

ANDRILL McMurdo Sound Tidal Current Analysis

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Introduction

A current meter mooring was deployed on October 25, 2006 on the frozen surface ice in McMurdo Sound in support of the ANtarctic DRILLing (ANDRILL) program. The mooring site named SMS was located at 77° 45.157' S and 165° 29.372' E, approximately 18 miles west northwest of McMurdo Station, Antarctica. The SMS mooring site was historically covered with seasonal sea ice, but at present the surface has been permanently frozen for about the past 10 years (Figure 1).

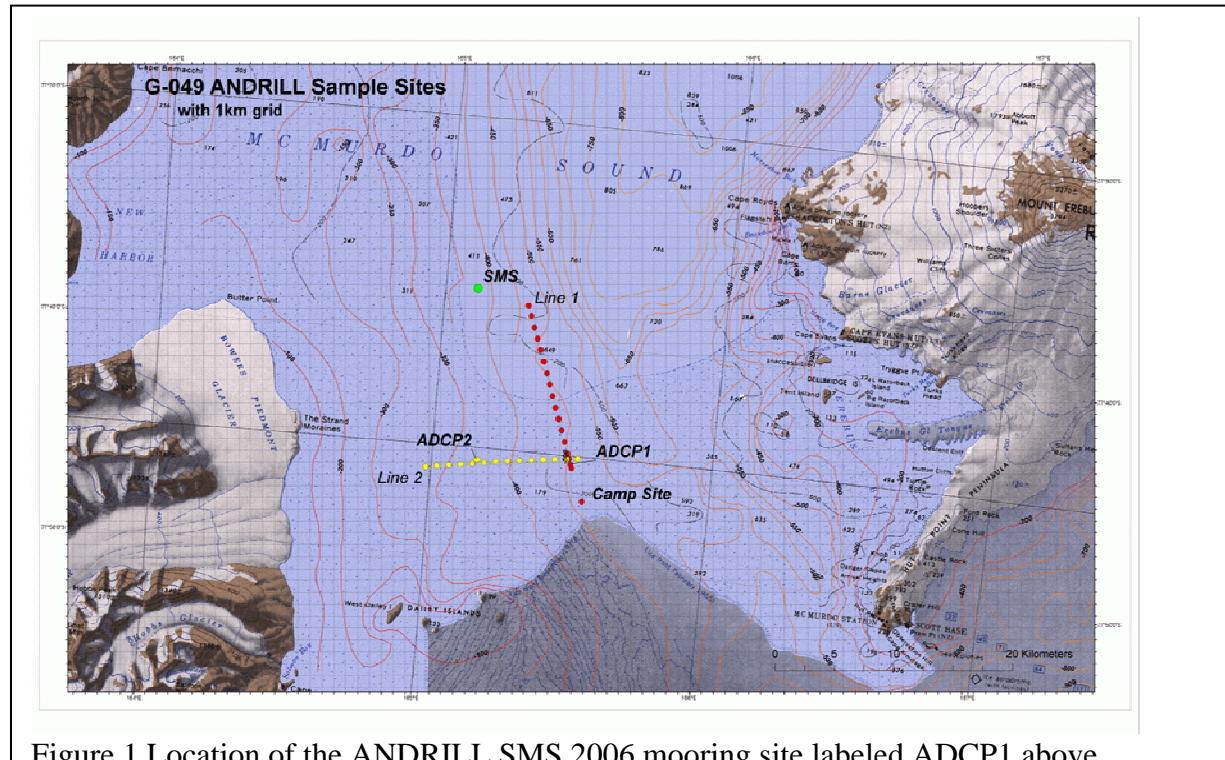


Figure 1 Location of the ANDRILL SMS 2006 mooring site labeled ADCP1 above.

This report presents a tidal analysis of the moored Aquadopp current meter data that were collected at the five design depths of 100 m, 200 m, 300 m, 400 m, and 480 m. For simplicity, we will use the design depths to identify the different current meter records, but note here that the actual instrument measurement depths varied considerable during the deployment. Time series of the instrument depths (based on the individual instrument pressure records) shown in Figure 2 indicate that the mooring began to rise after about 1.5 days until about yearday 300.5

when the entire mooring dropped for several hours back to its initial depth, then rose again for about 12 hours before returning to its initial depth on yearday 301.4. Then on yearday 302.8, the upper four instruments began a slow rise that finally reached a plateau on yearday 310, where

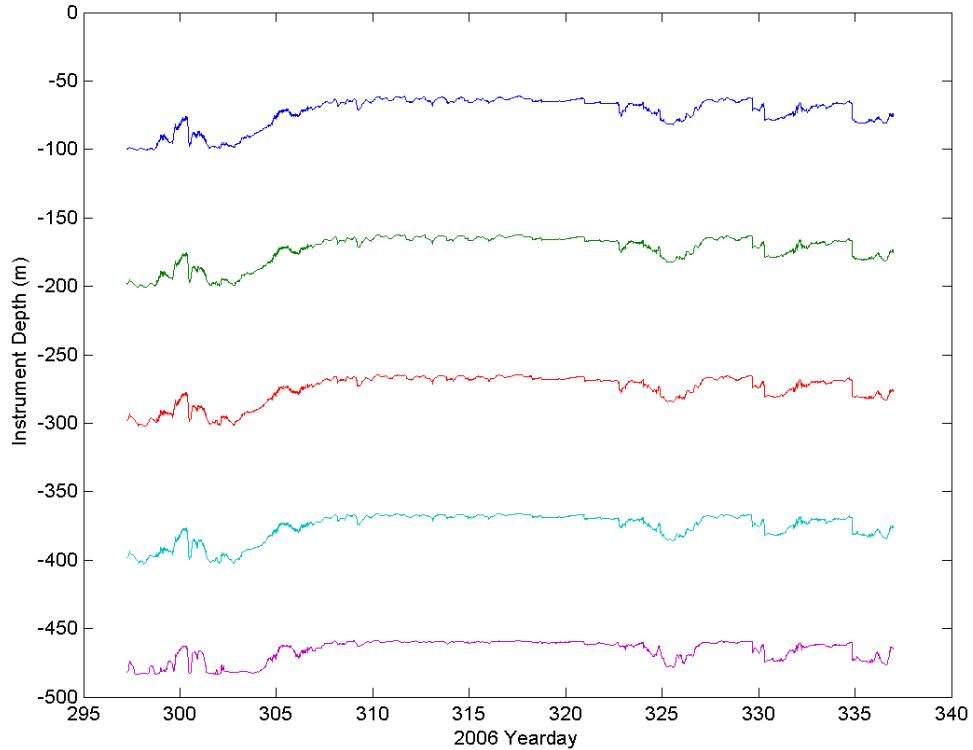


Figure 2 Time series of the five Aquadopp instrument depth (m) (based on the individual pressure data) as a function of 2006 yearday (yearday 300.0 is 00 GMT October 28). Note that the instruments are initially located close to their design depths of 100, 200, 300, 400, and 480 m.

