Unravelling how winds and surface heating control the Atlantic meridional heat transport

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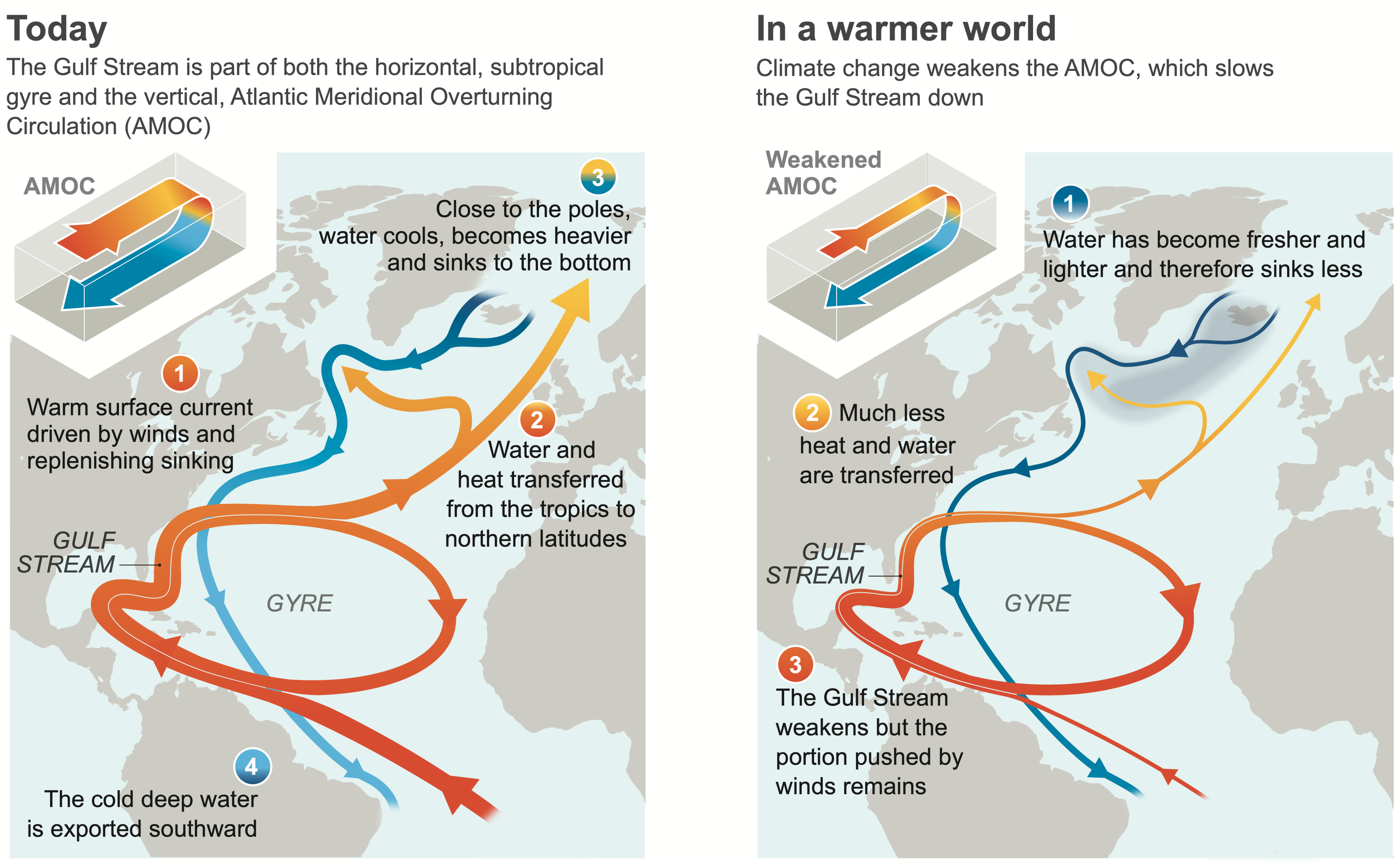
Key Takeaways

- We divide the North Atlantic meridional heat flux into a warm, cold, and mixed cell in latitude-temperature space in a series of eddy-permitting perturbed surface forcing simulations.
- The meridional heat fluxes are dominated by the mixed circulation, and are directly related to the applied meridional surface buoyancy fluxes.
- For wind stress variations, temperature differences between northward and southward flowing branches of each circulation compensate for changes in the circulation strength.

Why are we interested in the Atlantic basin?

