On the Uncertainty of the Atmospheric Response to Climate Change in Coupled Climate Models

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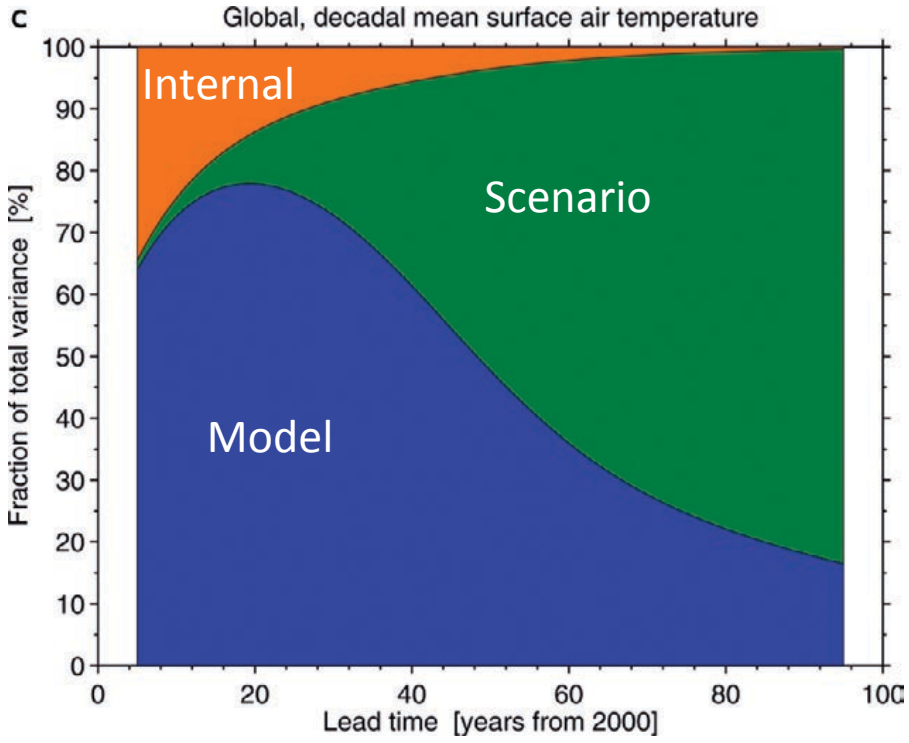
CMMAP Student Symposium

Motivation & Objectives

- Trends of the gen. circulation vary between models and ensembles making climate prediction difficult
- Determine what trends are robust across models and ensembles
- Sources of Uncertainty
  - Natural or Internal Variability
  - Forcing Scenario
  - Model Response
- Develop a proxy for trends of tropospheric and stratospheric circulation