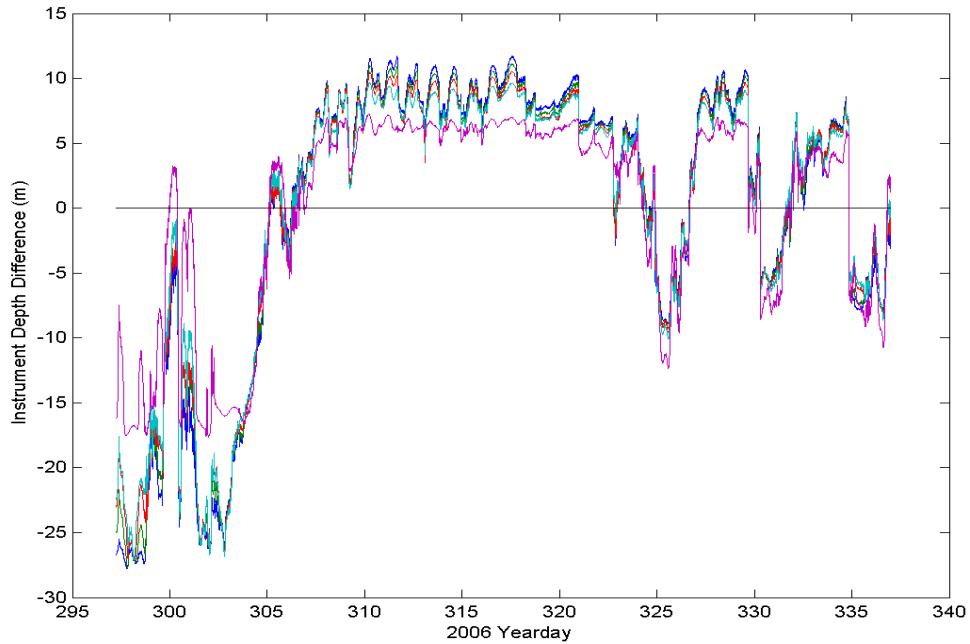


Figure 3 Time series of the five instrument depths from their mean depths (m) as a function of 2006 yearday. Note that the five instruments reached a depth plateau around yearday 310 that persisted for much of the rest of the deployment. The color code is the same as in Figure 2. they stayed near for the next eleven days. The deepest (480-m) instrument did not start this rise until yearday 303.8, but then rose along with the other instruments and remained at the plateau until it ended on yearday 321. The mooring then underwent three periods of deepening centered near yearday 325, 331, and from 335 to the end of the record, returning to near the plateau between the first two deeper periods.

Figure 3 shows time series of the difference of the instrument depth from its mean depth, illustrating the vertical movement of the mooring during the deployment. While some of the vertical movement occurred over hours to days, some of the drops in depth occurred rapidly over just a few minutes (e.g. the 12-m drop on yearday 334.85 took only two record cycles, 10 min.). In general, the upper four instrument depths tend to track one another in time to within a standard deviation of 1 m (with maximum differences of <4 m), while the difference in depth between the bottom two instruments is much more variable, with maximum differences of 10 m in the first six days and smaller differences of <4 m during the rest of the deployment. While one would expect some vertical movement of the instruments associated with the mooring tilt caused by the drag of the horizontal currents, this mechanism is not responsible for the 30+ m rise that occurred in the first 10 days and remained for much of the rest of the deployment. It seems likely that this large persistent rise was due to the formation of ice on parts of the mooring (most likely the very top instruments) that provided sufficient buoyancy to lift the mooring. Table 1 gives the mean, standard deviation, minimum, and maximum values of the instrument depth for the five Aquadopp current meters.

Instrument Depth* (m)	Mean (m)	Std (m)	Min (m)	Max (m)
100	72.9	11.2	61.1	100.6
200	173.3	10.8	162.1	201.0
300	275.0	10.4	264.5	302.1
400	375.7	10.1	366.0	402.8
480	466.0	7.7	458.7	483.6

Table 1 Record mean, standard deviation, minimum and maximum depths for the five Aquadopp current meters deployed at the design* depths listed in column one.

The tidal analysis presented next was conducted using the five Aquadopp edited basic 5-min time series of east (x) and north (y) current components as provided in Matlab format on our website (http://www.whoi.edu/science/PO/ANDRILL_Mooring/data06.html). Each record had a start time of 6:00 GMT October 25, 2006 and an end time of 00 GMT December 4, 2006, with a record length of 39.75 days. No attempt was made to adjust the data to fixed depths, but instead the results of the tidal analysis for each record are considered to be representative of the tidal currents at that instrument's mean depth (second column, Table 2). The tidal current analysis was made using the Matlab software T_Tide that provides a classical tidal harmonic analysis including error estimates (R. Pawlowicz, B. Beardsley, and S. Lentz, "Classical tidal harmonic

analysis including error estimates in MATLAB using T_TIDE", *Computers and Geosciences*, **28** (2002), 929-937). The means and linear trends were first removed by least-square fit from the east and north components before the harmonic analyses were made. T_Tide outputs the current ellipse parameters (major axis, minor axis, inclination, and GMT phase) with 95% confidence estimates limits, and a time series of the tidal currents synthesized using the tidal constituents with signal-to-noise ratio (snr) > 2.

Figures 4-8 show the basic east and north time series plotted in blue with the synthetic tidal east and north components plotted in red for the five Aquadopp records. Note that the individual basic and tidal time series tend to be offset in the vertical, a consequence of not adding the mean and linear trend back into the tidal time series in these plots. These figures show that the tidal currents have a strong fortnightly (~14 day) variation and capture a significant fraction of the total currents. Table 2 lists the variances of the east and north current components and combined (total) variance of the basic current time series (with means and linear trends removed) and the fraction (in percent) of the variances due to the fitted tidal components. Approximately 60% of the total variance is due to the tides in the upper three records, while the tides account for approximately 50% of the total variance in the lowest two records. Figure 9 is a spectrum of the tidal kinetic energy (variance) for the 300-m instrument, showing the dominance of the two diurnal components (K1 and O1) and much weaker but significant semidiurnal components (S2 and M2). This spectrum also shows significant contributions from the monthly (MM, 27.56 day period) and fortnightly (MSF, 14.77 day period) components. The origin of these two low frequency components is unclear due to the shortness of the current records.

