Comments in Support of Launching a New Climate Modeling Effort

John Marshall (MIT)

1. Concerns about the status quo

Are climate models fit for purpose?

Incremental, slow development pace

2. Ocean modeling challenges

Subpolar latitudes, seasonal ice zone

3. A way forward

Insurgent ‘outside the box’ activity

Emphasis on extreme computation and machine learning

Accelerate development, drive new science

Is the current generation of models fit for purpose?

It is found that there is virtually no improvement in all these measures [of tropical circulation] from the CMIP3 ensemble to the CMIP5 ensemble models…. No progress can be identified in the sub-ensembles of five best models from CMIP3 to CMIP5 even though more models participated in CMIP5, the systematic errors of excessive precipitation and overestimated SST in southeastern Pacific are even worse in the CMIP5 models.

Zhang et al, GRL 2015

Wintertime blocking frequency is heavily underestimated by almost all [CMIP5] models. This is particularly the case for the Euro-Atlantic sector, where the mean deficit is greater than 1⁄2 of the total daily frequency, in accordance with CMIP3 results

Masato et al 2015

See discussion
by Tim Palmer

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Implications of regional improvement in global climate models for agricultural impact research

Julian Ramirez-Villegas[1,2,3], Andrew J Challinor[2,3], Philip K Thornton[1,4] and Andy Jarvis[1,2]

[1] International Center for Tropical Agriculture (CIAT), Cali, Colombia
[2] CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), Denmark
[3] Institute for Climate and Atmospheric Science (ICAS), School of Earth and Environment, University of Leeds, Leeds, UK
[4] International Livestock Research Institute (ILRI), Nairobi, Kenya

E-mail: j.r.villegas@cgiar.org

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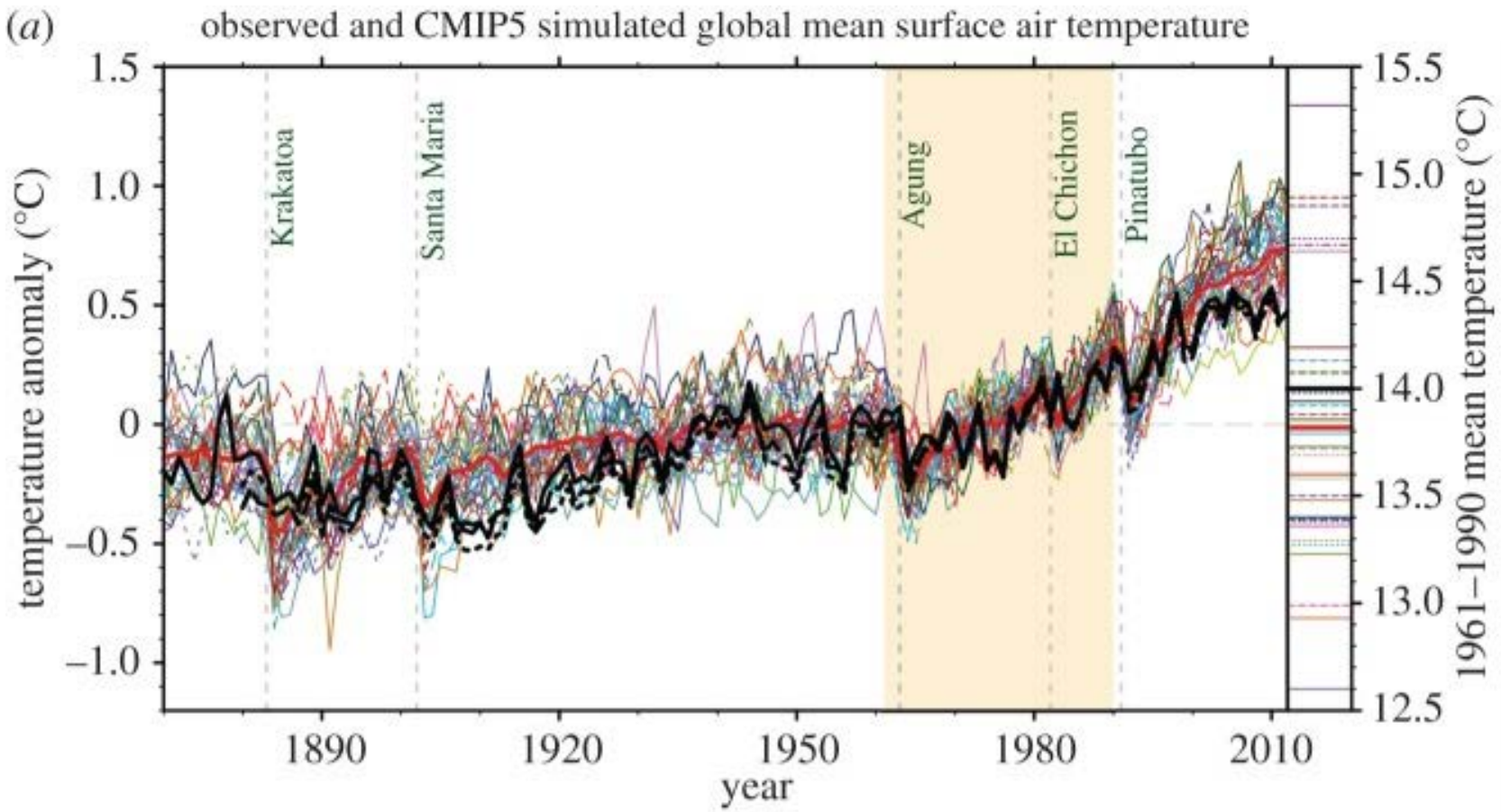
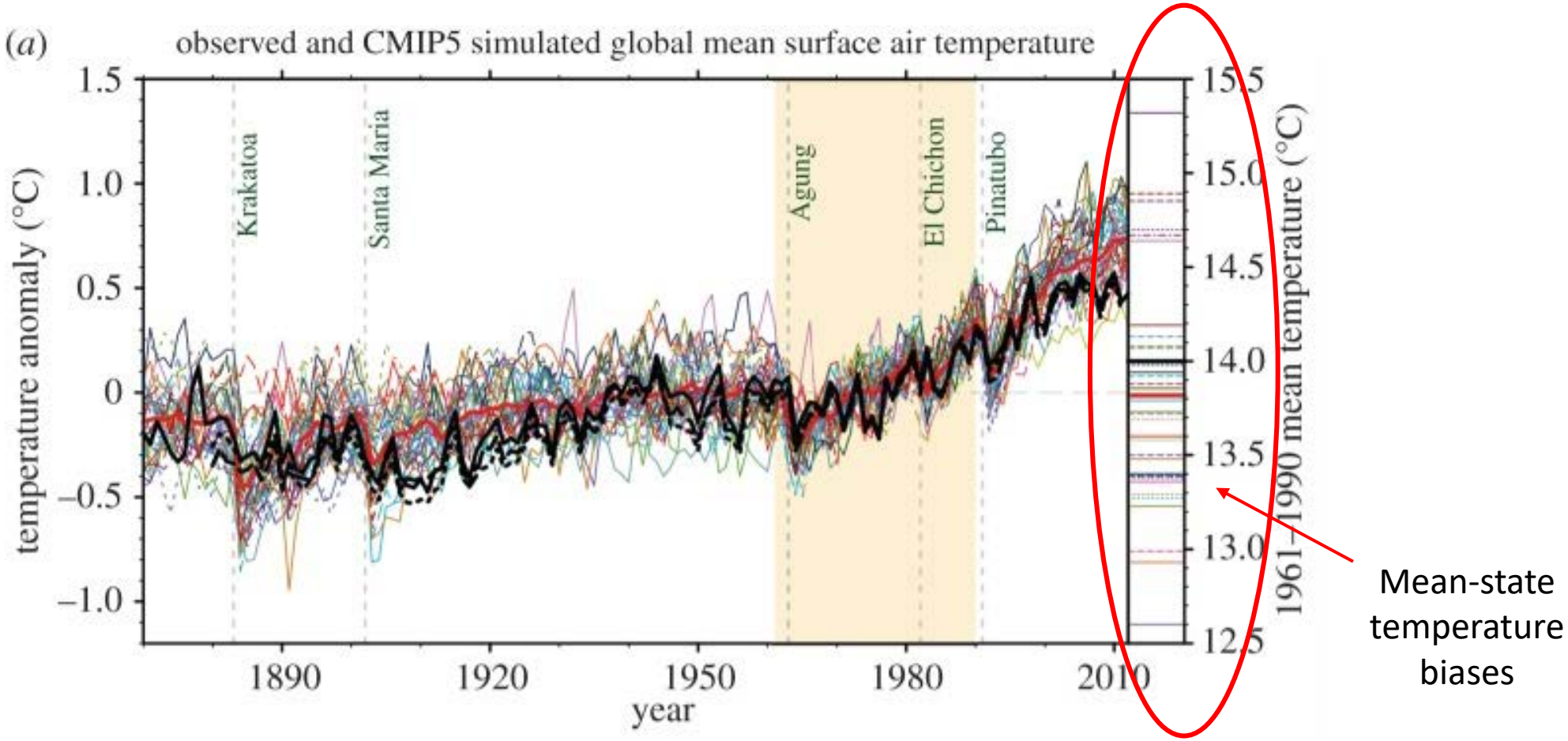
Abstract
Global climate models (GCMs) have become increasingly important for climate change science and provide the basis for most impact studies. Since impact models are highly sensitive to input climate data, GCM skill is crucial for getting better short-, medium- and long-term outlooks for agricultural production and food security. The Coupled Model Intercomparison Project (CMIP) phase 5 ensemble is likely to underpin the majority of climate impact assessments over the next few years. We assess 24 CMIP3 and 26 CMIP5 simulations of present climate against climate observations for five tropical regions, as well as regional improvements in model skill and, through literature review, the sensitivities of impact estimates to model error. Climatological means of seasonal mean temperatures depict mean errors between 1 and 18 °C (2–130% with respect to mean), whereas seasonal precipitation and wet-day frequency depict larger errors, often offsetting observed means and variability beyond 100%. Simulated interannual climate variability in GCMs warrants particular attention, given that no single GCM matches observations in more than 30% of the areas for monthly precipitation and wet-day frequency, 50% for diurnal range and 70% for mean temperatures. We report improvements in mean climate skill of 5–15% for climatological mean temperatures, 3–5% for diurnal range and 1–2% in precipitation. At these improvement rates, we estimate that at least 5–30 years of CMIP work is required to improve regional temperature simulations and at least 30–50 years for precipitation simulations, for these to be directly input into impact models. We conclude with some recommendations for the use of CMIP5 in agricultural impact studies.

