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Arctic closure as a trigger for Atlantic overturning at the Eocene-Oligocene Transition

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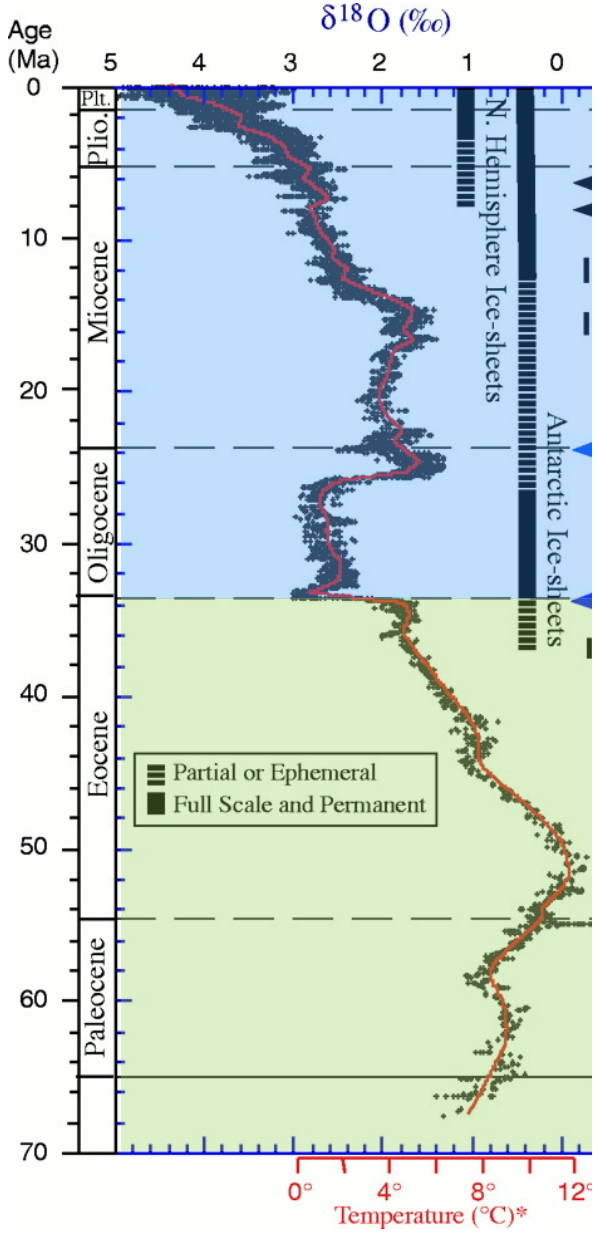
Eocene Oligocene Transition



Oligocene Icehouse

EOT

Eocene Greenhouse

- Major cooling event at 34 Ma
- Antarctic ice sheet first formed
- Decrease in CO2 a strong forcing of the change
- Start of Atlantic overturning circulation
- Changes in ocean gateways could be critical

Zachos et al (2001)

Atlantic MOC evolution

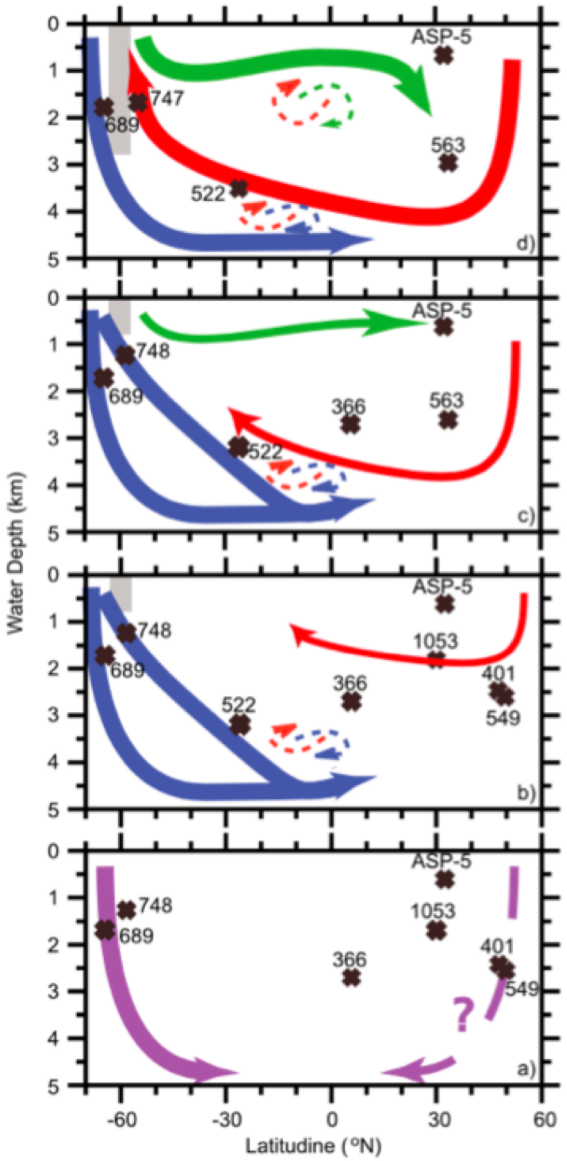
Borrelli et al (2014)

