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Revisions to a Modelling System for Tides in the Canadian Arctic Archipelago

by

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Abstract

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Improvements were made to the bathymetry of the Dunphy et al (2005) tidal model for the Canadian Arctic Archipelago. The model solutions were recalculated and the model validation redone. The biggest improvement is in the vicinity of Fury and Hecla Strait where the error in the K1 tide is reduced by 10 cm and the overall time series prediction error is reduced by 7 cm. Changes in error statistics in other regions are smaller (generally less than 1 cm). Overall, The *rms* error of the tidal constituents, when averaged across all the observations, is about 13 cm for M2 and (5, 7, 5, 2) cm for (N2, S2, K1, O1) respectively. The normalized rms error for M2 is about 13% and between 16-30% for the other four constituents. The regional tidal prediction errors range from 8-19 cm. These errors vary substantially from region to region, reflecting the regional tidal amplitudes, and from station to station. The tidal simulations are of sufficient quality for many applications. The fields ('arctic8d') are available over the internet as part of the WebTide tidal prediction package (www.mar.dfo-mpo.gc.ca/science/ocean/home.html).

Résumé

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Des Améliorations ont été apportées la bathymétrie du modèle de marée de l'archipel canadien arctique de Dunphy et al (2005). Les solutions du modèle ont été recalculées et la validation du modèle refaite. La plus grande amélioration se situe près du détroit de Furie et Hécla où l'erreur en marée K1 a été réduite de 10 cm et où l'erreur de prédiction des séries temporelles a été réduite de 7 cm. Les changements dans les statistiques des erreurs des autres régions sont plus faibles (en général moins de 1 cm). Globalement, les erreurs rms pour chaque constituantes de marée, lorsque moyennées sur toutes les observations, sont de 13 cm pour M2 et (5, 7, 5, 2) cm pour (N2, S2, K1, O1) respectivement. L'erreur rms normalisée pour M2 est de 13% et entre 16-30% pour les autres quatre constituantes. L'erreur de prédiction rgionale de marée varie entre 8-19 cm. Ces erreurs varie substantiellement d'une région à l'autre, refletant les amplitudes régionales de marée, et de station à station. Les simulations de marée sont de qualité suffisante pour des nombreuses applications. Les champs ('arctic8d') sont disponibles sur l'internet comme composante du logiciel WebTide de prédiction de marée (www.mar.dfo-mpo.gc.ca/science/ocean/home.html).

1 Introduction

This report documents the impacts of recent changes to the bathymetry in the tidal model of the Canadian Arctic Archipelago (Fig. 1) described by Dunphy et al. (2005). In the fall of 2007 analysis of the modelled tidal currents revealed that the water depths were much too shallow in several places, including Fury and Hecla Strait and Hell Gate. These depths were corrected and the modelling system described by Dunphy et al. (2005) (including the assimilation procedure) was used to generate a new set of fields for the five major constituents (M2, N2, S2, K1, O1).

The comparison with the observations was completely redone and is reported here. The primary improvement is a 10 cm reduction in the K1 elevation error in the Arctic Southwest region (the vicinity of Fury and Hecla Strait) and a 7 cm reduction in the tidal time series prediction error.

2 Methods

2.1 Modelling techniques

The modelling techniques are identical to those reported in Dunphy et al. (2005). The model depths were corrected in places where they were much too shallow and then the modelling system, including the assimilation procedure, was used to generate a new set of fields for the five major constituents (M2, N2, S2, K1, O1).

2.2 The mesh

The process of correcting the depths also involved adding a few nodes so the name of the the mesh has been changed to ‘arctic8d’ (from ‘arctic8c’). The number of nodes in ‘arctic8d’ is 17359 and the number of elements is 29358. The model depths for two portions of the Archipelago are shown in Fig. 2. The bathymetry changed by more than ten meters in only three regions: Hell Gate, Fury and Hecla Strait, and Lambert Channel (Fig. 3).

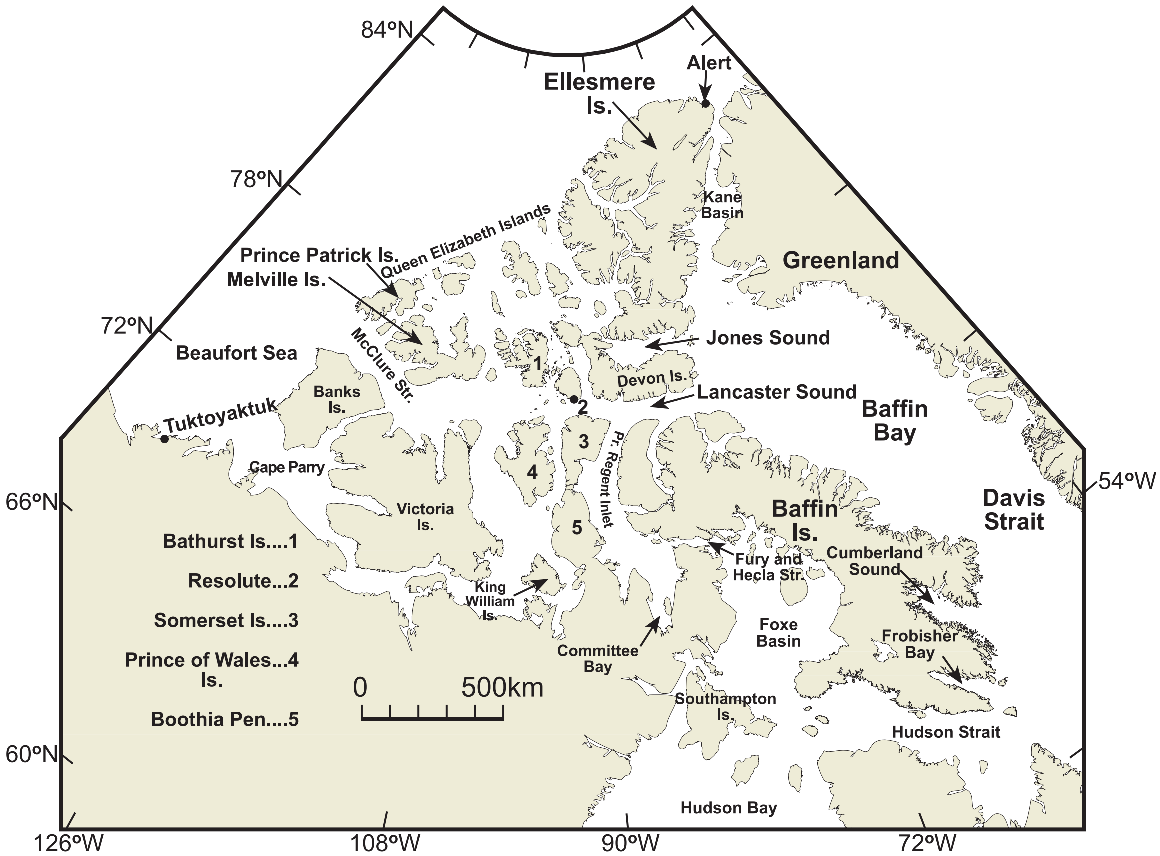

Figure 1: The Arctic Archipelago.

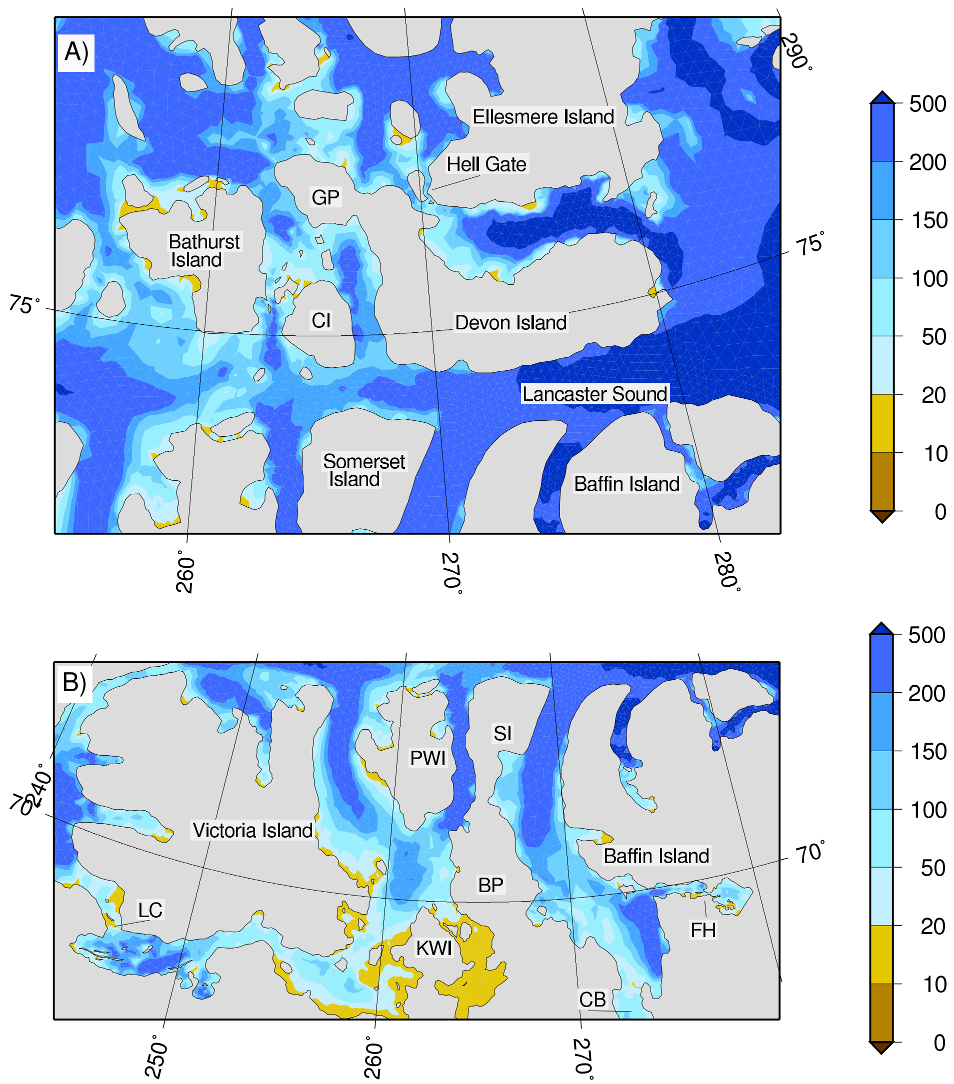

Figure 2: The water depths for the central (A) and southern (B) regions of the Archipelago. The location abbreviations are: BP - Boothia Peninsula; CB - Committee Bay; CI - Cornwallis Island; GP -Grinnell Peninsula; KWI - King William Island; LC - Lambert Channel; PWI- Prince of Wales Island; SI - Somerset Island. Hell Gate is the channel to the east of the island between Devon and Ellesmere Islands and Cardigan Strait is to the west. Penny Strait and Queens Channel are between the Grinnell Peninsula (GP) and Bathurst Island. Dundas Island is due south of the GP label.

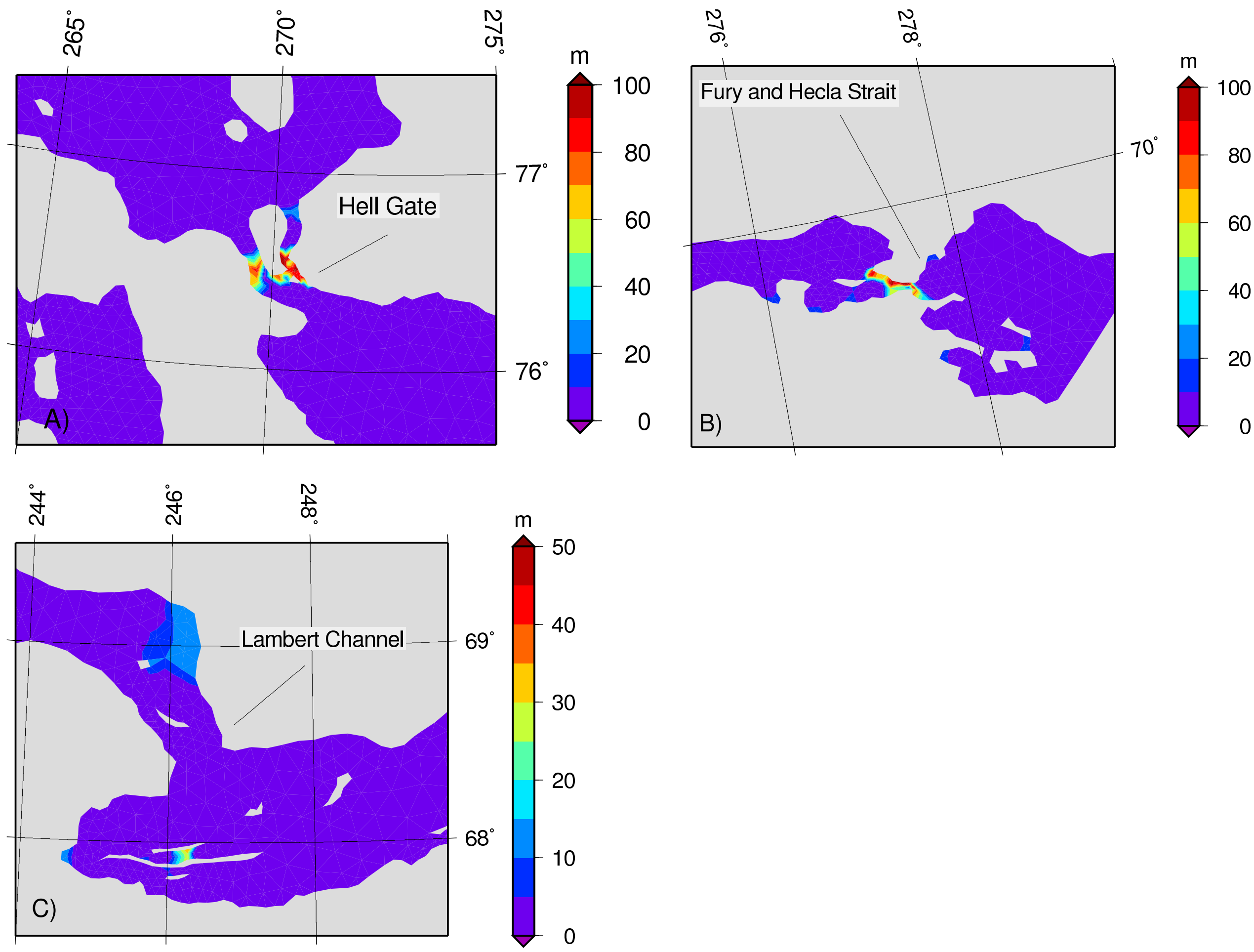

Figure 3: The difference between the old bathymetry (Arctic8c) and the revised bathymetry (Arctic8d) is shown for Hell Gate (A), Fury and Hecla Strait (B) and Lambert Channel (C, note different colour scale), the only regions where the model bathymetry was modified by more than 10m.

2.3 Error metrics

The model-data comparison is also identical to Dunphy et al. (2005). We repeat here the definition of the error metrics and the map of the regions that were used to compute regional statistics.

The first error metric was designed to measure how well each constituent was modelled. At each station (for each constituent) the error is defined as the magnitude of the observed constituent minus the modelled constituent evaluated in the complex plane:

$$\text{Error1} = |A_o e^{\phi_o} - A_m e^{\phi_m}| \quad (1)$$

where A_o, ϕ_o are the observed amplitude and phase and A_m, ϕ_m are the modelled values. This combines both elevation and phase error into a single error measure. To evaluate the solutions for one constituent over broader areas the root-mean-square (*rms*) values over multiple stations were calculated. This was done to evaluate whether the assimilation improved the solutions at the stations that were not assimilated and to estimate regional error statistics. A normalized version of this error was calculated by dividing by the observed amplitude (Error1$/A_o$). Regional averages (*rms*) of this normalized error were also calculated.

The second error metric was designed to measure the quality of tidal predictions made using the tidal solutions. At each station, tidal predictions for one year were made using the observed and modelled constituents. The prediction error was defined as

$$\text{Error2} = rms(T_{obs} - T_{mod}) \tag{2}$$

where T_{obs} and T_{mod} were the elevation time series constructed from the observed and modelled constituents. A relative error was also computed where the prediction error was scaled by the size of the observed time series:

$$\text{Relative Error2} = \frac{rms(T_{obs} - T_{mod})}{rms(T_{obs})} \tag{3}$$

The tidal synthesis was done using `T_PREDIC` which is part of the `T_TIDE` package (Pawlowicz et al., 2002).

The prediction error comparison was done for three cases. In the first, called 5 *vs.* 5, the tidal synthesis for both the observed and modelled tides was done using the five tidal constituents (M2,N2,S2,K1,O1). In the second, called 5 *vs. all*, the observed time series was constructed using all the available constituents. The first is a measure of how well the five constituents were modelled, the second is a measure of the expected error relative to the complete tidal spectrum. The third case, 5 *vs. signal*, was applied to data that was available as a water level time series. In this case, a time series was constructed from the model solution using `T_PREDIC` of the same duration and start date as the observed time series. The prediction error metric (2) was then applied using the constructed time series and the observed signal (with the mean removed). This 5 *vs. signal* measures how large the error is between the model and the water level.

There are large variations in the amplitudes and phases of the tides in the Archipelago. For example the M2 ranges from a few centimeters in the west along the Arctic shelf to over 1 m in the eastern areas. Error statistics in areas of large tides are not likely relevant in areas of small tides. Therefore for the purposes of reporting model error statistics, we chose to divide the Archipelago into seven regions. Figure 4 shows the partitioning of the model domain into regions which are shown in more detail in Appendix B (Figures 12-18.)

3 Data Sources

The data sources are identical to those reported in Dunphy et al. (2005), with the exception of Station B1489 in Barrow Strait (Table 2), which was found to have data

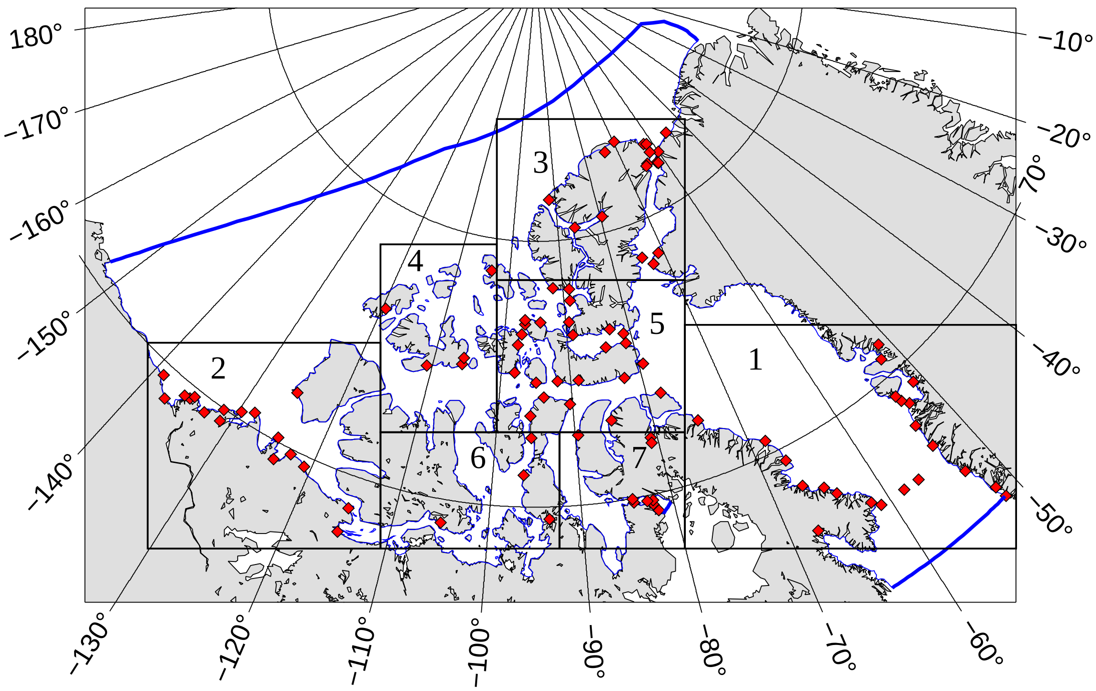

Figure 4: Map of the Arctic Archipelago showing the locations of the model open boundaries (thick blue lines) and the tide/pressure gauge distribution (red diamonds). The boxes labeled 1-7 are subregions for which statistics are calculated. The subregion names are given in Table 1.