"At these improvement rates we estimate … at least 30-50 years to improve regional precip, for these to be directly input into impact models."



Observed and simulated time series of the anomalies in annual and global mean surface temperature. All anomalies are differences from the 1961 to 1990 time-mean of each individual time series. The reference period 1961–1990 is indicated by yellow shading; vertical dashed grey lines represent times of major volcanic eruptions. (a) Single simulations for CMIP5 models (thin lines); multi-model mean (thick red line); different observations (thick black lines). Inset: the global mean surface temperature for the reference period 1961–1990, for each individual model (colours), the CMIP5 multi-model mean (thick red), and the observations.



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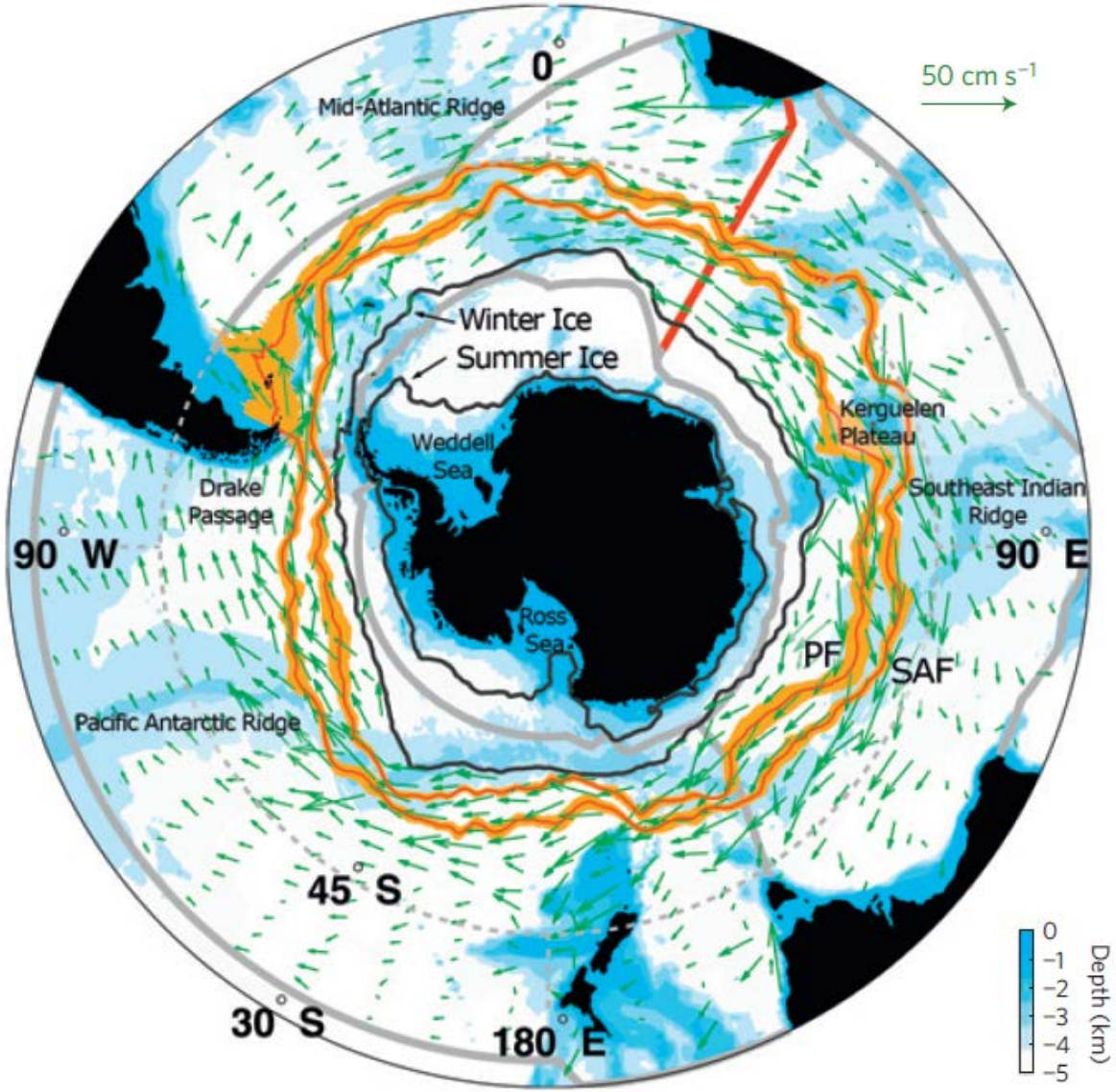
Southern Ocean



