Changes of the AMOC and MHT seasonal cycle in MPI-ESM CMIP5 climate projections

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Introduction

We examine potential changes of the Atlantic meridional overturning circulation (AMOC) and the meridional heat transport (MHT) and its seasonal cycle in future climate change projections in the RCP 8.5 scenario (strongest emission scenario of CMIP5 experiments) which are performed with the global coupled climate model MPI-ESM (~1.5° horizontal resolution in ocean model).

Associated with global warming, oceanic and atmospheric conditions change in RCP 8.5. The AMOC weakens coherently by about 50% compared to its current strength in the North Atlantic in RCP 8.5 (Fig.1), as well as the MHT. These changes are accompanied by a change in the seasonal cycle of the AMOC and MHT and its components.

Weakening of AMOC and MHT in RCP 8.5

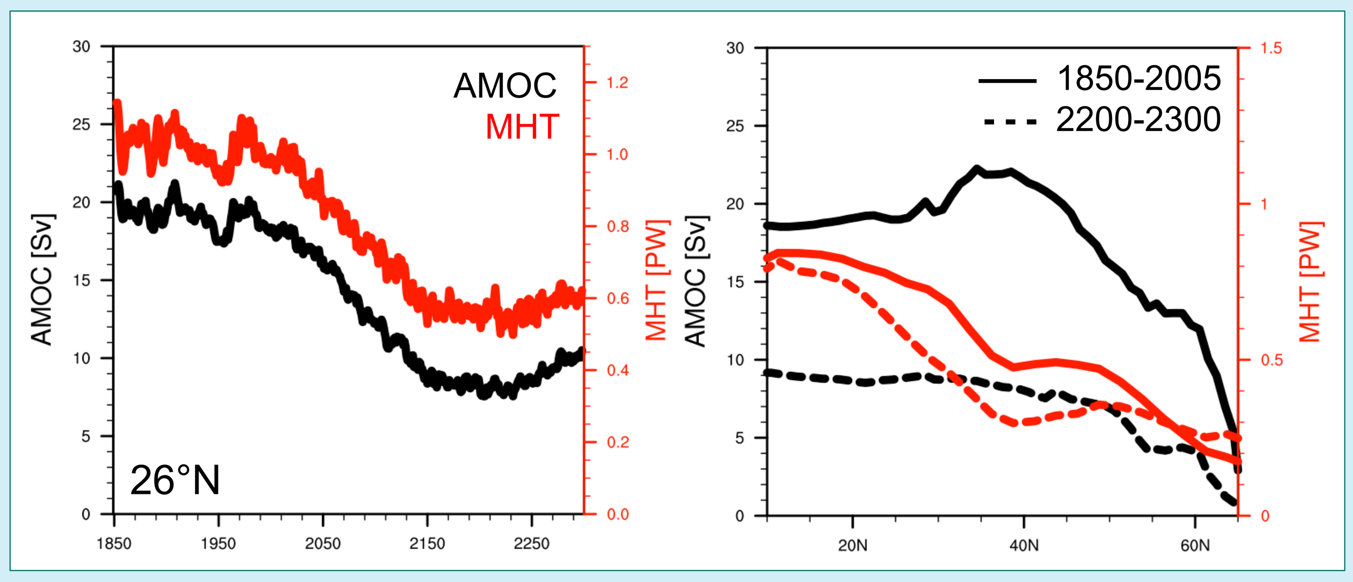

Fig.1: ***Left:*** Change of AMOC (in Sv, black) and Atlantic MHT (in PW, red) at 26°N for historical simulation (1850-2005) and RCP 8.5 (2006-2300). ***Right:*** time mean AMOC (black) and MHT (red) in the North Atlantic for the historical simulation (1850-2005, solid) and RCP 8.5 (2200-2300, dashed).

