

1 The OCEAN ICE mooring compilation: a standardised, pan-
2 Antarctic database of ocean hydrography and current time series

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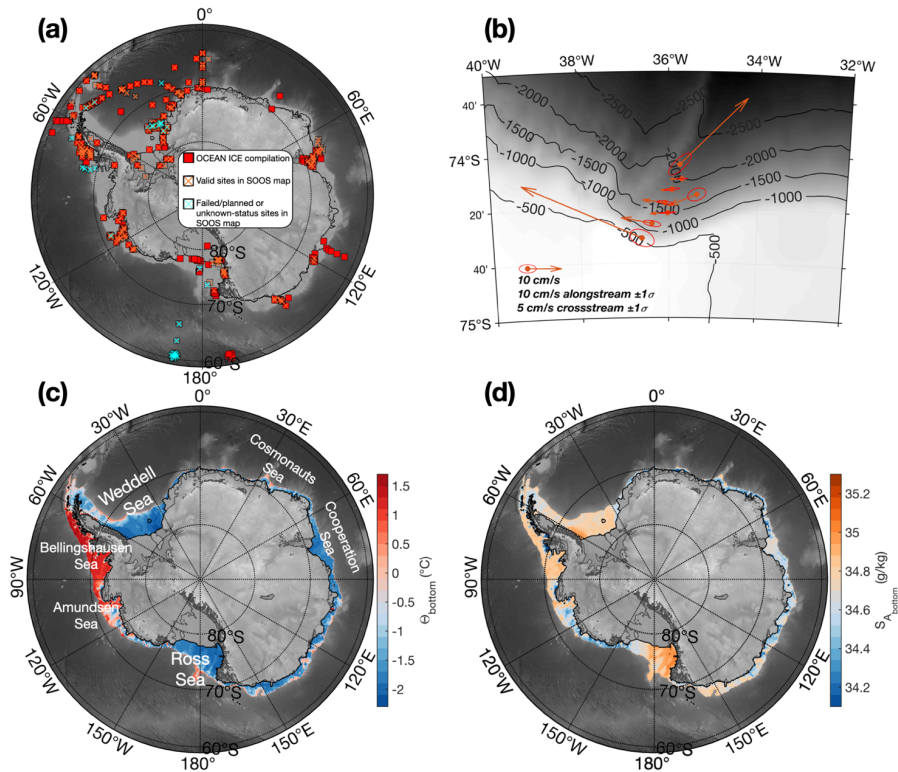
36 **Abstract.** Continuous moored time series of temperature, salinity, pressure and current speed and direction are of great
37 importance for understanding the continental shelf and under-ice-shelf dynamics and thermodynamics that govern water
38 mass transformations and ice melting in and around Antarctic marginal seas. In these regions, icebergs and sea ice make
39 ship-based mooring deployment and recovery challenging. Nevertheless, over decades, expeditions around the fringe of
40 Antarctica sporadically deployed and recovered hundreds of moored instruments, including those facilitated through ice
41 shelves boreholes. These datasets tend to be archived in a wide range of data centres, with, to our knowledge, no clear
42 format standardisation. As a result, systematic analysis of historical mooring time series in the marginal seas is often
43 challenging. Here we present the first version of a standardised pan-Antarctic moored hydrography and current time series
44 compilation, with broad international contributions from data centres, research institutes and individual data owners. The
45 mooring records in this compilation span over five decades, from the 1970s to the 2020s, providing an opportunity for a
46 systematic study of the pan-Antarctic water mass transport and shelf connectivity. As a demonstration of the utility of this
47 compilation, we present spectral analysis of the compiled current velocity time series, which unsurprisingly shows the
48 dominating presence of tidal variability within most records. This component of the variability is fitted using multi-linear
49 regression to tidal frequencies, and the tidal fit is removed from the original time series to leave de-tided variability. Given
50 the limited record durations to months to years, de-tided variability is dominated by synoptic (3-10 days period),
51 intraseasonal (10-80 days) and seasonal (~6 months-1 year) signals. The spatial distribution of the kinetic energy
52 integrated within frequency bands is presented and discussed within respective regional contexts, and future avenues of
53 research are proposed. This data compilation is assembled under the endorsement of Ocean-Cryosphere Exchanges in
54 Antarctica: Impacts on Climate and the Earth System (OCEAN ICE) project (<https://ocean-ice.eu/>) funded by the
55 European Commission and UK Research and Innovation. It is available and regularly updated in NetCDF format with the
56 SEANOE database at <https://doi.org/10.17882/99922> (Zhou et al. 2024a).

57 1 Introduction

58 The Antarctic continental shelves host multiple sites of unique water mass formation: coastal polynyas are the site of
59 intense ocean heat loss to the cold polar atmosphere, freezing the sea surface and via brine rejection creating dense salty
60 waters known as High Salinity Shelf Water (HSSW). In some parts around Antarctica, further heat loss via interaction
61 with the Antarctic ice sheet creates supercooled, saline water masses, known as Ice Shelf Water (ISW), which, together
62 with HSSW, form the precursors of the most voluminous water mass, Antarctic Bottom Water, that fills the global abyssal
63 ocean (Richardson et al. 2005, Li et al. 2023). Closer to the surface, freshwater resulting from sea ice and ocean-driven
64 glacial melt of the ice sheet modulates the interactions between atmosphere, ocean and sea ice (Richardson et al. 2005,
65 Bronsealer et al., 2018, Haumann et al., 2020). It also modifies exchanges between adjacent seas (e.g., Jacobs et al., 2022)
66 and with the Southern Ocean, as the slope current and front associated with lateral gradients of temperature and salinity
67 form a dynamic cross-shelf barrier (Thompson et al., 2018). Through turbulent mixing and modulation of source water

68 properties, shelf sea processes impact the deep ocean ventilation. These processes influence climate by setting the strength
69 and properties of the overturning circulation and the exchange of heat and moisture with the atmosphere. Capturing the
70 processes governing the formation and transport of these water masses is challenging using observations due to logistical
71 difficulties for ships to access these regions readily. As a result, our knowledge of the freshwater budget over the Antarctic
72 continental shelves and Southern Ocean is poor, with important repercussions for climate modelling and sea level rise
73 projections (Heywood et al., 2012).

74
75 Recent models and observations from a few locations (e.g. Han et al. 2023, 2024) have highlighted how tidal currents and
76 topographic Rossby waves can promote the mixing and descent of dense water plumes along the continental slope.
77 However, it remains unclear if these findings can be generalized to all dense water outflows. Similarly, the transport of
78 glacial meltwater affects oceanic processes downstream, including ice shelf melting, sea ice formation and the creation of
79 dense shelf waters, especially in the West Antarctic sector from the West Antarctic Peninsula to the Amundsen and Ross
80 Seas (Nakayama et al., 2020, Jacobs et al., 2022, Dawson et al., 2023, Flexas et al., 2024). However, due to the lack of
81 observations over most of the Antarctic continental shelf, little is currently known about the connectivity of the circum-
82 Antarctic shelf seas with few exceptions in region near the Antarctic Peninsula (e.g., Thompson et al. 2009).



