National Oceanography Centre

Atlantic Heat and Freshwater Transport Response to Future Climate Scenarios

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CMIP5/CMIP6 Data

Historical, rcp2.6/ssp126 and rcp8.5/ssp585 experiments are investigated

CMIP5 (27 historical & rcp8.5, 25 rcp4.5(+), 19 rcp2.6 (*)):

ACCESS1-0+, ACCESS1-3+, bcc-csm1-1+*, bcc-csm1-1-m+*, BNU-ESM+*, CanESM2*, CCSM4+*, CESM1-BGC+, CESM1-CAM5+*, CESM1-WACCM+*, CMCC-CESM, CMCC-CM+, CMCC-CMS+, CNRM-CM5+*, FGOALS-g2+*, GFDL-ESM2G+*, GFDL-ESM2M+*, GISS-E2-R+*, GISS-E2-R-CC+, HadGEM2-CC+, IPSL-CM5A-LR+*, IPSL-CM5A-MR+*, MPI-ESM-LR+*, MPI-ESM-MR+*, MRI-CGCM3+*, NorESM1-M+*, NorESM1-ME+*

CMIP6 (15 historical & ssp585, 13 ssp245 (+), 12 ssp126 (*)):

ACCESS-CM2+*, ACCESS-ESM1-5+*, BCC-CSM2-MR+*, CAMS-CSM1-0+*, CanESM5+, CESM2+*, CESM2-WACCM+*, CNRM-CM6-1+*, FGOALS-f3-L*, GFDL-CM4+, HadGEM3-GC31-LL+*, IPSL-CM6A-LR+, MPI-ESM1-2-HR+*, MPI-ESM1-2-LR*, UKESM1-0-LL+*

Transport Computations

- Total Heat Transport:

$$H(y,t) = \rho_o c_p \int_{-h}^{0} \int_{x_W}^{x_E} vT\,dxdz$$

- Total Freshwater Transport:

$$M(y,t) = \frac{-1}{S_o} \int_{-h}^{0} \int_{x_W}^{x_E} vS\,dxdz$$

- Overturning Heat Transport:

$$H_{ov}(y,t) = \rho_o c_p \int_{-h}^{0} \int_{x_W}^{x_E} \langle v^* \rangle \langle T \rangle\,dxdz$$

- Overturning Freshwater Transport:

$$M_{ov}(y,t) = \frac{-1}{S_o} \int_{-h}^{0} \int_{x_W}^{x_E} \langle v^* \rangle \langle S \rangle\,dxdz$$

- Azonal Heat Transport:

