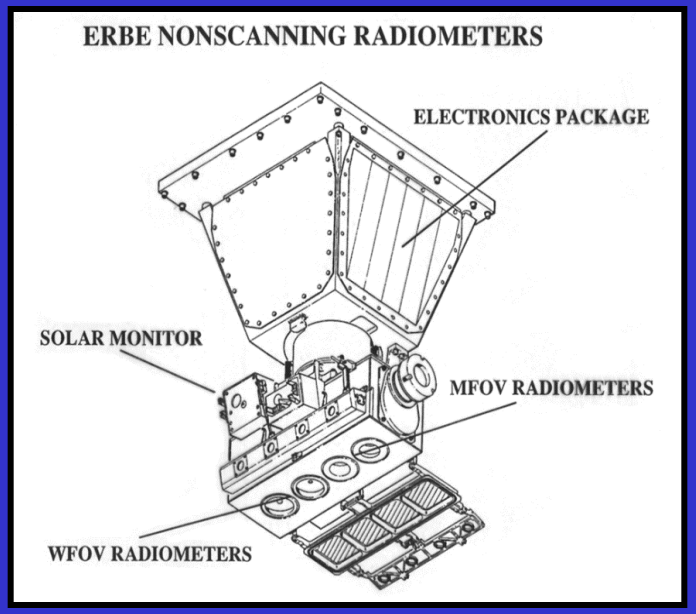
Earth Radiation Budget Satellite (ERBS)

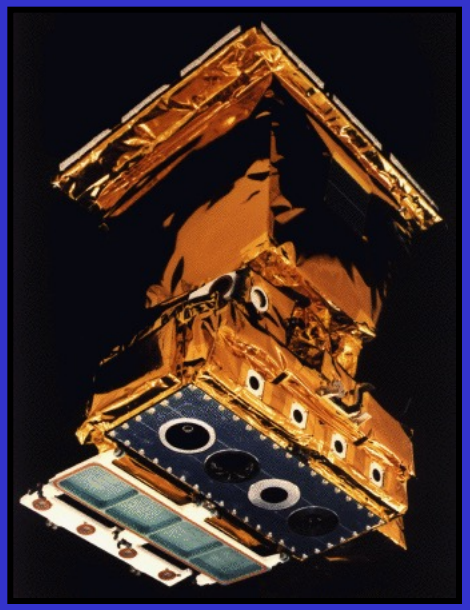




- NASA Earth Radiation Budget Satellite (ERBS) was deployed on 10/5/1984 by the Space Shuttle Challenger
  - Satellite altitude: 610 km
  - Orbit type: 57° inclined orbit
  - Equatorial crossing time: precessed through 24 local hours in ~72 days
- Carried three instrument packages
  - ERBE Scanner
  - **ERBE Nonscanner**
  - SAGE II
- Retired on 10/14/2005 after 21 years and 9 days of service
- Safely re-entered the Earth's atmosphere over the Bering Sea at 11:04 pm EST on 1/8/2023 (R.I.P. ERBS!!)

