Carbon Cycle Response to a Collapse of the AMOC

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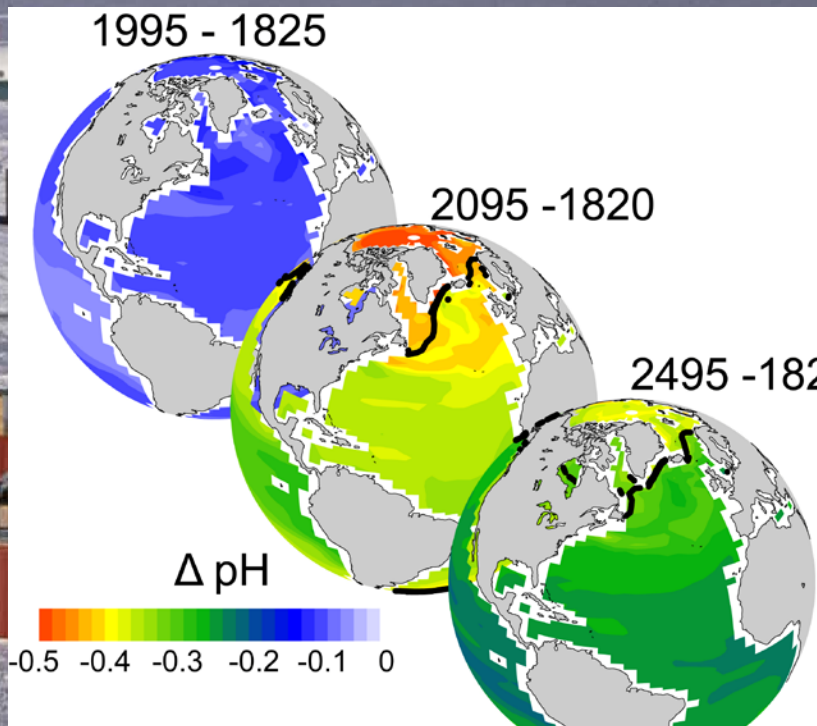

Key Questions

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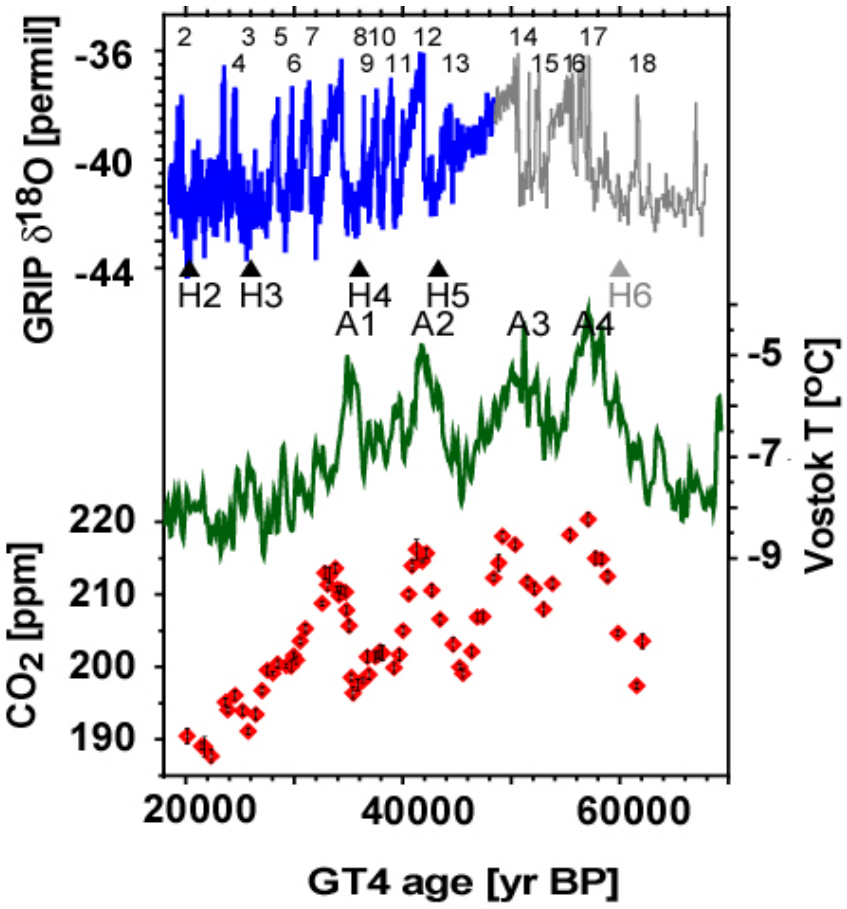

How does the carbon cylce respond to a collapse of the Atlantic Overturning?

Is there a difference in response to northern vs southern freshwater forcing?

