A Retrospective Look at CMIP5

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Outline

- Metrics of success
  – Impact on AR5
  – Papers
  – Participation
  – Data collected and transferred
- Opportunities for improvements
  – Infrastructure Issues
  – Science Gaps

Impacts on AR5

- CMIP5 data provide much of the core figures in the IPCC WG1 Report
- The multi-model mean (MMM) used to define response to historical and future changes in radiative forcing
- Individual model spread around MMM a measure of uncertainty
  - Variability
  - Model response error

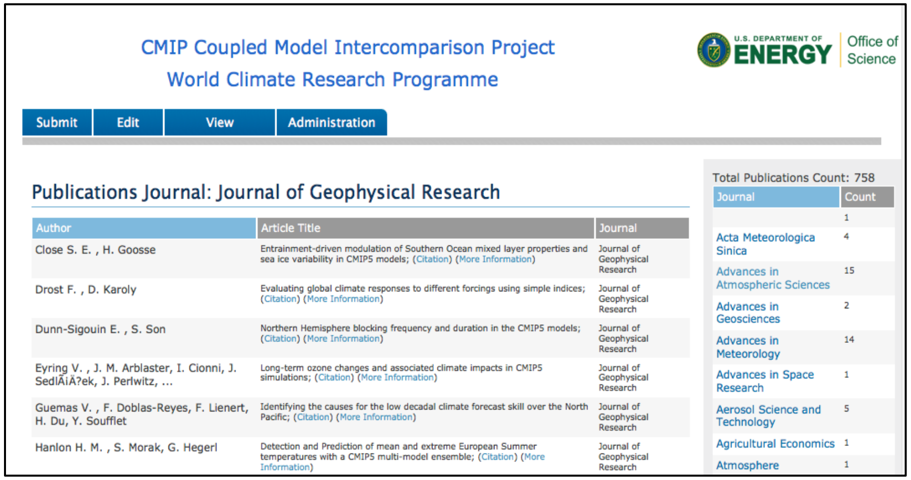
CMIP's impact on science can partly be gauged by number of publications relying on results

- 391* citations of AMIP1: Gates et al (1999)
- 1349* citations of CMIP3: Meehl et al. (2007)
- 1771* citations of CMIP5: Taylor et al. (2012)

Two of the top five most cited geoscience papers published since 2007 (out of ~300,000)

- Over 1000 CMIP5 articles have been recorded on the CMIP website:

http://cmip.llnl.gov/cmip5/publications



CMIP Coupled Model Intercomparison Project
World Climate Research Programme

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Publications Journal: Journal of Geophysical Research

Author	Article Title	Journal
Close S. E. , H. Goosse	Entrainment-driven modulation of Southern Ocean mixed layer properties and sea ice variability in CMIP5 models; (Citation) (More Information)	Journal of Geophysical Research
Drost F. , D. Karoly	Evaluating global climate responses to different forcings using simple indices; (Citation) (More Information)	Journal of Geophysical Research
Dunn-Sigouin E. , S. Son	Northern Hemisphere blocking frequency and duration in the CMIP5 models; (Citation) (More Information)	Journal of Geophysical Research
Eyring V. , J. M. Arblaster, I. Cionni, J. SedlÃiÄ?ek, J. Perlwitz, ...	Long-term ozone changes and associated climate impacts in CMIP5 simulations; (Citation) (More Information)	Journal of Geophysical Research
Guemas V. , F. Doblas-Reyes, F. Lienert, H. Du, Y. Soufflet	Identifying the causes for the low decadal climate forecast skill over the North Pacific; (Citation) (More Information)	Journal of Geophysical Research
Hanlon H. M. , S. Morak, G. Hegerl	Detection and Prediction of mean and extreme European Summer temperatures with a CMIP5 multi-model ensemble; (Citation) (More Information)	Journal of Geophysical Research

