The impact of tidal dissipation changes on the Last Glacial Maximum AMOC

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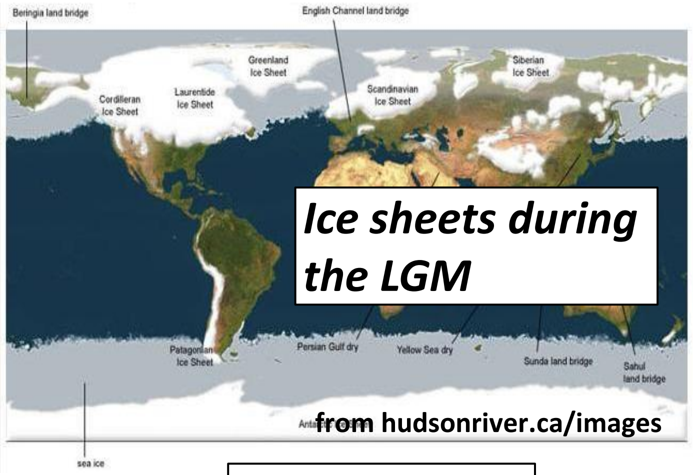
Tides during the Last Glacial Maximum (26.5 – 19 kyr BP)

- Sea-level during the LGM 120 – 130 lower than at present
- Ice sheets covered large parts of NH
- Tidal dynamics profoundly different
- M_2 tides strongly enhanced especially in the North and South Atlantic
- Dissipation 1.8 – 3 greater than at present but influenced by ice sheets (greater ice extent in the Atlantic → less dissipation; less ice → more dissipation)

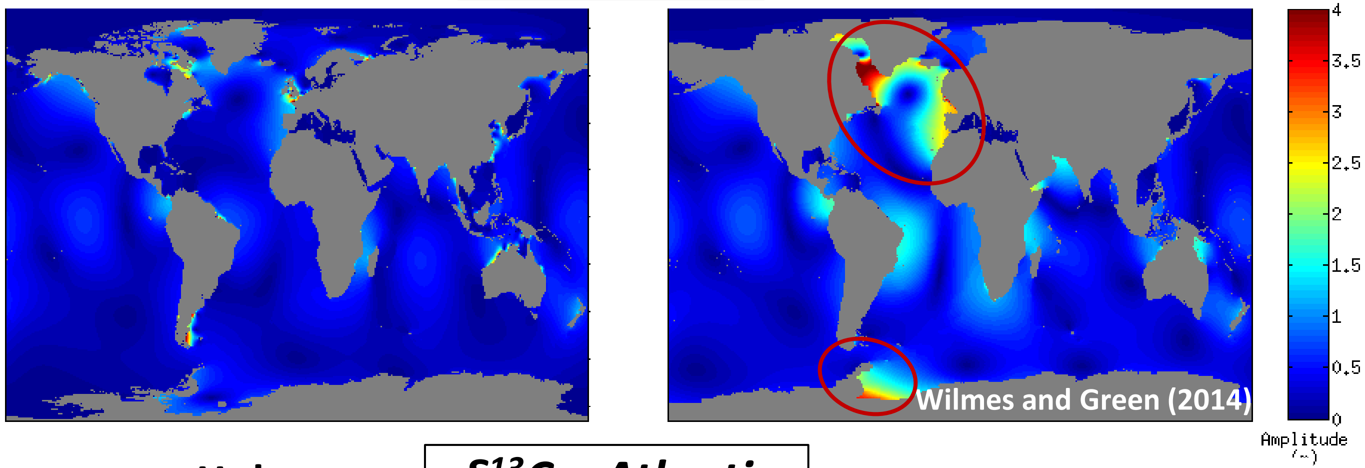
→ Implications for the glacial Atlantic Meridional Overturning Circulation (AMOC)?

→ Stronger mixing = stronger circulation?

