

22 Years of Hyperspectral Infrared Satellite Observations: Creating Climate Data Records and Examining Trends in Integrated Nadir Longwave Radiance (INLR), and Outgoing Longwave Radiation (OLR)



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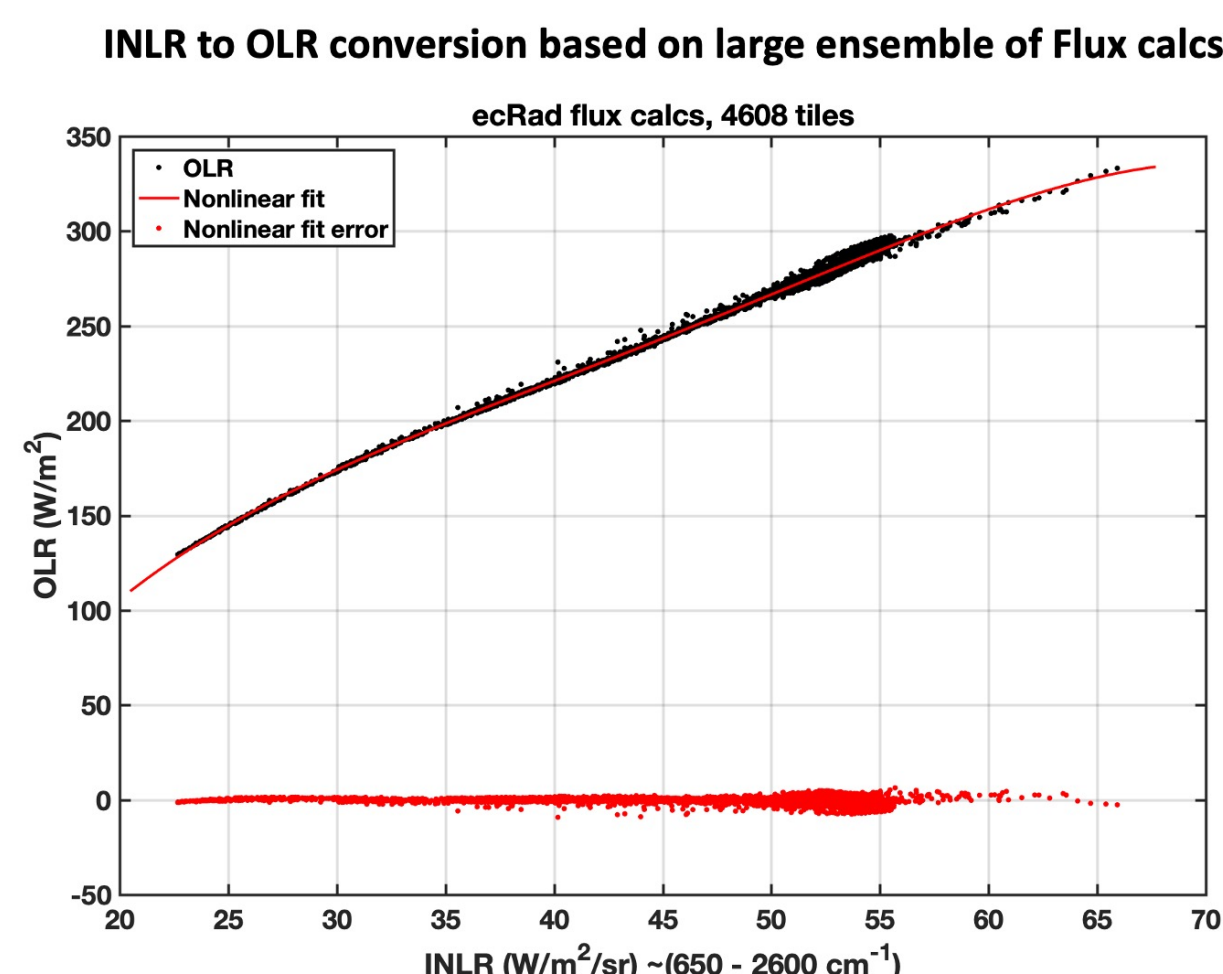
Abstract: Starting with the Atmospheric Infrared Sounder (AIRS) in 2002 and continuing with the Cross-track Infrared Sounders (CrIS) on S-NPP and the JPSS satellites, we now have 22 years of measurements of top-of-atmosphere infrared spectral radiance from the 1330 orbit. This poster summarizes recent, preliminary efforts to create and validate the radiance products, focusing on the spectral and radiometric traceability, accuracy and stability needed for climate products and long term studies, and presents resulting trends in Integrated Nadir Longwave Radiance (INLR) and Outgoing Longwave Radiation (OLR).

