Met Office

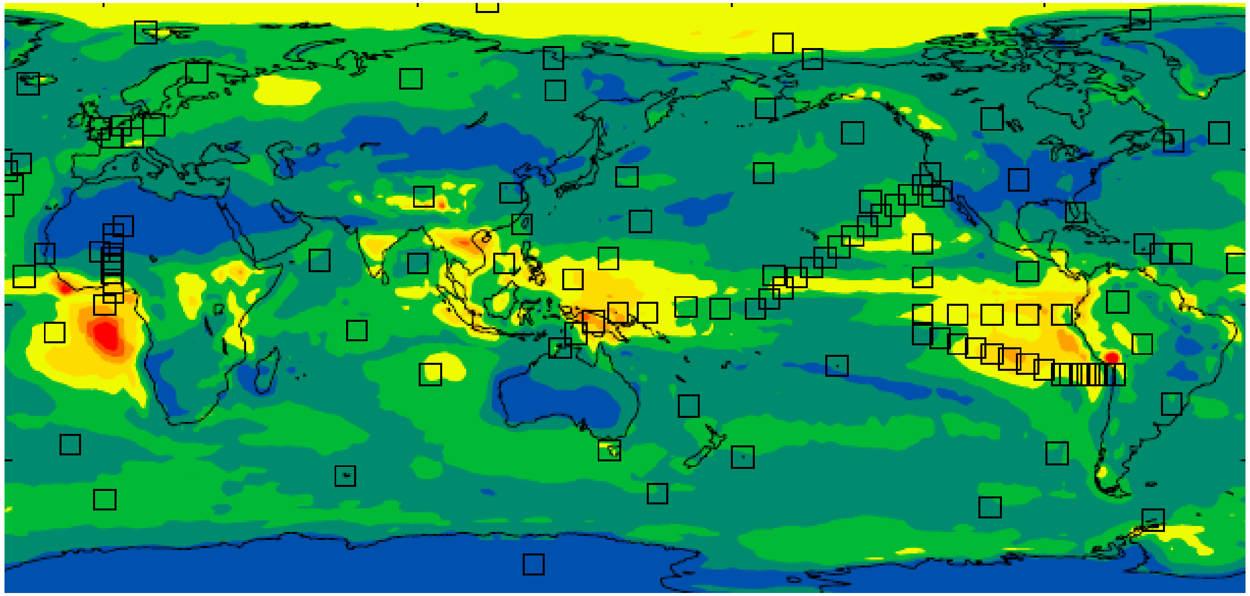
Using high frequency data at site locations to understand cloud feedbacks in the CFMIP-2 models.

Mark Webb and Adrian Lock

CFMIP/EUCLIPSE meeting, March 2013

Cloud Feedback Model Intercomparison Project

High frequency outputs at site locations



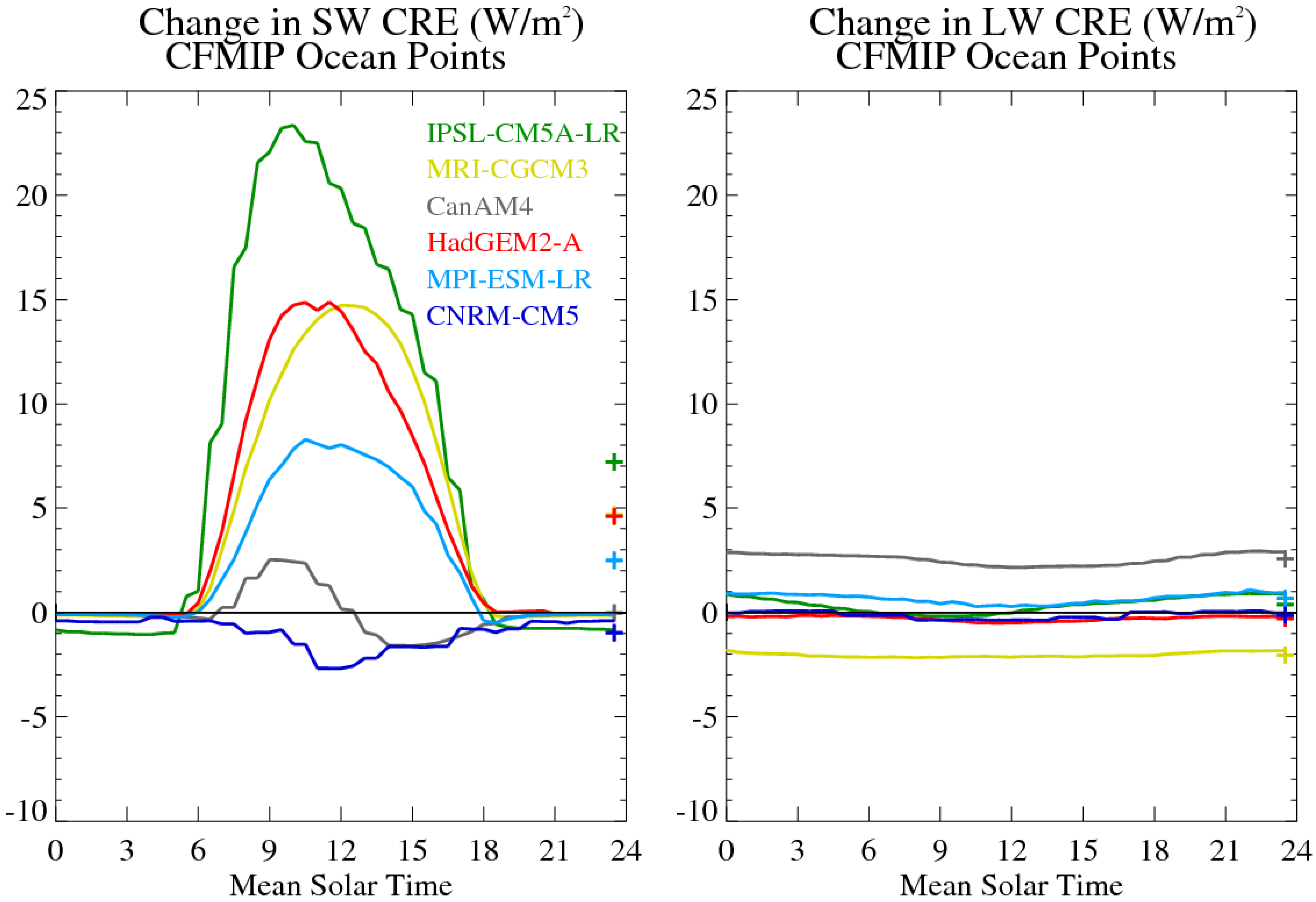
- Timestep level (e.g. 30 minute) frequency outputs at 120 locations
- AMIP, AMIP+4K, AMIP+4CO_2 and equivalent aquaplanet experiments
- Clouds, radiation, precipitation and environmental variables
- Temperature/humidity tendencies for advection, convection, BL, …

