Upper Ocean Manifestations of a Reducing AMOC

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1. Introduction

Climate models of the fourth IPCC assessment predict a slowing down of the Atlantic MOC. This could have a great influence on European climate.

But what is the zonal expression of such a change in the subtropics? Does the northward western boundary transport decrease? Or does the southward interior ocean transport increase? Such questions impact how we interpret and constrain past and present observations.

If the subtropical interior ocean is in Sverdrup balance, then the interior ocean transport can only change if the wind stress curl changes. So does Sverdrup balance hold and continue to hold under climate change? If so, does the wind stress curl increase under climate change?

We use a Control run and a 4xCO2 climate run from the coupled model, HiGEM, to investigate the subtropical zonal expression of a decreasing AMOC.

2. Are the interior subtropics in Sverdrup Balance?

$$V = \frac{\nabla \times \tau}{\rho \beta} + \delta$$

Fig1. Decadal mean Sverdrup balance terms

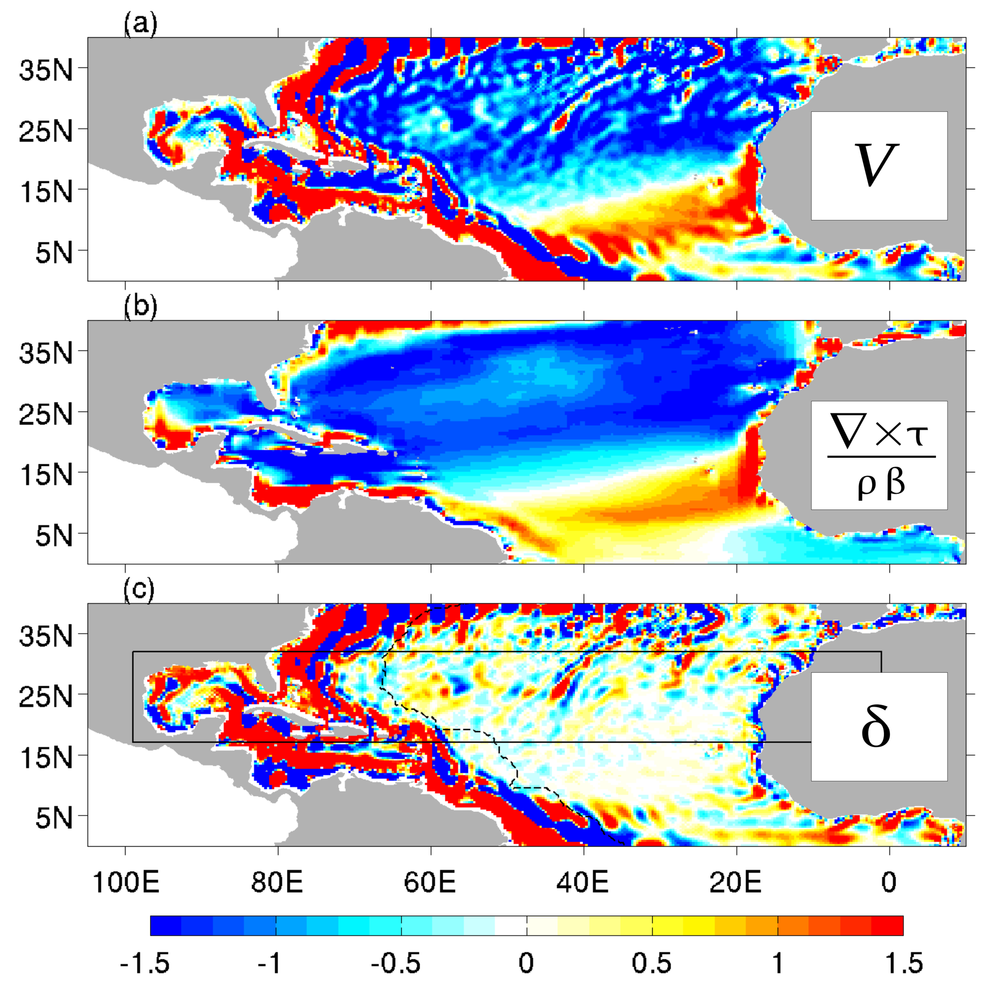
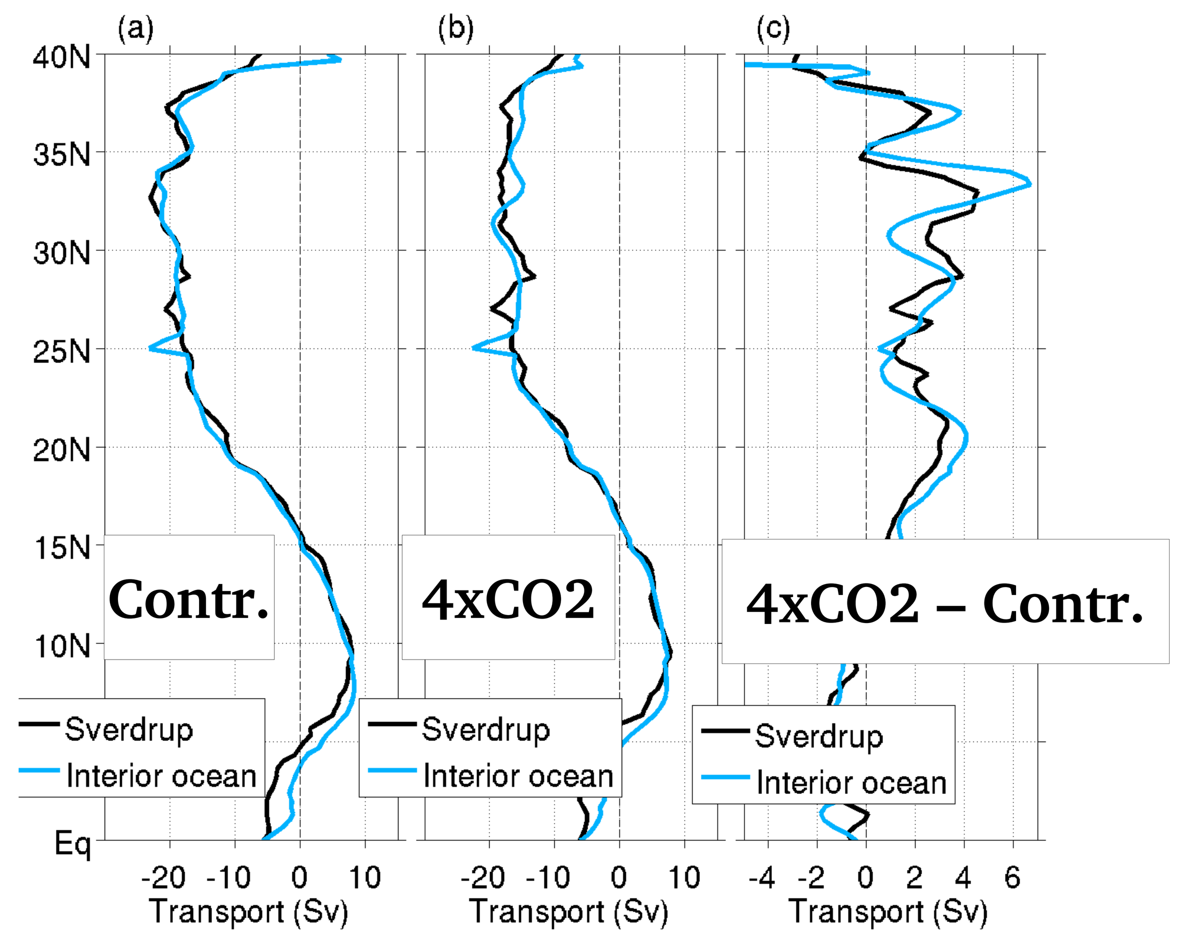


