# Modelling the Climate of the Last Interglacial Using a Fully Coupled General Circulation Model

**Emma J. Stone**[1] and Daniel J. Lunt[1]

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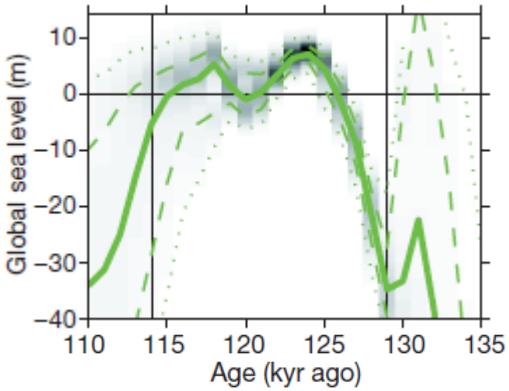
# Background to the LIG

## LIG sea-level




(*from* Kopp *et al.* 2009)

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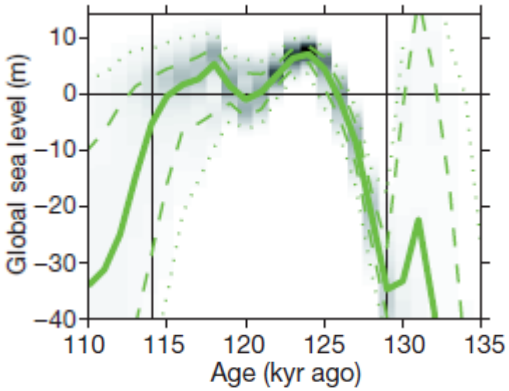


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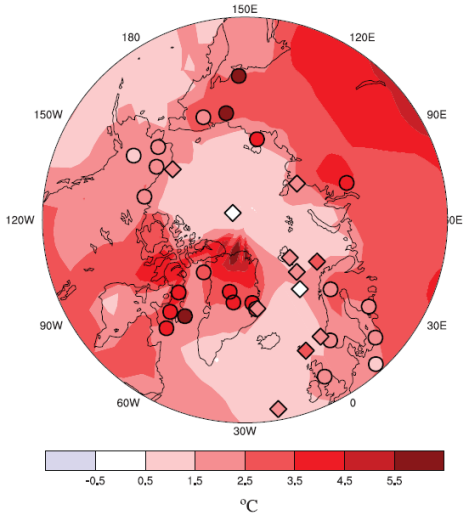


## Climate

Palaeodata and AOGCM indicate summer warming of ~2 - 5 C (IPCC, 2007)

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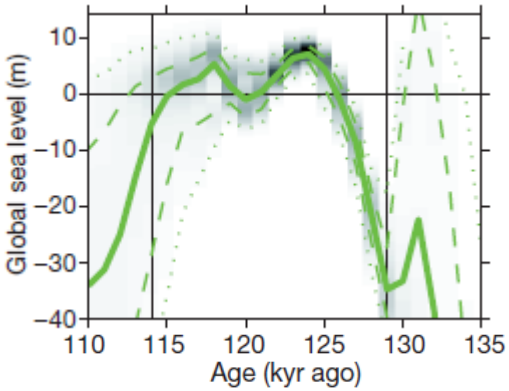


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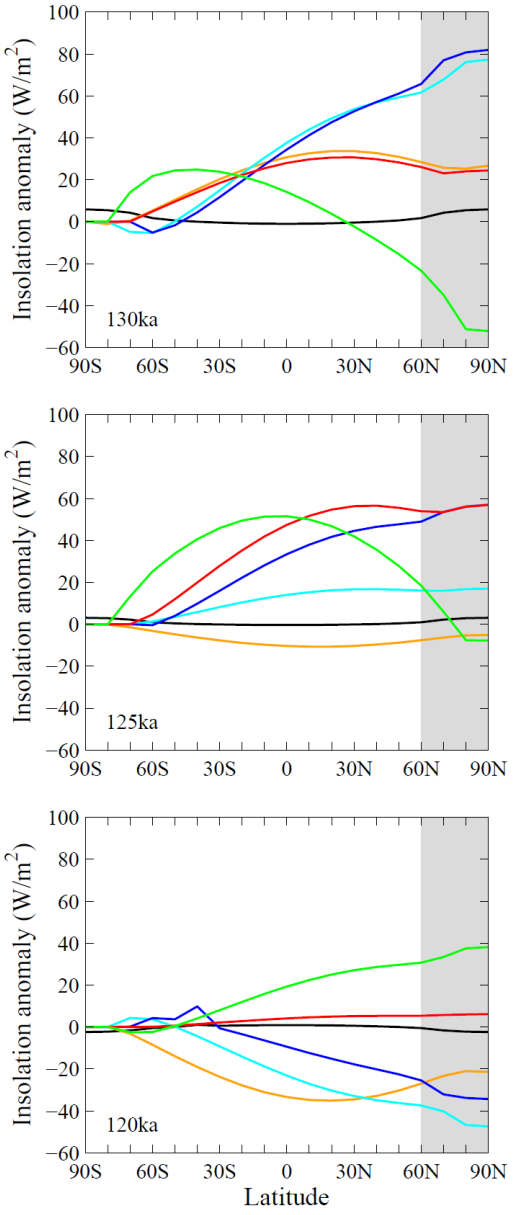
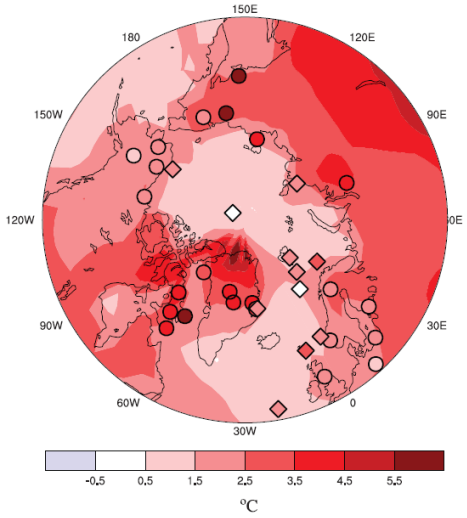
## Insolation forcing




## Climate

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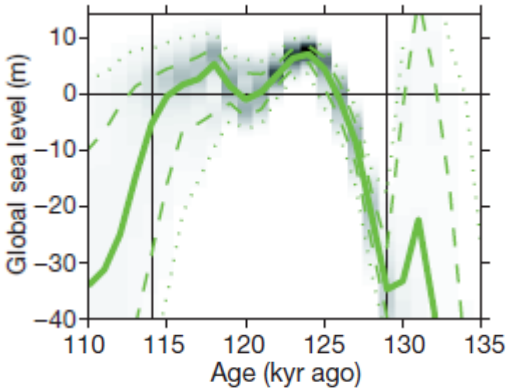


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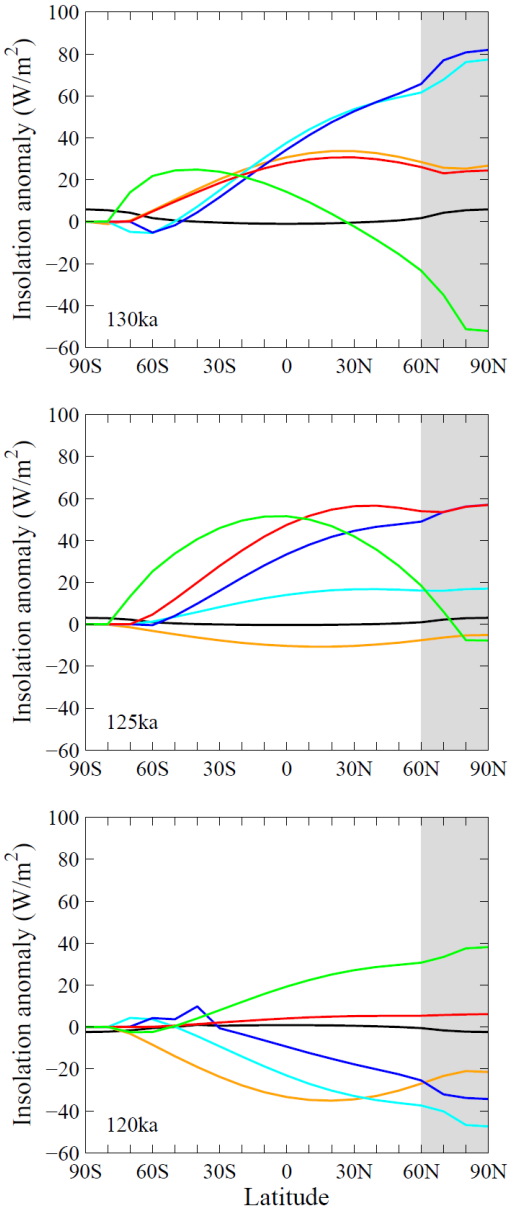
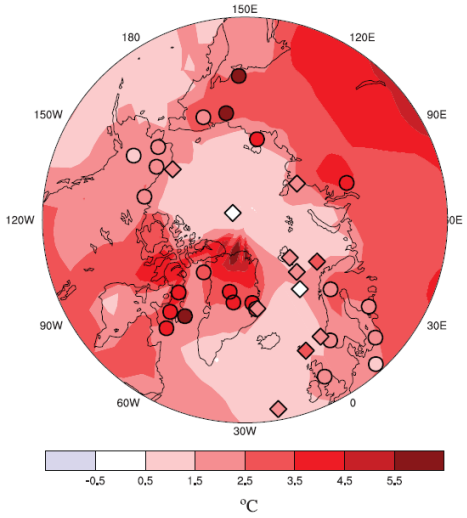