Potential applications for understanding cloud feedbacks

- Assess impact of changes in high frequency phenomena on cloud feedbacks – e.g. the diurnal cycle
- Identify cloud/boundary layer regimes and parameterizations contributing most to feedbacks
- Identify causal relationships between clouds and other variables using temporal precedence

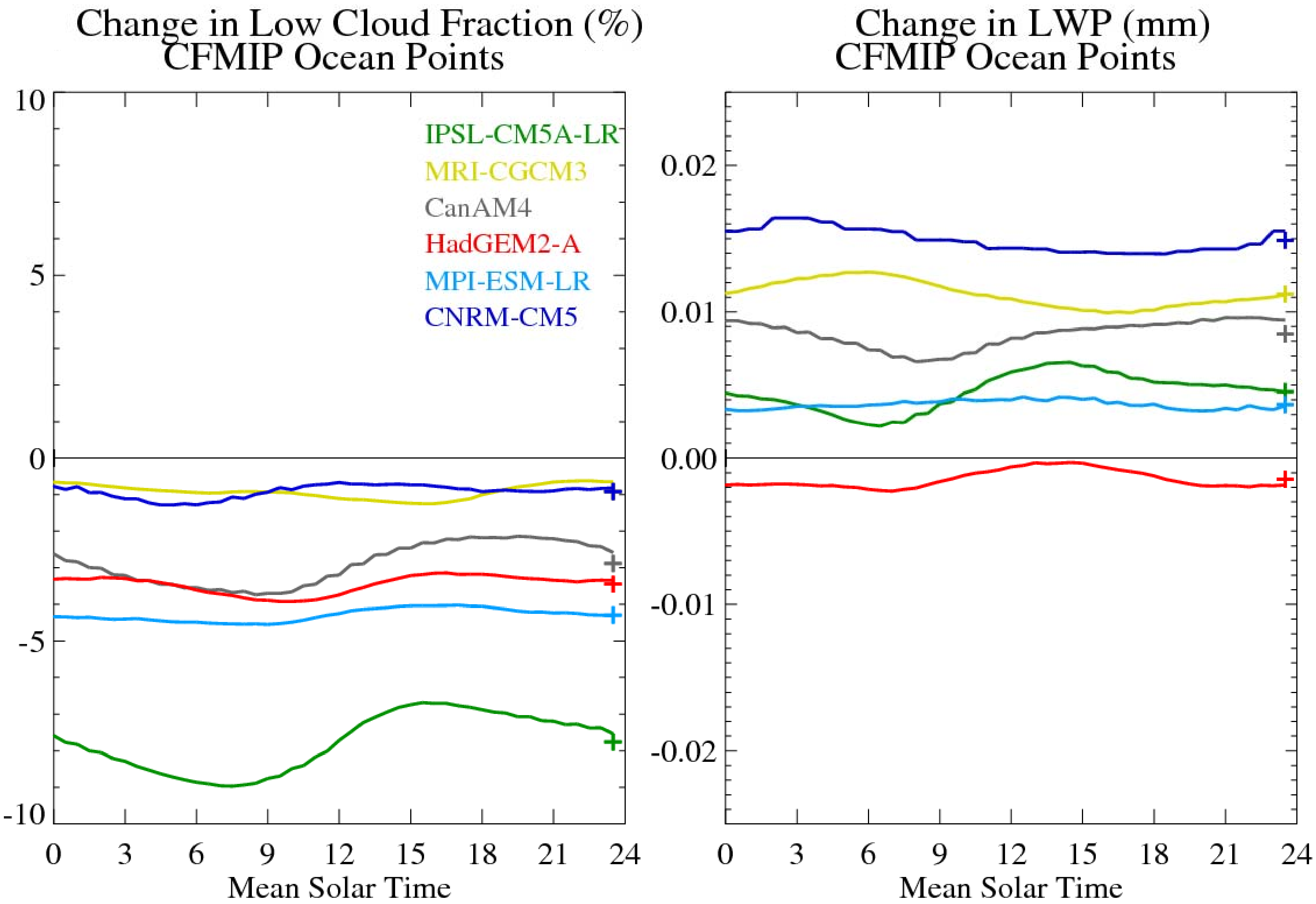
Diurnal Cycle of Cloud Feedback

Which times of day show the strongest cloud feedbacks?



