Observational Radiative Kernels and Contributions to TOA Flux Anomalies

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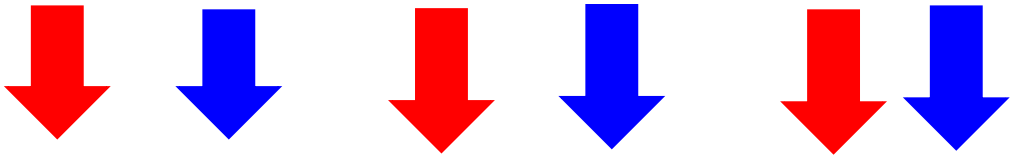
Feedbacks and Radiative Kernels

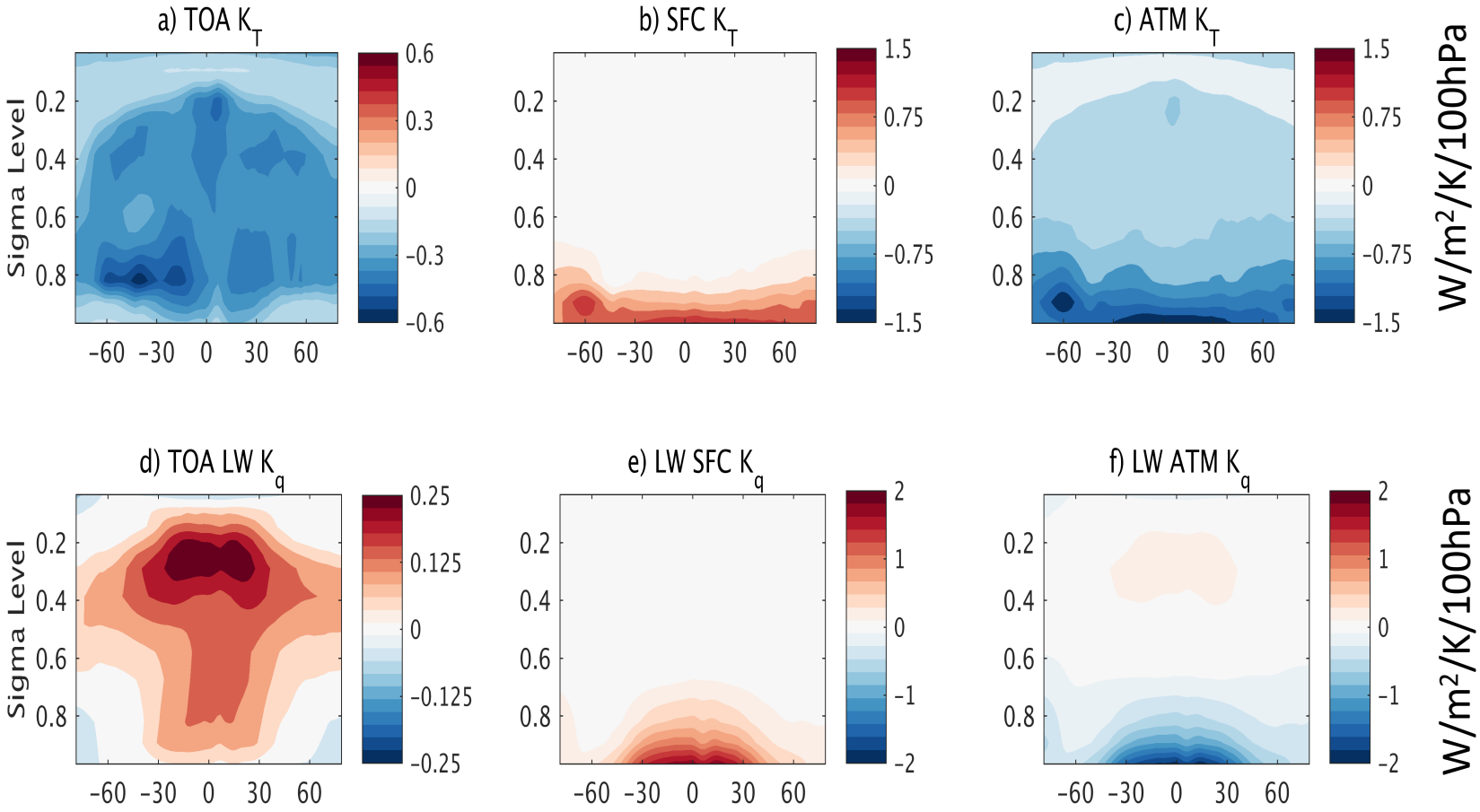


$$\lambda = -\frac{dR}{dT_s} = \frac{\delta R}{\delta T}\frac{dT}{dT_s} + \frac{\delta R}{\delta W}\frac{dW}{dT_s} + \frac{\delta R}{\delta \alpha}\frac{d\alpha}{dT_s} + \frac{\delta R}{\delta C}\frac{dC}{dT_s}$$

Feedback = Kernels **X** Climate Response

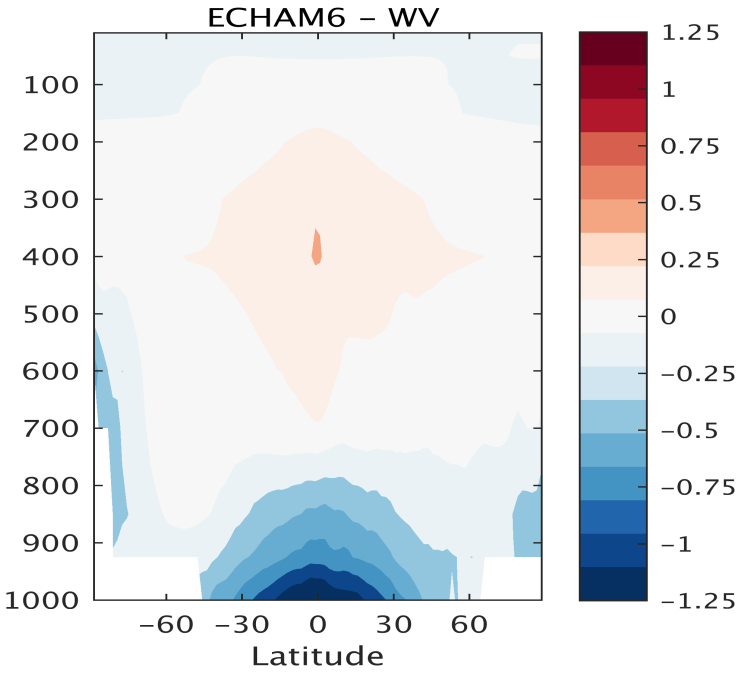
$$\frac{dR_C}{dTs} = \frac{dCRF}{dTs} + \sum (K_0^x - K^x) dx / dTs$$