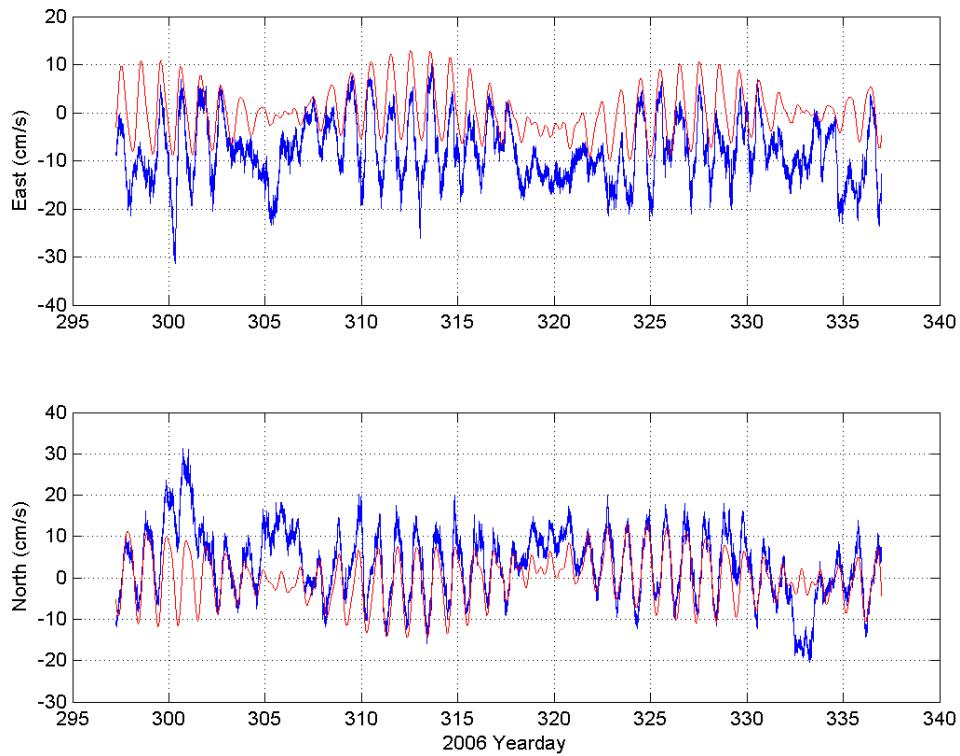


Figure 4 Time series of 100-m Aquadopp east and north current components (in blue) with tidal components (in red) plotted versus 2006 yeardays, with yearday 300.0 is 00 GMT October 28.

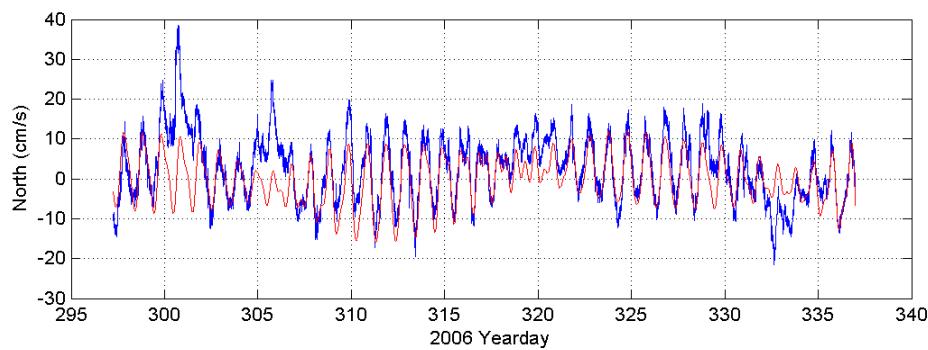
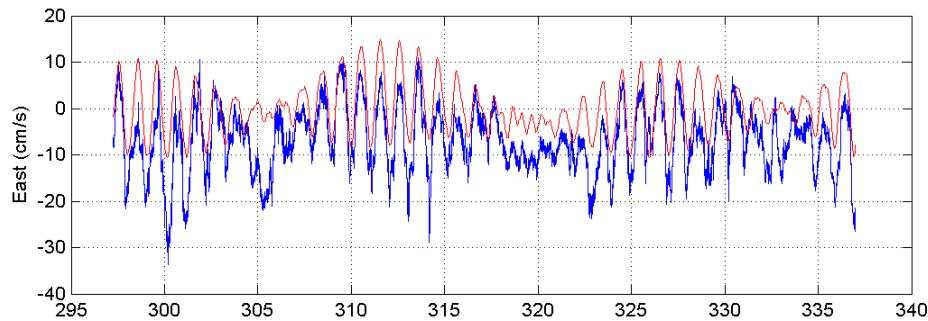


Figure 5 Time series of 200-m Aquadopp east and north current components (in blue) with tidal components (in red) plotted versus 2006 yeardays.

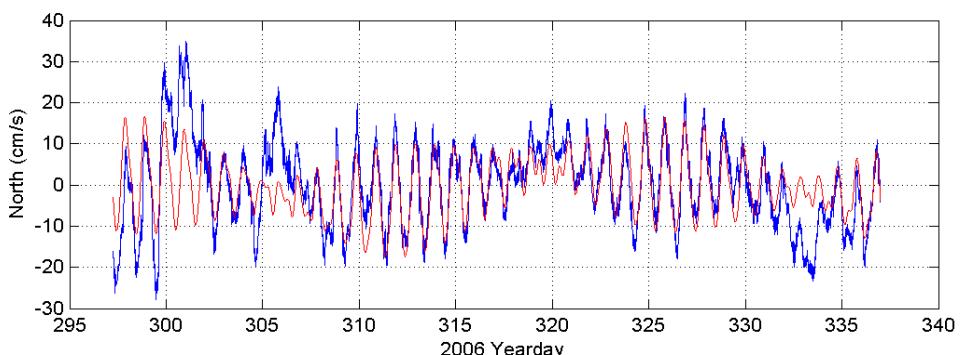
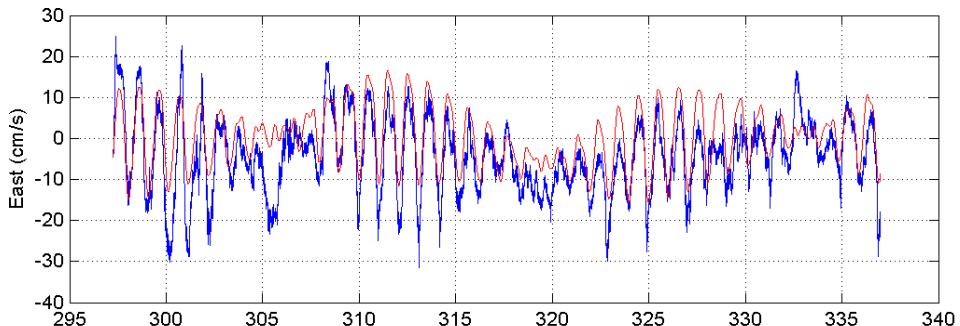


Figure 6 Time series of 300-m Aquadopp east and north current components (in blue) with tidal components (in red) plotted versus 2006 yeardays.

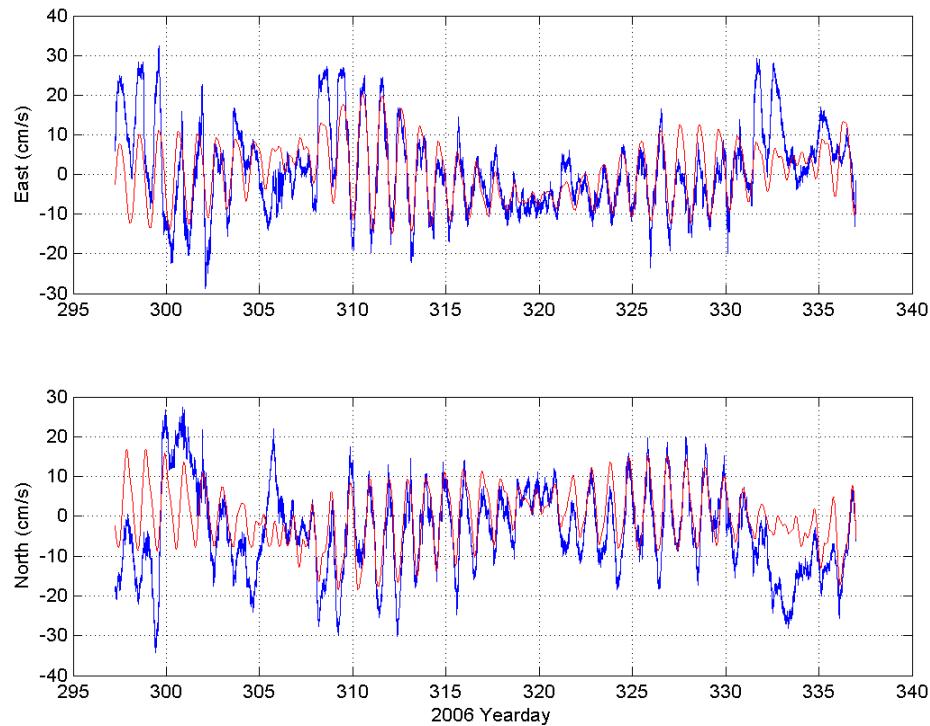


Figure 7 Time series of 400-m Aquadopp east and north current components (in blue) with tidal components (in red) plotted versus 2006 yeardays.

