Observational Evidence of Increasing Radiative Forcing in CERES

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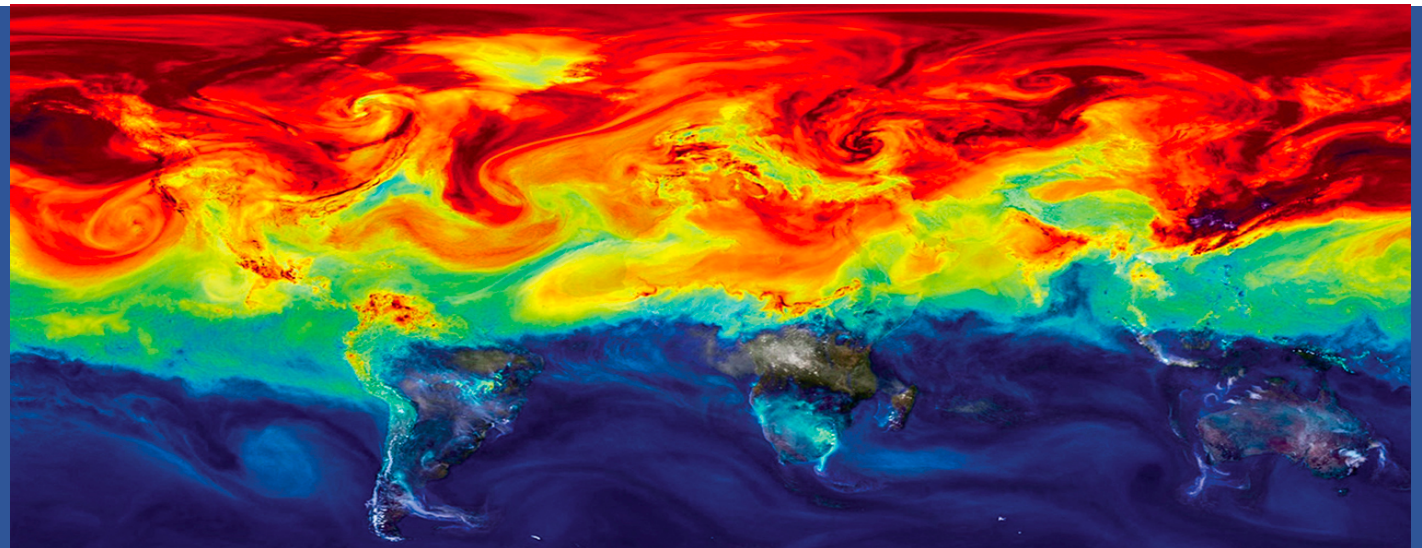
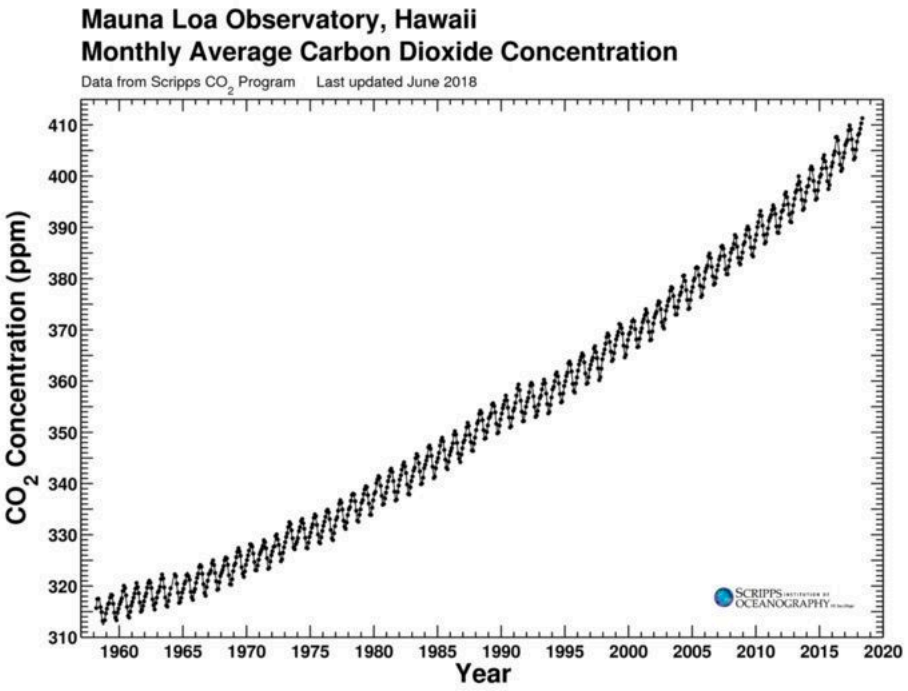
Fall 2020 CERES STM, September 16, 2020