Total Publications Count: 758

Journal	Count
	1
Acta Meteorologica Sinica	4
Advances in Atmospheric Sciences	15
Advances in Geosciences	2
Advances in Meteorology	14
Advances in Space Research	1
Aerosol Science and Technology	5
Agricultural Economics	1
Atmosphere	1

Statistics from Web of Science (2 Oct 2015)

Metrics (Infrastructure)

- Data in archive – 2-3pb
- Data transfer rates – download of whole archive every few months
- Published papers
- Number of modeling groups participating
  - 30 group, 63 models

Infrastructure Issues

- **Governance** of ESGF is occasionally an issue
- Database had a very **rough start** in CMIP5
  - Working better after a few months
  - Long downtime recently – security issues
- Mirroring - working?
  - I get emails saying that user can’t find our data
- **DOI’s** still an issue to be resolved (WIP whitepaper is proposing a way forward)

Infrastructure Science Metrics

- Common shared analysis tools (ESMval, PCMDI metrics, etc…)
  - Pros – a GREAT idea!
    - Standardize first looks at models
    - Improve models by looking at more metrics
    - Working towards understanding what matters for a given model's response to forcing changes
      - How to determine which model gives a better/more reliable projection?
  - Cons/Issues
    - Portability across a wide range of platforms
    - Maintenance (who is responsible for upgrades/ports?)

Science Gaps

- Radiative Forcing and response
  - Definitions
  - ECS estimates
- Model Biases
  - Double ITCZ etc
- Future changes:
  - Climate variability
  - Model response
  - Uncertainty in scenarios

