Using atmospheric regimes to assess CMIP5 models biases in the Arctic Surface Energy Budget

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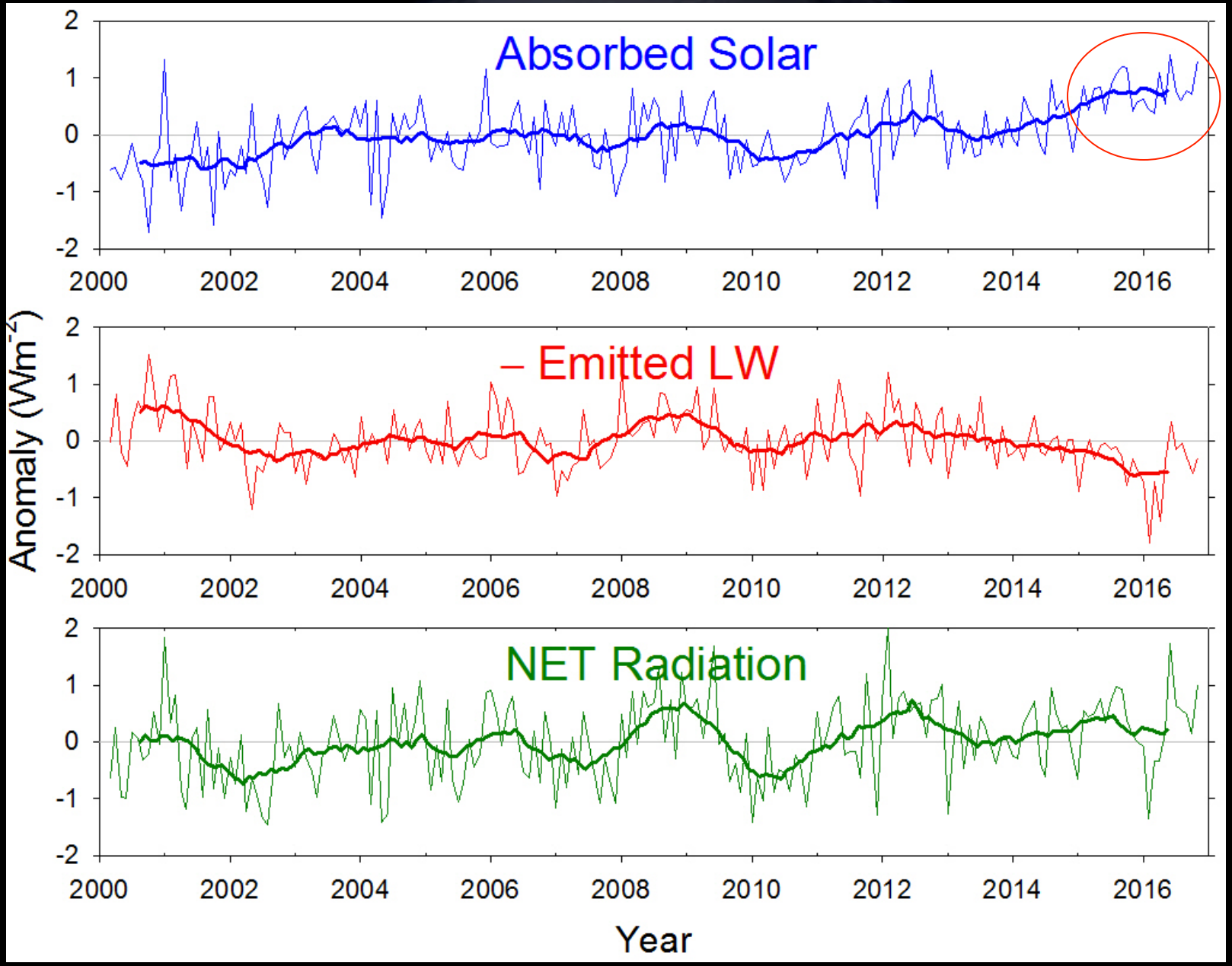
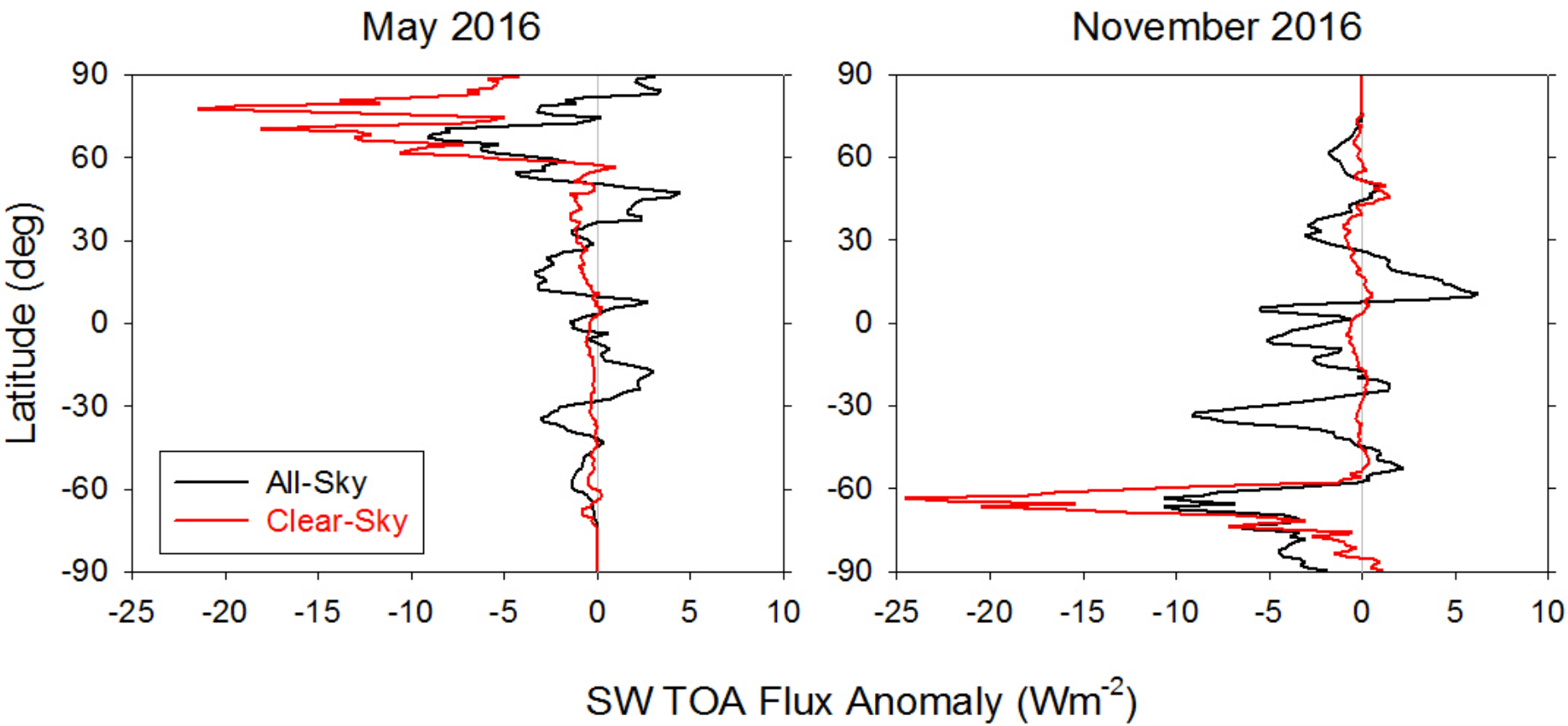
Global TOA **All-Sky** Radiation Anomalies
(CERES_EBAF_Ed4.0; 03/2000 – 11/2016)

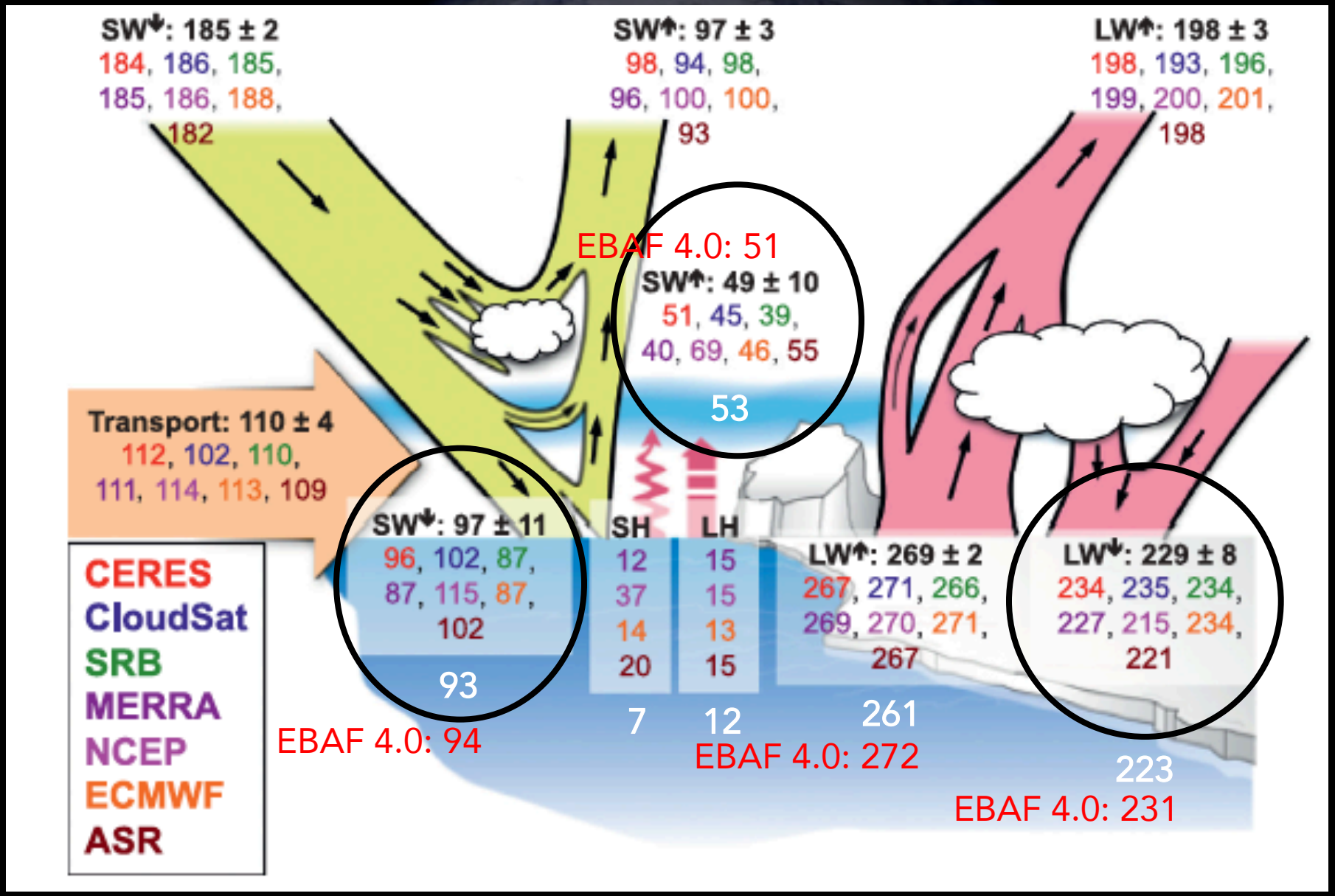


Zonal Mean SW TOA Flux Anomaly

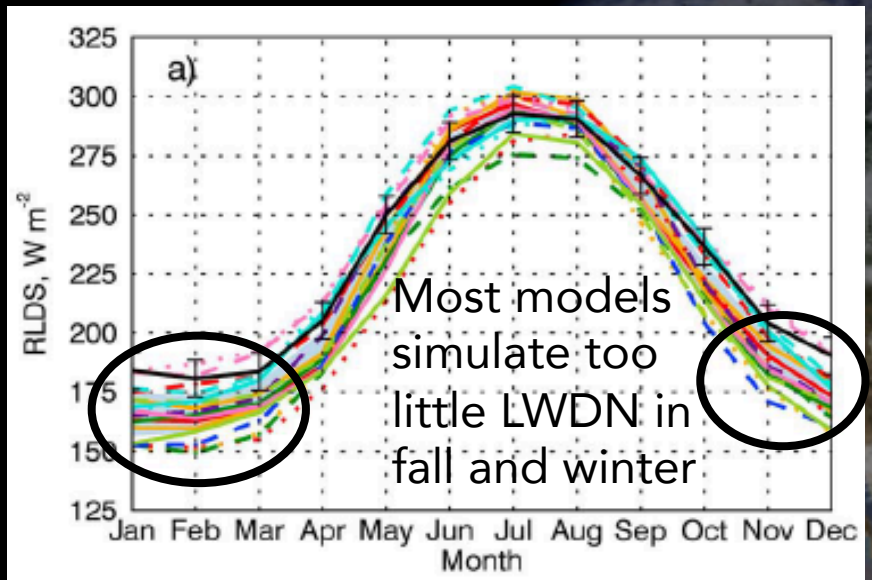


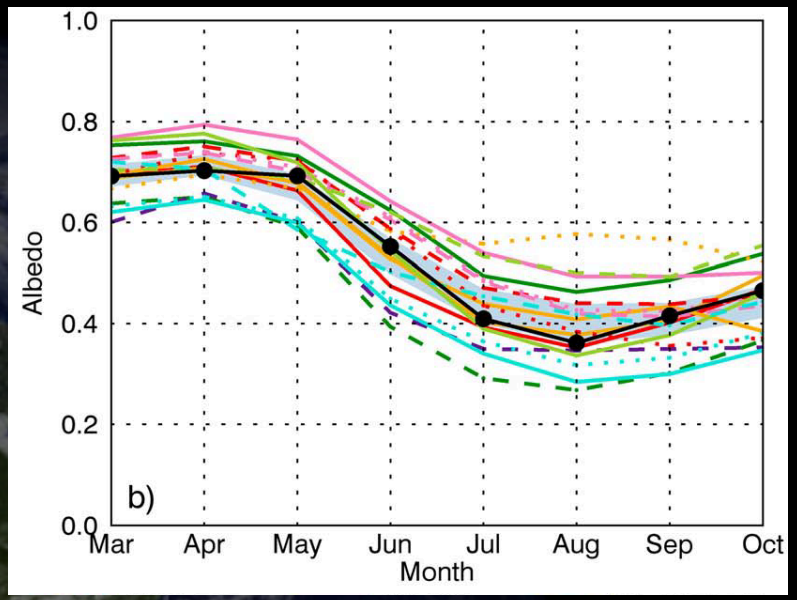
Arctic surface energy budget: Current Status

Christensen et al. (2016; BAMS)

