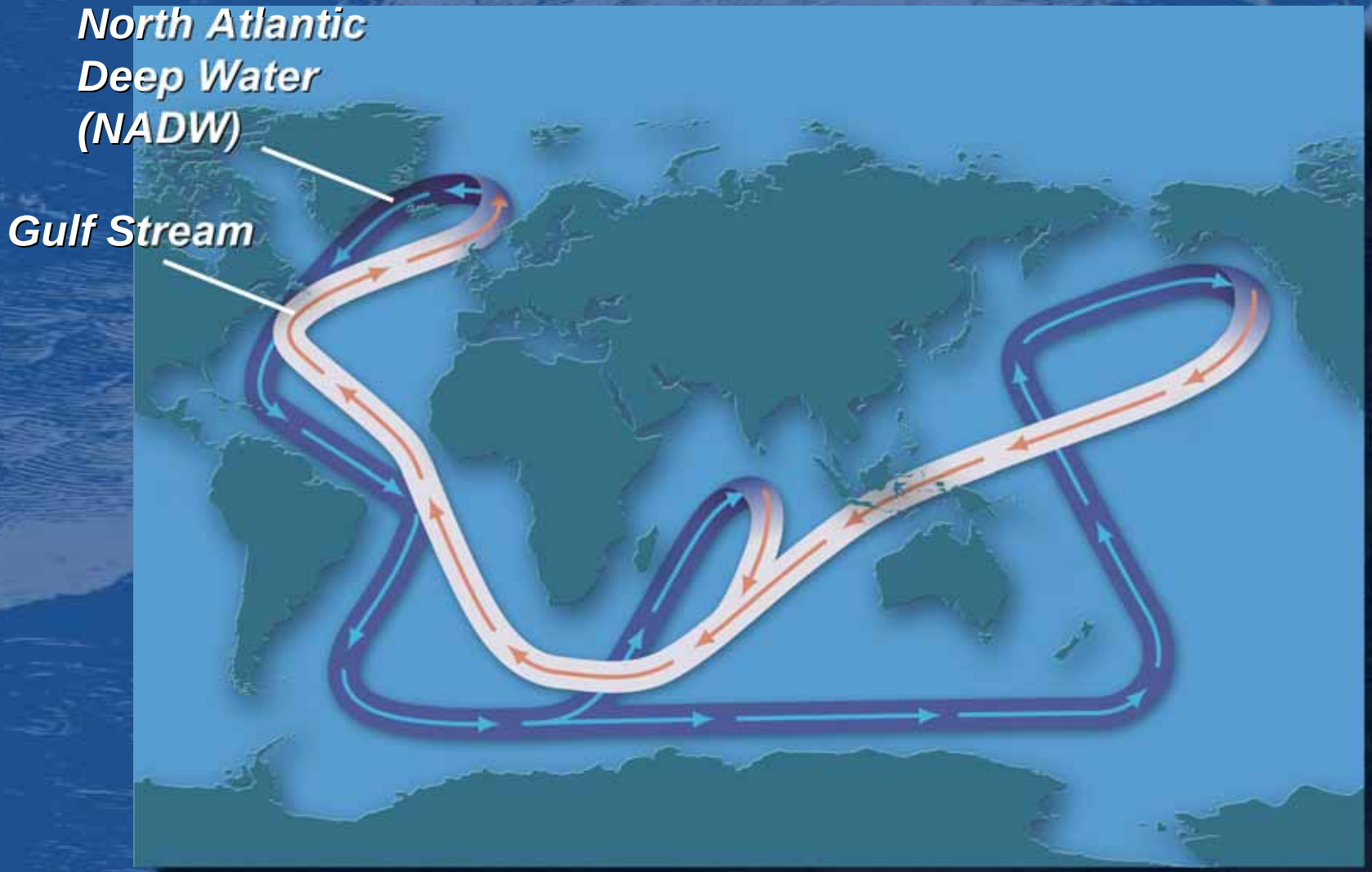
Gulf Stream surface salinity and solar variability during the Last Millennium

David Lund - MIT/WHOI Joint Program

- Estimating past changes in salinity
  - *oceanographic setting*
  - *planktonic foraminifera*
  - *salinity increased by 1 psu during the Little Ice Age (LIA: ~1200-1850 A.D.)*

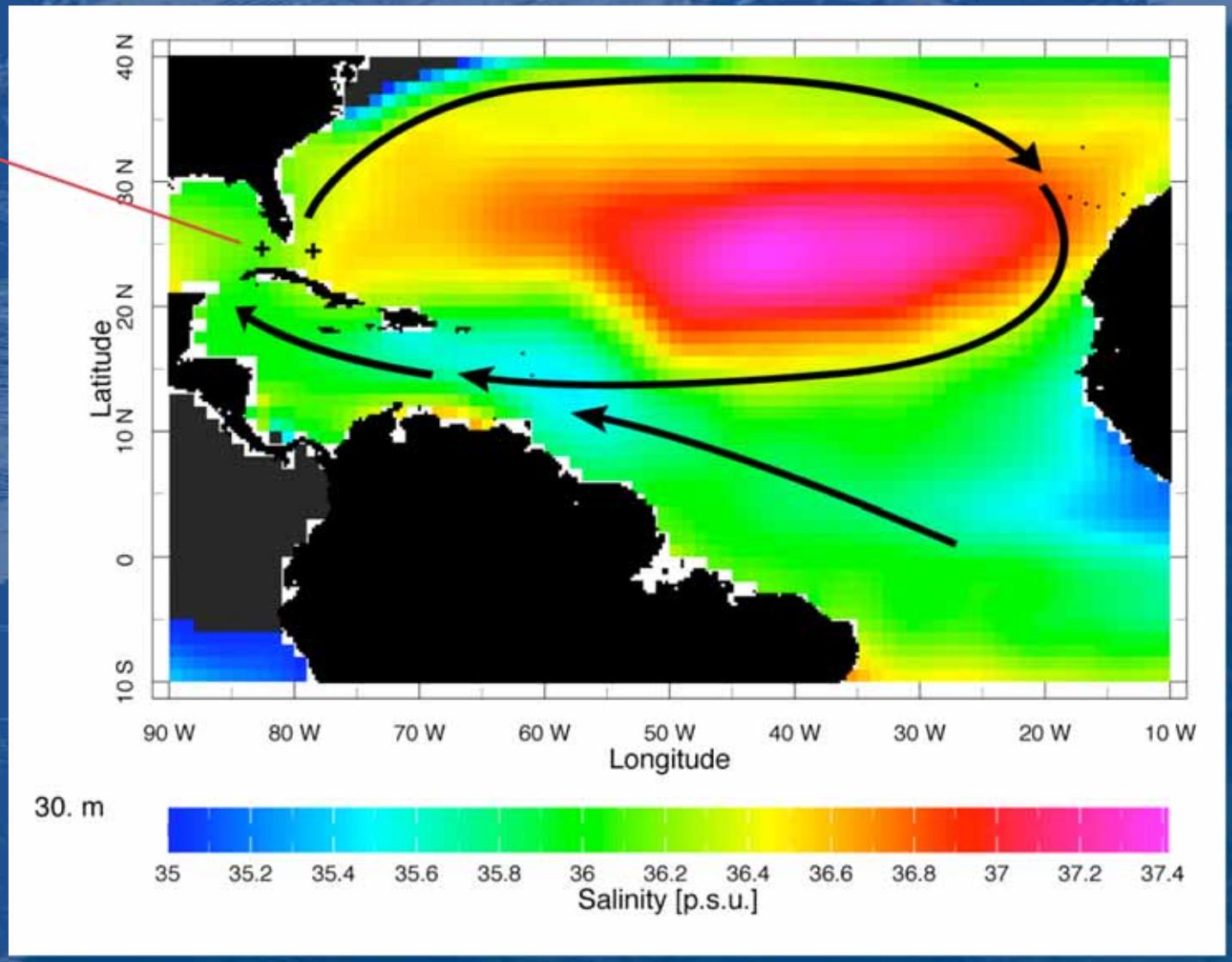
- Linking Gulf Stream salinity to solar variability
  - *solar variability triggered southward migration of the Inter-Tropical Convergence Zone and salinity changes at Dry Tortugas*

