# Freshwater accounts for early Last Interglacial high latitude temperature asynchronicity?

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PMIP3 Meeting, Namur, Belgium

BRIDGE

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# Outline

- Why study the Last Interglacial Period?
- A new data synthesis from 130 to 115 ka
- Model-data comparison at the high latitudes
- Reconciling any model-data mismatch?
- What next?

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## Scientists probe Earth's last warm phase

By Jonathan Amos
Science correspondent, BBC News, Vienna

NEEM ICE DRILLING PROJECT

The study used data from the new NEEM ice core drilled in Greenland

**Scientists now have a fuller picture of what happened at the poles during the last warm phase on Earth.**

Known as the Eemian, this time period extended from roughly 129,000 years ago to about 116,000 years before present.

The poles were known to have been a few degrees warmer than they are today.

But by pulling together more than 40 ice core and marine sediment records, researchers, led by the British Antarctic Survey (BAS), have obtained the most comprehensive assessment yet.

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# The Last interglacial Period (LIG)


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# The LIG

**+6-9 m**

(Kopp et al. 2009)

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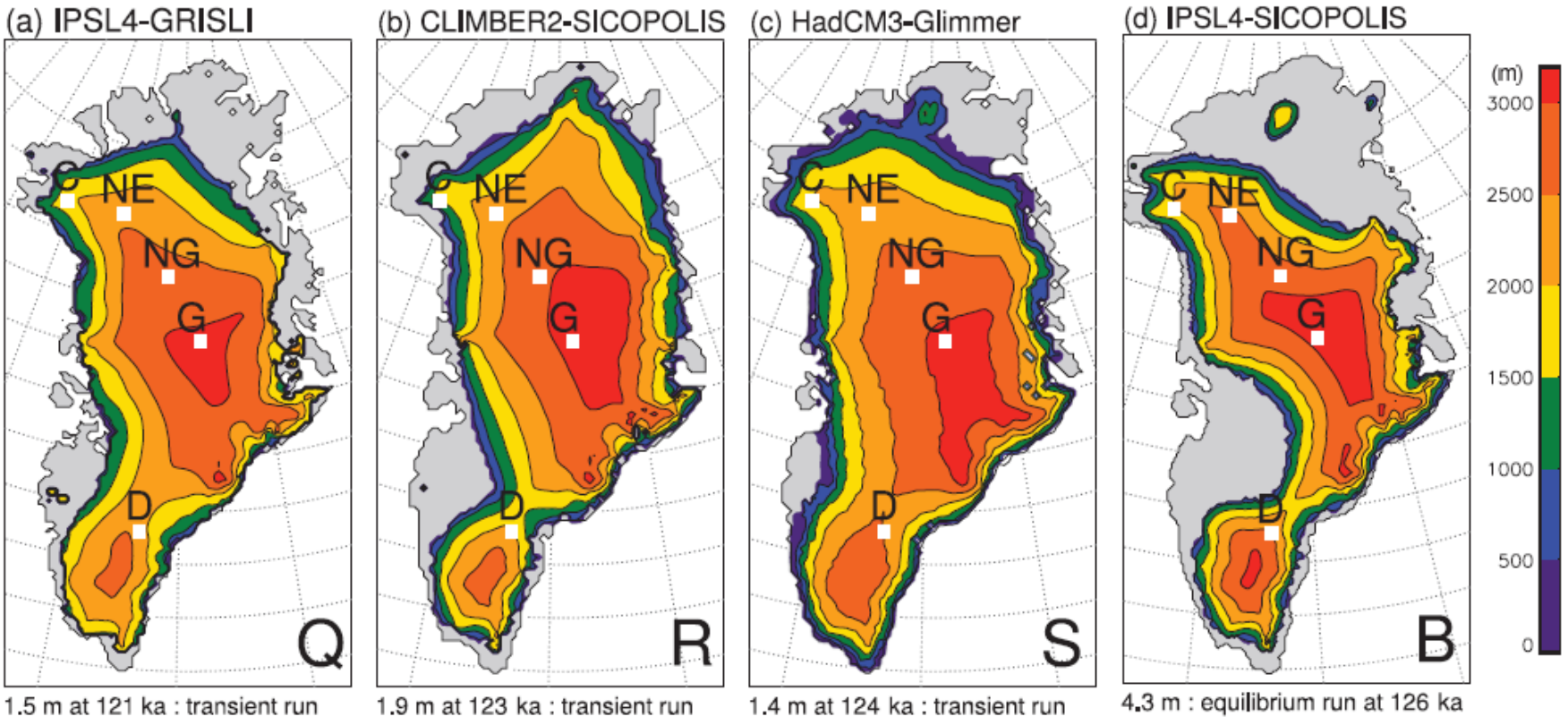
# The LIG


1.5 m at 121 ka : transient run

1.9 m at 123 ka : transient run

1.4 m at 124 ka : transient run

4.3 m : equilibrium run at 126 ka

**AR5**

**→Significant contribution from Antarctica**

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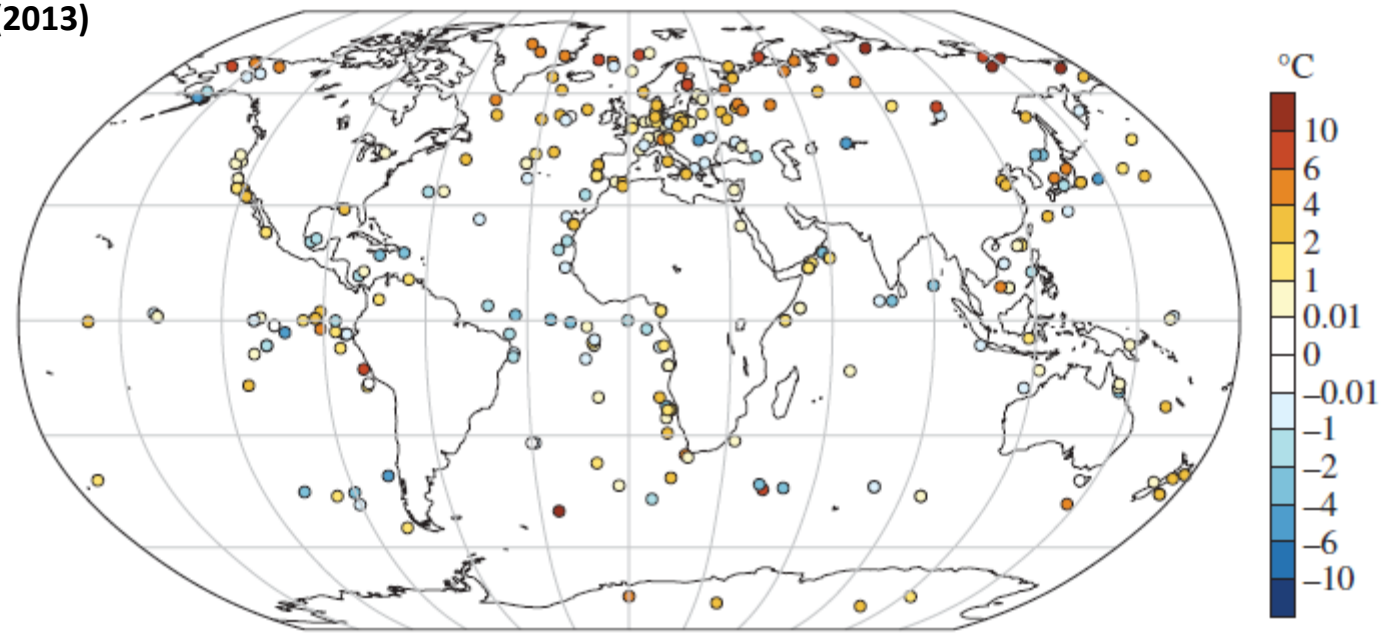
# Current LIG data synthesis

**Figure from Otto-Bliesner et al. (2013)**




- Comprehensive dataset
- Represents the *warmest* temperatures of the LIG
- No **temporal** resolution

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# Current LIG Model-data comparison

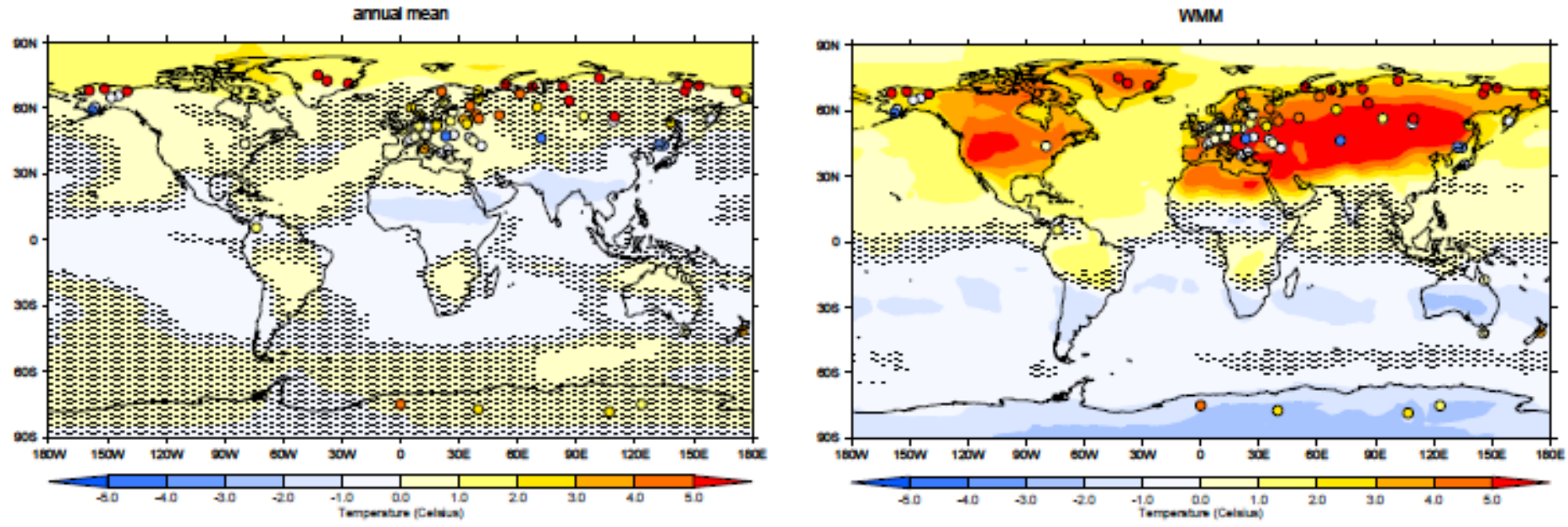


Figure from Lunt et al. (2013)

