The Importance of North Pacific Basin Geometry on Atlantic Overturning

Zho Ragen

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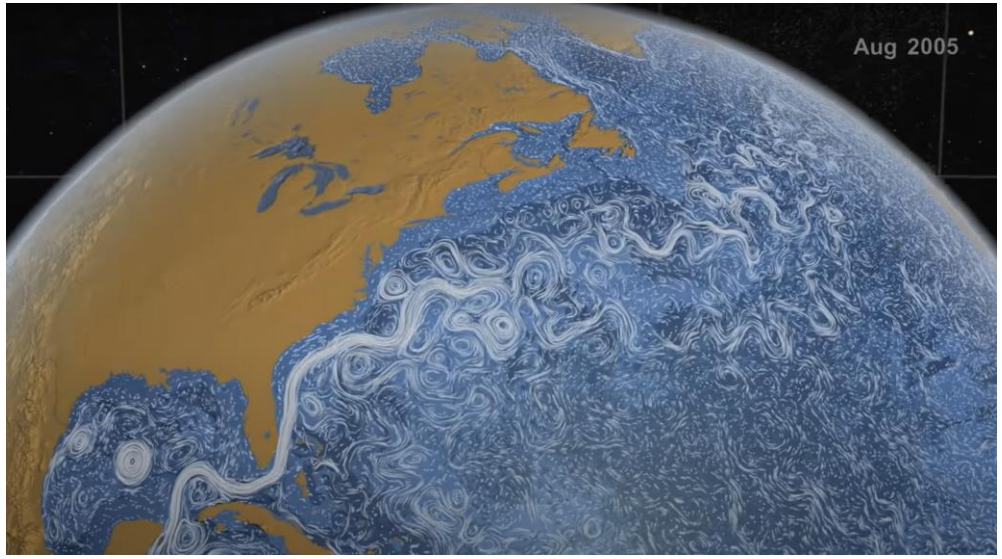
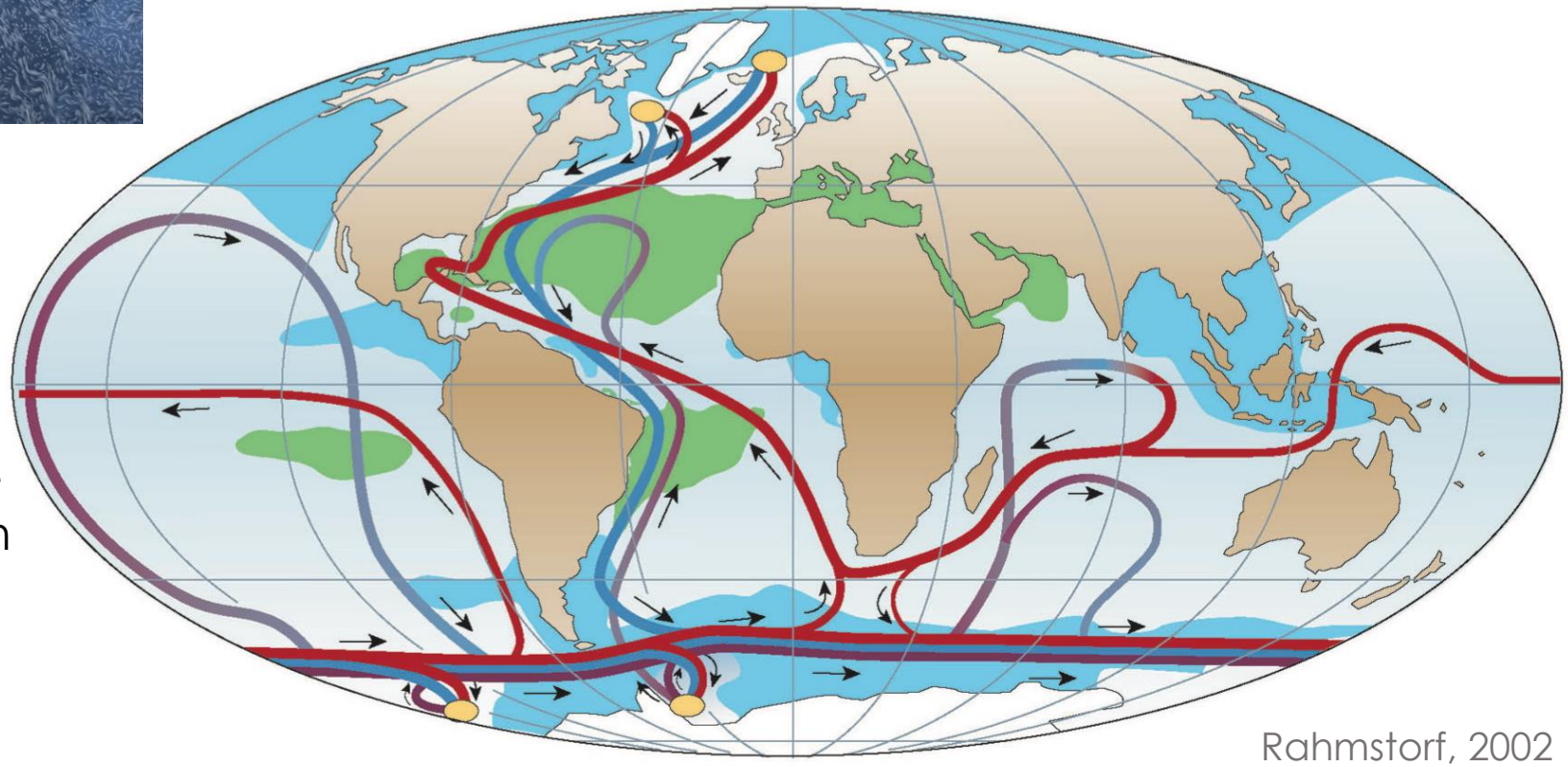
Ocean general circulation is driven by density (salt + heat) and wind



NASA

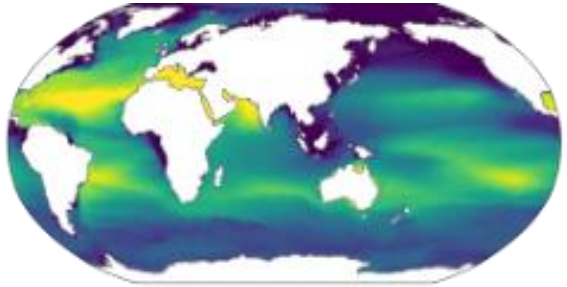
The ocean currents are made up of turbulent eddies, filaments, and fronts