Modern

Early Oligocene ~ 30 Ma

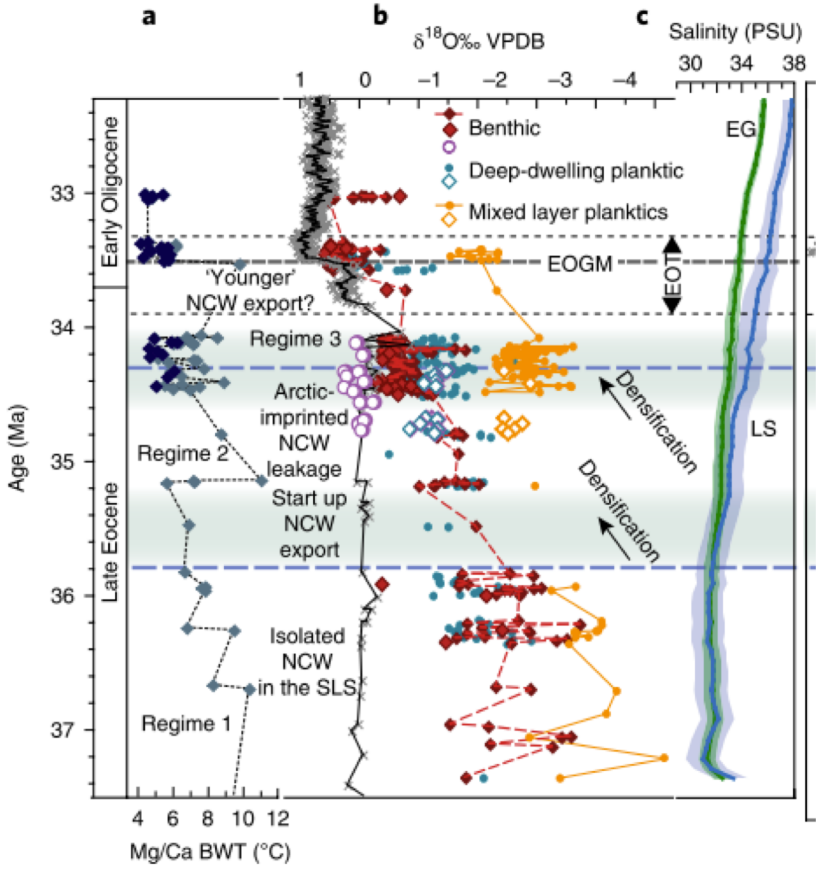
Late Eocene ~ 40 Ma

Early Eocene ~ 55 Ma



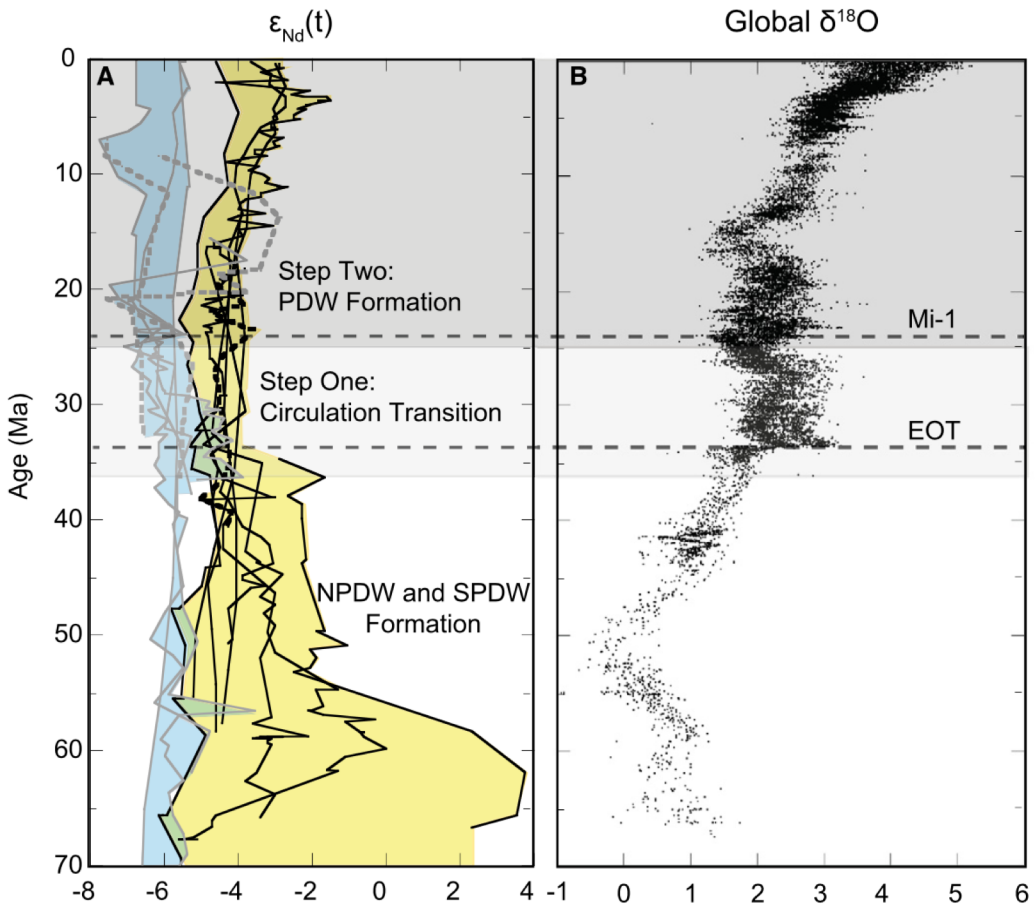
Coxall et al (2018)

Labrador Sea becomes saltier and denser around the EOT



Pacific overturning shuts down at EOT

- Neodymium isotopes suggest bipolar Pacific sinking from 70 - 36 Ma
- Gradual shut down from 36 Ma
- Salt advection between Atlantic and Pacific -> competition for sinking?