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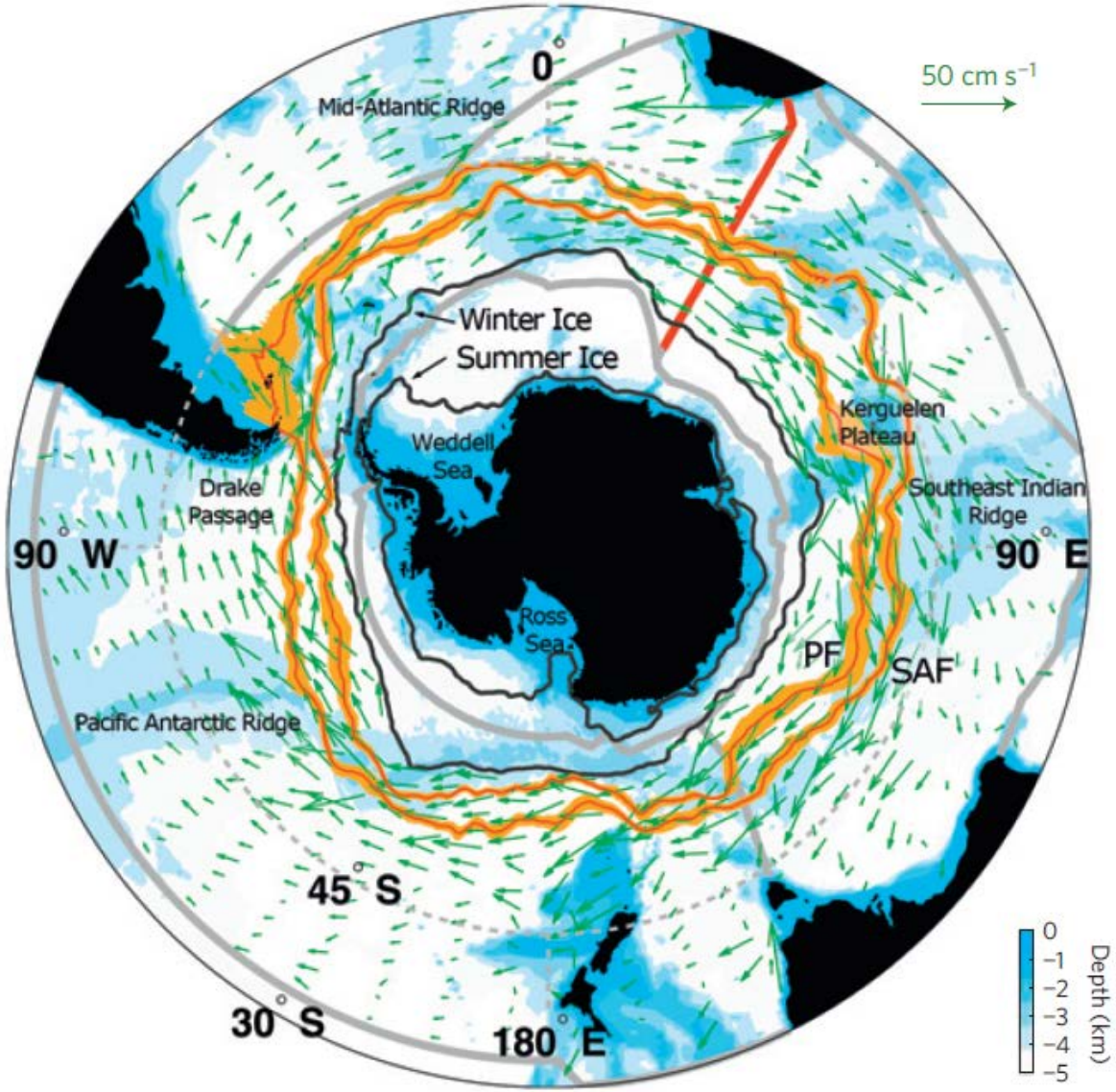

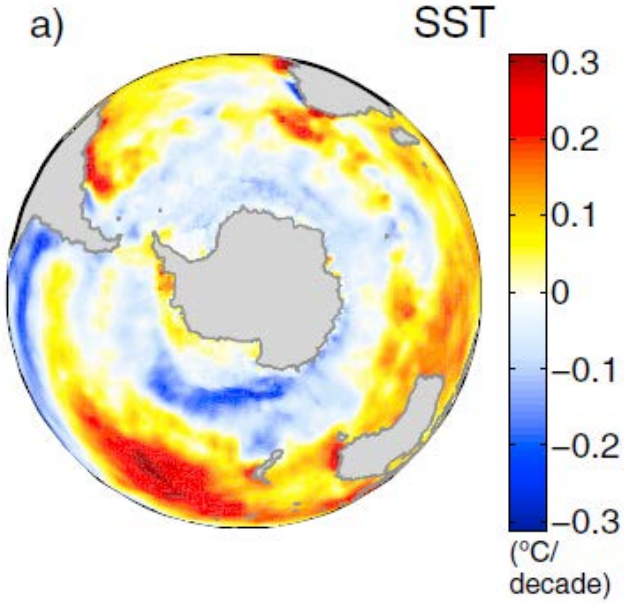

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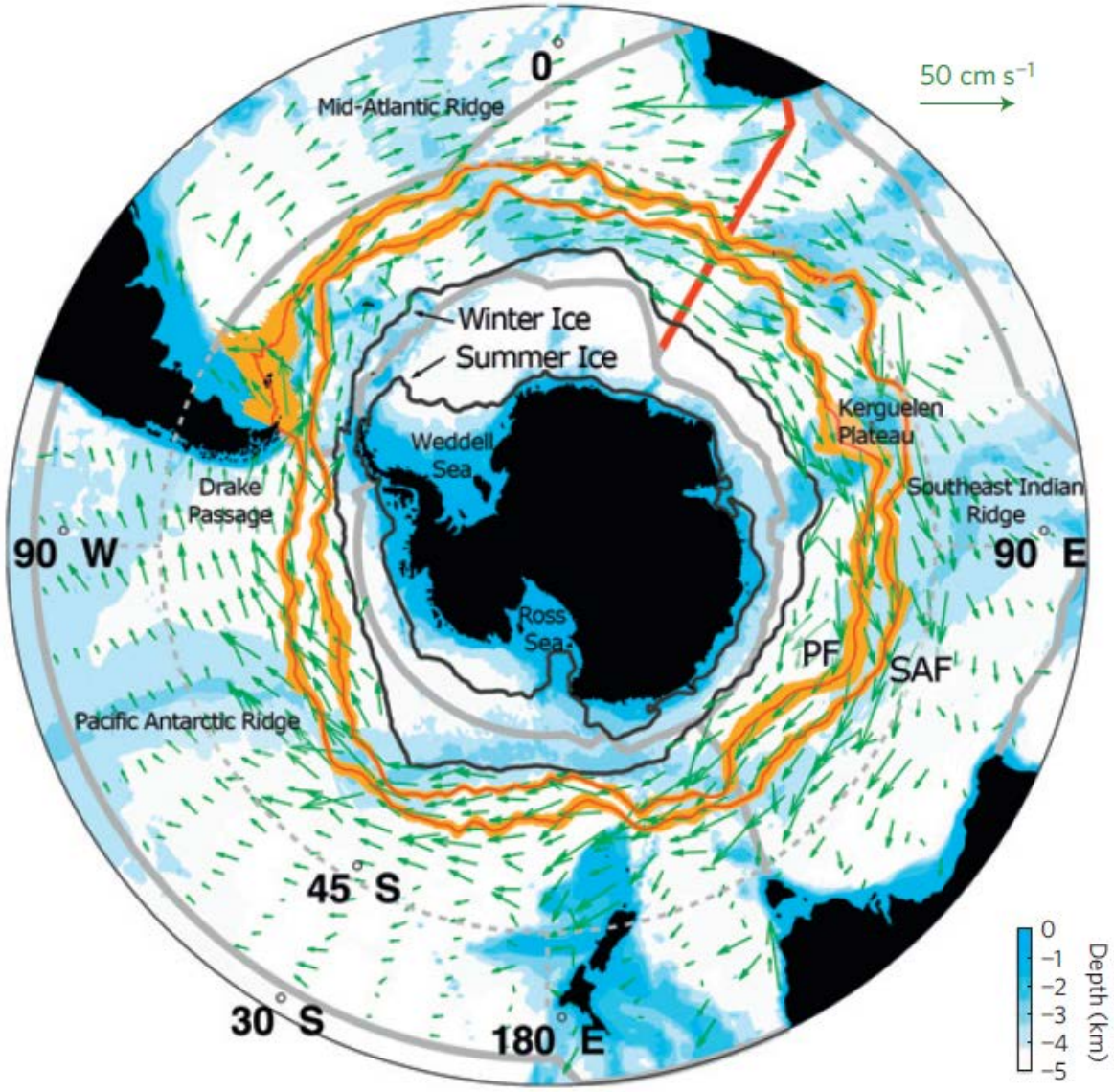

