

Using Seasonal Cloud Variation to Constrain Long-Term Cloud Feedback and Climate Sensitivity

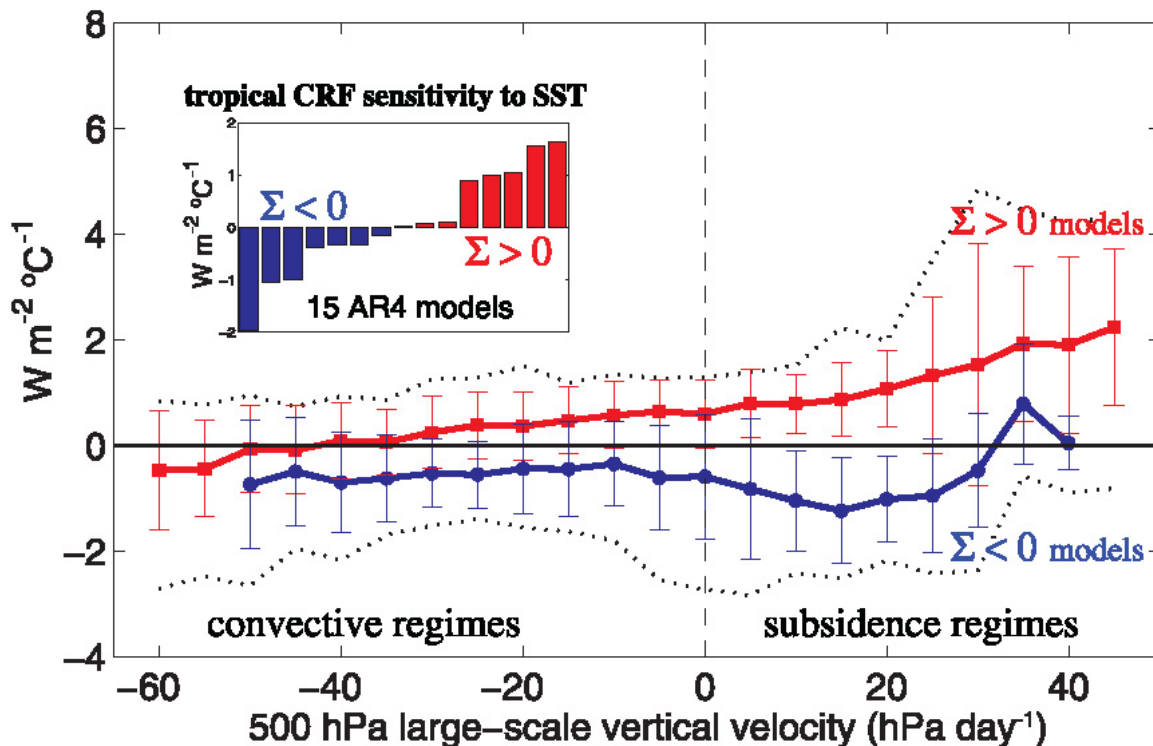
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Jet Propulsion Laboratory, California Institute of Technology

CFMIP – Meeting on Cloud Processes and Cloud Feedbacks, Monterey, CA, June 8-11, 2015

Cloud Feedback

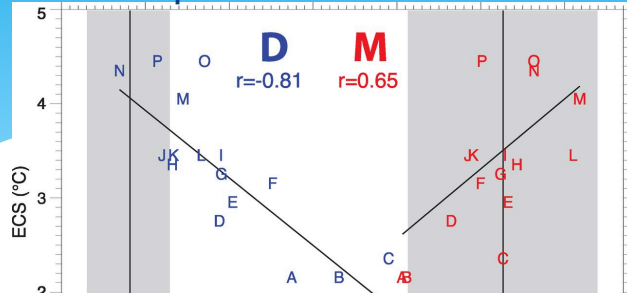
- Cloud feedback is one of the leading contributors to the inter-model spread in climate sensitivity (e.g., Cess et al. 1989; Stephens 2005)
- The sensitivity of marine boundary layer clouds (MBLC) to changing sea surface temperature constitutes the main source of uncertainty in tropical cloud feedbacks (Bony and Dufresne 2005).



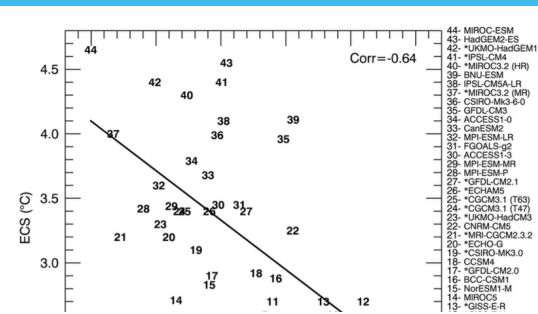
(Bony and Dufresne 2005)

