Reply from authors on comments from Referee #3

Abstract rewritten and shortened and focus more on results.

Clarified that chl a i used as a proxy for primary production.

CT measurements: added details on the measurement and added references. Also clarified the use of certified standard material for accuracy control and internal consistency check.
We estimated the standard error in fCO_2 to ±9 µatm (Chierici et al., 2012). This corresponds to an error of ±0.02 in ΩAr and ±0.03 in ΩCa. Moreover, in OSO2010/2011 we sampled water for post-cruise analysis of C_T to provide an internal consistency check and estimate the total error in our AT, CT and derived parameters.
We compared the C_T calculated from A_T and pH15 with the measured C_T determined from gas extraction of acidified sample followed by NDIR detection. Based on regression analysis of 26 data points we obtained a standard error of ±7 µmol/kg in C_T (r^2 of 0.904), and standard error in ΩAr was ±0.05 (r^2=0.842).

Reply on comment on Multivariate analysis: The multivariate analysis has been described more thoroughly and also included a table which summarizes the statistical output from the model runs (correlation, error and more, new Table 2).

Text on Multivariate added in method section (in blue table 2 follows):

OPLS-DA is a further development from PCA (Trygg and Wold, 2002). OPLS-DA is a regression method that finds information in the x-data which is related to the y-data to make predictions. Here we use OPLS-DA to investigate the major drivers explaining the variability in Ω_{Ar}. The OPLS-DA analysis was performed with ΩAr as y-variable and one of A_T/C_T/pH^{15}/chl a/SST/salinity as x-variables. Two models were made; one for Amundsen Sea and one for Ross Sea to investigate if controls on ΩAr were significantly different in the two regions.. All values were scaled with unit variance (UV) prior to modeling, which gives equal weight to all variables. The model was evaluated by Q2 and R2X, where Q2 is a measure of the quality of the model based on cross-validation, where fractions of data are systematically kept out. Q2 is a sum of squares that is accumulated for the deviations from the actual model response y. The Q2 values are calculated per model component and can be reported as a cumulative value for the determined number of components. In principle, R2X is the same measure but without cross validation. For OPLS-DA, R2X of the predictive component is also a measure of how much of the variation in X is related to the variation in Y. The statistical output from the PCA and OPLS-DA are summarized in Table 2.

Table 2

Name	Type	Components	Observations	R2X	R2Y	Q2
Interannual	PCA-X	2	219	0.808	---	0.708
AmS	OPLS-DA	1+1+0	69	0.554	0.99	0.99
RS	OPLS-DA	1+2+0	52	0.885	0.99	0.99

* OPLS-DA loading; Ω_{Ar} (y), 7 variables (x): AT/CT/pH/ pH^{15}/Chl a/SST/salinity; **1**+*1*+0, **1** correlates to y, *1* orthogonal to x, 0 orthogonal to y.

We also removed the text in the discussion regarding the influence of melt water on AT and salinity and differences between Amundsen and Ross seas since there were no statistically differences between the two. This has been removed and other less "firm" evidence has been removed from the text as well as in the abstract.
We do not use the PCA for future prognosis. Multivariate is used to obtain an objective view on the data which we find useful.
The results section has been extensively rewritten and more clearly following observations.

Figure 6 (and several others): increased fonts on axis and also ask the production of BGS to place maximum 2 figures on one sheet.

Several comments are based on a misconception that the data has large seasonal variability. This is not the case since measurements/samples were performed in December to beginning of January (except 2006 which ended 26th December). This is clearly stated in Table 1 in the previous version. In the revised version this has been clarified further in the text and figure captions and figures. It was an unfortunate denotation which has been changed in the text and figures and figures captions.

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Hydrography section
We have substantially rewritten the hydrography section and added information on the sub-Antarctic front and the Antarctic Polar Front for all years. We use the surface temperature definitions from Moore et al., 1999, and Dong et al., 2006 to explore the fronts. The references are added in the reference list.

Results

We have included more detailed analysis of the variability for all parameters based on observations. We have increased the font and ask the editor to include two figures/page instead of 6 as they are now.

