The Meridional Structure of the Effects of Global Warming on Atmospheric Radiative Cooling and Precipitation

Charlotte Connolly, Ohio University, Geography Department
Alexandra Naegle, Colorado State University, Department of Atmospheric Science
David Randall, Colorado State University, Department of Atmospheric Science

Background

- Atmospheric Radiative Cooling (ARC) is the net radiation loss from atmosphere
- ARC is positive when there is cooling
- The magnitude of ARC depends on various components of the global energy budget
- Cloud heights can influence ARC

Data

- Climate Model Intercomparison Project 5
- Variables used:
  - Radiative components for clear sky and all sky
  - Precipitation
  - Surface Temperature

Methodology

- Average across years 0-10 and 60-70 for each variable
- Calculate Atmospheric Radiative Cooling for all-sky and clear sky from the atmospheric radiative variables for each of the 18 models
  \[ \text{ARC} = (\text{LW}_{\text{TOA}} - \text{LW}_{\text{SFC}}) - (\text{SW}_{\text{TOA}} - \text{SW}_{\text{SFC}}) \]
- Take the difference between years 0-10 from 70-60 to return the change in ARC and precipitation
- Take zonal mean
- Average across models for the multi-model mean

Results and Conclusions

- Change in ARC clear-sky is larger than change in ARC all-sky (right)
- The tropics have no change in ARC all-sky (right)
- ARC has an inverse relation to precipitation (lower right)
- Wet gets wetter and dry gets drier (lower right)
- In the Arctic the change in ARC depends on the season with the largest increase in the fall (lower left)
- The greatest increases in water vapor and precipitation occur in the Tropics, despite the near-zero change in the ARC there (top)
- Correlations between the normalized global mean change in precipitation and both all-sky and clear-sky ARC are very similar (below)

Models

- CCSM4
- Hadgem
- GFDL-CM2
- GFDL-ESM2G
- GFDL-ESM2M
- GISS-E2-R
- ACCESS1.0
- HadCM3
- CNRM-CM5
- FIO-CM
- ISLP-CM4-LR
- ISLP-CM4-MR
- MIROC-ESM
- MIROC5
- MPI-ESM-LR
- MPI-ESM-P
- MPI-ESM-HR

This work has been supported by the National Science Foundation Research Experiences for Undergraduates Site in Climate Science at Colorado State University under the cooperative agreement No. AGS-1461270.

Contact: Charlotte Connolly cc620315@ohio.edu