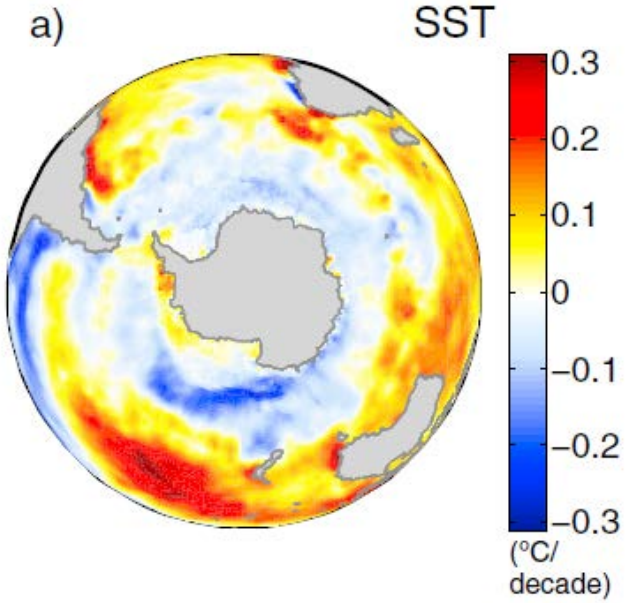

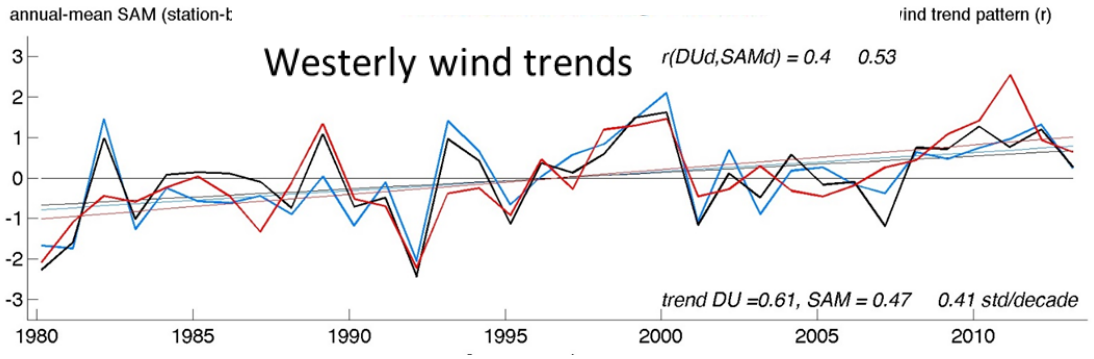

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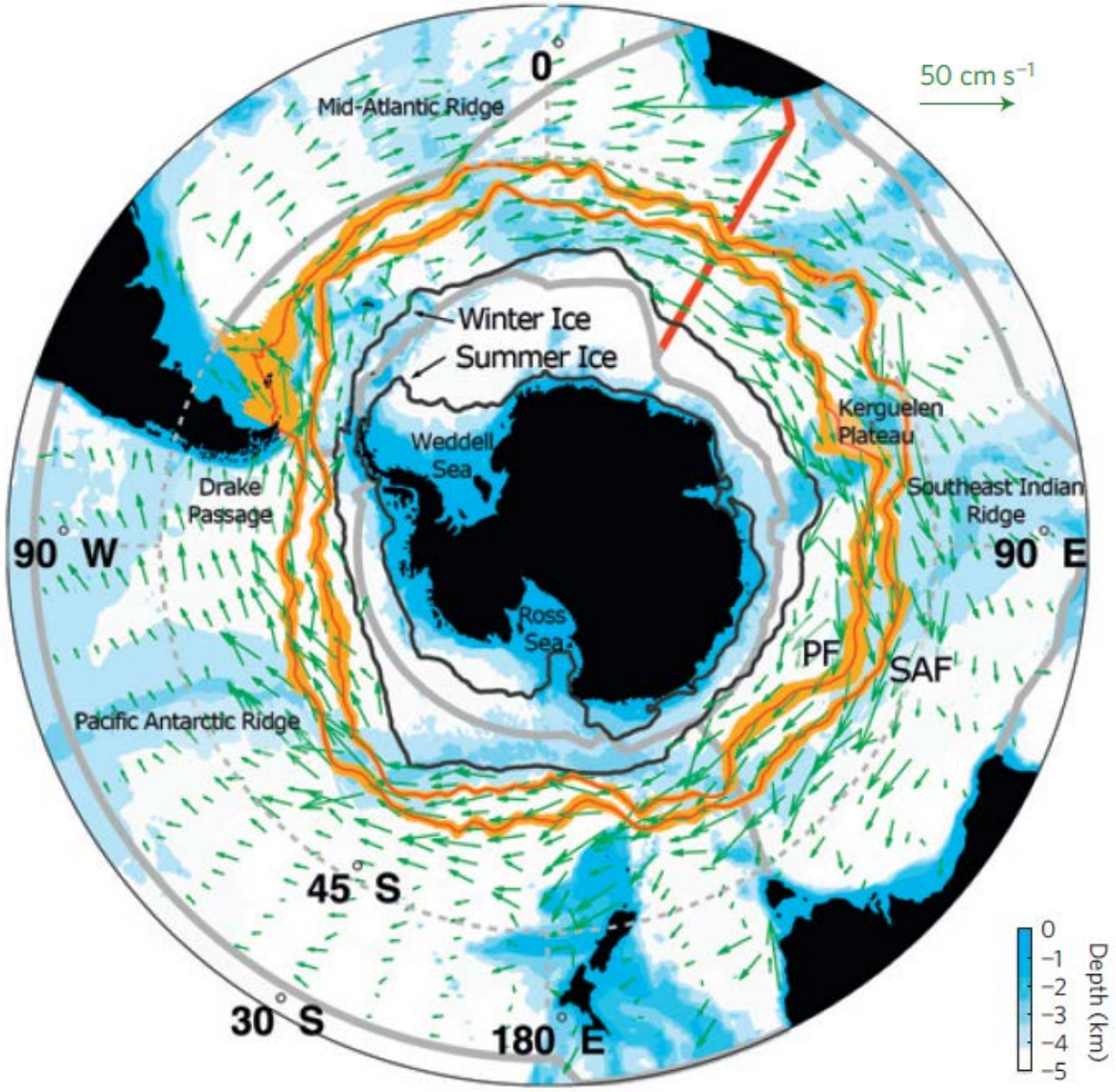
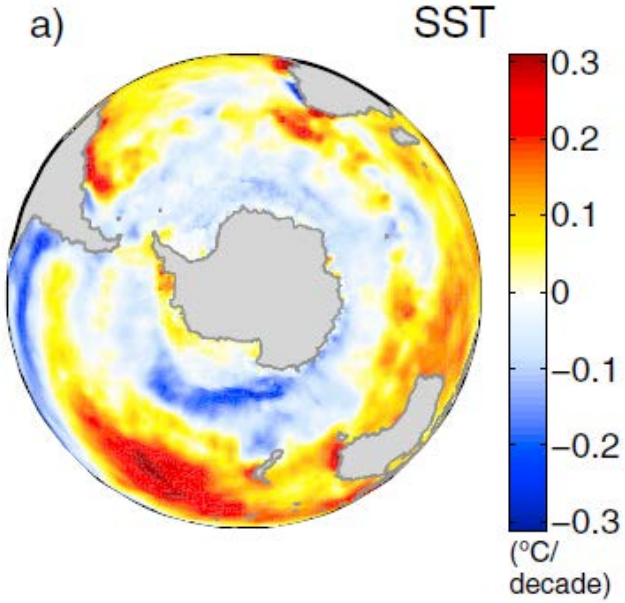
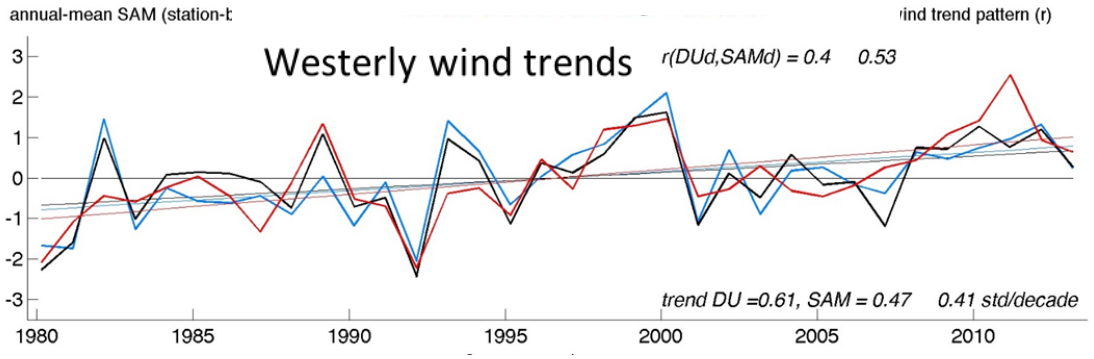
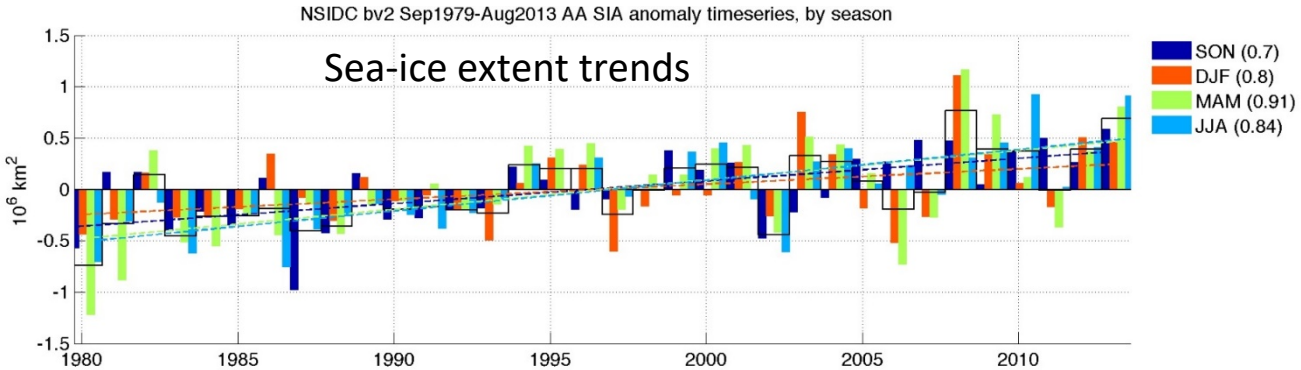




