Moorings from the Filchner Trough and the Ronne Ice Shelf Front: Preliminary Results

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Introduction

In January/February 1998, five current meter moorings were recovered from the continental slope area, north of the Filchner-Ronne Ice Shelf region - two moorings (FR1 and FR2) from the northern exit of the Filchner Trough, two (FR5 and FR6) from the Ronne Trough and one (FR3) from in front of the Ronne Ice Shelf at c.77°S, see Figure 1.

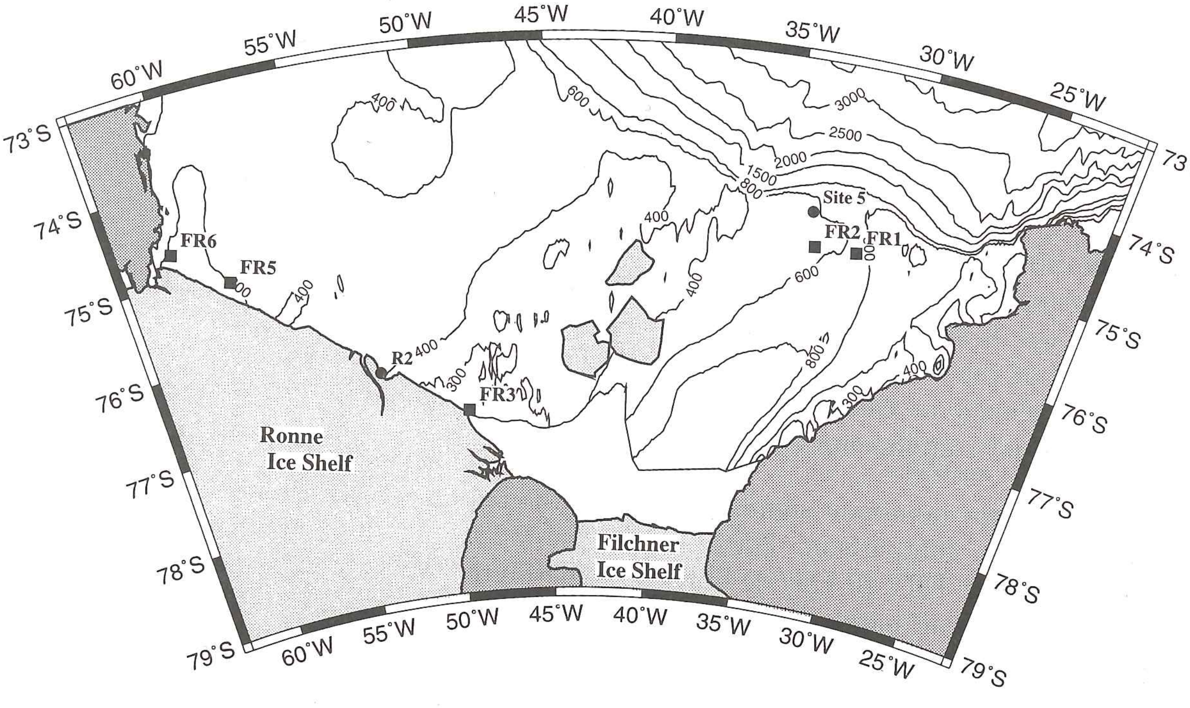

Figure 1: *Map of continental shelf region north of the Filchner-Ronne Ice Shelves. Squares mark the 5 moorings recovered in January/February 1998 (FR1,2,3,5,6) and circles, the sites of previous recovered moorings, R2 and Site 5.*

In total, 15 instruments yielded timeseries of current velocity and temperature of between 2 and 2.5 years duration, see Table 1. These data represent a substantial increase in current meter measurements in the region - previously only four long-period records have ever been recovered from these area, two from the mooring 'Site 5', just northwest of the northern exit of the Filchner Trough (Foldvik *et al.*, 1985) and two from the mooring R2 at the Ronne Ice Shelf at 76.5°S (Schröder *et al.*, 1997), (positions marked on Figure 1). The new data presented here not only greatly extend the measurements from the north

