Pan-Arctic oceanic volume, temperature & heat transport variabilities during 2004-2010

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Takamasa Tsubouchi, Wilken von-Appen, Ursula Schauer

Alfred Wegener Institute, Helmholtz Centre for Polar and Marine Research, Bremerhaven, Germany

1. Introduction

Entire Arctic boundary through Bering, Davis, Fram Straits and Barents Sea Opening (BSO) has been monitored since 2004. Gathering of all the data together allows for a comprehensive estimate of oceanic transports across the Arctic gateways: quasi-synoptic estimate in summer 2005 (Tsubouchi et al., 2012 JGR) and a full annual cycle in Sep. 2005 - Aug. 2006 (Tsubouchi et al., in prep.).

In this study, we focus on Oct. 2004 - May. 2010 and aim to

- quantify volume transport variabilities both on seasonal & inter-annual time scale.
- quantity associated temperature & heat transport variabilities.

2. Data

- ~ 1,000 moored instruments in Davis, Fram, Bering Straits and BSO (fig. 1).
- 37 repeat CTD sections in BSO during Aug. 2004 - Jun. 2010.
- PIOMAS sea ice thickness & velocity output data during Sep. 2005 - Aug. 2006 (tentative).

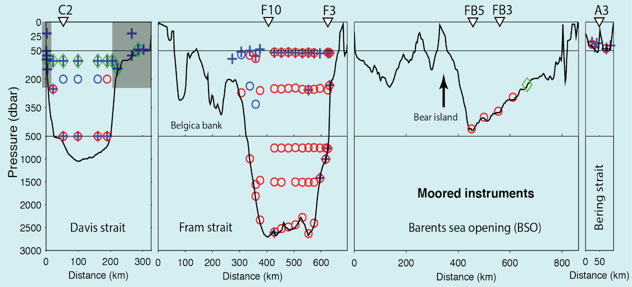


Fig. 1. Moored instrument locations during 2005-2006: Microcats (blue), RCMs (red), ADCPs (green). BI1-BI4 & WG1-WG4 in Davis Strait have not been analysed yet, and shaded in grey.

3. Method

3.1. Filtering & dealing with data gap

1. Filtering: tides are removed with t_tide and data are lowpass filtered with a 27 days cutoff Butteworth filter.
2. Combine 6 years hourly data and obtain daily TSV time series.
3. Data gap: When data gap is < 30 days, fill it by surrounding data. When data gap is > 30 days, fill it by mean annual cycle.
4. Finally, obtain monthly TSV time series (red circle in fig. 2).

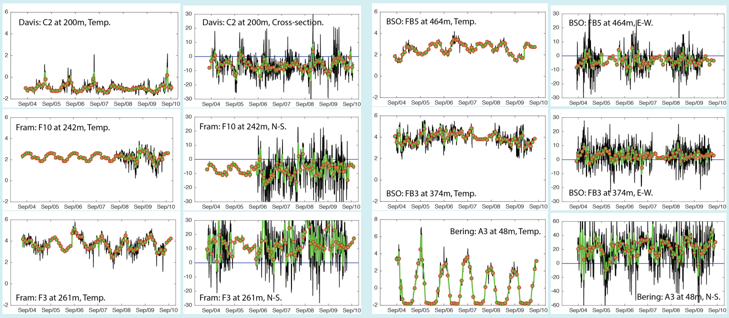


Fig. 2. Monthly temperature & velocity variabilities at each mooring location (red circle). Daily variabilities are also shown: detided (black) & low-pass filtered (green)

3.2. Monthly TSV fields

- Grid coordinate: 3 km in horizontal, 75 vertical layers, monthly time step.
- Linear interpolation: first in the vertical and then in the horizontal.
  - Assumes no stratification above the shallowest instruments.
  - Put zero velocity over Belgica Bank, north of Bear Island and western Greenland shelf (tentative).

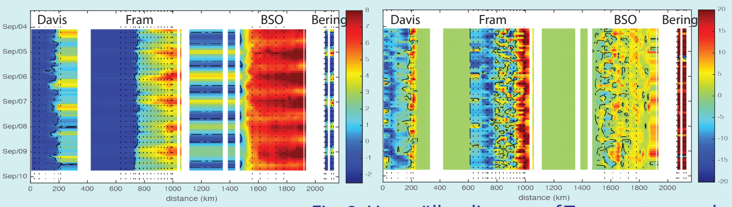


Fig. 3. Hovmöller diagram of Temperature and cross-sectional component of velocity at 50m.

3.3. Box inverse model

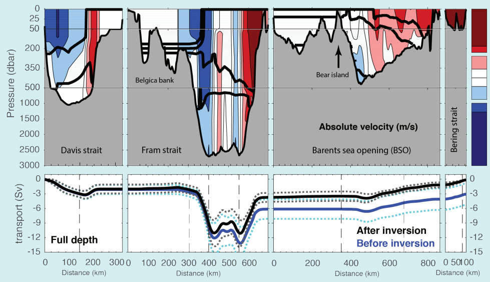
- Obtain volume conserved velocity fields for 68 consecutive months.