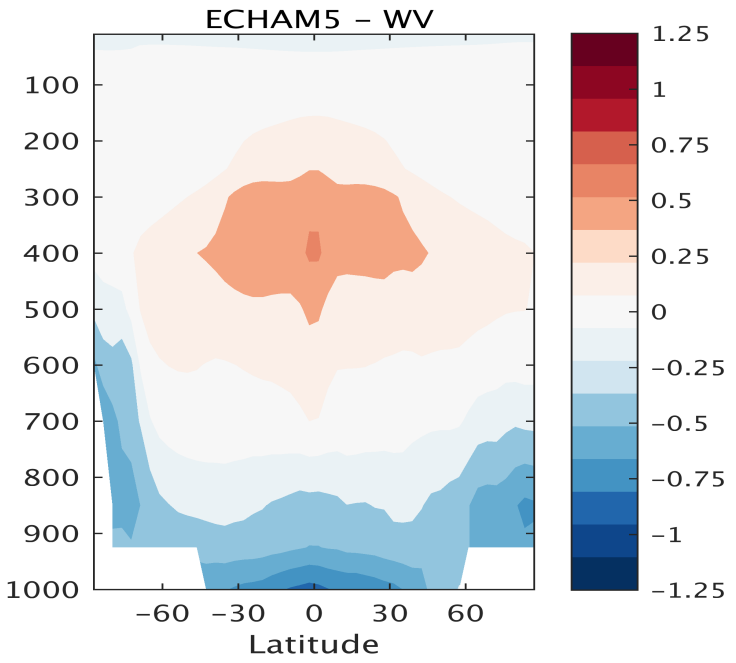
Radiative Kernels



Kramer et al. 2018a

Differing spatial distribution of LW Water Vapor kernel





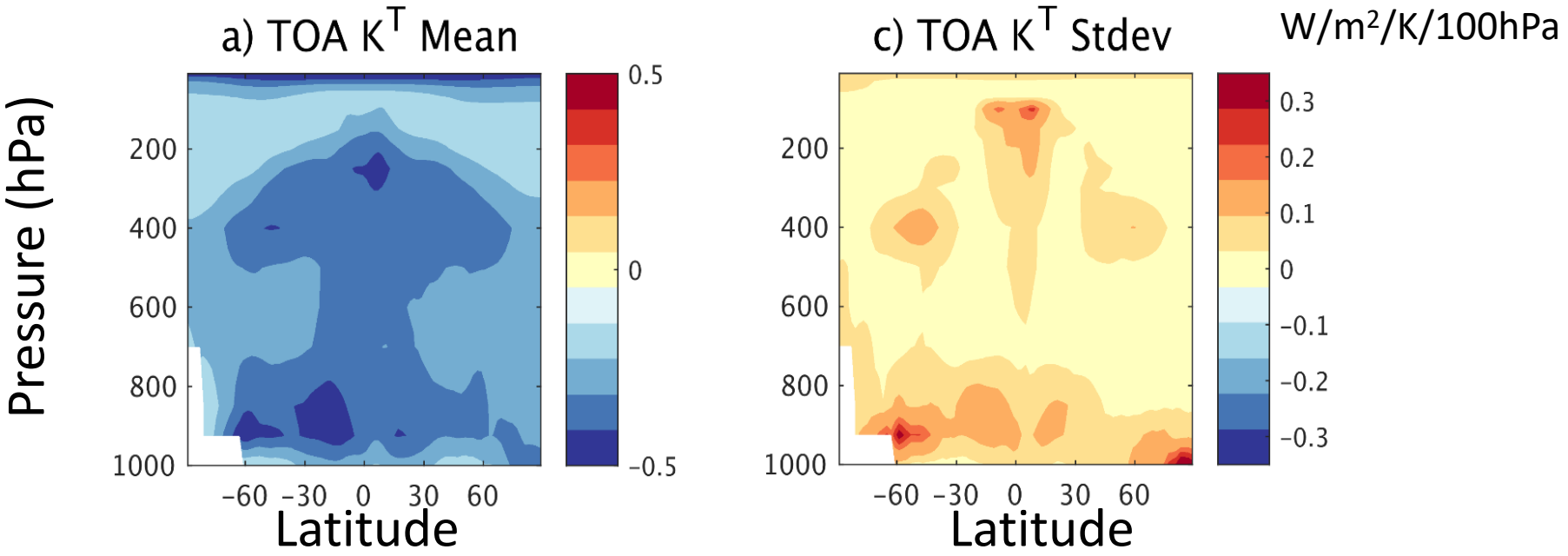
$\lambda_{WV,LW}$ = -0.66 W/m^2/K

$\lambda_{WV,LW}$ = 0.29 W/m^2/K

Flaschner et al. 2016

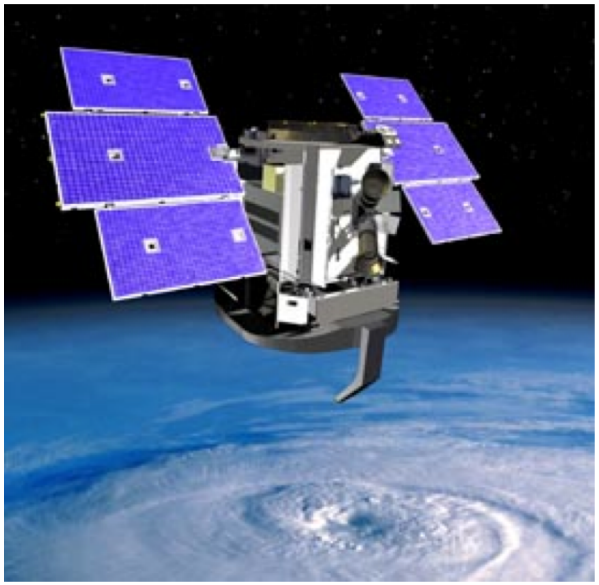
O'Gorman et al. 2012

Contributions to Radiative Kernel Differences



Kernel sensitivity to cloud climatology

CloudSat Radiative Kernels

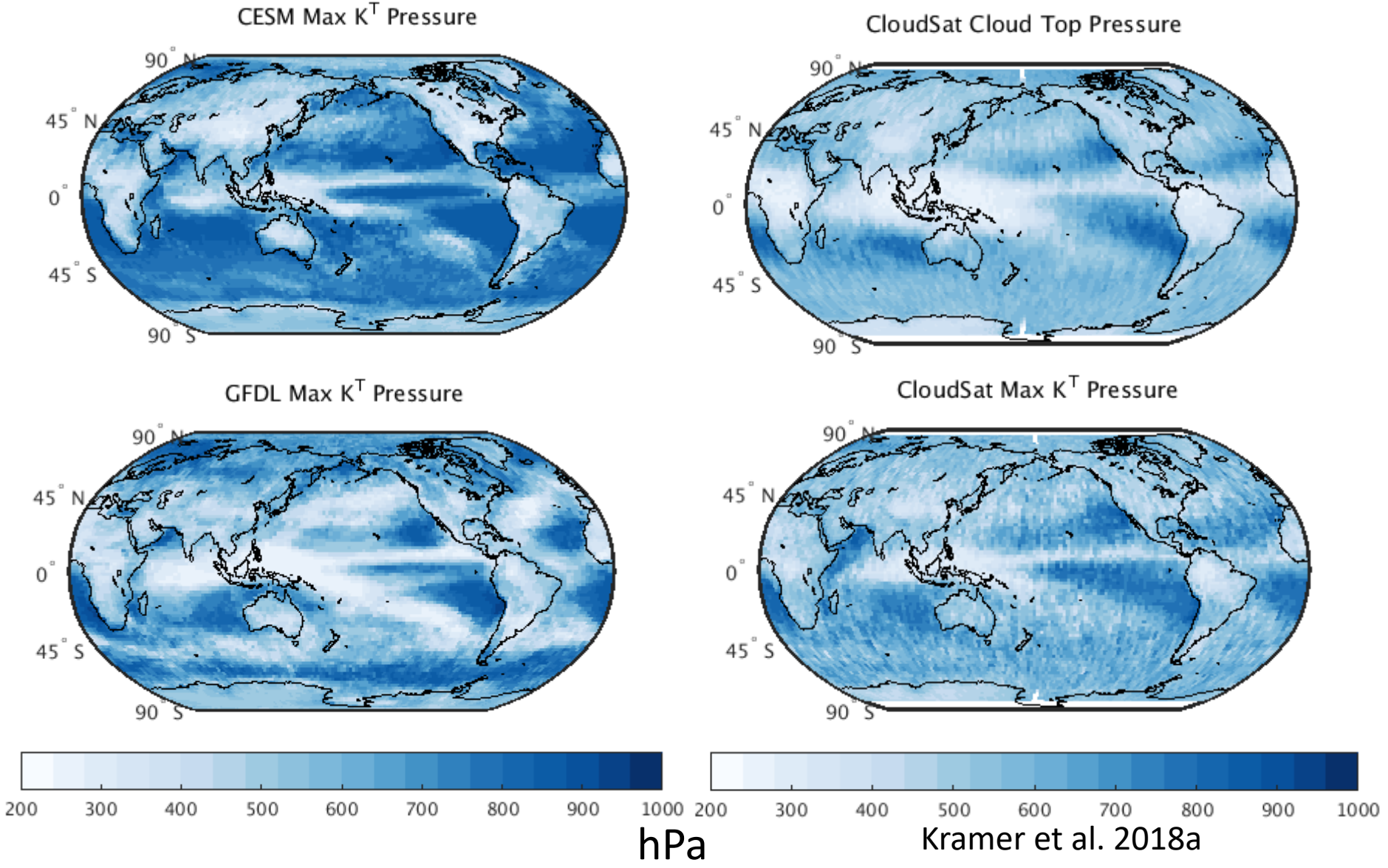


Observational Kernels from 2B-FLXHR-LIDAR:

Input	Source
Cloud Properties	CloudSat, CALIPSO
Temperature, Humidity	ECMWF Reanalysis
Surface Albedo	MODIS, AMSR-E
Aerosol Properties	CALIPSO