Cloud Radiative Response to Uniform +4K over Ocean Points

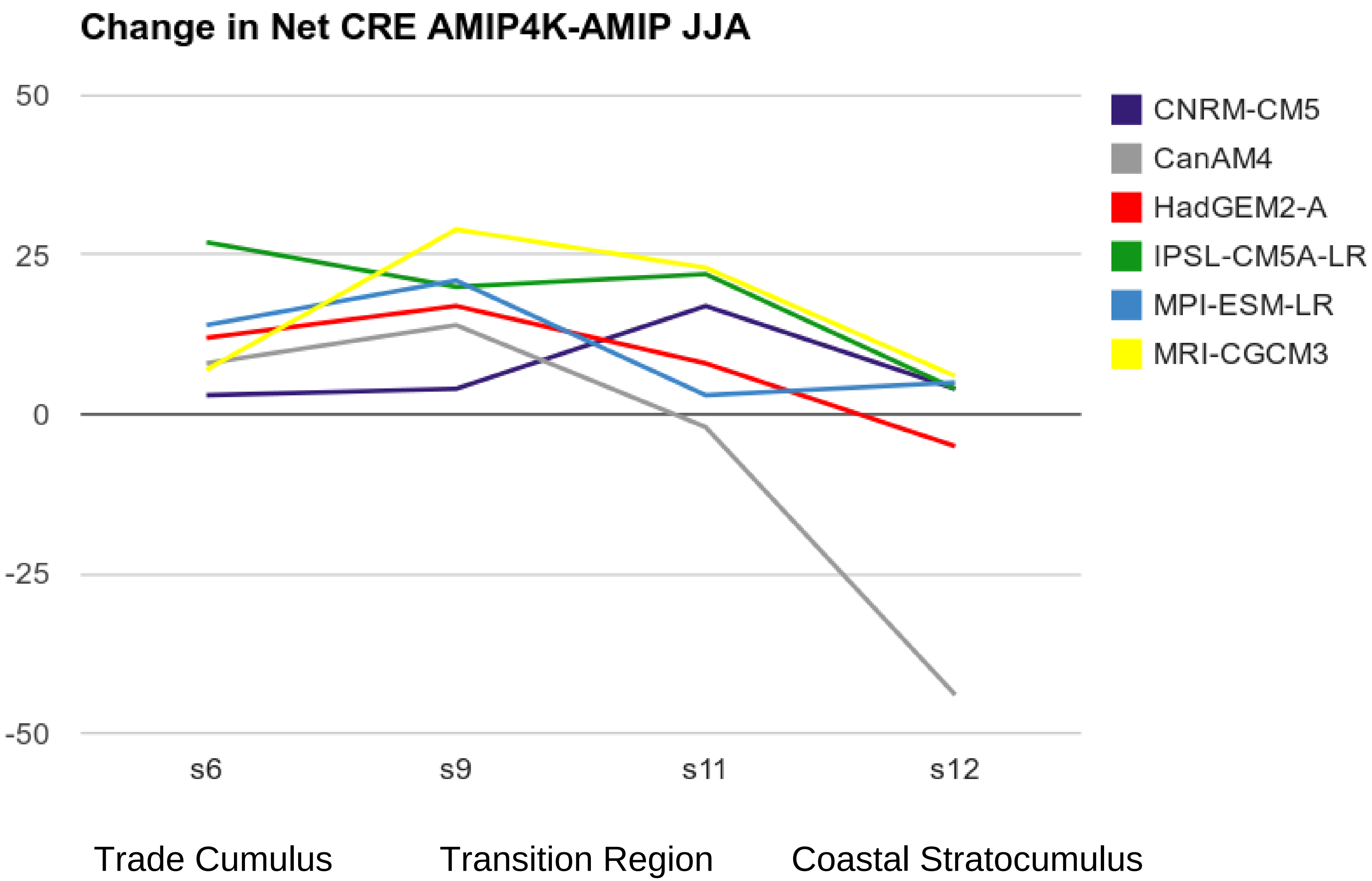
How important are changes in the diurnal cycle of clouds?



