

APS Climate Change Workshop

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What do you consider to be the greatest advances in understanding of the physical basis of climate change since AR4?

- Narrowing of uncertainty in the aerosol indirect effect

What do you consider to be the most important gaps in current understanding?

- Solar impacts on climate (including indirect effects)
- Multi-decadal natural internal variability
- Mechanisms of vertical heat transfer in the ocean
- Fast thermodynamic feedbacks (water vapor, clouds, lapse rate)

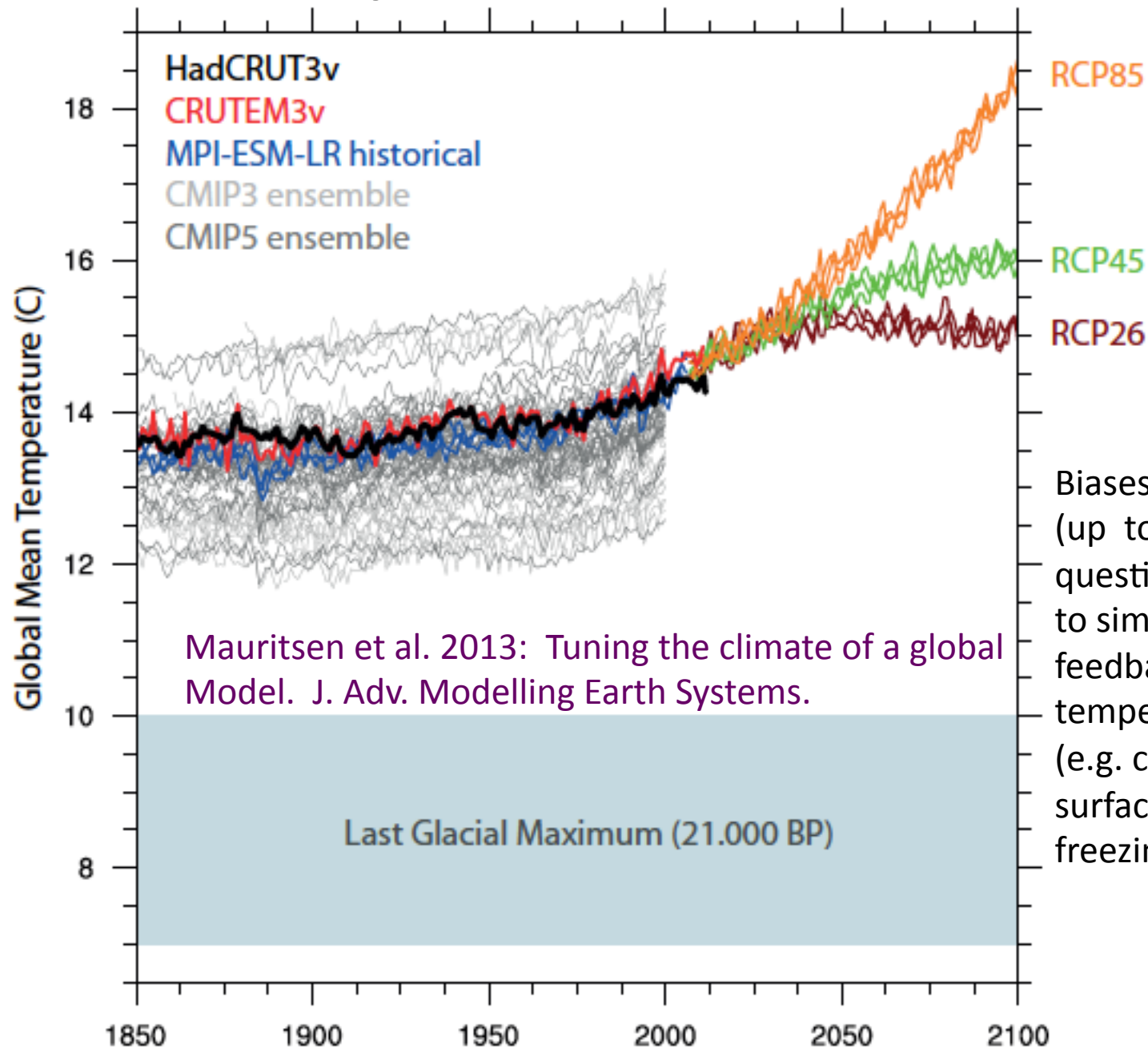
CLIMATE MODELS: How can one understand the IPCC's expressed confidence in identifying and projecting the effects of such small anthropogenic perturbations in view of such difficult circumstances?

Confidence in climate models derives from:

- Model relation to theory and physical understanding of processes
- Convergence of different climate models and agreement of successive generations of climate models
- Verification history of numerical weather prediction models
- Success in simulating observed global temperature anomaly trend during 1975-2000.

Curry and Webster 2011: Climate science and the uncertainty monster. *Bull Amer Meteorol. Soc.*, 92, 1667-1682.

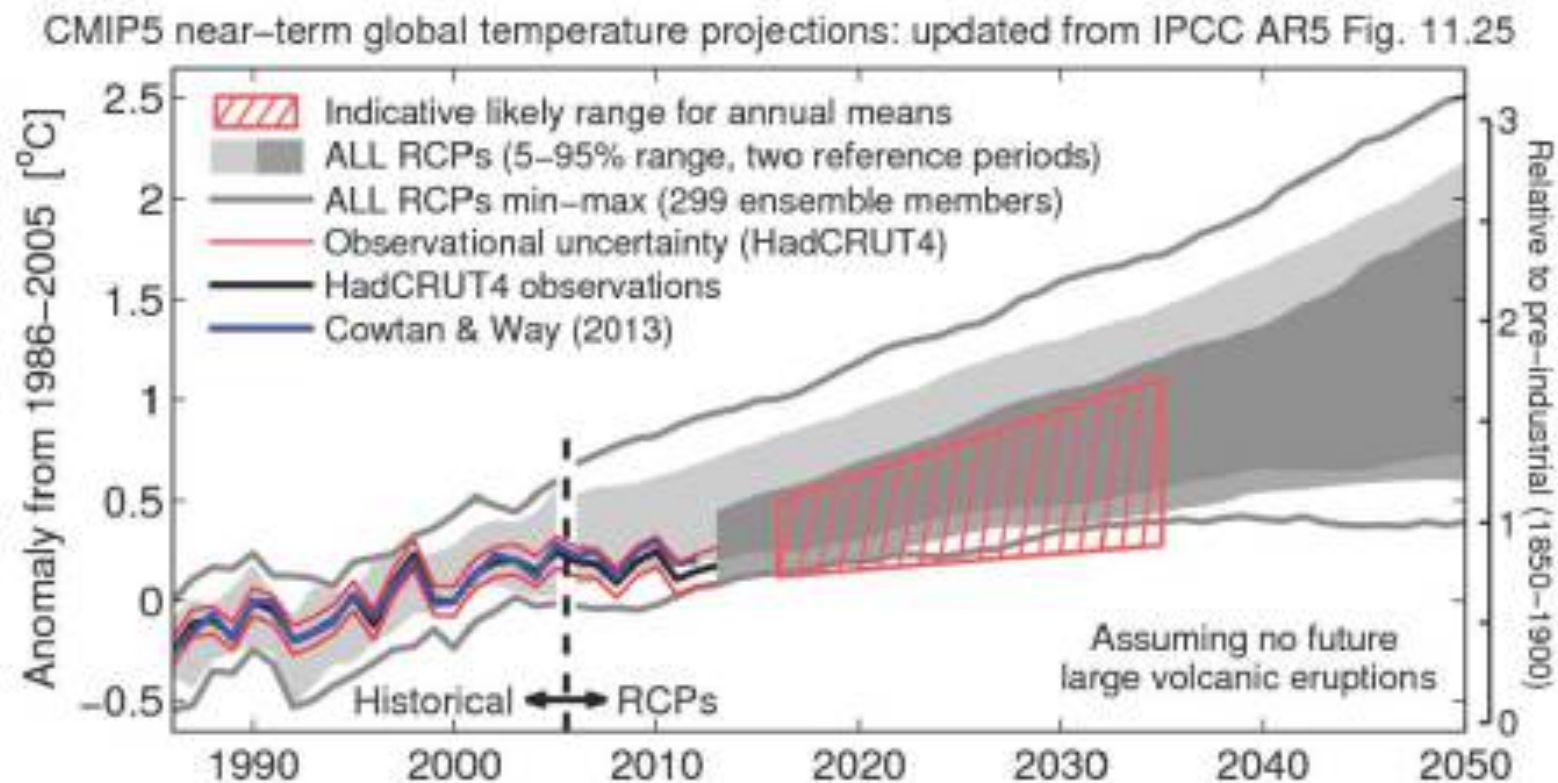
Absolute temperatures from climate model simulations



