Controlling Climate Model Tropical Bias Through Tropical Diabatic Heating Correction

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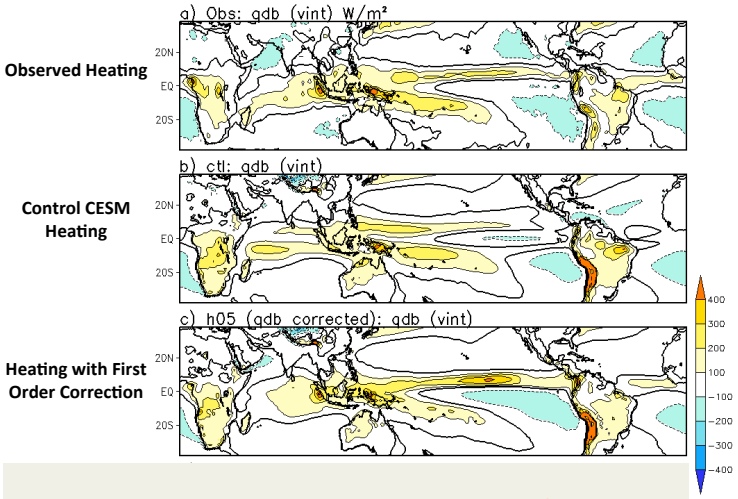
Improved simulation of stationary waves in climate models provides an important basis for enhancing the predictability of atmospheric teleconnections. We use an "added heating" technique to remove the bias in mean tropical diabatic heating in a global coupled model.

Stationary waves and many teleconnections are forced by tropical diabatic heating, which is mis-represented in most models, (e.g., poor simulation of the inter-tropical convergence zone or ITCZ). One approach to correcting simulated tropical diabatic heating is to control the sea-surface temperature (SST). However, this method does not allow one to control diabatic heating, since differences in convective parameterizations in models may lead to different diabatic heating structures.

The method we use consists of adding a correction to the tendency of temperature (or dry static energy) within the physics module of the code at each time step as the model runs. This time-independent tendency correction is calibrated to remove the bias (systematic error) in the full 3d diabatic heating in the tropical regions for the extended boreal winter (Oct. – Mar.). This approach circumvents uncertainty in the modeled diabatic heating response to SST or wind stress, while maintaining all model feedbacks.

This diabatic heating correction has been applied to the Community Earth System Model of the National Center for Atmospheric Research. The diabatic heating bias has been computed on the basis of model output and estimates of observed diabatic heating. The correction has been applied tropics-wide, and in a more localized way over different ocean basins (Pacific, Atlantic, and Indian Ocean). These experimental runs show improvements in: the ITCZ in the tropical Pacific and Atlantic Oceans, the upper level tropical divergence field, and the tropical SST, particularly in the Pacific. The stationary waves in mid-latitude are clearly improved, mostly due to correction of the Pacific basin heating.

Since the added heating tends to over-correct the tropical heating bias, we have carried out experiments with a "second order" correction to improve the total tropical diabatic heating in the model. But the first order correction already removes the double ITCZ, as seen in the Figure.



Vertically Integrated Heating (Oct-Mar). (W/m^2)
(a) Chan-Nigam Observations (b) Control CESM (c) Corrected CESM