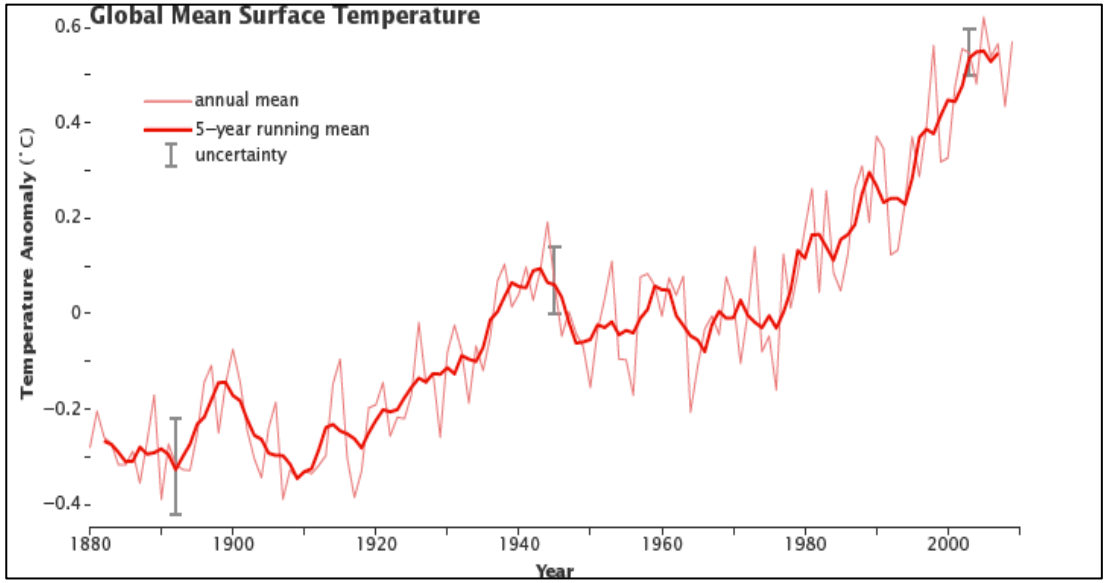


NASA GSFC

The Basics of Global Warming

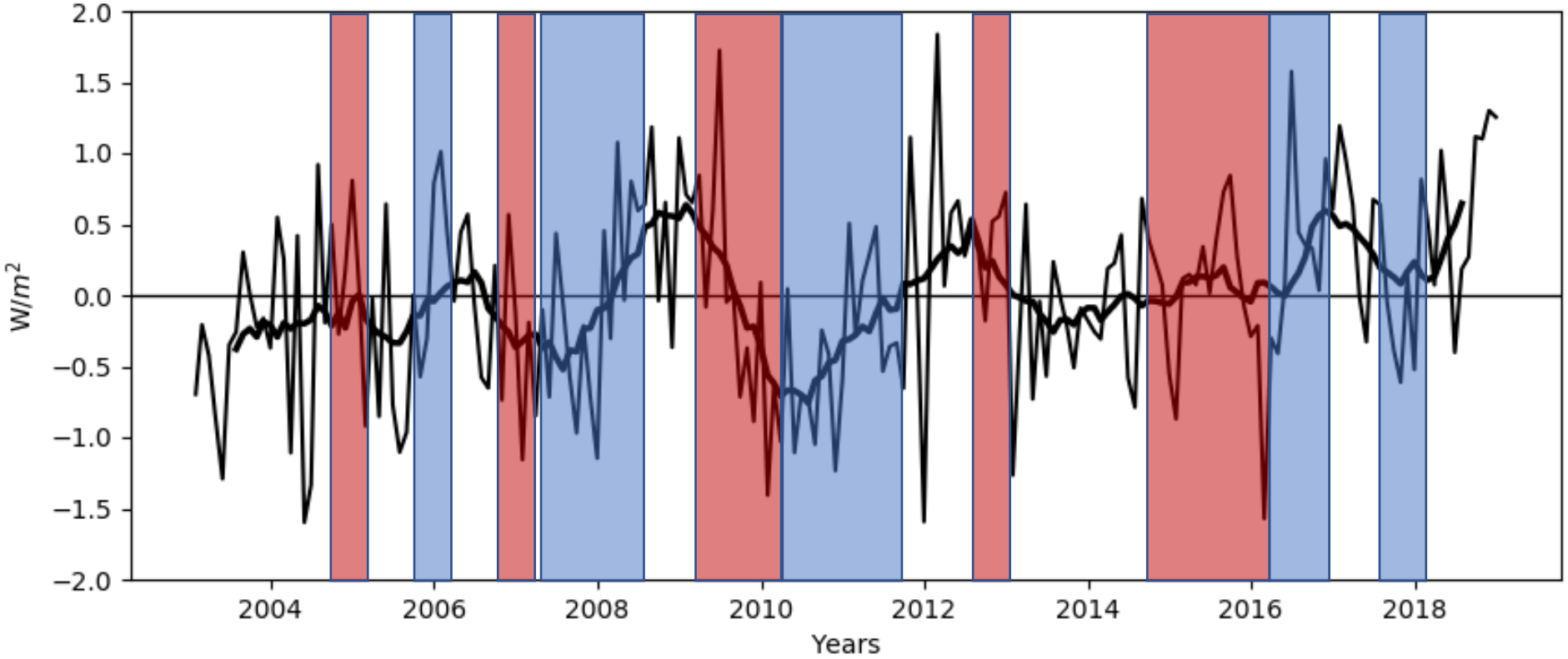


Radiation



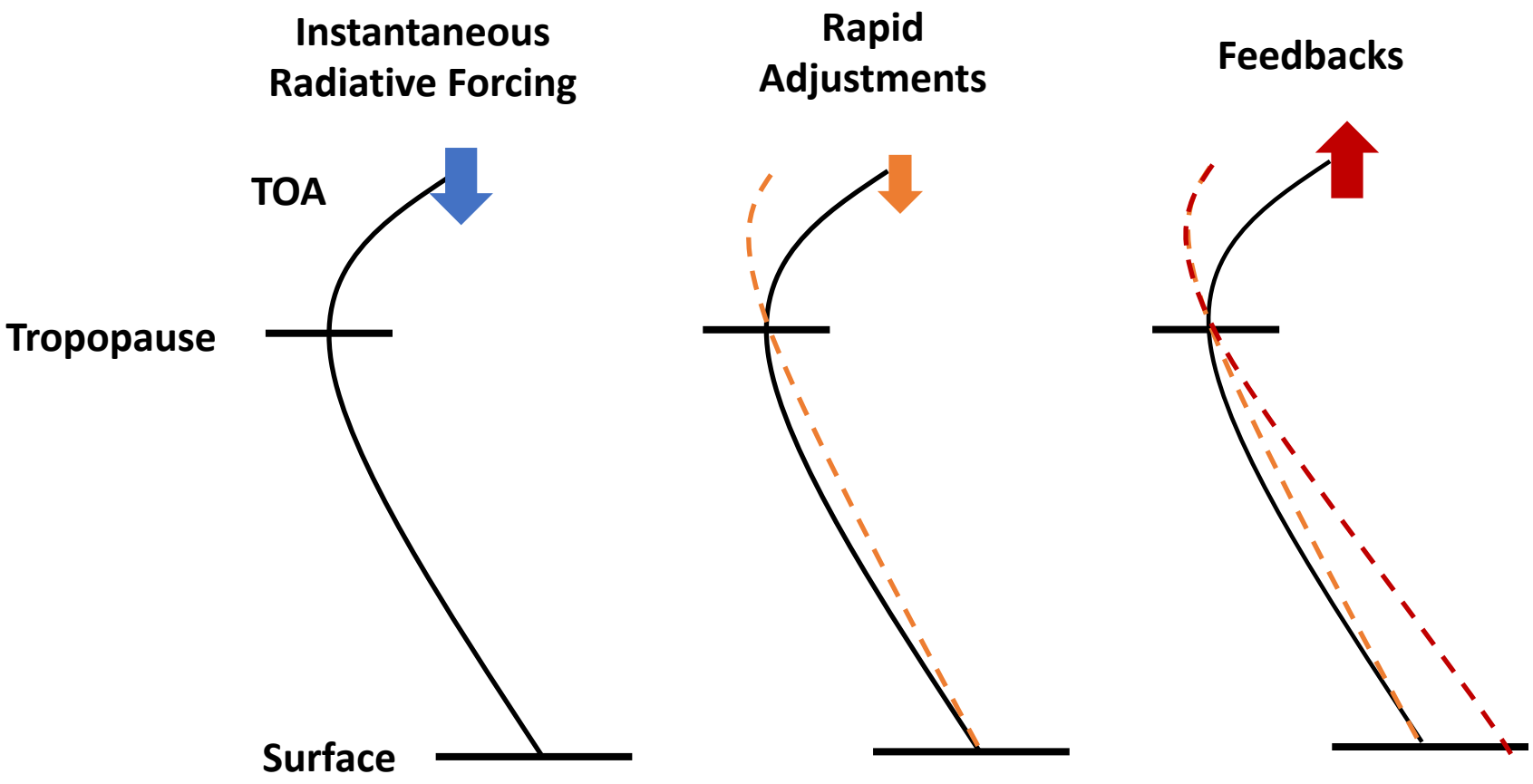
NASA Earth Observatory

Top-of-Atmosphere
CERES Net Radiative Flux Anomalies



Net = Longwave (LW) + Shortwave (SW)

