What spectral dimension can offer?

One sentence answer*:*

It can reveal compensating differences that cannot be revealed in broadband diagnostics alone.

I will use two examples to elaborate on this point.

Example 1: clear-sky flux comparison

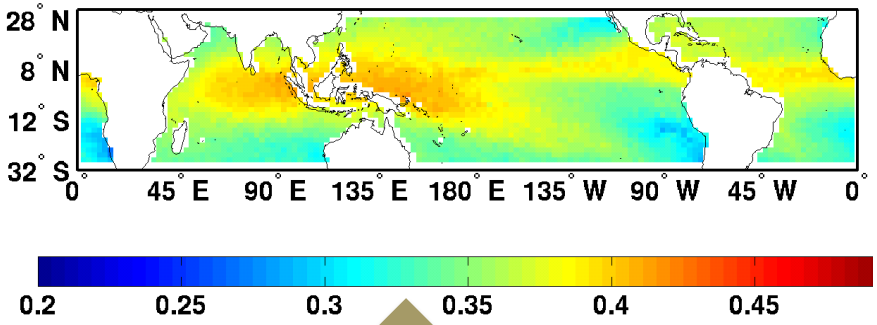
Using the green-house parameter to make the comparison.

Green-house parameter (efficiency)

$$g_{\Delta v} = \frac{\int_{\Delta v} B_v(T_s)dv - F_{\Delta v}(TOA)}{\int_{\Delta v} B_v(T_s)dv}$$

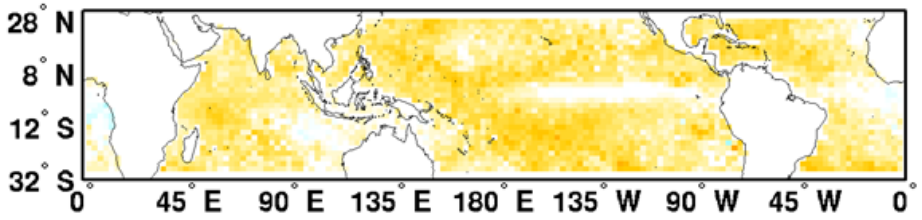
Physical Interpretation: Fraction of radiant energy over a given band that originates from surface but gets trapped within the atmosphere.

Collocated AIRS & CERES obs. LW broadband *2004 Annual Mean*

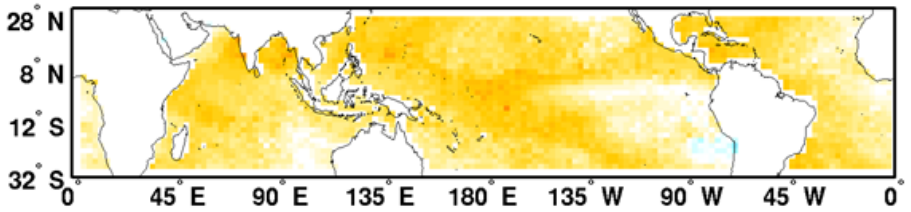


Observation

GFDL AM2 - Obs



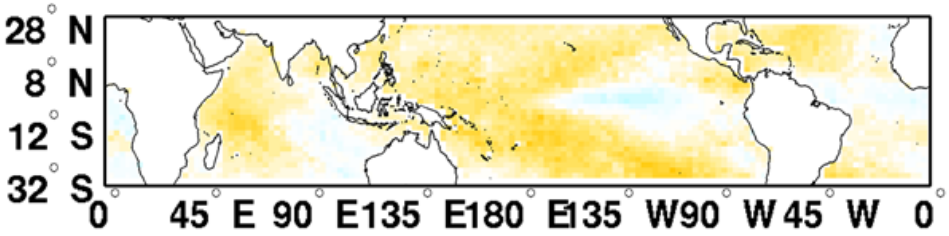
GEOS5 - Obs



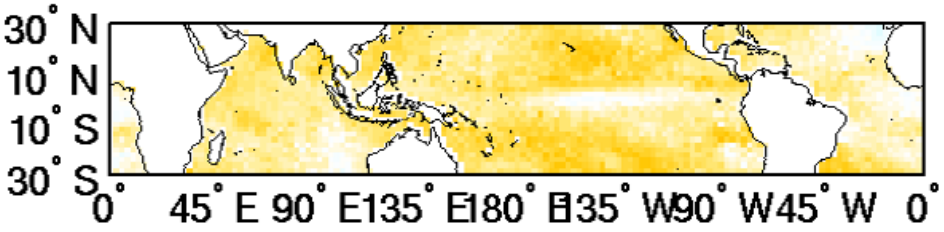
All AMIP runs

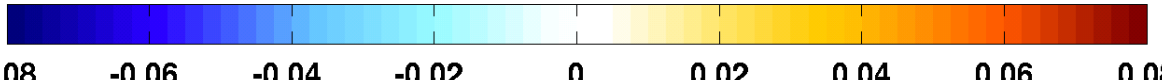
Four GCMs are similar, judged from the model-observation plot at the right. This is what you can conclude from broadband diagnostics.