Process for computing INLR and Global OLR from AIRS and CrIS radiances

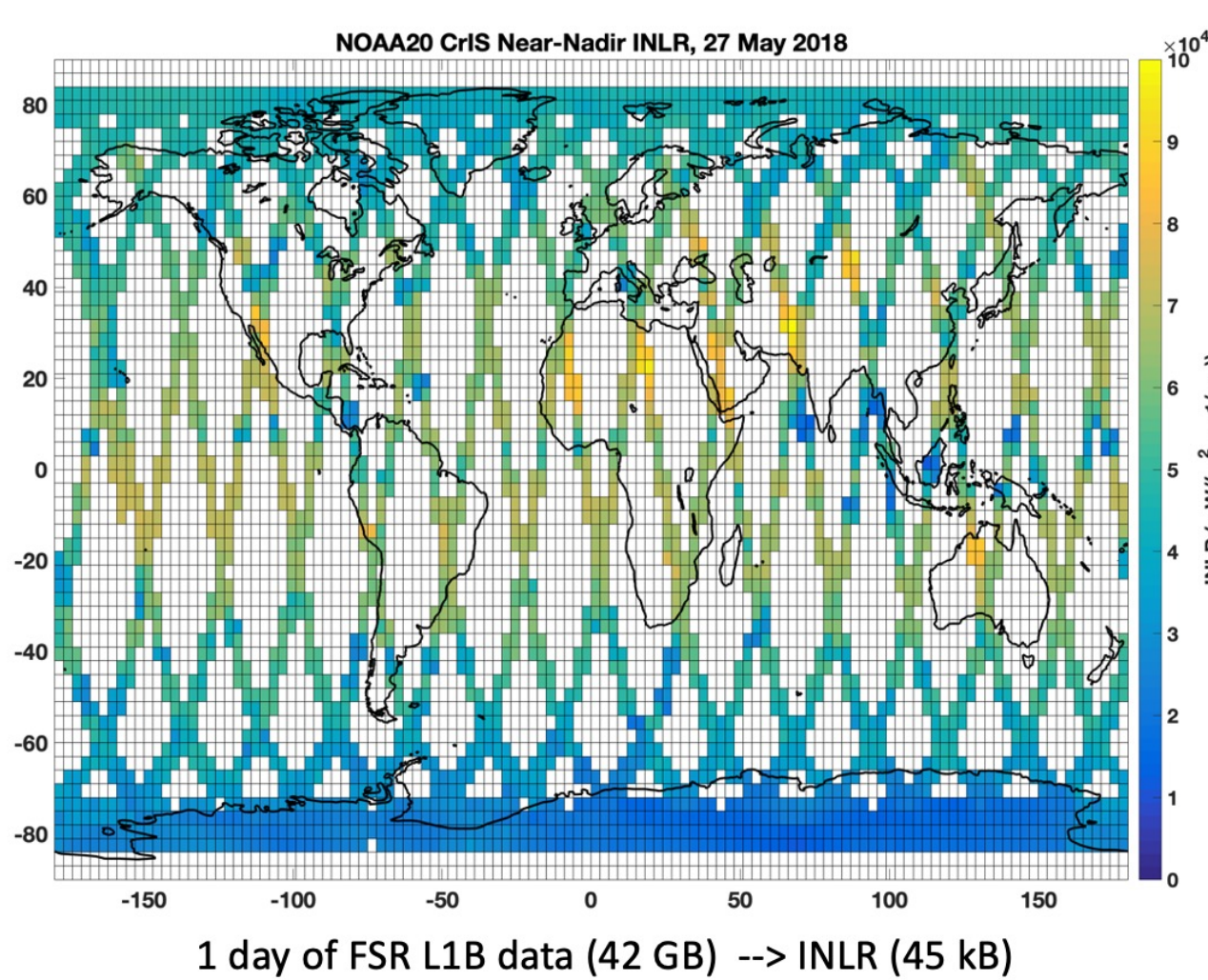
- For each day, select near nadir observations (AIRS cross-track scan indices 43 to 48, CrIS cross-track FORs 15 and 16)
- Compute the Integrated Nadir Longwave Radiance (INLR) (i.e. the sum of all channel radiances) for each spectrum
- Compute and store statistics of the INLR values on a 3x3 degree lat/lon grid
- Compute 16 day averages
- Compute Global averaged INLR (combining all Longitudes, cosine weighting by Latitude)
- Apply empirically determined static adjustment factors (scale and offset to global INLR values) to account for differences due to (1) NSR vs FSR CrIS spectral resolution, (2) AIRS vs CrIS spectral resolution and coverage, and (3) AIRS vs SNPP CrIS vs JPSS-1 CrIS calibration differences.
- Combine Global INLR values into one time series (AIRS from 9/6/2002 to 12/31/2012, SNPP CrIS from 1/1/2013 to 12/31/2019, and JPSS-1 CrIS from 1/1/2019 to 8/11/2024)
- Apply an empirical multiplicative factor to convert from INLR to W/m^2 , and then convert to total (spectrally) OLR using a regression based on a large ensemble of spectral Flux calculations.