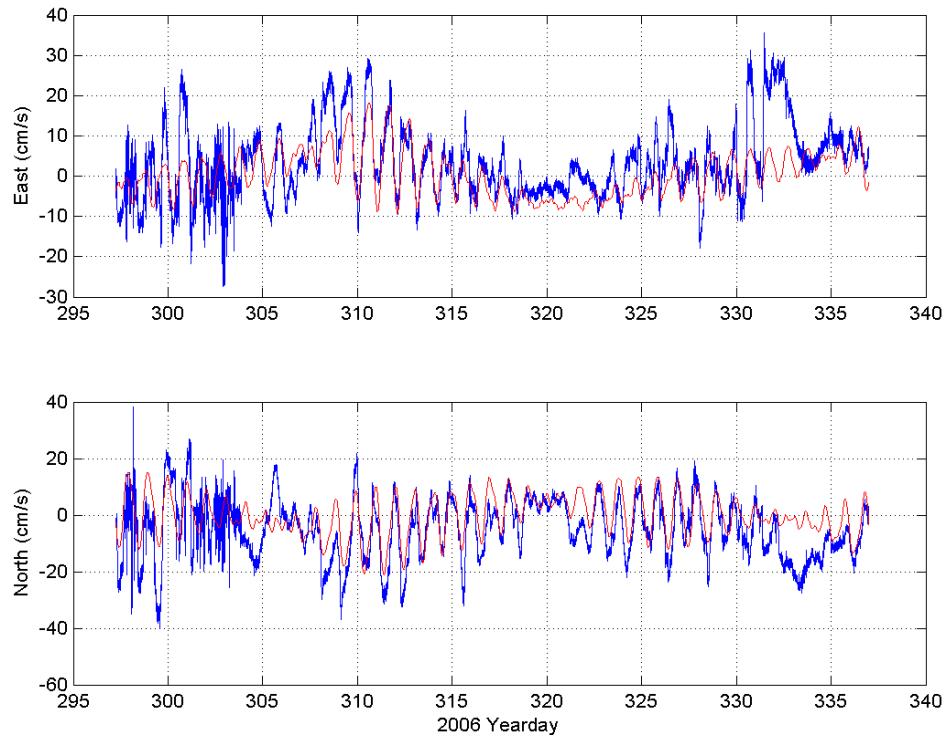


Figure 8 Time series of 480-m Aquadopp east and north current components (in blue) with tidal components (in red) plotted versus 2006 yeardays.

Instrument Depth* (m)	East (%)	North (%)	Total (%)
100	43.6 (58.8%)	67.3 (60.2%)	111.0 (59.7%)
200	49.5 (61.5%)	67.3 (59.1%)	116.8 (60.1%)
300	82.0 (65.7%)	105.8 (55.1%)	187.8 (59.7%)
400	108.7 (54.3%)	114.6 (48.2%)	223.3 (51.2%)
480	83.1 (46.0%)	113.8 (51.1%)	196.9 (48.9%)

Table 2 Variances of east and north current components and combined (total) variance with the fraction (in percent) of each variance due to the tidal constituents presented for the five Aquadopp current records.
Variance given in $(\text{cm/s})^2$.

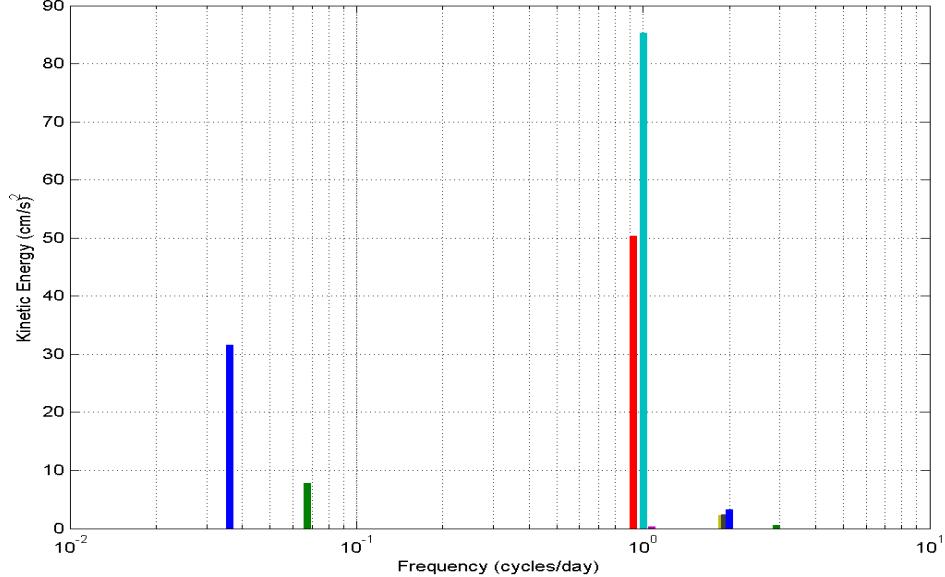


Figure 9 Spectrum of kinetic energy of the dominant tidal constituents.

The tidal ellipses of the dominant diurnal constituents (O1 and K1) and semidiurnal constituents (M2 and S2) from the five Aquadopp current meter records are shown in Figure 10. The design depth of each record is shown to the right of the ellipses. The major and minor axes are plotted in green and red dashed lines, and the direction of the current vector at 00 GMT is shown by the thick red line. The O1 and K1 ellipses show a consistent pattern in orientation, with little veering in the upper four records but a clockwise shift in the lowest record, and with maximum amplitudes in the 300-m and 400-m records. The major axes of both O1 and K1 are internally consistent and generally aligned with the axis of McMurdo Sound. These results suggest that the O1 and K1 can be considered to first order as barotropic tides in this region, with relatively little vertical variation outside the surface (under the ice) and bottom boundary layers. While this model is based on the tidal analysis of the five Aquadopp records with *no* correction for varying instrument depth, the lack of large changes in the ellipse character between the different records supports the analysis approach.