Focus: South America

Experimental Setup

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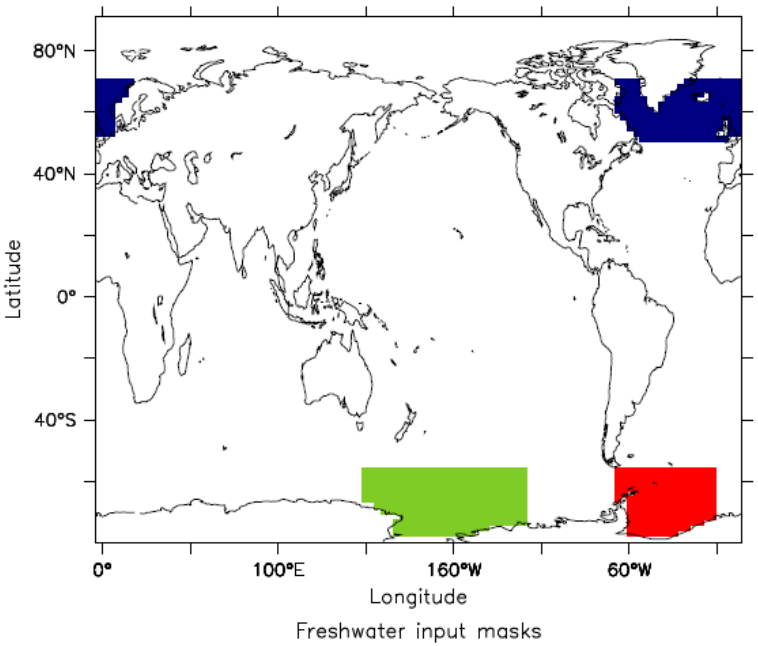
- Model: CSM1.4-carbon, T31
  Spin-up under preindustrial conditions (Doney et al., 2006)
  Freshwater input during 100 years, run continued for 200 yrs

- Ensembles of five runs:
  a) 1.0 Sv into North Atlantic
  b) 1.0 Sv into Ross Sea

- Single runs:
  c) 0.5 Sv into northern North Atlantic
  d) 0.3 Sv into northern North Atlantic
  e) 1.0 Sv into Weddell Sea

  f) control run



Physical Response:
Atlantic overturning and global temperature

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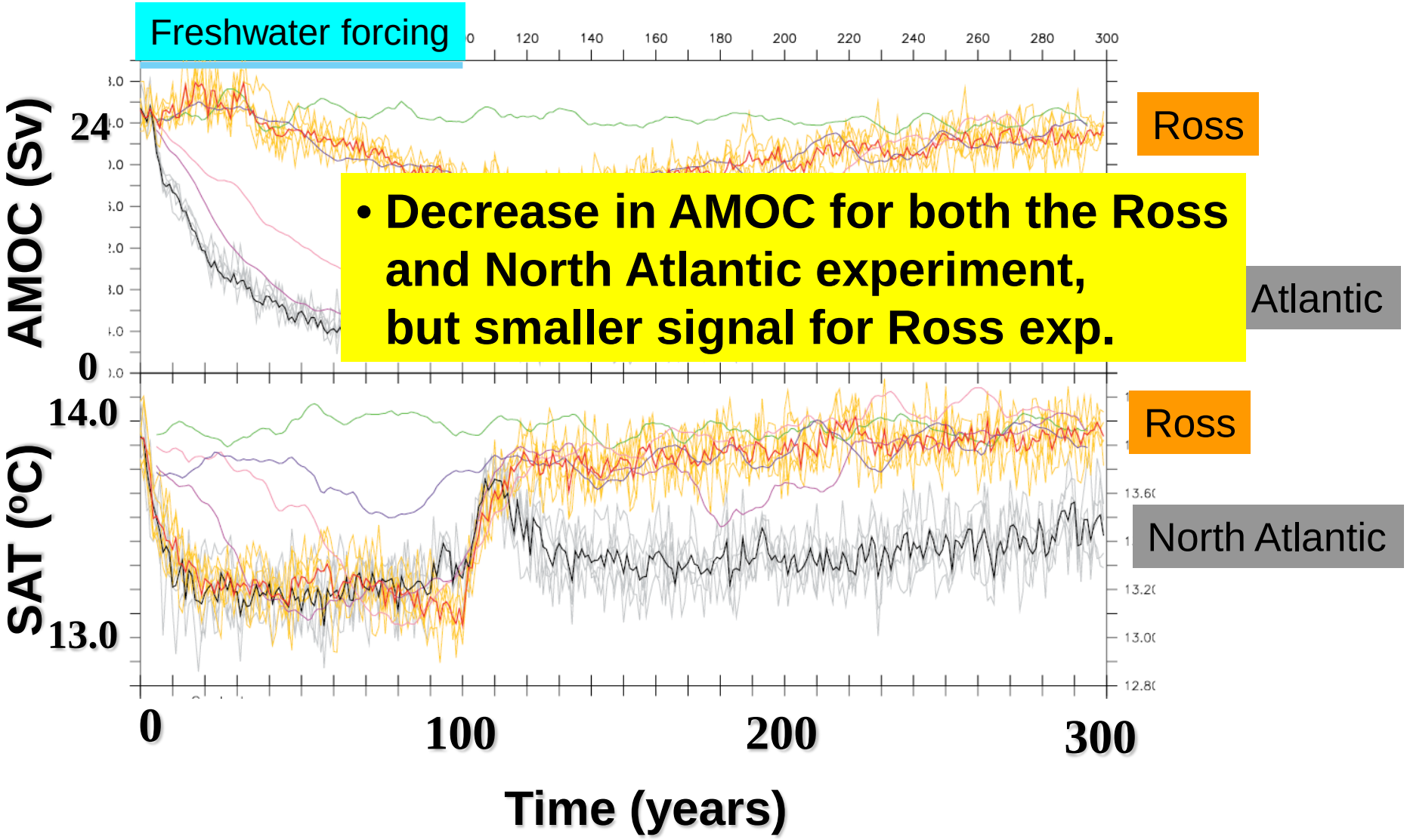