We can simplify it and approximate it as a global overturning circulation

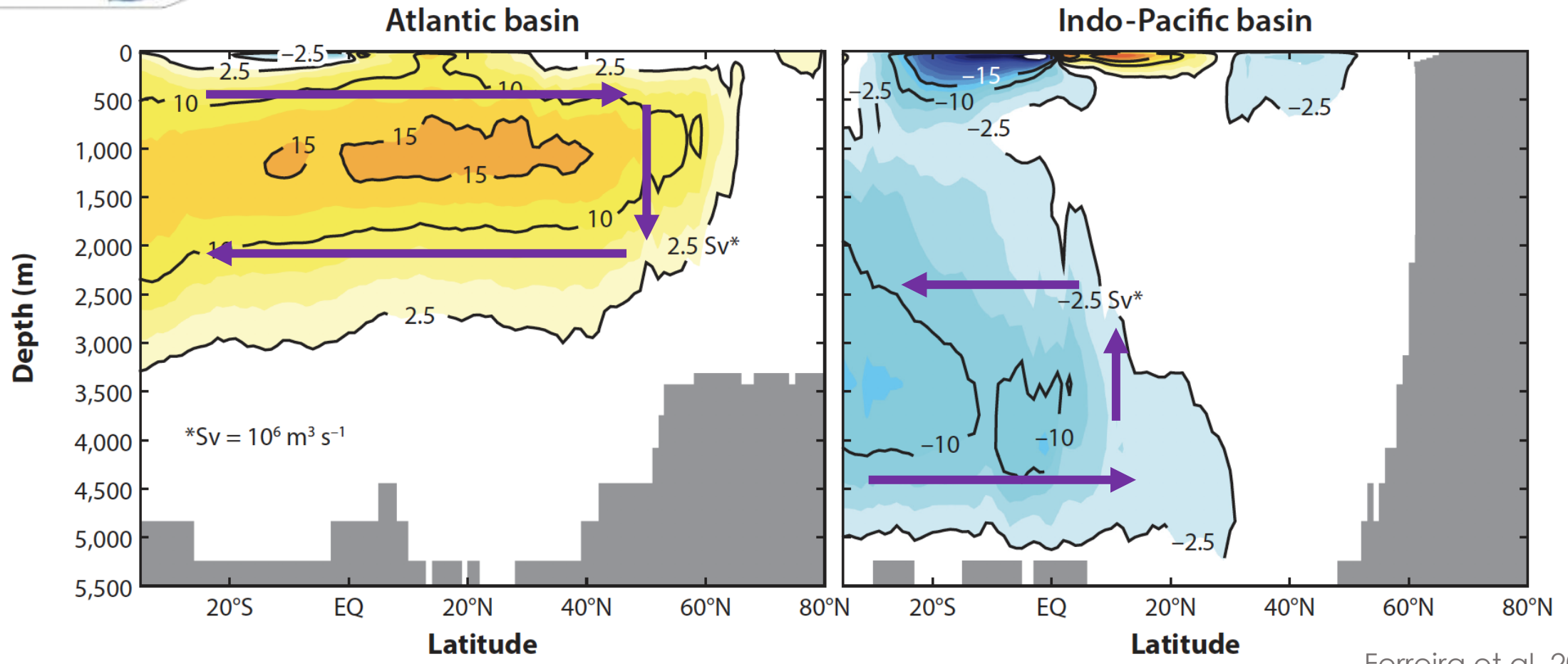


Rahmstorf, 2002

Circulation asymmetry between Atlantic and Indo-Pacific



Atlantic Meridional Overturning Circulation (AMOC) linked to elevated salinity of Atlantic basin

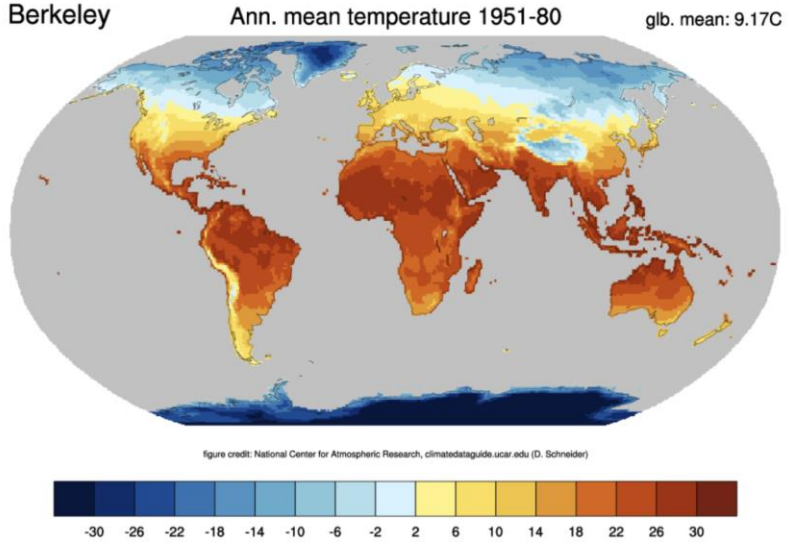


Ferreira et al, 2018

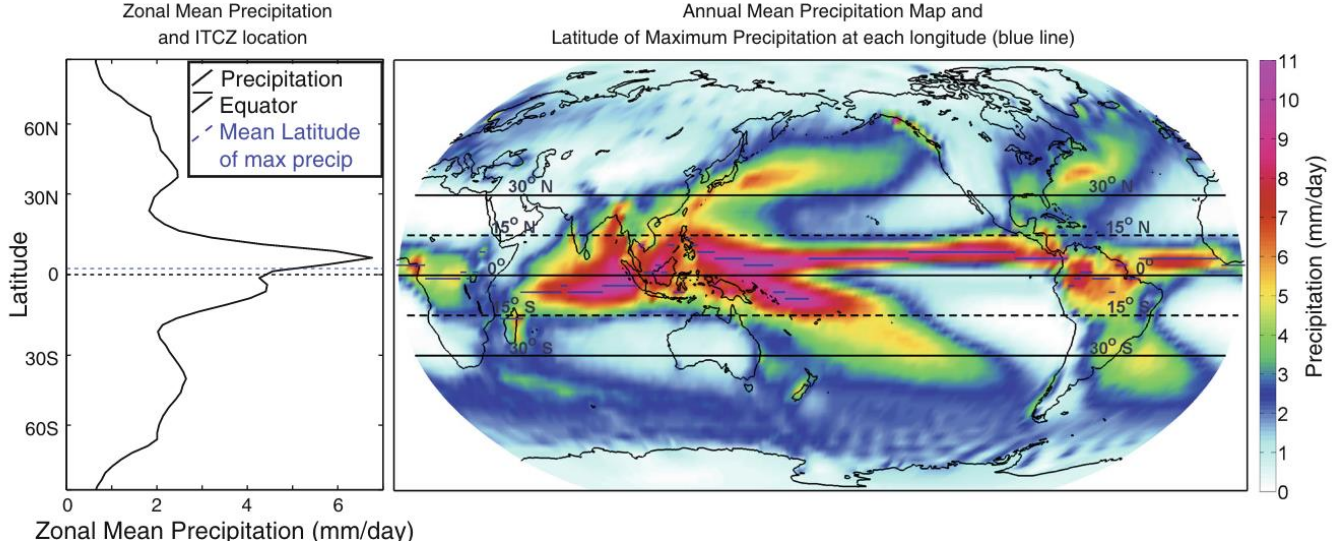
AMOC is important for the Earth's response to climate change