ID	Latitude and longitude	Water depth /m	Meter depth /m	Meter type /**	Extent of record		Mean of velocity during deployment	
					first, d/m/yr	time /days	mag. /cm s^{-1}	dir. /deg
FR1	75° 01.4' S	610	257	AA	3/2/95	828	4.3	336
	31° 45.6' W		378	AA	3/2/95	828	6.0	330
			484	AA	3/2/95	837	6.7	326
			590	ACM	3/2/95	691	7.6	338
FR2	75° 02.2' S	574	191	AA	3/2/95	829	3.0	95
	33° 33.3' W		342	AA	3/2/95	829	1.5	96
			448	AA	3/2/95	837	*0.7	*90
			554	ACM	3/2/95	693	1.1	91
FR3	77° 00.1' S	254	203	AA	26/1/95	837	2.0	301
	49° 01.3' W							
FR5	75° 09.8' S	601	204	AA	15/2/95	816	2.8	309
	58° 43.6' W		305	AA	15/2/95	830	2.0	329
			551	ACM	29/6/95	545	1.6	118
FR6	74° 42.3' S	613	261	AA	16/2/95	816	6.0	259
	60° 48.6' W		442	AA	16/2/95	830	5.3	260
			588	ACM	16/2/95	679	4.5	267

**AA= Aanderaa recording current meter; ACM=Neil Brown ACM-2

* averaged over 606 days, after which speed sensor fails

Table 1: *Summary of mooring data.*

of the Filchner Trough, but are also the first ever current measurements from the Ronne Trough, as well as being the only measurements from the same areas in winter.

Tidal versus Mean Flow

All the instruments, especially those of FR5 and FR3 and to a lesser extent FR6, were recovered significantly fouled with biological growth. However, this did not compromise the quality of the temperature and velocity data. Table 1 gives the record lengths and the mean velocity at each meter for the mooring period. Table 2 lists the six largest significant tidal components.

In all records, the dominant signal is the tidal, the record-mean currents being only small (1 to 8 cm/s) in comparison. For example, the M2 tide is maximum at FR6 (13 cm/s) and minimum at FR1 (6 cm/s), but everywhere greater than the velocity mean. The tides are, in general, barotropic, and at the ice shelf (FR3, 5 and 6), their major axis is perpendicular to the ice front.

For further analysis, the data are low-pass filtered to remove signals of period less than 40 hours.

The Filchner Trough

Moorings FR1 and FR2, on the northern sill of the Filchner Trough, record the flow of modified Ice Shelf Water (ISW), Figure 2. At FR1, the eastmost and deeper of the two moorings, the flow is dominantly barotropic, and almost unidirectional, flowing northwest out of the trough with mean velocity of 7.5 cm/s (at the deepest meter) and 4.3 cm/s (at the shallowest meter). The CTD section taken at the deployment of the moorings (Schröder *et al.*, 1997) shows this ISW core and also two separate branches of Modified Warm Deep Water (MWDW) - the warmer (-1°C) to the east of FR1 at 400m depth and

