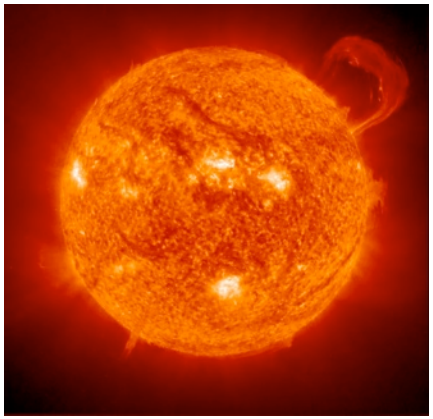
National Aeronautics and Space Administration
Goddard Institute for Space Studies

Goddard Space Flight Center
Sciences and Exploration Directorate
Earth Sciences Division

CLIVAR DecVar Nov 2015

Forced aspects of decadal predictability



Gavin A. Schmidt

NASA Goddard Institute of Space Studies, NY

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Sources of decadal predictability

- Long term trends
  - Ongoing response to anthropogenic forcing (>10 yrs)
- Short term response to variable forcings
  - Volcanic eruptions (Pinatubo, El Chichon etc.) (<4 yrs)
  - Solar cycle variability (~ 11yr)
  - Aerosols?
  - Problem: can these be predicted?
- Ocean mode initialization
  - ENSO related (good skill 6 mon/1yr)
  - Theoretically some skill to ~10 yrs(?) via AMOC/PDO
  - Technology maturing but not much demonstrated skill

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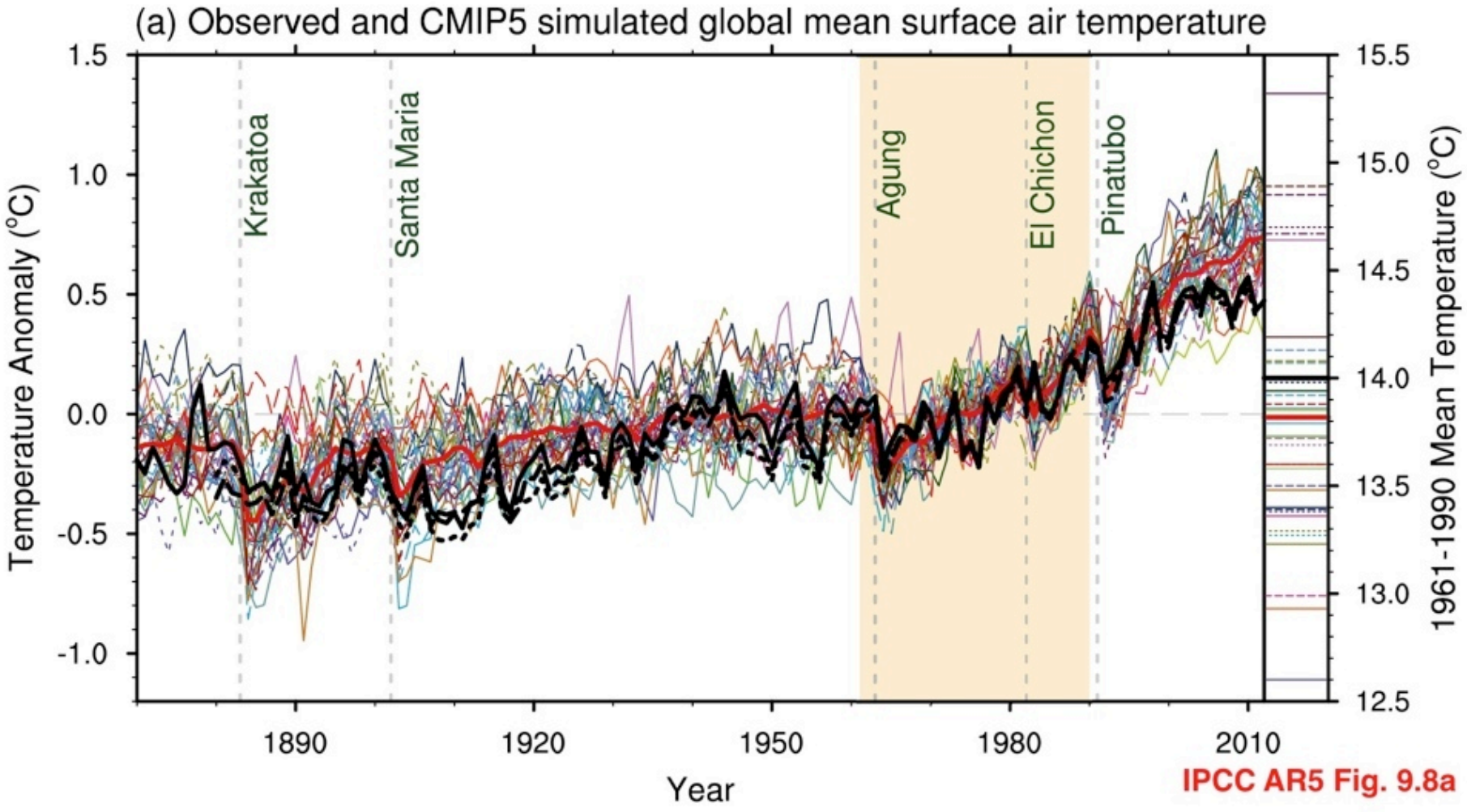
Recent multi-model ensemble divergence from observations?



Reasons for divergence?

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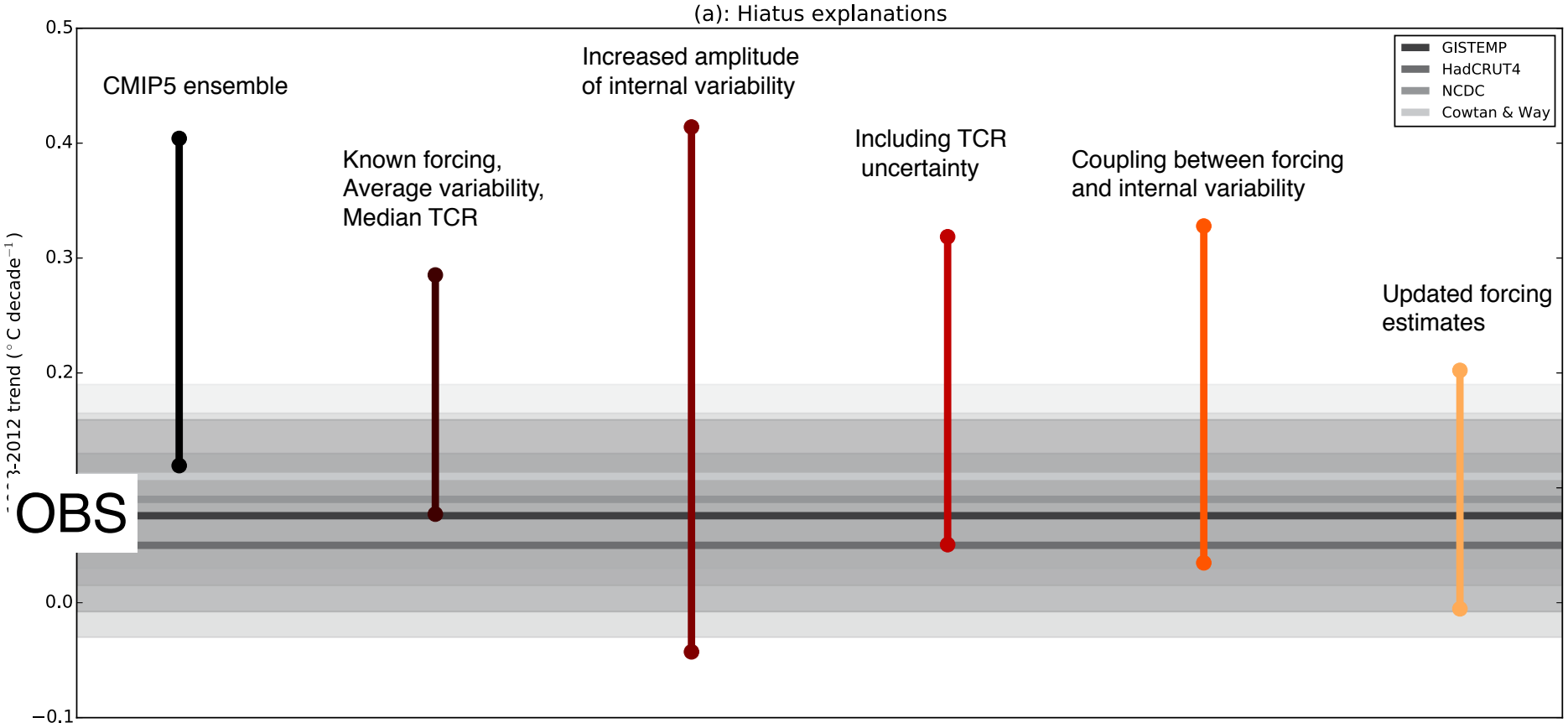

Range of 1998-2012 trends

Marvel et al (2015)