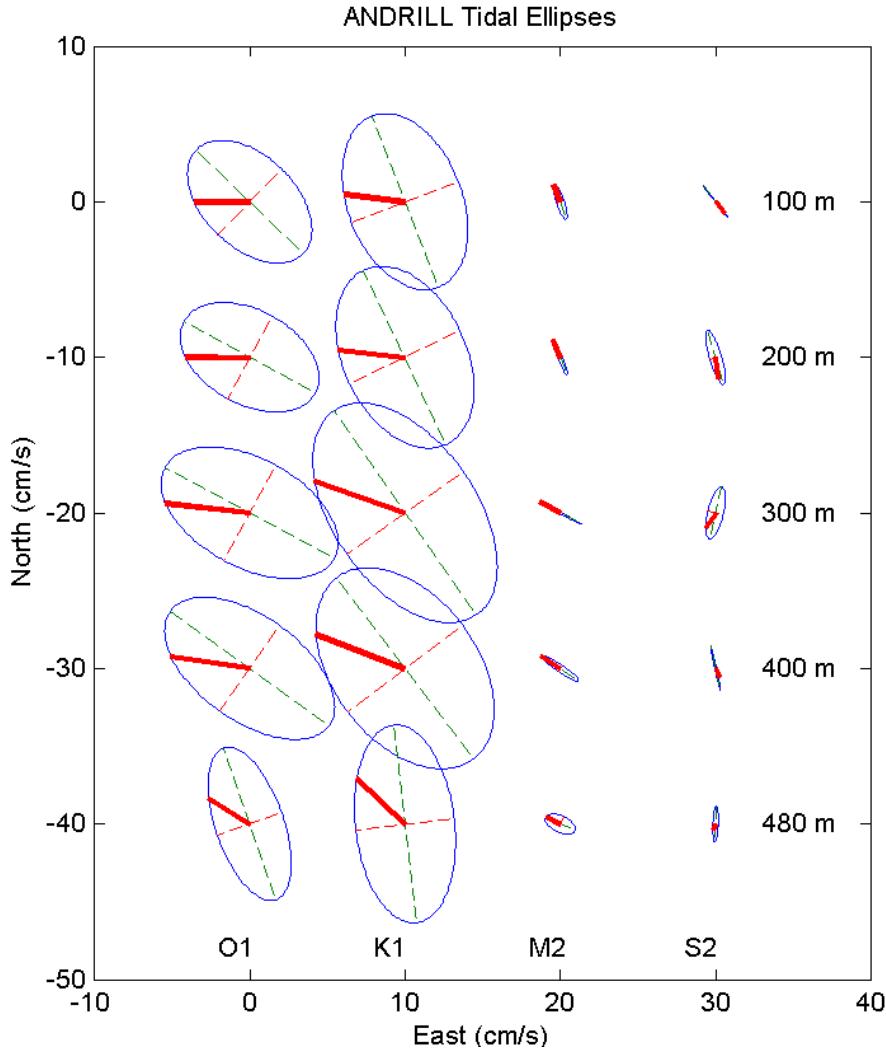


Figure 10 Plot of tidal ellipses (blue) for the dominant diurnal constituents (O1 and K1) and semidiurnal constituents (M2 and S2) from the five Aquadopp deployed at the design depths listed to the right. For each ellipse, the major and minor axes are plotted in green and red dashed lines, and the direction of the current vector at 00 GMT is shown by the thick red line.

The semidiurnal (S2 and M2) constituents are weaker with highly polarized ellipses. The uncertainties in the minor axes are generally larger than the minor axis values, and contribute to large uncertainties in the ellipse orientations and phases. Within the 95% confidence estimates, the orientations of each constituent are equal within about 22° for S2 and 9° for M2. Given the large uncertainties, the tidal results suggest that both S2 and M2 can be considered to first order as barotropic tides with little variation in the vertical outside the surface and bottom boundary layers.

The T_Tide output for the five Aquadopp current meter records are presented in Appendix A.

Appendix A. T_Tide output

ANDRILL 100-m AquaDopp tidal analysis

number of standard constituents used: 35

Points used: 11447 of 11448

percent of X var removed by fit: 58.78 %

percent of Y var removed by fit: 60.23 %

nodal corrections applied to amplitude and phase relative to center time

Using linearized error estimates

Generating prediction with nodal corrections, SNR is 2.000000

date: 16-Jul-2007

nobs = 11448, ngood = 11447, record length (days) = 39.75

start time: 25-Oct-2006 06:02:30

rayleigh criterion = 1.0

nodal corrections applied to amplitude and phase relative to center time

x0= -8.1, x trend= -0.242

var(x)= 43.6241 var(xp)= 25.6437 var(xres)= 17.9804

percent var predicted= 58.8 %

y0= 3.52, y trend= -4.33

var(y)= 67.3589 var(yp)= 40.5705 var(yres)= 26.7884

percent var predicted= 60.2 %

ellipse parameters with 95% CI estimates

tide	freq	major	emaj	minor	emin	inc	einc	pha	epha	snr
*MM	0.00151	3.498	0.363	-0.197	0.39	122.92	6.36	228.04	5.97	93
*MSF	0.00282	2.216	0.397	-0.089	0.35	160.77	9.11	276.01	10.28	31
*ALP1	0.03440	0.510	0.458	0.020	0.41	26.28	38.73	51.83	43.45	1.2
2Q1	0.03571	0.449	0.461	-0.154	0.41	155.76	53.79	179.71	59.41	0.95
*Q1	0.03722	0.518	0.412	0.207	0.46	60.80	54.38	175.53	50.60	1.6
*O1	0.03873	4.792	0.436	2.945	0.43	136.01	8.32	302.58	8.35	1.2e+002
*NO1	0.04027	0.501	0.470	0.151	0.39	167.97	32.83	267.46	37.96	1.1

*K1	0.04178	5.898	0.403	3.688	0.46	111.18	7.56	288.80	7.11	2.1e+002
*J1	0.04329	0.613	0.472	-0.286	0.39	173.01	47.46	42.03	53.44	1.7
OO1	0.04483	0.276	0.396	0.116	0.47	103.65	64.28	1.84	57.10	0.48
UPS1	0.04634	0.146	0.395	-0.003	0.47	102.45	101.18	294.40	85.09	0.14
*EPS2	0.07618	0.512	0.323	0.346	0.30	107.30	79.60	237.65	81.69	2.5
*MU2	0.07769	0.828	0.319	0.304	0.31	119.98	27.24	260.48	28.13	6.7
*N2	0.07900	0.582	0.323	-0.068	0.30	109.28	31.64	203.44	33.74	3.3
*M2	0.08051	1.201	0.323	0.249	0.30	107.98	15.96	352.31	16.99	14
*L2	0.08202	0.775	0.309	0.472	0.32	141.77	72.04	131.23	71.39	6.3
*S2	0.08333	1.311	0.315	-0.027	0.31	128.35	13.50	223.75	13.76	17
*ETA2	0.08507	0.367	0.320	0.163	0.30	117.63	44.42	133.60	45.87	1.3
*MO3	0.11924	0.290	0.218	-0.040	0.23	119.11	41.14	306.27	39.12	1.8
*M3	0.12077	0.248	0.214	0.052	0.23	104.24	60.93	327.88	56.25	1.3
*MK3	0.12229	0.382	0.220	0.126	0.23	126.20	37.42	358.49	36.53	3
*SK3	0.12511	0.369	0.225	0.079	0.22	136.99	33.37	78.34	33.58	2.7
*MN4	0.15951	0.235	0.174	0.062	0.20	69.66	59.31	312.99	51.64	1.8
*M4	0.16102	0.357	0.208	0.277	0.17	0.37	101.14	49.78	106.55	2.9
*SN4	0.16233	0.212	0.202	0.074	0.18	154.62	60.82	258.79	67.46	1.1
*MS4	0.16384	0.314	0.208	0.161	0.17	0.88	51.06	226.47	57.73	2.3
*S4	0.16667	0.205	0.202	0.081	0.18	154.58	63.95	116.67	70.43	1
2MK5	0.20280	0.098	0.158	-0.022	0.17	102.34	101.86	15.57	97.08	0.38
2SK5	0.20845	0.096	0.165	0.069	0.16	152.72	220.19	302.12	222.60	0.33
2MN6	0.24002	0.100	0.152	0.087	0.15	151.83	527.89	45.28	530.88	0.43
M6	0.24153	0.141	0.145	0.084	0.15	65.24	124.90	63.12	122.08	0.94
2MS6	0.24436	0.111	0.149	-0.015	0.15	133.74	84.71	281.71	84.44	0.56
2SM6	0.24718	0.071	0.148	-0.007	0.15	131.08	125.83	267.94	124.58	0.23
*3MK7	0.28331	0.108	0.096	0.048	0.10	100.76	69.57	69.81	69.85	1.3
*M8	0.32205	0.100	0.066	-0.008	0.07	148.31	46.01	10.74	43.91	2.3