- The Atlantic Ocean carries 1.25 PW of heat polewards via the subtropical gyre and the Atlantic Meridional Overturning Circulation (AMOC).
- Variations in ocean circulation, including the gyre and AMOC, are expected due to climate change.



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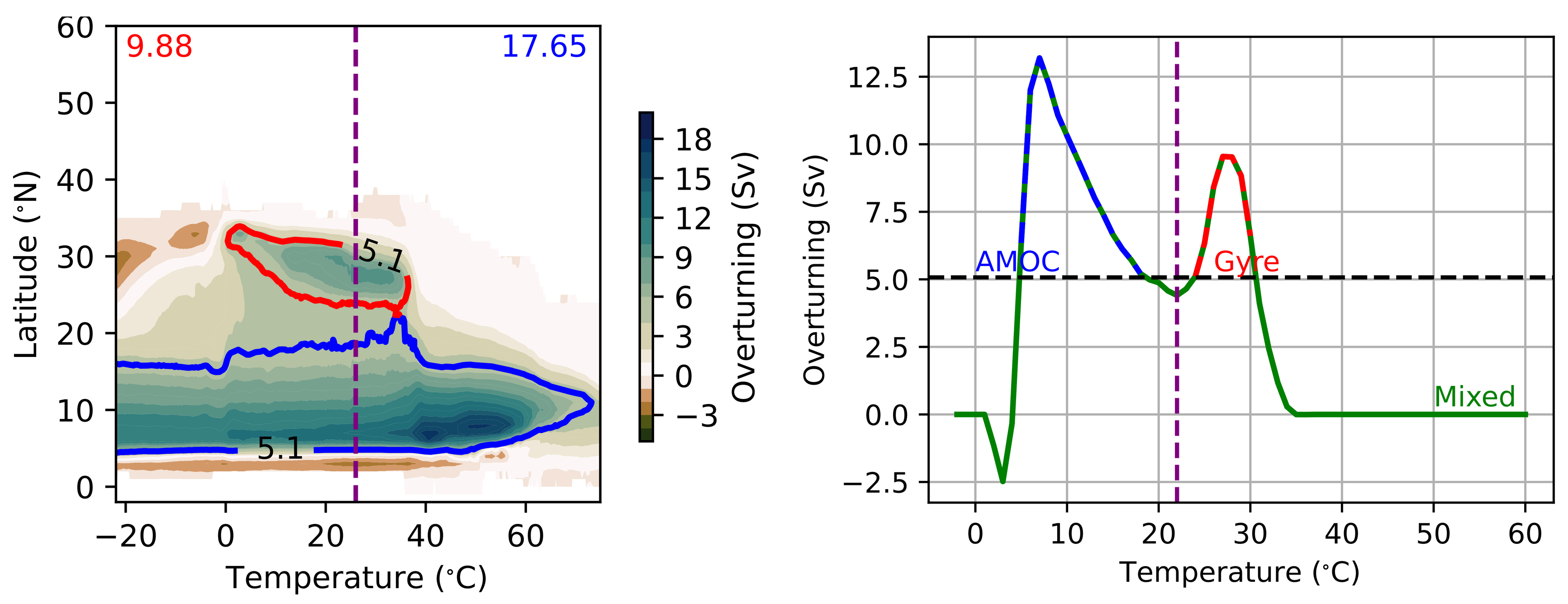
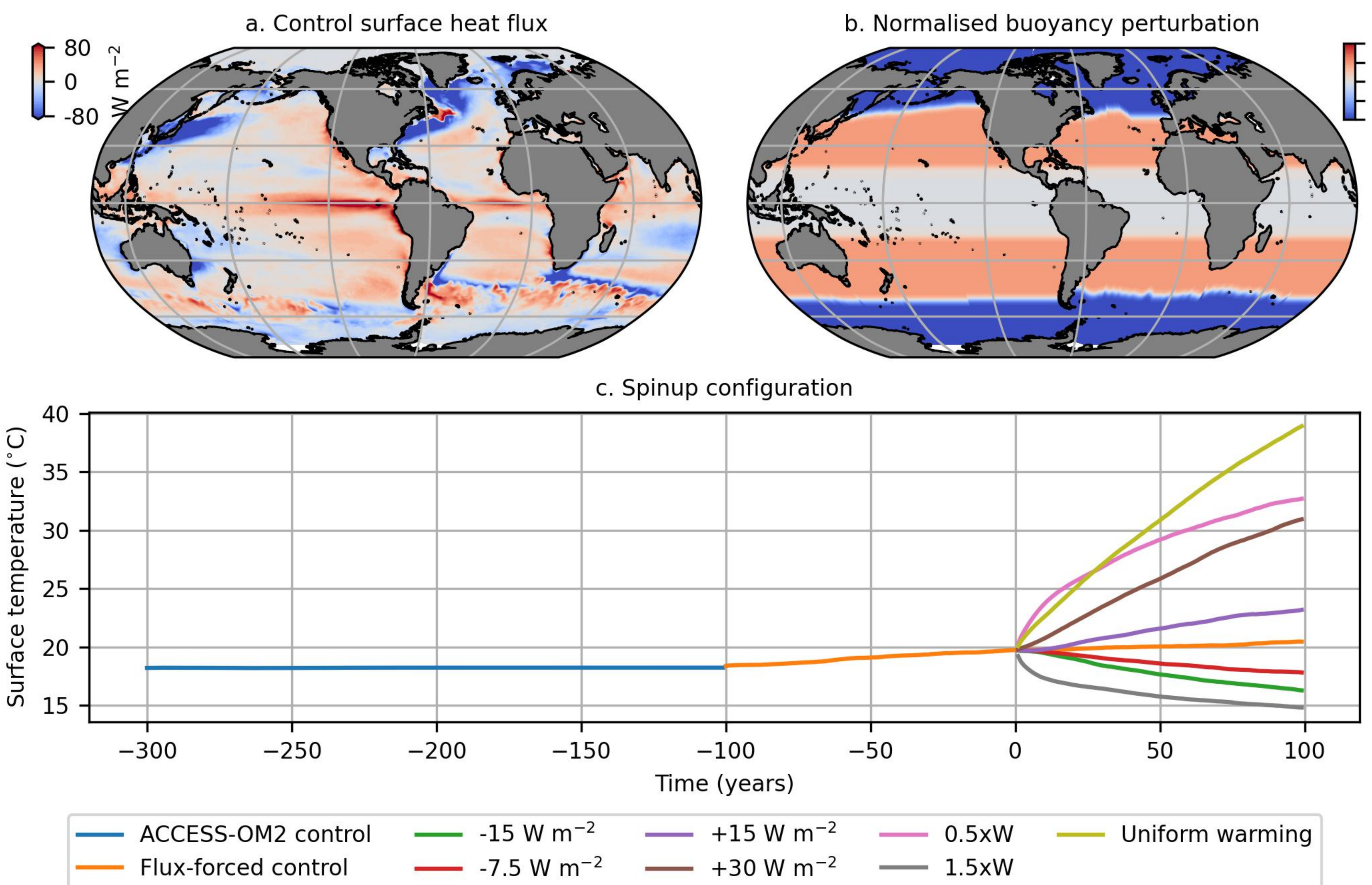
Dividing the Atlantic circulation in latitude–temperature space