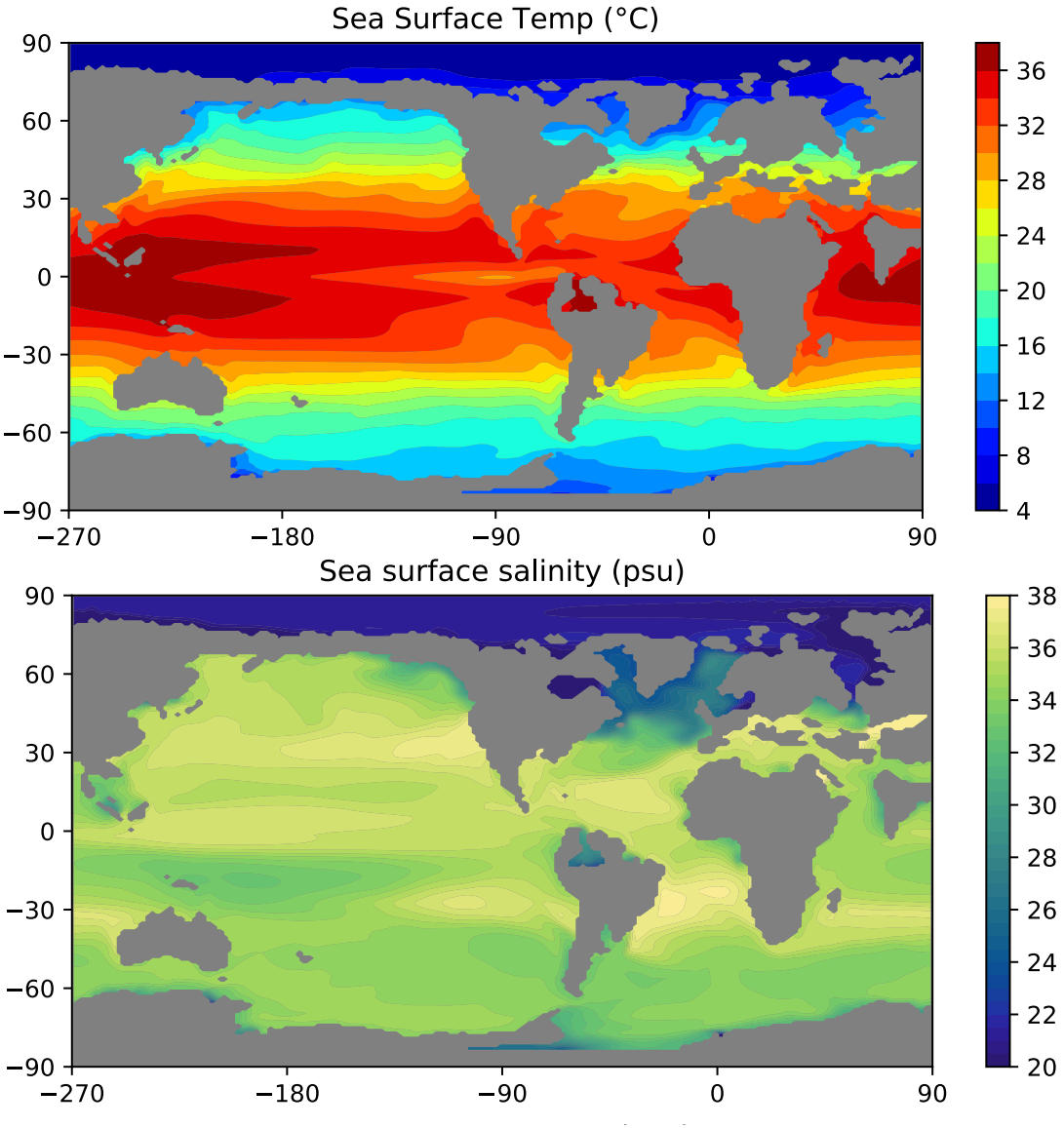


McKinley et al (2019)

Late Eocene Climate Model

- Based on GFDL CM2.1 climate model, modified to Eocene topography (Baatsen et al, 2016)
- Coarse resolution: ~1° ocean, ~3° atmosphere
  - improvement on previous coupled models of EOT
- Boundary conditions adjusted to late Eocene
- For model setup see Hutchinson et al. (2018)

Late Eocene Climate Model Simulation