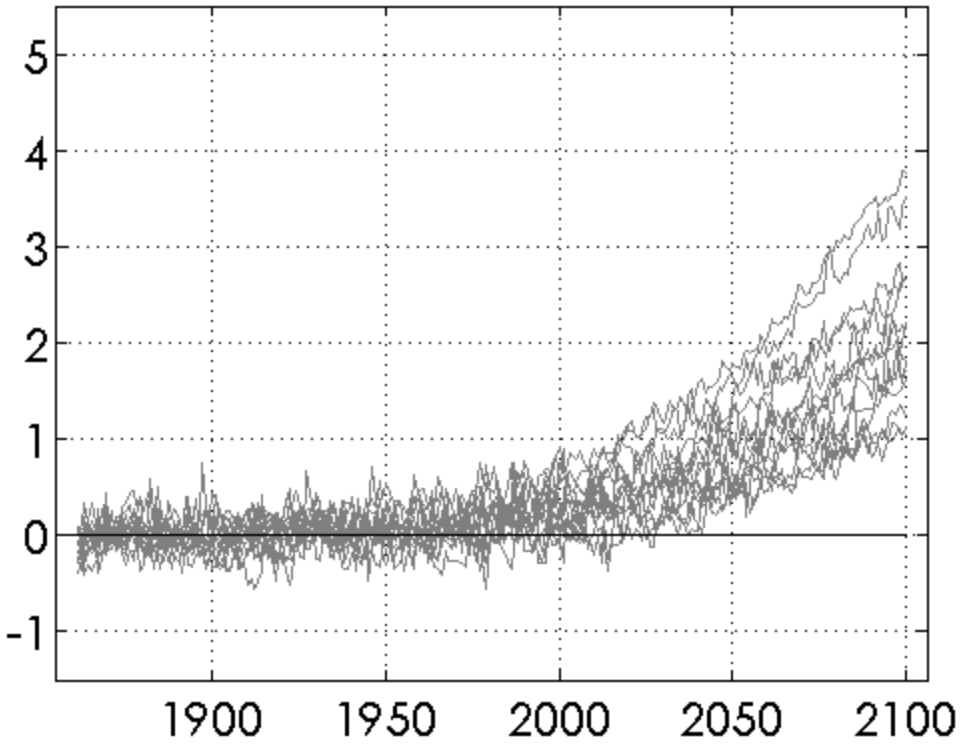




Model biases in the Southern Ocean

SST anomalies relative to control in CMIP5 models

Sea surface temperature between 50 and 60S

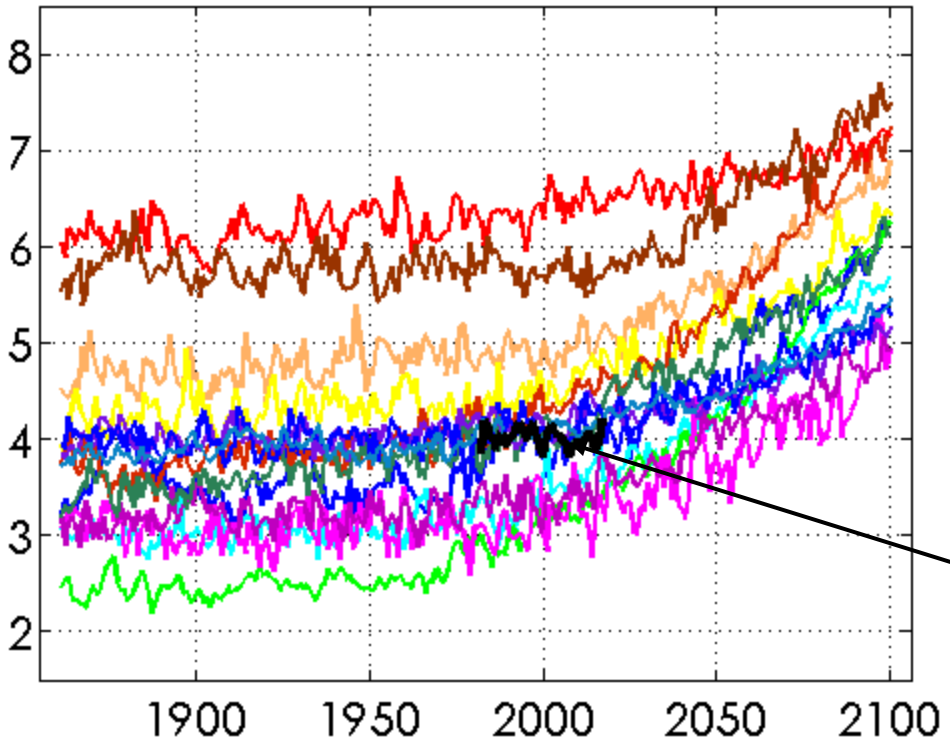


Yavor Kostov

Model biases in the Southern Ocean

Absolute values of SST

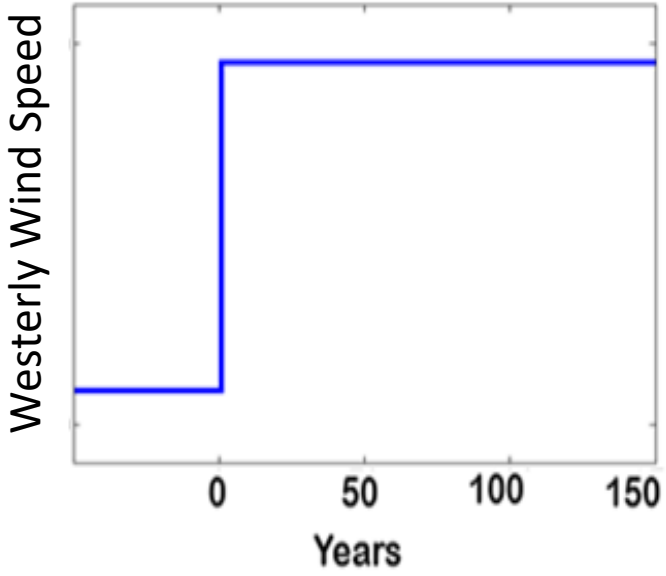
Sea surface temperature between 50 and 60S



observations

Yavor Kostov

How do coupled models respond to a step in the zonal wind?



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- The integral of the impulse response is the step response function.

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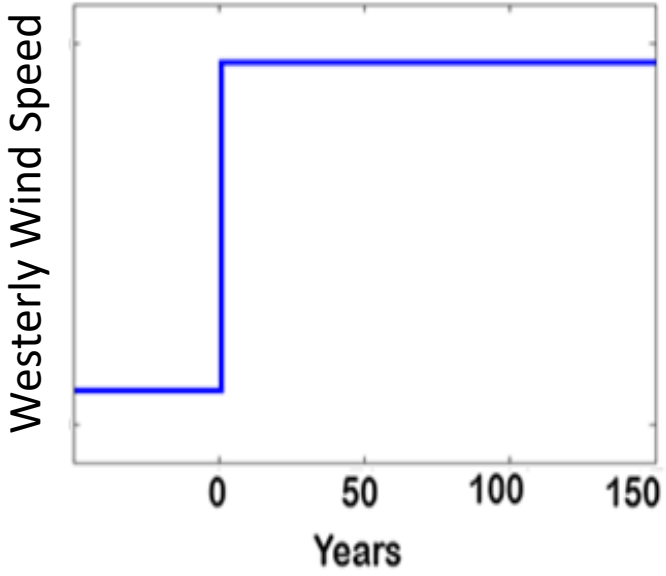