Emergent Constraints on Equilibrium Climate Sensitivity

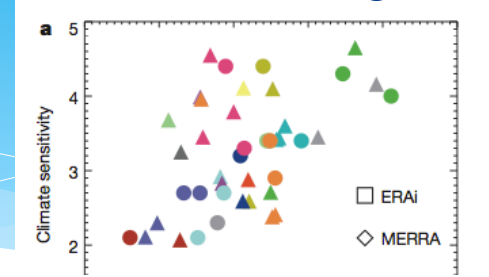
- Subtropical RH



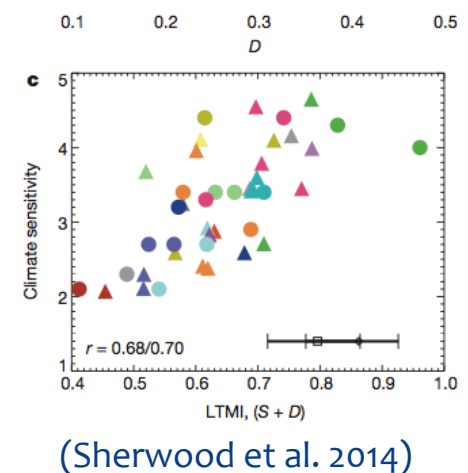
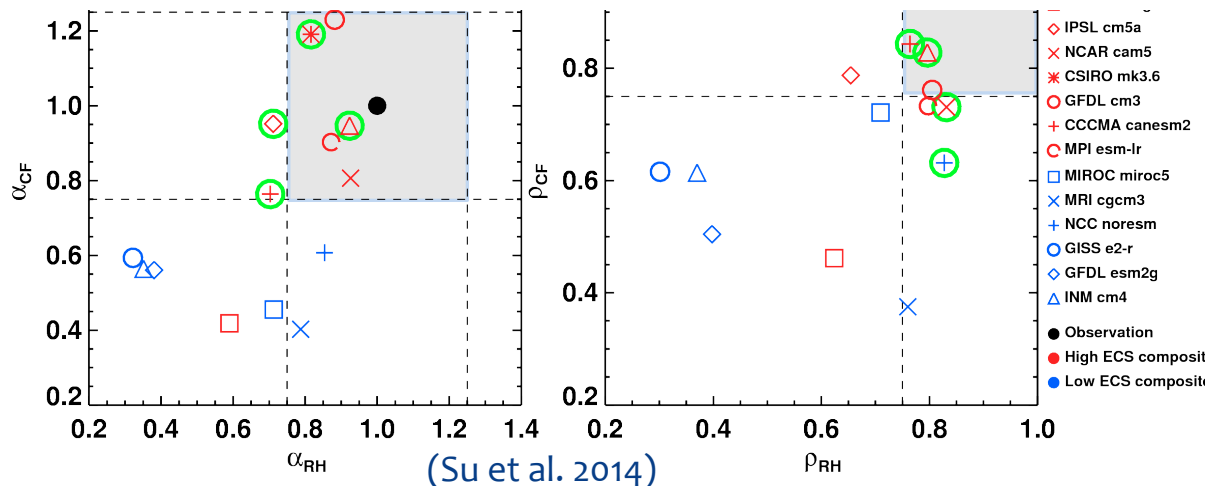
- Double ITCZ Bias



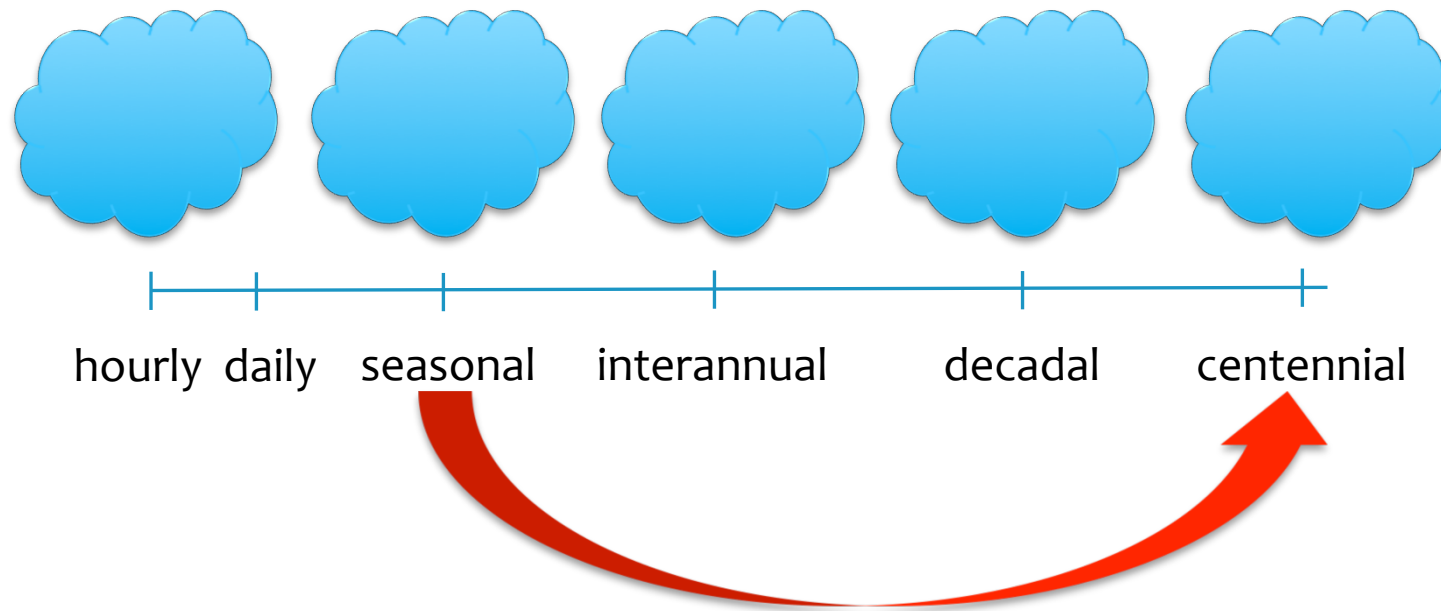
- Convective Mixing



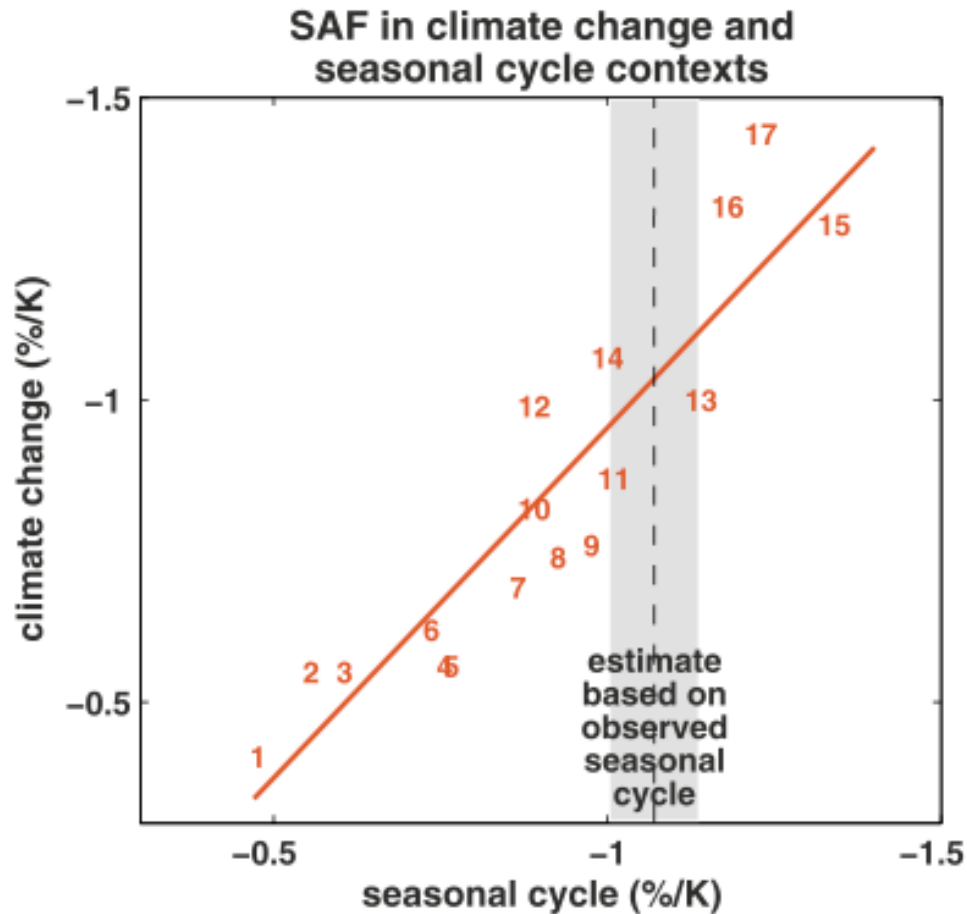
Models that match the observations better are the ones having higher ECS than the multi-model-mean.



