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Temporal evolution of strain rates at western Greenland moulins

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Moulins are key sources for subglacial water across western Greenland. The rate and timing at which they deliver surface meltwater to the subglacial system are crucial inputs for ice-sheet hydrology models. Intensive field campaigns coupled to remote sensing efforts have provided, to date, information on the timing of supraglacial lake drainages and water flux through the consequent moulins, but predicting the dates of moulin activation has remained an area of active research. This is vital for the construction of spatially variable basal-input hydrographs for models that will predict the future evolution of Greenland ice flow and sliding. In this study, we combine multiple remote sensing datasets to investigate the degree to which local strain rates can predict moulin activation dates, as indicated by supraglacial lake drainage events. We find that over the period 2009–2011 in the Pâkitsoq region, moulins with more-tensile background (wintertime InSAR-derived) strain rates tend to activate first, followed by moulins in less-tensile background strain regimes. This pattern is relatively consistent across years, although we find that background strain rates are less important in explaining the date of moulin activation than are moulin elevation or cumulative days of runoff. In the Russell Glacier area, we examine the temporal evolution of summertime, Landsat-derived strain rates at moulin locations. Principal component analysis shows that strain rates at moulin locations increased abruptly over June 2012, independent of moulin elevation; strain rates in localities without moulins varied more smoothly in time. We also compare the strain rate time series at each moulin to lake drainage dates derived from MODIS and Landsat imagery from 2012. We hypothesize that the contrasting bedrock topography of the regions (Pâkitsoq is rougher than Russell at the few-km scale) may drive variations in moulin opening patterns across the two regions. Our results will have implications for the potential parameterization of surface-to-bed hydrological connections in ice-sheet models for use in forecasting the dynamics of the Greenland Ice Sheet in future warm climates.