Control run: 800 ppm CO2

- 6500 year simulation starting from very warm conditions
- Steady surface, bottom temp still cooling!
- SST equator ~35°C
- Arctic ~4-6°C
- Southern Ocean ~15-20°C

Arctic Ocean very fresh ~ 20 psu

North Atlantic: 25-30 psu
-> much too fresh to sink

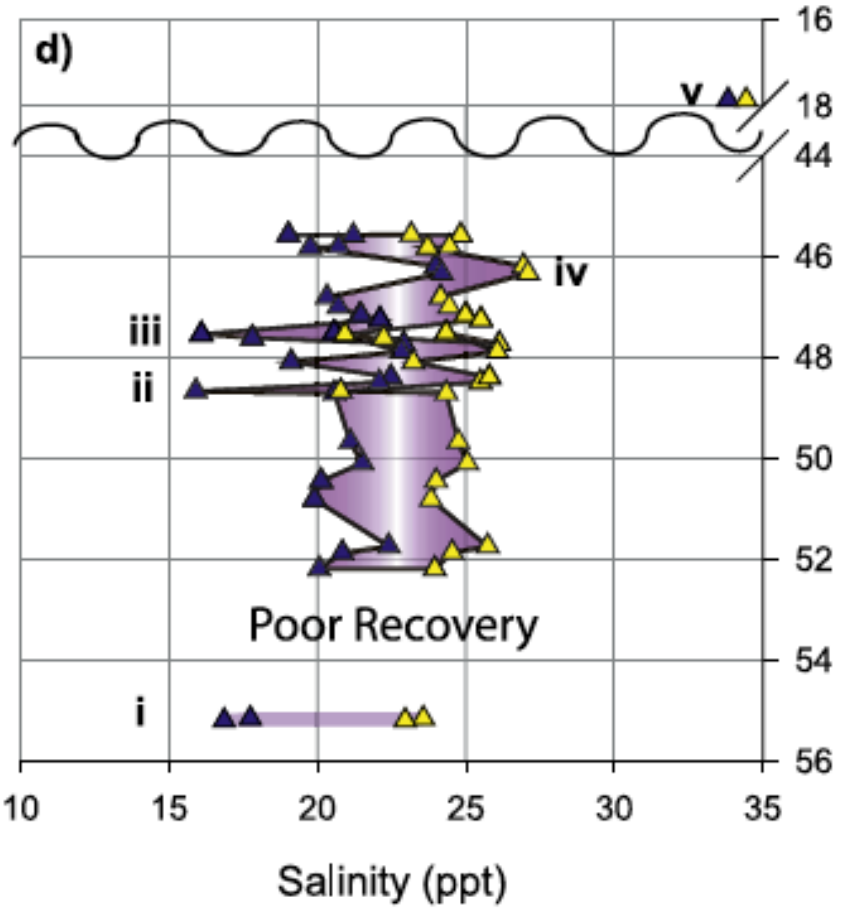
How might the salinity of the Atlantic increase to enable sinking?

