High basal shear stress vs. high basal melt: accelerations on the Getz Ice Shelf, West Antarctica

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The Getz Ice Shelf of West Antarctica occupies a rapidly changing region of the Amundsen Sea Sector, where the evolving Amundsen Sea Low and intrusions of Antarctic Circumpolar Deep Water (CDW) are re-shaping the shelf from above and below. CDW intrusions are of particular interest, as their influence has caused glaciers just to the east of the Getz, notably the Pine Island and Smith Glaciers, to dramatically increase in velocity in recent decades: velocities measured on Pine Island Glacier have increased by ~50% between 1972 and 2012, and Smith Glacier has accelerated >100% between 1992 and 2008, respectively. For the Getz, intrusions of CDW are melting the base at a rate of 4.3 ± 0.4 meters of water per year (Rignot et al., 2013, Science), causing variable thinning along the shelf of ~3-7 ma^{-1} (Pritchard et al., 2012, Nature), and producing more melt water than any other shelf in Antarctica. Despite the large magnitude of the basal melt, however, the Getz Ice Shelf has experienced only modest accelerations during the past few decades. This study uses MODIS imagery from the past decade, Landsat imagery from 1973-1986 and 1999-2003, and .5- to 3-meter commercial imagery licensed by the National Geospatial-Intelligence Agency from 2008-2013 to examine changes in velocity along the ice shelf, with a focus on the ice edge and grounding line region. The ice shelf, which comprises several relatively narrow regions of rapid outflow separated by slower areas, exhibits its fastest velocities near the western edge at DeVicq Glacier. This region, moving typically 400-800 ma^{-1} at the grounding line and 800-1000 ma^{-1} near the ice edge, has accelerated by ~20% near the grounding line over the past decade. The far eastern edge, where speeds are generally 150-400 ma^{-1} near the grounding line and 250-500 ma^{-1} near the ice edge, and where CDW influence is greatest, has accelerated by ~35% in the last decade. Central sections of the shelf have experienced <10% accelerations. In addition, IceBridge Airborne Topographic Mapper (ATM) data are used to examine elevation profiles across the grounding line of the Getz, revealing very steep slopes just above the grounding line. The IceBridge data are supported by ICESat profiles, and combined can be used to examine dh/dt in the grounding line region. We hypothesize that the steep slopes above the grounding line indicate high basal shear stress, and that this is largely responsible for the lack of significant acceleration. Thinning of the ice shelf increases the slope at the grounding line, raising the driving stress accordingly. However, as the driving stress is already very high, the percentage change is relatively low, making accelerations on the shelf and lower glacier regions modest.