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MONITORING OF THE STORFJORDEN OVERFLOW: CURRENT MEASUREMENTS IN 2007

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Contents

1 Introduction

Under the EU project "Developing Arctic Modelling and Observing Capabilities for Long-term Environment Studies - DAMOCLES", the Geophysical Institute/University of Bergen is maintaining an acoustic Doppler current profiler (ADCP) at the sill separating Storfjorden in Svalbard Archipelago and Storfjordrenna north of Storfjordbanken on the Barents Sea shelf (Fig. 1). Storfjorden, through its polynya activity, produces highly saline water near the freezing temperature which fills the fjord to the sill level (115m) and initiates a gravity driven overflow [Quadfasel et al., 1988, Schauer, 1995, Schauer and Fahrbach, 1999, Fer et al., 2004, Skogseth et al., 2005]. The overflow water is dense enough to penetrate below the Atlantic Water in the region. Because Storfjorden-origin water is occasionally observed in the Fram Strait [Quadfasel et al., 1988], it is considered to contribute to the ventilation of the Arctic Ocean. The objective of the deployment is to monitor the overflow, its (estimate of) volume flux, its interannual variability (through scheduled deployments every year) as well as meso to finescale variability at the sill.

Data from the first year of measurements (2004) was reported in Fer [2006] including processing details, data quality and observed velocity statistics, inferred tides and frequency domain description. A second report from the data acquired in 2004-2006 was given in 2007 [Fer, 2007]. Here we present the data acquired in 2007. Although the deployment was done in summer 2006 (see section 2), the data covers the freezing season in 2007 and is referred to as the 2007 deployment in the following.

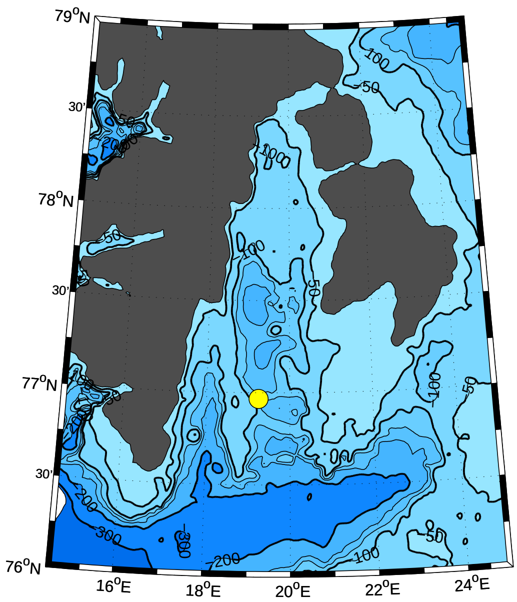

Figure 1: *Map of the Storfjorden region. The ADCP was deployed at the sill indicated by the yellow circle on the map. The bathymetry is from the International Bathymetric Chart of the Arctic Ocean [Jakobsson et al., 2008]*

2 Instrumentation, deployment and recovery

A self-contained 307.2 kHz broadband Workhorse, Sentinel, RD Instruments ADCP (SN3505) was deployed at the Storfjorden sill (Figure1)at the position 76^{o}N 58.022', 019^{o}E 18.310', 116 m depth on the 13.08.2006 05:00 utc. The frame was deployed during the cruise of R.V. Håkon Mosby HM2006 615 and recovered during the first leg of HM2007 613 on 15.07.2007, 23:04 utc. Unfortunately, the frame was hit by a trawler on the evening of 22.04.2007, estimated from the inspection of the recovered data. A SBE37 Microcat which was not sufficiently protected was lost. Cabling between the ADCP and the battery case was damaged. As a result of this incident, data is available only until 22.04.2007, 1630 utc. The total recovered data length is 252.45 days.

The instrument was installed in an aluminium trawl-proof frame, attached to a concrete block of 2.5x2.5x0.37 m dimension. The weight of the concrete block is about 2.5 (1.6) tones in air (water). The frame used in 2007, was identical to that used in 2004-2006 (see Fer [2007] for details).

Four beams (transducers) of the ADCP are slanted at 20^o from horizontal, in Janus configuration. The ADCP sampled at 4-m depth cell size (bins hereafter) averaging data (13 pings per ensemble) at 2 min intervals. The first bin was centered at about 6 mab (meter above bottom). The data are recorded in Earth co-ordinates. In addition to profiling the horizontal and vertical velocity components, the ADCP is equipped with temperature (mounted on transducer, precision $\pm 0.4^o C$, resolution 10mK), tilt (accuracy $\pm 0.5^o$, resolution 0.1^o) and compass (accuracy $\pm 2^o$, resolution 0.01^o) sensors. When sampled at 4-m bins the ADCP has a typical range of 86-113 m with a single ping standard deviation of $3 cm\, s^{-1}$. Because random error is uncorrelated from ping to ping, averaging reduces the standard deviation of the velocity error by the square root of the number of pings [RDI, 1996], in our case by a factor $(13)^{-1/2} = 0.28$, yielding $0.8 cm\, s^{-1}$.

More detailed information about the processing of the ADCP data can be found in Fer [2007]. The ADCP-data from 2004-2007 as well as the Microcat-data from 2006 are stored as NetCDF-files and submitted to the DAMOCLES Data Management. A summary of the files including all attributes are given in the appendix.

3 ADCP Data quality

Monthly averaged vertical profiles of parameters describing the data quality are shown in Figure 2. Data quality statistics for each bin are tabulated in Table 1. The average correlation over 4 beams, the percent good of 3 or 4 beam solutions, the echo intensity and rms error velocity are shown after excluding the flagged (bad) data. In the deepest 40 m, the data quality is excellent. Here, the average echo intensity ranges from 84 to 130 counts, and less than 1% of the data in each bin is flagged. The data quality is good, on the average up to about 70 mab. Between February and April we see a reduction in the correlation and percent good above 50 mab. This seasonal variation on the vertical range of good data is consistent with the results from 2004-2006 [Fer, 2007] and indicates less scattering in the water column during this period.