## Greenhouse gas forcing




## Climate

Palaeodata and AOGCM indicate summer warming of ~2 - 5 C (IPCC, 2007)

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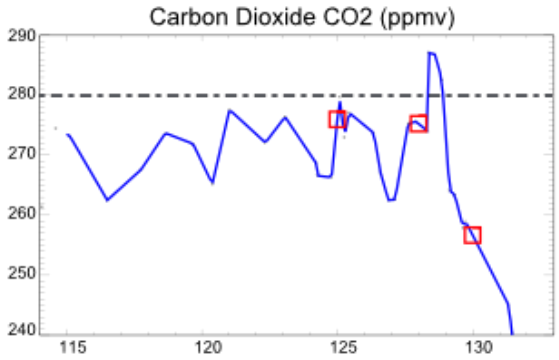
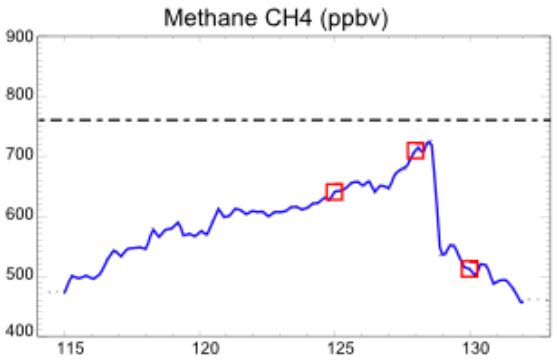
# Aim

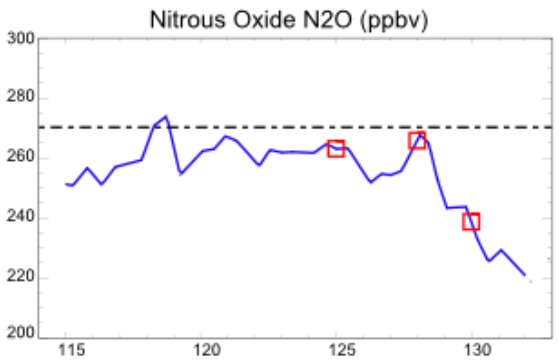
**"To characterise the baseline trend and variability of climate during the last interglacial"**

**PMIP3 protocol**

## (1) Greenhouse gases




## (2) Orbital parameters (precession, obliquity, eccentricity)

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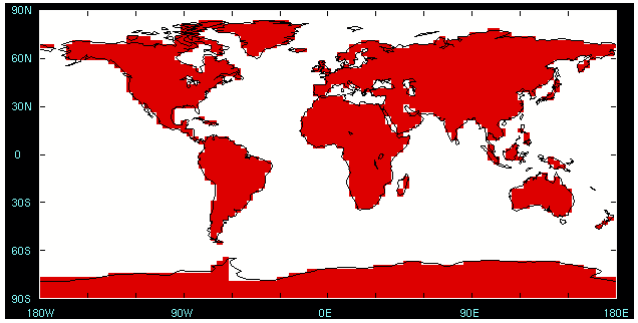
# Climate model setup

- **HadCM3 (UK Met Office Model)**

  - Coupled atmosphere-ocean sea-ice models
  - Ocean has a resolution of 1.25° x 1.25°
  - Horizontal resolution 2.5° x 3.75°
  - 19 levels in the vertical




- **4 simulations of 500 model years: 130, 128, 125 and 0 ka (BP)**

| | |
|---|---|
| **Changed orbital parameters (insolation)** | ✓ |
| **Changed GHGs** | ✓ |
| **Changed ice sheet** | ✗ |
| **Vegetation feedbacks** | ✗ |
| **Freshwater forcing** | ✗ |

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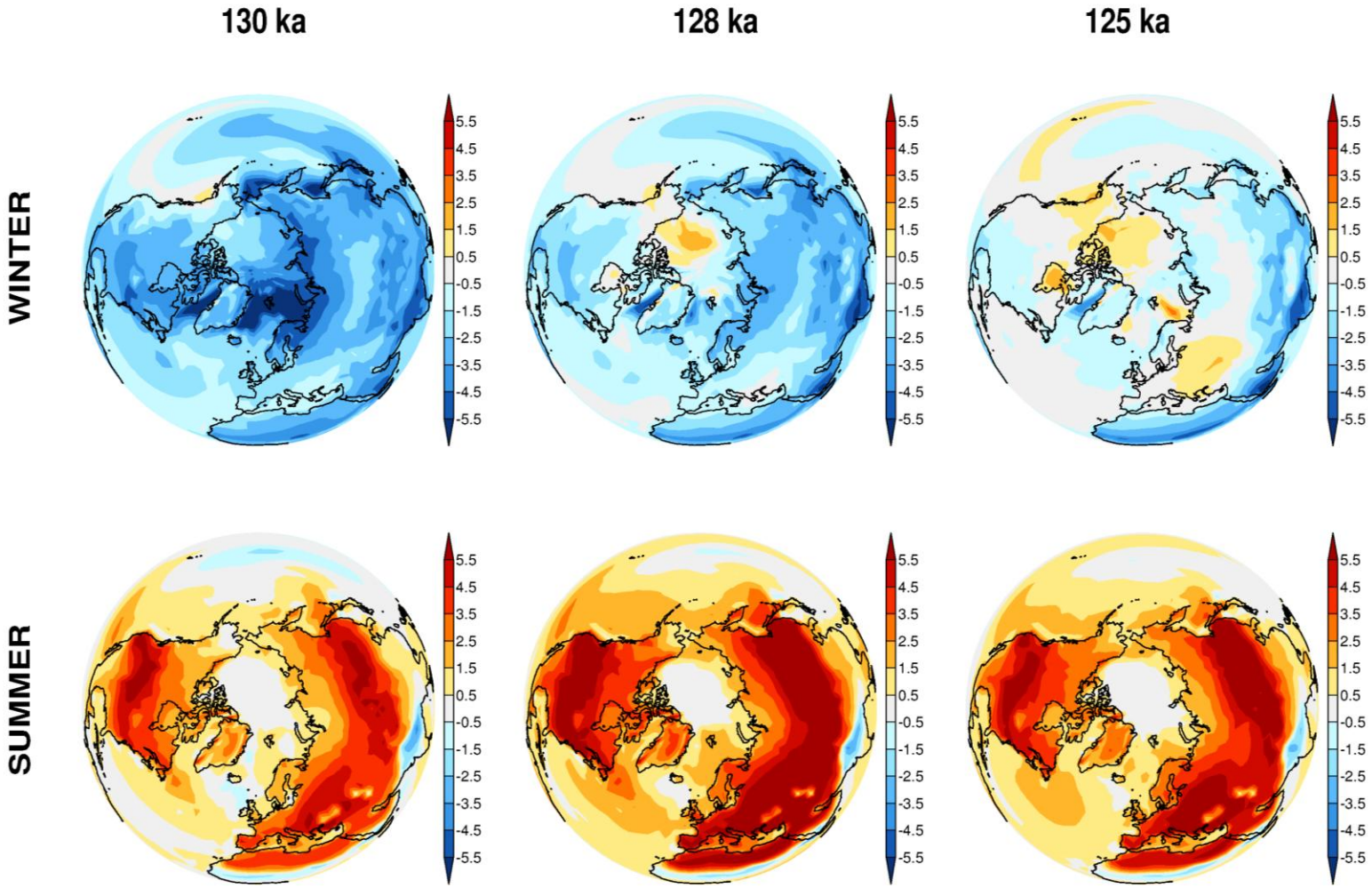
# LIG temperature: Northern Hemisphere