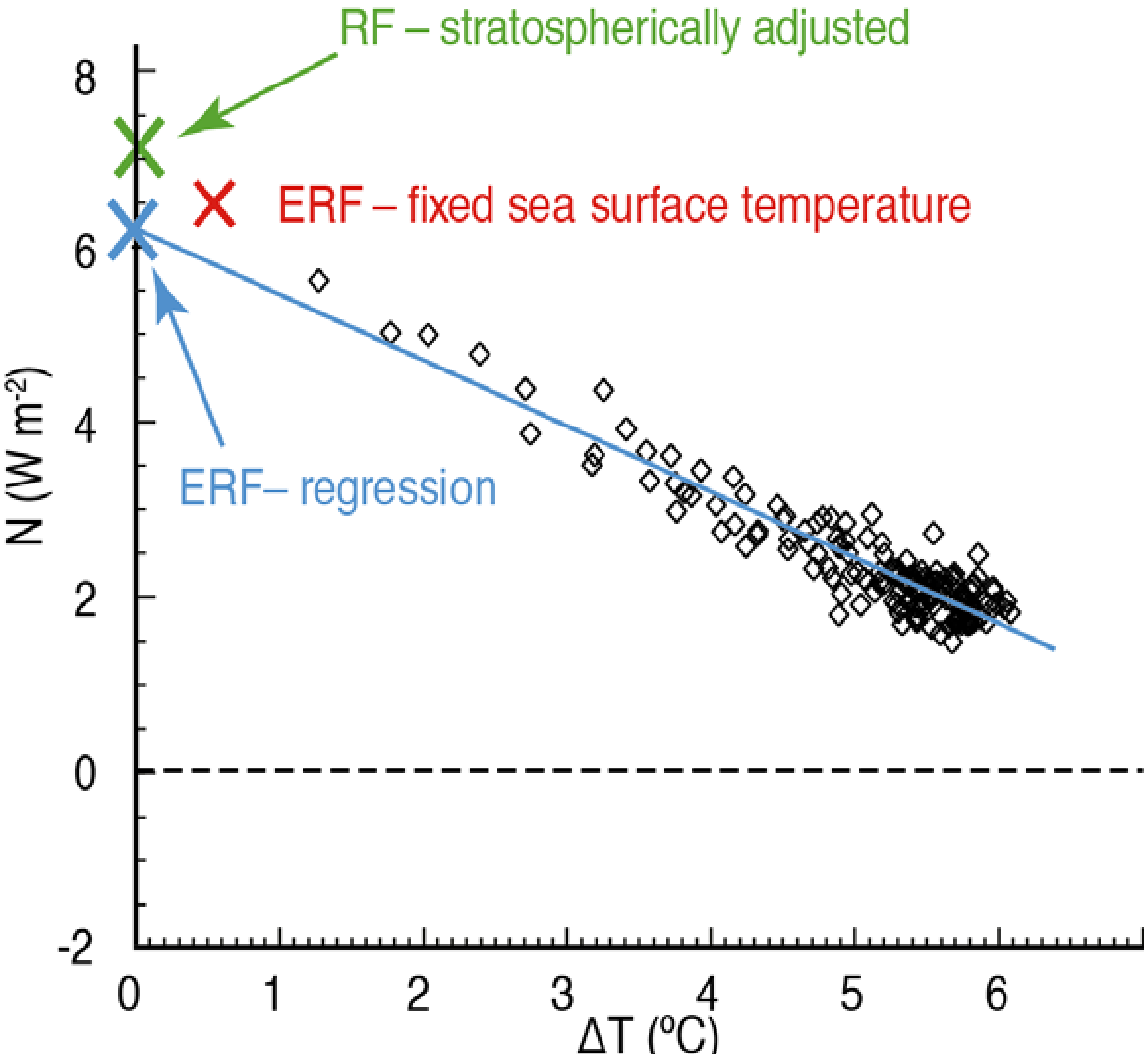
Radiative Forcing and Response

- Classical definitions (Hansen et al. 1981, Manabe and Wetherald 1988)
  - Forcing = flux changes due to change in atm chem, solar, volcanoes, aerosols
  - Response = climate changes resulting from forcing changes – fast and slow
  - Feedbacks = processes that damp or amplify the response

Radiative Forcing and Response

- AR5 developed new variables/definitions
  - Due to experimental design and newer models
  - Effective Radiative Forcing (ERF)
    - Allows *small* time for feedbacks
    - Therefore includes some response. These responses may not be **small**.

Gregory plot from AR5



- Switch-on run
- Each point is a annual average
- Possibility of multiple time scales (Winton et al. papers)

N == net radiation at the top
T == global mean surface air temp

GFDL ECS – TCR Estimates

Model	SST regression	ECS	TCR	atm-slab	ESM
GFDL ESM2G	3.1	2.4	1.1	3.5	3.5e
GFDL ESM2M	3.4	2.4	1.3	3.5	3.5e

Notes:

- ESMs run for ~5000 model years
- For 4XCO2 increase, the atm-slab value is 6.6C. The ESM values are 6.5C.
- ESM2M and ESM2G responses are remarkably similar at global scales throughout the atmosphere-ocean system.