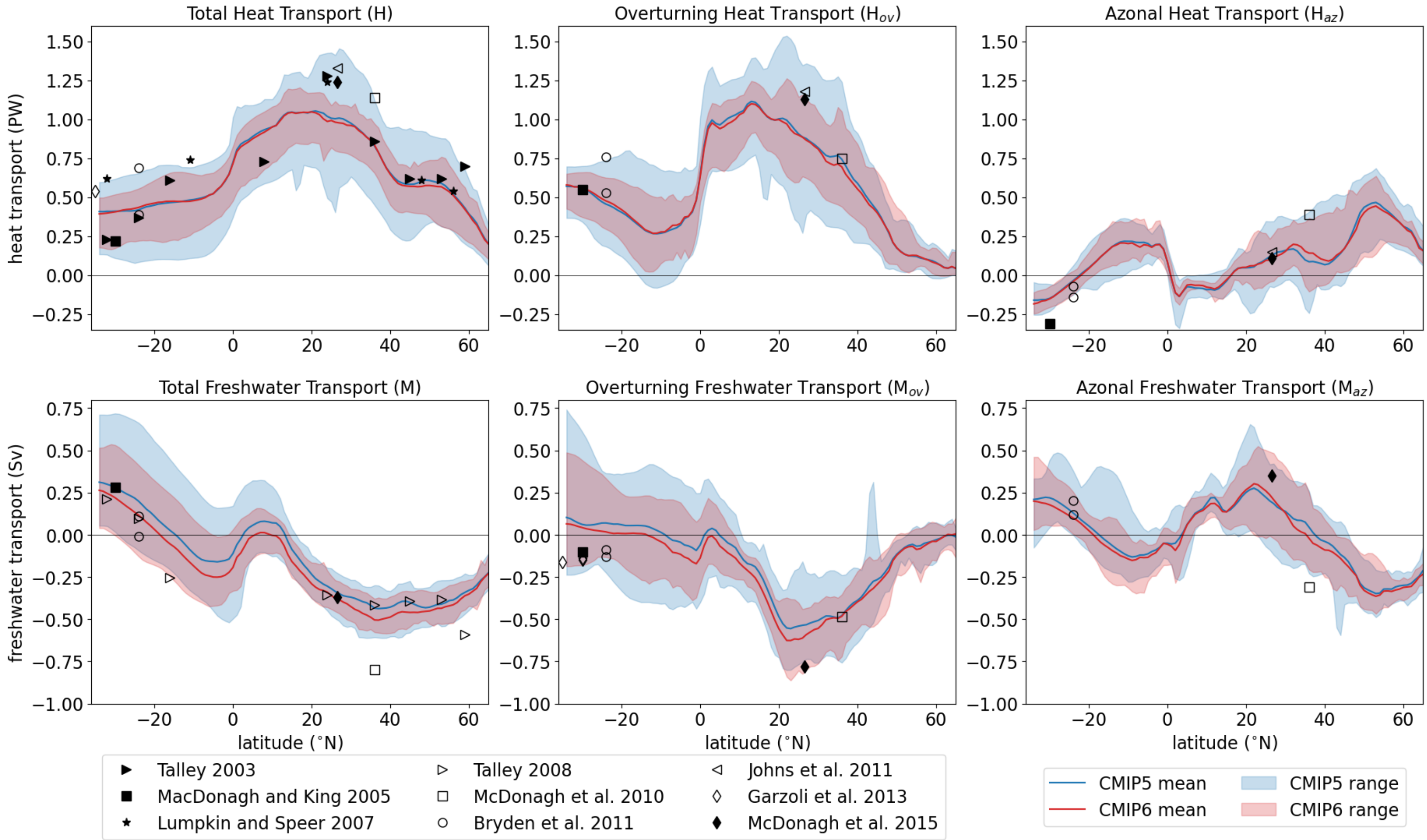
$$H_{az}(y,t) = \rho_o c_p \int_{-h}^{0} \int_{x_W}^{x_E} v^{*\prime} T'\,dxdz$$

- Azonal Freshwater Transport:

$$M_{az}(y,t) = \frac{-1}{S_o} \int_{-h}^{0} \int_{x_W}^{x_E} v^{*\prime} S'\,dxdz$$