Large scale oceanic circulation



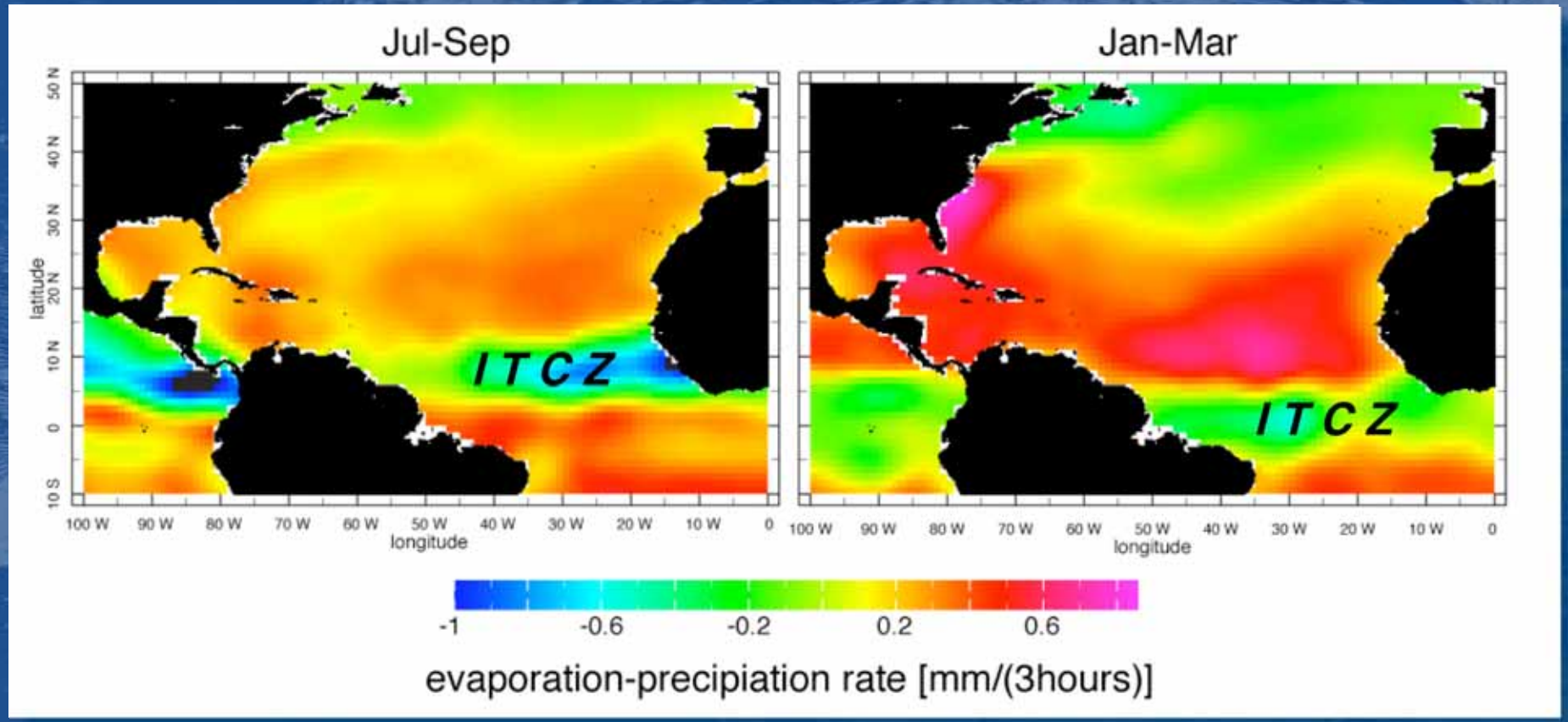
Dry Tortugas reflects tropical Atlantic salinity

Dry Tortugas
salinity= 36.0
79ggc and 62mc



Levitus, 1994

North Atlantic salinity controlled by basin-wide evaporation-precipitation patterns