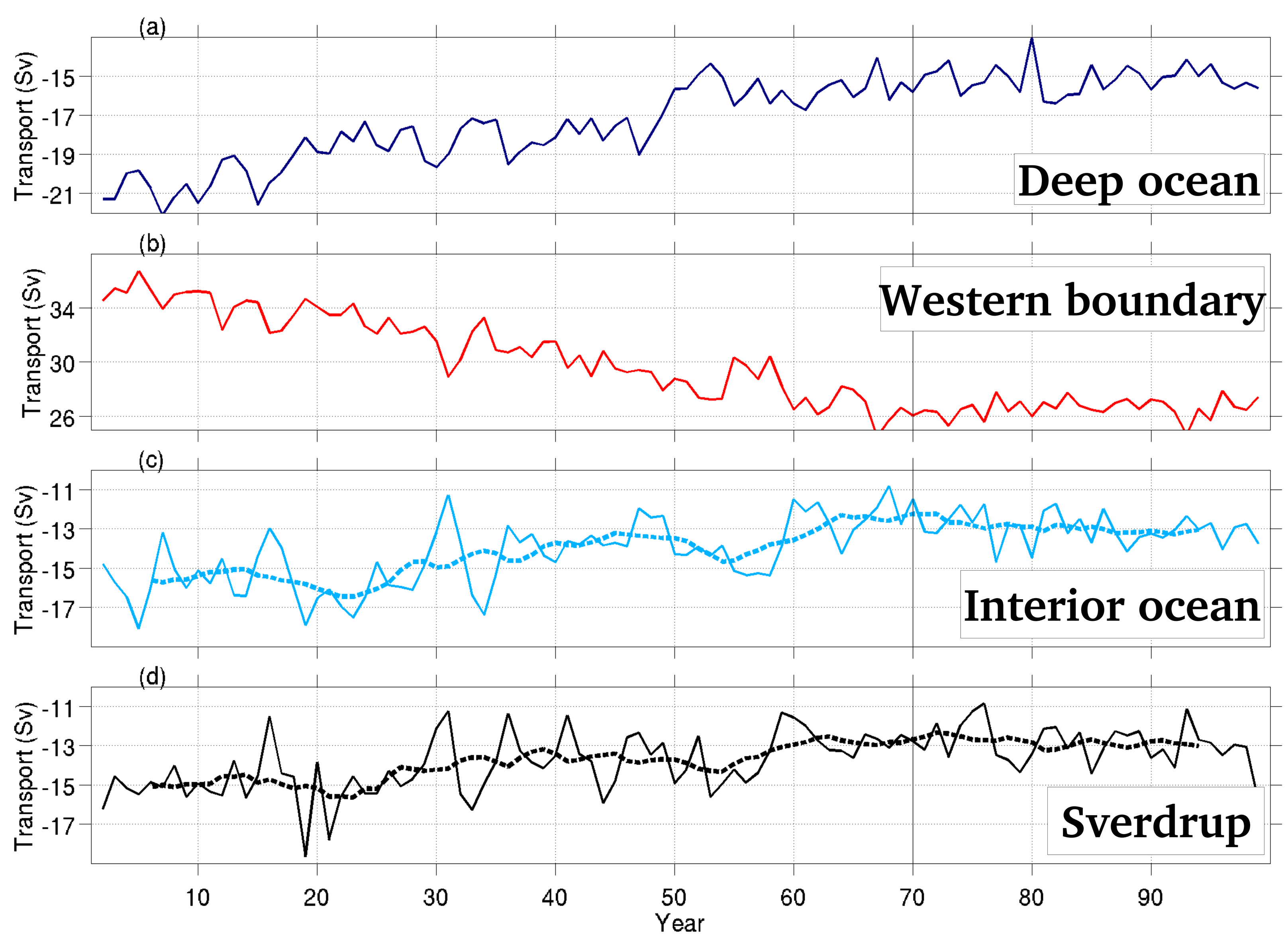
Fig2. Zonally Integrated Sverdrup



- Sverdrup balance holds well in HiGEM over large scales, particularly when transports are zonally integrated across the inteior subtropical ocean (Fig 1, Fig 2a).
- Sverdrup balance continues to hold throughout a changing climate (Fig 2b).
- Interior ocean transports are *reduced* in the climate change run, because of reduced wind stress curl (Fig 2c).
- AMOC changes should therefore only be expressed in the western boundary region.