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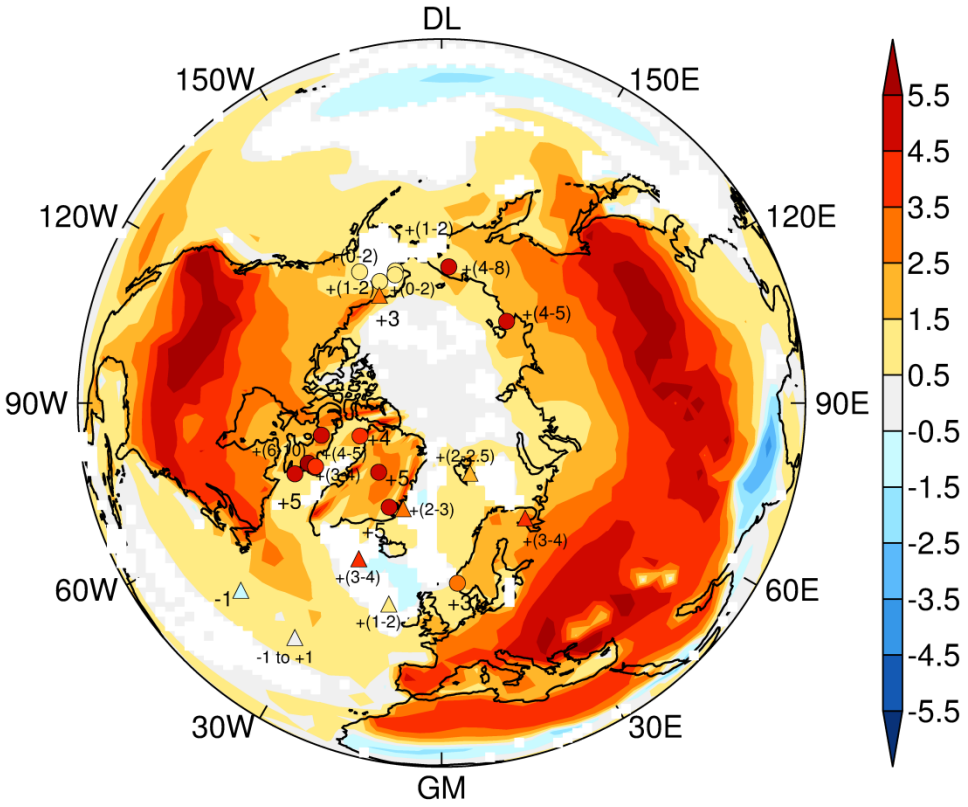
# JJA temperature change over the Arctic

130ka JJA temperature anomaly compared with maximum summer reconstructed proxy temperatures from the CAPE project, 2006.

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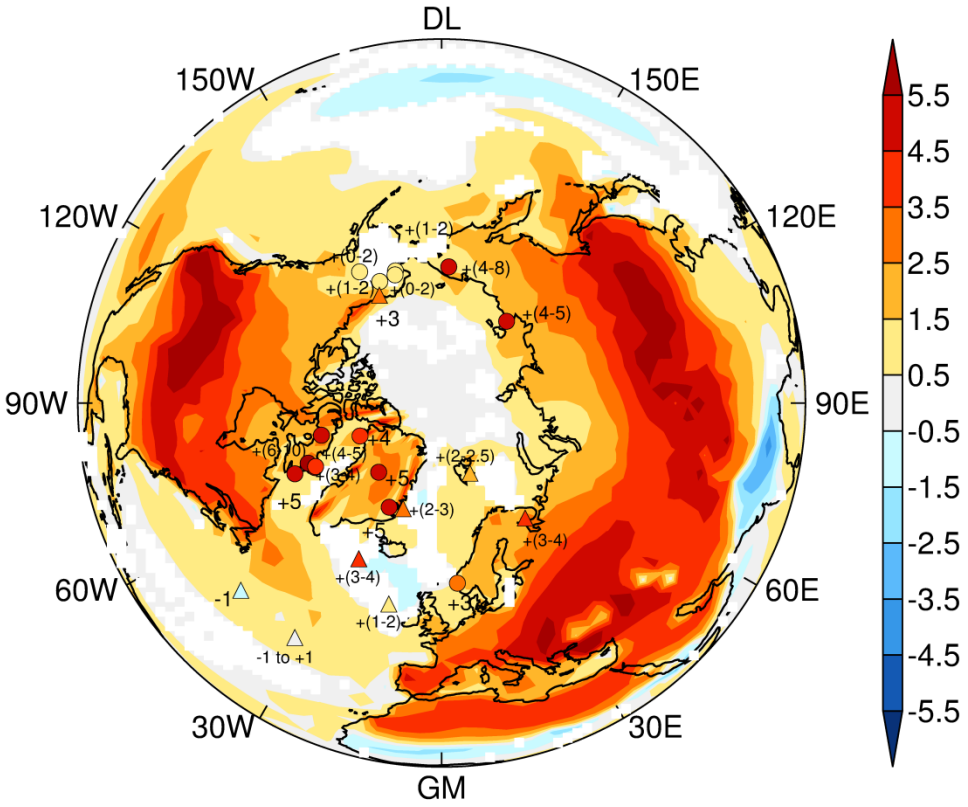


**Are we comparing the same time period?**

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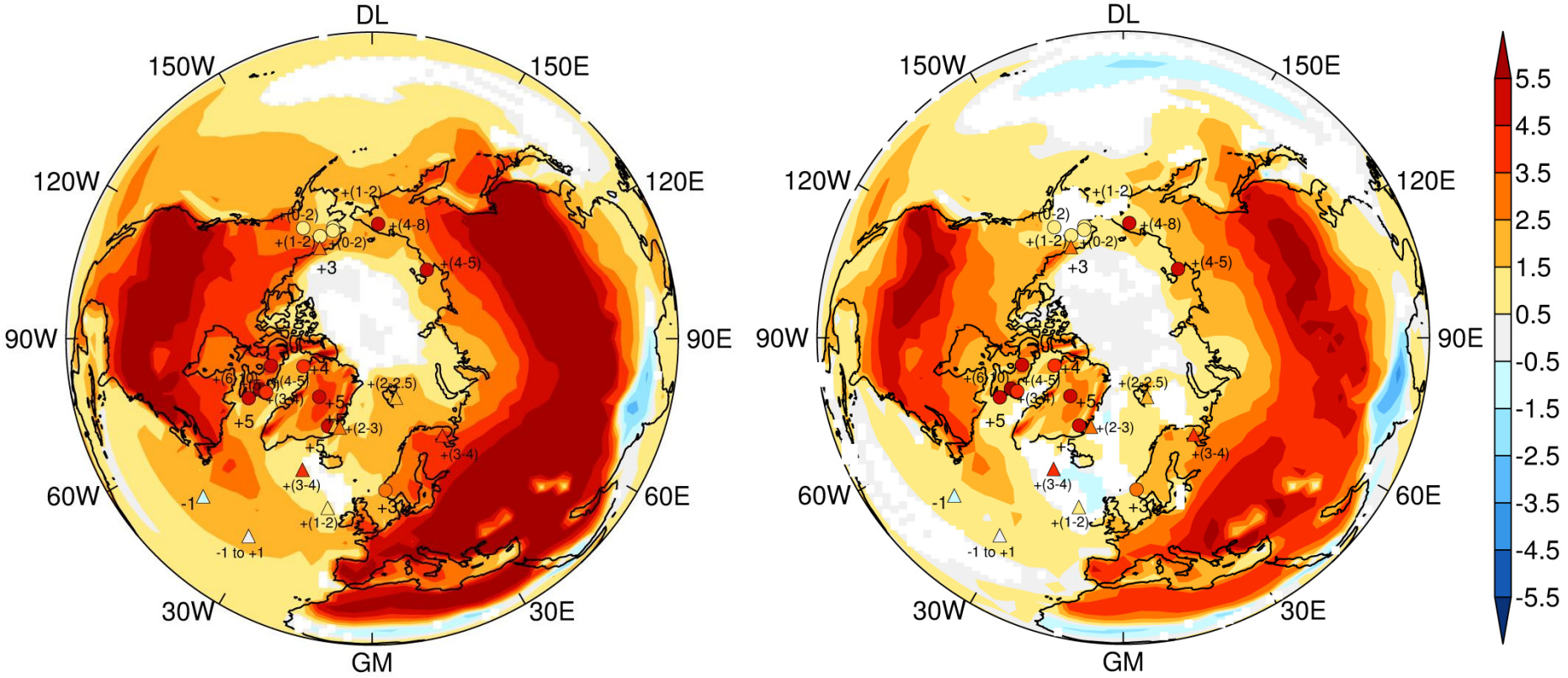
# JJA temperature change over the Arctic