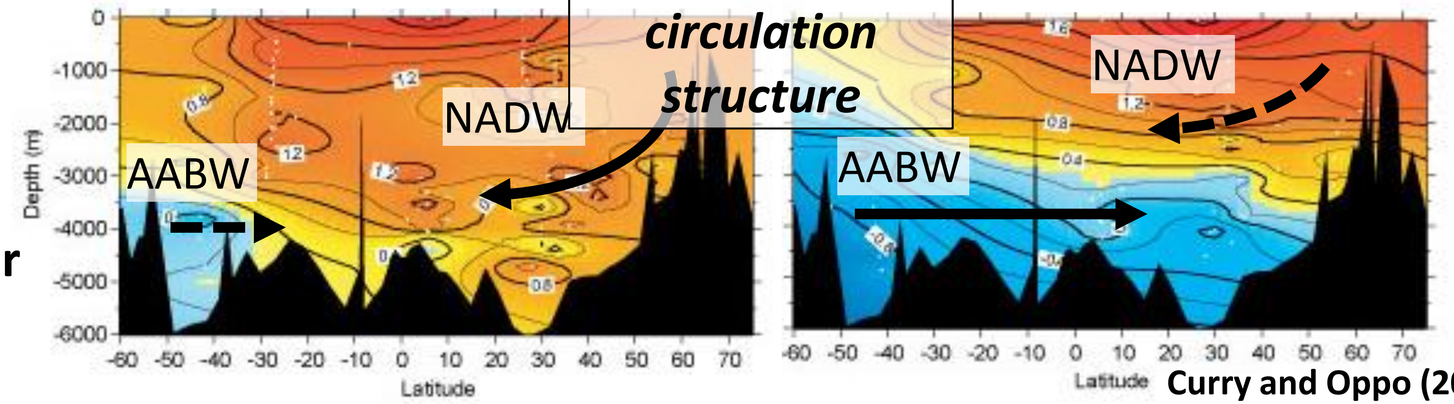
BUT: **AMOC thought to have been shallower and weaker during LGM with less NADW and more AABW**



present **M_2 Amplitudes** LGM



Holocene ***δ^{13}C – Atlantic circulation structure*** LGM



Curry and Oppo (2005)

Is a shallow, weakened glacial AMOC compatible with increased LGM tidal mixing?

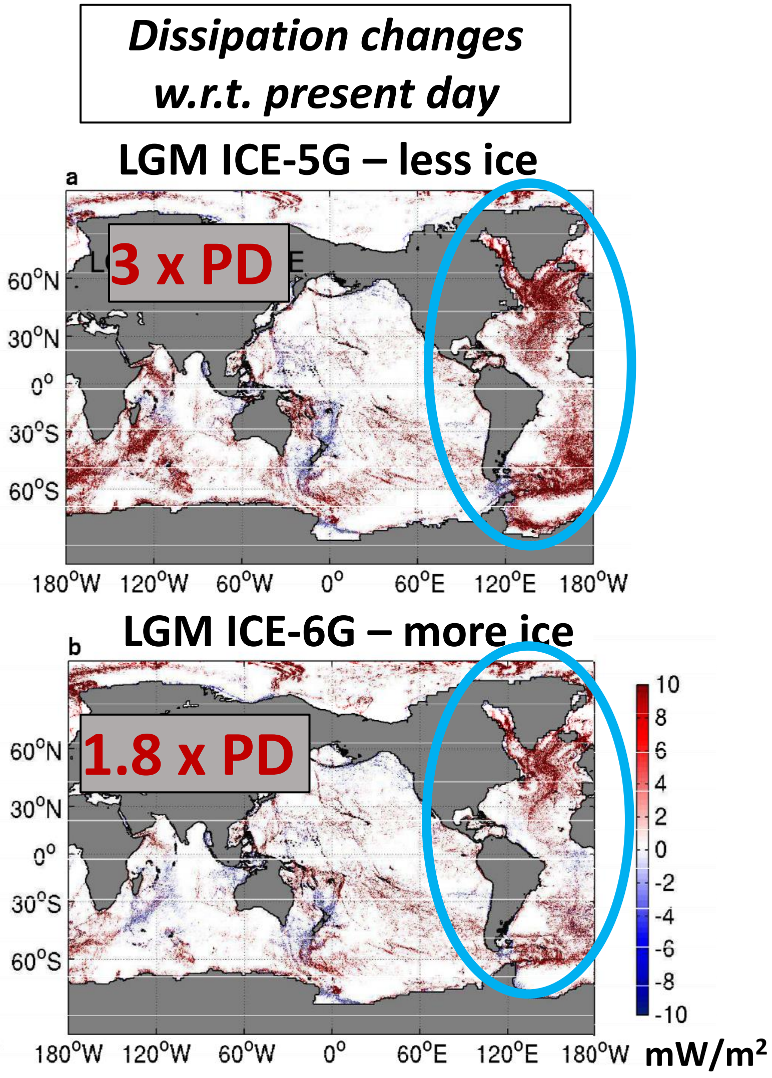
1. Generate ensemble of circulation strengths with different tidal forcing

