

Revisiting the problem of simulating polar amplification of warm icehouse periods with an Earth System Model

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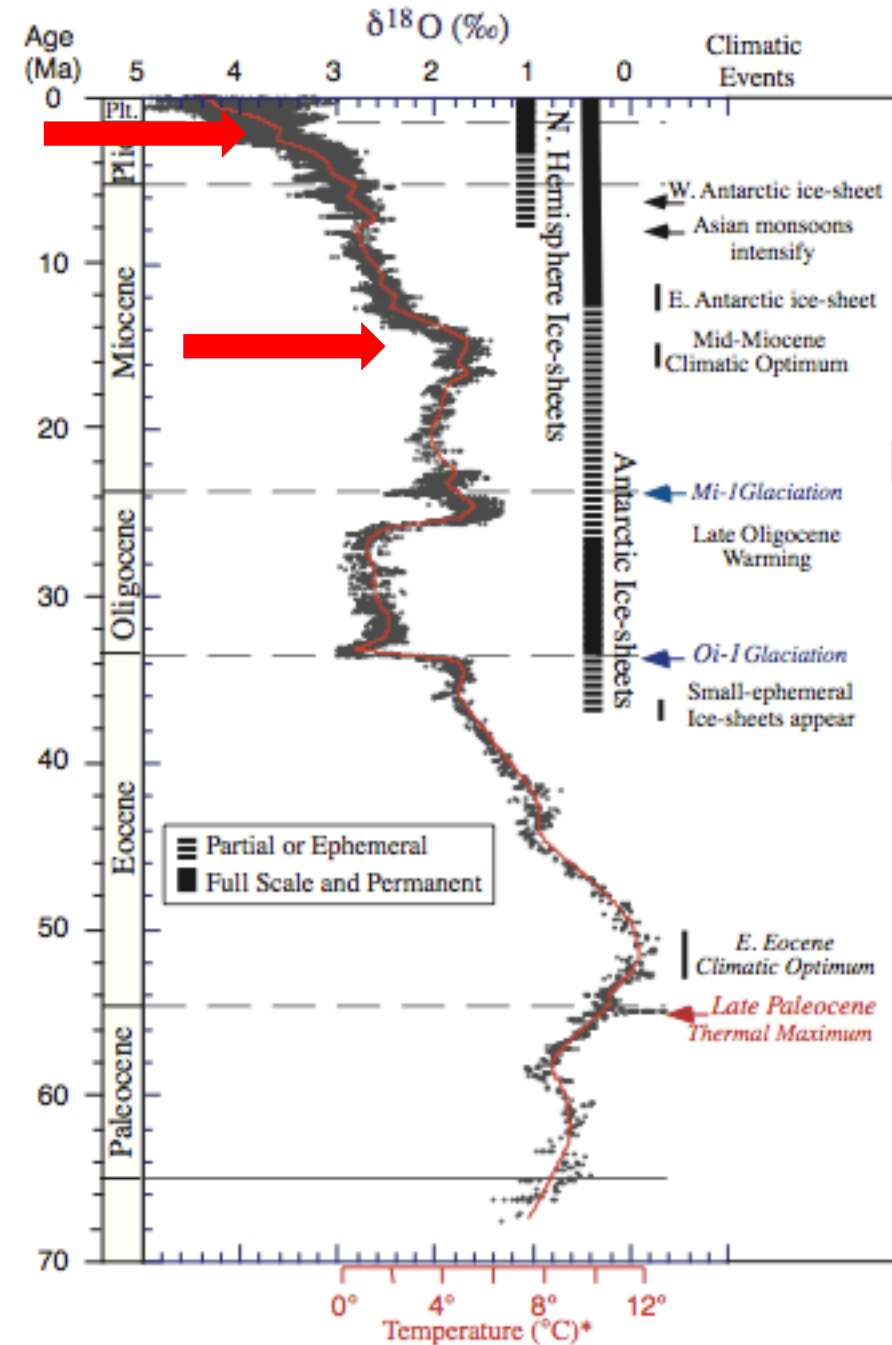
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Warm periods of Cenozoic icehouse climate

Mid-Pliocene Warm Period
(MPWP)