Number	Region
1	Baffin Bay
2	Arctic West : Amundsen Gulf and Victoria Island
3	Arctic North : Ellesmere Island and Nares Strait
4	Arctic Northwest : Prince Patrick Island, Melville Island and Amund Ringnes Island
5	Arctic Central : Barrow Strait, Lancaster Sound and Jones Sound
6	Arctic South Central : M'Clintock Channel and Somerset Island
7	Arctic Southeast : Baffin Island North

Table 1: The names of the regions in Fig. 4 used to provide summary statistics

Station Name	Station ID	Date	Duration
Barrow Strait (1)	B1489	Aug 2003- Aug 2004	358 days
Barrow Strait (2)	B1491	Aug 2003- Aug 2004	359 days
Resolute	B1492	Aug 2003- Jul 2004	353 days
Alert	M3765	Dec 2002- Jul 2004	589 days
HOLMAN	M6380	Dec 2003- Jul 2004	589 days
Tuktoyaktuk	M6485	Aug 2003- Jul 2004	341 days

Table 2: Additional tide/pressure gauge data used for model validation.

Tide	Assimilation			Validation			All
	prior	1^{st}	8^{th}	prior	1^{st}	8^{th}	8^{th}
M2	52.73	14.68	10.42	67.76	20.69	16.23	13.44
N2	9.22	2.81	2.35	12.47	6.49	6.22	4.68
S2	20.83	7.68	5.07	25.91	11.85	9.45	7.41
K1	19.56	6.81	5.21	24.42	7.72	5.78	5.49
O1	7.67	2.98	1.97	10.90	4.87	2.80	2.39

Table 3: *rms* value of Error1 for the prior, iteration 1 and iteration 8. The prior is the *rms* amplitude of the observations as there is no prior model solution (i.e. the model solution is set to zero in Error1). The 'Assimilation' columns were computed using the 54 assimilation stations, the 'Validation' columns were computed using the 47 validation stations, and 'All' represents the combination of both data sets.

quality issues. We have substituted it for a longer time series from a moored CTD at the same location, about 50 m higher in the water column.

4 Results

The assimilation loop was run eight times by which point the solutions were no longer improving. To evaluate the assimilation procedure we consider the basic error measure (1) averaged over the assimilation stations and the validation stations. The results in Table 3 show that the first iteration of the assimilation system captures most of the tidal signal. By the final iteration about three quarters of the signal is being captured.

The assimilation process reduced the M2 error at the assimilated stations by over 40 cm relative to the observed M2 amplitude (recall that there was no prior estimate of the solution), the N2 by 6 cm, the S2 by 15 cm, the K1 by 15 cm and the O1 by 5 cm. The improvement at the validation stations (not used in the assimilation) was as good or better. For the validation stations it is a bit higher, in the 0.13-0.33 range. This demonstrates that the assimilation procedure is not compromising the overall solution in order to reduce the

Tide	Normal Error		
	Assimilation	Validation	All
M2	0.124	0.127	0.126
N2	0.163	0.327	0.280
S2	0.119	0.238	0.196
K1	0.172	0.150	0.160
O1	0.203	0.162	0.178

Table 4: *rms* error for iteration 8. This is the *rms* value of each stations's normalised complex error.

error at the assimilation stations (within the limited established by the inversion parameters).

For stations used in the assimilation, the desired accuracy, E_{rms}, of 6 cm (see Dunphy et al. (2005)) was achieved for all constituents except M2 where the demand for smoothness has limited the accuracy. A value of E_{rms} less than 6 cm might be more appropriate for the other four constituents.

Table 4 shows the normalized values of the error after the 8^{th} iteration. For the assimilated stations, the normalized error is in the range 0.12-0.20 for each constituent.

The maps of amplitude and phase for each of the five modelled constituents are shown in Figures 5-9. Note that the colour scale is adjusted from figure to figure. The semi-diurnal tides all show an amphidromic system in Baffin Bay and large amplitude in Cumberland Sound. A feature of the M2 tide along the Arctic shelf (Tuktoyaktuk to Alert) is that it starts at about 12 cm in magnitude at Tuktoyaktuk, decreases to about 1 cm at Kleybolt Peninsula (station 6704) on the north coast of Ellesmere Island and then increases to 20 cm at Alert. The M2 solution captures the general character of this feature, but does not achieve the very low values.

The two diurnal tides are generally small with an amplification in the Gulf of Boothia (east of the Boothia Peninsula and south of Prince Regent Inlet). The diurnal amplification in the Gulf of Boothia is much smaller in the new solutions than in Dunphy et al. (2005). The deeper water in Fury and Hecla Strait has reduced the resonance in the region.

The bulk validation metrics do not provide information about the quality of the solutions at a particular station or over a given region. The amplitude and phase errors and the combined error metric (1) are tabulated for each constituent for each station in Appendix B. The tables are organized by region. Regional averages for amplitude, error and relative error are reported in the tables, however, given the large variability in tidal phase in each of the regions, it does not make sense to compute regional averages for phase.

The regional summaries of the error metric for the new solutions are presented in Table 5 and can be compared with the ones from Dunphy et al. (2005) in Table 6. Overall the

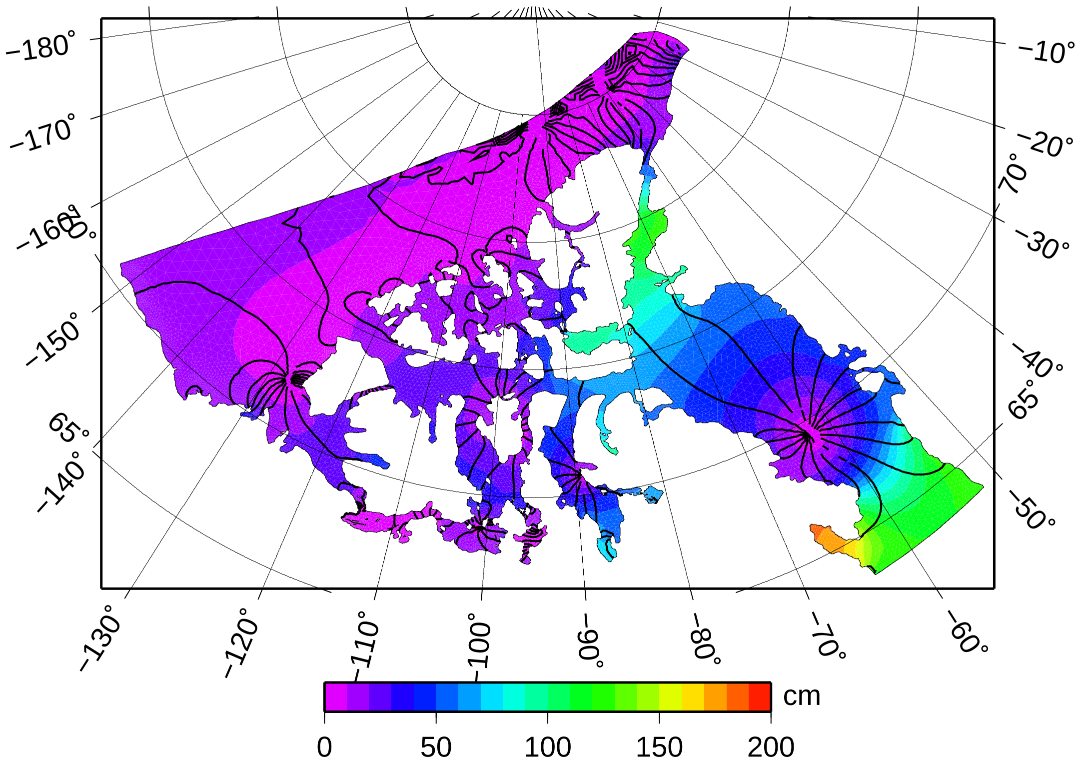

Figure 5: The M2 elevation solution. Phase lines are shown at 20 degree contours. It appears than the phase contour interval in Dunphy et al. (2005) was 45 degrees not 20 degrees as claimed.

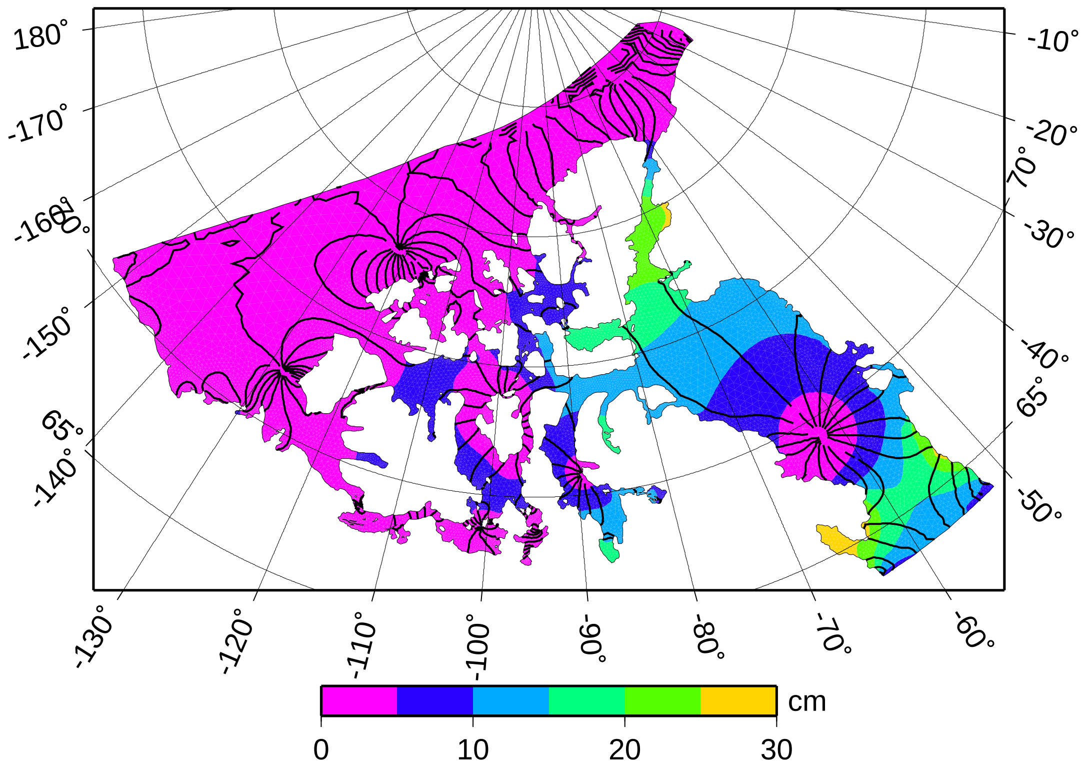

Figure 6: The N2 elevation solution.

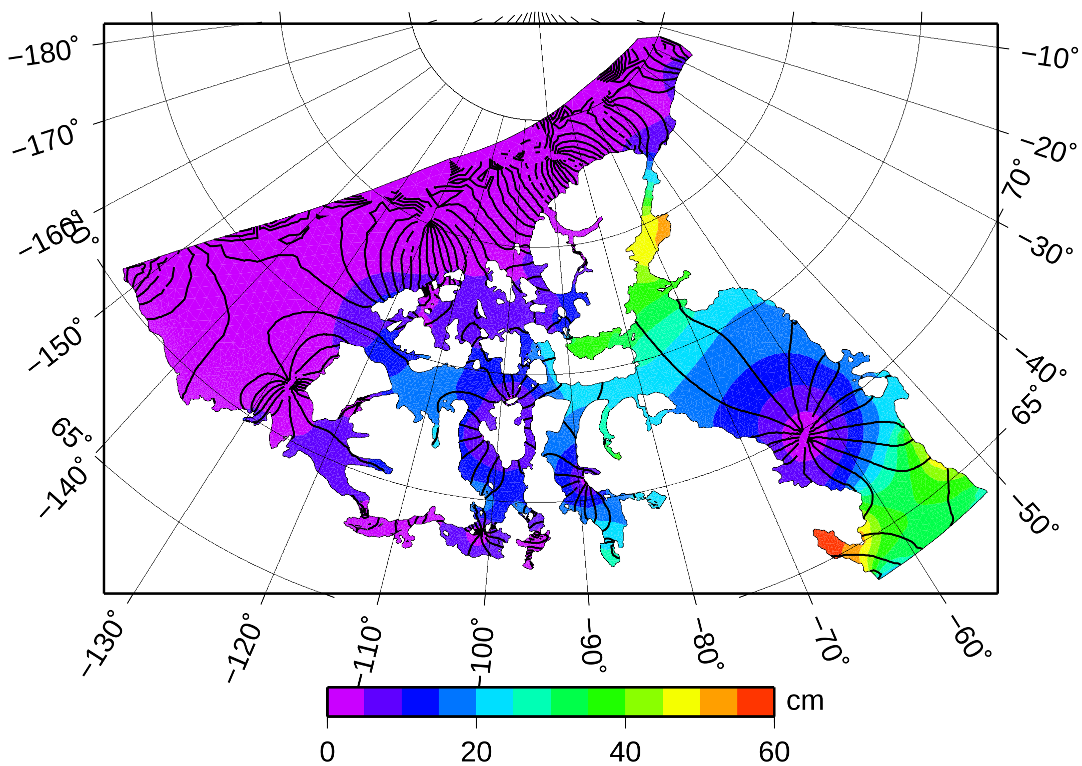

Figure 7: The S2 elevation solution.

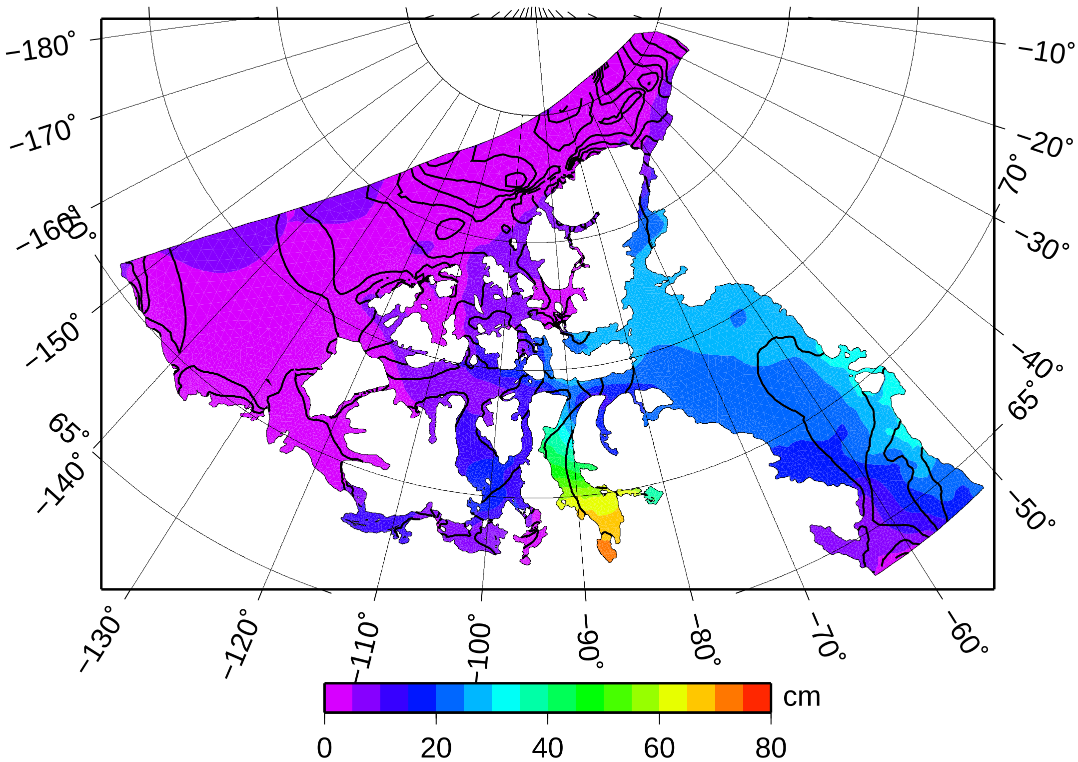

Figure 8: The K1 elevation solution.

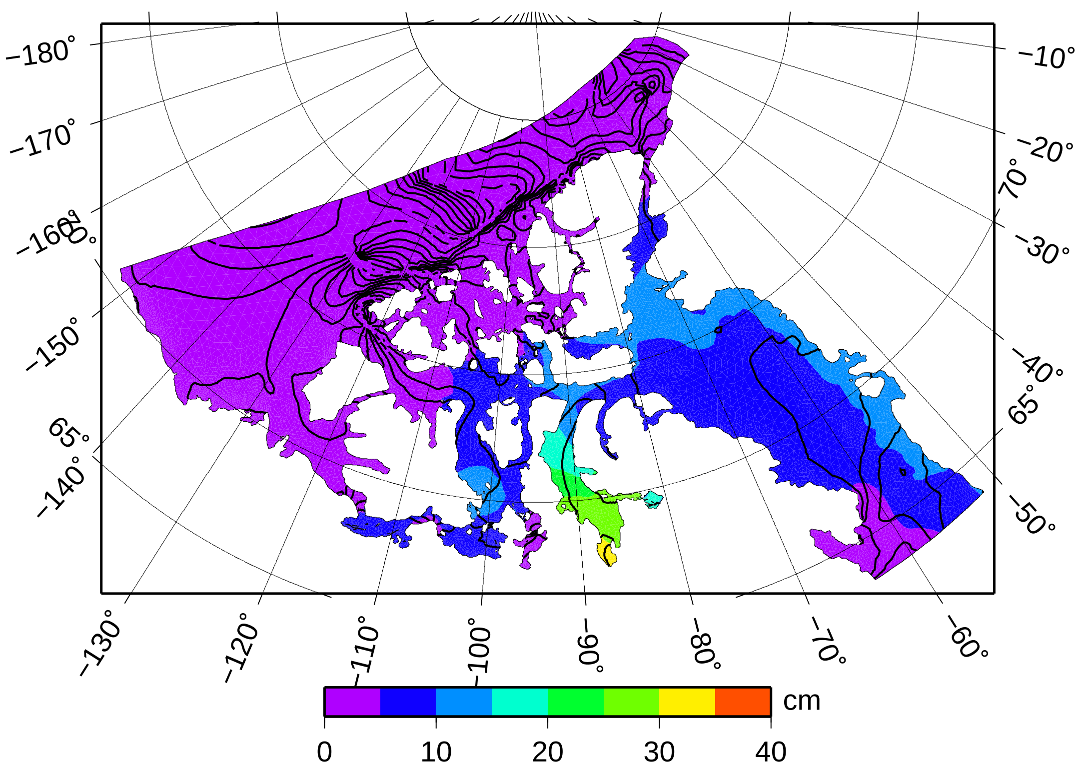

Figure 9: The O1 elevation solution.

Region	M2 (cm)	N2 (cm)	S2 (cm)	K1 (cm)	O1 (cm)
Baffin Bay	16.3	10.3	12.6	6.9	2.6
Arctic West	13.7	1.8	3.4	3.8	1.9
Arctic North	14.7	4.0	6.4	3.7	2.3
Arctic Northwest	7.4	1.5	3.9	4.8	2.2
Arctic Central	11.8	2.1	5.3	5.2	2.0
Arctic South Central	7.6	1.0	2.4	3.4	2.4
Arctic Southeast	11.4	4.9	5.7	8.5	3.7

Table 5: Regional comparison using Error 1 for each constituent.

Region	M2 (cm)	N2 (cm)	S2 (cm)	K1 (cm)	O1 (cm)
Baffin Bay	16.4	10.1	12.3	7.6	2.7
Arctic West	12.8	2.2	3.3	3.7	2.1
Arctic North	14.9	3.7	6.0	3.8	2.4
Arctic Northwest	7.4	1.6	3.6	5.1	2.1
Arctic Central	12.1	2.4	5.3	5.1	2.4
Arctic South Central	6.9	0.8	3.2	3.7	2.4
Arctic Southeast	14.0	5.1	7.0	18.8	7.5

Table 6: Regional comparison using Error1 for each constituent from Dunphy et al. (2005).

regional M2 errors remain in the 7-17 cm range. For the other constituents the regional errors are in the 2-7 cm range, with the exception of N2, S2 in Baffin Bay, and K1 in the Southeast (recall the large diurnal tides in the Gulf of Boothia).

The largest improvement, relative to Dunphy et al. (2005), is in the ‘Arctic Southeast’ region where K1 has improved by 10.3 cm, O1 by 3.8 cm and M2 by 2.6 cm. This reflects one of the important changes in the mesh, the substantial increase in water depth of Fury and Hecla Strait. There are changes in the other regions and they are not always an improvement. For example the M2 error for the ’Arctic Central’ region increases from 6.9 to 7.6 cm. However the changes in the regional average errors are generally small and always less than 1 cm. At some stations the errors have changed by more than 1 cm but increases at one location are balanced by decreases at another so that the regional errors did not change very much.