CanAM4 - Obs

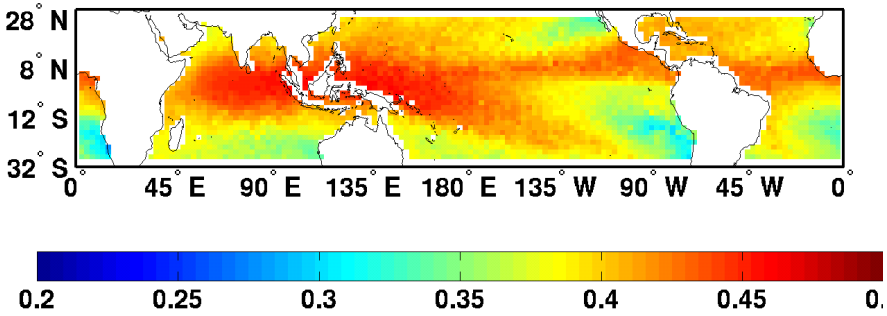


CESM - Obs

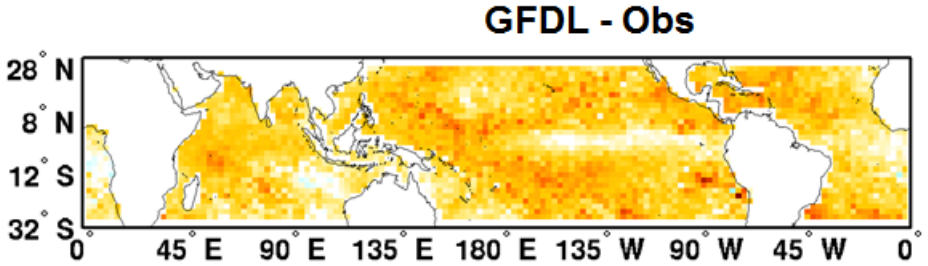


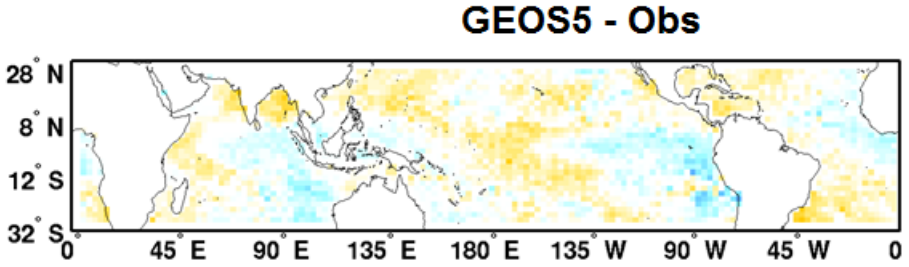


Collocated AIRS & CERES obs. H_2O bands (0-540cm^{-1}, >1400 cm^{-1})