Biases in modeled climate (up to 2°C) raise serious questions about the ability to simulate processes and feedbacks that are temperature dependent (e.g. cloud formation, surface evaporation, sea ice freezing/melting)

To what would you attribute the stasis?

- Natural variability (internal)
- Solar effects
- I am not convinced by arguments related to Chinese power plants, reductions in CFCs, volcanic activity



What is the definition of “internal variability”?

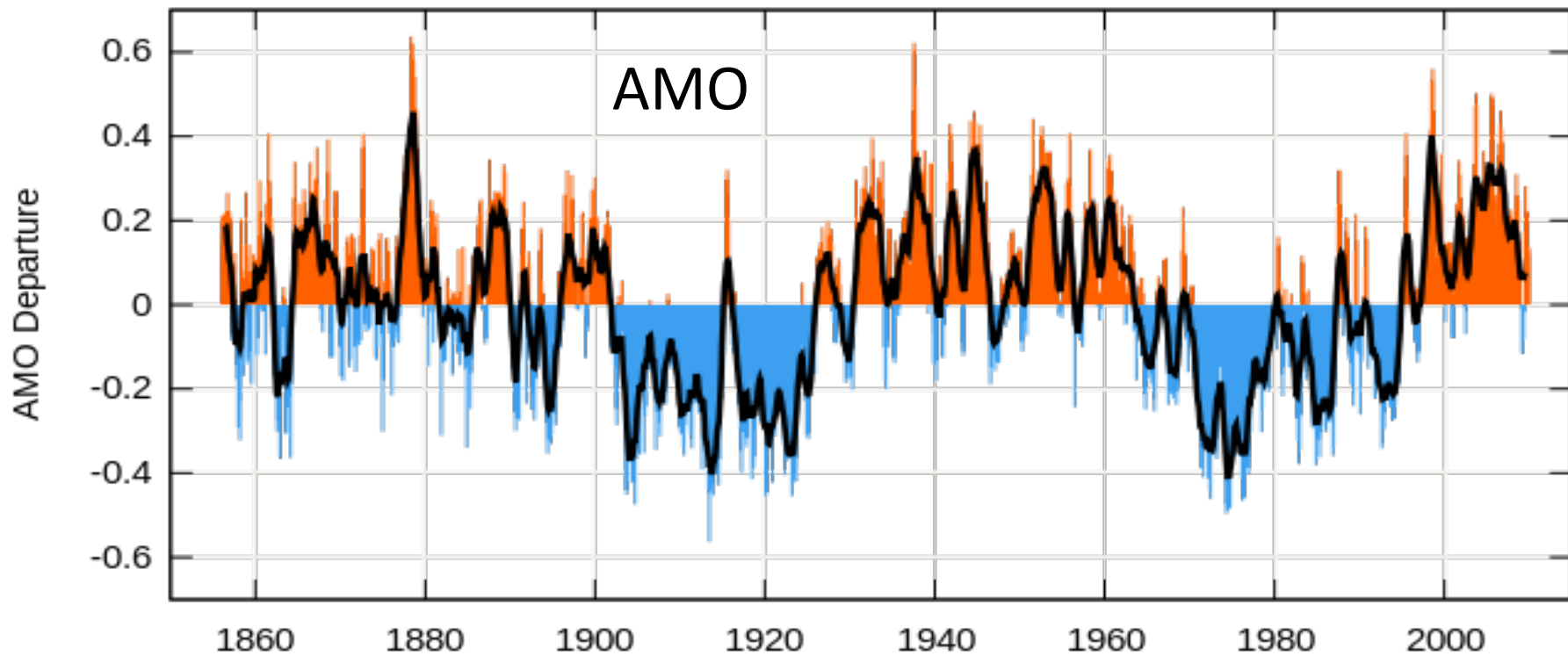
- Pure internal variability is associated with nonlinearities and chaotic nature of the coupled ocean/atmosphere system. External forcing projects onto the modes of internal variability and so influences the amplitude, tempo and phasing of the internal modes
- There is some predictability on decadal timescales of the multidecadal modes of climate variability, particularly the AMO

Are there any other possible multidecadal modes of variability besides ENSO? If so, how is that variability accounted for?

- AMO & PDO; stadium wave
- This variability is not accounted for in attribution studies

If non-anthropogenic influences are strong enough to counteract the expected effects of increased CO₂, why wouldn't they be strong enough to sometimes enhance warming trends, and in so doing lead to an over-estimate of CO₂ influence?

- I have argued that non anthropogenic influences (e.g. solar; warm phases of PDO and AMO) have enhanced the warming in the latter quarter of the 20th century