Hindcasts require the forcing history

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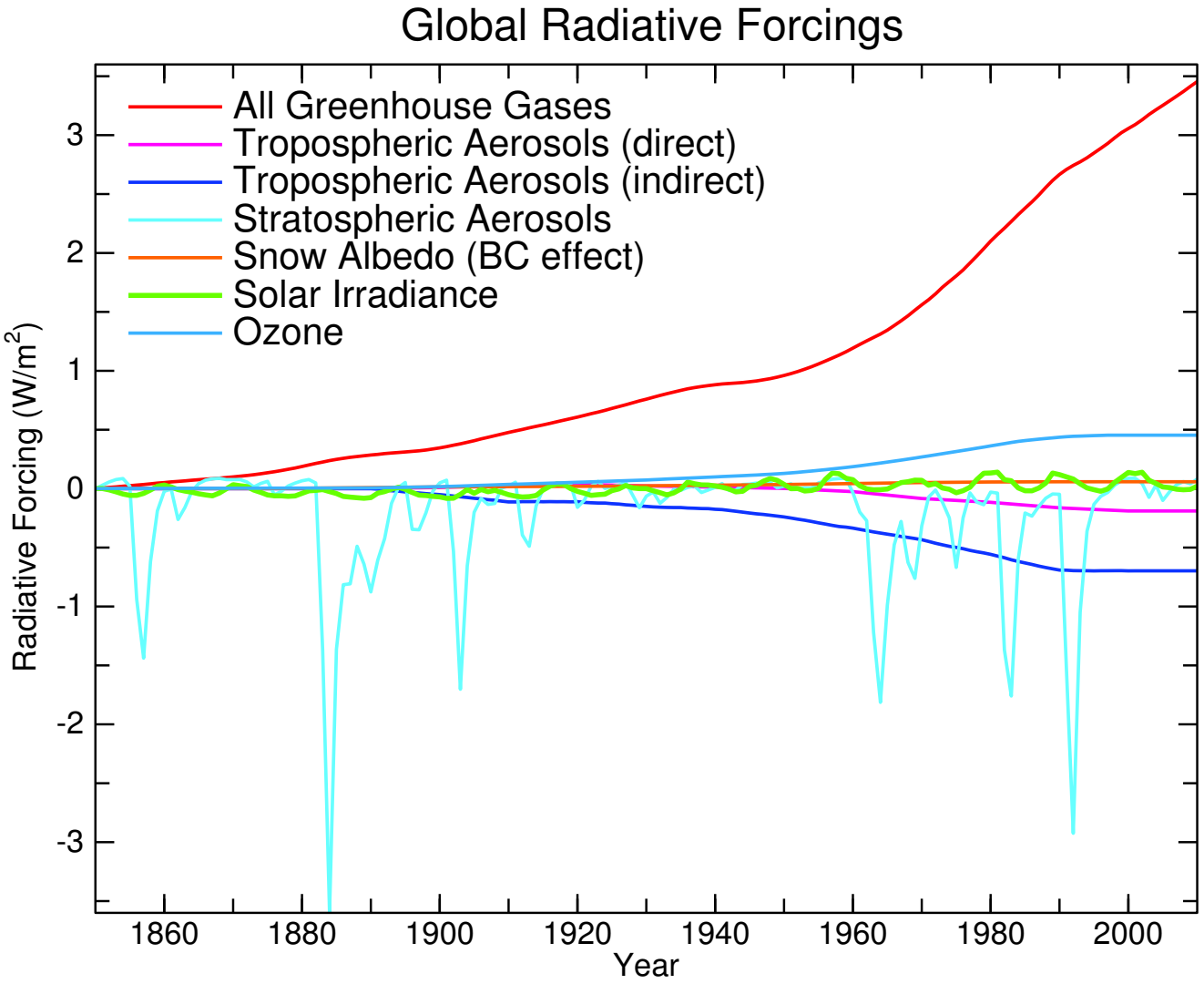

Historical simulations (1850–2012) with GISS ModelE2

Miller et al (2014)

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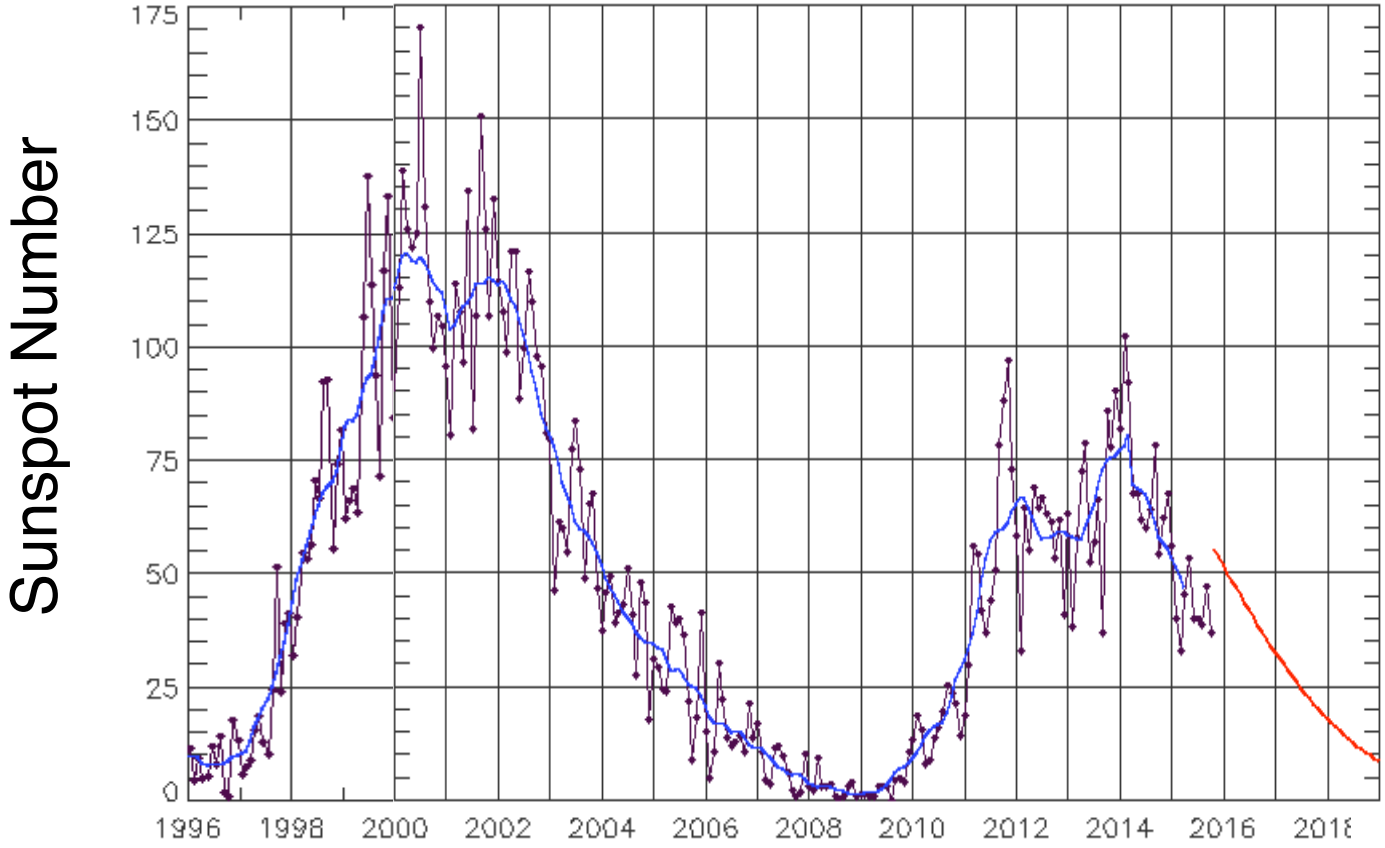
Solar cycle predictions?