Adjustments - Feedbacks

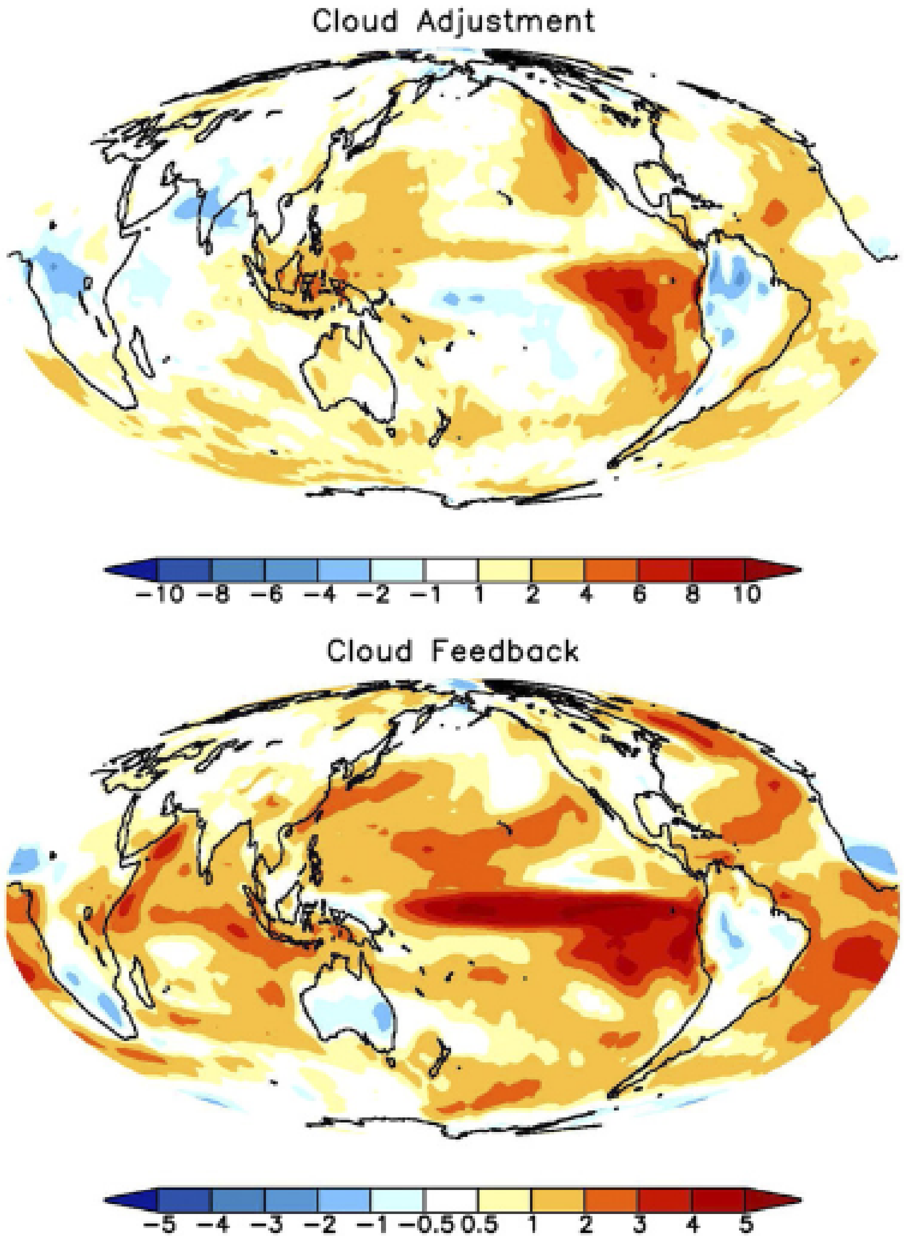


FIG. 11. Spatial pattern of the intermodel regression of the local values against the global mean: (top) cloud adjustment and (bottom) cloud feedback. The units are dimensionless, and the color scale for the adjustments is specifically twice that of the feedback.