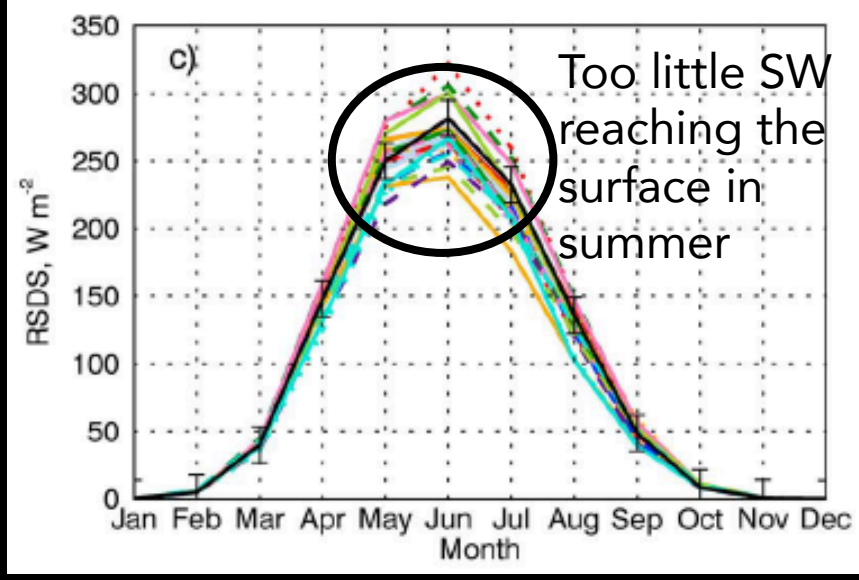


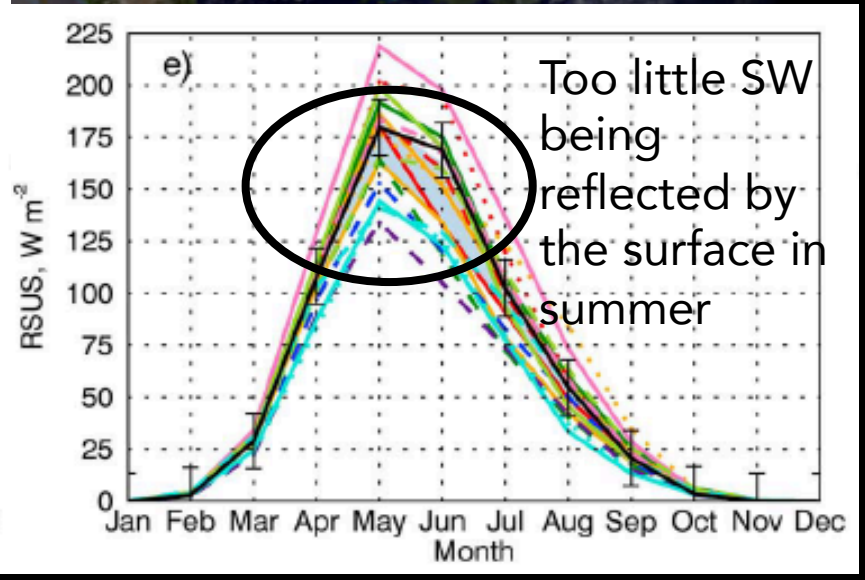
CMIP5 models disagree on key Arctic SEB components…



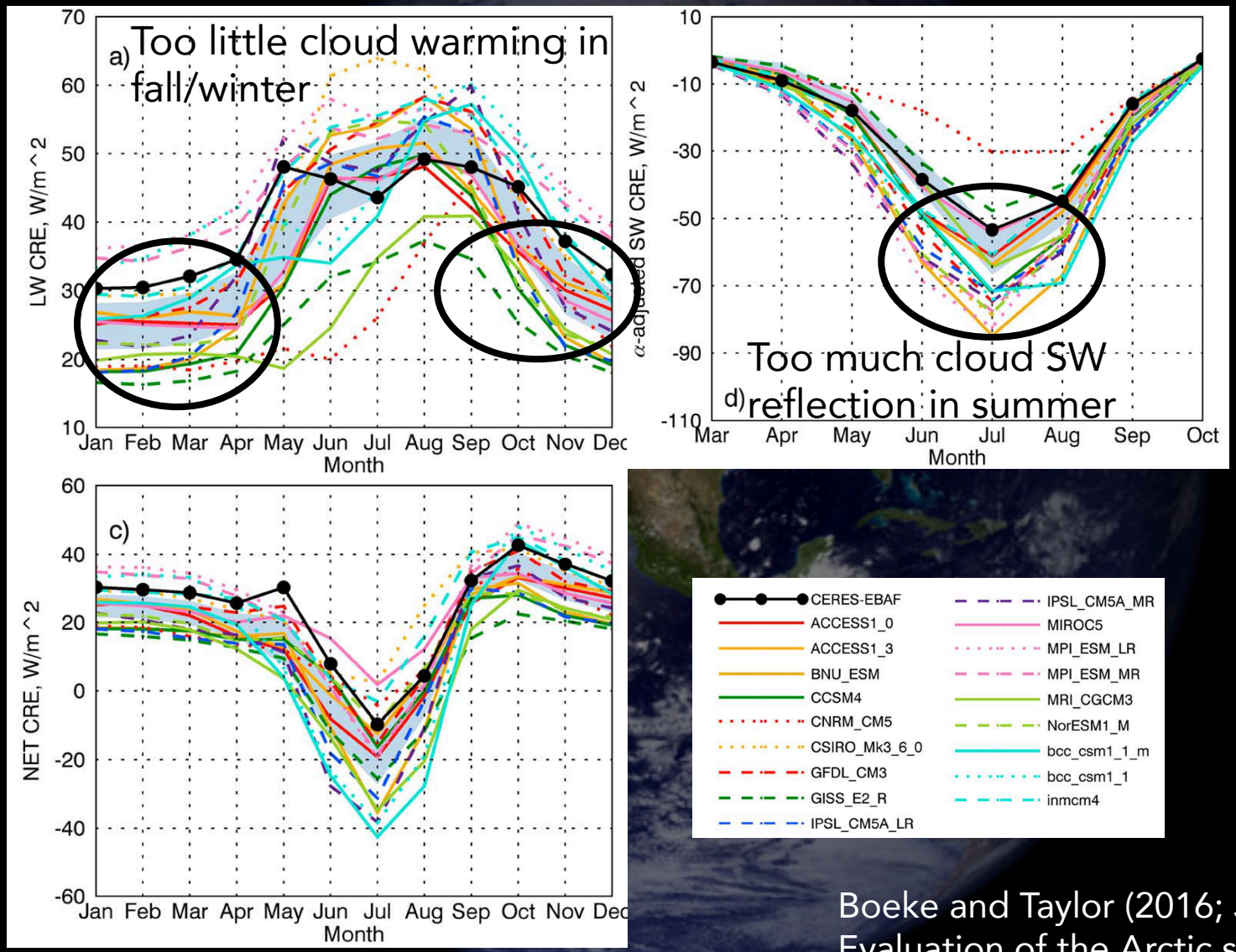


Boeke and Taylor (2016; JGR): Evaluation of the Arctic surface radiation budget in CMIP5 models





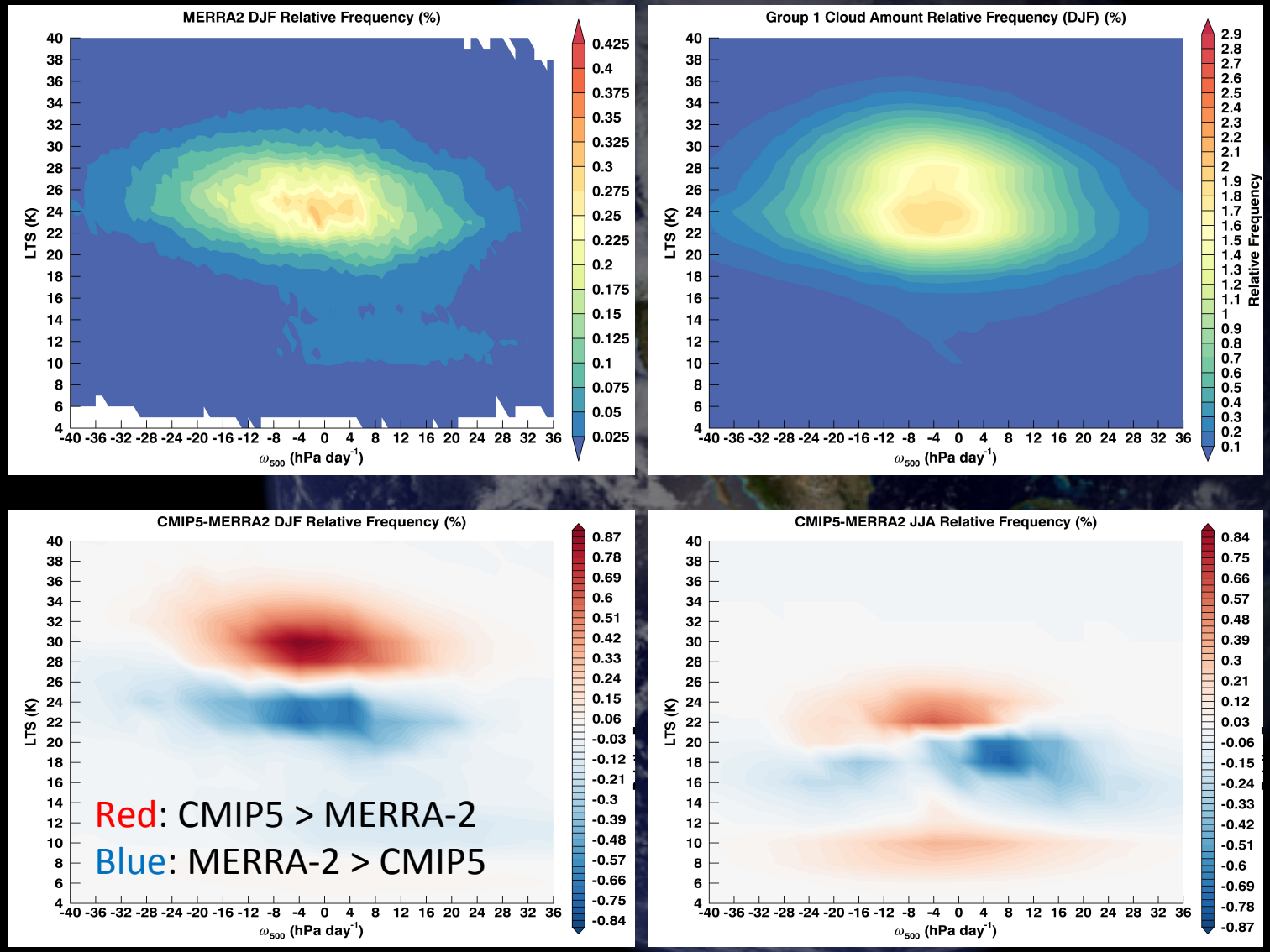
…many of which are cloud-related.



Boeke and Taylor (2016; JGR)
Evaluation of the Arctic surface radiation budget in CMIP5 models

Methodology: Regime Definition

LTS bins: 2 K
Omega500 bins: 4 hPa day^{-1}



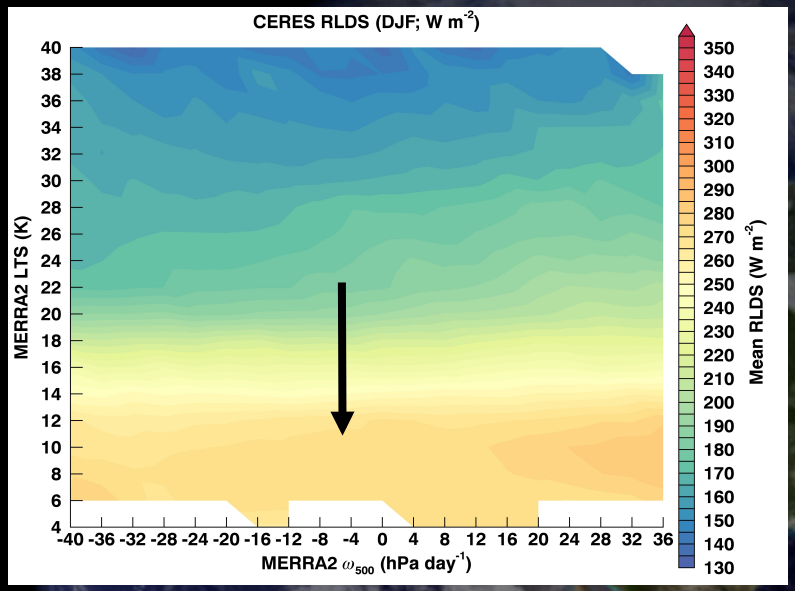
Data: CERES SFC_EBAF 4.0, MERRA-2, CMIP5 models (historical simulations)