Table 1: *ADCP data quality statistics for each bin for the 2007 deployment. The second column is the total percent of the flagged (bad) data. Error velocity, percent good and echo intensity are summarized with 5% and 95% quantiles, the mean and the standard deviation.*

Bin	**Flagged**	**Error velocity (cms^{-1})**				**Percent Good (%)**				**Echo Intensity (counts)**			
	%	**5%tile**	**95%tile**	**Mean**	**Std**	**5%tile**	**95%tile**	**Mean**	**Std**	**5%tile**	**95%tile**	**Mean**	**Std**
1	0.08	-1.7	1.7	0.02	1.03	92	100	99.32	2.55	114	154	129.9	12.3
2	0.08	-1.7	1.7	0	1.04	92	100	99.42	2.32	107	148	125.53	11.97
3	0.11	-1.7	1.8	0.01	1.07	99	100	99.54	2.04	96	138	117.32	11.66
4	0.15	-1.8	1.8	0.01	1.11	99	100	99.67	1.77	88	128	110.46	11.76
5	0.2	-1.9	1.9	0.01	1.16	100	100	99.77	1.54	81	122	104.69	12.26
6	0.26	-2	2	0.02	1.21	100	100	99.81	1.46	75	118	99.72	12.77
7	0.32	-2	2.1	0.02	1.26	100	100	99.83	1.44	71	114	95.37	13.1
8	0.44	-2.1	2.2	0.02	1.29	100	100	99.85	1.41	68	112	91.56	13.41
9	0.52	-2.2	2.2	0	1.34	100	100	99.85	1.33	65	108	87.91	13.6
10	0.89	-2.3	2.3	0.01	1.39	99	100	99.79	1.59	62	106	84.63	13.67
11	2.14	-2.4	2.4	0.01	1.44	99	100	99.69	1.97	61	104	81.76	13.49
12	4.44	-2.5	2.5	0.01	1.51	99	100	99.52	2.48	60	101	79.3	13.08
13	8.24	-2.6	2.6	0	1.58	99	100	99.35	2.92	59	99	77.31	12.63
14	13.97	-2.8	2.8	-0.01	1.66	99	100	99.21	3.25	58	98	75.9	12.1
15	20.88	-3	2.9	-0.01	1.75	92	100	99.12	3.44	58	96	74.81	11.48
16	28.23	-3.2	3.1	-0.02	1.84	92	100	99.07	3.57	58	94	73.88	10.84
17	35.98	-3.4	3.3	-0.02	1.94	92	100	99.12	3.5	58	93	73.22	10.18
18	42.84	-3.5	3.5	-0.03	2.03	99	100	99.22	3.27	59	92	72.27	9.73
19	49.61	-3.7	3.7	-0.02	2.15	99	100	99.2	3.28	59	89	71.38	9.25
20	55.78	-3.9	3.8	-0.01	2.25	99	100	99.23	3.22	59	87	70.42	8.56
21	61.2	-4	4	0.01	2.33	99	100	99.21	3.2	59	84	69.41	7.86
22	66.54	-4.1	4.1	0.01	2.42	92	100	99.08	3.44	59	82	68.6	7.4
23	72.02	-4.2	4.2	-0.01	2.5	91	100	98.94	3.72	59	81	68.16	7.16
24	64.31	-3.7	3.3	-0.22	1.93	92	100	99.3	2.96	152	182	167.45	9.3

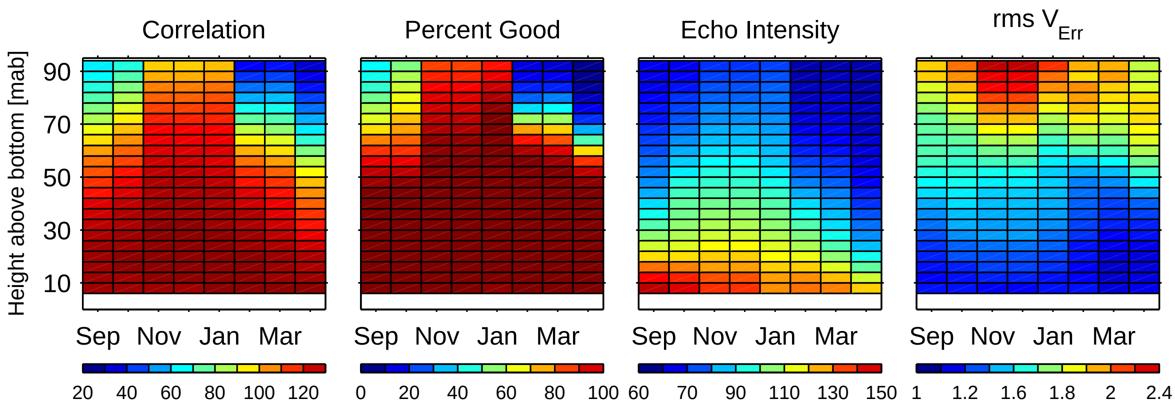

Figure 2: *Monthly mean data quality paramters for autumn 2006 to spring 2007. Average correlation and echo intesity (over 4 beams) are in counts. Rms of error velocity is in cm/s. Percent good is the percentage of good data with 3 or 4 beam solutions.*

4 Current Data

Time series of current data are presented in Figure 3 and Figure 4. The bottom temperature shown in Figure 3a) indicates that the overflow identified with T$< -1.8^oC$ ceases in October and starts up again in March. The transition from warm bottom temperatures (T$> 0.5^oC$) to near freezing point temperatures takes 32 days. This compares well with the results from 2006 (30 days) and is faster than 2004-2005 (42 and 60 days). In the absence of overflow water, the cross-sill current velocity is nearly barotropic showing negligible vertical shear. The bottom current velocities increase with the onset of the overflow and reaches a maximum ($V_{x-sill} > 20\ m^2\,s^{-1}$) in early April. The currents are strongest near the bottom (Figure 3b).