- Climate model UVic with biogeochemistry model MOBI
- Use **3 different tidal dissipation fields** for mixing:
  - Present day (PD)
  - LGM ICE-6G: 1.8 x more dissipation than PD
  - LGM ICE-5G: 3 x more dissipation than PD

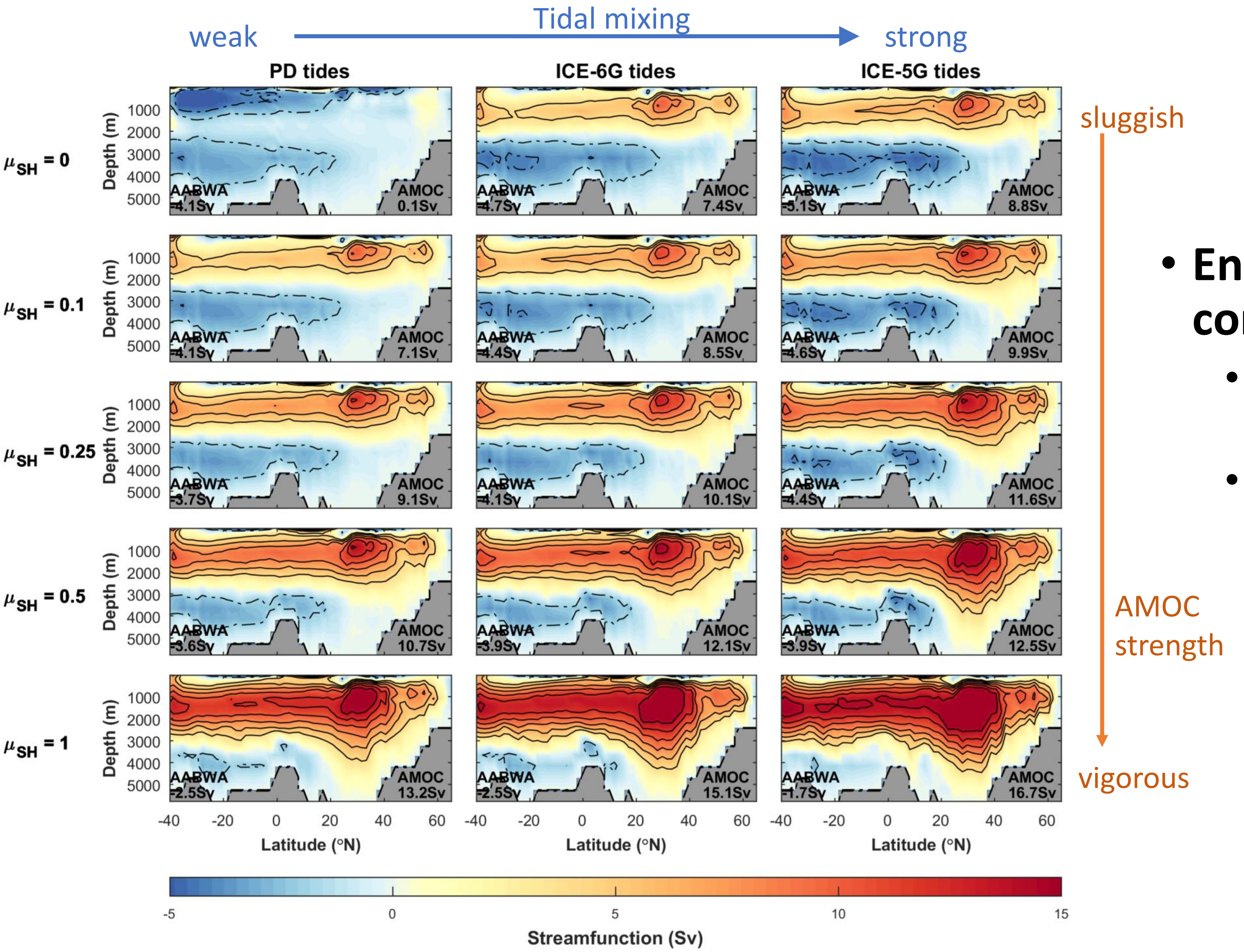
  } **Differ in ice sheet extent**
- **Vary strength of NADW and AABW** formation by altering SH moisture diffusivity