- Output from the first PMIP3 meeting in Crewe 2012

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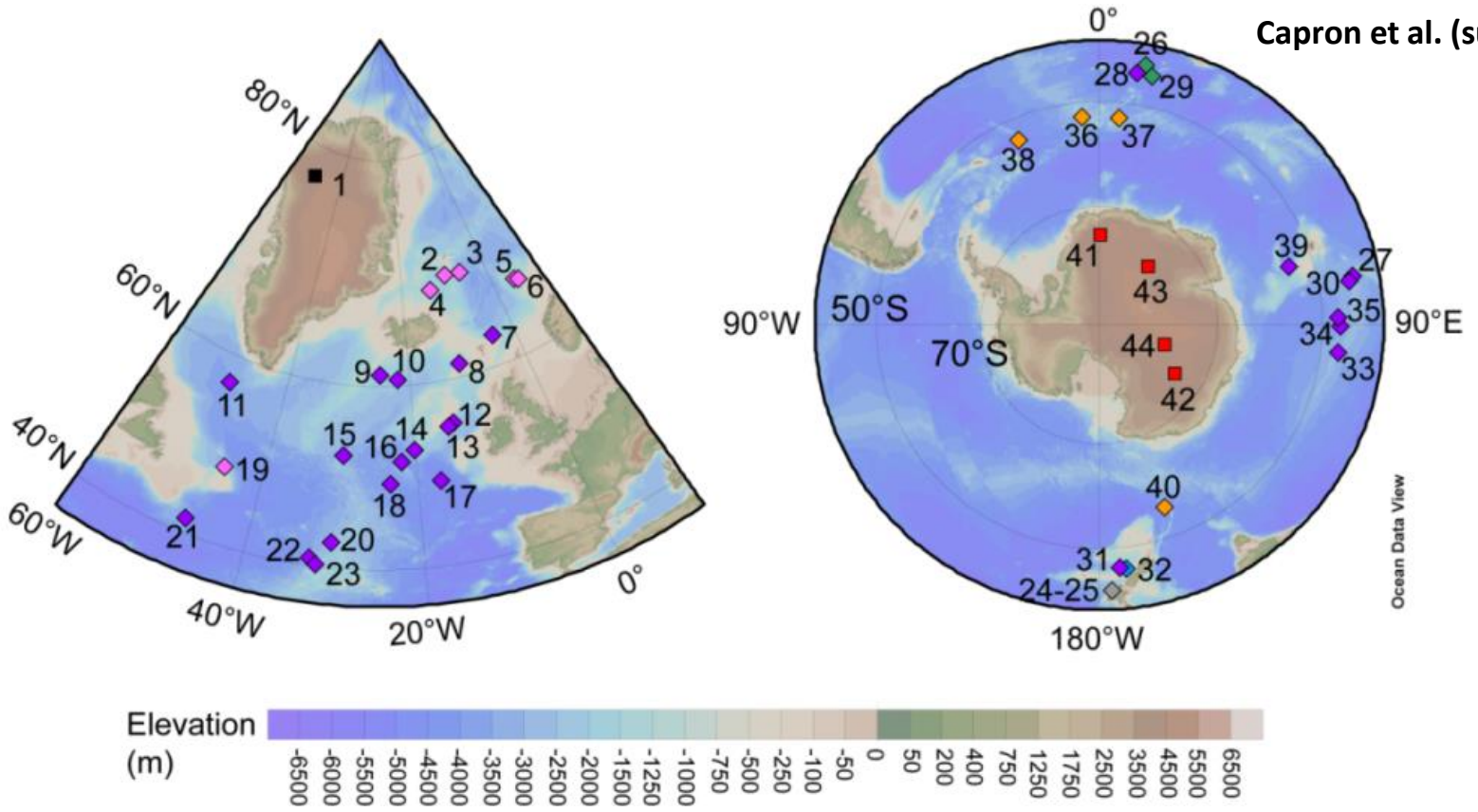
# A new data synthesis: Locations




- Air and sea surface temperature records from marine and ice cores
- Above lat. 40°N and 40°S and > 2000 yrs- resolution

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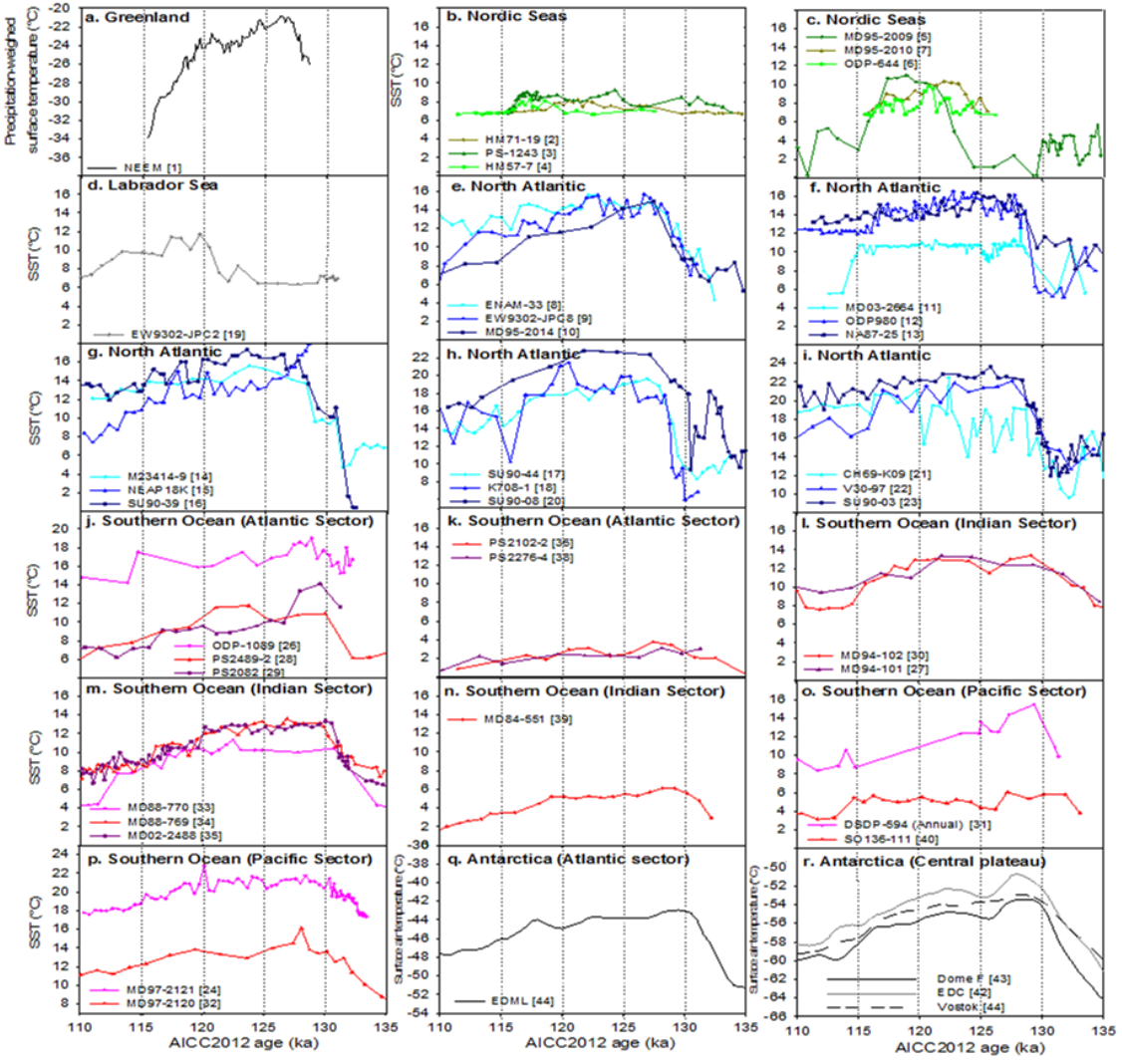
# Data synthesis: Reconstructing the LIG climate




Capron et al. (submitted)

**Spatial** and **temporal** reconstruction of the LIG climate

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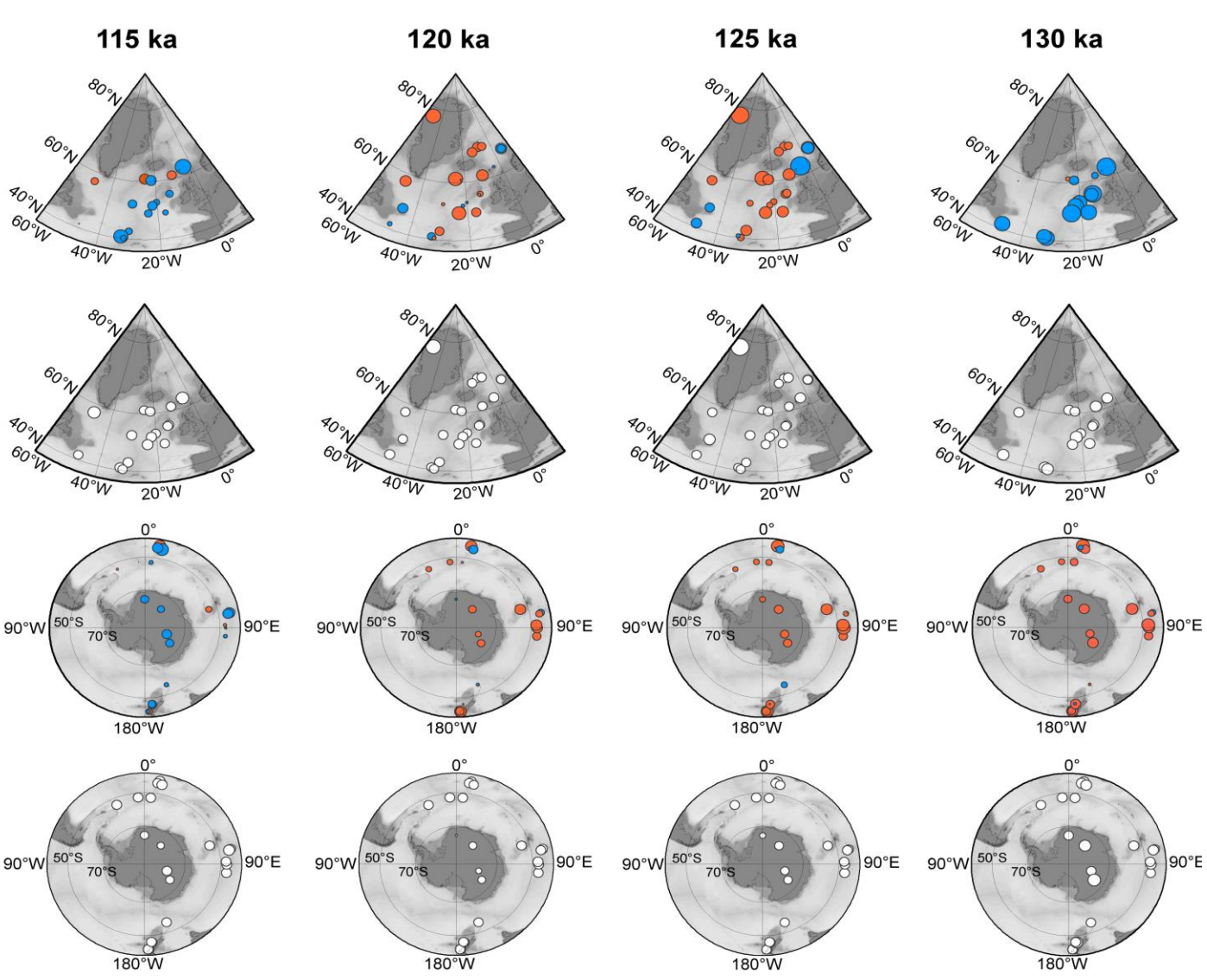
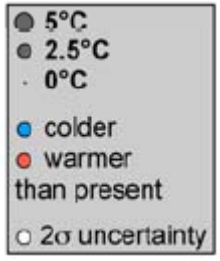
# Data synthesis: Time-slices