Added new (8 more figures, new Figure 3) for salinity and SST in surface plot ODV format to facilitate detailed viewing in the Amundsen and Ross Sea.

Discussion

The discussion has been rewritten and removed text which is not based on our data. We also comment on the role of melt water for the carbonate system and chl a values is restricted to the finding in the southern part of PFZ and at the ice edge, where we find the low salinity high chl a water in 2010. This has been clarified in the text.

In summer 2010/2011, the sea-ice edge has the northernmost extent which may imply a large marginal ice zone. This is also observed on the December anomalies where sea ice remains in 2010. Our view is that more sea-ice has the potential to create larger volumes of melt water than years with less sea ice. However, we realize there may be other causes for low salinity in the APF is less upwelling of CDW. This has been added to the text and we include a more nuanced explanation for the high chl a values.

We have removed large parts on the role of melt water. It is diffult to discern with our data.

Table 2: Statistical summary of the principal component analysis (PCA) and the two models from the OPLS-DA on the Amundsen Sea (AmS) and the Ross Sea (RS).

Name	Type	Components	Observations	R2X	R2Y	Q2
Interannual	PCA-X	2	219	0.808	---	0.708
AmS	OPLS-DA	1+1+0	69	0.554	0.99	0.99
RS	OPLS-DA	1+2+0	52	0.885	0.99	0.99

* OPLS-DA loading; Ω_{Ar} (y), 7 variables (x): AT/CT/pH/ pH^{15}/Chl a/SST/salinity; **1**+*1*+0, **1** correlates to y, *1* orthogonal to x, 0 orthogonal to y.

Table 4. Summary of the mean values and standard deviation of the carbonate system parameters, total alkalinity (A_T), total dissolved inorganic carbon (C_T), pH on total scale at 15 ºC (pH^{15}), pH on total scale at *in situ* temperature (pH *in situ*), aragonite saturation (Ω_{Ar}), and calcite saturation (Ω_{Ca}) in the Amundsen Sea (AmS, grey shade) and Ross Sea (RS) for each year. N denotes number of data points used in the study for each year. Minimum and maximum values are denoted min and max, respectively. * *In 2006, samples are located in northern Amundsen Sea (~68 ºS) and not in the polynya or coastal Amundsen Sea, thus intercomparison is irrelevant.*

Expedition (region)	**A_T ($\mu molkg^{-1}$)**	**min/ max**	**C_T ($\mu molkg^{-1}$)**	**min/ max**	**pH^{15}**	**min/ max**	**pH *in situ***	**min/ max**	**Ω_{Ar}**	**min/ max**	**Ω_{Ca}**	**min/ max**	**N**
*OSO2006 (AmS)**	*2303±12*	*2287/ 2316*	*2170 ±14*	*2147 /2192*	*7.846 ±0.017*	*7.819/ 7.871*	*8.106 ±0.016*	*8.082/ 8.130*	*1.54 ±0.05*	*1.46/ 1.63*	*2.45 ±0.09*	*2.33 2.61*	*16*
OSO2006 (RS)	2305±12	2289 /2331	2192 ±9	2181/ 2216	7.793 ±0.035	7.733/ 7.859	8.060 ±0.032	8.004/ 8.121	1.37 ±0.12	1.18/ 1.60	2.19 ±0.19	1.89/ 2.55	25
OSO2007/2008 (AmS)	2295±12	2270/ 2322	2190 ±22	2141/ 2225	7.771 ±0.063	7.675/ 7.900	8.038 ±0.067	7.932/ 8.179	1.30± 0.19	1.03/ 1.71	2.07 ±0.30	1.64/ 2.73	34
OSO2007/2008 (RS)	2313±19	2285/ 2343	2196±18	2153/ 2213	7.794 ±0.074	7.730/ 7.969	8.053 ±0.075	7.994/ 8.235	1.40± 0.27	1.18/ 2.05	2.23 ±0.43	1.88/ 3.27	9
OSO2008/2009 (AmS)	2288±11	2275/ 2315	2182 ±32	2094/ 2202	7.771 ±0.100	7.710/ 8.030	8.041 ±0.103	7.976/ 8.304	1.32± 0.36	1.11/ 2.26	2.10 ±0.58	1.77/ 3.61	13
OSO2008/2009 (RS)	2321±13	2299/ 2344	2185 ±20	2005/ 2205	7.876 ±0.109	7.780/ 8.180	8.101 ±0.067	8.039/ 8.443	1.58 ±0.25	1.34/ 3.02	2.52 ±0.40	2.13/ 4.82	20
OSO2010/2011 (AmS)	2293±14	2263/ 2313	2173 ±25	2137/ 2211	7.817 ±0.067	7.730/ 7.930	8.084 ±0.071	7.968/ 8.184	1.45 ±0.22	1.19/ 1.80	2.31 ±0.35	1.90/ 2.87	12
OSO2010/2011 (RS)	2309±11	2289/ 2326	2071 ±51	1989/ 2129	8.070 ±0.100	7.910 8.220	8.327 ±0.092	8.184/ 8.471	2.50 ±0.50	1.75/ 3.28	3.98 ±0.79	2.79/ 5.23	10
Mean AmS	2295±6		2179±9		7.801 ±0.037		8.067 ±0.033		1.40 ±0.11		2.23 ±0.18		
Mean RS	2312±7		2180±6		7.883 ±0.130		8.135 ±0.130		1.71 ±0.53		2.73 ±0.85		

