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Identifying the Causes of Model Errors in Southern Ocean Clouds

A Regime-Oriented Approach Applied to the ACCESS Model

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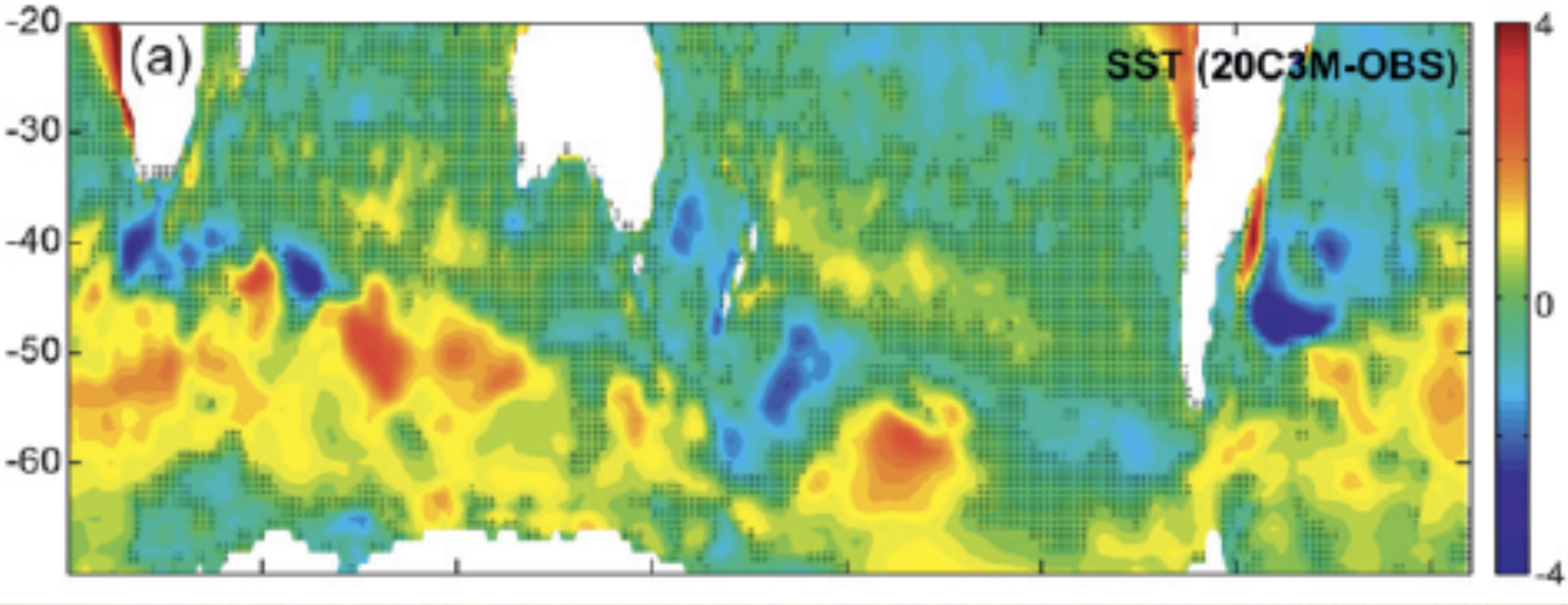
01/02/2012

Why do we care?