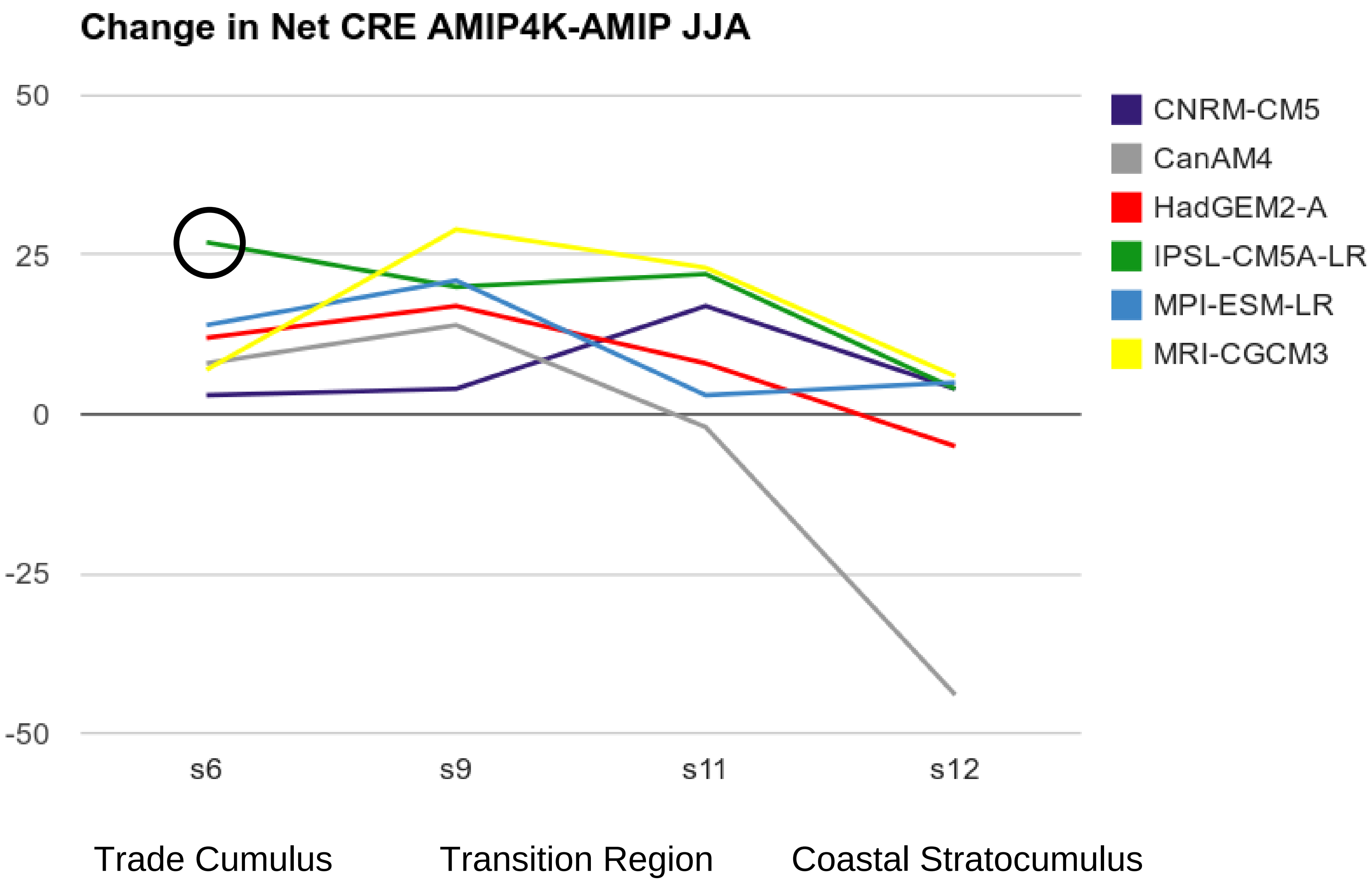
Low cloud and LWP Response to +4K over Ocean Points

Identifying cloud regimes and physical processes contributing most to feedbacks

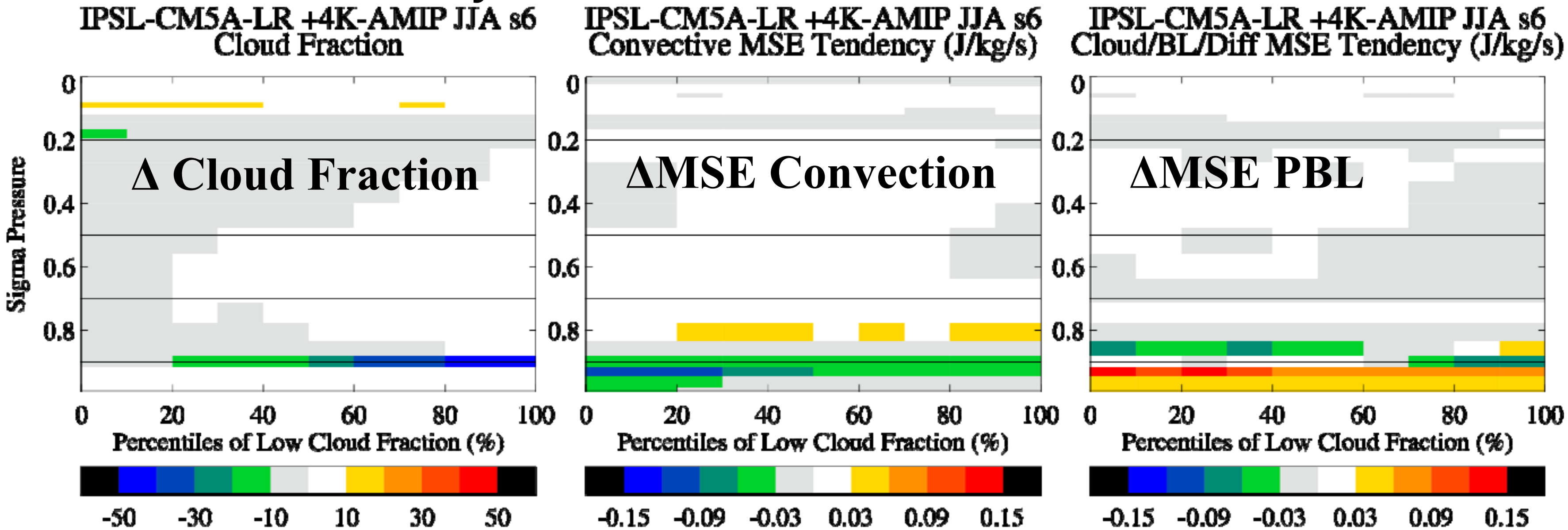
CFMIP-2 Uniform +4K Cloud feedbacks along the GPCI