83
84 **Figure 1:** (a) A comparison between the OCEAN ICE moored time series compilation and Southern Ocean Observing System
85 (SOOS, <https://www.soosmap.aq/>) map metadata information. The SOOS mooring map information is retrieved from the
86 SOOS map webpage by specifying the instrument type as ‘fixed platform’ in the interactive webpage. Each square represents a
87 record in either SOOS map or OCEAN ICE compilation. The red squares are those contained in the OCEAN ICE compilation.
88 Hollow squares with orange crosses are valid sites in SOOS map (with status of recovered or deployed). The overlapping sites
89 across the OCEAN ICE compilation and SOOS map are then denoted as a red square with an orange cross on top. Blue crosses
90 are those sites in SOOS map that are shown as either planned, failed or unknown status. These sites are either invalid, or the
91 data remains to be released. (b) An example of depth-averaged current vectors and the variance ellipses denoting the cross-
92 stream and along-stream current variabilities for a group of shelf break moorings in the southern Weddell Sea (Darelius et al.
93 2023). (c) Bottom temperature and (d) bottom salinity over the continental shelf (<1000 m) is shown to distinguish different
94 thermal regimes across the Antarctic continental shelves. Bottom properties are computed as the mean value over the bottom
95 150m from the seabed from a climatology product constructed from the hydrographic profiles (Zhou et al., 2024b, Zhou et al. in

96 prep). Bathymetry, in grey shading, is from RTopo 2.0.4 (Schaffer et al., 2016). Bottom water properties shown in panel (c) and
97 (d) are computed using TEOS-10 toolbox (McDougall and Barker, 2011)

98 Here, we present the first version of a standardized compilation of historical moored time series that have been deployed
99 over the past 50 years on the Antarctic continental shelves and slopes and present a rapid overview of energetic
100 characteristics of ocean circulation on and off the continental shelves along with their hydrographic context. This
101 compilation includes temperature, salinity, pressure and ocean current time series south of 60°S (Fig. 1a). The time series
102 are freely and publicly accessible in a standardized format at SEANOE (<https://www.seanoe.org/data/00887/99922/>, Zhou
103 et al. 2024a). We intend to maintain and enhance the compilation on an annual basis and welcome contributions for
104 inclusion in future releases. This mooring compilation is endorsed by the OCEAN ICE project funded by the European
105 Commission and UK Research and Innovation, and we refer to this data compilation as the OCEAN ICE mooring
106 compilation herein. This dataset aims to provide opportunities for regional or systematic pan-Antarctic studies on water
107 mass transport, formation processes and shelf connectivity.

108 **2 Data sets and processing**

109 **2.1 Overview**

110 In the OCEAN ICE mooring compilation, we collected 521 mooring time series, covering 470 deployment sites (Fig. 1a).
111 The comparison with the Southern Ocean Observing System (SOOS, <https://www.soosmap.aq/>) mooring map which aims
112 at compiling links to datasets from all past endeavours shows that our compilation includes additional mooring records,
113 e.g. in front of the Ross Ice Shelf and from instruments deployed through boreholes in the Ross and Amery ice shelves.
114 More importantly, while the SOOS interactive map displays mooring locations with limited metadata (name, country,
115 coordinates), it does not provide access to the underlying datasets or direct download links. In contrast, the OCEAN ICE
116 dataset presented here offers direct access to the full time series. Therefore, the OCEAN ICE mooring compilation is an
117 effort to improve spatial coverage and directly provide publicly available datasets, calling on experienced international
118 collaborators to obtain a compilation that is as complete as possible. This effort will be continued, and the compilation
119 will be expanded in future annual releases. At this stage, we have collated data from regions and features not represented
120 in SOOS, including the Antarctic Slope Current and Antarctic Bottom Water transport over the slope current from places
121 such as the southeastern Weddell Sea (Graham et al. 2013), Princess Elizabeth Trough (Heywood et al. 1999) and
122 Australian-Antarctic Basin (Peña-Molino et al., 2016), in addition to those that have been logged in the SOOS map. The
123 mooring time series are acquired from various sources. Some of them are archived in public databases such as Pangaea
124 Data repository, British Oceanographic Data Centre, UK Polar Data Centre, US Antarctic Program Data Center,
125 Australian Antarctic Data Centre, Korea Polar Data Centre, Norwegian Marine Data Centre and Norwegian Polar Data
126 Centre. Others are stored in places that are less commonly considered as Antarctic mooring data centres such as
127 NCEI/NOAA, or local databases hosted by individual institutes such as Lamont-Doherty Earth Observatory of Columbia
128 University and Oregon State University (e.g. the OSU Buoy Group, <https://cmrecords.net/history.html>). A list of mooring
129 record source links is stored with our database and is available as an additional file on SEANOE where the OCEAN ICE

Commented [SZ1]: In response to Reviewer #1's question about the SOOS and OCEAN ICE dataset difference. Here we feel that it is crucial to make the point clear that SOOS does not provide any dataset other than the very brief metadata, while our compilation delivers direct access to the actual mooring timeseries.

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Deleted: Additionally, whilst SOOS map provides an overview of moorings location and metadata in their interactive web map, the actual datasets or links directly leading to the datasets are not provided.

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mooring compilation is published. Fig. 1b showcases a regional example of current meter measurements and some basic information, namely the depth-averaged current vectors along with variance ellipses depicting the along-stream and cross-stream velocity variabilities. The broad spatial spread of these mooring sites covers different thermohaline regimes over the continental shelves as indicated by the climatological bottom water temperature/salinity in Fig. 1c and Fig. 1d, from the colder and saltier dense water formation site of the Ross, Weddell, and Cosmonaut seas to the warmer Amundsen and Bellingshausen seas. One notable characteristic of this dataset is its typical mid-water column to near-seabed sampling bias. Indeed, most mooring deployed in Antarctic shelf seas tend to avoid sampling the near surface region where drifting icebergs can damage instrumentation, especially those mooring located south of 70°S where iceberg drift are more frequent (Fig. 2a). Some exceptions where the instruments were mounted close to the top of the water column at 75°S (Fig. 2a) lie in two sub-iceshelf moorings that were designed to measurement the turbulence processes in the ocean-ice boundary layer in George IV ice shelf (Middleton et al. 2022) and Larsen C ice shelf (Davis and Nicholls 2019). Among 521 mooring timeseries, over 80% of them have the capacity of measuring at least current velocities and temperature (Fig. 2a). The mooring timeseries typically have a good coverage over different seasons (Fig. 2b) mainly because most of the mooring timeseries last for a full year or more (Fig. 2c).

Commented [SZ3]: In response to both reviewers' comments on the general additional metadata information.

Commented [4]: Not the surface: the ice shelf draft is not 0! in figure 2a, the normalised water depth needs to be defined somewhere: e.g. ratio of instrument location in the water column over the local water column thickness?

