Utilize a legacy of under-ice Argo float with the positional interpolation along isobath

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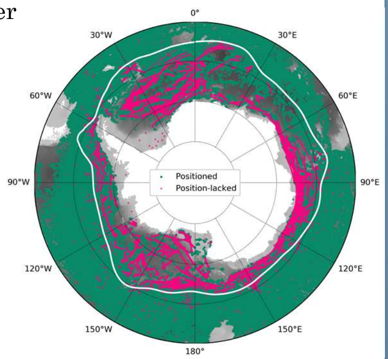
Facts of Under-ice Argo

Plenty of Argo float has been deployed in the Southern Ocean so far (more than 800 floats with 100,000 profiles), whereas the presence of sea ice prevents them from the acquisition of coordinate by satellite communication. Inside the Seasonal Ice Zone of the Antarctic ocean, <u>the data (40,000 profiles in total) include up to 36% of "position-lacked data"</u> (which mostly can be attributed to under-ice). Data distribution for the Antarctic region is shown in the figure below, with the climatological sea ice extent maximum in September as a reference of the SIZ.

Let alone works by Wong & Riser (2011, 2013), the under-ice data have scarcely been analyzed, in spite of <u>their preciousness as a clue of the winter condition</u>.

Not only the present number, under-ice data shall continue to increase, highly motivating and demanding the utilization.

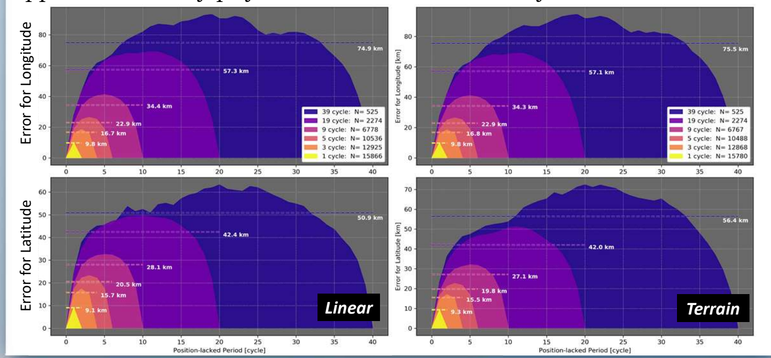
Here we present a new method to utilize position-lacked data, plotting to activate discussions on their usability.



Summary and Outlook

The diagrams present <u>the evolution of interpolation error with respect to the under-ice duration</u>, estimated by the interpolation tests using the positioned data south of 61 °S (the number of test set is denoted in the legend). Although the terrain method is not generally better than the linear method yet, error by the terrain method is more reduced when limiting the estimation area to the shallower depth range, indicating its effectivity.

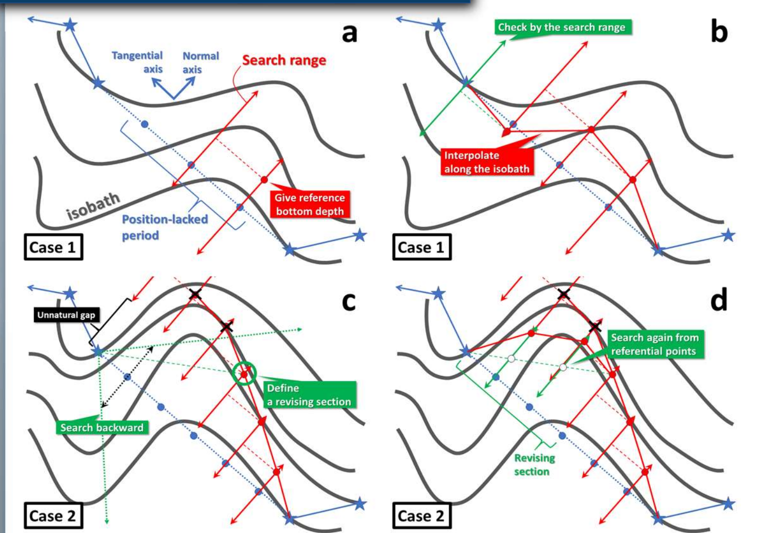
Our methodology is capable to quantify the interpolation error, of great importance for practice. This scheme is potent since it is applicable for any physical field instead of bathymetric data.



How Can They Be Utilized?

To use the position-lacked data, positions need to be interpolated and the error for the interpolation needs to be evaluated by any means. Even though the error quantification is challenging as it is impossible to know the truth, it is still possible to estimate it <u>by testing the interpolation for the positioned data</u>, assuming the flow pattern unlikely changes by occasions. Conventionally, the position-lacked data have been distributed with the positions linearly interpolated (which are denoted by the quality flag of position), however, no proof for the linear way to be the best.

Terrain-following Interpolation

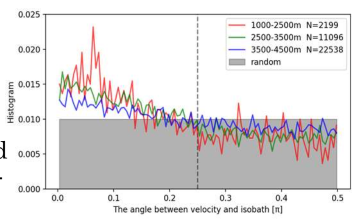


We devised a brand-new algorithm to achieve the Terrain-following Interpolation automatically. Four schematics explain the procedure. Stars denote positioned points, whereas circles denote position-lacked points, linearly interpolated as a default. Panels (a) and (b) describe the first step of the interpolation process, which executes interpolation according to the bathymetric data and the "reference bottom depth" (defined by a linear differentiation of the bottom depths at the positioned endpoints), with a certain "search range" normal to the flow direction.

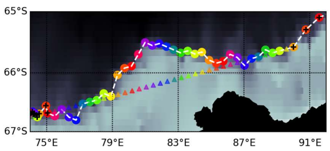
In many cases as in Case 1, the procedure is completed by the first step alone. However, in some cases (like Case 2), the second step is required to fix a gap in the end (ranging outside the search range), which compensates the discrepancy by adjusting some points inside a "revising section", as shown in panels (c) and (d). The revising section is determined by the length of search range and the two straight lines extended from the endpoint, as described in (c).

Why Along Isobath?

The angular momentum conservation yields the propensity of ocean current to align with the isobath. Based on this concept, the angle between the isobath and the flow direction was examined using all positioned data in the Southern Ocean. The histogram of the angle (upper figure) ensures <u>the along isobath tendency of the flow relative to random distribution</u> (gray shade), and the angle above 3500 m is narrower than the below 3500 m by a statistical significance (from the Wilcoxon signed-rank test), indicating the spatial variation of the bathymetric control.



There exists an extra reason to interpolate in a terrain-following manner. The lower figure is a comparison of interpolation method between the linear and the terrain-following (△ and ○, respectively), for the position-lacked data along the continental slope. This exhibits <u>physically unnatural positions by the linear method</u>, crossing over the shelf shallower than the parking depth of Argo floats (1000 dbar).



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