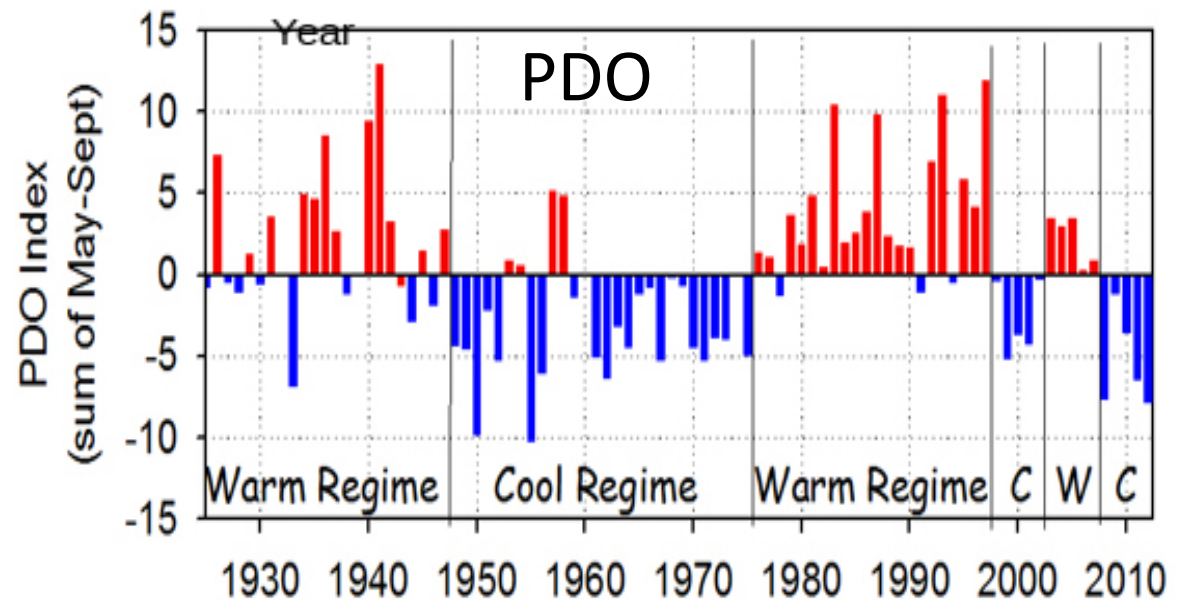


Currently:

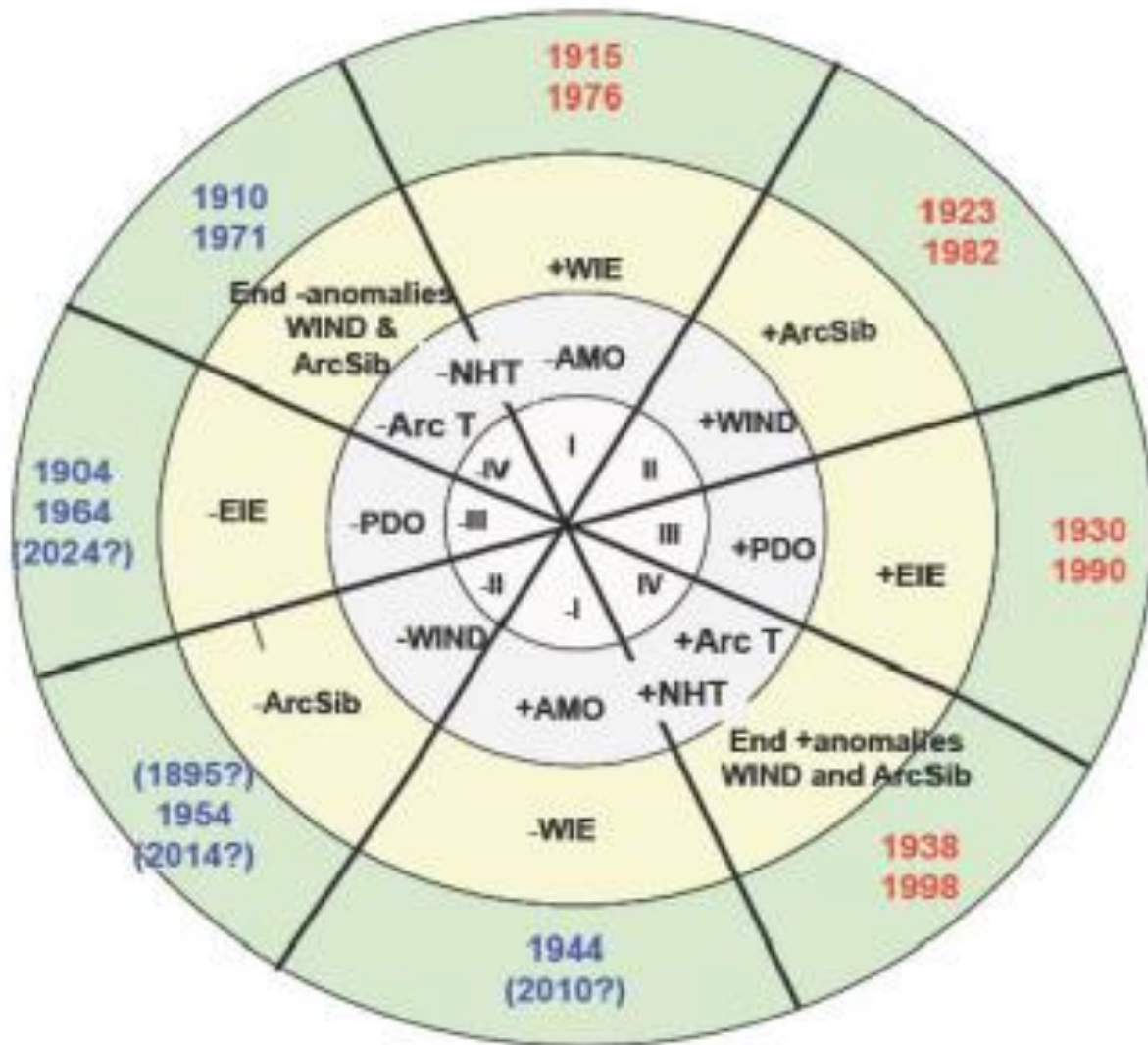
- Warm AMO
- Cool PDO

Previous analogue:

- 1946-1964



Stadium Wave



The 'stadium wave' climate signal propagates across the NH through a network of ocean, ice, and atmospheric circulation regimes that self-organize into a collective tempo.

How would the models' underestimate of internal variability impact detection and attribution?

- Incorrect simulations of natural internal variability results in biasing detection and attribution in favor of external forcing as the cause of any variability; in the latter half of the 20th century, the dominant external forcing is anthropogenic.

What are the implications of this stasis for confidence in the models and their projections?

- Models are not useful on timescales of up to 2 decades; serious implications for decadal projections and attribution analysis on time scale of decades (including 1975-2000 period of warming)

How long must the stasis persist before there would be a firm declaration of a problem with the models?

- Stasis persistence beyond 20 years would support a firm declaration of a problem with the models.