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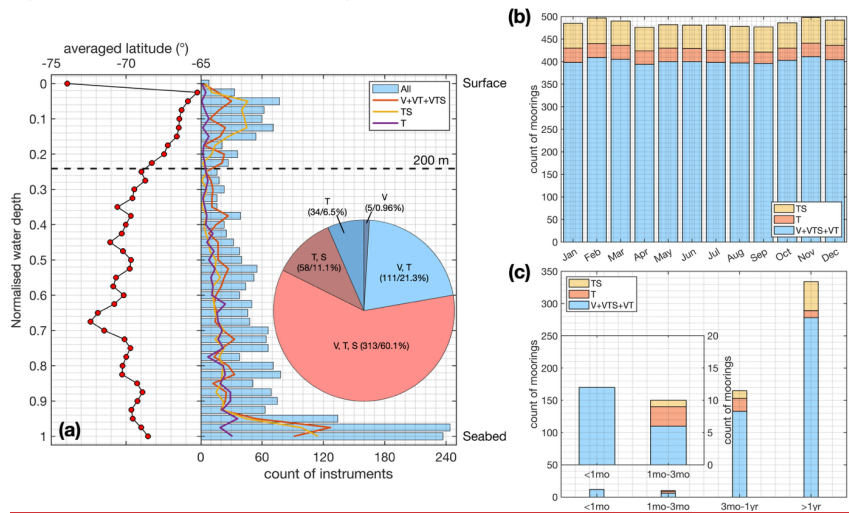


Figure 2. Overview of mooring compilation statistics on (a) instrument depths and location, inserted pie chart shows the measuring variables by all mooring compositions. 5 types of measuring variables combination are selected: VTS (current velocities, temperature, salinity), VT (current velocities and temperature), TS (temperature and salinity), T (temperature only), V (current velocities only). (b) Seasonal coverage of each type of measuring variable combination shown in the legend. (c) Same as (b) but for measuring period.

Commented [SZ5]: Figure 2 added in response to the comments from both reviewers' about enriching metadata information.

Commented [6R5]: Reply to Shenjie Zhou - BAS (07/02/2025, 11:58): "..."
What does the 200m line in panel a show??

157 **2.2 Data standardisation**

158 All the mooring time series are standardized and re-formatted into individual NetCDF files for each mooring site,
159 following a consistent file structure. The source of individual datasets is also provided, allowing further investigations and
160 analysis of the processing steps applied to each time series before we obtained them. We are not always aware, for
161 example, if corrections for current-induced motions of the sensors or the magnetic declination corrections on current
162 direction have been applied for each individual mooring. To support assessment of data quality and provenance, we
163 provide source links for each mooring dataset. These links direct users to original data landing pages, cruise or
164 deployment reports, or data owners, where details on applied quality control flags and processing procedures can be
165 obtained. Users are encouraged to consult these sources to evaluate the suitability of the data for their specific
166 applications. For moorings containing multiple instruments, to acknowledge the fact that these instruments are sampled at
167 different frequencies and over different periods of time, each instrument is accompanied by its own time vector in the
168 NetCDF file. **Table 1** shows examples of variable lists from three types of the most commonly deployed instruments -
169 Temperature, Conductivity and Pressure logger (e.g., SBE37 MicroCAT), Acoustic Doppler Current Profiler (ADCP, e.g.,
170 Teledyne RDI 75kHz ADCP), and current meter (e.g., Aanderaa Rotor Current Meter). Note that in the final form of the
171 mooring file, we retain the original sampling frequency for all the mooring instruments as we received it (some were
172 already processed and averaged), avoiding modifications of the temporal resolution as much as possible, to ensure broader
173 use of these mooring records for analysing processes spanning sub-daily to interannual time scale ranges. Additionally, we
174 performed minimum data clean up, solely replacing bad data identified by various flags or unrealistically large numbers
175 with NaNs. No additional interpolation/extrapolation is applied to retain the original mooring time series.

Filename/instrument name	Variable names	Attributions and units
SB_2013.nc/SBE37 MicroCAT	Instrument_01_info	Instrument type = sbe37_7224
	Instrument_01_date	Days since 1950-01-01 00:00:00
	Instrument_01_depth	Instrument depth (m)
	Instrument_01_press	Instrument water pressure (dbar)
	Instrument_01_salin	In-situ salinity (PSU)
	Instrument_01_temp	In-situ temperature (°C)
SB_2013.nc/Teledyne RDI 75kHz ADCP	Instrument_01_info	Instrument type = rdi_adcp_75khz_18447
	Instrument_01_date	Days since 1950-01-01 00:00:00
	Instrument_01_bindepth	ADCP depth bins (m)
	Instrument_01_binpress	ADCP pressure bins (dbar)
	Instrument_01_u	Current velocity zonal component (cm/s)
	Instrument_01_v	Current velocity meridional component (cm/s)
FDRAKE75_M12.nc/Aanderaa Rotor Current Meter	Instrument_05_info	Instrument type = Aanderaa_RCM5
	Instrument_05_date	Days since 1950-01-01 00:00:00
	Instrument_05_depth	Instrument depth (m)
	Instrument_05_press	Instrument water pressure (dbar)
	Instrument_05_u	Current velocity zonal component (cm/s)
	Instrument_05_v	Current velocity meridional component (cm/s)

Commented [S27]: In response to both reviewers' comment on the transparency of data quality.

176 **Table 1. An example of the variable lists for a SBE37 MicroCAT, a Teledyne RDI 75kHz ADCP equipped on mooring [named](#)**
177 **SB_2013.nc, and an Aanderaa Rotor Current meter equipped on mooring [named](#) FDRAKE75_M12.**

178 Individual instrument information is available in the variable descriptions, including the name of the instrument and its
179 serial number, if available. For those datasets where the instrument serial numbers were not made available to us,
180 instruments with identical names are differentiated by labelling them numerically in order of the mounted depth along the
181 mooring line. Both acoustic Doppler current meter and current profiler (ADCP) records are included in this compilation,
182 with units of cm/s, at time [*_date](#) (days since January 1st, 1950) and depth [*_depth](#) (m). Specifically, ADCP data are
183 stored in two-dimensional M×N arrays, M being the number of records, N being the number of vertical bins, and in this
184 case, depth is also two-dimensional. All temperature (°C, IPTS-90) and salinity (Practical Salinity Unit) data stored are in-situ
185 measurements, again using depth and time vectors structured identically to other records in the database.
186

187 **2.3 Inferred Tidal Energy and Eddy Kinetic Energy**

188 In the following, we present an initial estimate of the frequency content and spatial distribution of the kinetic energy
189 contained within the compiled records. We isolate the tidal components of the variability from individual records using a
190 multi-linear least square fit to tidal components (UTide, Codiga 2011), providing us with the fitted tidal harmonics. By
191 removing the fitted tidal harmonics from the original record, ‘de-tided’ time series can be used to reflect the energy
192 associated with non-tidal processes, hereafter referred to as eddy kinetic energy (EKE). In this work, a full list of pre-
193 defined tide constituents (145 in total) was used to compute the complete spectra of tidal signals as the default option in
194 the toolbox to retrieve the first glance of tidal harmonics and de-tided velocity fields. A manual of user-defined parameters
195 and options are discussed in detail by Codiga (2011).
196