Updates to CMIP5 forcings

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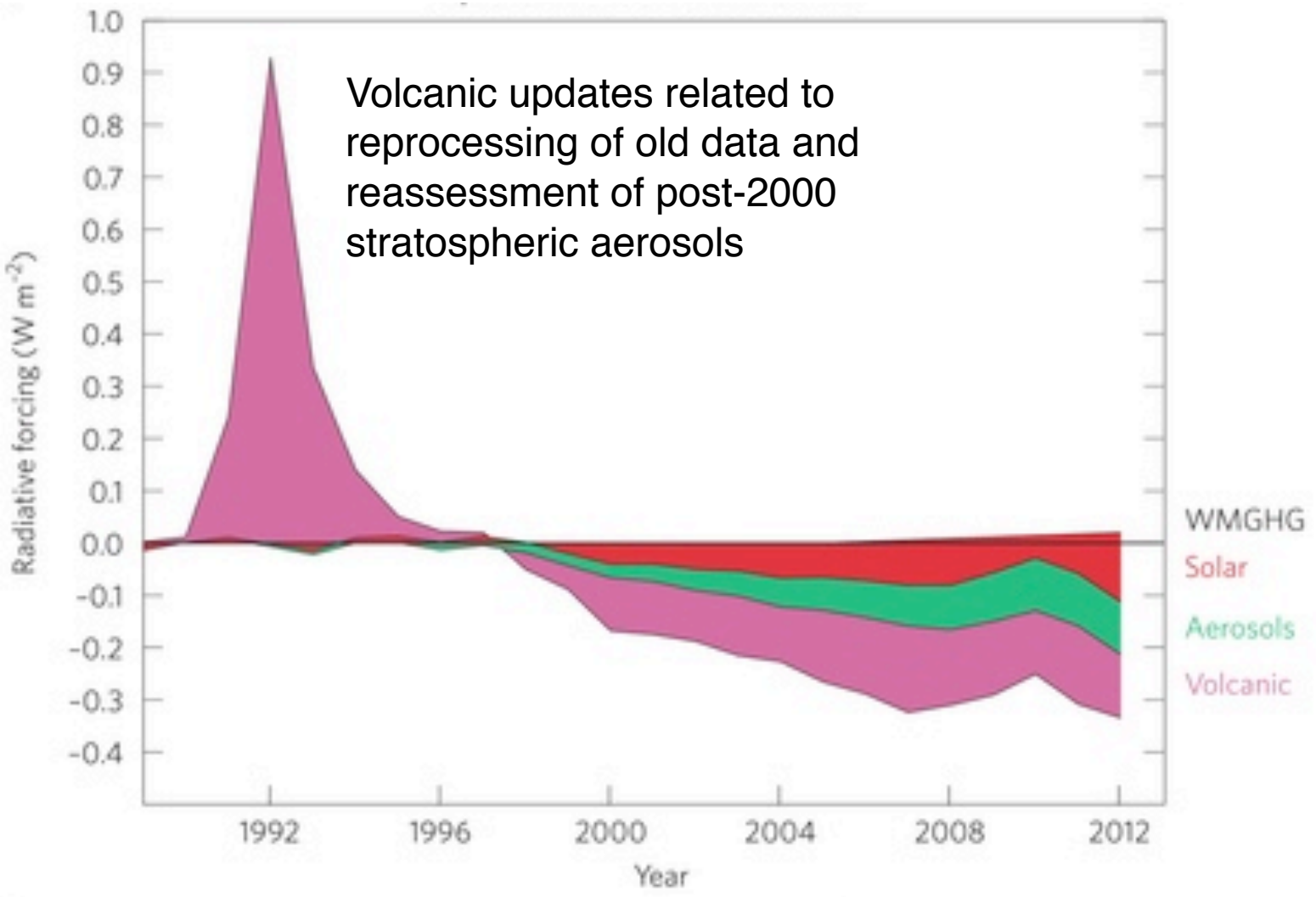

Schmidt et al (2014)

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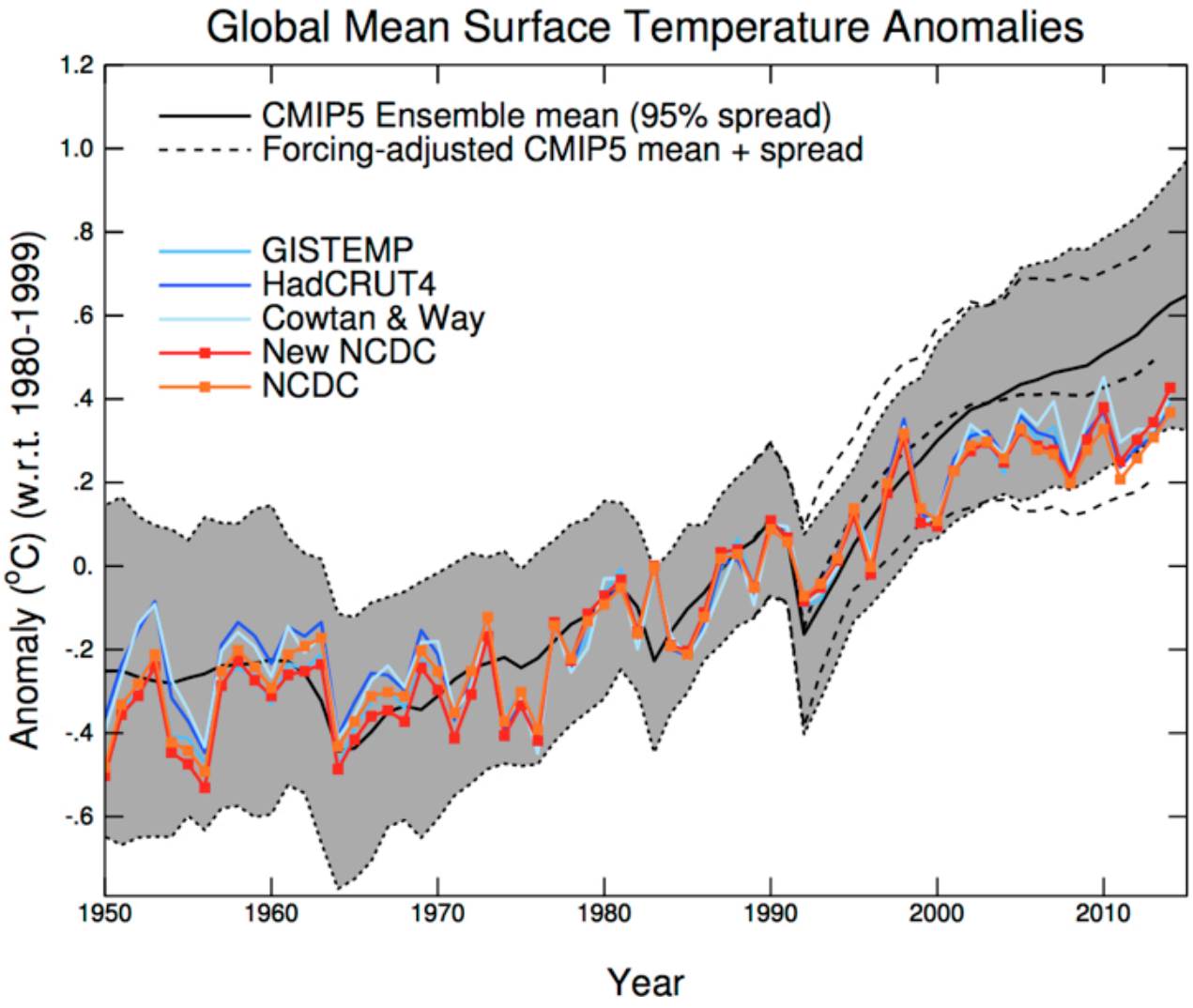
Post 1950 - w/estimated response to updates



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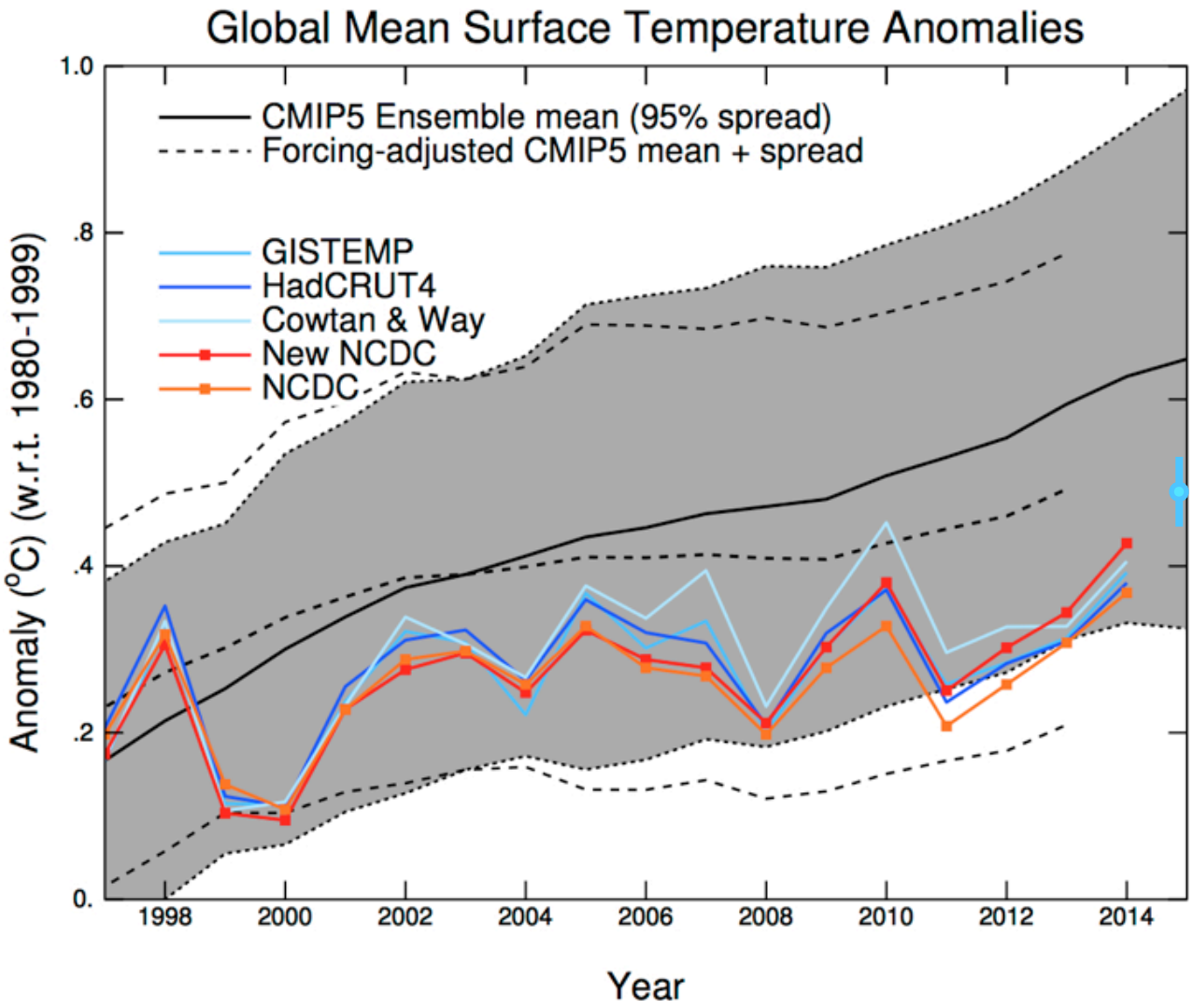
Post 1997...



