Some Lessons on Basal Physics of Ice Motion from Flow Variability of Whillans Ice Plain: the WISSARD GPS Experiment (in a Shadow of a Borehole)

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Here we report preliminary results from the largest ever glaciological on-ice cGPS experiment, which is taking place as part of the WISSARD project (and a pre-WISSARD OPP-Antarctic Glaciology project) since late 2007 on Whillans Ice Plain (WhIP), a regional flow feature with approximate dimensions of 100km by 100km by 1km. Overshadowed by a borehole and a subglacial lake in the eyes of the media, this experiment is yielding a (discontinuous) high-resolution time series of ice velocity and strain rates from one of the most erratically behaving parts of the West Antarctic ice sheet.

The WhIP has been slowing down since at least 1963. Prior constraints on this slowdown were consistent with a constant long-term deceleration rate. Here we show that the deceleration rate varies through time, including on interannual timescales. For instance, between 2009 and 2012 WhIP decelerated at a rate that was double the multi-decadal average. To identify the mechanism/s responsible for this slowdown, we used force budget models as well as a higher-order inverse model. All model results support the conclusion that the observed deceleration is caused by an increase in basal resistance with magnitude of 10-40 Pa/yr. Subglacial processes which may be responsible for such strengthening include basal freeze-on, changes in subglacial water drainage, or increases in the area of resistant basal substrate through differential glacial erosion. The WISSARD cGPS experiment captured an episode of Subglacial Lake Whillans (SLW) filling and draining in 2008 and 2009. During this time period, ice surface elevation over the lake went up and down by up to four meters. This subglacial lake activity resulted in a regional, temporary acceleration by about 2% of ice surface velocity. This acceleration shows up on all cGPS stations, including the ones located over 50km away from SLW, suggesting that lake activity is correlated in time with regional changes in subglacial hydrology.