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Radar measurements of surface deformation in the sub mm-range

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A portable low power Doppler radar at 24 GHz is used for volcano eruption observations since more than a decade (e.g. Hort and Seyfried, 1998, doi: 10.1029/97GL03482; Seyfried and Hort, 1999, doi: 10.1007/s004450050256; Vöge et al., 2005, doi: 10.1029/2005 EO510001, Vöge and Hort, 2009, doi: 10.1109/TGRS. 2008.2002693, Gerst et al., 2013, doi: 10.1002/jgrb.50234; Scharff et al, 2015, doi: 10.1130/G36705.1) The typical radar products are range resolved Doppler spectra containing information on the reflectivity, radial velocity and its distribution of ejected particles.

Here we present the analysis of the phase of radar signals for the detection of comparably slow and small deformations of the solid surface which may occur for example prior to an eruption [Hort et al., 2010, AGU Fall meeting, Abstract V32B-03]. While the phase analysis of weather radar echoes from ground targets is established for estimating the atmospheric refractivity [Besson and du Châtelet, 2013, http://dx.doi.org/ 10.1175/ JTECH-D-12-00167.1], we consider here the variability of the atmosphere as a source of uncertainty. We describe the implementation of this technique in a dedicated compact low power FMCW system. Observations at Stromboli suggest an expansion of the vent prior to the eruption on the order of millimeter which is on the same oder as reported by [Noferini et al., 2009, doi: 10.1109/IGARSS. 2009. 5416901] and in case of Santiaguito volcano we were able to observe the post eruptive subsidence of the volcanic dome. We suggest further to resolve the range/refractivity ambiguity by using a dual frequency radar with sufficient frequency separation for utilizing the frequency dependence of refractivity.