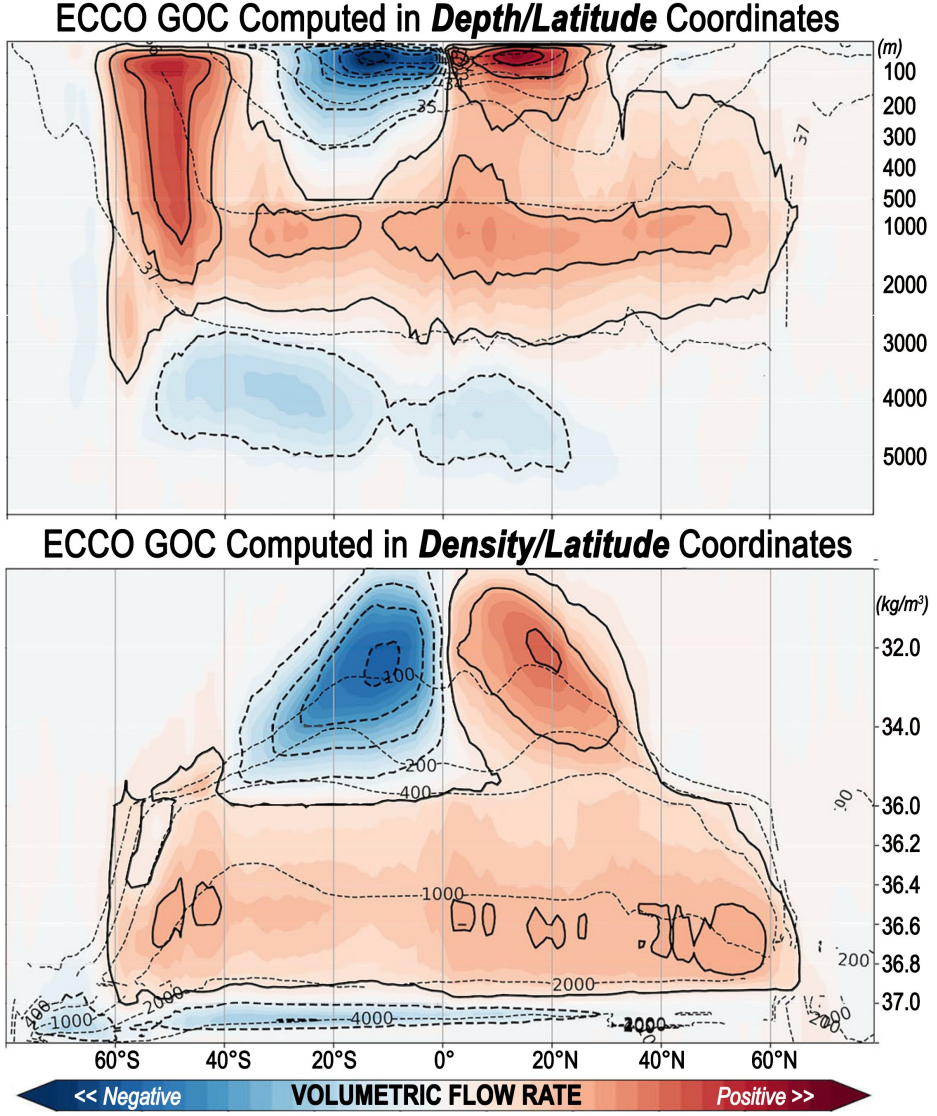
Controls of Global Overturning Ocean Circulation



The global overturning circulation (GOC) describes how seawater flows from pole-to-pole and from the surface to the seafloor. We use a physically-consistent ECCO global state estimate to describe how wind stress, air-sea heat & freshwater fluxes, and tides act to "control" the GOC via a combination of *pumping, convection* and *mixing.* The GOC is analyzed in 3 complementary streamfunctions: ***depth/latitude, density/latitude,*** *and* ***depth/density****.* Together, they reveal the GOC's **geometric structure, locations of density transformations,** and **potential-to-kinetic energy conversion rates.**

- **Depth/Latitude streamfunction** (top), red ↻ clockwise, blue ↺ counterclockwise contours trace major pathways of the GOC: wind *pumping* creates equatorial upwelling and mid-latitude downwelling (30°S—30°N), cooling in the Northern and Southern hemispheres (50°-60°N) leads to sinking *(convection)* which creates North Atlantic Deep Water and Antarctic Bottom Water, respectively.

- **Density/Latitude streamfunction** (bottom), red ↻ clockwise, blue ↺ counterclockwise contours show seawater density changes (sloped or vertical lines) associated with *convection* and *mixing* and that some waters traverse vast distances between hemisphere without significantly changing density (horizontal contours).

The GOC is not governed by a single dominant "driver" but rather emerges from the interplay of multiple processes that vary in space, time, and energetic contribution.

An important emphasis of this work presenting how different controls interact with each other to produce planet-scale overturning flows, making this view relevant to the study of past, present and future climates as well as to exoplanets' oceans.

Roquet, F. et al. (2025) Controls of the global overturning circulation of the ocean, npj Clim. Atmos. Sci., 8, 304, doi: 10.1038/s41612-025-01185-8