Data used

- NASA Aqua AIRS L1C v6.7
- NASA SNPP and JPSS-1/NOAA-20 CrIS L1B v3.0.1
- CERES EBAF TOA Ed 4.2 2000/03 - 2024/07, global and regional (1x1deg)
- CERES SSF 1deg Month Aqua MODIS Ed 4.1 Subset 2002/07 - 2024/05

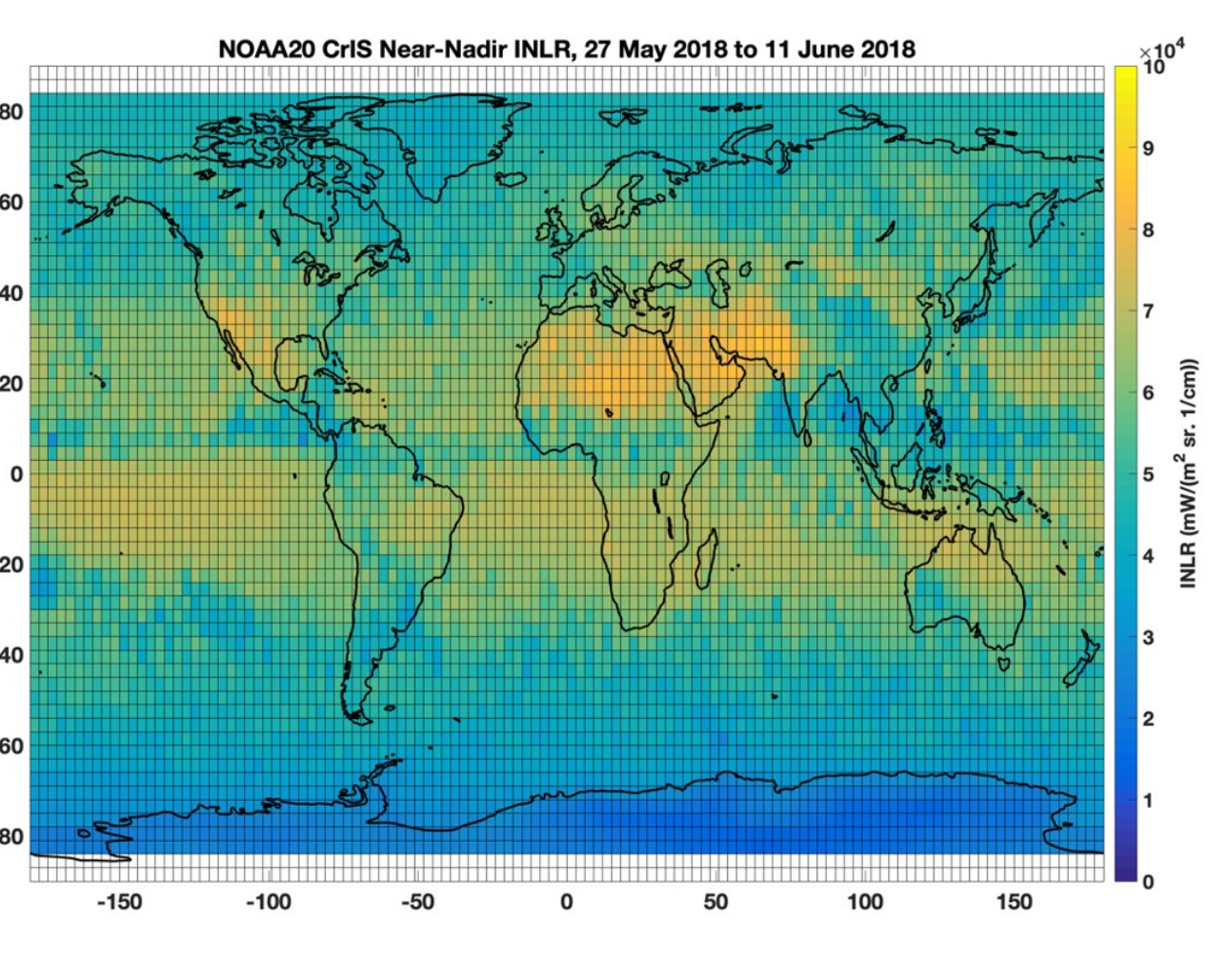


One day of NOAA-20 INLR on 3x3deg grid

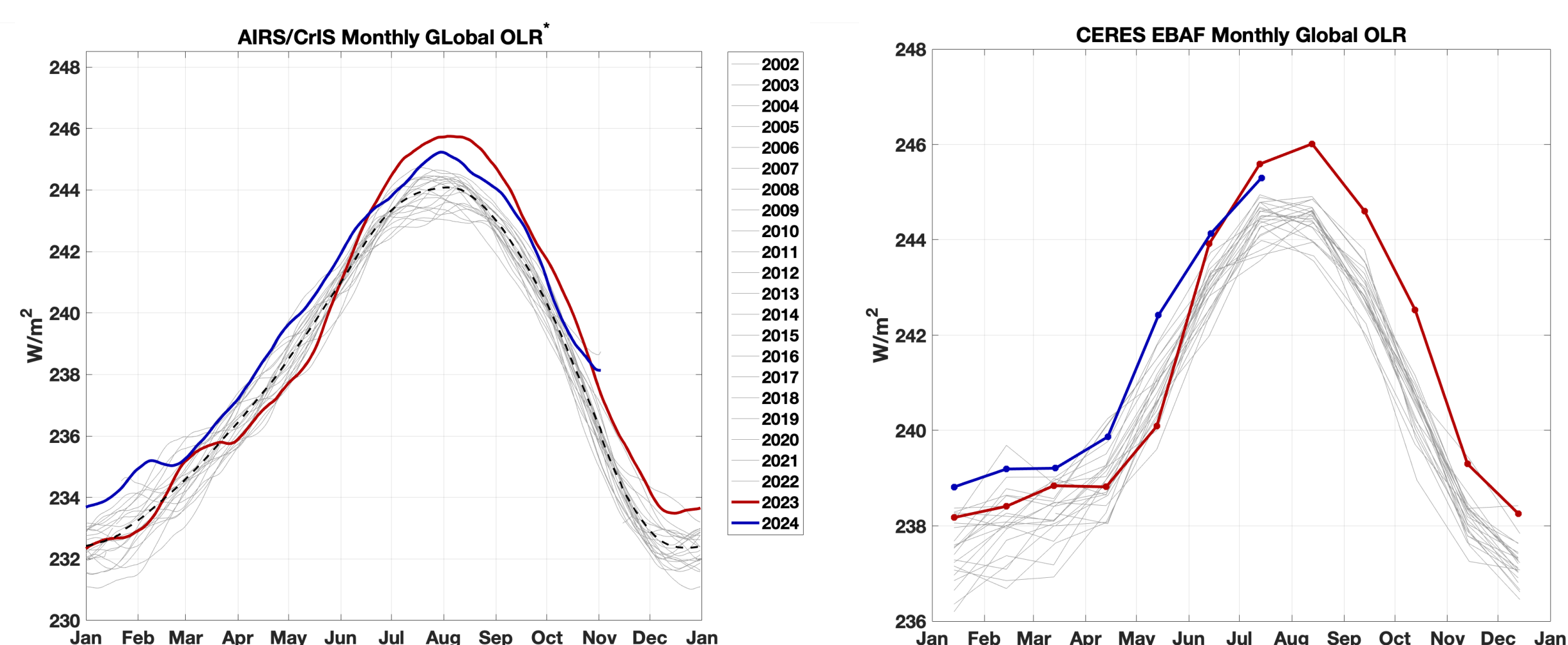


1 day of FSR L1B data (42 GB) -> INLR (45 kB)

