Observed Aerosol Forcing Trends Over the A-Train Satellite Era

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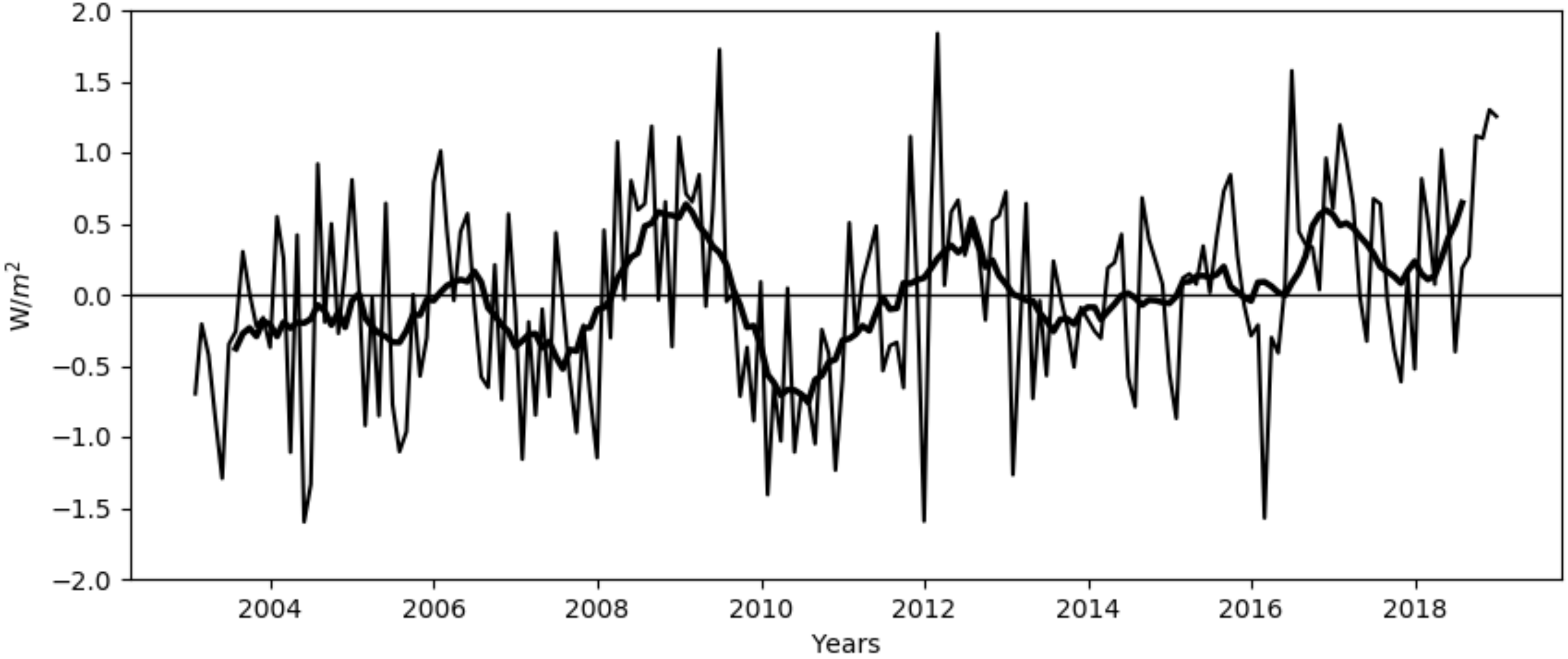
Top-of-Atmosphere
CERES Net Radiative Flux Anomalies



Net = Longwave (LW) + Shortwave (SW)