Estimated 2015

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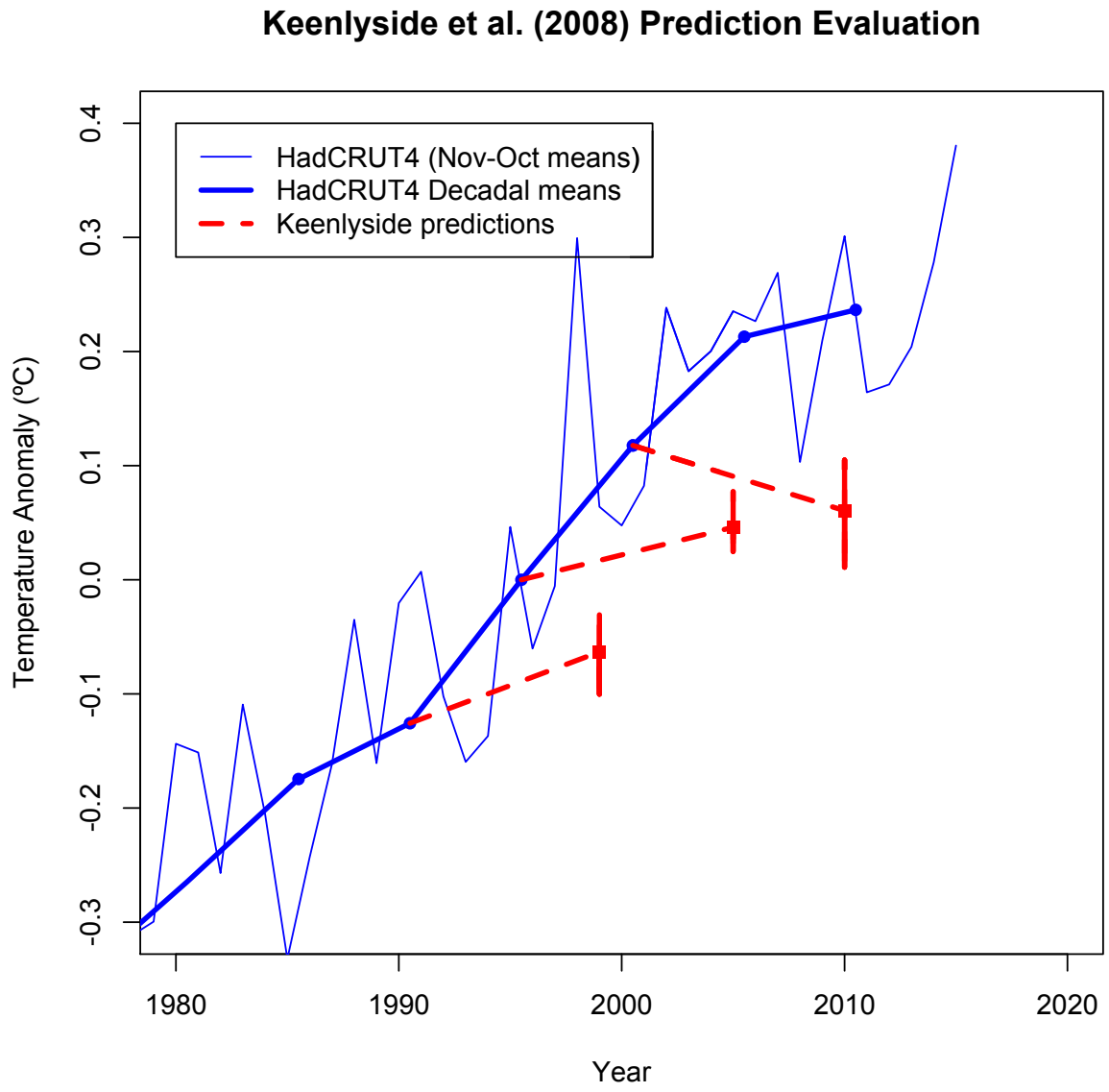
Evaluation of prior decadal predictions



Spatial patterns

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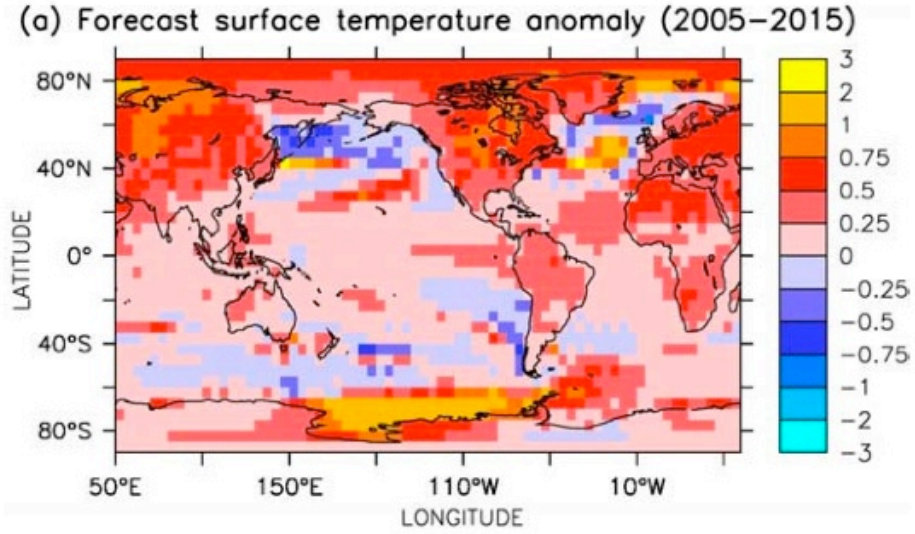
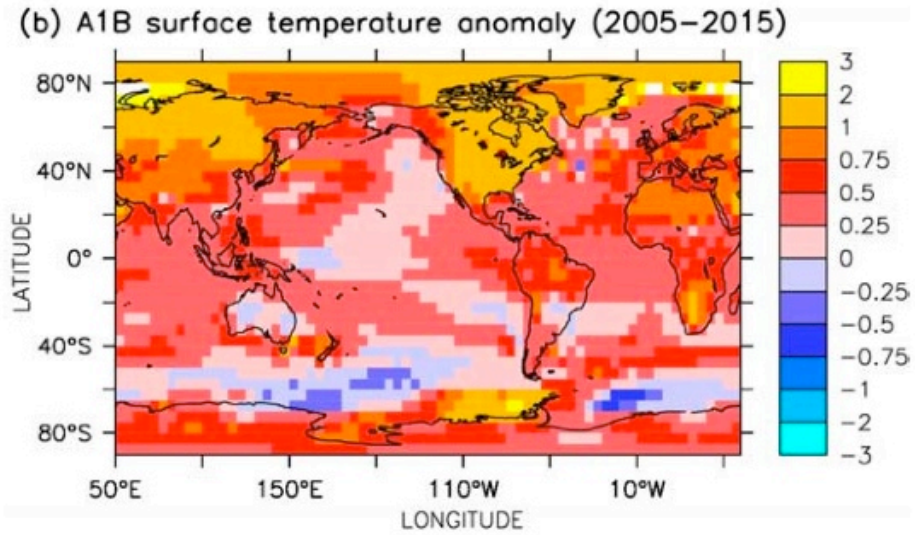
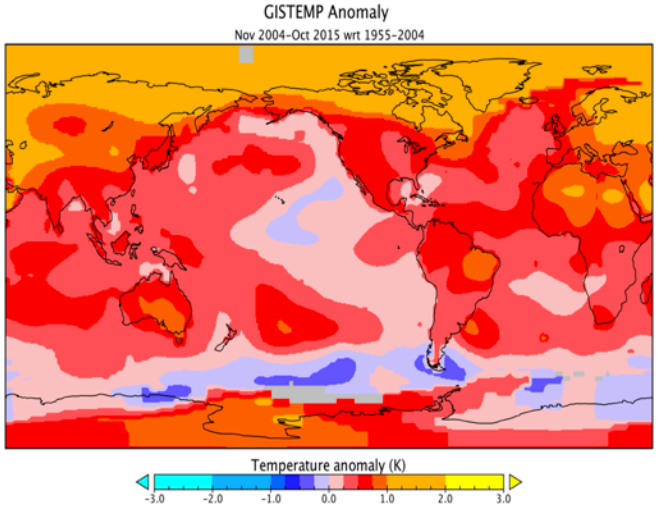




GISTEMP Anomaly (2005-2015)



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Can short-term forcing predictions improve things?

GHGs

Decadal variations around trend not important

Volcanoes

To be discussed in next talk

(But next time, let's not assume background ---> 0)

Solar

1) Needs better projections of solar activity

2) Needs full modeling effort for response:

Even without 1), we can still assess 2)...