197 [Figure 3](#) shows the probabilistic distribution function (PDF) plot of the current speed spectra integrating all the mooring
198 sites where current meters or ADCPs were deployed. For this exercise, ADCP records are first averaged in the vertical
199 over all recorded bins, giving a single time series per ADCP, from which the spectra are then extracted to be more readily
200 compared with single point current meters. [Fig. 3a](#) shows the spectra PDF resulting from the original time series. The heat
201 map pattern is predominantly characterised by a classic red spectrum, with pronounced tidal energy peaks at the semi-
202 diurnal (0.48 to 0.57 days), diurnal (0.9 to 1.2 days) and fortnightly (13.7 to 14.8 days) frequency bands. Distinct peaks
203 are also visible for higher and lower frequency tidal harmonics. The spectra PDF of the fitted tidal harmonics is shown in
204 [Fig. 3b](#) and highlights the presence of various tidal harmonics and their relatively elevated energy levels. The tide-free or
205 de-tided spectra PDF ([Fig. 3c](#)) show a smoother red form, with an overlay of relatively elevated energy peaks around the
206 semi-diurnal frequency range and a smaller, more diffuse energy bump around the synoptic timescales with periods
207 contained between 3 and 10 days.

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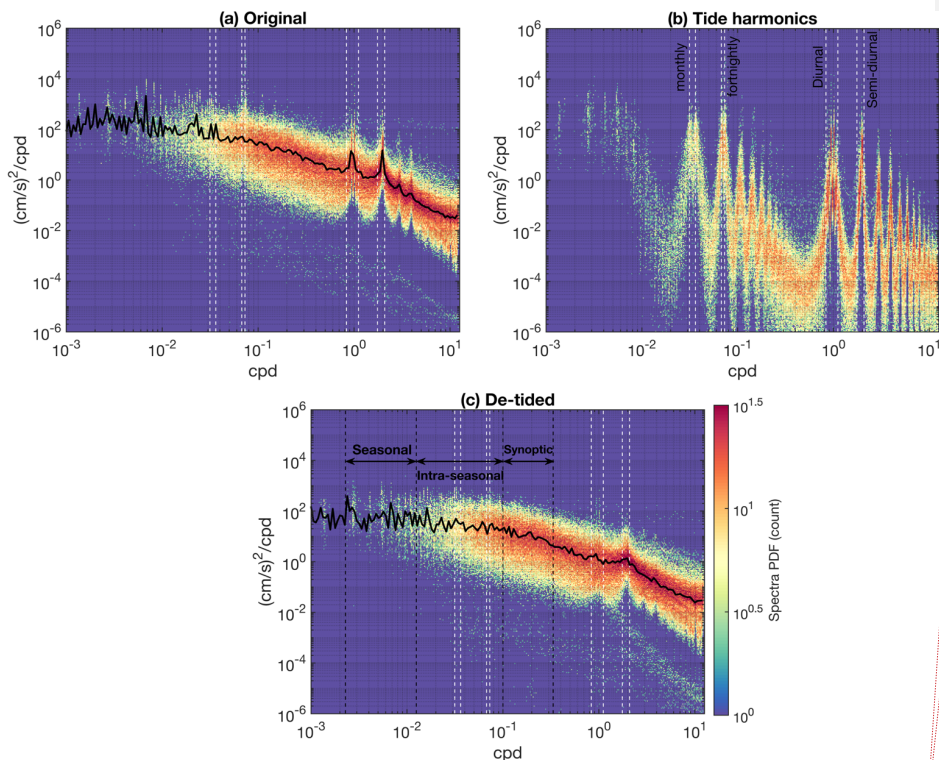
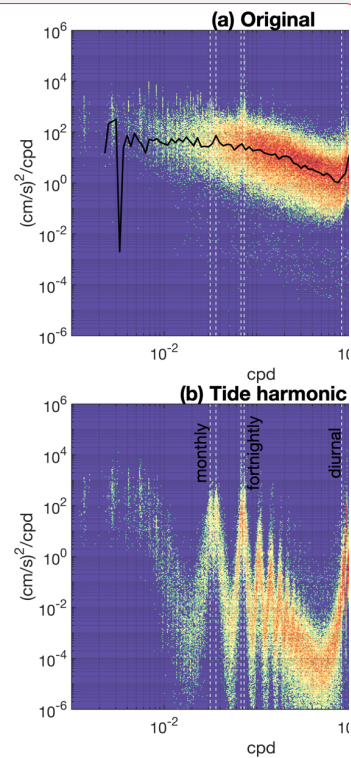


Figure 3. The colour shading shows the spectra probabilistic distribution function (PDF) of all the (a) original velocity time series, (b) the tidal harmonics and (c) de-tided velocity time series. Dashed vertical lines denote the upper and lower frequency bounds for monthly (27.6 to 31.8 days), fortnightly (13.7 to 14.8 days), diurnal (0.9 to 1.2 days) and semi-diurnal (0.48 to 0.57 days) tidal components. Higher/lower values (red/blue) mean that the level of energy is more frequently observed at given frequency across different mooring time series. Black dashed lines in panel (c) show the upper and lower frequency bounds for synoptic (3-10 days), intraseasonal (10-80 days) and seasonal-to-annual (80 days-1.2 years) timescales. Black lines in panel (a) and (c) denote the power density level that is the most frequently counted (i.e. the mode) at each frequency range.

To provide a view of the spatial distribution of kinetic energy, we further integrate the spectra of all three sets of time series (original, tidal harmonics and de-tided) for each record over a set of frequency ranges, representing the semi-diurnal (0.48 to 0.57 days), diurnal (0.9 to 1.2 days), fortnightly (13.7 to 14.8 days), synoptic (3 to 10 days), intraseasonal (10-80 days) and seasonal-to-annual (80 days to 1.2 years) timescales. An example of the spatial distribution of the kinetic energy

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Figure 2

228 before and after the tide removal is shown for the diurnal tidal range in Fig. 4. The original time series (Fig. 4a) in fact
229 contains a range of kinetic energy peaks close to the diurnal periodicity, most of which clearly correspond to the exact
230 tidal harmonics (Fig. 4c), such that the de-tided time series show much lower diurnal peaks. Broadly speaking, most of the
231 ocean kinetic energy at diurnal (Fig. 4 b-c), semi-diurnal (Fig. 5 a-b), and fortnightly (Fig. 5c-d) periodicity are indeed
232 driven by the tide, and the de-tided energy on these three frequency bands is much lower than the original and tidal
233 harmonics estimations (see also Fig. 3).