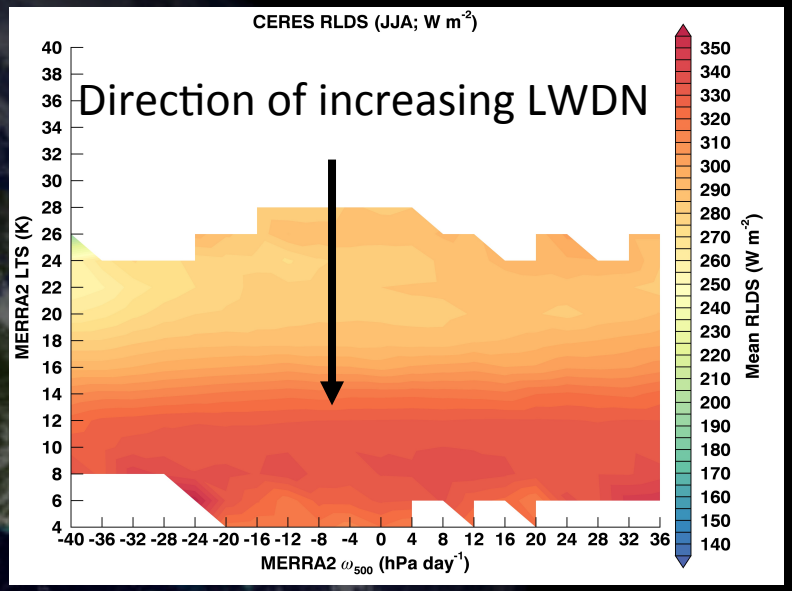
CERES LWDN surface fluxes

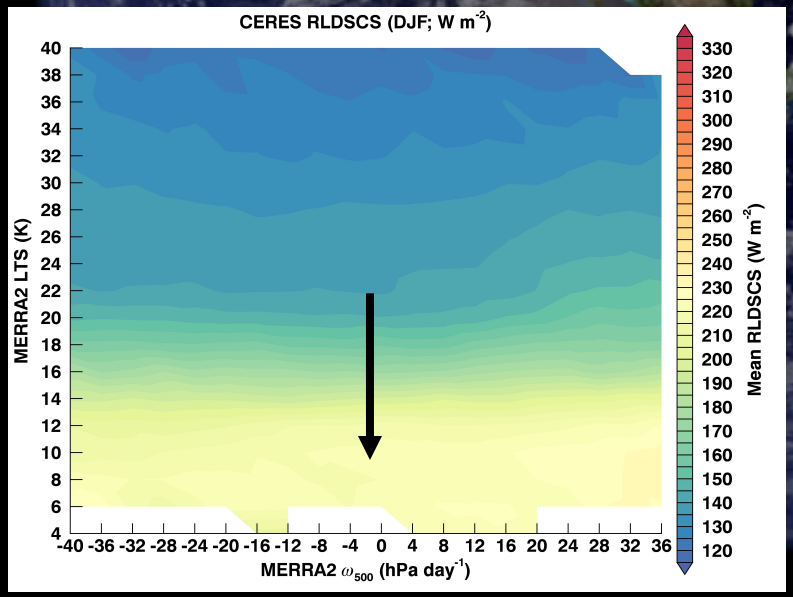
Winter

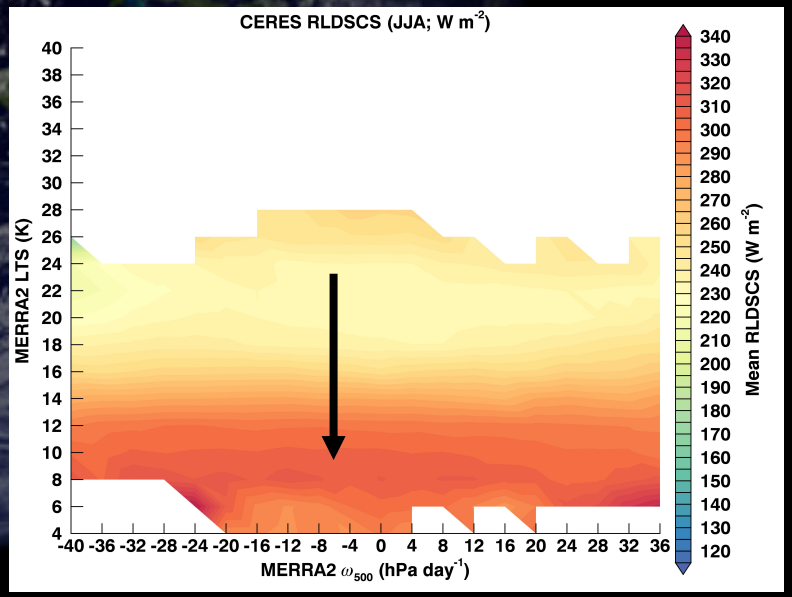
Summer

Stronger variations in LW fluxes are found w.r.t LTS than omega500



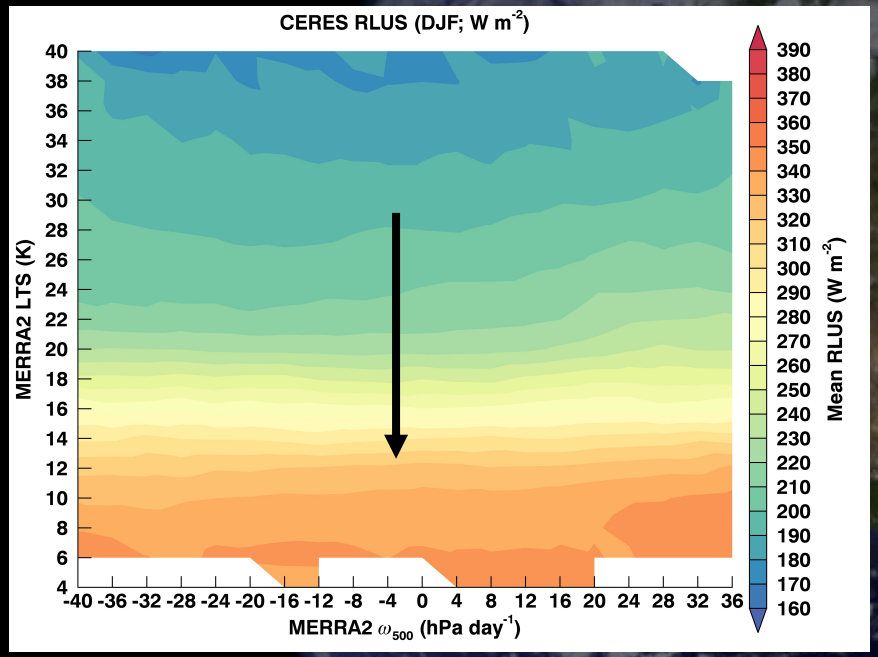




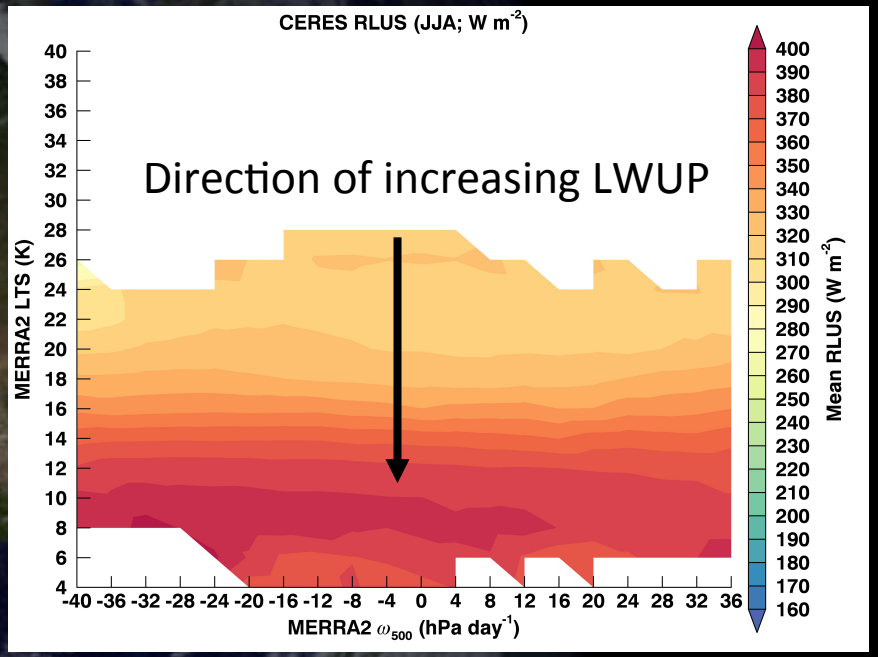


CERES LWUP surface fluxes

Winter

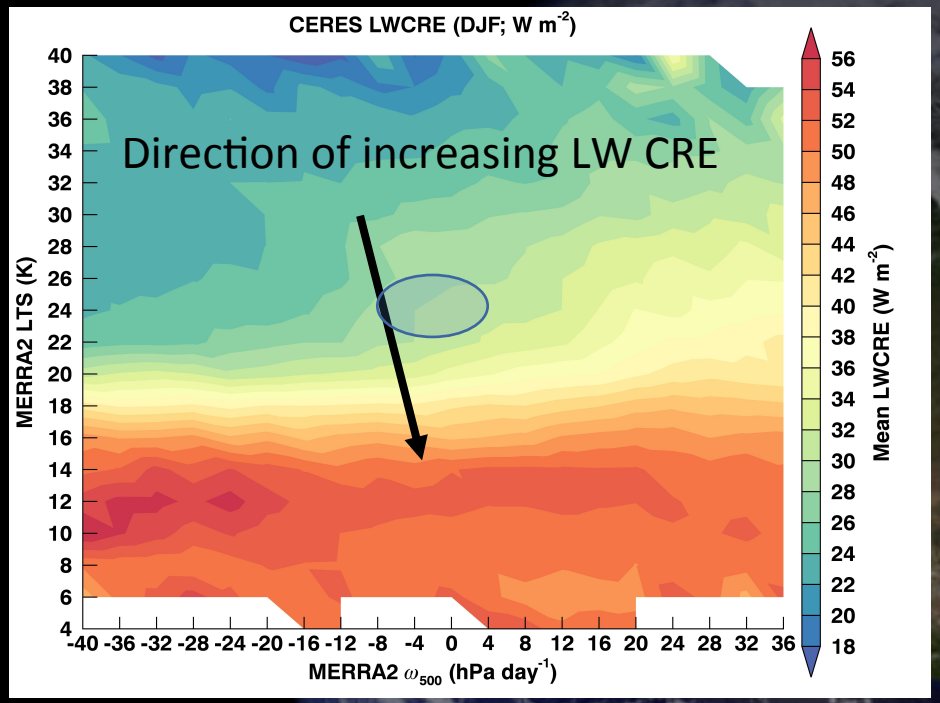


Summer

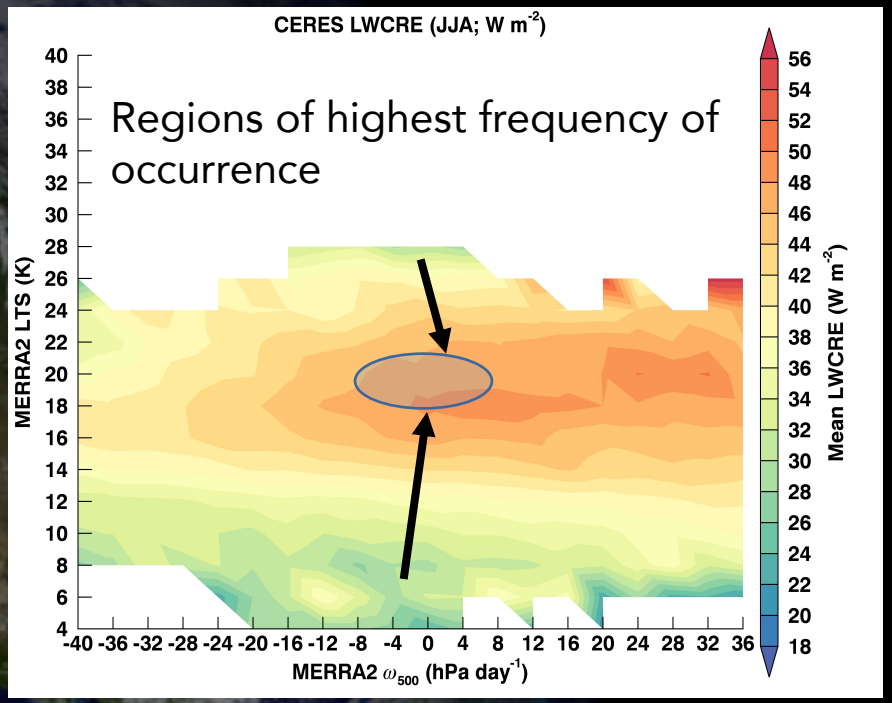


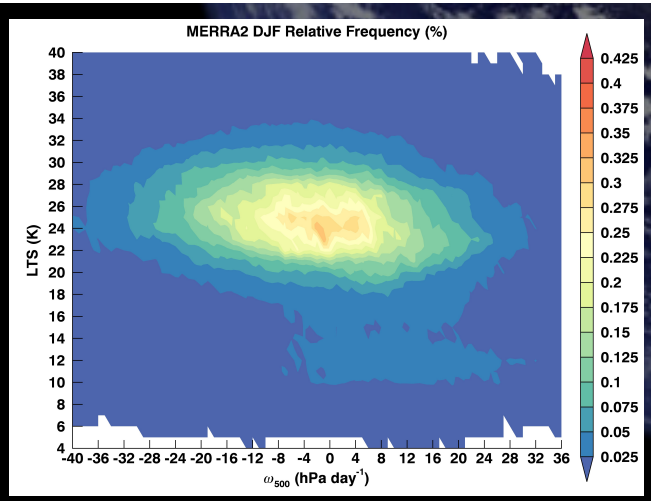
CERES Surface LW CRE

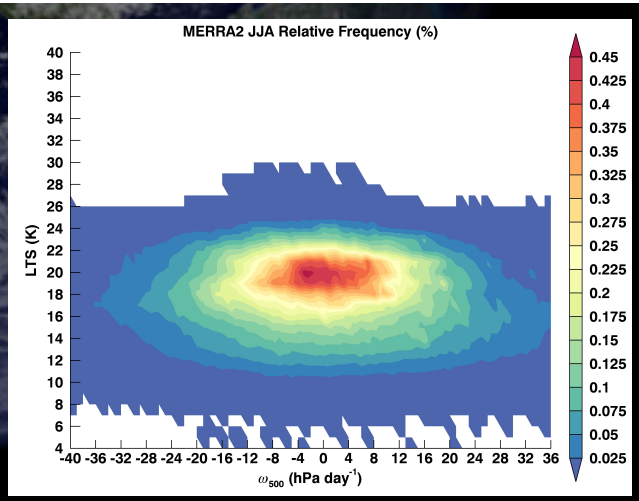
Winter



Summer

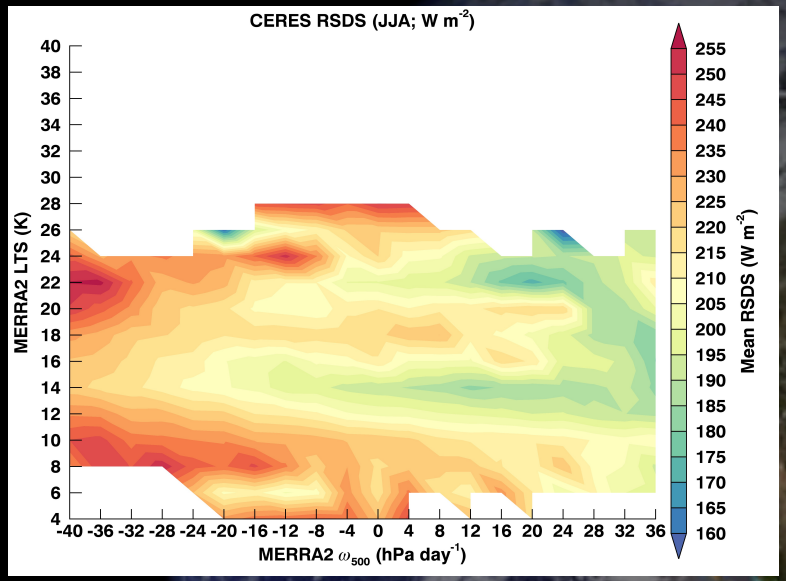




