Introduction

The circulation and stratification of the Southern Ocean is highly sensitive to the rate and distribution of freshwater input from the Antarctic continent, which is dominated by ice sheet melting and the melting of calved icebergs (Rignot et al., 2013). Freshwater input from Antarctica helps to maintain the Southern Ocean's stable salinity stratification, in which a layer of colder, fresher water (i.e. Circumpolar Deep Water) sits on top of a layer of warmer, saltier water (i.e. Antarctic Bottom Water) (Kjellsson et al., 2015). At present, ocean models that include the Southern Ocean use a variety of representations of Antarctic freshwater flux and display a wide range of stability and water mass properties (Heuzé et al., 2013).

Here, we derive a mean freshwater input field for the Southern Ocean using recently compiled measurements of ice sheet melting, iceberg calving, iceberg tracking, and river runoff. This freshwater flux field can be used in ocean models and in climate data analysis. We use geolocated ice sheet outlines, iceberg tracks, and river mouths together with their runoff volumes to derive a more accurate freshwater flux field. Figures 1 and 2 show a previously available flux field and our new flux field respectively. The previous estimate is a uniform flux distribution along a gridded coastline, whereas our new field uses spatial and volume data for a more realistic representation of freshwater input. The longitudinal distribution of flux in the new field is markedly different from the previous estimate, as shown by the 18° bins around the edges of Figures 1 and 2. The total freshwater input is 45% higher in the new field, as it has been tuned to be in better agreement with observational estimates of the total freshwater flux due to basal melting and iceberg calving (Rignot et al., 2013).

The British Oceanographic Data Centre (BODC) record contains our freshwater flux field on a 1/6° grid and a sample MATLAB script for reading and plotting the field. The flux file itself is in binary format and is thus universally readable. The input datasets used to produce the field, and MATLAB scripts that can be used to generate a new freshwater flux field with different input datasets are available on request from the authors in an extended dataset.
The longitude bins are 18° wide.

The free variable in this field is the proportion of large iceberg flux (distributed over the field from the tracks) to small iceberg flux (distributed over the Gaussian decaying flux from the coastline). We selected 50% for the proportion as this roughly matched the amount of flux in various sectors (e.g. Weddell Sea) predicted by the total iceberg calving volume data of (Rignot et al., 2013). Silva et al. (2006) used a more sophisticated approach which considered icebergs melting as they progressed along their paths.

2. Dataset location and format

The field itself is on a 2160 × 320 (1/6°) latitude–longitude grid with the freshwater flux calculated at each grid cell in units of m/year.

The BODC dataset contains the freshwater flux field in binary format, grid files in binary format, a PDF colourmap of the field, and a MATLAB script which reads and displays the field. The MATLAB script is included for convenience, but the freshwater input file and grid files are in binary format and are therefore universally readable.

The extended dataset (available on request from the authors) contains MATLAB scripts to generate a custom field using different data or on different grids. It also contains the raw ice sheet melting, iceberg calving, and iceberg tracking data used to generate the freshwater flux product.

3. Dataset use and reuse

We used our new freshwater flux dataset to improve the representation of Antarctic freshwater input in an eddy-permitting model of the Southern Ocean. The model setup (called BASSOON) is described in Jones et al. (2016). When forced with the previously available freshwater flux field, BASSOON developed large, open ocean polynyas associated with deep convection within 4–6 years in both the Weddell Sea and Ross Sea. When forced with our new freshwater input field, the Ross Sea stabilised such that polynya formation (and the associated runaway positive feedback loop of sea ice melt and vertical entrainment of warm water from the interior) was suppressed. Both (1) the increased total flux from the continent and (2) the newly estimated distribution of flux helped to stabilise the Southern Ocean against polynya formation and
overly vigorous deep mixing. However, the Weddell Sea was still subject to polynya formation and instability, indicating that more freshwater input (perhaps from precipitation) is required to stabilise this region. The details of this stability experiment are beyond the scope of this paper, but a technical report is available on request from the authors.

Our dataset can be used (1) in ocean models to replace a more basic freshwater runoff flux field or (2) as part of a broader observational data analysis. The extended dataset (available on request) will allow the user to generate their own field using different raw data. The user can change the grid of the field, change the ice sheet data, or add more iceberg tracks. It also contains data for freshwater runoff from rivers into the Southern Ocean, which can be added to the flux field if required. This is explained in detail in the extended dataset and does not require familiarity with MATLAB. The ice sheet data is stored in an Excel spreadsheet, and new iceberg tracks can be downloaded to a folder and automatically added.

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