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Projected changes of atmosphere and ocean

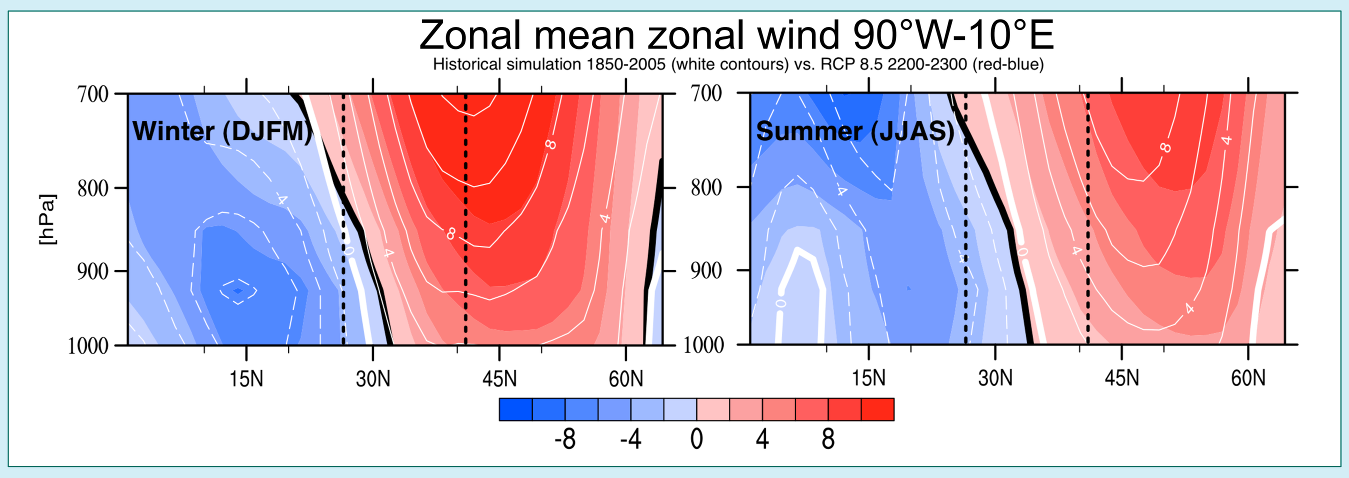

Fig.2: Shift of the zonal jet (in m/s) over the North Atlantic from historical simulation 1850-2005 (white contours) to RCP 8.5 2200-2300 (red-blue): winter (***left***) and summer (***right***) conditions.