- **Decrease in AMOC for both the Ross and North Atlantic experiment, but smaller signal for Ross exp.**

Physical Response at year 100: Change in Temperature and Precipitation

- Typical bipolar seesaw response for NA experiment
- Opposite shifts of ITCZ in NA vs Ross experiments

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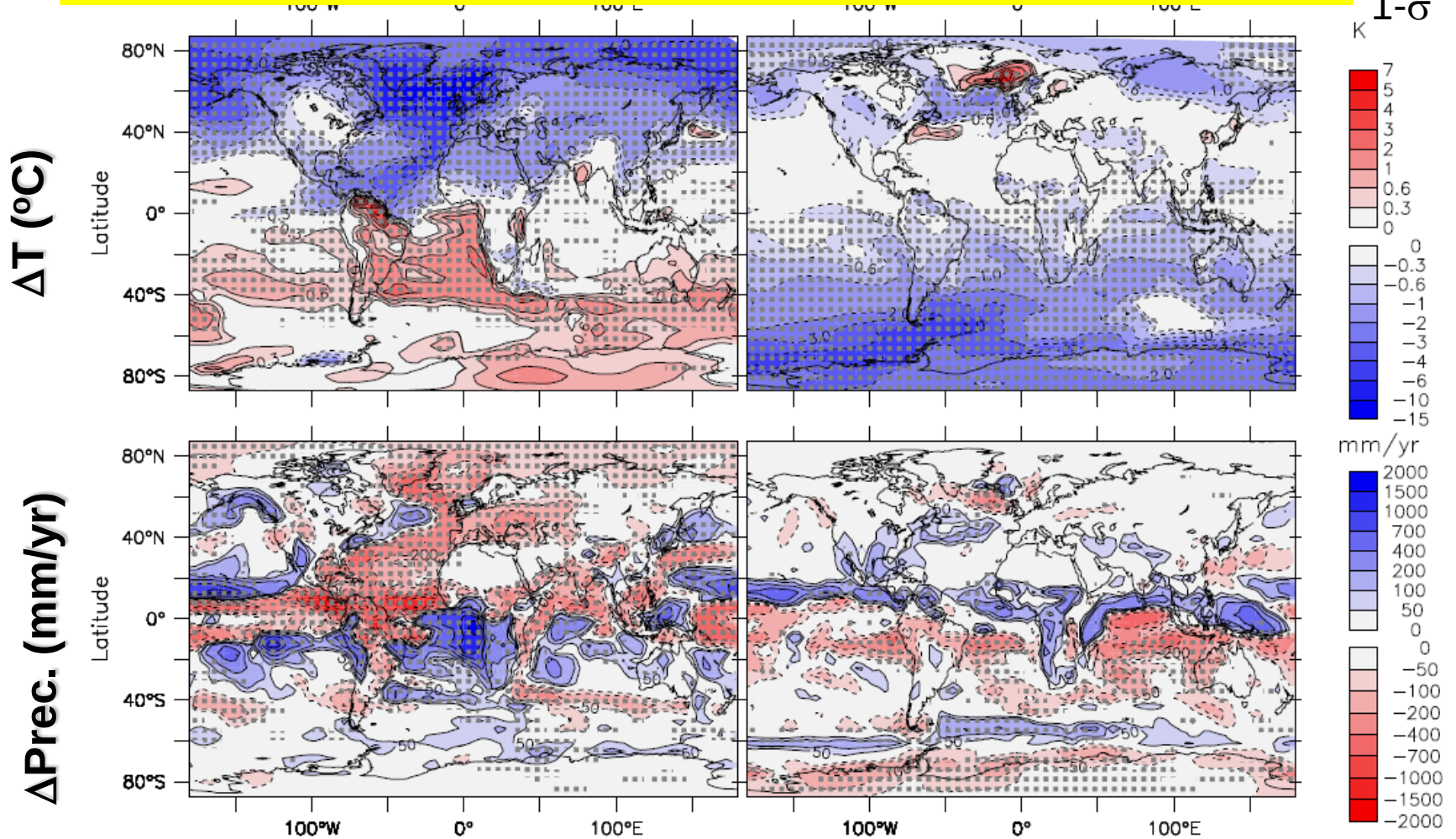
Stippling: 1-σ