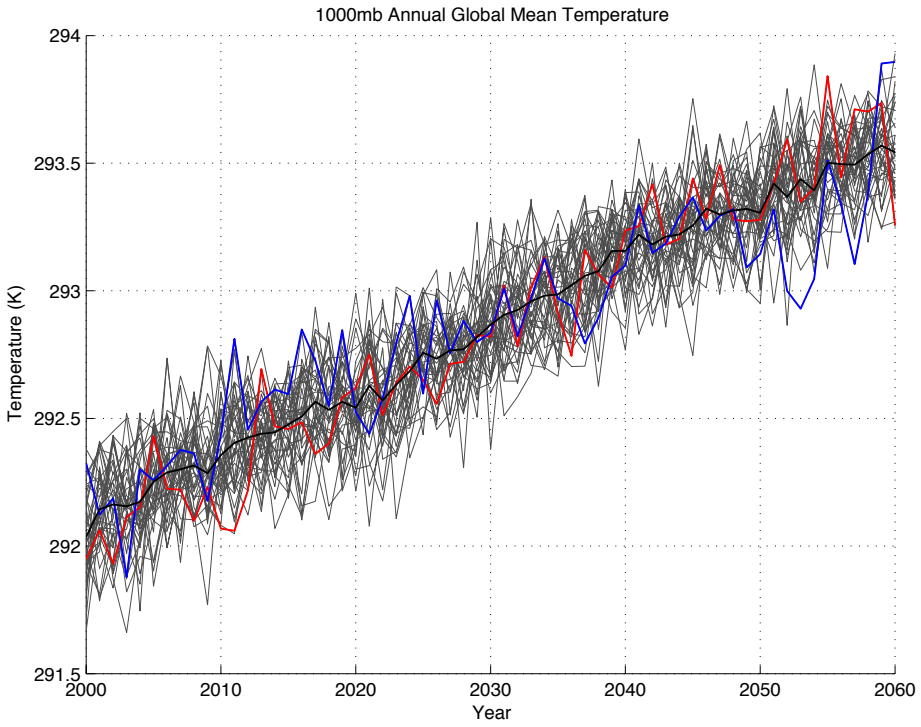
From: Hawking and Sutton 2009

Model Output

- NCAR CCSM3 40-Member Ensemble
  - 2.8° X 2.8° Horizontal Resolution & 17 Vertical Levels
  - 2000-2061
  - A1B Forcing Scenario

- CMIP5
  - 60 Models Total (8 used in short term)
  - Models differ in horizontal and vertical resolution
  - 2006-2100
  - Representative Concentration Pathway (RCP) 4.5

Uncertainty Associated with Internal Variability

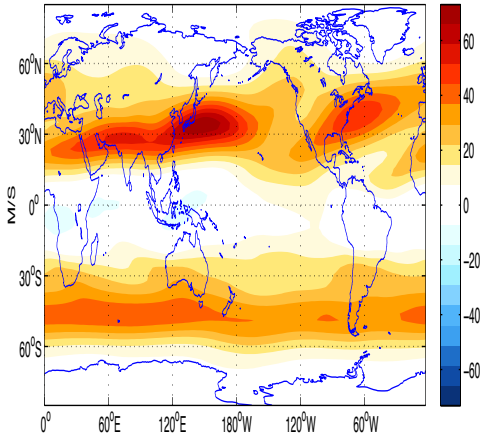


- Intramodel spread is representative of natural variability
- Some trends likely to be within natural variability
- Global mean warming trend is ~.25°K per decade
- Spread in warming trend varies with height

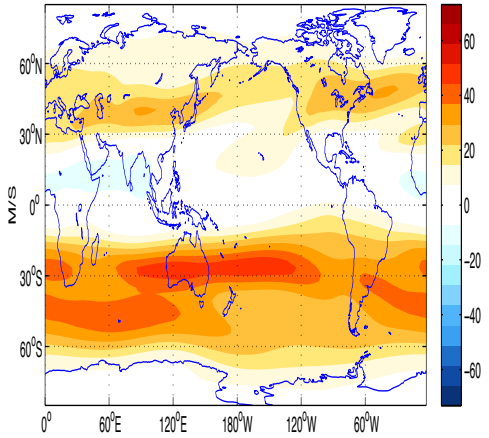
Intramodel Zonal Wind Mean State

- Most internal variability of zonal winds in mid latitudes
- More internal variability in DJF than JJA
- Internal variability greater in NH

