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Velocity Variability of a Debris-Covered Glacier at Hourly to Annual Timescales

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The potential for glacier, ice cap, and ice sheet discharge acceleration has been highlighted as a major source of uncertainty in sea level rise predictions and is particularly uncertain in the case of debris-covered glaciers. Changes affecting basal sliding can cause the flow of glaciers and ice sheets to change at a variety of timescales. Debris-cover influences basal sliding by buffering the glacier against short-term melt events and changing the overall glacier profile. Here we use a long-term GPS deployment to investigate the flow of Tasman Glacier, a large debris covered glacier in the Southern Alps of New Zealand. Tasman Glacier demonstrates no detectable diurnal velocity variability, significant seasonal variability, and remarkable acceleration in response to rainfall events. During times of heavy rainfall, Tasman Glacier accelerates to speeds of up to 36 times its normal speed (from 0.12 m d-1 to 4.45 m d-1). Peak speeds are maintained for periods of less than 12 hours before rapidly decaying to slightly above background levels. Recording many speed up events allows the relationship between rain-rate and glacier speed to be determined enabling us to estimate the effect rainfall events have on annual glacier speed and inter-annual variability. Comparing speed up events with bed separation estimates indicates that the initial acceleration is likely a direct result of the growth of basal cavities. Basal sliding theory implies that the sensitivity of glacier speed to water input is increased by glacier down wasting, which lowers the effective pressure at the bed, indicating that rain induced speed-up events are likely to become increasingly common on Tasman Glacier.