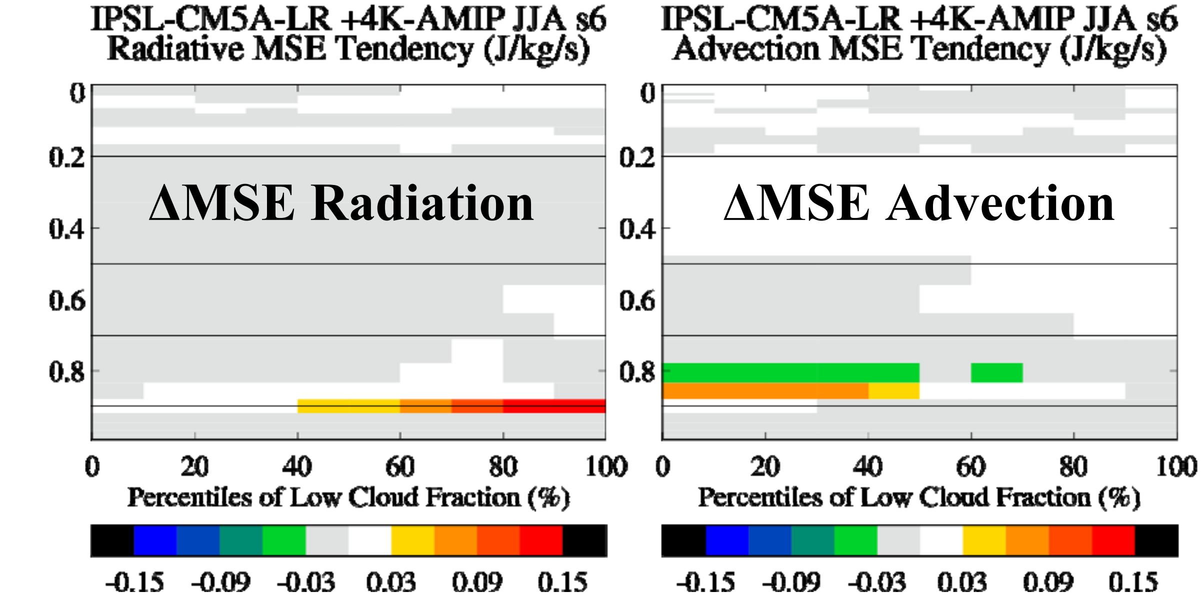


CFMIP-2 Uniform +4K Cloud feedbacks along the GPCI



Moist Static Energy Budget Approach following Brient and Bony 2013, Webb and Lock 2013