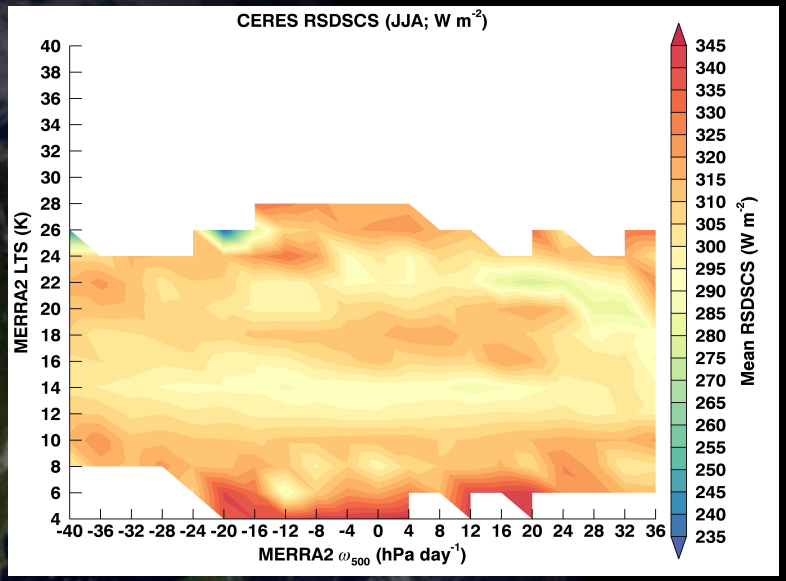


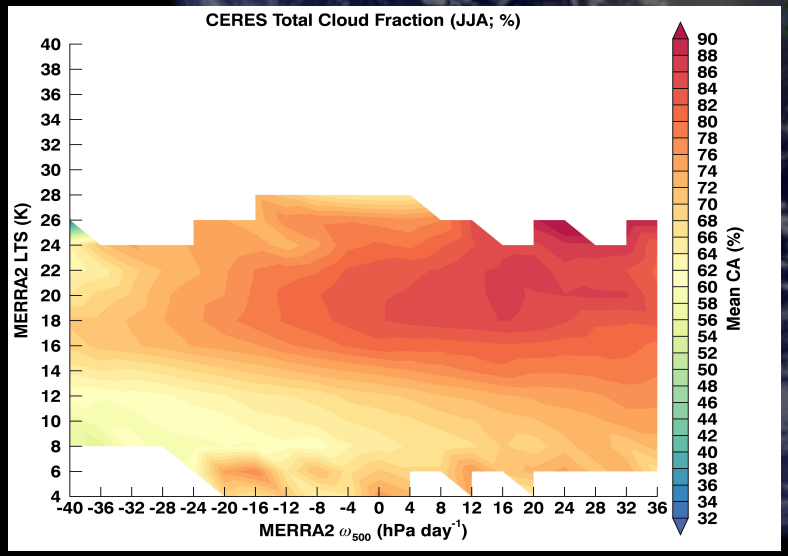
CERES SWDN surface fluxes: Summer

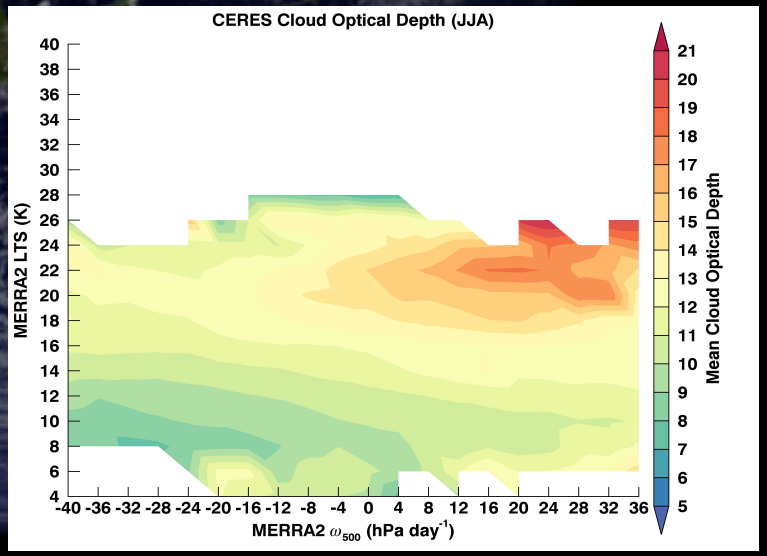
SWDN_all



SWDN_clr

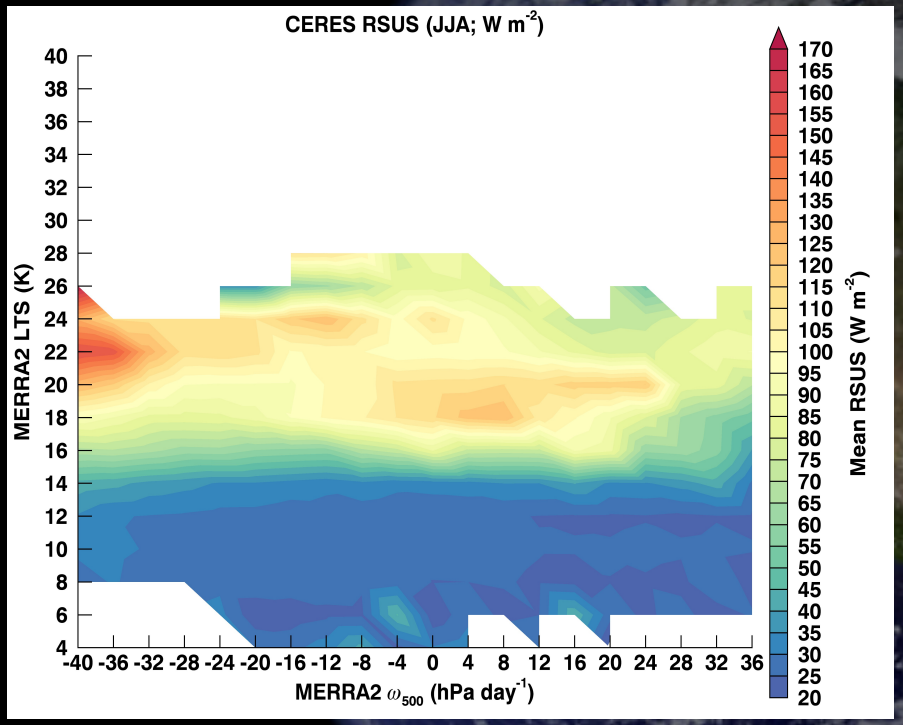




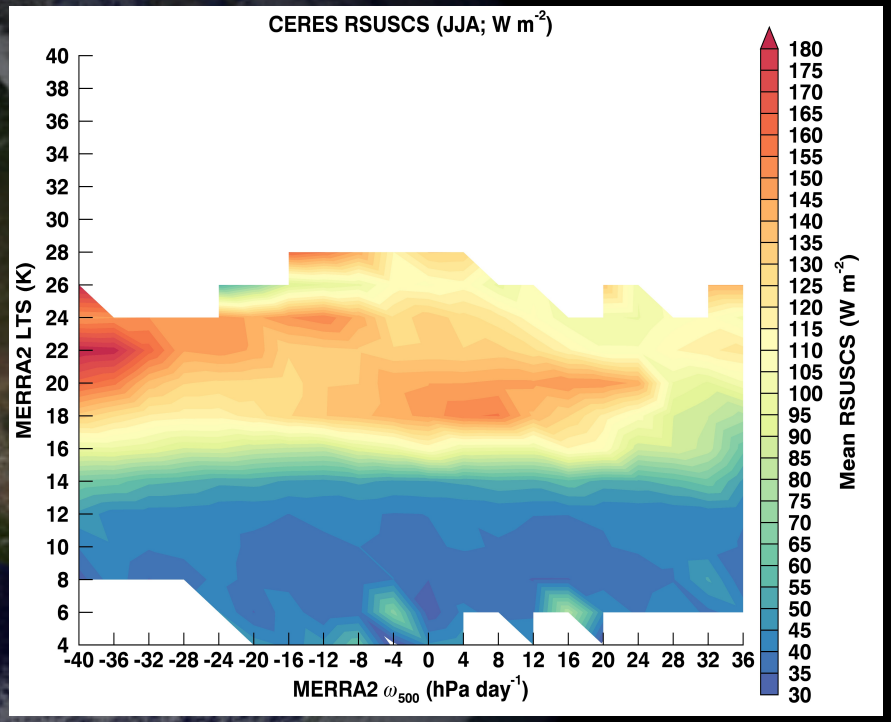


CERES SWUP surface fluxes: Summer

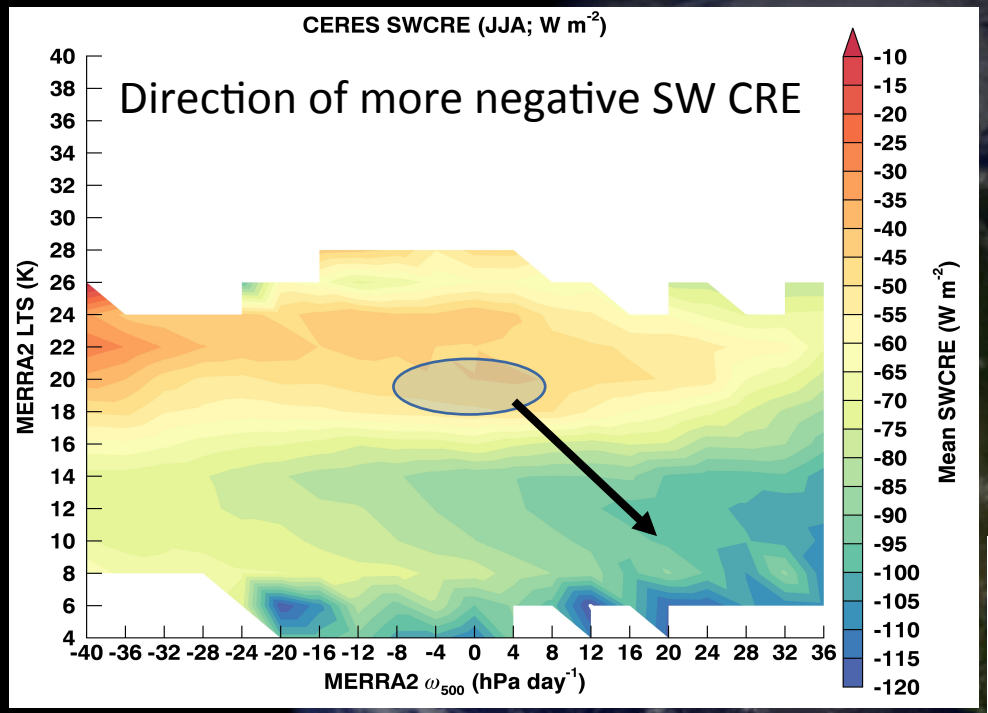
SWUP_all

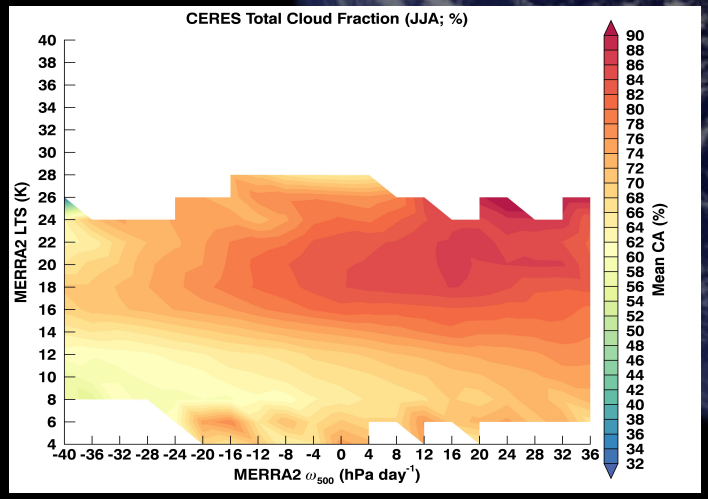


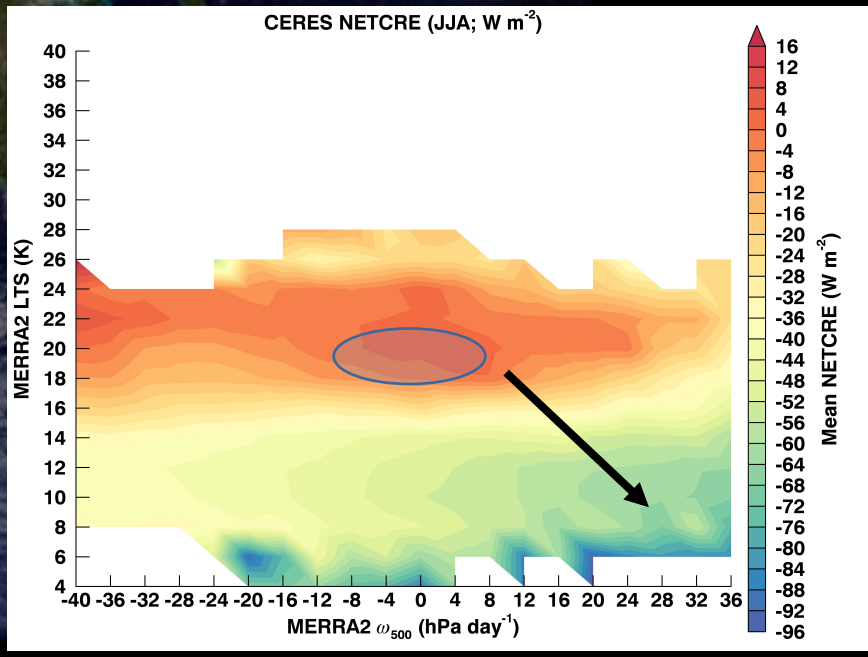
SWUP_clr



CERES Surface SW and Net CRE

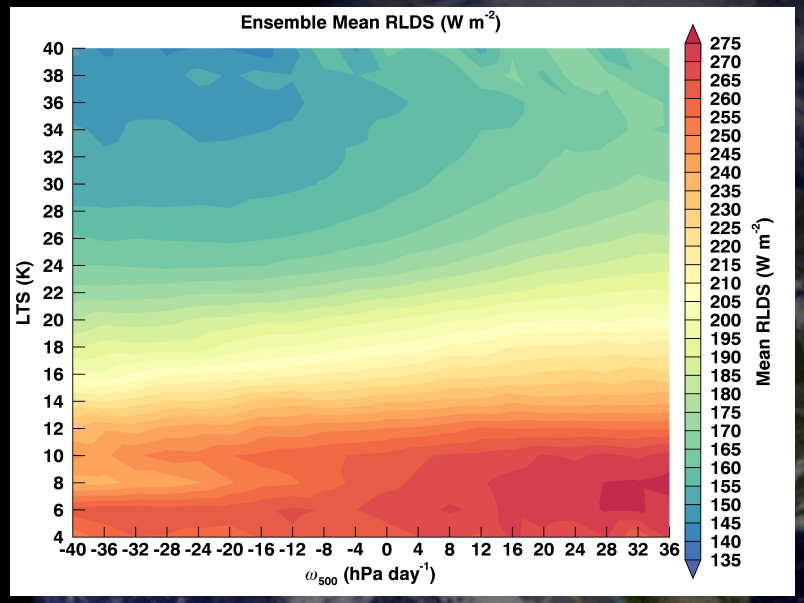


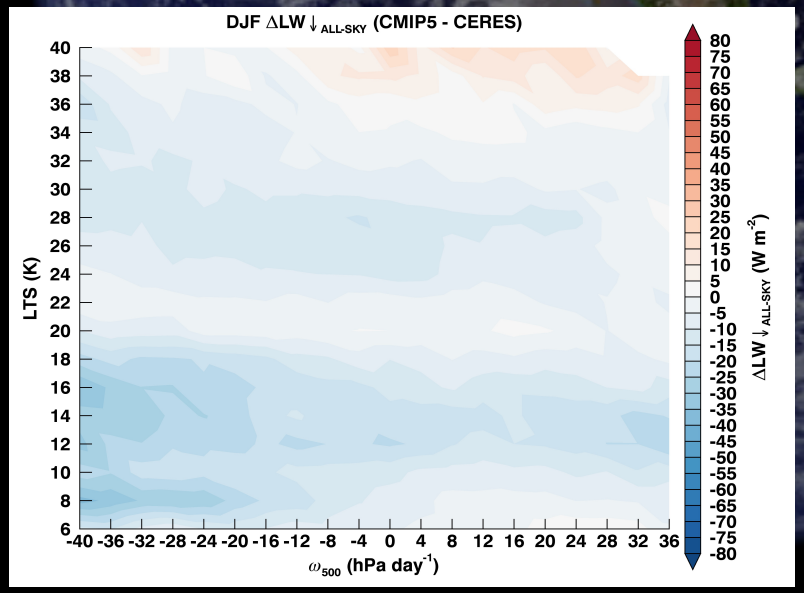




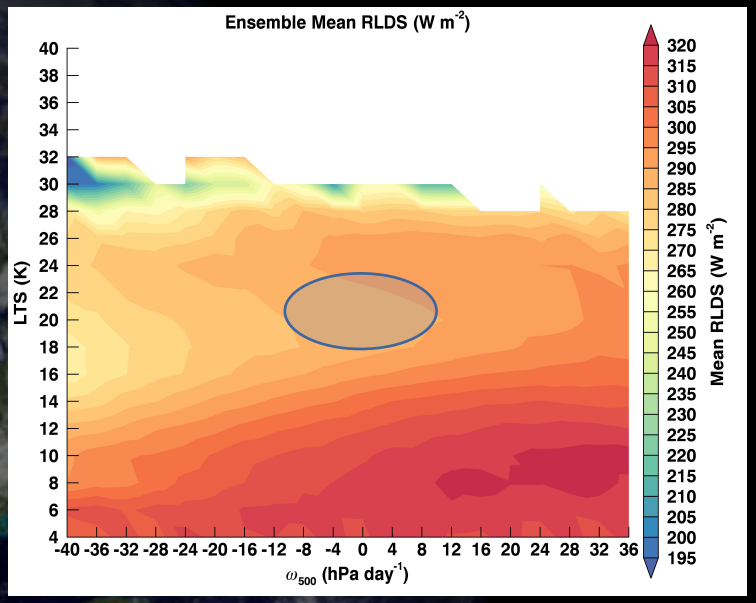
CMIP5 Ensemble LWDN surface fluxes