Cloud Feedbacks at Various Time Scales

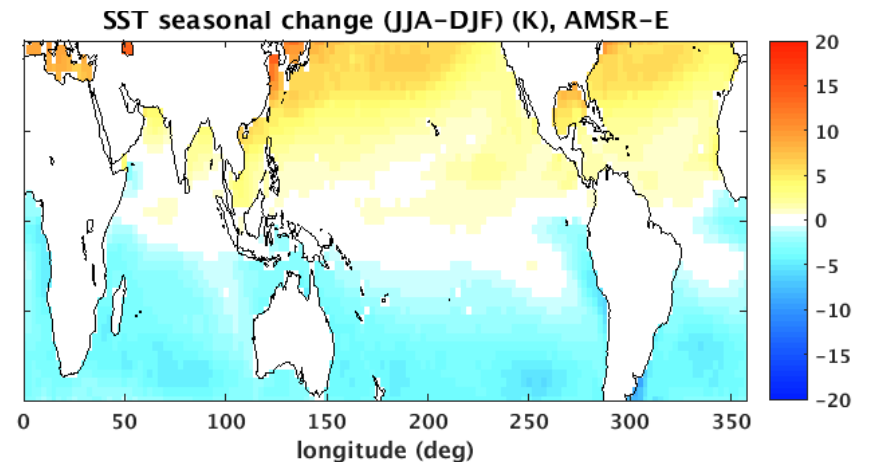
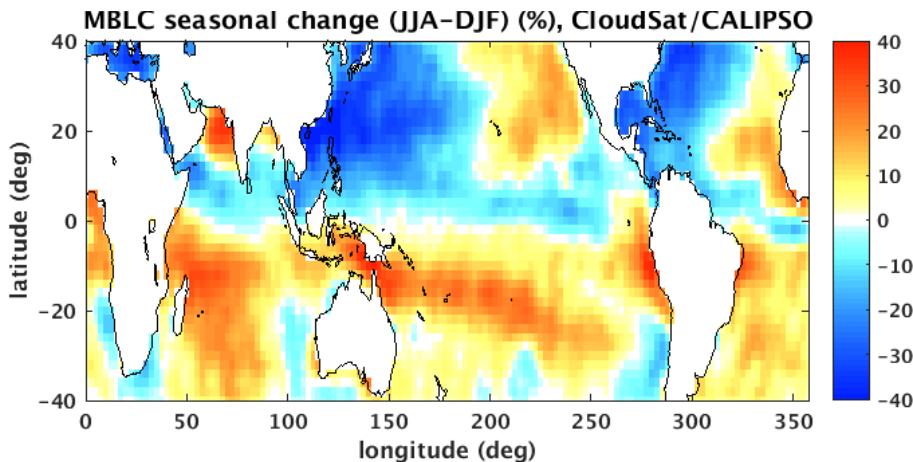
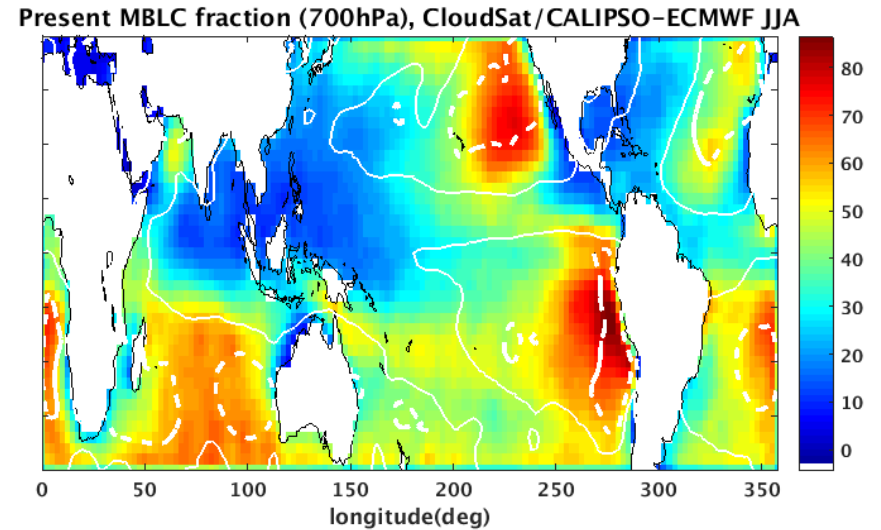
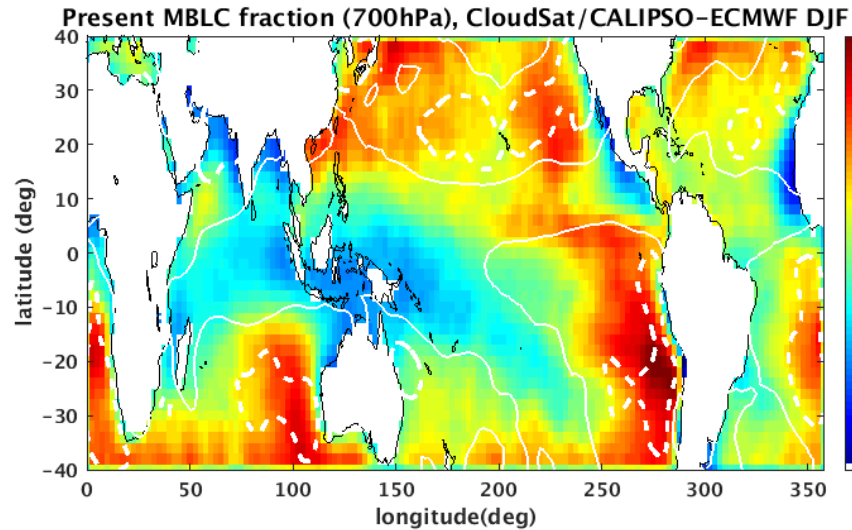


