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Estimation of lava flow field volumes and volumetric effusion rates from airborne radar profiling and other data: Monitoring of the Nornahraun (Holuhraun) 2014/15 eruption in Iceland

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Monitoring of lava-producing eruptions involves systematic measurement of flow field volumes, which in turn can be used to obtain average magma discharge over the period of observation. However, given inaccessibility to the interior parts of active lava fields, remote sensing techniques must be applied. Several satellite platforms provide data that can be geo-referenced, allowing area estimation. However, unless sterographic or tandem satellite data are available, the determination of thicknesses is non-trivial.

The ongoing eruption ("Nornaeldar")at Dyngjusandurin the Icelandic highlands offers an opportunity to monitor the temporal and spatial evolution of a typical Icelandic lava flow field. The mode of emplacementis complex and includesboth horizontal and vertical stacking, inflation of lobes and topographic inversions. Due to the large extent of the flow field ($>$83 km^2 on 5 Jan 2015, and still growing) and its considerable local variation in thickness ($<$5 m to $>$30 m) and surface roughness, obtaining robust quantification of lava thicknesses is very challenging,despite the lava is being emplaced onto a low-relief sandur plain. Creative methods have been implemented to obtain as reliable observation as possible into the third dimension: Next to areal extent measurements from satellites and maps generated with airborne synthetic-aperture radar (SAR), lava thickness profiles are regularly obtained by low-level flights with a fixed-wing aircraft that is equipped with a ground clearance radar coupled witha submeter DGPS,a system originally designed for monitoring surface changes of glaciers above geothermally active areas.The resulting radar profile data are supplemented by analyses of aerial photos and complemented by results from an array of ground based thickness measurement methods.

The initial results indicate that average effusion ratewas $\sim$200 m^3/s in the first weeks of the eruption (end August, early September) but declined to 50-100 m^3/s in November to December period. We discuss the used methods and their range of application in detail, present the resulting volume estimates of the new lava field and pinpoint the implications with emphasis on the temporal evolution of its effusion rate.