Transports heat northward at all latitudes in the Atlantic:

Implications for climate in Europe compared to same latitudes in North America

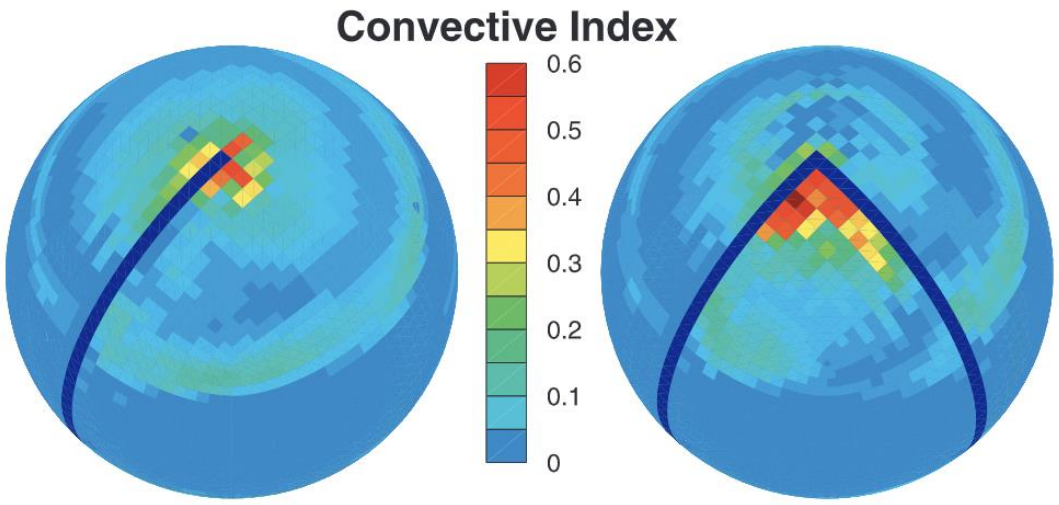


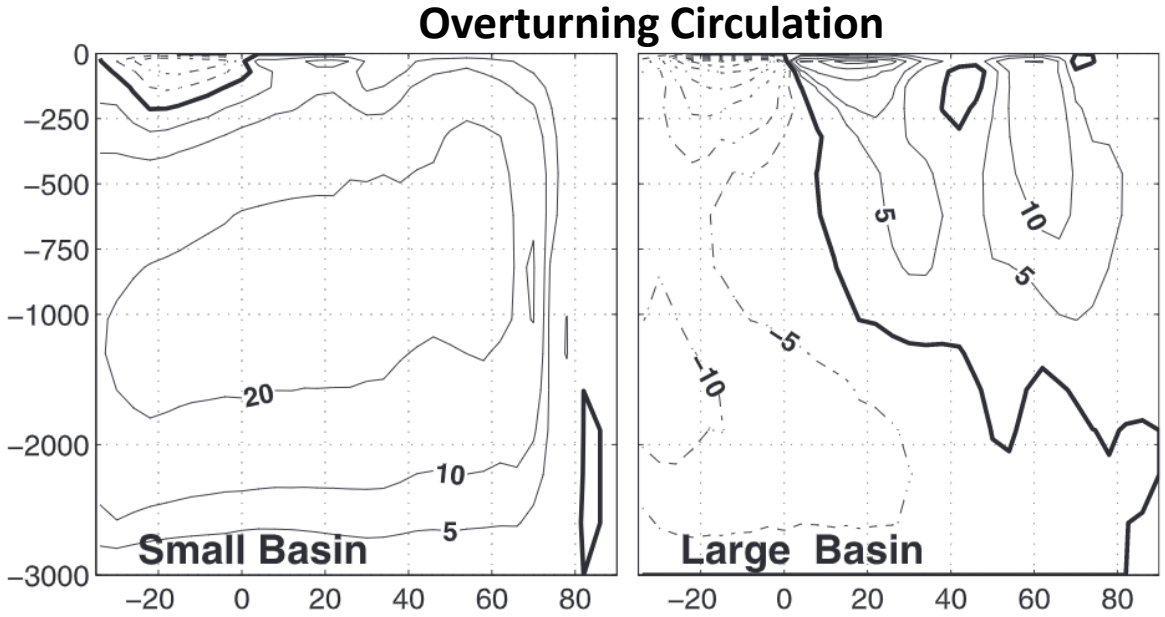
Influences location of tropical rainfall maximum (Frierson et al 2013, Marshall et al 2014)



Motivating Questions:

- What causes hemispheric circulation asymmetries in the ocean and atmosphere?
- How does ocean basin geometry impact the localization of meridional overturning circulation (MOC)?
  - Land distribution in the North Pacific is key to location of deep water formation





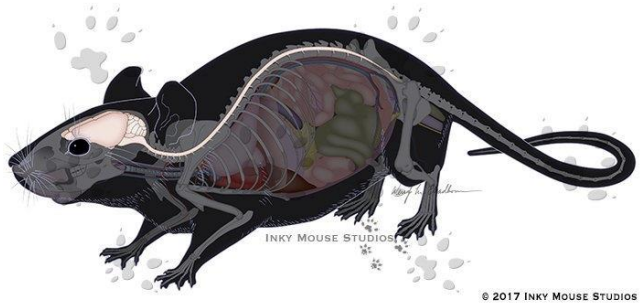
Ferreira et al, 2010

Idealized modeling: a hierarchy of simpler models (Held, 2005)