Aerosols

Need better emission datasets (annual/seasonal)

Explicit acknowledgement of uncertainty

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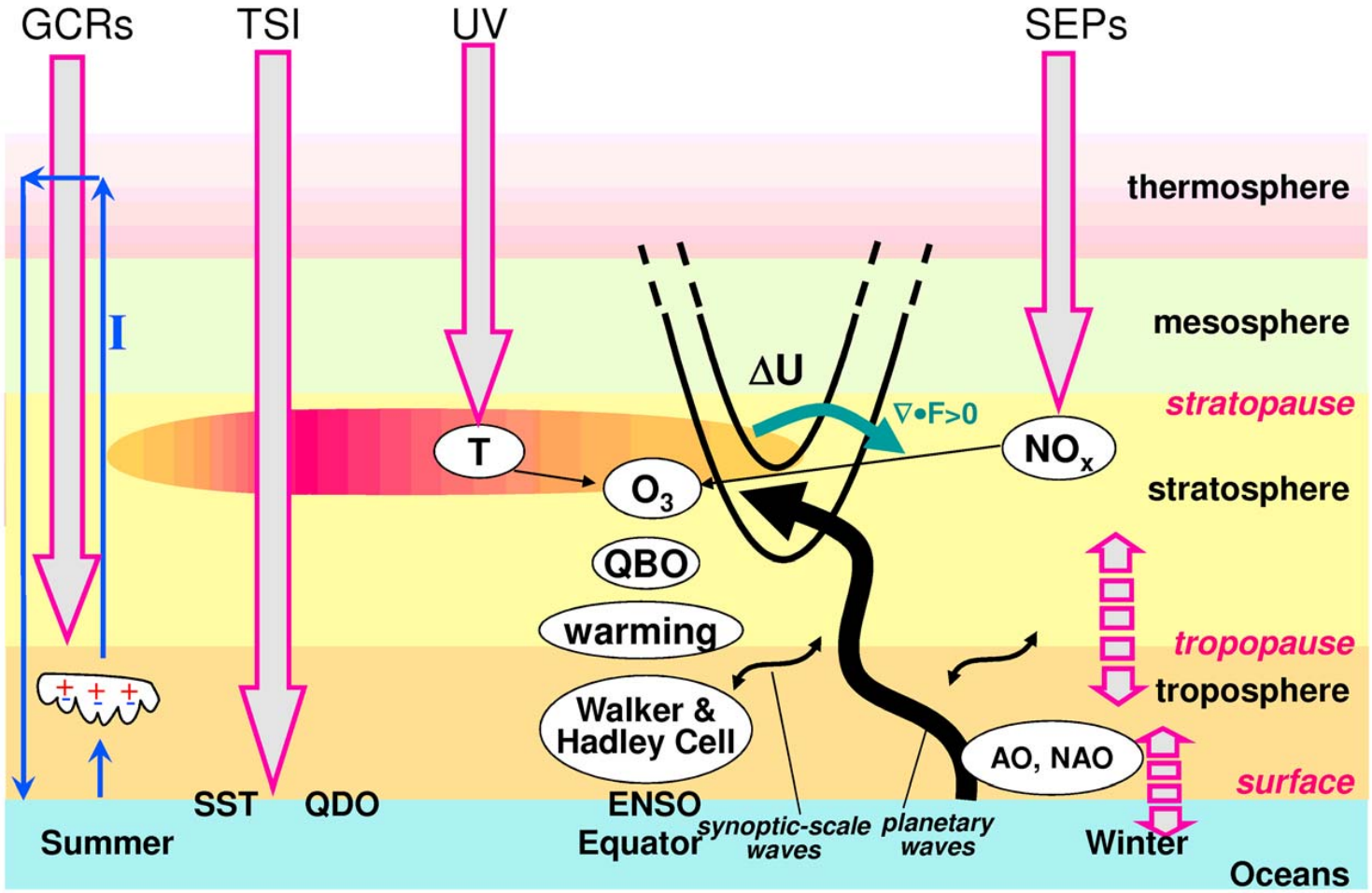
Solar mechanisms



Gray et al after K. Kodera

GISS modelling of solar impacts

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CMIP5: interactive, OAGCM 20th C transients

- **NINT**: non-interactive aerosols/chemistry (~AR4)
- **TCADI**: Interactive all-atmosphere chemistry (bulk aerosols) + first indirect effect
- 5 member ensembles
- two ocean models (**GISS-E2-R** & **GISS-E2-H**)
- All-forcings + solar-only + ozone response only

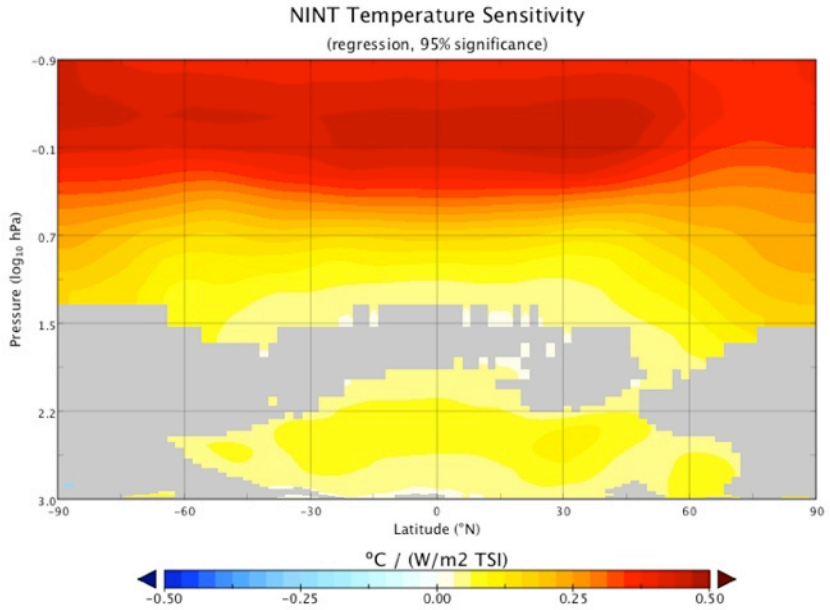
TCADI/MATRIX (aerosol moment scheme)

- Includes nucleation/ionisation

Forcing:

- 20th C: Spectral: Lean (2009) TSI: Wang et al. (2005)

Solar-only regressions



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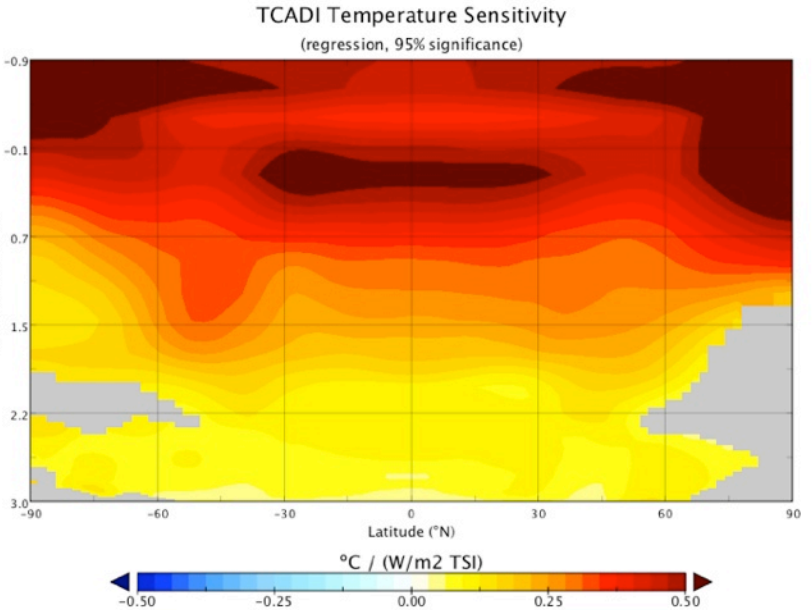