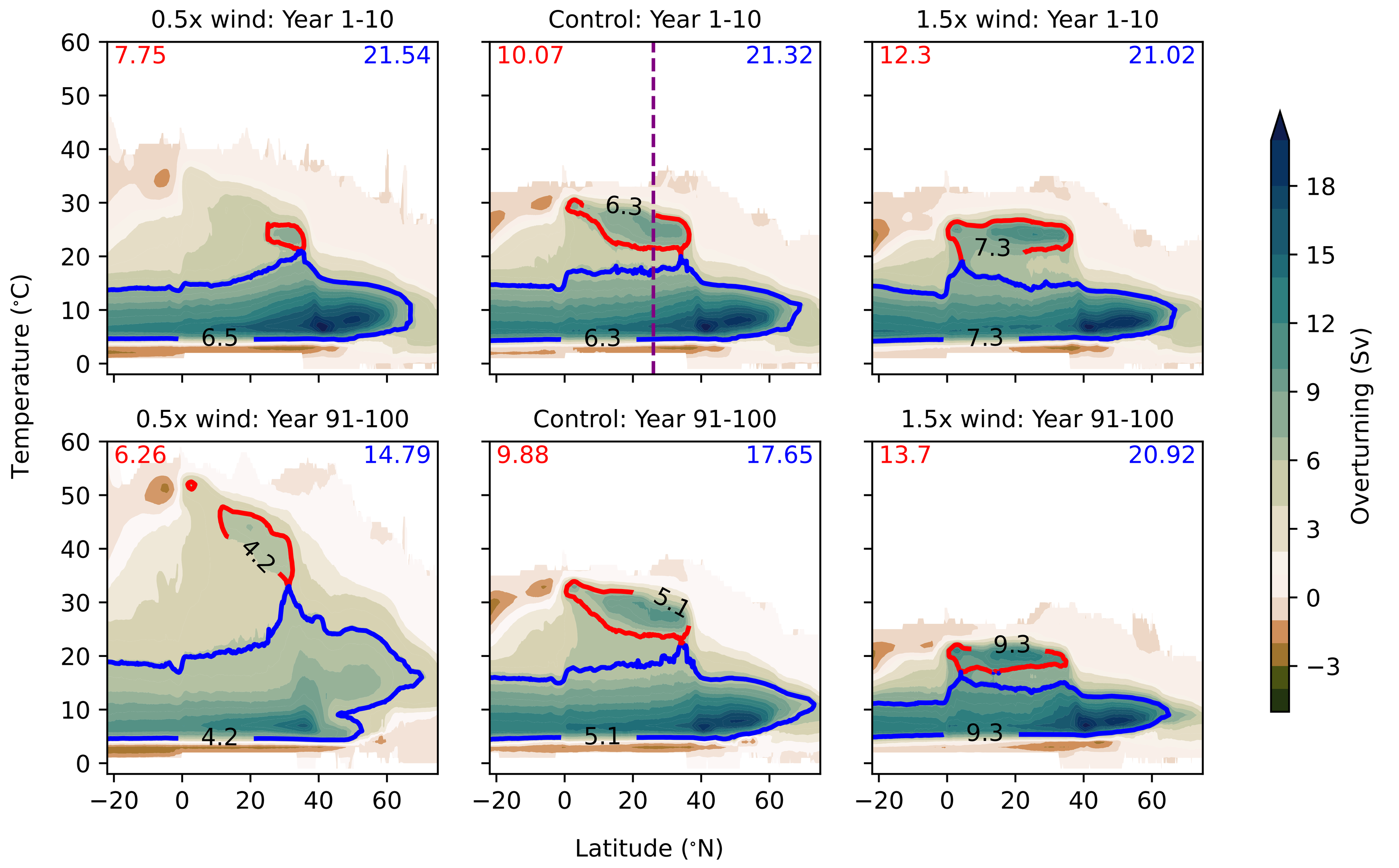
- We divide the total Atlantic meridional heat transport into contributions from a warm (gyre; red), deep (AMOC; blue), and a mixed (green) circulation (*Ferrari and Ferreira 2011*).
- The mixed circulation, driven by both wind stress and surface buoyancy forcing, transports around 70% of the total heat in the Atlantic basin at 26°N.