ID		M2			S2			K1			O1			Other components	
	Depth /m	Ma	Mi	I	Ma	Mi	I	Ma	Mi	I	Ma	Mi	I	Name & Ma	Name & Ma
FR1	257	5.7	2.4	63	3.6	1.3	67	2.5	2.2	29	1.2	0.7	13	SA 1.3	MSF 1.1
	378	6.3	2.6	67	3.8	1.5	67	2.7	2.2	17	1.2	0.7	8	MSF 1.5	K2 1.2
	484	6.4	2.8	70	3.8	1.4	68	2.7	2.1	18	1.4	0.7	10	MSF 1.5	K2 1.2
	590	5.3	1.4	77	3.8	1.2	74	2.7	2.1	9	1.2	0.6	178	MSF 2.2	SSA 1.8
FR2	191	7.1	4.0	62	3.9	1.8	61	3.6	3.1	178	2.1	1.2	172	SSA 1.4	N2 1.4
	342	6.3	3.4	64	3.8	1.8	66	3.3	2.9	177	1.9	1.1	172	N2 1.3	K2 1.2
	448	5.5	2.8	64	3.5	1.7	65	3.2	2.7	3	1.8	1.0	177	SSA 1.2	P1 1.1
	554	3.3	0.6	71	2.8	0.8	77	2.9	2.5	173	1.6	0.9	171	SSA 1.0	SA 1.0
FR3	203	11.9	0.9	30	7.0	0.0	28	4.3	0.5	158	3.6	0.5	148	SA 4.6	N2 2.1
FR5	204	10.6	-3.2	58	6.8	-1.5	59	6.4	-3.9	77	6.4	-4.2	81	P1 2.3	K2 2.0
	305	11.8	-2.2	51	7.3	-1.2	51	6.4	-3.8	77	6.5	-4.1	78	P1 2.3	K2 2.3
	551	14.0	-0.6	62	9.4	-0.6	58	6.8	-2.9	71	6.6	-3.6	70	K2 3.6	MKS2 2.6
FR6	261	12.9	-1.0	57	7.8	-0.8	56	6.0	-1.1	59	5.7	-1.2	59	K2 2.7	N2 2.1
	442	13.7	-0.1	52	8.1	-0.4	51	6.0	-1.1	61	5.7	-1.2	60	K2 2.7	N2 2.4
	588	11.8	-3.1	55	7.1	-1.8	55	5.9	-1.2	51	5.3	-1.2	48	K2 2.6	SA 2.5

Table 2: *Tidal components. Ma = major axis in cm/s; Mi = minor axis in cm/s; I = inclination in degrees.*

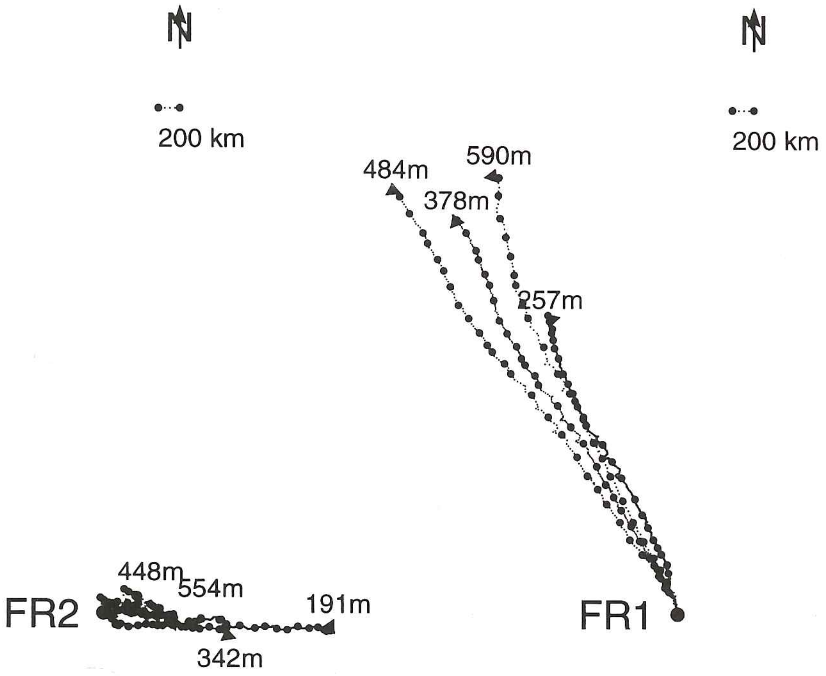

Figure 2: *Progressive vector diagrams for the timeseries at FR2 and FR1, starting on 3rd February 1995. Dots are separated by 30 days.*

