The impacts of increased atmospheric CO_2 on the 3-D structure of the AMOC in the North Atlantic Ocean

Sotiria Georgiou, Caroline A. Katsman, Michele Petrini,

Raymond Sellevold and Miren Vizcaino

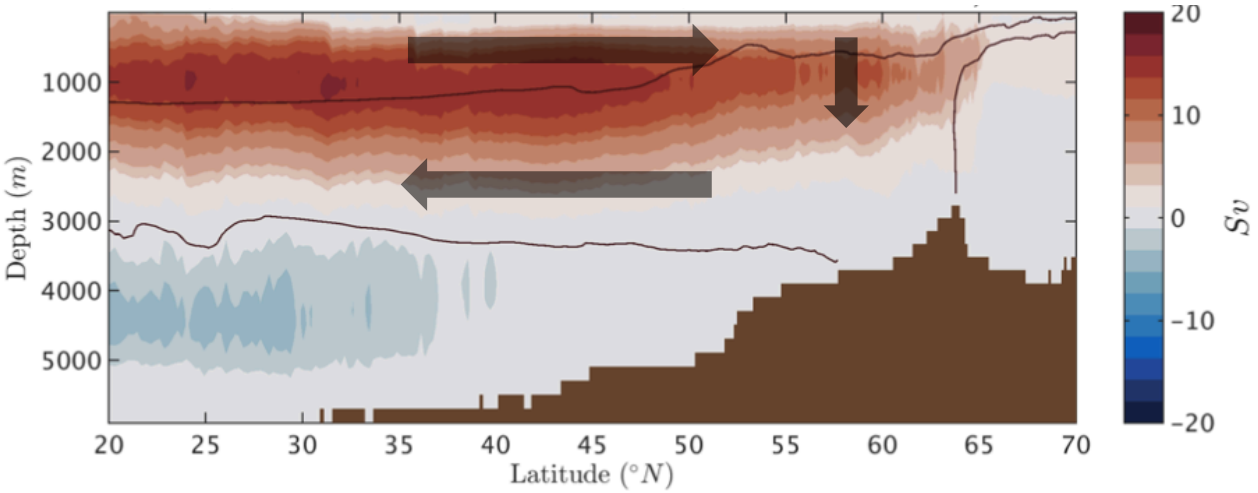
February 3rd 2021

European Research Council

Established by the European Commission

TU Delft Delft University of Technology

Downwelling branch of AMOC in the North Atlantic



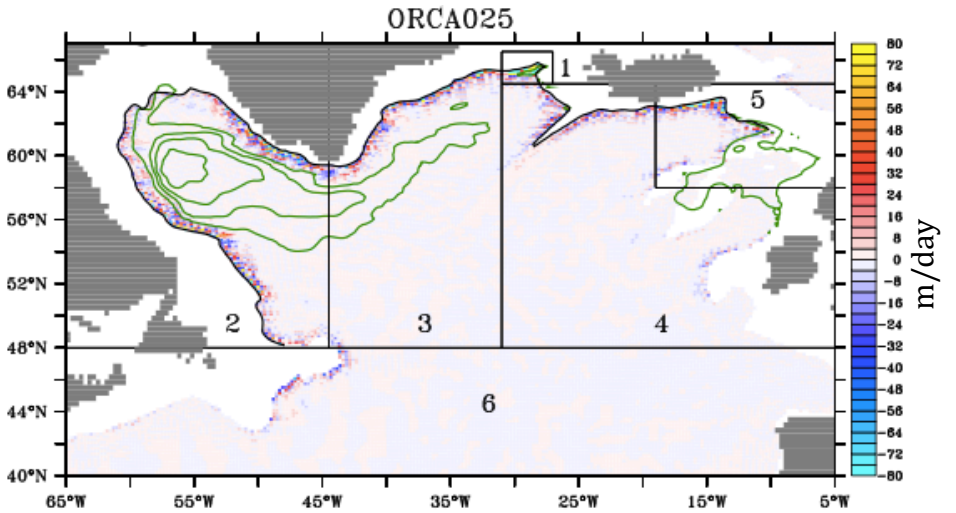
MacGilchrist et al. (2020)

