Supporting Information for "Genesis of the Antarctic Slope Current in West Antarctica"

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Introduction

The following text and figures are provided as supplementary material to the manuscript "Genesis of the Antarctic Slope Current in West Antarctica" in *Geophysical Research Letters*. All of the supplementary figures are discussed in the main text and citations that appear in the figures captions below are also referenced in the main text. The supplementary figures use data sets that are not integrated into figures in the main text, therefore, they are described below. A summary of the figures in the supplementary material is also provided.

Supplementary material methods

To supplement the ship-based hydrographic data, two ocean gliders were deployed during the NBP 19-01 cruise: one (SG621) on the western side of the Bellingshausen Sea on December 27, 2018 and the other (SG659) along to the Antarctic Peninsula, near Marguerite Trough on January 19, 2019 (Figure 1, orange dots). The gliders sampled until February 20 and March 13, 2019, respectively. Due to sea ice coverage, the gliders had limited access to the continental shelf earlier in the campaign. Therefore we restrict our analysis to data collected by SG539 near the mouth of the Latady Trough as well as over the continental slope to the east of the trough.

The glider collected vertical profiles of temperature and salinity, dissolved oxygen, optical backscatter and fluorescence at roughly 1 m intervals. Here we focus on the hydrographic data, which was collected using a Sea-Bird Electronics CT Sail. The raw glider data were processed using the University of East Anglia's Seaglider Toolbox, which corrects for lag and inertial effects and then were manually despiked. Temperature and salinity were converted into potential density surfaces using the TEOS-10 toolbox (McDougall & Barker 2011). Effective glider station spacing varied between two and five kilometers on the basis of current speed and water column depth.

We also make use of hydrographic data from instrumented elephant seals, which are made available though the MEOP (Marine Mammals Exploring the Oceans Pole to Pole) program (Roquet *et al.* 2017). This data is applied to support the formation of a salty version of WW in BellS polynyas over the continental shelf. The data presented in the supplementary material is taken from the data set analyzed by Zhang *et al.* (2016), which

also provides details of the data coverage in both space and time, as well as processing techniques.

Supplementary figure summary

• **Figure 1:** Summary of wind stress at the shelf break in West Antarctica.

• **Figure 2:** Temperature / salinity diagrams across the continental shelf and slope throughout the Bellingshausen Sea.

• **Figure 3:** Distribution of sea ice and salinity in the Bellingshausen Sea indicative of polynya formation.

• **Figure 4:** Temperature, salinity, and velocity distributions across the eastern Bellingshausen Sea continental slope from NBP19-01.