Pattern of adjustments similar to pattern of feedback

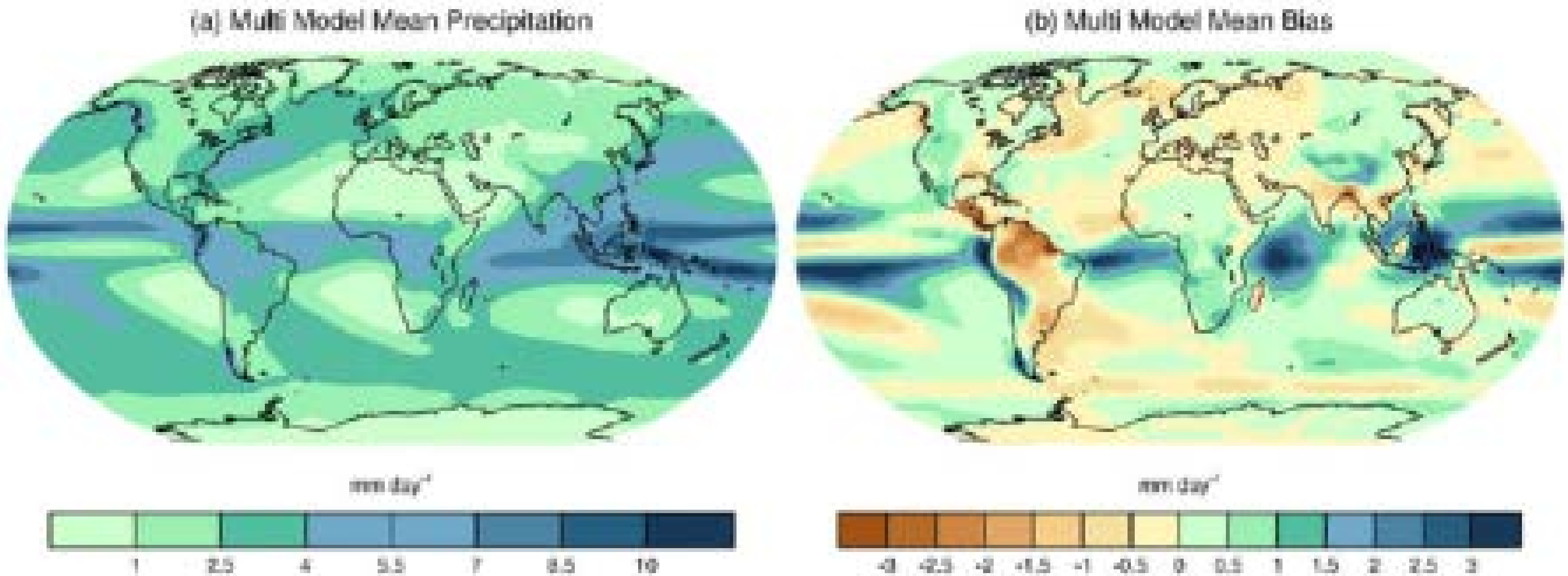
Fast responses in adjustments

From Chung and Soden 2015

Possible Solutions

- Multiple radiation runs during model integrations changing only 1 forcer at a time
  - Pro – classical forcing definition (see M&W 1988)
  - Con – Expensive (people and cpu), limited periods?
- RFMIP and AerChemMIP both are addressing this issue