**Sequence of time slices** rather than a "peak warmth" snapshot

**Capron et al. (submitted)**

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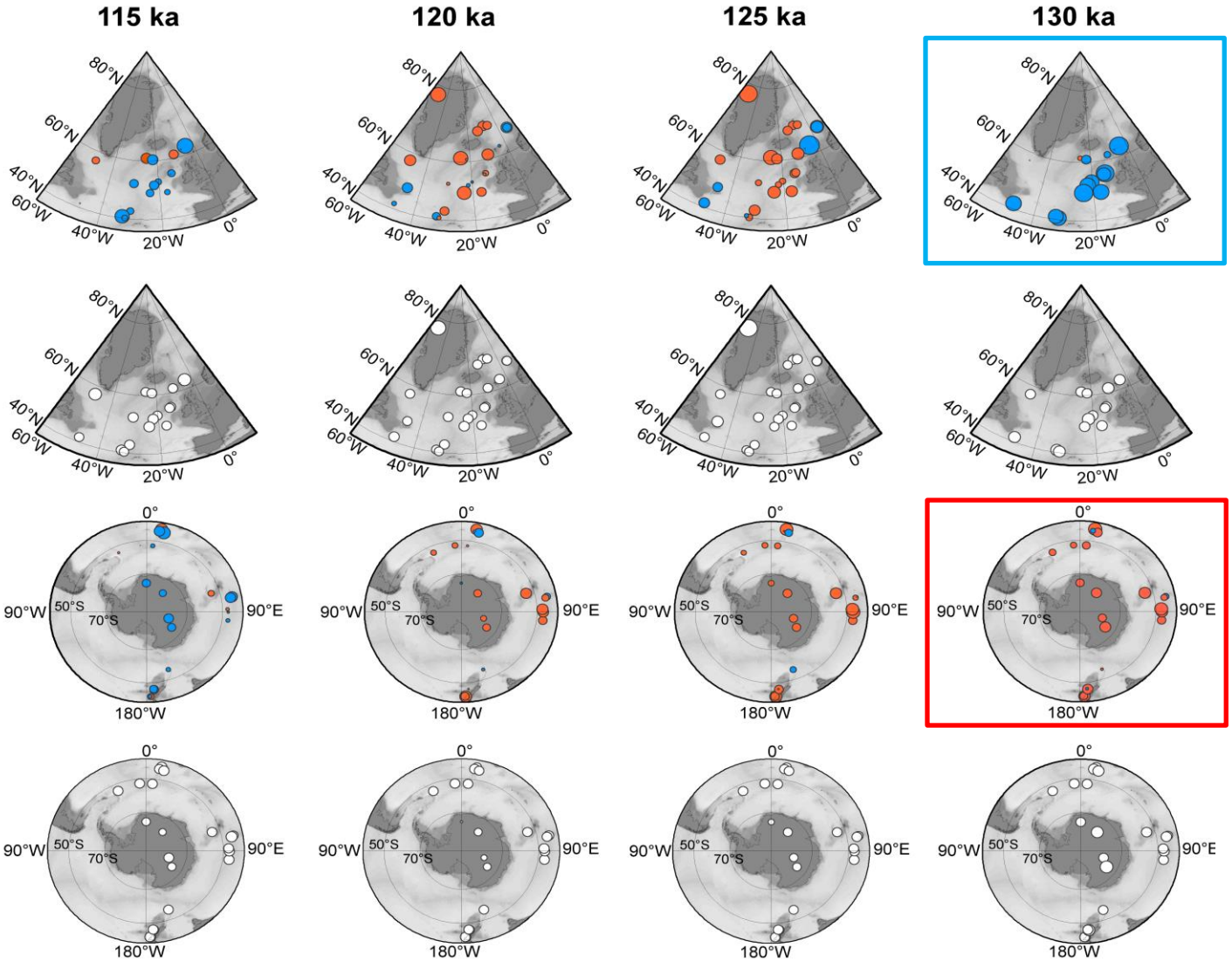
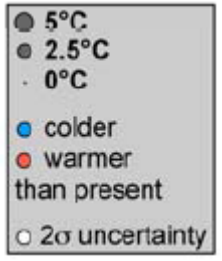
# Data synthesis: Time-slices

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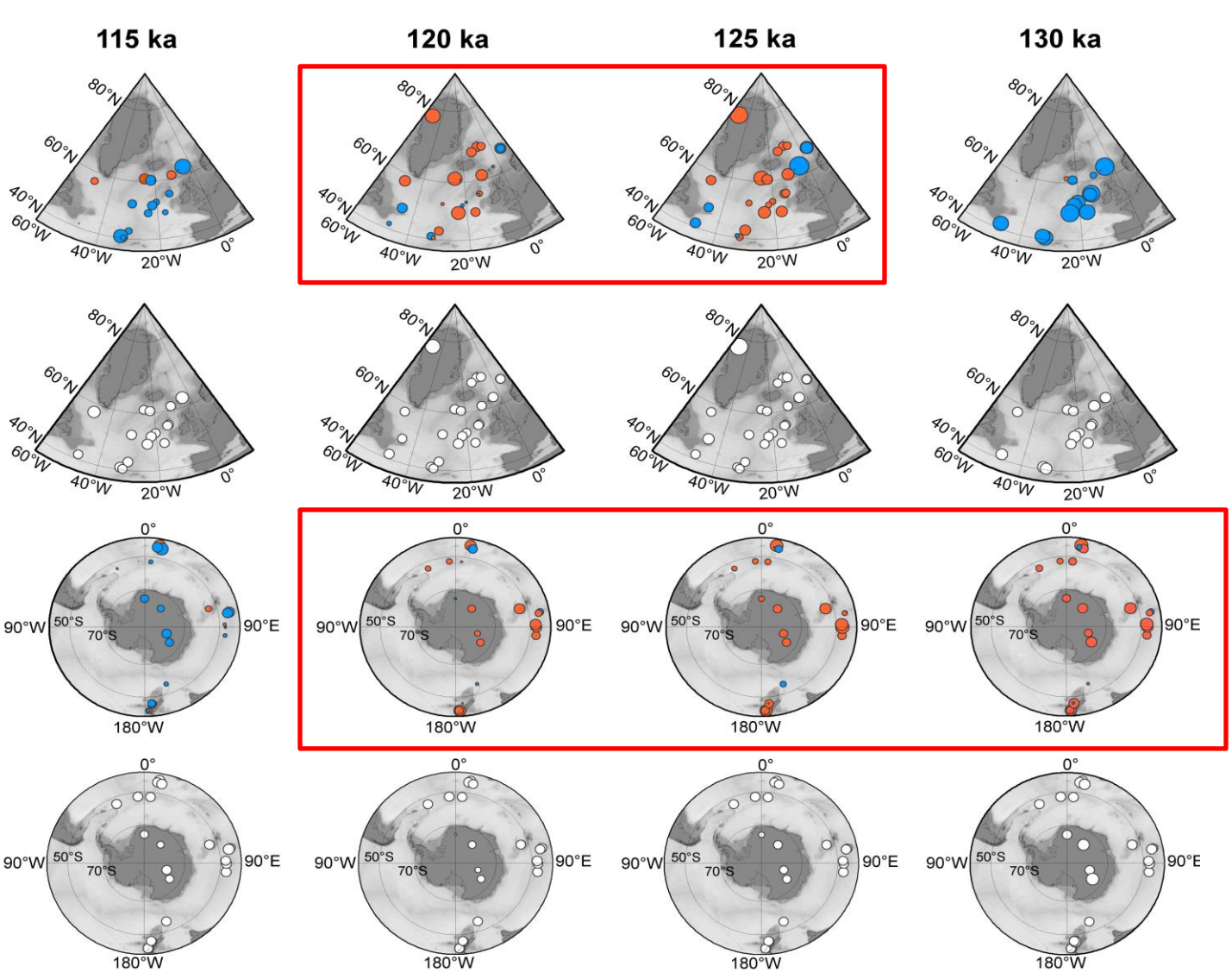


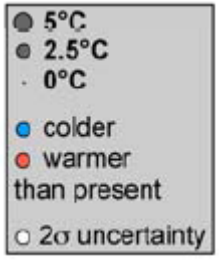


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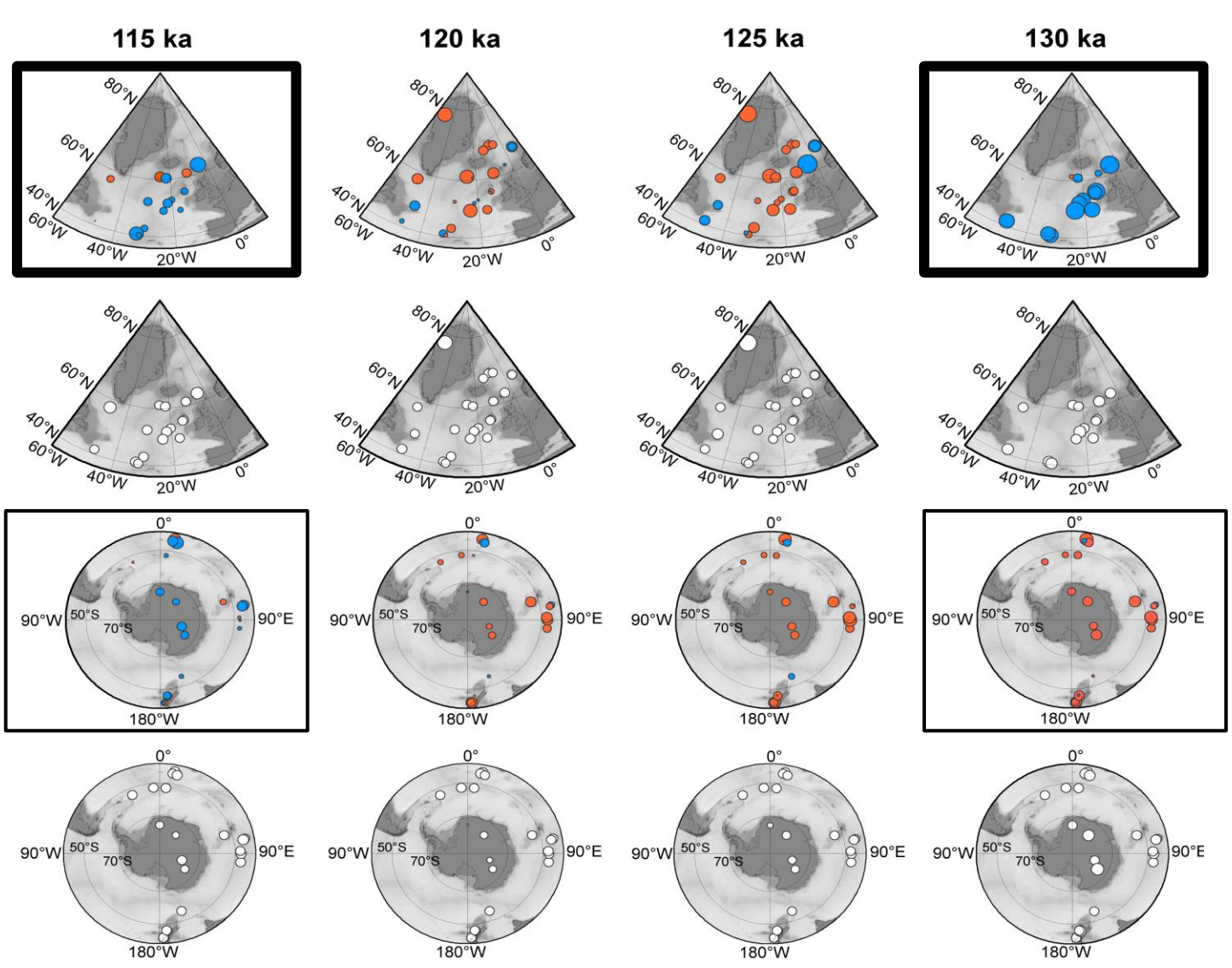