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

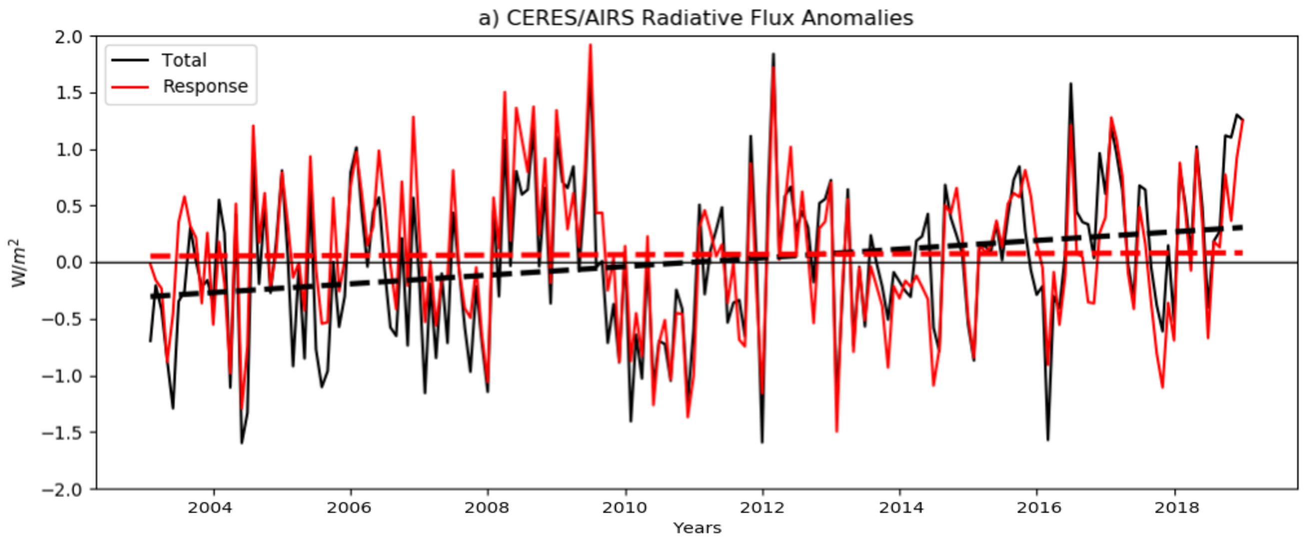
$$IRF = dQ - \sum CR_x$$

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

Radiative Kernel