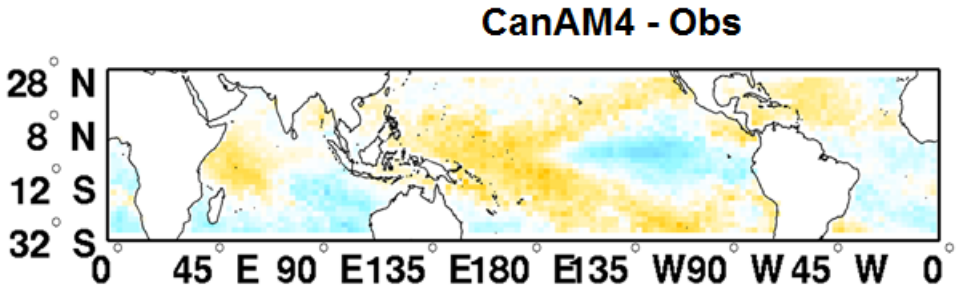


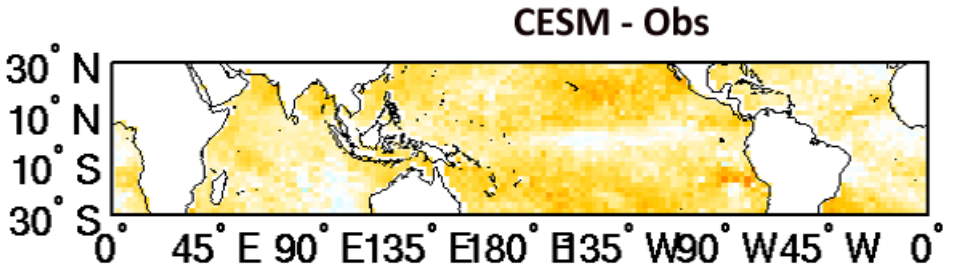
Observation

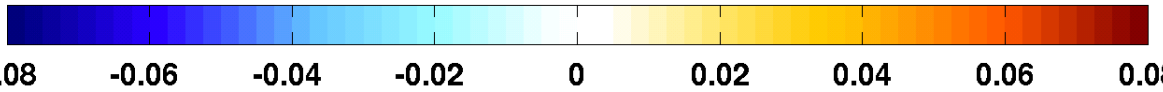




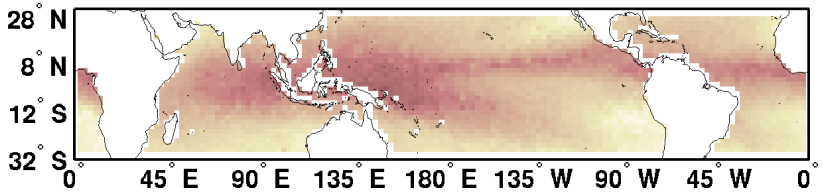
H_2O bands, four GCMs are not the same as shown from the model-obs differences.

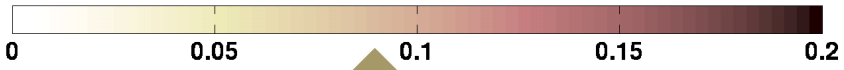






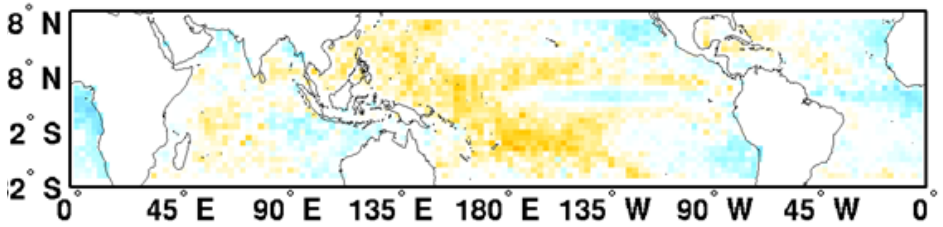
Collocated AIRS & CERES obs., window region (800-980cm^{-1})



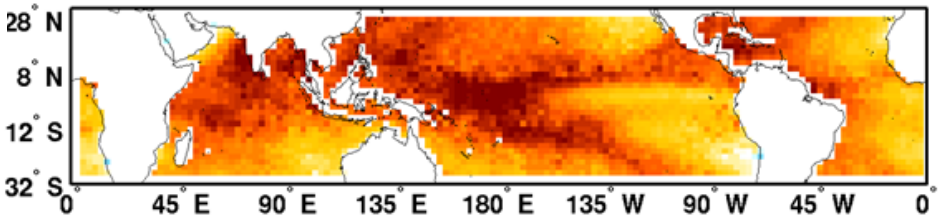


Observation

GFDL AM2 - Obs

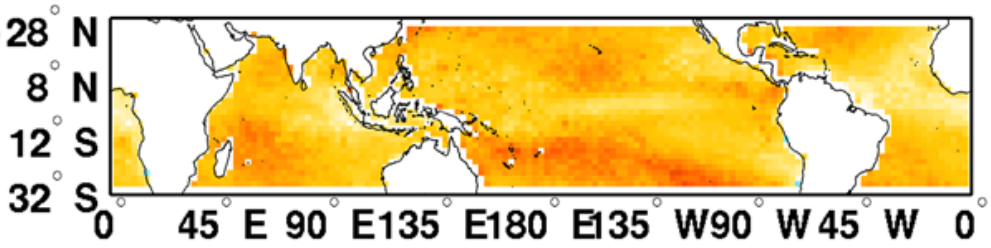


GEOS5 - Obs



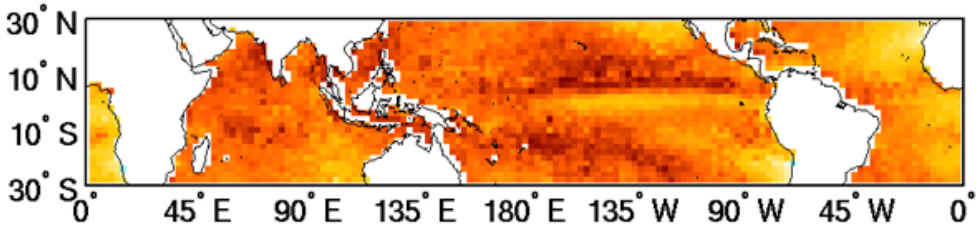
Four GCMs are different for the window band too.