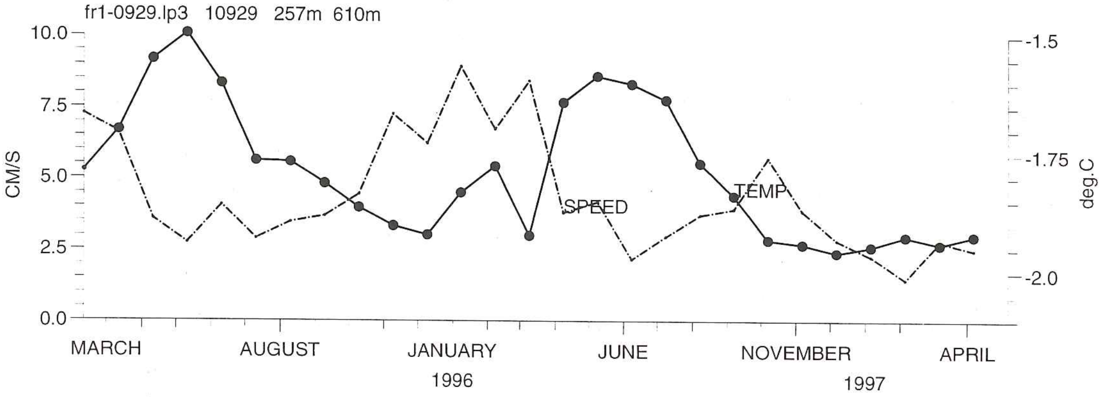

Figure 3: *Monthly-means of temperature and speed for the top instrument on FR1. Temperature = solid line; Speed = dot-dashed line.*

presumably southward-flowing, and the colder (-1.3 °C), shallower (200-400m) branch to the west of FR2. Over the mooring period, the MWDW is never found at depth at FR1, indicating the southward-flowing MWDW core lies always to the east of this position. At FR2, the flow is smaller (3.0-0.8 cm/s) and eastward, directed by the local topography (Vaughan *et al.*, 1994). From FR1 and FR2, the mean volume of northward-flowing ISW can be estimated at about 0.4 Sv.

All records show seasonal and interannual variations. At FR1, for example, there is a strong decrease in speed and increase in temperature in winter, (see Figure 3). The latter marks the intrusion of the shallower MWDW branch over the moorings, limiting the modified ISW to the deeper instruments. The reduction in both speed and thickness of the ISW layer suggests the ISW outflow has a strong seasonal variation, ranging from about 0.2 Sv in winter to 0.7 Sv in summer. The reduced outflow in winter could be due either to changes in the source of ISW or to a blocking effect from MWDW driven higher up onto the shelf by winter winds.

The Ronne Trough

The data from the Ronne Trough, (see Figure 4), show a more complex structure. At FR5, the eastern mooring, the flow at the top current meter (204m), which is shallower than the bottom of the ice shelf, is directed to the northwest along the ice shelf, as would be expected from a current driven by the off-shelf winds. The lowest current meter (551m) on the same mooring shows an opposing eastsoutheastward flow, suggesting a deep flow which follows the depth contours (Vaughan *et al.*, 1994), moving with the shallower water on its left. These mean flows are, however, comparatively small (1.6 to 2.7 cm/s) and some events, presumably eddies, show coherent directions throughout the water column.

On the other side of the Trough, FR6 records a westward flow at all three instruments, with currents being stronger (4.5 to 6.0 cm/s) than at FR5. Although this flow appears to be directed under the ice shelf, the bathymetry and ice shelf position are complex at this location and model simulations of the flow (Grosfeld & Gerdes, this volume) suggest a complicated flow, with interacting, variable, small scale, cyclonic and anticyclonic features.