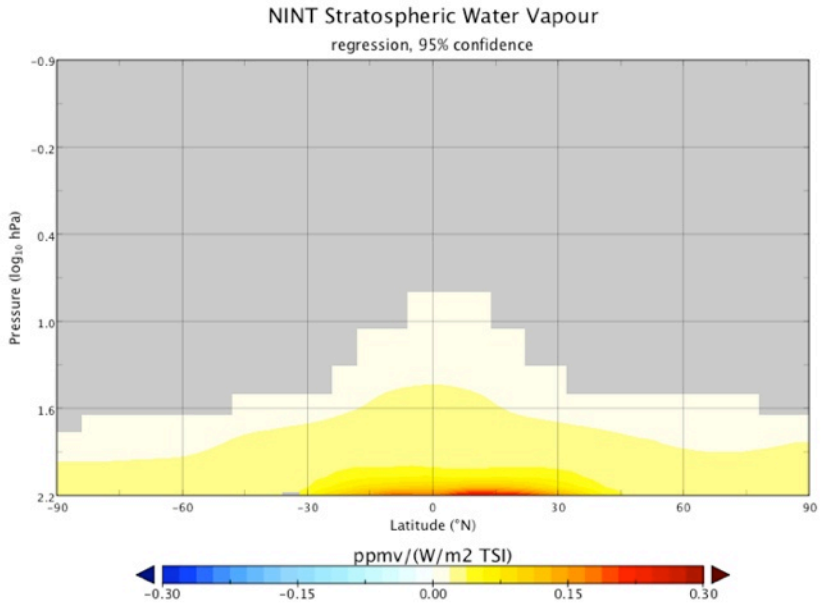

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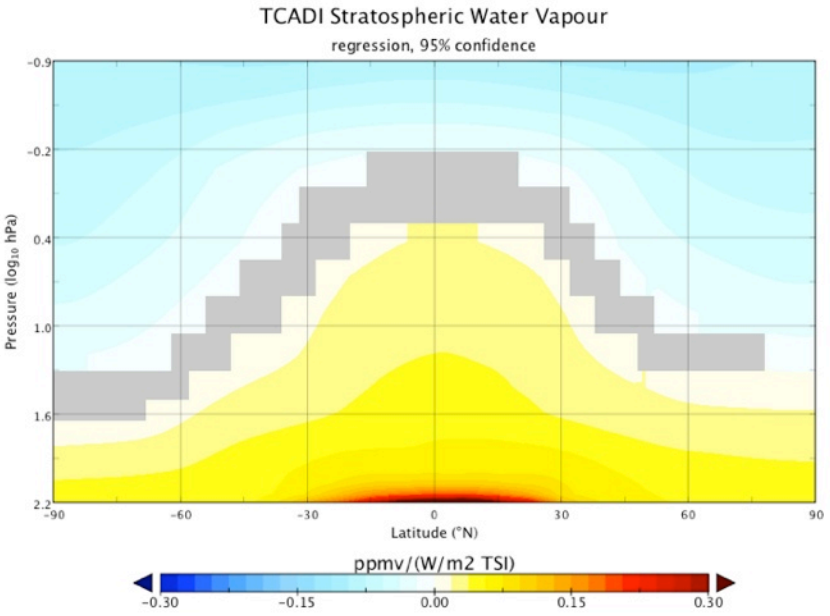

Ozone solar cycle response

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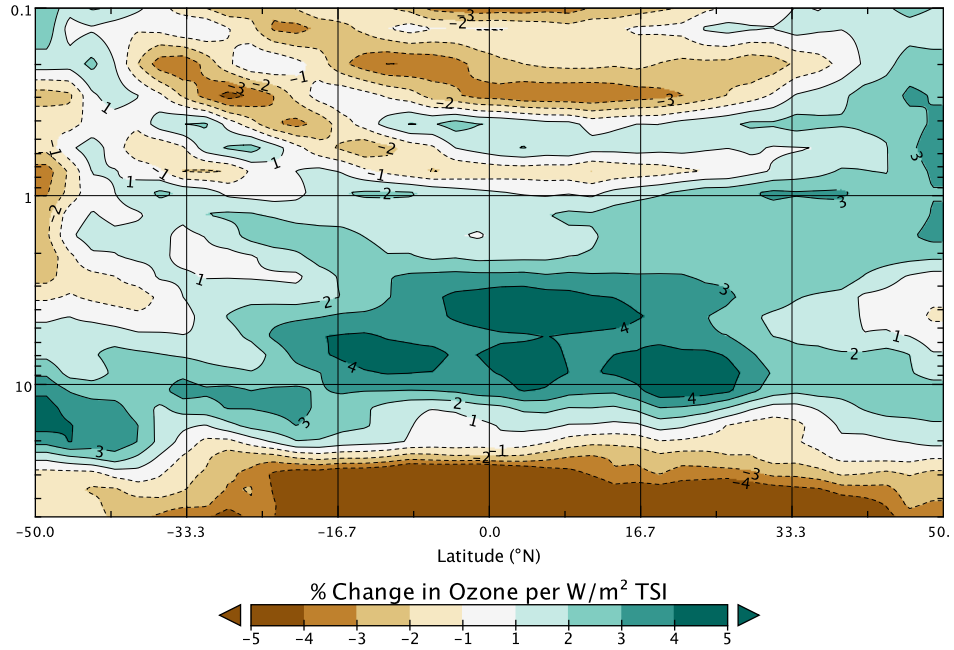
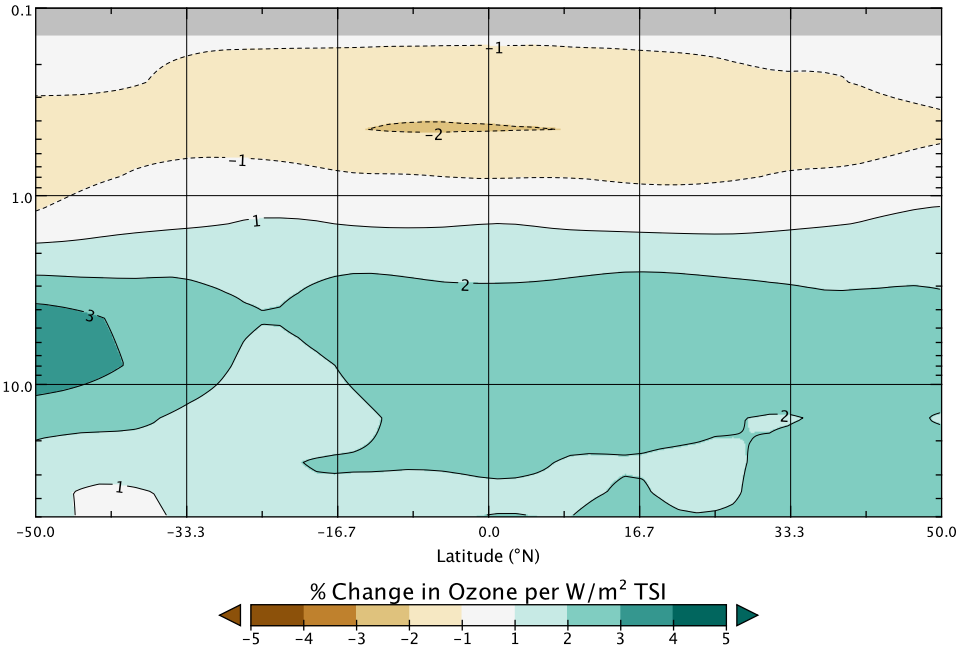
Ozone response to solar cycle (SABER)



Ozone response 2001–2002 to 2007–2008 (run d)



SABER: Merkel et al. (2011)
(One cycle: 2002/3 - 2008/9)

Model: single ensemble member
(2001/2 - 2007/8)

Chemistry impacts on CH_4 and H_2O

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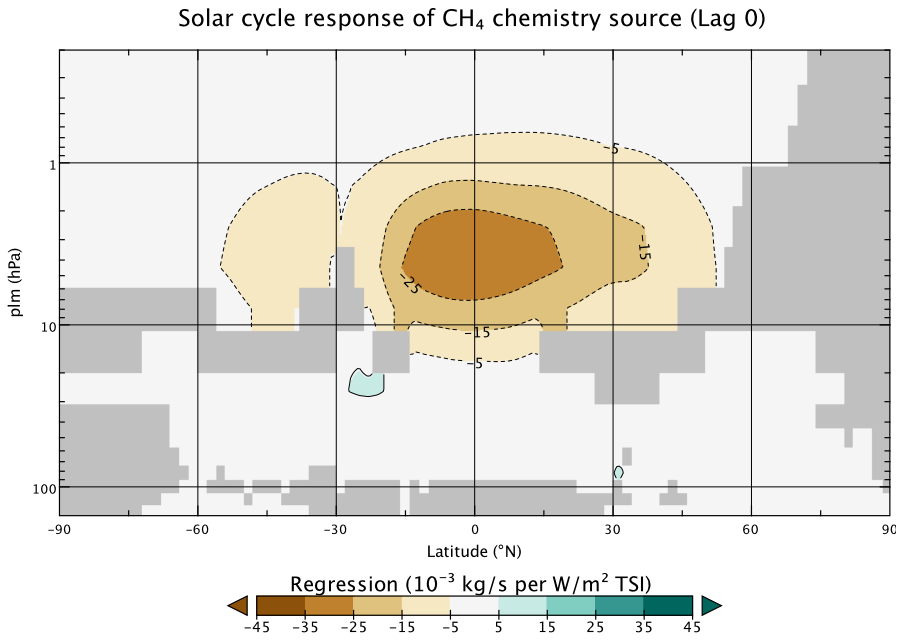

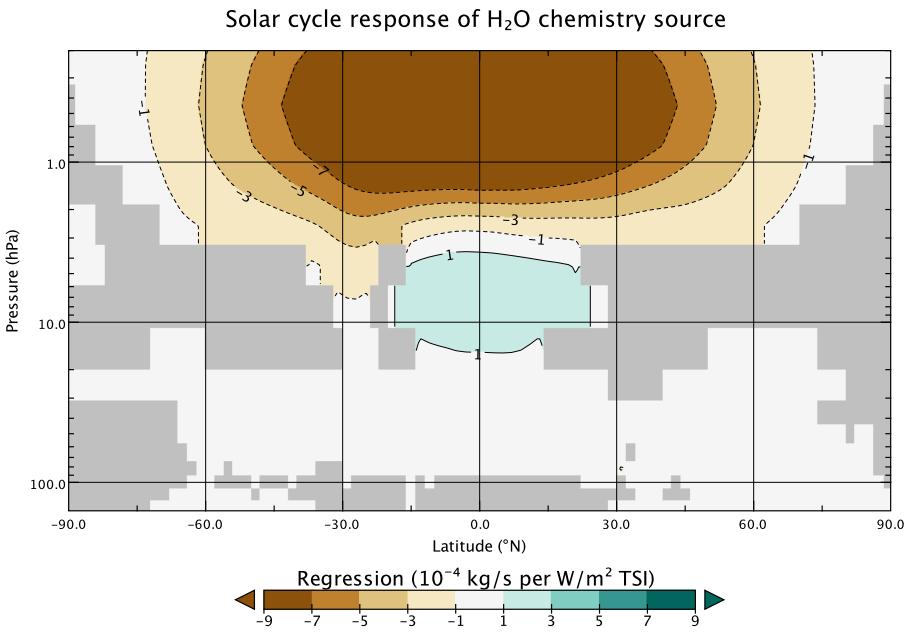

O_3 response photochemical and dynamic - strat & trop

=> increase of CH_4 oxidation

& photolytic reduction in upper strat H_2O (~0.2 ppmv)

=> warms upper stratosphere

=> provides memory for longer term impact...