ERBE Nonscanner Instrument Package

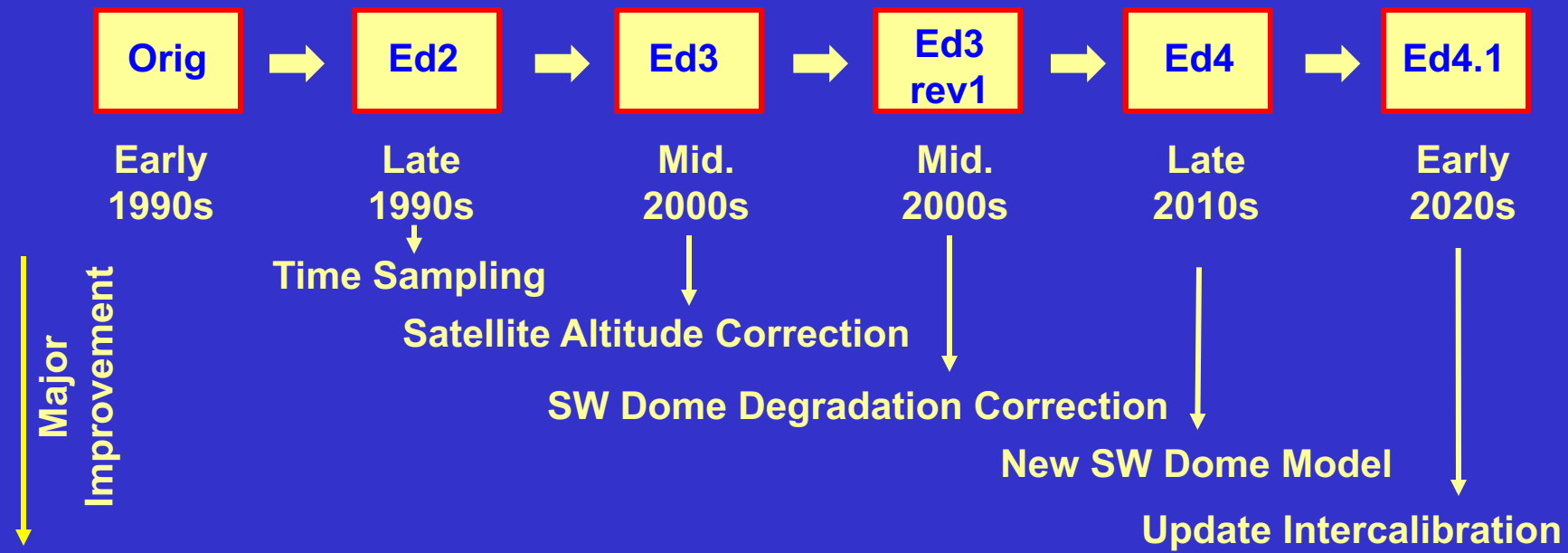




- ERBE Nonscanner instrument package contained (1) Solar Monitor, (2) Medium-field-of-view (MFOV) broadband radiometers (Total, SW), and (3) Wide-field-of-view (WFOV) broadband radiometers (Total, SW)
- Sensor type: Active cavity radiometer
- Stability monitoring: On-board blackbody source, shortwave Tungsten lamps, the Sun, and Deep Space

ERBS WFOV Nonscanner Data Editions

- The ERBE/ERBS nonscanner operated nominally from 11/1984 to 9/1999; giving a high quality calibrated ~15-year all-sky radiation budget (SW, LW, and Net) dataset on a 10°x10° equal-angle grid (Note: no clear-sky data)
- Over the past 30 years, numbers of new science and data quality control procedures had been introduced to the ERBE/ERBS WFOV nonscanner data processing system to improve the quality of this dataset



ERBS WFOV Nonscanner Data Editions (Long Version)

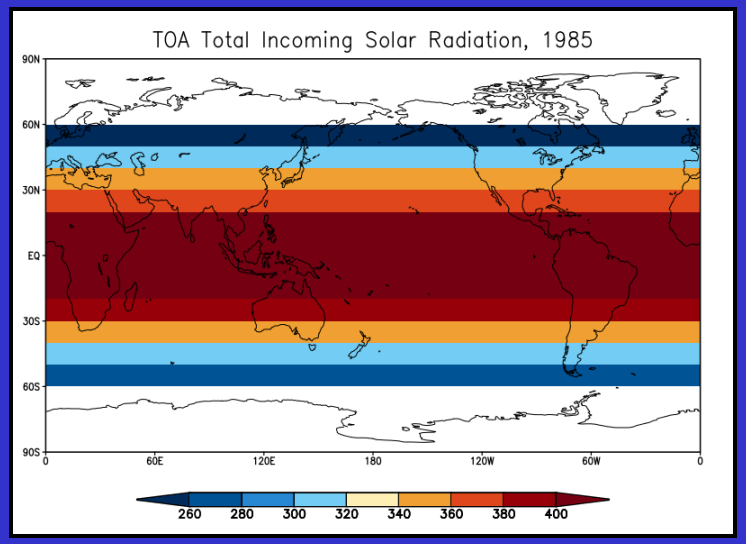
- Original: based on original ERBE Nonscanner data processing system (ERBE NS inversion and ERBE NS Time-space Averaging)
- Edition2: Fixed time-space sampling issues (Monthly mean data only)
- Edition3: Correction for satellite altitude changes
- Edition3rev1: Fixed SW dome degradation issue using wavelength independent corrections, added 36-day cycle and 72-day cycle time-space averaged data to match satellite orbital cycle
- Edition4: Revised SW dome degradation corrections using wavelength dependent models, inter-calibrated* with CERES, provided global mean using 60NS to global correction factors, introduced NetCDF format
- Edition4.1: Improved ERBE to CERES intercalibration*, fixed additional time-space average data quality issues, added ERBS WFOV 1999 data