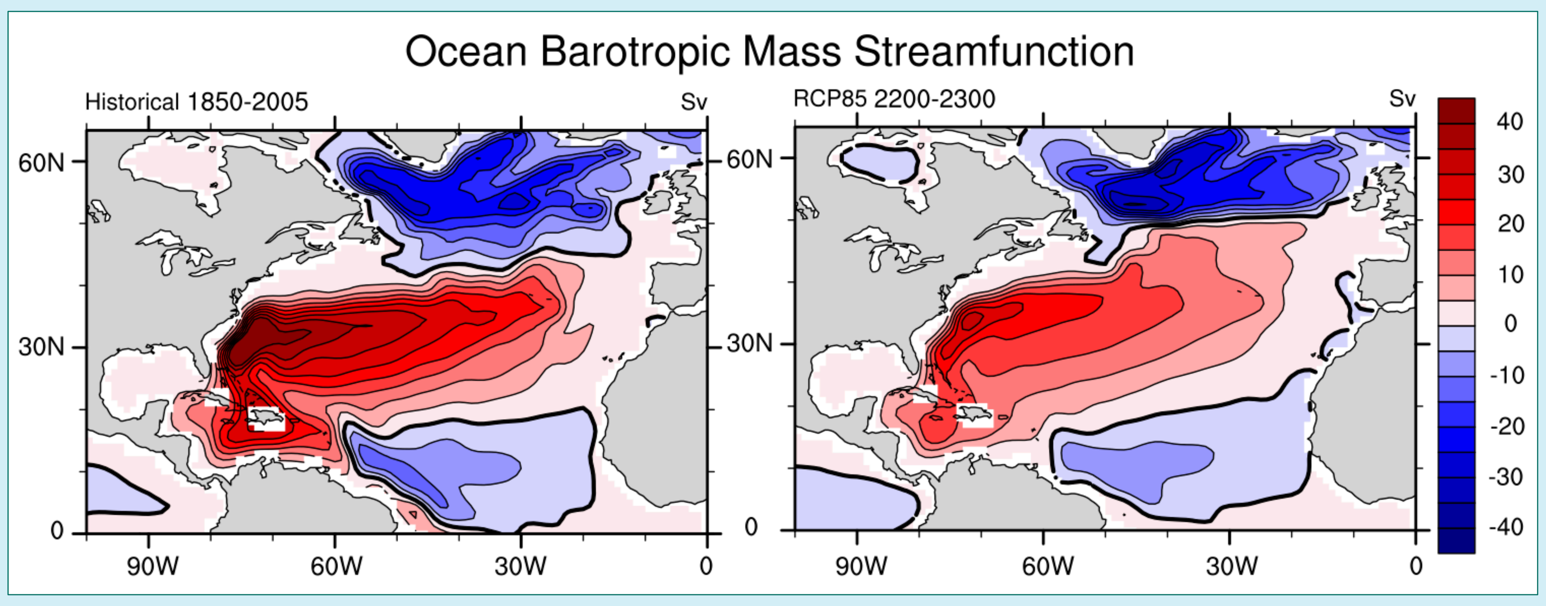

Fig.3: Barotropic stream function (in Sv) in the historical simulation (1850-2005, ***left***) and RCP 8.5 (2200-2300, ***right***) showing a weakening of the subtropical gyre and northward shift of the gyre boundary.

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Seasonal cycle: AMOC and MHT