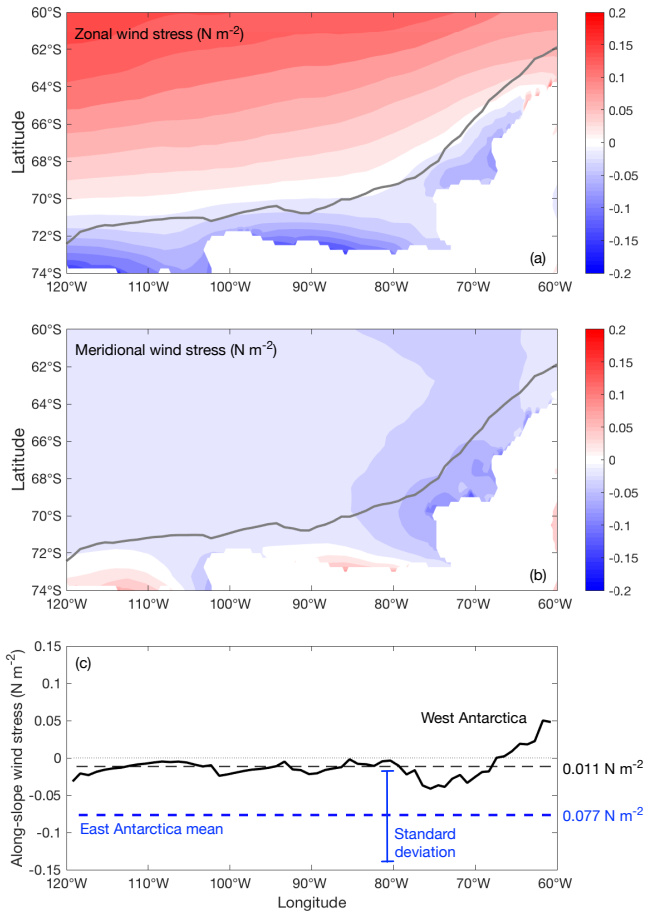

Figure S1: Multidecadal mean (a) zonal and (b) meridional wind stress (N m^{-2}) in West Antarctica from 1979-2014 ERA-Interim. (c) Multidecadal along-slope wind stress evaluated along the 1000 m isobath, indicative of the shelf break (black curve). Mean along-slope wind stress at the 1000 m isobath is indicated by the dashed lines for West Antarctica (120°W to 60°W, black) and East Antarctica (all other longitudes, blue). The standard deviations of the along-slope wind stress outside of West Antarctica is also provided (blue vertical line). Figure modified from Fig. 1 of Hazel and Stewart (2019).