ANDRILL 200-m AquaDopp tidal analysis

number of standard constituents used: 35

Points used: 11447 of 11448

percent of X var removed by fit: 61.51 %

percent of Y var removed by fit: 59.05 %

nodal corrections applied to amplitude and phase relative to center time

Using linearized error estimates

Generating prediction with nodal corrections, SNR is 2.000000

date: 16-Jul-2007

nobs = 11448, ngood = 11447, record length (days) = 39.75

start time: 25-Oct-2006 06:02:30

rayleigh criterion = 1.0

nodal corrections applied to amplitude and phase relative to center time

x0= -6.8, x trend= 0.671

var(x)= 49.4703 var(xp)= 30.4288 var(xres)= 19.0415

percent var predicted= 61.5 %

y0= 2.77, y trend= -2.96

var(y)= 67.3402 var(yp)= 39.7644 var(yres)= 27.5758

percent var predicted= 59.1 %

ellipse parameters with 95% CI estimates

tide	freq	major	emaj	minor	emin	inc	einc	pha	epha	snr
*MM	0.00151	3.789	0.393	0.443	0.34	123.29	5.30	229.02	6.05	93
*MSF	0.00282	1.925	0.309	0.632	0.42	165.39	14.41	255.38	11.29	39
ALP1	0.03440	0.274	0.410	-0.187	0.36	57.85	150.06	31.77	156.88	0.45
*2Q1	0.03571	0.636	0.404	0.016	0.37	125.61	28.40	201.83	31.08	2.5
*Q1	0.03722	1.073	0.378	0.373	0.40	40.09	21.64	164.94	20.84	8.1
*O1	0.03873	4.823	0.357	3.020	0.42	151.34	7.84	319.56	7.34	1.8e+002

*NO1	0.04027	0.703	0.431	0.399	0.34	105.17	31.20	252.53	35.32	2.7
*K1	0.04178	6.196	0.420	3.946	0.35	115.48	6.17	291.81	6.65	2.2e+002
*J1	0.04329	0.585	0.381	-0.171	0.39	138.26	38.60	96.40	37.58	2.4
OO1	0.04483	0.360	0.405	0.198	0.37	54.68	50.46	343.44	53.02	0.79
UPS1	0.04634	0.263	0.438	0.051	0.33	88.64	42.11	339.12	54.86	0.36
*EPS2	0.07618	0.533	0.247	0.154	0.28	114.25	35.10	252.65	31.67	4.7
*MU2	0.07769	0.714	0.238	-0.210	0.29	94.90	26.94	252.43	23.13	9
*N2	0.07900	0.896	0.252	0.660	0.27	121.90	48.14	240.40	47.00	13
*M2	0.08051	1.241	0.245	0.135	0.28	111.30	13.65	351.24	11.96	26
L2	0.08202	0.177	0.281	-0.117	0.24	21.00	292.29	111.99	308.39	0.4
*S2	0.08333	1.828	0.242	0.383	0.28	106.78	9.39	222.68	8.16	57
*ETA2	0.08507	0.296	0.238	0.224	0.29	93.43	103.73	119.02	98.71	1.5
MO3	0.11924	0.170	0.235	-0.026	0.29	71.49	88.95	313.88	73.01	0.52
*M3	0.12077	0.355	0.278	-0.042	0.25	32.12	43.47	91.96	48.47	1.6
*MK3	0.12229	0.276	0.241	0.124	0.28	65.42	73.78	17.03	65.97	1.3
SK3	0.12511	0.211	0.260	0.158	0.27	47.82	180.57	62.82	179.27	0.66
*MN4	0.15951	0.399	0.238	-0.027	0.25	57.57	39.19	303.76	37.13	2.8
M4	0.16102	0.132	0.258	-0.004	0.23	168.02	107.81	70.62	121.22	0.26
*SN4	0.16233	0.303	0.260	0.108	0.23	175.83	55.45	181.40	61.19	1.4
MS4	0.16384	0.168	0.228	0.089	0.26	90.23	140.12	25.06	130.36	0.54
S4	0.16667	0.211	0.229	0.036	0.26	100.26	72.98	7.49	65.14	0.84
2MK5	0.20280	0.142	0.164	0.118	0.17	141.40	277.54	313.62	274.56	0.75
2SK5	0.20845	0.057	0.163	-0.006	0.18	37.11	159.25	352.26	148.41	0.12
*2MN6	0.24002	0.113	0.102	0.075	0.11	70.01	132.96	231.01	128.41	1.2
M6	0.24153	0.085	0.100	0.000	0.11	93.43	84.84	40.70	75.45	0.72
2MS6	0.24436	0.097	0.102	0.044	0.11	68.07	96.81	6.95	91.59	0.9
*2SM6	0.24718	0.260	0.113	0.061	0.10	6.15	24.99	59.34	27.71	5.3
3MK7	0.28331	0.112	0.131	0.028	0.12	55.14	68.66	298.76	73.22	0.74
M8	0.32205	0.035	0.084	0.007	0.08	7.47	168.63	278.43	169.10	0.17