**Comparison with max. LIG simulation temperatures (130,128, 125ka)**

**Comparison with 130ka simulation**

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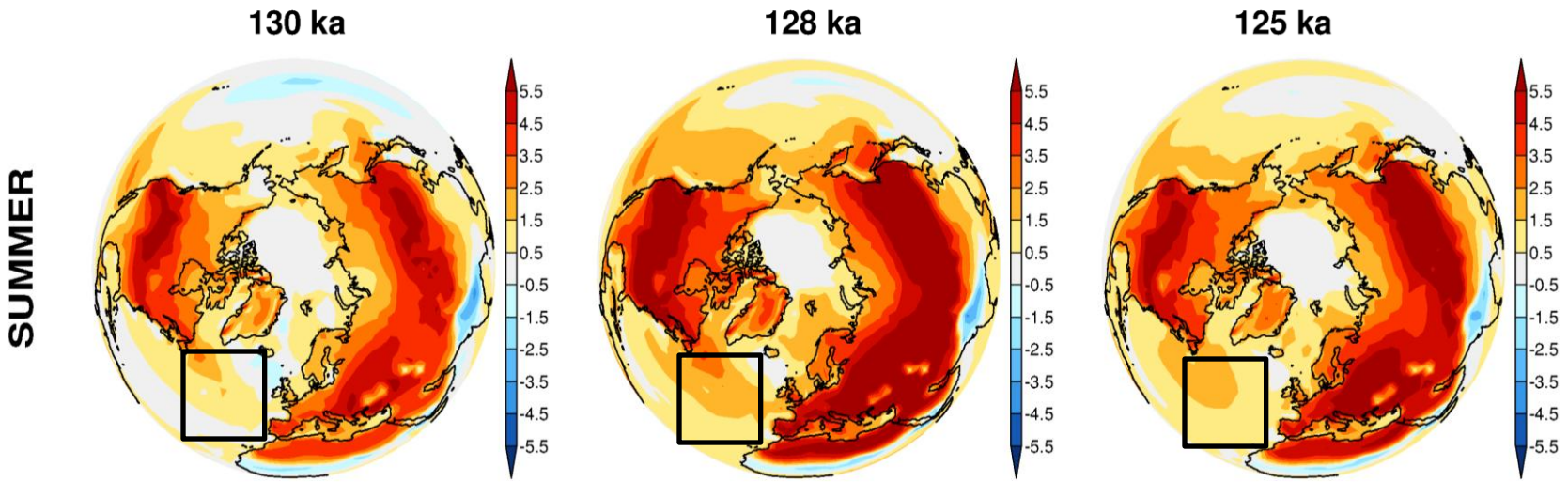
# COIN data comparison: JJA temperature



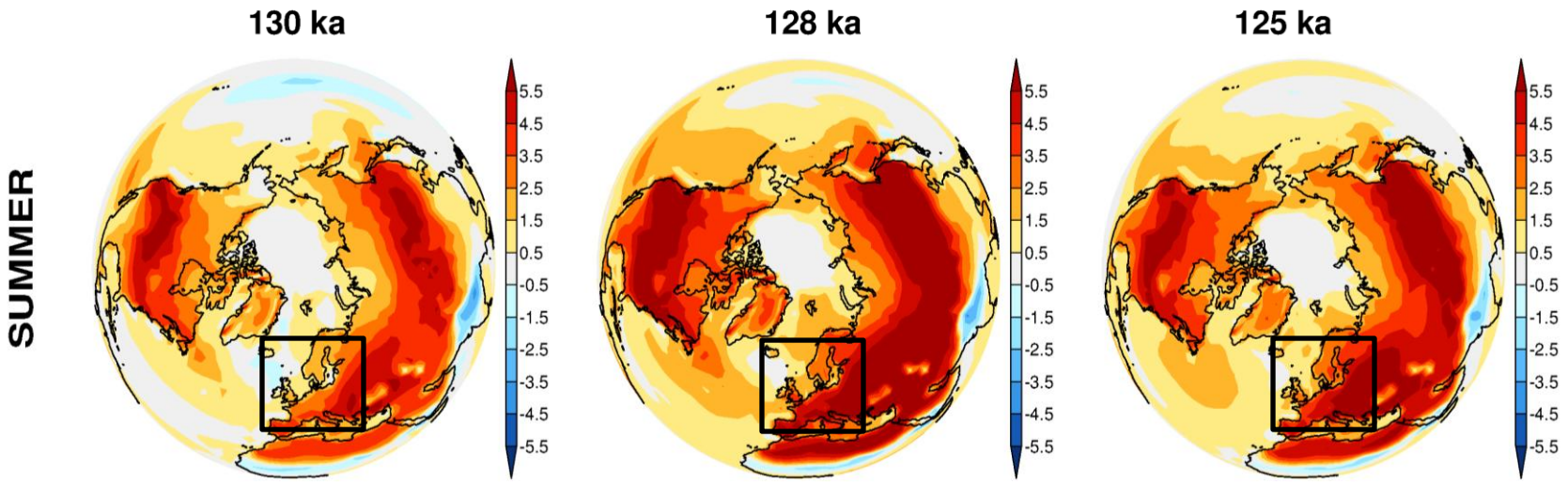

**Atlantic**

**DATA**: +4 to 6ºC

**MODEL**: +2 to 4ºC

**(Data kindly provided by Matthias Prange and Stefanie Müller)**

# COIN data comparison: Temperature




**Atlantic**

**DATA**: +4 to 6ºC

**MODEL**: +2 to 4ºC

**Europe**

**DATA**: +0 to 2ºC

**MODEL**: +2 to 6ºC

**(Data kindly provided by Matthias Prange and Stefanie Müller)**

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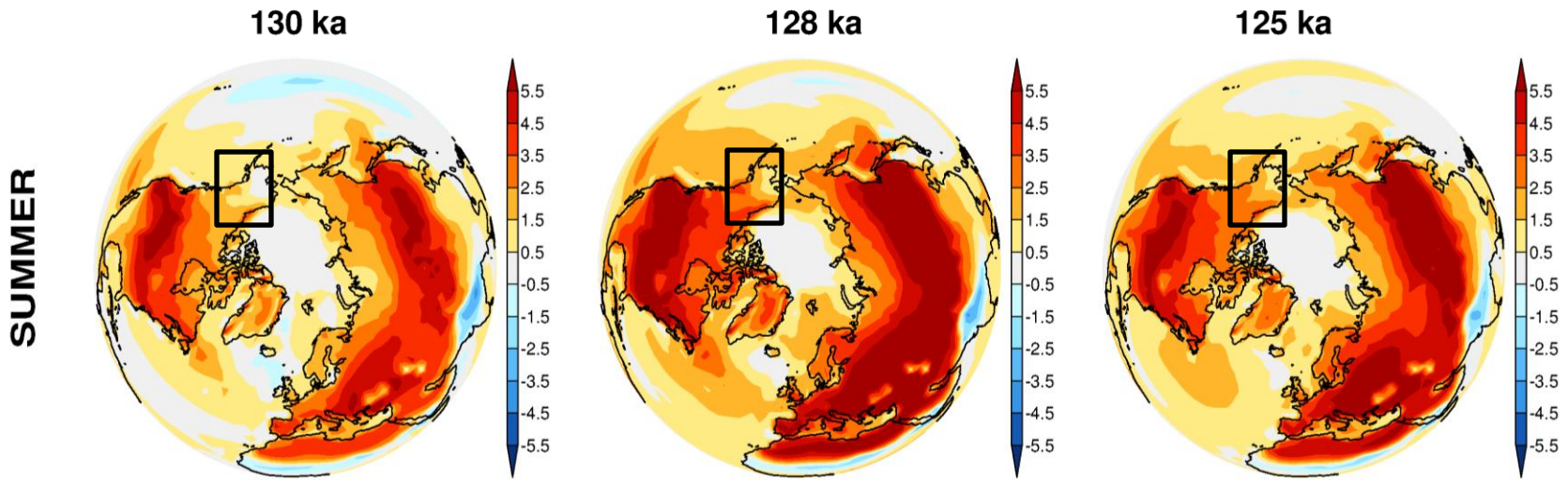
# COIN data comparison: Temperature