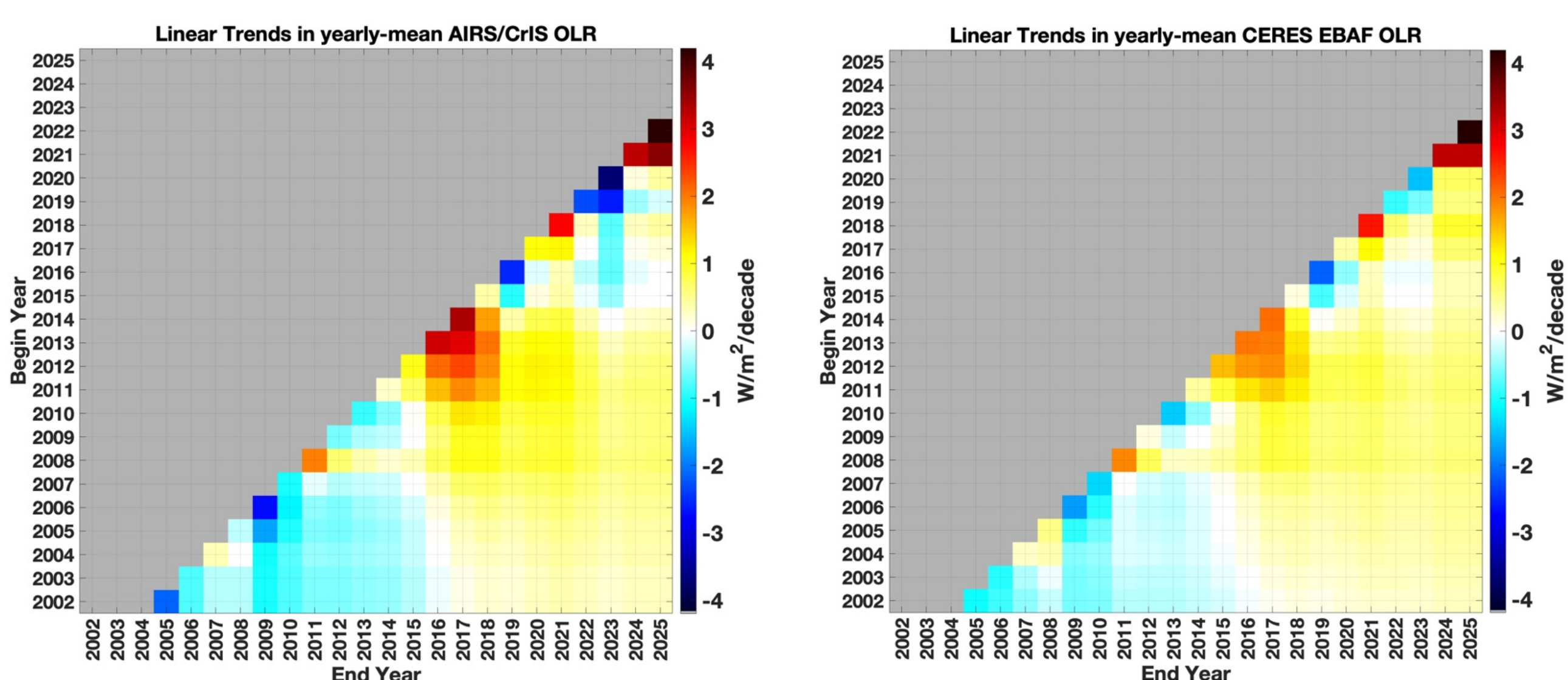
16 day mean of NOAA-20 INLR on 3x3deg grid



Yearly patterns of Global OLR with 2023 and 2024 highlighted



Trends for range of begin and end years



HS and CERES show similar trends on short and longer scales

Motivation:

How We Know that Global Warming is Accelerating and that the Goal of the Paris Agreement is Dead

10 November 2023

James Hansen, Pushker Kharecha, Norman Loeb, Makiko Sato, Leon Simons, George Tselioudis, and Karina von Schuckmann

The drive for global temperature change is Earth's energy imbalance (EEI), the difference between the energy Earth receives from the Sun and energy Earth reflects and radiates back to space. We have good measurement of EEI today based on precise satellite data for change of reflected and emitted radiation calibrated by decadal ocean ...