2. Compare modelled carbon isotope distributions with isotopes in LGM sediment cores

- Radiocarbon
- $\delta^{13}C$

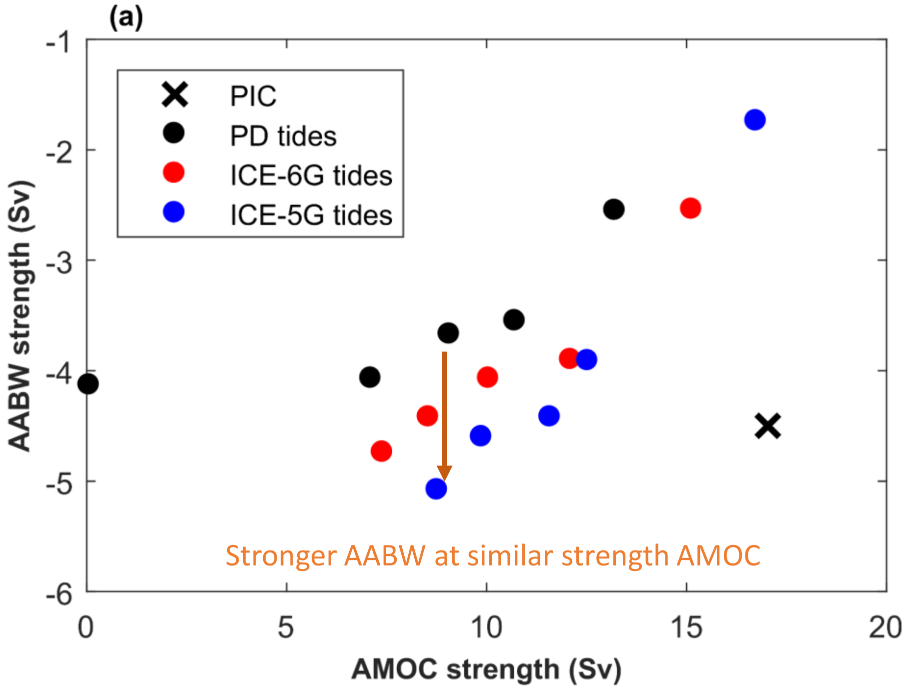


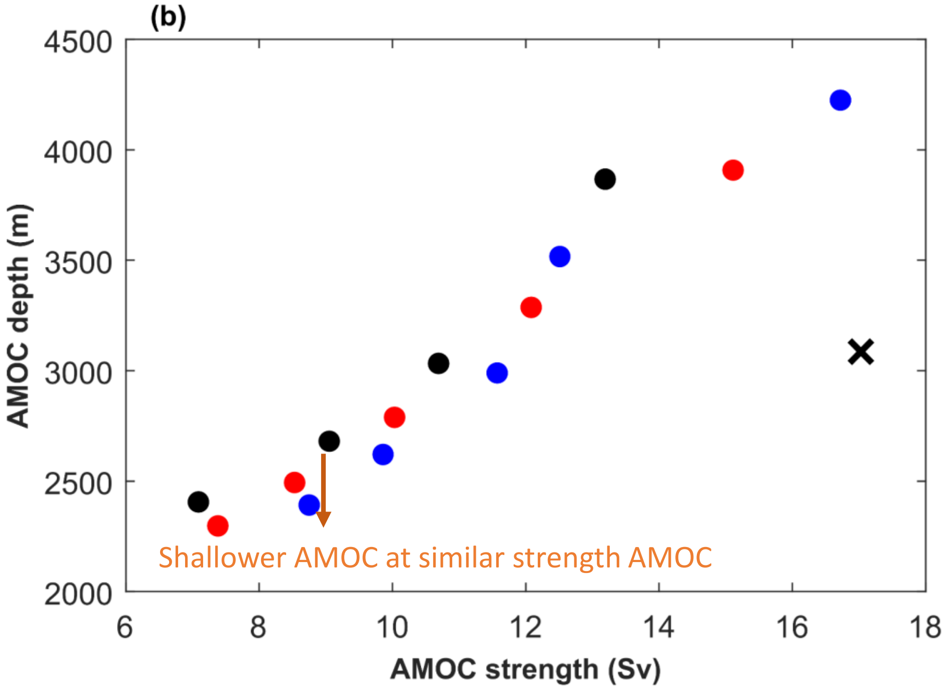
Wilmes et al. (2019)