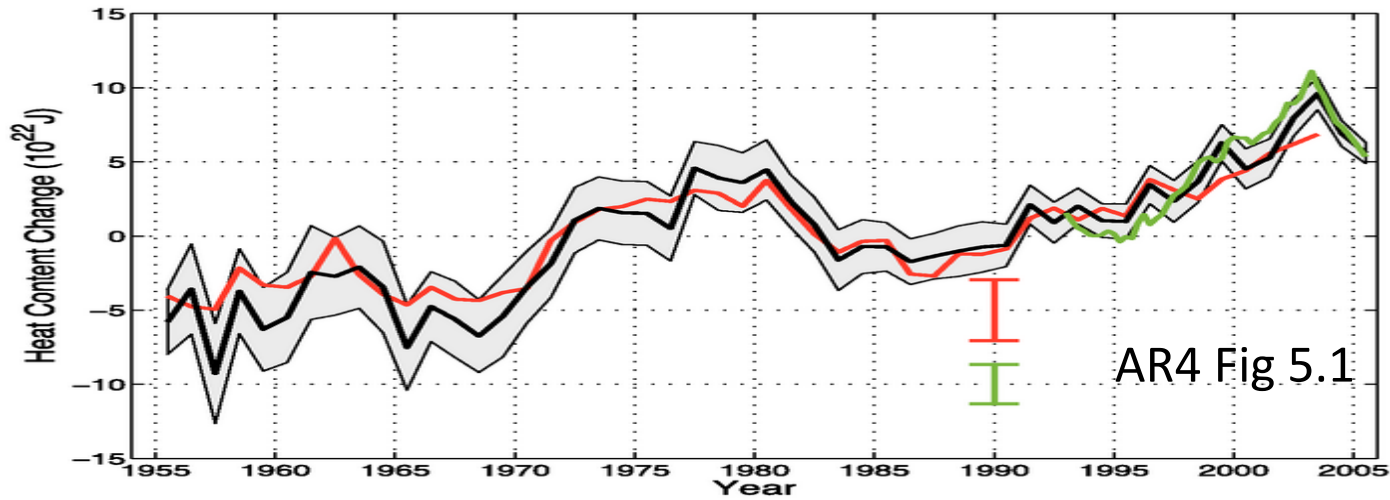
If that occurs, would the fix entail: A retuning of model parameters? A modification of ocean conditions? A re-examination of fundamental assumptions?

- The problems are with the ocean circulation and coupling with the atmosphere. No easy fixes, although higher resolution would help. Some fundamental unknowns in terms of how the ocean rapidly transports heat in the vertical.

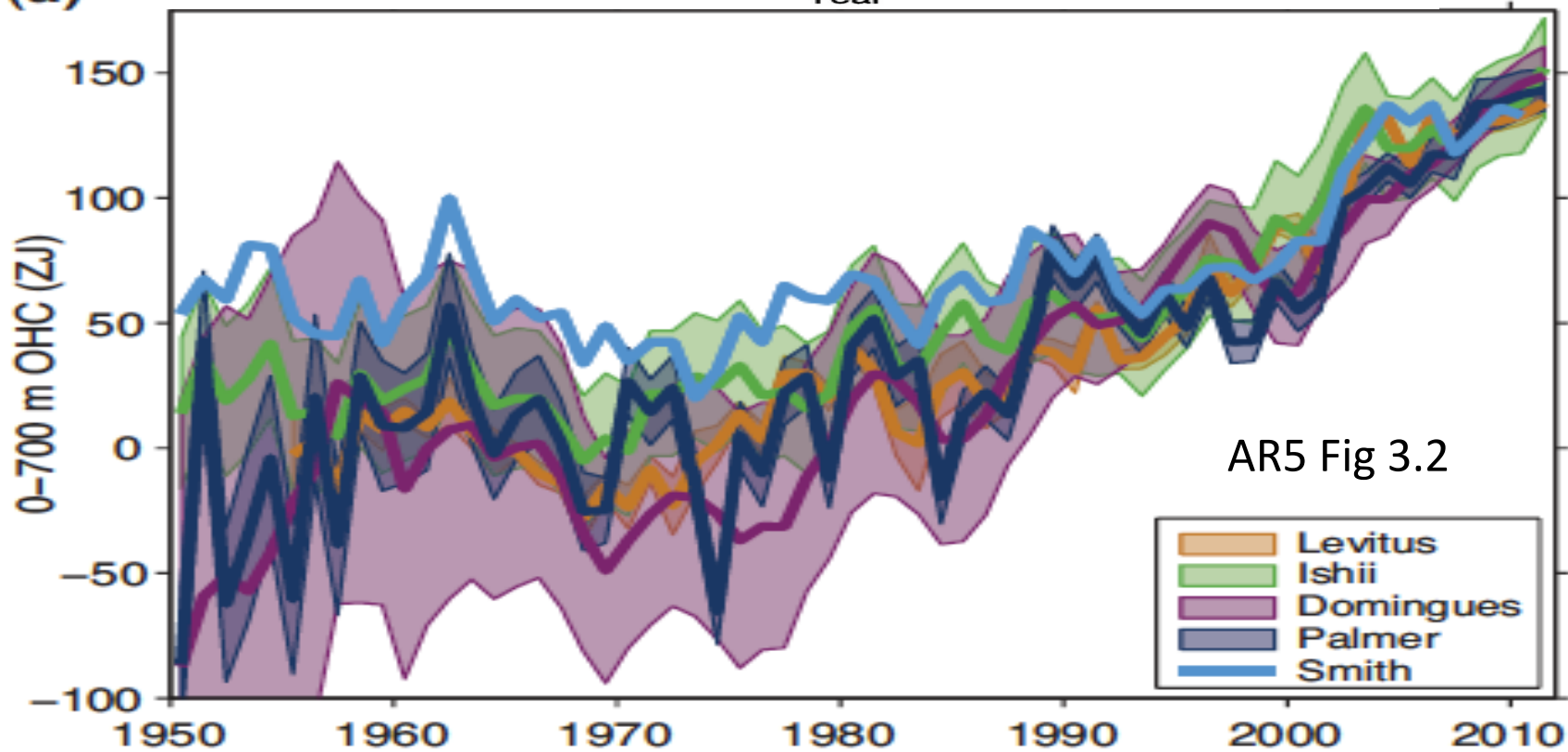
What do you see as the likelihood of solar influences beyond TSI? Is it coincidence that the stasis has occurred during the weakest solar cycle in about a century?