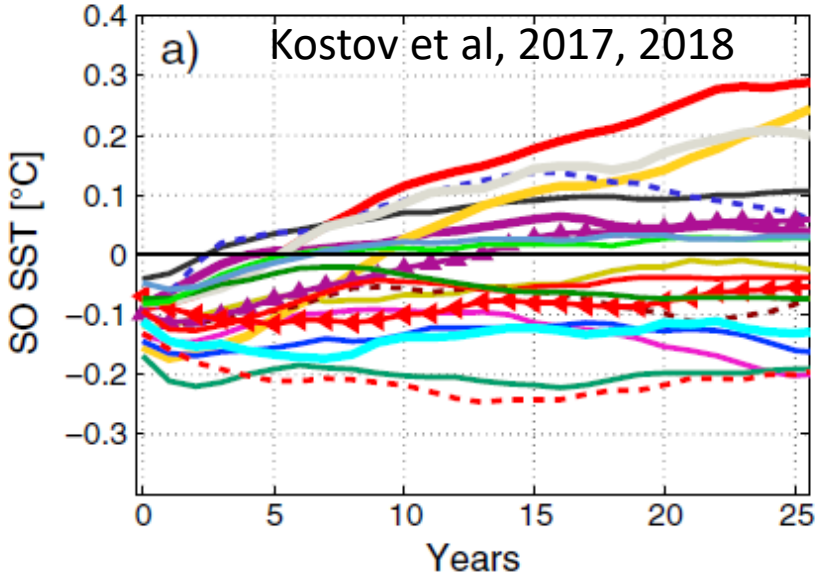

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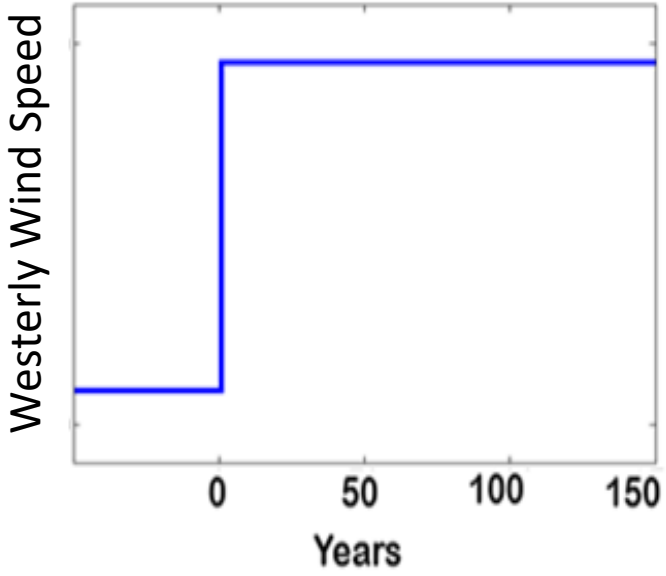

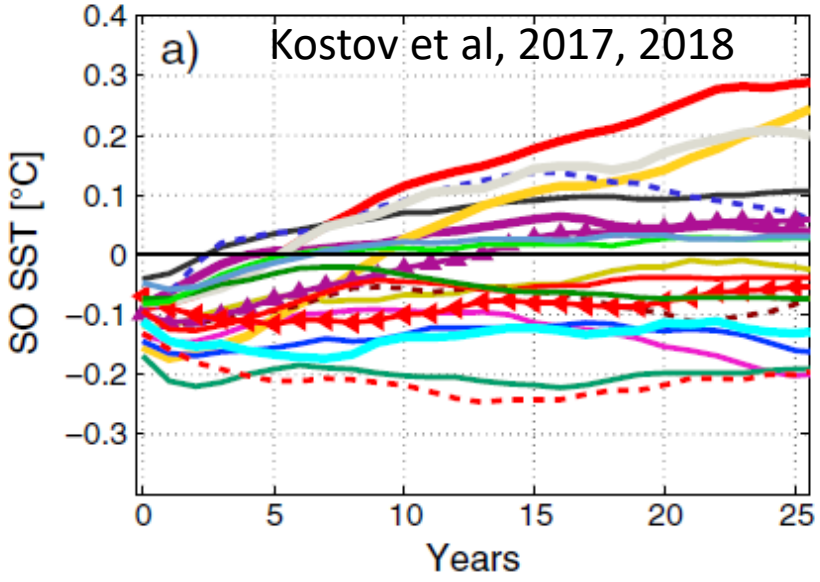

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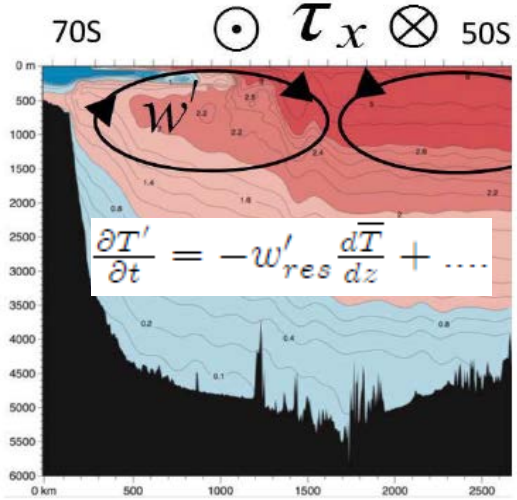
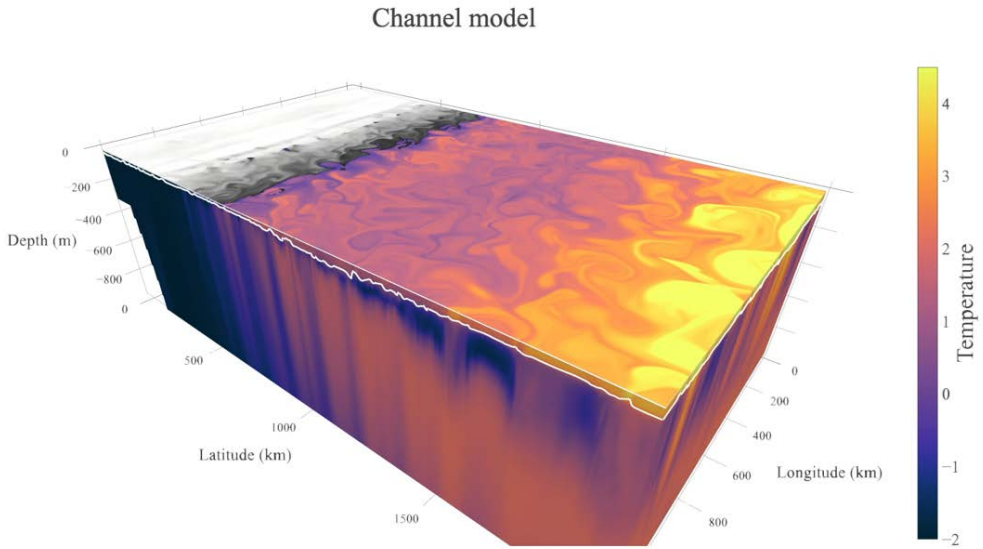


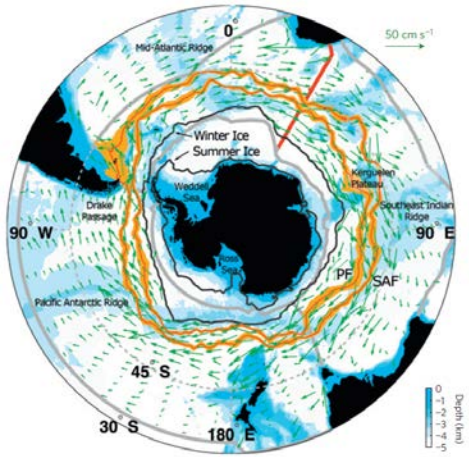
Positive SAM

Eddying channel model of a sector of the Southern Ocean

4km horizontal resolution

Temperature & sea-ice





Ed Doddridge, MIT

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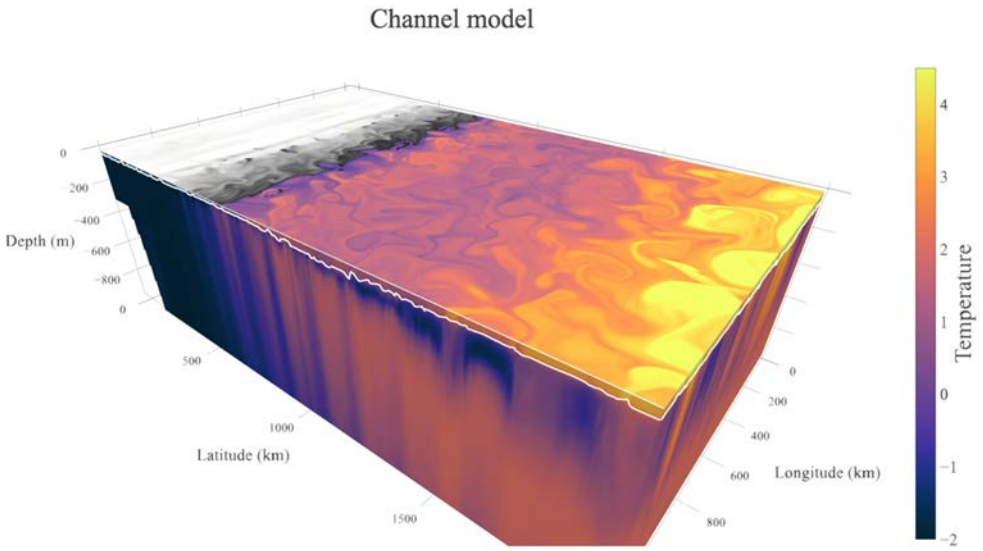

