Shifting pathways of meridional circulation: drifters, altimetry, models

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Warm, saline subtropical Atlantic waters have recently increased their penetration northward through the subpolar latitudes.

Prior to 2000, the warm water branches of the North Atlantic Current fed by the Gulf Stream turned southeastward in the eastern Atlantic. Since 2001, these pathways have shifted toward the north and east, reaching Rockall Trough, through which the most saline North Atlantic waters pass to the Nordic Seas. The changes have had far-reaching impacts on climate and ecosystems (Hatun et al. Prog. In Oceanog 2009). Decadal variability of this kind is evident in past hydrography, though this is the first time the actual circulation changes have been observed.

Our object here is to show explicitly the Lagrangian (particle-following) and Eulerian (pressure-related) currents that correspond to these thermohaline shifts, to show the image of this transition in the AMOC overturning cells and potential vorticity fields. The wind field responsible appears not to be the ‘simple’ NAO, but rather a combination of an NAO- and ‘intergyre’ EOF of the windstress curl.

1. The years 1990-2008 saw remarkable variability in the temperatures and salinities of the high latitude oceans. Here we show explicit changes in the Lagrangian (particle-following) currents. Subsurface drifting buoy, all launched in the cyan rectangle spanning the Gulf Stream at (48N-78W, 35W-47N)

1991-1995: during a century-high NAO phase drifters were nearly all retained in the subtropical gyre

1996-2000: sudden reversal of the NAO to a record minimum expands the drifter tracks eastward

2001-2005: drifters penetrate far into the subpolar gyre, entering Rockall Trough and beginning to enter the Norwegian Sea

2003-2008: Continuing to show the cross-gyre exchange.


3. The maximum of the overturning streamfunction in latitude-

potential density space shows distinct AMOC variability since the mid-1990s in POM, POM-Z (Häkkinen) and ECCO-K models, with less definite trend in SODA assimilation model.

4. The AMOC overturning streamfunction for the SODA assimilation model shows a change from 1994/2000 to 2001/2006 which contains a small ‘intergyre’ at 27-0.27.5 potential density, expressing the northward penetration and identifying its density structure. These figures of the AMOC show the ocean above 1500m depth.

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