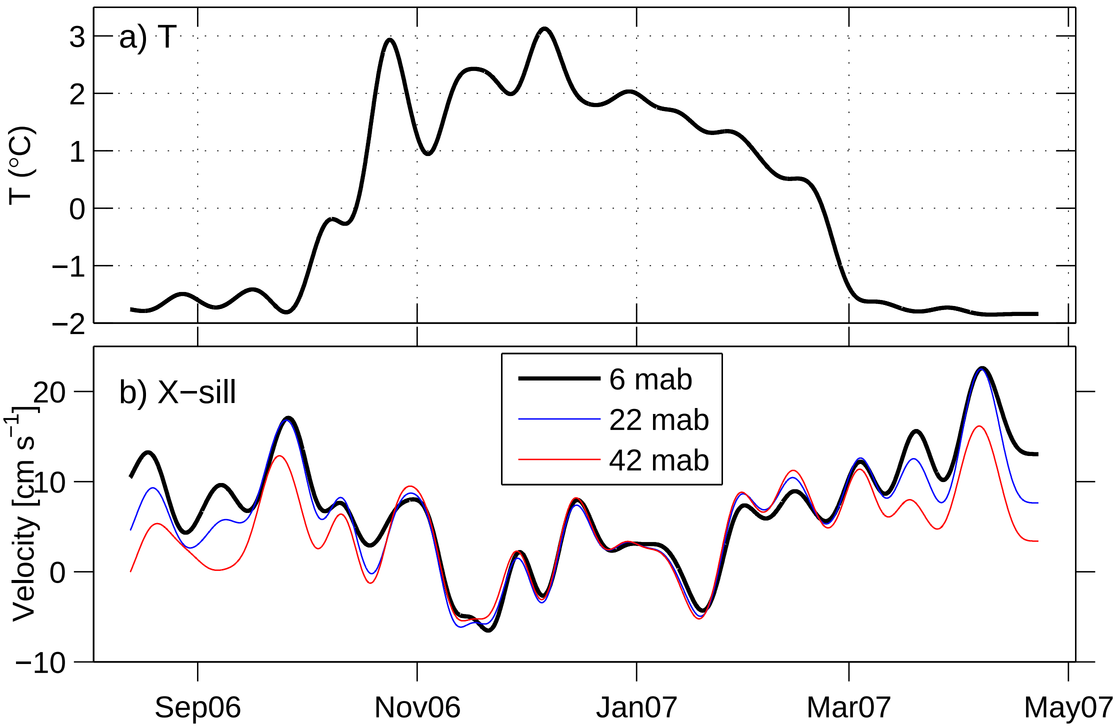

Figure 3: *a) Bottom temperature and b) cross sill component of the velocity (positive values out of the fjord) at 6, 22 and 42 mab, for 2007 deployment. 15-day low-passed hourly data are presented.*

The vertical component (w) of the currents also increases when there is overflow water present (Figure 4c). The vertical velocity is positive closest to the sea-floor and negative higher up. It is noteworthy that the cross-sill overflow develops a gradually strengthening westward component following the freezing season in 2007. On the other hand, the flow of Atlantic-derived water (T$> 0^oC$) occurring between the end of and the start of subsequent overflow periods is mainly directed in/out fjord (i.e. +/- north component) with weak zonal component (Figure 4a-b).