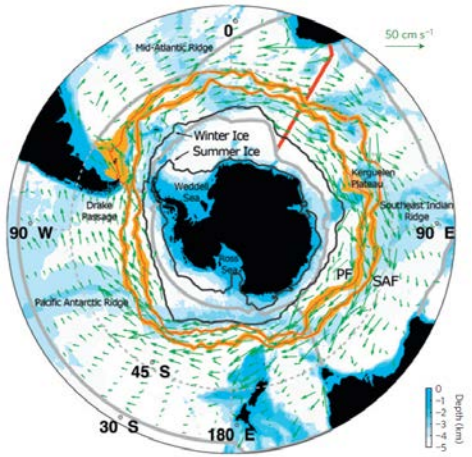

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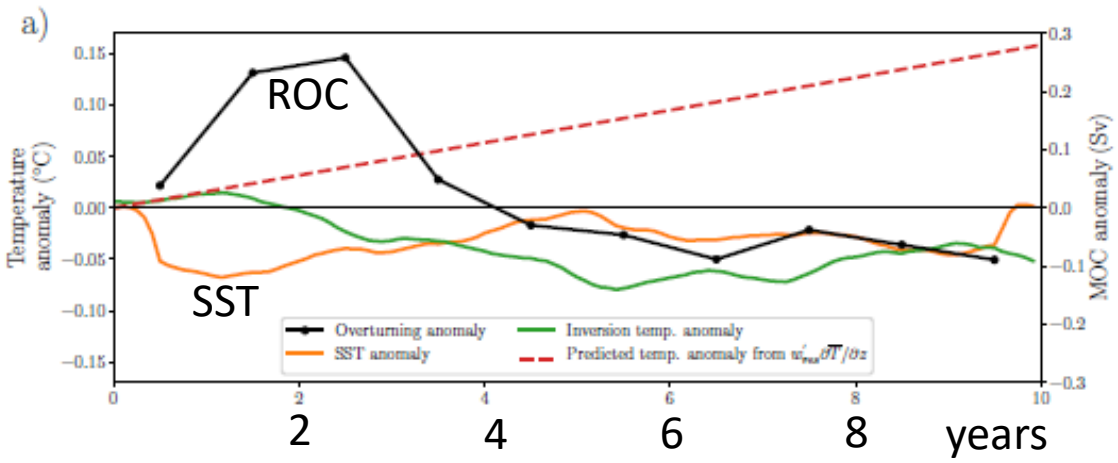
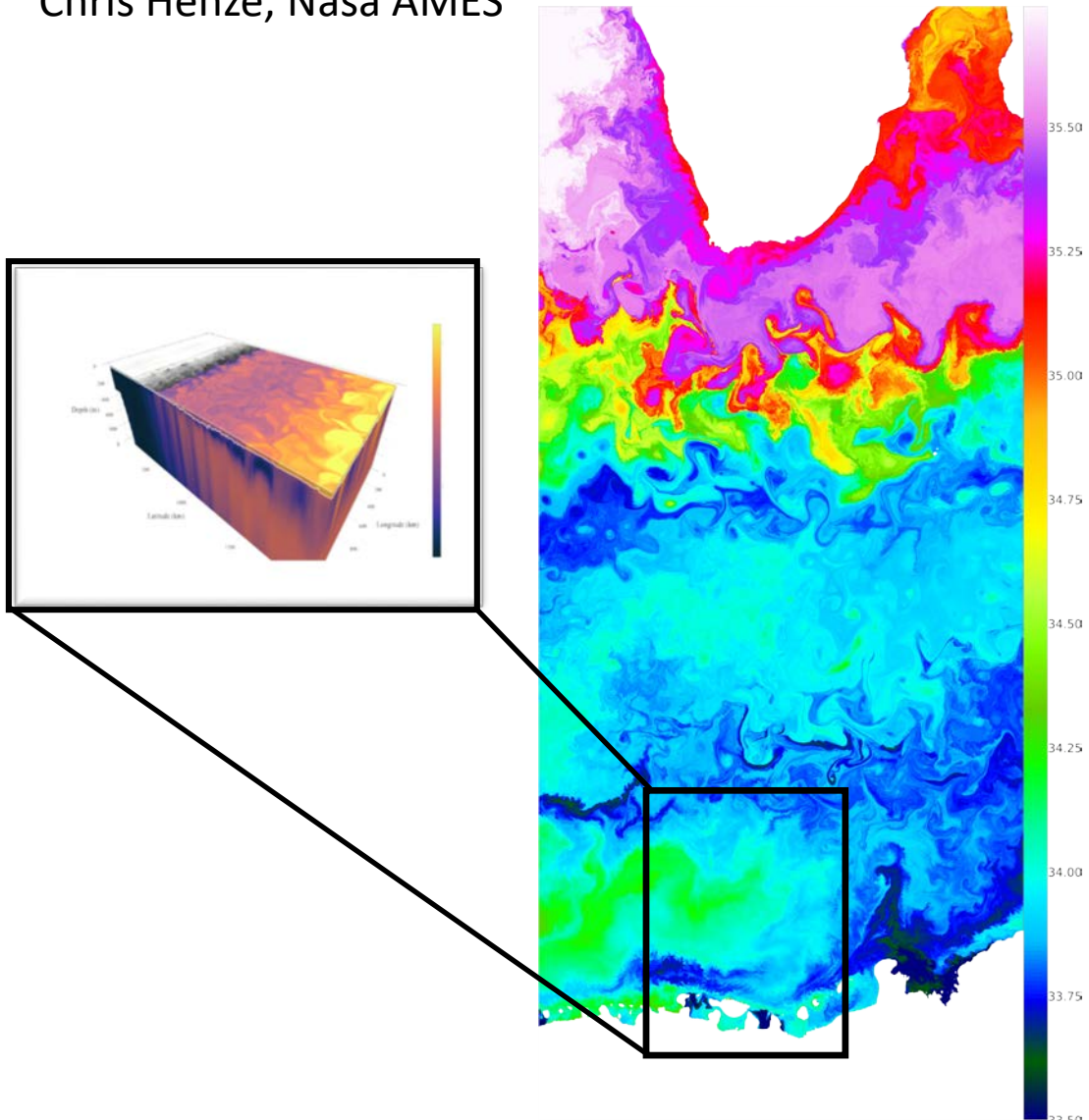