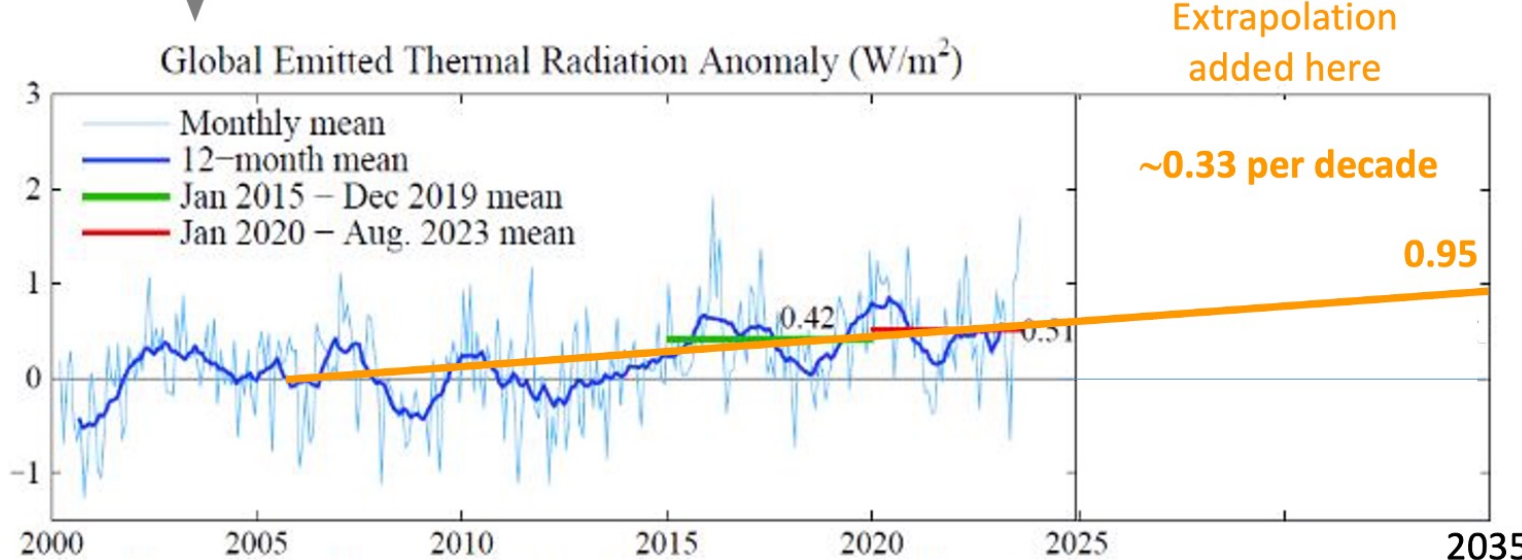
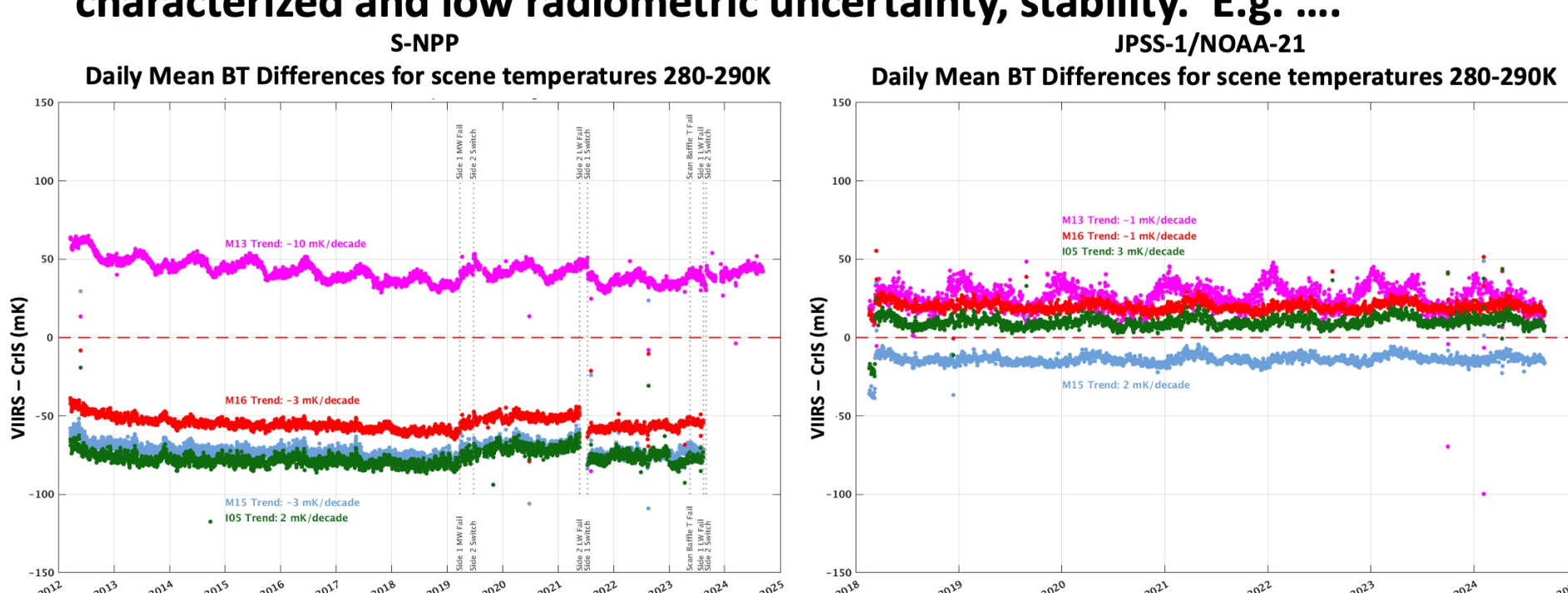