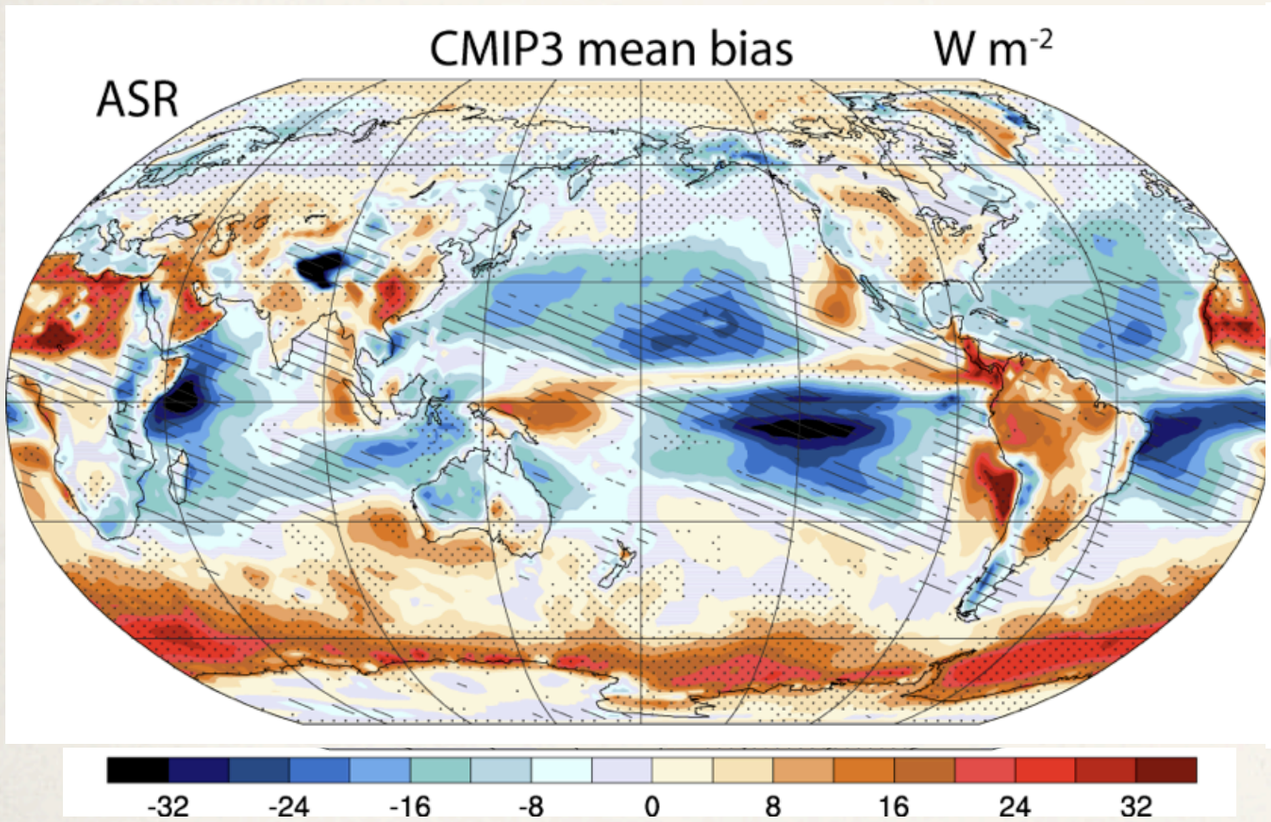


CMIP3 model ensemble mean SST bias

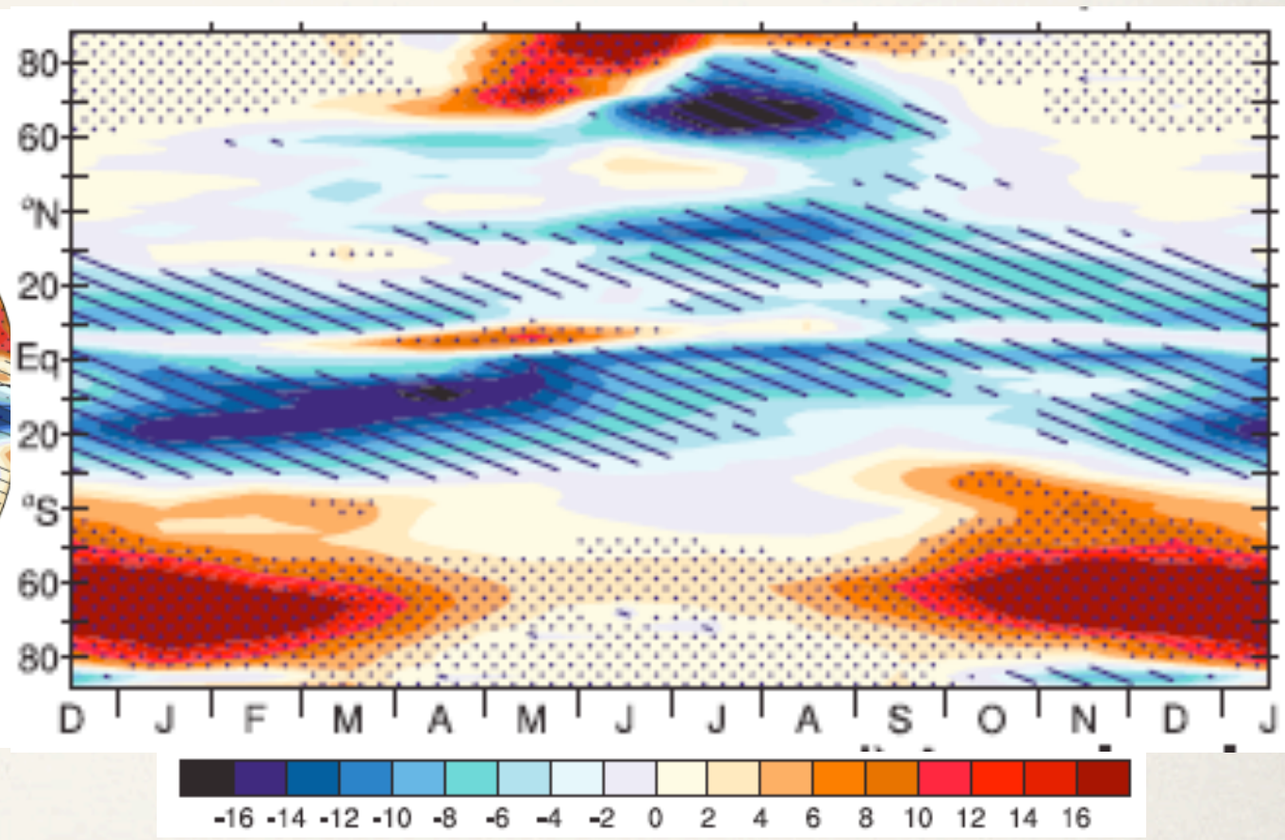
Sen Gupta et al., JCL2009

Why do we care?