ANDRILL 300-m AquaDopp tidal analysis

number of standard constituents used: 35

Points used: 11447 of 11448

percent of X var removed by fit: 65.74 %

percent of Y var removed by fit: 55.07 %

nodal corrections applied to amplitude and phase relative to center time

Using linearized error estimates

Generating prediction with nodal corrections, SNR is 2.000000

date: 16-Jul-2007

nobs = 11448, ngood = 11447, record length (days) = 39.75

start time: 25-Oct-2006 06:02:30

rayleigh criterion = 1.0

nodal corrections applied to amplitude and phase relative to center time

x0= -4.67, x trend= 0.594

var(x)= 81.996 var(xp)= 53.9074 var(xres)= 28.0886

percent var predicted= 65.7 %

y0= 0.332, y trend= -3.35

var(y)= 105.7979 var(yp)= 58.2632 var(yres)= 47.5347

percent var predicted= 55.1 %

ellipse parameters with 95% CI estimates

tide	freq	major	emaj	minor	emin	inc	einc	pha	epha	snr
*MM	0.00151	5.588	0.730	-0.624	0.68	131.04	7.12	214.84	7.62	59
*MSF	0.00282	2.707	0.639	0.707	0.77	145.61	17.83	243.78	15.20	18
*ALP1	0.03440	0.826	0.476	-0.204	0.42	92.60	27.19	350.53	30.29	3
*2Q1	0.03571	0.644	0.431	0.132	0.47	155.07	37.60	185.09	34.97	2.2
*Q1	0.03722	0.625	0.427	-0.260	0.47	18.12	47.61	144.00	44.42	2.1
*O1	0.03873	6.182	0.434	3.486	0.46	151.92	6.08	325.37	5.87	2e+002

NO1	0.04027	0.164	0.425	-0.007	0.47	14.45	102.91	69.76	92.50	0.15	
*K1	0.04178	8.012	0.459	4.597	0.44	124.99	4.91	309.08	5.02	3.1e+002	
*J1	0.04329	0.623	0.430	0.330	0.47	22.31	58.89	280.41	56.09	2.1	
*OO1	0.04483	0.537	0.442	0.191	0.46	142.47	30.22	84.18	29.49	1.5	
UPS1	0.04634	0.380	0.455	0.021	0.44	128.99	36.85	47.47	37.80	0.7	
*EPS2	0.07618	0.747	0.390	0.065	0.52	171.07	41.90	179.91	31.52	3.7	
*MU2	0.07769	0.729	0.476	0.048	0.44	128.10	36.48	254.43	39.13	2.4	
*N2	0.07900	1.109	0.482	1.005	0.44	125.19	186.73	240.58	188.55	5.3	
*M2	0.08051	1.529	0.420	-0.071	0.50	152.04	19.34	347.74	16.38	13	
*L2	0.08202	1.009	0.390	0.326	0.52	9.43	56.58	104.05	44.90	6.7	
*S2	0.08333	1.715	0.517	0.512	0.39	76.30	15.51	233.21	19.39	11	
ETA2	0.08507	0.271	0.517	0.096	0.39	76.68	71.45	144.82	88.05	0.28	
MO3	0.11924	0.164	0.318	0.115	0.23	174.87	196.34	202.01	217.78	0.27	
*M3	0.12077	0.369	0.318	0.105	0.23	174.46	44.60	309.61	58.11	1.3	
*MK3	0.12229	0.634	0.275	0.421	0.28	47.58	50.64	47.15	50.09	5.3	
*SK3	0.12511	0.370	0.318	0.188	0.23	174.78	53.18	259.31	63.73	1.4	
MN4	0.15951	0.108	0.225	-0.048	0.22	132.09	170.44	106.42	173.45	0.23	
*M4	0.16102	0.264	0.192	0.047	0.25	174.53	60.35	196.93	47.46	1.9	
*SN4	0.16233	0.255	0.195	-0.018	0.25	14.51	57.60	335.24	45.97	1.7	
*MS4	0.16384	0.366	0.235	0.181	0.21	120.69	51.20	139.90	55.15	2.4	
*S4	0.16667	0.242	0.209	-0.027	0.23	32.12	55.99	127.46	50.21	1.3	
2MK5	0.20280	0.132	0.165	0.035	0.18	122.18	82.94	82.55	77.31	0.65	
*2SK5	0.20845	0.206	0.168	0.112	0.18	128.18	70.00	146.69	68.34	1.5	
*2MN6	0.24002	0.291	0.141	-0.094	0.17	166.99	43.92	220.38	37.29	4.3	
*M6	0.24153	0.237	0.166	0.053	0.15	61.09	43.28	253.13	48.20	2	
2MS6	0.24436	0.161	0.165	0.003	0.15	59.24	56.91	326.22	63.31	0.94	
2SM6	0.24718	0.112	0.174	0.006	0.14	96.54	73.73	358.27	91.79	0.42	
3MK7	0.28331	0.120	0.129	-0.059	0.12	103.69	87.39	168.00	89.52	0.87	
*M8	0.32205	0.089	0.087	0.080	0.08	82.31	414.42	267.40	417.55	1.1	

ANDRILL 400-m AquaDopp tidal analysis

number of standard constituents used: 35

Points used: 11447 of 11448

percent of X var removed by fit: 54.32 %

percent of Y var removed by fit: 48.21 %

nodal corrections applied to amplitude and phase relative to center time

Using linearized error estimates

Generating prediction with nodal corrections, SNR is 2.000000

date: 16-Jul-2007

nobs = 11448, ngood = 11447, record length (days) = 39.75

start time: 25-Oct-2006 06:02:30

rayleigh criterion = 1.0

nodal corrections applied to amplitude and phase relative to center time

x0= 0.4, x trend= -0.281

var(x)= 108.6751 var(xp)= 59.033 var(xres)= 49.6421

percent var predicted= 54.3 %

y0= -3.42, y trend= -2.23

var(y)= 114.631 var(yp)= 55.2668 var(yres)= 59.3642

percent var predicted= 48.2 %

ellipse parameters with 95% CI estimates

tide	freq	major	emaj	minor	emin	inc	einc	pha	epha	snr
*MM	0.00151	6.593	0.974	-1.148	0.97	137.26	8.79	210.15	8.86	46
*MSF	0.00282	2.378	0.969	1.140	0.97	134.33	33.67	193.39	33.62	6
*ALP1	0.03440	0.956	0.499	0.176	0.36	155.04	19.57	274.77	26.28	3.7
*2Q1	0.03571	1.294	0.456	-0.017	0.42	140.47	15.73	215.72	17.22	8.1
*Q1	0.03722	2.108	0.528	0.287	0.32	172.94	7.76	317.28	12.52	16
*O1	0.03873	6.292	0.469	3.361	0.40	144.42	5.14	316.80	5.60	1.8e+002