Long Standing Model Biases

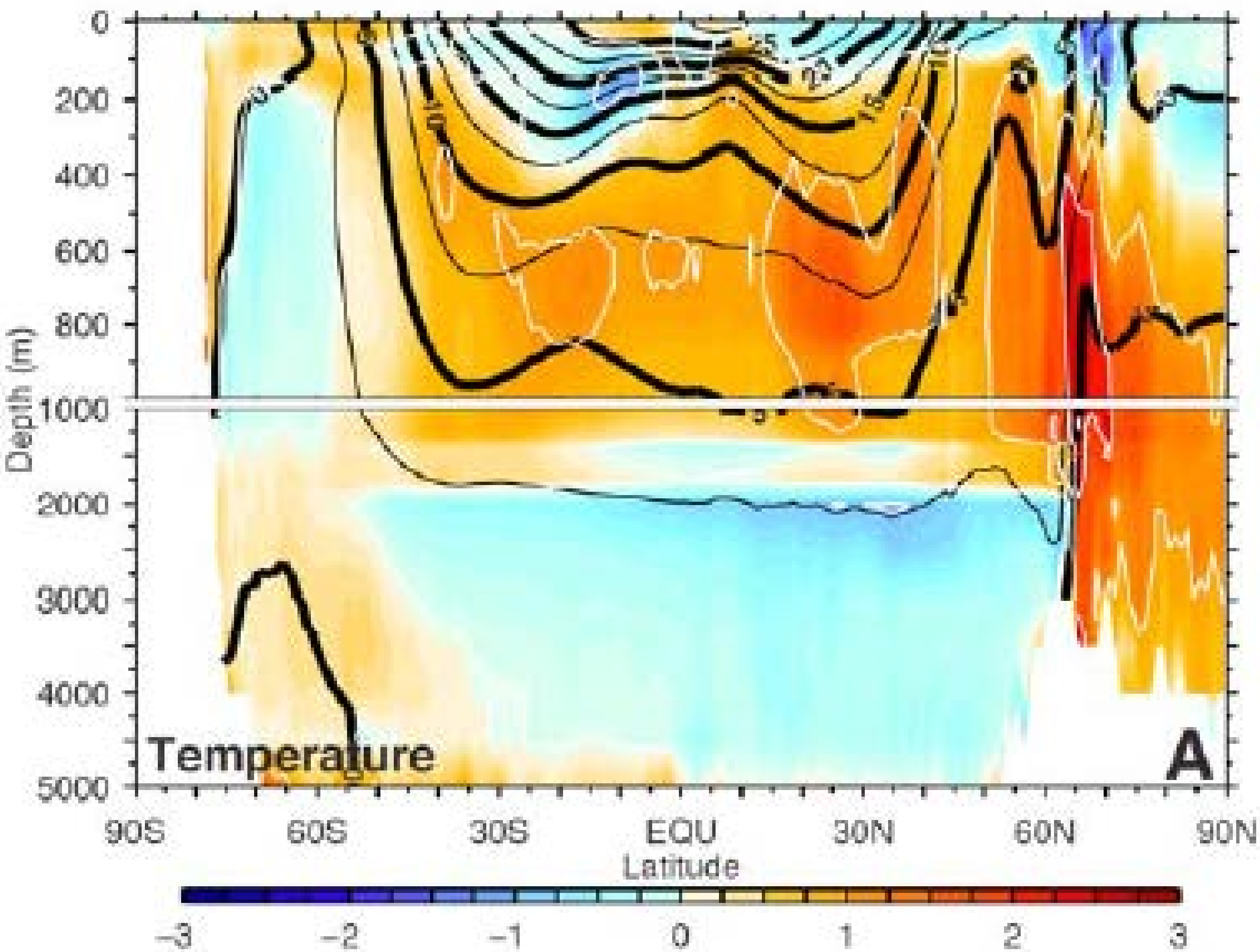


Double ITCZ

Related to dry Amazon and carbon issues?