**Atlantic**

**DATA**: +4 to 6ºC

**MODEL**: +2 to 4ºC

**Europe**

**DATA**: +0 to 2ºC

**MODEL**: +2 to 6ºC

**Alaska and Western Canada**

**DATA**: +0 to 2ºC

**MODEL**: +0.5 to 4ºC

**(Data kindly provided by Matthias Prange and Stefanie Müller)**

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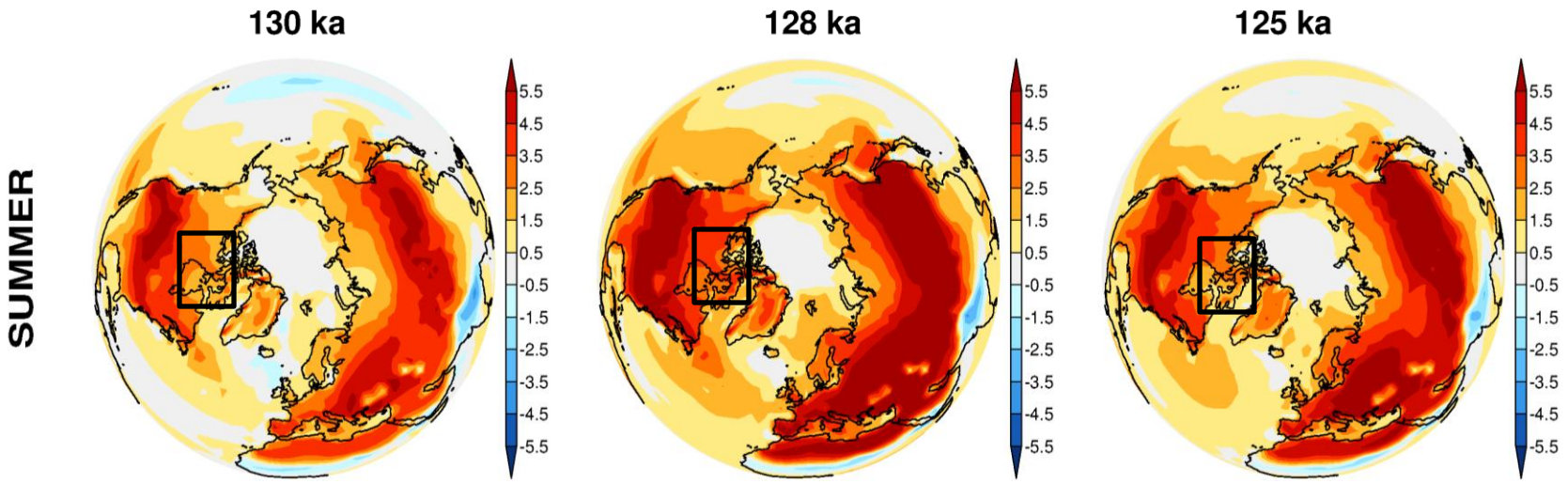
# COIN data comparison: Temperature




**Atlantic**

**DATA**: +4 to 6ºC

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**Europe**

**DATA**: +0 to 2ºC

**MODEL**: +2 to 6ºC

**Alaska and Western Canada**

**DATA**: +0 to 2ºC

**MODEL**: +0.5 to 4ºC

**North Eastern Canada**

**DATA**: +5ºC

**MODEL**: +1 to 5ºC

**(Data kindly provided by Matthias Prange and Stefanie Müller)**

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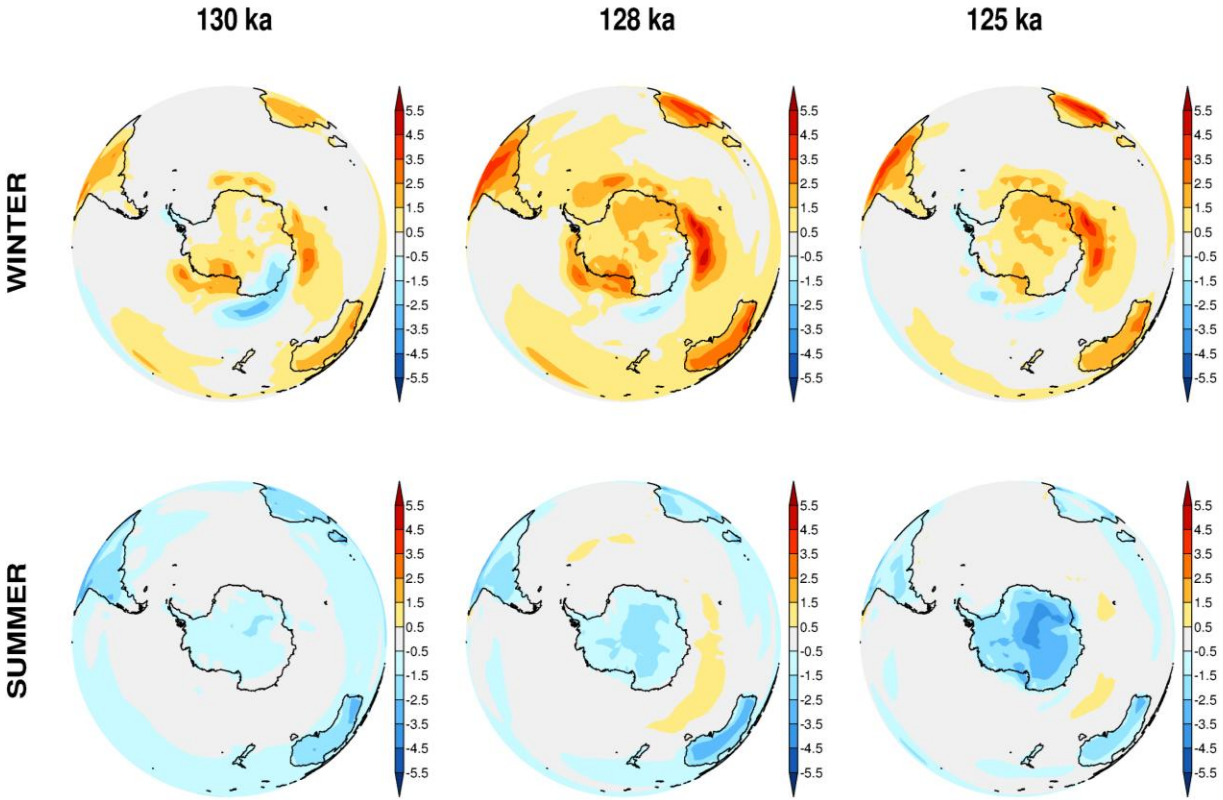
# LIG temperature: Southern Hemisphere




**Warming**

**Cooling**

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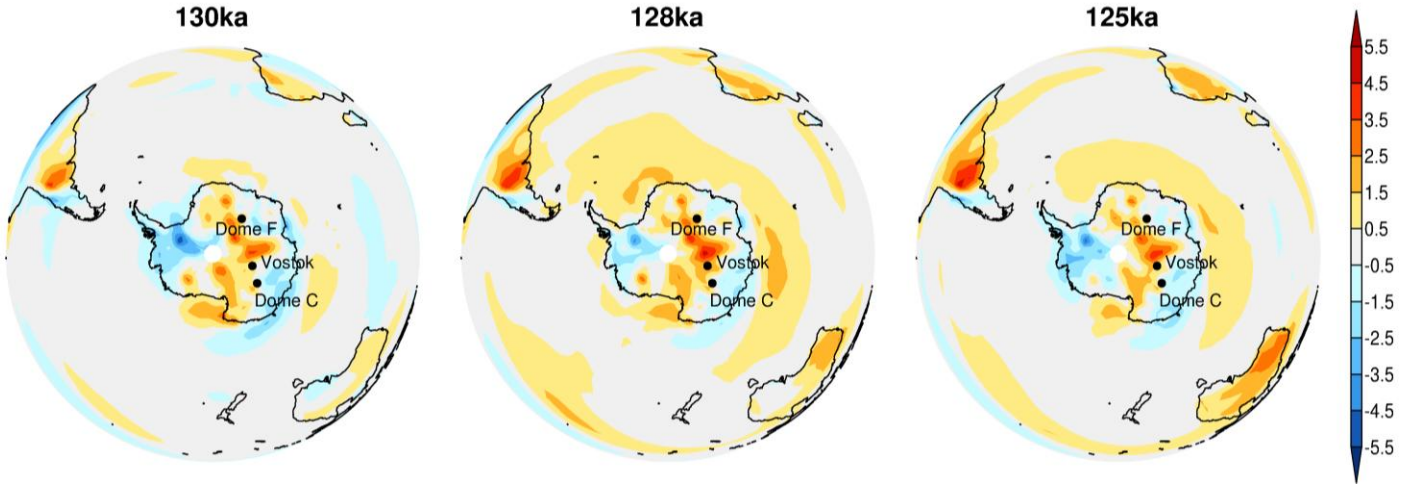
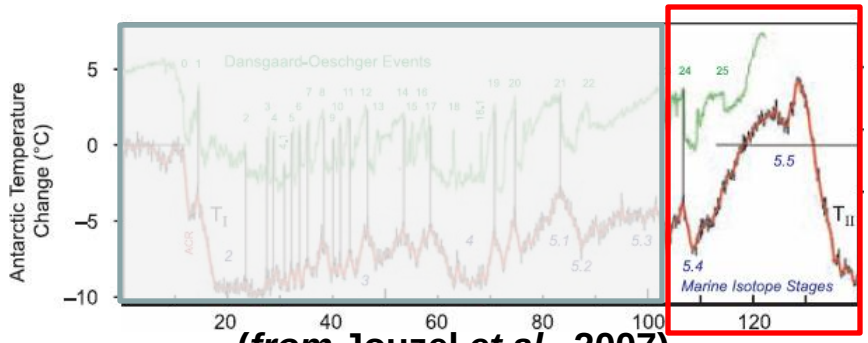
# Southern Hemisphere: Temperature comparison with ice core records