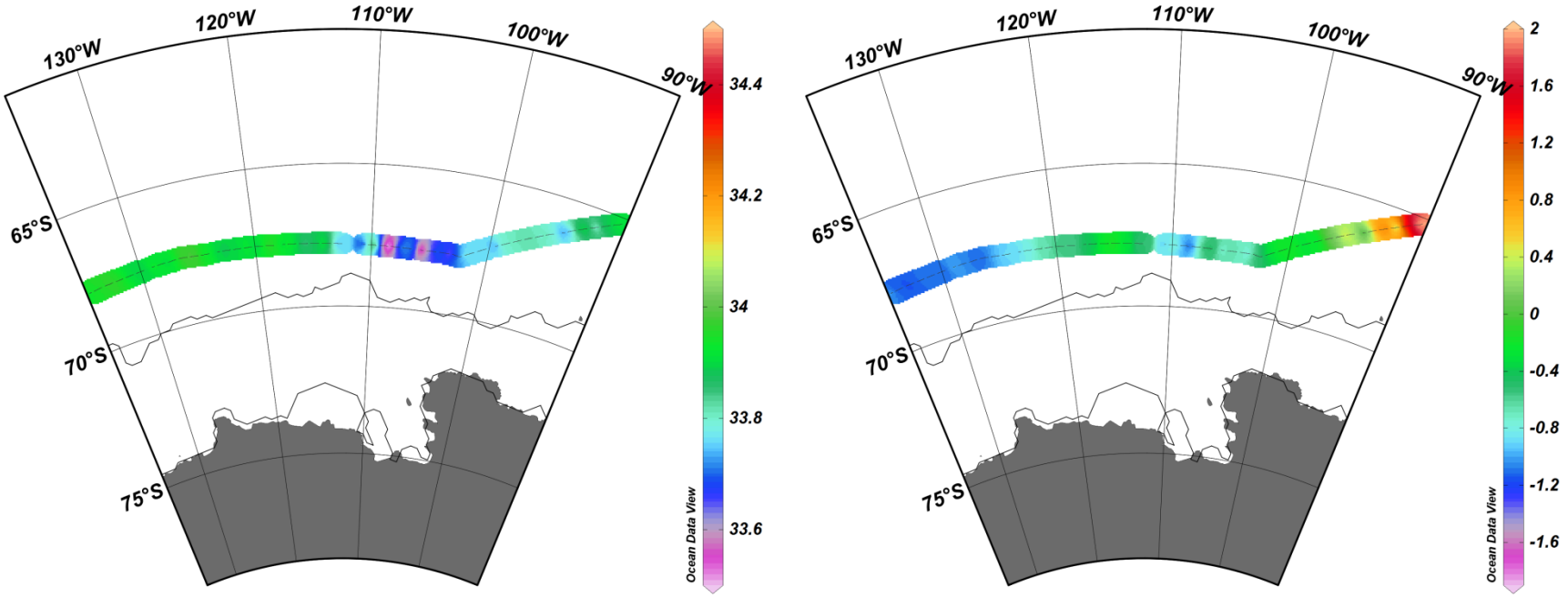


Figure 3: Variability of a) salinity and b) SST in the Amundsen Sea in 2006. The grey thin lines mark the December sea-ice edge.