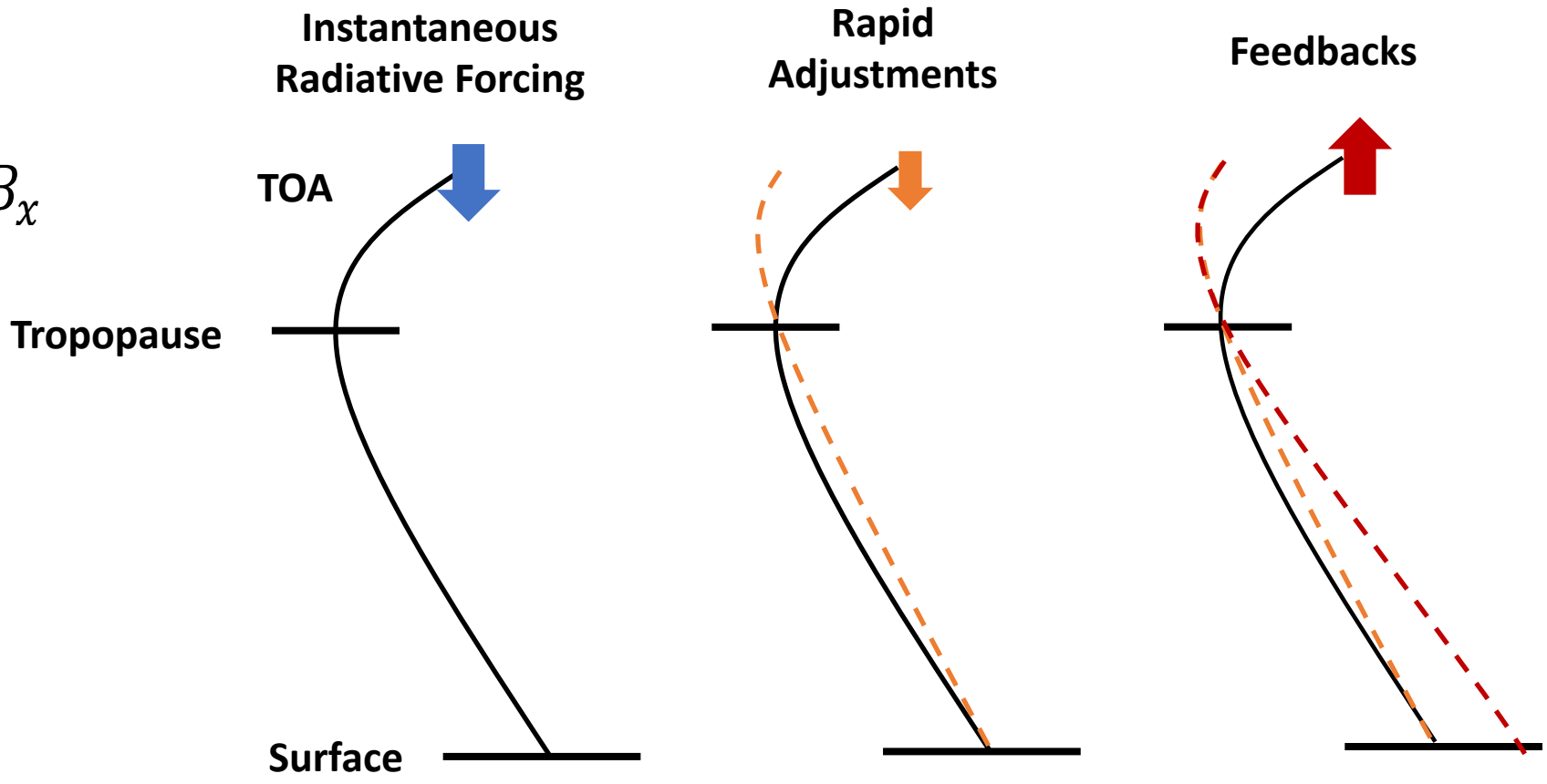
Forcing-Response Framework



Forcing-Response Framework

$$dQ = IRF + \underbrace{\sum ADJ_x + \sum FB_x}$$

$$dQ = IRF + \sum CR_x$$



Diagnosing Radiative Responses with Kernels

Variable	Source
Temperature (T)	AIRS V6 L3
Specific Humidity (q)	AIRS V6 L3
Surface Albedo (a)	CERES-EBAF Ed4.1
Clouds (C) [Net Radiative Fluxes]	CERES-EBAF Ed4.1
Aerosol Forcing	MERRA2
GHG Forcing	NOAA-ESRL

