Evolving Toward the Next Antarctic Ice Shelf Disintegration: Recent Ice Velocity, Climate, and Ocean Observations of the Larsen B Ice Shelf Remnant at Scar Inlet

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Ice shelf / ice tongue retreats have a major effect on glacier mass balance, and nowhere has this been more evident than in the northern sections of the Larsen Ice Shelf in the Antarctic Peninsula. Glacier ice flux in this region surged 2- to 6-fold after the 1995 and 2002 ice shelf disintegration events, driven by a group of processes based on the presence of extensive surface melt lakes. However, precursor changes in the ice shelves beginning more than a decade before the events have been identified. A new assessment of these provides insight on the earliest causes of ice shelf change.

Ice flow speed on the central Scar Inlet Ice Shelf has increased 60% between 2002 and 2012 (425 to 675 m/yr), and 20% (540 to 660 m/yr) at the grounding line of Flask Glacier, a tributary. In late 2002, and again in late 2012, major new rifts formed on the southern portion of the Scar Inlet shelf, and the northwestern shear zone has rapidly evolved. The ice speed increase and the new rifts are inferred to be due to significant structural changes in the ice shelf shear margin on its northern side (concentration of shear motion and disruption of the shelf margin area).

Weather data collected under LARISSA highlights the importance of foen winds in causing both surface melting and reducing sea ice at the ice shelf fronts, and show that specific weather patterns lead to frequent foen events. Oceanographic data from CTD casts show that deep ocean water near the Larsen Ice Shelf region retains a small capacity for inducing melt in the shelf cavity. At Seal Nunataks, ICESat detects surface lowering at 0.25 m/yr, but the implied shelf thinning rate is similar to that observed at adjacent Robertson Is. due to melt runoff.

An examination of satellite imagery spanning 1963 to the present shows that shear margins on the Larsen B and Scar Inlet were essentially unchanged through 1986. Following that time, ice shelf shear zones show significant evolution, including increased and expanded areas of rifting, concentration of shear, and ice flow speed increases. These changes are the initial events leading to effects described in Glasser and Scambos, 2008 J. Glaciol., Vieli et al., 2007 EPSL, and Khazendar et al., 2007 GRL. These early changes, occurring prior to shelf area loss, suggest either increased ocean-driven basal melt or effects of increased meltwater on the shelf and tributary glaciers are the cause of early shelf weakening that led to disintegration.