A DEM of West Antarctica from MODIS and ICESat -- Method, Accuracy, and Applications

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An image enhancement approach is being used to develop a new digital elevation map of West Antarctica, combining repeat MODIS imagery and ICESat laser altimetry profile data. The method utilizes the multiple, continent-wide image coverage of MODIS, its high radiometric sensitivity (which equates to a high sensitivity to surface slope in the sunward direction), and the high precision and accuracy of ICESat along-track data.

ICESat has acquired a series of eight near-repeat tracks over the Antarctic during the period September 2003 to June 2006, covering the continent to 86 deg S. ICESat data are aquired as a series of spot elevations, averaging a ~60m diameter surface region every ~172m. Using the multiple-track 'ribbons' of data, two of us (DY and JZ) were able to generate along- and across-track surface slope fields for the Antarctic continent. However, ICESat track paths have spacings wide enough (2 km at 85 deg; 20 - 50 km at 75deg) that some surface ice dynamical features (e.g. flowlines, undluations, ice rises) are missed by the slope and track data.

We are combining the restricted-coverage but high-accuracy ICESat data with cloud-cleared MODIS band 1 data from the 2003-2004 austral summer, used in generating the Mosaic of Antarctica, MOA, surface morphology image map. Past analyses of the slope-brightness relationship for MODIS have shown ice surface slope precisions of +/- 0.00015. Multiple images can improve the single-scene precision (e.g. the effective radiometric resolution) and spatial resolution (nominally 250m for a single scene). ICESat spot elevation have nominal precisions of ~5cm, although thin-cloud effects and mis-location errors can magnify these.

A suite of applications for an enhanced DEM are identified and explored. A full representation of the WAIS undulation field permits a better investigation of the relationship between accumulation and topography, and surface temperature and topography. Further, addressing the shape modifications introduced by the variations in accumulation across undulations is a necessary prerequisite before inverting surface topography for bed elevation. Lastly, surface topography and detailed bed topography are both required for inferring sub-ice-sheet hydrostatic pressure. We will discuss these potential applications.