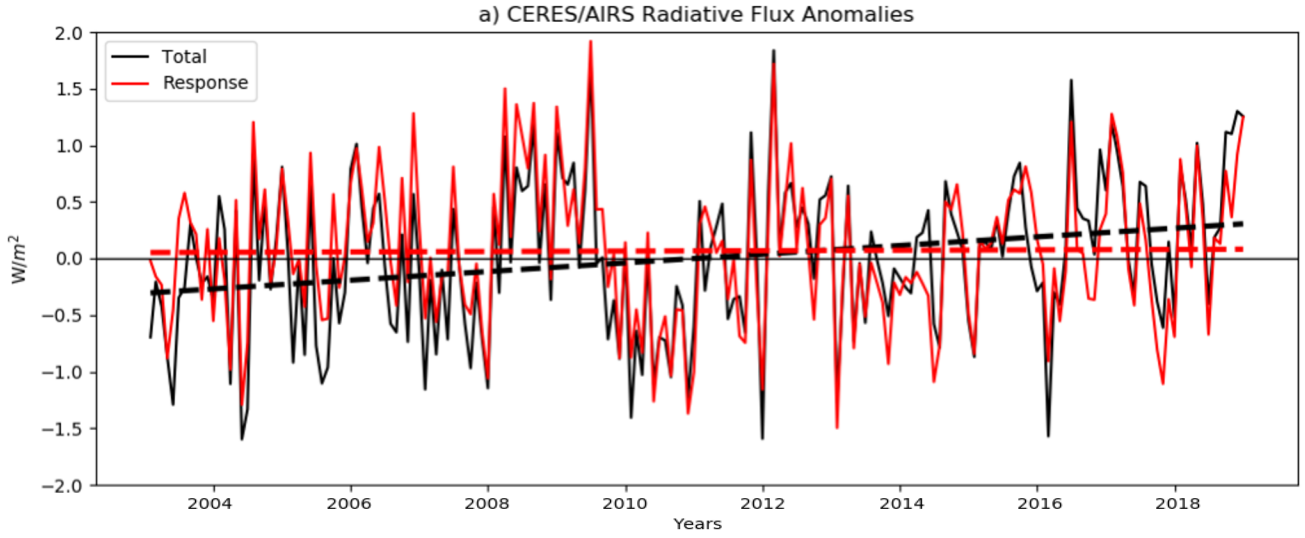
$$IRF = dQ - \sum CR_x$$

$$CR_x = \frac{\delta R}{\delta x} dx$$

Radiative Kernel

$$x = T, q, a, C$$

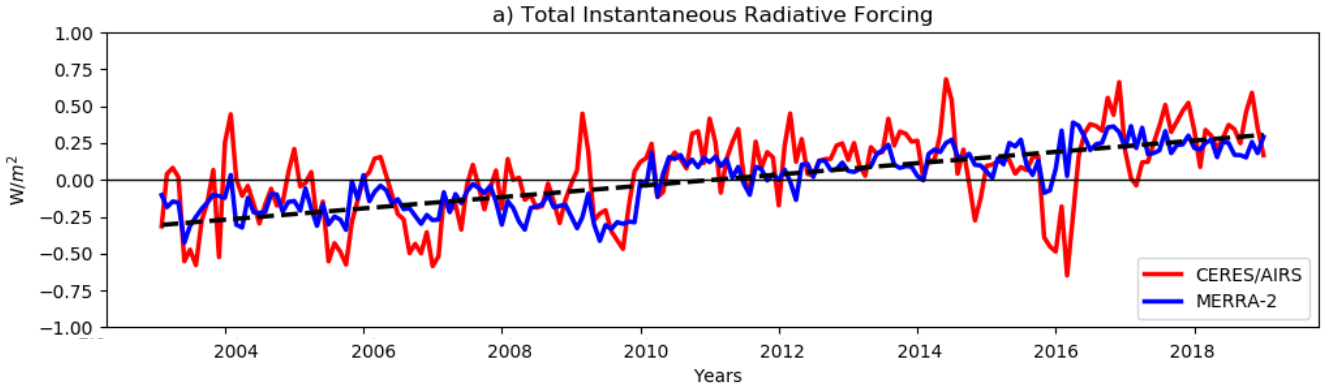
TOA Radiative Flux Anomalies



Total trend = 0.038 +/- 0.02 W/m²/Year

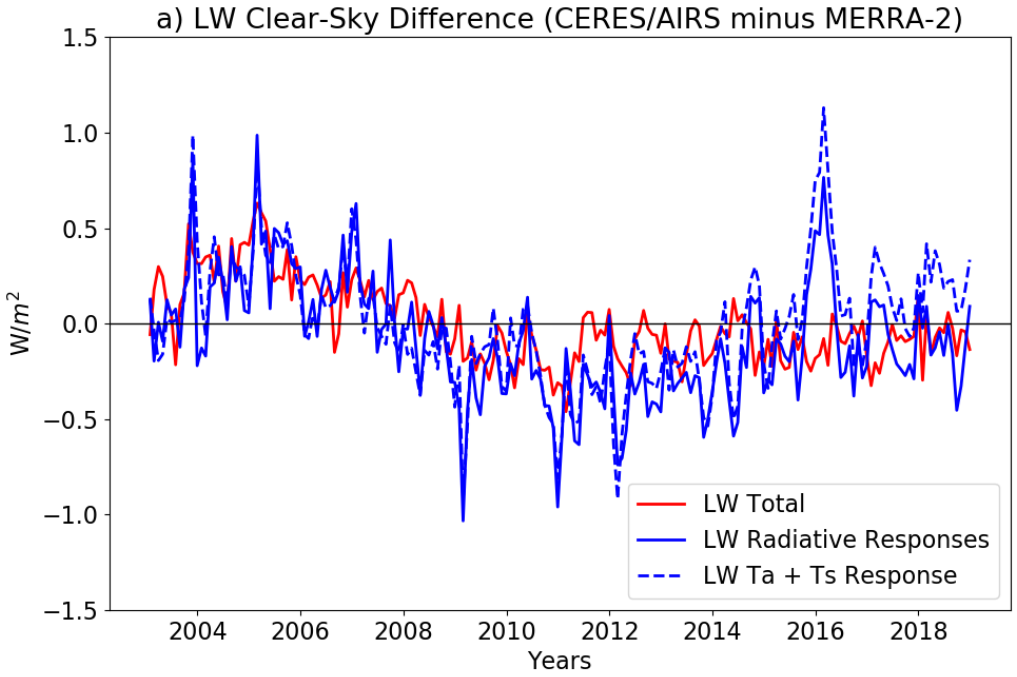
Radiative Response trend = 0.002 +/- 0.02 W/m²/Year