Kramer et al. 2018a

Impact of Cloud Field on TOA T Kernels

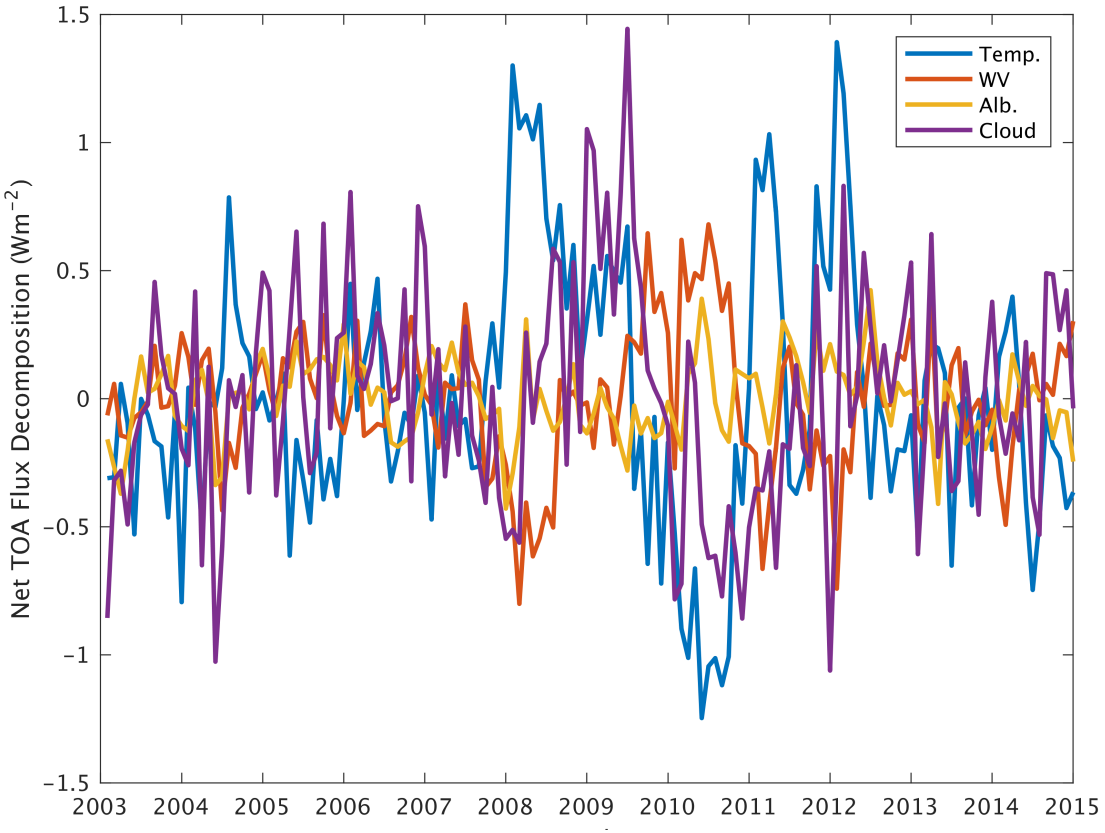


Kramer et al. 2018a

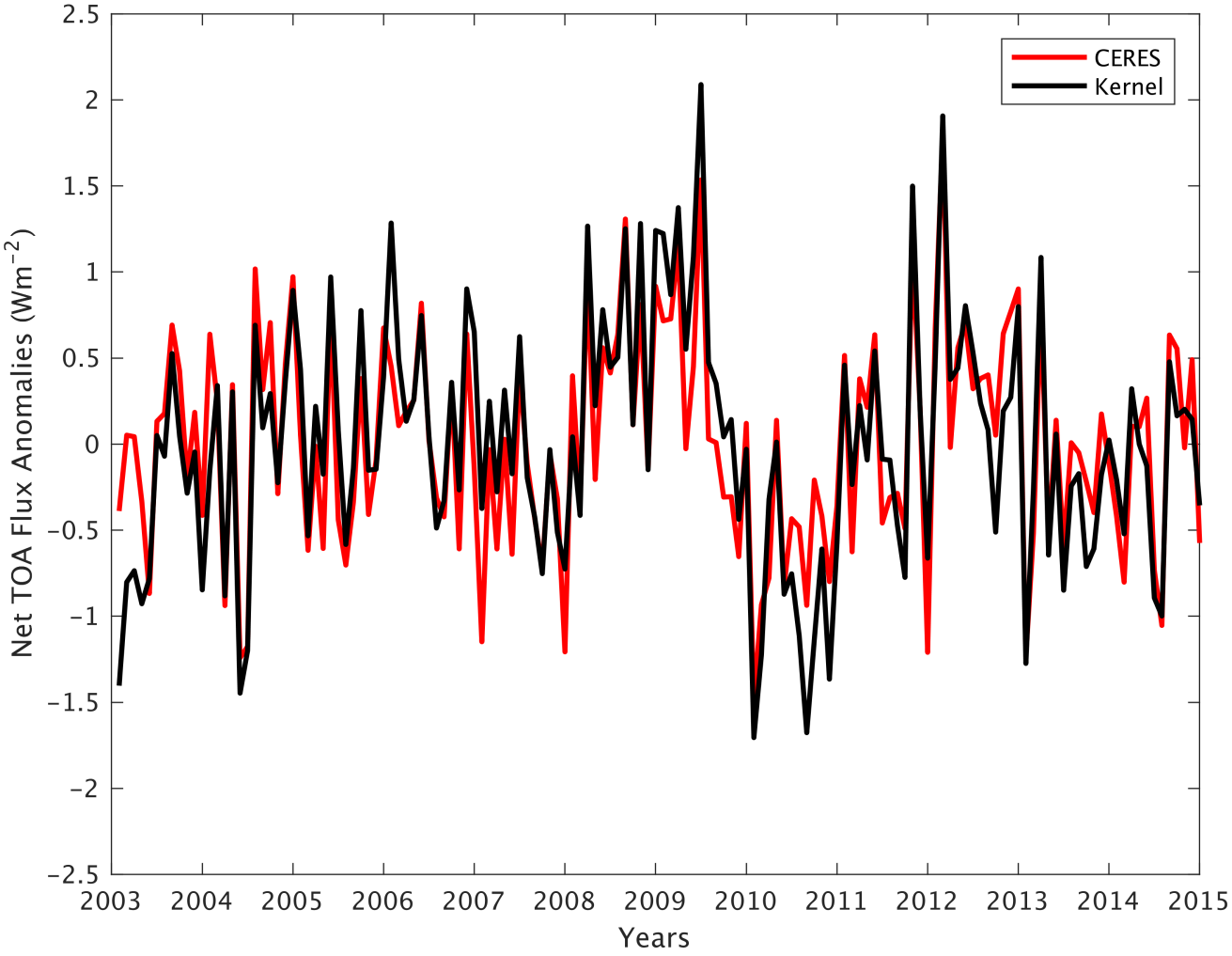
Individual Contributions to TOA Flux Anomalies using AIRS