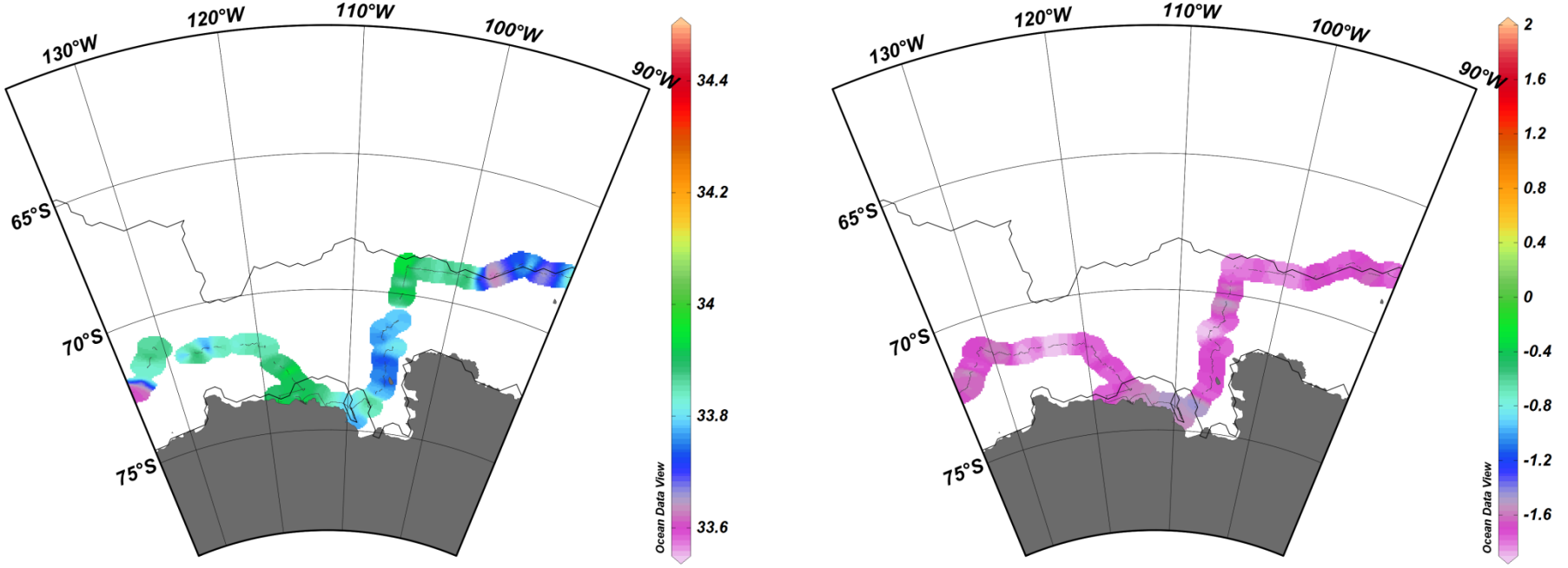


Figure 3: Variability of c) salinity and d) SST in the Amundsen Sea in 2007. The grey thin lines mark the December sea-ice edge.