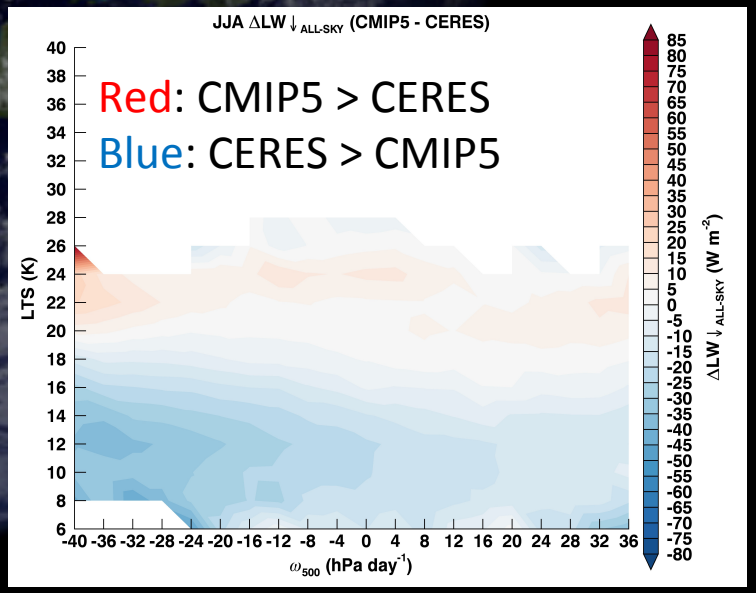
Winter





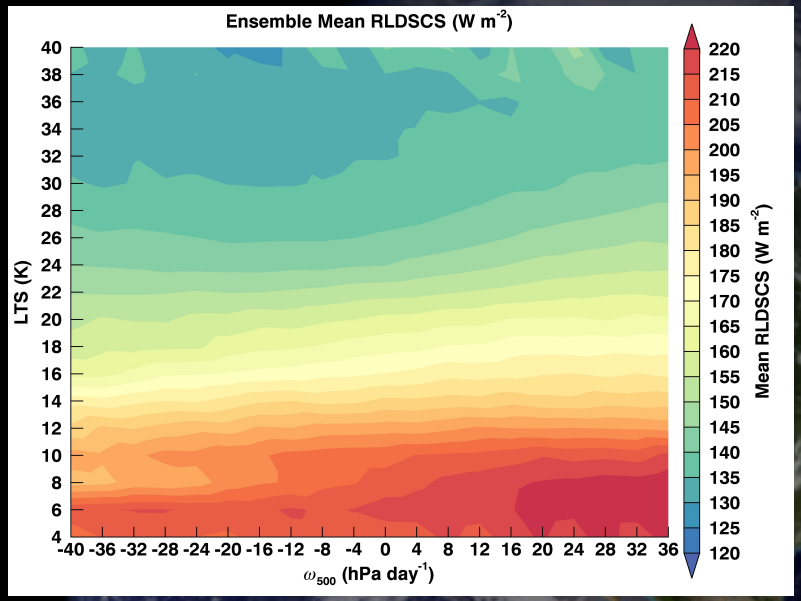
Summer



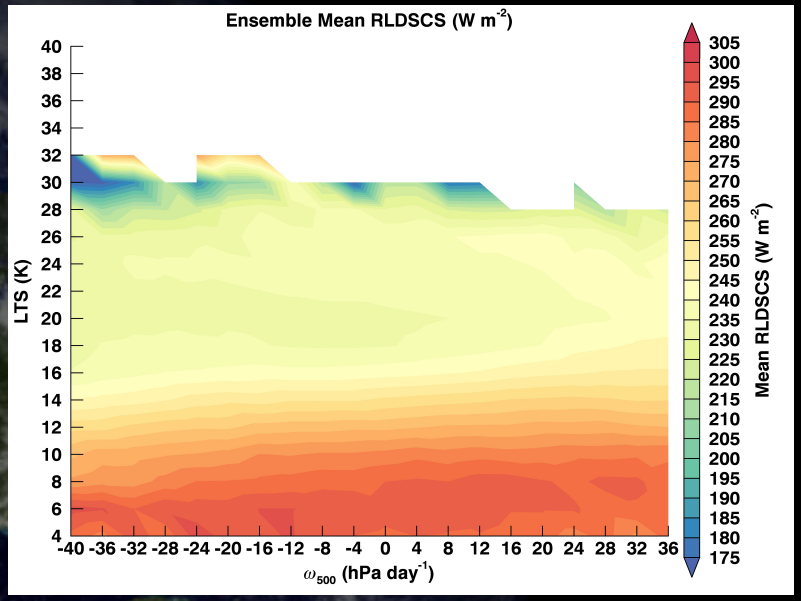


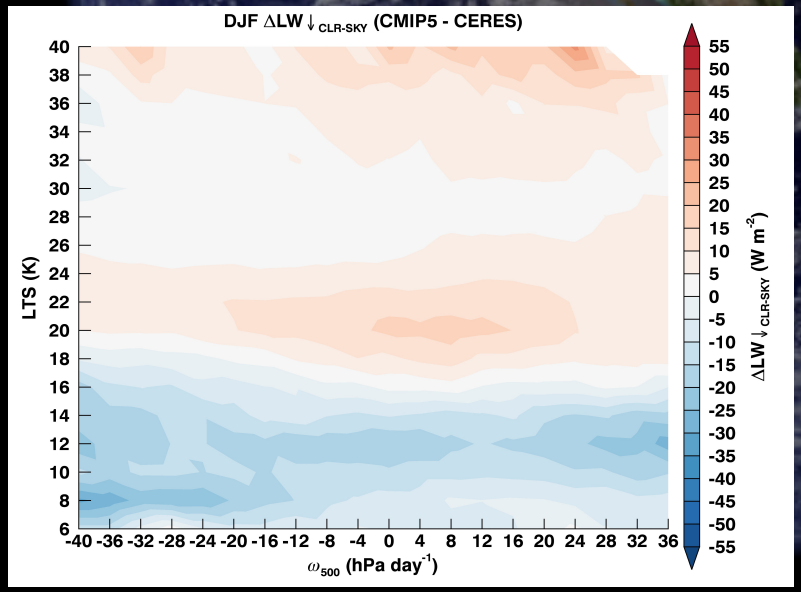
CMIP5 Ensemble LWDN_clr surface fluxes

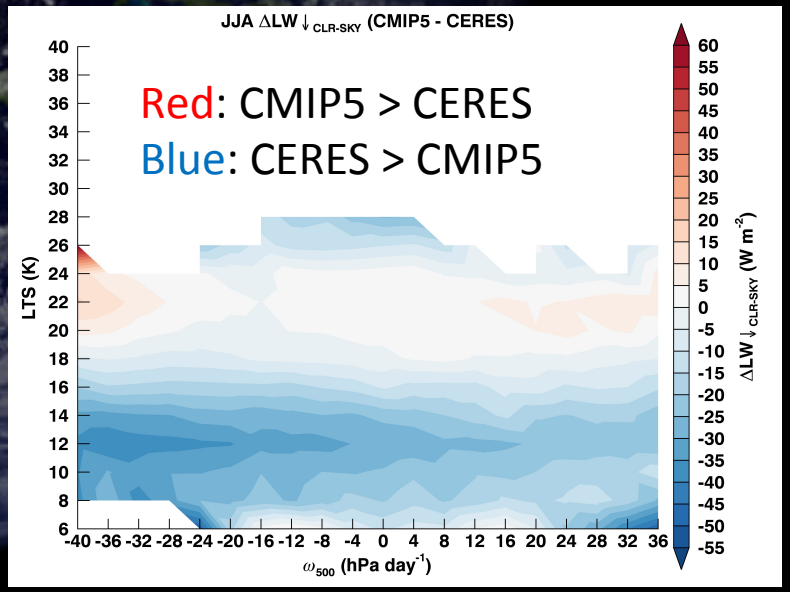
Winter



Summer

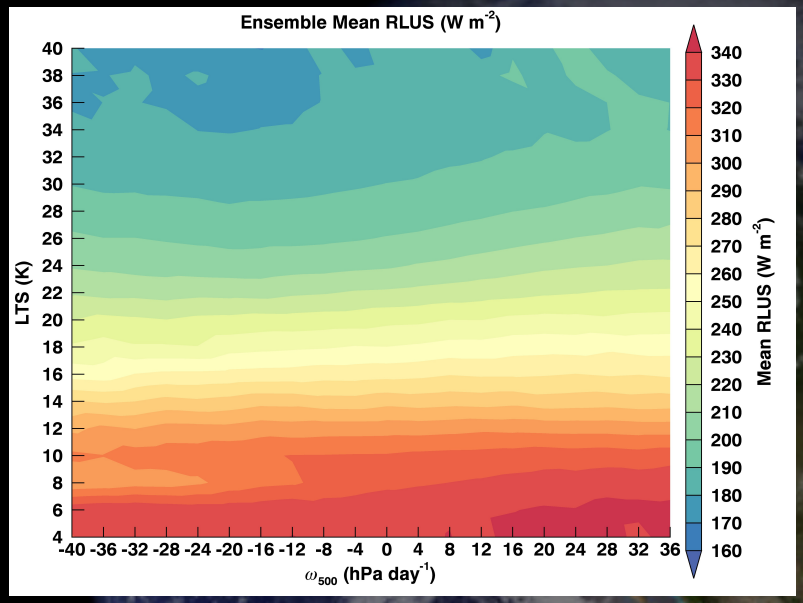


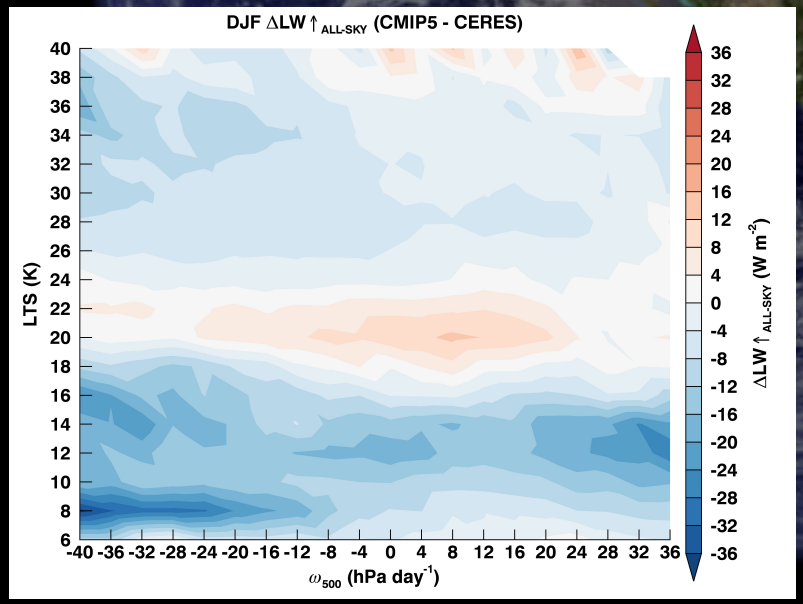




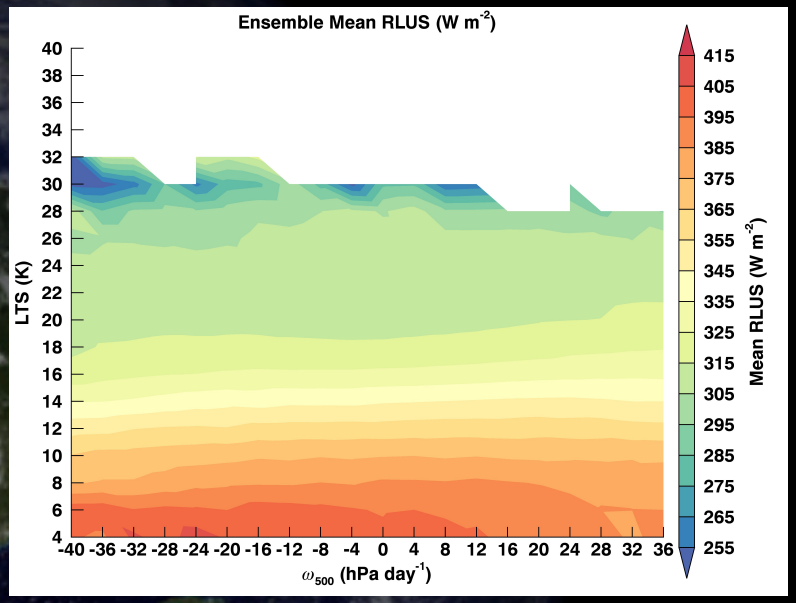
CMIP5 Ensemble LWUP surface fluxes

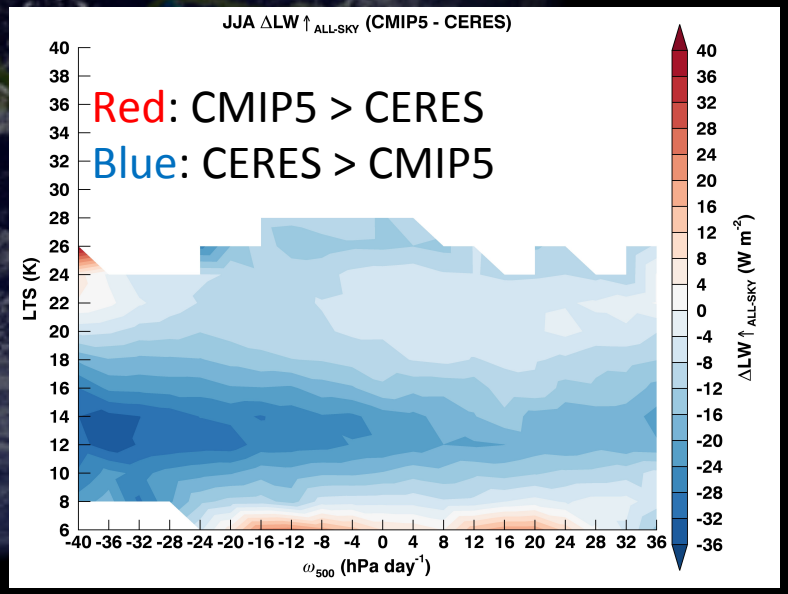
Winter





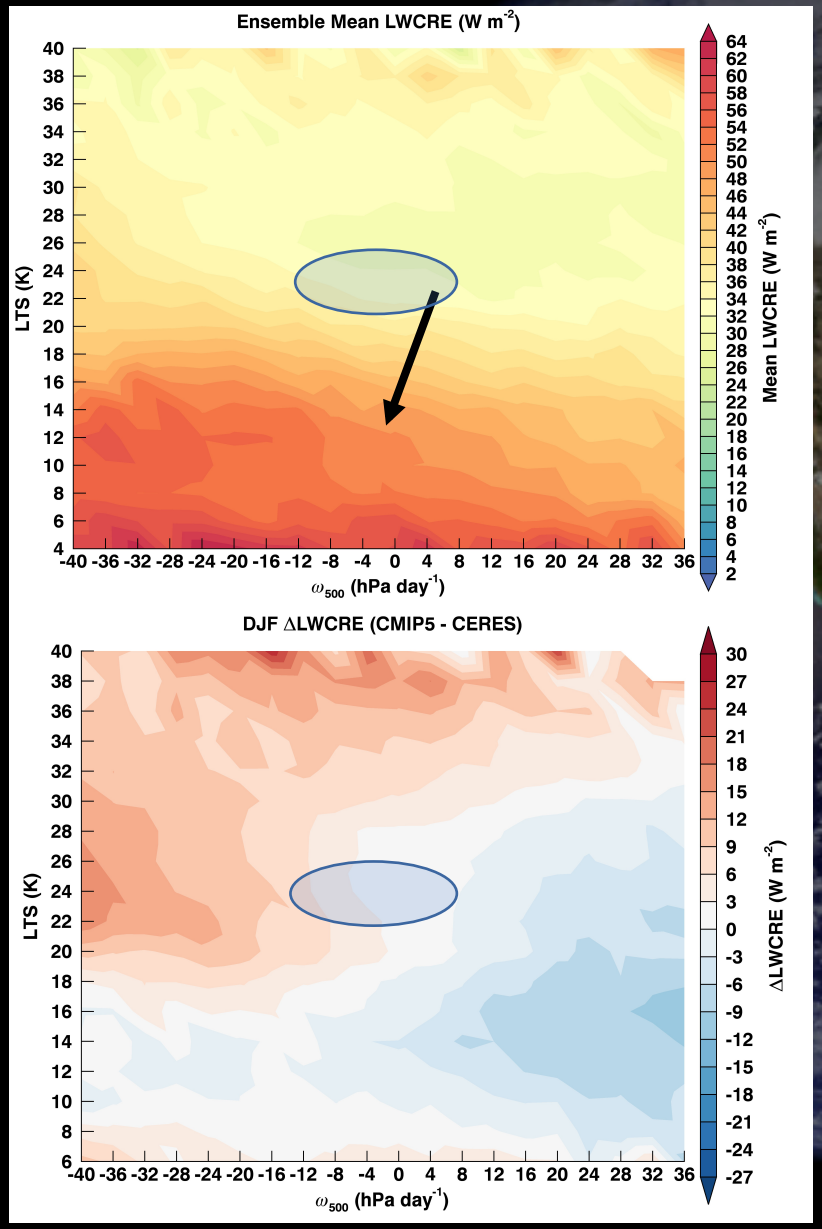
Summer



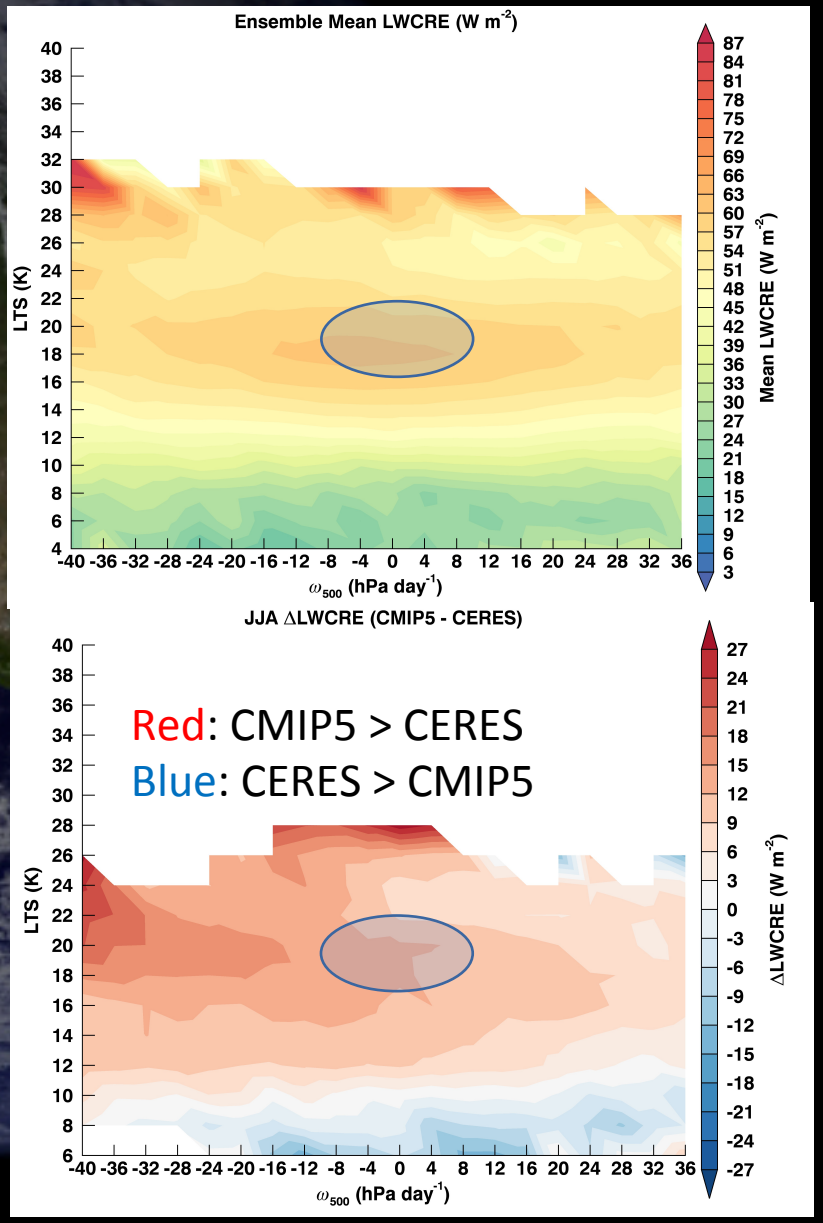


CMIP5 Ensemble Surface LW CRE

Winter