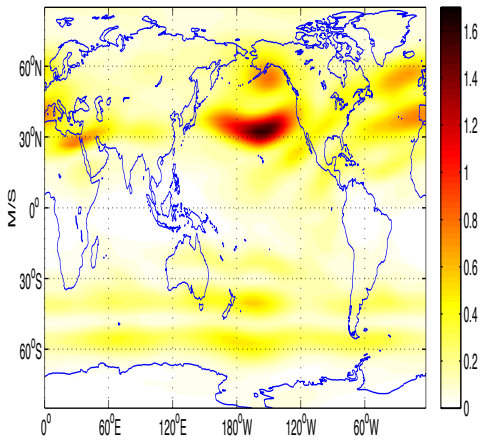
250mb DJF UA Mean



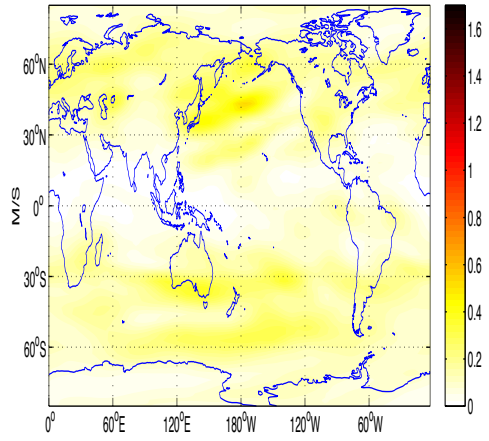
250mb JJA UA Mean



250mb DJF UA Variance

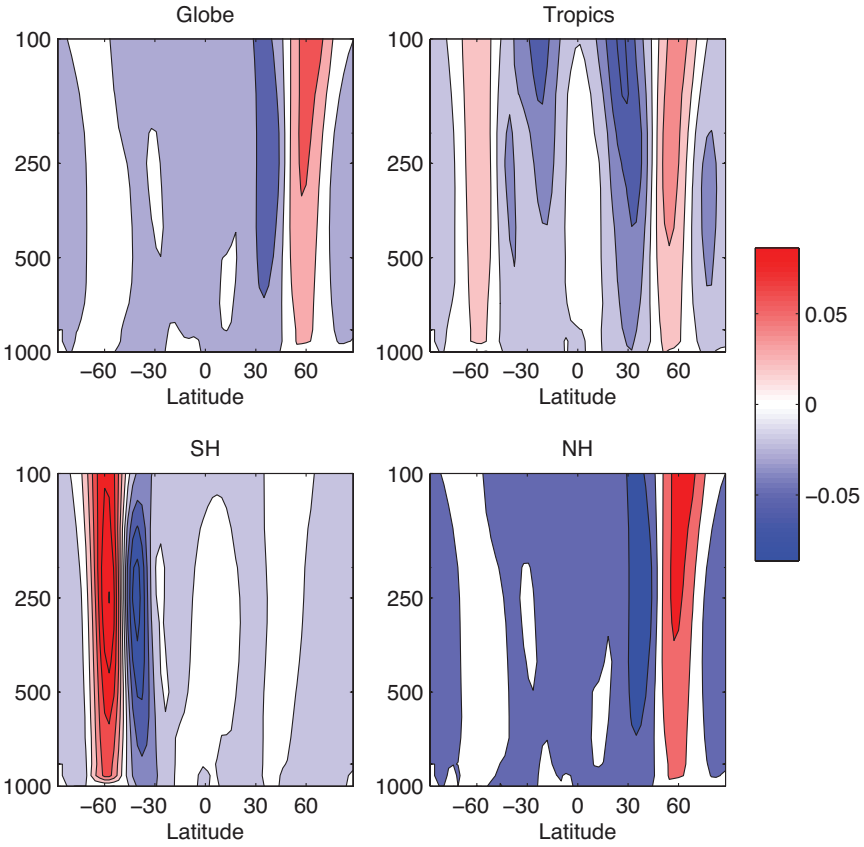


250mb JJA UA Variance



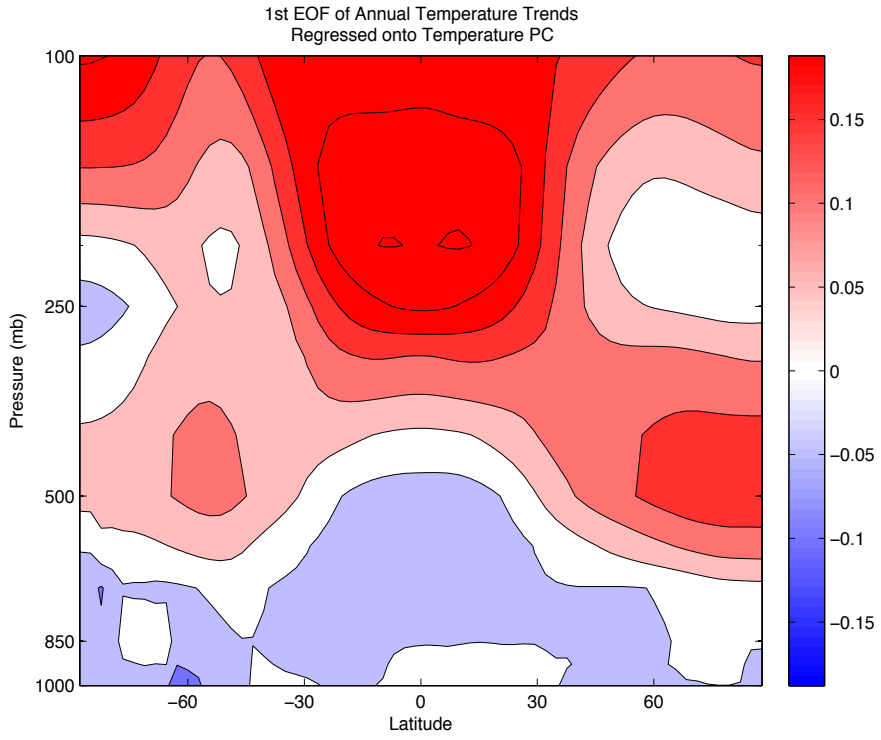
Intramodel Zonal Wind Regressed Onto Intramodel 850 Zonal Wind PC

- Leading Pattern of Uncertainty is the NAM
- SAM is weaker due to ozone recovery
- Sam may become more prominent when assessed seasonally