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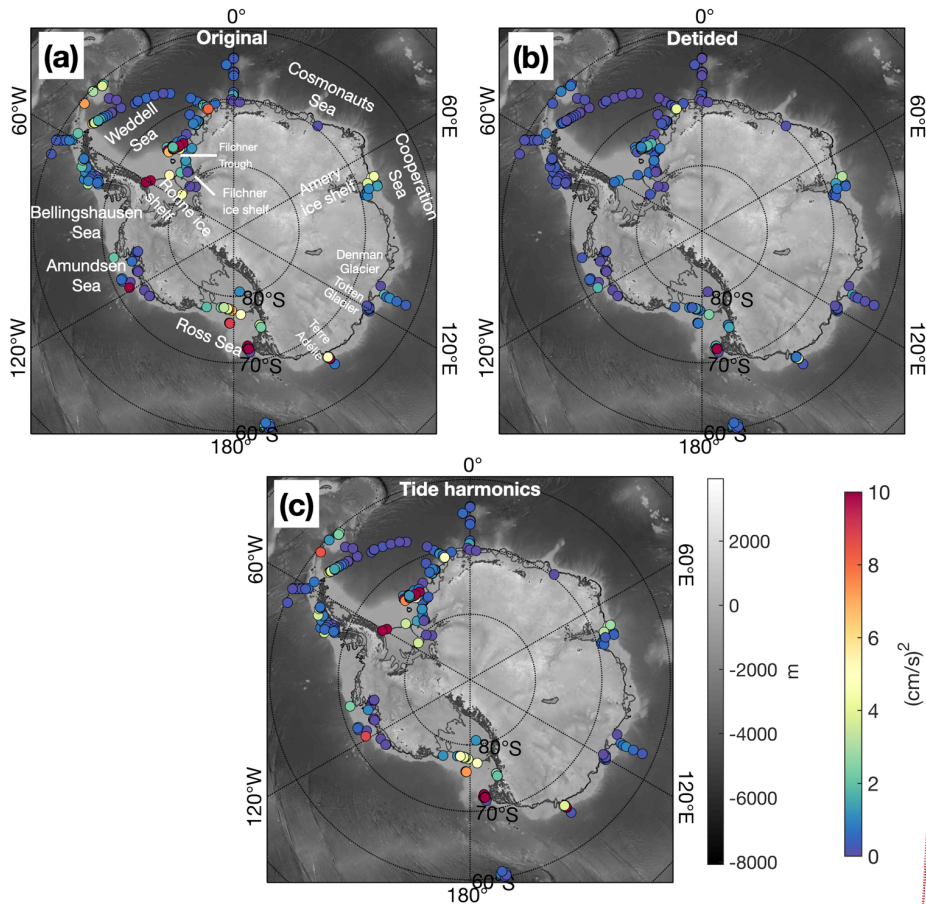
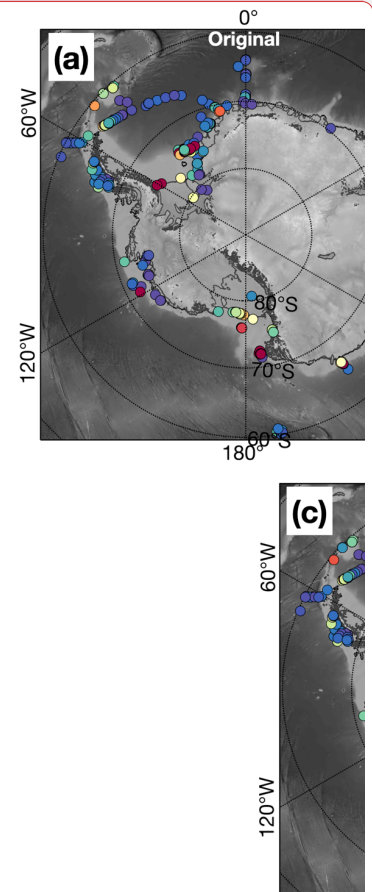


Figure 4. The spatial distribution of the kinetic energy integrated over the diurnal frequency band (0.9 to 1.2 days) using (a) original time series, (b) de-tided time series and (c) fitted tidal harmonics. Grey shading shows the bathymetry, coloured circles showing the magnitude of the kinetic energy integrated over the diurnal frequency band.

However, we note that some of the de-tided records still retain relatively strong energy levels within the diurnal (Fig. 4b) and semi-diurnal (Fig. 5a) ranges. This property is particularly pronounced in regions where dense shelf water flows out

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255 of the Ross Sea, the Cosmonaut Sea (off the Amery Ice Shelf) and the Terre Adélie Sea. The ice front of the Ross and
256 Filchner-Ronne Ice Shelf and the entrance of the Filchner Trough also show elevated levels of diurnal and/or semi-diurnal
257 variability in de-tided time series. The presence of the semi-diurnal to diurnal variability within the de-tided records may
258 result from other sources of variability, e.g. overlapping with the inertial range which is closer to semi-diurnal in polar
259 regions, and/or dispersion of tidal energy around the exact tidal harmonic frequency via mixing processes (e.g., Foster et
260 al. 1987, Whitworth and Orsi, 2006, Padman et al. 2009) or spectral diffusion in more poorly sampled records. Near
261 inertial and tidal motions can be distinguished using rotary spectral analysis, which quantifies kinetic energy as a function
262 of rotational direction. In the Southern Hemisphere, inertial oscillations are consistently anticyclonic, whereas tidal
263 motions may exhibit either cyclonic or anticyclonic rotation (Trasviña et al. 2011). The fact that there is little EKE in the
264 de-tided records at the daily and fortnightly periodicity may indicate a generally low level of spectral diffusion, though
265 this factor is frequency dependent. It also lends support to a hypothesized importance of inertial dynamics as a source of
266 EKE around the semi-diurnal frequency. We note that high kinetic energy (Fig. 5b) is found in mooring sites for de-tided
267 time series where the current meters were instrumented close to the seabed, where the current is arguably more susceptible
268 to turbulence driven by local topography. However, the more detailed analysis required to elucidate the reason for the
269 elevated energy level remaining around tidal frequency ranges within de-tided time series is beyond the scope of this
270 publication.