Linkage Between Seasonal Cycle and Climate Change



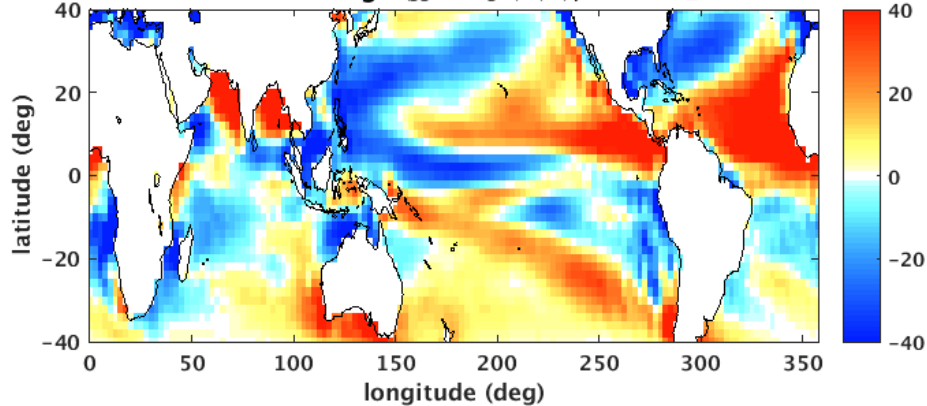
(Hall and Qu 2006)

Observed MBLC Seasonal Variations

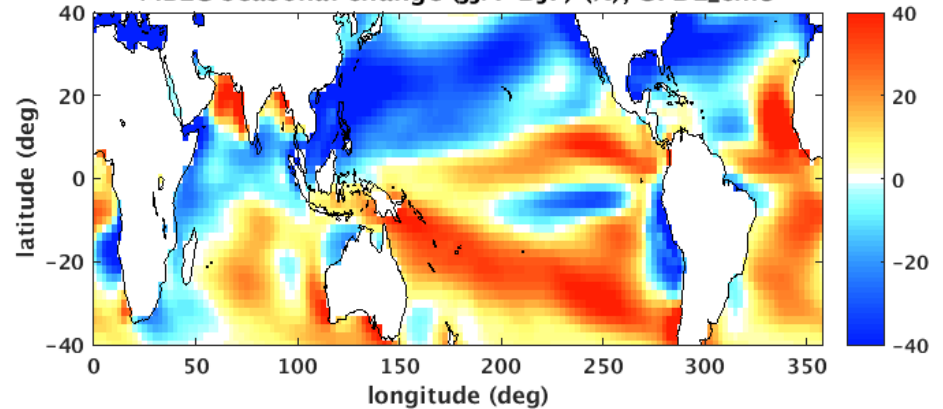


Modeled MBLC Seasonal Variations

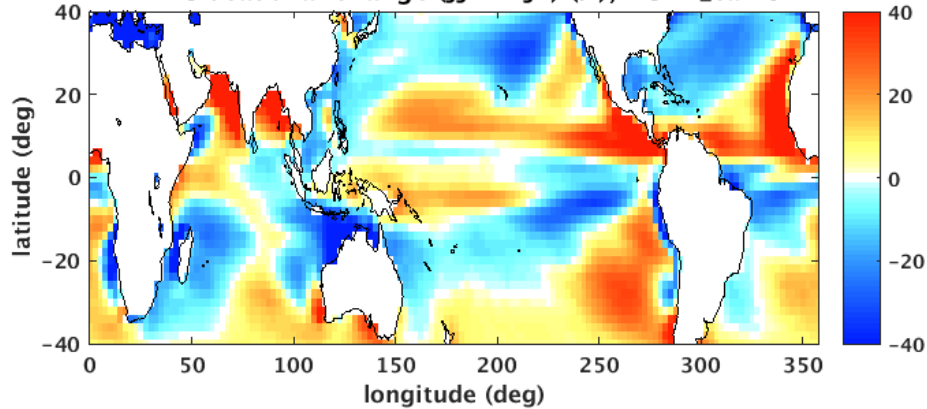
MBLC seasonal change (JJA-DJF) (%), CCCMA_canesm2



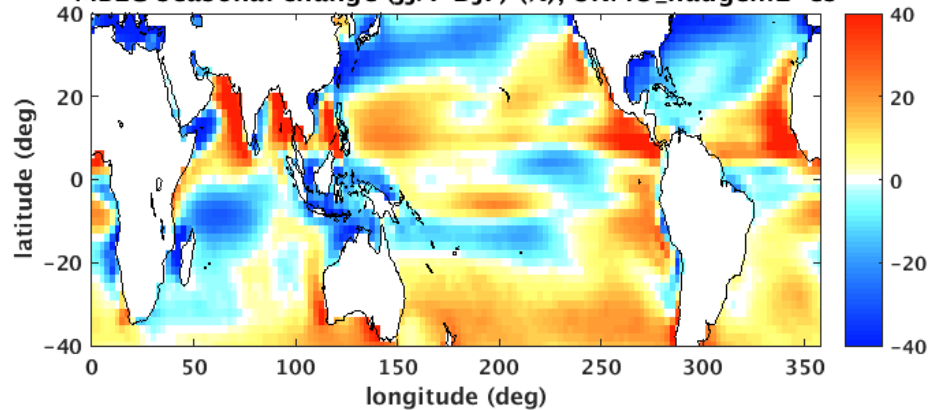
MBLC seasonal change (JJA-DJF) (%), GFDL_cm3