CMIP3 model ensemble mean shortwave radiation biases



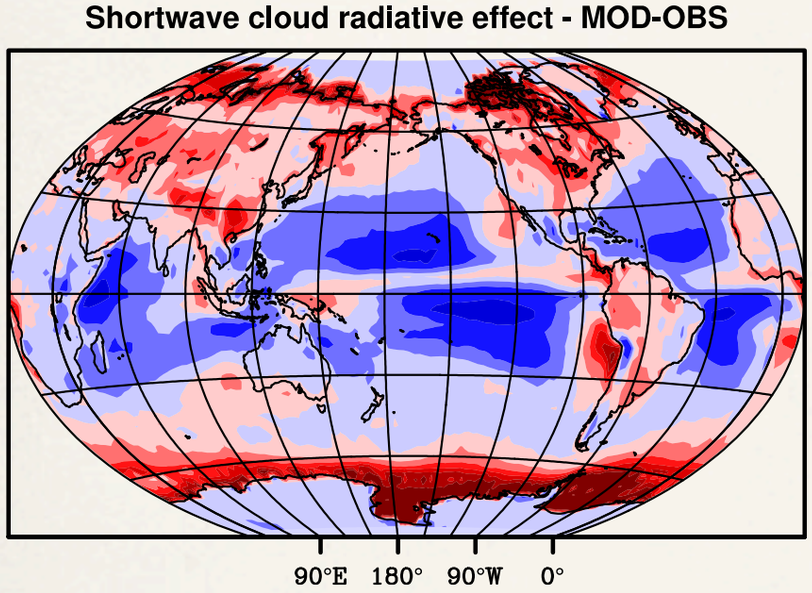
Annual mean

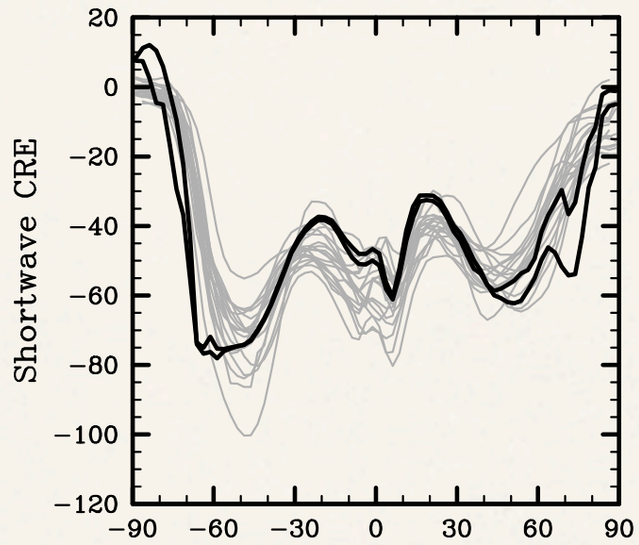


Zonal mean annual cycle

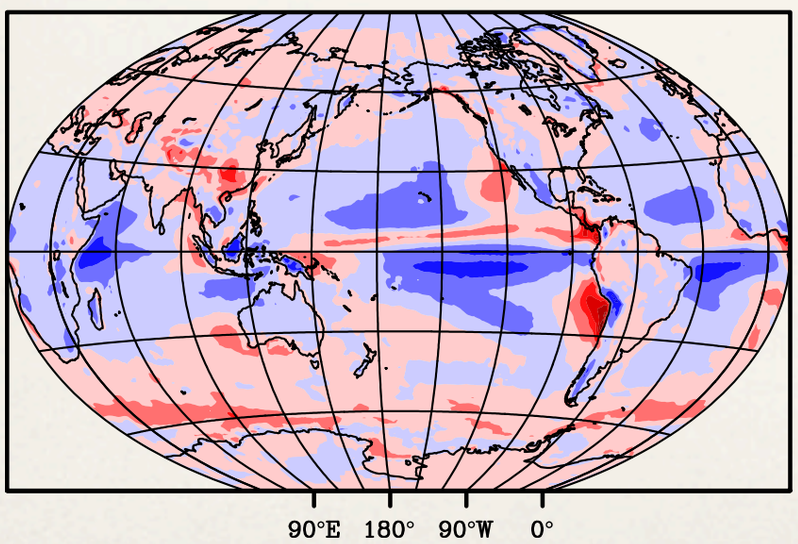
Trenberth and Fasullo, JCL2010

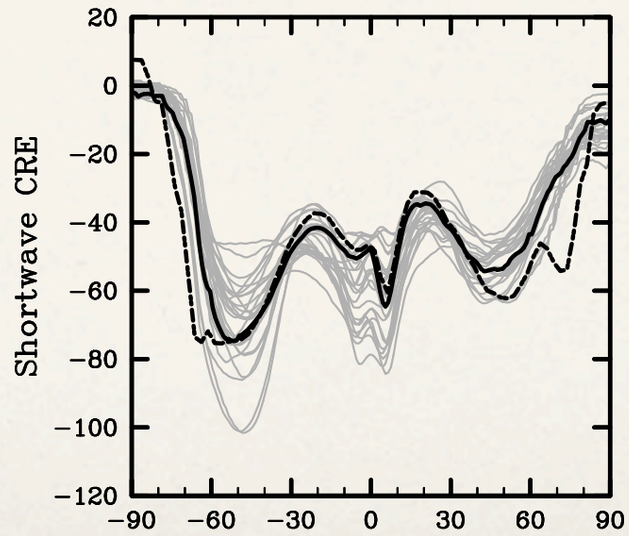
Observational uncertainty



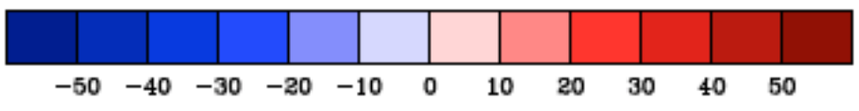


CMIP3

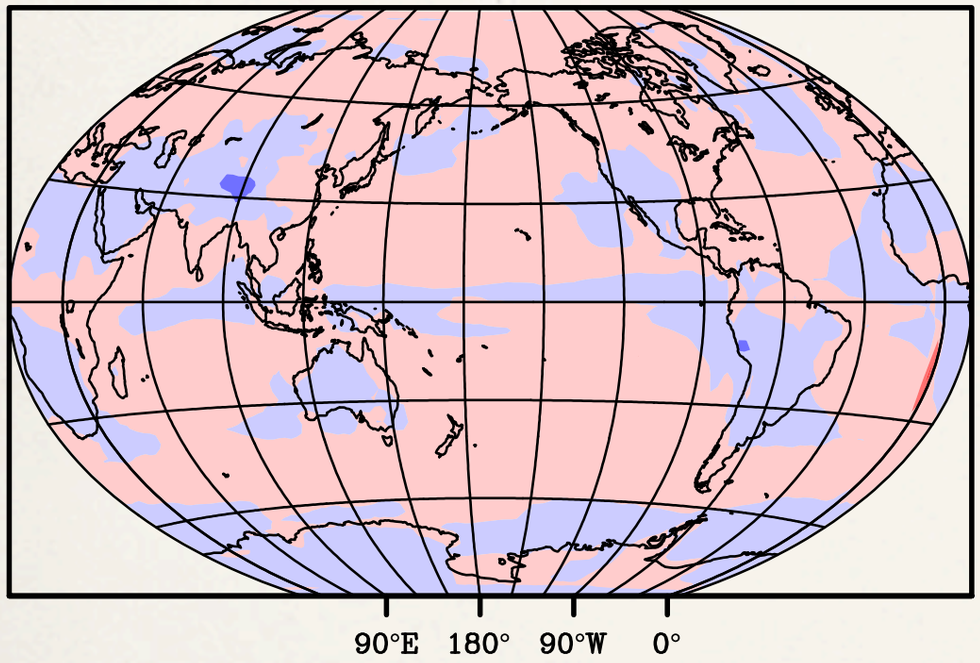


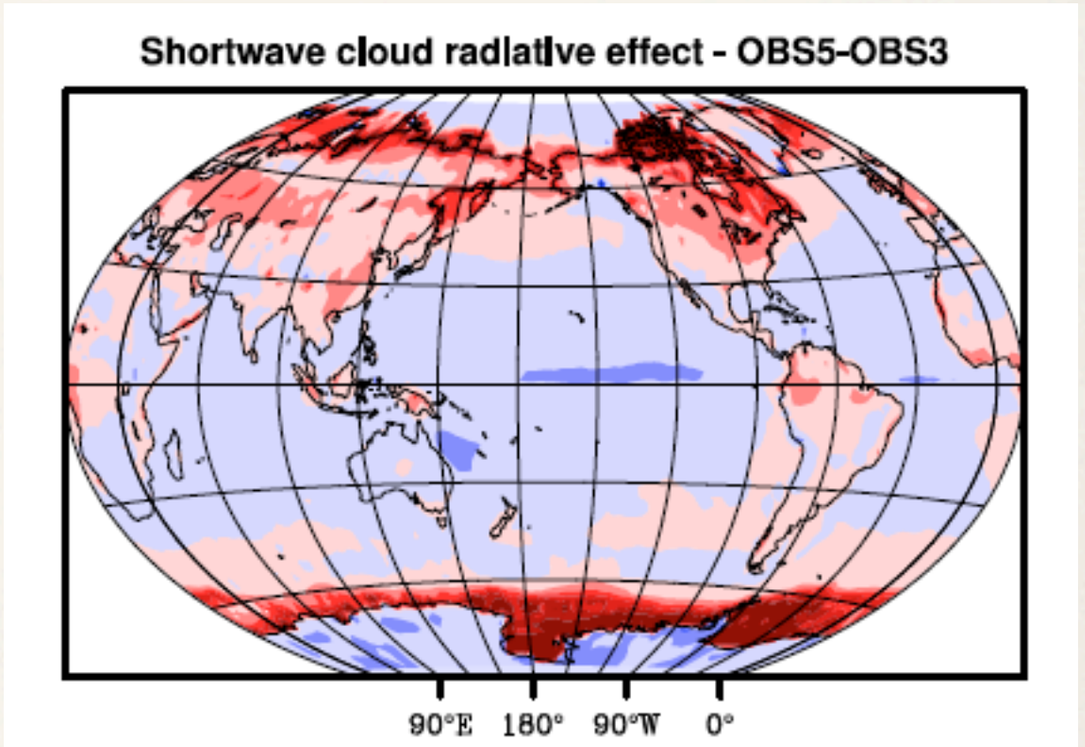


CMIP5