1. Provide first guesses for each parameter.
   - Ocean circulation , Sea ice (PIOMAS) , surface FW input (set 180 mSv).
2. 1,283 unknowns are derived from 6 constraints.
   - Volume conservations for 5 defined layers & whole layer.
   - Unknowns: Bottom vel. (639), Sea ice vel. (639),Diapyncal vel. (4), Surface FW input (1) .

4. Results

4.1. Volume conserved velocity field

- Initial monthly imbalances are -3.0±2.2 Sv (fig. 4).
- Most of the adjustment happens in the Fram Strait and BSO (fig. 5 bottom).



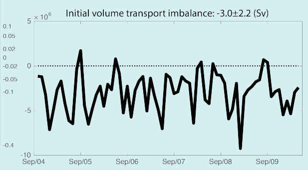


Fig. 4. Initial full depth volume transport (m^3s^{-1}) imbalances.

Fig. 5. (top) Inverted velocity section averaged over the 68 months. (bottom) associated cumulative full depth volume transport (Sv). Dashed lines show the standard deviation.

4.2. Volume transport variabilities

- Volume transports in major gateways looks reasonable (fig. 6, table 1).
- WSC is more variable than EGC (table 1).
- Large variability both on seasonal & inter-annual time scale (table 1).

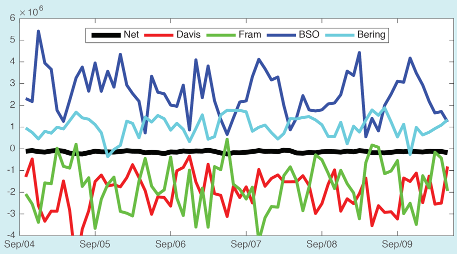


Table 1: Mean & standard deviation of volume transports (Sv). Standard deviation of mean seasonal cycle and its anomaly are also shown.

	All	Seasonal cycle	Seasonal cycle removed
Davis	-2.0 ± 0.9	± 0.5	± 0.7
Fram	-1.7 ± 1.1	± 0.6	± 0.9
BSO	2.6 ± 1.1	± 0.7	± 0.8
Bering	1.0 ± 0.5	± 0.4	± 0.3
Net	-0.14 ± 0.04	± 0.04	± 0.02
Fram Strait components			
Belgica	-0.1 ± 0.5	± 0.2	± 0.5
EGC	-6.8 ± 1.8	± 1.4	± 1.1
Middle	-2.0 ± 2.5	± 1.3	± 2.1
WSC	7.3 ± 2.6	± 2.0	± 1.7

Fig. 6. Net & each gateway volume transports (m^3s^{-1}) time series.

4.3. Temperature & heat transport variabilities

- Reference potential temp. is time variable boundary mean of 1.06±0.17˚C.
- Net oceanic heat transport is 154±50 (TW; fig. 7 & table 2).
- Magnitude of seasonal cycle in the net heat transport becomes larger (fig. 7).

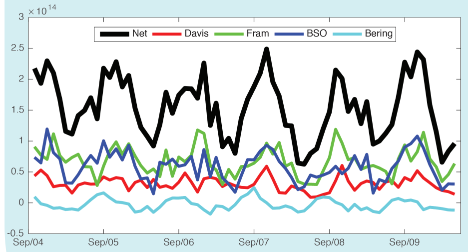


Table 2: Same as table 1, but for temperature transport (TW-eq) and net heat transport (TW) as shown in bold.

	All	Seasonal cycle	Seasonal cycle removed
Davis	31 ± 11	± 8	± 8
Fram	67 ± 23	± 17	± 15
BSO	59 ± 24	± 18	± 16
Bering	-3 ± 9	± 8	± 4
Net	**154 ± 50**	**± 42**	**± 25**
Fram Strait components			
Belgica	2 ± 4	± 2	± 4
EGC	23 ± 8	± 6	± 5
Middle	9 ± 9	± 3	± 9
WSC	33 ± 14	± 10	± 11

Fig. 7. Temperature transports (TW-eq) in each gateway and net heat transport (TW).

5. Summary

- pan-Arctic volume conserved velocity fields are obtained for 2004-2010.
- Volume & temperature transports have large variabilities both on seasonal & interannual time scale.
- WSC is more variable than EGC both on volume & temperature transports.
- Estimated net oceanic heat transport is 154±50 (TW).
- Magnitude of seasonal cycle in the net heat transport becomes larger.

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Contact: takamasa.tsubouchi@awi.de

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MARIE CURIE ACTIONS

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