The overall quality of the solutions for predicting the tides was estimated using the prediction errors defined by (2) and (3) in Section 2. The station by station prediction errors are tabulated in Appendix C and regional averages are given in Table 7. For the Greenland stations, the results for 5 *vs.* 5 and 5 *vs. all* are identical because only four constituents were available (M2, S2, K1, O1).

Overall, the 5 *vs.* 5 errors are the in the range 6-18 cm and the biggest change relative to Dunphy et al. (2005) is the 6 cm improvement for ‘Arctic Southeast’. The 5 *vs. all* errors

Region	**5 vs 5**		**5 vs all**	
	cm	norm	cm	norm
Baffin Bay	17.8	0.43	18.9	0.43
Arctic West	10.5	0.92	12.6	0.96
Arctic North	13.2	0.82	14.7	0.79
Arctic Northwest	7.1	0.43	8.1	0.45
Arctic Central	10.1	0.25	12.7	0.30
Arctic South Central	6.4	0.67	7.9	0.71
Arctic Southeast	11.7	0.21	17.9	0.30

Table 7: Regional prediction error (using the Error2 metric). The normalized error (norm) is the *rms* regional value of the station by station normalized error.

are slightly larger at 8-19 cm. This indicates that the five tidal constituents include most of the tidal variability. The exception is the Arctic Southeast where the 6 cm increase in the error suggests that some important tidal constituents were not modelled. Closer inspection of the tide gauge data in that region reveals that the MM and NO1 constituents contribute a significant percentage to the total signal. However, the contribution is inconsistent across the stations in the region, ranging from 0 to 19%. This suggests that the route to improved tidal modelling is better modelling of the five constituents rather than increasing the number of constituents.

The two regions with the highest quality simulations are the Arctic Central region (Barrow Strait) and the Arctic Southeast. In both cases the normalized error for 5 *vs. all* is about 0.3. The regions with small tides, Arctic West, North, and South Central have large normalized errors (0.7 - 1.0). Baffin Bay and Arctic Northwest are intermediate with normalized errors in the range 0.4-0.5, However, in all cases the normalized error is < 1 indicating that using the model is better than using nothing. However there are individual stations where the prediction error is > 1.

The lowest quality region is Arctic West with normalized errors close to 1. However investigation of Tables 15 and 22 shows that not all the individual station comparisons are bad. Five stations have 5 *vs.* 5 predictions errors greater than 1 and 12 have 5 *vs.* 5 errors between 0.2 and 1. This suggests that improvements may be possible with improved resolution of the coastline and bathymetry.

The prediction errors for the additional stations are tabulated in Table 8. Although 5 *vs. signal* error is still high (30 cm) the 5 *vs. all* error at B1489 is much improved compared to Dunphy et al. (2005) because the observed time series was replaced with a better quality time series. The 5 *vs. all* errors are in the 6-20 cm range and consistent with the regional analysis. The prediction error relative to the entire sea level (or pressure) signal ranges from about 1-10 cm larger than when compared to the tides. The exception is M6485 (Tuktoyaktuk) where there is clearly a large non-tidal signal.

The results of Padman and Erofeeva (2004) provide the opportunity for a model

Station	5 *vs. all*(cm)	*rms*(all) (cm)	5 *vs. signal*(cm)	*rms*(signal) (cm)
M3765	7.2	19.0	11.9	21.3
M6380	13.8	17.0	17.1	19.8
M6485	5.2	8.6	21.7	22.7
B1489	19.7	50.6	29.5	55.2
B1491	12.3	56.5	13.4	56.8
B1492	12.4	40.0	14.0	40.5

Table 8: Prediction Errors for the additional stations: 5 *vs. all* is as before; *rms*(all) is the *rms* amplitude of the observed tidal time series (reconstructed from the constituents); 5 *vs. signal* is the *rms* error found when using the modelled tides to predict the observed pressure signal (tides plus everything else) with the mean removed; *rms*(signal) is the *rms* amplitude of the observed signal. Thus 5 *vs. signal* is the expected error found using the model to predict observed sea level at the stations and *rms*(signal) is the *rms* sea level (or subsurface pressure) variability at each location.

Constituent	AODTM	AOTIM	Arctic8d
Baffin Bay			
M2	14.5	11.8	14.8
N2	NA	NA	3.8
S2	6.5	2.5	7.3
K1	7.6	2.9	3.7
O1	2.6	1.7	1.8
Nares Strait			
M2	4.2	3.5	3.7
N2	NA	NA	1.1
S2	2.2	1.9	1.6
K1	1.6	1.1	1.3
O1	0.7	0.3	1.2

Table 9: Comparison of the errors in our Arctic8d solutions with the model of Padman and Erofeeva (2004) (who did not compute an N2 component). AODTM is the dynamics only model of Padman and Erofeeva (2004) and AOTIM is the assimilation model. The errors for Arctic8d were assessed using stations that corresponded visually to those shown on the map in Padman and Erofeeva (2004). The error metric used is that of Padman and Erofeeva (2004) which is $1/\sqrt{2}$ smaller than the peak error of Error1 (1) as tabulated in Appendix D.

intercomparison. They report on a tidal model of the entire Arctic Ocean with 5 km resolution that includes good solutions in the Archipelago. For a rough comparison of their solutions with ours we have computed regional errors using approximately the same stations as Padman and Erofeeva (2004) for two of their regions: Baffin Bay (their region 6) and Nares Strait (their region 7). The identification of common locations was not precise, we did a visual inspection of our map and theirs. The stations (and errors) used from our results are listed in Appendix D.

The comparison is shown in Table 9. The AODTM solutions of Padman and Erofeeva (2004) were computed using a tidal model and their best boundary conditions at the edges of the Arctic Ocean. The solutions reported here (Arctic8d) are generally as good or better than the AODTM solutions. The AOTIM solutions are an assimilation that combines the AODTM solution with corrections in the model interior related to the model-data misfit. This assimilation scheme is different from ours because we use the model-data misfit to modify the boundary conditions and then compute the new solution using the tidal model. Therefore, we do not expect to match the AOTIM solutions, and it is not surprising that our Arctic8d solutions are generally a little worse than the AOTIM solutions.

The station errors listed in Appendix D show that our errors are dominated by large errors at few locations. A more careful evaluation of which stations were used by Padman and Erofeeva (2004) may indicate locations where our model is performing particularly badly or where the observations are incorrect.

5 Tidal currents in Barrow Strait

For the comparison of the observed and modelled tidal ellipses the ADCP data was depth-integrated below 10 m; data above 10 m was rejected following RDI's standard echo intensity quality criterion. The locations of the ADCP moorings in Barrow Strait are shown in Figure 10. The records at A1438 and A1439 were merged (A1439_39) to provide coverage over the water column at that location. The comparison of the observed and modelled tidal ellipse parameters for M2 and K1 are tabulated in Table 10, and the rest are tabulated in Appendix E (Table 30). For M2 and K1 the major axis is well modelled (within 1 or 2 cm/s) and the inclination of the ellipse is also reasonably well modelled (generally the errors are less than about 10°). The exceptions are the 3 cm/s error in K1 amplitude at A1438_39 and the 20° inclination error in M2 at A1445. The magnitude of the minor axis (or eccentricity) is less well modelled.

The observed M2 phases show more variability across the strait than the modelled ones (note A1443 in particular). In addition there is a mean bias of about 50°. Even ignoring A1443, the M2 phase differences are much larger than can be attributed to the ten minute drift over one year that occurred with some of the instruments. The K1 phase errors are much smaller, ranging from 1-30°, indicating that instrument failure or a methodological issue are unlikely to blame for the poor M2 phase agreement. The phase differences require further investigation.

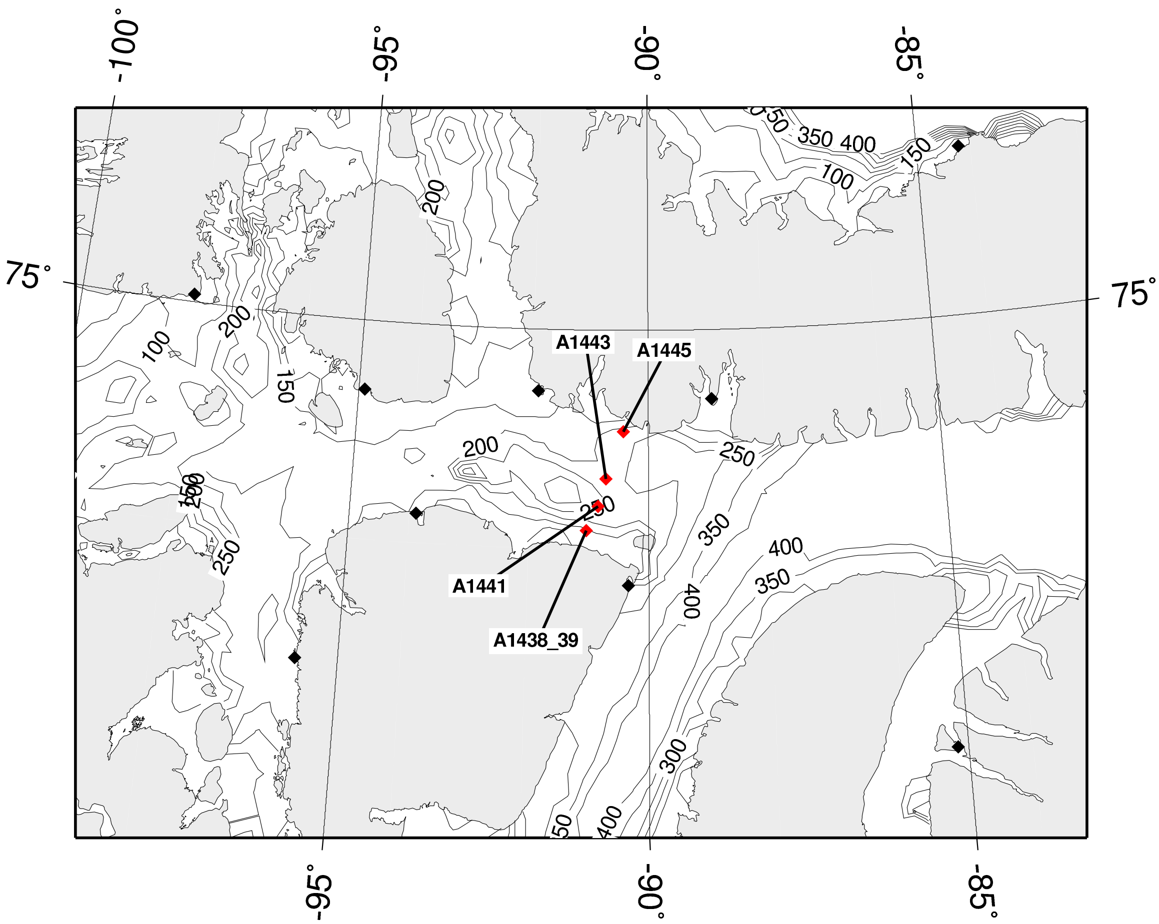

Figure 10: Map of Barrow Strait showing the locations of the ADCP moorings. The black diamonds are the tide gauge locations.

Stat #	Major		Eccentricity		Inclination		Phase	
	obs	mod	obs	mod	obs	mod	obs	mod
M2								
A1438_39	8.9	8.6	-0.079	-0.022	167.3	162.1	160.5	208.3
A1441	8.9	8.5	-0.168	-0.075	172.8	168.0	146.2	208.6
A1443	9.8	9.1	-0.137	-0.080	167.0	174.0	83.2	205.9
A1445	9.3	8.4	0.013	-0.343	160.8	180.3	153.2	183.8
K1								
A1438_39	9.0	12.1	0.237	0.038	160.5	157.9	328.4	341.4
A1441	11.8	11.9	-0.044	-0.073	163.0	159.1	354.3	351.7
A1443	12.2	11.7	-0.206	-0.157	167.4	165.4	328.9	351.9
A1445	10.2	10.6	0.059	-0.039	158.5	160.2	314.0	315.5

Table 10: Tidal current comparison for M2 and K1. The major axis is the maximum tidal current (cms^{-1}). Eccentricity (dimensionless) is the ratio between the semi-minor axis and the semi-major axis, and is negative if the ellipse is traversed clockwise. The inclination is the angle in degrees of the major axis with the x (east) axis measured counterclockwise (the mathematical convention). The phase is the timing of the maximum current, expressed as phase lag relative to Greenwich, in degrees.

6 Tidal Mixing

Tidal currents can make a major contribution to vertical mixing. Features such as tidal mixed fronts are important for both the physics and biology of shelf regions. The parameter h/u^3 is commonly used as an indicator of the strength of tidal mixing relative to the stratifying potential of the surface heat flux (Simpson and Hunter, 1974; Garrett et al., 1978). In the Arctic the surface salinity is at least as important as the surface heat flux in stratifying the water column. Nevertheless we will use h/u^3 as an indicator of the potential of the tidal currents to homogenize the water column.

Figure 11 is a map of

$$\log_{10} \frac{h}{\text{rms}(|u|^3)} \tag{4}$$

where h is the water depth and u is a one year time series of tidal currents reconstructed from the tidal constituents. Garrett et al. (1978) argue that, in a thermally stratified regime, values below 2 indicate well mixed water, values higher than 4 indicate stratification, and values between 2 and 4 represent transitional zones. Most of the region has values greater than 4 suggesting a stratified water column. The only location with values less than to 2 is Fury and Hecla Strait (lower panel), a narrow channel with very large tidal currents. Several areas with narrow channels or shallow sills have values in the 2 to 3 range.

Topham et al. (1983) argue that strong tidal mixing combined with a nearby source of warm water can lead to polynya formation. The well known Hell Gate polynya (Fig. 10 of Smith and Rigby, 1981) is the best known example. Several of the polynyas identified by Smith and Rigby (1981) such as Penny Strait and Queens Channel, Hell Gate and Cardigan Channel, and Committee Bay (south the Gulf of Boothia) can be identified with regions in Fig. 11 where $\log_{10} h/u^3 < 3$ (red and yellow). Obvious exceptions are the coastal leads and the well known North Water polynya (Barber et al., 2001) whose formation mechanisms are not related to tidal mixing. The Bellot Strait polynya between the Boothia Peninsula and Somerset Island is not represented likely because the model mesh does not resolve the narrow Bellot Strait which is the probable source of the large tidal currents. Overall we expect that regions with values close to 2 would freeze later in the season than surrounding waters and melt earlier. The relationship between polynyas and Fig. 11 has been explored further in Hannah et al. (2008).

7 Conclusion

The model bathymetry used in Dunphy et al. (2005) has been revised and tidal fields recalculated for the Canadian Arctic Archipelago. The most significant result of the modified bathymetry was in the the Arctic Southeast region, where K1 regional error was reduced by 10 cm. The revised fields are available over the internet as part of the WebTide tidal prediction package (www.mar.dfo-mpo.gc.ca/science/ocean/home.html, or search for ‘WebTide BIO’).

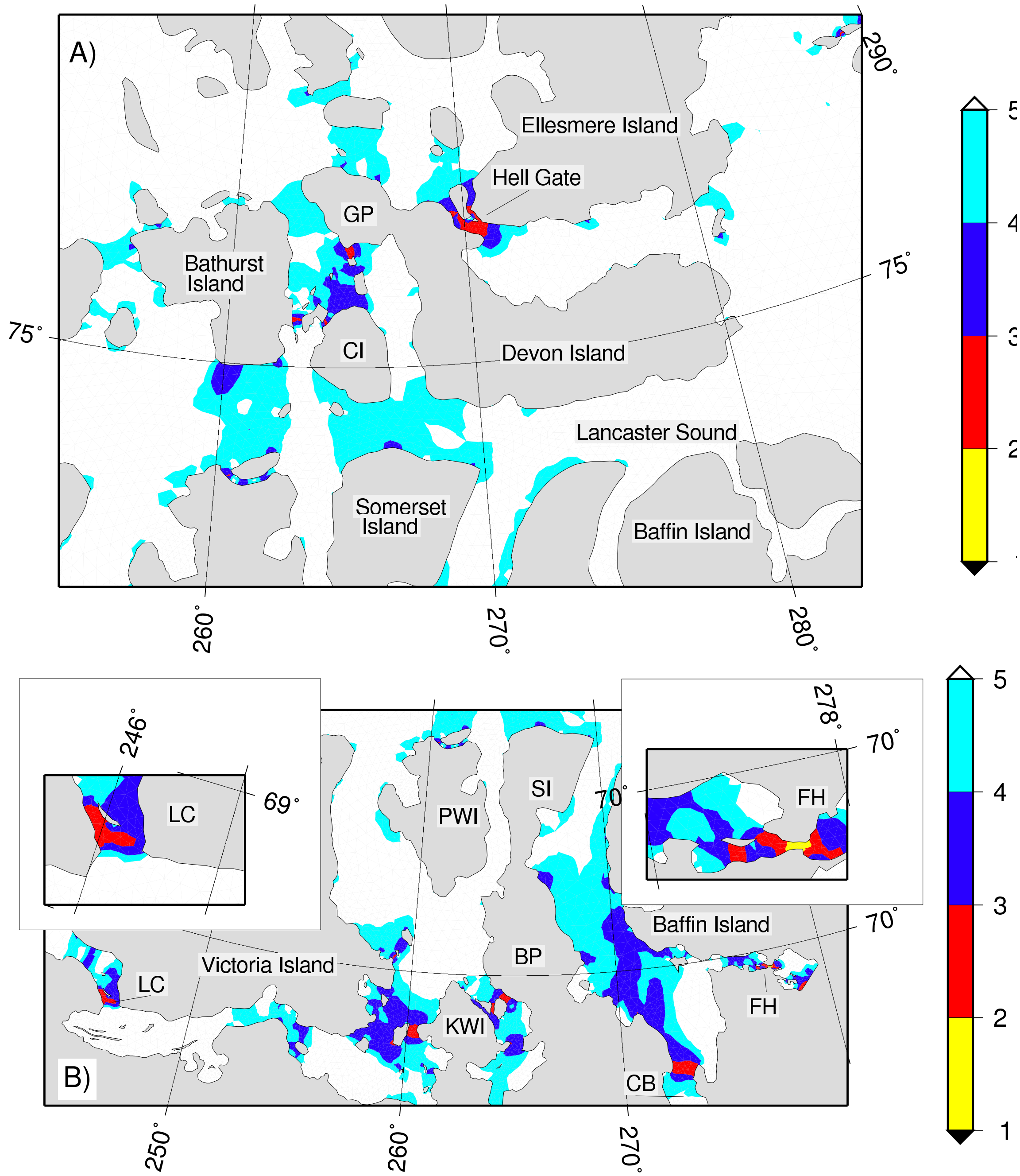

Figure 11: The tidal mixing parameter $\lambda = \log(h/U^3)$ for the central (A) and southern (B) regions. The location labels are as in Figure 2.

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References

Barber, D., R. Marsden, P. Minnett, G. Ingram, and L. Fortier, 2001: Physical processes within the North Water (NOW) polynya. *Atmos. Ocean*, **39**, 163–166.

Dunphy, M., F. Dupont, C. G. Hannah, and D. Greenberg, 2005: Valdiation of a modelling system for tides in the Canadian Arctic Archipelago. Can. Tech. Rep. Hydrogr. Ocean Sci. 243:vi+70pp. Available at www.dfo-mpo.gc.ca/Library/316074.pdf.

Garrett, C. J. R., J. R. Keeley, and D. A. Greenberg, 1978: Tidal mixing versus thermal stratification in the Bay of Fundy and Gulf of Maine. *Atmos. Ocean*, **16**, 403–423.

Hannah, C. G., F. Dupont, and M. Dunphy, 2008: Polynyas and Tidal Currents in the Canadian Arctic Archipelago. *Arctic*. In revision.

Padman, L., and S. Erofeeva, 2004: A barotropic inverse tidal model for the Arctic Ocean. *Geophys. Res. Letters*, **31**, LO2303.

Pawlowicz, R., B. Beardsley, and S. Lentz, 2002: Classical tidal harmonic analysis including error estimates in MATLAB using T_TIDE. *Computers and Geosciences*, **28**, 929–937.

Simpson, J. H., and J. R. Hunter, 1974: Fronts in the Irish Sea. *Nature*, **250**, 404–406.

Smith, M., and B. Rigby, 1981: Distribution of polynyas in the Canadian Arctic. *Polynyas in the Canadian Arctic*, I. Stirling and H. Cleator, eds., Occasional Paper Number 45, Canadian Wildlife Service, pp. 7–19.

Topham, D. R., R. G. Perkin, S. D. Smith, R. Anderson, and G. den Hartog, 1983: An investigation of a polynya in the Canadian Arctic Archipelago, 1, introduction and oceanography. *J. Geophys. Res.*, **88**, 2888–2899.