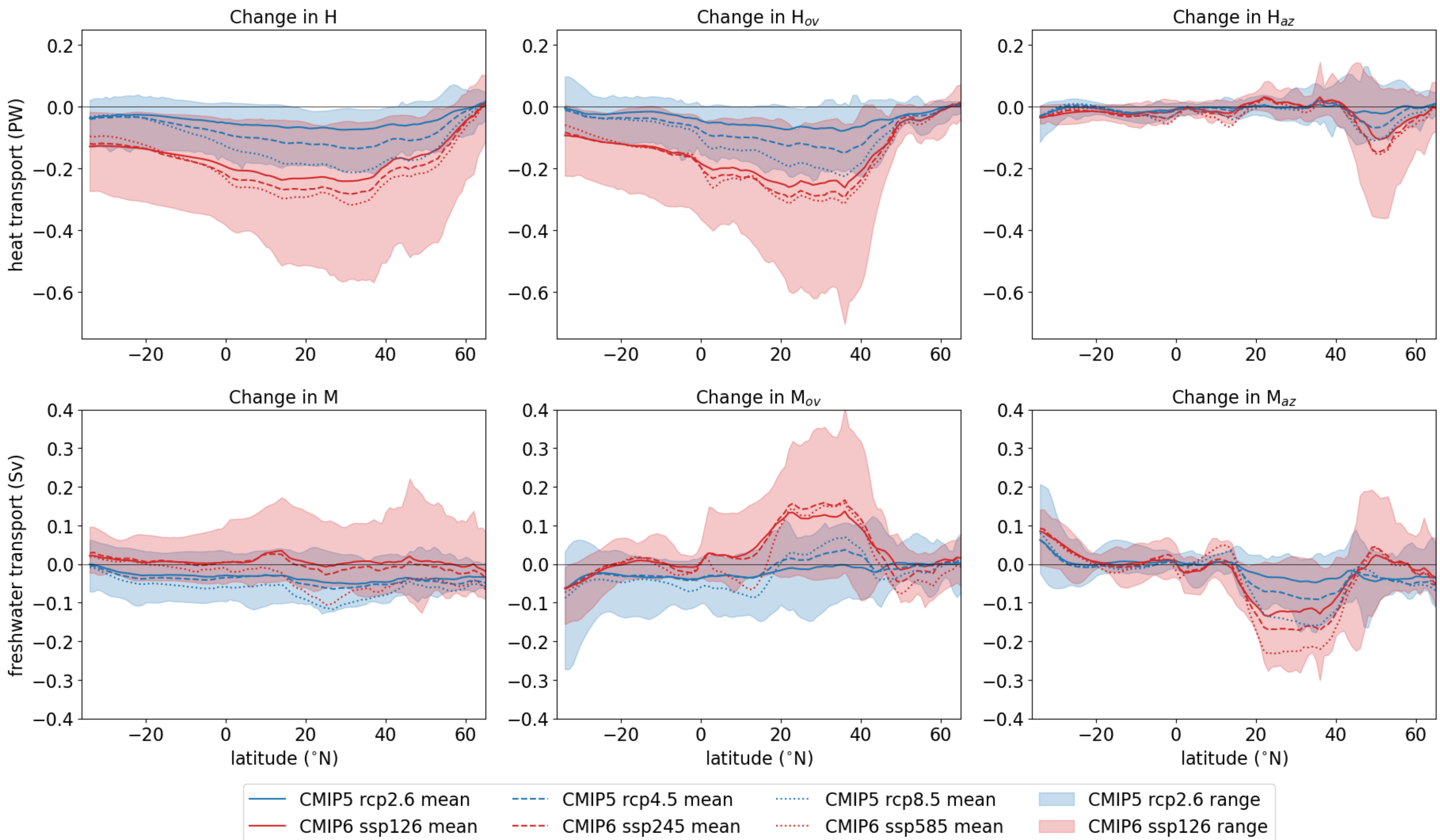
$$v^* = v - \frac{\int_{-h}^{0}\int_{x_W}^{x_E} v\,dxdz}{\int_{-h}^{0}\int_{x_W}^{x_E} dxdz} \qquad \langle\cdot\rangle = \frac{\int_{x_W}^{x_E} \cdot\, dx}{\int_{x_W}^{x_E} dx} \qquad \cdot' = \cdot\; - \langle\cdot\rangle \qquad S_o = \frac{\int_{-h}^{0}\int_{x_W}^{x_E} S\,dxdz}{\int_{-h}^{0}\int_{x_W}^{x_E} dxdz}$$