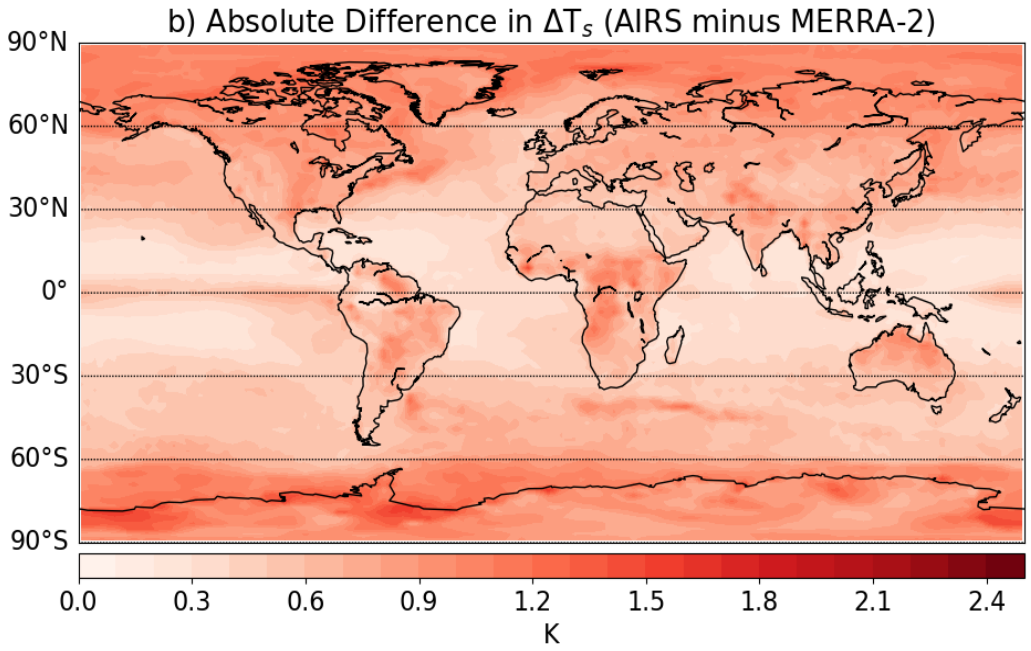
Instantaneous Radiative Forcing



0.53 +/- 0.11 W/m^2

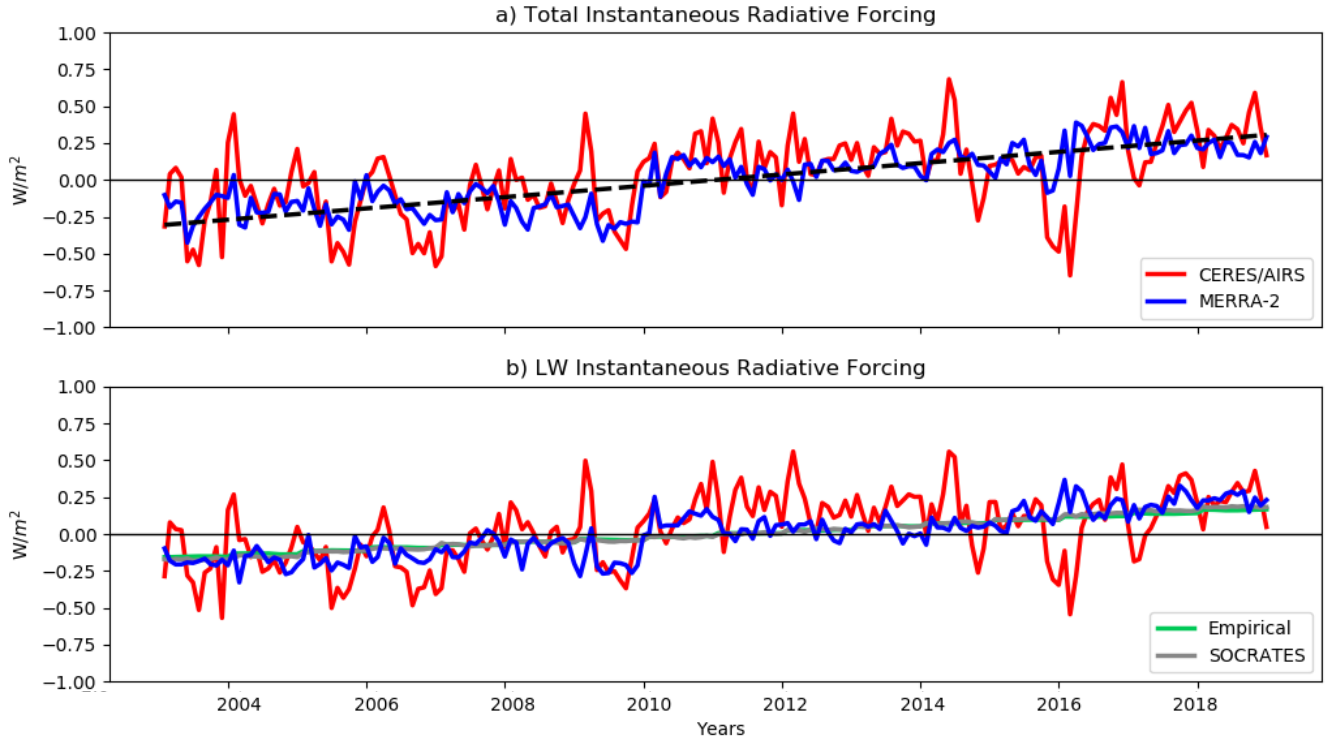
Inconsistency in short-term variability