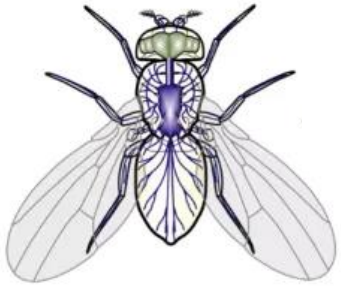
Human

Prokop, 2015

Mouse

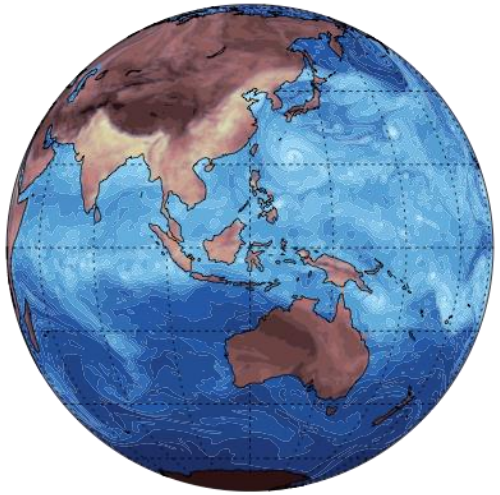


Fruit fly

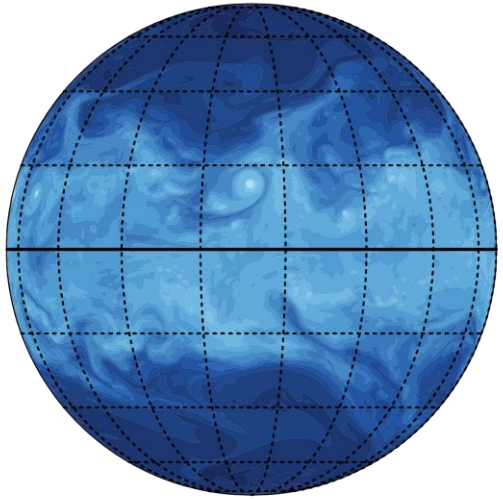


Earth's Climate

Climate Model



Aquaplanet



Figures from Xiaoning Wu

Idealized modeling: a hierarchy of simpler models (Held, 2005)

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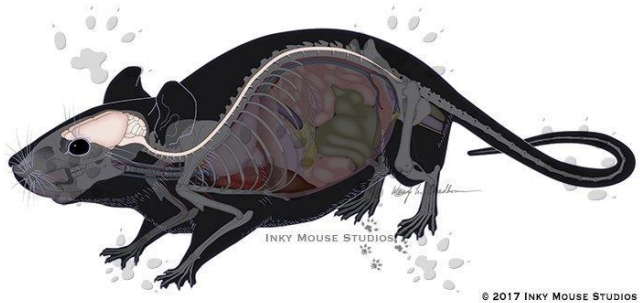

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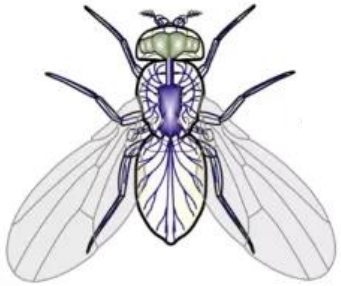

Earth's Climate

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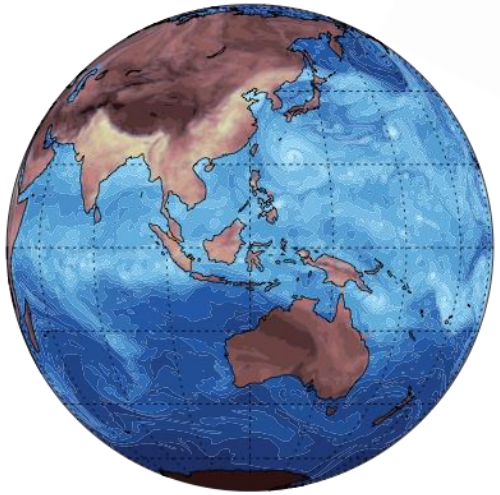

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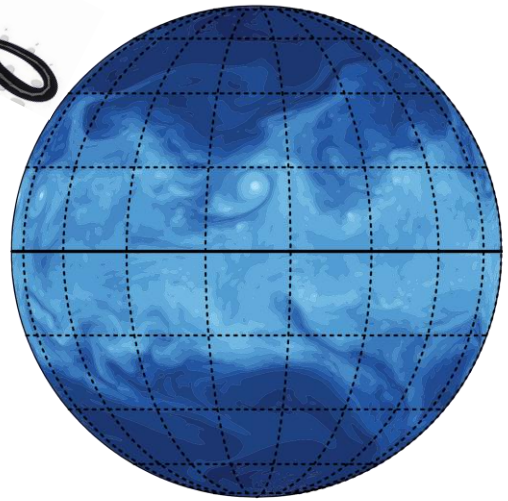
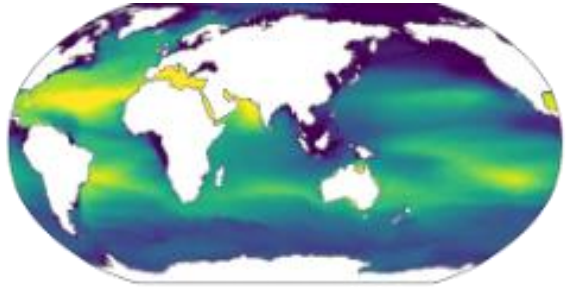