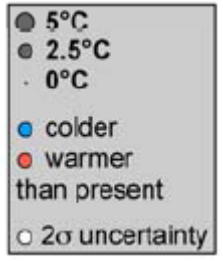


**Sequence of time slices** rather than a "peak warmth" snapshot

**Capron et al. (submitted)**

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# Modelling the LIG climate

**Changed orbital parameters (insolation)** ✓

**Changed GHGs** ✓

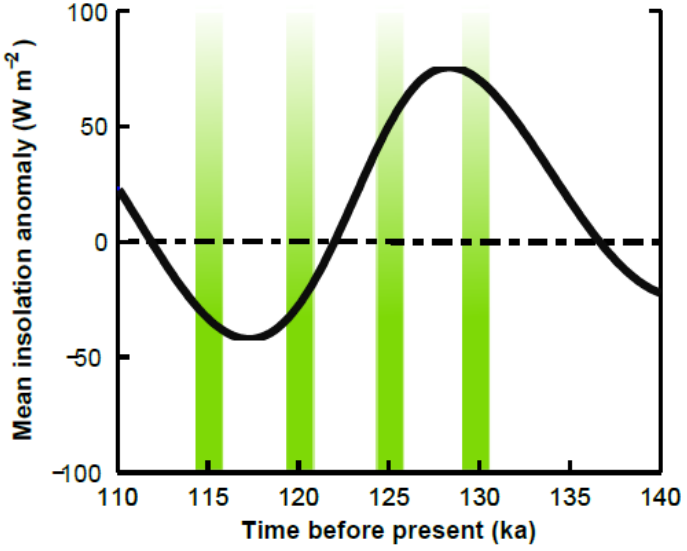
**Changed ice sheet** ✗

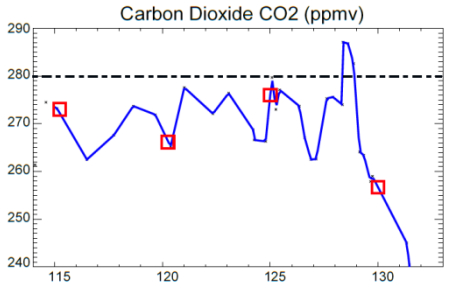
**Vegetation feedbacks** ✗

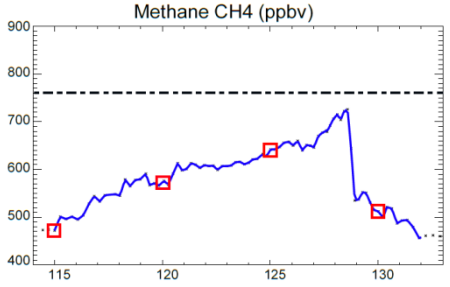
**Freshwater forcing** ✗

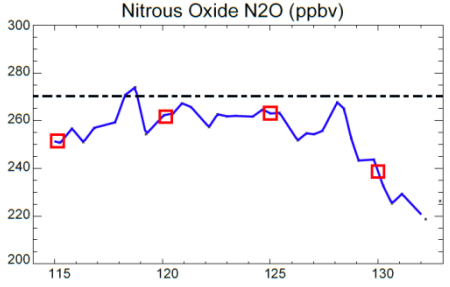
**HadCM3 = SNAPSHOTS**

- **4 simulations of 550 model years: 130, 125, 120 and 115 ka (BP)**

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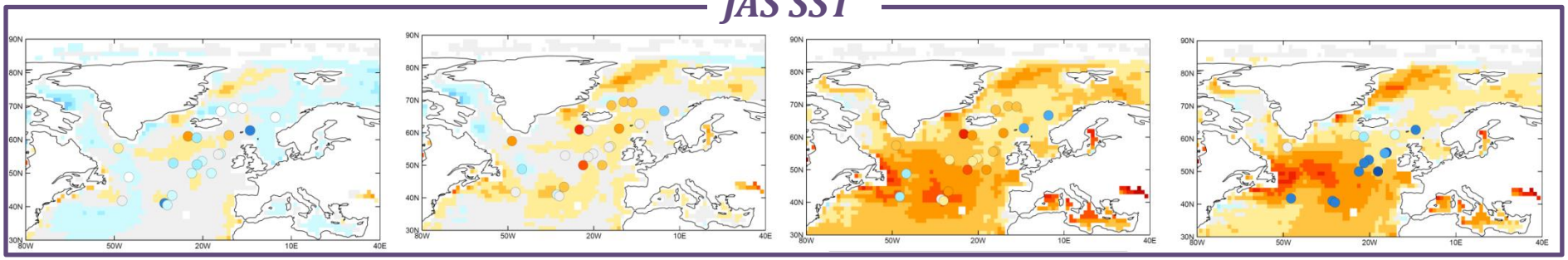
# Model-data comparison

115 ka | 120 ka | 125 ka | 130 ka

*JAS SST*



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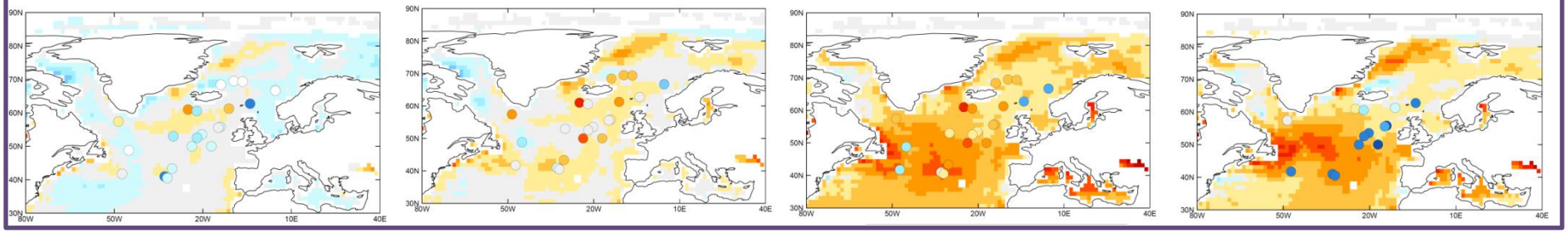
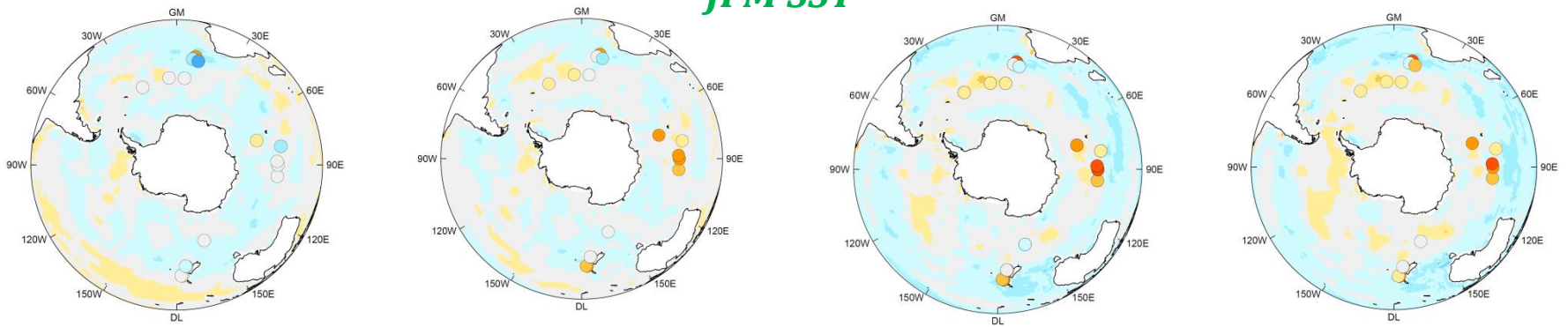



*JFM SST*



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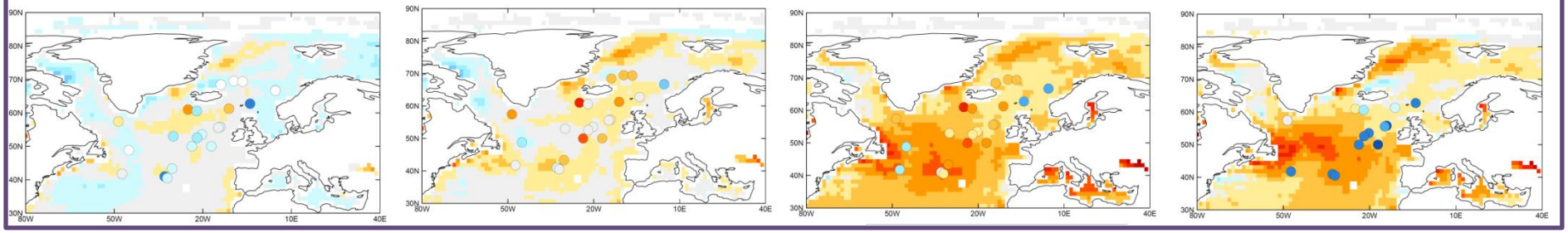