Chapter 9, AR5

Long Standing Model Biases



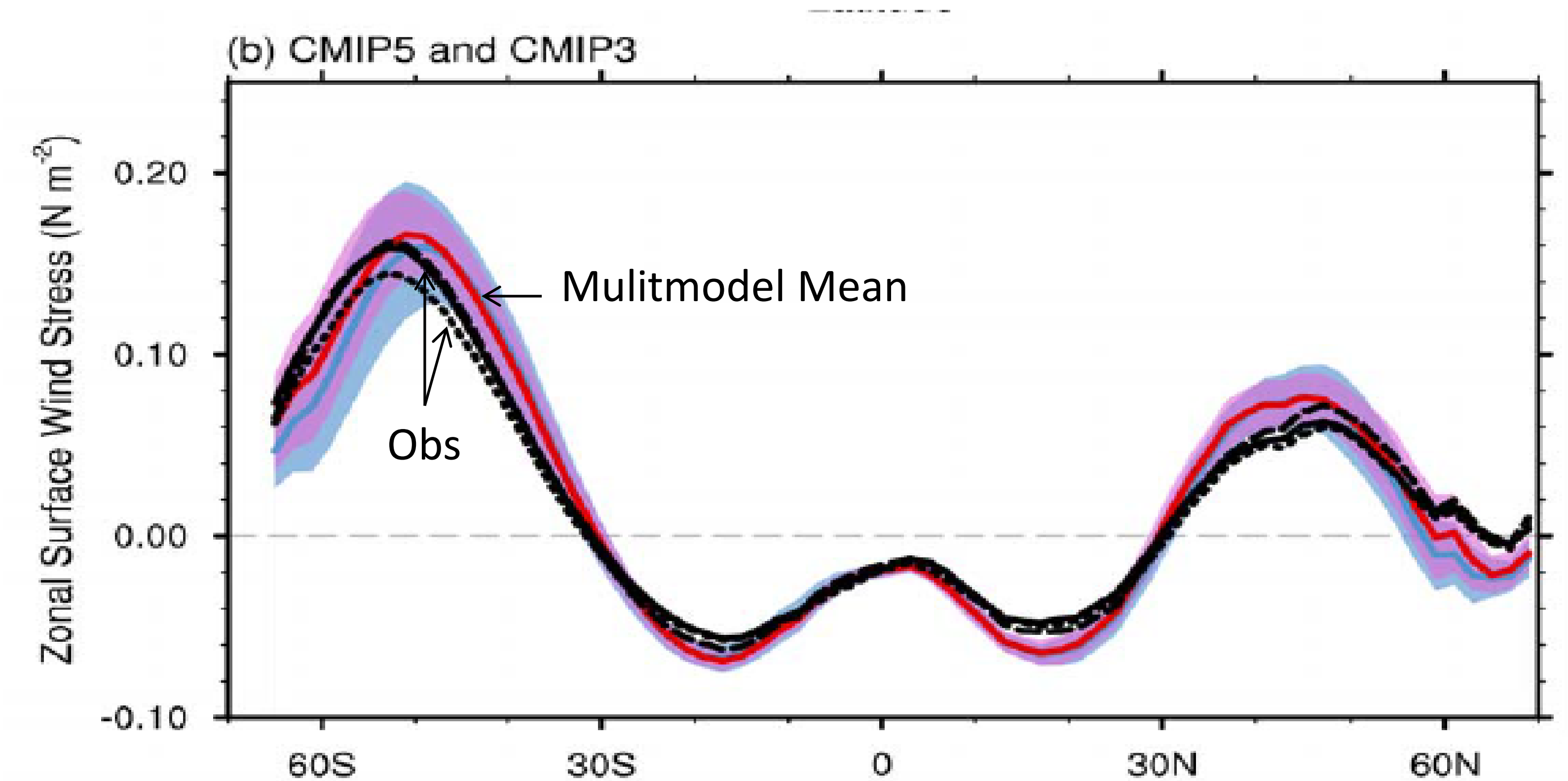
Model Bias °C

Chapter 9, AR5

Too warm, too depth tropical thermocline

Impacts oceanic heat uptake

Long Standing Model Biases



SH atmospheric jet located too far north

Impacts Southern Ocean heat and carbon uptake

Chapter 9, AR5

Long Standing Model Biases

- Use of Common metrics
  - Easier to see common model errors
  - Should lead to more rapid solutions
  - Word of caution – Many of these errors have been around for a long time and will be hard to fix.

Future Changes: *Variability*

- S/N ratios – Define "N"
- Noise estimates important for detection/attribution studies
- Leads to a certain amount of irreducible uncertainty in projections
- Predicting the "noise" part of decadal prediction

Future Changes: *Future Scenarios*

- Function of things outside of climate models
  - Population growth, technological growth, societal changes
- Uncertainty associated with the above
- Changes in method of interactions between scenario makers and climate modeler
  - CMIP5 first attempt
  - CMIP6 to improve ability to estimate cost and benefits of various scenarios

Future Changes: *Decadal Prediction*

- CMIP5 first attempt at a decadal prediction MIP
  - Trying to predict the “noise” and forcing signal
  - Some success at extending skill beyond 1 year
  - Most success found -
    - Over oceanic areas
    - Temperature more than other variables
  - Needs for better experimental design (happening for CMIP6) and development of standard methods for bias correction

Summary

- CMIP5 continued and expanded on earlier CMIP successes
- CMIP unique in the sciences
- Technological challenges to make large volumes of data available are being addressed and solved
- Science Gaps in CMIP5 being addressed in CMIP6