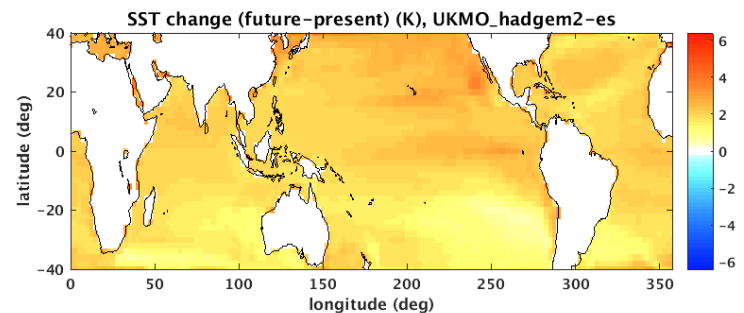
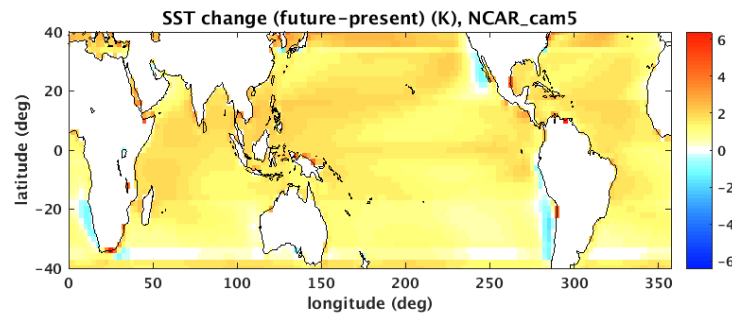
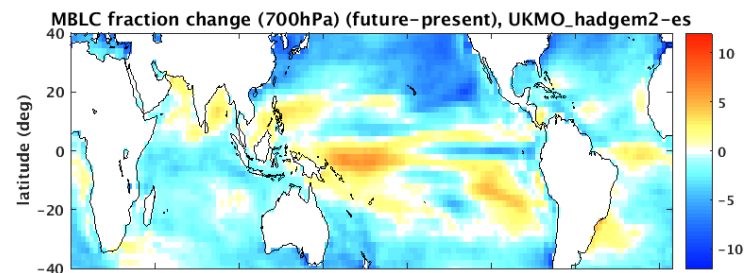
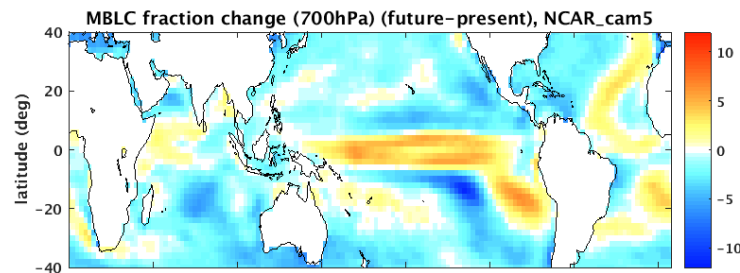
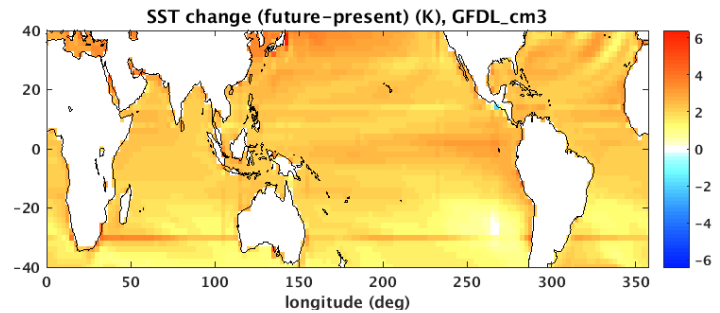
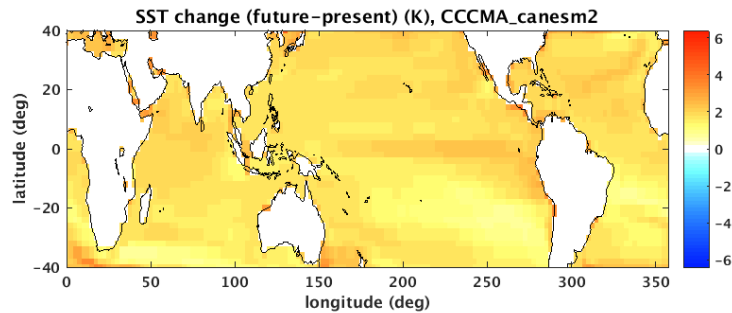
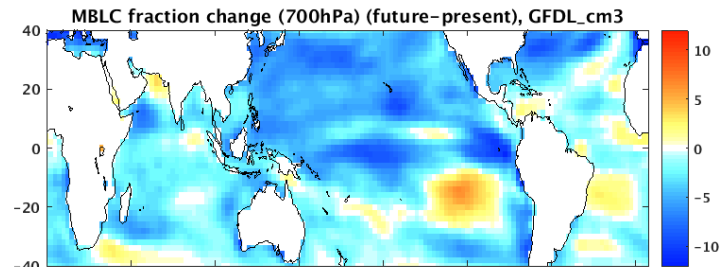
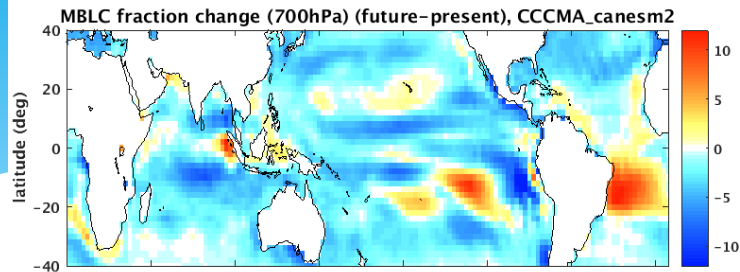
MBLC seasonal change (JJA-DJF) (%), NCAR_cam5