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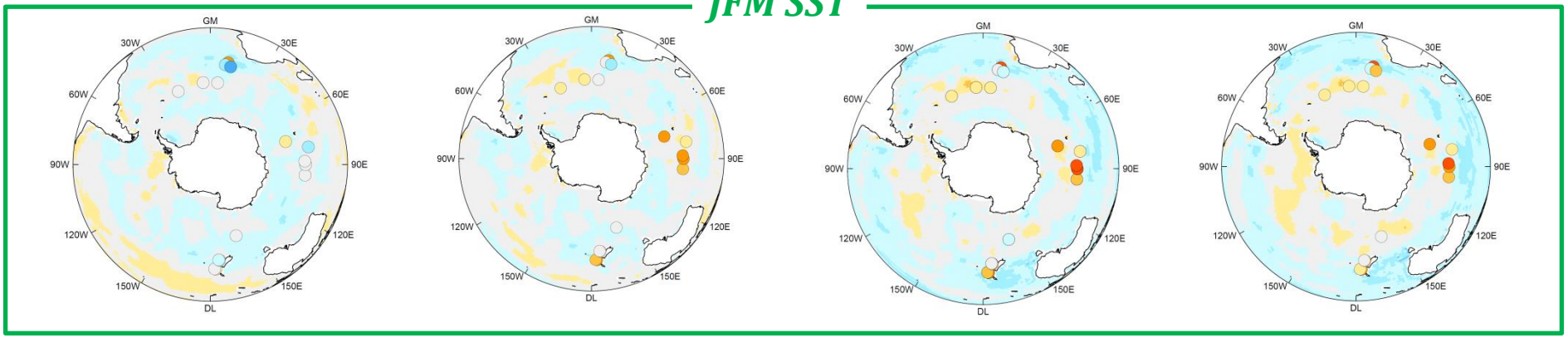
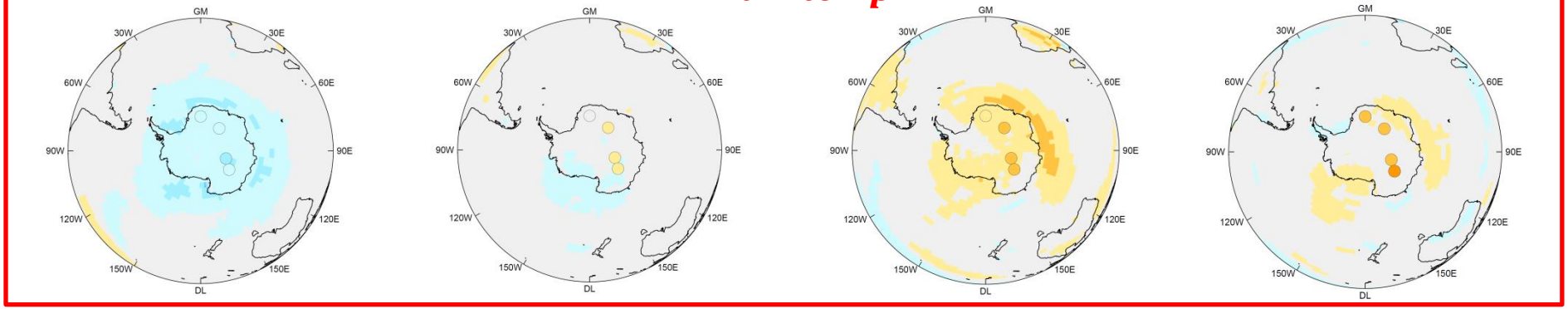
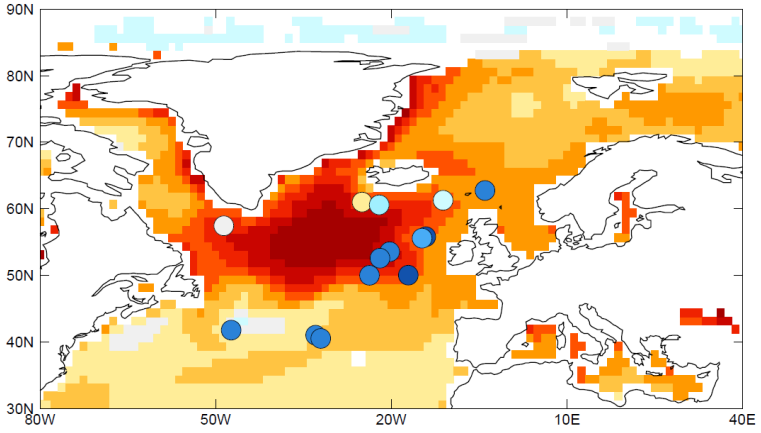


*Ann air temp*



# What about comparing with other models?

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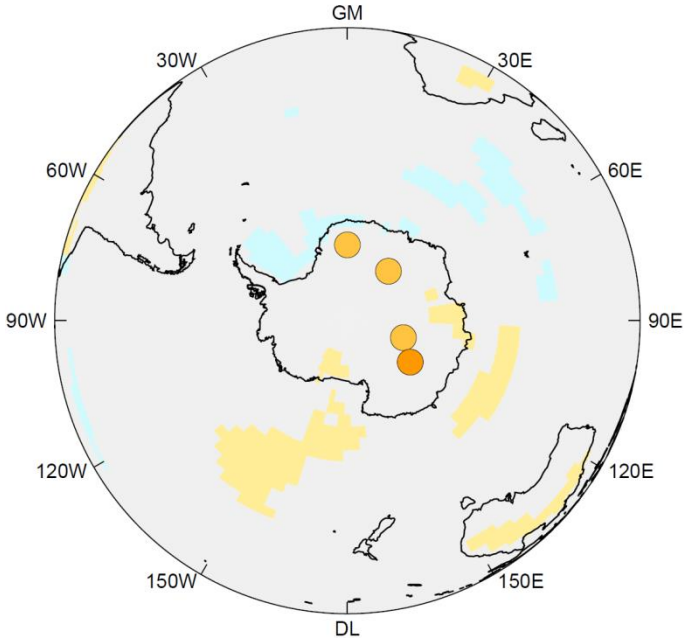


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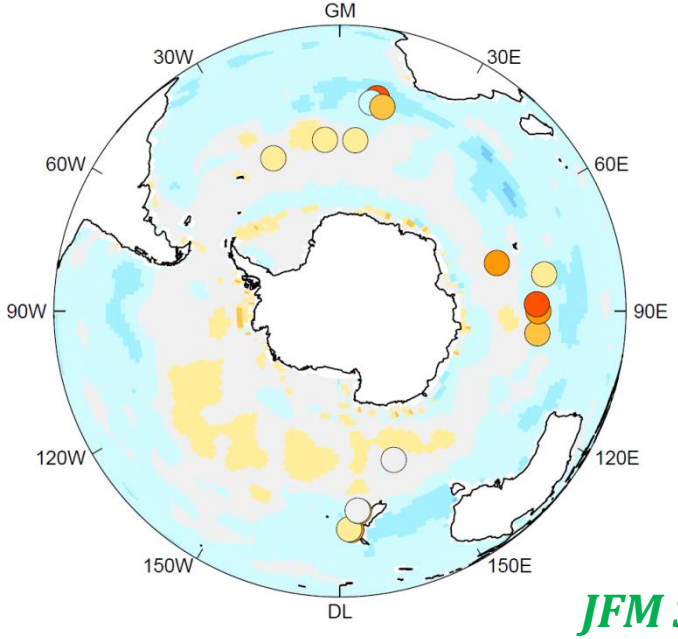


*JFM SST*

**130ka with CCSM3 (Otto-Bliesner et al. 2013)**

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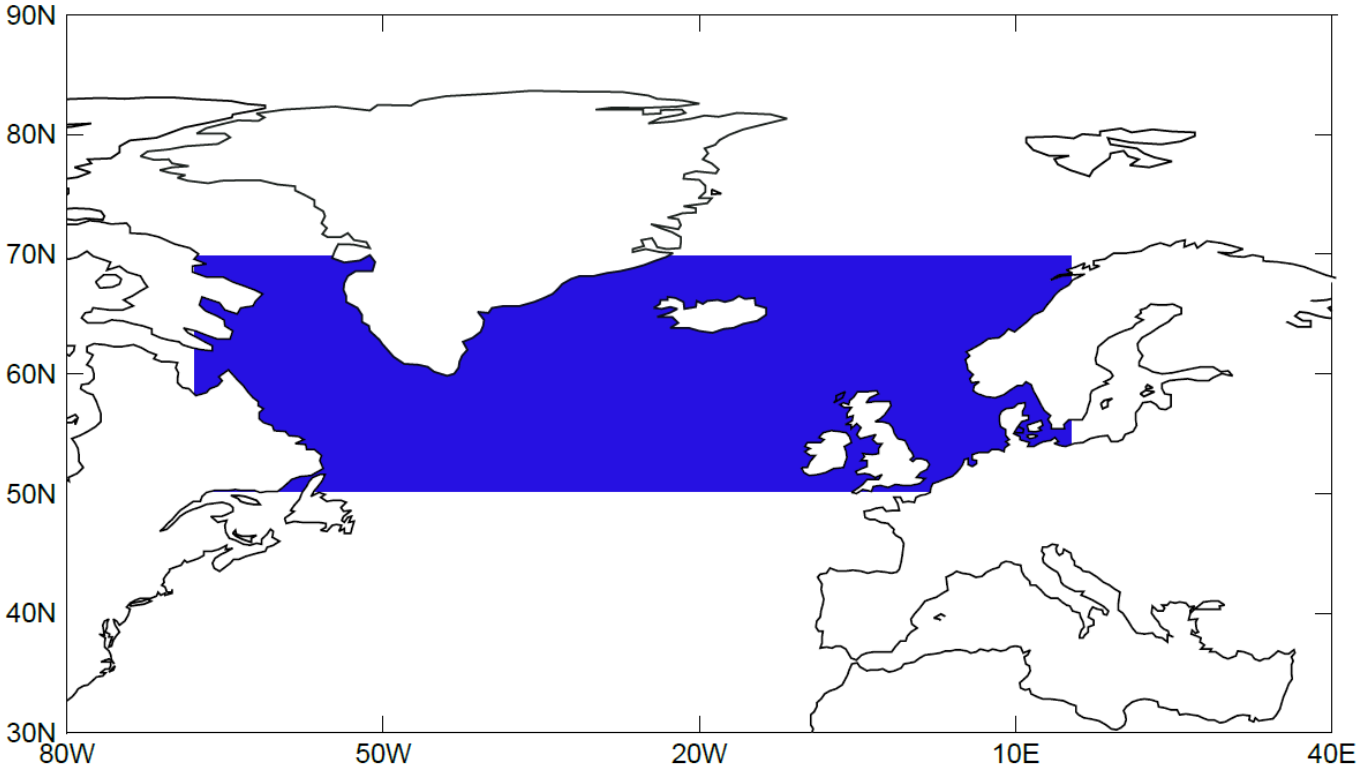
# Reconciling the mismatch: 1 Sv forcing