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

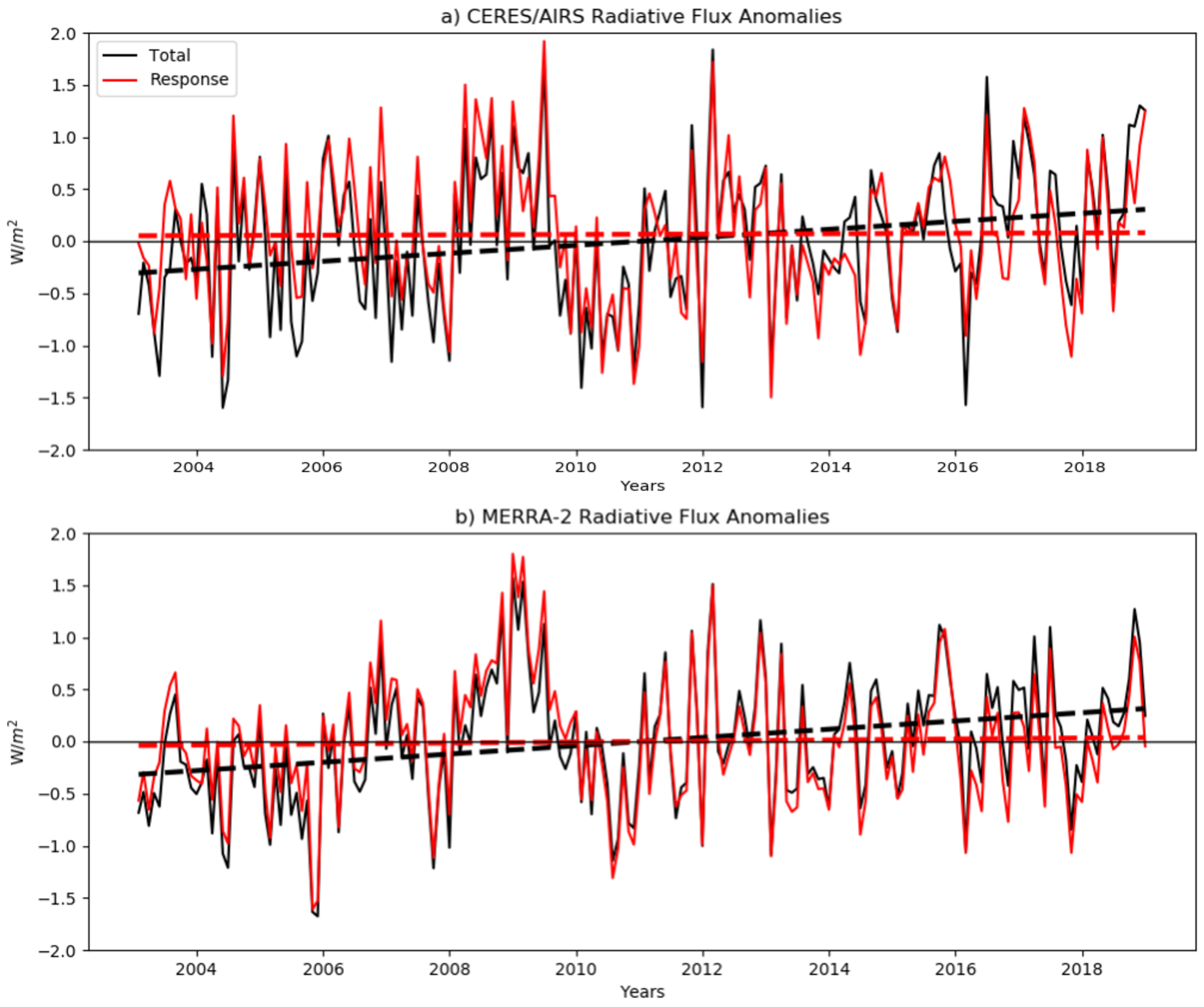
TOA Radiative Flux Anomalies



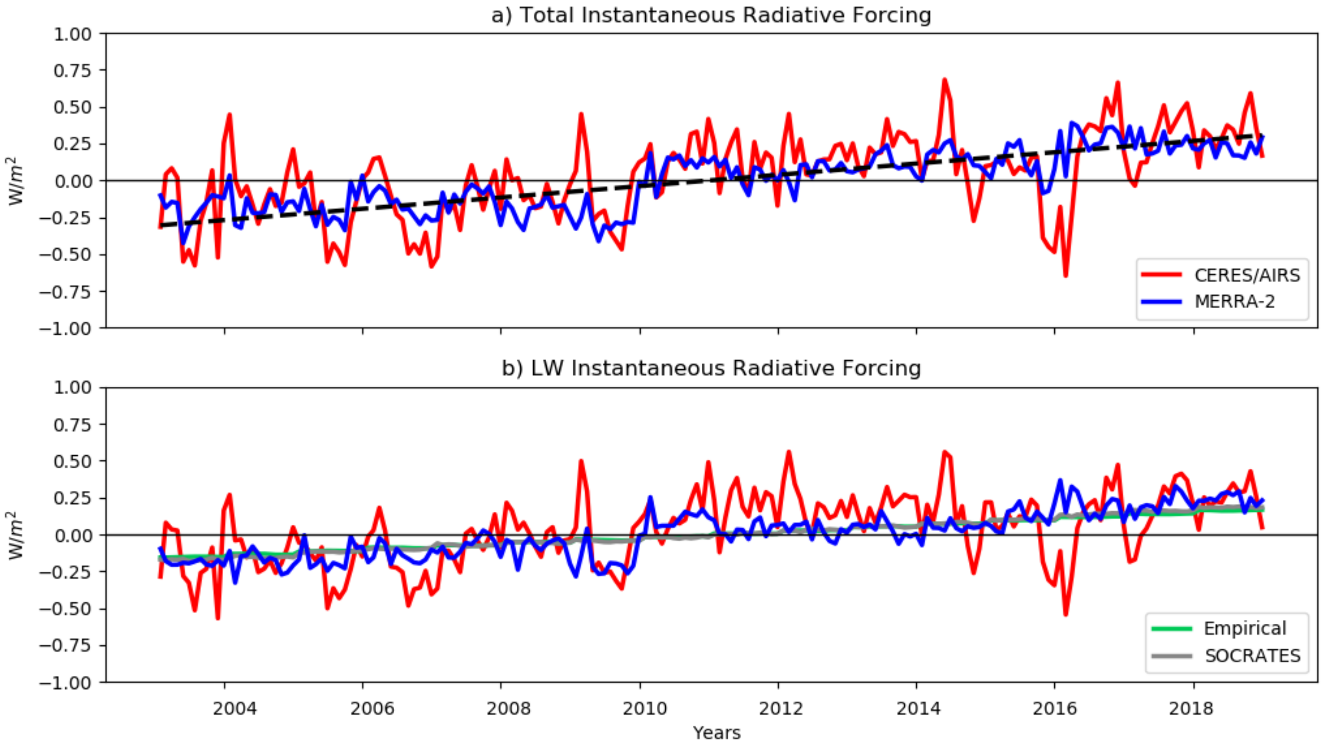
Total trend = 0.038 +/- 0.02 W/m²/Year