- **Ensemble of circulation configurations:**
  - From shut-down to vigorous circulation
  - Tidal mixing strengthens circulation cells

LGM tidal mixing affects circulation structure





→ LGM tidal mixing **increases AABW strength**

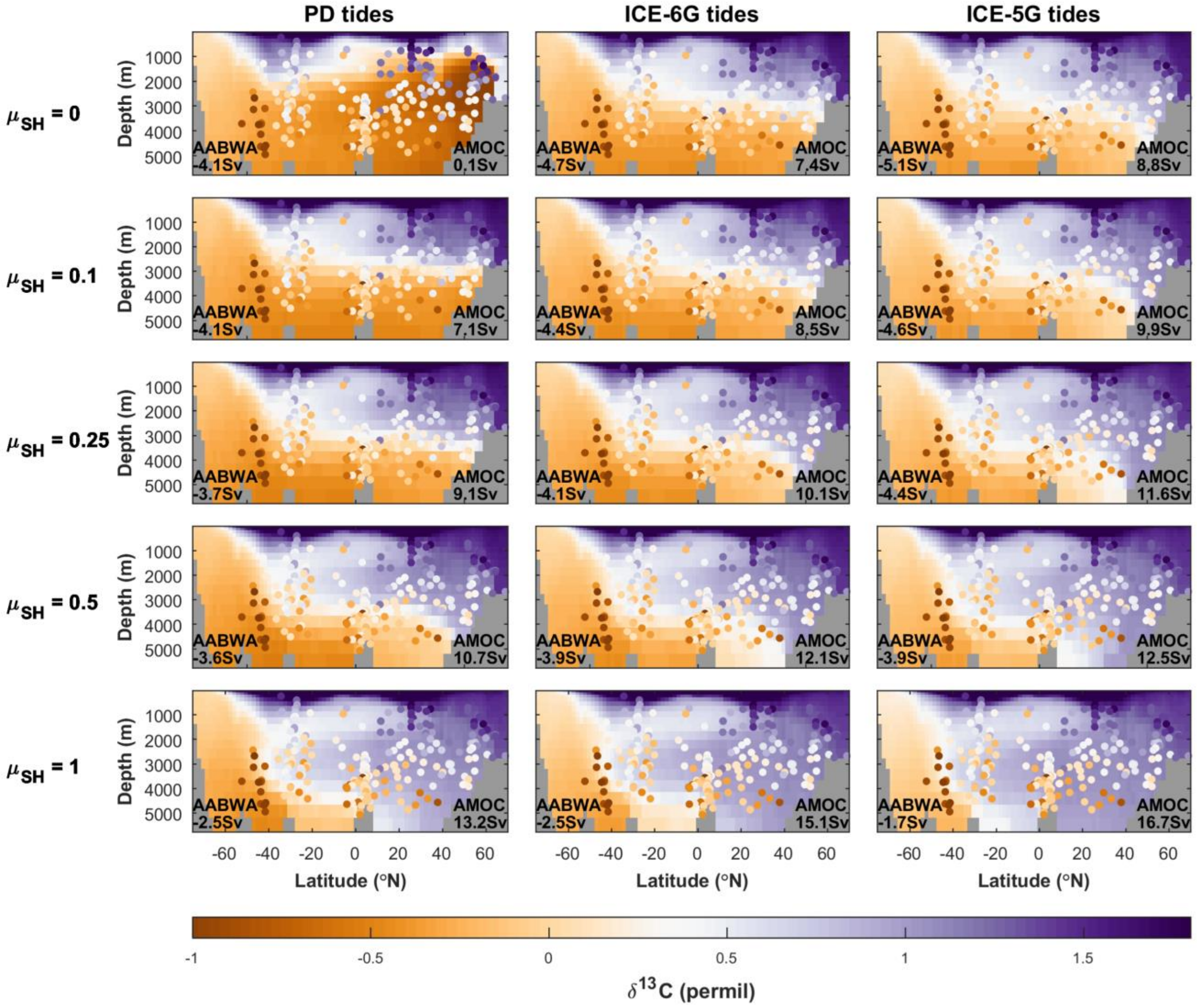
Increased tidal mixing in the southern Atlantic increases AABW formation