Physical Response at year 100: Temperature and Precipitation Changes in South America

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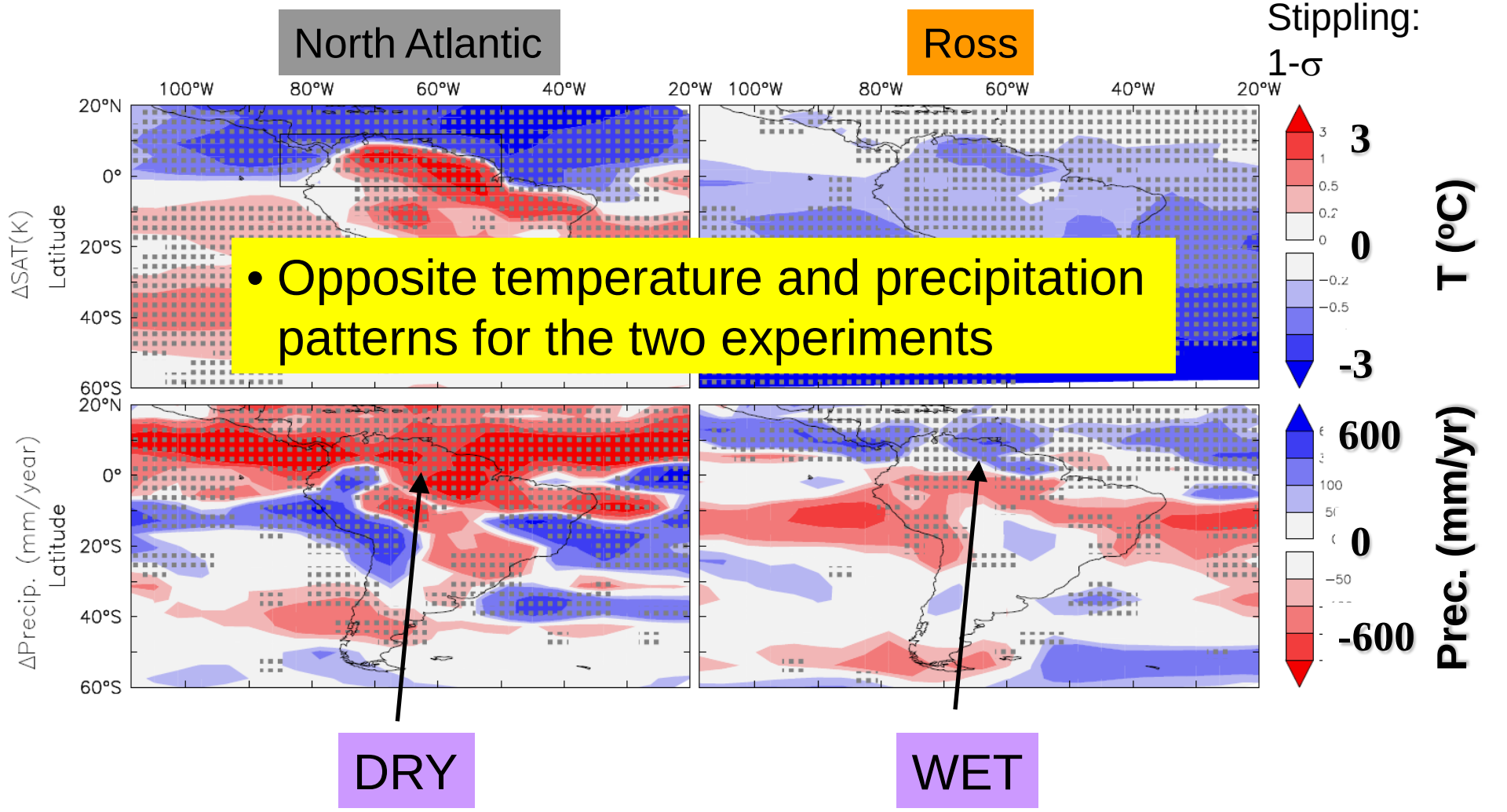