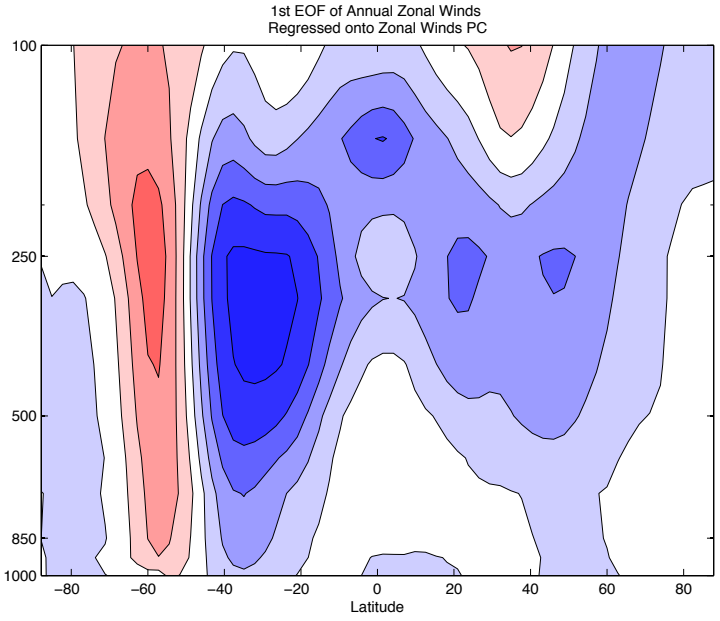
Uncertainty Associated with Model Response

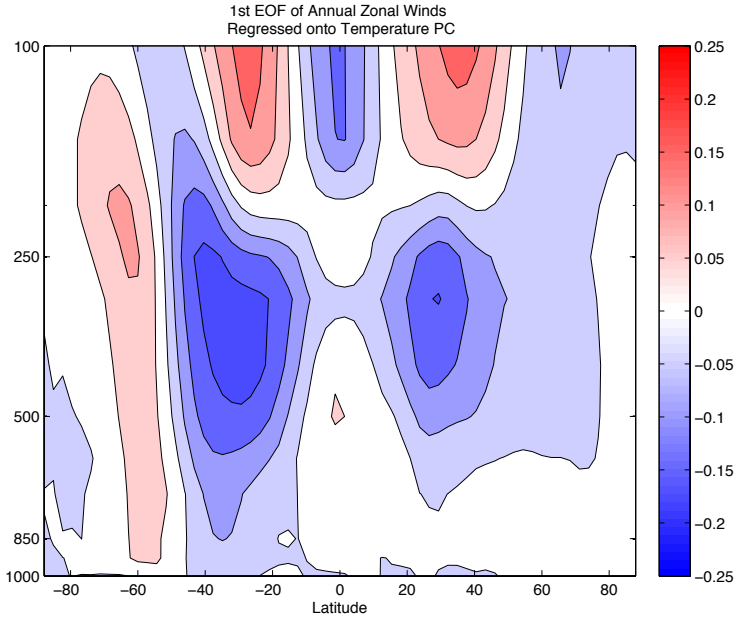
- 8 models with identical forcing but different amplitudes of response
- Leading pattern of uncertainty of temperature field is in tropical upper troposphere
- More agreement in the lower troposphere than the upper troposphere
- Difference are intended to distinguish model physics