- During convection: downwelling within plumes is balanced by upwelling between them → no net downwelling
- Theory predicts that significant downwelling can occur near the topographic boundaries
- The amount of near-boundary sinking has been linked to alongshore density changes (Spall and Pickart,2001):

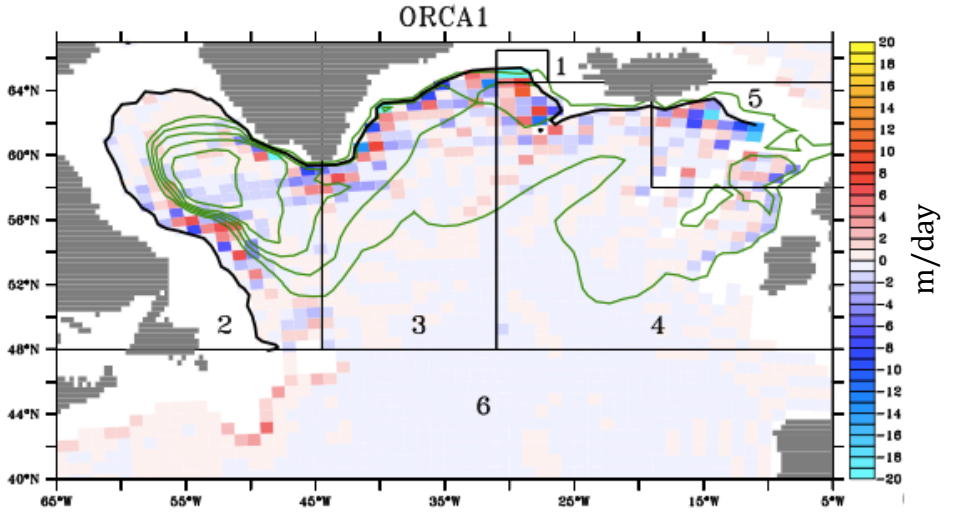
$$W_B = \frac{g\,\Delta\rho_B z_{sink}^2}{2\rho_0 f}$$

Downwelling in global ocean model

- ORCA ¼°
- strong vertical velocities near the boundaries



- ORCA 1°
- enhanced vertical velocities also in the ocean interior

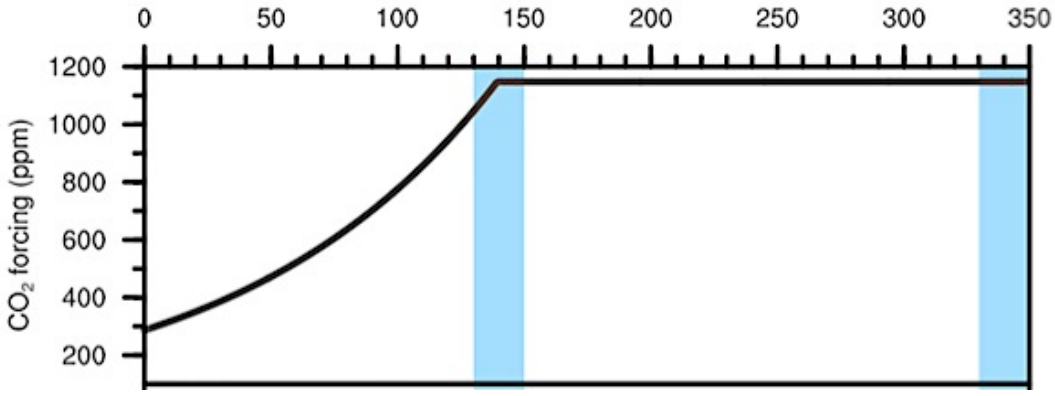


Katsman et al.(2018)