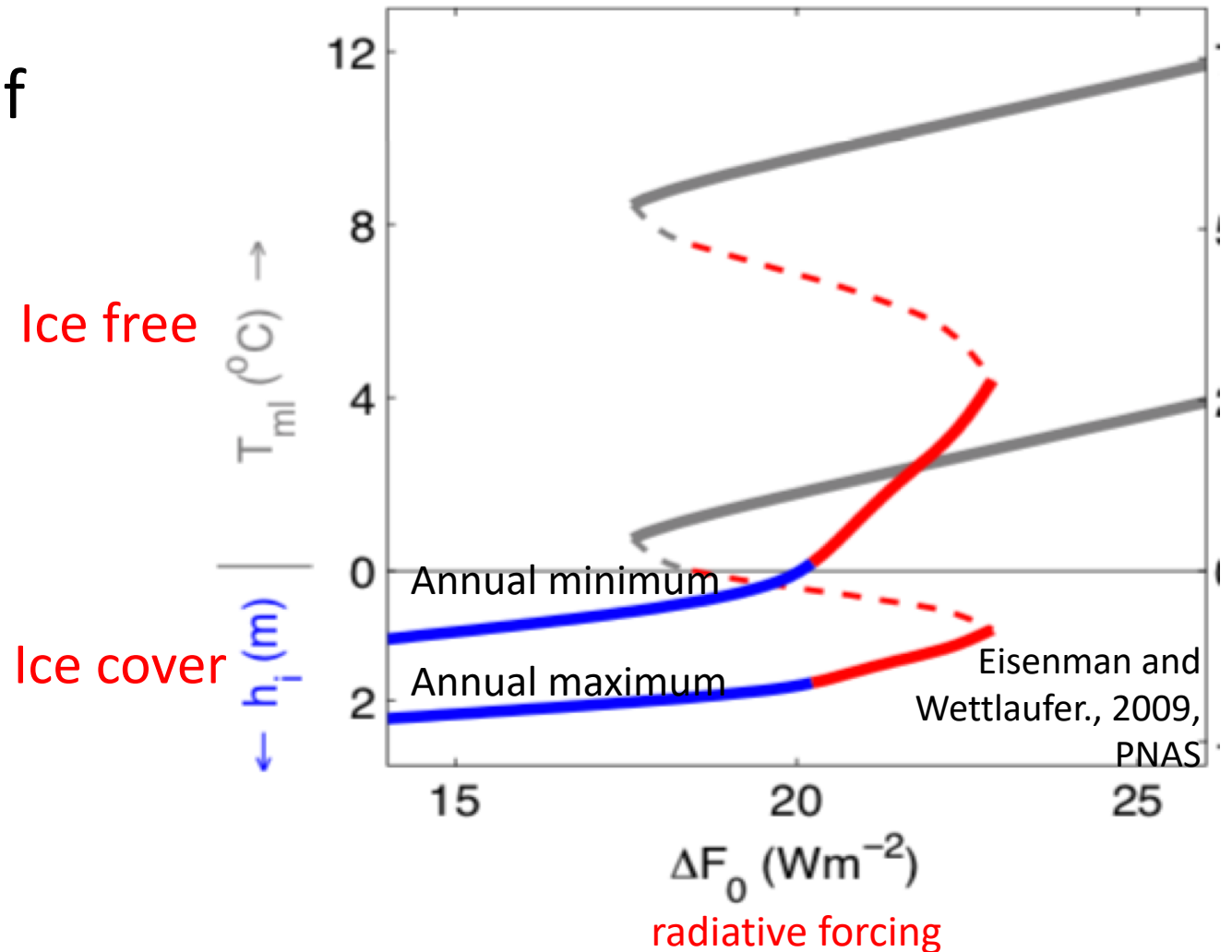
Mid-Miocene Climate Optimum
(MMCO)