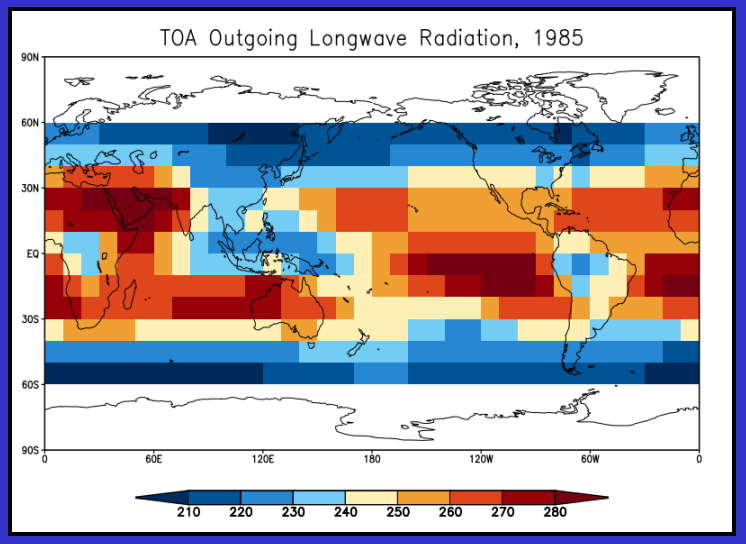
* based on titled WFOV nonscanner data between 1999 and 2002