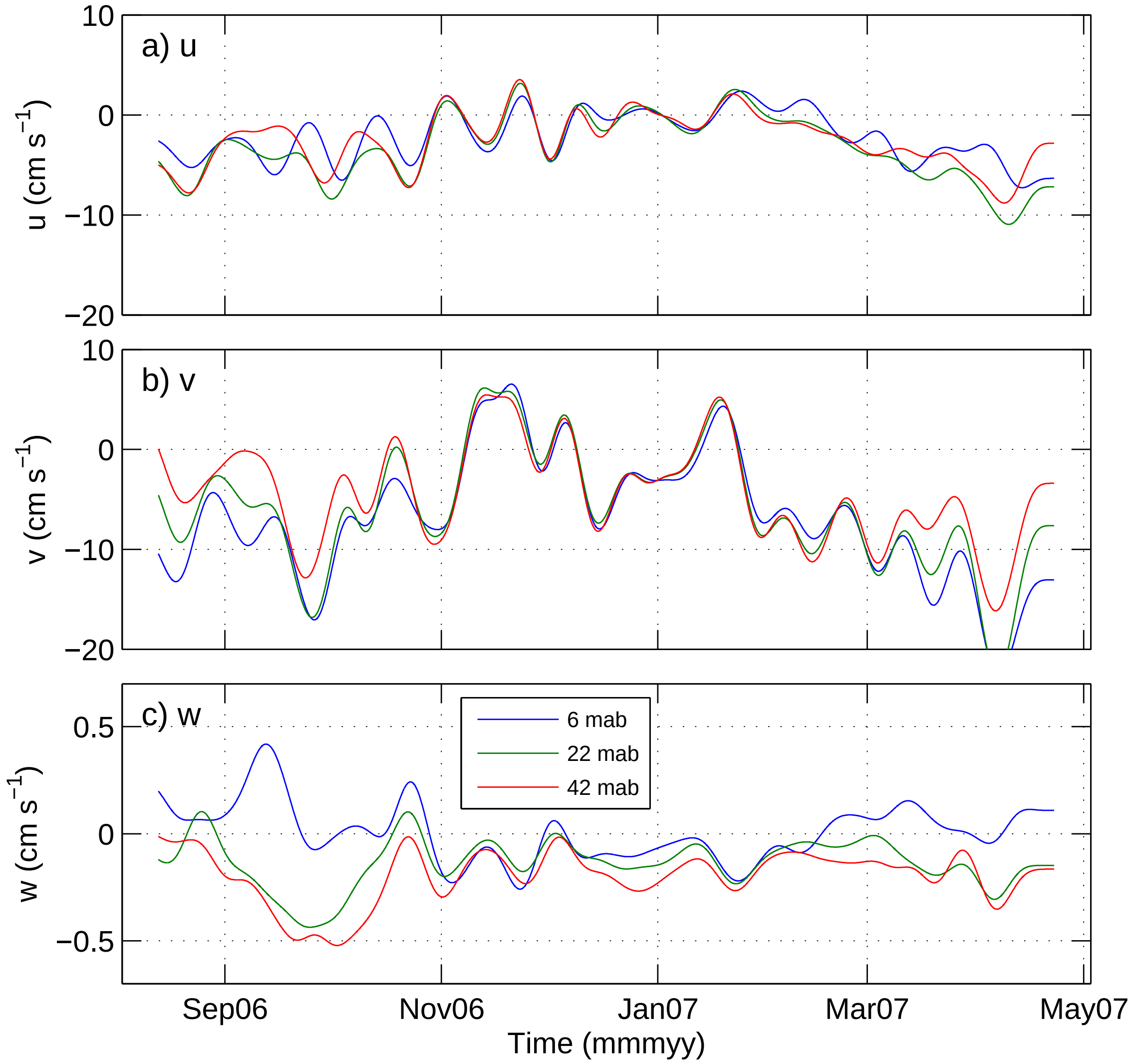

Figure 4: *Time series of a) east b) north and c) vertical component of the velocity recorded by the ADCP at the sill. Record from three selected depths are shown: (black) the bottom-most cell 6 meter above bottom (mab), (blue) 22 mab and (red) 42 mab. Data are hourly averaged and 15-day low-pass filtered.*

Statistics for the current velocities are summarized in Table 2. The stability factor (SF, defined as the ratio of the length of the average current vector to the average speed) is about 0.6 in the deepest bin and decreases further up in the water column. The standard deviations and the percent of gaps in the data series also show the best results in the deepest bins.

Table 2: *Statistics (mean and standard deviation over the total duration of the record) of the velocity components (cm s^{-1}), speed (cm s^{-1}), direction (°T) and stability factor, SF, for each bin. The percent of gaps in the data in each bin is given in the second column.*

Bin	**Gap**	**East**		**North**		**Vertical**		**Speed**		**Direction**		**SF**
		mean	**std**	**mean**	**std**	**mean**	**std**	**mean**	**std**	**mean**	**std**	
1	0	-2.09	6.6	-6.87	8.96	0.01	0.54	11.85	5.91	193.5	72	0.61
2	0	-3.22	7.45	-6.95	9.68	-0.05	0.57	12.79	6.66	197	74	0.6
3	0	-3.42	7.63	-6.63	9.67	-0.08	0.59	12.2	6.74	197.8	75.4	0.59
4	0	-3.35	7.6	-6.28	9.49	-0.11	0.59	12.43	6.65	198	76.2	0.57
5	0	-3.24	7.54	-5.92	9.31	-0.14	0.6	12.1	6.52	198.3	77.1	0.56
6	0	-3.04	7.42	-5.56	9.1	-0.15	0.61	11.74	6.33	198.1	78.1	0.54
7	0	-2.87	7.32	-5.22	8.9	-0.17	0.61	11.42	6.15	197.6	79.1	0.52
8	0	-2.7	7.26	-4.92	8.72	-0.18	0.62	11.16	5.98	197.4	79.9	0.5
9	0	-2.57	7.21	-4.65	8.57	-0.19	0.63	10.93	5.86	197.3	80.9	0.49
10	0	-2.47	7.14	-4.45	8.41	-0.2	0.64	10.73	5.7	197.1	81.6	0.47
11	0.29	-2.36	7.02	-4.24	8.25	-0.2	0.65	10.5	5.53	196.8	82.2	0.46
12	1.45	-2.23	6.89	-4.03	8.15	-0.2	0.67	10.28	5.41	196.8	83.1	0.45
13	3.48	-2.15	6.79	-3.83	8.12	-0.19	0.7	10.14	5.35	196.5	84.4	0.43
14	7.45	-2.13	6.78	-3.66	8.18	-0.18	0.72	10.1	5.36	196.3	85.3	0.42
15	13.22	-2.14	6.82	-3.45	8.28	-0.17	0.75	10.12	5.39	196.2	86.8	0.4
16	19.66	-2.17	6.95	-3.23	8.39	-0.15	0.79	10.19	5.48	196.3	88.3	0.38
17	26.76	-2.18	7.2	-2.87	8.5	-0.14	0.83	10.28	5.6	196.6	90.4	0.35
18	33.09	-2.18	7.43	-2.52	8.67	-0.12	0.86	10.4	5.77	197	92.2	0.32
19	38.53	-2.22	7.71	-2.25	8.93	-0.1	0.89	10.66	5.97	196.8	94	0.3
20	43.07	-2.45	8.2	-2.15	9.36	-0.07	0.94	11.18	6.37	198	94.3	0.29
21	46.38	-2.64	8.76	-1.95	9.92	-0.04	0.97	11.79	6.85	199.9	95	0.28
22	49.38	-2.91	9.5	-1.74	10.71	-0.01	1.04	12.64	7.52	201.6	95.6	0.27
23	52.25	-3.33	10.15	-1.65	11.88	0	1.11	13.72	8.35	204.5	96.2	0.27
24	25.65	-17.82	49.09	-25.6	58.17	0.66	3.76	66.64	48.23	200.4	77.1	0.47

Monthly mean northward current profiles are shown in Figure 5. Negative values indicate outward cross-sill flow. In the period November-January there is little sign of overflow water. The currents are weak, and in November the mean flow is directed in-fjord. If we compare these results with the deployments from 2004-2006 [Fer, 2007], we see that the outflow velocities for 2007 are comparable or slightly stronger than in 2006, when the highest current velocities are reported.

The progressive vector diagram in Figure 6 is derived from low-passed currents between January and May 2007. It shows weak westward current components and decreasing speed with height above bottom. The progressive vector diagram for 2007 is similar to that of 2006 except a slightly weaker westward component throughout the water column and a weaker southward component in the deepest bin (6 mab).