**1 Sv in North Atlantic for 200 years…**

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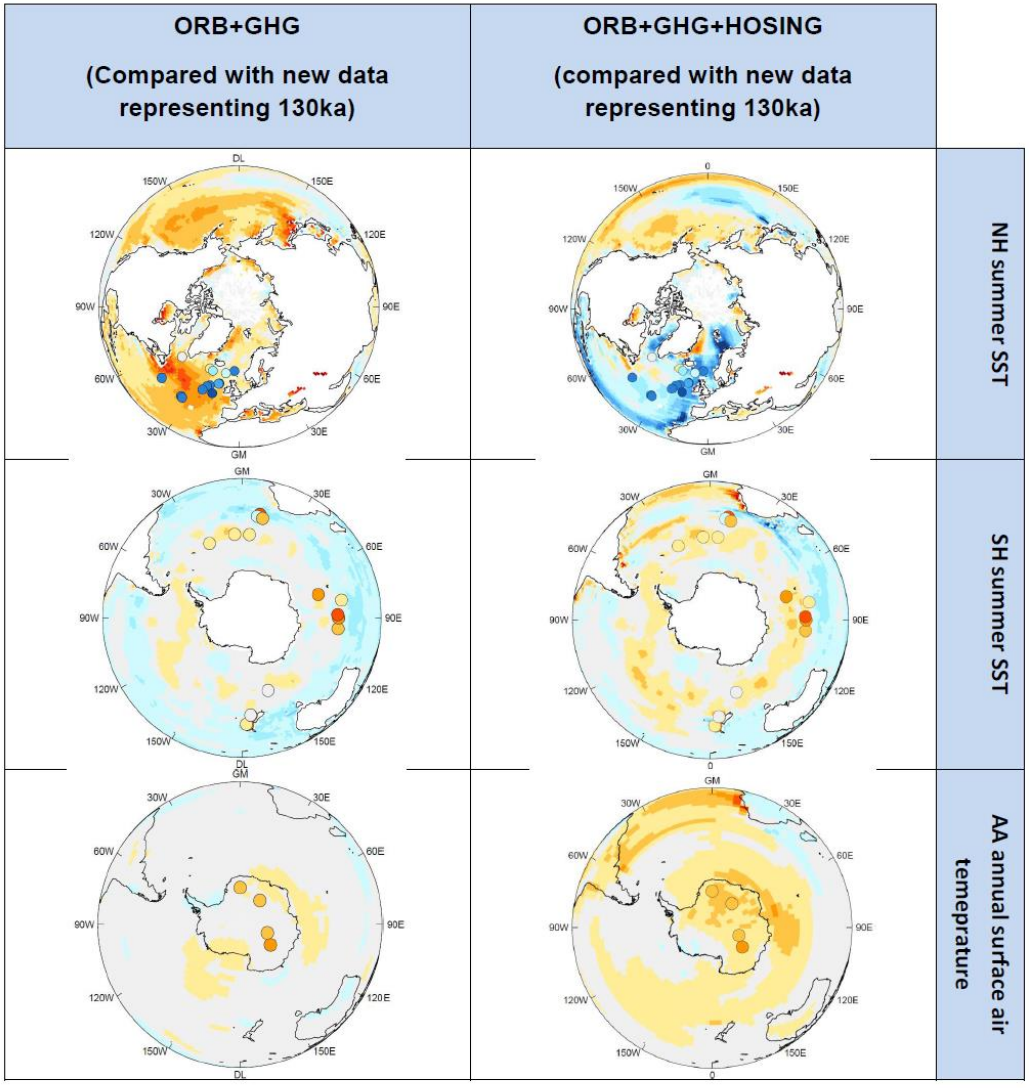


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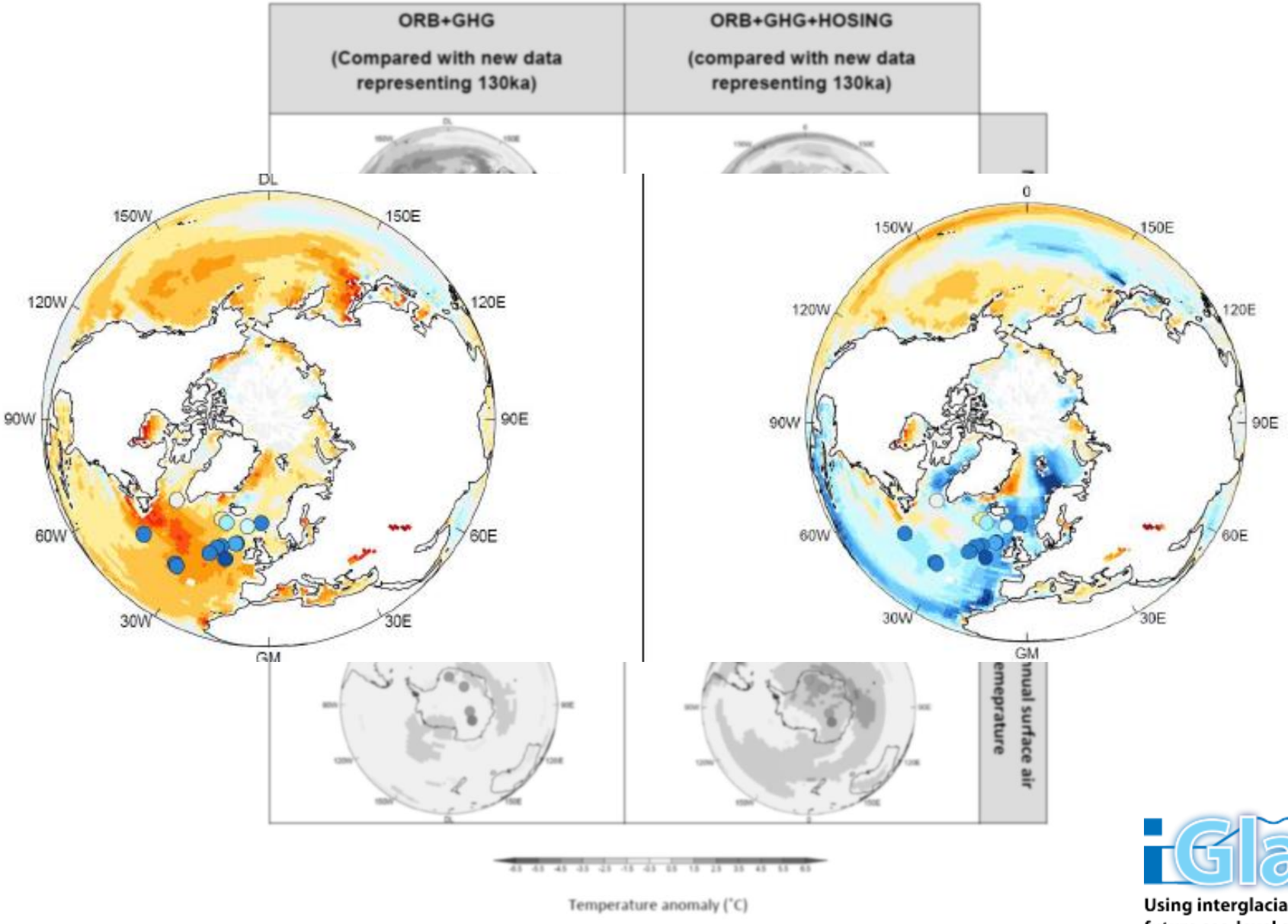


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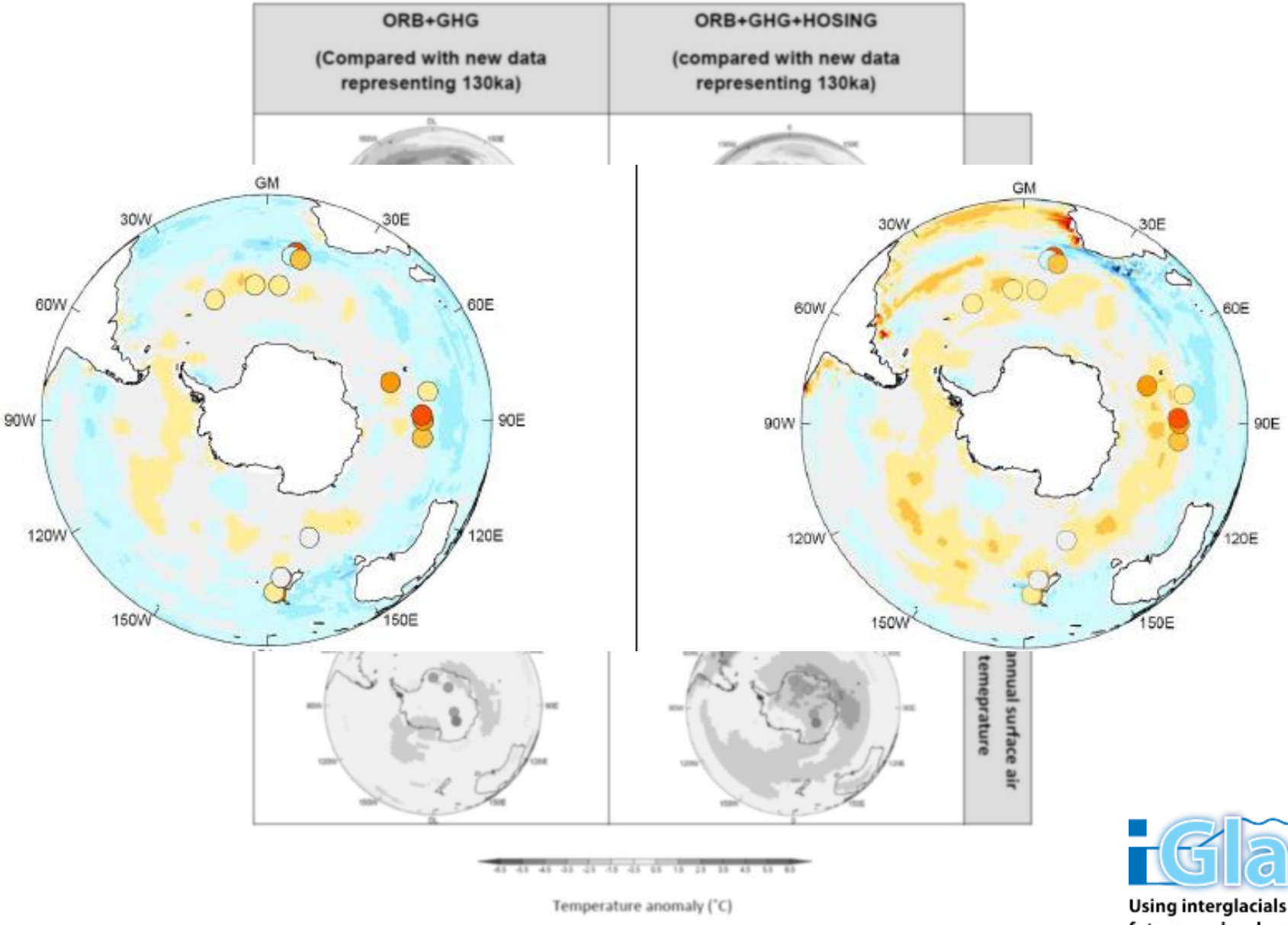