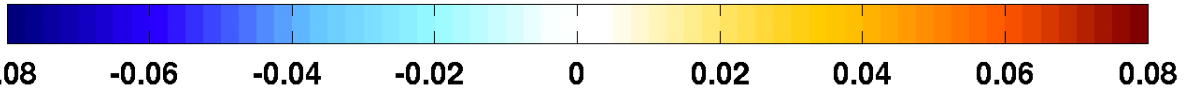
CanAM4 - Obs



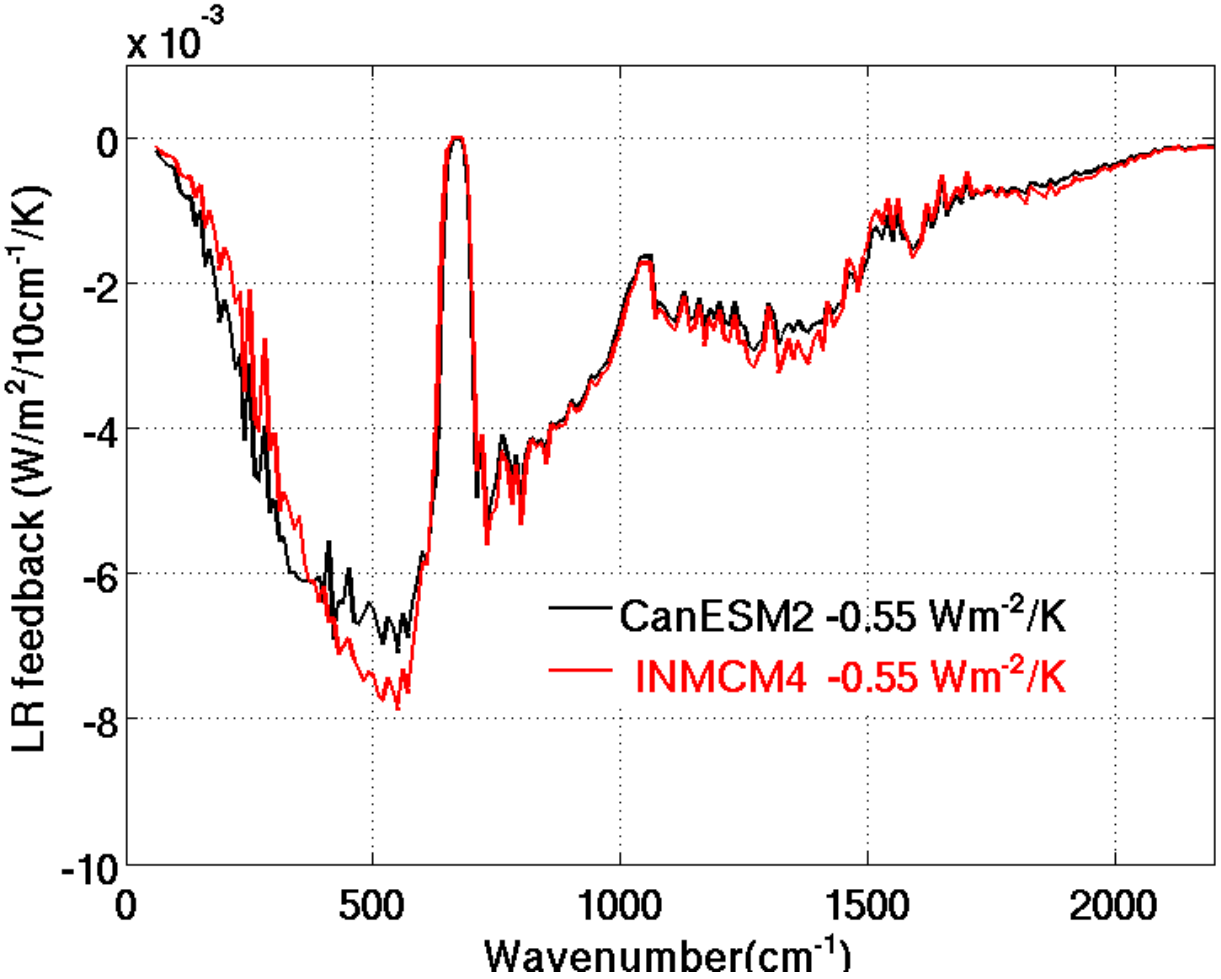
The seemingly good agreement in broadband among four GCMs is indeed a cancellation of biases between H_2O bands and the window band.

CESM - Obs





Example 2: Spectral decomposition of broadband lapse-rate feedback



Two GCMs have identical broadband lapse-rate feedback. But the spectral decomposition is quite different in the far-IR, which implies the vertical temperature change in the two GCMs are different.

Huang, X. L., X. H. Chen, B. J. Soden, X. Liu, 2014B: The spectral dimension of longwave feedbacks in the CMIP3 and CMIP5 experiments, *Geophysical Research Letters*, 41, doi:10.1002/2014GL061938