

West Antarctic Balance Fluxes: Impact of smoothing, algorithm and topography

*Anne Le Brocq, Tony Payne, Martin Siegert and Jonathon Bamber
University of Bristol*

Grid-based calculations of balance flux and velocity have been widely used to understand the large-scale dynamics of ice masses and as indicators of their state of balance. This research investigates a number of issues relating to their calculation for the West Antarctic Ice Sheet: 1) different topography smoothing techniques; 2) different grid based flow-apportioning algorithms; 3) the source of the flow direction, whether from smoothed topography, or smoothed gravitational driving stress; 4) different flux routing techniques and 5) the impact of using different topographic datasets.

The different algorithms described below lead to significant differences in both ice stream margins and values of fluxes within them. This encourages caution in the use of grid-based balance flux/velocity distributions and values, especially when considering the state of balance of individual ice streams.

1) Most previous calculations have used the same numerical scheme (Budd and Warner, 1996) applied to a smoothed topography in order to incorporate the stresses that smooth ice flow (over distances of a number of ice thicknesses). There are two options to consider when smoothing the topography, the size of the averaging filter and the shape of the averaging function. However, this is not a physically-based approach to incorporating smoothed ice flow and also introduces significant flow artefacts when using a variable weighting function.

2) Different algorithms to apportion flow are investigated; using 4 or 8 neighbours, and apportioning flow to all down-slope cells or only 2 (based on derived flow direction).

3) A theoretically more acceptable approach of incorporating smoothed ice flow is to use the smoothed gravitational driving stress in x and y components to derive a flow direction. The flux can then be apportioned using the flow direction approach used above.

4) The original scheme (Budd and Warner, 1996) uses an elevation sort technique to calculate the balance flux contribution from all cells to each individual cell. However this cannot be used for smoothed driving stresses, as it is permissible for ice to flow in an uphill direction. Other possible techniques include using a recursive call for each neighbour or using a sparse matrix solution.

5) Two continental scale Antarctic DEMs are used as input data, which have significant differences in coastal and mountainous areas. The largest difference in flux calculations is therefore in these areas. Of particular interest is the difference in the Rutford Ice Stream/Carlson Inlet and Kamb Ice Stream (Ice Stream C) fluxes.

Budd, W. F. and Warner, R.C. (1996). A computer scheme for rapid calculations of balance-flux distributions. *Annals of Glaciology* 23 (21-27).