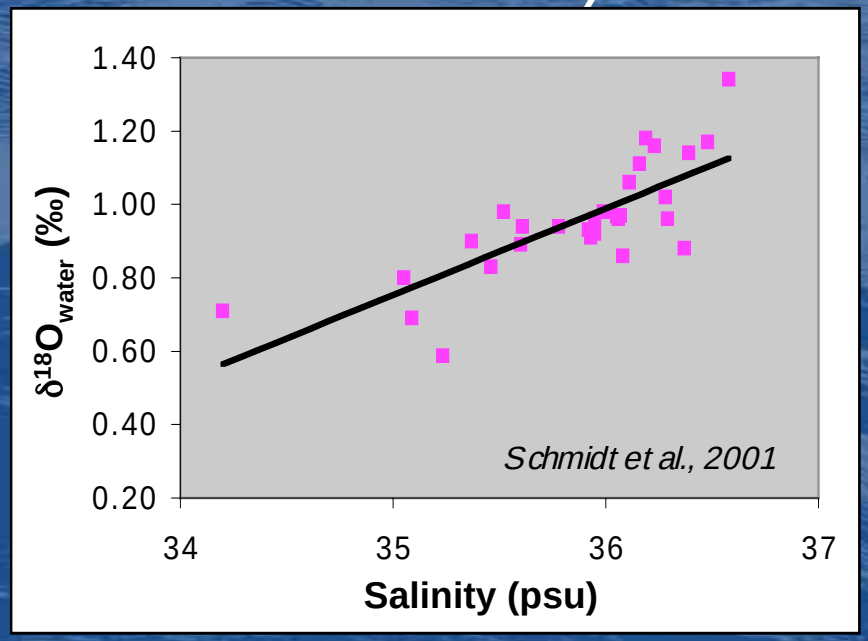
daSilva et al., 1994

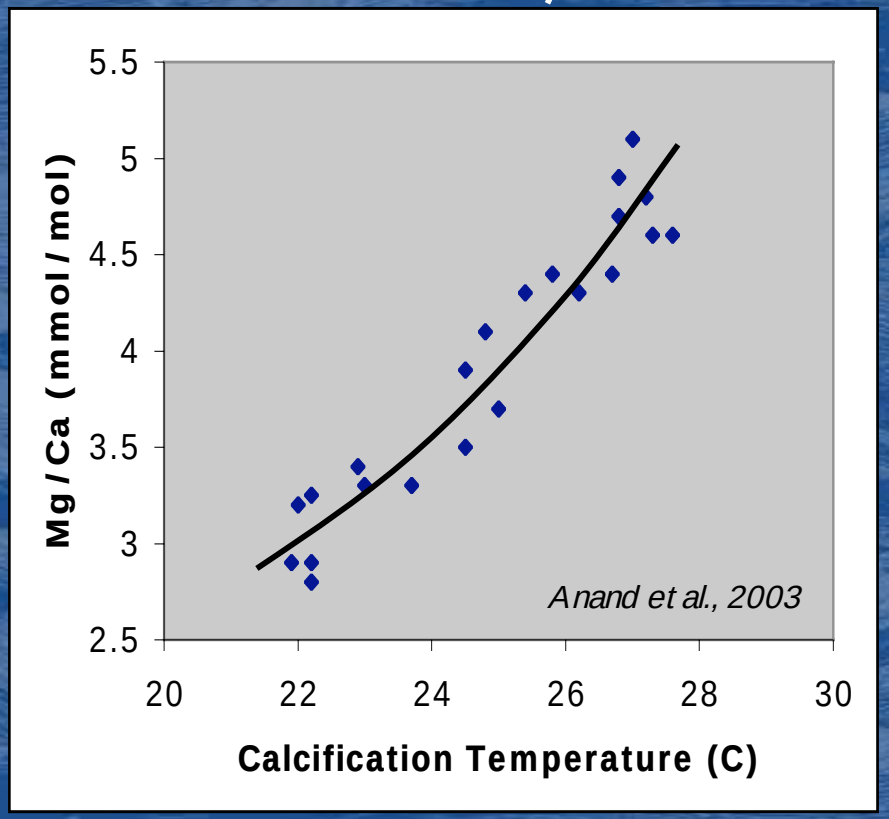
Calculating surface salinity using planktonic foraminifera

$$\delta^{18}O_{calcite} = \delta^{18}O_{water} - 0.20(SST) + 2.98$$

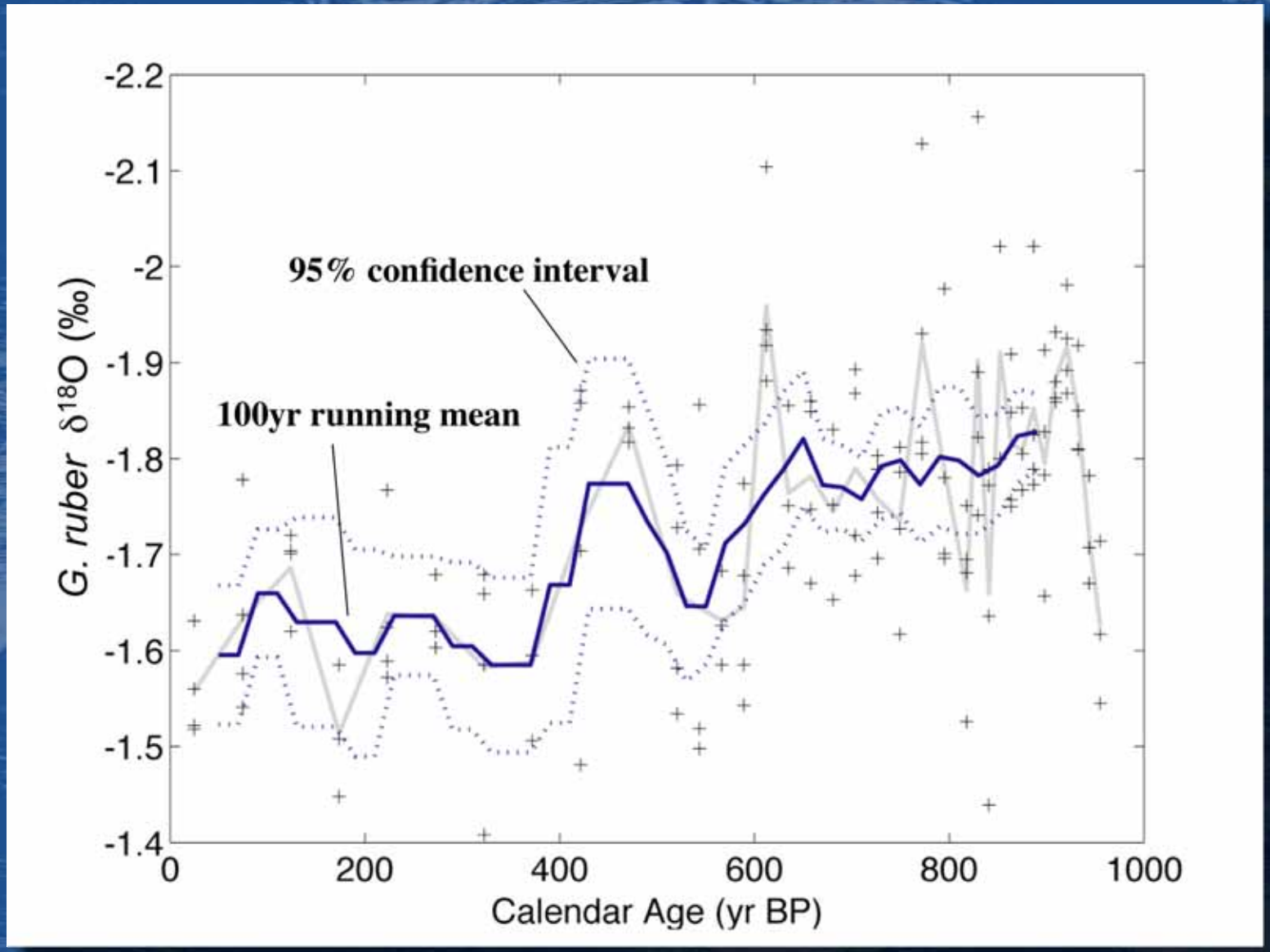
Bemis et al., 1998;
Kim and O'Neil, 1997