Appendix

A Stations

Table 11: The stations selected for the assimilation process including the MEDS code and record length (in days). For the Greenland data, the station number has a G prefix and the record length is unknown.

Station Name	Station Number	Record Length
DAVIS STRAIT	64000	1 X 398
DAVIS STRAIT	64005	1 X 399
DAVIS STRAIT	64010	1 X 395
RENSSELAER BAY	3710	1 X 44
THANK GOD HARBOUR	3735	1 X 44
NEWMAN BAY GREENLAND	3740	1 X 42
CAPE BRYANT	3755	1 X 44
ALERT	3765	1 X 362
CAPE LIVERPOOL	3902	1 X 52
NOVA ZEMBLA ISLAND	3916	1 X 53
CAPE CHRISTIAN	3941	1 X 54
AULITIVING ISLAND	3948	1 X 49
BROUGHTON ISLAND	3980	1 X 44
IGLOOLIK	5295	1 X 105
CAPE COCKBURN	5428	1 X 61
RESOLUTE	5560	1 X 364
MCBEAN ISLAND	5920	1 X 52
OTRICK ISLAND	6090	1 X 58
TASMANIA ISLAND	6110	1 X 56
SPENCE BAY	6150	1 X 112
CAMBRIDGE BAY	6240	1 X 331
COPPERMINE	6290	1 X 290
PEARCE POINT	6340	1 X 69
CAPE PARRY	6360	1 X 363
SACHS HARBOUR	6424	1 X 174
BAILLIE IS (S. SPIT)	6443	1 X 58
ATKINSON POINT	6476	1 X 59
TUKTOYAKTUK	6485	1 X 333
RAE ISLAND	6492	1 X 57
HOOPER ISLAND	6495	1 X 49
GARRY ISLAND	6498	3 X 56

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Station Name	**Station Number**	**Record Length**
HERSCHEL ISLAND	6525	1 X 50
CAPE SKOGN NWT	6560	1 X 61
GRISE FIORD NWT	6570	1 X 62
BAY OF WOE	6580	1 X 43
HELL GATE	6584	1 X 43
BERE BAY	6588	1 X 45
NORWEGIAN BAY	6595	1 X 142
CAPE SOUTHWEST	6598	1 X 42
HYPERITE POINT	6605	1 X 42
DISRAELI FIORD	6730	1 X 78
NORAH ISLAND	6781	1 X 43
Rae Point Melville I	6835	1 X 366
ISACHSEN	6910	1 X 29
MOULD BAY	6955	1 X 29
Aasiatt-Egedesminde	G01	N/A
ILulissat-Jacobshavn	G09	N/A
Kronprinsens-Ejland	G14	N/A
Maniitsoq-Sukkertoppen	G16	N/A
Qaamarujuk	G24	N/A
Qeqertarsuaq-Godhavn	G26	N/A
Rifkol	G28	N/A
Sisimiut-Holsteinsborg	G29	N/A
Uummannaq	G31	N/A

Table 12: The stations used for validating the modelled results including the MEDS code and record length (in days). For the Greenland data, the station number has a G prefix and the record length is unknown.

Station Name	Station Number	Record Length
GODTHAAB	3575	4 X 29
FOULKE FIORD	3690	2 X 29
CAPE LUPTON GREENLAND	3736	1 X 33
CAPE SHERIDAN	3780	5 X 29
LINCOLN BAY	3782	1 X 35
ST.PATRICK BAY	3788	1 X 35
DISCOVERY HARBOUR	3790	1 X 29
PIM ISLAND	3840	1 X 29
		continued on next page

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Station Name	**Station Number**	**Record Length**
CAPE HOOPER	3960	1 X 29
KIVITOO	3970	1 X 29
CAPE DYER	3995	1 X 29
CLEARWATER FIORD	4040	1 X 29
BOUVERIE ISLAND	5305	1 X 29
SEVIGNY POINT	5310	1 X 31
BONNE ISLAND	5315	1 X 32
PURFUR COVE	5330	1 X 32
BAFFIN	5332	1 X 32
DUNDAS HARBOUR	5430	1 X 29
BEECHY ISLAND	5510	1 X 29
MAXWELL BAY	5530	1 X 32
CAPE CAPEL	5600	1 X 31
WINTER HARBOUR	5645	1 X 29
KOLUKTOO BAY	5790	1 X 29
MILNE INLET (HEAD)	5791	1 X 29
ARCTIC BAY	5865	1 X 29
PORT LEOPOLD	5905	1 X 29
CUNNINGHAM INLET	5910	1 X 37
WADSWORTH ISLAND	6080	1 X 59
BERNARD HARBOUR	6310	1 X 29
TYSOE POINT	6338	1 X 36
PAULATUK	6350	1 X 29
KRUBLUYAK POINT	6457	1 X 46
CAPE DALHOUSIE	6472	1 X 29
SHINGLE BAY	6505	1 X 36
KING EDWARD POINT	6556	1 X 30
BELCHER POINT	6557	1 X 31
ICEBERG POINT	6660	1 X 29
GREELY FIORD	6670	1 X 29
KLEYBOLT PENINSULA	6704	1 X 29
CAPE ALDRICH	6735	1 X 29
AIRSTRIP POINT	6765	1 X 29
HYDE PARKER ISLAND	6770	1 X 39
NORTHUMBERLAND SOUND	6780	1 X 29
BYAM CHANNEL(Z3)	6834	1 X 38
Foulke-Havn	G08	N/A
Kangerluarsoruseq-Faering	G11	N/A
Thank-God-Havn	G30	N/A

Table 13: The stations not used for assimilation or validation including the MEDS code and record length (in days).

Station Name	**Station Number**	**Record Length**
EKALUGARSUIT	3515	1 X 29
NORTH STAR BAY	3670	1 X 24
WRANGEL BAY	3785	1 X 17
CAPE DEFOSSE	3800	1 X 24
CLYDE RIVER	3940	1 X 98
AULATSIVIK PT.	4031	1 X 27
IMIGEN ISLAND	4045	1 X 15
BREVOORT HARBOUR	4070	1 X 29
RESOR ISLAND	4100	1 X 29
FROBISHER S FARTHEST	4120	1 X 29
LEWIS BAY	4135	1 X 29
FROBISHER	4140	1 X 337
ACADIA COVE	4170	1 X 63
LAKE HARBOUR	4205	1 X 362
PORT BURWELL	4265	1 X 29
KOKSOAK R. WEST ENT.	4295	1 X 29
FORT CHIMO	4298	1 X 26
LEAF BASIN	4315	1 X 29
HOPES ADVANCE BAY	4325	2 X 29
AGVIK ISLAND	4335	1 X 29
PIKIYULIK ISLAND	4340	1 X 29
KOARTAC	4379	1 X 113
CAPE WILSON 3	5230	1 X 55
CAPE WILSON 1	5231	1 X 18
CAPE WILSON 2	5232	1 X 46
ROCHE BAY	5252	1 X 48
HALL BEACH	5275	1 X 338
ENTRANCE ISLAND	5350	1 X 28
NEEDLE COVE	5358	1 X 35
LONGSTAFF BLUFF #1	5385	1 X 32
RIGBY BAY	5490	2 X 15
RADSTOCK BAY	5500	1 X 15
HAMILTON ISLAND	5615	1 X 15
PISIKTARFIK ISLAND	5795	1 X 15
STRATHCONA SOUND	5860	1 X 15

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Station Name	**Station Number**	**Record Length**
FORT ROSS	5930	1 X 15
CROWN PRINCE FREDERICK	5970	1 X 27
FALSE STRAIT	6100	1 X 15
FRANKLIN BAY	6367	1 X 21
BAILLIE ISLAND	6442	1 X 21
LIVERPOOL BAY	6455	1 X 23
ESKIMO LAKES STN 1C	6461	1 X 17
ESKIMO LAKES STN 2B	6462	1 X 19
PELLY ISLAND	6497	1 X 20
KAY POINT YUKON.	6515	1 X 25
SURPRISE FIORD	6600	1 X 18
EUREKA	6640	1 X 15
TANQUARY CAMP	6680	1 X 29
LITTLE CORNWALLIS IS.	6757	1 X 27
BYAM CHANNEL(LP)	6833	1 X 15
Ammassalik	G02	N/A
Danmarkshavn	G04	N/A
Danmarks-0	G05	N/A
Finsch-Oer	G07	N/A
Kangilinnguit-Gronnedal	G12	N/A
Mestersvig	G17	N/A
Nanortalik	G18	N/A
Narsaq	G19	N/A
Nuuk-Godthab	G22	N/A
Paamiut-Frederikshab	G23	N/A
Qaqortoq-Julianehab	G25	N/A
Uunarteq-Kap-Tobin	G33	N/A

B Complete station by station comparisons

B.1 Baffin Bay

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
G01	66.7	-9.0	57.9	-4.0	8.8	-5.1	10.4	0.156
G09	66.7	-2.0	57.3	1.3	9.4	-3.4	10.1	0.151
G11	116.5	-70.0	122.7	-68.7	-6.2	-1.3	6.8	0.058
G14	57.0	-13.0	55.3	-3.1	1.7	-9.9	9.9	0.173
G16	124.7	-58.9	126.2	-60.4	-1.5	1.5	3.6	0.029
G24	45.6	40.0	43.1	42.4	2.5	-2.4	3.1	0.068
G26	59.5	-6.0	55.3	-1.6	4.2	-4.5	6.1	0.103
G28	78.0	-38.0	70.7	-12.1	7.3	-26.0	34.2	0.438
G29	117.1	-44.0	107.9	-41.6	9.2	-2.4	10.4	0.088
G31	46.5	35.0	43.1	42.4	3.4	-7.4	6.7	0.144
3575	138.0	-68.1	127.5	-68.4	10.5	0.4	10.5	0.076
3916	44.8	138.3	47.4	129.5	-2.6	8.8	7.6	0.169
3941	11.0	151.3	31.3	139.3	-20.3	12.0	20.6	1.876
3948	18.7	-156.5	22.2	175.0	-3.5	28.6	10.6	0.569
3960	20.4	-122.1	19.4	-151.3	1.0	29.3	10.1	0.495
3970	24.6	-106.1	20.6	-135.1	4.0	29.0	12.0	0.486
3980	30.4	-106.1	25.0	-123.3	5.4	17.2	9.9	0.325
3995	83.5	-87.1	80.7	-102.4	2.8	15.3	22.0	0.264
4040	226.7	-66.1	182.0	-71.1	44.7	5.0	48.1	0.212
64000	89.9	-88.2	85.8	-92.1	4.1	3.9	7.3	0.081
64005	90.2	-67.1	81.9	-69.8	8.3	2.7	9.3	0.103
64010	98.9	-58.0	88.3	-60.0	10.6	2.0	11.1	0.112
Mean	75.2	–	70.5	–	4.7	4.2	12.7	0.3
Absolute	–	–	–	–	7.8	9.9	–	–
RMS	89.6	82.9	81.7	89.0	12.0	13.9	16.3	0.473

Table 14: Baffin Bay - M2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
G01	NaN	NaN	12.2	-24.8	NaN	NaN	NaN	NaN
G09	NaN	NaN	12.1	-19.3	NaN	NaN	NaN	NaN
G11	NaN	NaN	6.2	-141.3	NaN	NaN	NaN	NaN
G14	NaN	NaN	11.6	-23.9	NaN	NaN	NaN	NaN
G16	NaN	NaN	24.2	-126.8	NaN	NaN	NaN	NaN
G24	NaN	NaN	9.5	22.8	NaN	NaN	NaN	NaN

G26	NaN	NaN	11.6	-22.4	NaN	NaN	NaN	NaN
G28	NaN	NaN	15.1	-34.9	NaN	NaN	NaN	NaN
G29	NaN	NaN	23.3	-73.1	NaN	NaN	NaN	NaN
G31	NaN	NaN	9.5	22.7	NaN	NaN	NaN	NaN
3575	28.3	-90.7	7.6	-169.5	20.7	78.8	27.8	0.984
3916	10.9	114.3	10.5	104.0	0.4	10.3	2.0	0.180
3941	2.4	132.6	7.2	112.6	-4.8	20.0	5.0	2.069
3948	6.5	174.9	5.0	143.7	1.5	31.2	3.4	0.525
3960	3.0	-157.2	4.1	174.0	-1.1	28.8	2.0	0.679
3970	4.5	-158.2	4.1	-168.6	0.4	10.4	0.9	0.193
3980	5.1	-130.2	4.9	-154.7	0.2	24.5	2.1	0.418
3995	12.8	-129.2	17.1	-121.2	-4.3	-8.0	4.7	0.371
4040	36.5	-81.2	27.4	-49.2	9.1	-32.0	19.7	0.539
64000	18.4	-113.8	16.9	-108.6	1.5	-5.2	2.2	0.119
64005	18.3	-91.5	14.5	-93.1	3.8	1.6	3.8	0.210
64010	20.1	-81.6	15.8	-88.3	4.3	6.7	4.7	0.236
Mean	13.9	–	12.3	–	2.7	13.9	6.5	0.5
Absolute	–	–	–	–	4.3	21.5	–	–
RMS	17.3	125.0	13.9	105.9	7.0	29.4	10.3	0.751

Table 14 continued: Baffin Bay - N2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
G01	25.8	25.0	23.7	30.7	2.1	-5.7	3.2	0.125
G09	27.4	30.0	23.5	35.8	3.9	-5.8	4.7	0.171
G11	40.0	-34.0	26.2	-51.5	13.8	17.5	17.0	0.424
G14	27.0	25.0	22.7	31.5	4.3	-6.5	5.1	0.189
G16	44.7	-25.3	45.3	-42.1	-0.6	16.8	13.2	0.295
G24	17.0	62.0	16.7	75.7	0.3	-13.7	4.0	0.237
G26	24.6	31.0	22.7	33.1	1.9	-2.1	2.1	0.084
G28	32.0	-8.0	28.7	22.4	3.3	-30.4	16.2	0.507
G29	45.1	-8.0	43.4	-8.3	1.7	0.3	1.8	0.039
G31	18.1	61.0	16.7	75.7	1.4	-14.7	4.7	0.257
3575	56.6	-30.0	29.1	-58.1	27.5	28.1	33.9	0.598
3916	15.1	-176.6	16.7	171.7	-1.6	11.7	3.6	0.241
3941	3.4	-165.1	10.2	-177.7	-6.8	12.6	7.0	2.044
3948	6.7	-90.5	7.2	-132.9	-0.5	42.4	5.0	0.751
3960	5.7	-60.0	7.2	-93.3	-1.5	33.3	3.9	0.693
3970	10.9	-54.0	8.1	-79.0	2.8	25.0	4.9	0.451
3980	12.8	-60.0	10.2	-70.1	2.6	10.1	3.3	0.258
3995	24.6	-41.0	32.2	-53.7	-7.6	12.7	9.8	0.399
4040	81.3	-23.0	58.0	-1.3	23.3	-21.7	34.8	0.428

64000	33.9	-45.5	33.1	-43.7	0.8	-1.8	1.3	0.039
64005	34.9	-27.3	30.5	-28.1	4.4	0.8	4.4	0.126
64010	38.2	-19.8	33.1	-22.5	5.1	2.7	5.4	0.141
Mean	28.4	–	24.8	–	3.7	5.1	8.6	0.4
Absolute	–	–	–	–	5.4	14.4	–	–
RMS	33.6	65.9	27.9	76.5	8.8	18.3	12.6	0.565

Table 14 continued: Baffin Bay - S2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
G01	35.5	-151.9	30.9	-145.5	4.6	-6.4	5.9	0.167
G09	34.1	-139.9	31.3	-143.2	2.8	3.3	3.4	0.099
G11	18.2	170.1	23.8	160.1	-5.6	10.0	6.7	0.367
G14	35.0	-146.9	30.2	-144.4	4.8	-2.5	5.0	0.142
G16	21.0	165.7	22.0	166.1	-1.0	-0.3	1.0	0.050
G24	36.5	-160.9	31.0	-129.0	5.5	-31.9	19.3	0.529
G26	31.7	-145.9	29.7	-143.5	2.0	-2.3	2.4	0.075
G28	36.0	-154.9	32.3	-154.6	3.7	-0.3	3.7	0.103
G29	33.5	179.1	31.7	-177.3	1.8	-3.5	2.7	0.081
G31	35.5	-124.9	31.0	-129.0	4.5	4.1	5.1	0.143
3575	20.1	174.1	23.9	165.1	-3.8	9.0	5.1	0.255
3916	26.3	-108.0	20.7	-116.4	5.6	8.4	6.6	0.250
3941	10.5	-104.0	21.3	-112.5	-10.8	8.4	11.0	1.051
3948	22.7	-99.2	19.8	-111.6	2.9	12.3	5.4	0.238
3960	18.8	-108.8	19.2	-112.4	-0.4	3.6	1.3	0.067
3970	21.3	-110.8	18.2	-112.7	3.1	1.9	3.2	0.148
3980	24.6	-110.8	18.2	-115.1	6.4	4.3	6.6	0.267
3995	10.9	-103.8	11.9	-106.6	-1.0	2.8	1.1	0.102
4040	8.2	99.2	7.2	-143.7	1.0	-117.2	13.1	1.599
64000	6.2	-80.4	9.7	-124.4	-3.5	44.0	6.8	1.089
64005	16.3	-155.6	16.4	-154.4	-0.1	-1.2	0.3	0.021
64010	23.8	-149.7	20.1	-155.7	3.7	6.0	4.3	0.182
Mean	23.9	–	22.7	–	1.2	-2.2	5.5	0.3
Absolute	–	–	–	–	3.6	12.9	–	–
RMS	25.8	136.9	23.9	139.0	4.3	28.1	6.9	0.509

Table 14 continued: Baffin Bay - K1 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative

G01	10.6	-178.2	11.7	172.6	-1.1	9.2	2.1	0.197
G09	11.6	178.8	11.8	174.7	-0.2	4.1	0.9	0.075
G11	9.7	141.8	10.4	119.4	-0.7	22.4	4.0	0.411
G14	12.0	166.8	11.4	173.5	0.6	-6.7	1.5	0.123
G16	10.1	126.9	10.1	129.5	-0.0	-2.5	0.4	0.044
G24	8.9	-170.2	11.6	-172.1	-2.7	1.9	2.7	0.308
G26	12.8	177.8	11.2	174.4	1.6	3.5	1.7	0.135
G28	9.0	148.8	12.2	165.4	-3.2	-16.5	4.4	0.487
G29	12.7	139.8	12.4	144.9	0.3	-5.0	1.2	0.091
G31	11.9	-165.2	11.6	-172.0	0.3	6.9	1.4	0.120
3575	10.3	132.8	10.5	123.7	-0.2	9.1	1.7	0.160
3916	9.3	-149.5	7.1	-154.0	2.2	4.5	2.3	0.249
3941	3.4	-153.9	7.6	-151.5	-4.2	-2.4	4.2	1.236
3948	7.3	-146.9	6.9	-150.4	0.4	3.4	0.6	0.077
3960	12.4	-162.2	6.7	-152.6	5.7	-9.6	5.9	0.480
3970	6.0	-159.2	6.2	-153.1	-0.2	-6.1	0.7	0.116
3980	8.2	178.8	6.3	-156.9	1.9	-24.4	3.6	0.437
3995	2.7	-172.2	3.7	-148.9	-1.0	-23.3	1.6	0.592
4040	2.7	114.8	2.4	143.9	0.3	-29.1	1.3	0.487
64000	1.3	-172.6	2.9	-172.0	-1.6	-0.6	1.6	1.234
64005	7.3	147.7	6.2	157.8	1.1	-10.1	1.6	0.218
64010	10.1	159.2	8.1	159.4	2.0	-0.2	2.0	0.201
Mean	8.6	–	8.6	–	0.1	-3.3	2.2	0.3
Absolute	–	–	–	–	1.4	9.2	–	–
RMS	9.3	157.5	9.1	156.4	2.0	12.4	2.6	0.470