Carbon Cycle Response :
Carbon Stock Changes in Atm – Ocean – Land

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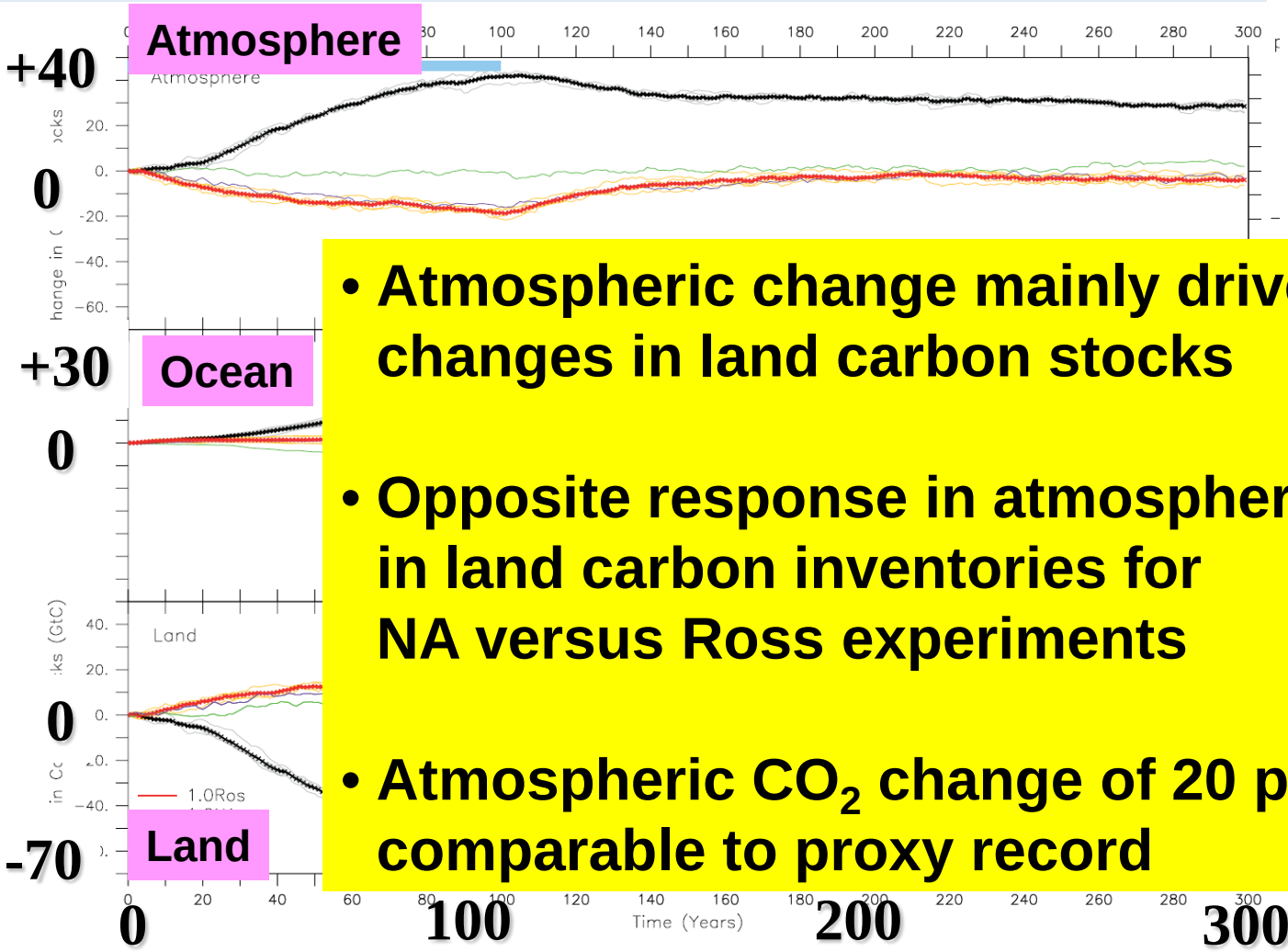
North Atlantic

Ross



- **Atmospheric change mainly driven by changes in land carbon stocks**
- **Opposite response in atmosphere and in land carbon inventories for NA versus Ross experiments**
- **Atmospheric CO_2 change of 20 ppm comparable to proxy record**