MBLC seasonal change (JJA-DJF) (%), UKMO_hadgem2-es

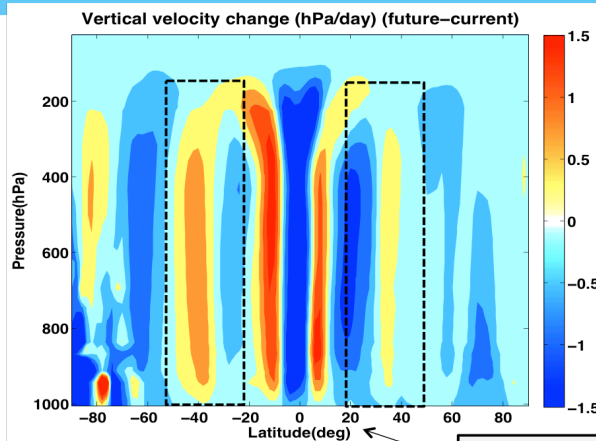


Modeled MBLC Changes From Present-day to RCP4.5

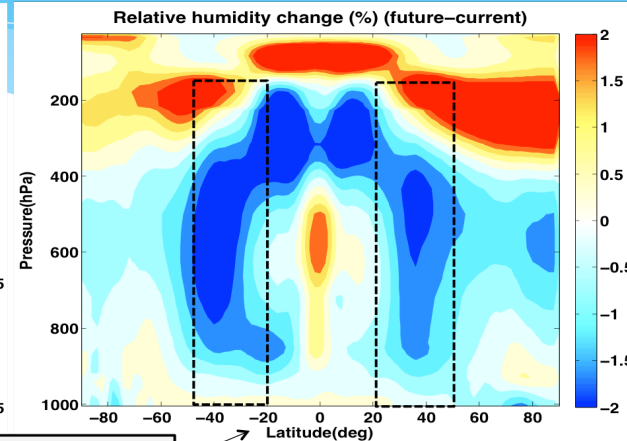


Seasonal and Long-term Changes of Large-scale Environmental Conditions

Vertical velocity change

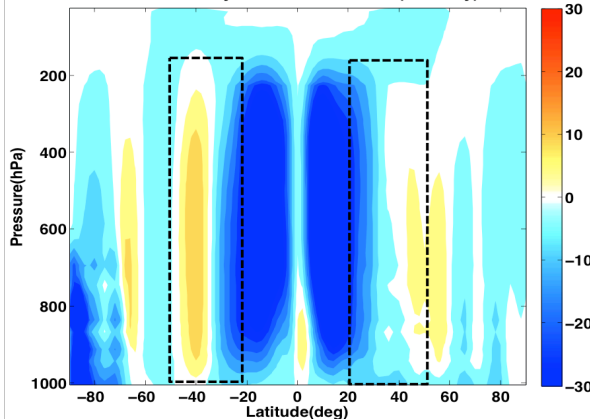


Relative humidity change

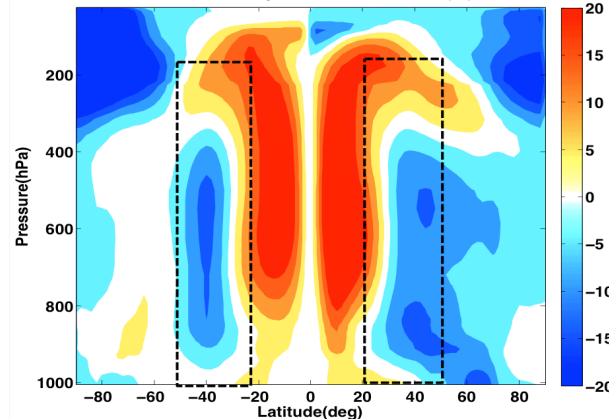


Global warming

Current vertical velocity seasonal variation(hPa/day)