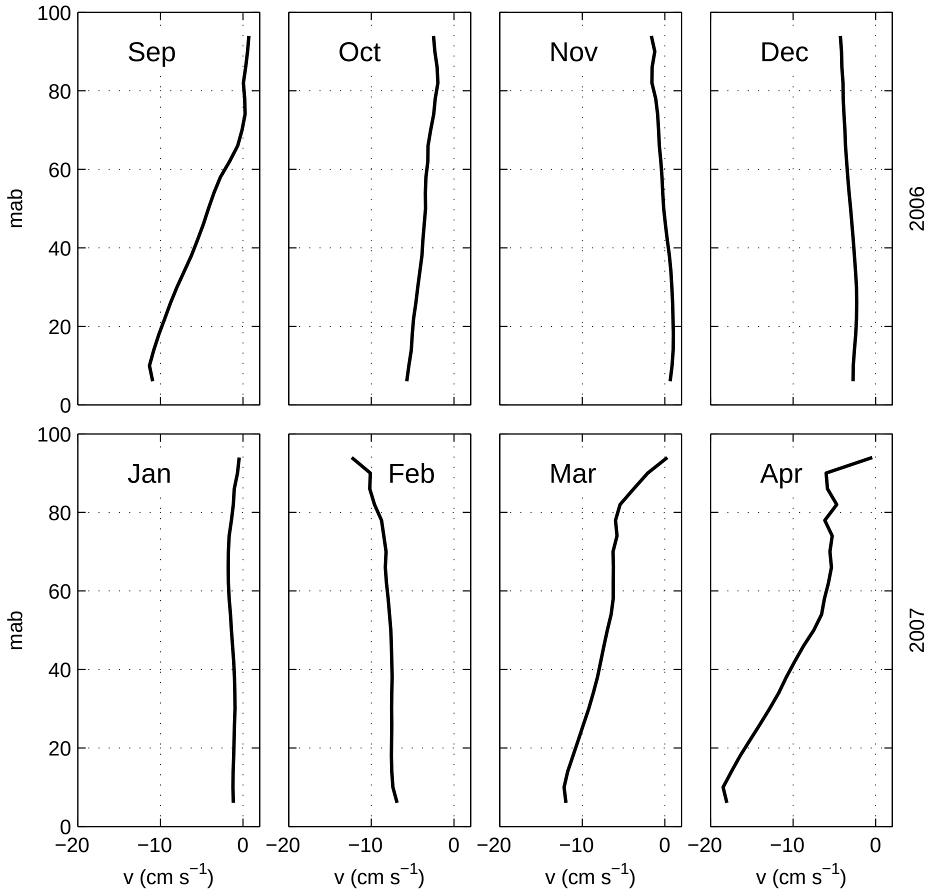

Figure 5: *Monthly mean current profiles for the north component of the velocity. Negative values indicate approximately cross-sill flow directed out of the fjord.*

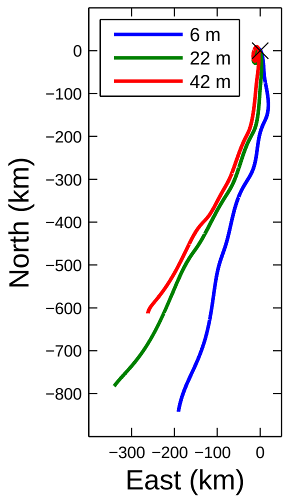

Figure 6: *Progressive vector diagrams for the 1st of January to the 22nd of April 2007. The blue, green and red lines show the results for the bins at 6, 22 and 42 mab, respectively. 15-day low-passed hourly data are shown.*

5 Overflow Volume Transport

Overflow volume transport estimates are made assuming a sill width of $B = 15$km. This is chosen in order to be consistent with Schauer [1995] and the data reports from 2004-2006 [Fer, 2006, 2007]. The volume transport is $Q = \langle u \rangle hB$, where u is the plume speed (out of the fjord) and angle brackets denote averaging over the plume thickness, h. The plume speed is approximated with two alternative schemes: 1) The cross-sill component of the flow (approximately negative north component) and 2) any flow out of the fjord (i.e. directed within $90 - 270^o$). Hourly averaged profiles are used. The overflow is assumed to occur when the bottom temperature is colder than $-1.5^o C$ and near bottom u (averaged over the deepest 5 bins) is greater than $2cm\, s^{-1}$. The thickness of the plume is estimated as the height above bottom where u first falls below $2cm\, s^{-1}$. The transport is then calculated in Sverdrup (1 Sv=$10^6\, m^3\, s^{-1}$) every hour. Weekly averages and standard deviations are showed in Figure 7 and Figure 8 for the transport normal to the sill and out of the fjord, respectively.

The overflow starts in March. The height of the plume is comparable to former years [Fer, 2007]. The speed and volume transports are higher in 2007 than in 2004-2005, but agrees well with the results from 2006. It is worth mentioning that the averaging period for the mean volume transport is shorter in 2007, since there is no data after the 22.04.2007. The data only covers the most intense overflow period, and the mean volume transports are therefore higher than they would be if the whole overflow period was covered. If we calculate the volume transport in 2004-2006 for the same period, the transports are 0.079, 0.078 and 0.126 Sv for cross-sill flow and 0.11, 0.108 and 0.149 Sv for the flow directed within 90-270^{o}T.

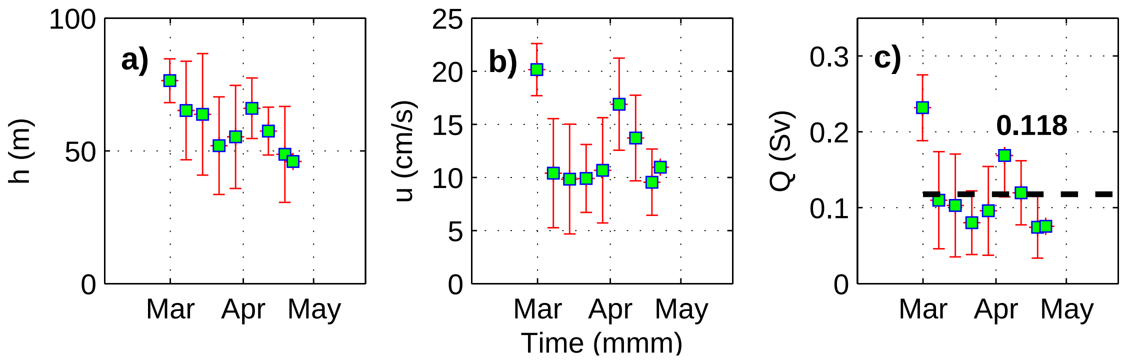

Figure 7: *Weekly mean and standard deviation estimates for a) Storfjorden overflow plume thickness h, b) speed over the extend of h, and c) volume transport assuming a width of 15 km. Estimates are made using hourly averaged time series of cross-sill velocity profiles using the following conditions: Near bottom speed (averaged over 5 deepest bins) must be greater than 2 cm/s and bottom temperature must be less than -1.5^{o}C. Plume thickness is the first bin above the bottom where the cross-sill velocity profile is less than 2cm/s.*