IRF = Total Radiation – Radiative Responses

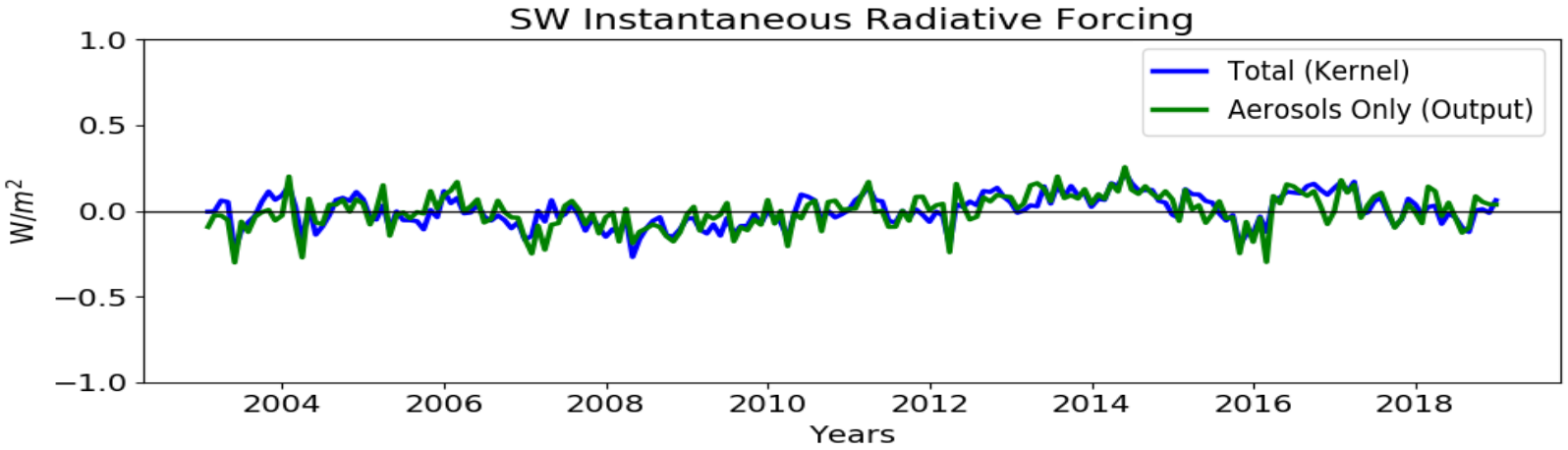
Instantaneous Radiative Forcing



0.53 +/- 0.11 W/m^2

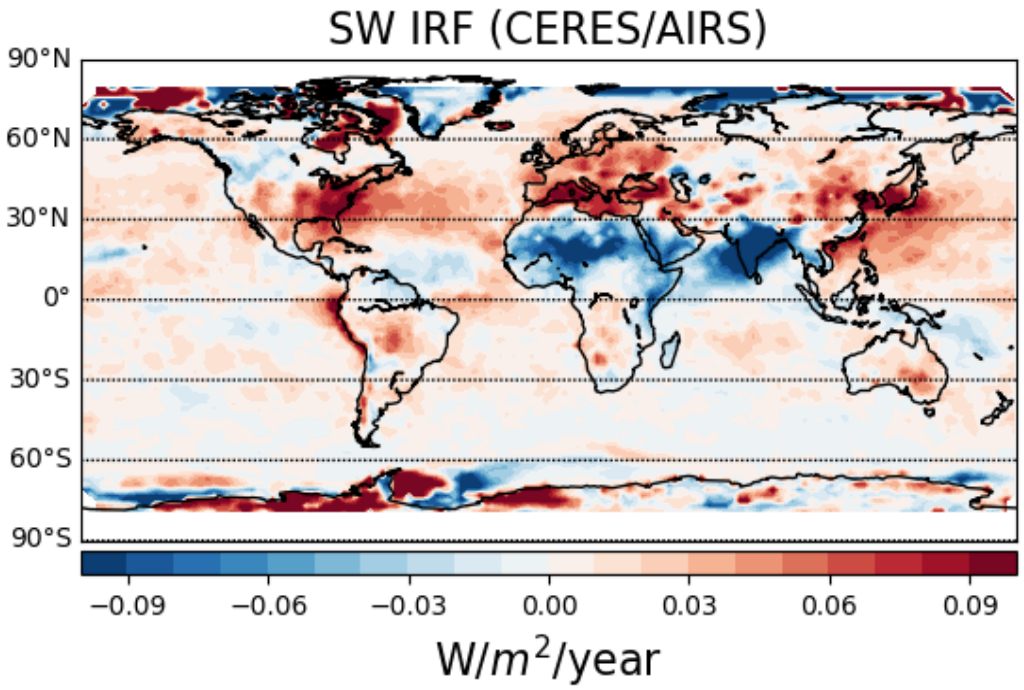
0.43 +/- 0.1 W/m^2