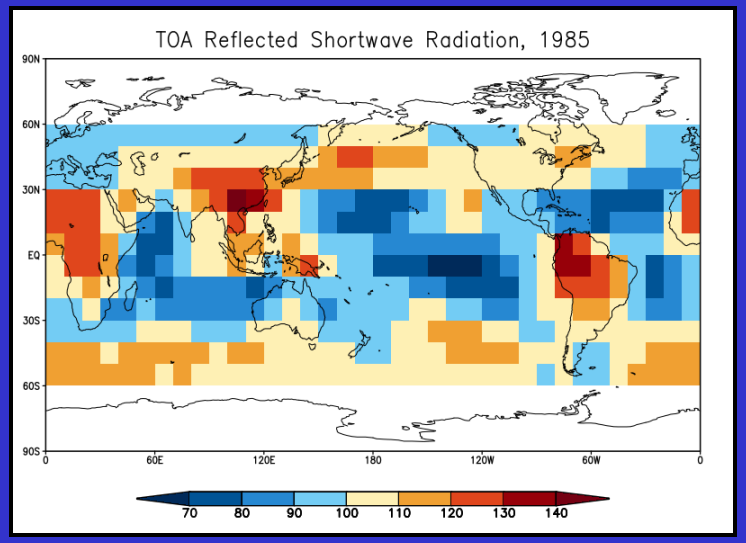
ERBS WFOV Nonscanner Edition4.1

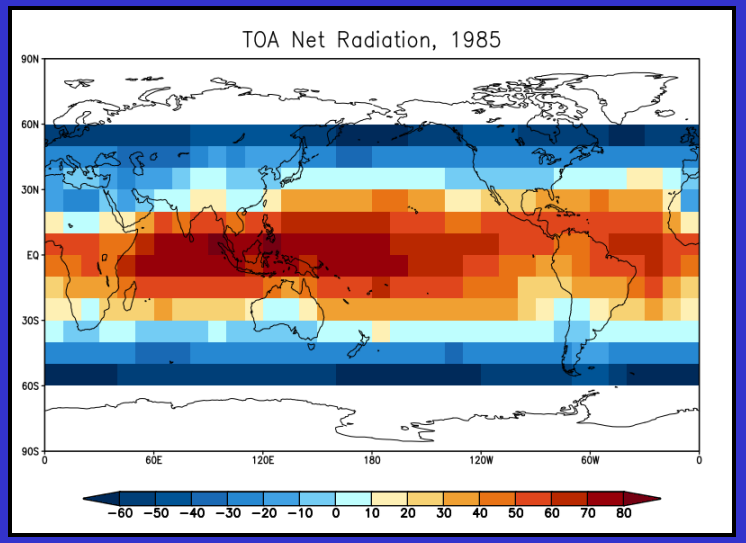
- Time-space averaged data in NetCDF format (no instantaneous satellite footprint data)
- Variables: All-sky TOA Outgoing Longave Radiation, All-sky TOA Reflected Shortwave Radiation, All-sky TOA Net Radiation, and TOA Total Solar Incoming Radiation (No clear-sky data)
- Period: 1985 to 1999
- Types of Data: Gridded 10° x 10° regional data (60°N-60°S) and large-area average time series data (30°N-30°S, 0°-60°N, 0°-60°S, 60°N-60°S, and estimated global)
- Time Resolution: 36-day averages, 72-day averages, annual averages
- Edition4.1 and Edition4 data are available online from NASA ASDC OPeNDAP server (https://opendap.larc.nasa.gov/opendap/ERBE/S10N/)
- Edition4.1 data quality summary is also located online at NASA ASDC (https://asdc.larc.nasa.gov/documents/measures/quality_summaries/ERBS_Ed4.1_DQS.pdf)

