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Integrative monitoring of high-frequency high-magnitude ice-rock avalanches on Iliamna volcano, Alaska

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Iliamna is an andesitic stratovolcano of the Aleutian arc with regular gas and steam emissions, located in the Cook Inlet region of Alaska. Several glaciers mantle the flanks of Iliamna (3053 m asl) comprising a total ice volume of ca. 15 km3. As monitoring activities have revealed, Iliamna is characterized by an extraordinary high frequency of large ice-rock avalanches which originate from the summit region with steep glaciers and hydrothermally altered rocks. This contribution describes the nature of these avalanches and demonstrates how they can be monitored. To this end, a variety of monitoring techniques are applied, including a seismic network with 6 short-period instruments, high-resolution optical satellite imagery, thermal satellite imagery, multi-temporal digital terrain analysis, and fixed-wing overflight observations. Seismic records of avalanches exhibit a characteristic but so far rarely observed precursory signal of up to 2 hours before actual failure. After about an hour, the discrete earthquakes gradually transform into a continuous ground-shaking with increasing frequency and amplitude. The actual avalanche is represented by a spindle-shaped broadband signal typical for mass movements. The seismic record enables us to constrain the avalanche in terms of location and flow velocity, and relate the signal to the failure mechanism, thought to represent slip processes at the ice-ice or ice-bedrock interface. Determination of avalanche timing and location by the seismic network facilitates application of remotely based monitoring techniques, such as high-resolution satellite imagery for assessment of avalanche dimensions or thermal satellite data for identification of zones of geo/hydrothermal activity. Due to the high frequency of large avalanches and the monitoring instruments available, Iliamna volcano repre-

sents a unique laboratory for advancing related monitoring and hazard assessment techniques, using measurements integratively. Short-term avalanche warning may be possible in the future if precursory seismic signals and failure mechanism are further investigated.