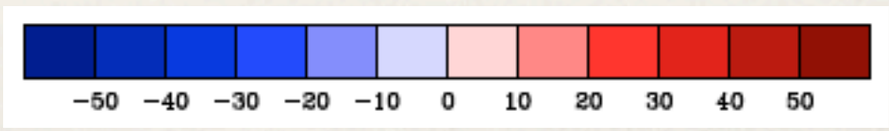
Observational uncertainty





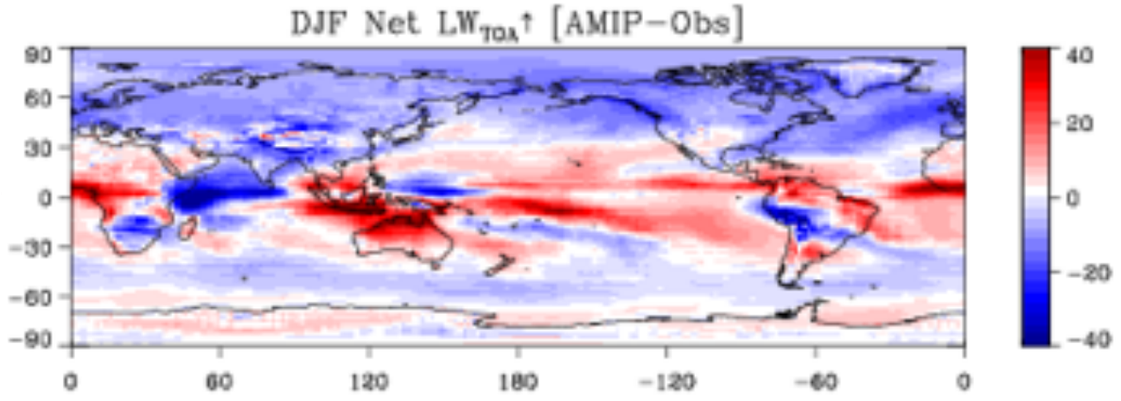
CMIP5-CMIP3

OBS_new-OBS_old

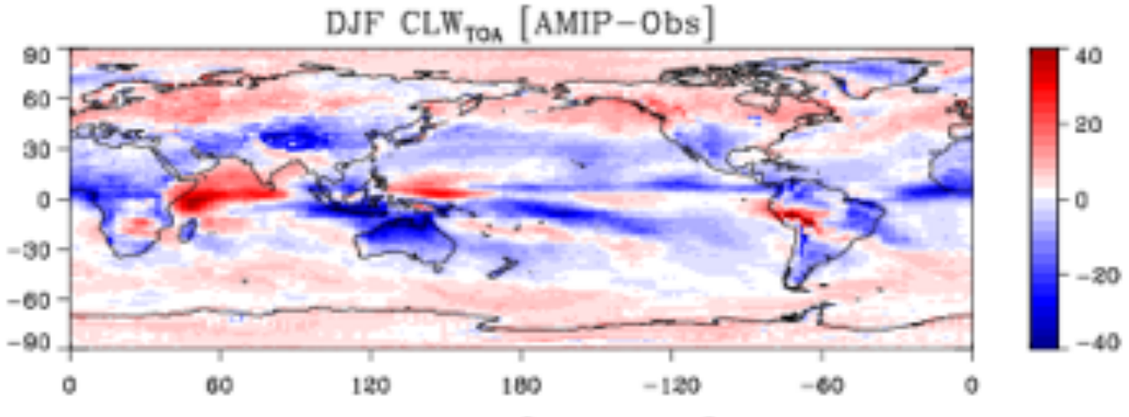


The ACCESS model

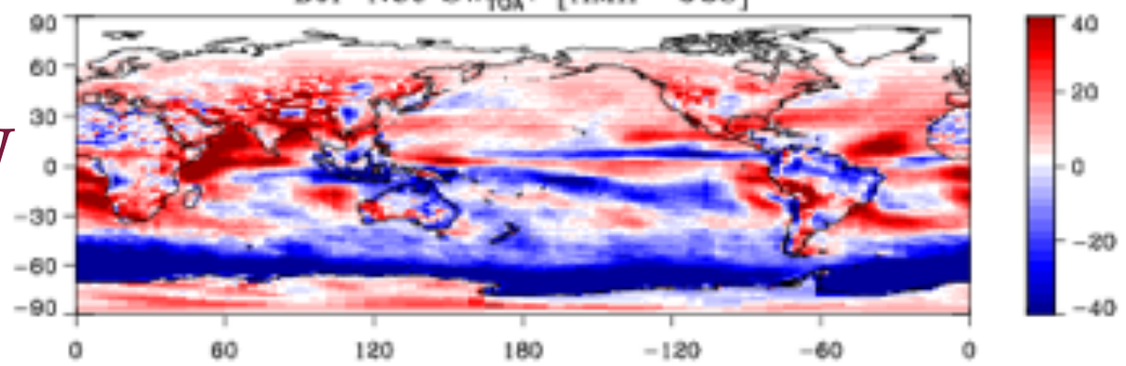
LW



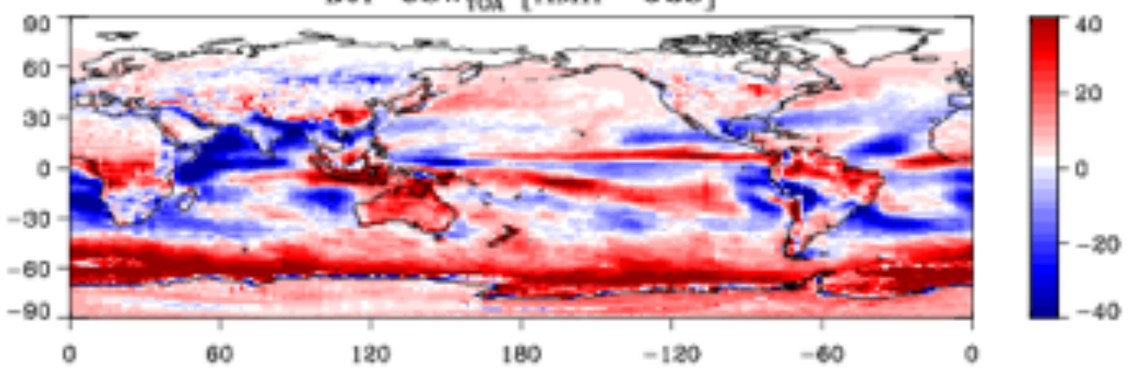
CF LW



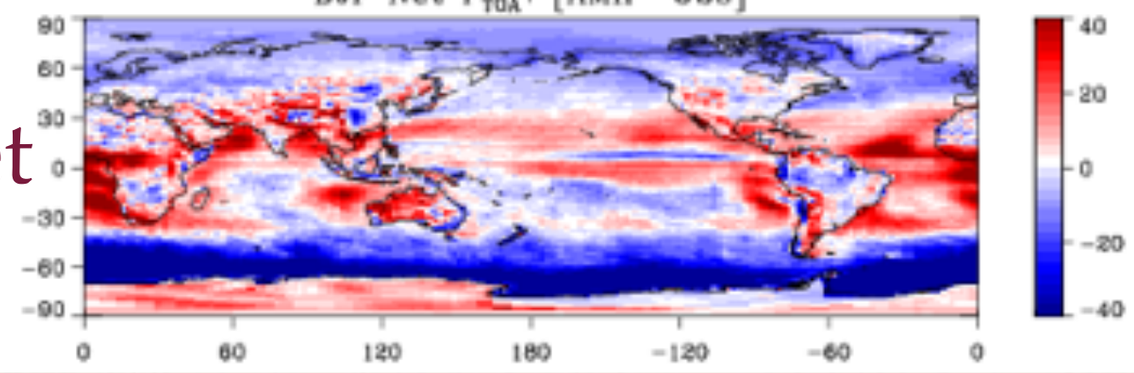
SW



CF SW

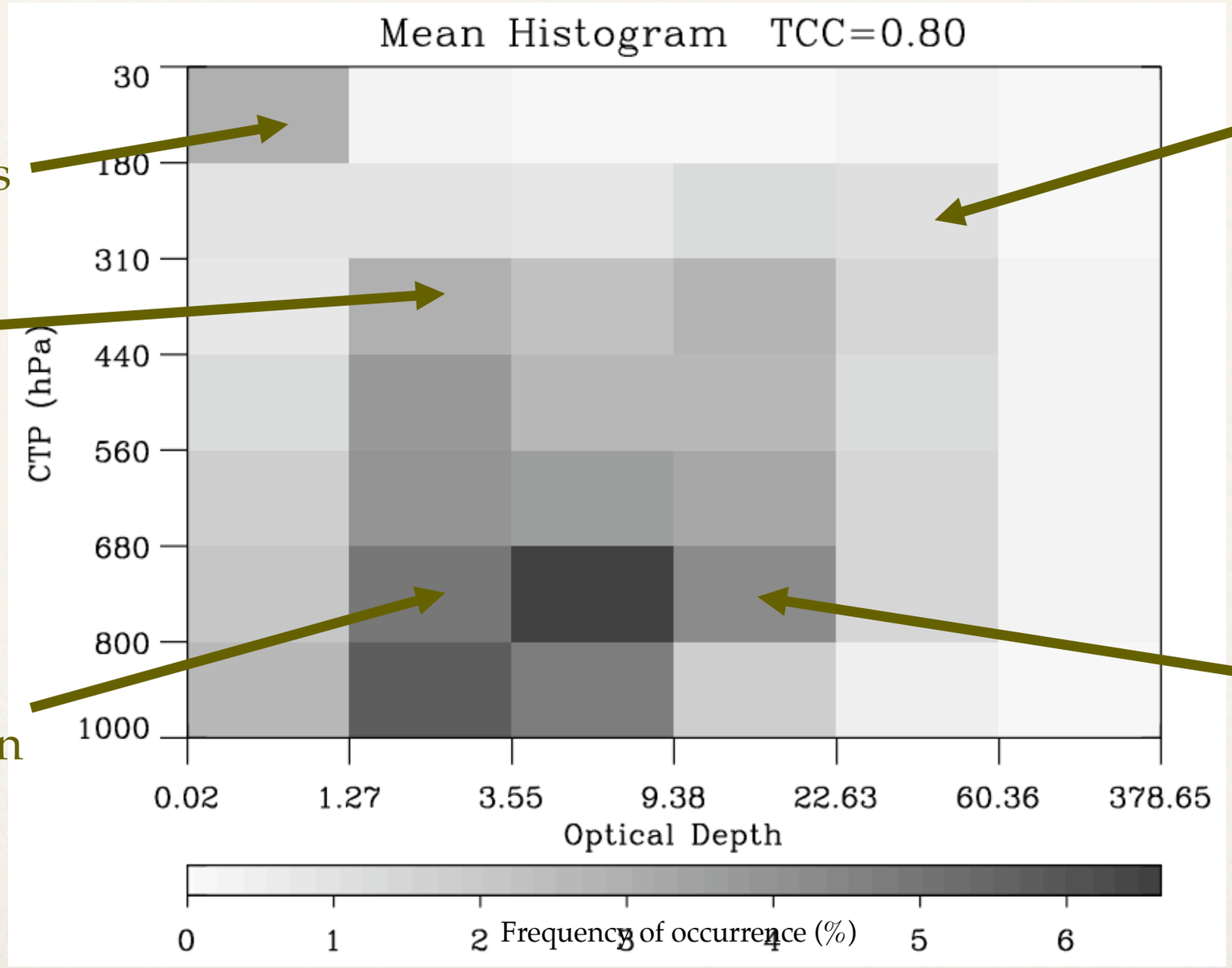


Net



ACCESS model DJF TOA errors - AMIP

Our main Tool – The ISCCP histogram



Thin cirrus