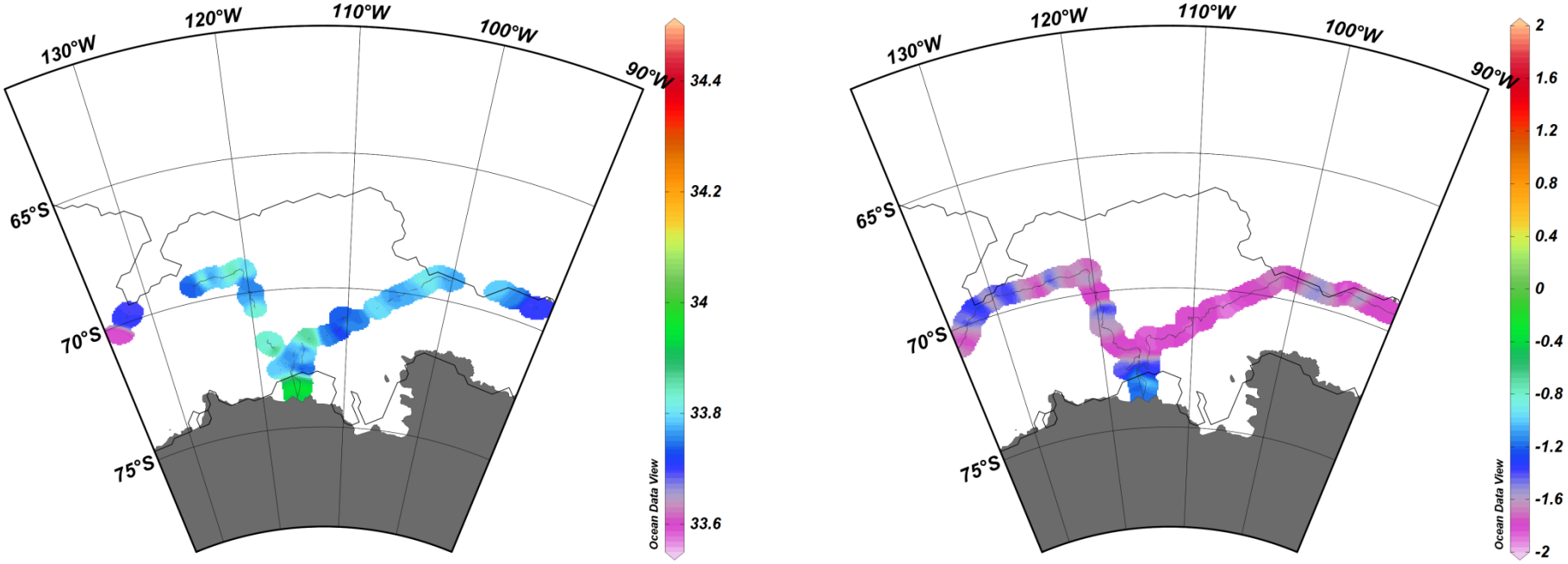
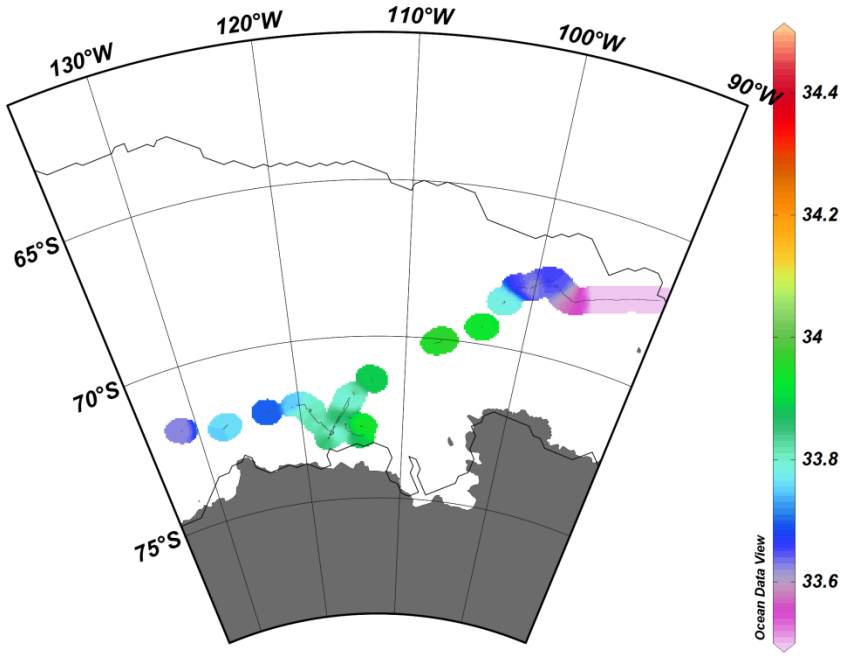


Figure 3: Variability of e) salinity and f) SST in the Amundsen Sea in 2008. The grey thin lines mark the December sea-ice edge.



