OMPS LP aerosol observations of Kelut and Calbuco volcanic eruptions

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Introduction

The limb scatter technique combines relatively high spectral resolution (1-3 km) and a near global coverage of the sunlit hemisphere. The OMPS LP sensor is a triple-slit prism spectrometer that simultaneously image the whole vertical extent of the Earth’s limb over the wavelength region of 290-1000 nm. One slit is centered above the satellite ground track, and the other two are 4.25° on each side, 250 km in space and full global coverage is obtained in 4 days (figures 1-2). Although the instrument was designed primarily for vertical ozone profile measurement, it has a high sensitivity to stratospheric aerosols, cirrus clouds in the upper troposphere, and stratospheric and mesospheric clouds. The relatively high vertical and spatial sampling allow detection and tracking of periodic events when aerosol particles are injected into the stratosphere, including volcanic eruptions and meteor explosions.

Methods

- OMPS LP current aerosol retrieval algorithm uses Chahine’s non-linear method.
- Uses 675 nm Rayleigh-corrected radiances \(I(I_0)\).
- \(I_0\) is calculated using MERLRA data assuming no aerosols and 45.5 km reflectivity.
- Aerosol phase function determined by aerosol size distribution, refractive index and shape.
- Use a constant aerosol size distribution (ASD), single-mode log-normal, with no altitude variation, \(\gamma_0, \sigma = (0.06, 1.73)\)
- Data are screened for clouds using Chen et al. [2016]
- Current data Version 0.5
- New version 1.0 to be released soon
- Improved straylight corrections and bimodal lognormal size distribution model.

Comparison of OMPS LP with OSIRIS

Figure 3: Plot of typical daily ground track of OMPS LP for three slits. 160 measurements each slit, 14-15 orbits, ~7200 a day.

Figure 4: OMPS 6 CCD images. Each image is collected twice, long and short integration. Only selected pixels are downloaded.

Global observations of Kelut volcanic eruption (20 km)

Figure 5: Left panel is aerosol extinction at selected altitudes for OSIRIS (red) and OMPS LP (blue) at 10S-0° latitude zone. Right panel is the percent difference between the two measurements.

Figure 6: Zonal mean plot of the aerosol extinction profile at 10S-0° latitude for OSIRIS (top), OMPS LP (middle), and the difference in percent (bottom). Black line is the tropopause height.

Stratospheric column

Figure 7: Aerosol stratospheric column for OSIRIS (top), OMPS LP (middle) and percent difference (bottom). The symbols in each plot indicate volcanic eruptions (Nabro; June 2011, Kelut; February 2014, Calbuco; April 2015.

Quasi-Biennial Oscillation (QBO) signature

Figure 8: Global weekly maps of OMPS LP aerosol extinction, tracking Kelut volcanic eruption at 20.5 km altitude. Superimposed MERRA Winds.

Figure 9: Weekly maps illustrating Kelut aerosol plume transport poleward in synoptic scale tongue of air (NH) and by anticyclone (SH) where the aerosol plume is trapped inside for weeks.

Global observations of Calbuco volcanic eruption

Figure 10: OMPS LP aerosol extinction monthly zonal means plots from April to Dec 2015, tracking Calbuco volcanic eruption and the transport of volcanic plume inside the polar vortex.

Figure 11: Aerosol daily zonal means in SH (01/2015-07/2016).

Figure 12: Total stratospheric aerosol columns (01/2015-07/2016).