Thick high-top cloud, e.g., fronts

Cirrus

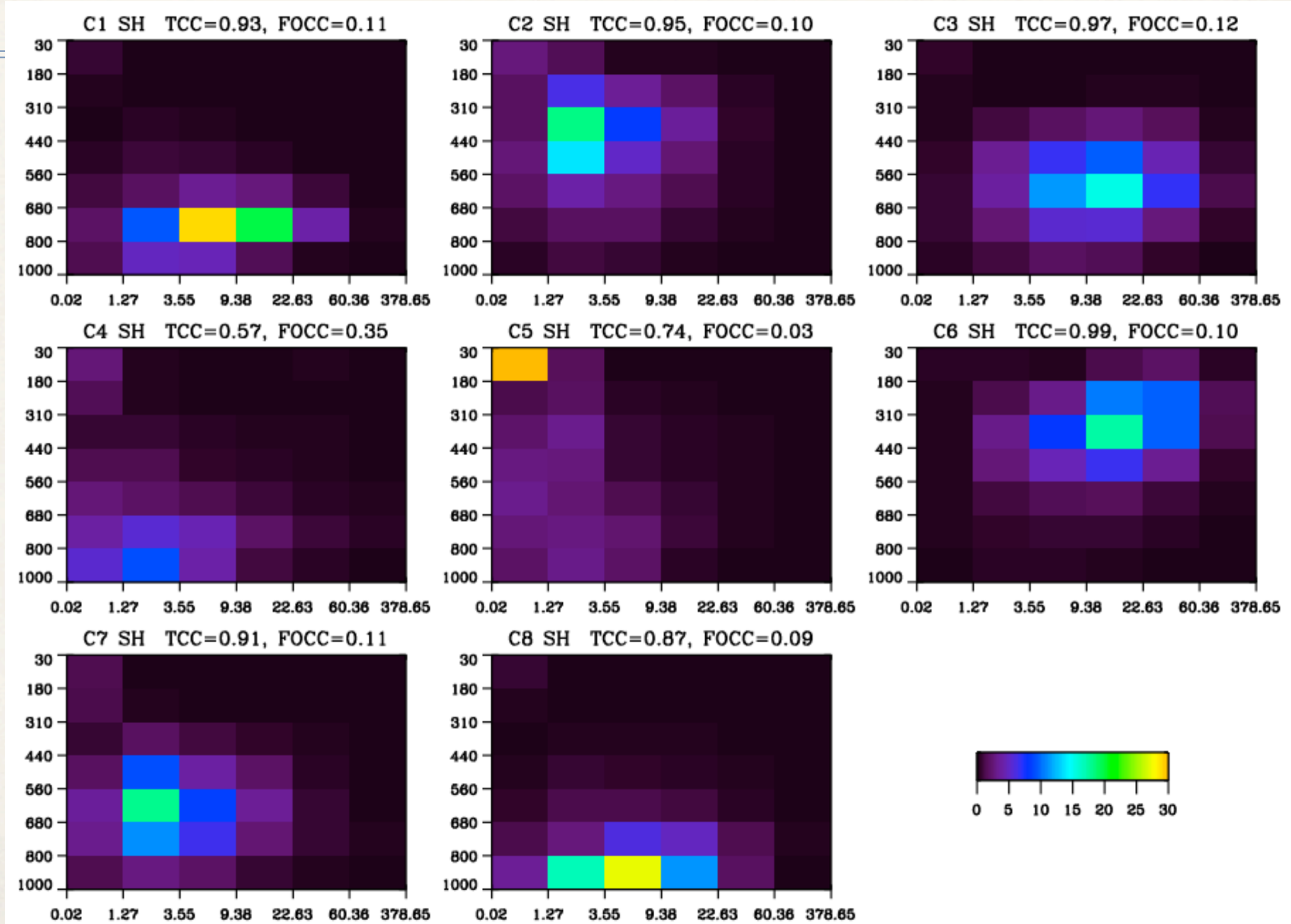
Shallow convection

Thick low cloud

Mean histogram for 1983-2008 averaged over the Southern Hemisphere (35 S-60 S).

SH Cloud regimes

K-Means Cluster analysis - 8 clusters



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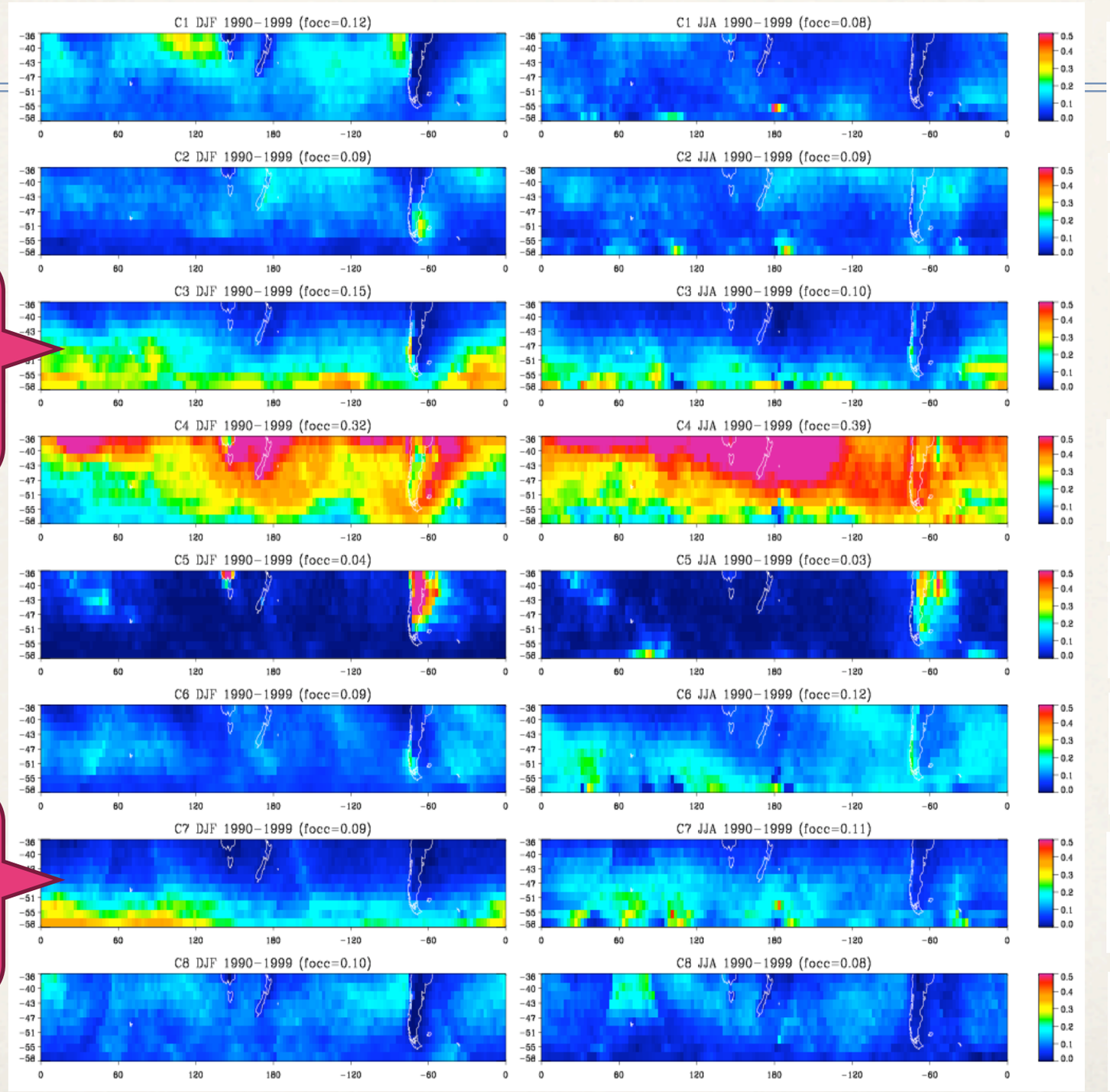
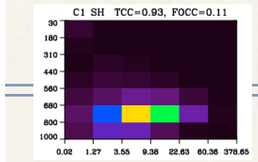
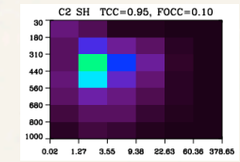
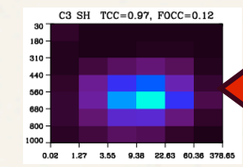
SH Cloud regimes