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

TOA Radiative Flux Anomalies



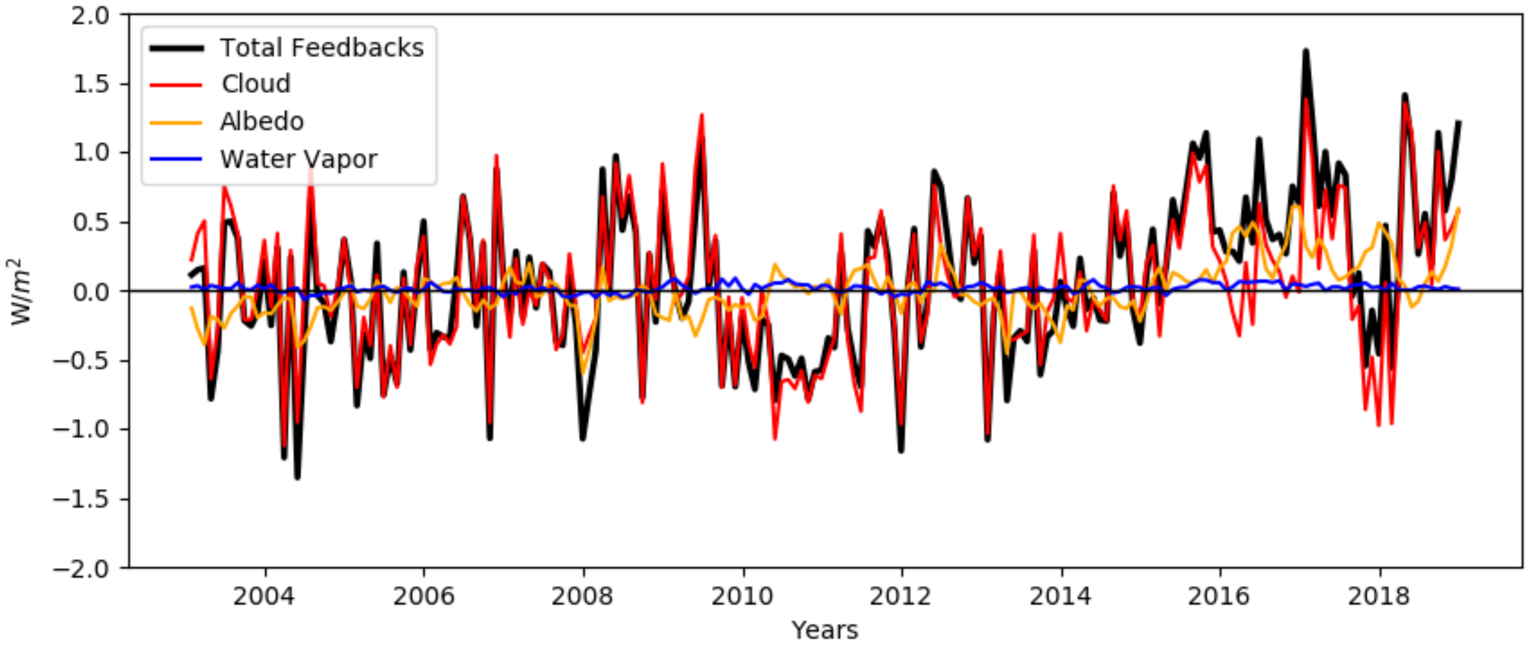
Instantaneous Radiative Forcing



0.53 +/- 0.11 W/m^2