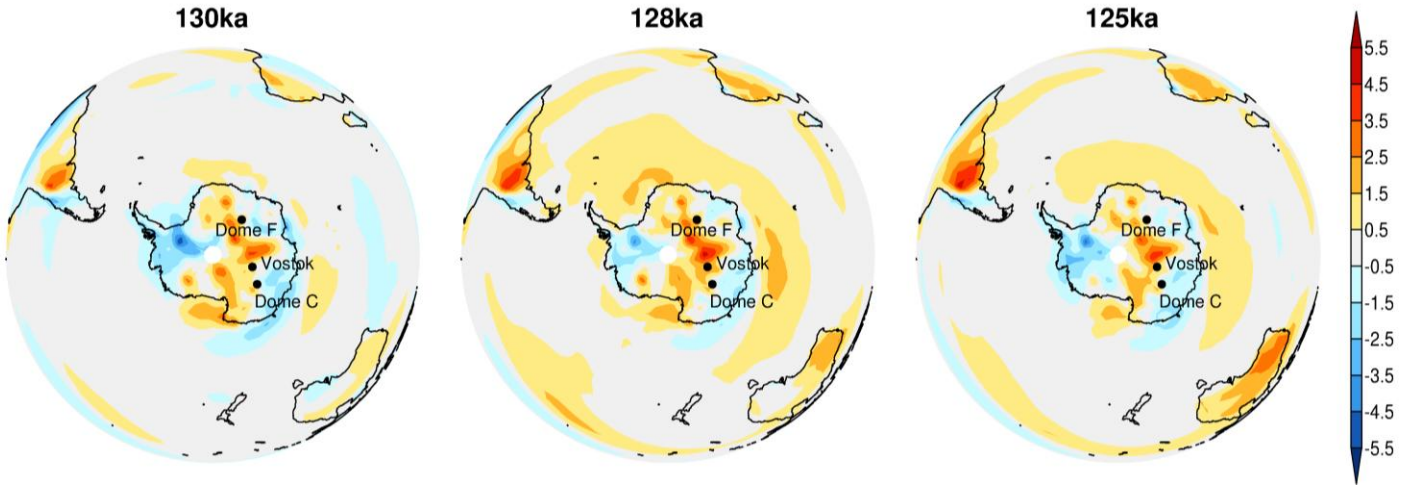



**Dome C**

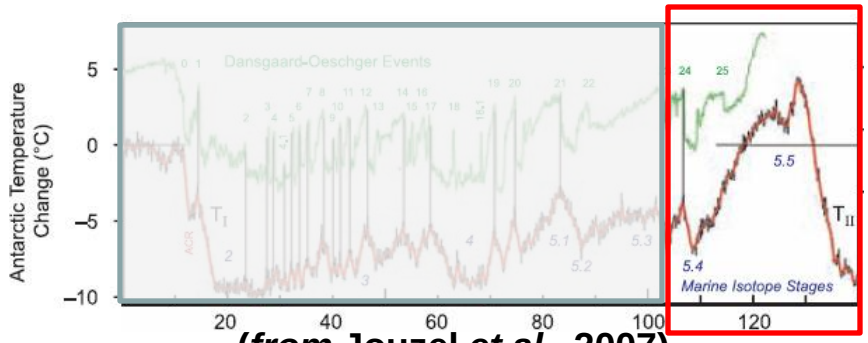



(*from* Jouzel *et al*., 2007)

# Southern Hemisphere: Temperature comparison with ice core records




**Dome C**




(*from* Jouzel *et al.*, 2007)

➢6ºC (Sime *et al.*, 2009)

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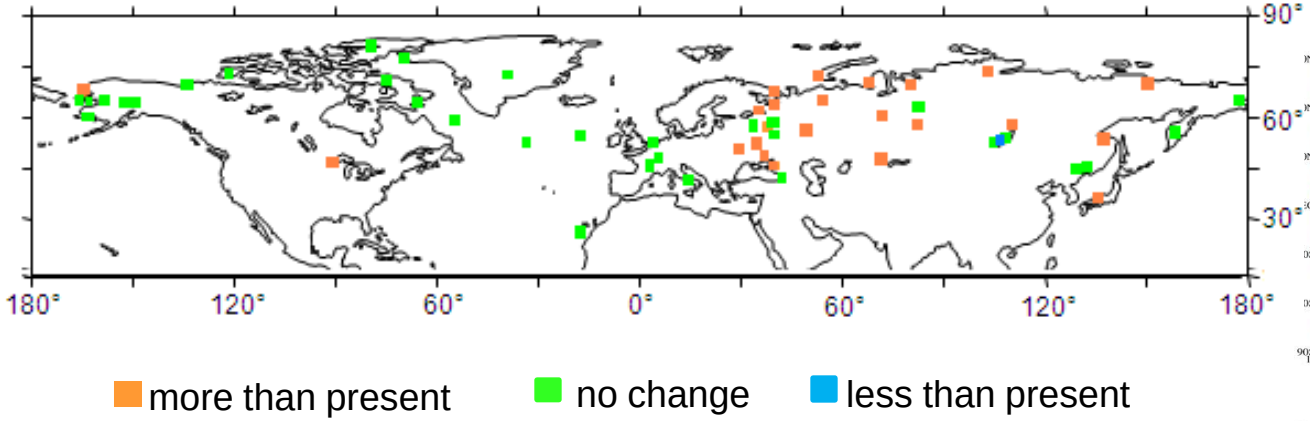
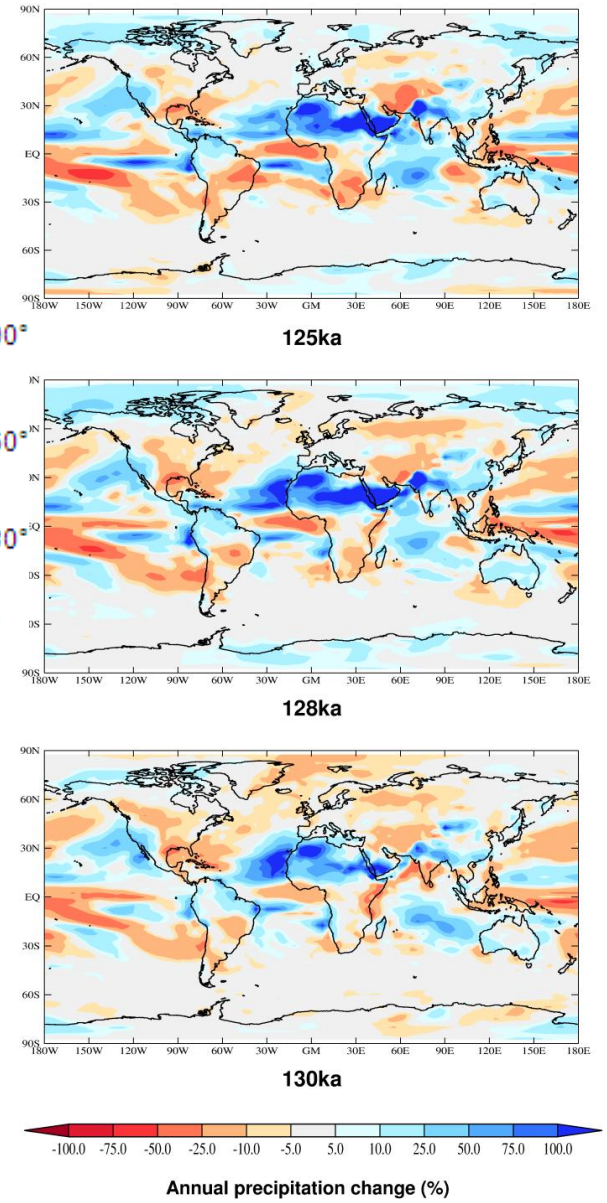
# Mean annual precipitation