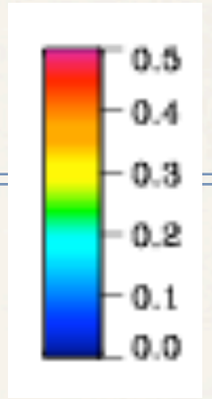
Frequency of occurrence



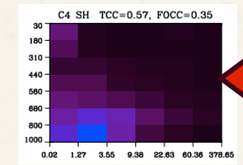




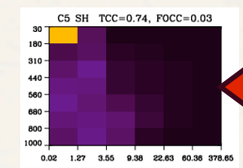




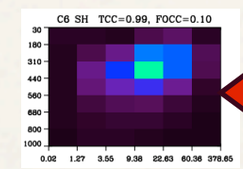
middle-top (?) thick



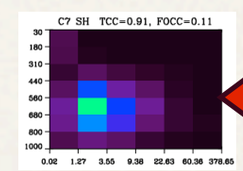
low thin



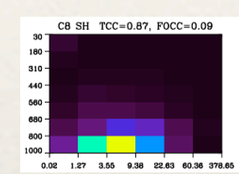
thin cirrus



thick frontal



middle top (?) thin

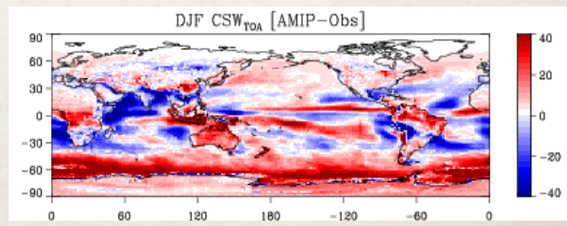


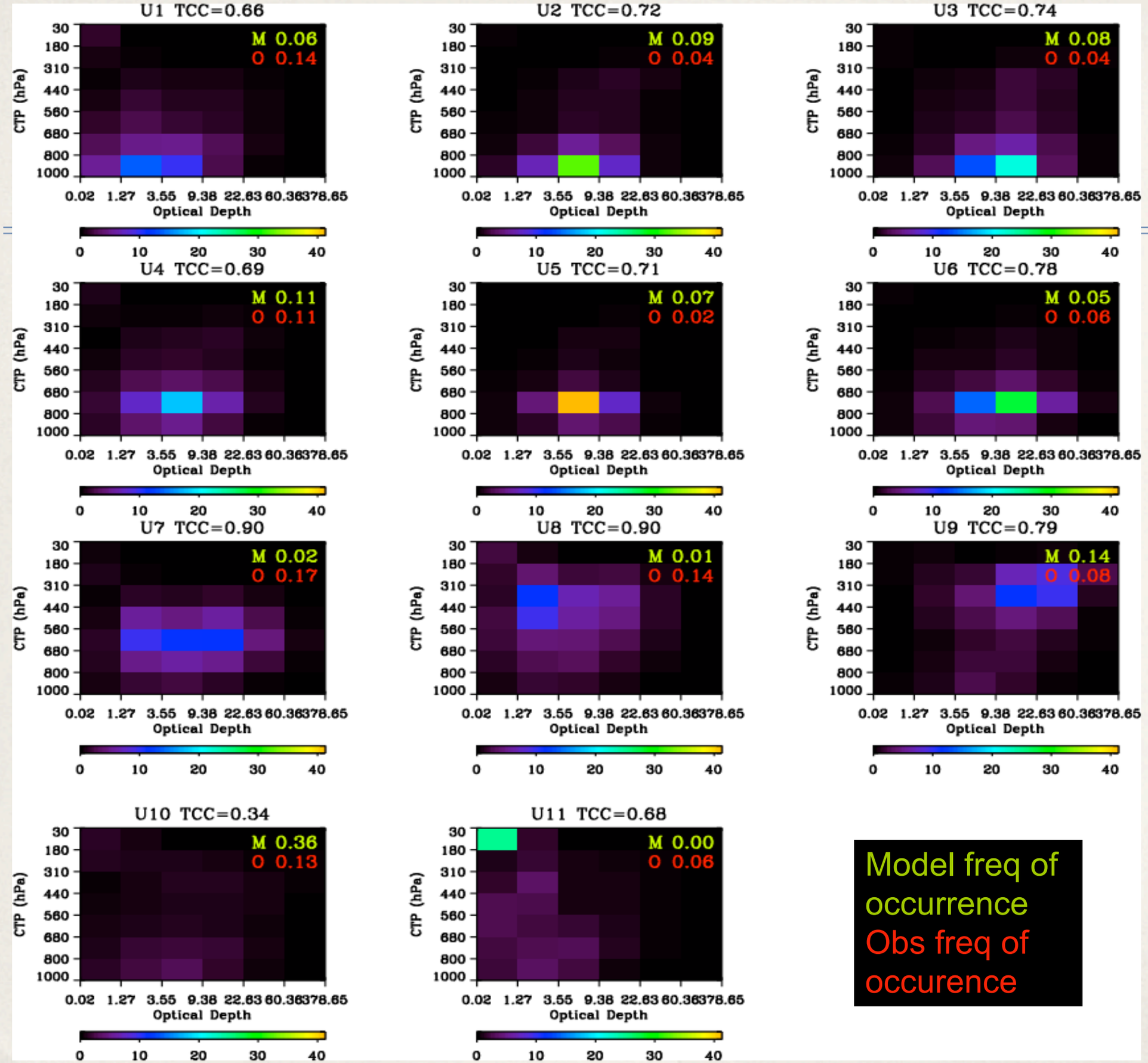
most frequent in region of rad error

most frequent in region of rad error

DJF

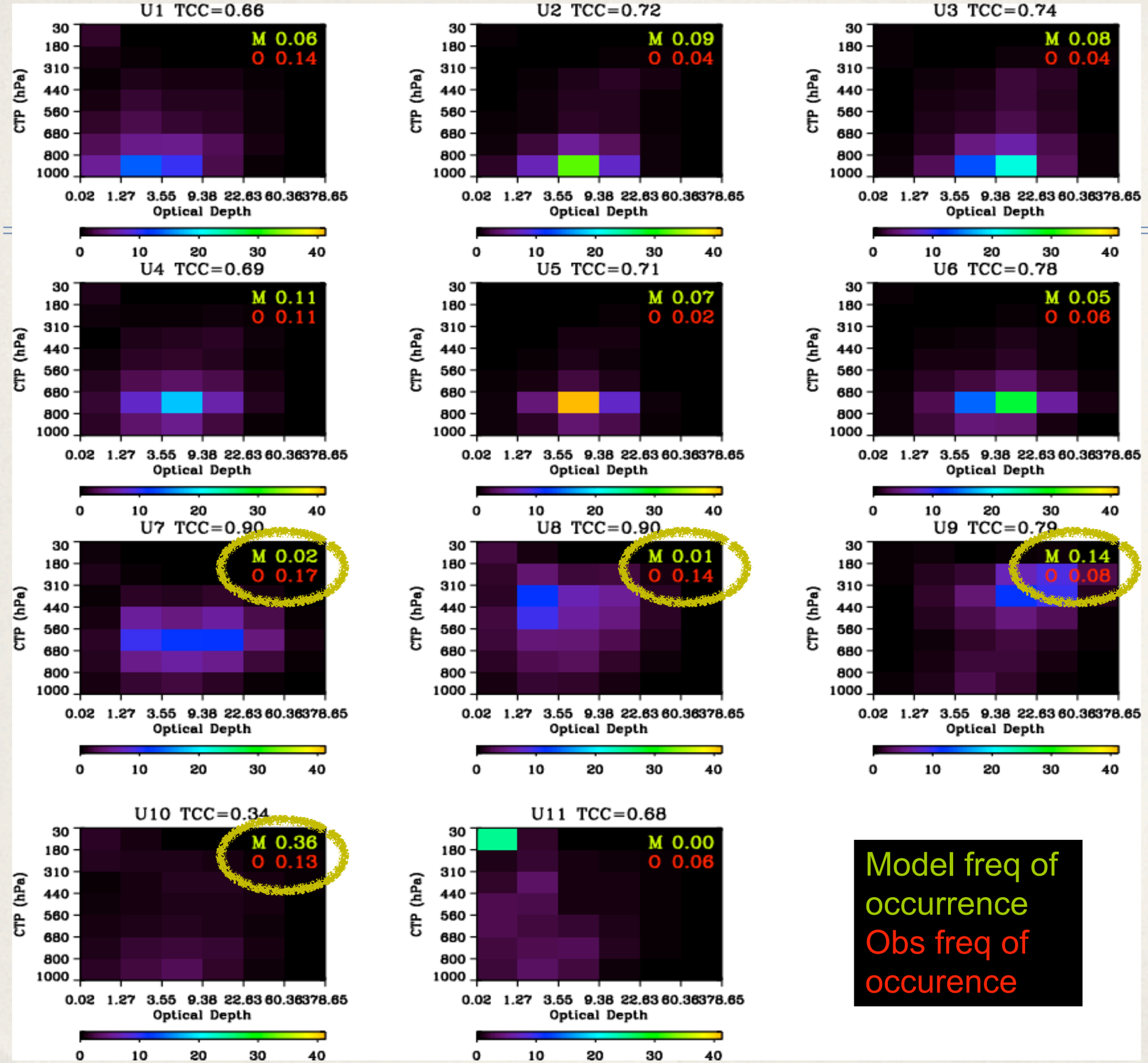
JJA





Hybrid model/ obs regimes

Model freq of occurrence
Obs freq of occurence



Hybrid model/ obs regimes

Model freq of occurrence
Obs freq of occurence

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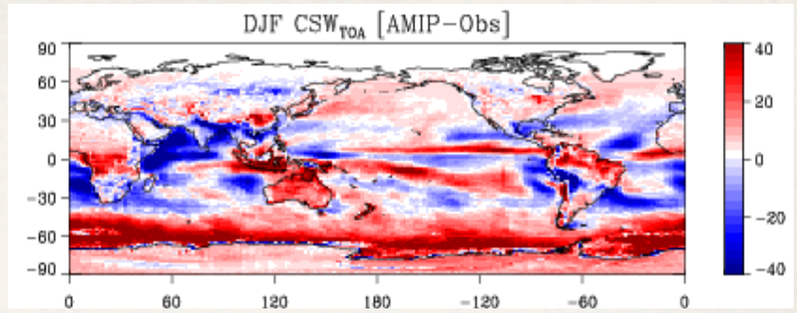
Regime occurrence