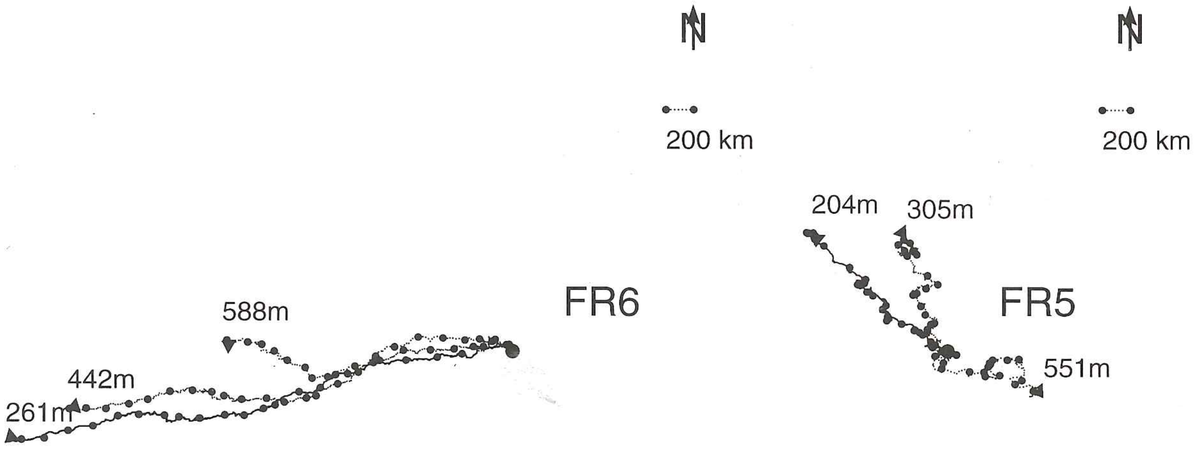

Figure 4: *Progressive vector diagrams for the timeseries at FR6 and FR5, starting on 5th July 1995. Dots are separated by 30 days. Note different scale to Figure 2.*

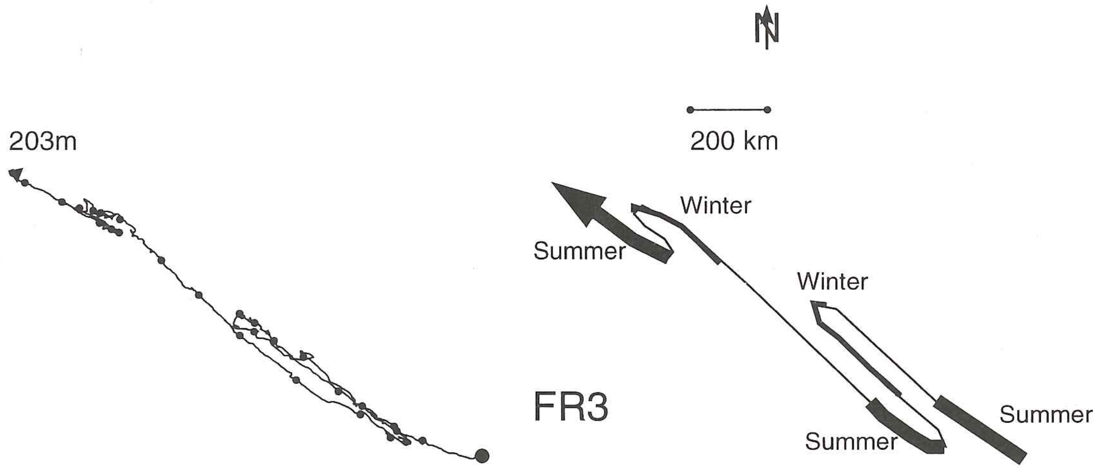

Figure 5: *Progressive vector diagram for FR3 (left) starting on 26th January 1995, and schematic thereof, where different line thicknesses represent different seasons - thickest for summer, medium for winter and thinnest for autumn and spring. Dots are separated by 30 days. Note different scale to Figure 4.*

In the temperatures records, strong seasonal and interannual variability is present in the shallower instruments, while the records at depth show far less, if any, variability. At the instruments shallower than 400m, ISW is only present in spring/summer at FR5 and summer/autumn at FR6, with the waters being at the surface freezing point in winter. This suggests that winter convection blocks the outflow of ISW.

The Ronne Ice Front south of the Ronne Trough

The final mooring at 77°S in 203m of water carried only one functioning current meter. This showed small record-mean currents (2.0 cm/s), but a strong seasonal variation in current direction, Figure 5, with flow being northwestward (i.e. out from under the shelf) in summer and autumn, and southeastward (i.e. in, under the shelf) in spring. As at FR5 and FR6, water is at the surface freezing point in late winter. However, at FR3, the ISW is only present in autumn, i.e. later in the year than at FR5 and FR6.

Conclusions

These preliminary results indicate the wealth of information contained in these new data. They substantially increase the recorded observations in the region and will be invaluable for verification (or otherwise) of old and new hypotheses. In particular, the exceptional quality and length of the timeseries show significant interannual and, previously unobserved, seasonal variations in the outflows.

Acknowledgements

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