$$\Delta R_{TOA} = \Sigma \Delta R_x + F$$

$$\Delta R_x = K_x * dx$$



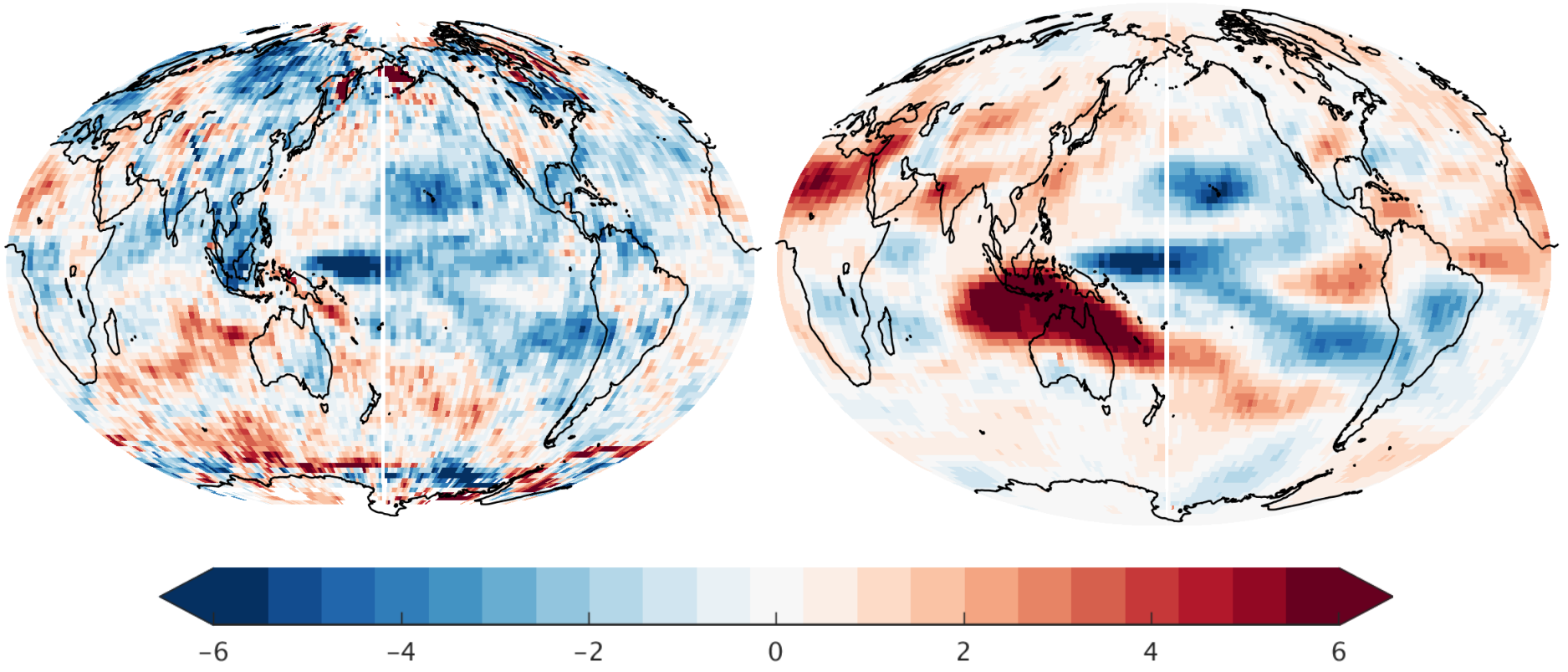
Net TOA Flux Anomalies



Flux Anomalies 6/2010-10/2010

Net ΔTOA (CERES-Kernel)