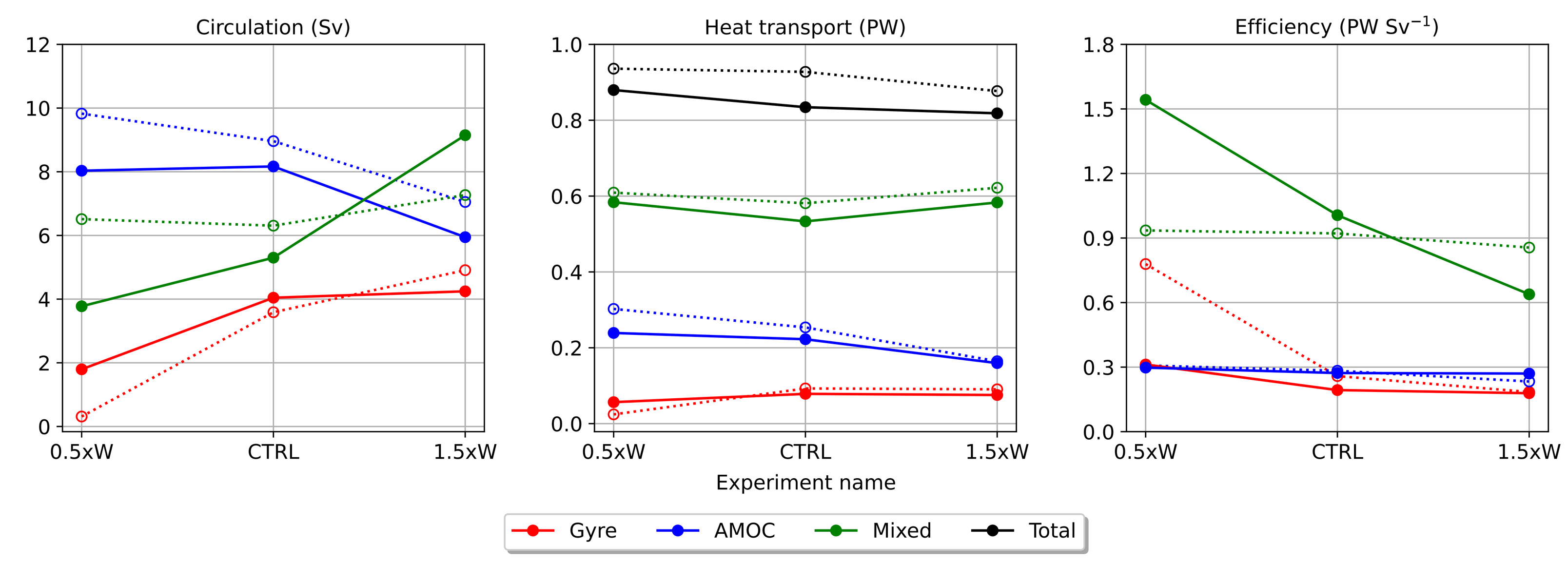
Flux-forced simulations

- We conduct global ocean simulations by prescribing surface fluxes, which isolates the impact of each forcing on the circulation.
- We change either the wind stress or surface buoyancy fluxes and compare anomalies in the meridional heat transport over short (10 year) and long (> 10 year) timescales.