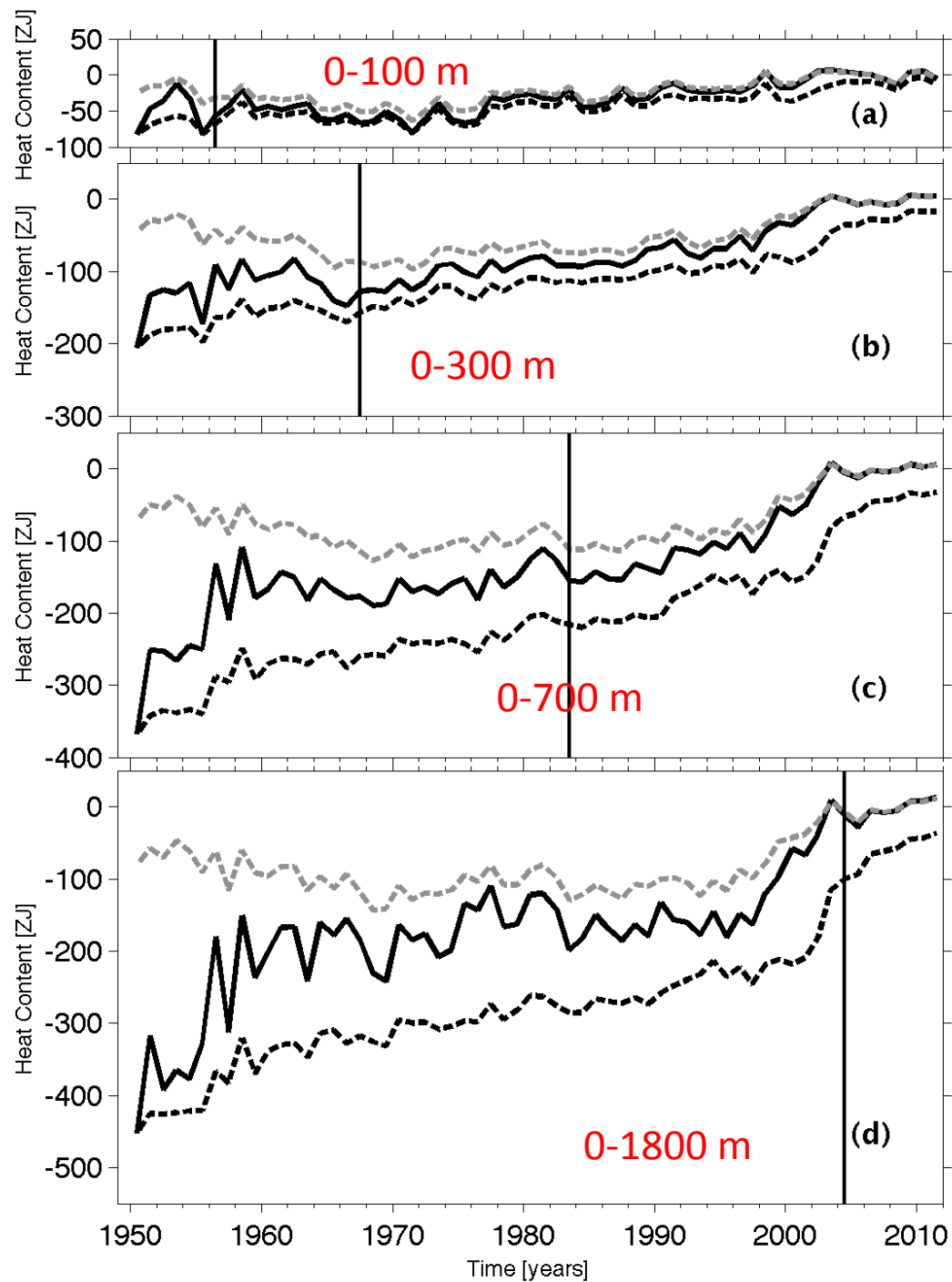
- Solar effects beyond TSI are the major known unknown (e.g. cosmic rays, global electric circuit, magnetic field). We simply don't know, but I wouldn't be surprised if they are important. It is not known to what extent solar effects have caused the stasis, this may be coincidence or not

Ocean Heat Content 0-700 m



(a)



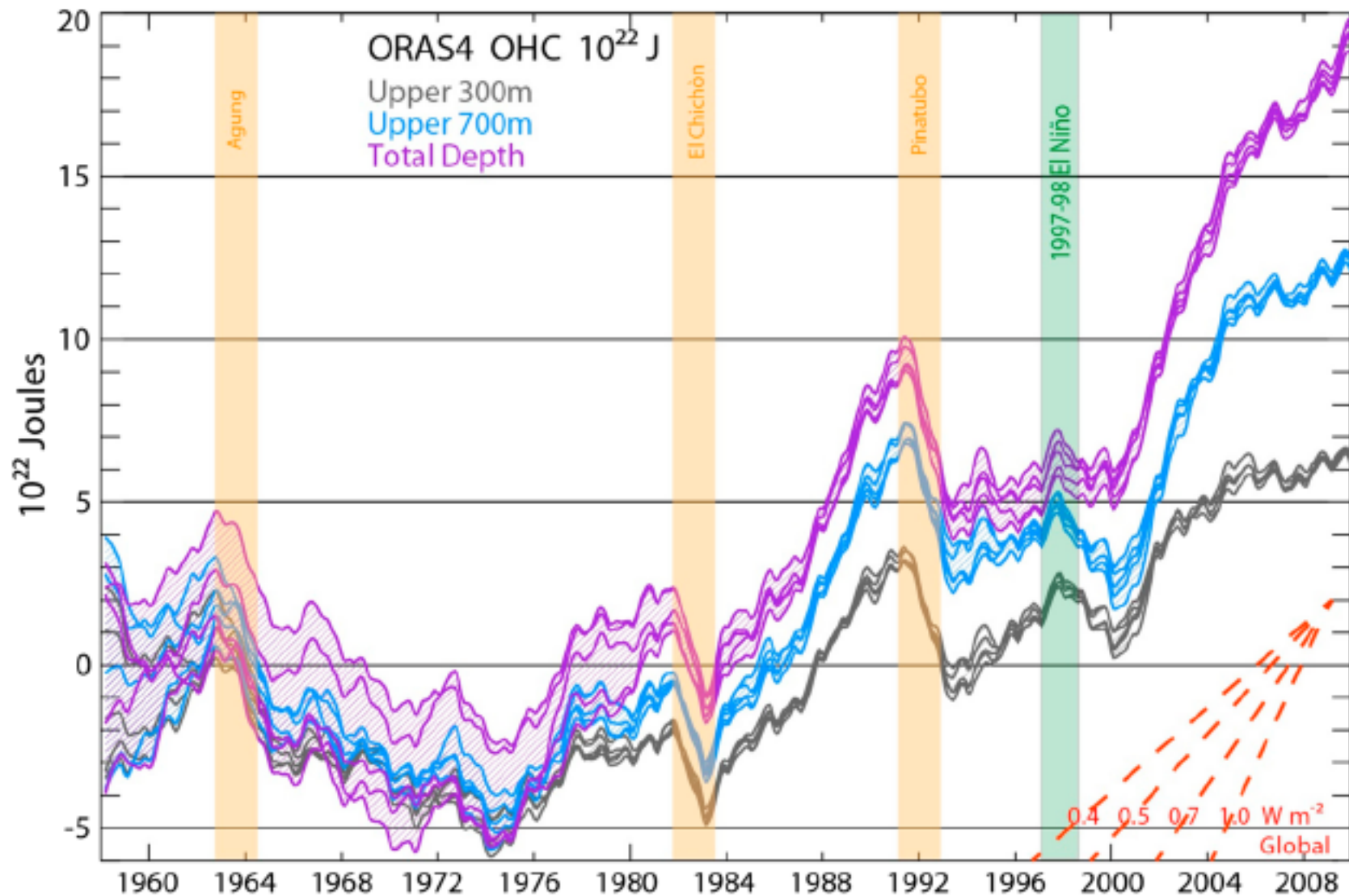


Ocean Heat Content

(observations constrained by SSH)

Lyman & Johnson, 2014:
J. Climate, in press

Ocean Reanalysis – ECMWF



Balmaseda et al. 2013: J. Geophys Res.

Some have suggested that the “missing heat” is going into the deep ocean, causing mK temperature rises. Are deep ocean observations sufficient in coverage and precision to bear on this hypothesis quantitatively?

- No. There are substantial uncertainties in data coverage and calibration, and reanalysis estimates disagree quantitatively with each other and with data only analyses. (uncertainty estimates)

Why would the heat sequestration have “turned on” at the turn of this century?

