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Investigating the value of passive microwave observations for monitoring volcanic eruption source parameters

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Volcanic eruptions inject both gas and solid particles into the Atmosphere. Solid particles are made by mineral fragments of different sizes (from few microns to meters), generally referred as tephra. Tephra from volcanic eruptions has enormous impacts on social and economical activities through the effects on the environment, climate, public health, and air traffic. The size, density and shape of a particle determine its fall velocity and thus residence time in the Atmosphere. Larger particles tend to fall quickly in the proximity of the volcano, while smaller particles may remain suspended for several days and thus may be transported by winds for thousands of km. Thus, the impact of such hazards involves local as well as large scales effects. Local effects involve mostly the large sized particles, while large scale effects are caused by the transport of the finest ejected tephra (ash) through the atmosphere.

Forecasts of ash paths in the atmosphere are routinely run after eruptions using dispersion models. These models make use of meteorological and volcanic source parameters. The former are usually available as output of numerical weather prediction models or large scale reanalysis. Source parameters characterize the volcanic eruption near the vent; these are mainly the ash mass concentration along the vertical column and the top altitude of the volcanic plume, which is strictly related to the flux of the mass ejected at the emission source. These parameters should be known accurately and continuously; otherwise, strong hypothesis are usually needed, leading to large uncertainty in the dispersion forecasts.

However, direct observations during an eruption are typically dangerous and impractical. Thus, satellite remote sensing is often exploited to monitor volcanic emissions, using visible (VIS) and infrared (IR) channels available on both Low Earth Orbit (LEO) and Geostationary Earth Orbit (GEO) satellites. VIS and IR satellite imagery are very useful to monitor the dispersal fine-ash cloud, but tend to saturate near the source due to the strong optical extinction of ash cloud top layers. Conversely, observations at microwave (MW) channels from LEO satellites have demonstrated to carry additional information near the volcano source due to the relative lower opacity. This feature makes satellite MW complementary to IR radiometry for estimating source parameters close to the volcano emission, at the cost of coarser spatial resolution.

The presentation shows the value of passive MW observations for the detection and quantitative retrieval of volcanic emission source parameters through the investigation of notable case studies, such as the eruptions of Grímsvötn (Iceland, May 2011) and Calbuco (Cile, April 2015), observed by the Special Sensor Microwave Imager/Sounder and the Advanced Technology Microwave Sounder.