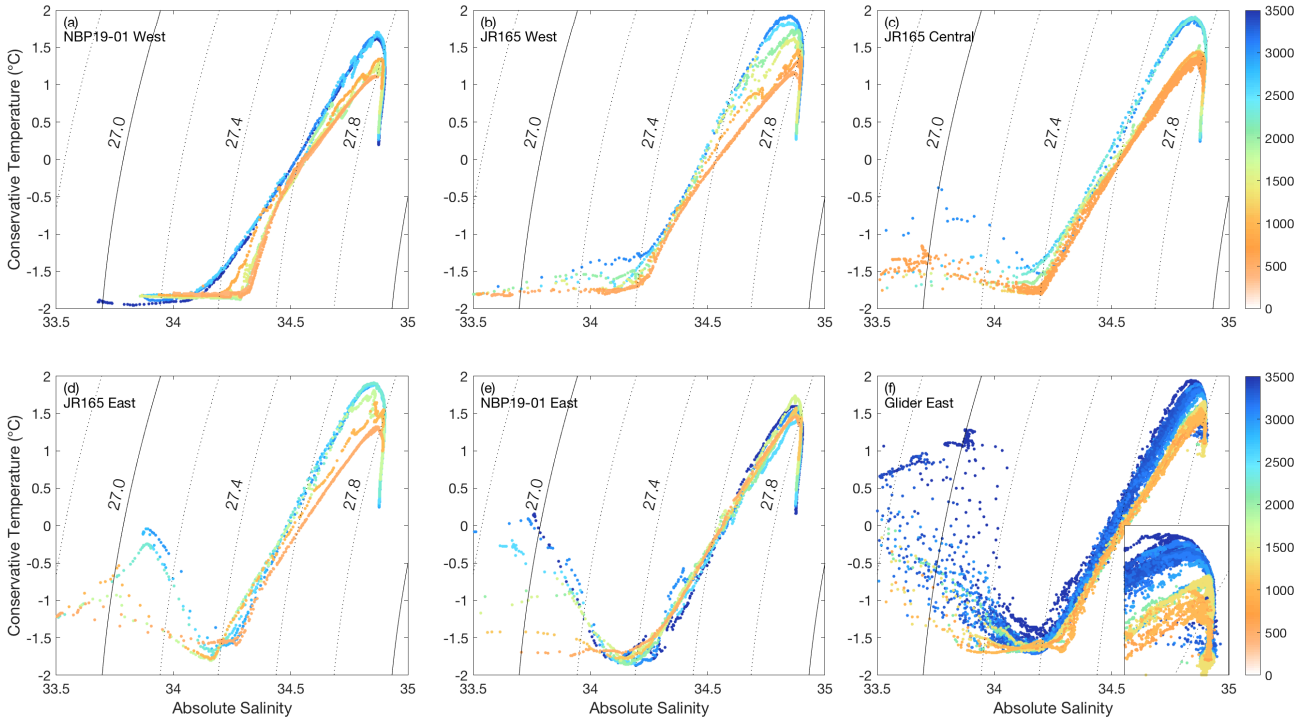

Figure S2: Conservative temperature-absolute salinity diagrams for all of the cross-slope sections depicted in Figure 1b. The panels are organized from west to east, and were collected from NBP19-01 (panels a, e; red squares in Figure 1), JR165 (panels b, c, d, yellow circles in Figure 1), and from an ocean glider deployed in 2019 (panel f; large orange dots in Figure 1) (Methods). In panel (f), only the glider data for the transect aligned long 78°W are plotted. The points are colored by the water column depth at the CTD locations. Contours show potential density (σ_0), at 0.2 kg m^{-3} intervals. Panels (a), (c) and (e) are repeated from Figure 1 for clarity. The diagrams show distinct progressions in frontal structure in three different density classes: (i) Antarctic Surface Water (AASW) become warmer and fresher with more lateral variability moving west to east; (ii) Winter Water (WW) shows an abrupt transition or front in salinity in the westernmost section (a) but is weaker everywhere to the east; (iii) a front in Circumpolar Deep Water (CDW) is apparent across most of the Belgica Trough (panels (a-d), but disappears or is weak to the east of Latady Trough (panels e,f).

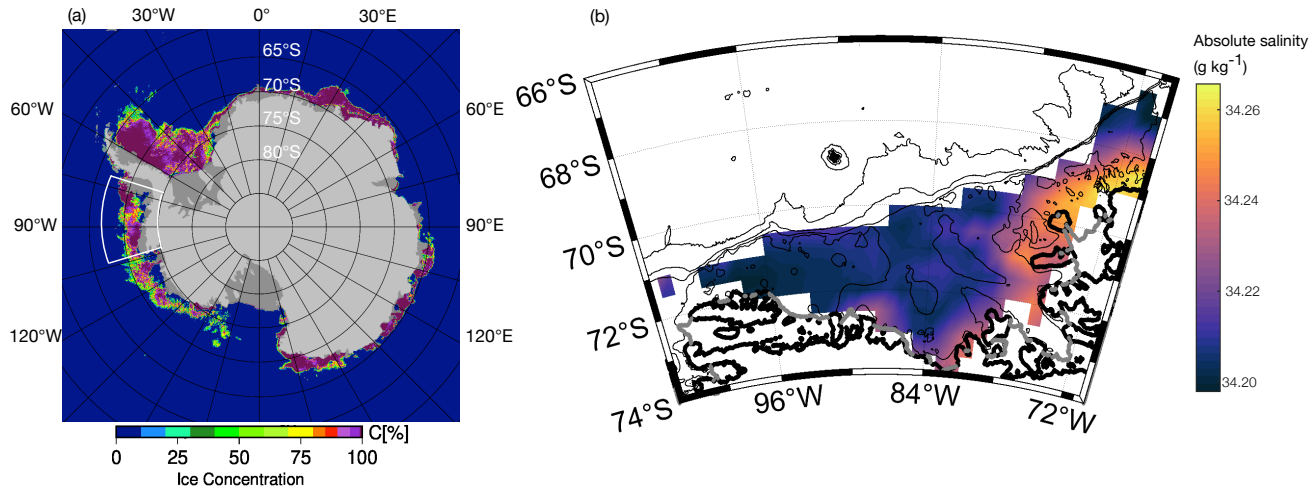

Figure S3: (a) Antarctic sea ice concentration from January 20, 2019. This distribution is indicative of climatological distributions and shows large polynyas in the southern Bellingshausen Sea. (b) Distribution of absolute salinity (g kg^{-1}) for the region indicated in white in panel (a), based on data collected by instrumented seals between 2007 and 2014 (Roquet *et al.* 2017, Zhang *et al* 2016). The salinity has been interpolated on to the $\sigma_0 = 27.4$ kg m^{-3} density surface, which is associated with Winter Water (Figure 1, Suppl. Figure 2). Coastal regions that are populated by large polynyas most years (Tamura *et al.* 2008), are shown to be elevated in salinity, which suggests regions of sea ice formation and brine rejection.