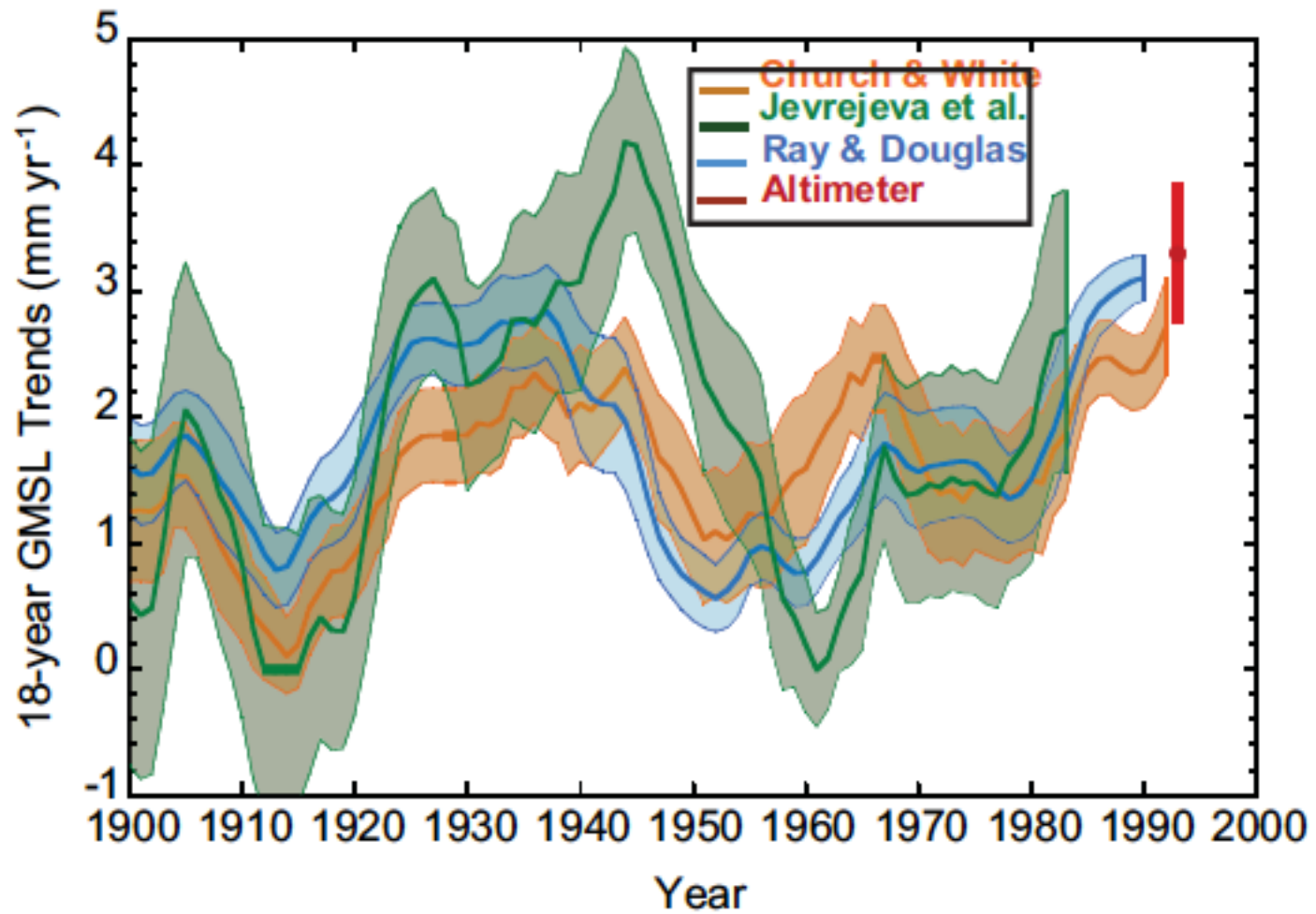
- Presumably associated with natural internal variability

What could make it “turn off” and when might that occur?

- Same; the next shift in the stadium wave is expected in the 2030's

Is there any mechanism that would allow the added heat in the deep ocean to reappear in the atmosphere?

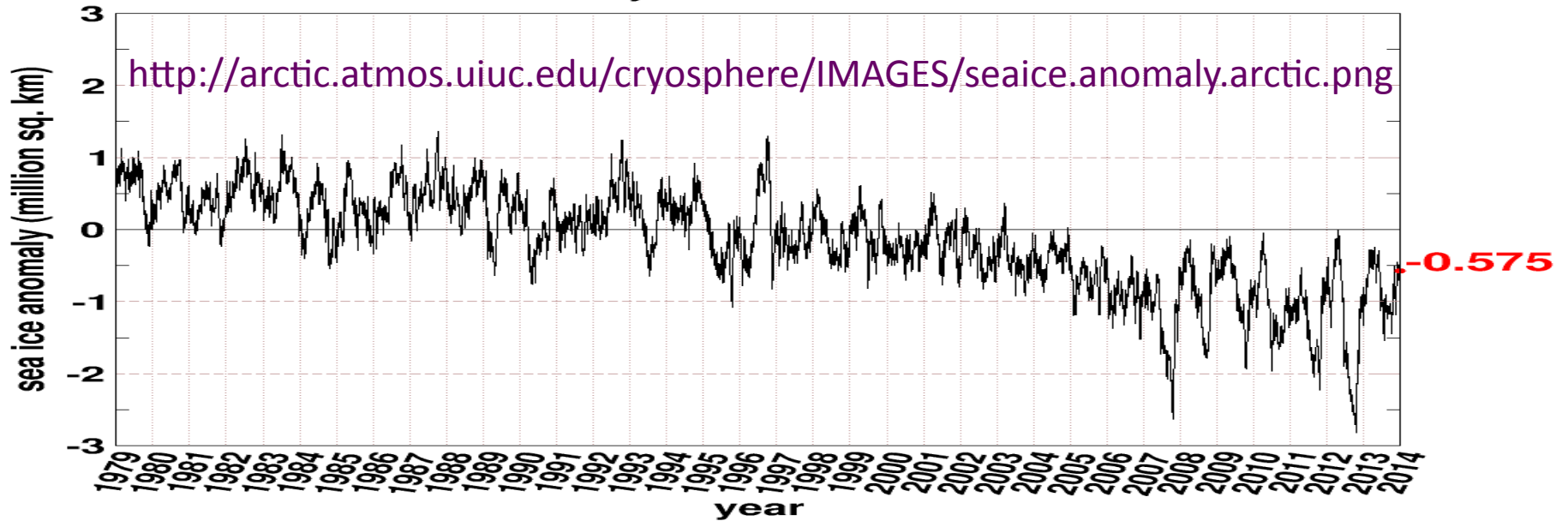
- The deep ocean has warmed approximately 0.05K; if the heating is well mixed in the ocean, there is no way for warming in the atmosphere to occur beyond 0.05K