Examples of 10° x 10° Regional Data

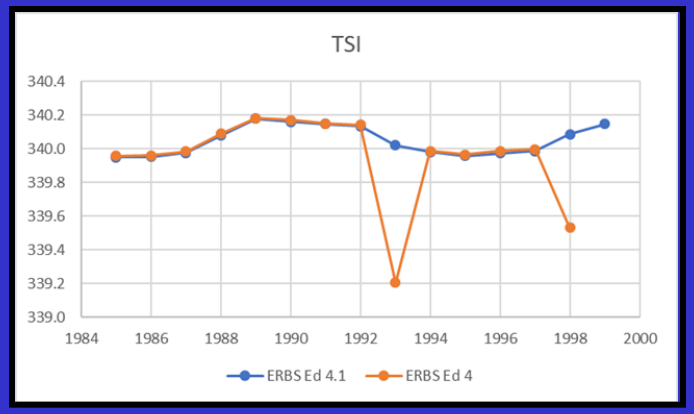


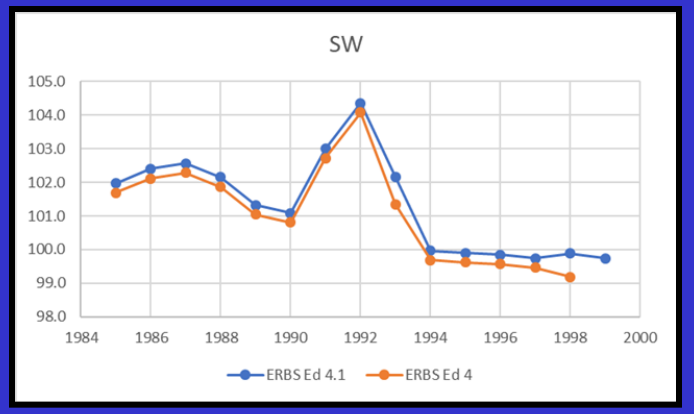


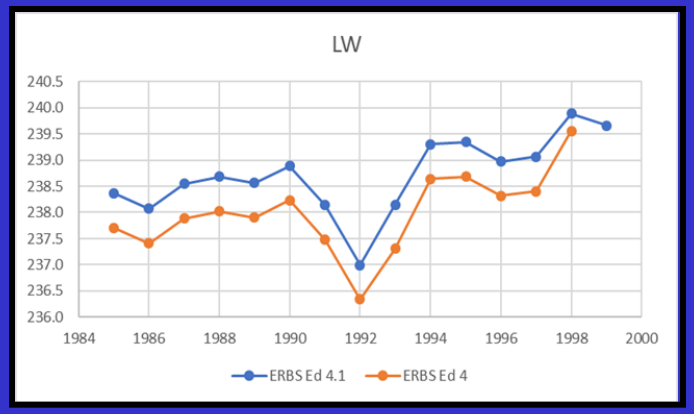


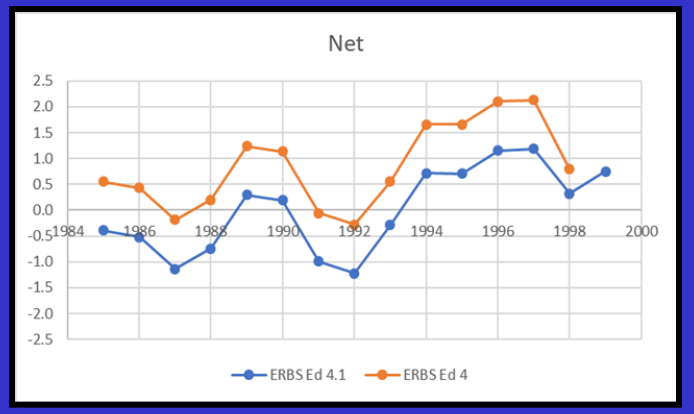


Ed4.1 vs Ed4 Global Annual Time Series









- Improved ERBE to CERES intercalibration; closer to zero net values
- Fixed time-space averaging data quality issues; reduced noises in data
- Added 1999 Data (missing in Edition4)

Ed4.1 vs Ed4 Climatological Mean

Ed4 and Ed4.1 Climatological Global Annual Mean (1985-1998) and Interannual variability

	Edition4.1	Edition4	Ed4.1 minus Ed4
TSI	340.04 (0.17)	339.95 (0.54)	0.09 (0.51)
SW	101.45 (2.88)	101.10 (2.93)	0.35 (0.35)
LW	238.64 (1.41)	237.99 (1.53)	0.65 (0.21)
Net	-0.05 (1.64)	0.85 (1.64)	-0.91 (0.25)

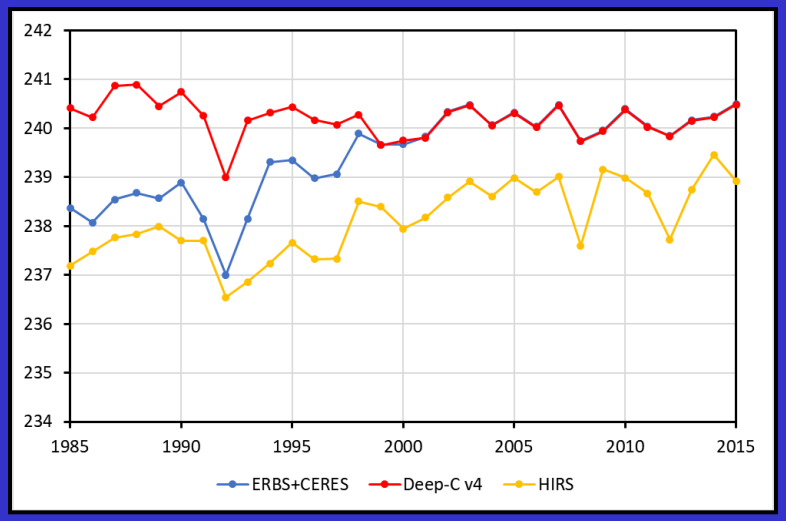
- Ed4.1 TSI is higher by 0.09 Wm^{-2}
- Ed4.1 SW and LW are higher by 0.35 and 0.65 Wm^{-2}, respectively
- The combined changes in Ed4.1 TSI, SW, and LW lower the Ed4.1 Net by 0.91 Wm^{-2}
- Ed4.1 Net is closer to Net zero than Ed4
- Interannual variabilities for TSI, SW, and LW are all smaller in Edition 4.1; less noisy