Historical Mean State



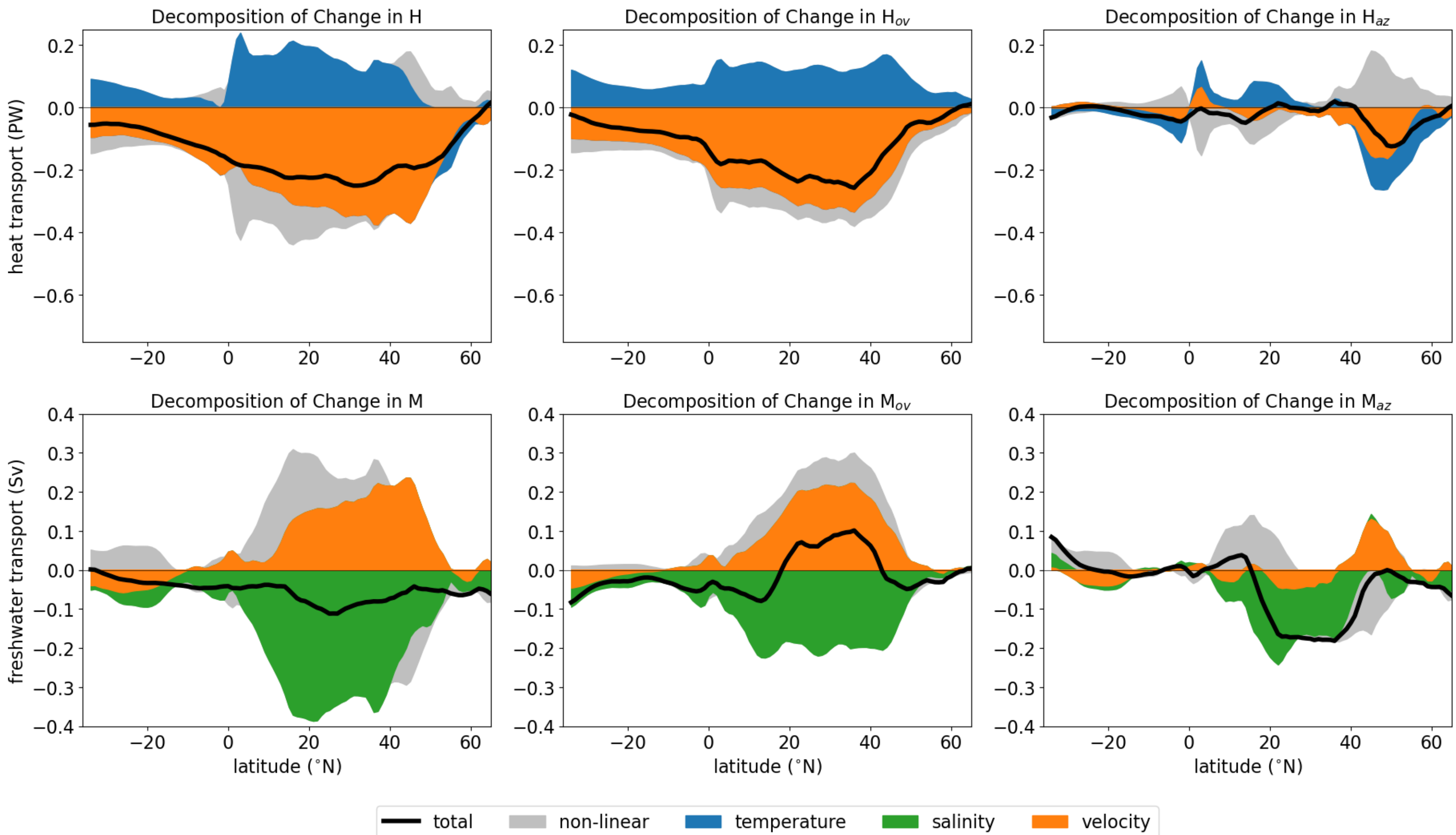
Mean heat and freshwater transports 1970-1999