Fig. 6. Global emitted thermal radiation (W/m^2) relative to mean of the first 120 months of CERES data. CERES data are available at <https://ceres.larc.nasa.gov/data/>

➤ Estimate OLR from the hyperspectral data while preserving its well characterized and low radiometric uncertainty, stability. E.g.



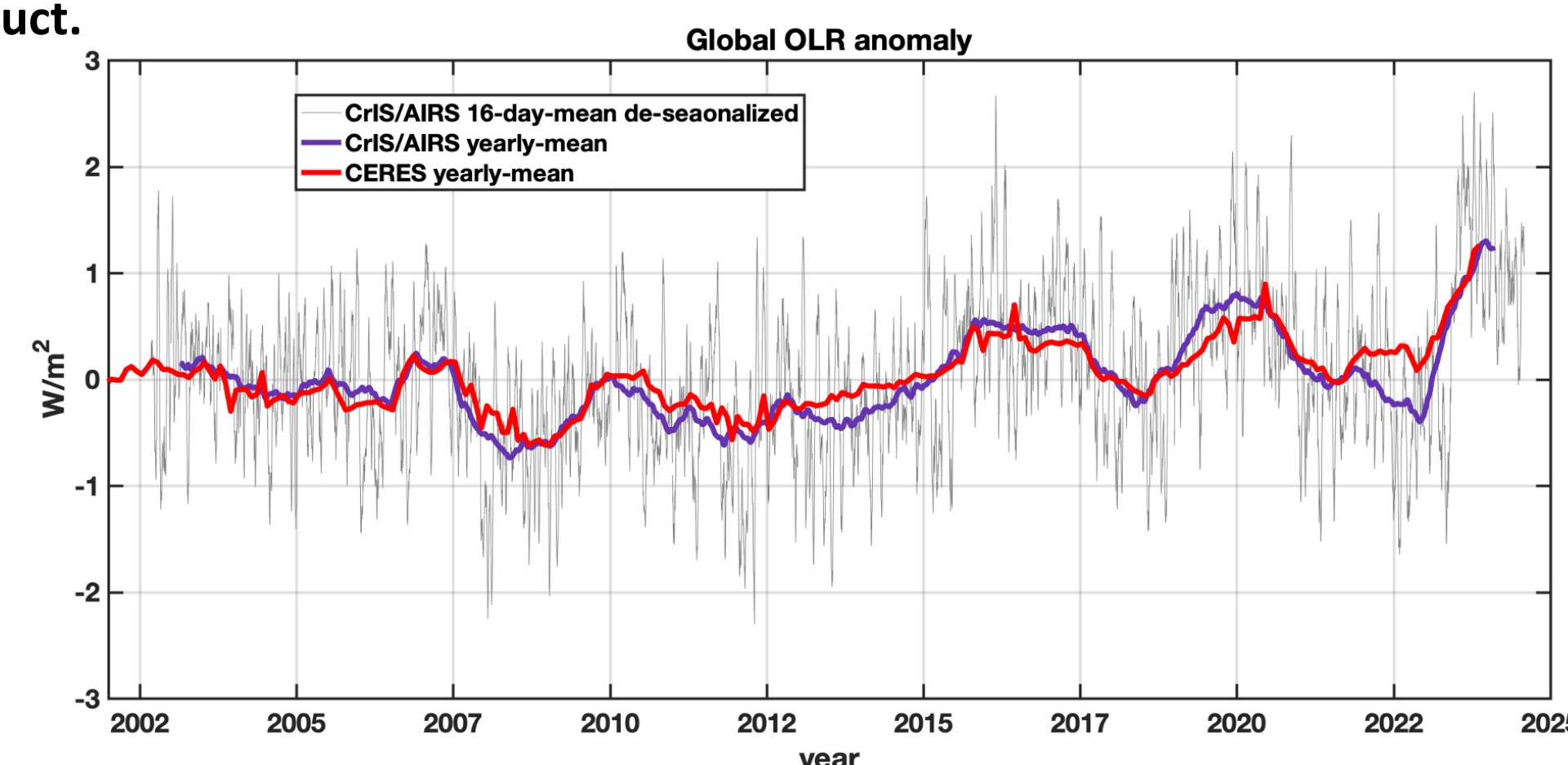
Using the temperature to flux relationship, the fractional uncertainty in flux is $(\delta F/F) = T/4 \text{ dT}$. CrIS stability of 10 and 30 mK/decade corresponds to OLR trend uncertainties of ~0.04 and ~0.12 $W/m^2/decade$.