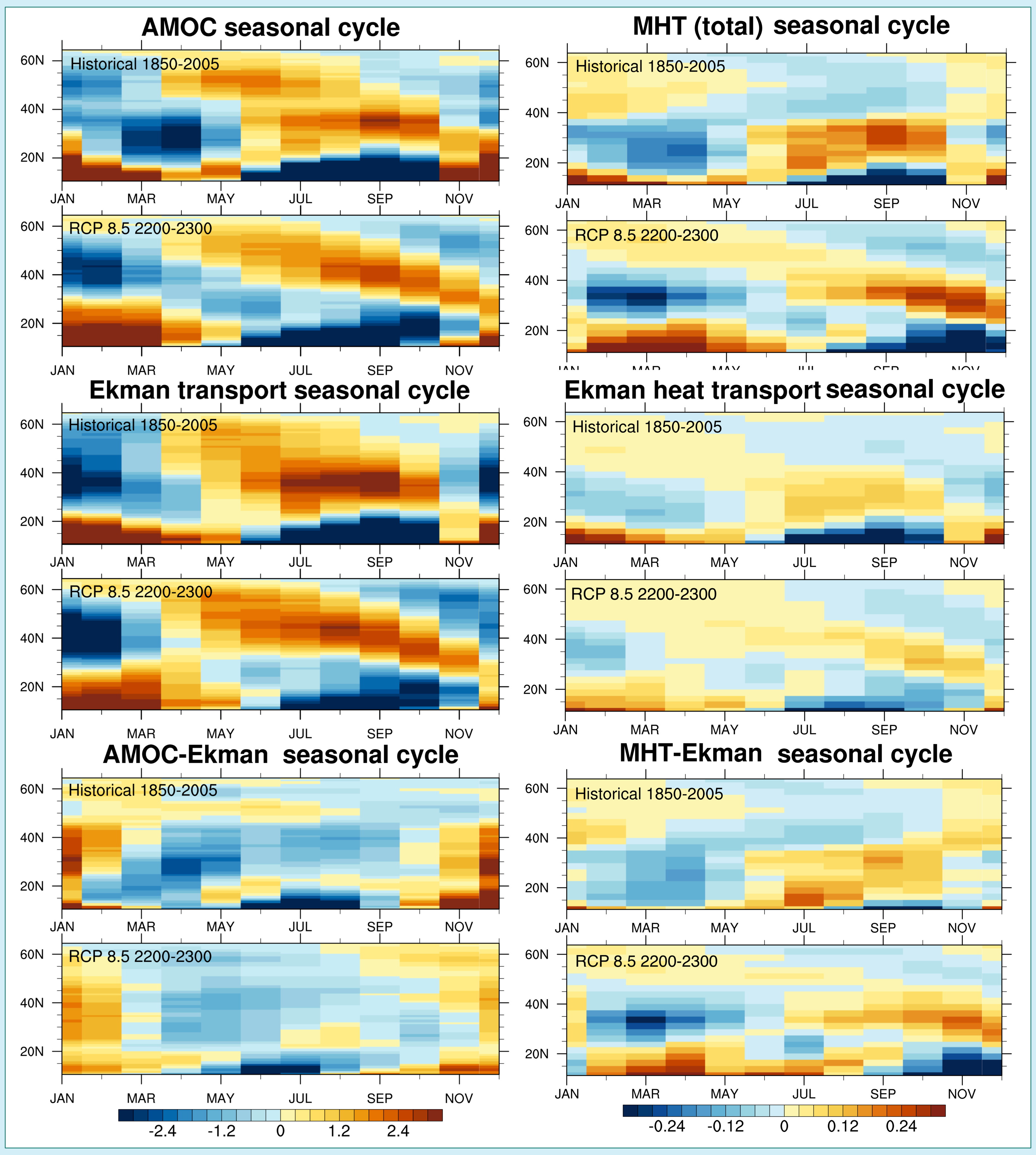

Fig.4: Latitude dependent change of the seasonal cycle of AMOC (in Sv, ***left***) and MHT (in PW, ***right***) from the historical simulation (1850-2005) to the end of RCP8.5 (2200-2300): AMOC and MHT (top), Ekman volume and heat transport (middle) and AMOC-Ekman and MHT-Ekman (bottom). Shown are anomalies relative to the annual mean.

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26°N: seasonal cycle of AMOC and MHT