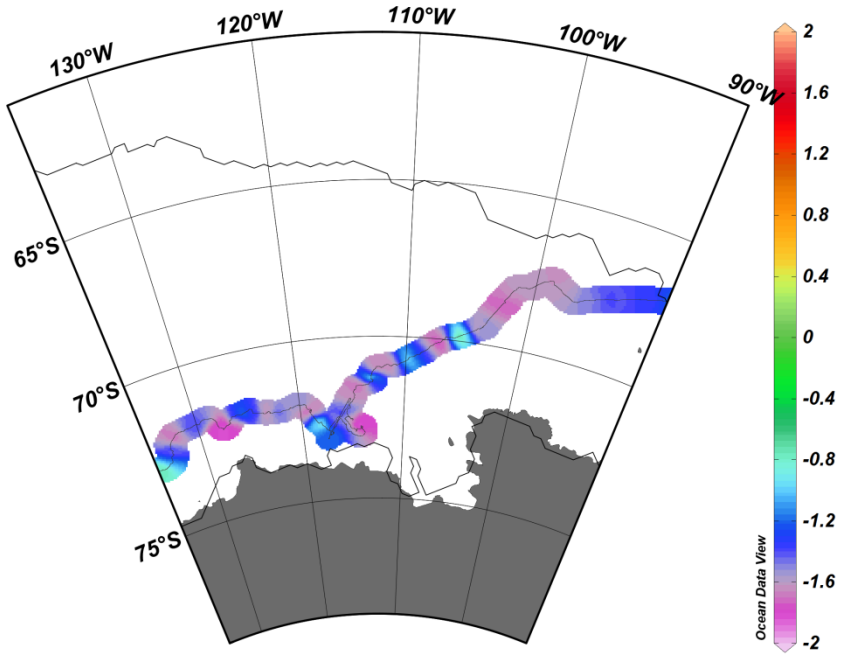
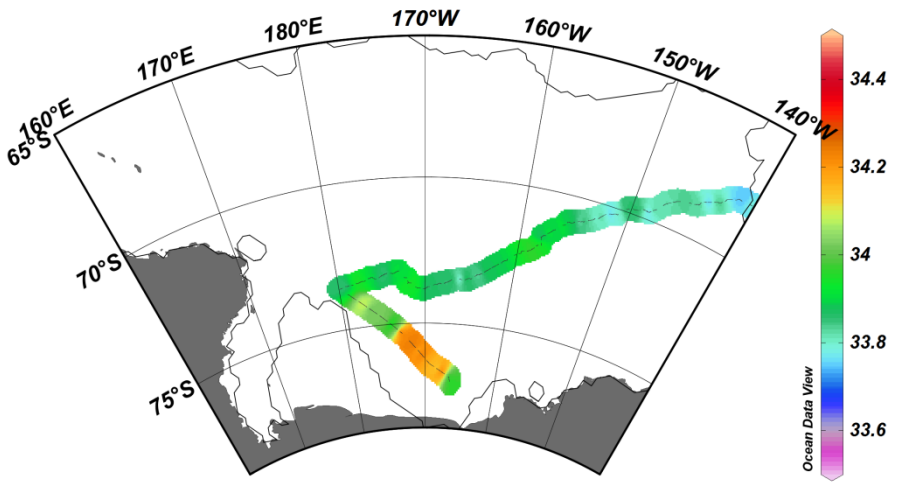


Figure 3: Variability of g) salinity and h) SST in the Amundsen Sea in 2010. The grey thin lines mark the December sea-ice edge.