Details of the model

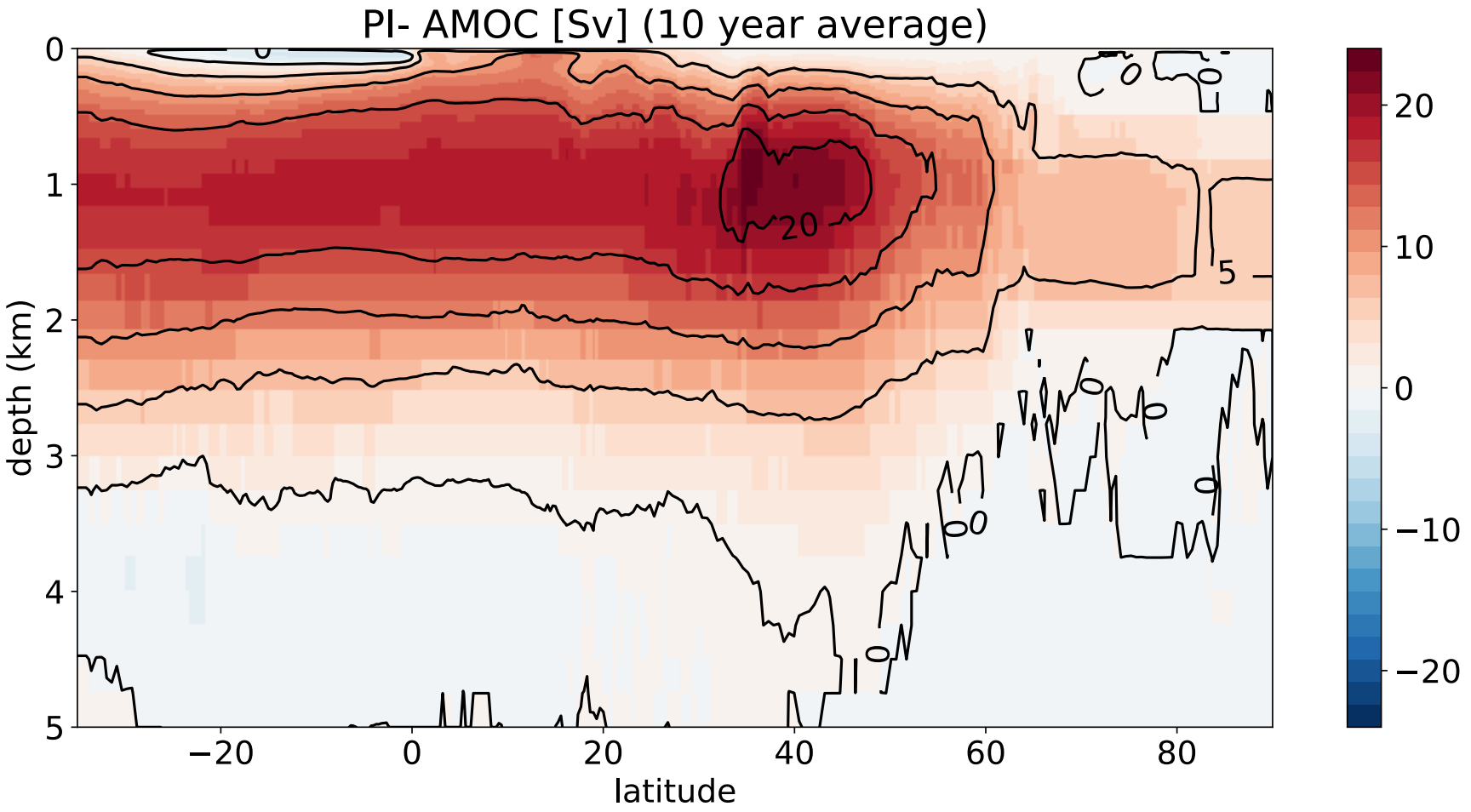
- CESM2.1- CISM2.1
- ocean component [POP2]
  - 1° horizontal resolution
  - 60 vertical layers
  - GM-parameterization for tracer advection