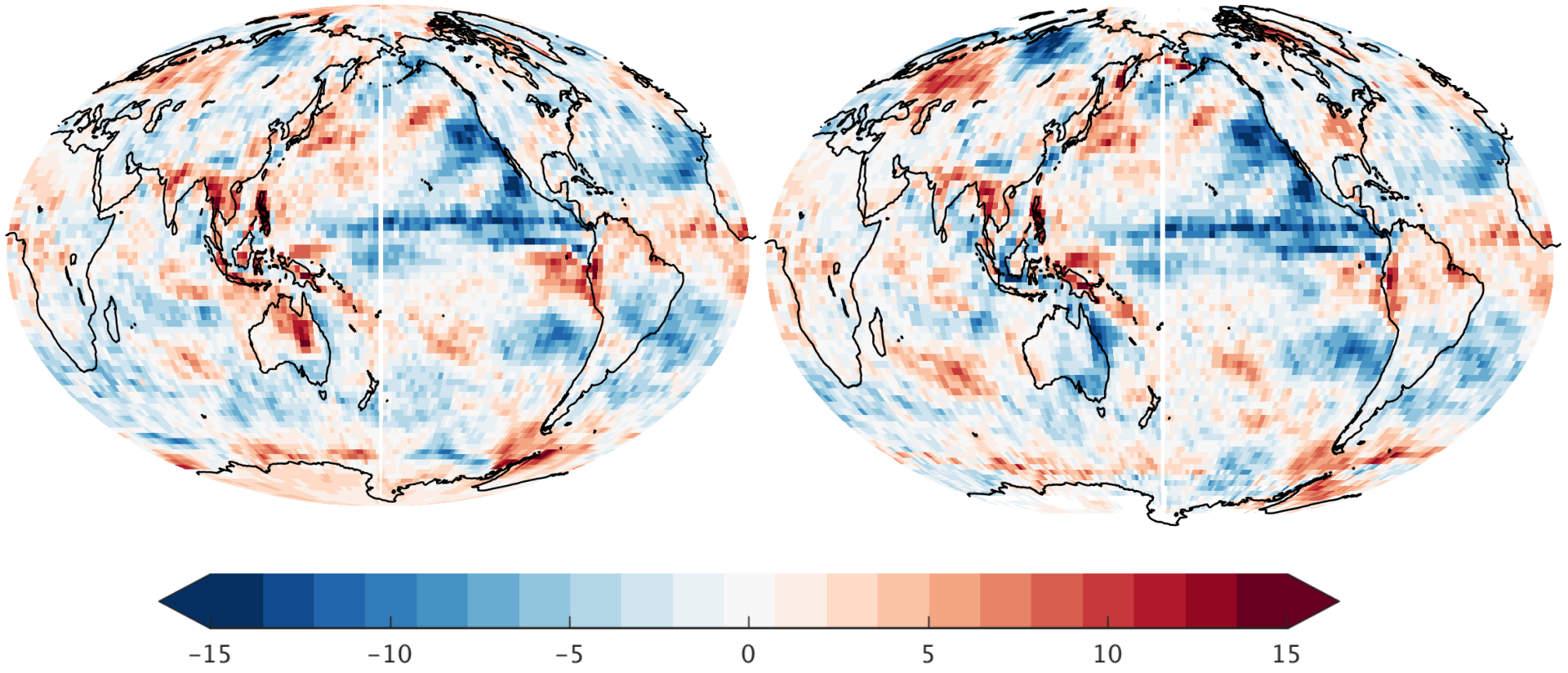
Water Vapor Flux



Flux Anomalies 6/2010-10/2010

Net TOA CERES

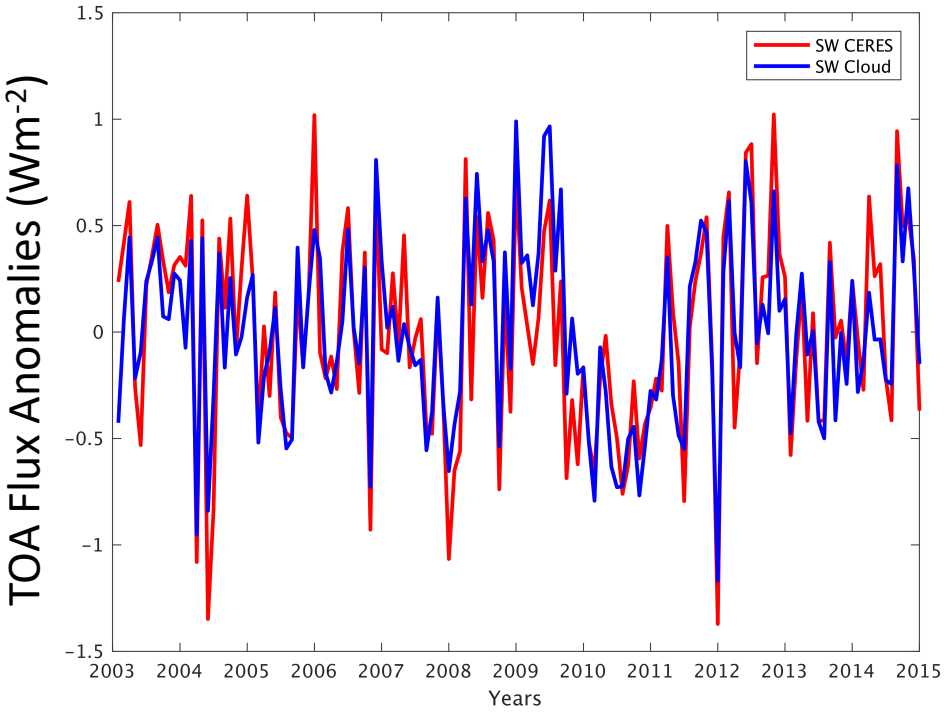
Cloud Fluxes



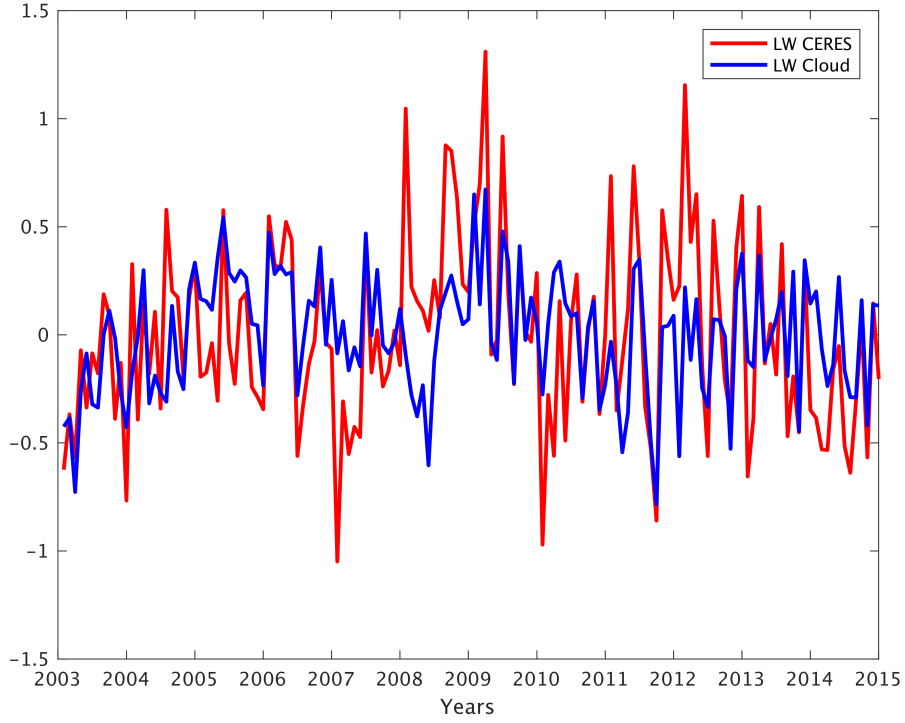
W/m^2

Cloud Flux Contribution

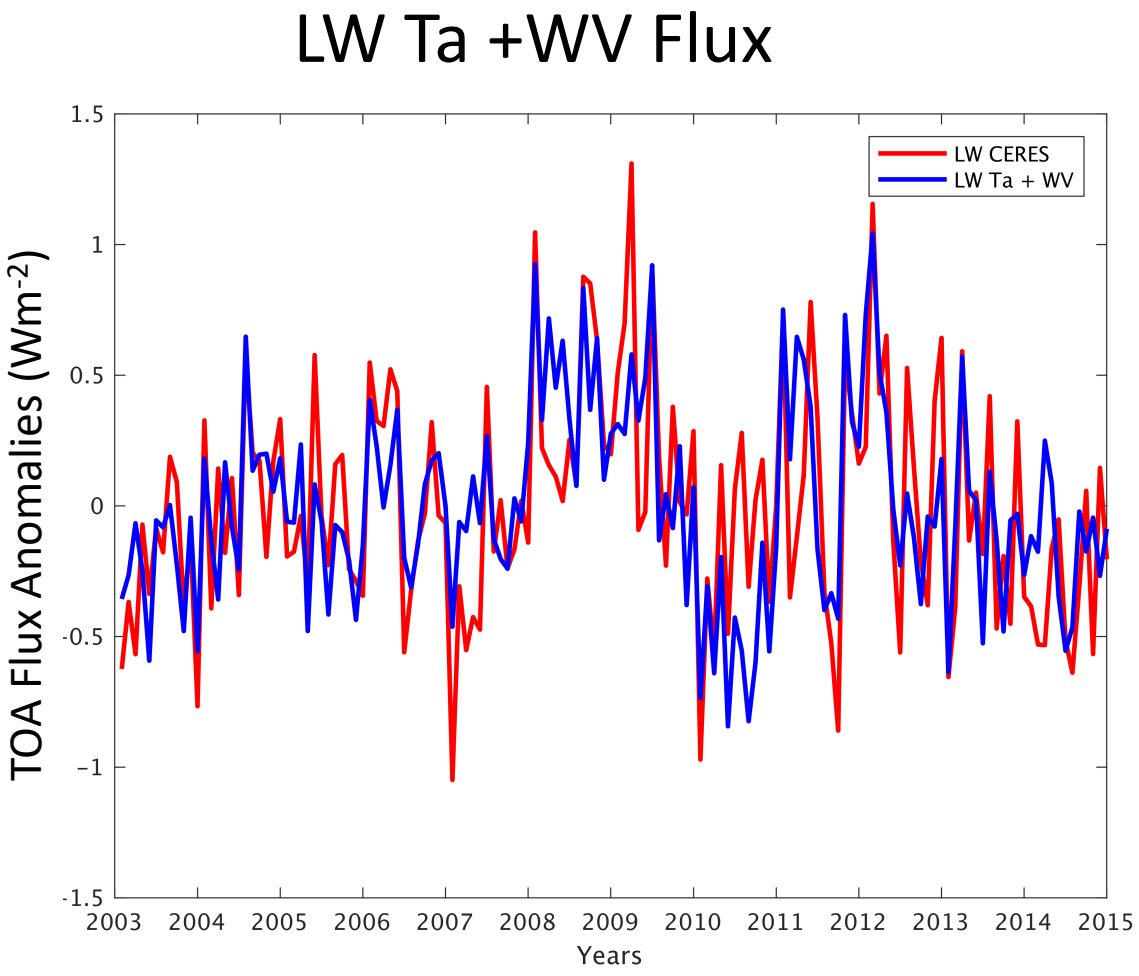
SW Cloud Flux



LW Cloud Flux



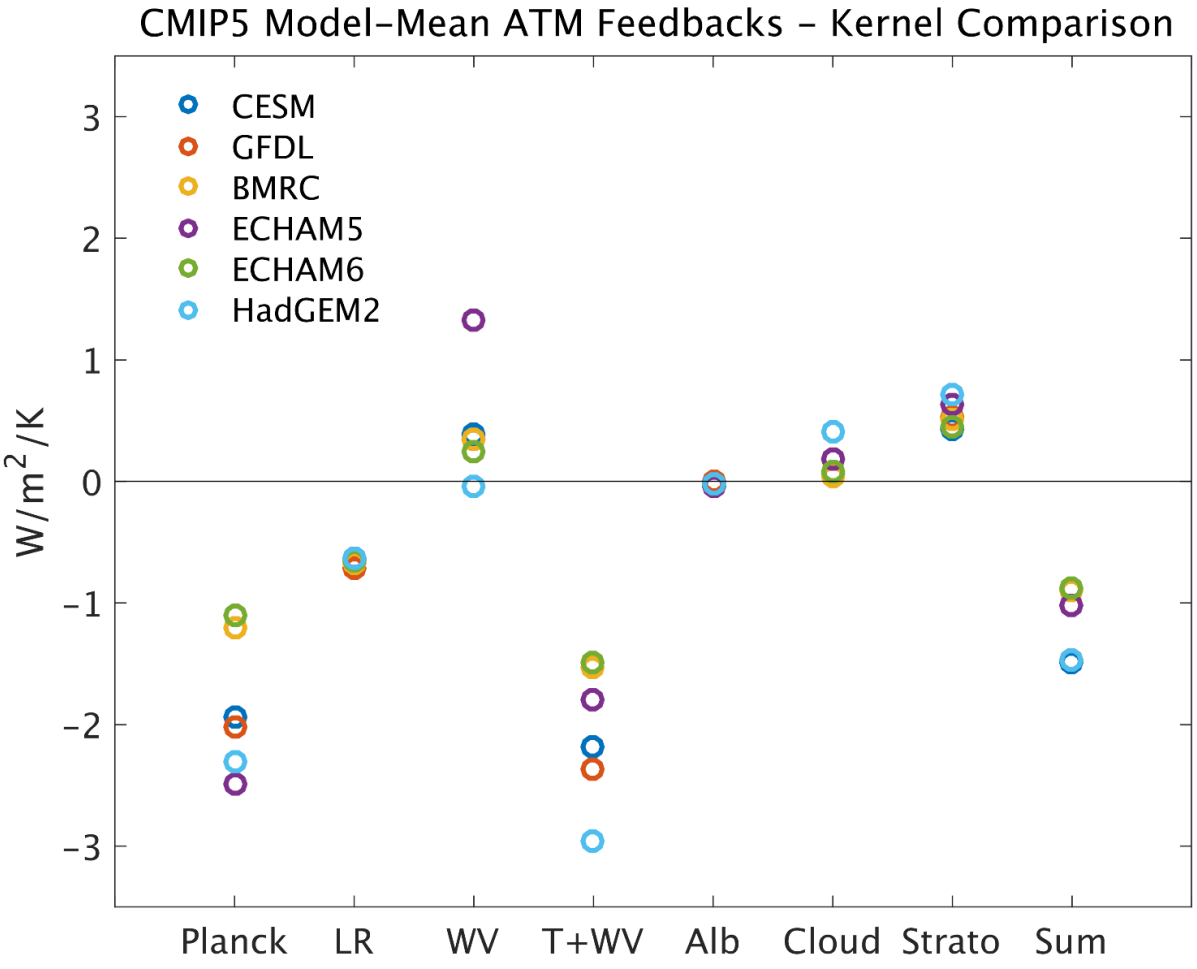
Non-Cloud Flux Contribution