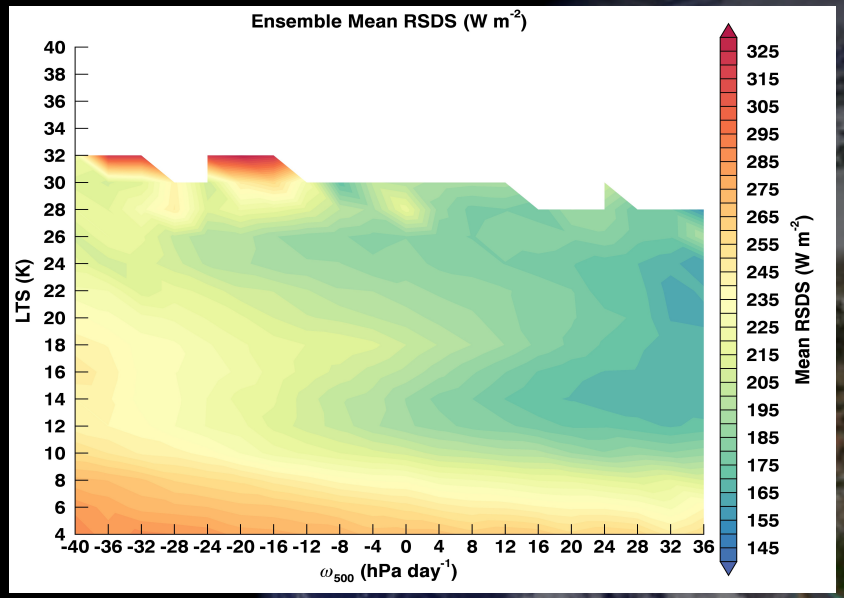


Summer

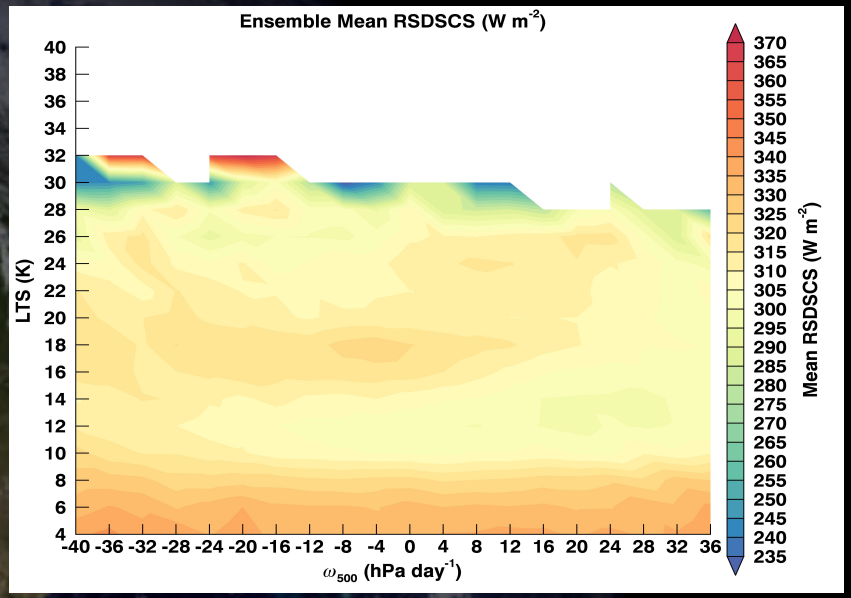


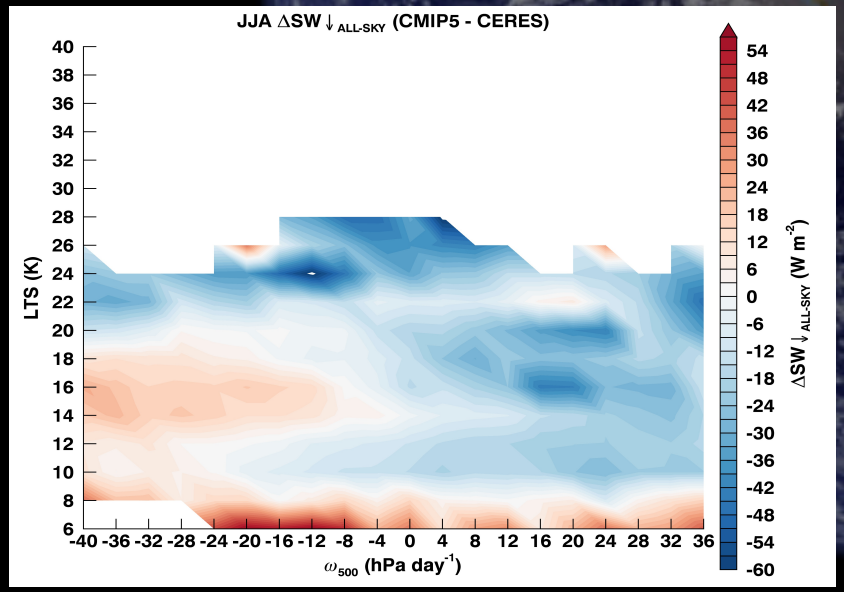
CMIP5 Ensemble Surface SWDN

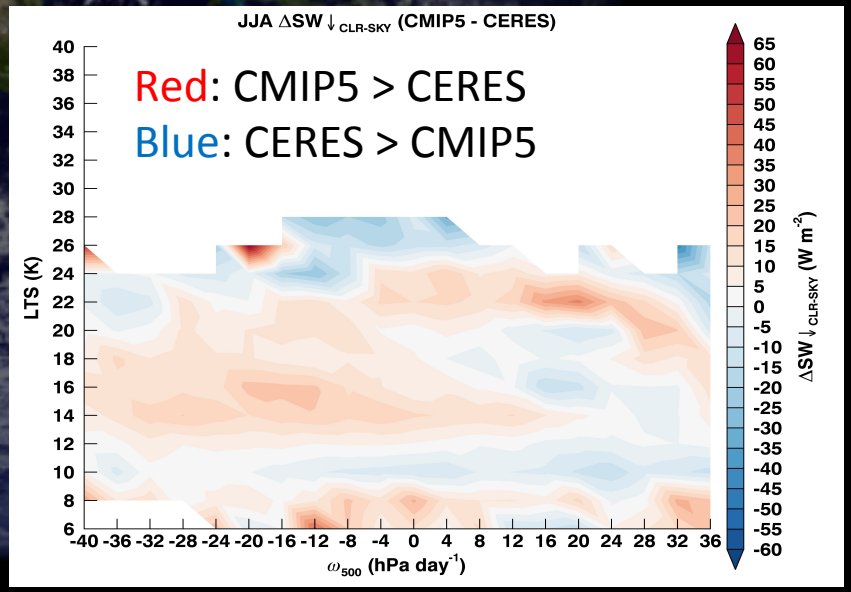
SWDN



SWDN_clr

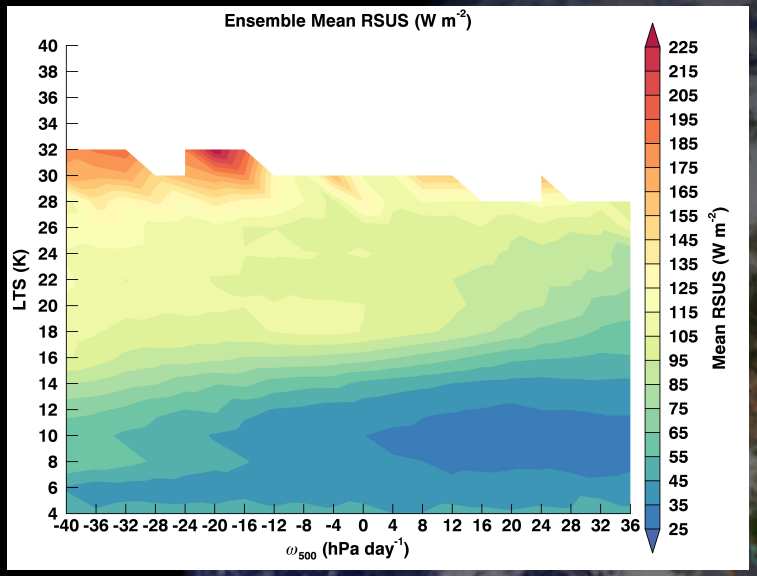




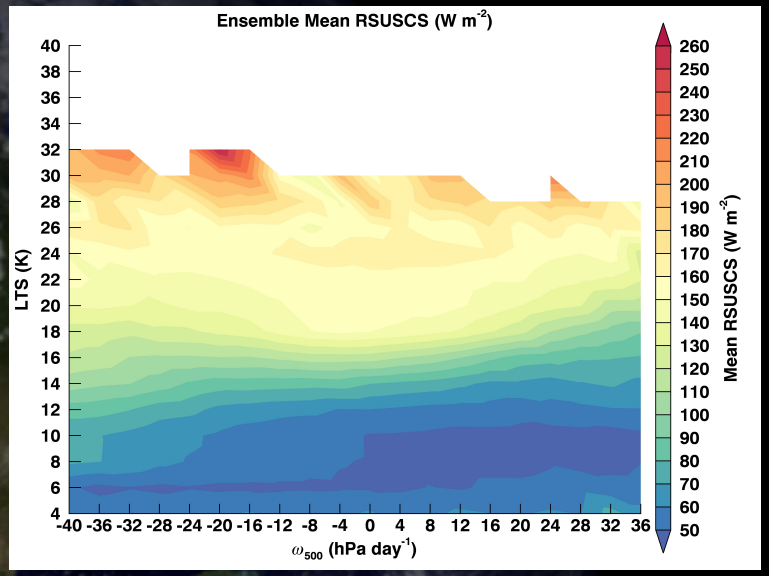


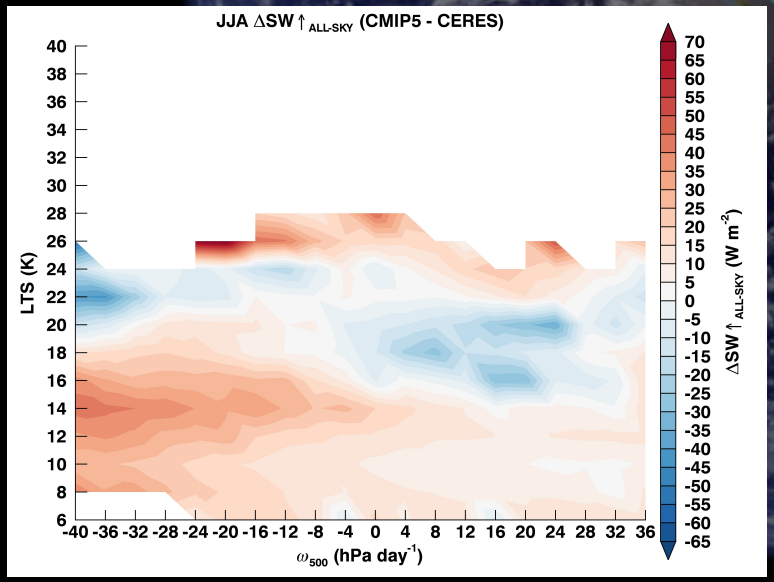
CMIP5 Ensemble Surface SWUP

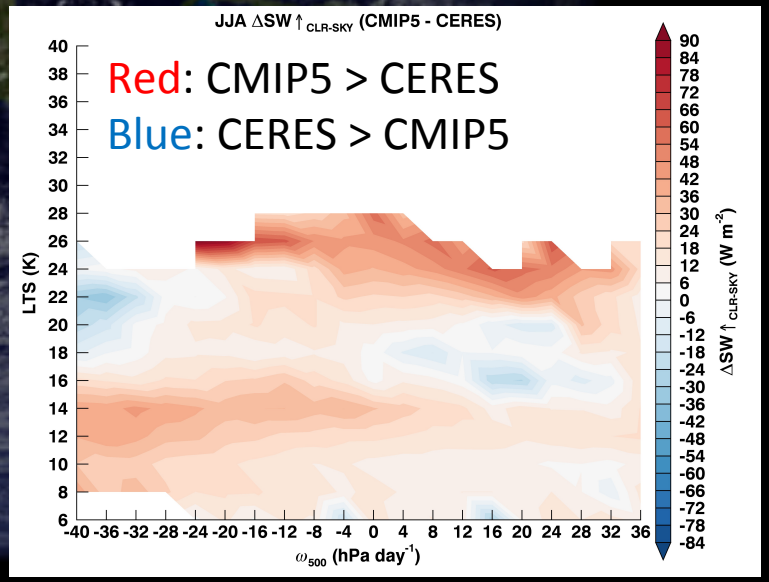
SWUP



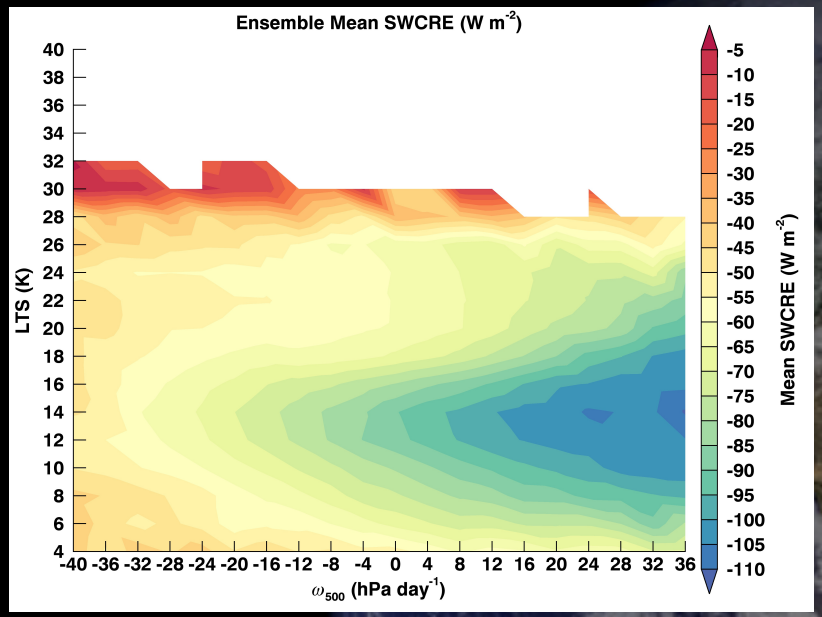
SWUP_clr

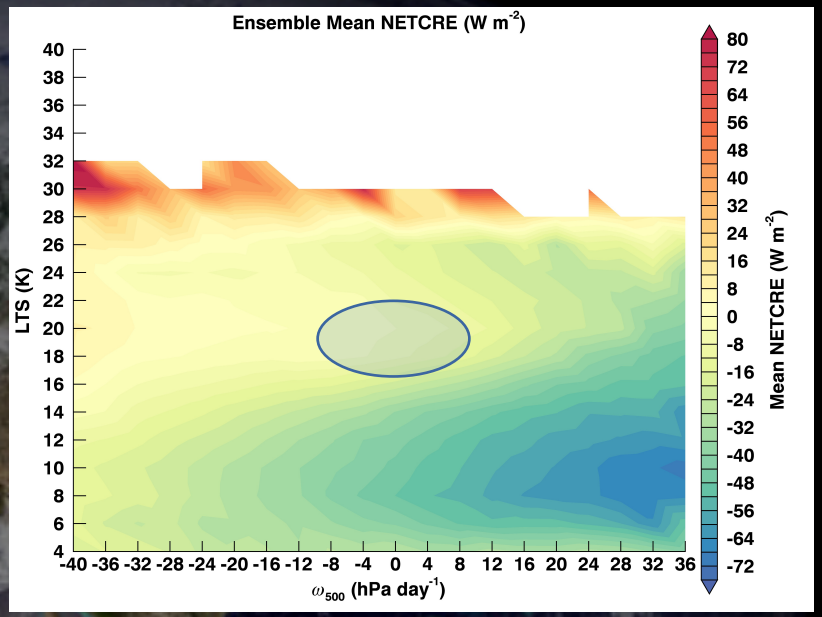




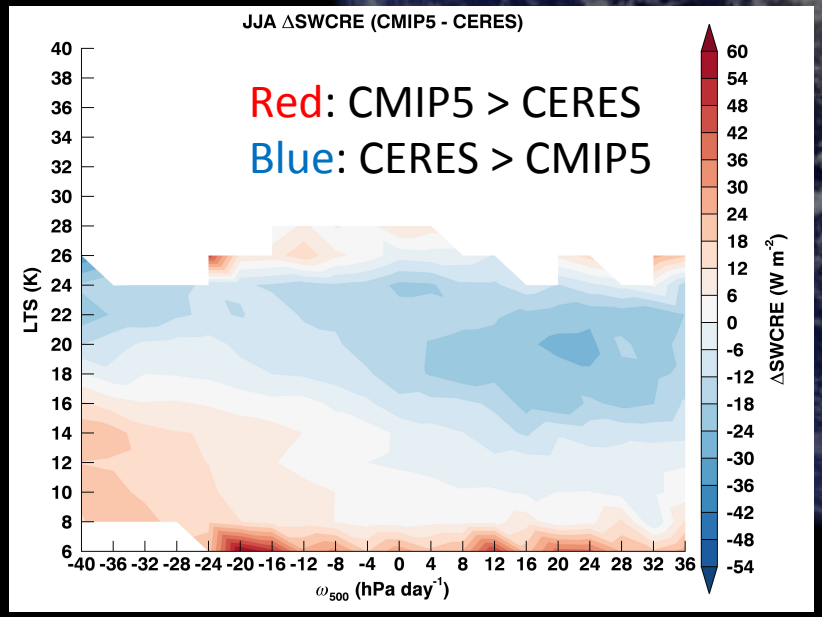


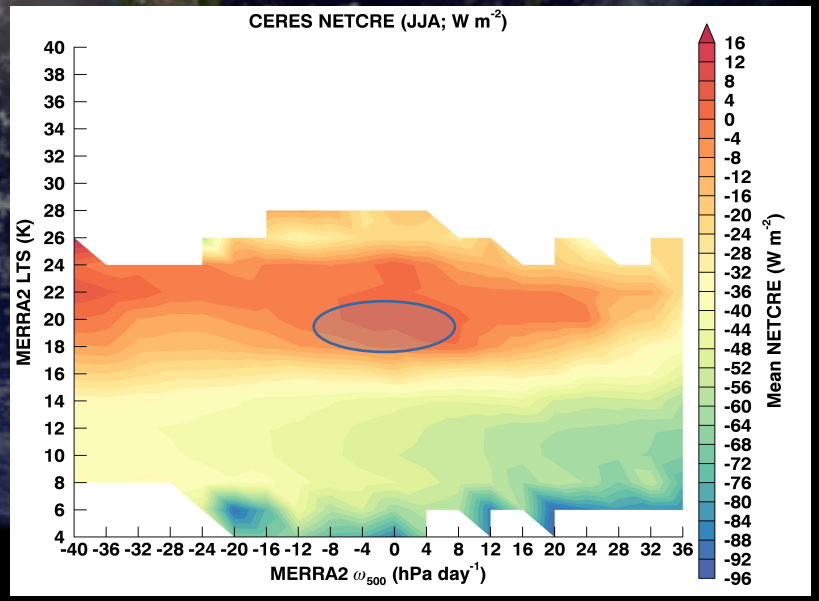
CMIP5 Ensemble Surface SW and Net CRE