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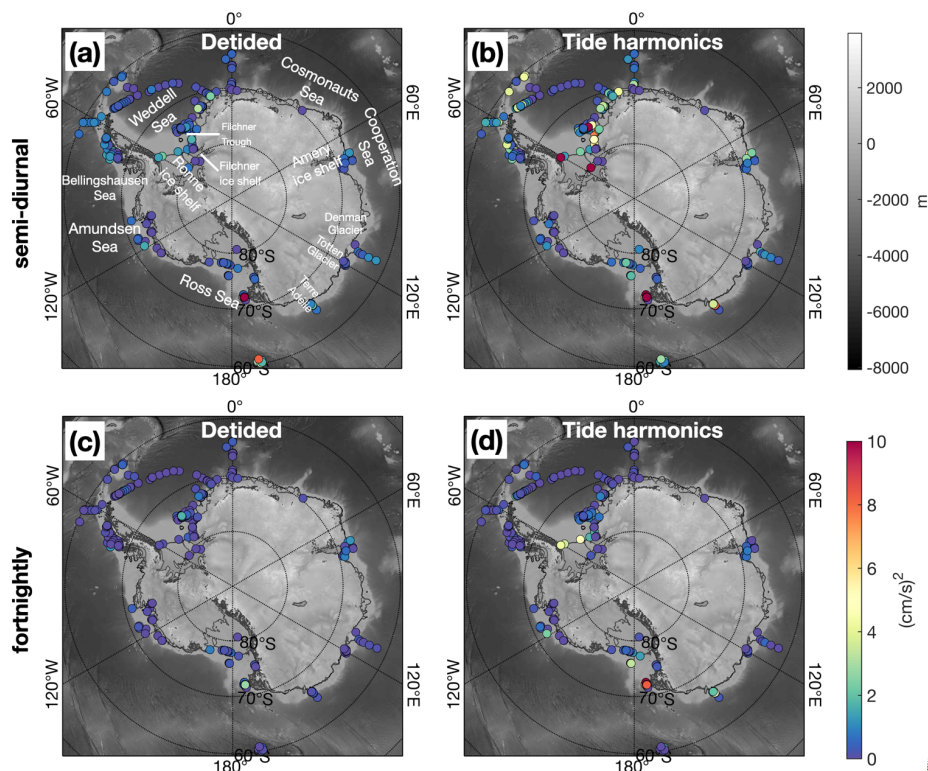
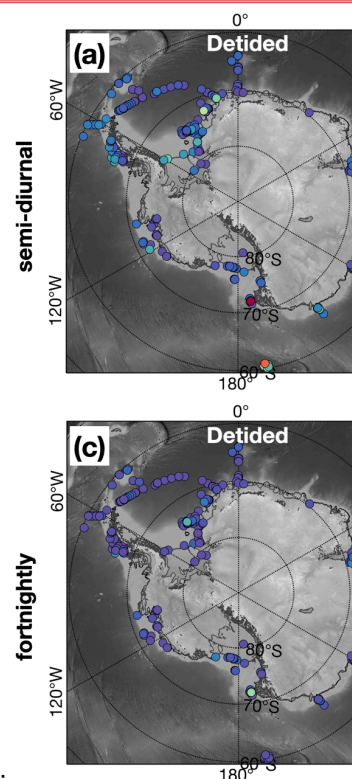


Figure 5. The spatial distribution of (a) de-tided kinetic energy integrated over semi-diurnal periodicity (0.48 to 0.57 days), (b) kinetic energy estimated from fitted tide harmonics over semi-diurnal periodicity. (c/d) Same as a/b but for fortnightly periodicity (13.7 to 14.8 days). Grey shading shows the bathymetry, coloured circles showing the magnitude of the kinetic energy integrated over the respective frequency bands.

At lower frequency, EKE can be divided into three bands (Fig. 6), namely synoptic (3 to 10 days), intraseasonal (10 to 80 days) and seasonal-to-annual (80 to 1.2 years) timescales. The synoptic band shows elevated energy levels along most of the Antarctic continental shelf break (Fig. 6a). Inshore, and along glacier fronts, a notable energy distribution pattern emerges - regions corresponding to relatively high depth integrated ocean heat content and associated glacial melt such as the Amundsen and Bellingshausen seas (e.g., Dutriex et al. 2014, Jenkins et al. 2018, Nakayama 2018) and the Totten

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Figure 4

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289 ([e.g., Rintoul et al. 2016, Gwyther et al. 2018, Silvano et al. 2019](#)) and Denman ([e.g., Adusumilli et al. 2020, Miles et al.](#)
290 [2021](#)) glacier fronts all show relatively low synoptic EKE level, in contrast to the higher EKE levels in regions
291 characterised by cold regimes in front of the Ross ([e.g., Whitworth III and Orsi 2006, Castagno et al. 2019, Silvano et al.](#)
292 [2020](#)), Filchner-Ronne ([e.g., Gordon et al. 2001, Nicholls et al. 2009, Hatterman et al. 2021, Zhou et al. 2023](#)) and Amery
293 ice shelves ([e.g., Ohshima et al. 2013](#)). We speculate that this difference is associated with the heightened sensitivity of
294 cold regions to synoptic atmospheric variability through the response of the ocean surface to sea ice formation and
295 stronger katabatic wind events, whilst warmer regions tend to be more stratified, somewhat insulating the lower part of the
296 water column from surface synoptic variability. In addition, the dense water produced through the sea ice formation can
297 also lead to strong pulses of outflow and imprints on the synoptic timescales, leading to heightened EKE levels in cold
298 regimes.

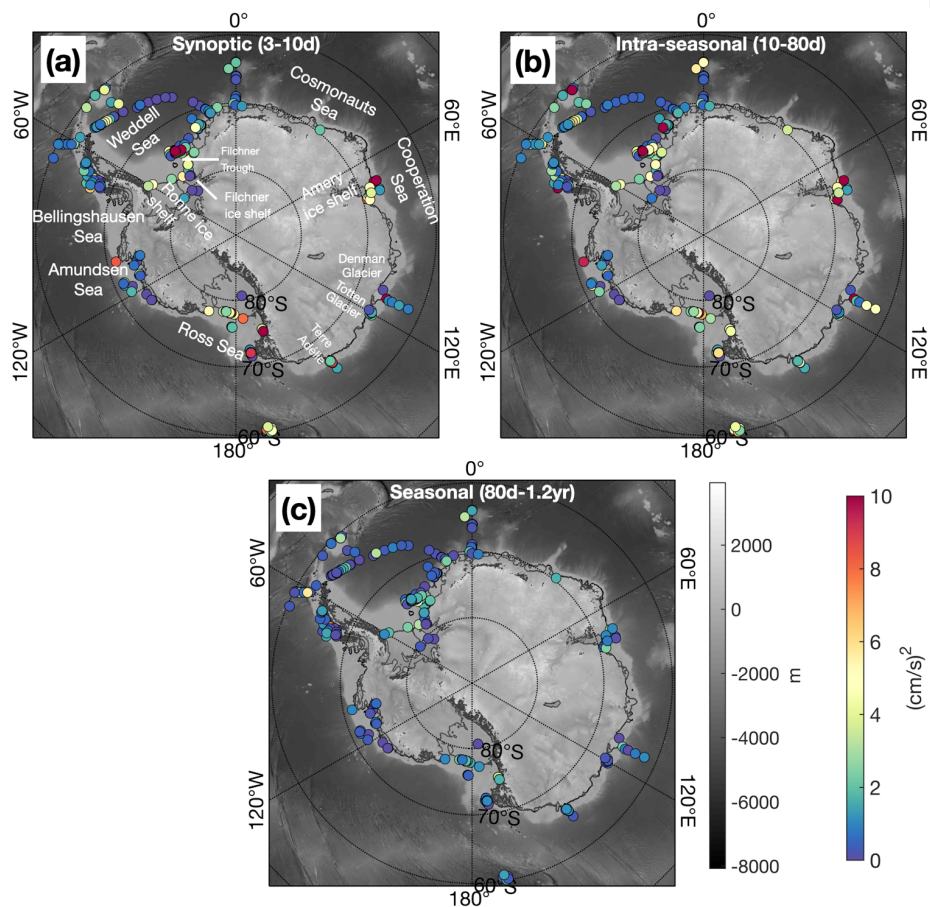


Figure 6. The spatial distribution of the de-tided kinetic energy integrated over (a) synoptic (3 to 10 days), (b) intraseasonal (10 to 80 days), (c) seasonal-to-annual (80 days to 1.2 years) frequency bands. Grey shading shows the bathymetry, coloured circles showing the magnitude of the kinetic energy integrated over the respective frequency bands.

