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Assessment of Range Bias in the ICESat (2003-2009) Elevation Time Series and Elevation Changes at Large Subglacial Lake Sites, Antarctica

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Antarctica's largest subglacial lakes such as Recovery Lakes A/B (∼4000 km2 each) and Lake Vostok (∼15,690 km2) were extensively measured by Ice, Cloud, and land Elevation Satellite (ICESat) laser altimetry profiles in two different repeat track patterns. Lake Vostok's scale and the proximity of the Recovery Lakes to onset of the Recovery Ice Stream means that accurately assessing lake level change is relevant to broader ice sheet stability. Since ICESat's on-orbit operations began in 2003, eighteen distinct campaigns were completed using the Geoscience Laser Altimeter System's (GLAS) three lasers over a range of transmit and receive energies with the final data acquired in October 2009 by Laser 2. These data have enabled elevation change results to be calculated across many ice sheet areas during the mission's lifetime (Pritchard et al., 2009, Nature) but with substantial uncertainty in magnitude and trends due to evident inter-campaign biases (C. Shuman et al., T. Urban, 2010 EOS).

We use all 8-day and partial 91-day repeat track crossovers to assess elevation changes both on and off these subglacial lake sites in order to assess the full 2003-2009 mission elevation time series. By comparing on-lake to off-lake crossovers, we show that Lake Vostok has not changed elevation nor has Recovery Lake B (swamp? K. Langley et al., 2010 EOS) within our data's resolution, whereas Recovery Lake A shows a ∼12 cm elevation increase over the ∼7 year ICESat time series. While our altimetry-derived lake level change result is compatible with an independent multi-year GPS study around Vostok Station (Richter et al., 2008, GRL), both on-lake and off-lake crossovers show a distinct elevation difference pattern that is correlated with higher received laser energy during 2003-2006. This pattern at Vostok is quite similar to those from across East Antarctica at the Recovery Lakes indicating a range bias is impacting all ice sheet data. We then use Lake Vostok's elevation stability to derive an empirical correction that accounts for up to 60 cm elevation errors observed early in the ICESat time series (without standard saturation correction). By fully compensating for this received energy bias, the correction removes a >1 cm/yr positive bias in elevation over the nearly 7 year mission that leads to incorrect mass balance assessments in Antarctica and Greenland.