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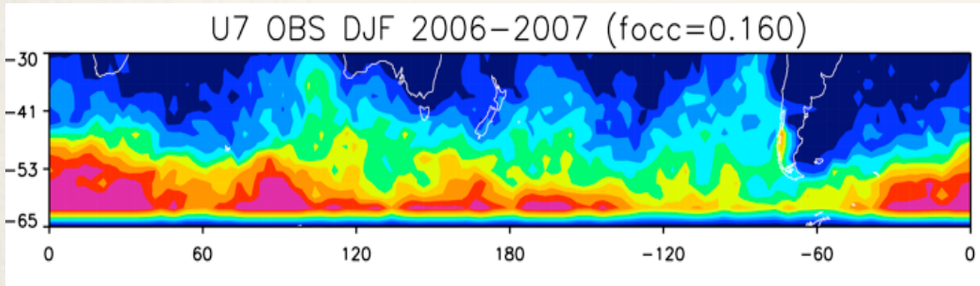

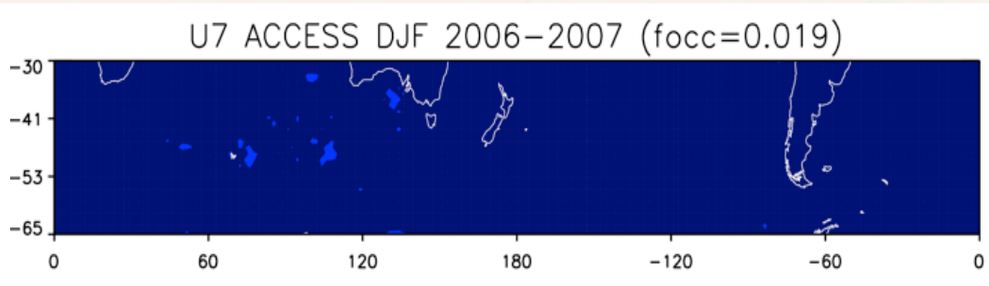

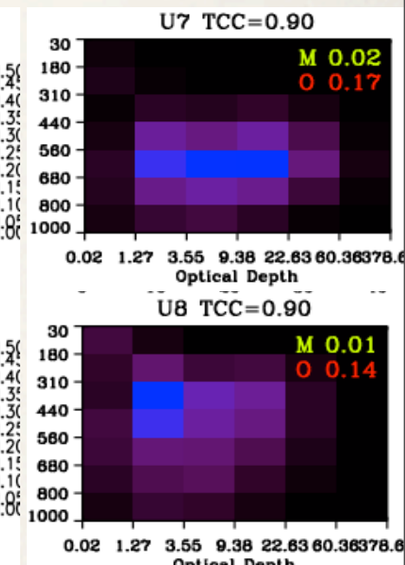

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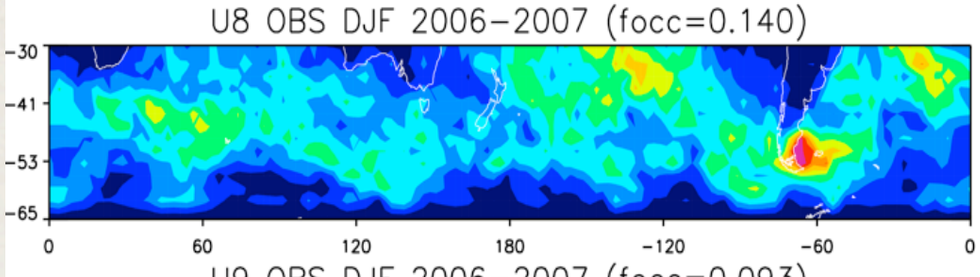

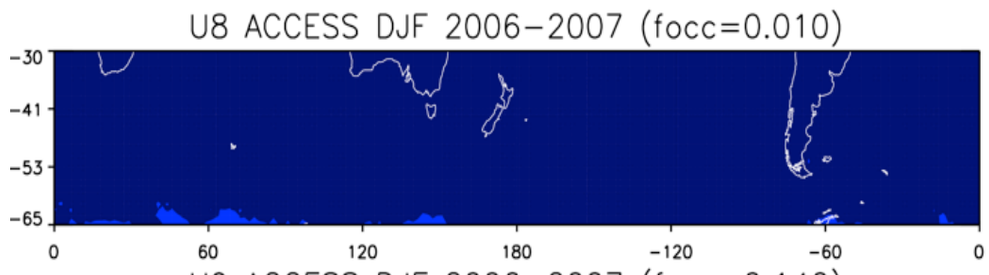

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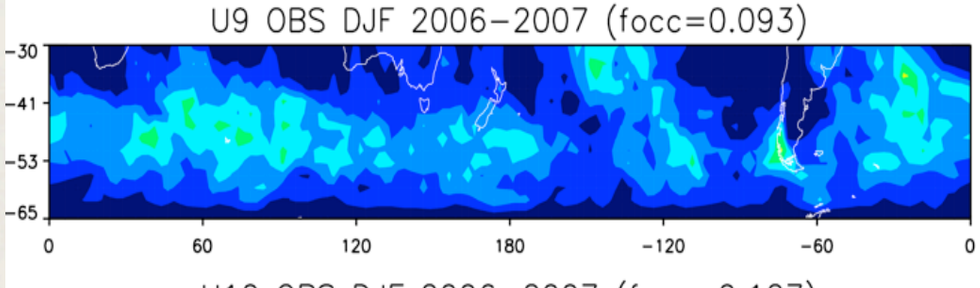

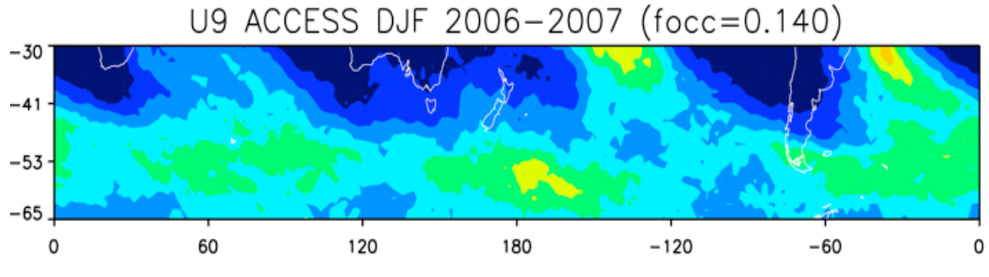

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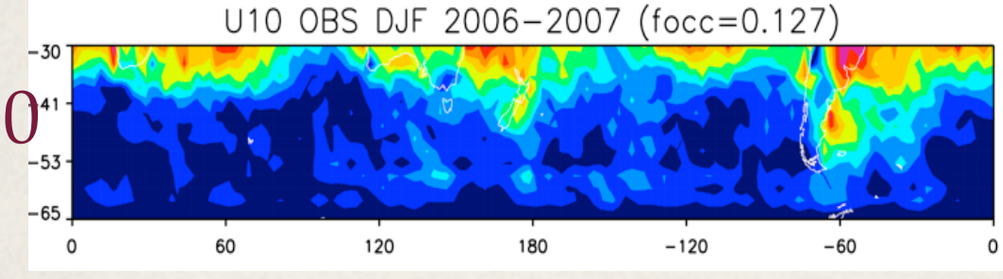

