Change in the Stick-Slip Cycle of Whillans Ice Stream, West Antarctica

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The motion of the Whillans Ice Stream has been previously documented to be changing with time. The trend of long term deceleration has been observed to be variable over inter-annual time scales with the maximum observed magnitude of declaration occurring between 2009 and 2014 at a rate of up to 10 m/yr^2. Additionally, the lower portion of the ice stream, Whillans Ice Plain, exhibits motion characterized by longer periods of slow stable sliding (6 to 24+ hours at <0.5 m/day) and rapid sliding slip events (~30 minutes at up to 20 m/day) for which the timing is tidally modulated.

Through the use of continuous GPS observations of Whillans Ice Plain ice surface displacement, we show that the stick-slip cycle is changing in two main ways, 1) the frequency of slip events is decreasing at ~30 events per year and 2) the rate of stable sliding is decreasing. The observed reduction in total ice surface displacement is partitioned equally between these two types of ice motion. Given the time since the last slip event, the magnitude of the following slip event is predictable. This slip-predictability is unchanged throughout the duration of the observations.

We compare two simple models of ice stream stick-slip motion to determine likely mechanisms for observed changing stick-slip behavior. One model, a frictional slider block model, requires a reduction in compressional stress loading rate or an increasing threshold of slip initiation to reduce the frequency of slip events. Reduction in stress loading is potentially supported by observations of slower stable sliding magnitudes and slower upstream ice velocity, which does not experience stick-slip motion. Complicating this interpretation are observations of increased compressional strain rates along ice stream flow for portions of the ice stream between 2007 and 2013. An increasing stress threshold for slip initiation is potentially precluded by consistent slip-predictability.

A second model used was a slip-predictable elastic force balance model. To match observations the model requires a temporal increase or decrease in both mean basal resistance and compressional stress loading. Alternatively, an increase in ice surface slope coupled with either,

or both, a decrease in compressional stress loading and an increase in mean basal resistance yield similar results. Pervious work suggests that mean basal resistance is increasing with time and that the spatial variability of ice surface elevation change results in increased mean surface slope along Whillans Ice Plain. These observations generally support the second possible result

Neither model is complete in its treatment of ice stream stick-slip motion. But both models suggest increased ice stream surface slope coupled with increased basal resistance is consistent with secular and spatial trends of slow down. These mechanisms are consistent with the observation of stick-slip cycle variability. These results reinforce the sensitivity of ice stream motion to internal dynamic and geometric feedbacks.

Theme: Changes in WAIS from observations (*The Times They are a-Changin')*