ATS/CIRA Colloquium

Aaron Donohoe

from the University of Washington

Hosted by Maria Rugenstein

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ATS 101 and Microsoft Teams

The partitioning of poleward energy transport in the climate system; model biases and the near invariance of total energy transport under climate forcing

The total (atmosphere plus ocean) poleward energy transport (PET) is nearly climate state invariant in an ensemble of simulations spanning from the Last Glacial Maximum to a world with carbon dioxide concentrations of four times the preindustrial values. In contrast, the PET differs by 20% between different models in simulations of the present-day climate. Here, we ask why PET is insensitive to climate forcing within a given model but can vary between different models.

We analyze the poleward energy transport (PET) from two different perspectives: i) radiative perspective whereby PET is equal to the net radiative deficit of the extratropics and ii) dynamic perspective whereby poleward energy transport is equal to the energy contrast between poleward and equatorward moving air and water masses in the atmosphere and ocean respectively.

From a radiative perspective, PET is equal to the difference between the equator-to-pole contrast in absorbed solar radiation (ASR*) and that in outgoing longwave radiation (OLR*). The invariance of PET under climate forcing results from compensating changes in ASR* and OLR* associated with the darkening of the extratropics and reduction in the equator-to-pole temperature gradient with warming. In contrast, the inter-model spread in PET results from the spread in ASR* due to cloud biases that are uncompensated by OLR* differences.

From a dynamic perspective, models have too little poleward ocean energy transport – especially in the Southern Ocean – relative to observations. Models differ widely in the mechanisms of PET in the atmosphere and generally have weaker energy transport by stationary eddies relative to observations. The near invariance of PET under climate forcing results from a complicated compensation between energy transport by stationary eddies, transient eddies, and mean overturning circulations and moist and dry transports.

We analyze some targeted idealized simulations to probe the mechanisms responsible for the radiative and dynamic compensation seen in comprehensive models.