*NO1	0.04027	0.609	0.359	0.421	0.50	113.57	62.90	254.19	56.06	2.9
*K1	0.04178	7.302	0.407	4.633	0.46	127.04	6.28	315.70	5.94	3.2e+002
*J1	0.04329	0.989	0.501	-0.297	0.36	155.67	22.05	76.76	28.85	3.9
OO1	0.04483	0.426	0.504	0.072	0.36	156.88	26.08	75.32	35.98	0.71
UPS1	0.04634	0.332	0.516	0.019	0.34	163.13	32.38	45.99	49.08	0.41
*EPS2	0.07618	0.504	0.468	-0.009	0.55	122.92	64.63	221.81	55.36	1.2
*MU2	0.07769	1.020	0.443	-0.132	0.57	114.85	33.91	292.90	26.68	5.3
*N2	0.07900	1.303	0.435	0.599	0.57	112.09	35.29	251.07	29.56	9
*M2	0.08051	1.488	0.544	0.220	0.47	146.06	19.53	358.24	22.38	7.5
L2	0.08202	0.478	0.525	-0.083	0.49	139.87	103.27	252.70	109.65	0.83
*S2	0.08333	1.460	0.414	-0.059	0.59	102.72	23.10	246.56	16.24	12
ETA2	0.08507	0.156	0.443	0.047	0.57	114.94	160.67	192.85	130.99	0.12
*MO3	0.11924	0.426	0.253	0.191	0.31	105.14	48.41	87.62	42.69	2.8
*M3	0.12077	0.347	0.288	0.061	0.27	38.25	50.21	121.05	52.67	1.5
*MK3	0.12229	0.345	0.307	0.059	0.25	12.35	40.97	95.73	49.47	1.3
SK3	0.12511	0.072	0.257	-0.055	0.30	111.21	643.49	103.69	617.86	0.077
MN4	0.15951	0.140	0.204	-0.093	0.22	130.06	202.62	158.03	197.26	0.47
*M4	0.16102	0.296	0.192	0.125	0.23	57.71	61.42	29.64	54.42	2.4
*SN4	0.16233	0.301	0.163	0.152	0.25	92.82	69.62	39.31	54.59	3.4
*MS4	0.16384	0.330	0.163	0.131	0.25	92.51	54.94	116.33	40.67	4.1
*S4	0.16667	0.207	0.164	0.025	0.25	86.28	69.80	243.94	46.37	1.6
2MK5	0.20280	0.137	0.209	0.013	0.18	27.42	74.97	331.95	85.85	0.43
2SK5	0.20845	0.130	0.174	0.007	0.22	102.83	85.72	263.45	69.00	0.56
2MN6	0.24002	0.142	0.159	0.025	0.16	133.96	75.37	189.88	75.47	0.8
M6	0.24153	0.124	0.161	-0.016	0.16	67.13	83.14	231.13	85.26	0.59
*2MS6	0.24436	0.202	0.157	-0.020	0.16	17.81	50.01	15.06	48.54	1.7
*2SM6	0.24718	0.166	0.156	0.018	0.16	175.41	58.69	234.42	56.61	1.1
3MK7	0.28331	0.048	0.108	-0.022	0.11	113.05	186.14	102.96	186.04	0.19
M8	0.32205	0.058	0.082	-0.019	0.08	103.39	110.99	306.50	111.47	0.49

ANDRILL 480-m AquaDopp tidal analysis

number of standard constituents used: 35

Points used: 11447 of 11448

percent of X var removed by fit: 46.00 %

percent of Y var removed by fit: 51.07 %

nodal corrections applied to amplitude and phase relative to center time

Using linearized error estimates

Generating prediction with nodal corrections, SNR is 2.000000

date: 16-Jul-2007

nobs = 11448, ngood = 11447, record length (days) = 39.75

start time: 25-Oct-2006 06:02:30

rayleigh criterion = 1.0

nodal corrections applied to amplitude and phase relative to center time

x0= 2.72, x trend= 3.47

var(x)= 83.1137 var(xp)= 38.2316 var(xres)= 44.8822

percent var predicted= 46.0 %

y0= -4.9, y trend= -1.86

var(y)= 113.7949 var(yp)= 58.12 var(yres)= 55.6749

percent var predicted= 51.1 %

ellipse parameters with 95% CI estimates

tide	freq	major	emaj	minor	emin	inc	einc	pha	epha	snr
*MM	0.00151	7.686	0.365	-0.448	0.43	141.40	3.20	215.10	2.74	4.4e+002
*MSF	0.00282	2.283	0.410	0.347	0.38	132.34	10.00	227.72	10.64	31
*ALP1	0.03440	1.314	0.763	0.405	0.69	144.24	29.54	257.16	32.08	3
*2Q1	0.03571	1.555	0.732	0.635	0.72	136.28	29.48	217.89	29.78	4.5
*Q1	0.03722	1.388	0.791	-0.545	0.66	152.73	30.28	313.23	34.65	3.1
*O1	0.03873	5.158	0.630	2.197	0.81	108.98	9.89	298.07	8.31	67

*NO1	0.04027	0.972	0.736	0.347	0.72	137.09	32.18	243.75	32.76	1.7
*K1	0.04178	6.392	0.605	3.192	0.83	96.59	9.50	300.70	7.88	1.1e+002
*J1	0.04329	1.839	0.813	-0.526	0.63	161.35	20.12	70.76	24.98	5.1
OO1	0.04483	0.512	0.752	-0.250	0.70	38.58	59.44	147.27	62.06	0.46
UPS1	0.04634	0.549	0.730	0.505	0.72	44.30	367.48	63.05	367.71	0.56
*EPS2	0.07618	0.720	0.579	0.259	0.48	73.47	49.89	101.26	57.51	1.5
*MU2	0.07769	1.478	0.525	-0.574	0.54	138.36	27.38	275.07	26.86	7.9
*N2	0.07900	1.829	0.581	0.011	0.48	104.82	15.62	238.59	18.94	9.9
*M2	0.08051	1.020	0.491	-0.546	0.57	156.48	51.26	347.73	47.18	4.3
L2	0.08202	0.467	0.519	0.076	0.54	38.57	116.01	326.57	110.77	0.81
*S2	0.08333	1.146	0.587	0.171	0.47	88.08	24.43	250.23	30.20	3.8
ETA2	0.08507	0.536	0.586	-0.142	0.47	84.11	38.86	159.42	46.92	0.84
*MO3	0.11924	0.364	0.351	-0.127	0.39	16.82	65.02	177.49	59.72	1.1
M3	0.12077	0.370	0.392	0.293	0.35	73.48	205.25	339.44	210.47	0.89
MK3	0.12229	0.137	0.351	0.003	0.39	164.74	153.15	172.24	136.85	0.15
SK3	0.12511	0.341	0.396	-0.136	0.35	91.17	68.16	80.79	74.94	0.74
*MN4	0.15951	0.338	0.232	0.148	0.21	25.31	53.11	168.23	56.68	2.1
*M4	0.16102	0.426	0.226	0.095	0.22	142.51	33.88	70.47	35.11	3.6
*SN4	0.16233	0.447	0.213	0.382	0.23	120.85	143.17	354.34	141.56	4.4
*MS4	0.16384	0.414	0.214	-0.096	0.23	122.90	35.34	155.94	33.42	3.7
*S4	0.16667	0.296	0.212	-0.170	0.23	62.45	74.87	305.85	71.66	2
*2MK5	0.20280	0.263	0.229	-0.162	0.20	52.21	81.54	353.30	87.52	1.3
*2SK5	0.20845	0.342	0.263	-0.091	0.15	106.97	26.28	293.81	42.87	1.7
*2MN6	0.24002	0.292	0.193	0.069	0.15	72.78	36.63	195.17	45.51	2.3
*M6	0.24153	0.222	0.194	0.041	0.15	75.57	45.73	76.29	58.22	1.3
*2MS6	0.24436	0.172	0.167	-0.048	0.18	142.20	71.50	236.23	67.22	1.1
*2SM6	0.24718	0.200	0.147	0.040	0.20	8.19	61.07	209.64	46.99	1.8
*3MK7	0.28331	0.252	0.138	-0.076	0.12	105.86	32.53	74.23	35.87	3.3
*M8	0.32205	0.190	0.090	0.017	0.09	30.47	33.07	97.60	31.75	4.5