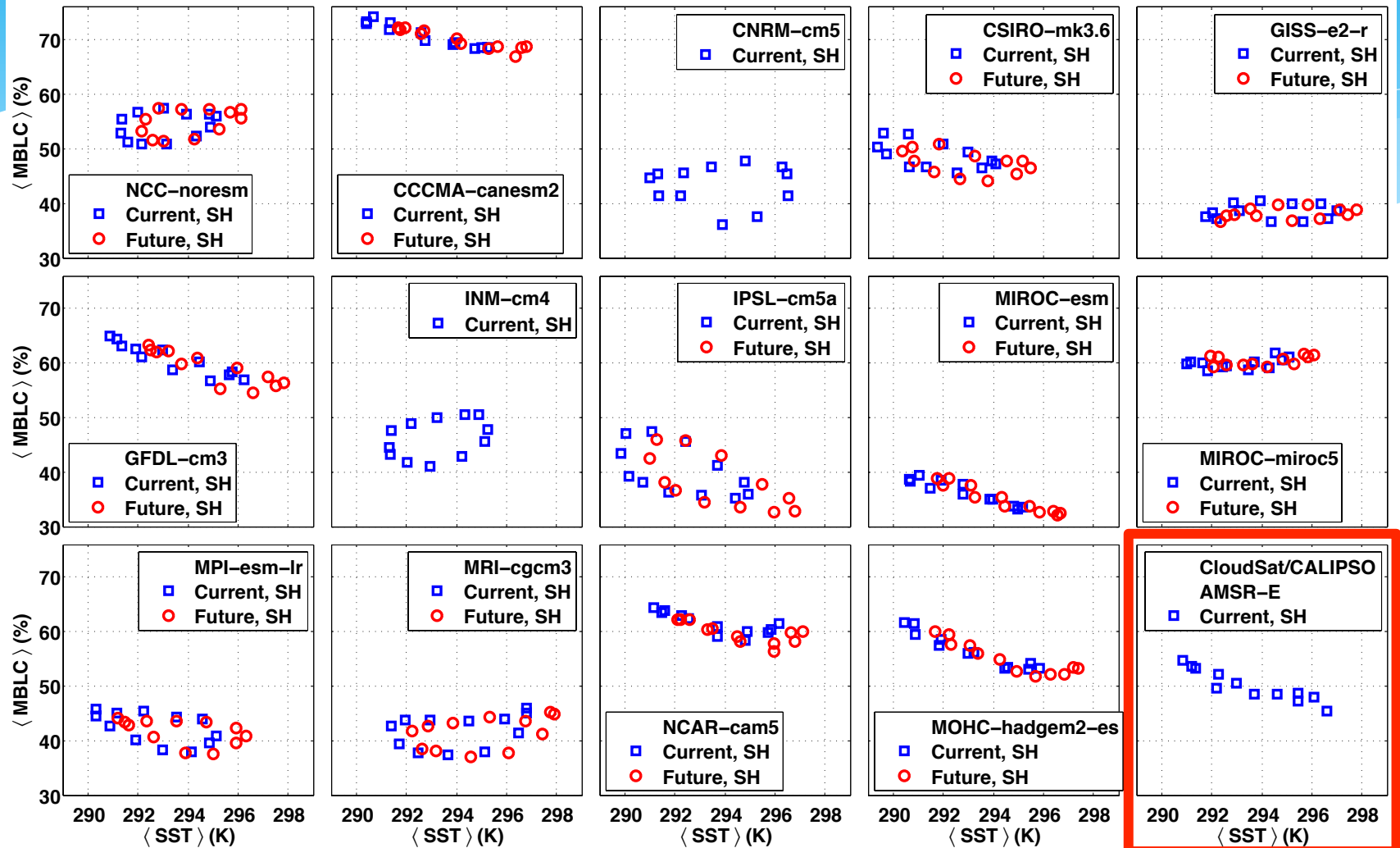


Current relative humidity seasonal variation(%)

