



The thermohaline stream function in a changing climate

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The thermohaline stream function is a powerful tool to analyse water mass transformation (WMT). Traditionally, the meridional overturning circulation is visualised in geographical coordinates with stream functions as a function of latitude whereby the meridional velocity is zonally integrated. Conversely, in the thermohaline framework the entire global ocean is represented in oceanographic well-established coordinates namely absolute salinity and potential temperature. This allows to analyse WMT between cold and warm as well as saline and fresh waters in one single graph. It is generally constituted of a tropical cell, a conveyor belt and a polar cell. Here, we present stream functions from various CMIP6 climate scenarios computed by the EC-Earth model and compare pre-industrial, present-day and climate scenario simulations to study changes in WMT. We further provide background information on how the thermohaline stream function (left panel of the attached Figure) is motivated physically and computed mathematically using Helmholtz decomposition. This allows us to identify sources and sinks of mass in the corresponding thermohaline tendency potential, as shown in the right panel of the attached Figure. The position in the temperature and salinity space of the overturning cells reveal significant differences in the climate scenarios, as well as differences in the mass sources and sinks revealed by the tendency potentials. These sources are due to the fresh water fluxes through the sea surface and for the data assimilation data sets, they are also due to mass, heat and salt sources and sinks within the ocean subsurface domain.

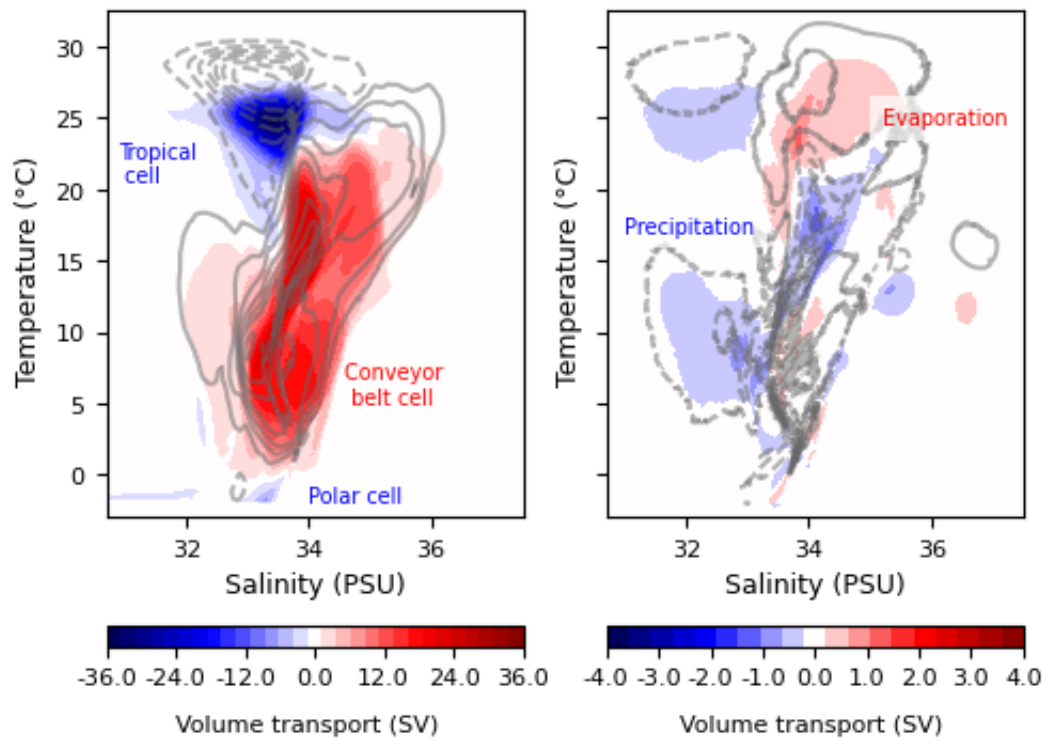


Fig: The thermohaline stream function (left panel) and tendency potential (right panel) computed using data from the ocean component of an EC-Earth model (present-day simulation coloured in red and blue, SSP585-simulation in grey contour lines). They capture the entire ocean circulation in two figures describing the water mass transformation in temperature and salinity.