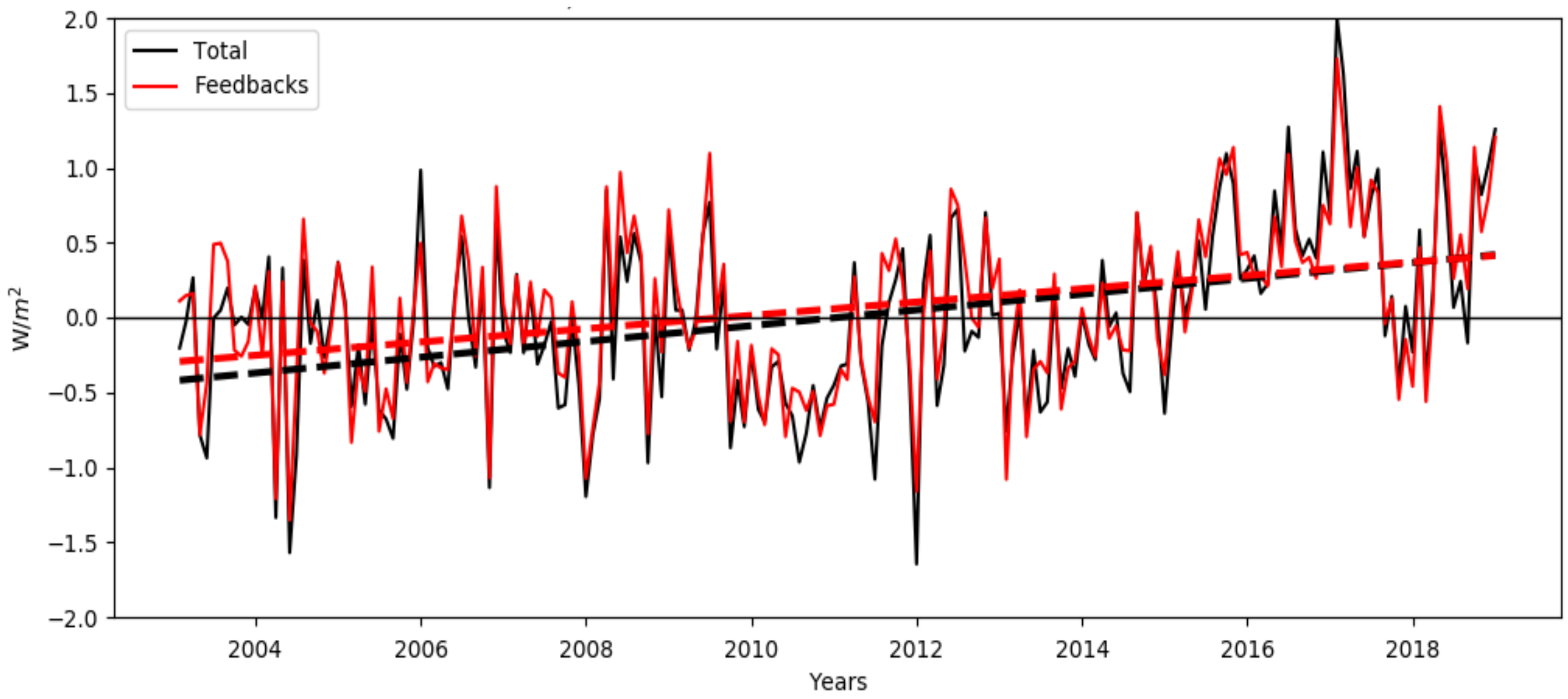
0.43 +/- 0.1 W/m^2

SW Feedback Decomposition



Cloud Radiative Feedbacks explain most of SW variability and trend

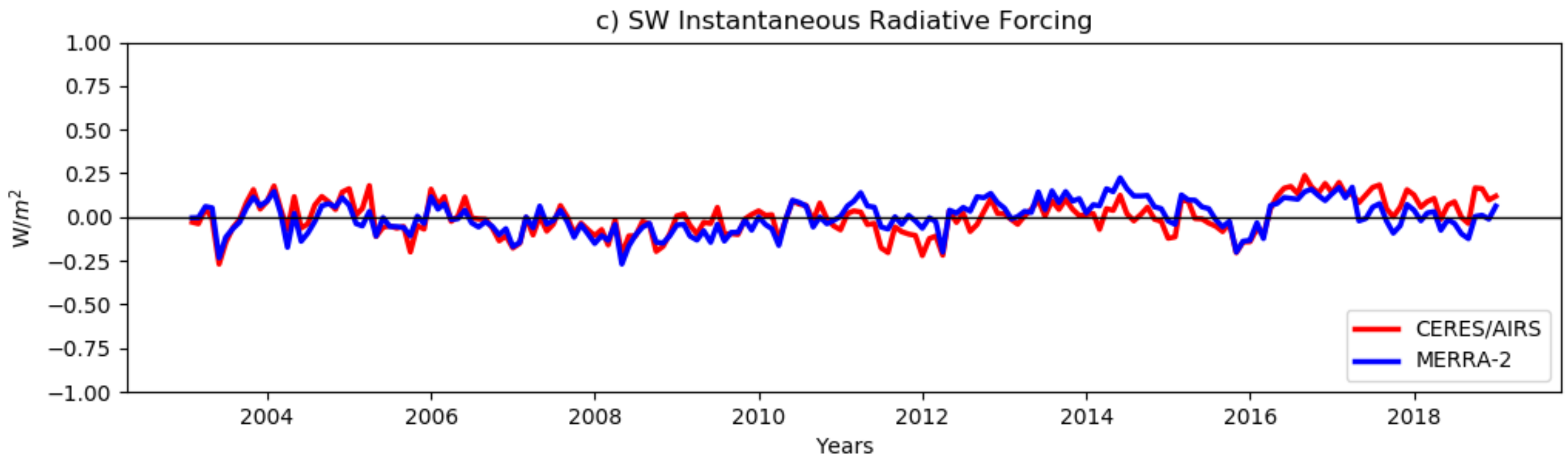