$$\delta^{18}O_{water} = \delta^{18}O_{calcite} - 2.98 + 0.20(SST)$$

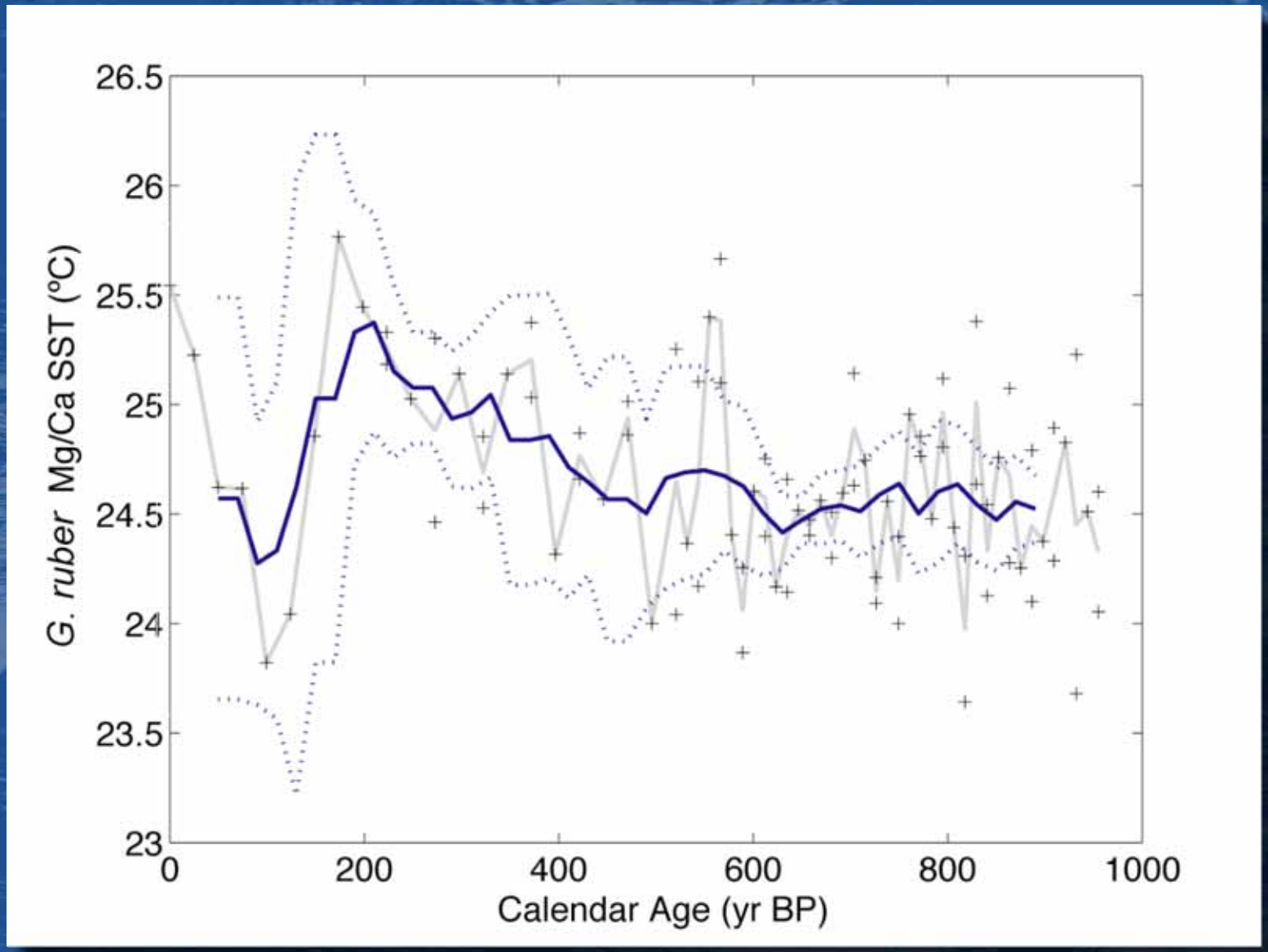




Dry Tortugas $\delta^{18}O_{calcite}$ increased during LIA

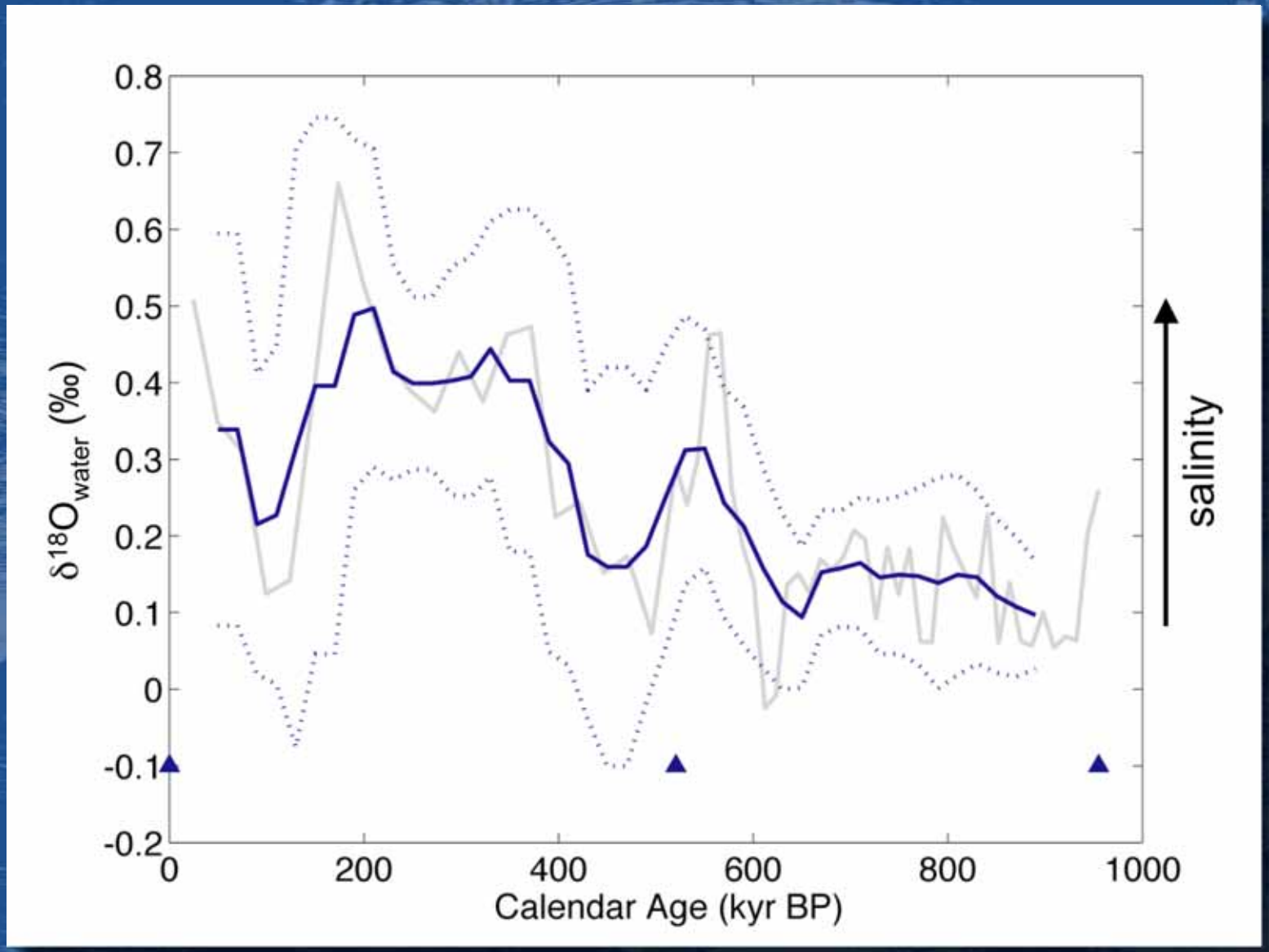