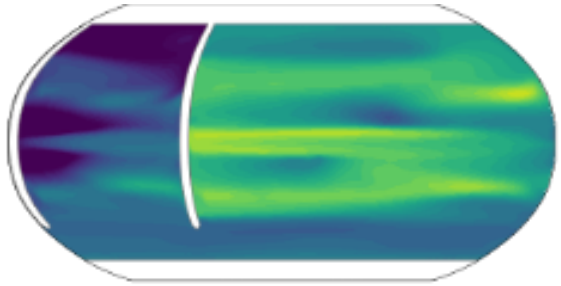
Figures from Xiaoning Wu

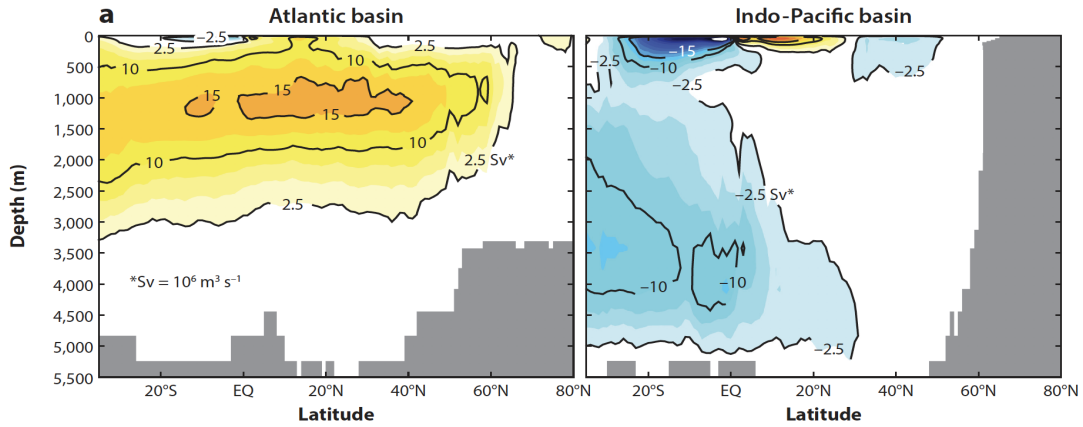
Results differ from previous work: size of basin not sufficient for MOC location