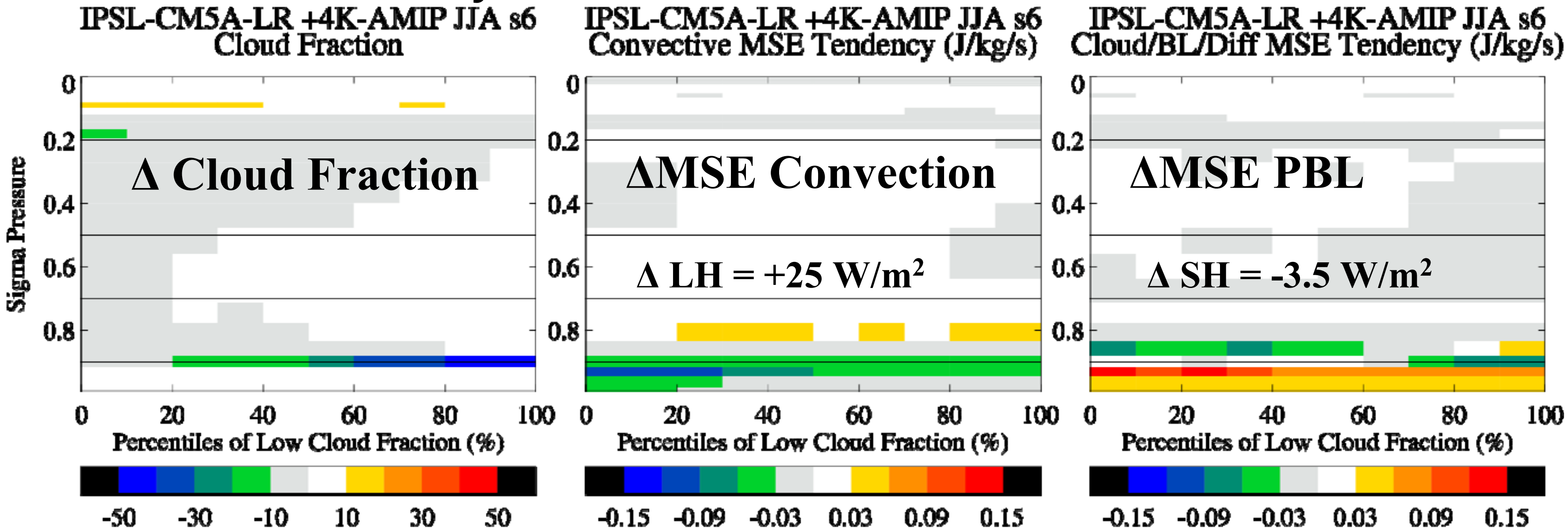


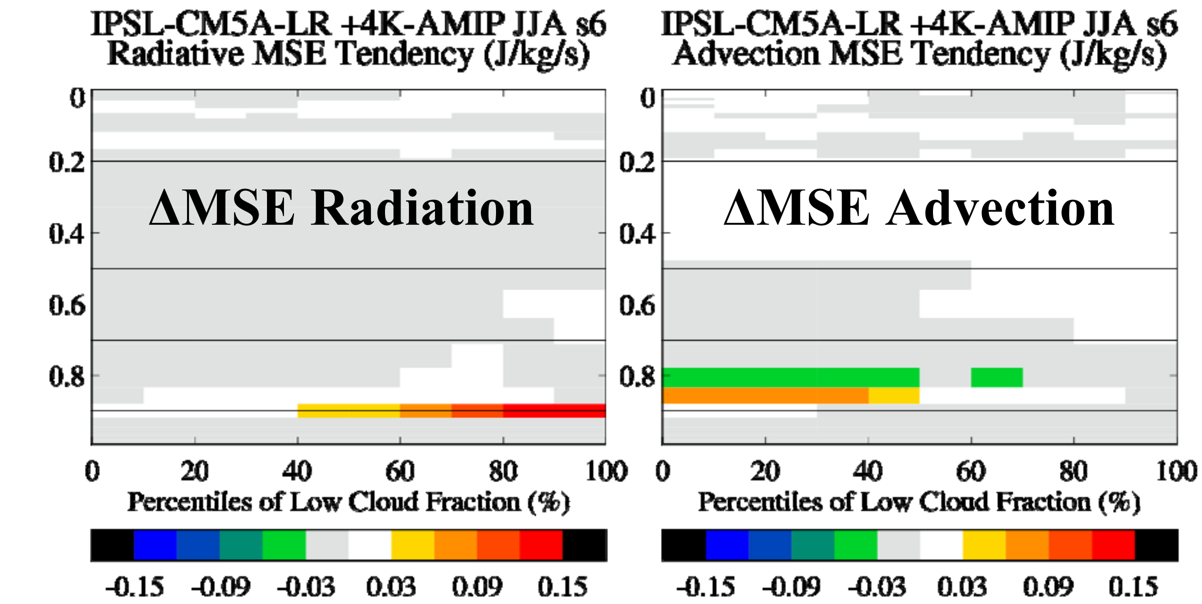


IPSL-CM5A-LR
Trade Cu s6
AMIP 4K – AMIP
Response JJA

MSE = $C_P T + L_v q + zg$ is conserved for phase changes

Moist Static Energy Budget Approach following Brient and Bony 2013, Webb and Lock 2013