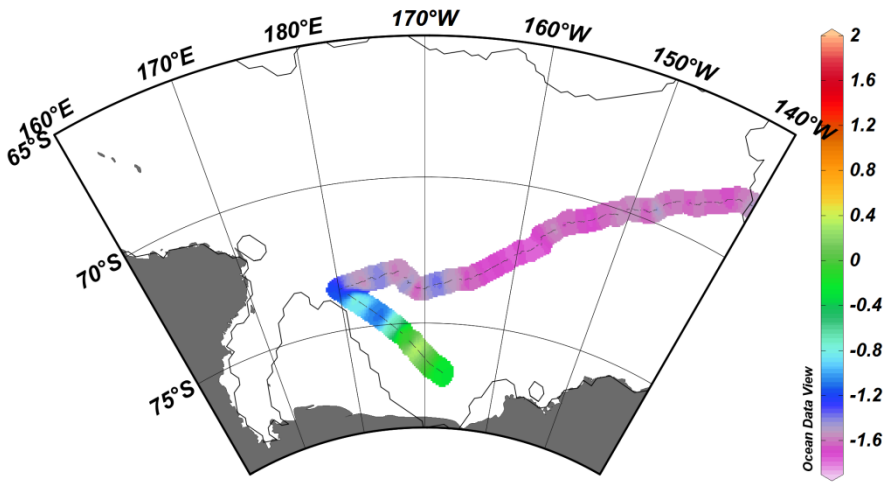


Figure 3: Variability of i) salinity and j) SST in the Ross Sea in 2006.
The grey thin lines mark the December sea-ice edge.

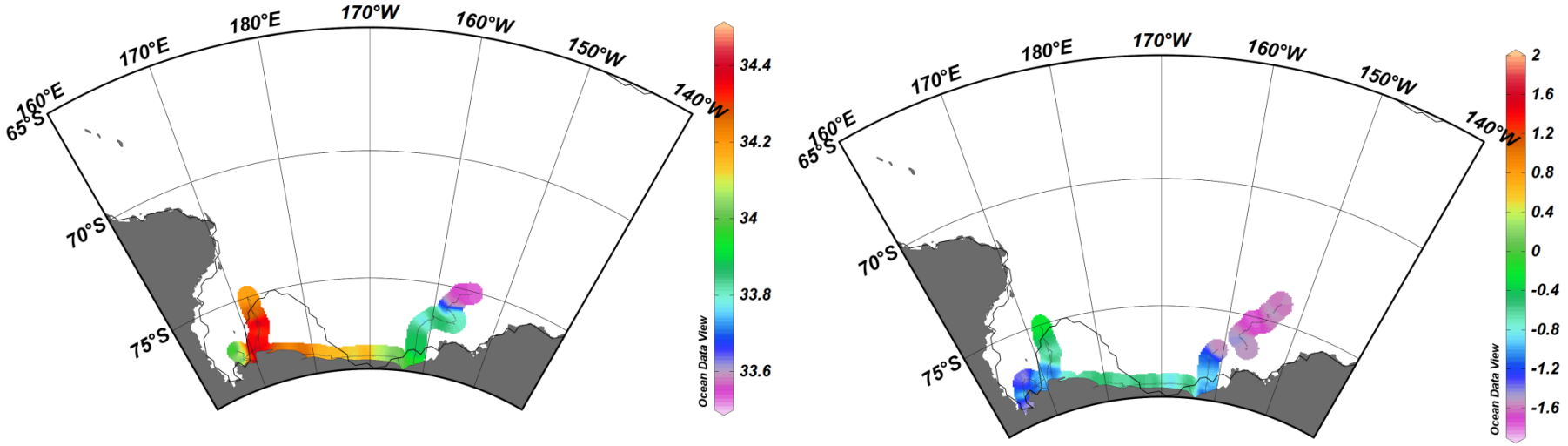


Figure 3: Variability of k) salinity and l) SST in the Ross Sea in 2007/2008. The grey thin lines mark the December sea-ice edge.