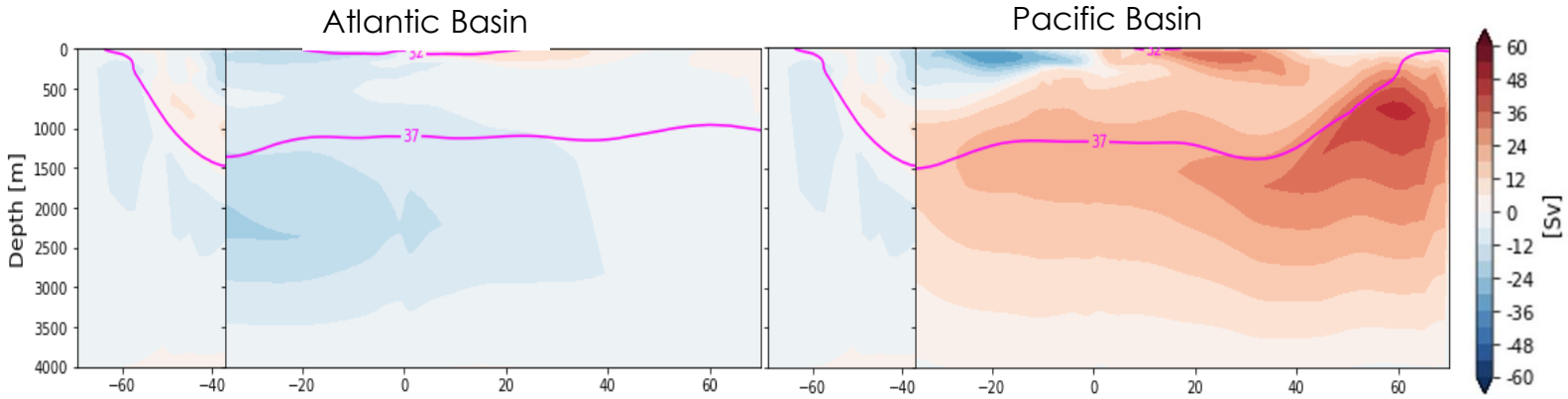
EN4 Observations



Double Drake

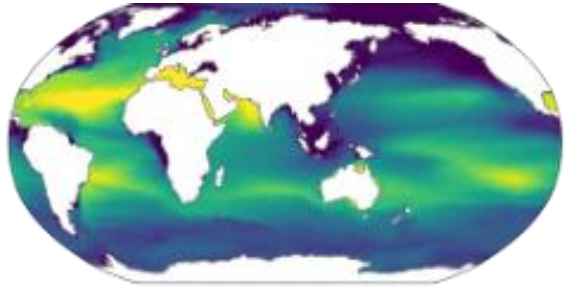




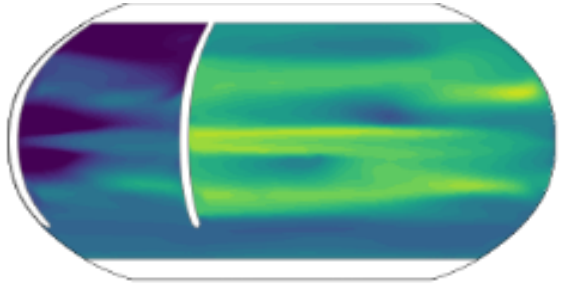


Geometry of North Pacific basin key for pattern of overturning circulation

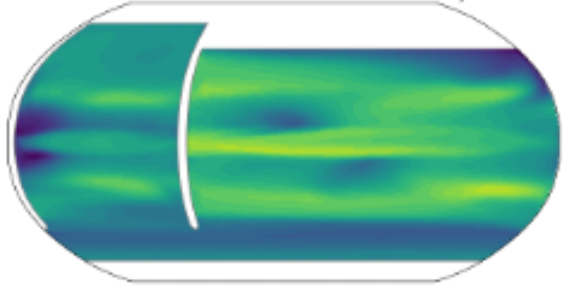
EN4 Observations

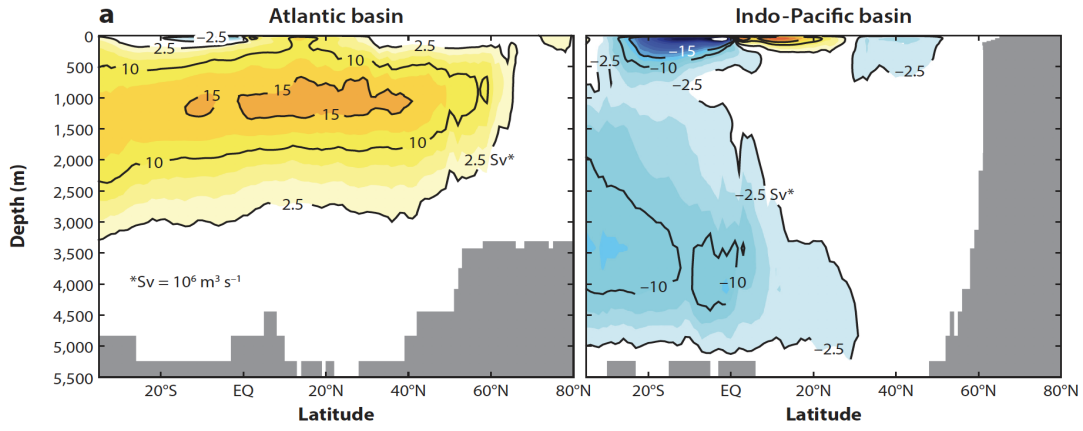


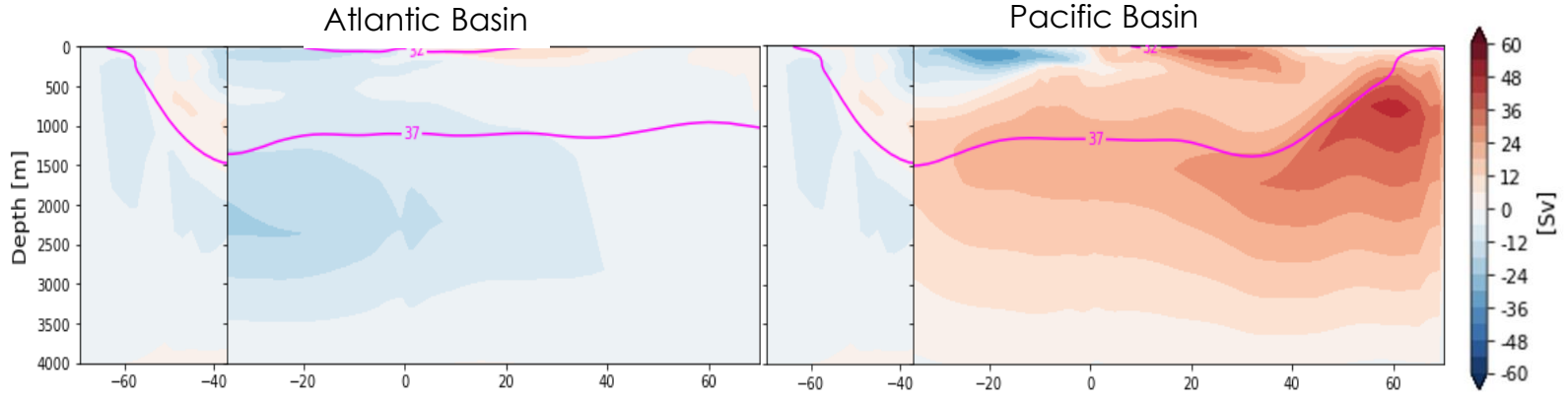
Double Drake

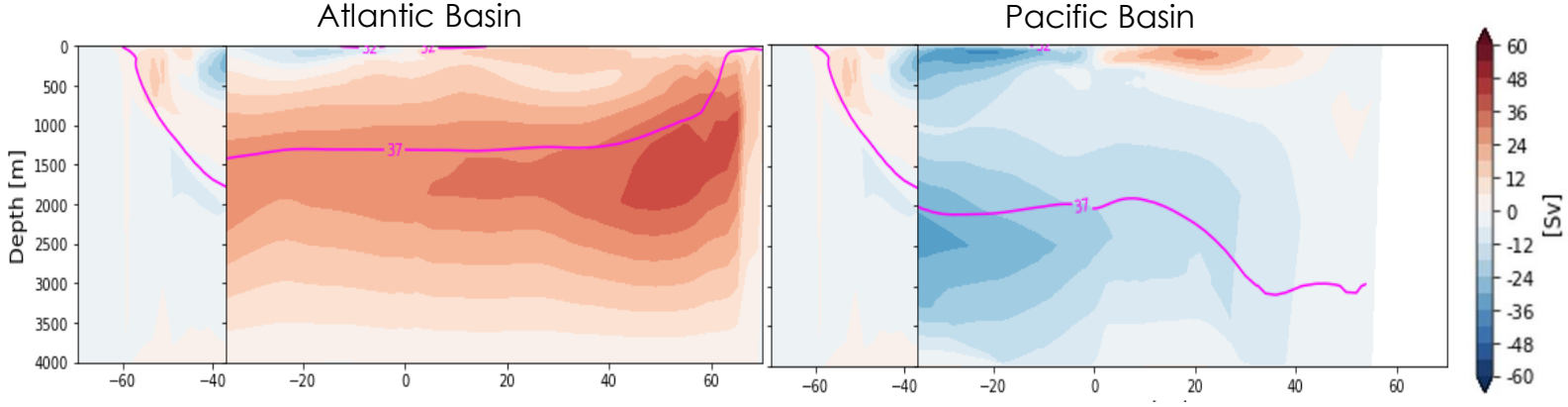


NorthPacific DoubleDrake



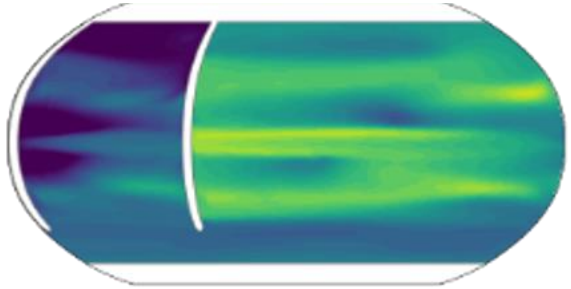




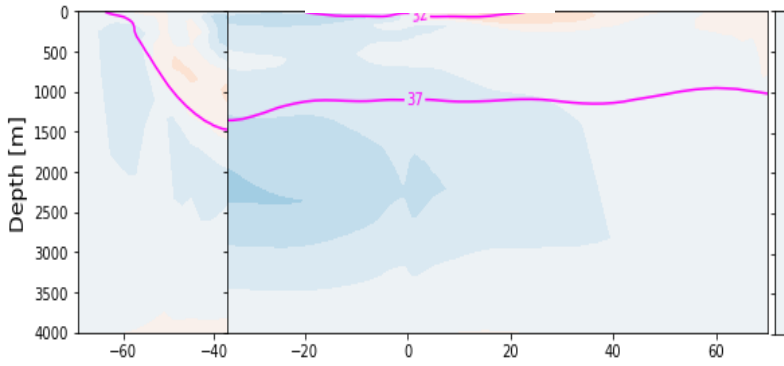


Don’t need land in the North Pacific, just a latitudinal barrier

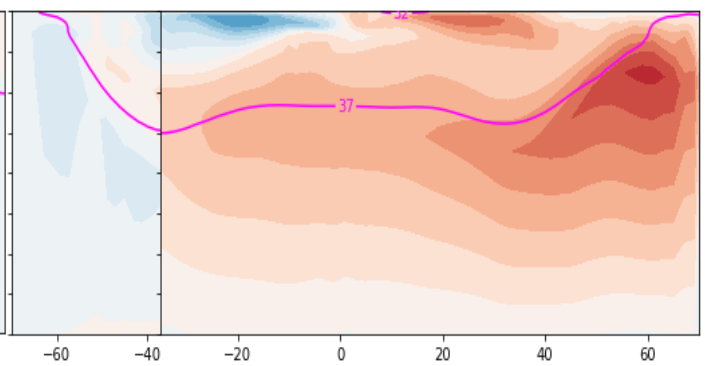
Double Drake