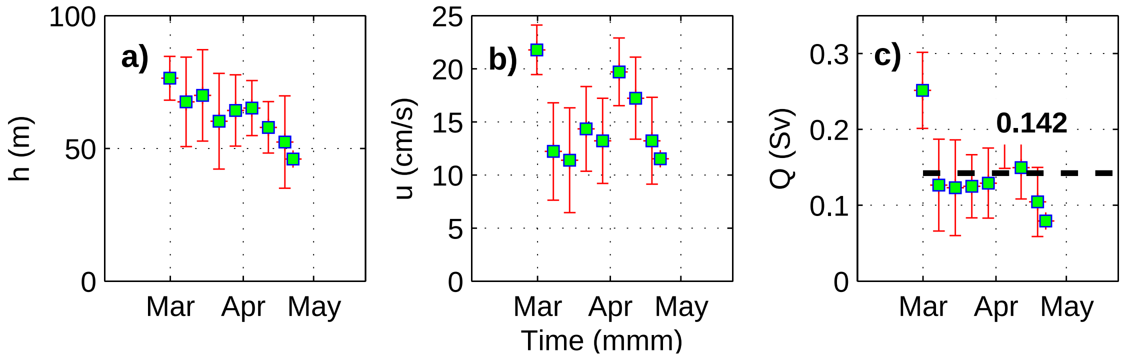

Figure 8: *Same as Figure 7, but using data from the velocity profiles when the direction is between 90-270° T.*

We note that the first data point of average u, and accordingly the volume transport estimate, in March 2008 stands out (Figure 7 and 8). The 15-day low-passed data (Figure 3) does not catch this episode of strong overflow observed early in March. Inspection of the unfiltered hourly velocity data (used in transport calculation prior to weekly averaging) show x-sill velocity between 15-25 $cm\, s^{-1}$ in this period.

6 Concluding Remarks

An Acoustic Doppler Current Profiler (ADCP) was deployed at the Storfjorden sill, monitoring the overflow occurring as a result of dense water formation during winter. The ADCP recorded current profiles for 254.42 days (13.08.2006 to 22.04.2007). In general, the observations for 2007 agrees well with the observations from 2006. The agreement is seen for both the data quality and the observed current speeds and directions. The westward component seen in the progressive vector diagram (Figure 6) is slightly weaker in 2007 than in 2006, but for the cross-sill component of the flow, the currents are stronger in 2007. The volume transport in 2007 compares well with the transport in 2006.

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A APPENDIX

Below is a summary of the NetCDF files compiled from the Storfjorden ADCP from 2004-2007 as well as the Microcat data from 2006. The submitted public data are hourly averages.

A.1 File: Storfjorden_ADCP_2004.nc

dimensions:

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        vert_depth = 23 ;
        instrument_depth = 1 ;
        lat = 1 ;
        lon = 1 ;
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        time: standard_name = "time"
        time: axis = "T"
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        :abstract ="Under the Developing Arctic Modeling and Observing Capabilities for
                Long-term Environmental Studies (DAMOCLES) project, an acoustic
                Doppler current profiler (ADCP) was deployed at the sill separating the
                Storfjorden in Svalbard Archipelago and Storfjordrenna north of
                Storfjordbanken on the Barents Sea shelf. Storfjorden, through its
                polynya activity, produces highly saline water near the freezing
                temperature which fills the fjord to the sill level (115 m) and initiates
                a gravity driven overflow. A self-contained 307.2 KHz broadband
                Workhorse, Sentinel, RD Instruments ADCP was deployed at 76deg
                58min N, 19deg 15min E at the 111 m isobath on 4 September 2003,
                17:30 UTC. The deployment was conducted from R.V. G.O. Sars, during
                the last leg of the cruise 2003010 (01.09 - 14.09 2003). The instrument was
                recovered from R.V. G.O. Sars on 19 August 2004. The instrument is
                installed in an aluminum trawl-proof frame, attached to a concrete block
                of 2.5x2.5x0.37 m dimensions. The ADCP sampled at 4-m depth cell size,
                averaging data (33 pings per ensemble) at 10 min intervals. The first cell
                was centered at about 6 mab (meter above bottom). This dataset
                consists of hourly averaged vertical profiles of current velocities as well as
                temperature for the bottommost cell depth."

        :topic_category = "oceans"
        :keywords = "Storfjorden, ADCP, current, overflow"
        :gcmd_keywords = "Oceans, Ocean Circulation, Ocean Currents"
        :activity_type = "Moored instrument"
        :Conventions = "CF-1.0"
        :product_name = "Horizontal velocity and temperature at Storfjorden Sill"
        :History = "2008-09-03 Creation"
        :area = "Barents Sea"
        :southernmost_latitude = 76.97
        :northernmost_latitude = 76.97
        :westernmost_latitude = 19.25
        :easternmost_latitude = 19.25
        :start_date = "04-Sep-2003 16:25:00"
        :stop_date = "19-Aug-2004 09:25:00"
        :institution = "University of Bergen"
        :PI_name = "Ilker Fer"
        :contact = "ilker.fer@gfi.uib.no"
        :Platform_name = "Bottom mounted frame"
        :project_name = "DAMOCLES"
        :distribution_statement = "free"
```

A.2 File: Storfjorden_ADCP_2005.nc