Table 14 continued: Baffin Bay - O1 Results

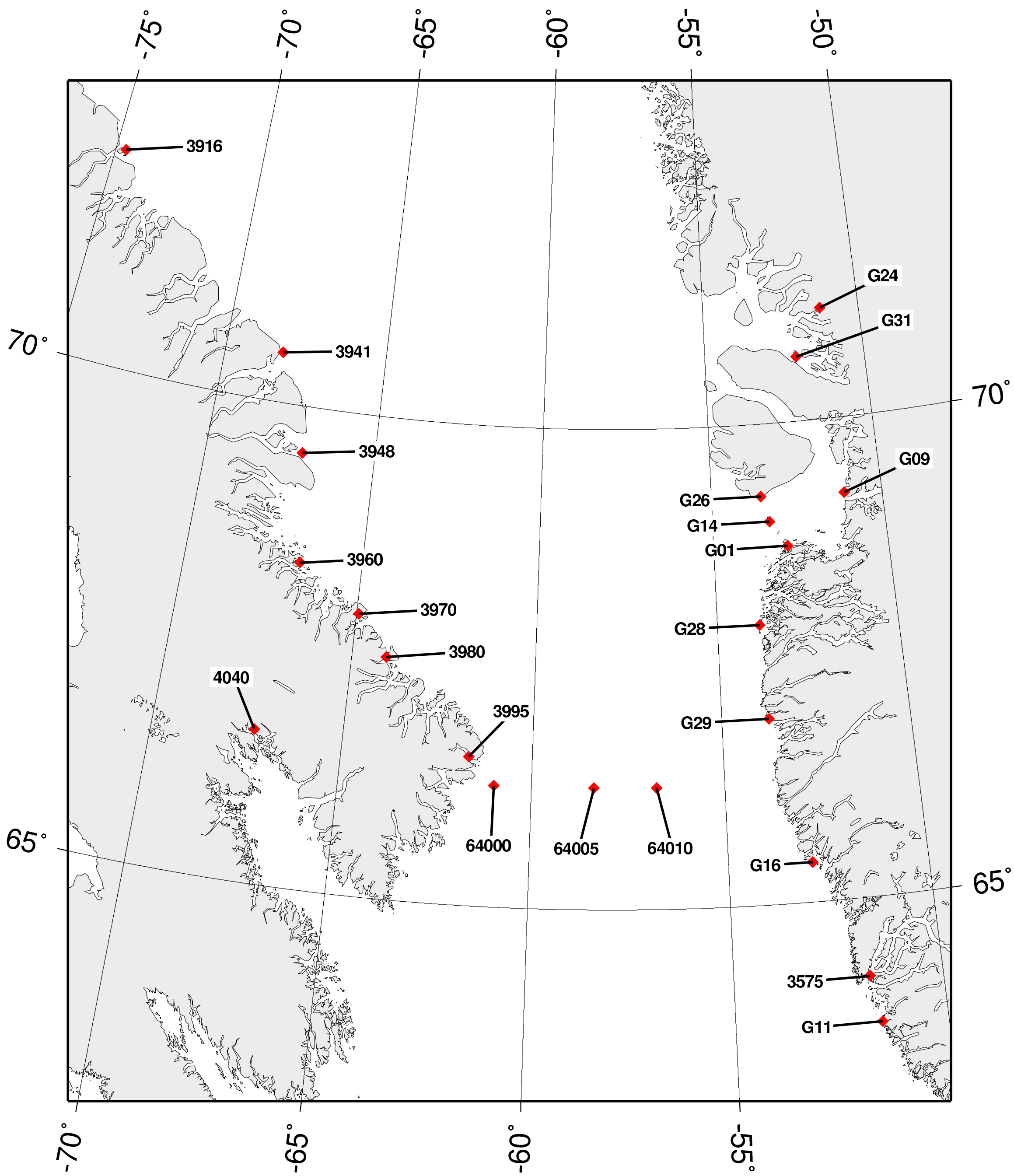

Figure 12: Baffin Bay

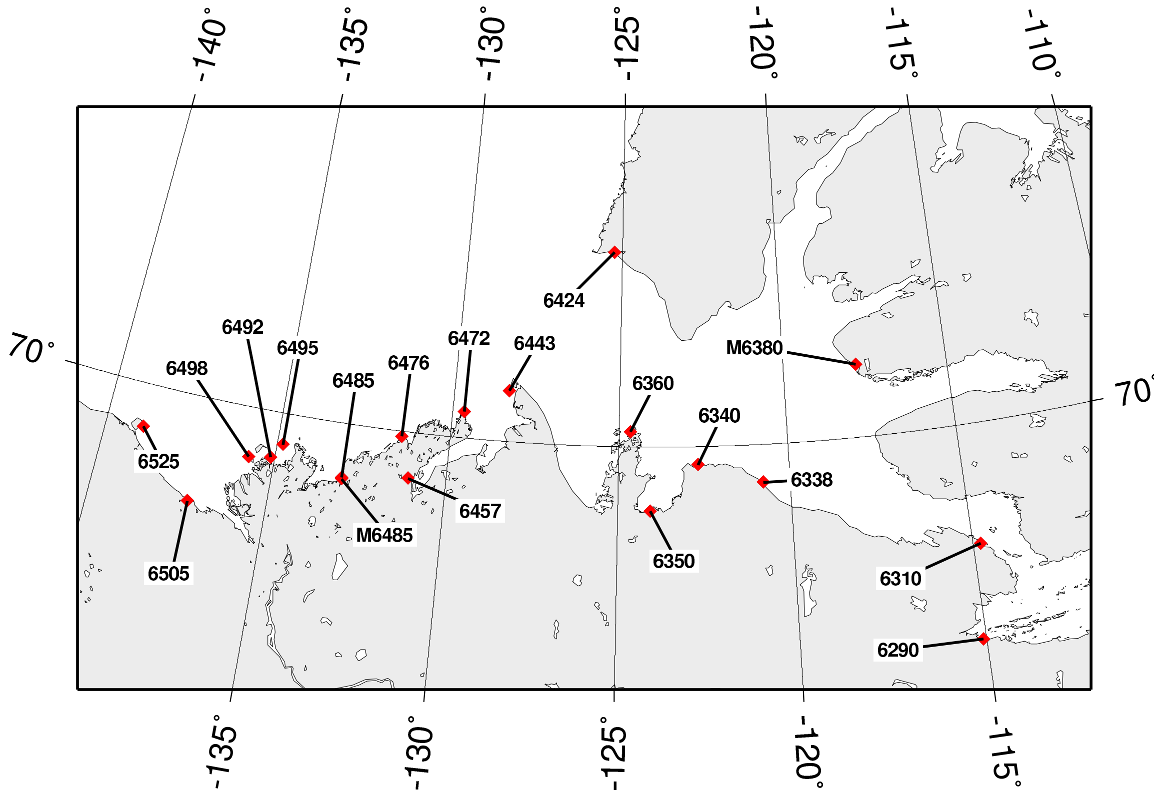

Figure 13: Arctic West

B.2 Arctic West

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
6290	1.6	-18.0	7.9	-99.2	-6.3	81.1	7.9	4.915
6310	17.3	80.9	17.4	93.3	-0.1	-12.4	3.7	0.216
6338	17.3	45.4	25.2	74.5	-7.9	-29.1	13.1	0.759
6340	13.2	48.0	22.1	70.4	-8.9	-22.4	11.1	0.841
6350	16.4	48.9	22.9	69.3	-6.5	-20.4	9.5	0.578
6360	11.9	40.0	19.0	57.9	-7.1	-17.9	8.5	0.717
6424	4.6	134.3	9.5	114.1	-4.9	20.2	5.4	1.179
6443	8.1	14.2	19.1	22.1	-11.0	-7.9	11.1	1.370
6457	31.7	91.3	15.9	-59.8	15.8	151.1	46.3	1.461
6472	21.8	-36.8	23.1	-23.8	-1.3	-13.0	5.2	0.240
6476	12.8	-88.9	15.4	-60.5	-2.6	-28.4	7.3	0.574
6485	12.1	-55.6	15.5	-64.4	-3.4	8.7	4.0	0.330
6492	3.9	-58.6	11.2	-60.3	-7.3	1.7	7.3	1.867
6495	6.7	-101.2	11.2	-63.2	-4.5	-38.0	7.2	1.072

6498	5.2	-80.4	11.8	-57.2	-6.6	-23.2	7.3	1.402
6505	10.2	-89.3	15.5	-69.3	-5.3	-20.0	6.9	0.673
6525	7.9	-100.4	12.1	-72.0	-4.2	-28.4	6.4	0.805
Mean	11.9	–	16.2	–	-4.2	0.1	9.9	1.1
Absolute	–	–	–	–	6.1	30.8	–	–
RMS	14.0	73.7	16.9	70.1	7.1	46.3	13.7	1.533

Table 15: Arctic West - M2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
6290	0.3	-71.9	1.2	-130.8	-0.9	58.9	1.1	3.677
6310	2.7	46.1	2.7	38.2	-0.0	7.9	0.4	0.138
6338	2.8	4.7	3.9	24.5	-1.1	-19.8	1.6	0.569
6340	2.4	-21.5	3.5	21.1	-1.1	-42.6	2.4	0.981
6350	3.0	13.5	3.6	20.2	-0.6	-6.7	0.7	0.238
6360	2.7	8.5	3.0	10.2	-0.3	-1.7	0.3	0.113
6424	0.8	107.6	1.8	60.7	-1.0	46.9	1.3	1.683
6443	1.4	8.1	2.6	-25.1	-1.2	33.2	1.6	1.168
6457	4.5	27.5	1.6	-117.8	2.9	145.2	5.8	1.299
6472	3.5	-74.1	2.8	-72.7	0.7	-1.4	0.7	0.199
6476	2.1	-86.1	1.4	-118.8	0.7	32.7	1.2	0.564
6485	1.9	-82.2	1.0	-122.6	0.9	40.4	1.3	0.681
6492	0.3	18.4	0.6	-80.4	-0.3	98.8	0.7	2.321
6495	0.3	-109.8	0.6	-92.4	-0.3	-17.4	0.3	1.002
6498	1.0	-54.1	0.7	-72.5	0.3	18.4	0.4	0.383
6505	1.7	-51.8	1.2	-86.4	0.5	34.6	1.0	0.582
6525	1.1	-127.4	0.9	-90.7	0.2	-36.7	0.7	0.600
Mean	1.9	–	1.9	–	-0.0	23.0	1.3	1.0
Absolute	–	–	–	–	0.8	37.8	–	–
RMS	2.2	66.1	2.2	80.0	1.0	51.9	1.8	1.302

Table 15 continued: Arctic West - N2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
6290	0.6	47.7	1.3	-14.7	-0.7	62.4	1.1	1.867
6310	6.0	143.0	5.3	121.6	0.7	21.4	2.2	0.368
6338	6.4	105.5	6.6	109.3	-0.2	-3.8	0.5	0.074
6340	3.5	93.7	5.8	105.4	-2.3	-11.7	2.5	0.704
6350	4.8	106.0	6.0	104.3	-1.2	1.7	1.3	0.261
6360	3.4	85.0	4.9	93.5	-1.5	-8.5	1.7	0.487

6424	1.1	-166.4	2.6	147.4	-1.5	46.2	2.0	1.852
6443	2.4	63.7	4.7	61.0	-2.3	2.7	2.3	0.941
6457	8.6	153.3	4.2	-23.9	4.4	177.2	12.8	1.493
6472	6.4	18.4	5.8	15.1	0.6	3.3	0.7	0.112
6476	5.1	-30.7	4.1	-25.1	1.0	-5.6	1.1	0.211
6485	4.8	-7.0	4.3	-31.2	0.5	24.2	2.0	0.410
6492	2.5	-9.5	3.0	-33.0	-0.5	23.5	1.2	0.490
6495	3.3	-39.0	3.0	-34.9	0.3	-4.1	0.4	0.110
6498	2.4	-37.2	3.1	-30.4	-0.7	-6.8	0.7	0.312
6505	4.5	-30.4	3.9	-42.4	0.6	12.0	1.1	0.234
6525	3.2	-54.0	3.0	-44.8	0.2	-9.2	0.5	0.170
Mean	4.1	–	4.2	–	-0.2	19.1	2.0	0.6
Absolute	–	–	–	–	1.1	25.0	–	–
RMS	4.5	85.6	4.4	73.8	1.5	48.3	3.4	0.827

Table 15 continued: Arctic West - S2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
6290	7.8	-135.2	13.0	158.1	-5.2	66.7	12.2	1.568
6310	8.5	133.3	7.8	141.8	0.7	-8.5	1.4	0.165
6338	5.5	137.8	4.2	111.7	1.3	26.1	2.5	0.462
6340	5.2	137.8	3.9	109.8	1.3	28.0	2.5	0.487
6350	6.4	124.3	4.0	109.4	2.4	14.8	2.7	0.429
6360	5.5	115.0	3.8	103.2	1.7	11.8	1.9	0.352
6424	4.0	150.8	3.1	123.9	0.9	26.9	1.9	0.468
6443	2.1	132.0	1.4	89.1	0.7	42.9	1.4	0.683
6457	1.5	-126.8	2.0	135.8	-0.5	97.4	2.7	1.776
6472	0.7	-155.0	1.2	127.2	-0.5	77.8	1.3	1.794
6476	2.8	122.9	2.1	134.7	0.7	-11.8	0.9	0.304
6485	3.1	165.6	2.7	129.4	0.4	36.2	1.8	0.595
6492	7.0	-179.4	3.2	117.2	3.8	63.4	6.3	0.894
6495	2.9	148.2	3.0	118.4	-0.1	29.8	1.5	0.520
6498	3.2	134.3	3.3	113.2	-0.1	21.2	1.2	0.371
6505	3.5	147.7	3.4	99.5	0.1	48.2	2.8	0.801
6525	2.8	137.8	3.1	99.9	-0.3	37.9	2.0	0.699
Mean	4.3	–	3.8	–	0.4	35.8	2.8	0.7
Absolute	–	–	–	–	1.2	38.2	–	–
RMS	4.8	141.1	4.7	120.2	1.8	45.4	3.8	0.877

Table 15 continued: Arctic West - K1 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
6290	2.3	129.1	6.4	74.8	-4.1	54.3	5.4	2.328
6310	3.9	141.6	2.8	104.8	1.1	36.8	2.4	0.606
6338	3.1	155.8	2.4	156.8	0.7	-1.0	0.7	0.237
6340	3.2	140.9	2.3	156.4	0.9	-15.5	1.1	0.356
6350	3.0	149.5	2.4	156.3	0.6	-6.8	0.7	0.235
6360	3.3	147.0	2.3	152.4	1.0	-5.4	1.0	0.314
6424	2.6	-177.5	2.1	164.5	0.5	18.0	0.9	0.340
6443	1.7	177.2	1.4	156.8	0.3	20.4	0.6	0.374
6457	1.9	-116.5	1.7	157.8	0.2	85.7	2.5	1.305
6472	2.0	-154.5	1.5	160.8	0.5	44.7	1.4	0.706
6476	2.7	168.6	1.8	157.2	0.9	11.4	1.0	0.383
6485	2.4	-172.7	1.9	154.0	0.5	33.3	1.3	0.550
6492	3.3	179.8	2.0	147.8	1.3	32.0	1.9	0.583
6495	2.5	160.3	1.9	148.1	0.6	12.2	0.7	0.293
6498	2.1	161.5	2.1	145.4	0.0	16.2	0.6	0.280
6505	4.8	147.7	2.2	134.5	2.6	13.2	2.7	0.572
6525	3.2	157.2	2.0	134.3	1.2	22.9	1.6	0.486
Mean	2.8	–	2.3	–	0.5	21.9	1.6	0.6
Absolute	–	–	–	–	1.0	25.3	–	–
RMS	2.9	156.1	2.5	146.6	1.4	32.6	1.9	0.771

Table 15 continued: Arctic West - O1 Results

B.3 Arctic North

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
G08	110.9	117.0	107.5	106.5	3.4	10.4	20.1	0.181
G30	54.9	115.0	54.2	110.4	0.7	4.5	4.4	0.080
3690	110.9	82.9	107.5	106.5	3.4	-23.6	44.8	0.404
3710	102.7	93.9	117.9	107.6	-15.2	-13.7	30.3	0.295
3735	54.8	111.9	54.2	110.4	0.6	1.5	1.6	0.029
3736	55.5	114.9	53.1	110.4	2.4	4.5	4.9	0.088
3740	38.3	118.2	35.4	110.1	2.9	8.1	6.0	0.156
3755	12.8	123.9	18.3	106.4	-5.5	17.6	7.2	0.564
3765	20.9	64.9	24.0	64.9	-3.1	0.1	3.1	0.149
3780	24.3	65.9	28.1	78.1	-3.8	-12.2	6.7	0.277
3782	37.9	101.5	41.4	97.0	-3.5	4.6	4.7	0.125
3788	58.2	106.7	54.0	101.1	4.2	5.7	7.0	0.120
3790	59.7	103.9	55.1	101.3	4.6	2.6	5.3	0.089
3840	116.7	113.9	112.2	111.0	4.5	3.0	7.4	0.064
6660	4.5	-101.8	11.1	-138.5	-6.6	36.7	8.0	1.772
6670	5.1	-86.8	11.8	-138.0	-6.7	51.2	9.5	1.864
6704	1.2	116.5	9.6	-125.0	-8.4	-118.5	10.2	8.536
6730	3.7	14.5	12.9	-51.7	-9.2	66.2	11.9	3.212
6735	11.5	9.9	13.6	-8.2	-2.1	18.1	4.5	0.389
Mean	46.6	–	48.5	–	-2.0	3.5	10.4	1.0
Absolute	–	–	–	–	4.8	21.2	–	–
RMS	60.3	98.3	60.5	103.5	5.8	35.7	14.7	2.185

Table 16: Arctic North - M2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
G08	NaN	NaN	22.3	83.5	NaN	NaN	NaN	NaN
G30	NaN	NaN	10.8	90.1	NaN	NaN	NaN	NaN
3690	20.4	54.8	22.3	83.5	-1.9	-28.7	10.8	0.528
3710	21.3	63.8	24.3	84.7	-3.0	-20.9	8.8	0.412
3735	10.6	85.8	10.8	90.1	-0.2	-4.3	0.8	0.077
3736	8.5	81.1	10.6	90.2	-2.1	-9.1	2.5	0.300
3740	5.6	91.8	6.9	91.7	-1.3	0.1	1.3	0.235
3755	2.4	109.8	3.3	92.1	-0.9	17.6	1.3	0.524
3765	3.4	43.9	4.4	45.6	-1.0	-1.7	1.0	0.291
3780	4.2	38.8	5.2	58.5	-1.0	-19.8	1.9	0.454
3782	5.8	65.3	8.1	76.7	-2.3	-11.4	2.6	0.454
3788	9.7	74.1	10.6	80.1	-0.9	-6.0	1.4	0.144

3790	11.5	78.8	10.9	80.4	0.6	-1.6	0.7	0.059
3840	26.2	99.2	23.2	87.7	3.0	11.5	5.8	0.221
6660	1.4	-125.6	3.4	-99.7	-2.0	-25.8	2.2	1.581
6670	2.4	-107.9	3.1	-104.9	-0.7	-3.0	0.7	0.286
6704	0.4	123.5	3.5	-88.5	-3.1	-148.0	3.8	9.611
6730	0.6	-53.4	2.1	-49.2	-1.5	-4.2	1.5	2.480
6735	1.8	-25.8	2.4	-17.5	-0.6	-8.2	0.7	0.385
Mean	8.0	–	9.9	–	-1.1	-15.5	2.8	1.1
Absolute	–	–	–	–	1.5	18.9	–	–
RMS	11.1	82.9	12.4	81.4	1.8	38.4	4.0	2.458

Table 16 continued: Arctic North - N2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
G08	46.3	150.0	43.5	149.0	2.8	1.0	3.0	0.064
G30	25.3	156.0	22.4	157.3	2.9	-1.3	3.0	0.118
3690	46.3	125.0	43.5	149.0	2.8	-24.0	18.8	0.407
3710	45.4	132.0	48.4	150.6	-3.0	-18.6	15.5	0.341
3735	25.2	153.0	22.4	157.3	2.8	-4.3	3.4	0.133
3736	24.3	155.7	21.9	157.5	2.4	-1.8	2.5	0.103
3740	16.1	162.4	14.5	159.2	1.6	3.2	1.9	0.116
3755	7.0	167.0	7.1	159.9	-0.1	7.1	0.9	0.124
3765	10.1	114.4	8.5	115.5	1.6	-1.1	1.6	0.160
3780	11.5	114.0	10.4	128.1	1.1	-14.1	2.9	0.252
3782	18.2	147.0	16.6	145.1	1.6	1.9	1.7	0.095
3788	24.0	148.4	21.9	148.0	2.1	0.4	2.1	0.088
3790	NaN	NaN	22.4	148.2	NaN	NaN	NaN	NaN
3840	48.1	148.0	45.4	154.2	2.7	-6.2	5.7	0.119
6660	0.2	-128.3	2.8	68.5	-2.6	163.2	3.0	15.083
6670	1.5	117.4	2.6	67.3	-1.1	50.1	2.0	1.324
6704	2.6	4.6	3.2	60.8	-0.6	-56.2	2.8	1.063
6730	2.2	58.9	4.0	-21.3	-1.8	80.2	4.3	1.933
6735	4.8	64.0	4.0	33.4	0.8	30.6	2.4	0.510
Mean	19.9	–	19.2	–	0.9	11.7	4.3	1.2
Absolute	–	–	–	–	1.9	25.9	–	–
RMS	25.8	131.5	24.5	130.8	2.1	47.7	6.4	3.612