- Pre-industrial run [PI run]
  - 300 years
- 1% increase in CO_2 until 4xCO_2 stabilization [1PCT run]
  - 350 years



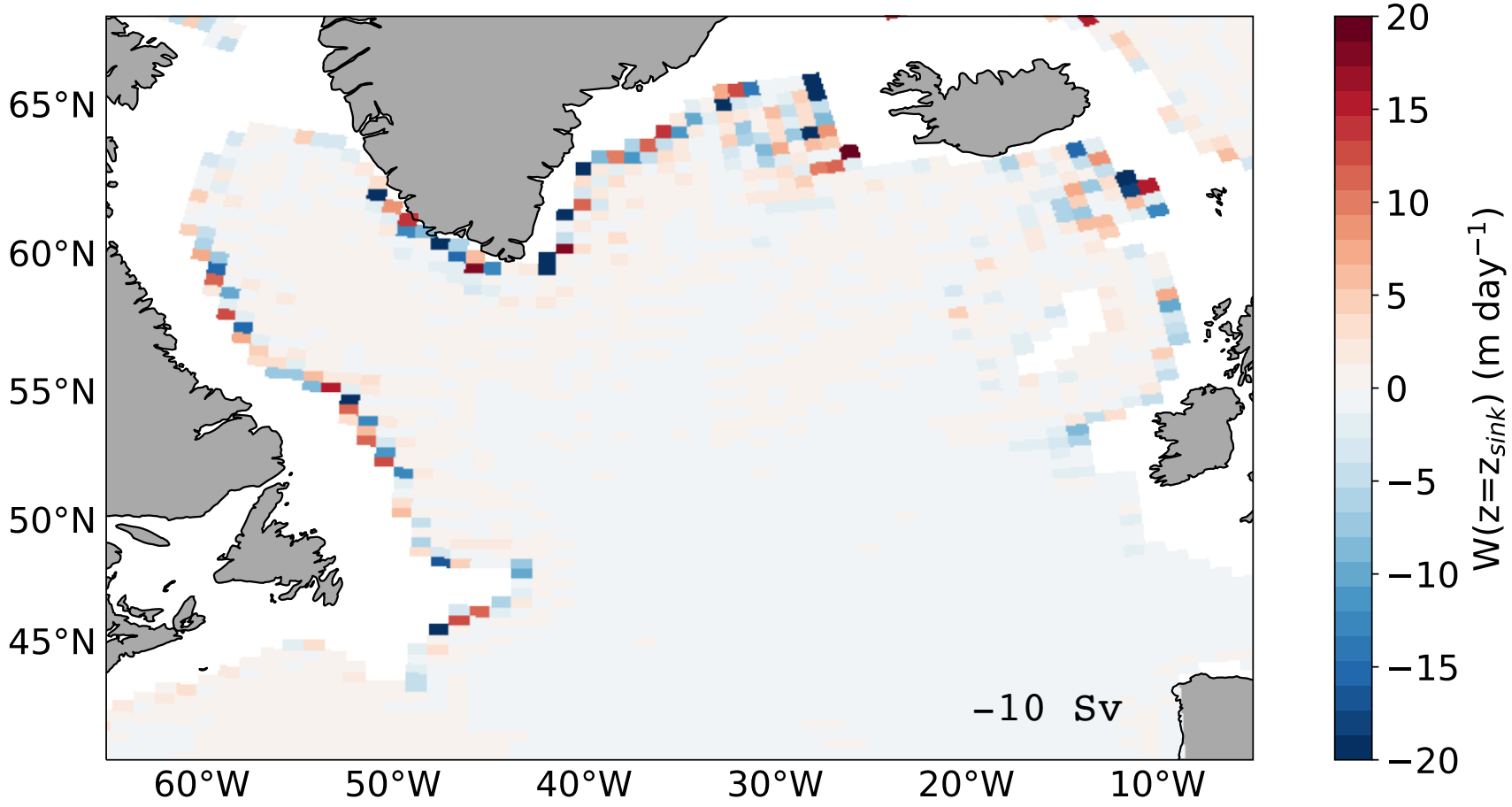
Muntjewerf et al.(2020)