Shortwave TOA Radiative Flux Anomalies



Total trend = 0.053 +/- 0.02 W/m²/Year

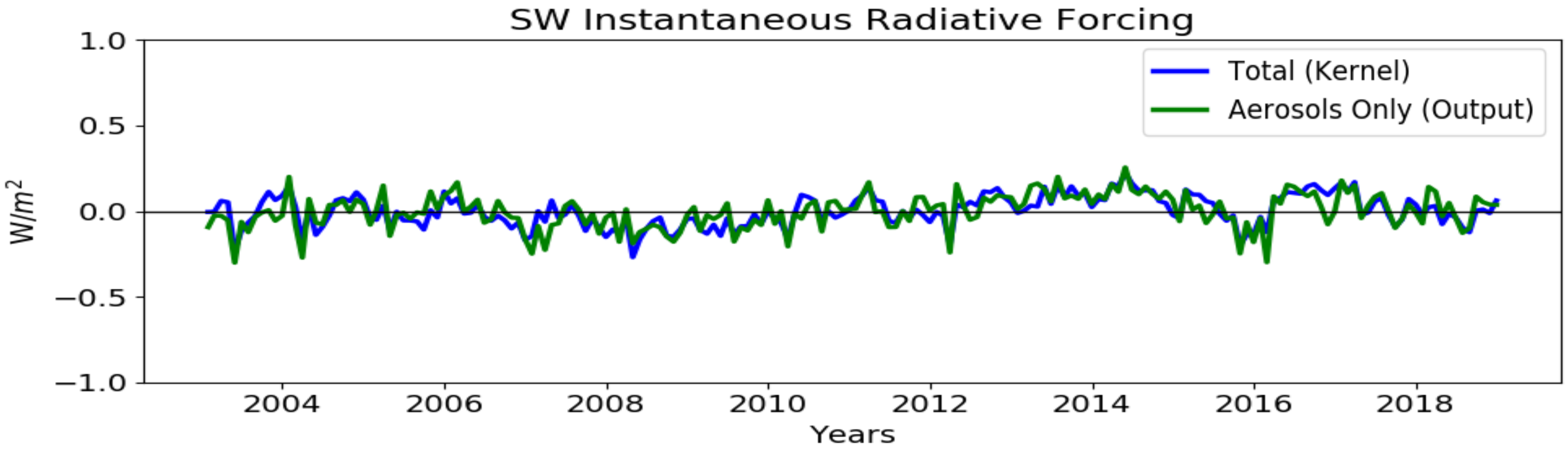
Radiative Response trend = 0.044 +/- 0.04 W/m²/Year