Summary

- Documented differences in atmospheric GCM-based radiative kernels
- GCM-based Radiative kernels are subject to biases in climatological clouds. Instead we can use CloudSat-based radiative kernels.
- Clouds explain variability in observed SW TOA flux anomalies while non-cloud changes explain LW TOA

Estimating Feedbacks with different Radiative Kernels



- ECHAM5 WV Kernel is an outlier
- Planck spread associated with near-surface vertical resolution differences and RTM artifacts
- Stratospheric response sensitive to vertical resolution near TOA
- Cloud feedback spread due to cloud masking differences

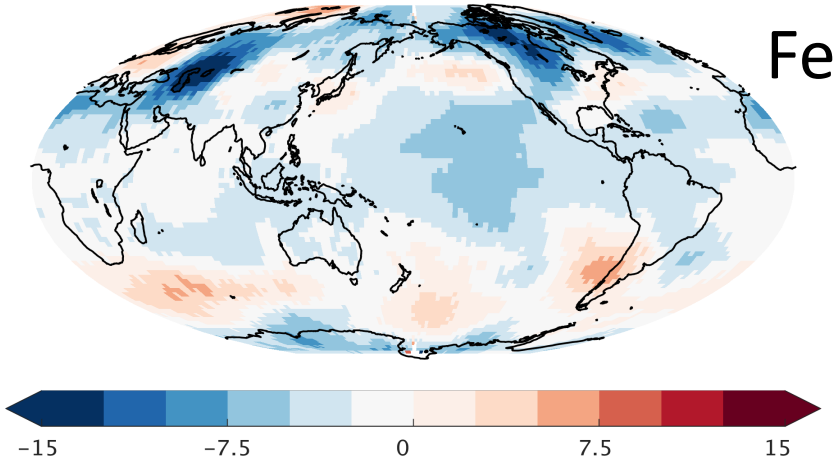
Kramer et al. 2018b

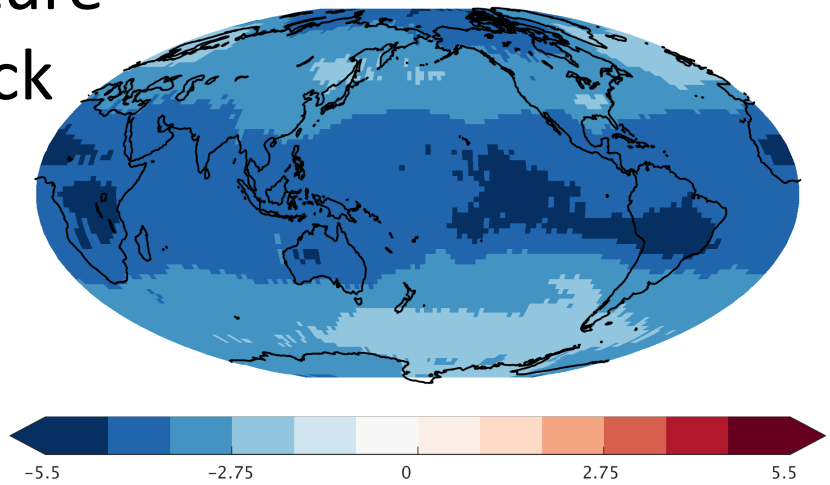
Inter-annual versus Climate Change Feedbacks

