Empirical Correction To Tropical Heating:

Can We Correct Mid-Latitude Model Biases?

David M. Straus  
*George Mason University / COLA*

Youkyoung Jang  
*Florida International University*

J. Shukla  
*George Mason University / COLA*
Goals of This Research

Apply a technique to reduce the tropical bias in monthly mean diabatic heating in CESM simulations

Verify that some aspect of the mid-latitude bias in stationary waves is reduced

Determine if seasonal forecasts from real Initial Conditions are so improved.
**Simple Recipe to Correct Model Tropical Heating Bias**

- Zeroth Order “Correction” Technique

  - Subtract model bias in monthly mean climatological tropical diabatic heating
  - Three-dimensional model bias in diabatic heating is estimated from:
    (a) 49 Oct-March simulations with CESM 1.0.5
    (b) Estimates of observed diabatic heating from Chan and Nigam (2009)*
  - The correction term (equal to minus the model bias) *is added directly to the tendency of dry static energy in the coupled model*
  - *The model moist, radiation and other parameterizations are still fully operative*, thus can react to the added heating
  - All the coupled model feedbacks are retained

Simple Recipe to Correct Model Tropical Heating Bias

➢ First Order “Correction” needed:
  - Model heating reacts so as to magnify correction and thereby lead to over-correcting
  - Simple fix is to multiply the heating correction by 0.5
Vertically Integrated Heating (Oct-Mar)  
(a) Chan-Nigam Obs (b) Control CESM (c) Corrected CESM
Vertical Integral of the Correction Added to Temperature Tendencies of CESM (Oct-Mar avg)

a) all tropical heating: 0.5*(OBS-CTL) = qdb (vint) W/m²

b) Pacific Ocean heating

c) Atlantic Ocean heating

d) Indian Ocean heating
Control CESM Heating = $Q_{GCM}$

\[ \frac{dT}{dt} = \cdots + (Q_{OBS} - Q_{GCM}) \]  
(Zeroth Order Correction)

\[ \frac{dT}{dt} = \cdots + 0.5 \times (Q_{OBS} - Q_{GCM}) \]  
(First Order Correction)

Oct-Mar Vertically Integrated Heating Biases
Simple Recipe to Correct Model Tropical Heating Bias

- Second Order “Correction” needed:
  - Model heating reacts so as to magnify correction and thereby lead to over-correcting.
  - Simple fix is to multiply the heating correction by 0.5
  - Clearly this is not adequate

- Higher Order “Correction” will be needed:
  Iterate this technique to provide an additive correction term that will reduce the climatological model tropical diabatic heating error to near zero (on a monthly basis)
Bias Corrections in Subseasonal to Interannual Predictions

Pacific Basin Only

Atlantic Basin Only

Indian Ocean Basin Only

Oct-Mar Vertically Integrated Heating Biases
Regional Heating Correction Experiments
Bias Corrections in Subseasonal to Interannual Predictions

- **Obs:** z500 eddy
- **ctl:** z500 eddy
- **h05 (qdb corrected):** z500 eddy

500 hPa Geopotential Height Eddy Field (Oct-Mar)

(a) Chan-Nigam Obs (b) Control CESM (c) Corrected CESM
Bias Corrections in Subseasonal to Interannual Predictions

Control CESM Heating = $Q_{GCM}$

$$\frac{dT}{dt} = \ldots + (Q_{OBS} - Q_{GCM})$$
(Zeroth Order Correction)

$$\frac{dT}{dt} = \ldots + 0.5 \times (Q_{OBS} - Q_{GCM})$$
(First Order Correction)

Bias in 500 hPa Geopotential Eddy Field (Oct-Mar)
Sub-Monthly Transients
300 hPa meridional velocity

\[ \overline{v'v'} = \overline{v^2} - \left( \overline{v} \right)^2 \]

a) DJFM vv300: OBS

b) DJFM vv300: CTL

c) DJFM vv300: 0.5HTG
Biases in Transients

\[ \overline{v'v'} = \overline{v^2} - \left( \overline{v} \right)^2 \]

Bias Corrections in Subseasonal to Interannual Predictions
Bias Corrections in Subseasonal to Interannual Predictions

Linearity of Response for 500 hPa Geopotential Height Eddy Field

Top: Response to Global Heating Correction
Bottom: Sum of Responses to Individual Ocean Basin Heating Corrections
Conclusions

- Heating correction does reduce heating biases (particularly double ITCZ)
- More work needed on refining the heating correction
- Stationary Waves in Mid-Latitude Atlantic Region clearly improved
- Corresponding improvement is seen in sub-monthly transients
- This improvement mostly due to correction of the Pacific Basin Heating

Future Work

Apply the bias reduction in seasonal re-forecasts: *Will it lead to any improvement in forecast skill?*