Changes in land carbon inventories linked to precipitation in the tropics

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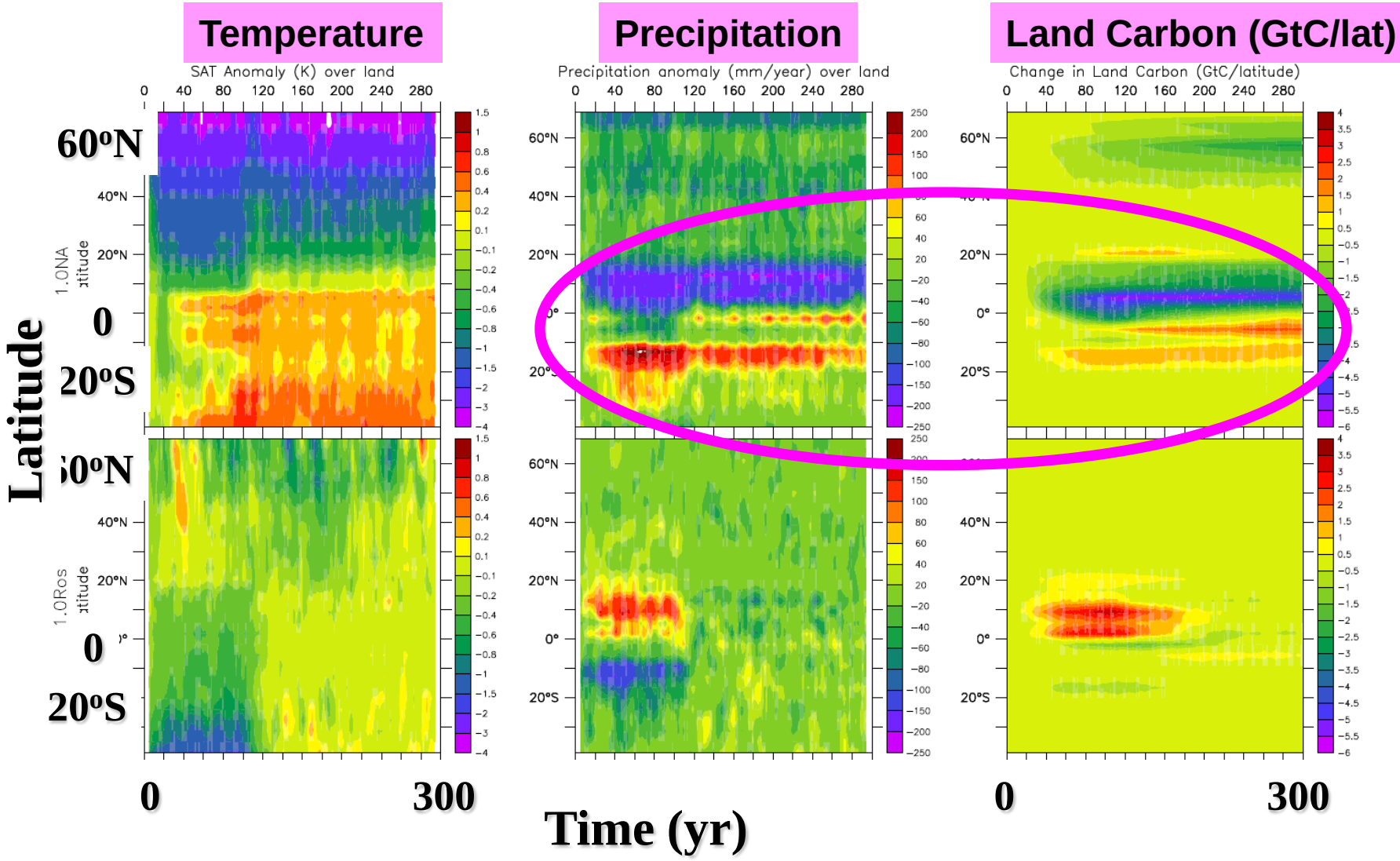

High correlation between NPP and soil moisture in South America (similar for NA and Ross experiments)

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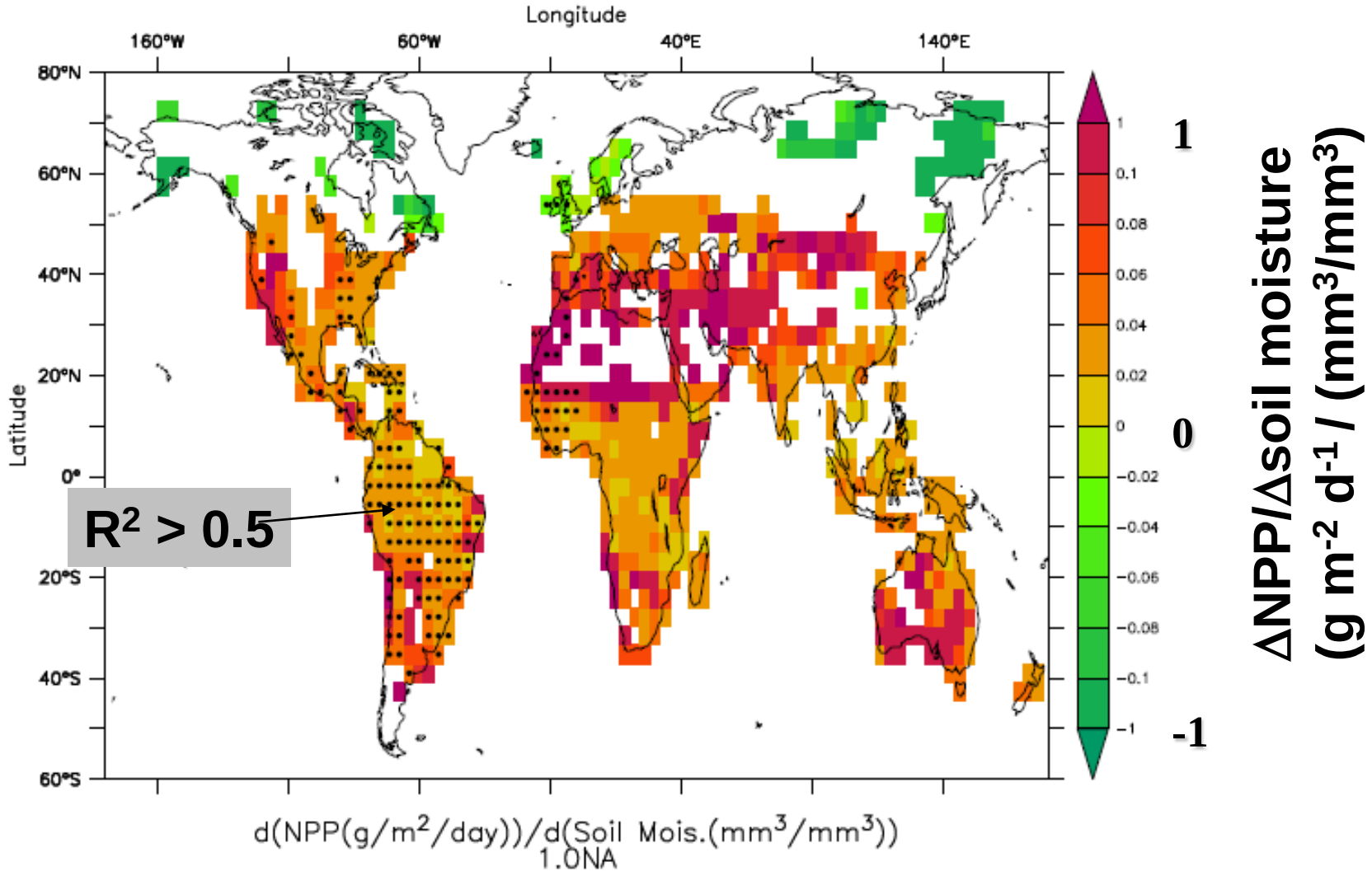