```
dimensions:
        time = 5688 ;
        vert_depth = 23 ;
        instrument_depth = 1 ;
        lat = 1 ;
        lon = 1 ;

variables:
      float time(time), shape = [5688]
        time: units = "days since 2004-01-01 00:00:00"
        time: long_name = "time of measurement"
        time: standard_name = "time"
        time: axis = "T"
      double vert_depth(vert_depth), shape = [23]
        vert_depth: units = "height above seafloor [m]"
        vert_depth: long_name = "vertical cell depth"
        vert_depth: axis = "Z"
      double instrument_depth(instrument_depth), shape = [1]
        instrument_depth: units = "height above seafloor [m]"
        instrument_depth: long_name = "instrument depth"
      double lat(lat), shape = [1]
        lat: units = "decimal degrees"
        lat: long_name = "latitude"
      double lon(lon), shape = [1]
        lon: units = "decimal degrees"
        lon: long_name = "longitude"
      double E_velocity(time,vert_depth), shape = [5688 23]
        E_velocity: units = "[m s-1]"
        E_velocity: long_name = "Eastward sea water velocity"
        E_velocity: Fill_value = "-999."
      double N_velocity(time,vert_depth), shape = [5688 23]
        N_velocity: units = "[m s-1]"
        N_velocity: long_name = "Northward sea water velocity"
        N_velocity: Fill_value = "-999."
      double Temp(time,instrument_depth), shape = [5688 1]
        Temp: units = "Celcius"
        Temp: long_name = "Sea water temperature at the ADCP instrument depth"
        Temp: Fill_value = "-999."
```

```
//global attributes:
        :title = "Acoustic Doppler Current Profiler data from the Storfjorden Sill, 2004/2005"
        :abstract = "Under the Developing Arctic Modeling and Observing Capabilities for
                Long-term Environmental Studies (DAMOCLES) project, an acoustic Doppler
                current profiler (ADCP) was deployed at the sill separating the Storfjorden in
                Svalbard Archipelago and Storfjordrenna north of Storfjordbanken on the
                Barents Sea shelf. Storfjorden, through its polynya activity, produces highly
                saline water near the freezing temperature which fills the fjord to the sill
                level (115 m) and initiates a gravity driven overflow. A self- contained 307.2
                KHz broadband Workhorse, Sentinel, RD Instruments ADCP was deployed at
                76deg 58min N, 19deg 15min E at the 111 m isobath on 17 december 2004. The
                instrument was recovered on 12 August 2005. The instrument is installed in
                an aluminum trawl-proof frame, attached to a concrete block of 2.5x2.5x0.37 m
                dimensions. The ADCP sampled at 4-m depth cell size, averaging data (33 pings
                per ensemble) at 10 min intervals. The first cell was centered at about 6 meter
                above seafloor. This dataset consists of hourly averaged vertical profiles of
                current velocities as well as temperature for the bottommost cell depth."
        :topic_category = "oceans"
        :keywords = "Storfjorden, ADCP, current, overflow"
        :gcmd_keywords = "Oceans, Ocean Circulation, Ocean Currents"
        :activity_type = "Moored instrument"
        :Conventions = "CF-1.0"
        :product_name = "Horizontal velocity and temperature at Storfjorden Sill"
        :History = "2008-09-03 Creation"
        :area = "Barents Sea"
        :southernmost_latitude = 76.97
        :northernmost_latitude = 76.97
        :westernmost_latitude = 19.25
        :easternmost_latitude = 19.25
        :start_date = "18-Dec-2004 00:25:00"
        :stop_date = "11-Aug-2005 23:25:00"
        :institution = "University of Bergen"
        :PI_name = "Ilker Fer"
        :contact = "ilker.fer@gfi.uib.no"
        :Platform_name = "Bottom mounted frame"
        :project_name = "DAMOCLES"
        :distribution_statement = "free"
```

A.3 File: Storfjorden_ADCP_2006.nc

```
dimensions:
        time = 5760 ;
        vert_depth = 23 ;
        instrument_depth = 1 ;
        lat = 1 ;
        lon = 1 ;
variables:
      float time(time), shape = [5760]
        time: units = "days since 2005-01-01 00:00:00"
        time: long_name = "time of measurement"
        time: standard_name = "time"
        time: axis = "T"
      double vert_depth(vert_depth), shape = [23]
        vert_depth: units = "height above seafloor [m]"
        vert_depth: long_name = "vertical cell depth"
        vert_depth: axis = "Z"
      double instrument_depth(instrument_depth), shape = [1]
        instrument_depth: units = "height above seafloor [m]"
        instrument_depth: long_name = "instrument depth"
      double lat(lat), shape = [1]
      double lon(lon), shape = [1]
      double E_velocity(time,vert_depth), shape = [5760 23]
        E_velocity: units = "[m s-1]"
        E_velocity: long_name = "Eastward sea water velocity"
        E_velocity: Fill_value = "-999."
      double N_velocity(time,vert_depth), shape = [5760 23]
        N_velocity: units = "[m s-1]"
        N_velocity: long_name = "Northward sea water velocity"
        N_velocity: Fill_value = "-999."
      double Temp(time,instrument_depth), shape = [5760 1]
        Temp: units = "Celcius"
        Temp: long_name ="Sea water temperature at the ADCP
                          instrument depth obtained from ADCP"
        Temp: Fill_value = "-999."
      double MC_Temp(time,instrument_depth), shape = [5760 1]
        MC_Temp: units = "Celcius"
        MC_Temp: long_name ="Sea water temperature at the ADCP
                             instrument depth obtained from Microcat"
        MC_Temp: Fill_value = "-999."
      double MC_sal(time,instrument_depth), shape = [5760 1]
        MC_sal: units = "practical salinity units, psu"
        MC_sal: long_name ="Sea water salinity at the ADCP
                            instrument depth obtained from Microcat"
        MC_sal: Fill_value = "-999."
```