→ LGM tidal mixing **decreases AMOC depth**

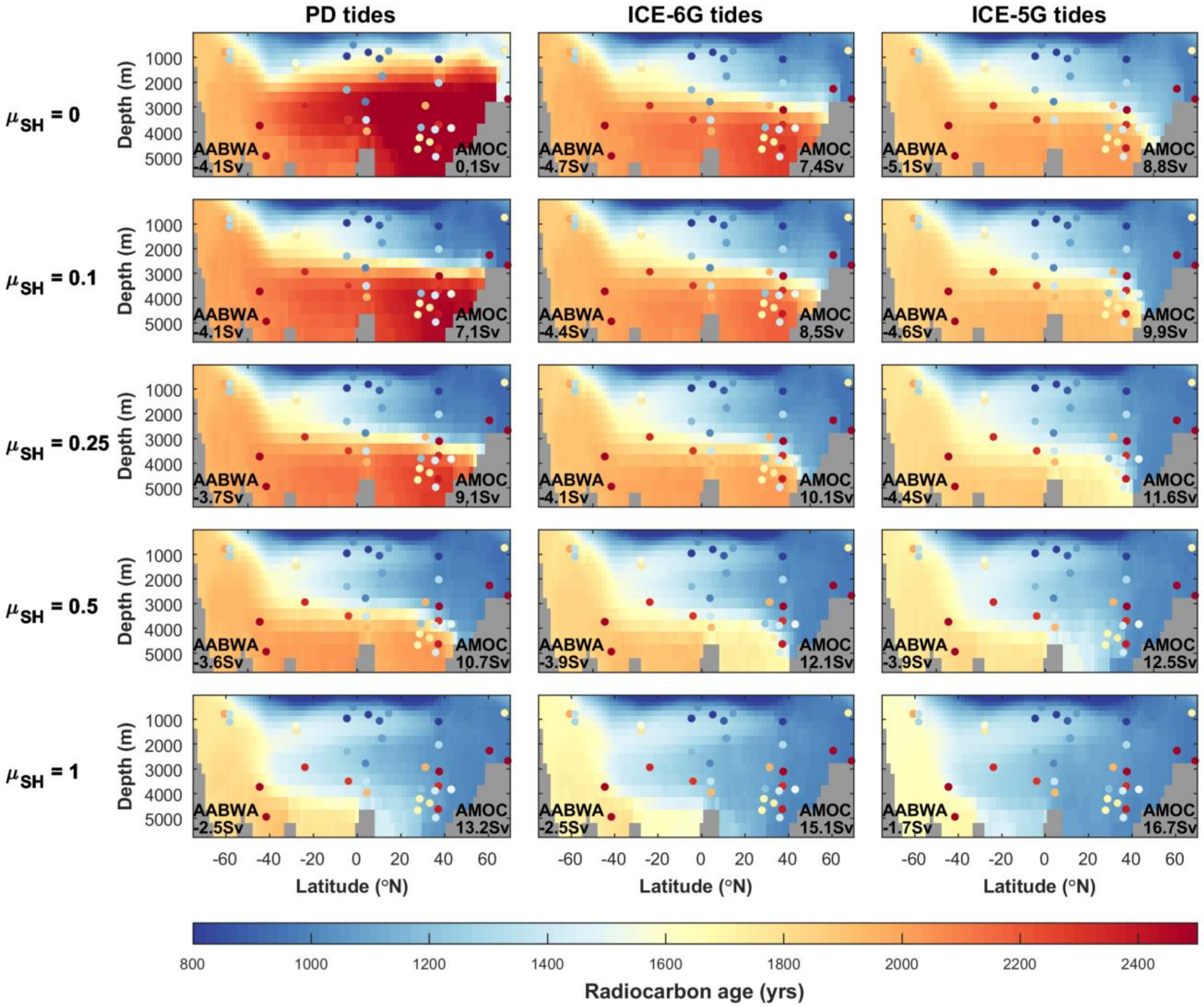
Increased amount of AABW displaces NADW upwards and reduces AMOC depth