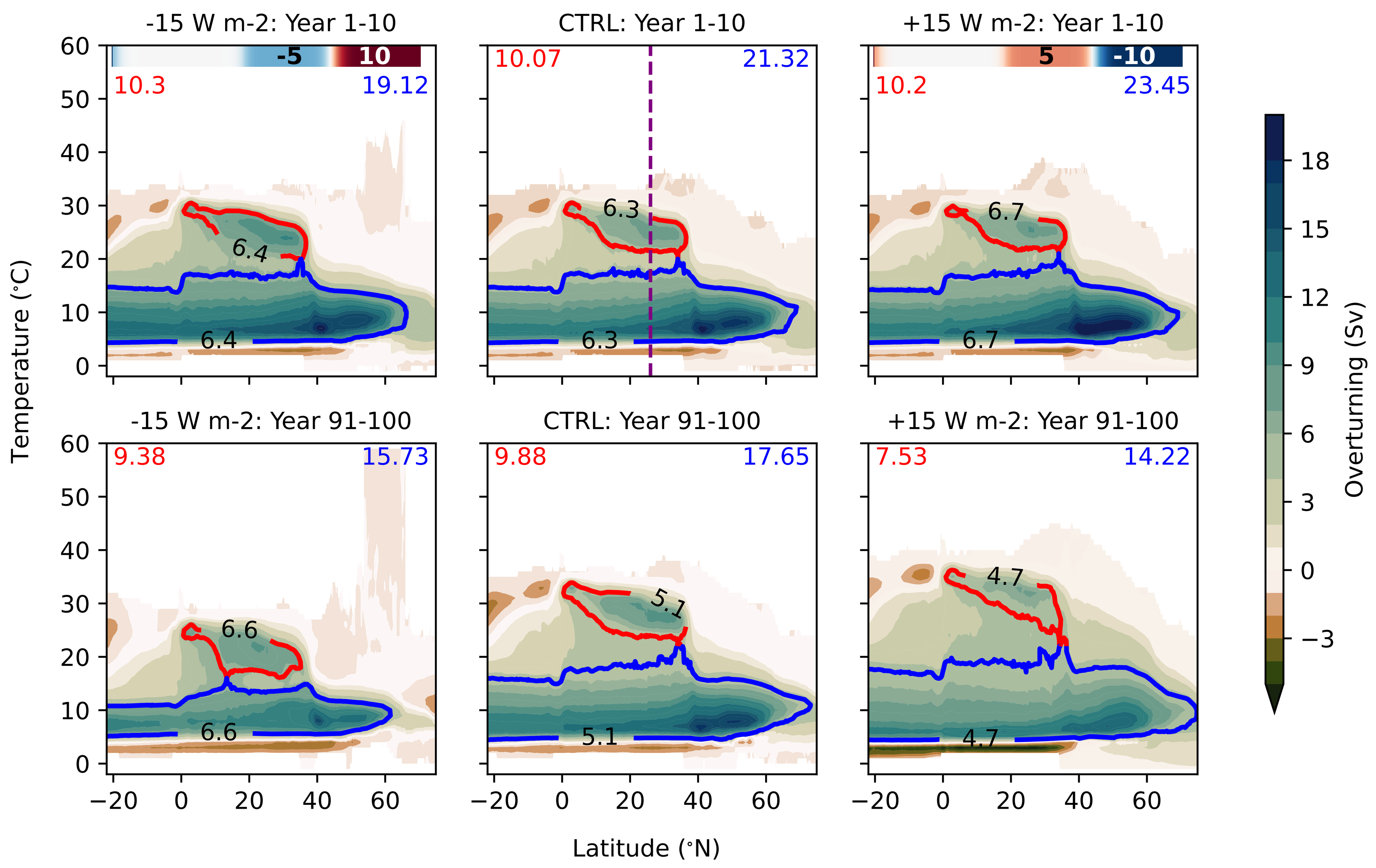
Wind stress perturbation experiments

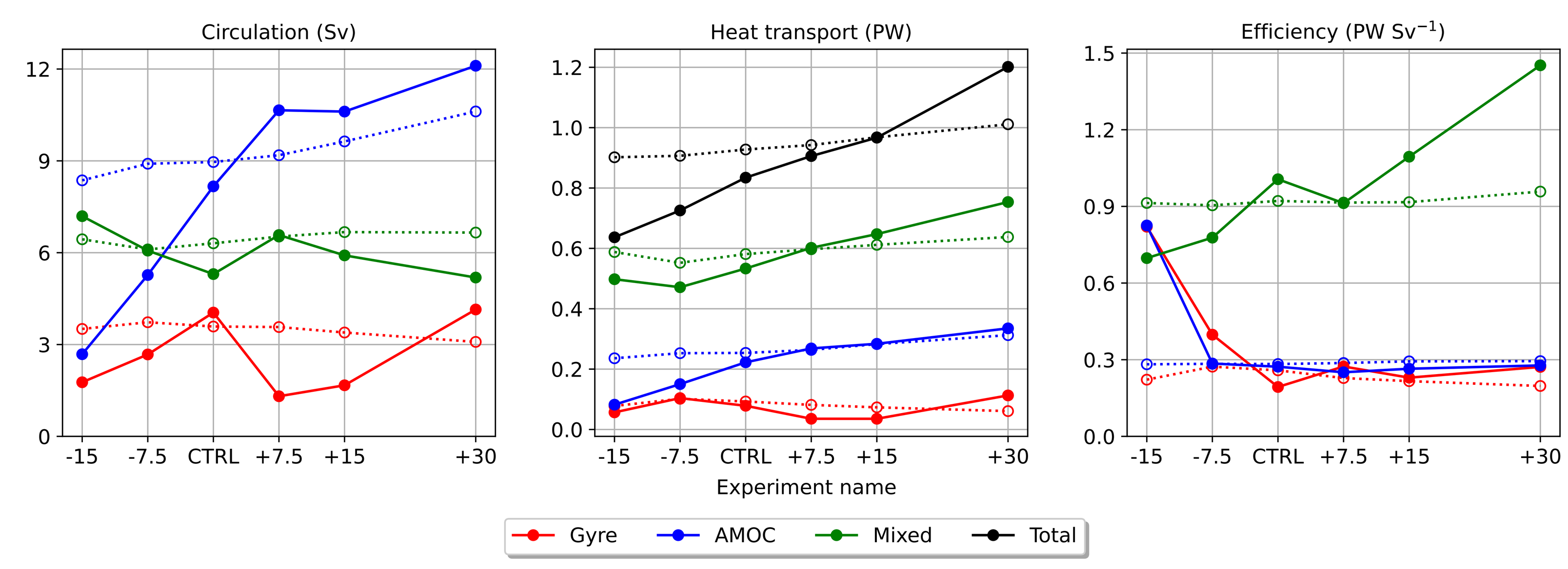




- The total meridional heat fluxes stay constant, and changes in circulation strength are compensated by a change in the circulation's temperature.
- The strength of gyre and mixed cells is directly related to the strength of surface winds.
- The meridional heat transport efficiency (heat transport per unit volume for a given circulation) reduces with an increase in wind stress.

Surface buoyancy flux contrast experiments





- Changes in convection at high-latitudes creates anomalies in the AMOC, while the gyre and mixed circulation are found to be anti-correlated with each other.
- The meridional heat fluxes carried by each circulation increase with an increase in the surface meridional heat flux contrast, but the mechanisms adopted by each circulation are different.
- The mixed circulation strength stays similar, but the temperature difference between its northward and southward flow changes significantly. On the other hand, this temperature difference stays similar for the AMOC, and it spins up to flux more heat.