3. Transport trends

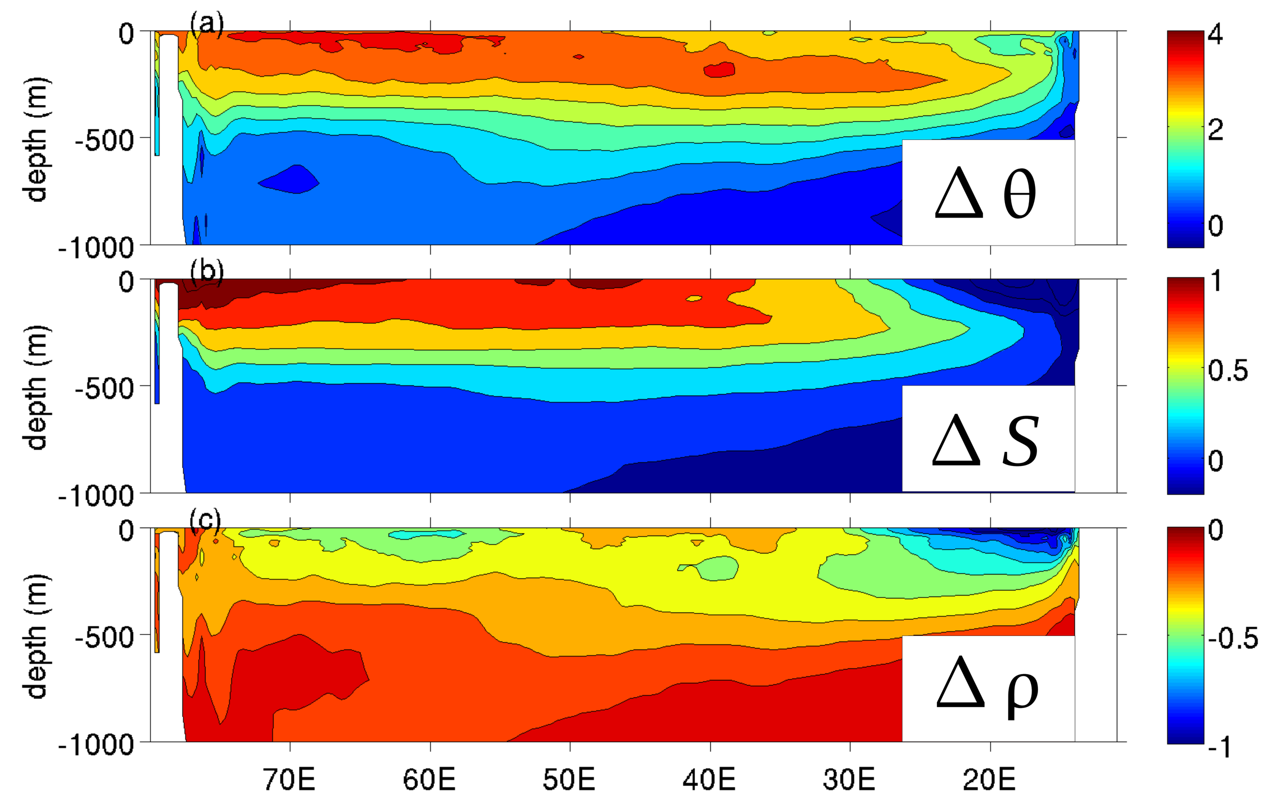
Fig3. transport time series' integrated within the domain shown in Fig 1c



A 5 Sv reduction in deep transport is balanced entirely by a reduction in the western boundary transport (Fig 3). A further 3 Sv reduction in western boundary transport also occurs because of a wind stress curl-induced reduction in interior ocean transports.

4. Ocean property changes

Fig5. Decadal mean temperature, salinity & density differences (4xCO2 minus Control) at 27ºN



Enhanced warming in the west (a) is offset by salinification (b). Largest density reductions occur in the east (c). This flattens isopycnals and reduces geostrophic currents.

5. Conclusions

- Sverdrup balance holds, and continues to hold, under a changing climate. Also wind stress curl does not increase in strength.
- Changes in deep transport must (and are) therefore balanced entirely by changes in the western boundary.
- A further reduction in western boundary transport occurs because of a decreased interior transport, caused by wind stress curl reductions. This is accompanied by reduced densities in the east.
- Transport changes are brought about by complex offsetting changes in T and S.

Further reading

- Thomas M. D. *et al.*,(2012). Upper Ocean Manifestions of a reducing Meridional Overturning Circulation. *Geophys. Res. Lett.* **39**
- de Boer A. M and Johnson H. L. (2012). Inferring the Zonal Distribution of Measured Changes in the Meridional Overturning Circulation. *Ocean Science,* **3**
- Thomas M. D *et al.* (2014). Spatial and Temporal Scales of Sverdrup Balance. *J. Phys. Ocean.* **44**