Residual overturning circulation 'turns off', leading to a cessation of warming

Resolving the mesoscale is essential to represent 'compensation' correctly

We are now integrating at channel resolutions globally

Chris Hill, MIT
Dimitris Menemenlis, JPL
Chris Henze, Nasa AMES



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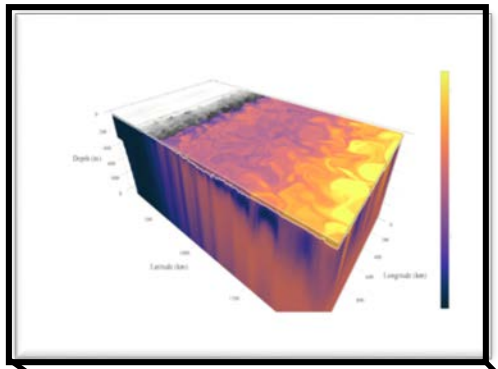
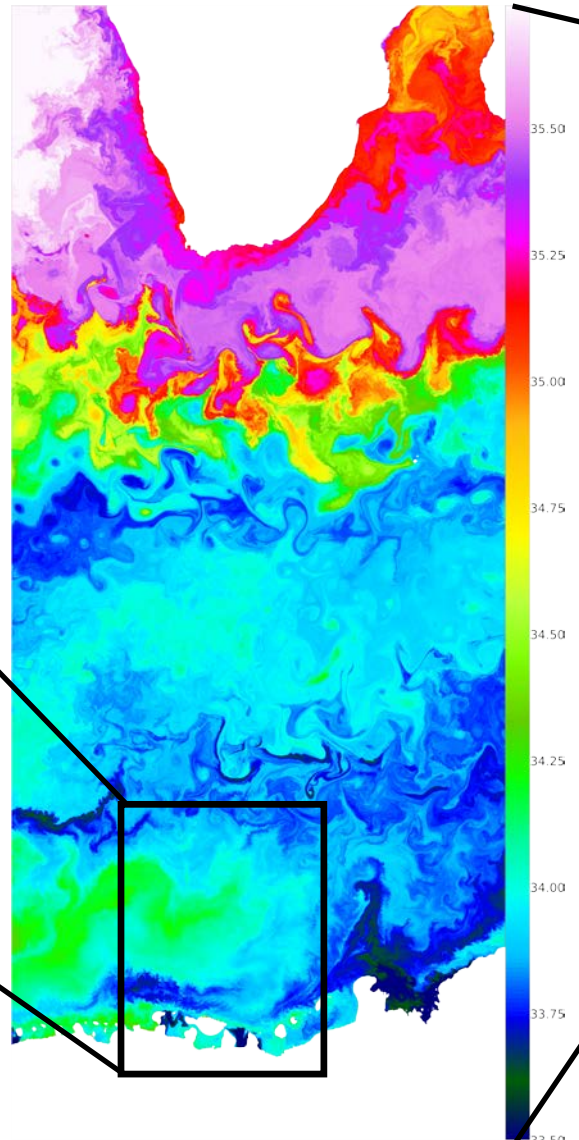
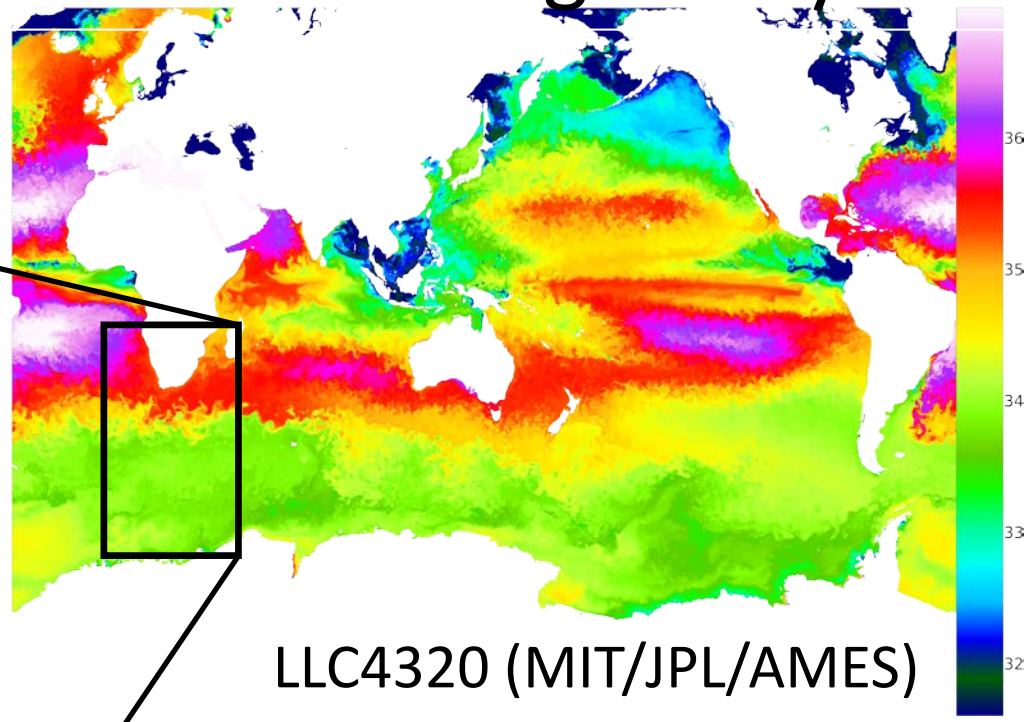






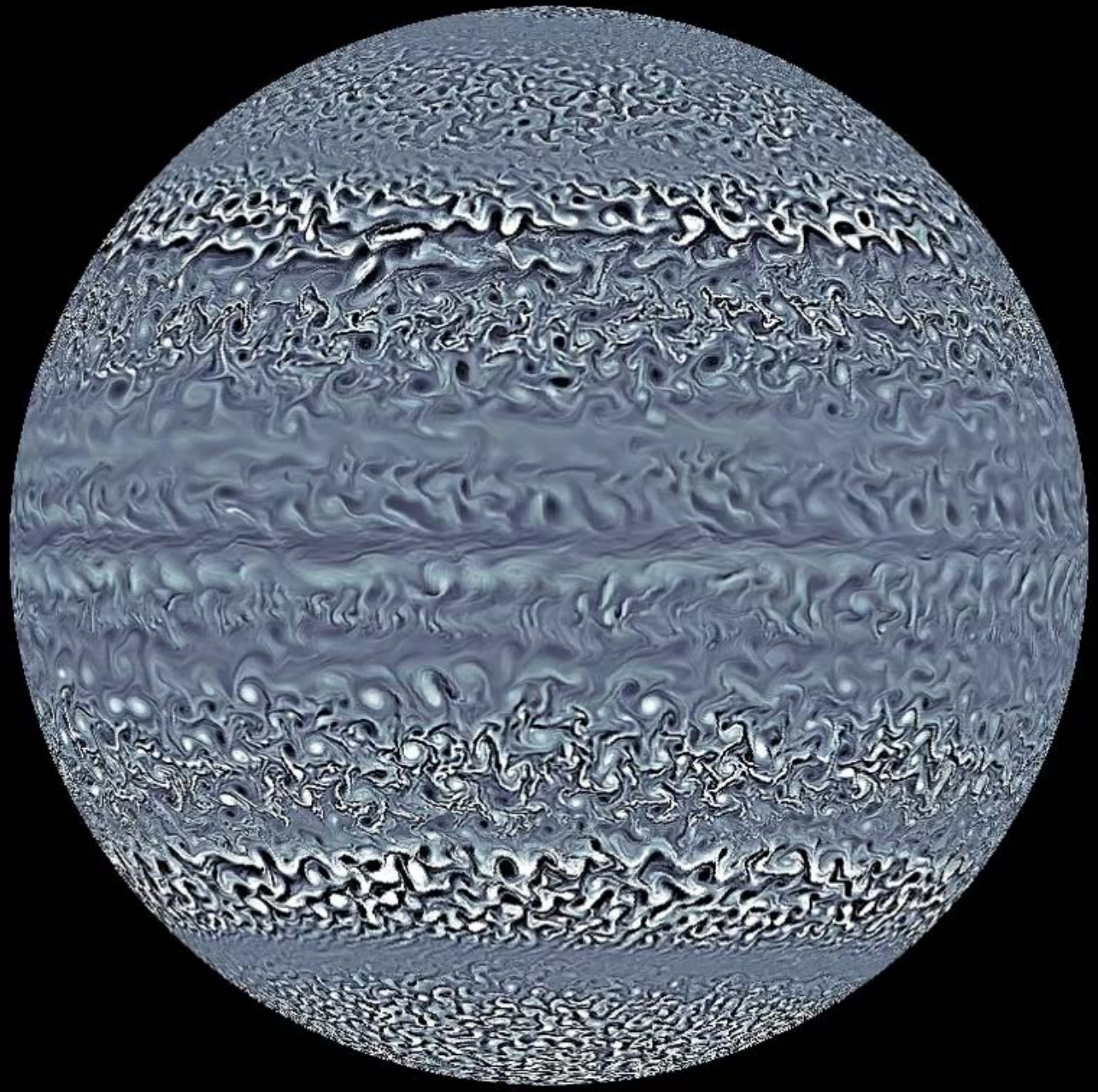
LLC4320 (MIT/JPL/AMES)

Global, 1-2km horizontal resolution
17 x real-time on 3000 computers
1 year in 21 days

Factor of 100 suggests
5 years per day is in reach

450 km

Turing Test!



What the ocean (Earth) would look like if there were no land

Summary

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