

## **Correcting the record of volcanic stratospheric aerosol impact: Nabro and Sarychev Peak**

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Since 2010 several papers have been published that reveal a pattern of discrepancies between stratospheric aerosol data from the Optical Spectrograph and InfraRed Imaging System (OSIRIS) instrument and comparable measurements or model simulations of volcanic plumes from Kasatochi (2008), Sarychev Peak (2009), and Nabro (2011). The OSIRIS discrepancies are two-fold: a post-eruption lag in aerosol onset/increase and low bias in maximum stratospheric aerosol optical depth. Assumed robustness of the OSIRIS data drove various conclusions, some controversial. For example, one conclusion was that the June 2011 Nabro (northeast Africa) plume was strictly tropospheric, and entered the stratosphere indirectly via Asian monsoon convection. In that case the conclusions were driven by OSIRIS data and a volcano activity report by the Smithsonian Institution that indicated strictly tropospheric injection heights. We address the specific issue of Nabro's eruption chronology and injection height, and the reasons for the OSIRIS aerosol discrepancies that impacted these several case studies.

First we lay out the time line of Nabro injection height with geostationary nadir image data, and stratospheric plume evolution for 4 days after eruption onset using nadir and limb-view retrievals of sulfur dioxide and sulfate aerosol. Satellite- and ground-based observations show that Nabro injected sulfur directly into the lowermost stratosphere (up to heights of 18 km) upon the initial eruption on 12/13 June, and again on 16 June 2011. Next, OSIRIS data are examined for non-volcanic and volcanically perturbed (Nabro and Sarychev Peak) conditions. In non-volcanic conditions OSIRIS profiles systematically terminate 1-4 km above the tropopause; the balance of the lowermost stratosphere is thus unresolved and potentially unaccounted for. Additionally, our analysis reveals that OSIRIS profiles terminate when 750 nm aerosol extinction exceeds  $\sim 0.0025/\text{km}$ ; optically denser stratospheric plumes—which we show to be common after volcanic and pyroconvective injections—are not sampled. Care must therefore be taken when using OSIRIS data in order to account for significant biases in aerosol loading following a strong volcanic eruption.

Our findings largely resolve the unexplained discrepancies in published works involving OSIRIS aerosol data and invite a new interpretation of previous conclusions. They also offer a correction to the Smithsonian report of the Nabro injection-height and eruption chronology.