

Review of *'Large-scale temperature and salinity changes in the upper Canadian basin of the Arctic Ocean at a time of drastic Arctic Ocean Oscillation'* by P. Bourgain, J.C. Gascard, J. Shi, and J. Zhao

General comments

The manuscript by Bougain et al. reports on several cruises from the Canada Basin from the summer-fall periods of 2008 and 2010. The main data used for this paper are from the 2008 and 2010 CHINARE cruises. Several other cruises combined with ITP data are used to complete the picture for the Canada Basin. This is one of the first times that the 2008 and 2010 data from the CHINARE expeditions are presented. The physical data are used to compare three features – the near surface temperature maximum, the Pacific and Atlantic waters and the freshwater content – and an attempt is made to put these data into context of the Arctic Ocean Oscillation. While it is intriguing to interpret the data in the context of a rapid shift in the phase of the Arctic Ocean Oscillation, 2008 and 2010 are just two points of data. It is inconclusive to interpret two years of data in the context of an interdecadal process. The choice of saying that all changes in the Canada Basin from 2008 to 2010, including changes to the Atlantic water, can be caused by an interdecadal oscillation is not convincing. Thus I do not believe that this paper can be published in its current form. Major revisions that include a different interpretation of the data are recommended. More precisely, I recommend that the authors focus on one storyline at a time and interpret this with other data. For example, the authors could focus on quantifying the sea ice concentration in conjunction with the near-surface temperature maximum or they could examine the Pacific waters with the nutrient data.

Specific comments

The paper is poorly cited. There are often statements with no reference (e.g. see the first paragraph of the introduction – how do you know that the largest sea ice changes occurred over the Canada Basin?) or the wrong references for the statement (e.g. Woodgate and Aagaard 2005 did not find that Pacific waters are nutrient rich). Several recent important Canada Basin papers are missing from the paper (e.g. Yamamoto-Kawai et al., JGR, 2009; Timmermans et al., JGR, 2011; Steele et al., JGR, 2011; Jackson et al., JGR, 2011; Mizobata and Shimada, DSRII, 2012; McLaughlin et al., JGR, 2009; Lique and Steele, JGR, 2012) and these papers can help with the interpretation of the results.

There are many acronyms that the reader is expected to follow. I would recommend adding a table of acronyms.

The English used is confusing and often incorrect. While I understand the difficulties of not having English as a first language, the writing makes the

manuscript difficult to read and interpret. I think that several of the points of the paper are lost in translation.

The authors use both the terms Canada Basin and Canadian Basin throughout the paper. Steele et al (2011) give a good description of the differences between Canada and Canadian Basin. This should be read and made clear in this manuscript.

The authors refer to IPY years several times in the paper but don't define what years those are.

Introduction

The introduction is too short and is poorly cited. Although the emphasis of this paper is the Arctic Oscillation, no description of the Arctic Oscillation is given. A description of known interactions between the Arctic Oscillation and Canada Basin waters should be included. Figure 1 is presented as the Arctic Oscillation Index but no information is given on how this was calculated nor were any references provided.

Data

Section 2.2 is missing a lot of information and is confusing. I understand that the emphasis is the CHINARE cruises but the authors still need to report more information on the other methods of data collection. For example, what types of CTDs were used on the LSSL and Polarstern cruises? What is the temperature and salinity precision for the CTD and ITP data? What are the exact dates of the cruises?

Information of the ITP data presented are wrong. ITP1 (line 20, page 2005) did not collect data in 2008 to 2010 – it functioned from 2005-2007. Very vague information is presented on ITP collection dates. The ITPs collect up to 4 profiles per day and several ITPs are present in the Canada Basin each year so I don't understand why only 59 profiles were presented in 2008 and 22 profiles in 2010 for the July to October time period. ITP data are invaluable in this region and could greatly augment the dataset.

New results from the NSTM

The authors use data from July to October to calculate NSTM properties throughout the Canada Basin. In general, cruises were later in 2010 than in 2008. Studies by both Jackson et al (2010) and Steele et al (2011) found that the NSTM cooled and deepened from the summer to the fall. Thus I don't think that you can say that the NSTM cooled and deepened from 2008 to 2010 without taking seasonal variability into consideration. Perhaps augmenting the CTD data with more ITP data will help solidify your argument.

The authors compare their NSTM findings with sea ice studies published by Stroeve et al (2011). Unfortunately, Stroeve et al. did not examine sea ice

concentrations in 2008. So lines 11-14 on page 2008 are untrue. Thus the statement 'that the sea ice concentration could be a major driver of the NSTM variability' (lines 26-27, page 2008) is unfounded. Perhaps the authors can include sea ice data in their analysis.

Pacific Waters new results

There is no description as to how the authors calculated the temperature and depths presented in figures 5-8. For example, was a constant salinity used to make the graphs or was the temperature maximum and minimum plotted? This needs to be discussed for all of the 4 water masses.

For both the Pacific waters, the diffusion of heat that cools the Pacific Summer Water and warms the Pacific Winter Water needs to be considered. For example, Steele et al (2004) suggest that the temperature maximum and minimum disappears after several years of transit. Thus it is possible that warmer Pacific Summer Water is 'newer' (i.e. less heat lost) while warmer Pacific Winter Water is 'older' (i.e. more heat gained from Pacific Summer Water and Atlantic Water). Thus the different properties observed in 2008 and 2010 can't simply be discussed in the context of Arctic Oscillation.

Atlantic waters

Is there any evidence that Atlantic waters in the Canada Basin are influenced by Arctic Oscillation? I don't understand how the pulse-like event is part of the Arctic Oscillation story.

Technical notes

- Lines 10-11 on page 2002 – Neither the Pacific nor the Atlantic waters are advected into the deep Canada Basin. Deep Canada Basin water is normally thought of as the water below Atlantic water.
- The paragraph from lines 23 on page 2002 to line 3 on page 2003 is unclear

Data

- Reporting conductivity accuracy to represent salinity is confusing – why not report it in salinity units?

Methodology

- The sentence on lines 25-26 on page 2005 is confusing. I don't understand what raw gradients are.
- Please be more specific about how you calculated the minimum radius for kriging (lines 5-8 on page 2006). Do you mean that you always used a radius of 300 km?

- Some description as to why the estimation error due to kriging is so high in Figures 5-8 is needed. It is disconcerting to see errors that are greater than the observation.

Regional hydrography and recent changes

- Coachman and Barnes (1961) should be cited here because they were the first to discuss Pacific and Atlantic waters.

The NSTM

- Lines 3-5 on page 2007 state that ice-free waters form the NSTM. This is not true – the central Canada Basin was not ice-free during their study. Likewise, lines 22-23 on page 2007 state that Perovich et al (2008) highlighted the important of the NSTM to the ice mass balance. This is not true – Jackson et al, GRL, 2012 found this.

The Pacific waters

- The second paragraph of page 2009 is long, repetitive and confusing.
- Lines 23-24 on page 2009 – A discussion of the properties of the Summer Pacific waters on the Chukchi Sea shouldn't be confused with properties of the SPaW in the Canada Basin. The waters in the Chukchi Sea are further modified before it enters the Canada Basin. Perhaps the author's own 2012 GRL paper or the Jackson et al (2011) JGR give a better description of sPaW properties inside the Canada Basin.

The freshwater content

- Line 5 says that Pacific waters and river runoff are the primary sources of freshwater in the Arctic. The authors forget about sea ice melt and I would recommend papers by Yamamoto-Kawai et al, JGR, 2009 and Guay et al, JGR, 2009.
- Rudels et al, JGR, 1996, first published the freshwater content calculation on page 2013.