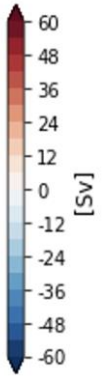


Atlantic Basin

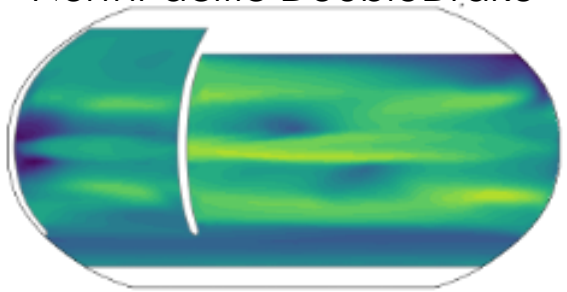


Pacific Basin

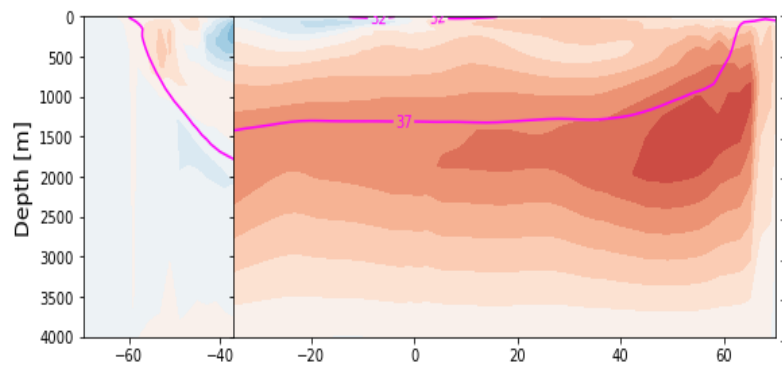




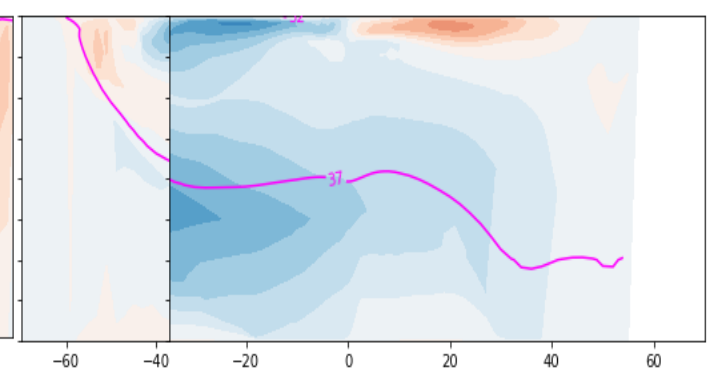
NorthPacific DoubleDrake

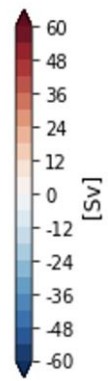


Atlantic Basin

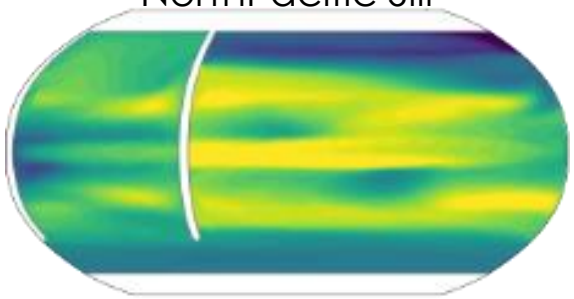


Pacific Basin

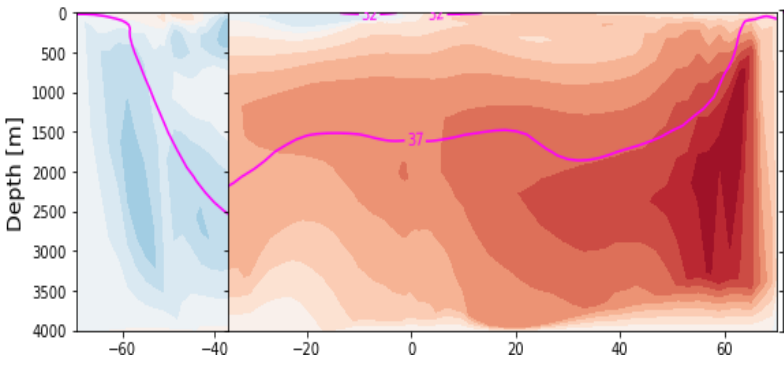




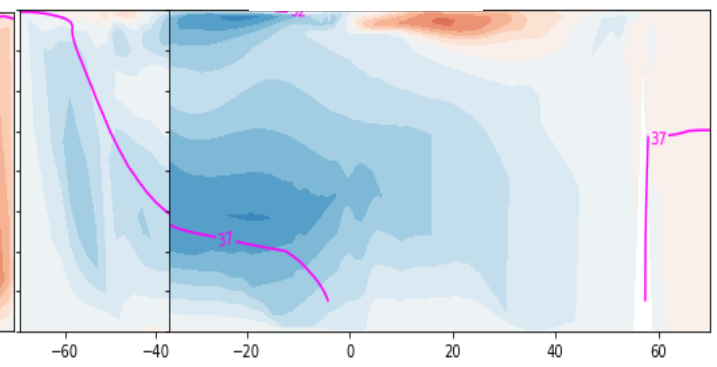
NorthPacific Sill

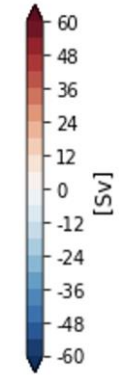


Atlantic Basin



Pacific Basin





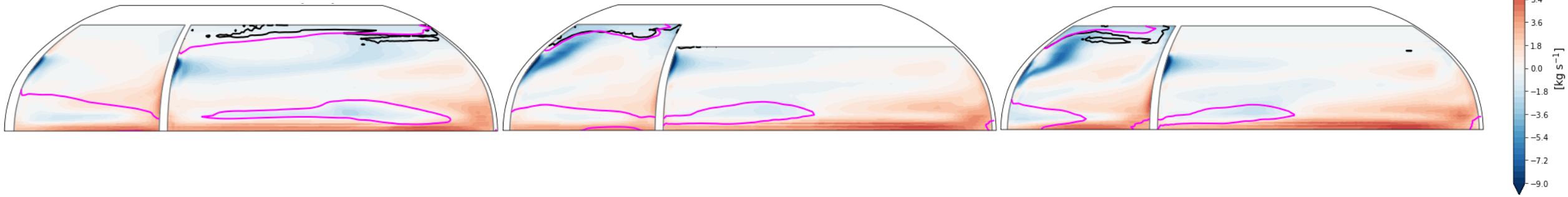
Where dense water at the surface is exposed to cold air, it sinks

Surface Buoyancy Fluxes

Double Drake

NorthPacific DoubleDrake