Dry Tortugas sea surface temp. increased during LIA



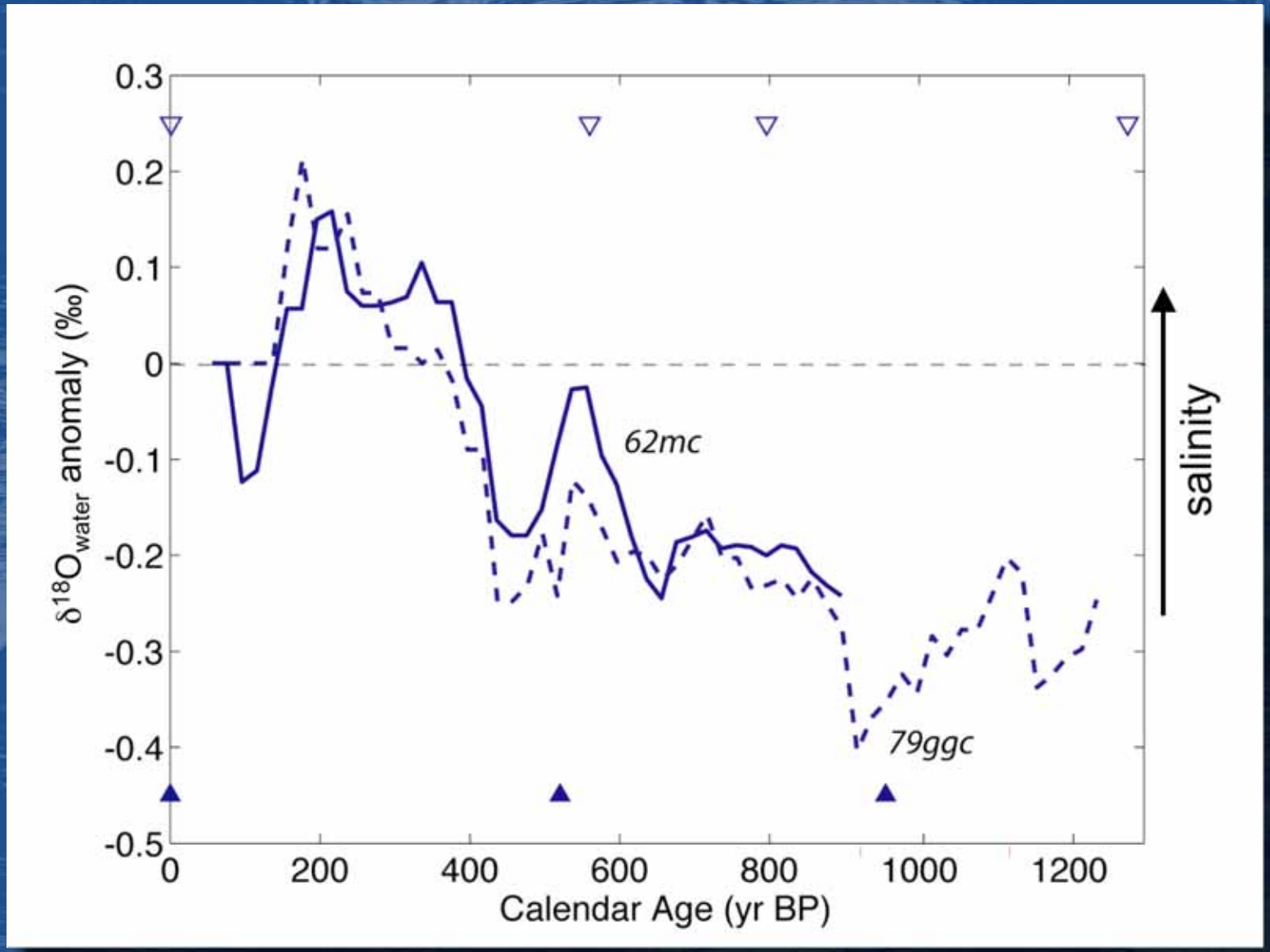
calibration from Anand et al., 2003

Dry Tortugas $\delta^{18}O_{water}$ increased during LIA

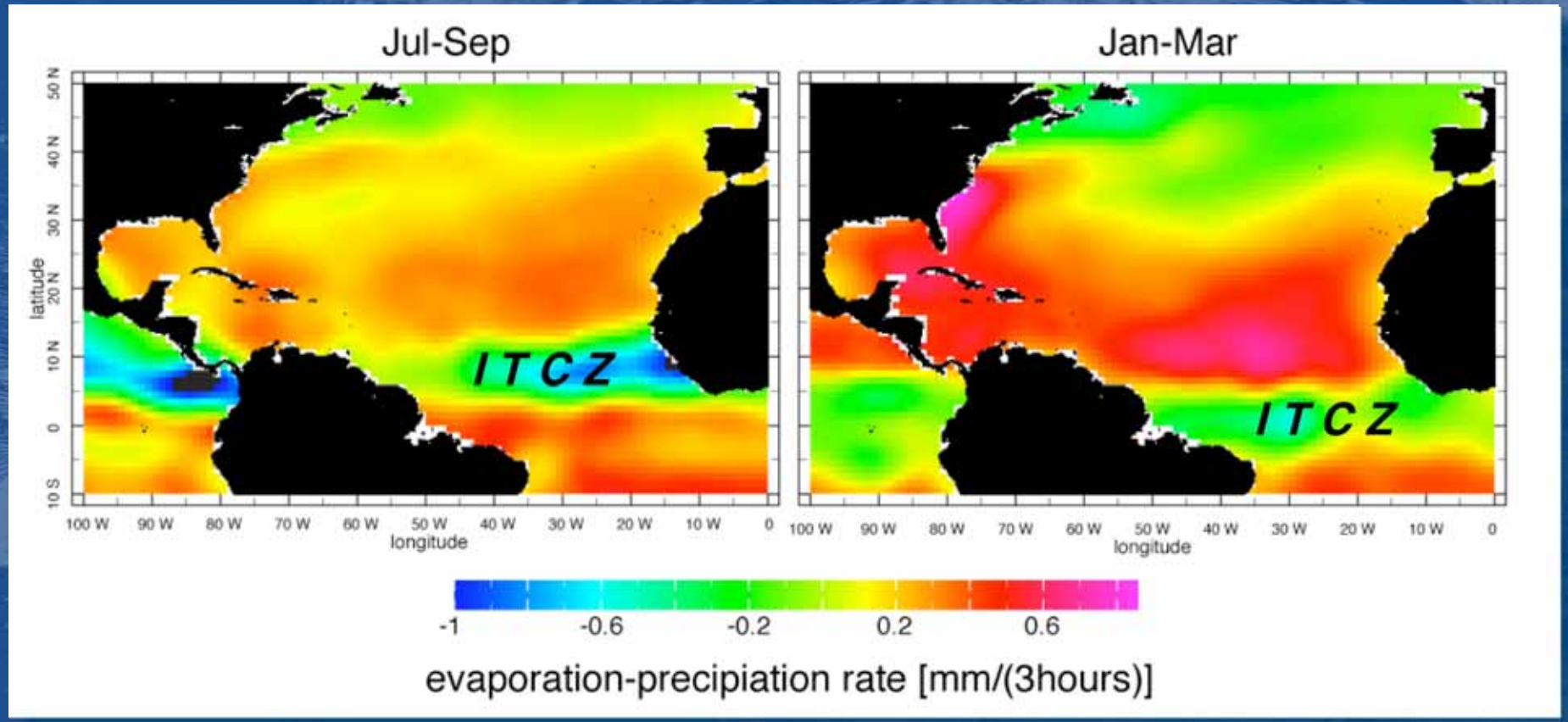