more than present  no change  less than present




**(Figure kindly provided by Matthias Prange and Stefanie Müller)**

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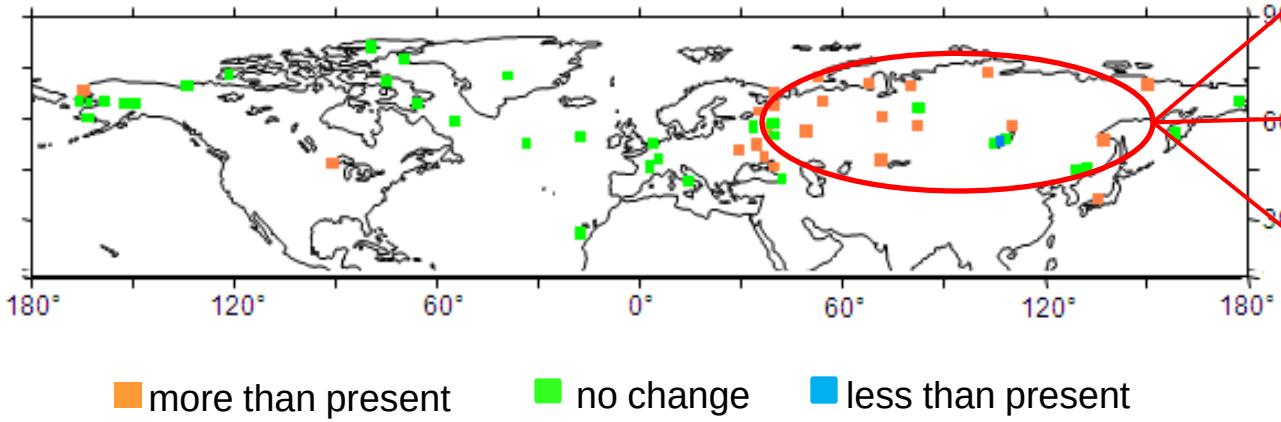
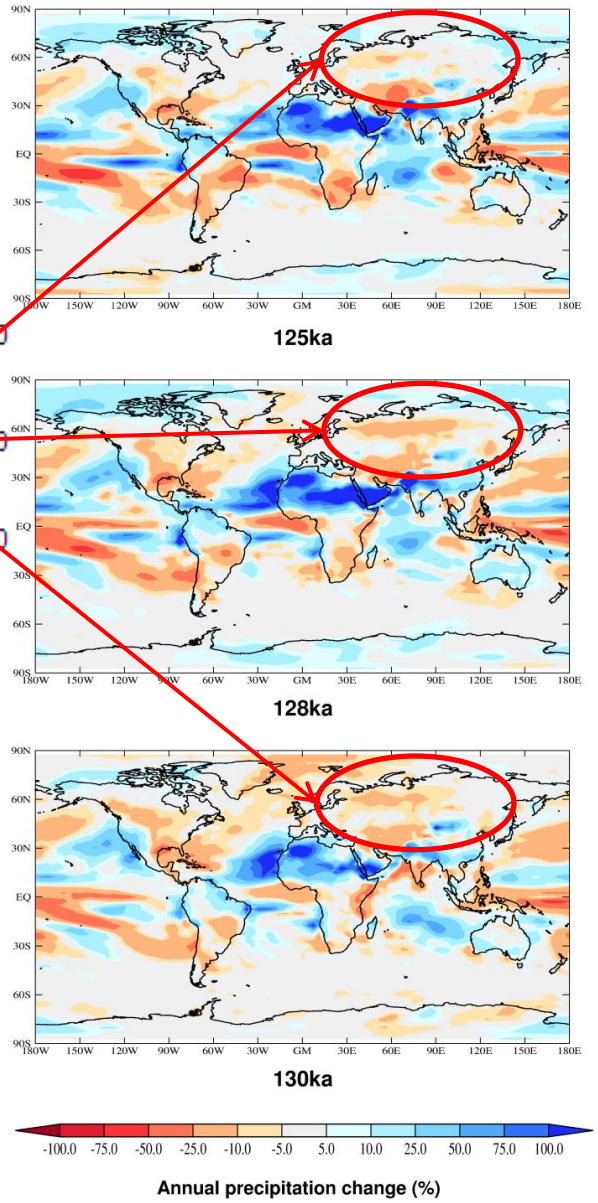



more than present  no change  less than present

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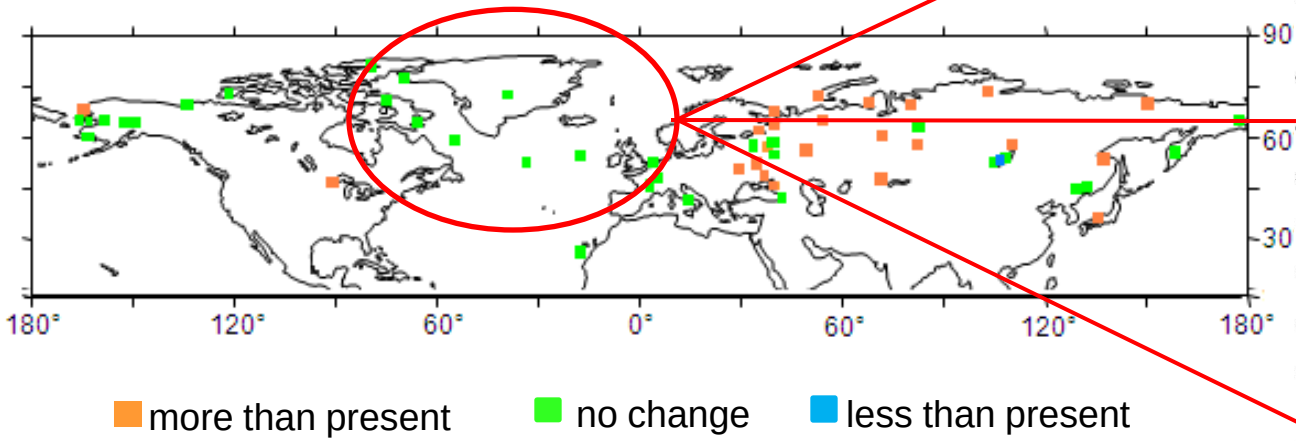


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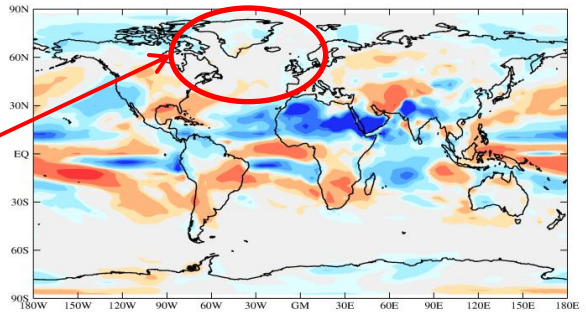
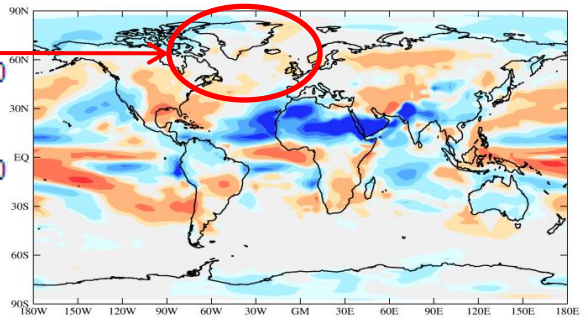
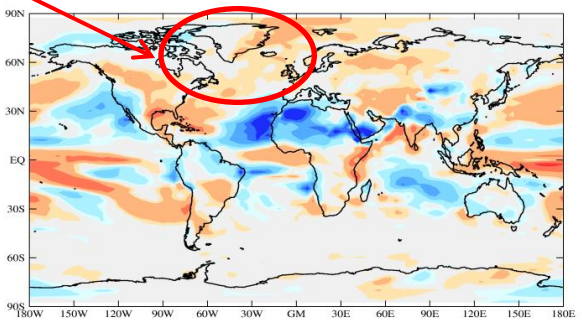


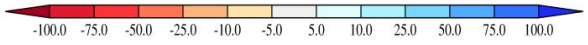

125ka




128ka




130ka




Annual precipitation change (%)

**(Figure kindly provided by Matthias Prange and Stefanie Müller)**

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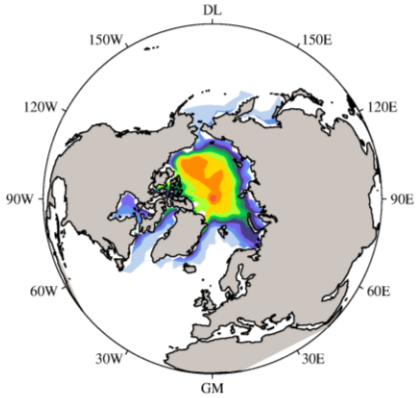
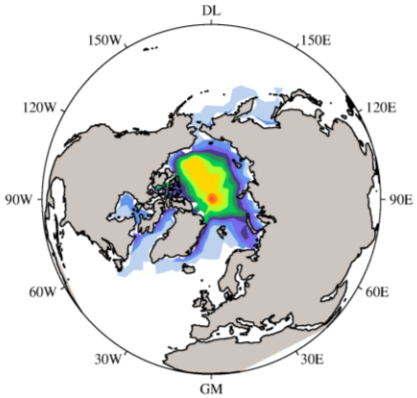
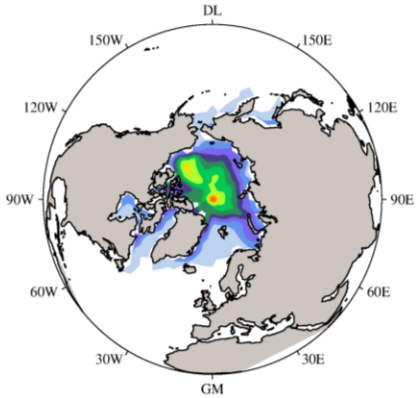
# JJA Arctic sea-ice extent



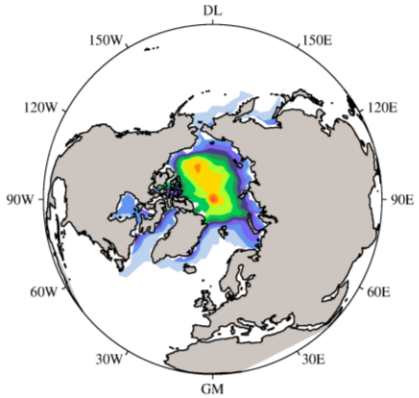

0ka



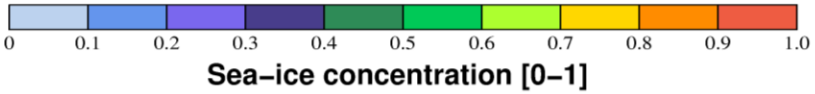

130ka




128ka




125ka




Sea–ice concentration [0–1]

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# Conclusions and outlook

- Climate simulations show ~5ºC summer warming in Arctic region.
- Reasonable agreement between LIG maximum summer temperature anomalies compared with the CAPE (2006) data compilation.
  - Illustration of time resolution issue
- Large discrepancy between model temperature results and data from the COIN project synthesis for Europe, Alaska and Western Canada.
- LIG summer temperatures over Antarctica unable to replicate results from ice cores- how can this be reconciled?
- Precipitation changes:
  - Shifts in the ITCZ at low latitudes and changes in Indian and African monsoon activity
  - ~30% drier over Europe and Asia compared with qualitatively 'wetter' COIN data, lack of vegetation feedbacks?
- Arctic summer sea-ice extent reduced by up to 50% compared with preindustrial.