AMOC in depth-latitude view



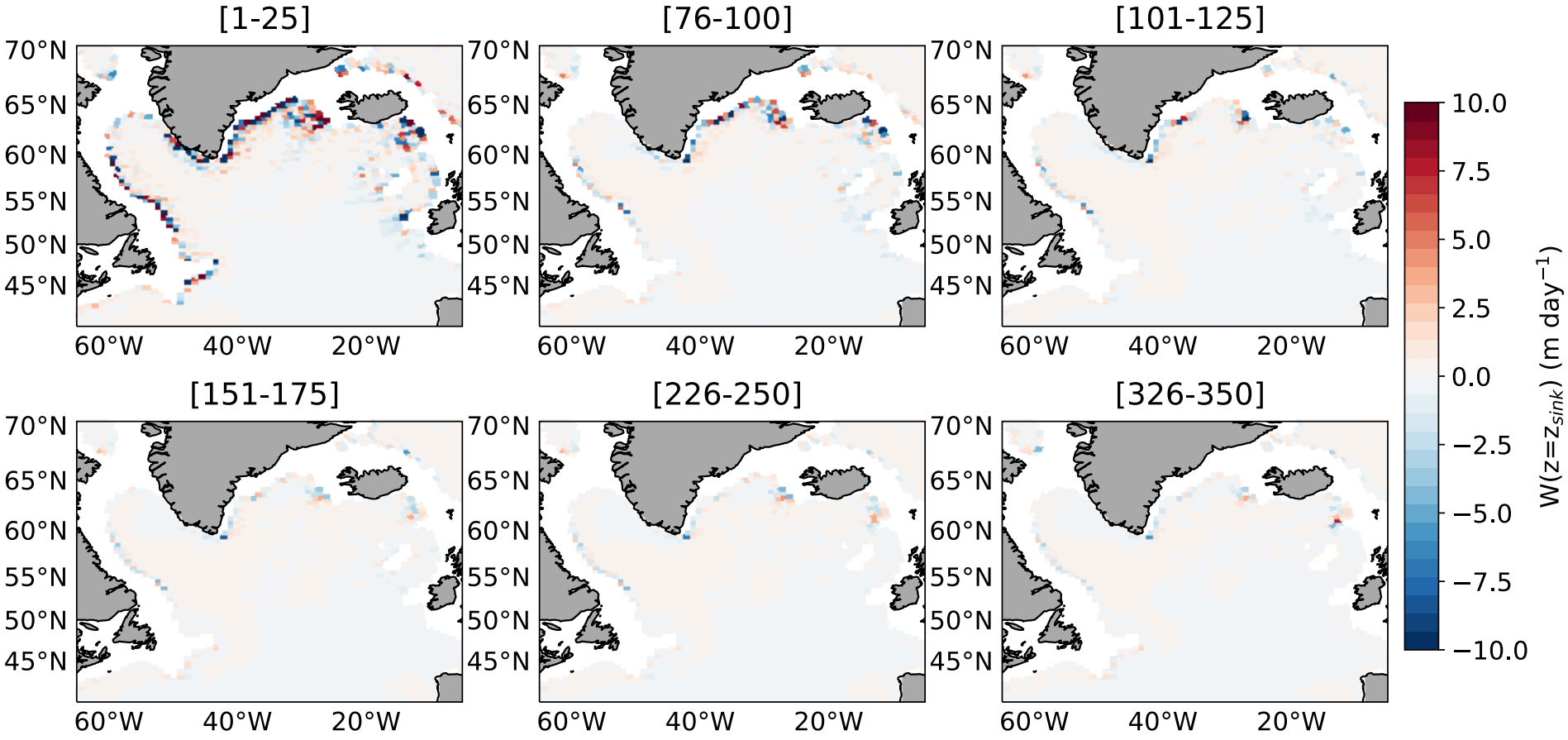
AMOC maximum at z_{sink}= 928 m

Vertical velocity at z_{sink}=928 m [PI run]