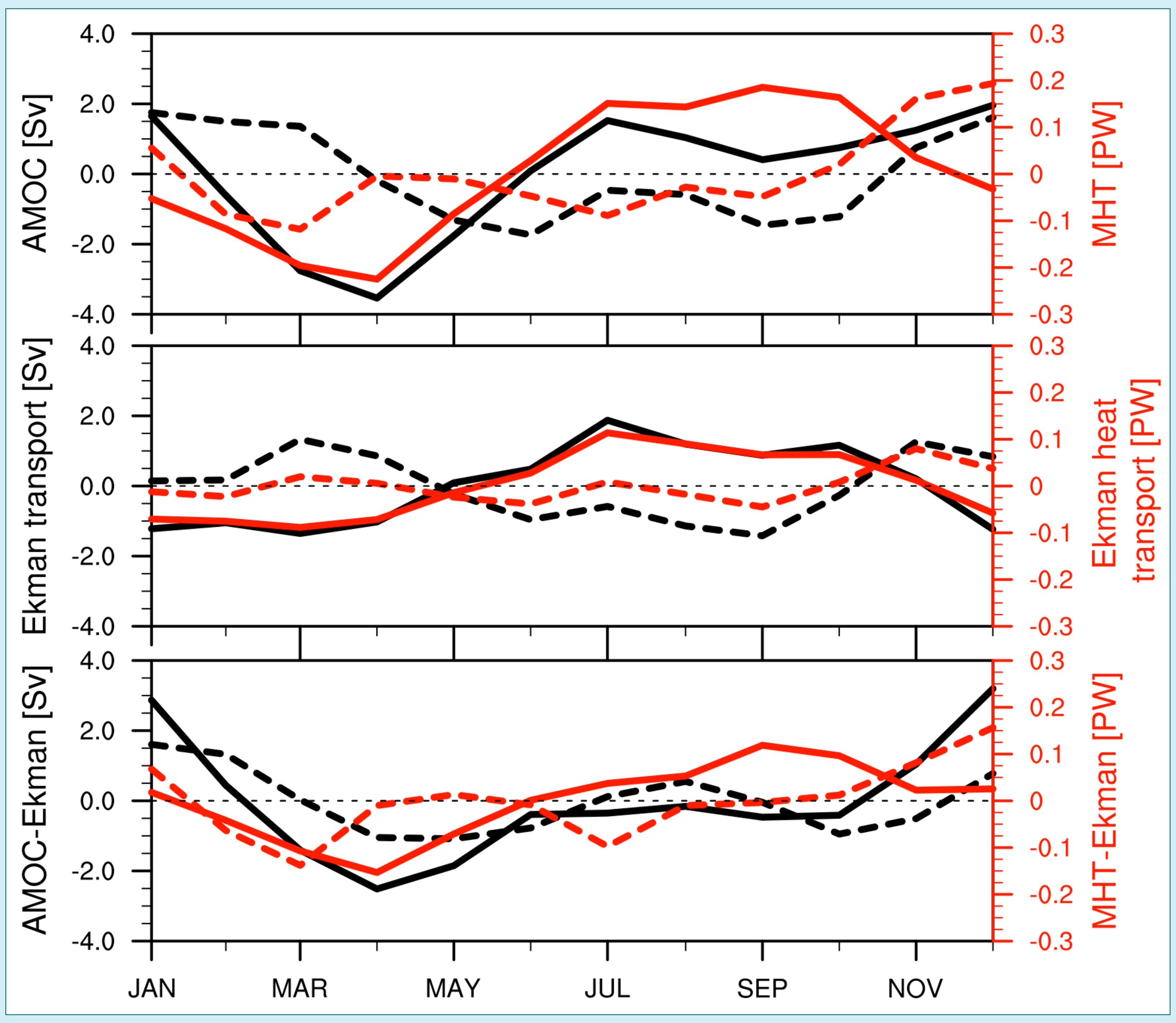

Fig.5: MOC and MHT at 26°N: ***Top:*** change of the seasonal cycle of AMOC (in Sv, black) and total MHT (in PW, red). ***Middle:*** Ekman volume (black) and heat transport (red). ***Bottom:*** AMOC-Ekman transport (black) and MHT-Ekman heat transport (red). Shown are anomalies relative to the respective annual mean at 26°N. **Solid:** mean seasonal cycle of historical simulation 1850-2005, **dashed:** mean seasonal cycle of RCP 8.5 2200-2300.

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Preliminary conclusions:

- AMOC and MHT weaken in the North Atlantic in RCP8.5 resulting from a weakening of the geostrophic transport (Fig.1).
- A shift of the atmospheric jet (Fig.2) leads to a shift of the surface wind stress, a northward shift of the gyre boundary (Fig.3), and significant changes of the seasonal cycle of the Ekman transport between ~20°N-40°N.
- The change of the AMOC seasonal cycle mostly results from a change in the Ekman transport, but also from changes in the boundary densities. The seasonal cycle of the geostrophic transport is shifted in time, and particularly in the subtropical gyre, it is weakened (Fig.4).
- The seasonal cycle of the total MHT is strongly influenced by an intensified seasonal cycle of geostrophic heat transport in the subpolar gyre (Fig.4) and a shift of the gyre boundary.
- At 26°N (Fig.5), the seasonal cycle of AMOC and MHT is entirely changed, mostly resulting from a shift of the Ekman transport, which changes from a maximum in summer in the historical simulation to a minimum in summer in RCP 8.5.
- Changes of the geostrophic transport volume and heat transport need further analysis.
- These findings, especially the change in the seasonal cycle of the geostrophic transport, may have important implications for the impact of climate change on the decadal predictability of the AMOC and the MHT.

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