20th century sea level trends co-varies with the AMO and the stadium wave

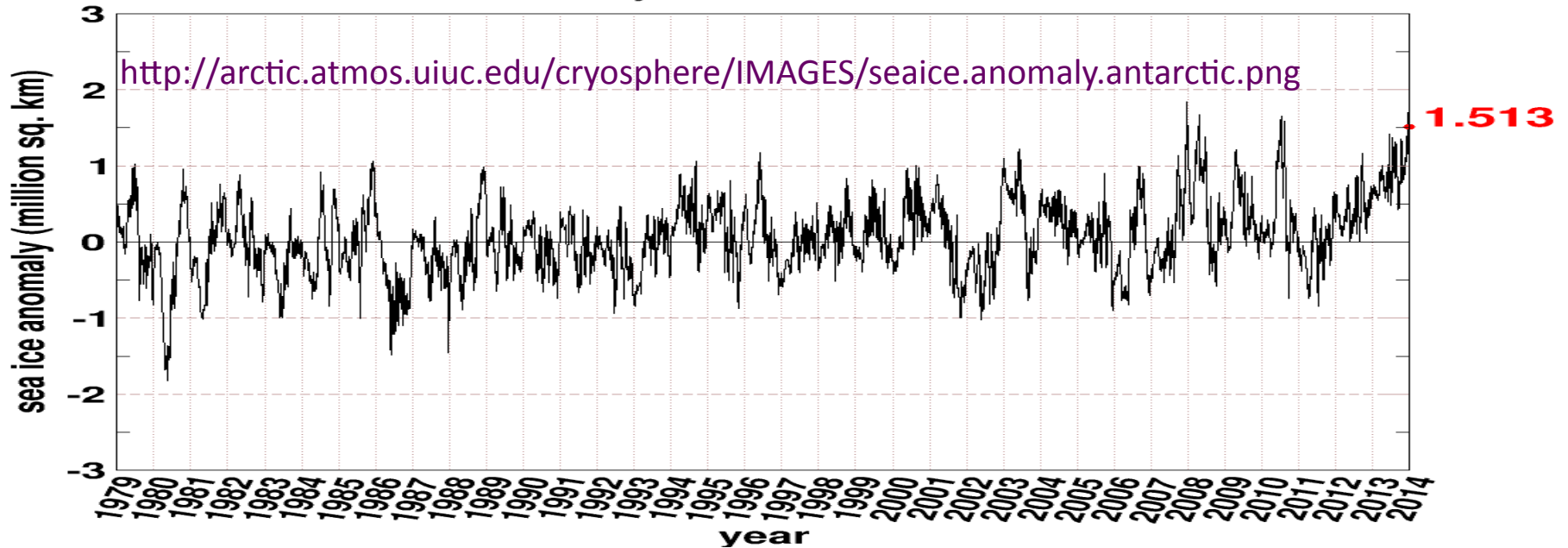
Northern Hemisphere Sea Ice Anomaly

Anomaly from 1979-2008 mean

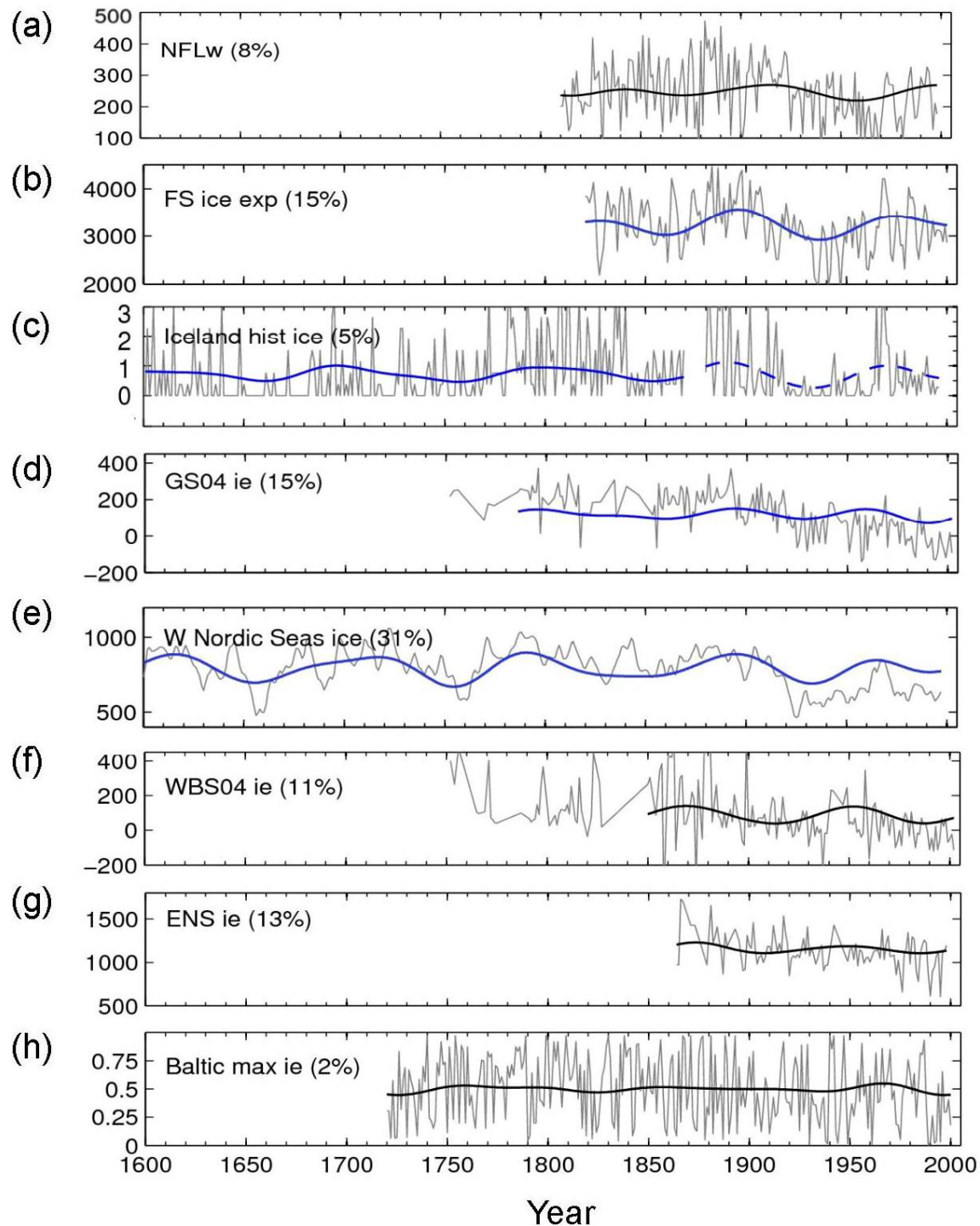


Southern Hemisphere Sea Ice Anomaly

Anomaly from 1979-2008 mean



Arctic sea ice variability



Miles et al. 2014:
J. Geophys. Res., in press

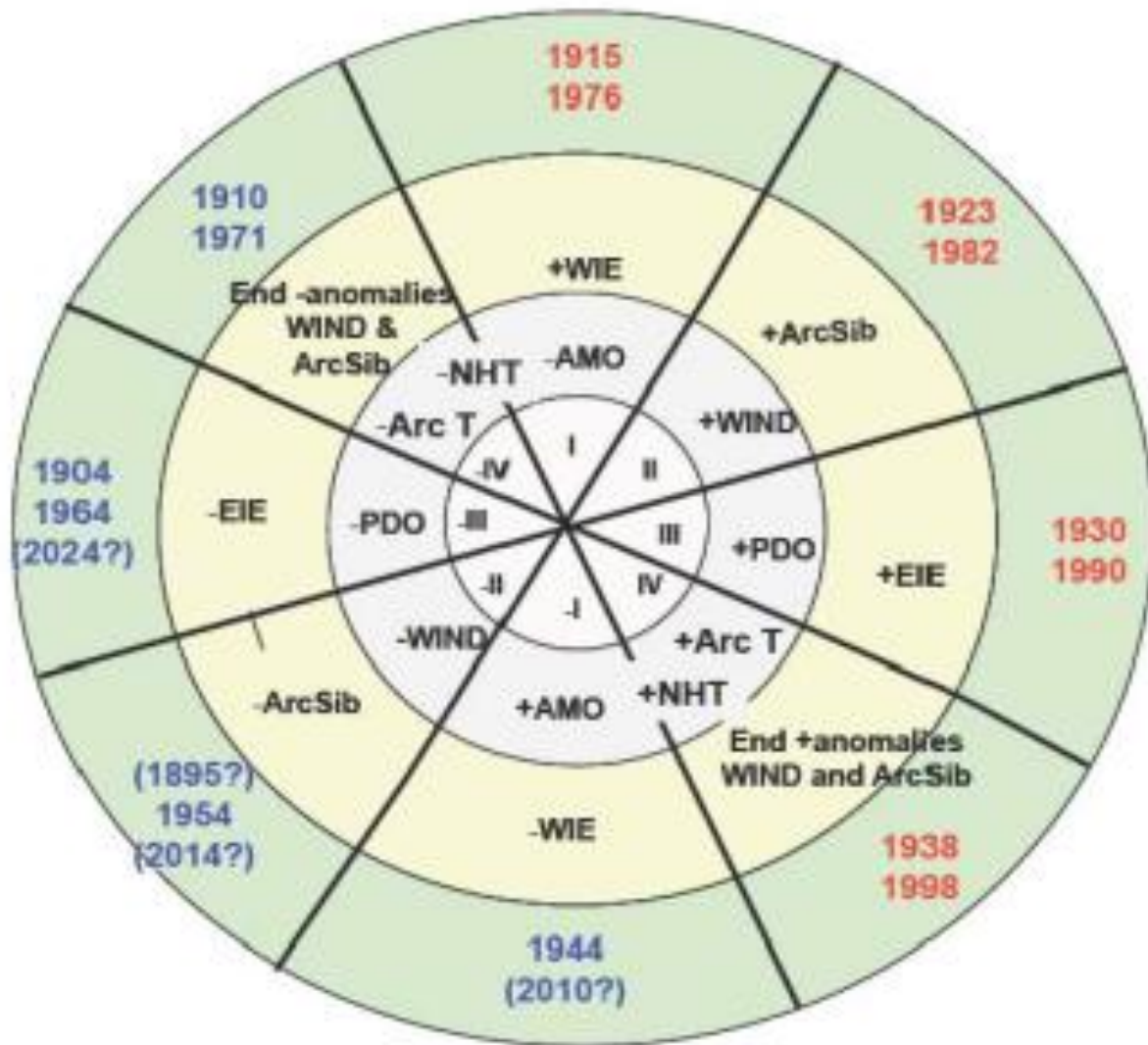
To what extent do you believe the recent Arctic decline to be unusual: “There is medium confidence that the current ice loss and increasing SSTs in the Arctic are anomalous at least in the context of the last two millennia.”?

- Determining sea ice extent prior to the satellite era is very challenging, using proxies and historical data. Much more work is needed on this topic, and I find the ‘medium confidence’ to be wholly unconvincing.

Please comment on the ability of the models to reproduce the Arctic trend, but not the Antarctic trend.

- ~ 47-60% of the Arctic sea ice decline is natural (Stroeve et al. 2012); climate models that reproduce the observed trend without correct natural variability have CO2 sensitivities that are too high (e.g. two wrongs make a right).
- Antarctic sea ice increase is complex interplay between the hydrological cycle, winds, and ocean mixed layer, which models do not correctly simulate (Liu, Curry et al. PNAS 2010)

Stadium Wave



Natural variability is contributing to beginning of sea ice recovery
In the Eurasian Arctic; natural recovery to continue to ~2050

How are the IPCC confidence levels determined?

From the IPCC AR5 Uncertainty Guidance Note:

- *Confidence in the validity of a finding, based on the type, amount, quality, and consistency of evidence (e.g., mechanistic understanding, theory, data, models, expert judgment) and the degree of agreement. Confidence is expressed qualitatively.*

From Curry and Webster 2013: Climate Change: No Consensus on Consensus:

“With regards to the IPCC, cognitive biases in the context of an institutionalized consensus building process have arguably resulted in the consensus becoming increasingly confirmed in a self-reinforcing way, to the detriment of the scientific process.”