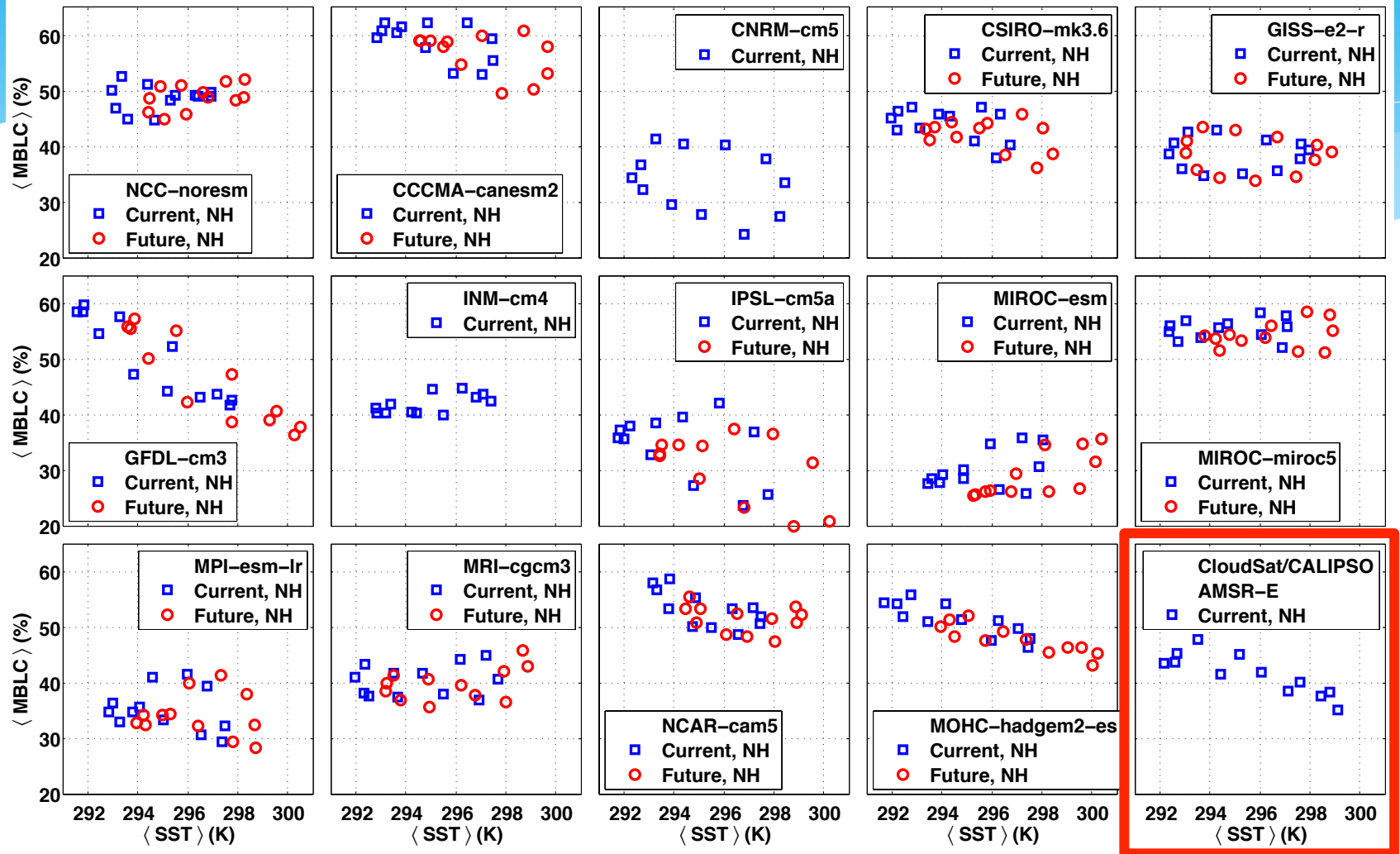


Seasonal, summer-winter

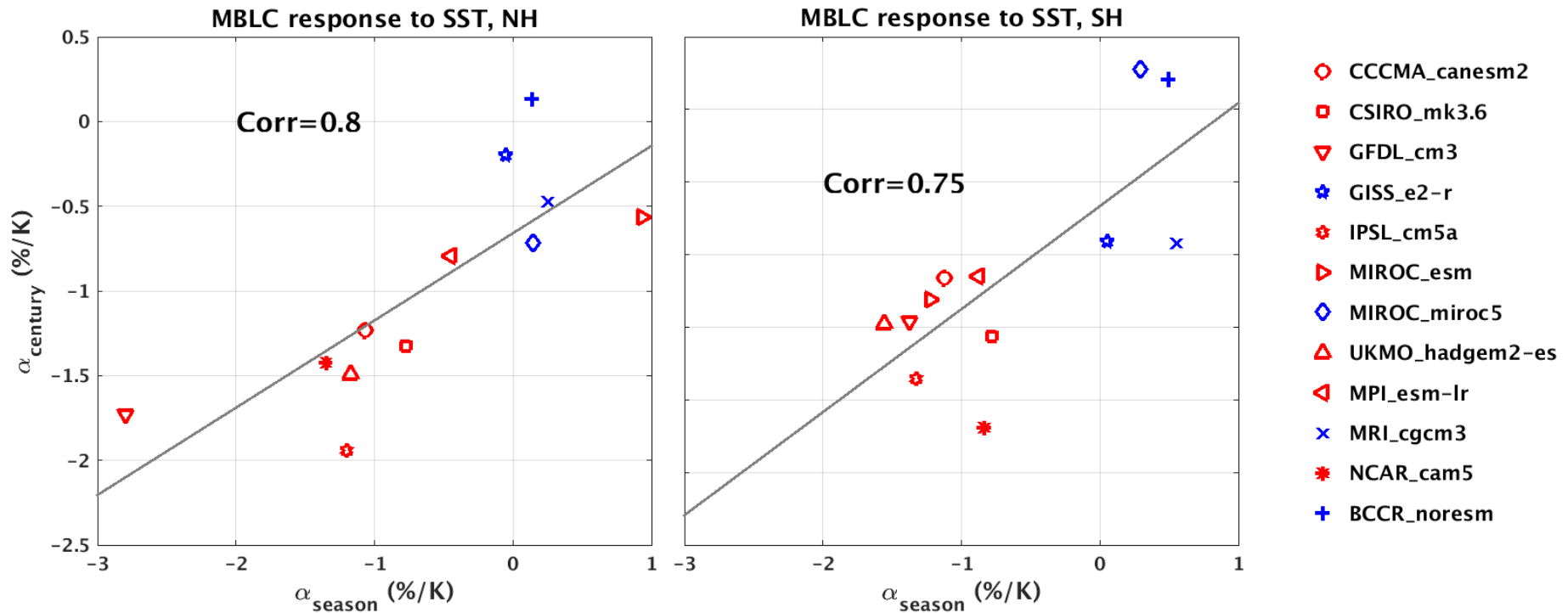
MBLC Seasonal Variation, 20°S – 40°S



MBLC Seasonal Variation, 20°N – 40°N

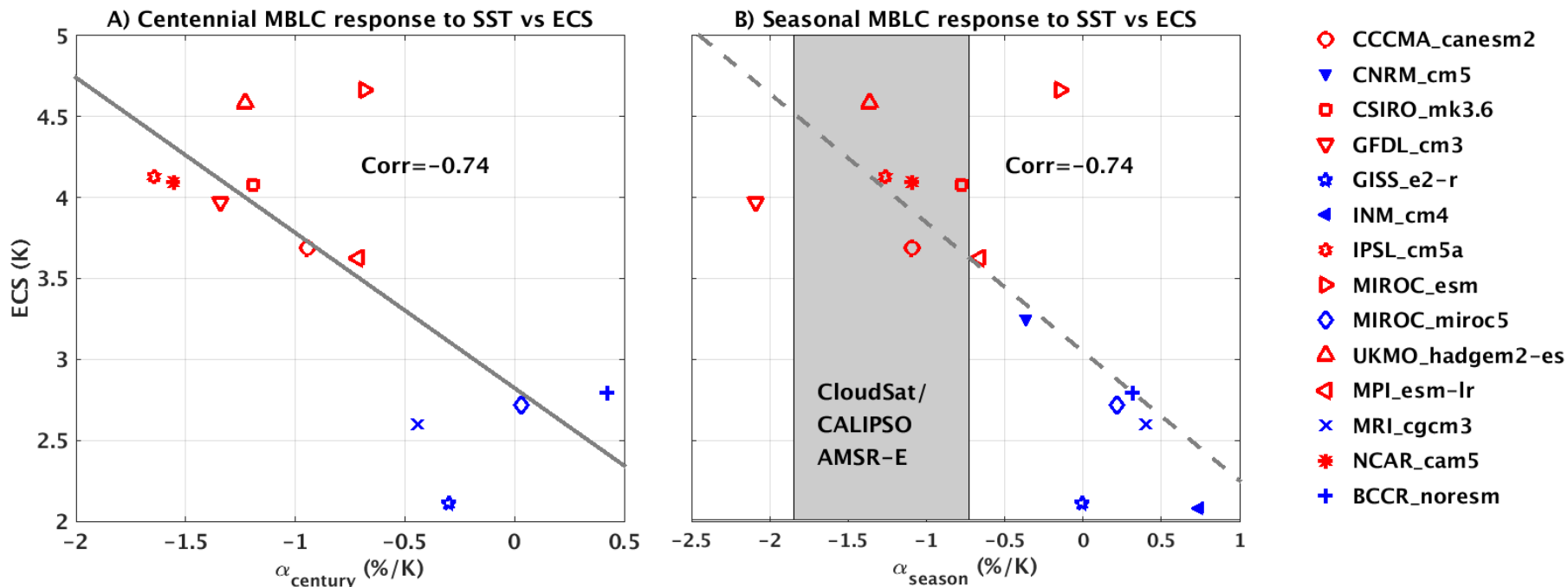


MBLC Sensitivity to SST at Seasonal and Centennial Time Scales



The sensitivity of subtropical MBLC fraction to SST on the seasonal time scale is highly correlated with that on the centennial time scale.

Using Observed MBLC Seasonal Cycle to Constrain ECS



Satellite observations of MBLC seasonal cycle suggest that the best estimate of ECS ranges from 3.6 to 4.6 K, with a mean of 4.1 K and a standard deviation of 0.3 K.

Conclusions

- The inter-model spread in the variation of marine boundary layer cloud (MBLC) fraction with surface warming on the seasonal time scale is strongly correlated with that on the centennial time scales.
- Models that simulate better the seasonal variations of MBLC fraction have climate sensitivity higher than the multi-model-mean.

Zhai, C., J. H. Jiang and H. Su: Long term cloud change imprinted in seasonal cloud variation: another evidence of high climate sensitivity, GRL, in revision, 2015.