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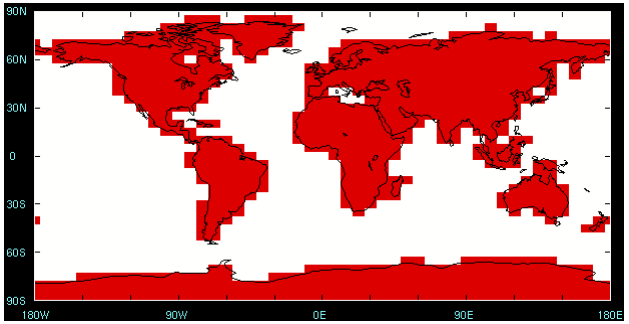
# Conclusions and outlook

- Transient simulations with low resolution version of HadCM3 (FAMOUS) to:
  - Investigate sensitivity to orbital forcing/GHGs
  - Inclusion of vegetation feedbacks
  - Freshwater forcing

- A need for comparison with new, more tightly constrained proxy data from the LIG; particularly in the tropics.

- Coupled climate ice-sheet simulations for Greenland (and Antarctica)




**FAMOUS model resolution**

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# Thank you

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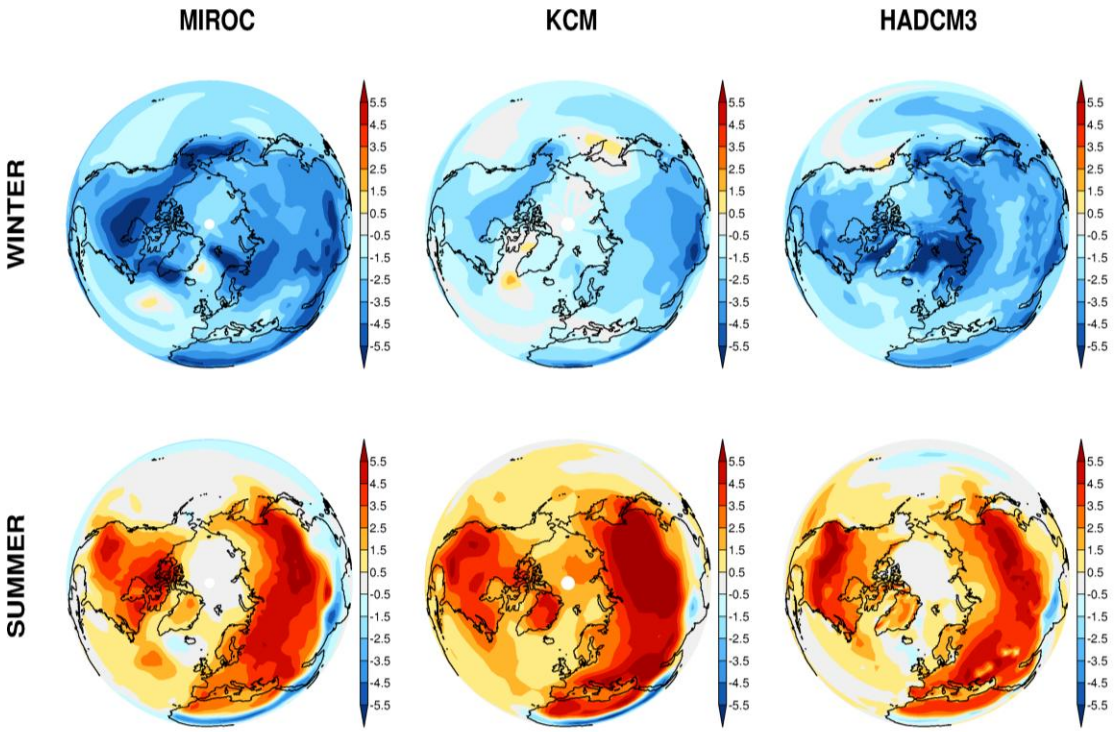
**References:**

J. Jouzel *et al*., Orbital and Millennial Antarctic Climate Variability over the Past 800,000 Years. *Science* **317**, 793-796 (2007).

R. E. Kopp, F. J. Simons, J. X. Mitrovica, A. C. Maloof, M. Oppenheimer, Probabilistic assessment of sea level during the last interglacial stage. *Nature* **462**, 863-868 (2009).

L. C. Sime, E. W. Wolff, K. I. C. Oliver, J. C. Tindall. Evidence for warmer interglacials in East Antarctic ice cores, Nature **462**, 342-345 (2009).

# 130 ka model comparison

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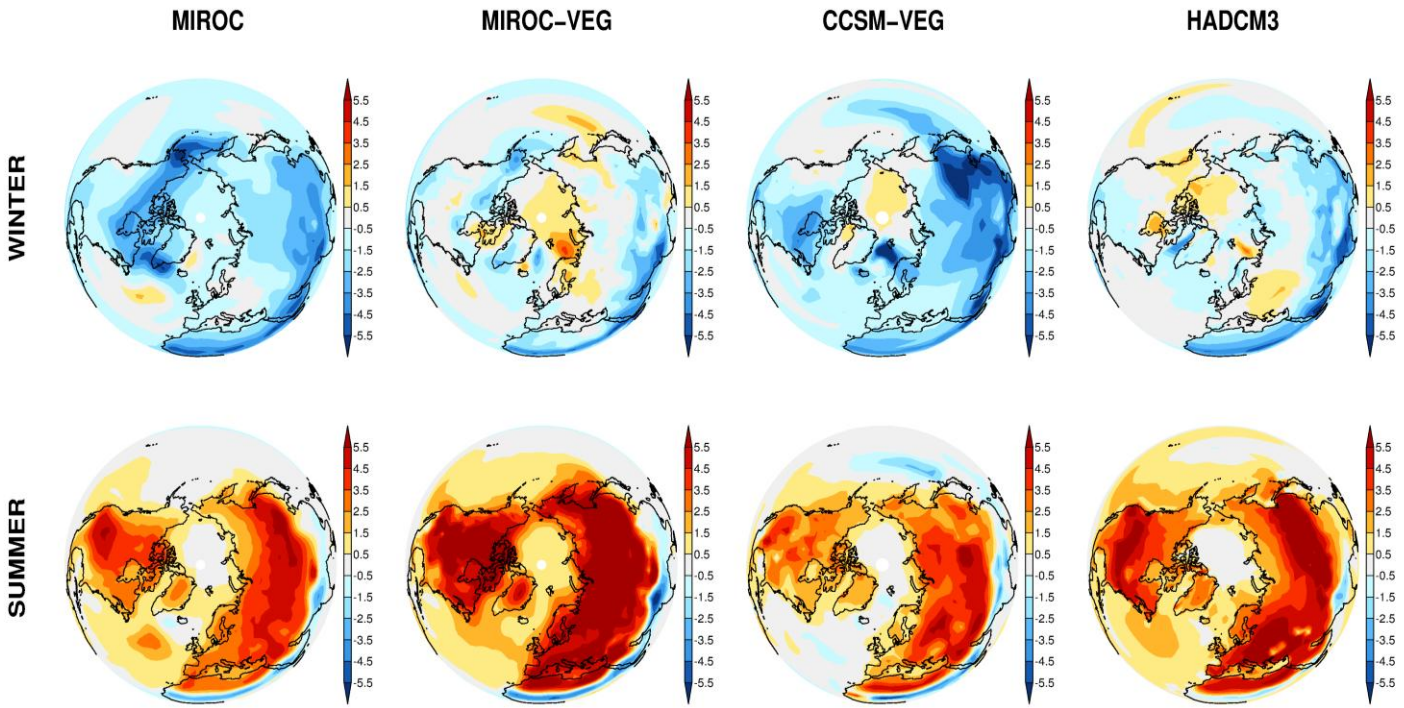
# 125 ka model comparison

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