Observed

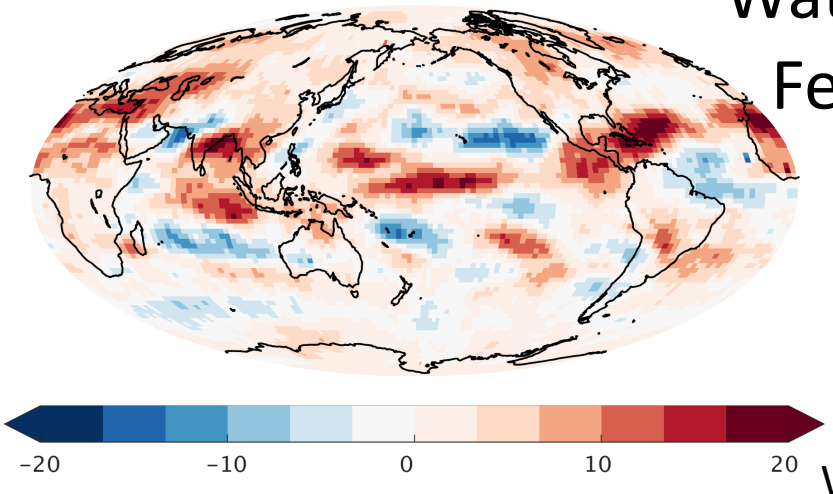
Long-term (CMIP5)

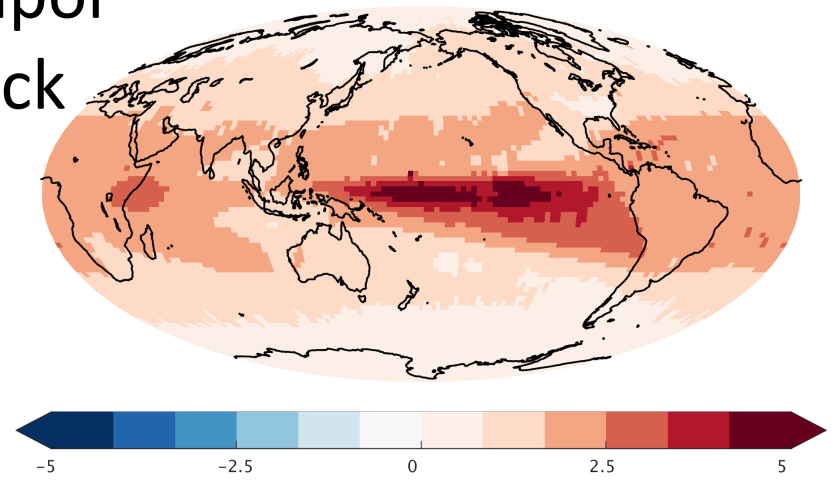
Temperature Feedback





Water Vapor Feedback

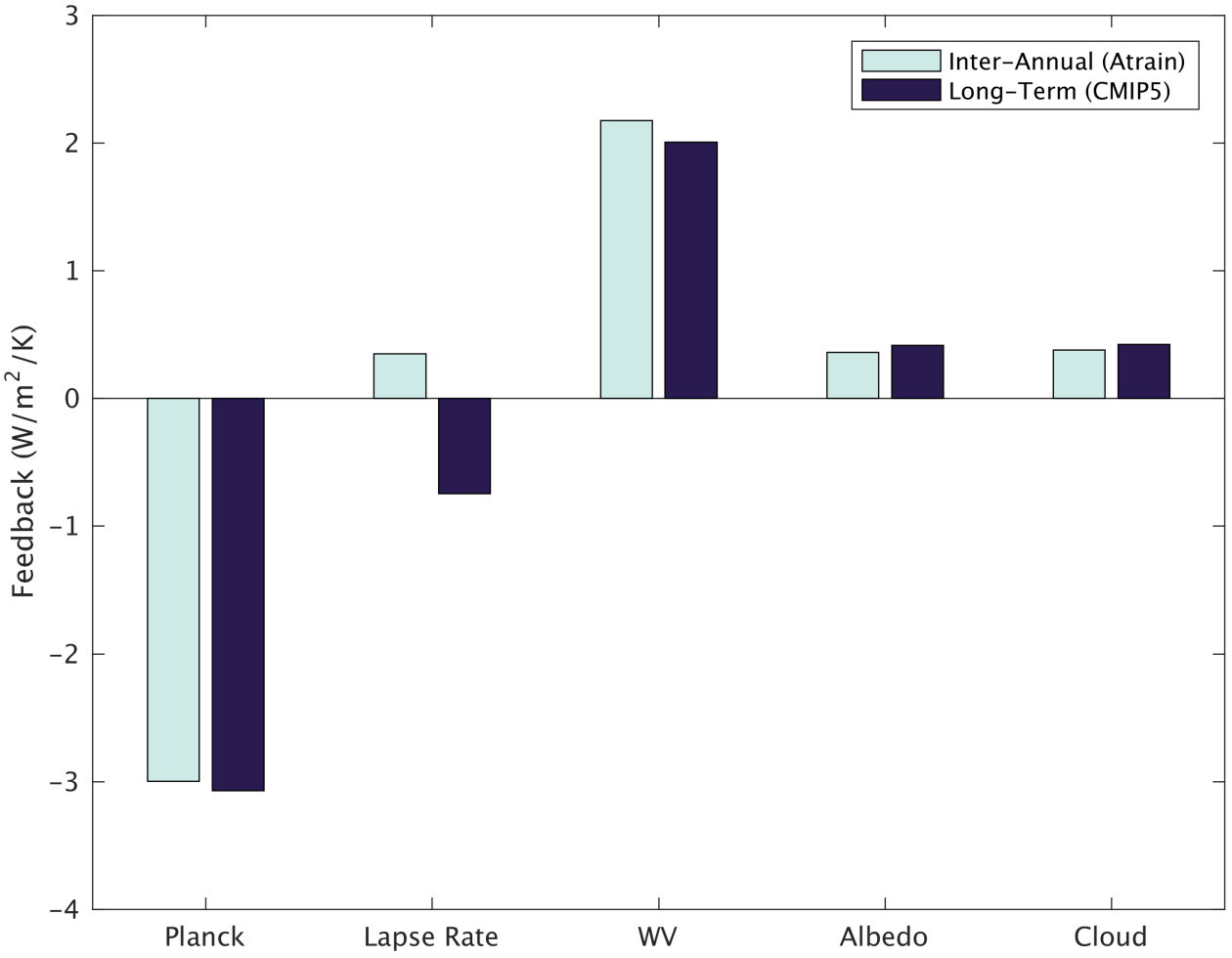




$W/m^2/K$

Kramer et al. 2018c

Feedback magnitude consistent between timescales



Kramer et al. 2018c