Table 16 continued: Arctic North - S2 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative

G08	32.0	-99.9	28.0	-104.8	4.0	4.9	4.7	0.148
G30	12.2	-51.9	10.3	-62.8	1.9	10.9	2.8	0.233
3690	32.0	-112.8	28.0	-104.8	4.0	-8.0	5.8	0.181
3710	25.9	-106.8	26.8	-101.3	-0.9	-5.5	2.7	0.105
3735	12.1	-53.8	10.3	-62.8	1.8	9.0	2.5	0.206
3736	12.2	-56.7	10.2	-61.8	2.0	5.0	2.2	0.183
3740	9.6	-38.6	8.9	-42.8	0.7	4.2	1.0	0.105
3755	9.7	-13.8	8.0	-16.1	1.7	2.2	1.8	0.182
3765	4.7	2.8	4.2	-2.1	0.5	5.0	0.7	0.142
3780	4.8	-0.8	4.0	-16.9	0.8	16.1	1.5	0.306
3782	6.5	-52.7	5.7	-54.5	0.8	1.8	0.8	0.124
3788	8.3	-65.0	7.3	-72.5	1.0	7.4	1.5	0.175
3790	8.5	-73.8	7.4	-73.6	1.1	-0.2	1.1	0.125
3840	34.4	-106.8	25.4	-108.0	9.0	1.2	9.0	0.261
6660	5.5	35.5	5.7	99.1	-0.2	-63.6	5.9	1.074
6670	6.2	101.5	6.1	105.1	0.1	-3.6	0.4	0.064
6704	8.0	64.9	6.1	101.7	1.9	-36.8	4.8	0.600
6730	2.9	27.9	4.0	-47.8	-1.1	75.7	4.3	1.493
6735	5.1	21.2	4.4	-7.2	0.7	28.4	2.4	0.477
Mean	12.7	–	11.1	–	1.6	2.8	2.9	0.3
Absolute	–	–	–	–	1.8	15.2	–	–
RMS	16.1	67.1	14.0	74.4	2.7	25.8	3.7	0.484

Table 16 continued: Arctic North - K1 Results

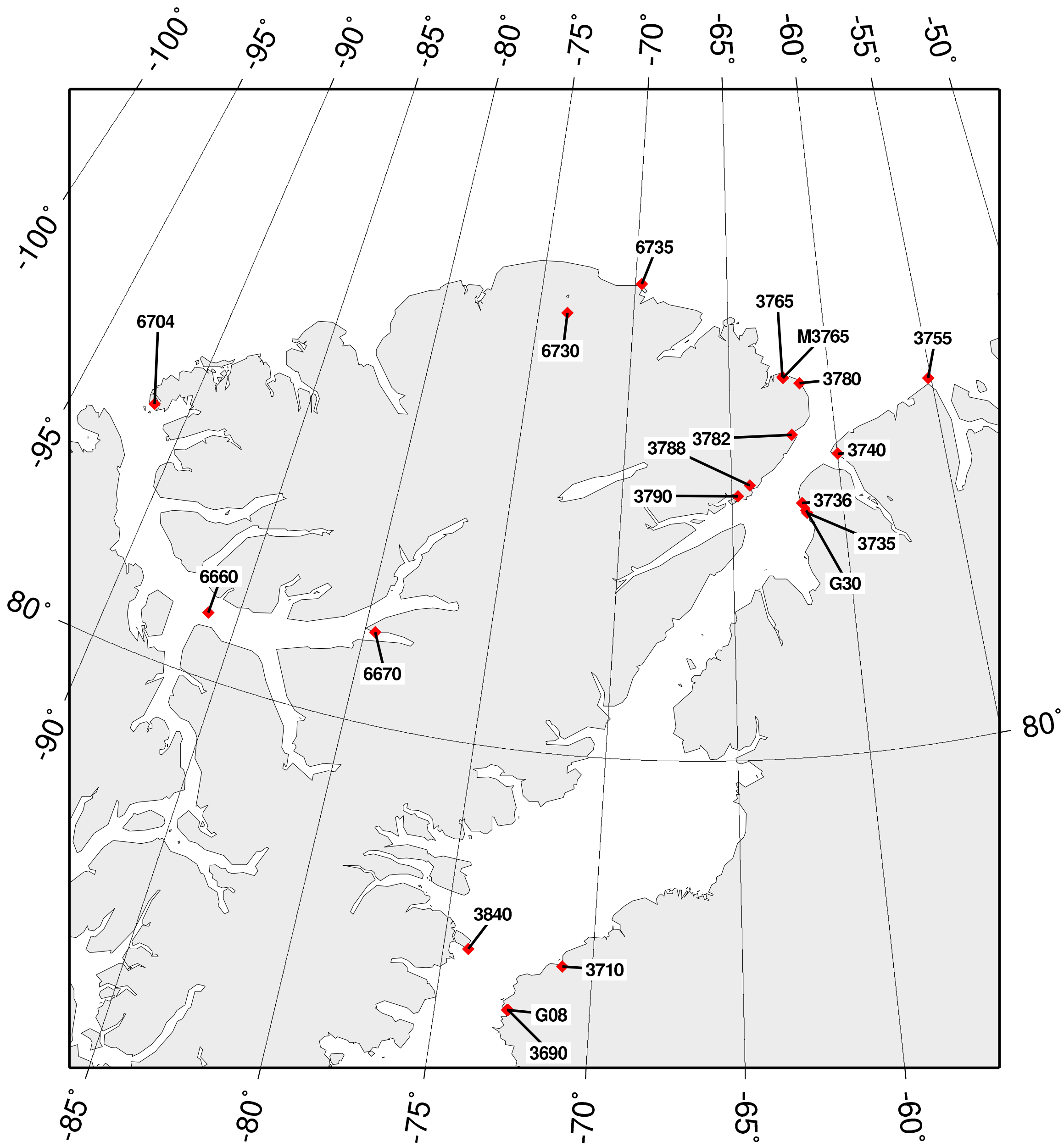

Figure 14: Arctic North

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
G08	12.4	-142.2	10.4	-147.9	2.0	5.8	2.3	0.188
G30	4.6	-89.2	3.1	-110.5	1.5	21.4	2.1	0.449
3690	12.4	-154.2	10.4	-147.9	2.0	-6.3	2.4	0.193
3710	12.8	-149.2	9.9	-144.8	2.9	-4.4	3.1	0.240
3735	4.5	-91.2	3.1	-110.5	1.4	19.3	1.9	0.421
3736	4.3	-89.1	3.0	-109.1	1.3	20.0	1.8	0.414
3740	3.7	-78.0	2.4	-83.8	1.3	5.8	1.4	0.367
3755	4.2	-38.2	2.2	-50.2	2.0	12.0	2.1	0.505
3765	2.6	-17.1	1.1	-5.2	1.5	-11.9	1.6	0.598
3780	2.7	-19.2	0.7	-22.2	2.0	3.0	2.0	0.733
3782	2.1	-74.9	1.3	-105.1	0.8	30.1	1.2	0.565
3788	3.0	-94.0	2.0	-127.4	1.0	33.4	1.7	0.572
3790	2.7	-96.2	2.1	-128.5	0.6	32.2	1.5	0.537
3840	13.1	-161.3	9.5	-152.0	3.6	-9.4	4.1	0.309
6660	2.7	-2.7	1.9	53.0	0.8	-55.7	2.3	0.839
6670	5.0	38.7	1.6	36.4	3.4	2.3	3.4	0.686
6704	2.1	-53.6	2.0	50.5	0.1	-104.1	3.2	1.541
6730	1.3	8.6	1.5	-61.4	-0.2	70.0	1.6	1.266
6735	3.3	-9.3	1.5	-20.6	1.8	11.4	1.8	0.554
Mean	5.2	–	3.7	–	1.6	3.9	2.2	0.6
Absolute	–	–	–	–	1.6	24.1	–	–
RMS	6.6	89.7	5.0	99.7	1.9	35.4	2.3	0.667

Table 16 continued: Arctic North - O1 Results

B.4 Arctic Northwest

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5645	36.8	-104.1	25.6	-108.6	11.2	4.5	11.5	0.312
6834	30.4	-112.1	24.8	-119.3	5.6	7.2	6.6	0.217
6835	32.1	-123.5	23.8	-127.0	8.3	3.5	8.5	0.264
6910	8.8	-102.1	10.2	-119.2	-1.4	17.0	3.1	0.357
6955	14.6	-83.1	14.5	-99.6	0.1	16.5	4.2	0.286
Mean	24.5	–	19.8	–	4.8	9.7	6.8	0.3
Absolute	–	–	–	–	5.3	9.7	–	–
RMS	26.8	105.8	20.7	115.1	6.8	11.4	7.4	0.291

Table 17: Arctic Northwest - M2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5645	5.1	-142.9	5.5	-122.0	-0.4	-20.9	2.0	0.389
6834	4.2	-126.4	5.4	-137.1	-1.2	10.7	1.5	0.355
6835	5.9	-155.2	5.4	-148.6	0.5	-6.6	0.8	0.135
6910	2.1	-133.9	3.0	-170.1	-0.9	36.2	1.8	0.869
6955	2.4	-104.9	3.4	-116.7	-1.0	11.7	1.1	0.471
Mean	3.9	–	4.6	–	-0.6	6.2	1.4	0.4
Absolute	–	–	–	–	0.8	17.2	–	–
RMS	4.2	133.7	4.7	140.2	0.9	20.2	1.5	0.504

Table 17 continued: Arctic Northwest - N2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5645	21.6	-55.0	16.8	-43.5	4.8	-11.5	6.2	0.285
6834	11.3	-64.6	14.6	-56.0	-3.3	-8.6	3.9	0.342
6835	14.5	-69.1	13.7	-66.8	0.8	-2.3	1.0	0.070
6910	2.4	-56.0	5.2	-99.7	-2.8	43.7	3.8	1.592
6955	7.0	-36.0	9.5	-41.4	-2.5	5.4	2.7	0.380
Mean	11.4	–	12.0	–	-0.6	5.3	3.5	0.5
Absolute	–	–	–	–	2.9	14.3	–	–
RMS	13.1	57.3	12.7	65.0	3.1	20.7	3.9	0.759

Table 17 continued: Arctic Northwest - S2 Results

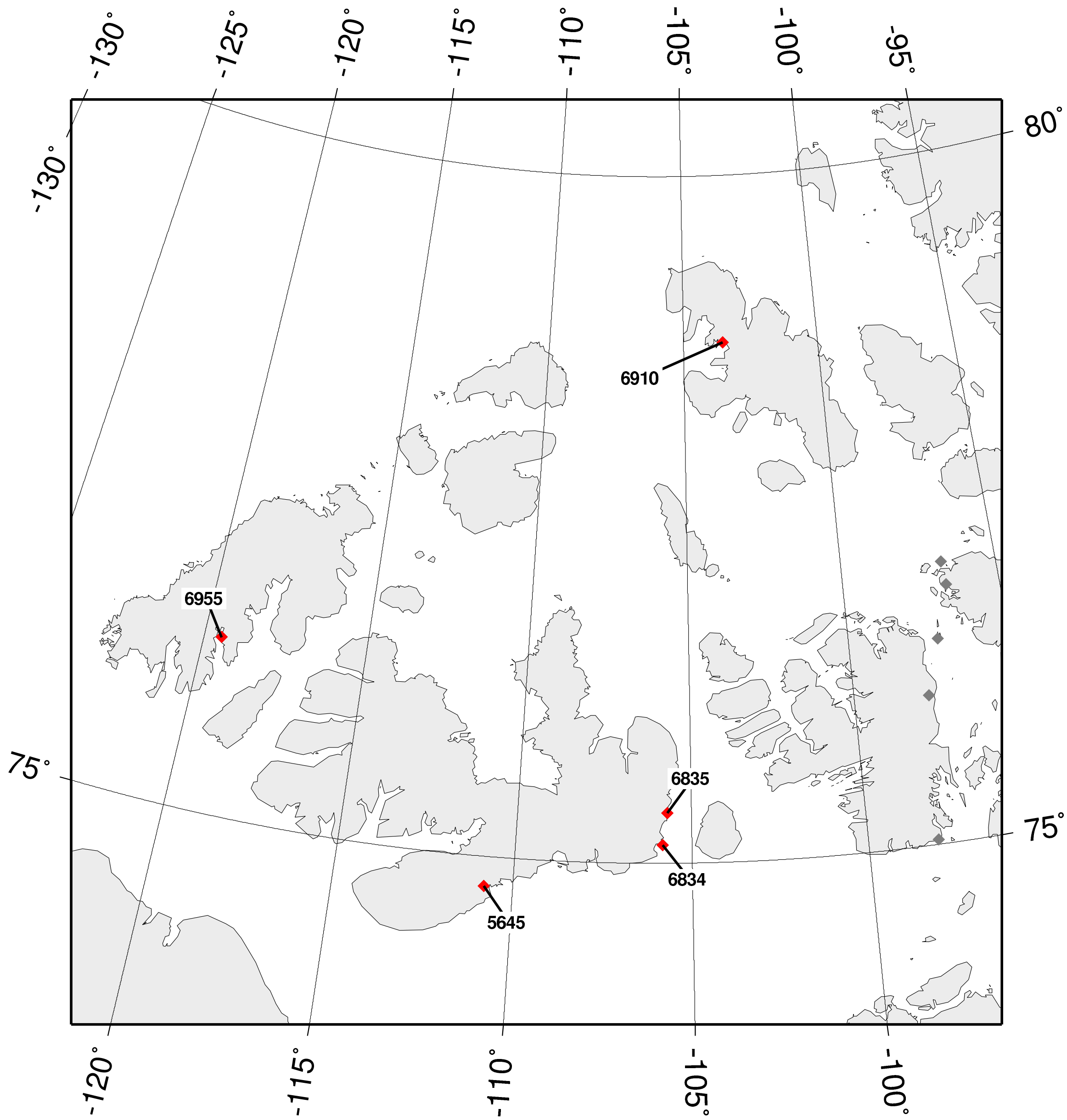

Figure 15: Arctic Northwest

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5645	6.7	18.3	8.6	9.4	-1.9	8.9	2.2	0.330
6834	7.2	-18.0	9.9	-2.7	-2.7	-15.3	3.5	0.490
6835	6.9	5.0	8.4	-5.1	-1.5	10.1	2.0	0.293
6910	4.8	43.3	6.1	44.4	-1.3	-1.1	1.3	0.266
6955	3.9	-132.7	5.6	50.9	-1.7	176.4	9.5	2.438
Mean	5.9	–	7.7	–	-1.8	35.8	3.7	0.8
Absolute	–	–	–	–	1.8	42.3	–	–
RMS	6.0	63.5	7.9	30.6	1.9	79.4	4.8	1.136

Table 17 continued: Arctic Northwest - K1 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5645	3.0	-119.4	4.3	-82.5	-1.3	-36.9	2.6	0.864
6834	5.6	-53.1	5.4	-86.8	0.2	33.7	3.2	0.571
6835	3.5	-103.4	4.6	-91.7	-1.1	-11.7	1.4	0.399
6910	2.1	-14.4	2.0	-33.9	0.1	19.5	0.7	0.335
6955	0.9	139.6	1.0	-46.1	-0.1	-174.3	1.9	2.163
Mean	3.0	–	3.5	–	-0.5	-33.9	2.0	0.9
Absolute	–	–	–	–	0.6	55.2	–	–
RMS	3.4	97.4	3.8	72.2	0.8	81.7	2.2	1.097

Table 17 continued: Arctic Northwest - O1 Results

B.5 Arctic Central

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
3902	53.9	135.9	59.3	127.7	-5.4	8.3	9.8	0.182
5428	69.0	134.6	68.1	126.8	0.9	7.8	9.3	0.135
5430	66.4	137.9	66.3	130.4	0.1	7.5	8.6	0.130
5510	60.9	170.9	53.5	155.0	7.4	15.9	17.4	0.286
5530	67.5	172.4	61.4	143.8	6.1	28.6	32.4	0.480
5560	46.3	178.6	35.8	169.6	10.5	9.0	12.3	0.265
5600	36.8	-160.7	30.0	-170.1	6.8	9.5	8.7	0.237
5865	61.2	147.9	69.4	132.6	-8.2	15.3	19.2	0.314
5905	60.9	151.9	55.9	143.7	5.0	8.2	9.7	0.160
5910	43.6	162.6	36.6	145.8	7.0	16.8	13.6	0.312
6080	22.9	152.0	16.2	131.6	6.7	20.4	9.6	0.417
6556	89.4	129.9	88.1	124.2	1.3	5.7	8.9	0.100
6557	84.7	132.7	84.7	126.8	0.0	5.9	8.7	0.103
6560	88.4	135.9	91.8	128.6	-3.4	7.3	11.9	0.135
6570	96.3	132.5	91.6	125.9	4.7	6.6	11.8	0.122
6580	82.3	142.4	85.8	136.3	-3.5	6.1	9.6	0.117
6584	42.3	165.2	37.6	160.8	4.7	4.4	5.7	0.134
6588	23.8	165.4	22.1	162.2	1.7	3.2	2.1	0.089
6595	35.1	169.1	31.9	168.6	3.2	0.5	3.2	0.091
6598	28.1	176.4	27.8	174.4	0.3	2.0	1.0	0.036
6605	33.7	173.1	31.3	171.8	2.4	1.3	2.5	0.075
6765	37.7	-174.1	31.5	166.4	6.2	19.5	13.2	0.351
6770	32.2	-168.9	26.6	174.8	5.6	16.3	10.0	0.311
6780	20.1	-166.1	17.3	-172.9	2.8	6.8	3.6	0.177
6781	18.6	-160.3	17.6	-173.0	1.0	12.7	4.1	0.222
Mean	52.1	–	49.5	–	2.6	9.8	9.9	0.2
Absolute	–	–	–	–	4.2	9.8	–	–
RMS	57.1	156.7	55.5	151.0	5.0	11.9	11.8	0.229