calculated using Kim and O'Neil, 1997

Dry Tortugas $\delta^{18}O_{water}$ record is robust



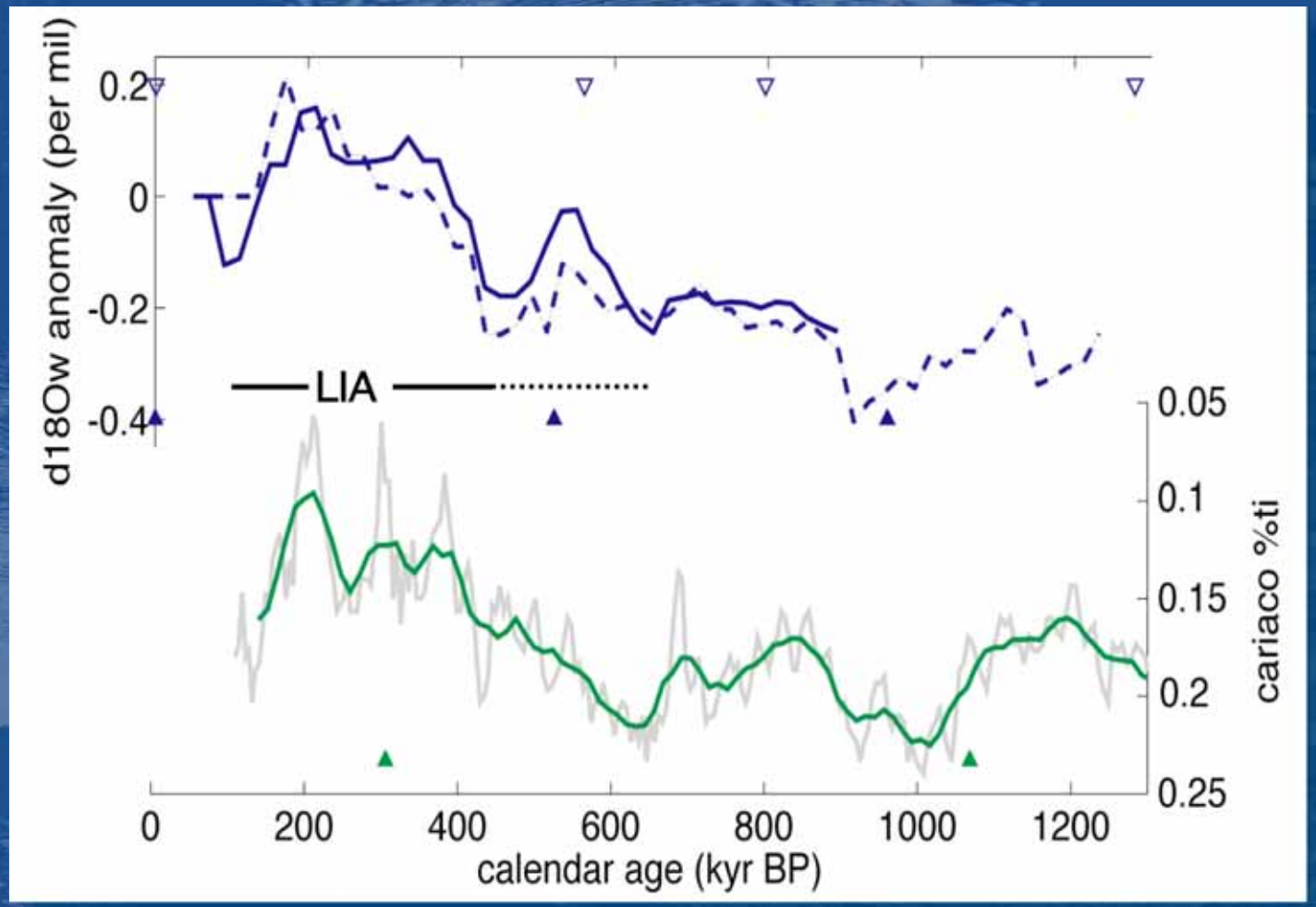
Higher LIA salinity driven by southward ITCZ migration