Carbon Cycle Response at year 100: NPP and carbon stock changes in South America

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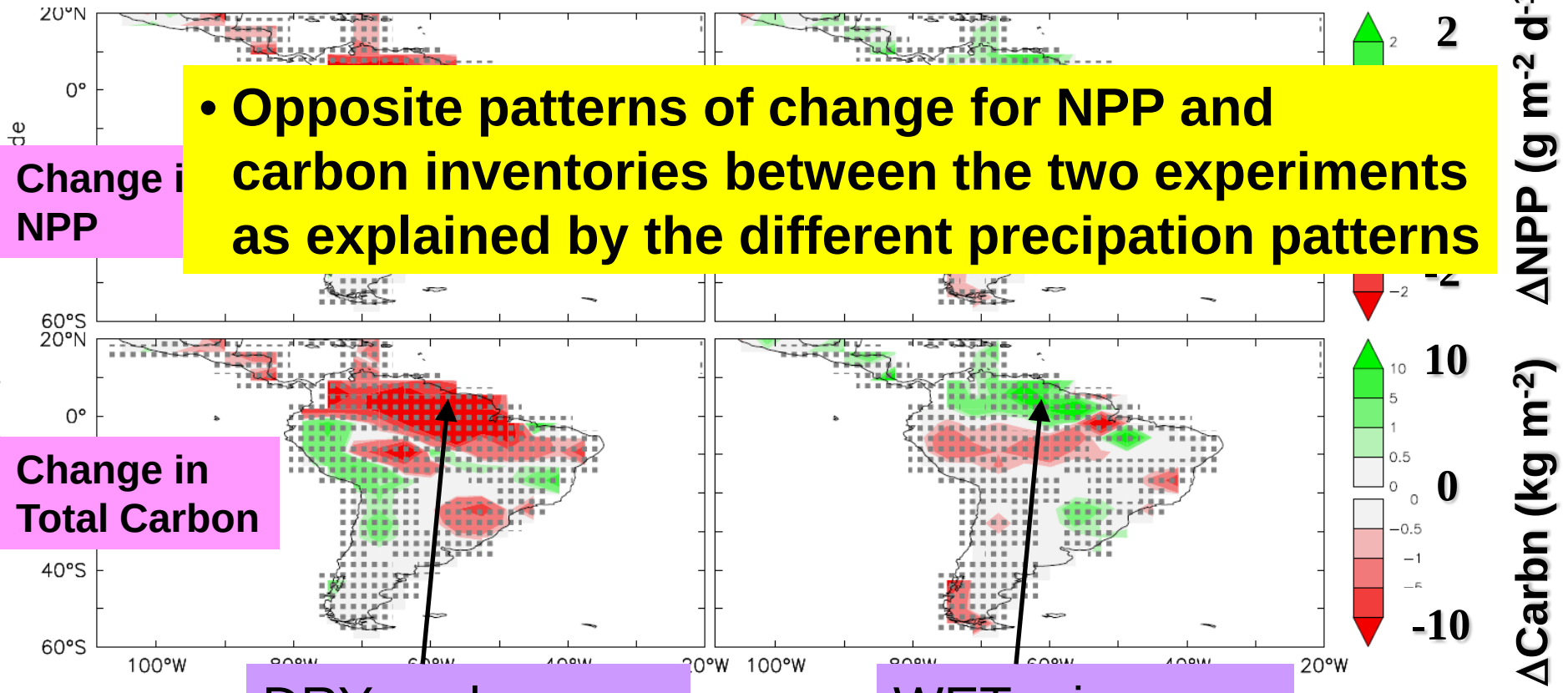
Stippling: 1-σ

North Atlantic

Ross



- **Opposite patterns of change for NPP and carbon inventories between the two experiments as explained by the different precipation patterns**

Change i NPP

Change in Total Carbon

DRY -> decrease

WET-> increase

Comparison between simulated precipitation and proxy records for the Younger Drias event