Summary

- Integrated (spectrally) Nadir Longwave Radiance (INLR) observations from AIRS and CrIS were combined to produce a long term time series on a 3x3deg spatial grid
- OLR was estimated from INLR using pre-computed ensembles of radiance and spectral flux
- A global AIRS/CrIS OLR time series was produced and compared to CERES

Preliminary Conclusions

- The long term global OLR time series from AIRS and CrIS agrees very well with CERES, with both showing a significant positive trend over the past decades, and similar short term behavior.
- INLR from AIRS and CrIS shows very similar anomaly patterns as OLR, but with very well characterized and small uncertainties, and can be considered as a new and valuable climate product.

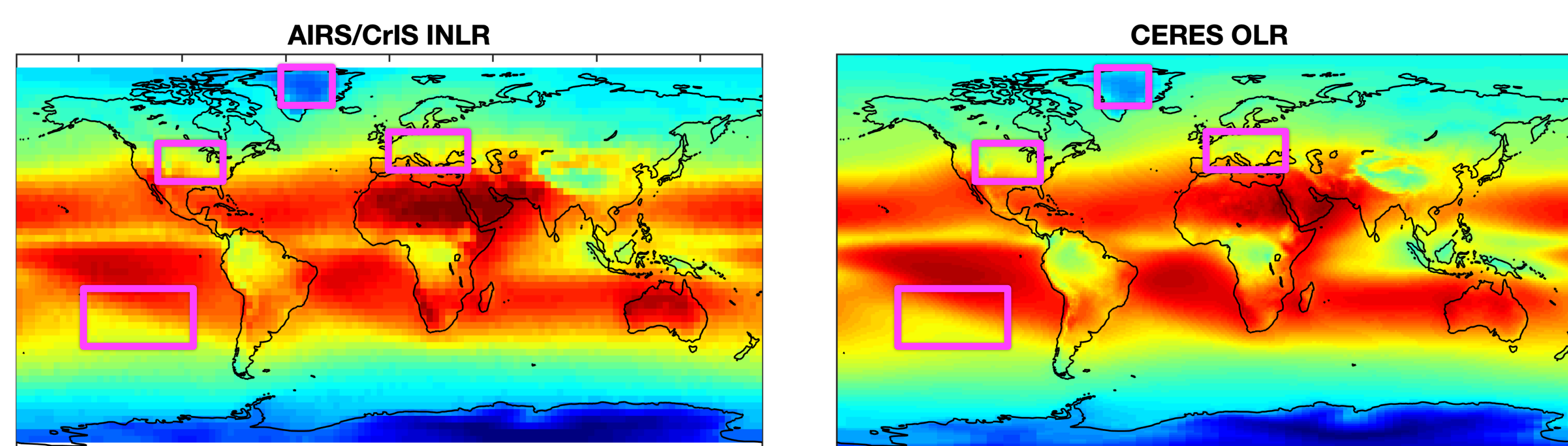


2005-2024 Trend: CrIS/AIRS 0.33 $W/m^2/decade$ CERES 0.35 $W/m^2/decade$

➤ Very good agreement in anomalies/trends measured by CrIS/AIRS and by CERES

- Global INLR from CrIS/AIRS shows very similar anomalies as CERES OLR ... INLR as a climate variable
- Regional trends/anomalies computed from CrIS/AIRS INLR shows very similar patterns as CERES OLR

Example Regional INLR and OLR trends/anomalies



Yearly Means, Percent Difference from 2005-2023 mean:

