Ocean Sci. Discuss., 8, C971–C974, 2012
www.ocean-sci-discuss.net/8/C971/2012/

Ocean Science
Discussions

Interactive comment on "Arctic Ocean circulation and variability – advection and external forcing encounter constraints and local processes" *by* B. Rudels

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Received and published: 9 February 2012

I want to thank the reviewer for the comments about the article and for the questions.

Minor comments:

p.2320: The mentioning of the long coastline was meant relative to the area of the ocean (compare the Arctic Ocean and the Pacific).

P.2320. The possible contribution from a barotropic current will be brought up.

P 2327: Thanks!

TS diagrams & Figures: The figures will be remade following the suggestions from all reviewers.

Figure 11: The arrow in the southern Amundsen Basin indicates (as do all arrows in the Eurasian Basin) that north of the boundary current a front is present, approximately in the central Nansen Basin. North of this front the flow is westward, towards Fram Strait. This return flow carries mainly Fram Strait branch water in the Nansen Basin but the fraction of Barents Sea branch water increases steadily towards the Amundsen Basin and the Lomonosov Ridge. The actual positions of the arrows do not represent localized streams but a more general drift. I agree with the reviewer that at deeper levels, below 1500m, an eastward flow is expected in the southern Amundsen Basin (see e.g. Fig 4.5 in Lemke & Jacobi, 2012). This transport, however, might be dominated by eddies rather than representing a distinct stream.

P 232335-2336: I can only agree with the reviewer. This situation should be investigated thoroughly.

P2338: Observations in the Beaufort Sea of the hydrography, of gravity, of the pressure from bottom mounted pressure gauges and of the sea level height from altimeter (satellite) indicate that when the water column is less dense the bottom pressure goes down (Kwok et al., 2010). The rise in sea level does not compensate fully for the reduction in density. Translating this to the Lomonosov Ridge, a larger dynamical depth implies a less dense water column. If the dynamical depth between surface and 2000db is larger in the Amundsen Basin than in the Makarov Basin, it indicates that the negative pressure gradient along a geopotential surface at that depth would be directed from the Makarov Basin towards the Amundsen Basin. This would force water at the sill from the Makarov Basin into the intra-basin and then to the Amundsen Basin. This was the situation in 2005. In 1996 the dynamical height between sea surface and 2000db was larger in the Makarov Basin than in the Amundsen Basin and a flow at sill depth from the Amundsen Basin to the Makarov Basin should then be possible.

2339-2343: In the classical two stations geostrophic calculation the transport between two stations (A & B) would change vertically, bringing water with average characteristics between the stations either north or south. When we only look at a two layer system with a buoyant boundary current at a wall, it is usually assumed that the deeper layer (station A) is at rest and beyond the boundary current the lower layer, still at rest, reaches the surface (station B). In the present situation with two boundary currents and several layers I have tried to extend the simple buoyant boundary layer picture to also involve water masses located in the deeper part of the water column and at the same time avoid transporting waters with mean and unrealistic characteristics. The flow will change direction with depth as the pressure gradient changes sign but only one water mass is moving in each layer. I think that this approach is useful in the conceptual description attempted here. The main result from this exercise is that it is not possible to have a baroclinic flow that exactly balances the thermodynamic forcing and the water mass transformations. A barotropic component is required to close the mass balance. In addition there will be the wind driven, and also, as the reviewer points out, the directly eddy driven transport through the strait. The question is – how will these exchanges affect the heat (and freshwater) balance? A stronger exchange would imply smaller average changes in water mass properties, but will the net heat flux nevertheless be larger or stay the same? If it stays the same, then the transports driven by other forcing mechanisms essentially only bring warm water into the Arctic Ocean, where it circulates, temporarily increasing the heat storage of the Arctic Ocean, and then returns without giving up its heat. To answer this question is the rational, and the major challenge, behind keeping the current meter array in Fram Strait.

References:

Kwok et al. (2010) Combining satellite altimeter, time varying gravity and bottom pressure observations to understand the Arctic Ocean: A transformative opportunity. In Sustained Ocean Observations and Information for Society, vol. 2, edited by J. Hall, D.E. Harrison and D. Stammer, ESA Publ., WPP-306,

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Interactive comment on Ocean Sci. Discuss., 8, 2313, 2011.