Trop. warms, increases trop H_2O and strat input

Surface Air Temperature

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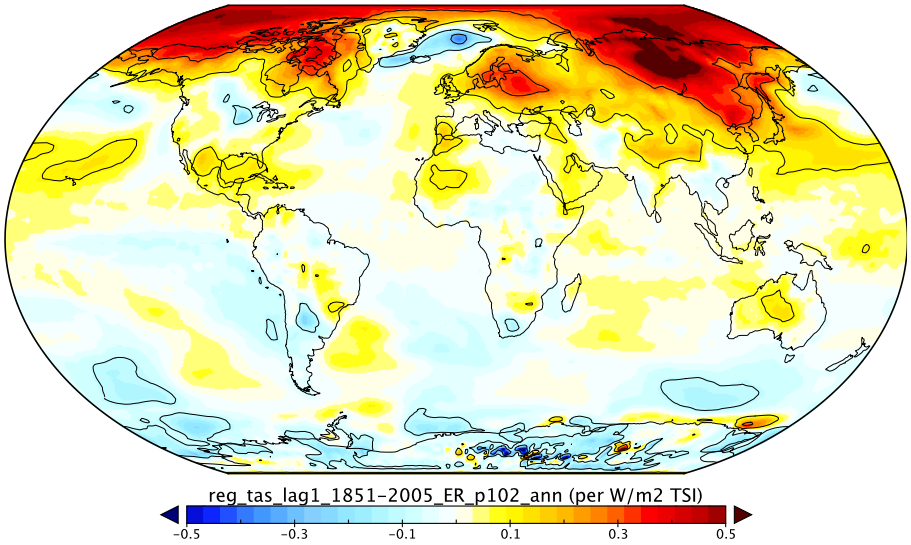
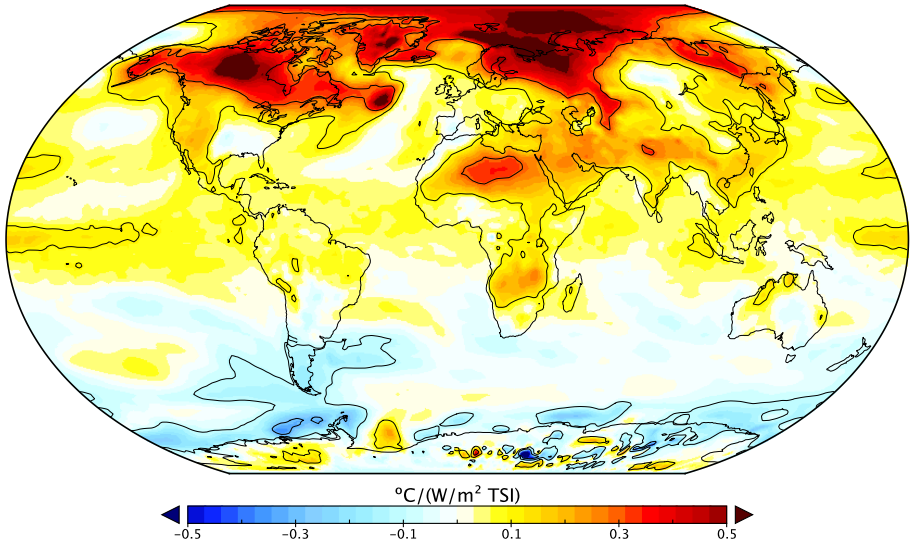
NINT-R: Lag 1



TCADI-R: Lag 1



Interactivity in GISS-E2R greatly increase tropical and Arctic response

Solar Max-Min: zonal SLP

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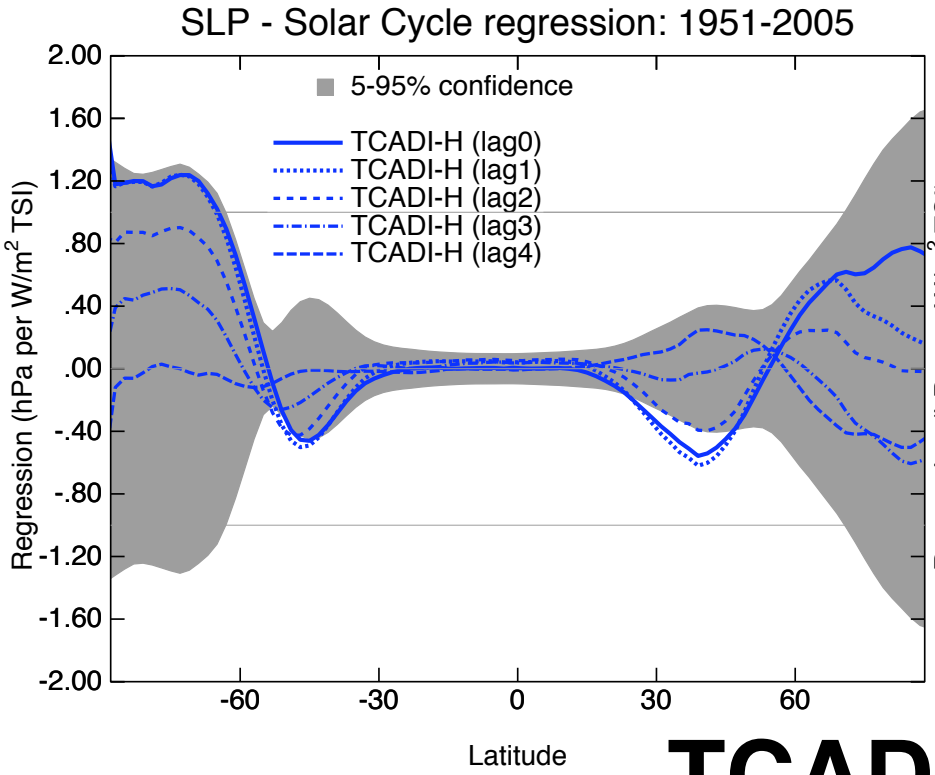