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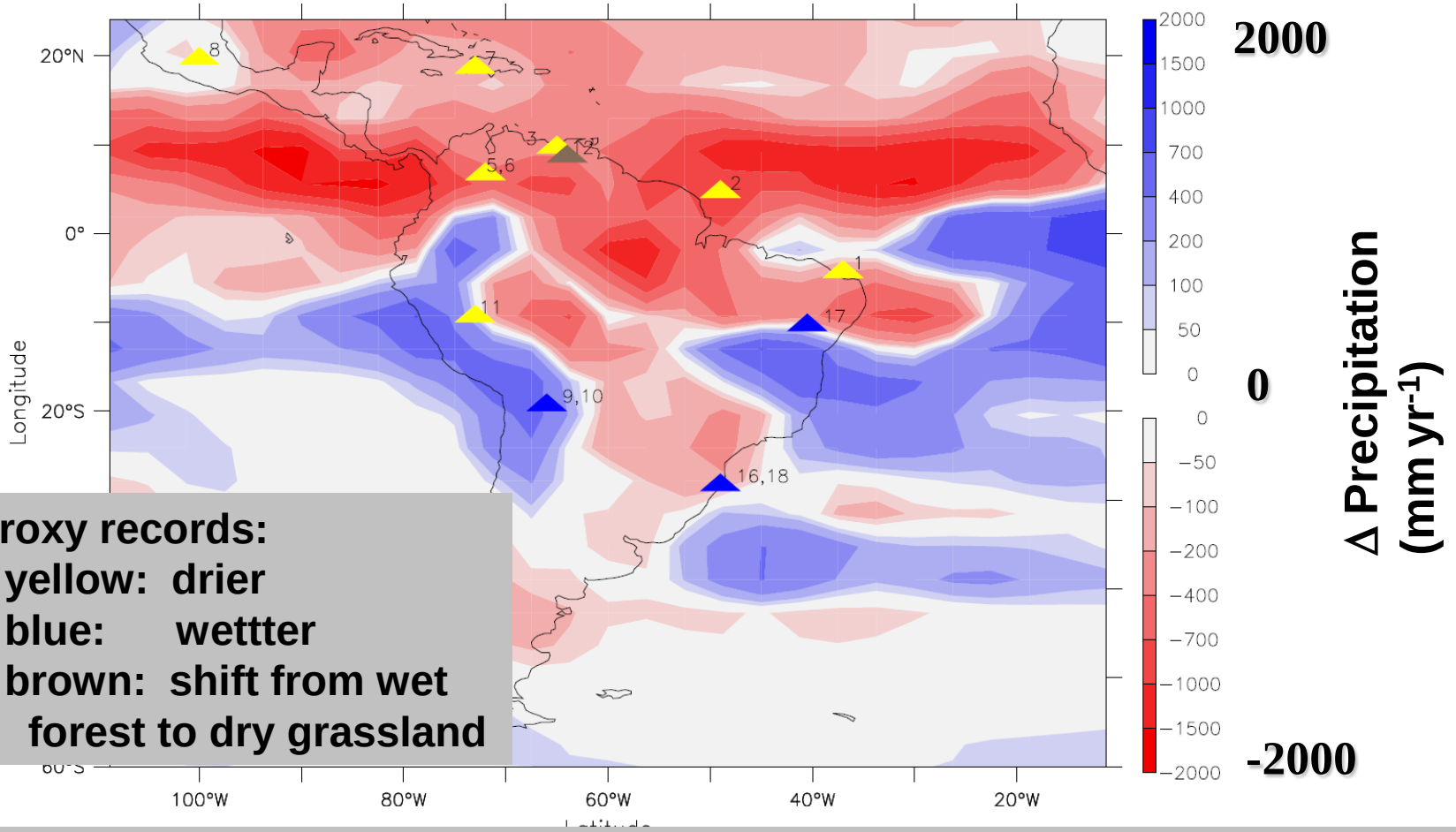

Proxy records:

- **yellow: drier**
- **blue: wettter**
- **brown: shift from wet forest to dry grassland**

Arz et al,1998; Maslin and Burns, 2000; Haug et al., 2001; Van der Hammen and Hooghiemstra, 1995; van't Veer et al., 2000; Hodell et al., 1991; Flores-Diaz, 1986;Baker et al., 2001; Thompson et al., 1998; Hughen et al., 2004; Cruz et al., 2005; Wang et al, 2004+2007

Conclusions

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- **Response pattern in T, Precip, NPP, carbon inventory is different for North Atlantic vs Ross freshwater experiments**
  -> southward vs northward shift of ITCZ
- Tropical land carbon changes linked to soil moisture changes
- Agreement in simulated and proxy-based precipitation pattern for Younger Drias
- Simulated response in atmospheric CO_2 (20 ppm) is compatible with the last glacial ice core CO_2 record; with contributions from both the land and marine carbon cycle
- Caveat: experiments performed for “preindustrial conditions”; sensitivity to initial state (Köhler et al., 2005) not addressed