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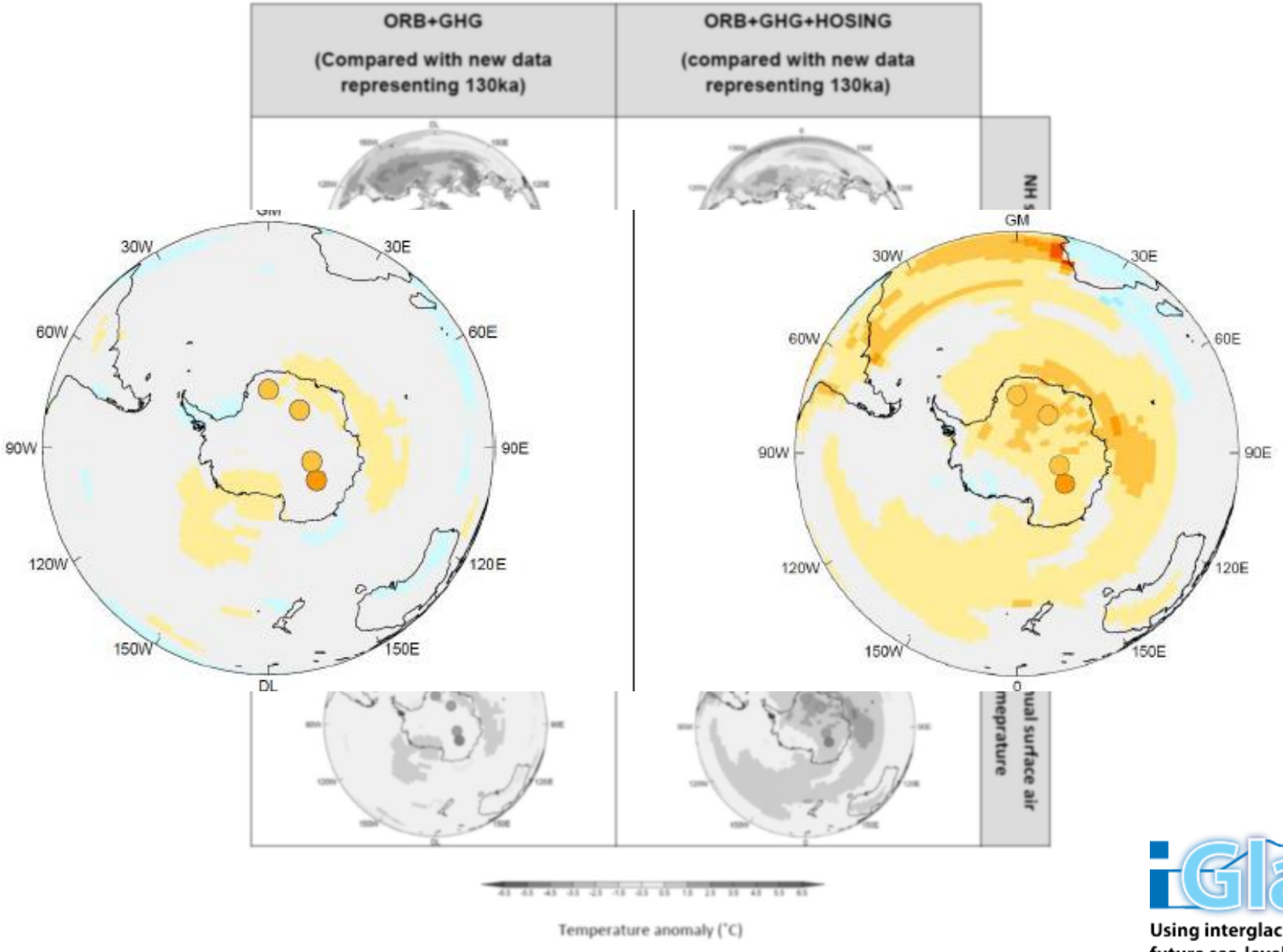


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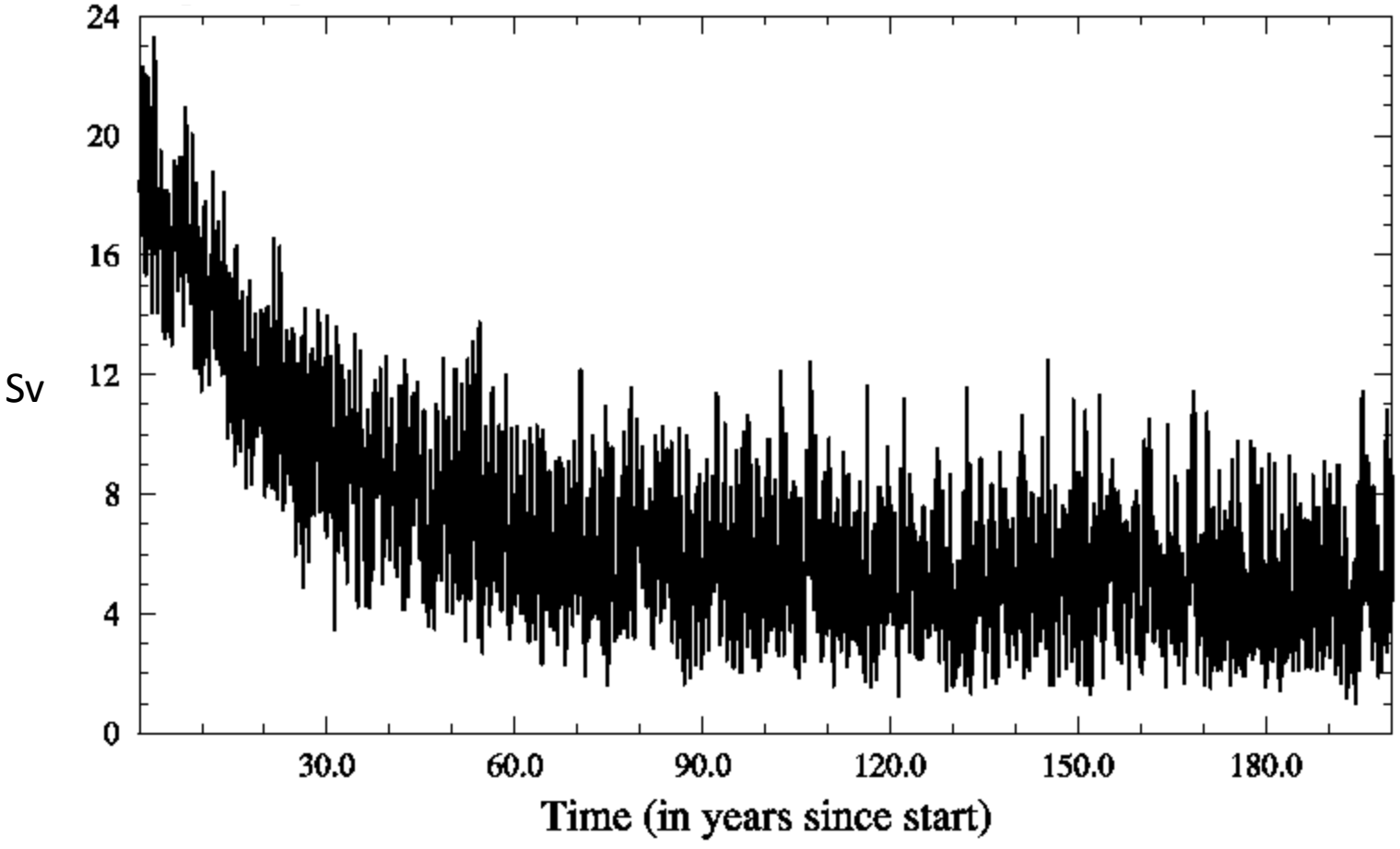


**Maximum Atlantic overturning circulation (between 20-80˚N) for 1 Sv forcing**

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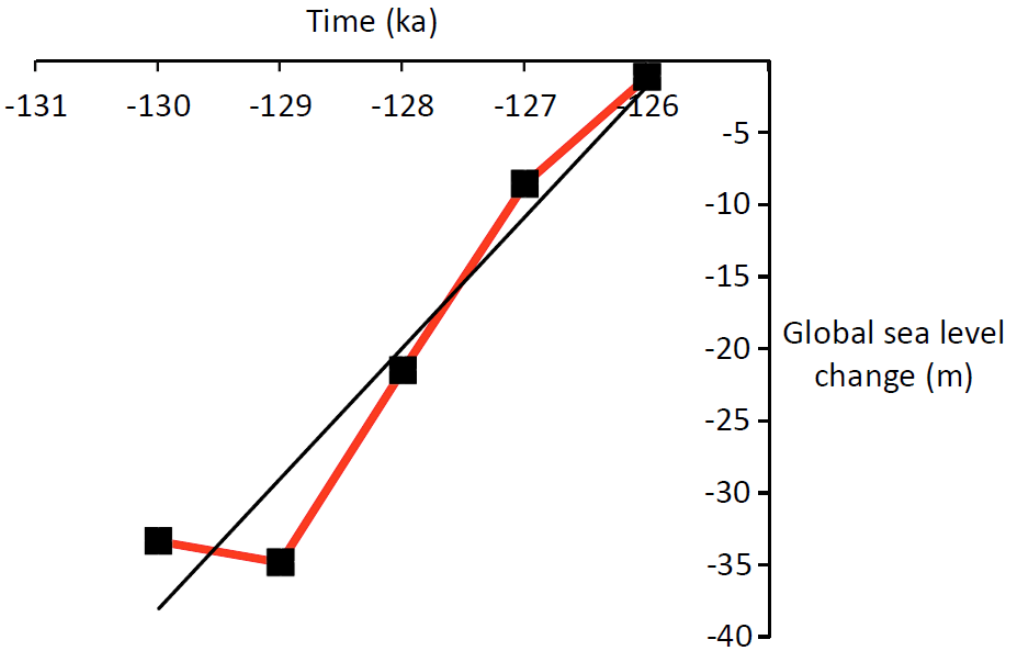
# Reconciling the mismatch: freshwater sensitivity

**Is the forcing too large?**

1 Sv over 200 years is equivalent to ~2 GrIS melting unrealistic!

Calculate rate of sea-level change from Kopp et al. (2009)