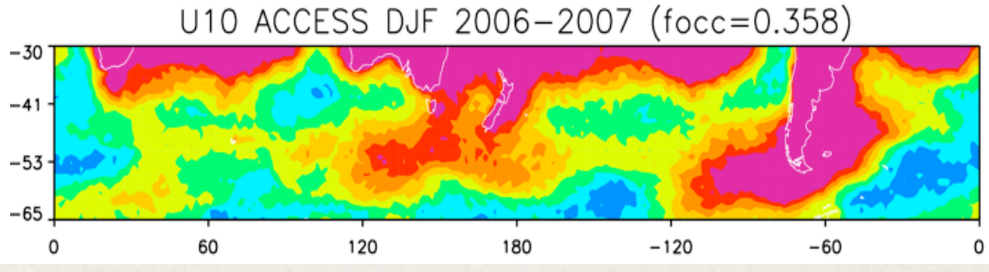

Observations

Model

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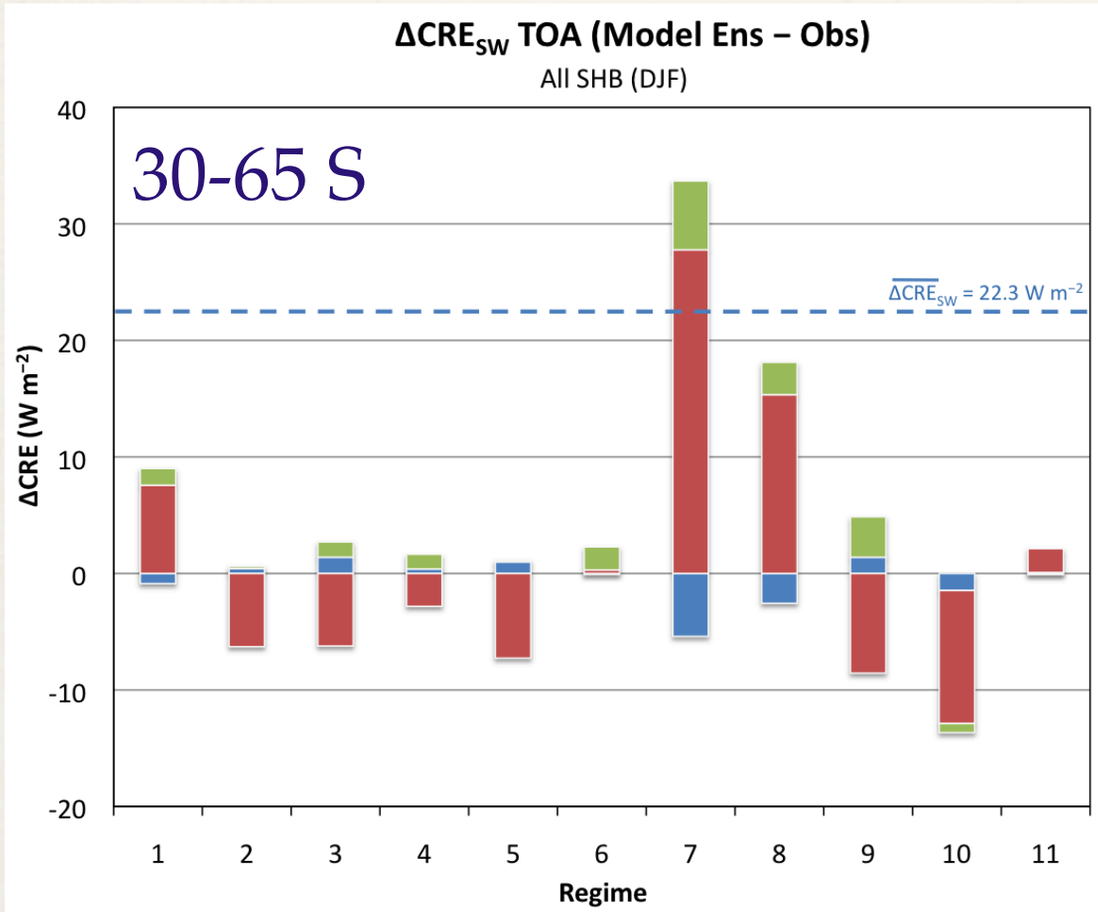
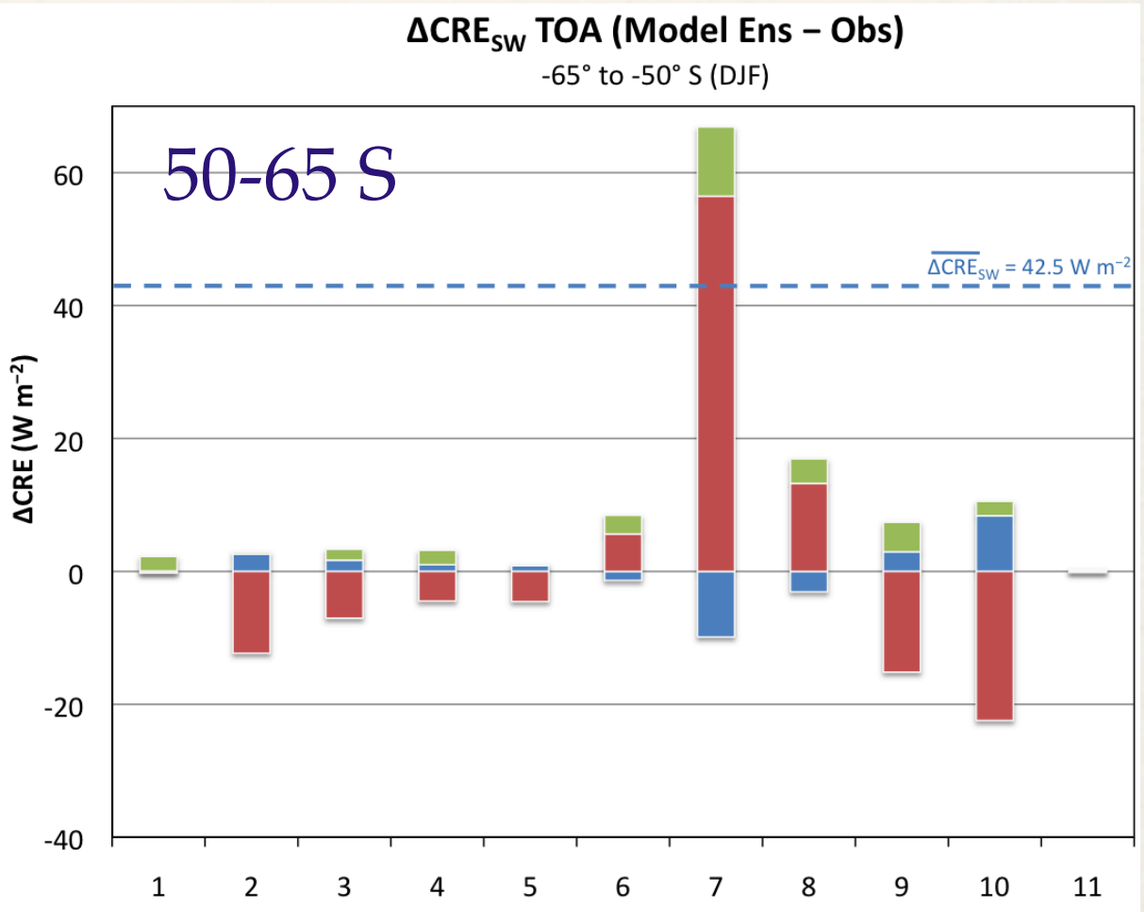
A model error decomposition



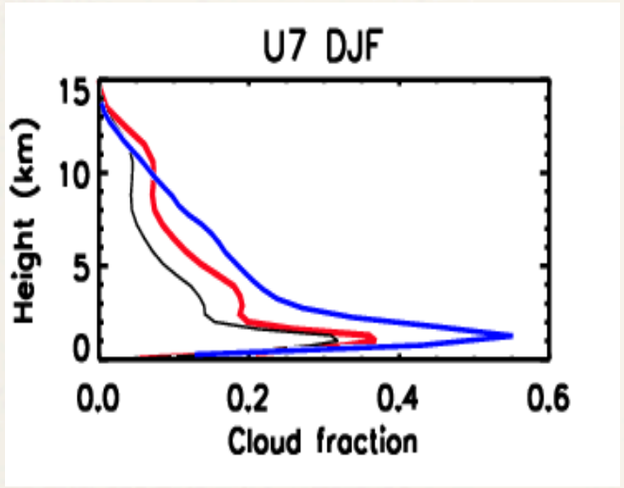


$$\Delta CRE = \sum_{r=1}^{11} RFO_r \Delta CRE_r + \sum_{r=1}^{11} CRE_r \Delta RFO_r + \sum_{r=1}^{11} \Delta RFO_r \Delta CRE_r$$

Total error = CRE error in regime + Error in occurrence + Cross Terms

It works great, so what's next?

What types of clouds are the U7 cloud regime?



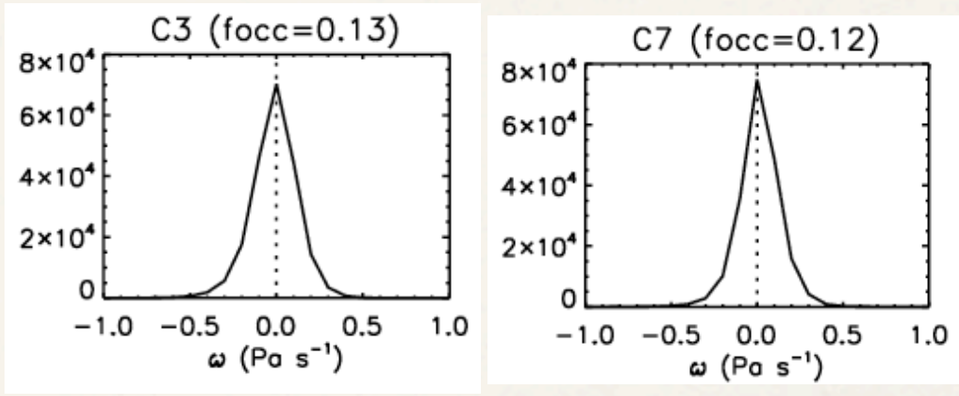
blue - obs

red - model

black - model

ls

Under which conditions do they occur?



observed regimes equivalent to U7 vs ω at 500 hPa

Why can't the model make them?