Table 18: Arctic Central - M2 Results

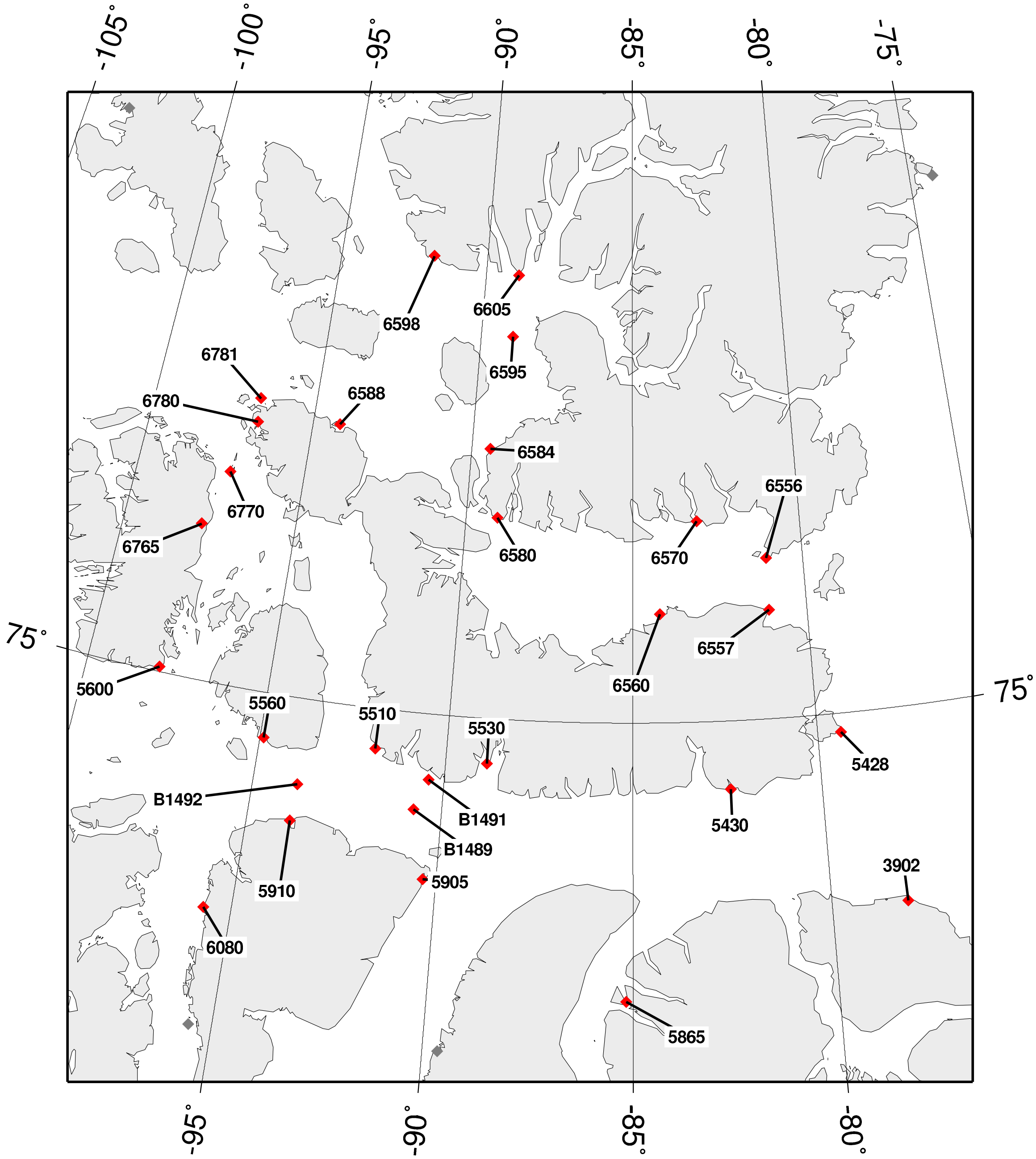

Figure 16: Arctic Central

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
3902	12.2	110.6	12.8	102.3	-0.6	8.3	1.9	0.155
5428	13.1	106.0	14.5	102.0	-1.4	4.0	1.7	0.127
5430	13.5	102.6	14.0	105.2	-0.5	-2.6	0.8	0.059
5510	13.1	138.6	11.0	130.4	2.1	8.3	2.7	0.209
5530	8.1	126.9	12.6	118.3	-4.5	8.6	4.8	0.591
5560	8.4	149.6	7.1	146.5	1.3	3.2	1.4	0.165
5600	7.6	174.6	5.9	169.1	1.7	5.5	1.8	0.235
5865	14.6	116.2	14.6	106.5	0.0	9.7	2.5	0.169
5905	12.8	116.6	11.4	117.5	1.4	-0.9	1.4	0.113
5910	5.5	137.3	7.3	120.6	-1.8	16.8	2.5	0.463
6080	3.6	119.3	3.1	106.1	0.5	13.2	0.9	0.253
6556	20.0	97.9	18.4	100.4	1.6	-2.5	1.8	0.089
6557	16.7	107.5	17.7	102.7	-1.0	4.8	1.7	0.104
6560	18.7	101.7	19.0	105.0	-0.3	-3.3	1.1	0.059
6570	16.4	98.0	19.1	102.3	-2.7	-4.3	3.0	0.182
6580	18.8	128.0	17.8	115.1	1.0	12.9	4.2	0.225
6584	9.6	149.9	8.3	153.4	1.3	-3.4	1.4	0.146
6588	5.6	149.2	5.8	161.7	-0.2	-12.5	1.3	0.225
6595	7.9	149.3	7.4	164.3	0.5	-14.9	2.0	0.259
6598	6.5	161.0	6.7	170.3	-0.2	-9.2	1.1	0.168
6605	7.7	157.8	7.2	167.0	0.5	-9.2	1.3	0.166
6765	7.0	169.6	7.4	152.0	-0.4	17.7	2.2	0.320
6770	6.9	150.4	6.7	158.8	0.2	-8.4	1.0	0.147
6780	3.9	175.6	5.5	171.6	-1.6	4.0	1.6	0.414
6781	3.9	162.9	5.5	171.6	-1.6	-8.6	1.7	0.446
Mean	10.5	–	10.7	–	-0.2	1.5	1.9	0.2
Absolute	–	–	–	–	1.1	7.9	–	–
RMS	11.6	136.6	11.7	135.7	1.5	9.1	2.1	0.256

Table 18 continued: Arctic Central - N2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
3902	19.4	-176.9	21.6	170.7	-2.2	12.4	4.9	0.255
5428	26.0	-178.1	25.5	170.0	0.5	11.9	5.4	0.206
5430	26.2	180.0	24.8	174.7	1.4	5.3	2.8	0.105
5510	21.0	-142.0	21.2	-155.4	-0.2	13.4	4.9	0.234
5530	25.6	-140.1	23.5	-169.0	2.1	28.9	12.4	0.485
5560	19.1	-129.6	14.4	-136.2	4.7	6.6	5.1	0.266
5600	15.6	-112.2	12.9	-109.3	2.7	-2.9	2.8	0.178
5865	21.9	-160.0	25.8	177.8	-3.9	22.2	9.9	0.454
5905	19.5	-151.0	21.2	-167.8	-1.7	16.8	6.2	0.317
5910	16.5	-150.7	13.9	-160.4	2.6	9.7	3.7	0.223
6080	8.9	-151.1	7.7	-175.3	1.2	24.2	3.7	0.412
6556	34.6	170.2	33.9	167.6	0.7	2.6	1.7	0.049
6557	32.4	175.0	32.4	170.2	-0.0	4.8	2.7	0.083
6560	36.7	173.4	35.4	172.5	1.3	0.9	1.5	0.040
6570	37.7	177.5	35.3	169.6	2.4	7.9	5.6	0.148
6580	33.2	-175.0	32.7	-178.6	0.5	3.6	2.1	0.064
6584	17.1	-159.4	12.6	-143.1	4.5	-16.3	6.1	0.358
6588	9.1	-163.4	8.2	-128.1	0.9	-35.3	5.3	0.584
6595	14.5	-157.7	10.8	-131.0	3.7	-26.7	6.9	0.474
6598	11.2	-151.1	9.7	-123.0	1.5	-28.1	5.3	0.472
6605	13.7	-153.4	10.6	-128.4	3.1	-25.0	6.1	0.443
6765	14.9	-134.0	14.0	-134.7	0.9	0.7	0.9	0.063
6770	11.0	-119.9	12.2	-127.3	-1.2	7.4	1.9	0.174
6780	7.0	-135.0	8.6	-111.9	-1.6	-23.1	3.5	0.503
6781	4.6	-116.4	8.7	-112.4	-4.1	-4.0	4.1	0.889
Mean	19.9	–	19.1	–	0.8	0.7	4.6	0.3
Absolute	–	–	–	–	2.0	13.6	–	–
RMS	22.0	154.6	21.2	152.4	2.4	17.0	5.3	0.361

Table 18 continued: Arctic Central - S2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
3902	21.6	-105.7	19.4	-110.2	2.2	4.5	2.7	0.126
5428	30.1	-97.2	26.5	-103.0	3.6	5.8	4.6	0.152
5430	34.1	-91.8	24.3	-91.4	9.8	-0.4	9.8	0.286
5510	27.4	-24.8	26.6	-41.0	0.8	16.3	7.7	0.281
5530	28.1	-40.0	27.7	-59.3	0.4	19.4	9.4	0.335
5560	19.5	-21.2	20.6	-27.8	-1.1	6.6	2.5	0.130
5600	16.2	-6.2	17.6	-16.6	-1.4	10.4	3.4	0.209
5865	15.8	-79.8	15.0	-91.1	0.8	11.3	3.1	0.198
5905	27.4	-53.8	24.9	-61.0	2.5	7.3	4.2	0.152
5910	10.6	-39.3	12.7	-49.5	-2.1	10.3	3.0	0.281
6080	8.7	-12.8	11.0	-19.9	-2.3	7.2	2.6	0.295
6556	35.8	-99.6	27.1	-103.9	8.7	4.3	9.0	0.252
6557	33.4	-103.3	26.0	-105.0	7.4	1.7	7.4	0.222
6560	32.0	-100.9	25.2	-102.9	6.8	2.0	6.8	0.214
6570	30.8	-94.8	26.8	-102.7	4.0	7.9	5.6	0.183
6580	23.3	-83.8	23.2	-90.0	0.1	6.2	2.5	0.108
6584	8.6	-35.8	3.6	-19.5	5.0	-16.3	5.3	0.611
6588	5.4	37.8	7.1	54.0	-1.7	-16.1	2.4	0.444
6595	6.3	-19.7	3.7	23.0	2.6	-42.6	4.4	0.693
6598	5.6	-2.9	4.1	29.7	1.5	-32.6	3.1	0.549
6605	5.7	-12.5	3.7	23.5	2.0	-35.9	3.5	0.610
6765	10.9	-13.8	6.4	-24.3	4.5	10.6	4.7	0.434
6770	10.2	6.6	7.7	-1.9	2.5	8.5	2.8	0.279
6780	9.4	11.2	9.3	34.3	0.1	-23.0	3.7	0.397
6781	8.3	29.5	8.9	34.0	-0.6	-4.5	0.9	0.108
Mean	18.6	–	16.4	–	2.2	-1.2	4.6	0.3
Absolute	–	–	–	–	3.0	12.5	–	–
RMS	21.4	61.3	18.6	66.8	4.0	16.4	5.2	0.344

Table 18 continued: Arctic Central - K1 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
3902	7.8	-147.1	7.0	-145.9	0.8	-1.2	0.8	0.099
5428	12.7	-143.1	10.3	-146.1	2.4	3.1	2.4	0.193
5430	10.8	-134.4	10.1	-133.6	0.7	-0.8	0.7	0.066
5510	14.9	-106.3	12.8	-95.5	2.1	-10.8	3.3	0.223
5530	16.3	-96.2	12.9	-109.2	3.4	13.0	4.7	0.291
5560	10.9	-82.0	10.6	-88.2	0.3	6.2	1.2	0.110
5600	8.1	-78.4	9.3	-82.0	-1.2	3.6	1.3	0.160
5865	8.2	-120.3	6.6	-122.2	1.6	1.9	1.6	0.201
5905	13.5	-112.3	11.8	-108.7	1.7	-3.7	1.9	0.137
5910	8.7	-106.7	7.9	-99.9	0.8	-6.8	1.3	0.147
6080	7.2	-95.2	7.8	-87.1	-0.6	-8.2	1.2	0.172
6556	12.8	-136.7	10.4	-147.5	2.4	10.8	3.3	0.255
6557	11.7	-140.9	10.0	-148.0	1.7	7.1	2.2	0.187
6560	11.1	-138.5	9.8	-146.2	1.3	7.7	1.9	0.174
6570	12.8	-141.0	10.3	-146.4	2.5	5.4	2.7	0.214
6580	8.6	-132.8	8.3	-136.7	0.3	3.8	0.6	0.073
6584	4.1	-80.3	2.3	-76.4	1.8	-3.9	1.8	0.434
6588	2.8	-27.6	2.7	-29.3	0.1	1.7	0.1	0.039
6595	3.1	-63.2	2.0	-56.8	1.1	-6.5	1.1	0.357
6598	2.9	-54.7	2.1	-50.0	0.8	-4.7	0.9	0.301
6605	2.8	-59.0	2.0	-56.9	0.8	-2.1	0.8	0.288
6765	5.7	-75.3	3.9	-94.7	1.8	19.4	2.4	0.421
6770	6.5	-62.5	4.0	-75.6	2.5	13.0	2.7	0.421
6780	4.5	-50.3	3.8	-41.9	0.7	-8.4	0.9	0.201
6781	4.7	-35.7	3.7	-42.5	1.0	6.8	1.1	0.239
Mean	8.5	–	7.3	–	1.2	1.9	1.7	0.2
Absolute	–	–	–	–	1.4	6.4	–	–
RMS	9.4	103.4	8.1	105.7	1.6	7.7	2.0	0.241

Table 18 continued: Arctic Central - O1 Results

B.6 Arctic South Central

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
6090	15.9	103.4	10.6	76.1	5.3	27.3	8.1	0.509
6110	23.4	53.8	22.9	30.5	0.5	23.3	9.4	0.400
6150	6.1	100.0	2.3	-155.6	3.8	-104.4	7.1	1.158
6240	14.7	178.9	9.6	173.1	5.1	5.8	5.2	0.356
Mean	15.0	–	11.4	–	3.7	-12.0	7.4	0.6
Absolute	–	–	–	–	3.7	40.2	–	–
RMS	16.2	117.9	13.5	123.4	4.1	55.3	7.6	0.687

Table 19: Arctic South Central - M2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
6090	2.1	71.3	2.0	52.4	0.1	19.0	0.7	0.326
6110	3.3	12.2	4.3	6.4	-1.0	5.8	1.1	0.327
6150	1.2	65.2	0.3	172.7	0.9	-107.6	1.3	1.122
6240	2.7	140.7	2.1	135.6	0.6	5.1	0.6	0.222
Mean	2.3	–	2.2	–	0.1	-19.4	0.9	0.5
Absolute	–	–	–	–	0.6	34.4	–	–
RMS	2.5	85.6	2.6	112.9	0.7	54.7	1.0	0.617

Table 19 continued: Arctic South Central - N2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
6090	7.2	167.2	7.8	148.4	-0.6	18.8	2.5	0.351
6110	9.3	126.1	11.7	120.3	-2.4	5.8	2.6	0.282
6150	2.4	158.4	1.0	-58.2	1.4	-143.4	3.2	1.340
6240	5.5	-121.2	5.0	-117.6	0.5	-3.6	0.6	0.110
Mean	6.1	–	6.4	–	-0.3	-30.6	2.2	0.5
Absolute	–	–	–	–	1.2	42.9	–	–
RMS	6.6	144.6	7.5	115.9	1.5	72.4	2.4	0.709

Table 19 continued: Arctic South Central - S2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative

6090	9.9	-0.4	12.8	-10.9	-2.9	10.5	3.5	0.358
6110	10.2	11.3	13.3	1.5	-3.1	9.9	3.7	0.365
6150	2.1	137.2	2.4	151.9	-0.3	-14.8	0.7	0.320
6240	5.1	128.9	7.7	94.9	-2.6	34.0	4.5	0.886
Mean	6.8	–	9.1	–	-2.2	9.9	3.1	0.5
Absolute	–	–	–	–	2.2	17.3	–	–
RMS	7.6	94.3	10.1	89.8	2.5	19.9	3.4	0.536

Table 19 continued: Arctic South Central - K1 Results

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
6090	7.6	-93.2	8.8	-82.9	-1.2	-10.4	1.9	0.249
6110	7.4	-91.2	9.1	-75.8	-1.7	-15.4	2.8	0.375
6150	1.6	30.4	1.8	81.7	-0.2	-51.3	1.5	0.920
6240	3.6	-13.8	6.0	8.6	-2.4	-22.4	3.0	0.832
Mean	5.0	–	6.4	–	-1.4	-24.9	2.3	0.6
Absolute	–	–	–	–	1.4	24.9	–	–
RMS	5.7	67.3	7.1	69.6	1.6	29.5	2.4	0.660

Table 19 continued: Arctic South Central - O1 Results

B.7 Arctic Southeast

Stat #	**Observed**		**Modelled**		**Error**		**Complex Error**	
	cm	deg	cm	deg	cm	deg	cm	relative
5295	65.6	0.0	67.4	0.8	-1.8	-0.8	2.1	0.031
5305	68.3	4.8	67.7	-1.8	0.6	6.6	7.9	0.115
5310	64.2	8.0	65.9	-1.0	-1.7	9.0	10.4	0.162
5315	61.4	-14.3	60.2	-26.3	1.2	12.0	12.7	0.208
5330	49.3	-20.1	55.9	-35.2	-6.6	15.1	15.3	0.311
5332	47.9	-20.9	52.9	-33.6	-5.0	12.7	12.2	0.254
5790	57.3	139.9	58.5	127.8	-1.2	12.1	12.3	0.214
5791	55.6	132.5	58.5	127.8	-2.9	4.7	5.5	0.099
5920	52.5	163.5	43.0	147.2	9.5	16.3	16.5	0.314
Mean	58.0	–	58.9	–	-0.9	9.8	10.5	0.2
Absolute	–	–	–	–	3.4	9.9	–	–
RMS	58.4	85.0	59.4	79.9	4.4	11.0	11.4	0.211