Certain regimes do indicate a shift from a net cooling to a net warming effect.

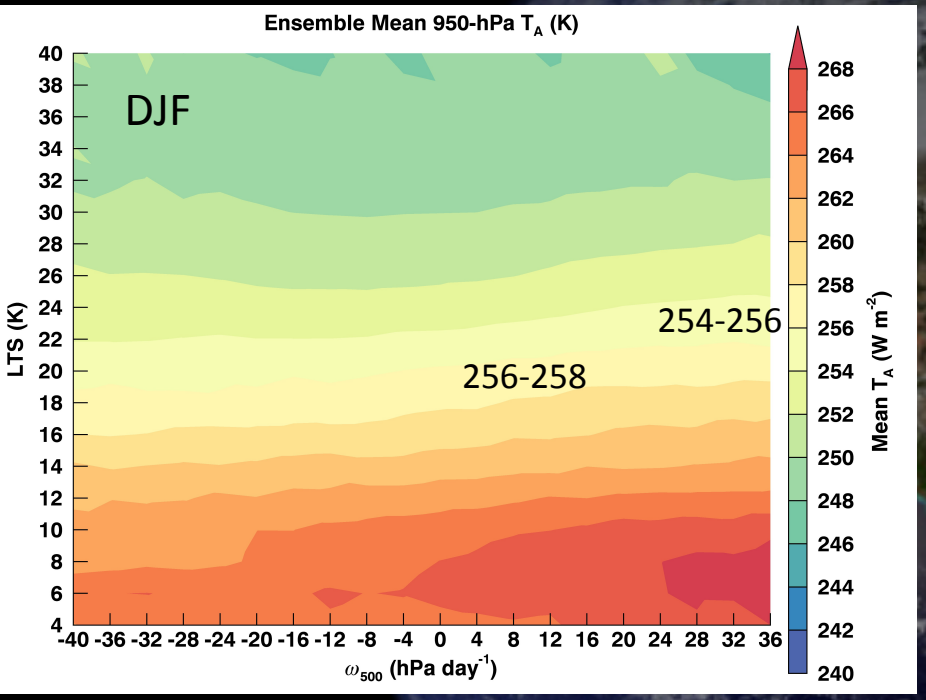


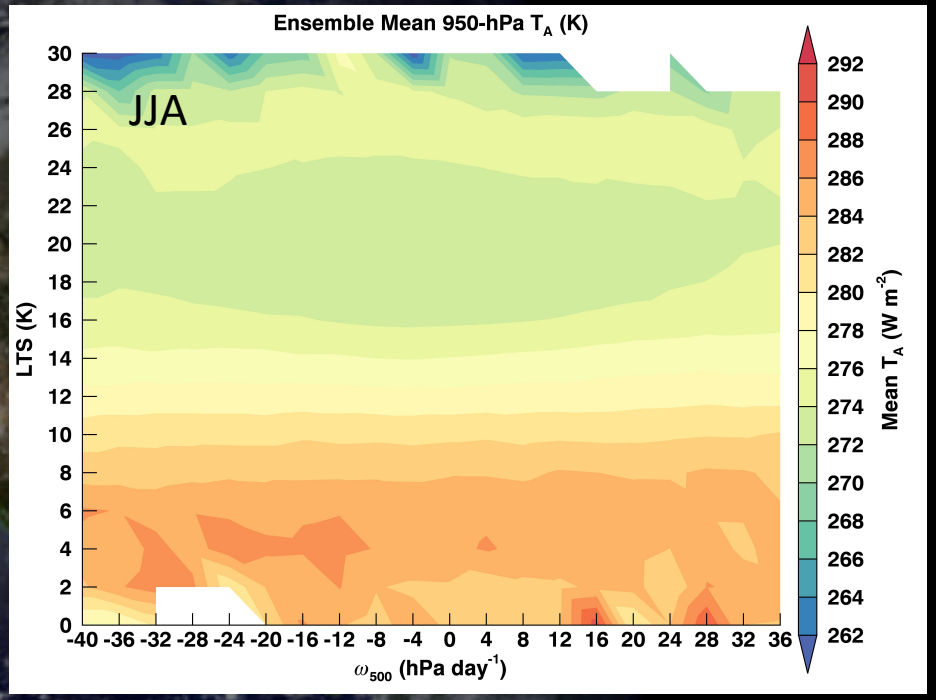


Takeaways…

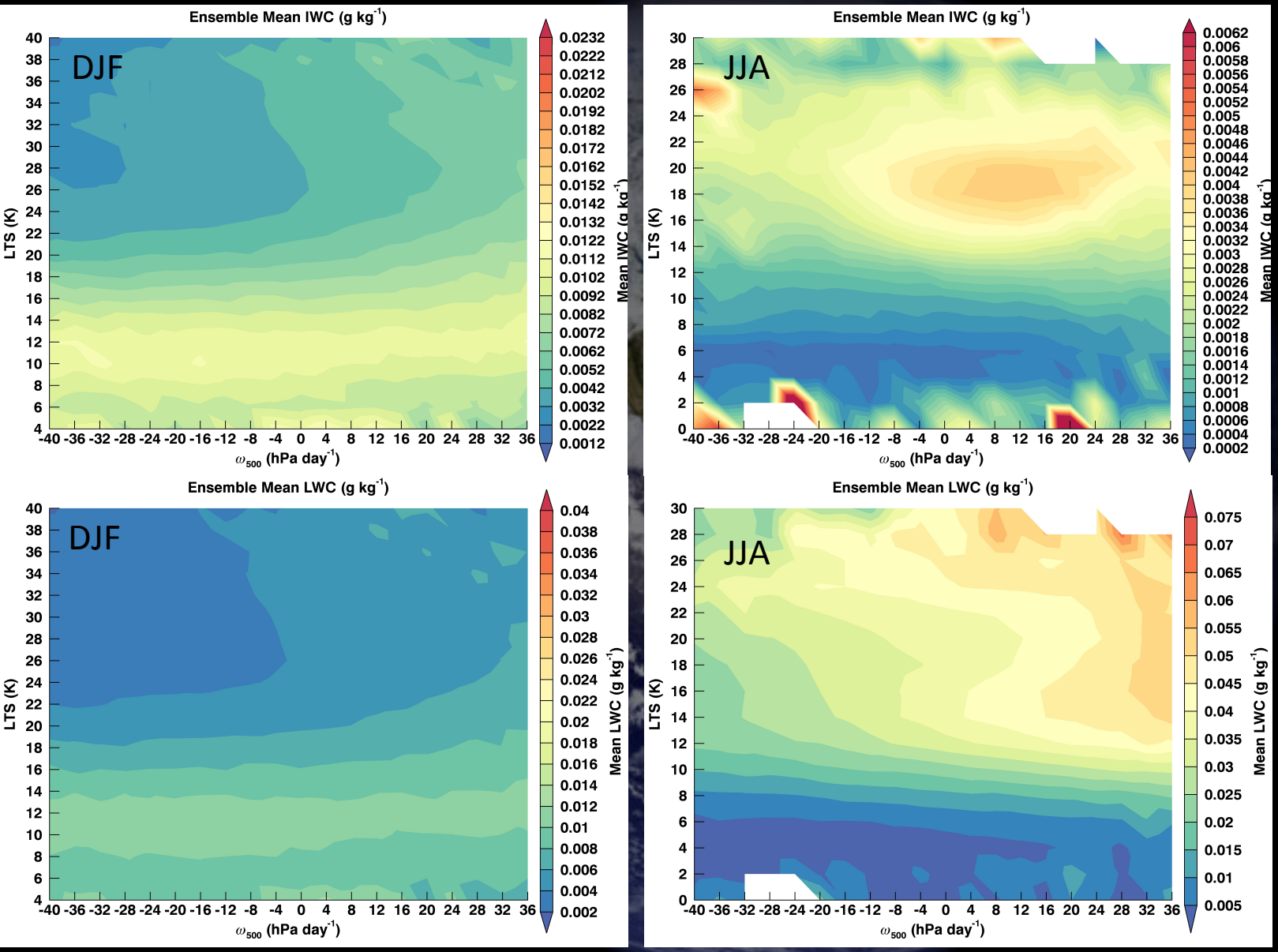
- A regime approach allows a better assessment of the implications that of model processes on the surface energy budget as well as the implication of surface energy budget errors on processes.
- Results suggest a slew of relevant and important biases in CMIP5 relative to CERES.
- Using the regime framework shows significant gradients in the sensitivity of the surface energy budget terms to small changes in LTS.

