Stick/Slip Behavior of Ice Streams: Modeling Investigations

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A puzzling phenomena of ice-stream flow is the stick/slip motion displayed by Whillans Ice Stream. To investigate the origin and implications of this phenomena, a simple mechanical model widely used in seismology to study origins of earthquakes is used to examine how periodic tidal forcing and spatial variability in basal friction leads to the cyclic stick/slip motion in an ice stream. Spatially variable friction has a strong influence on the velocity amplitude and periodicity of slip events. Periodic forcing designed to mimic ocean tides near the grounding line of the ice stream can pace the periodicity of slip events (e.g., determine the fundamental periodicity of a doublet of slip events occurring once per tidal cycle), however intrinsic properties of the mechanical system (e.g., as determined by friction parameters) determine whether aftershock slip events follow the fundamental slip event triggered by external tidal forcing during each cycle. By analogy with mechanical stick/slip oscillators that display onset of stick-slip cycling from uniform slip as the speed of motion reduces, a slowing ice-stream exhibiting gradual increase in basal friction is likely to enter a transitional phase of behavior when steady flow gives way to stick/slip flow prior to complete shut-down of the ice stream.