Table 20: Arctic Southeast - M2 Results

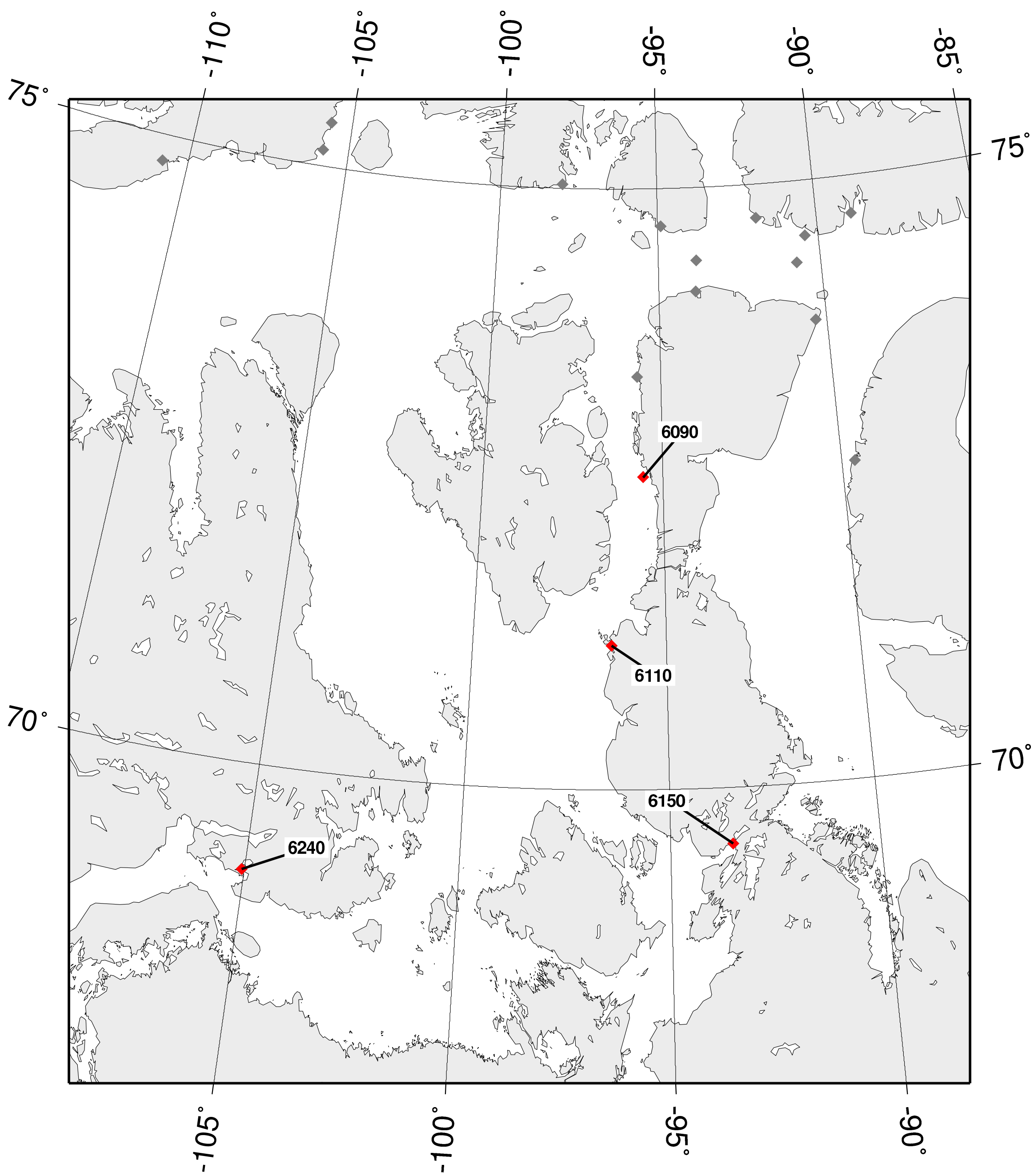

Figure 17: Arctic South Central

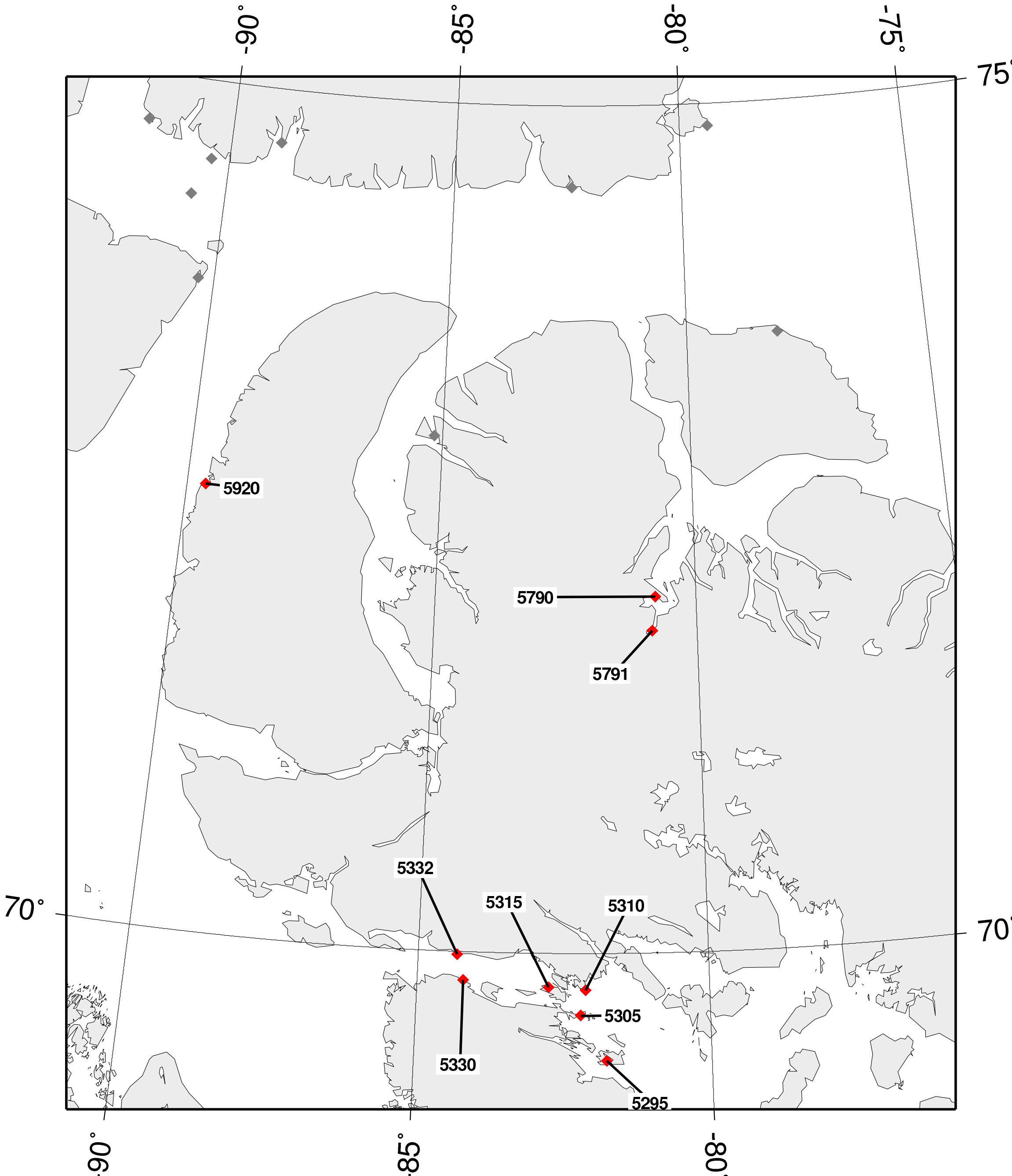

Figure 18: Arctic Southeast

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5295	9.8	-40.1	10.0	-39.1	-0.2	-1.0	0.2	0.025
5305	15.6	-39.6	10.3	-43.2	5.3	3.6	5.4	0.344
5310	10.9	-15.9	9.9	-44.0	1.0	28.1	5.1	0.472
5315	8.9	-11.2	11.6	-57.2	-2.7	46.0	8.4	0.941
5330	16.7	-68.0	11.4	-63.3	5.3	-4.7	5.5	0.327
5332	16.8	-54.7	10.9	-62.5	5.9	7.8	6.2	0.367
5790	12.8	103.2	12.7	102.3	0.1	0.9	0.2	0.017
5791	9.7	85.0	12.7	102.3	-3.0	-17.3	4.5	0.463
5920	9.0	131.4	8.5	119.1	0.5	12.3	1.9	0.215
Mean	12.2	–	10.9	–	1.4	8.4	4.2	0.4
Absolute	–	–	–	–	2.7	13.5	–	–
RMS	12.6	71.7	11.0	75.8	3.5	19.6	4.9	0.438

Table 20 continued: Arctic Southeast - N2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5295	23.0	57.5	23.8	59.2	-0.8	-1.7	1.0	0.045
5305	23.0	52.1	23.7	55.3	-0.7	-3.2	1.5	0.065
5310	21.8	68.5	22.9	56.1	-1.1	12.4	4.9	0.227
5315	21.5	56.8	21.6	25.1	-0.1	31.7	11.8	0.548
5330	15.1	28.0	20.6	15.2	-5.5	12.8	6.7	0.445
5332	21.0	16.3	19.4	16.2	1.6	0.1	1.6	0.077
5790	20.4	-176.0	21.2	170.5	-0.8	13.5	4.9	0.242
5791	23.4	-178.9	21.2	170.5	2.2	10.6	4.7	0.200
5920	18.5	-143.4	16.4	-161.8	2.1	18.4	6.0	0.322
Mean	20.9	–	21.2	–	-0.3	10.5	4.8	0.2
Absolute	–	–	–	–	1.6	11.6	–	–
RMS	21.0	104.6	21.3	102.8	2.2	14.8	5.7	0.291

Table 20 continued: Arctic Southeast - S2 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5295	34.1	48.3	39.2	51.9	-5.1	-3.6	5.6	0.163
5305	34.8	18.3	39.6	46.3	-4.8	-28.0	18.6	0.534
5310	30.6	35.5	35.7	49.1	-5.1	-13.6	9.4	0.306
5315	65.4	13.6	59.0	10.1	6.4	3.5	7.5	0.114
5330	61.4	2.7	64.4	3.8	-3.0	-1.1	3.3	0.053
5332	61.6	-0.4	60.8	3.4	0.8	-3.8	4.2	0.067
5790	25.6	-111.8	20.4	-112.7	5.2	1.0	5.2	0.205
5791	25.3	-114.3	20.4	-112.7	4.9	-1.5	5.0	0.196
5920	21.5	-9.6	26.8	-20.1	-5.3	10.5	6.9	0.319
Mean	40.0	–	40.7	–	-0.7	-4.1	7.3	0.2
Absolute	–	–	–	–	4.5	7.4	–	–
RMS	43.3	57.5	43.8	60.7	4.8	11.2	8.5	0.260

Table 20 continued: Arctic Southeast - K1 Results

Stat #	Observed		Modelled		Error		Complex Error	
	cm	deg	cm	deg	cm	deg	cm	relative
5295	16.4	-21.6	16.4	-18.7	-0.0	-2.8	0.8	0.050
5305	15.9	-28.8	16.2	-24.6	-0.3	-4.2	1.2	0.077
5310	15.6	-29.3	14.8	-23.4	0.8	-5.9	1.8	0.113
5315	27.0	-49.7	25.8	-50.8	1.2	1.1	1.3	0.047
5330	29.3	-35.3	27.8	-55.6	1.5	20.4	10.2	0.348
5332	28.9	-52.8	26.5	-55.9	2.4	3.1	2.8	0.098
5790	8.2	-150.3	7.2	-149.1	1.0	-1.1	1.0	0.121
5791	7.5	-158.6	7.2	-149.1	0.3	-9.4	1.2	0.166
5920	13.6	-70.7	13.2	-75.5	0.4	4.8	1.2	0.088
Mean	18.0	–	17.2	–	0.8	0.7	2.4	0.1
Absolute	–	–	–	–	0.9	5.9	–	–
RMS	19.7	82.6	18.8	82.0	1.1	8.2	3.7	0.151

Table 20 continued: Arctic Southeast - O1 Results

C Prediction errors

C.1 Baffin Bay

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
G01	4	138.6	12.4	0.217	12.4	0.217	0.0
G09	4	139.8	11.9	0.208	11.9	0.208	0.0
G11	4	184.4	14.7	0.166	14.7	0.166	0.0
G14	4	131.0	11.9	0.229	11.9	0.229	0.0
G16	4	200.5	19.7	0.207	19.7	0.207	0.0
G24	4	108.0	15.8	0.361	15.8	0.361	0.0
G26	4	128.6	9.6	0.186	9.6	0.186	0.0
G28	4	155.0	29.0	0.445	29.0	0.445	0.0
G29	4	208.4	18.3	0.198	18.3	0.198	0.0
G31	4	112.0	9.6	0.217	9.6	0.217	0.0
3575	9	279.4	32.1	0.295	34.2	0.313	2.1
3916	31	130.2	7.8	0.198	10.7	0.265	2.8
3941	31	48.3	17.9	1.567	18.5	1.498	0.6
3948	31	81.8	9.5	0.422	11.2	0.481	1.7
3960	9	68.4	8.9	0.406	9.9	0.443	1.0
3970	9	80.3	9.5	0.381	11.0	0.433	1.6
3980	9	94.1	9.2	0.308	11.2	0.365	2.0
3995	9	147.8	17.5	0.278	18.4	0.291	0.9
4040	7	381.5	45.2	0.262	48.1	0.277	2.8
64000	69	206.6	7.4	0.106	11.7	0.167	4.3
64005	69	214.4	7.8	0.110	12.3	0.172	4.5
64010	69	245.7	10.0	0.127	14.7	0.185	4.7
RMS	–	–	17.8	0.427	18.9	0.430	–

Table 21: Baffin Bay Prediction error

C.2 Arctic West

Stat #	**# Cons.**	**MaxTide**	**5 vs 5**		**5 vs All**		**Diff**
			cm	norm	cm	norm	
6290	39	21.4	11.0	1.873	11.3	1.752	0.3
6310	9	44.7	3.7	0.249	4.4	0.297	0.8
6338	25	42.5	9.6	0.686	10.2	0.709	0.6
6340	25	39.9	8.5	0.788	9.6	0.823	1.1
6350	9	37.8	7.1	0.535	7.3	0.546	0.2
6360	48	51.7	6.4	0.633	11.1	0.818	4.7
6424	41	21.1	4.5	0.928	5.3	0.947	0.9
6443	28	29.4	8.2	1.283	10.9	1.132	2.7
6457	28	69.6	34.4	1.461	34.7	1.443	0.4
6472	28	56.1	4.0	0.246	8.3	0.466	4.3
6476	28	41.1	5.4	0.529	8.9	0.715	3.5
6485	40	49.6	3.7	0.377	9.8	0.738	6.2
6492	28	34.7	7.0	1.099	10.0	1.045	2.9
6495	27	32.6	5.2	0.882	8.7	0.953	3.4
6498	28	18.7	5.3	1.072	5.4	1.066	0.1
6505	29	60.9	5.7	0.631	17.5	0.928	11.8
6525	27	32.2	4.9	0.720	8.2	0.868	3.3
RMS	–	–	10.5	0.924	12.6	0.958	–

Table 22: Arctic West Prediction error

C.3 Arctic North

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
G08	4	201.6	22.0	0.248	22.0	0.248	0.0
G30	4	97.0	8.9	0.204	8.9	0.204	0.0
3690	8	246.5	35.5	0.396	37.3	0.413	1.9
3710	7	229.0	25.0	0.299	27.1	0.322	2.1
3735	8	118.7	3.5	0.079	6.6	0.148	3.1
3736	27	136.0	4.8	0.108	9.6	0.212	4.8
3740	29	97.9	4.7	0.154	8.4	0.268	3.7
3755	8	41.8	5.6	0.435	6.2	0.472	0.6
3765	48	63.4	2.9	0.168	6.2	0.347	3.4
3780	11	53.5	5.6	0.287	6.1	0.310	0.5
3782	27	92.6	4.2	0.138	7.3	0.235	3.1
3788	27	134.6	5.5	0.121	9.7	0.210	4.2
3790	9	101.7	16.4	0.375	18.1	0.409	1.8
3840	10	269.4	10.5	0.110	16.4	0.171	5.9
6660	10	17.6	7.7	1.410	7.9	1.387	0.1
6670	10	26.9	7.3	1.052	8.0	1.044	0.7
6704	10	24.2	9.0	1.457	10.0	1.328	0.9
6730	28	15.0	9.6	2.524	9.7	2.378	0.1
6735	11	30.7	4.2	0.429	4.5	0.451	0.3
RMS	–	–	13.2	0.816	14.7	0.791	–

Table 23: Arctic North Prediction error

C.4 Arctic Northwest

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
5645	10	82.8	9.7	0.313	10.6	0.340	0.9
6834	28	89.8	6.5	0.270	8.6	0.350	2.2
6835	52	88.5	6.3	0.245	8.0	0.304	1.7
6910	9	22.9	3.9	0.508	4.0	0.525	0.2
6955	9	31.2	7.7	0.650	7.8	0.652	0.1
RMS	–	–	7.1	0.427	8.1	0.454	–

Table 24: Arctic Northwest Prediction error

C.5 Arctic Central

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
3902	31	157.5	8.1	0.182	12.3	0.270	4.1
5428	33	185.3	8.6	0.148	12.6	0.215	4.1
5430	9	170.0	9.5	0.165	13.3	0.228	3.8
5510	8	150.9	14.3	0.277	15.4	0.298	1.2
5530	28	196.8	26.0	0.461	28.5	0.495	2.5
5560	18	138.9	9.7	0.246	13.3	0.331	3.7
5600	25	104.0	7.1	0.225	9.2	0.288	2.1
5865	9	134.6	15.6	0.320	16.5	0.337	0.9
5905	18	158.1	8.8	0.173	11.1	0.216	2.3
5910	27	129.5	10.4	0.302	15.3	0.421	4.9
6080	27	65.5	7.6	0.391	8.2	0.421	0.7
6556	31	233.5	9.5	0.127	14.9	0.198	5.4
6557	33	222.5	8.6	0.123	14.0	0.198	5.5
6560	31	238.9	10.0	0.136	15.8	0.214	5.9
6570	31	233.7	10.5	0.135	15.2	0.193	4.7
6580	27	200.7	7.8	0.117	12.1	0.179	4.3
6584	27	99.4	7.2	0.213	8.5	0.250	1.3
6588	23	57.3	4.5	0.236	5.3	0.275	0.8
6595	27	80.9	6.4	0.230	7.4	0.264	1.0
6598	27	67.9	4.5	0.201	5.7	0.251	1.2
6605	27	79.1	5.4	0.201	6.6	0.246	1.3
6765	10	90.0	10.3	0.338	11.5	0.374	1.3
6770	27	83.4	7.8	0.299	8.9	0.336	1.1
6780	11	52.1	4.6	0.272	5.3	0.309	0.7
6781	20	48.7	4.4	0.287	5.1	0.324	0.6
RMS	–	–	10.1	0.248	12.7	0.296	–

Table 25: Arctic Central Prediction error

C.6 Arctic South Central

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
6090	27	57.1	6.7	0.438	7.5	0.479	0.8
6110	27	67.2	7.7	0.384	8.4	0.414	0.7
6150	27	22.3	5.7	1.121	6.3	1.096	0.6
6240	48	57.9	5.4	0.444	9.1	0.645	3.8
RMS	–	–	6.4	0.670	7.9	0.710	–

Table 26: Arctic South Central Prediction error

C.7 Arctic Southeast

Stat #	# Cons.	MaxTide	5 vs 5		5 vs All		Diff
			cm	norm	cm	norm	
5295	27	183.3	4.3	0.076	10.6	0.185	6.3
5305	25	199.3	14.8	0.253	18.1	0.304	3.3
5310	31	194.3	11.2	0.206	15.7	0.282	4.5
5315	26	252.9	14.6	0.214	22.4	0.319	7.8
5330	25	252.0	14.6	0.237	30.6	0.456	16.0
5332	26	231.4	10.4	0.167	17.0	0.270	6.7
5790	10	141.5	10.1	0.211	12.4	0.257	2.3
5791	10	139.2	7.1	0.150	10.2	0.214	3.2
5920	27	138.1	13.4	0.307	14.9	0.338	1.5
RMS	–	–	11.7	0.212	17.9	0.301	–

Table 27: Arctic Southeast Prediction error

D Errors at Padman and Erofeeva (2004) locations

Padman and Erofeeva (2004) report on a tidal model of the Arctic Ocean that includes well-modelled solutions in the Archipelago. Their solutions were computed on a model domain that covered the entire Arctic Ocean at 5 km resolution and using a very different assimilation scheme.

The Arctic8d solutions have been evaluated at several locations modelled by Padman and Erofeeva (2004) for a rough comparison of the two solutions. Results were compared for two regions for which several common stations could be found: Baffin Bay (their region 6) and Nares Strait (their region 7). The identification of common locations was not precise; it was done by a visual inspection of each model's associated station maps. Twelve common locations were identified in Baffin Bay (for M2) out of a total of nineteen reported by Padman and Erofeeva (2004). At least two of the rejected stations were located in southern Greenland, outside the domain of Arctic8d. Nine common locations were identified in Nares Strait. While the station lists may not be identical, we think they suffice for a rough comparison of the errors based on similar region partitioning.

Tables 28 and 29 list Arctic8d errors at the stations identified (extracted from the tables in Appendix B). The comparison with the regional statistics of Padman and Erofeeva (2004) are reported in Section 4. It is worth noting that the regional errors are dominated by large errors at a few stations.

Note that our error metric is the difference in the tidal phasors and represents a peak error. The errors reported by Padman and Erofeeva (2004) are the rms error which is the peak error divided by $\sqrt{2}$.

Stat #	M2	N2	S2	K1	O1
	cm	cm	cm	cm	cm
G09	10.1	NaN	4.7	3.4	0.9
3995	22	4.7	9.8	1.1	1.6
G16	3.6	NaN	13.2	1	0.4
G28	34.2	NaN	16.2	3.7	4.4
3970	12	0.9	4.9	3.2	0.7
3902	9.8	1.9	4.9	2.7	0.8
5428	9.3	1.7	5.4	4.6	2.4
6557	8.7	1.7	2.7	7.4	2.2
6556	8.9	1.8	1.7	9	3.3
3840	7.4	5.8	5.7	9	4.1
3710	30.3	8.8	15.5	2.7	3.1
3690	44.8	10.8	18.8	5.8	2.4
RMS	20.9	5.4	10.3	5.2	2.5

Table 28: Errors at Padman and Erofeeva (2004) stations in Baffin Bay (their region 6).

Stat #	M2	N2	S2	K1	O1
	cm	cm	cm	cm	cm
3755	7.2	1.3	0.9	1.8	2.1
3765	3.1	1	1.6	0.7	1.6
3782	4.7	2.6	1.7	0.8	1.2
3788	7	1.4	2.1	1.5	1.7
3790	5.3	0.7	NaN	1.1	1.5
G30	4.4	NaN	3	2.8	2.1
3735	1.6	0.8	3.4	2.5	1.9
3736	4.9	2.5	2.5	2.2	1.8
3740	6	1.3	1.9	1	1.4
RMS	5.2	1.6	2.3	1.8	1.7

Table 29: Errors at Padman and Erofeeva (2004) stations in Nares Strait (their region 7).

E Tidal ellipse errors for Barrow Strait ADCP data

Here we report the comparison between the modelled and observed tidal currents for N2, S2, O1. The larger velocity components are reported in Section 5.

Stat #	Major		Eccentricity		Inclination		Phase	
	obs	mod	obs	mod	obs	mod	obs	mod
N2								
A1438_39	1.5	1.8	-0.053	-0.211	163.7	13.4	102.0	357.7
A1441	1.6	1.9	-0.054	-0.156	165.4	8.9	94.3	359.6
A1443	2.1	2.0	-0.322	-0.073	164.9	174.4	35.2	179.9
A1445	1.9	2.0	0.027	-0.000	163.7	161.3	110.2	158.6
S2								
A1438_39	2.5	3.3	0.076	-0.018	172.2	162.7	267.2	243.3
A1441	3.5	3.4	-0.130	-0.057	176.4	168.8	244.9	243.1
A1443	3.4	3.6	-0.153	-0.066	165.4	174.0	178.4	240.9
A1445	3.6	3.6	0.010	-0.001	166.7	160.5	224.3	220.1
O2								
A1438_39	4.2	4.3	0.175	0.041	159.8	157.8	215.3	283.1
A1441	5.3	4.3	-0.005	-0.067	161.3	158.1	249.3	293.9
A1443	5.4	4.2	-0.198	-0.160	163.9	164.0	231.4	293.6
A1445	4.2	3.7	0.053	-0.037	160.5	159.9	239.5	253.8

Table 30: Tidal current comparison for N2, S2, and O1. The major axis is the maximum tidal current (cms^{-1}). Eccentricity (dimensionless) is the ratio between the semi-minor axis and the semi-major axis, and is negative if the ellipse is traversed clockwise. The inclination is the angle in degrees of the major axis with the x (east) axis measured counterclockwise (the mathematical convention). The phase is the timing of the maximum current, expressed as phase lag relative to Greenwich, in degrees.