Response to Future Scenarios



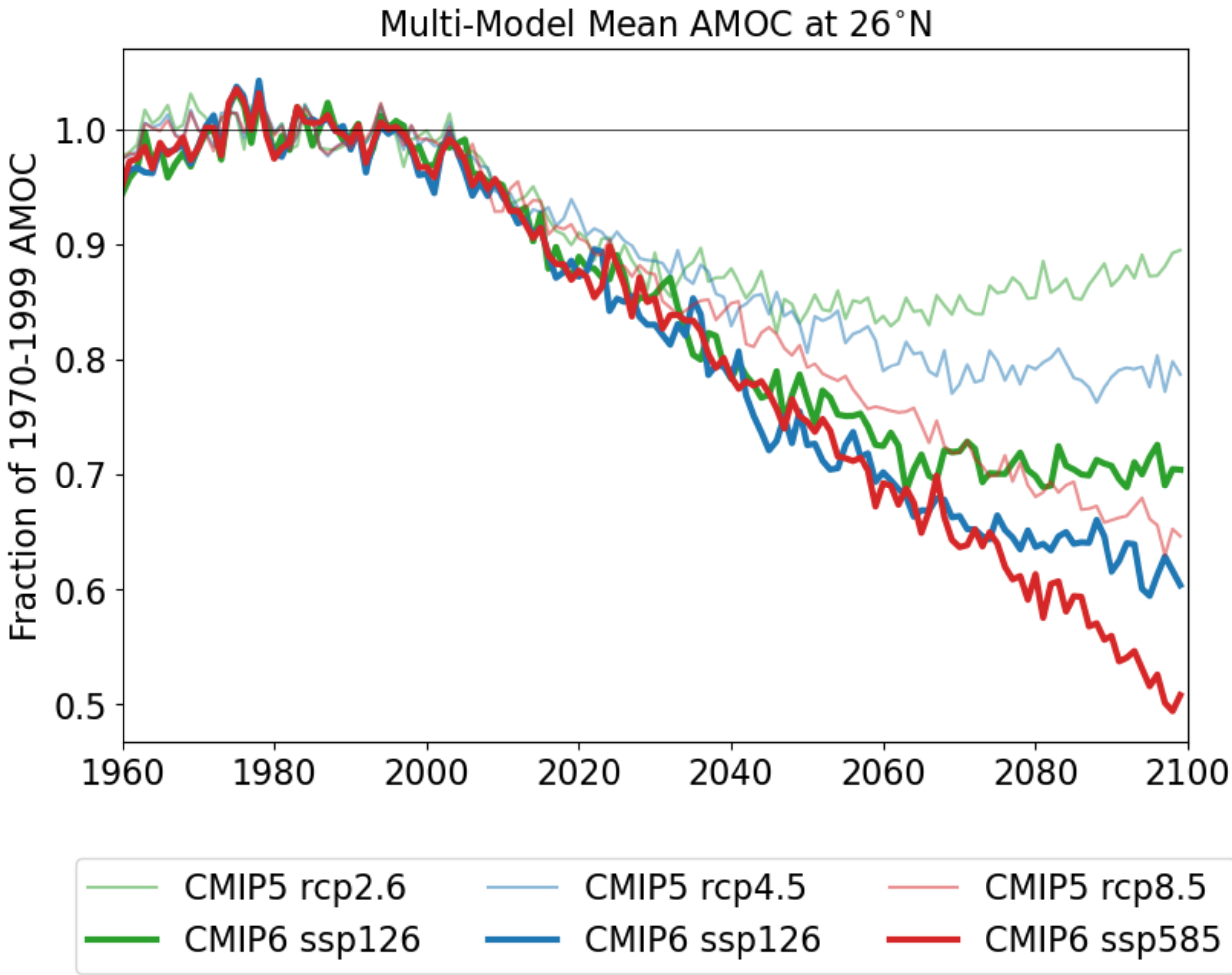
Heat and Freshwater changes ssp/rcp *X* 2070-2099 - historical 1970-1999