Estimated Eocene–Miocene Arctic salinity

Proxies suggest Arctic salinity was around 20-25 psu in the Eocene

Excursions to low salinity: suggest the Arctic became isolated periodically

Large hiatus around the EOT!



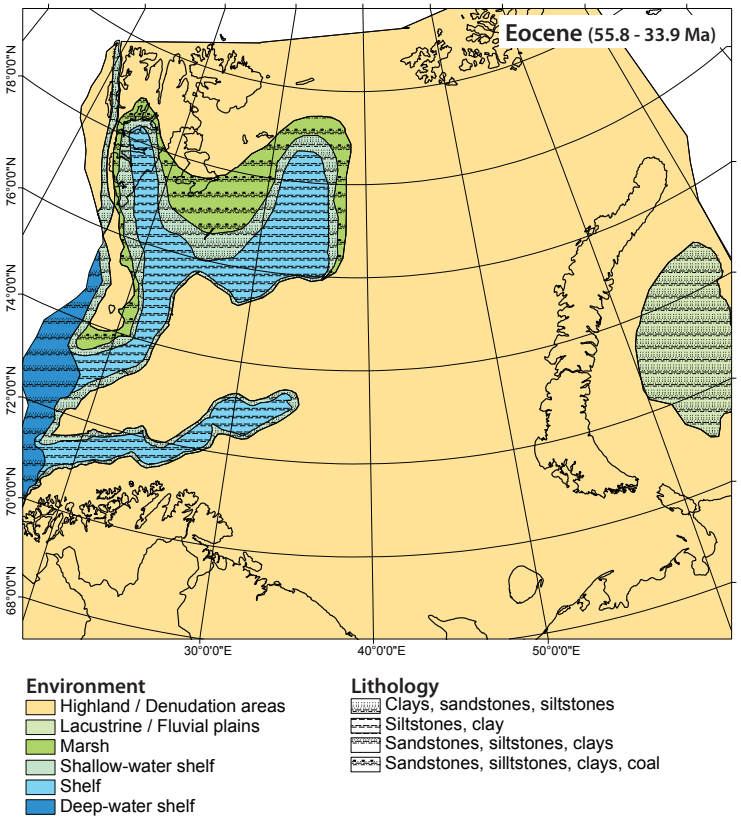
Waddell and Moore, 2008

Barents Sea uplift

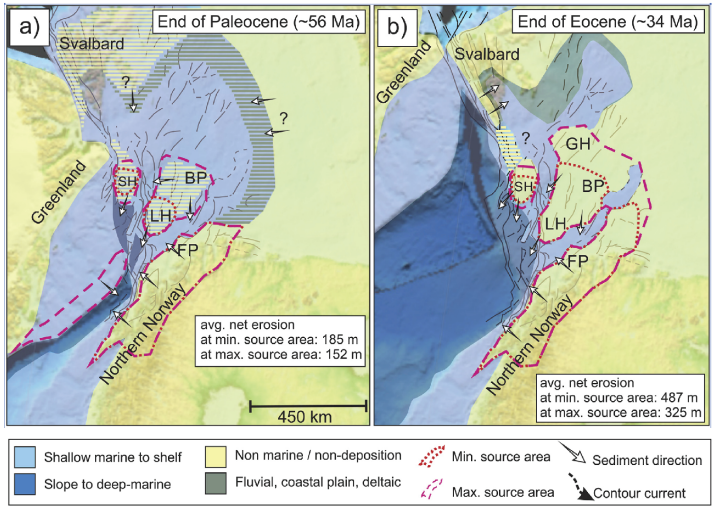
Arctic was connected to the Atlantic in the early-middle Eocene