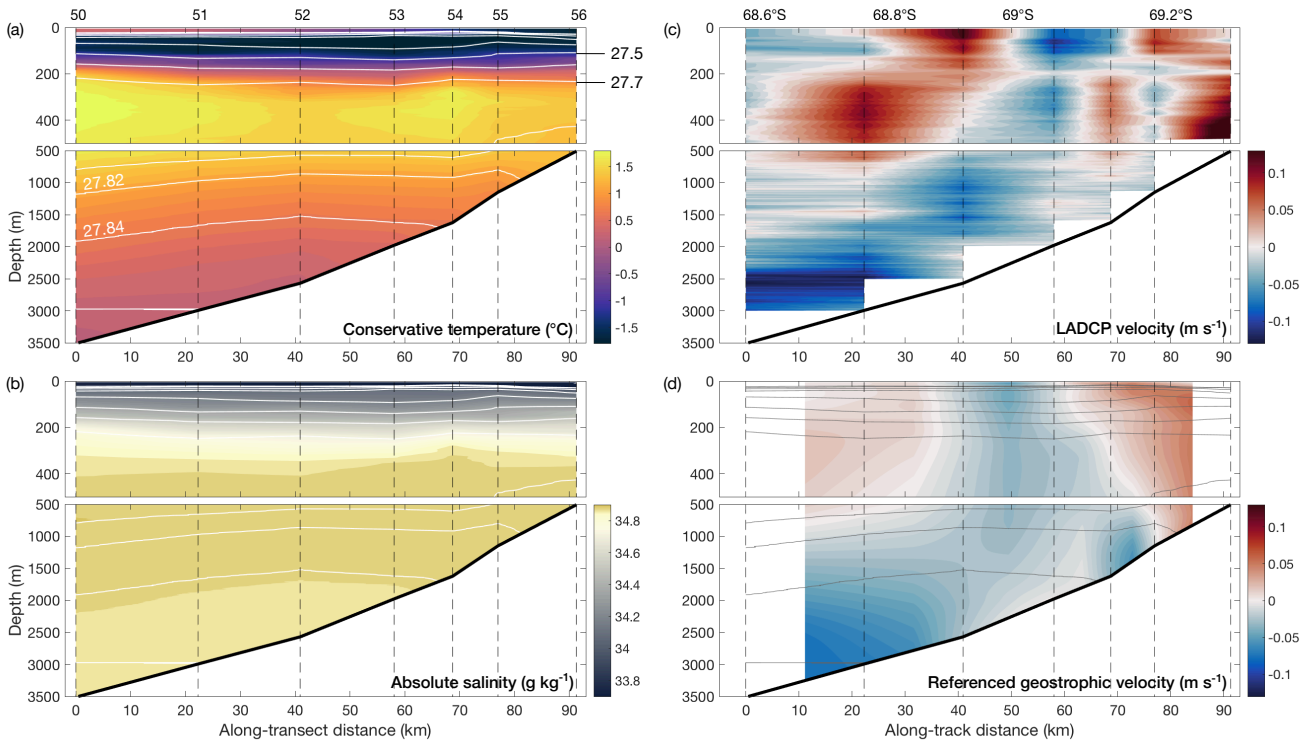

Figure S4: Cross-slope section located to the east of the Latady Trough from NBP19-01 (section E in Figure 1): (a) Conservative Temperature (°C), (b) Absolute Salinity (g kg^{-1}), (c) across-transect velocity from the lowered acoustic Doppler current profiler (LADCP) (m s^{-1}), (d) geostrophic velocity referenced to the LADCP (m s^{-1}). In panels (a), (b) and (d) the contours show potential density σ_0 with contours intervals of 0.1 kg m^{-3} between 27 and 27.8 kg m^{-3} and intervals of 0.02 kg m^{-3} between 27.8 and 27.86 kg m^{-3}. In panels (c) and (d), positive and negative (red and blue) velocities indicate eastward (retrograde) and westward (prograde) flow, respectively. The thick black curve shows the depth of the seafloor while the dashed curves indicate the positions of individual CTD casts (corresponding to stations 50-56). Station numbers are listed above panel (a); latitude is listed above panel (c).