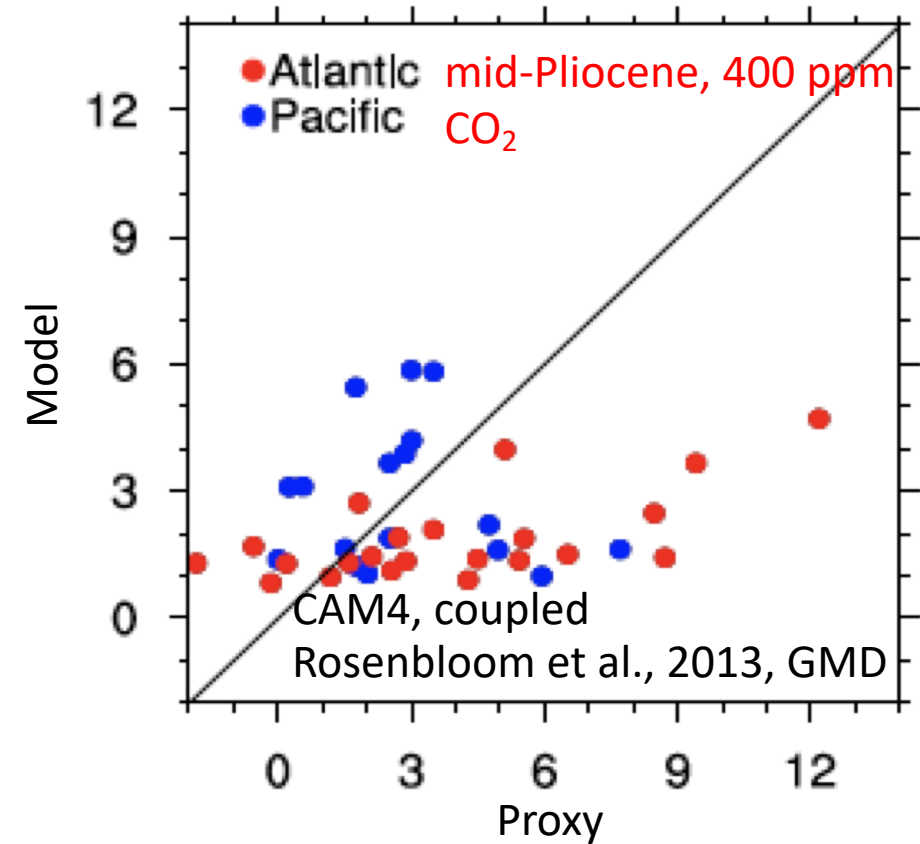
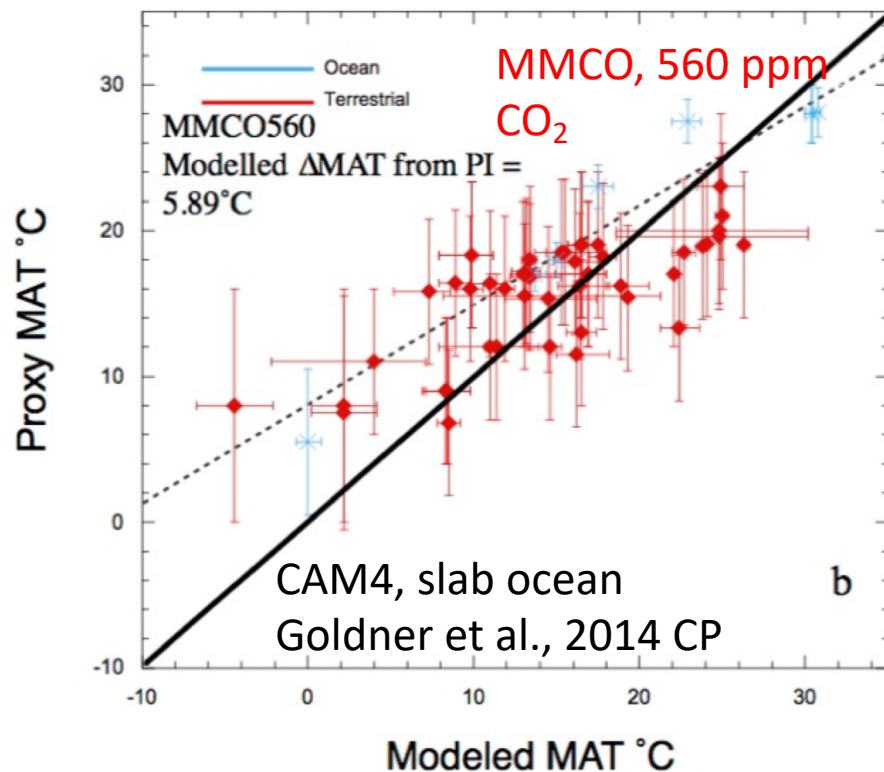
A different problem for greenhouse climate?