Land barrier emerged by the end of Eocene

Smelror et al., 2009, *Geologic History of the Barents Sea*



Lasabuda et al., 2018, *Marine and Petroleum Geology*

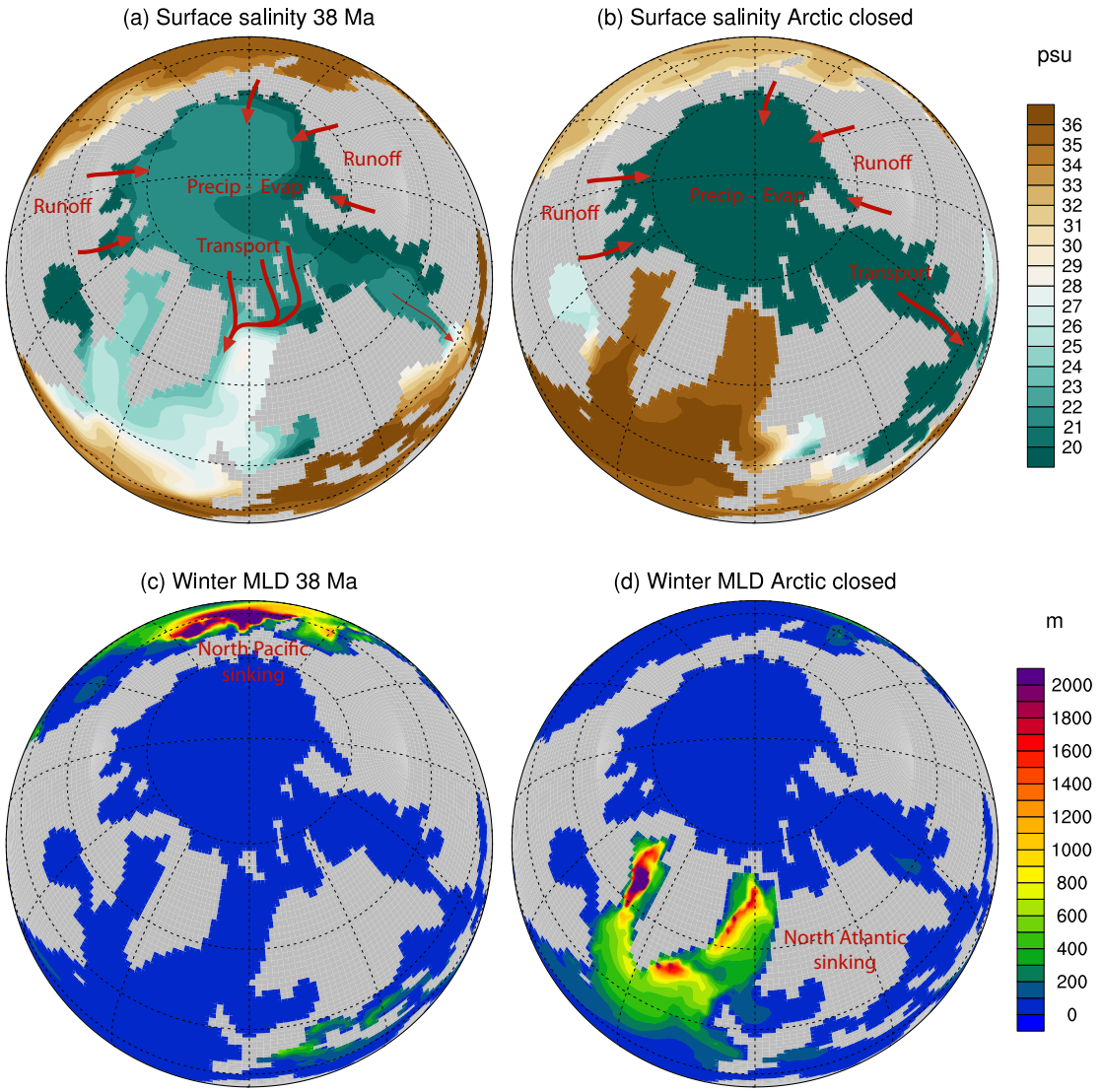


Closing the Arctic-Atlantic Gateway