➢ ~0.1 Sv

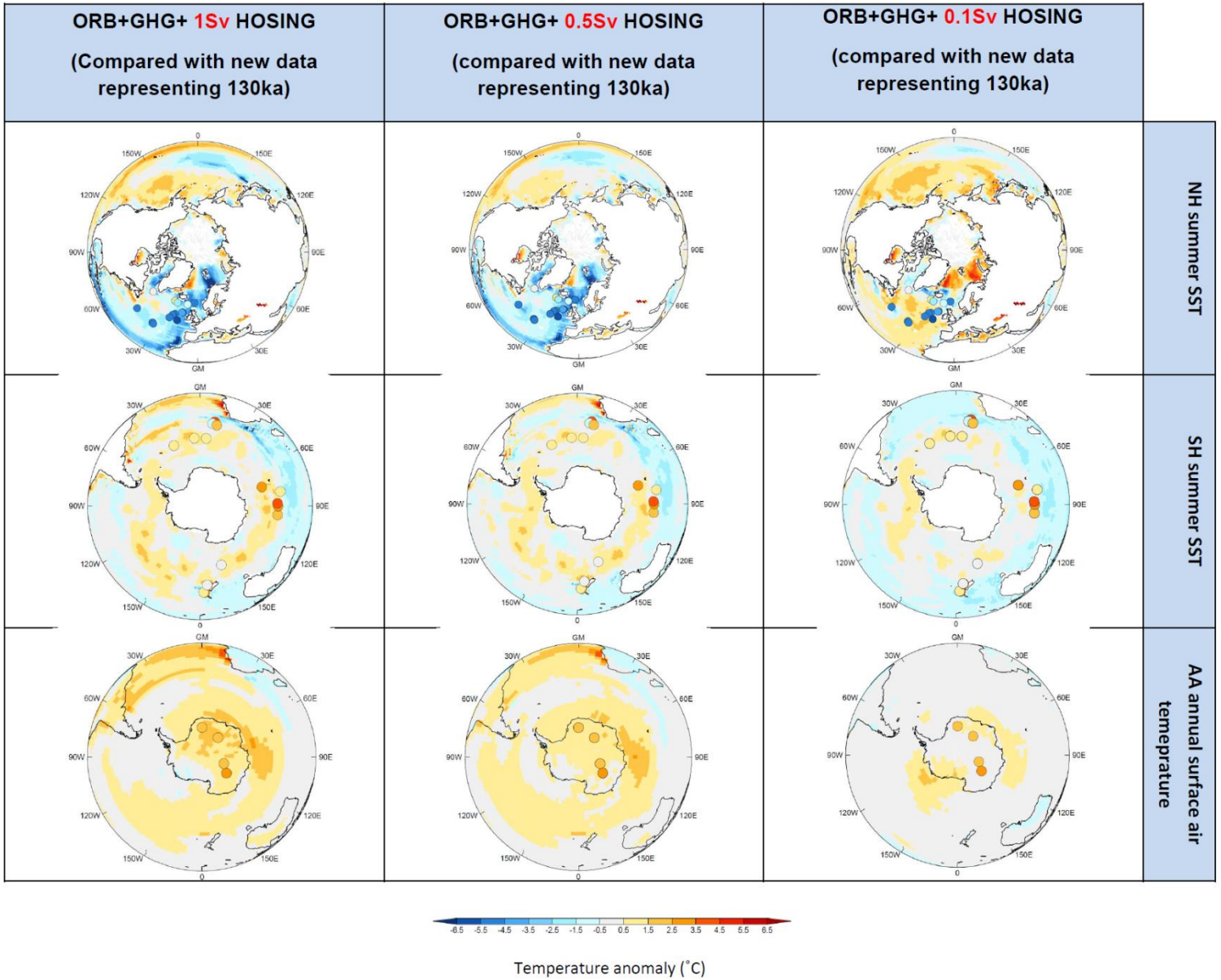



From Kopp et al. (2009)

**Sensitivity experiments:-**

1. **0.1 Sv**
2. **0.5 Sv (represent deglaciation and H11?)**

# Reconciling the mismatch: freshwater sensitivity



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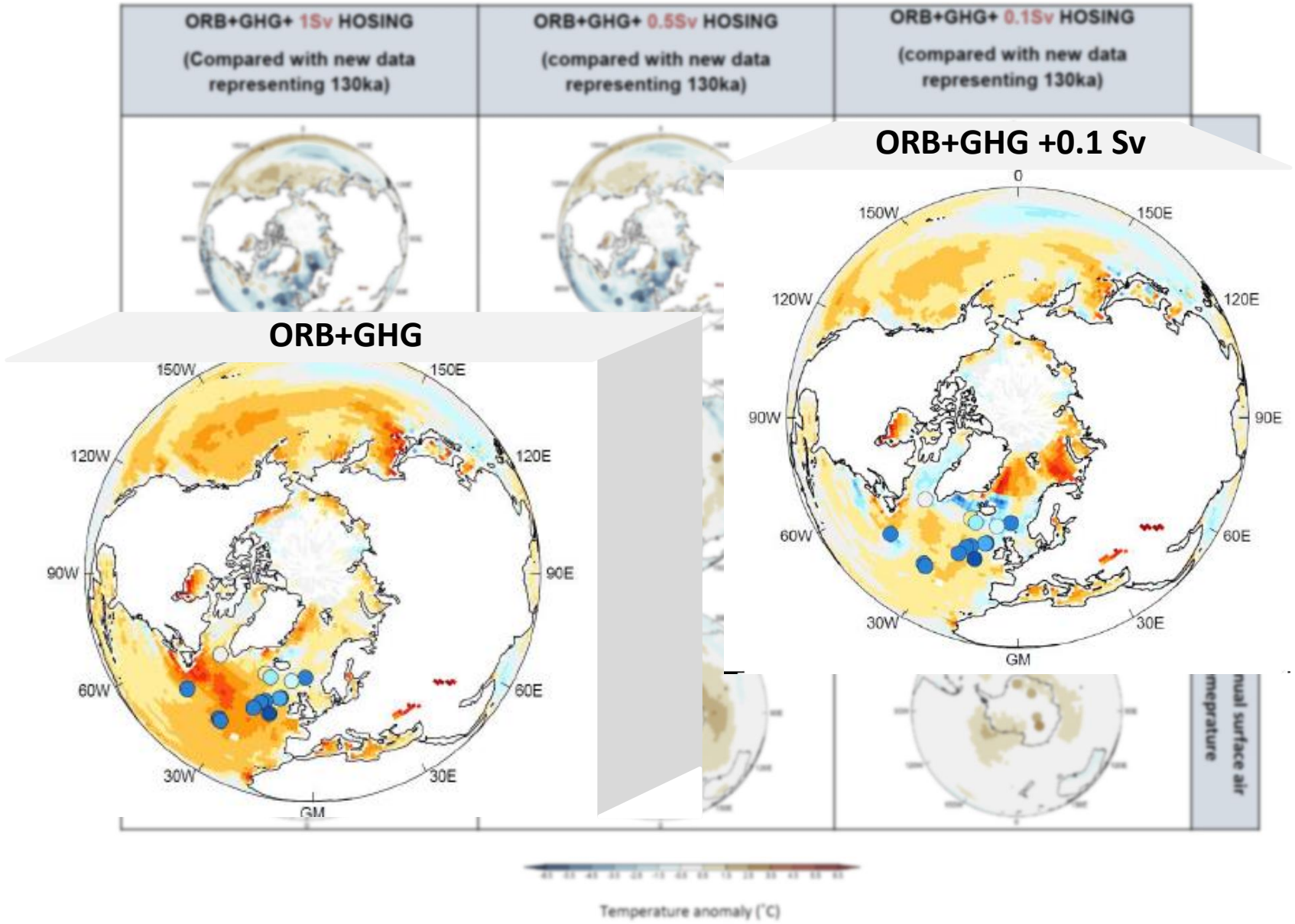


# Conclusions and what next?

- A new LIG high latitude temperature data synthesis with time slices at 130 ka, 125 ka, 120 ka, 115 ka has been produced with associated quantitatively estimated uncertainties

- Relatively good agreement (within ± 2°C) between HadCM3 115 ka, 120 ka, 125 ka simulations and the data time slices

- 130 ka:
  - Non-synchronous maximum summer temperature changes between the two hemispheres with the Southern Ocean and Antarctica records showing early warming compared with North Atlantic records

  - Comparison with model simulations (ORB+GHG only)shows that the models predict warmer than present conditions earlier than documented in the North Atlantic records, while the reconstructed early Southern Ocean and Antarctic warming is not captured

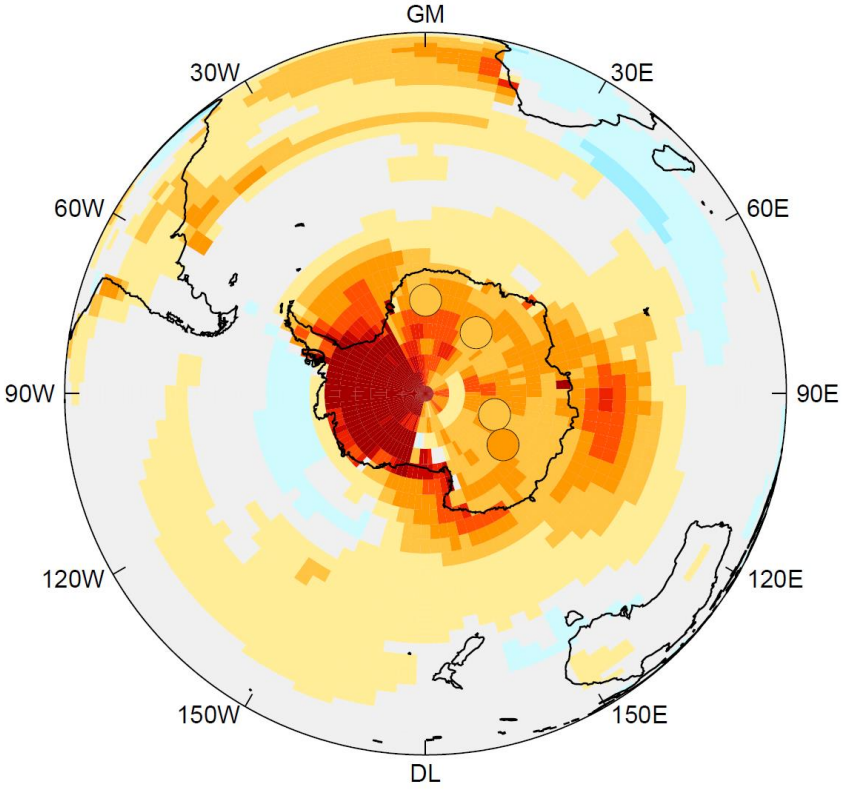
    - **MISSING processes/feedbacks in the models**

- This Bipolar seesaw in temperature between hemispheres at 130 ka can be reproduced in the model with a freshwater hosing of 1 Sv

- Preliminary sensitivity studies show that a similar response can be attained with 0.5 Sv but not 0.1 Sv in HadCM3

# What next?

- To investigate sensitivity of temperature response to location of freshwater hosing during the early LIG
- Can warming of the Southern Ocean account for melting of the WAIS?
- Any other feedback processes not accounted for? Interactions between atmosphere and ocean/sea ice?
- Lowering the WAIS –what is the effect?




**Adapted from Holden et al. (2010)**

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- Any other feedback processes not accounted for? Interactions between atmosphere and ocean/sea ice?
- Lowering the WAIS
- Quantify skill of simulations compared with data

**This work reaffirms the need for temporal and spatial coverage in the palaeo-data record (and if possible uncertainty values) in order to understand the climate mechanisms that operate in the past and likely also in the future**

## Thank you

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