- Three equilibrium states of sea ice:

- perennial ice
- seasonal ice
- ice free



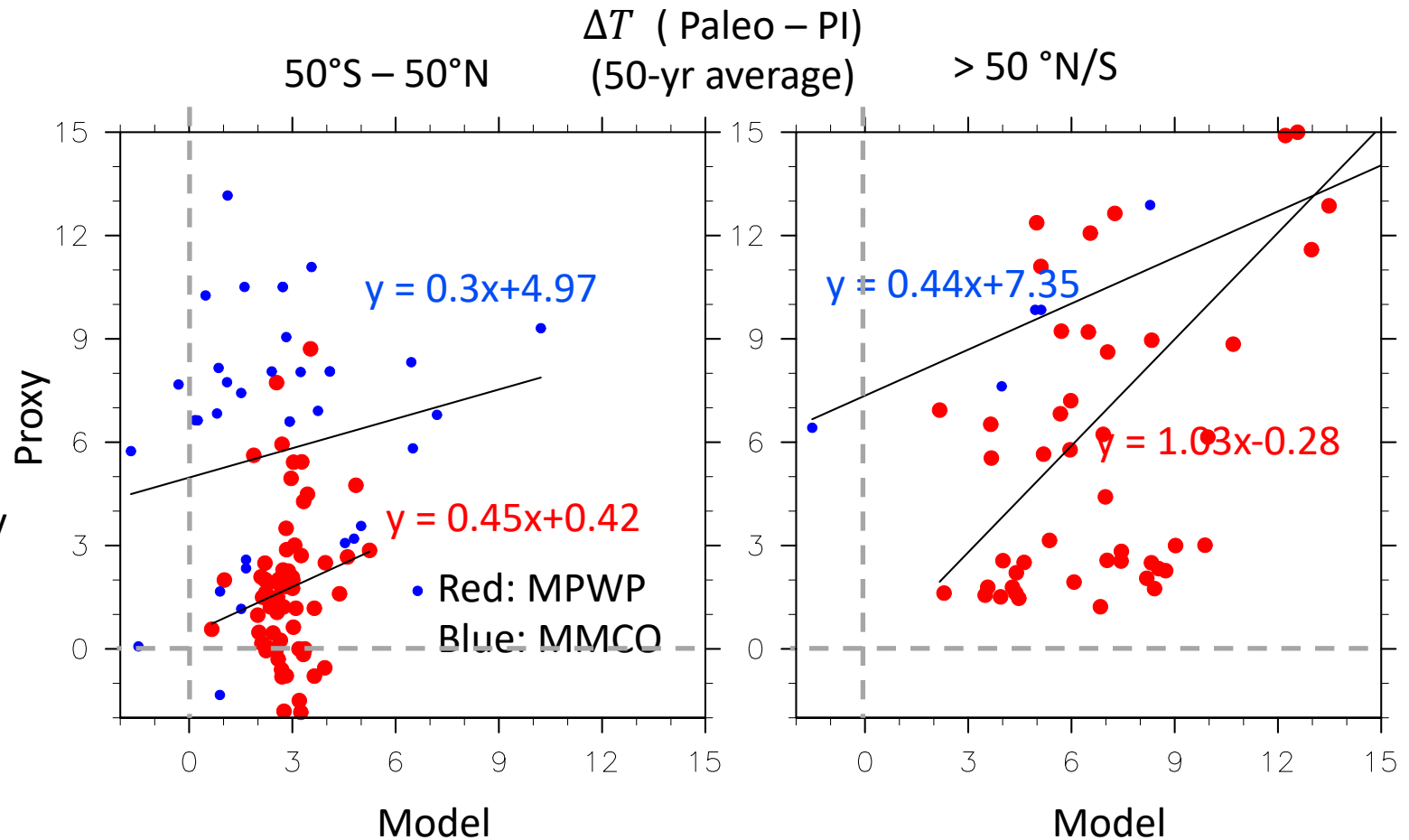
Polar amplification is poorly simulated traditionally



High latitude surface temperatures are underestimate in the ocean and on land.

CESM1.2 does a much better job

- Experiment configuration
 - CESM1.2 (0.9 x 1.25, 394x320)
 - MPWP: 400 ppm CO₂, Haywood et al., (2016, CP), > 500 yrs
 - MMCO: 560 ppm CO₂, Frigola et al., (2018, GMD), > 400 yrs
- Low-to-middle latitudes: 50°S – 50°N
- High latitudes: > 50°N/S
- MPWP: high latitude records are very well matched
 - 0.06°C warmer
- MMCO: not enough data from high latitudes, data-model comparison is systematically worse
 - ~3.5°C colder



Key to seasonally Arctic sea ice free – summer insolation

- Small forcing can lead to transition from perennial Arctic sea ice state to seasonal sea ice state at CO₂ level of ~400 ppm and with northward expanded boreal forests at MPWP
 - Compare simulation without anthropogenic pollutants and with anthropogenic pollutants → 0.8 W/m² forcing