Radiation Budget Comparisons

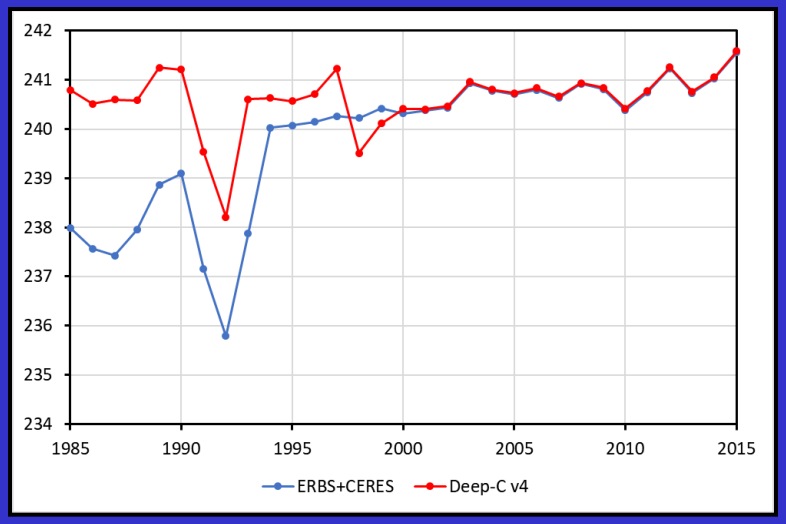
- Data Sets:
  - ERBS WFOV Ed4.1 + CERES EBAF Ed4.1
  - NOAA HIRS OLR Monthly CDR
  - Deep-C v4
- Time Period:
  - 1985-2015 (30-year period)
- Variables:
  - OLR, ASR, and Net

ERB Data Comparisons (OLR, ASR)

Outgoing Longwave Radiation



Absorbed Shortwave Radiation



30-year (1985 to 2015) Summary Statistics

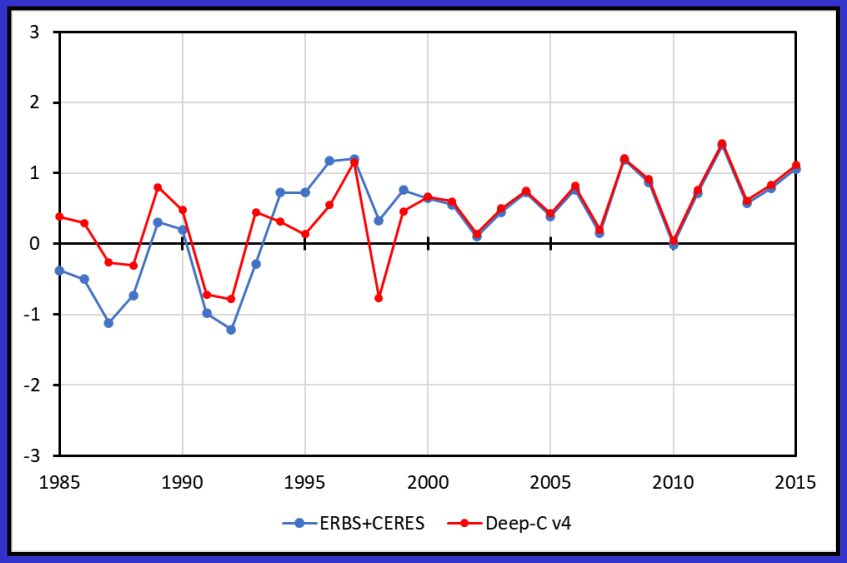
OLR	Mean	2-σ	Slope	95%conf.
ERBS+CERES	239.44	1.80	0.08	0.06, 0.10
HIRS	238.12	1.49	0.06	0.04, 0.08
Deep-C v4	240.19	0.76	-0.01	-0.03, 0.01

ASR	Mean	2-σ	Slope	95%conf.
ERBS+CERES	239.78	2.91	0.13	0.10, 0.17
HIRS	n/a	n/a	n/a	n/a
Deep-C v4	240.61	1.25	0.02	0.00, 0.05

(Mean, 2-σ in W m^{-2}, Slope, 95%conf in W m^{-2} per year)

ERB Data Comparisons (Net)