daSilva et al., 1994

Parallel changes in northern Venezuela precipitation

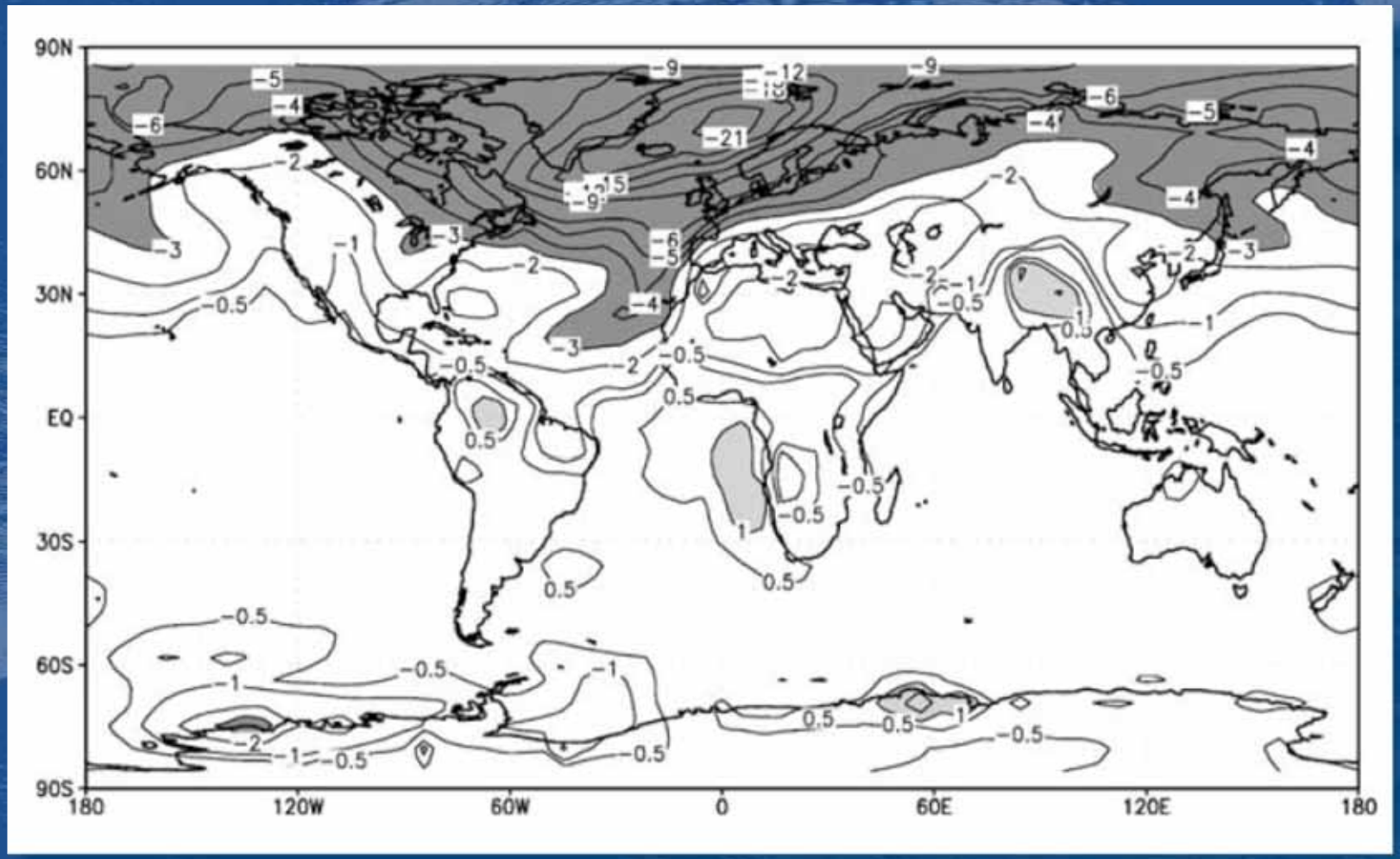
saltier northern tropical Atlantic



drier northern Venezuela

Haug et al., 2001

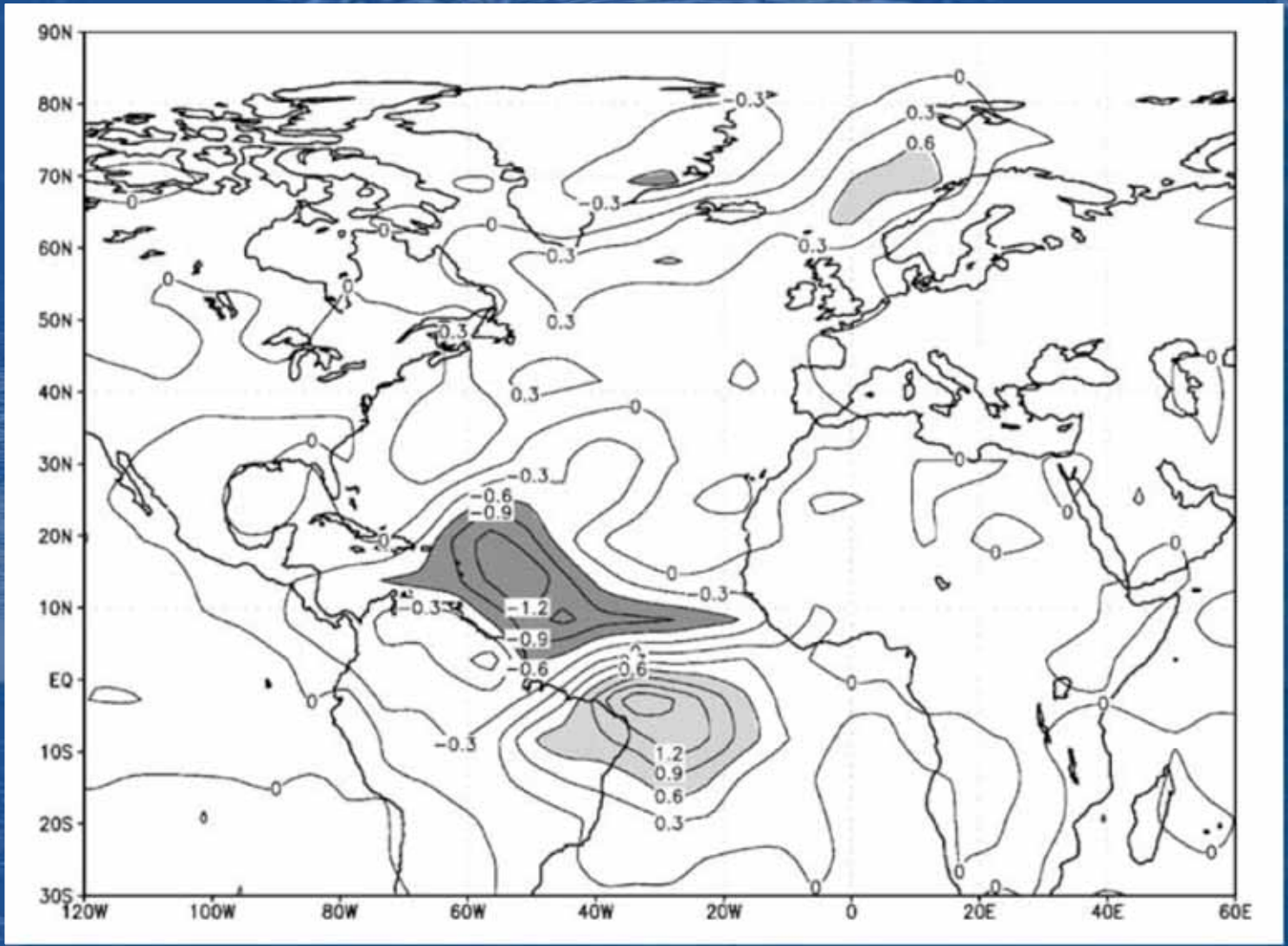
North Atlantic cools when NADW is ‘off’



Anomalous surface air temperature for NADW ‘off’ experiment (°C)
Hamburg coupled ocean-atmosphere model