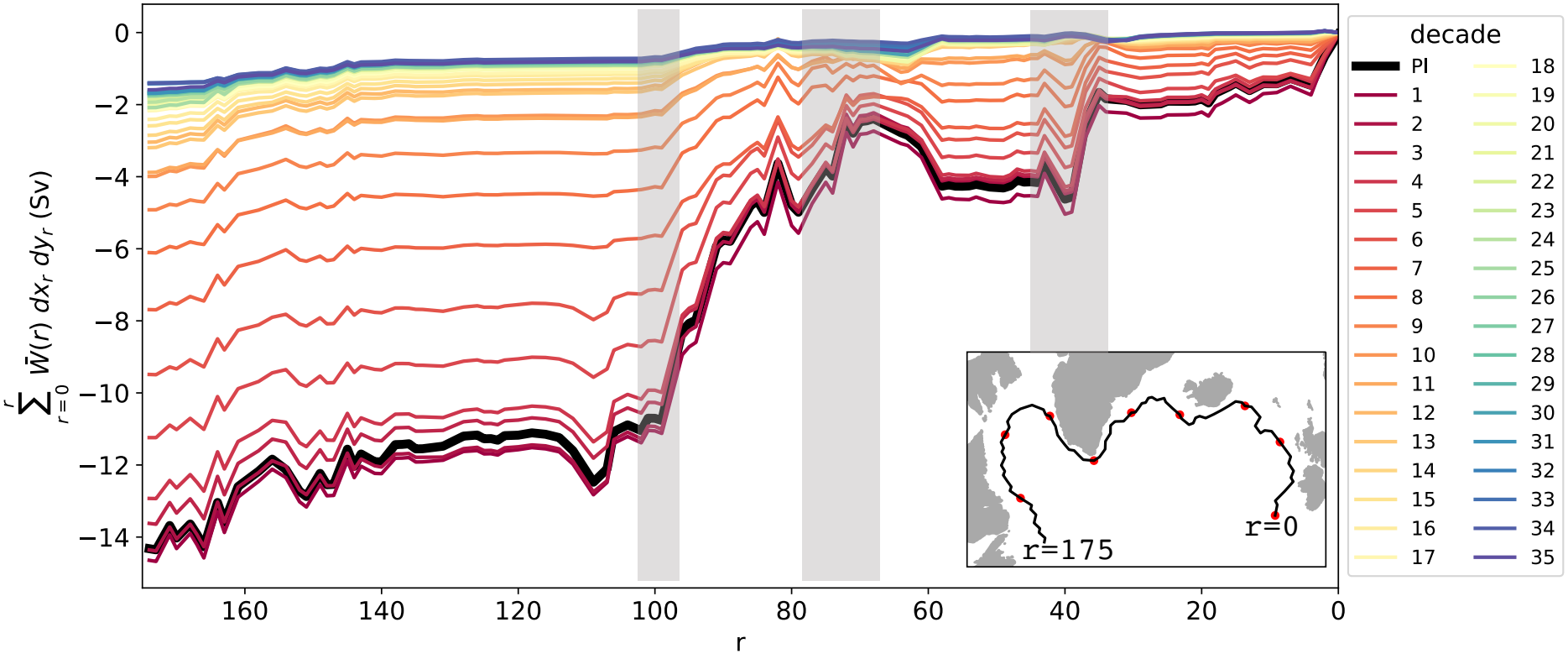


near boundary strong vertical velocities