Model – sediment isotope comparison

$\delta^{13}C$

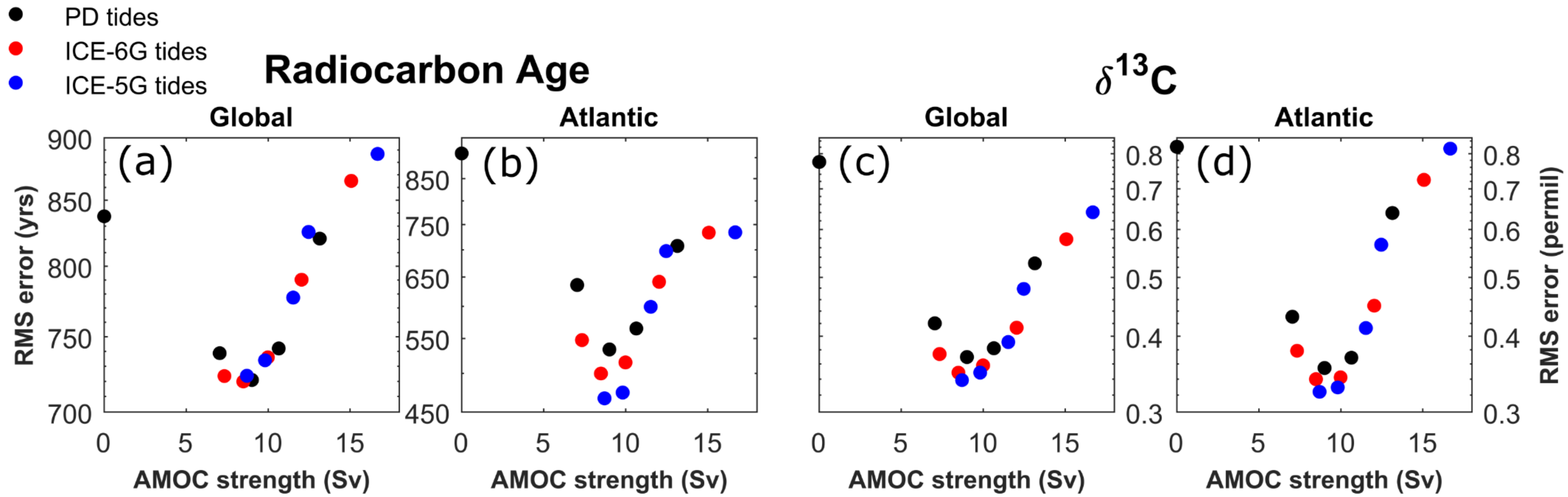


Radiocarbon ages



Modelled Atlantic $\delta^{13}C$ (left) and radiocarbon (right) distributions with sediment isotope data overlain (dots). Sediment isotope data comes from Peterson et al. (2014) and Skinner et al. (2017)

Model – sediment isotope evaluation



- Overall model – sediment isotope fit dominated by AMOC strength
- BUT ~10% improvements in the Atlantic with strong LGM tidal mixing
- Best fit for run with AMOC of 9 Sv & LGM ICE-5G tidal mixing

→ Shallow and weak AMOC **compatible with enhanced tidal mixing**

→ **LGM tidal mixing improves model isotope fit**

Conclusions

- Shallow and weak AMOC (9 Sv) best explains radiocarbon and $\delta^{13}C$ data
- Using **LGM tidal mixing improves fit by ~10 %**
- Shallow and weak AMOC **compatible with enhanced tidal mixing**
- Enhanced tidal mixing increases AABW strength and decreases AMOC depth