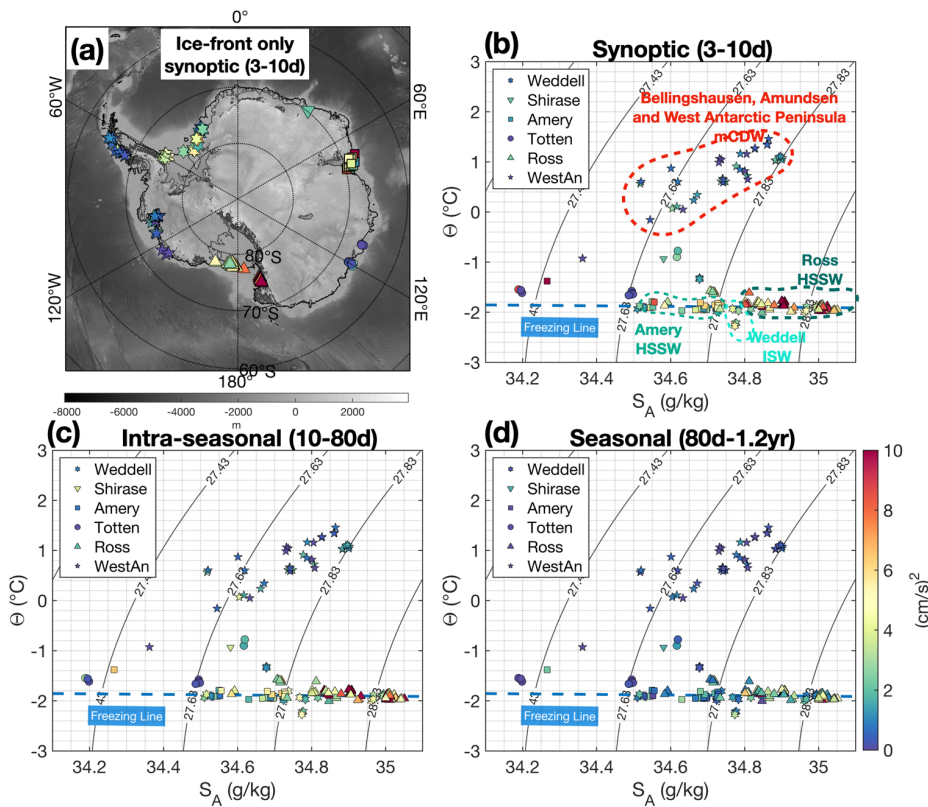
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Another source of EKE can be short coastal waves excited by the atmospheric forcing (Chavanne et al. 2010), dense outflows (Jensen et al. 2013) or resulting from local flow instability excited by topographic features (e.g., St-Laurent et al.

2013, Liu et al. 2025). This source of variability, which appears visible in a few bottom pressure records and sea surface height (McKee and Martinson 2020) would probably apply to a broader range of frequencies, from synoptic to seasonal. Interestingly, the regional pattern of spatial variability in EKE revealed above for synoptic time scales also holds for longer (intraseasonal) time scales (Fig. 6b). A deeper analysis cross correlating atmospheric and ocean variability and applying coastal wave model responses to wind forcing may help to elucidate the processes driving the synoptic-to-intraseasonal EKE. And a more detailed attribution study investigating the processes associated with sea ice formation, dense water production/outflow and the response of ocean currents to the mechanical stirring from the surface stresses is warranted.

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317 Figure 7. (a) The locations of ice-front moorings coloured by de-tided synoptic scale energy. To avoid overlap, data points from
318 the same mooring sites, but with different sampling depths or time periods, were offset by on average 0.5° in longitude and
319 latitude. Grey shading shows the bathymetry. Panel (b)-(d) shows the EKE magnitude integrated over synoptic, intraseasonal
320 and seasonal-to-annual scales in potential temperature (Θ)-absolute salinity (S_A)-space. [The freezing line in the Θ - S_A -space
321 diagram represent the temperature and salinity features associated with surface freezing processes, i.e., the sea ice formation,
322 mCDW locates higher up in the Θ - S_A diagram due to its warm and saline signature while the HSSW falls closer to the freezing
323 line due to its association with sea ice freezing. Depending on the intensity of the sea ice formation rate at different regions, the
324 HSSW can vary in salinity (and density) as seen in the diagram. ISW, the supercooled water mass, falls beneath the surface
325 freezing line as the freezing point is lower at the higher water pressure where ISW is formed (beneath the base of the ice shelf),
326 typically seen in Filchner Sill in the Weddell sector.

327
328 Finally, we present the EKE within the seasonal range (Fig. 6c). While the overall EKE level on seasonal timescales is
329 lower than that on synoptic and intraseasonal timescales, the same spatial distribution pattern - whereby EKE levels are
330 enhanced in cold regime shelf seas - still holds. This further highlights the influence of the sea ice thermodynamic and
331 dynamic interactions with the ocean, either through sea ice production and associated deep convection in cold regime shelf
332 seas, and/or modification of the surface stress transmitted by the wind to the ocean via the sea-ice and the downward
333 propagation of this energy to the lower part of the water column (that is more frequently sampled in this database). A
334 deeper analysis is needed to disentangle the roles of each process in each sector, and as a function of time. To further
335 emphasize the regional correlation between local shelf properties and EKE, we sub-selected ice-front moorings within 50
336 kilometres of the Antarctic ice sheet (Fig. 7a) and plotted EKE at these locations as a function of climatological bottom
337 temperature and salinity (Zhou et al. in prep), with colour-coded EKE levels displayed in potential temperature-absolute
338 salinity diagrams (Fig. 7 b-d). Data points with elevated EKE over synoptic to seasonal scales concentrate near and below
339 the freezing line, confirming that elevated EKE occurs over regions where HSSW are formed (e.g., Filchner-Ronne,
340 Amery and Ross). In contrast, warm ice shelves in West Antarctica (Amundsen, Bellingshausen and the West Antarctic
341 Peninsula sectors) are mostly quiescent on synoptic-to-seasonal timescales after tidal motions are removed.

342 **3 Future work**

343 We have highlighted a few potential avenues for future research above. One additional obvious future element of work
344 remaining at the pan-Antarctic scale is a comparison between observed current tidal harmonics with those predicted by
345 models. Around Antarctica, the most used tide prediction model is the Circum-Antarctic Tide Simulations (CATS,
346 Padman et al., 2002, Padman et al., 2008). This tidal model was recently updated (CATS2008_v2023) with improved
347 representation of coastline, ice shelf grounding line, bathymetry and ice draft (therefore water depth) using the
348 BedMachine Antarctic v3 bathymetry product (Morlighem et al. 2020). It also incorporates an ice flexure model to reflect
349 the tidal deflection near the grounding zone (Howard et al., 2024). Below, we present a brief comparison, focusing solely
350 on the magnitude of the K1 tidal component, which aims at prompting further analysis elsewhere.