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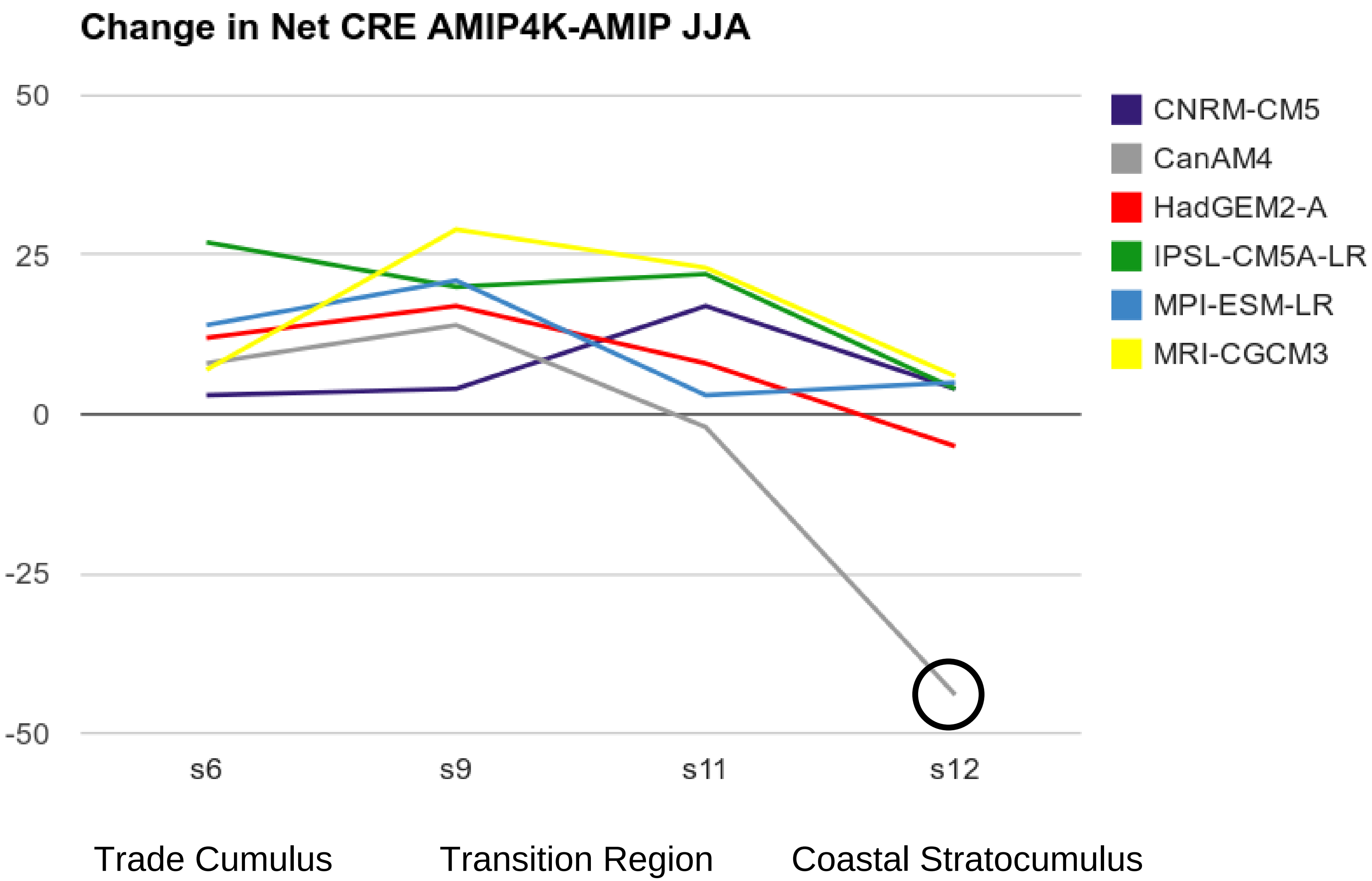
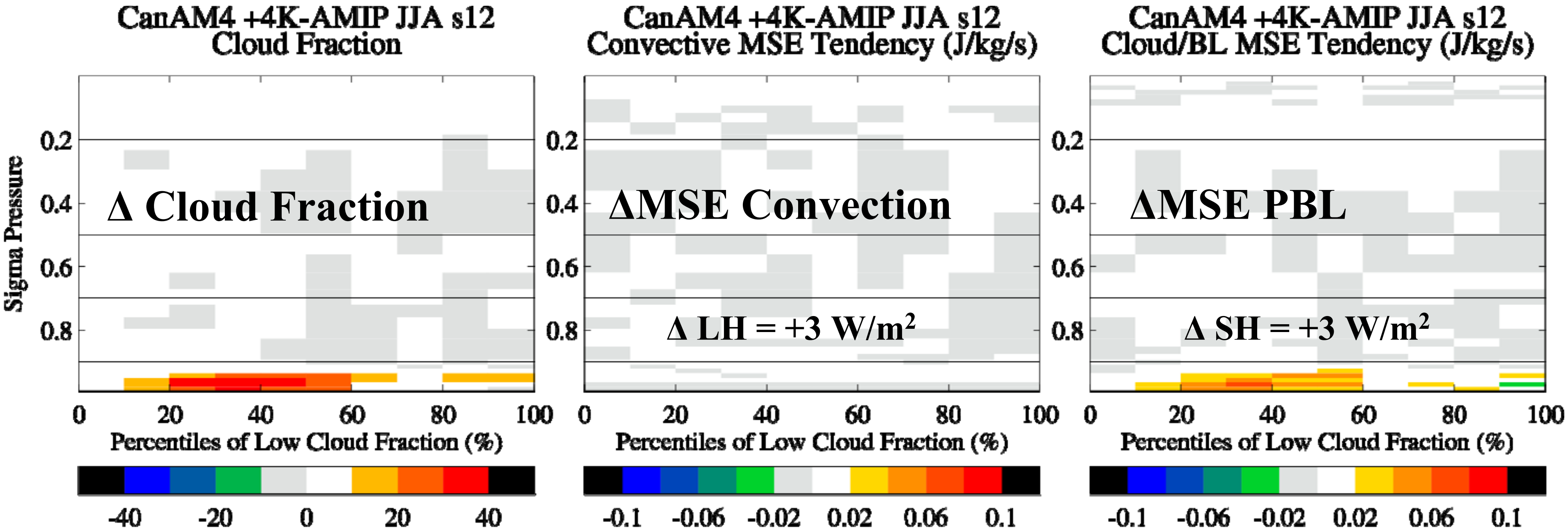
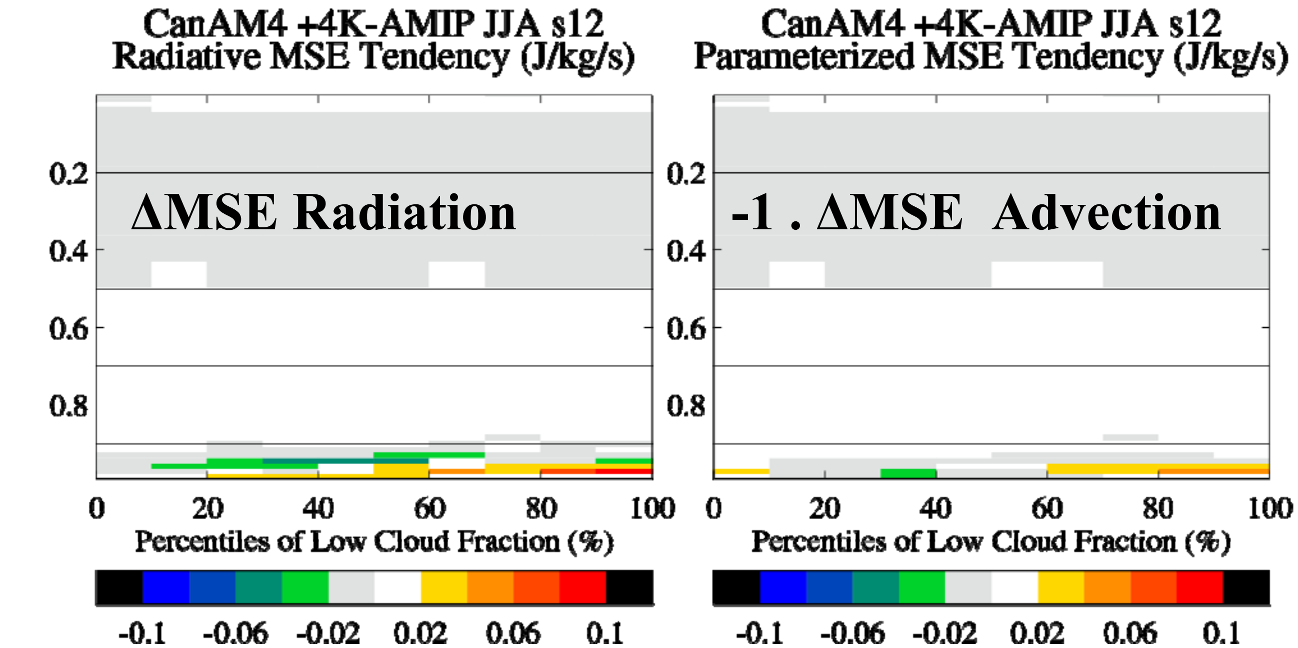