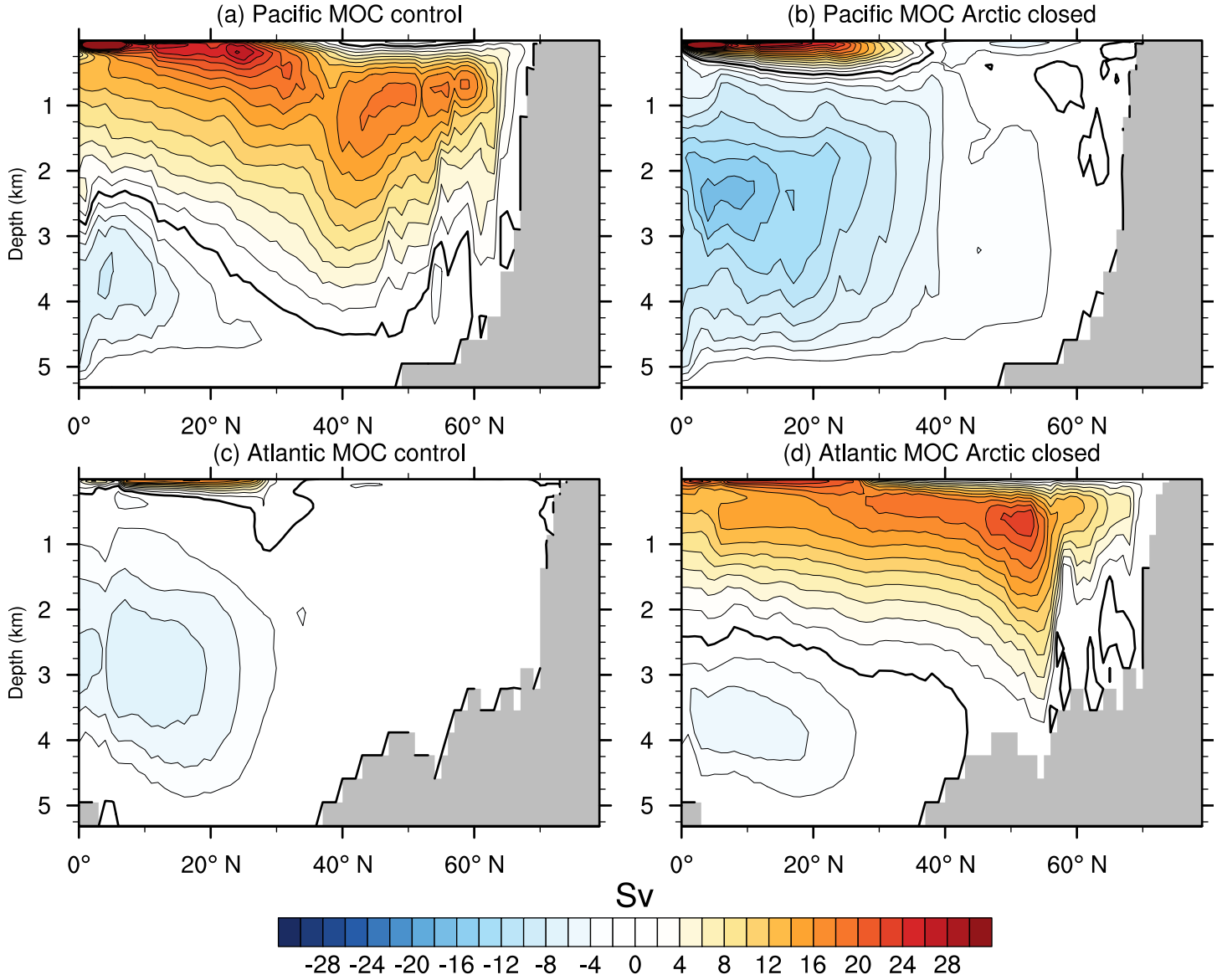
Closing the Arctic-Atlantic gateway leads to Atlantic becoming saltier than Pacific

N. Pacific overturning shuts down, N. Atlantic overturning starts up.

Freshwater transport from Arctic may control Atlantic sinking?