SW Instantaneous Radiative Forcing



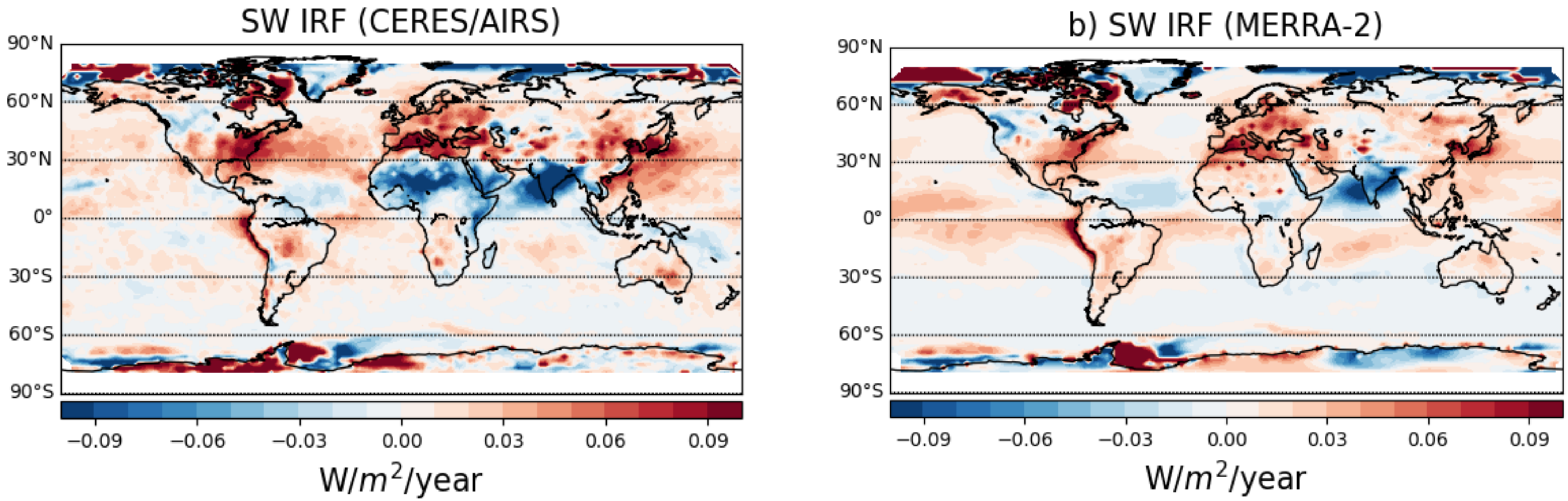
0.1 +/- 0.05 W/m²

SW Instantaneous Radiative Forcing



0.1 +/- 0.05 W/m^2

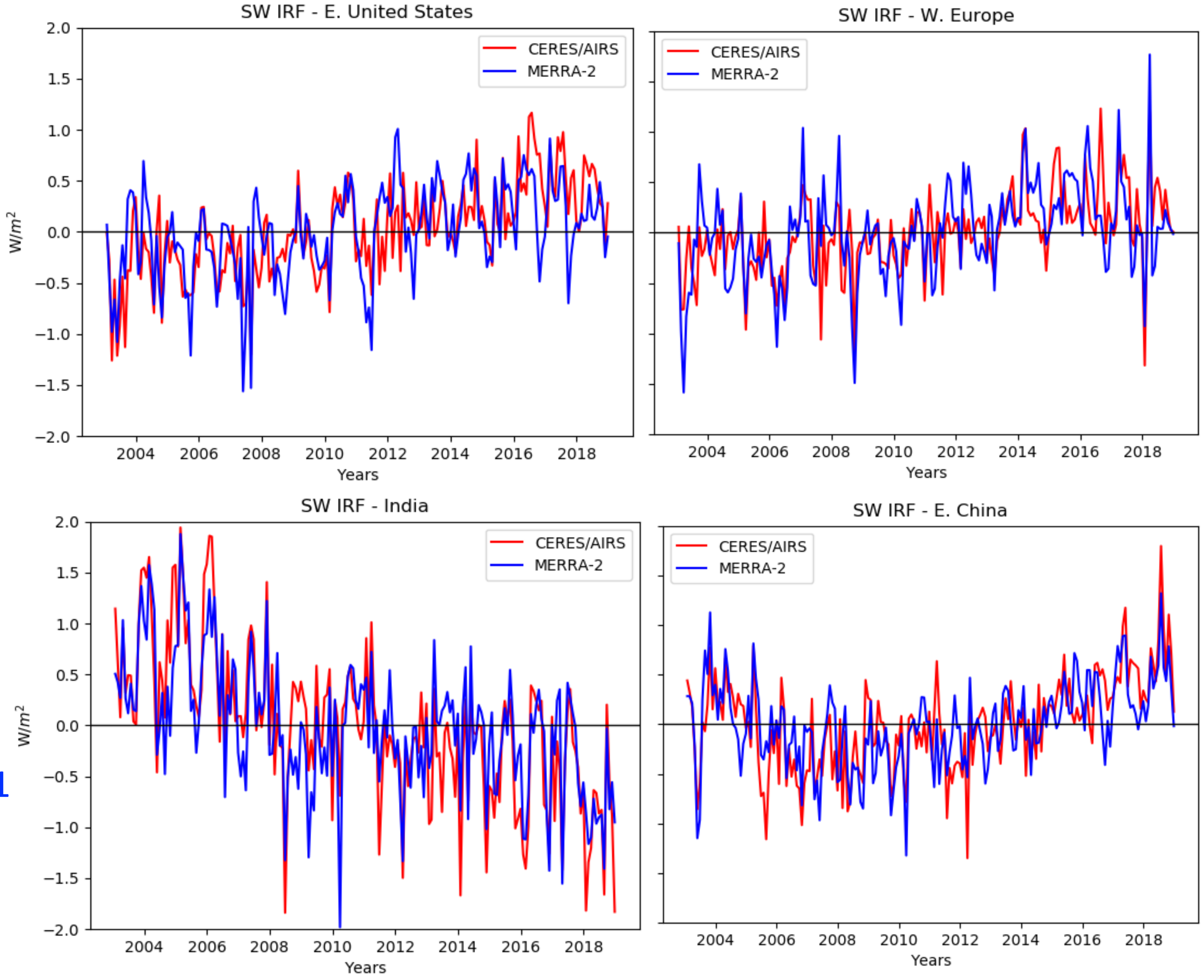
Local Trends in SW IRF (2003-2018)



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

Regional Behavior

Trends in $W/m^2/Yr$



E. United States: 0.064 +/- 0.02 (CERES/AIRS); 0.041 +/- 0.02 (MERRA-2)

W. Europe: 0.042 +/- 0.006 (CERES/AIRS); 0.038 +/- 0.01 (MERRA-2)

India: -0.11 +/- 0.01 (CERES/AIRS); -0.072 +/- 0.01 (MERRA-2)

E. China: 0.042 +/- 0.02 (CERES/AIRS); 0.028 +/- 0.015 (MERRA-2)

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
  - Not true in SW-only, where radiative responses dominate trend, but don’t account for all of it
- Roughly 0.1+/-0.05 W/m^2 of this increase comes from SW aerosol radiative forcing