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Monitoring eruptive activity, estimating effusion rates, forecasting collapse events and mapping the distribution of pyroclastic deposits from Sinabung volcano during 2013-2016 using satellite imagery

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We used remote sensing to forecast eruptive activity at Sinabung volcano and to characterize five phases during this long-term and ongoing eruption. We divide the eruption into 5 phases. We use a variety of satellite remote sensing data (optical, infrared, radar) to observe the summit area, lava dome and lava flow and to forecast collapse events, map the resulting pyroclastic deposits, and estimate eruption rates and deposit volumes. Our remote sensing data was used in combination with ground-based monitoring to inform warning and evacuation decisions. Unusual aspects of the Sinabung eruption include a transition from lava-dome to lava-flow morphology, and frequent occurrence of lava-flow-front and flow-margin collapses, which created deadly pyroclastic density currents (PDCs). Because of the importance to hazards and to distinguish from the better-known "Merapi type" of summit-dome collapses, we propose that lava flow-front and flow-margin collapses with associated PDC's be known as "Sinabung type." Our observations show clear evidence of at least one slope-parallel high-velocity and dilute PDC (a "blast") that emanated from a flow-margin collapse site ~500 m downslope from the vent. This 1 February 2014 blast downed and singed a forest out to at least 3.9 km and killed 16 people. Since lava emission began, daily to weekly effusion rates have varied from <1 to >20 m/s. In a few cases, periods of increased extrusion preceded lava flow-front collapses by a few days to a week, suggesting delays in transmittance of effusion pulses as lava moves from vent to flow front. As of 1 January 2016, the total area covered by deposits was 10^7 square meters, producing an approximate volume of 3X10^8 cubic meters.