Decomposition of Changes



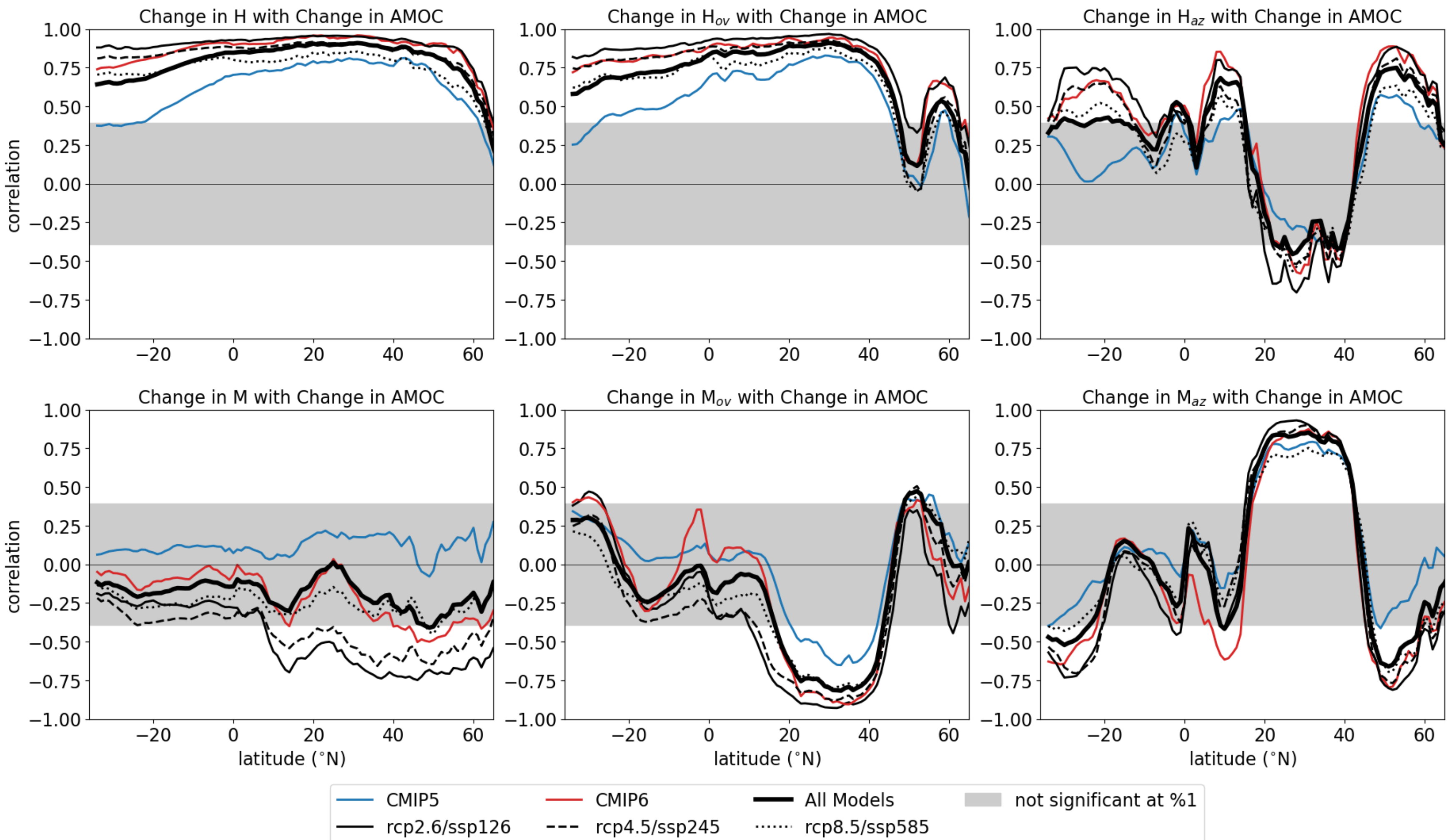
Heat and Freshwater changes ssp585 & rcp8.5 combined 2070-2099 - historical 1970-1999

Role of the AMOC



AMOC response in CMIP6 to future climate scenarios is larger across all scenarios than CMIP5

Correlation with AMOC



Correlation with change in AMOC at 26ºN, shading is significance for 'All Models'

Conclusions

- In the historical simulation of heat transports in CMIP6 models have a smaller range of values than CMIP5, while the freshwater transports exhibit a similar range
- With the exception of the total freshwater transport (M) the CMIP6 models have a larger response to climate change scenarios than CMIP5
- Changes to heat transports are mostly dominated by changes in velocity and dampened by changes in temperature, while changes in freshwater transports are mostly dominated by changes in salinity and dampened by changes in velocity. However, this result varies a bit by latitude
- The larger response of CMIP6 models to the climate change scenarios can be linked with CMIP6 models having a stronger reduction in AMOC across all scenarios

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