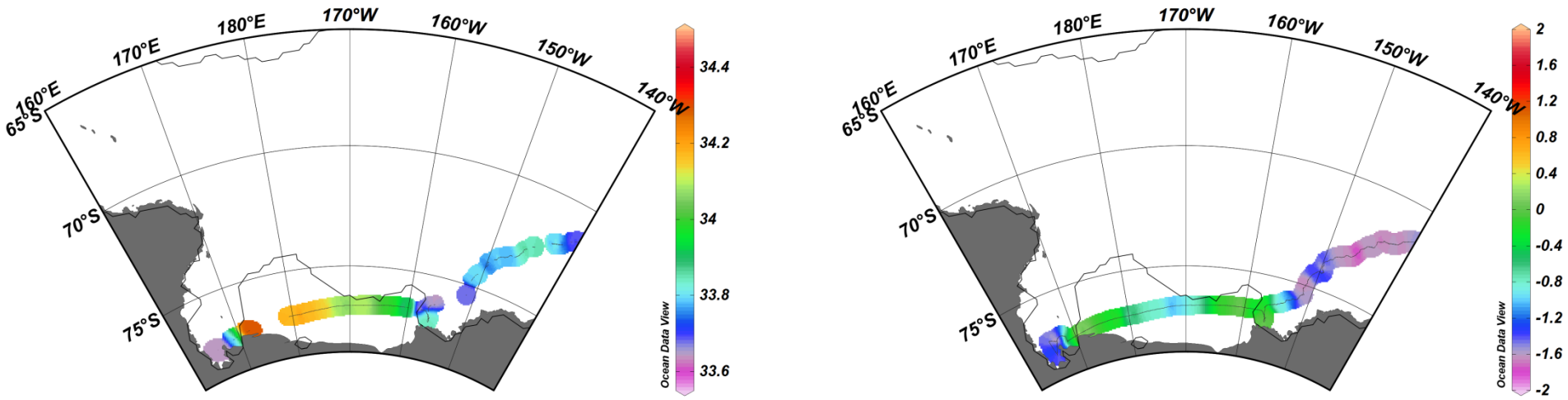


Figure 3: Variability of m) salinity and n) SST in the Ross Sea in 2008/2009. The grey thin lines mark the December sea-ice edge.

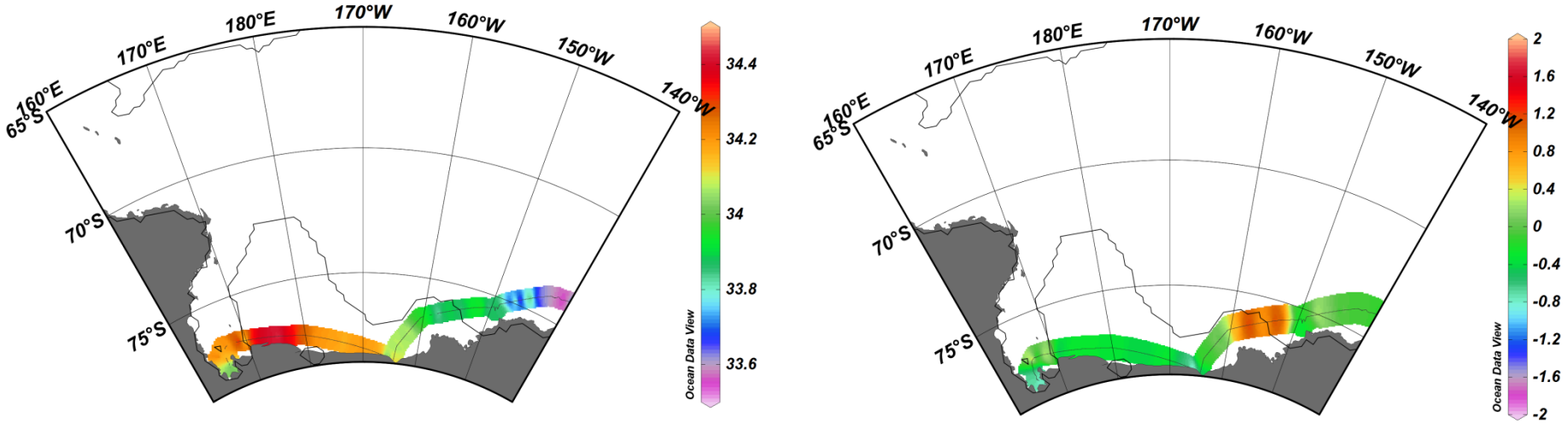


Figure 3: Variability of o) salinity and p) SST in the Ross Sea in 2010/2011. The grey thin lines mark the December sea-ice edge.