What has caused the 5% increase in IPCC confidence from 2007 to 2013?

- AR4 (2007) SPM: “Most of the observed increase in global average temperatures since the mid-20th century is **very likely** due to the observed increase in **anthropogenic greenhouse gases**.”
- AR5 (2013) SPM: “It is **extremely likely** that **human influence** has been the dominant cause of the observed warming since the mid-20th century .”

From AR5 Chapter 10:

- More than half of the observed increase in GMST from 1950-2010 is **very likely** due to the observed increase **in anthropogenic greenhouse gases**.’
- It is **extremely likely** that **human activities*** caused more than half of the observed increase in GMST from 1951-2010

* GHG, aerosols, ozone, land use changes (increased confidence in these forcings)

References:

Curry and Webster 2011: Climate science and the uncertainty monster. *Bull Amer Meteorol. Soc.*. (Slide 3) <http://journals.ametsoc.org/doi/pdf/10.1175/2011BAMS3139.1>

Mauritsen et al. 2014: Tuning the climate of a global Model. *J. Adv. Modelling Earth Systems*. (Slide 4) http://www.mpimet.mpg.de/fileadmin/staff/klockedaniel/Mauritsen_tuning_6.pdf

Ed Hawkins (Slide 5) <http://www.climate-lab-book.ac.uk/2013/updates-to-comparison-of-cmip5-models-observations/>

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http://www.cgd.ucar.edu/cas/Trenberth/website-archive/trenberth.papers-moved/Balmaseda_Trenberth_Kallen_grl_13.pdf

John Walsh (Slide 15)

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<http://arctic.atmos.uiuc.edu/cryosphere/IMAGES/seaice.anomaly.antarctic.png>

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<http://onlinelibrary.wiley.com/doi/10.1002/2013GL058084/abstract>

Stroeve et al. 2012: Trends in Arctic sea ice in CMIP3, CMIP5 and observations (Slide 17) <http://onlinelibrary.wiley.com/doi/10.1029/2012GL052676/abstract>

Liu & Curry et al. 2010: Accelerated warming of the Southern Ocean and its impacts on the hydrological cycle and sea ice. *PNAS*, (Slide 17)

<http://www.pnas.org/content/early/2010/08/09/1003336107.abstract>

Curry & Webster 2013: Climate Change: No Consensus on Consensus. CAB Reviews, (Slide 20) <http://judithcurry.com/2012/10/28/climate-change-no-consensus-on-consensus/>