Geophysical Research Abstracts,
Vol. 10, EGU2008-A-11513, 2008
SRef-ID: 1607-7962/gra/EGU2008-A-11513
EGU General Assembly 2008

Greenland and Antarctic ice sheet surface roughness from MISR correlates

with climate, accumulation, and ice dynamics

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We use a multiangle normalized difference approach to map roughness variations in time and space in the West Greenland and the East Antarctic. MISR's red channel permits mapping of roughness variations at a 275-m scale. For these studies, we used a fore and aft pointing pair of MISR's nine cameras to formulate the Normalized Difference Angular Index (NDAI; Nolin et al., 2002), a proxy for surface roughness. Larger values of NDAI correspond to a rougher surface.

On the Greenland ice sheet, we examined a northeast trending transect along the ice sheet, extending from the Jakobshavn Isbræ on the west coast to Summit (72.6° N, 38.5° W, 3200 m a.s.l). Seasonal variations in Greenland ice sheet roughness were investigated by mapping roughness values along MISR paths 8-10 for the 2003 sunlit season (April to September). Preliminary investigation of the Jakobshavn Isbræ (the roughest area along our transect of study) reveals a change in NDAI roughness values on the trunk of Jakobshavn glacier near the terminus from about 0.18 to 0.51 from May 17 to July 29 during the height of the melt season. Variations in roughness on the order -.011 to 0.04 on the wet snow or bare ice portion of the glacier facies (further upglacier) also show an overall increase in roughness during that time period as melt continues. Those values correspond to airborne LiDAR roughness variations (at 70 m scale) of about 120 centimeters in the roughest regions of the transect, near the

heavily crevassed terminus of Jakobshavn Glacier, and less than 10 centimeters in the smoother, inland regions of the ice sheet (corresponding to the percolation and dry snow zones).

A study of Antarctic seasonal variations across a range of elevations was accomplished by mapping roughness values along Path 90 throughout the 2003 and 2006 daylight season (October to February, 2003/04; September to February, 2006/07). There are clear, consistent, semi-permanent variations in roughness Antarctica, particularly at high elevation, i.e. in regions of low accumulation and no surface melt. Roughness values range from 0.35 (extremely rough) to -0.15 (smooth and/or glazed). These variations are associated with a combination of wind regime and accumulation variations, associated with topography on a few-kilometer scale. In addition to semi-permanent patterns of roughness, the ice sheets are overprinted with transient patterns associated with surface frosts (with roughness variations of 0.05 to 0.10). At lower elevations, roughness is more seasonally variable, but still shows consistent spatial patterns that can be recognized throughout the daylit season. Crevasses show very high backscatter, up to 0.35, high-melt areas trend from rough to smooth as melt season progresses. Regional patterns Antarctic roughness are examined, we compiled a partial mosaic of the East Antarctic in 2003 using $\sim$26 scenes from December 2003. The mosaic shows patters associated with known roughness variations such as blue ice, megadunes, and wind glaze areas. The approach shows promise for inferring accumulation rates, based on a correlation of accumulation and roughness noted by several high-plateau traverses.