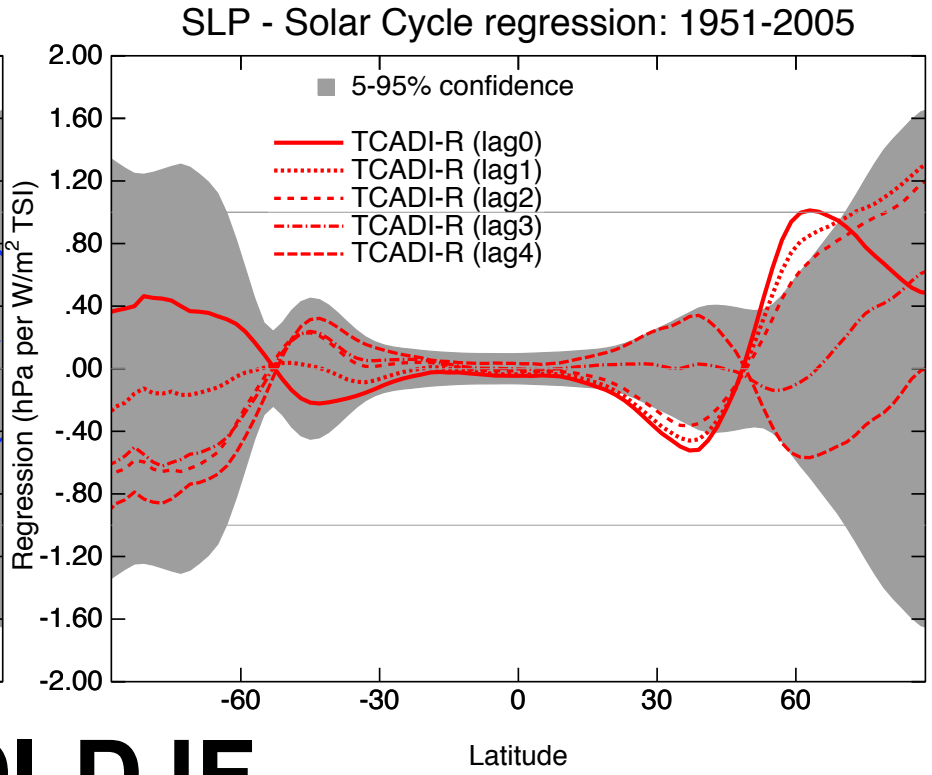

TCADI DJF

Interactive models have larger shifts in annular modes

Solar Max-Min: zonal SLP

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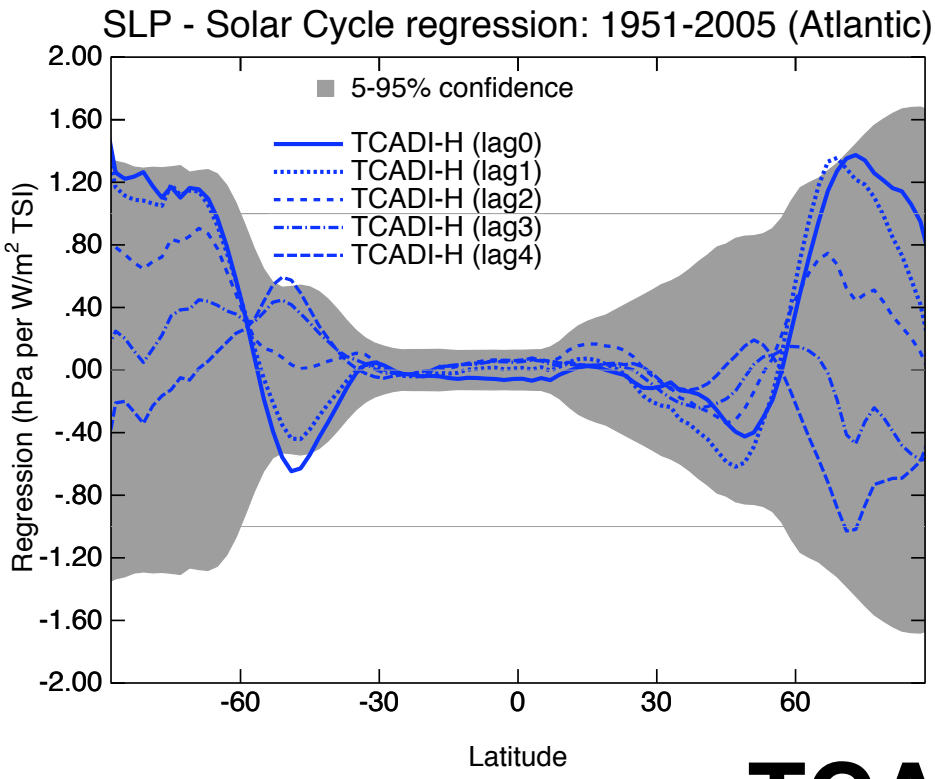

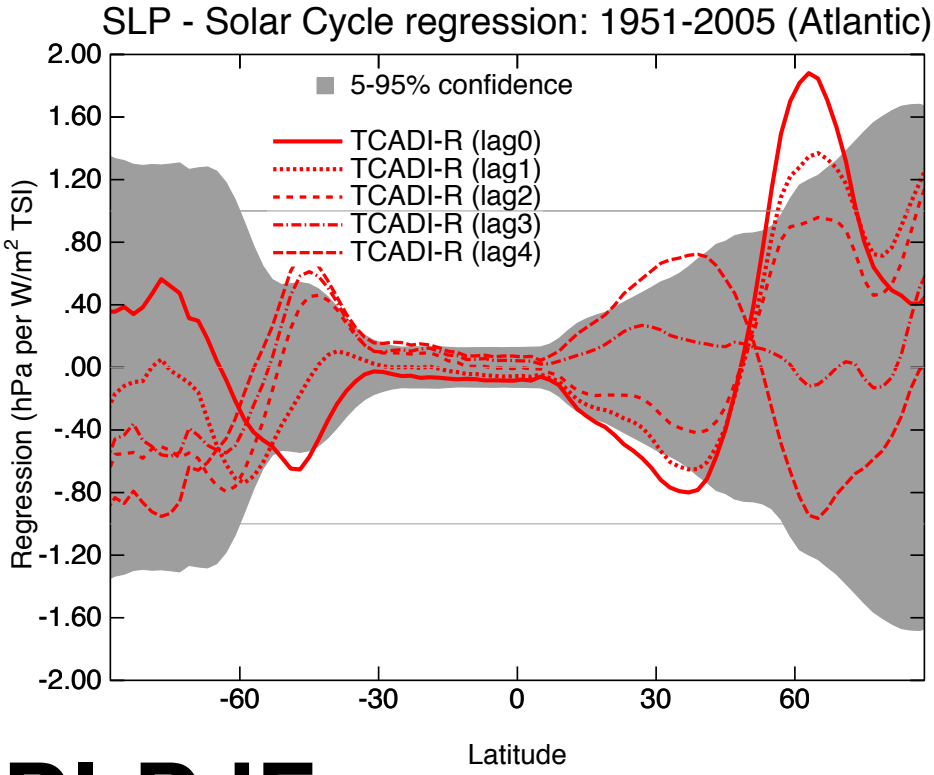

TCADI DJF

Particularly in the Atlantic...

Impact on North Atlantic Ocean?

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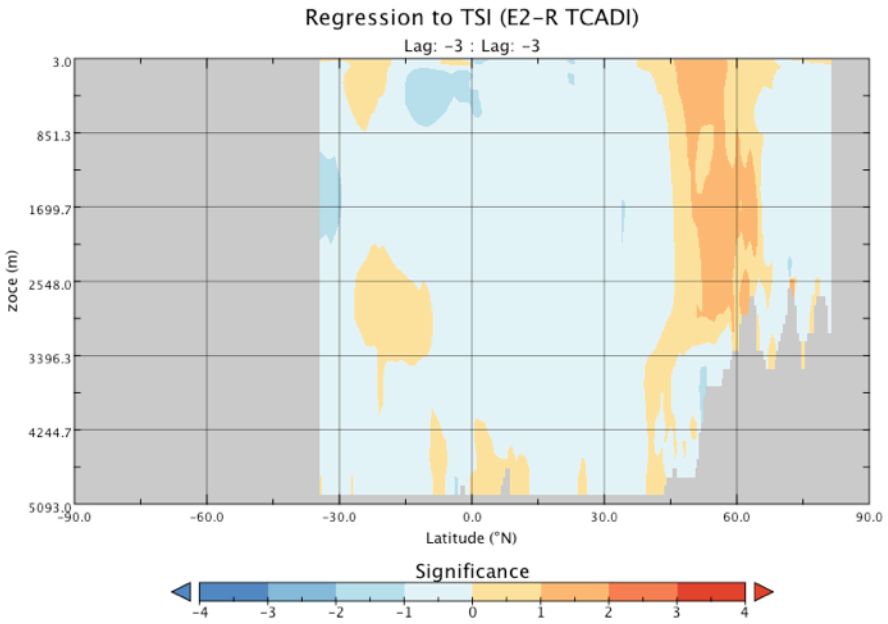
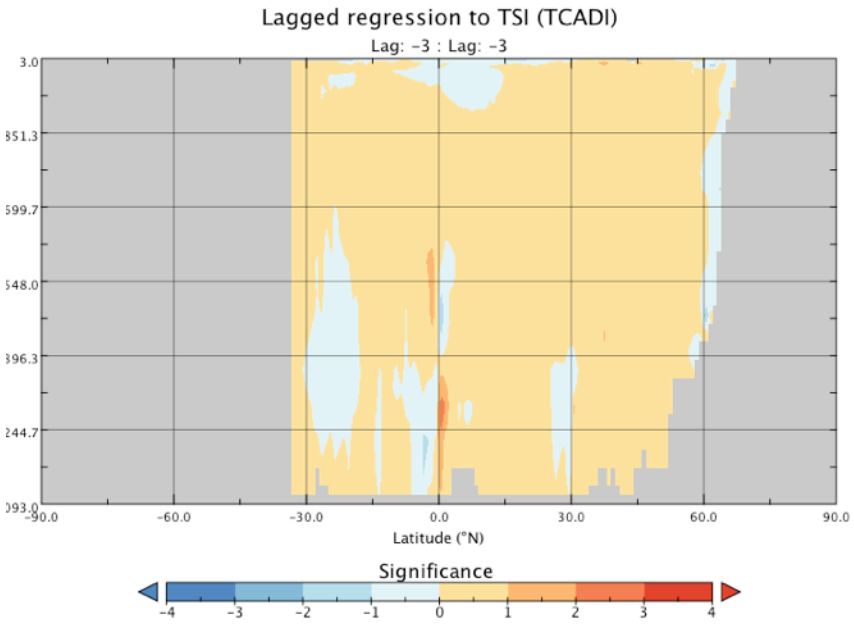
TCADI-R



TCADI-H



Lagged regression to TSI
± 0.5 Sv over a solar cycle
Max. +ve change 8-6 yr lag to TSI

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Conclusions

Forcing changes clearly influence decadal variability and can inform predictions

Ocean initialization experiments have some way to go

Uncertainty in future forcings is non-negligible and needs to be included in experimental design

Solar forcing has detectable influences on stratosphere, annular modes which may be predictable

Interactive composition important to include or parameterize

Evolution of North Atlantic coupled system depends on both top-down forcing and ocean responses.

Differing responses in coupled models impacted by variations in control/internal modes ocean variability.