Quantifying Ice-sheet/Ice-shelf Dynamics and Variability with Meter-scale DEM and Velocity Timeseries

David Shean, Ian Joughin, Ben Smith, Zach Moratto, Claire Porter, Paul Morin

Both the Antarctic and Greenland ice sheets are losing mass at an increasing rate, although loss due to accelerating flow and dynamic thinning remains poorly understood. We are using complementary data from repeat satellite and airborne observations to investigate the relationship between ice-sheet/ice-shelf dynamics and geometry on seasonal to interannual timescales. High-resolution along-track stereo imagery from commercial satellite vendors DigitalGlobe and GeoEye provides unprecedented spatial (~0.5 m/px with ~17 km swath width) and temporal (weekly/monthly) resolution for these efforts.

We have developed an automated pipeline using open-source software to produce orthoimage, DEM, and surface velocity products from DigitalGlobe imagery. High-contrast surface texture (e.g. sastrugi, crevasses) visible at sub-meter resolution provides near-perfect image correlation (~99% success rate) during DEM and velocity map derivation. Elevation data from IceBridge ATM/LVIS, ICESat GLAS, and GPS campaigns are used to correct DEMs and perform accuracy assessment. Preliminary tests over exposed bedrock provide relative vertical accuracy estimates of <1-2 m for Worldview-1/2 DEMs. Velocity data from TerraSAR-X and GPS campaigns provide validation for surface velocity products, with horizontal error estimates of <10 m.

Velocity and elevation change products with 2-4 m/px spatial resolution allow for unprecedented 3D dynamic characterization of sub-km flow transition zones (e.g. grounding lines, shear margins), capturing both local and regional variations due to surface/sub-shelf melting and dynamic thinning. We present preliminary elevation/velocity timeseries for Pine Island Glacier from 2010-2012, and provide estimates for grounding line position and ice shelf thickness. These observations complement ongoing efforts to measure and model outlet glacier dynamics, with implications for future ice-sheet mass balance estimates.