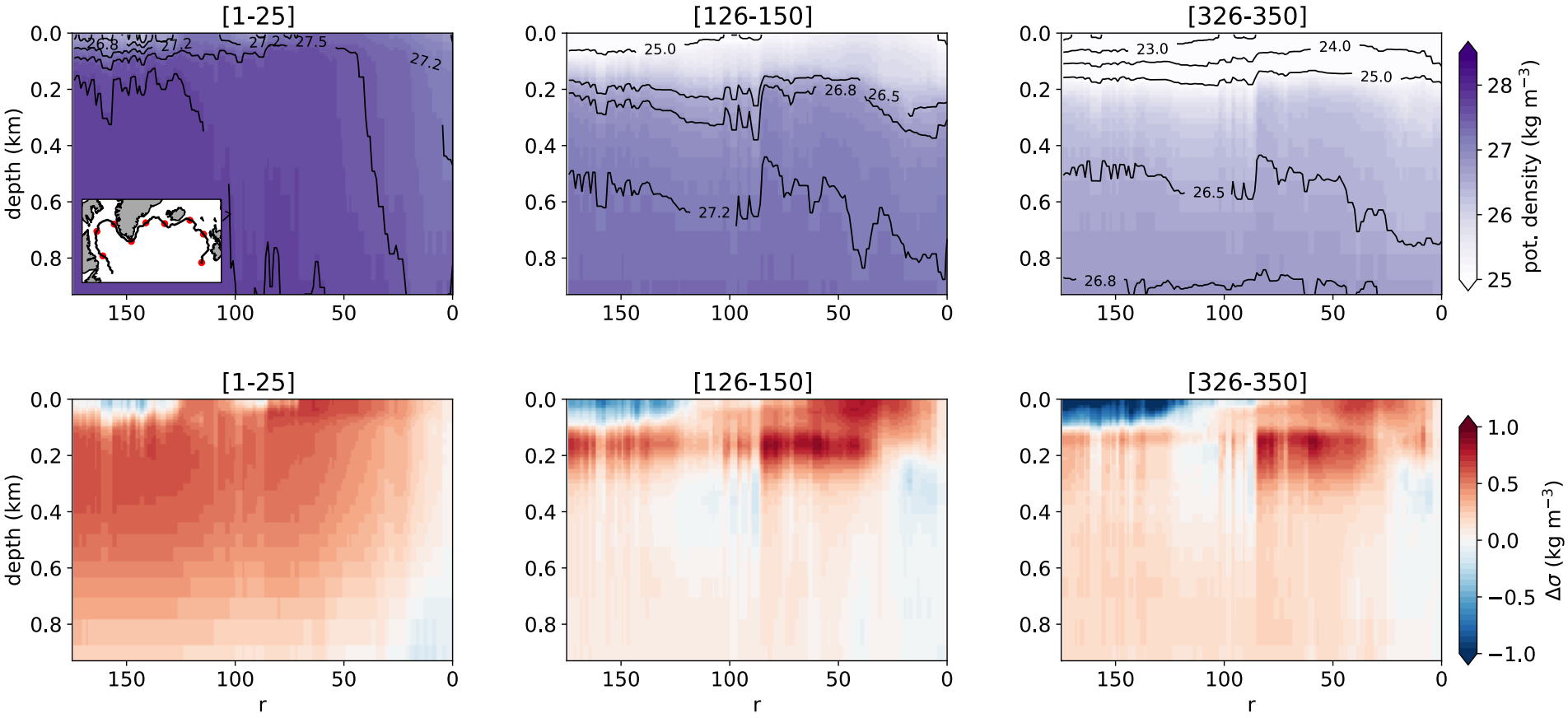
Vertical velocity at z_{sink}=928 [1PCT run]