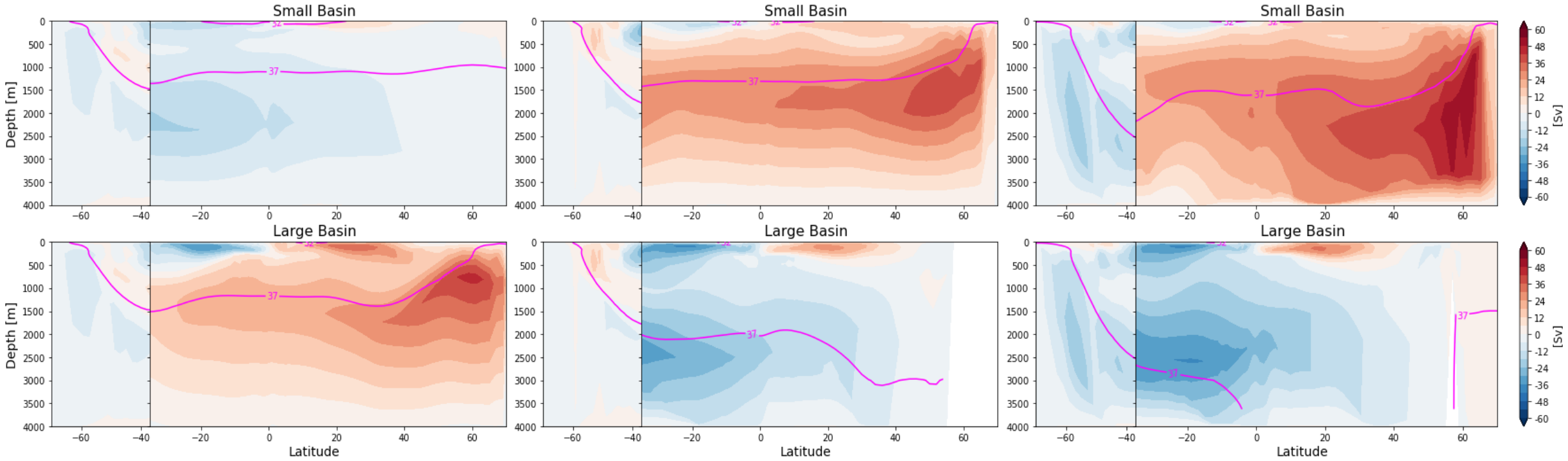
NorthPacific Sill



Double Drake

NorthPacific DoubleDrake

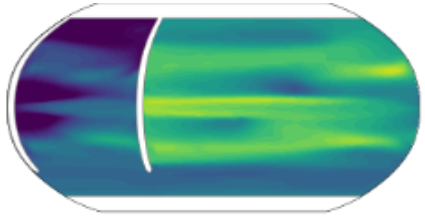
NorthPacific Sill

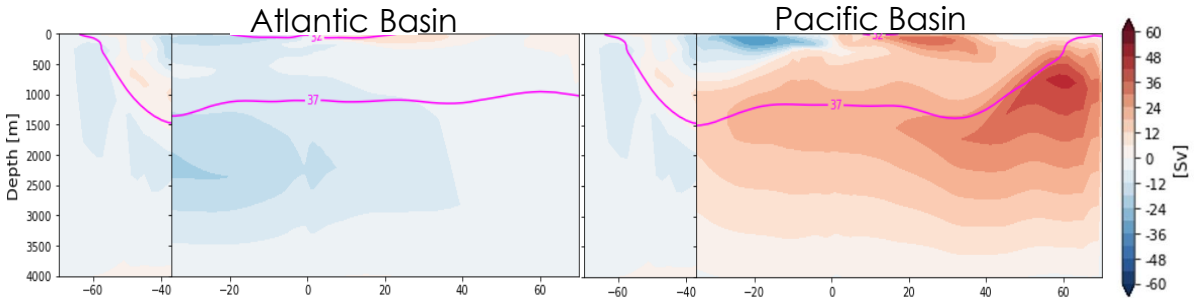


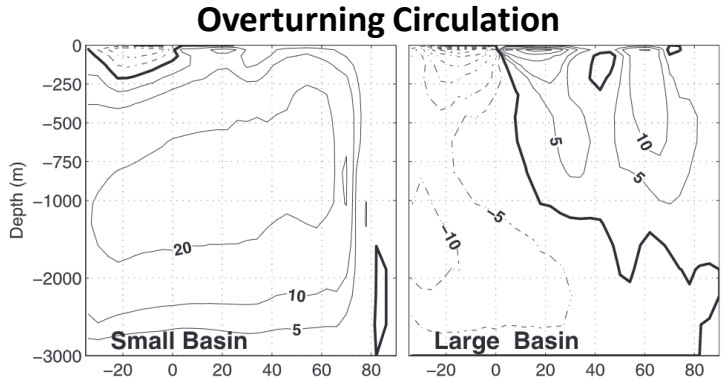
Key takeaways:

Basin width is not sufficient to generate an AMOC in our model

Double Drake







Ocean basin geometry and surface fluxes in the Pacific play an important role in overturning circulation and AMOC localization

Ocean takes up heat at low latitudes and must deliver it to high latitudes, but is indiscriminate about the region where heat loss occurs

Surface Buoyancy Fluxes

Double Drake

NorthPacific DoubleDrake