Lohmann, 2003

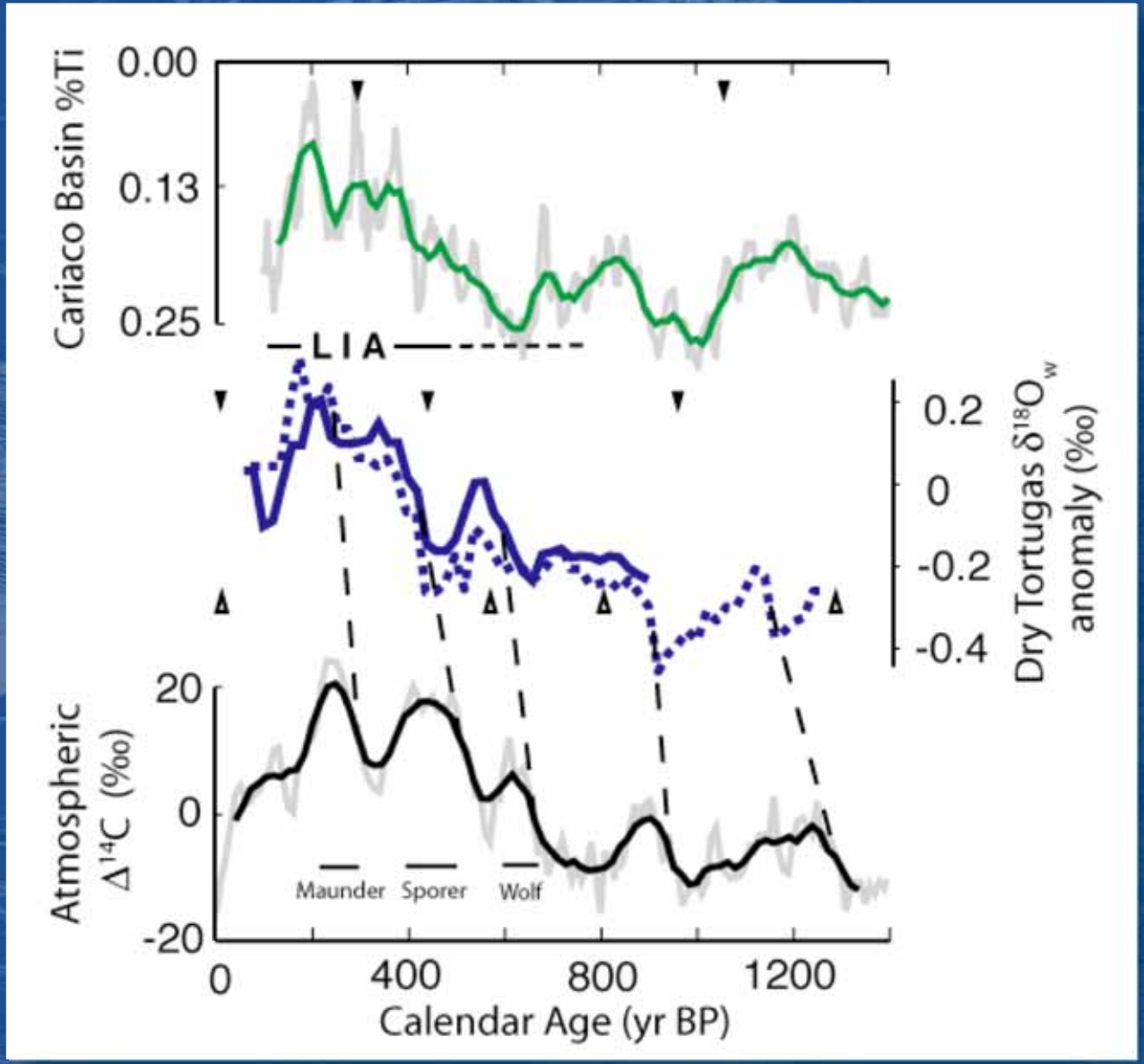
Cooling causes southward ITCZ migration



Anomalous annual mean freshwater flux P-E (m/yr)

Lohmann, 2003

Parallel changes in salinity and atmospheric $\Delta^{14}C$



Stuiver et al., 1998

Conclusions

- Gulf Stream surface salinity increased by ~1 psu during the Little Ice Age
- Data are consistent with a southward shift of the Hadley circulation
- Similarity to Cariaco Basin drought record implies widespread and abrupt changes in Atlantic hydrologic cycle on centennial time-scales
- Parallel changes in Gulf Stream salinity and atmospheric radiocarbon suggest solar pacing of ITCZ movement may influence the Atlantic overturning circulation

Acknowledgements

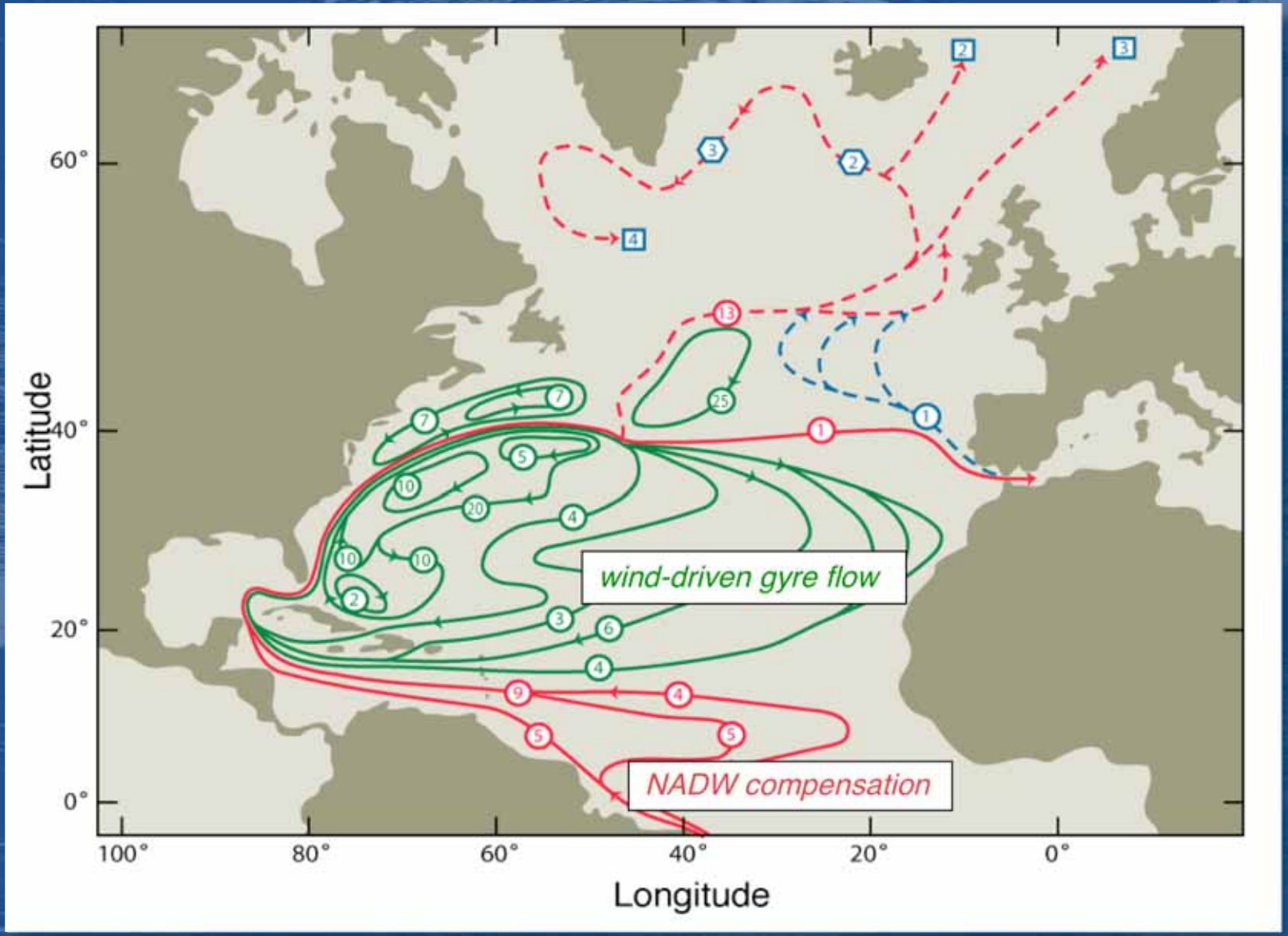
William Curry and Jean-Lynch Stieglitz

Rindy Ostermann, Marti Jeglinski, Anne Edwards, and Shawn Johnson

Rose Came and Simon Thorrold

Captain and crew of R/V Knorr

North Atlantic surface circulation



Schmitz, 1996