Cumulative vertical transport along the path

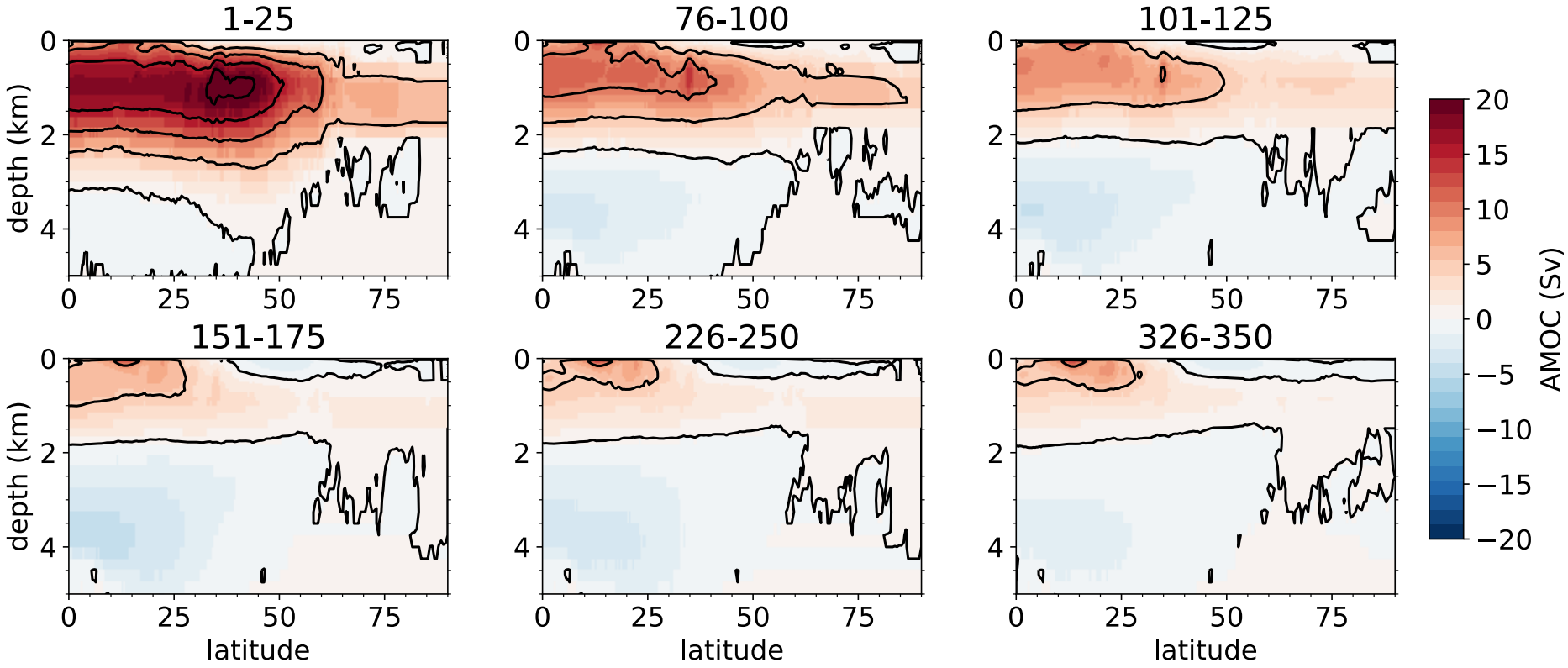


Density along the path [1PCT run]



$\Delta\sigma = \sigma(r,z) - \sigma(0,z)$

AMOC response to increasing CO_2 [1PCT run]



Summary & next steps

PI run:

- The near boundary downwelling is well represented

1PCT run:

- The strength of the downwelling branch of the AMOC weakens as CO_2 concentration increases
- Negligible net downward transport in the North Atlantic after 70 years
- North Atlantic is getting fresher $\overset{?}{\rightarrow}$ weaker downwelling
- Role of the freshwater fluxes on the downwelling dynamics?
  - Differences with simulations without an interactive Greenland ice sheet component?

S.Georgiou@tudelft.nl