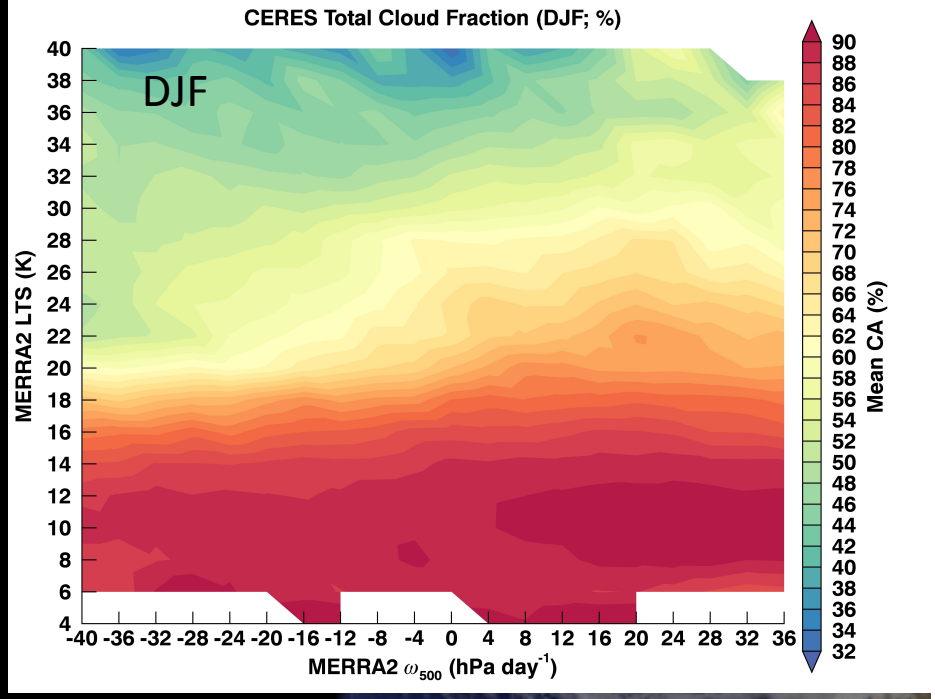
CMIP5 Ensemble mean 950 hPa Air Temperature

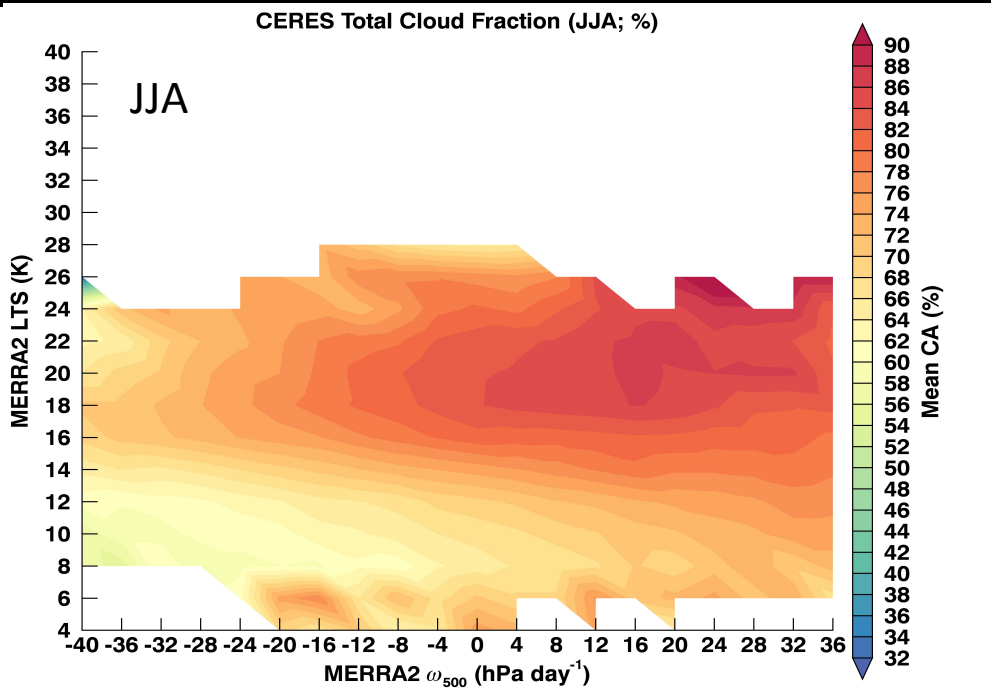


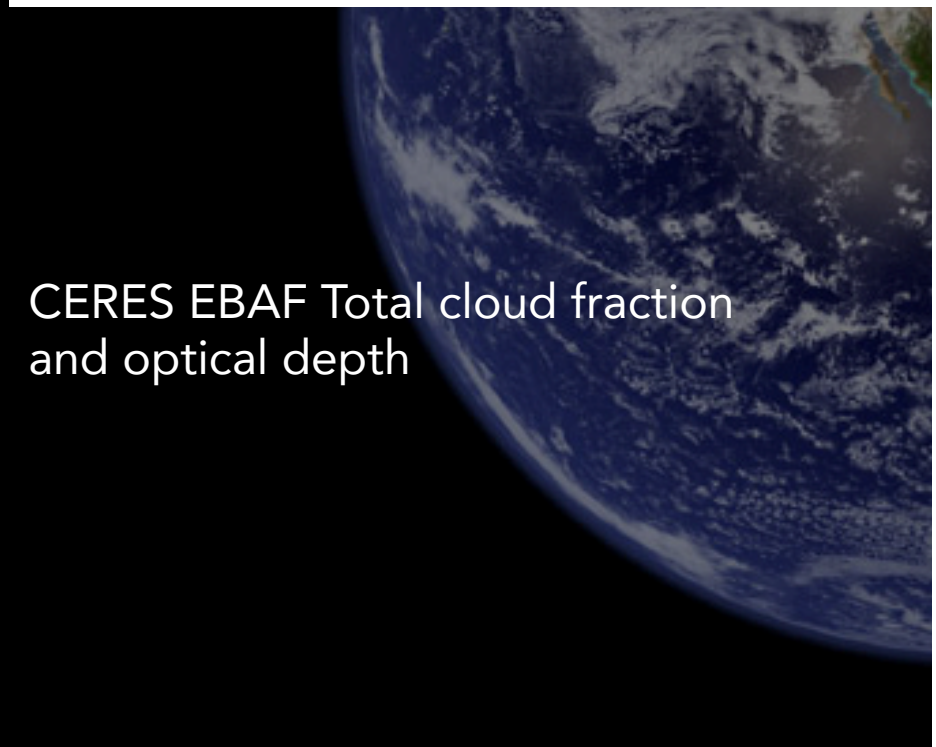


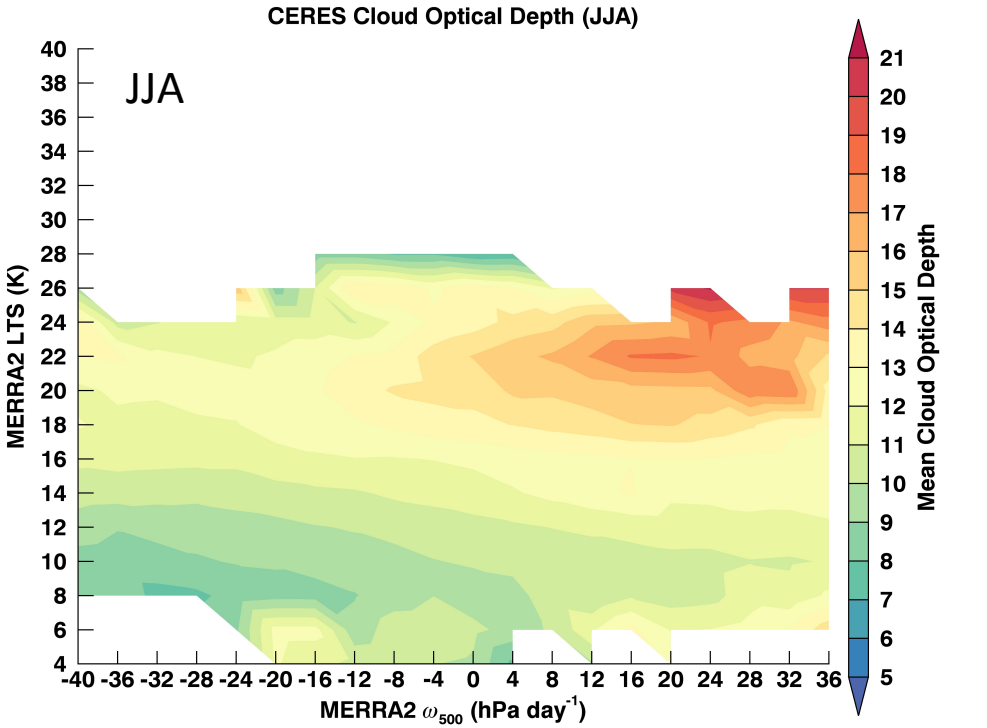
CMIP5 Ensemble mean lower tropospheric IWC and LWC



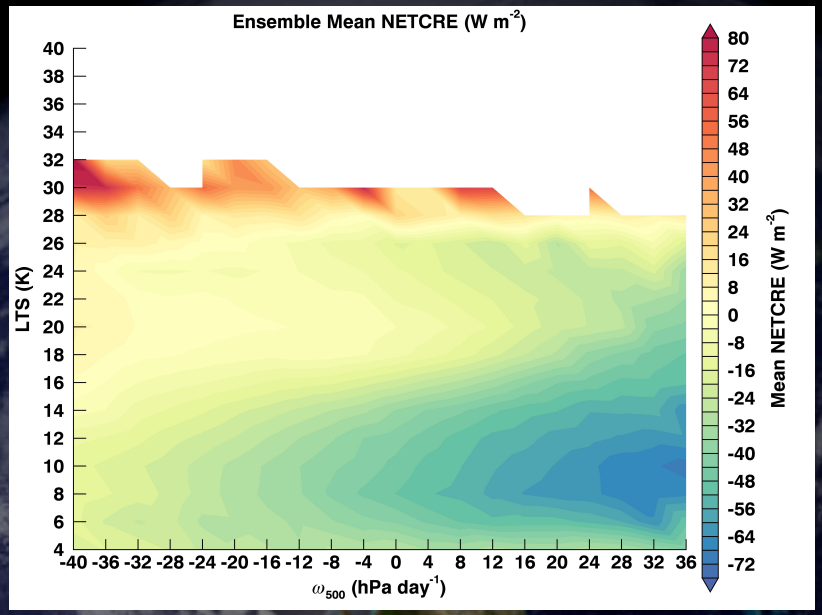

CERES Total Cloud Fraction (DJF; %)
DJF
MERRA2 LTS (K)
MERRA2 ω_{500} (hPa day^{-1})
Mean CA (%)


CERES Total Cloud Fraction (JJA; %)
JJA
MERRA2 LTS (K)
MERRA2 ω_{500} (hPa day^{-1})
Mean CA (%)

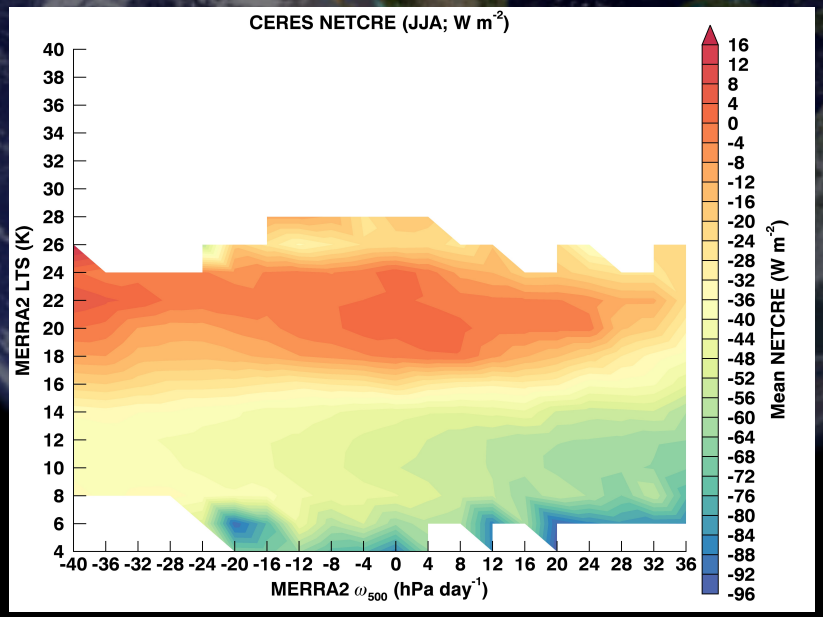

CERES EBAF Total cloud fraction
and optical depth

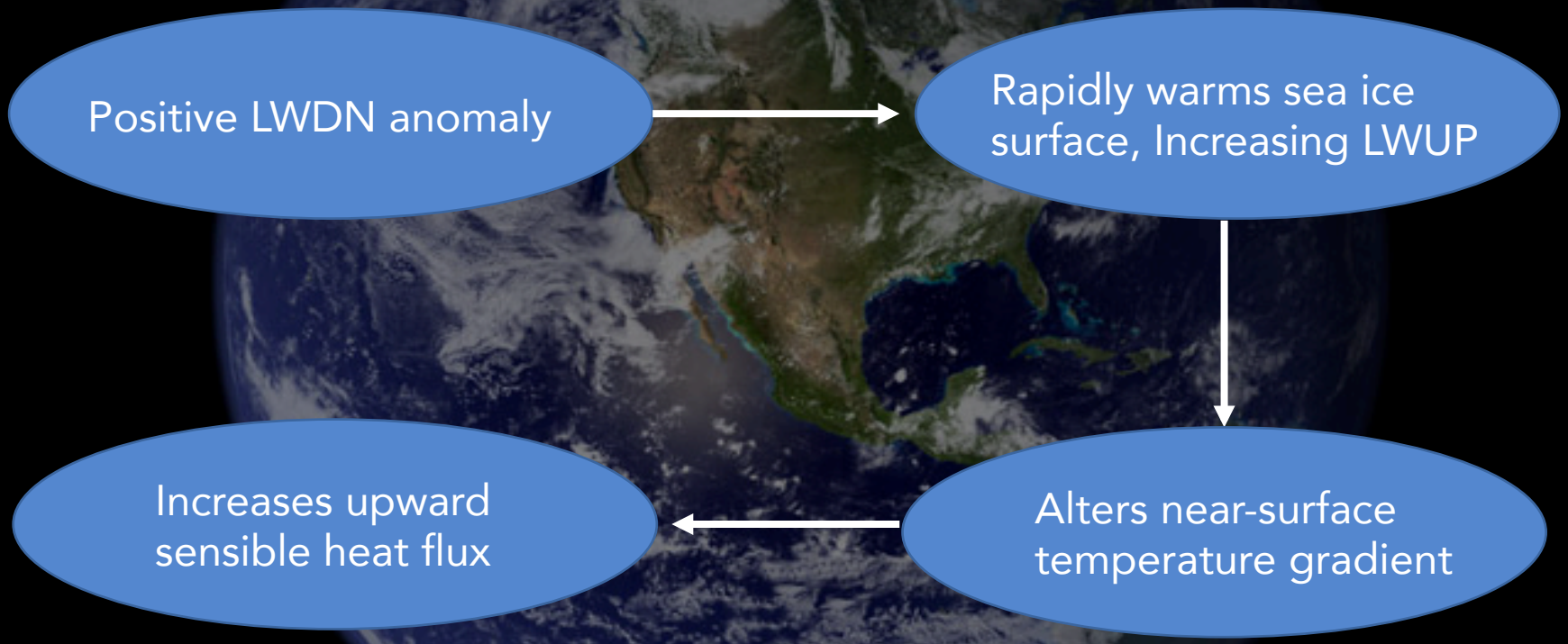

CERES Cloud Optical Depth (JJA)
JJA
MERRA2 LTS (K)
MERRA2 ω_{500} (hPa day^{-1})
Mean Cloud Optical Depth

CERES Surface Net CRE



Certain regimes do indicate a shift from a net cooling to a net warming effect.



Surface energy budget biases can lead to compensating effects

From NICE data…