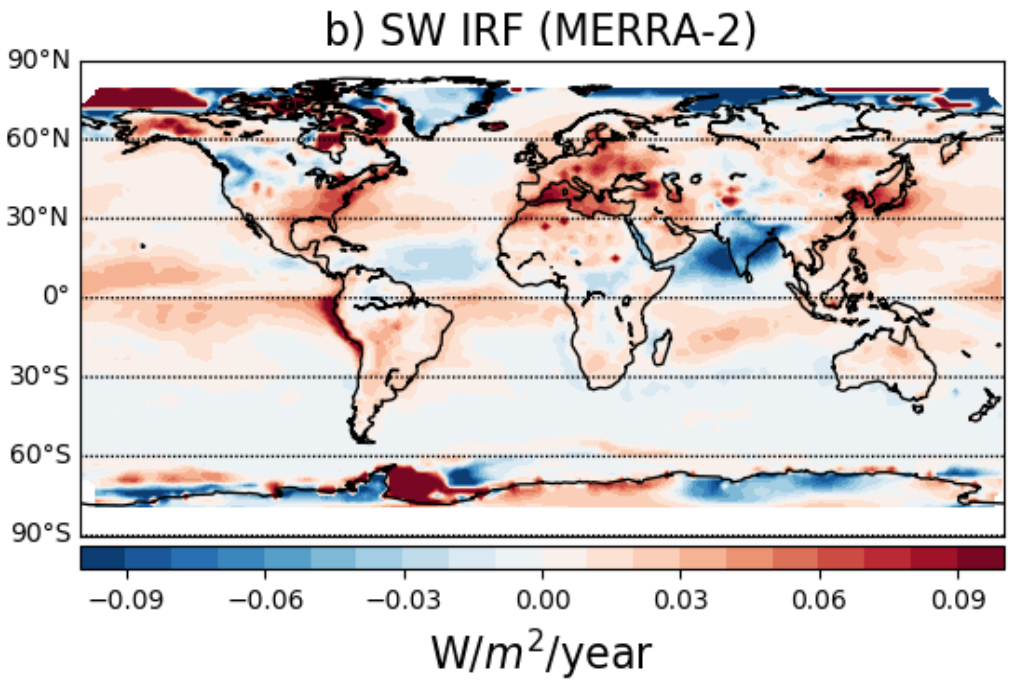
SW Instantaneous Radiative Forcing



0.1 +/- 0.05 W/m^2

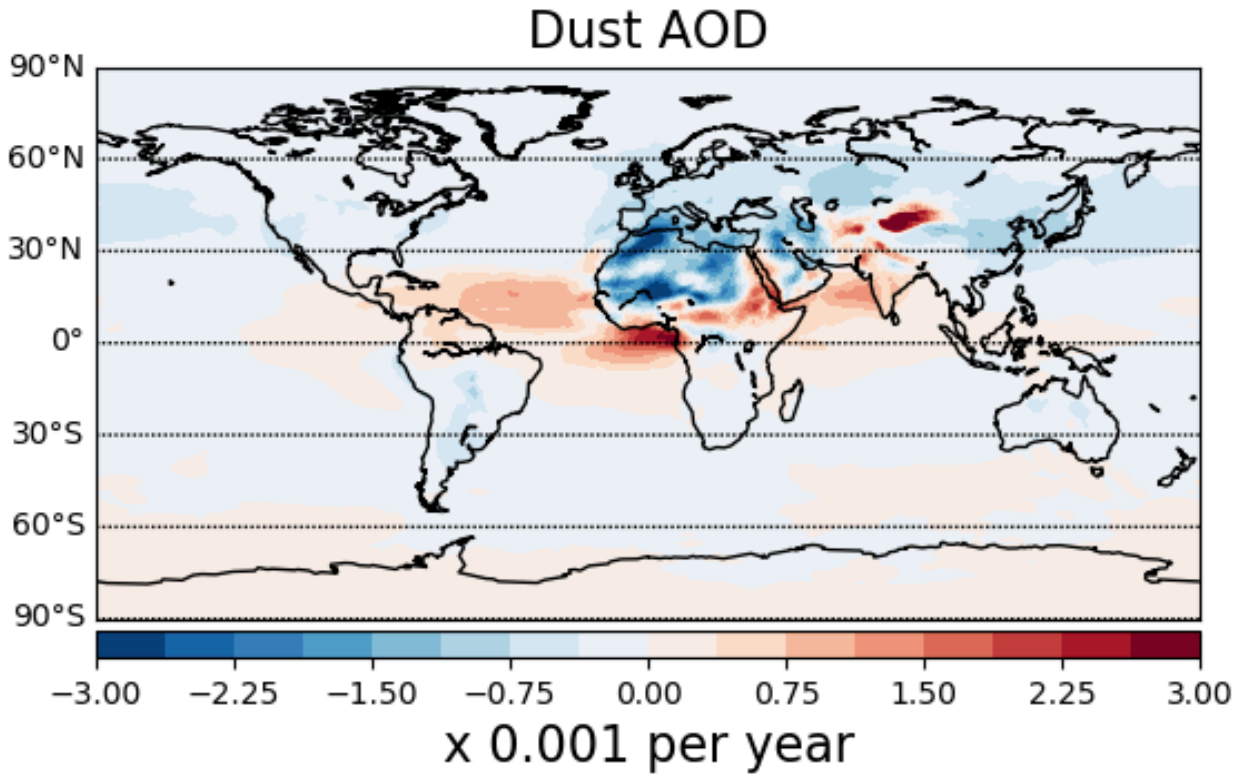
Local Trends in SW IRF (2003-2018)