```
double MC_pres(time,instrument_depth), shape = [5760 1]
   MC_pres: units = "dbar"
   MC_pres: long_name ="Sea water pressure at the ADCP
                        instrument depth obtained from Microcat"
   MC_pres: Fill_value = "-999."
//global attributes:
   :title = "Acoustic Doppler Current Profiler data from the Storfjorden Sill, 2005/2006"
   :abstract = "Under the Developing Arctic Modeling and Observing Capabilities for
        Long-term Environmental Studies (DAMOCLES) project, an acoustic Doppler
        current profiler(ADCP) and a Microcat were deployed at the sill separating
        the Storfjorden in Svalbard Archipelago and Storfjordrenna north of Storfjord-
        banken on the Barents Sea shelf. Storfjorden, through its polynya activity,
        produces highly saline water near the freezing temperature which fills the
        fjord to the sill level (115 m) and initiates a gravity driven overflow.
        A self-contained 307.2 KHz broadbandWorkhorse, Sentinel, RD Instruments
        ADCP and a Sea-Bird SBE37SM Microcat (S/N 4011), temperature-conductivity
        -pressure recording unit was deployed at 76deg 58.08min N, 19deg 14.95min E
        at the 111 m isobath on 12 december 2005. The instruments were recovered on
        9 August 2006. The instruments are installed in an aluminum trawl-proof frame,
        attached to a concrete block of 2.5x2.5x0.37 m dimensions. The ADCP sampled
        at 4-m depth cell size, averaging data (33 pings per ensemble) at 10 min
        intervals. The first cell was centered at about 6 meter above seafloor.
        The Microcat sampled at 10min intervals. This dataset consists of hourly
        averaged vertical profiles of current velocities as well as ADCP-
        temperature and Microcat-temperature/salinity/pressure for the instrument
        cell depth."
   :topic_category = "oceans"
   :keywords = "Storfjorden, ADCP, current, overflow, Microcat"
   :gcmd_keywords = "Oceans, Ocean Circulation, Ocean Currents"
   :activity_type = "Moored instrument"
   :Conventions = "CF-1.0"
   :product_name = "Horizontal velocity and temperature at Storfjorden Sill"
   :History = "2008-09-03 Creation"
   :area = "Barents Sea"
   :southernmost_latitude = 76.97
   :northernmost_latitude = 76.97
   :westernmost_latitude = 19.25
   :easternmost_latitude = 19.25
   :start_date = "12-Dec-2005 15:05:00"
   :stop_date = "09-Aug-2006 14:05:00"
   :institution = "University of Bergen"
   :PI_name = "Ilker Fer"
   :contact = "ilker.fer@gfi.uib.no"
   :Platform_name = "Bottom mounted frame"
   :project_name = "DAMOCLES"
   :distribution_statement = "free"
```

A.4 File: Storfjorden_ADCP_2007.nc

```
dimensions:
        time = 6060 ;
        vert_depth = 23 ;
        instrument_depth = 1 ;
        lat = 1 ;
        lon = 1 ;
variables:
      float time(time), shape = [6060]
        time: units = "days since 2006-01-01 00:00:00"
        time: long_name = "time of measurement"
        time: standard_name = "time"
        time: axis = "T"
      double vert_depth(vert_depth), shape = [23]
        vert_depth: units = "height above seafloor [m]"
        vert_depth: long_name = "vertical cell depth"
        vert_depth: axis = "Z"
      double instrument_depth(instrument_depth), shape = [1]
        instrument_depth: units = "height above seafloor [m]"
        instrument_depth: long_name = "instrument depth"
      double lat(lat), shape = [1]
        lat: units = "decimal degrees"
        lat: long_name = "latitude"
      double lon(lon), shape = [1]
        lon: units = "decimal degrees"
        lon: long_name = "longitude"
      double E_velocity(time,vert_depth), shape = [6060 23]
        E_velocity: units = "[m s-1]"
        E_velocity: long_name = "Eastward sea water velocity"
        E_velocity: Fill_value = "-999."
      double N_velocity(time,vert_depth), shape = [6060 23]
        N_velocity: units = "[m s-1]"
        N_velocity: long_name = "Northward sea water velocity"
        N_velocity: Fill_value = "-999."
      double Temp(time,instrument_depth), shape = [6060 1]
        Temp: units = "Celcius"
        Temp: long_name = "Sea water temperature at the ADCP instrument depth"
        Temp: Fill_value = "-999."
```

```
//global attributes:
        :title = "Acoustic Doppler Current Profiler data from the Storfjorden Sill, 2006/2007"
        :abstract = "Under the Developing Arctic Modeling and Observing Capabilities for
                Long-term Environmental Studies (DAMOCLES) project, an acoustic Doppler
                current profiler (ADCP) was deployed at the sill separating the Storfjorden
                in Svalbard Archipelago and Storfjordrenna north of Storfjordbanken on the
                Barents Sea shelf. Storfjorden, through its polynya activity, produces highly
                saline water near the freezing temperature which fills the fjord to the sill
                driven overflow. Alevel (115 m) and initiates a gravity self-contained 307.2
                KHz broadband Workhorse, Sentinel, RD Instruments ADCP was deployed
                at 76deg 58min N, 19deg 18min E at the 116 m isobath on 13th ofAugust 2006,
                05:00 UTC. The deployment was conducted from R.V. Hǫn Mosby, during
                the cruise HM2006 615. The instrument was recovered during the first leg of
                HM2007 613 on the 15 of July 2007, 23:04 utc. The instrument was installed in
                an aluminum trawl-proof frame, attached to a concrete block of 2.5x2.5x0.37 m
                dimensions. The ADCP sampled at 4-m depth cell size, averaging data (13 pings
                per ensemble) at 2 min intervals. The first cell was centered at about 6 mab
                (meter above bottom). This dataset consists of hourly averaged vertical
                profiles of current velocities as well as temperature at the instrument depth."
        :topic_category = "oceans"
        :keywords = "Storfjorden, ADCP, current, overflow"
        :gcmd_keywords = "Oceans, Ocean Circulation, Ocean Currents"
        :activity_type = "Moored instrument"
        :Conventions = "CF-1.0"
        :product_name = "Horizontal velocity and temperature at Storfjorden Sill"
        :History = "2008-10-21 Creation"
        :area = "Barents Sea"
        :southernmost_latitude = 76.97
        :northernmost_latitude = 76.97
        :westernmost_latitude = 19.3
        :easternmost_latitude = 19.3
        :start_date = "13-Aug-2006 05:33:38"
        :stop_date = "22-Apr-2007 16:24:38"
        :institution = "University of Bergen"
        :PI_name = "Ilker Fer"
        :contact = "ilker.fer@gfi.uib.no"
        :Platform_name = "Bottom mounted frame"
        :project_name = "DAMOCLES"
        :distribution_statement = "free"
```