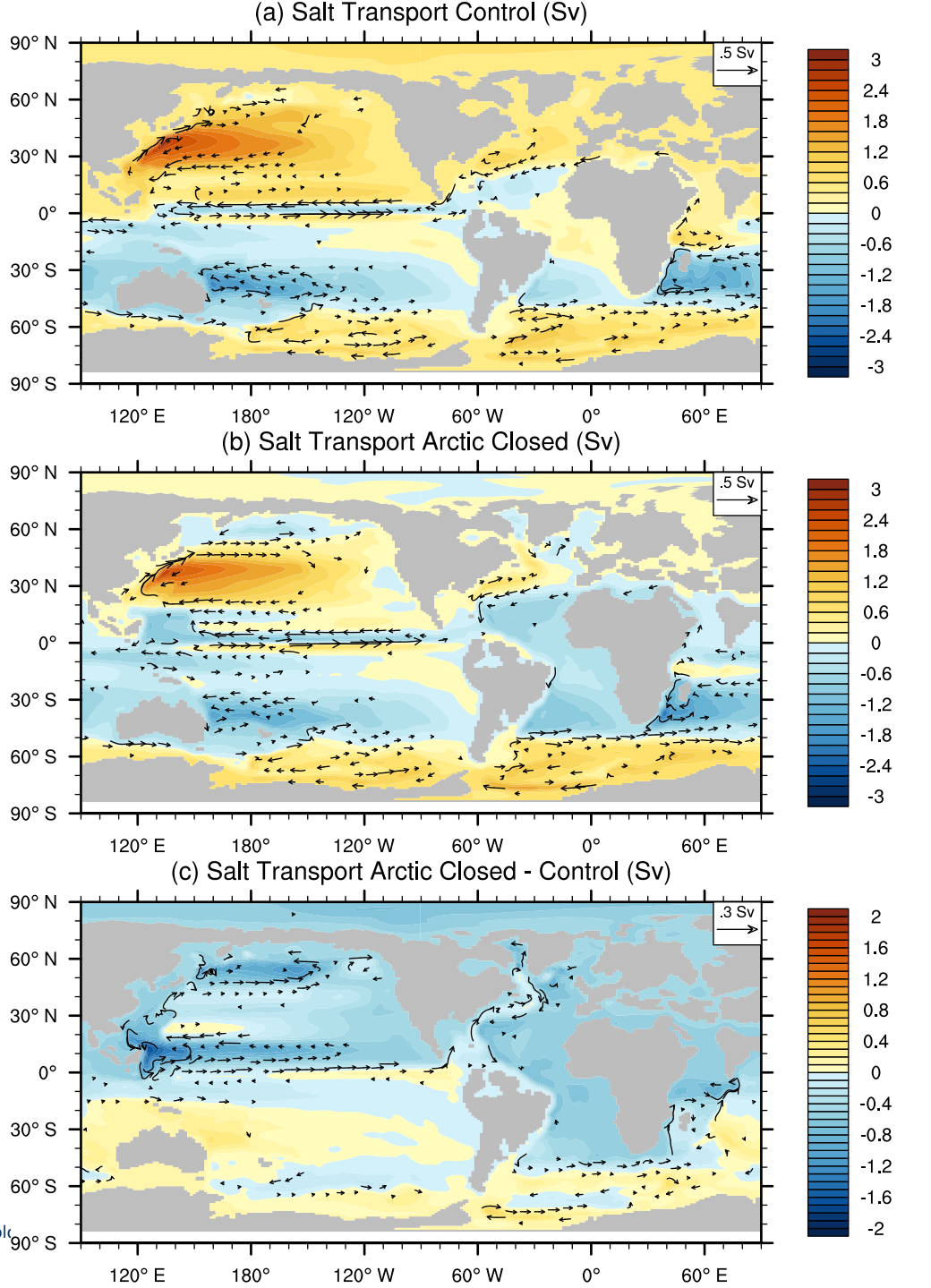


Atlantic Overturning with Arctic Closure



Salt advection feedbacks

Westward transport through Panama virtually stops



Conclusion

- Late Eocene control run shows very low salinity in the North Atlantic, which prevents sinking
- Closure of the Arctic-Atlantic gateway greatly increases Atlantic salinity and may trigger N. Atlantic sinking
- Salt advection feedback causes switch from Pacific to Atlantic sinking. This is supported by independent proxies from both ocean basins.

- Hutchinson et al, 2019: *Nature Communications*, **10**, 3797. https://www.nature.com/articles/s41467-019-11828-z
- Data available from: https://doi.org/10.17043/hutchinson-2019

References

- Baatsen et al (2016) http://doi.org/10.5194/cp-12-1635-2016
- Borrelli et al (2014) http://doi.org/10.1002/2012PA002444
- Coxall et al (2018) http://doi.org/10.1038/s41561-018-0069-9
- Hutchinson et al (2018) http://doi.org/10.5194/cp-14-789-2018
- Lasabuda et al (2018) http://doi.org/10.1016/j.marpetgeo.2018.05.039
- McKinley et al (2019) http://doi.org/10.1016/j.epsl.2019.06.009
- Smelror et al (2009) http://www.ngu.no/en/publikasjon/atlas-geological-history-barents-sea
- Waddell and Moore (2008) http://doi.org/10.1029/2007PA001451
- Zachos et al (2001) http://doi.org/10.1126/science.1059412