Net Radiation



30-year (1985 to 2015) Summary Statistics

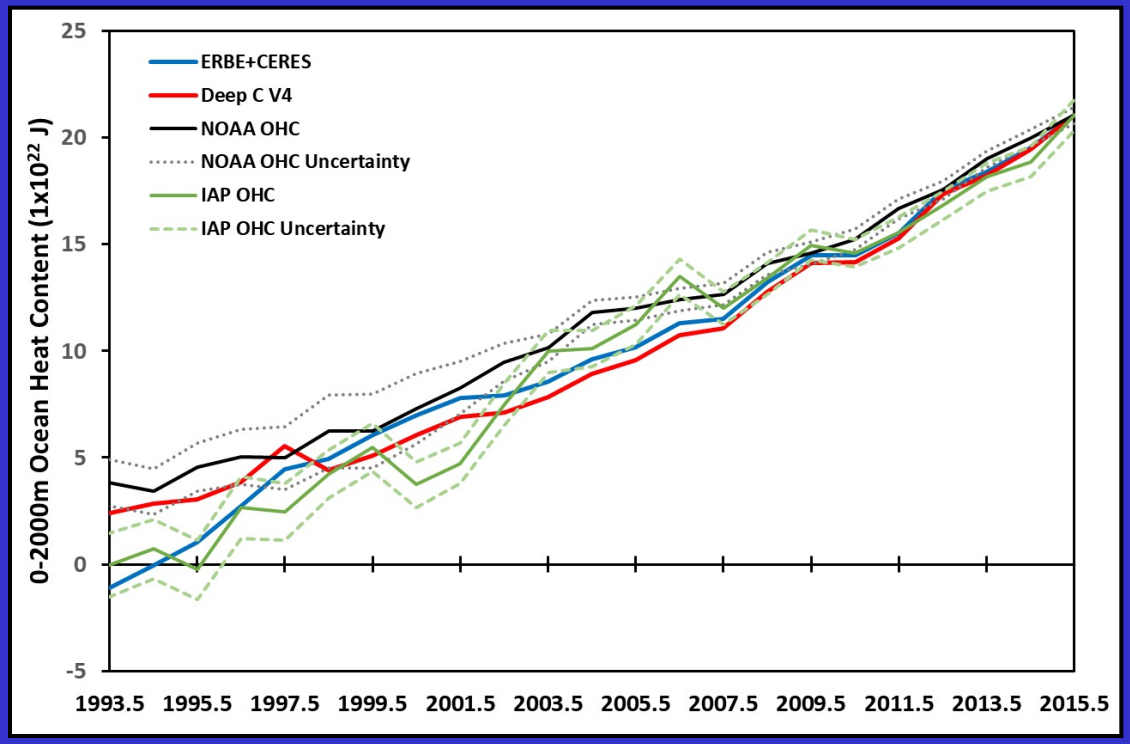
Net	Mean	2-σ	Slope	95%conf.
ERBS+CERES	0.34	1.40	0.05	0.03, 0.07
HIRS	n/a	n/a	n/a	n/a
Deep-C v4	0.43	1.11	0.03	0.01, 0.05

(Mean, 2-σ in W m^{-2}, Slope, 95%conf in W m^{-2} per year)

Ocean Heat Content (OHC) Comparisons

- Method:
  - Turn TOA net radiation data into OHC data through backward integration in time
  - Assuming 90% of the net radiation goes into heating the ocean
- Data Sets:
  - ERBS+CERES calculated OHC
  - Deep-C v4 calculated OHC
  - NOAA OHC data (In situ)
  - IAP OHC data (In situ)
- Time Period: 1993-2015 (22-year period)

Ocean Heat Content Comparisons



- All datasets show a consistent upward tend in ocean heat content (OHC) over time; indicating a warming world
- Total cumulation ~20×10^{22} J of energy over a 22-year period (1993-2015)
- Earlier OHC data have larger sampling uncertainty than recent AGRO data

Summary

- Discussed ERBS satellite mission and ERBE WFOV Nonscanner instrument package
- Provided history of ERBE/ERBS WFOV data editions and improvements
- Discussed the latest Edition4.1 data and their impacts on OLR, RSR, Net, and incoming solar radiation; changes driven mostly by updated intercalibration values
- Long-term 30-year comparisons with limited radiation datasets show good agreements
- However, small level shift in the WFOV OLR and RSR values after the 1993 satellite battery anomaly event may require additional corrections
- Comparisons of OHC show very good agreements among datasets with an upward tend over the 1993-2015 period; indicating a warming world
- Plan: one more final Nonscanner data update to fix remaining issues