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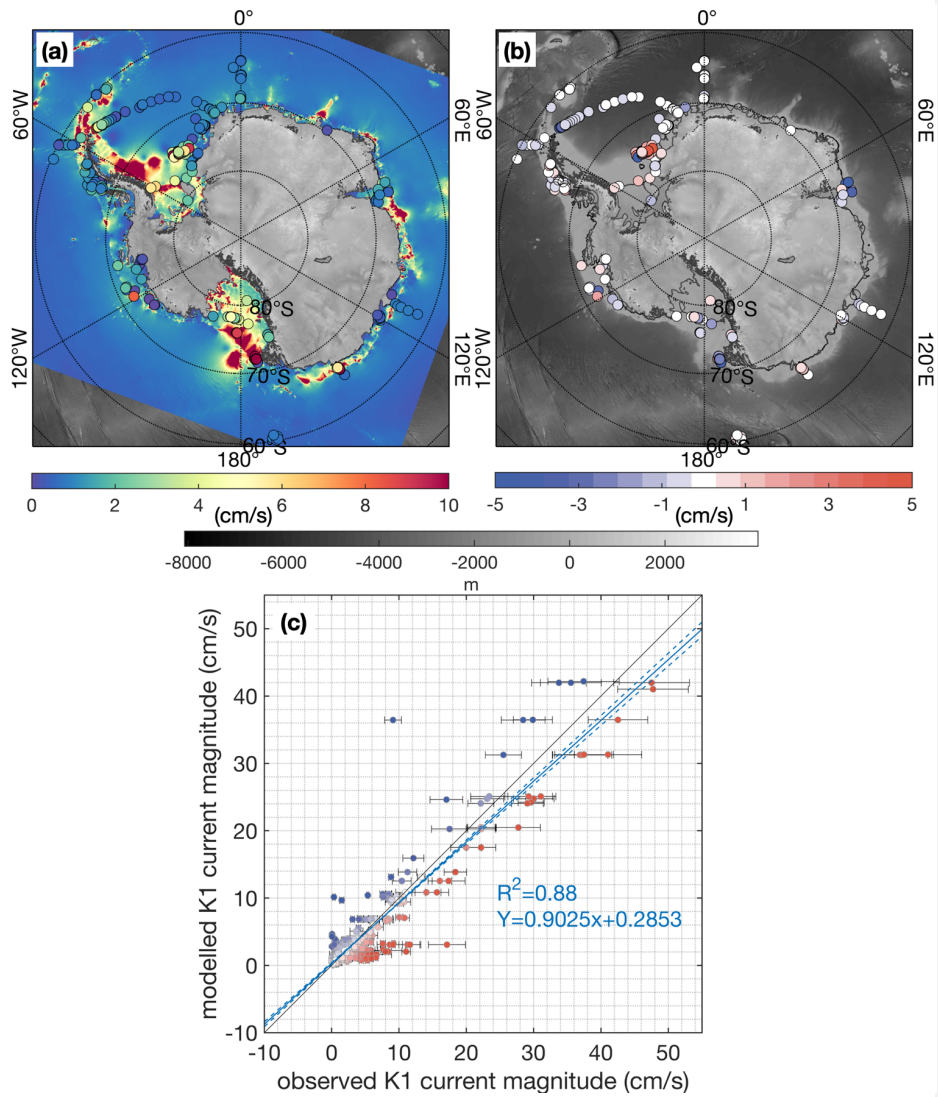
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361 **Figure 8.** (a) Magnitude of the K1 component of the tidal current (cm/s) as predicted in CATS2008 (Padman et al., 2002,
362 coloured background) and that fitted with the OCEAN ICE mooring compilation using UTide (overlaid coloured circles). (b)
363 The difference between OCEAN ICE mooring compilation and CATS2008_v2023 model predictions at each mooring location.
364 Red/Blue means moored observations show larger/weaker K1 magnitude compared with the model. Grey shading shows the
365 bathymetry (c) Scatter plot of OCEAN ICE mooring compilation K1 current magnitude against model prediction. The linear
366 fitting suggests an overall good agreement between two methods, but with significant regional spread. 95% confidence levels are
367 shown as error bars for the observed K1 magnitude estimated using UTide. Colours showing the same difference in K1 current
368 magnitude as in panel (b).

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370 A broad agreement between observations and predictions is found over the open ocean, off the continental shelves, where
371 the tidal signals are generally weaker (Fig. 8a-b). Estimates from two methods tend to drift away more significantly over
372 some of the shelf break mooring sites, potentially because of resonant shelf waves at diurnal frequencies (e.g., Semper and
373 Darelus, 2017). Overall, the tidal information extracted from the OCEAN ICE mooring compilation is generally
374 consistent with the CATS2008_v2023 model prediction in K1 periodicity - the model slightly underestimates the K1
375 current magnitude compared with the observations suggested by the slope of the linear fitting (Fig. 8c). Even with
376 improved BedMachine Antarctica v3 bathymetry information, which does not necessarily provide an accurate bathymetry
377 and ice draft geometry information everywhere (Charrassin et al., 2025), errors in the model predictions can still be
378 sourced from a variety of factors, including incomplete representation of the seabed and ice base geometries, leading to
379 inaccurate water-column thickness. These factors are expected to be specifically significant underneath ice shelves and
380 over the continental shelves where sea ice historically precluded detailed observations of the geometry (Padman et al.,
381 2002). The assumption of the barotropicity in tidal currents by CATS2008_v2023 tide model may also become
382 problematic in regions featuring complex topographies or in regions with distinct vertical stratification, where internal
383 tides with amplitude and phase varying in depth have been documented in Antarctic continental shelf and Southern Ocean
384 settings (e.g., Makinson 2002, Makinson et al. 2006, Heywood et al. 2007). A more detailed analysis, comparing
385 predictions to observations at other frequencies, or scrutinising the baroclinicity of tidal flows at available observation
386 sites, would help refine the prediction model. Given the importance of tides for numerous processes in Antarctic shelf
387 seas, from ice flexure and impacts on grounding zone positions (e.g. Wallis et al., 2024), migration (Rignot et al., 2024),
388 and ice-ocean interactions (Gadi et al., 2023), improving predictions would be a very useful endeavour. We hope the
389 OCEAN ICE compilation presented here will provide a continuously growing backbone for regional and circum-Antarctic
390 analyses in years to come.

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391 **4 Data Availability**

392 The OCEAN ICE mooring compilation is published on SEANOE Data Repository with the doi link,
393 <https://doi.org/10.17882/99922> (Zhou et al. 2024a). The data publication contains two files: a compressed file (2.8 GB)
394 including all the mooring time series files in NetCDF format and a spreadsheet containing [two tabs](#) – [tab 1](#) lists the
395 mooring file names, locations, starting date, end date and the doi link to the original individual data file; [tab 2](#) lists all the

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individual instruments in each mooring files, their deployment depth, the observational period, the variables measured and the depth of the seabed of the mooring location.

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Author contribution

S.Z. and P.D. jointly conceived the study. S.Z. and P.D. discussed about the needed analysis and figures to present in this work. S.Z. performed all the analysis and figure production. S.Z., P.D. and C.F.G. curated the dataset. S.Z. wrote the original draft. All the authors contributed to the data collating and draft revising.

Competing interests

The authors declare that they have no conflict of interest.

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