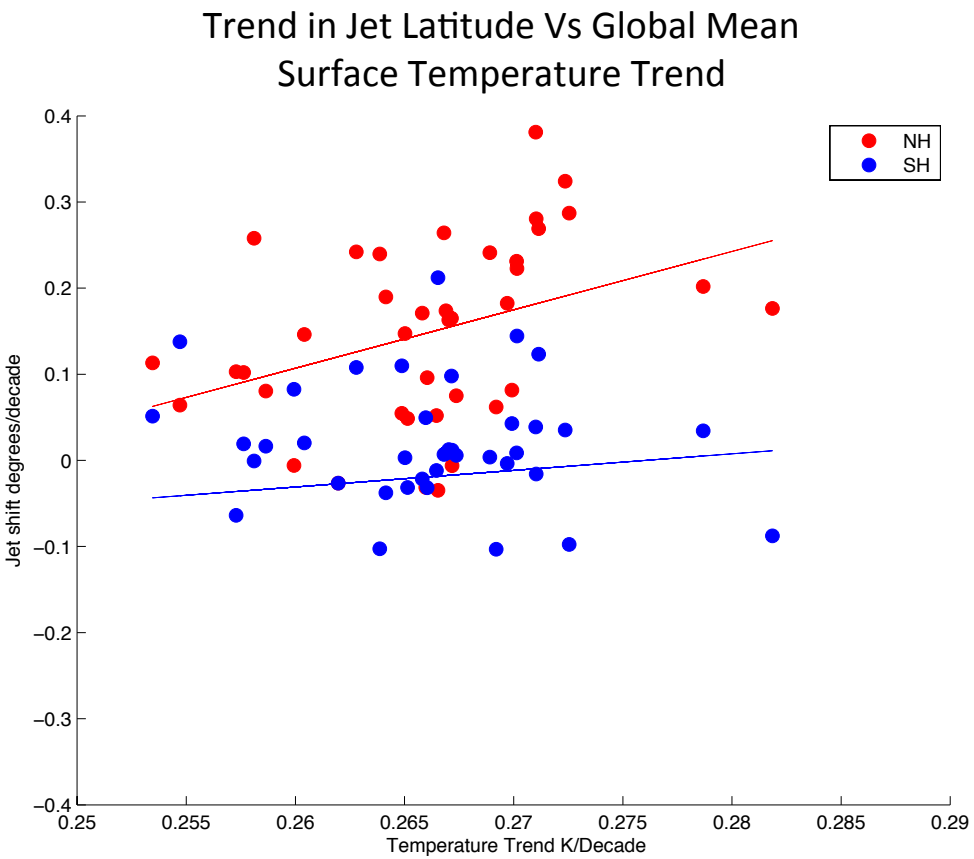
Intermodel Zonal Mean Wind EOFs

- Most intermodel variability in zonal wind field is in mid latitudes
- Uncertainty in zonal wind field is explained by SAM
- Uncertainty in temperature field influences annular modes and the subtropical jet





Temperature and the Annular Modes



- Some correlation between global mean warming trend and jet shift
- SH weak due to ozone recovery
- SH should show stronger correlation in 2nd half of 21st century
- Similar results with tropical upper troposphere

Next Steps

- Defining “Robust Trends”
- Statistical significance of trends against the mean state
- Determine the number of models needed to detect a forced response at 95% significance level
- Further examination of link between warming in tropical upper tropospheric and the general circulation
- Extend analysis to the stratosphere

References

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