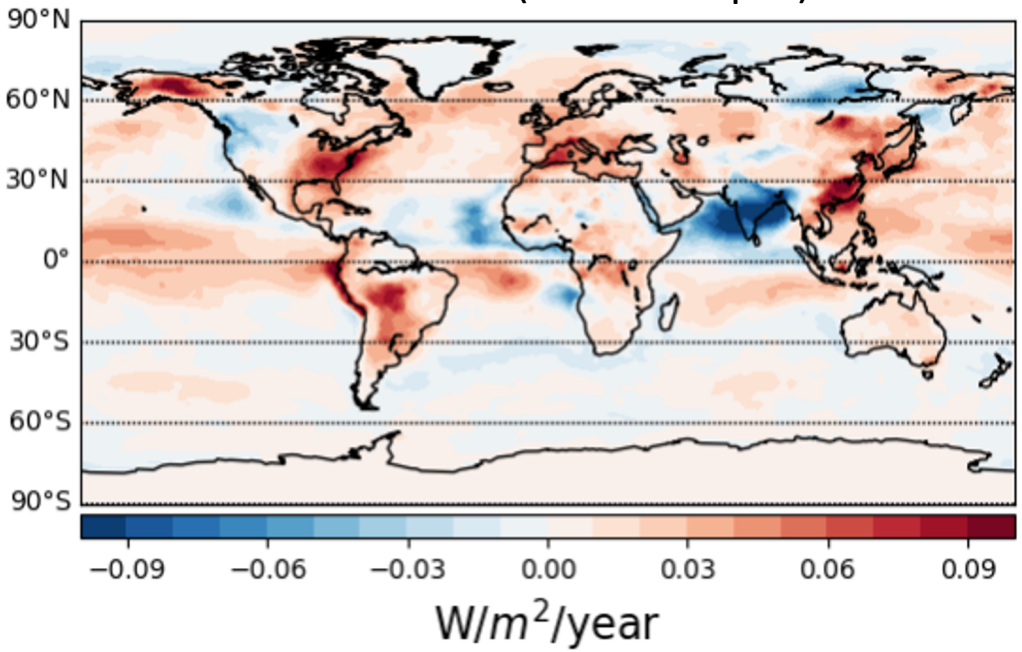
Red = Radiative Heating **and** **Blue = Radiative Cooling**

Dust Trends in MERRA-2

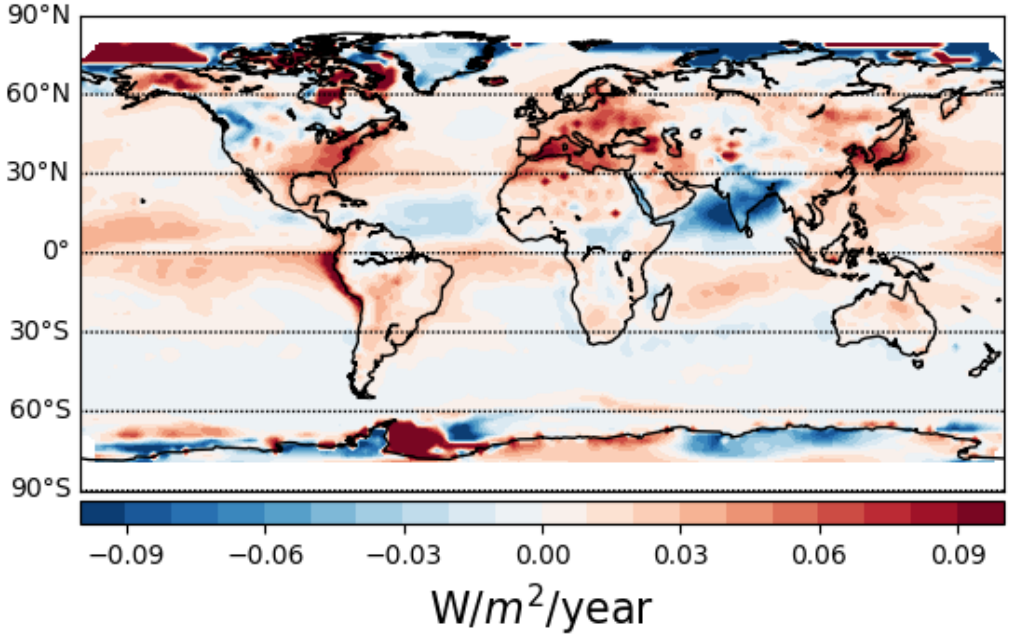


Local Trends in MERRA-2 SW IRF (2003-2018)

Aerosol SW IRF (Direct Output)



Total SW IRF (Kernel Method)



Conclusions

- Nearly all of the increase in CERES-observed TOA radiative imbalance is due to an increase in instantaneous radiative forcing of roughly 0.53+/-0.11 W/m^2
  - LW = 0.43+/-0.1 W/m^2; SW = 0.1+/-0.05 W/m^2

- Large LW IRF increases from increasing GHG concentrations
- Smaller SW IRF increase from aerosol emission reductions
- Observations of the distinct fingerprint of anthropogenic activity on Earth's energy budget