Change in Net CRE AMIP4K-AMIP JJA
50
25
0
-25
-50
s6
s9
s11
s12
CNRM-CM5
CanAM4
HadGEM2-A
IPSL-CM5A-LR
MPI-ESM-LR
MRI-CGCM3
Trade Cumulus
Transition Region
Coastal Stratocumulus

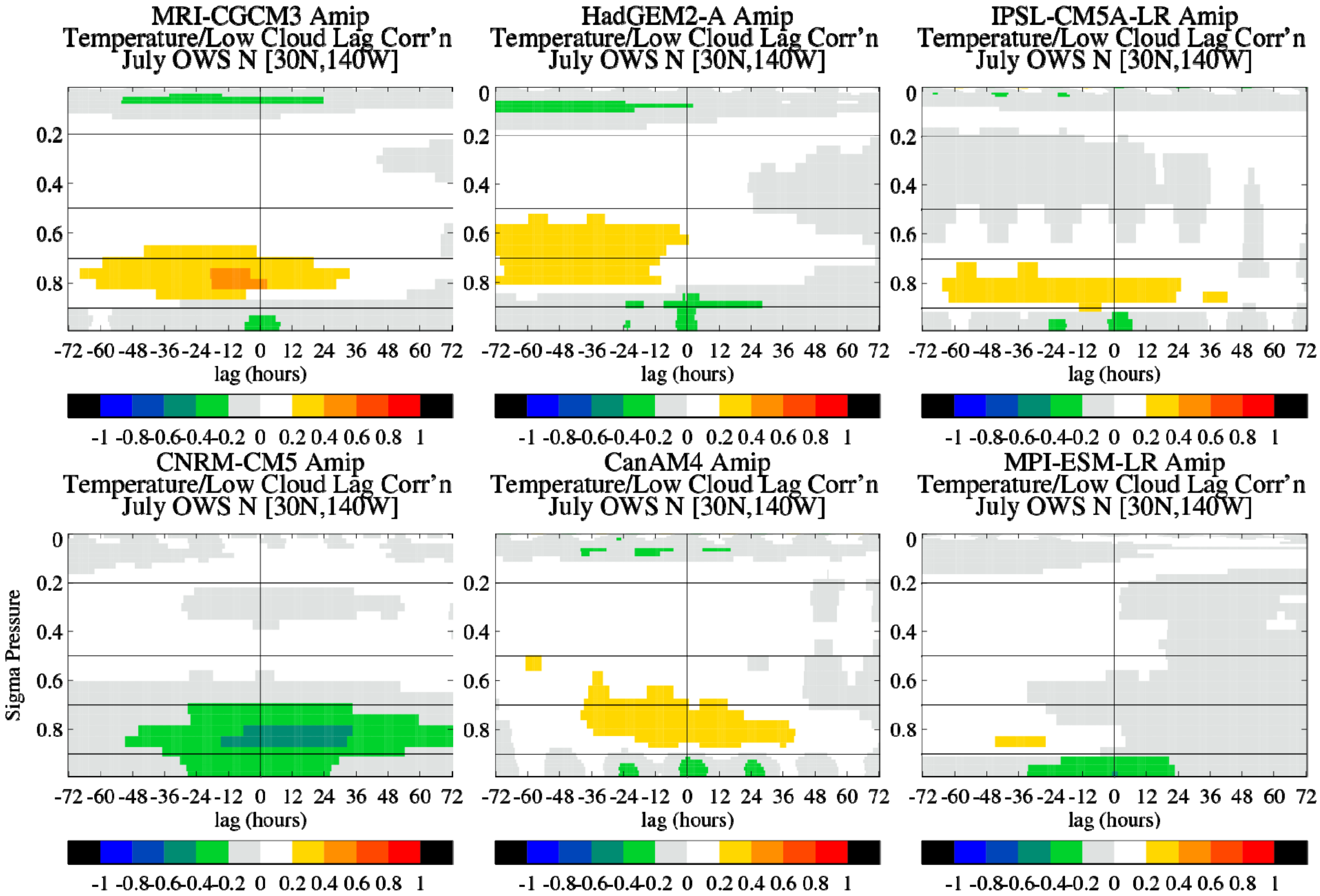




CanAM4 Coastal Sc s12 AMIP 4K – AMIP Response JJA

Identifying causal relationships between clouds and other variables using temporal precedence

Lag correlation approach following Mapes et al (2008)



Conclusions

- The diurnal cycle of the oceanic low cloud feedback tends to be small compared to the inter-model spread in diurnal mean cloud feedback, so probably not that relevant to overall feedback uncertainty
- High frequency temperature and humidity tendency terms can give an indication of the relative roles of convection/BL/advection in cloud feedbacks sorted into cu / transition / stratocumulus regimes.
- Lag correlations show that some models build up low cloud following warming above the inversion, consistent with ‘moisture trapping’ ideas. Directly relating low cloud to stability will not reproduce this effect.
- Please consider submitting more cfSites data to CFMIP-2!

Conclusions

- The diurnal cycle of the oceanic low cloud feedback tends to be small compared to the inter-model spread in diurnal mean cloud feedback, so probably not that relevant to overall feedback uncertainty

- In the limited cases examined, low cloud feedbacks are typically strongest in the broken cloud regime, where cloud reductions are not offset by increasing liquid water paths. This demonstrates the importance of handling transition cases well.

- Lag correlations show that some models build up low cloud following warming above the inversion, consistent with ‘moisture trapping’ ideas. Directly relating low cloud to stability will not reproduce this effect.