Crossroads of the Atlantic Meridional Overturning Circulation: The Charlie-Gibbs Fracture Zone

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Introduction

While intense observational effort has recently been made to describe the basic structure and (in some cases) low-frequency variability at a few locations along the paths of the AMOC, relatively little attention has been paid to the Charlie-Gibbs Fracture Zone (CGFZ), a gateway for both the warm and cold limbs of the AMOC over the Mid-Atlantic Ridge. A combined observational and modeling study of the AMOC at the CGFZ is underway. An array of eight current meter and hydrographic moorings was installed across the CGFZ for two years beginning in July 2010 (with ship time provided by M. Rhein, University of Bremen) to measure the currents and water properties between the bottom and 500 m. This array provides the first long-term, simultaneous observations of both the westward and eastward flows over the CGFZ. This study will provide a transport benchmark for critical evaluation of climate models.

Recent results

All the mooring data has been processed and detailed descriptions are given in a data report published this year (Furey et al. 2014). These data were used to make a preliminary estimate of the record mean westward transport of Iceland-Scotland Overflow Water (ISOW) through the CGFZ, -1.7±0.2 (standard error) Sv, of which about two thirds was located in the northern transform valley (Figure 1). This is about 30% lower than an earlier one-year mean estimate from 1988-89 of -2.4±0.5 Sv (Saunders 1994). A preliminary analysis suggests that the difference is due mainly to the use of a fixed ISOW layer thickness in the earlier estimate (no temperature/salinity time series were available). If the new estimate holds up in the final analysis, a revision of the pathways of ISOW over the Mid-Atlantic Ridge may be required.

A simple model has been developed for the behavior of a western boundary current to the west of a mid-ocean ridge with a gap, such as for the CGFZ. The mean flow for strongly nonlinear flows resembles the linear flow pattern with boundary current separation to the west of the gap. However, a viscous sublayer produces anomalous potential vorticity, which is advected into the basin interior by the separated boundary current, resulting in a quasi-periodic state of westward propagating meanders in the interior and large meridional excursions of the separation point of the western boundary current. This is similar to what is observed for the East Australia Current near the southern tip of Australia and west of New Zealand. It is also consistent with the separation of the North Atlantic Current at the latitude of the CGFZ. A scaling theory for the amplitude and frequency of the oscillation is derived from consideration of the vorticity budget in the viscous sublayer and wave dynamics in the interior (Spall 2014). The influence of topography (islands, gappy ridges) on a strong zonal flow is now being explored using idealized numerical models and theory. Preliminary results suggest both standing and propagating wave patterns are possible with strong sensitivity to the location of the topography.

Bibliography

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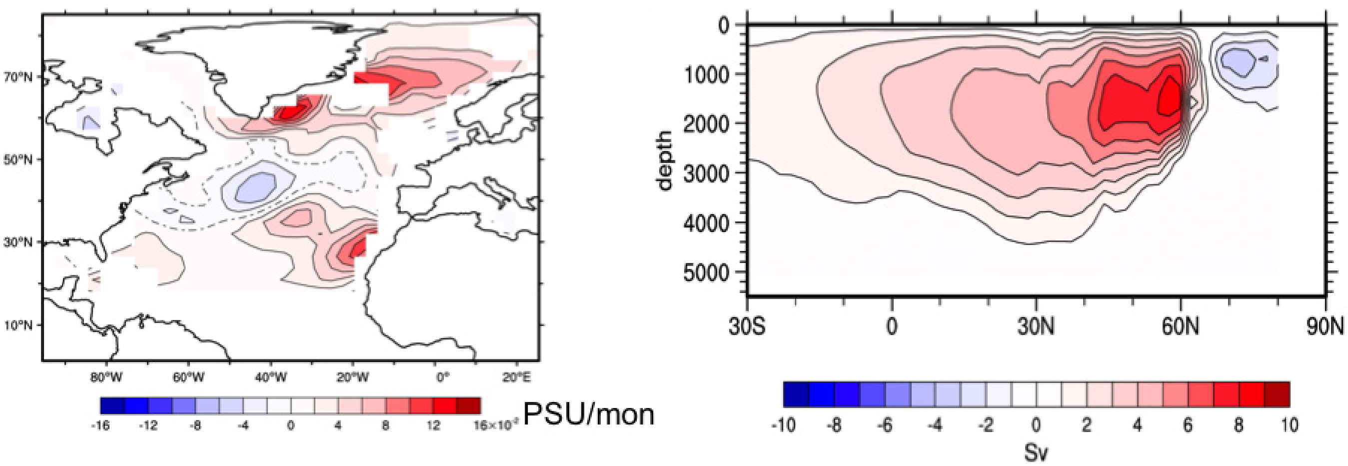

Figure 1: Two-year time series of ISOW transport through the CGFZ: total (upper), northern (middle) and southern (lower) transform valleys. Thin lines are daily averages and heavy lines are low-pass filtered with a 60-day cut-off period. As in Saunders (1994), there was significant low-frequency transport variability, including sign reversals.