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.

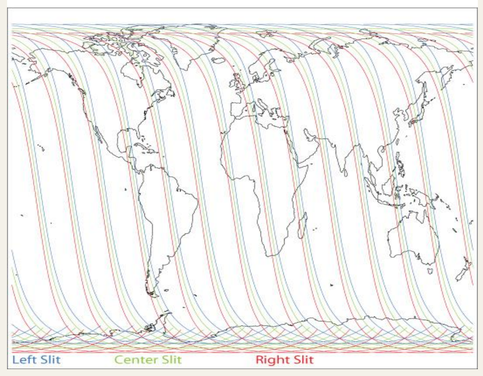

Figure 1: Plot of typical daily ground track of OMPS LP for three slits. 160 measurements each slits, 14-15 orbits, ~7200 a day.

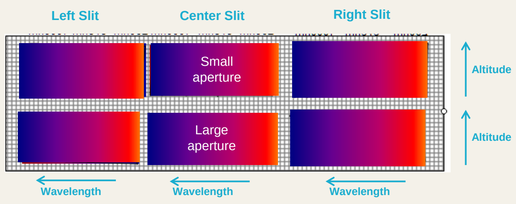

Figure 2: OMPS 6 CCD images. Each image is collected twice, long and short integration. Only selected pixels are downloaded.

Methods

- OMPS LP current aerosol retrieval algorithm uses Chahine's non-linear relaxation method
- Uses 675 nm Rayleigh-corrected radiances $(I-I_0)/I_0$
  - I_0 is calculated using MERRA 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, $(r_g, \sigma) = (0.06\ \mu m, 1.73)$
- 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

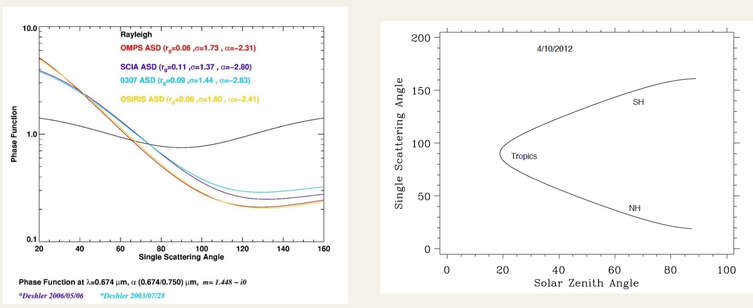

Figure 3: Left panel is plot of aerosol scattering phase function for different aerosol size models, right plot shows variations of OMPS single scattering angle along the orbit.

Quasi-Biennial Oscillation (QBO) signature

February 2012 (Easterly phase) May 2012 (Westerly phase)

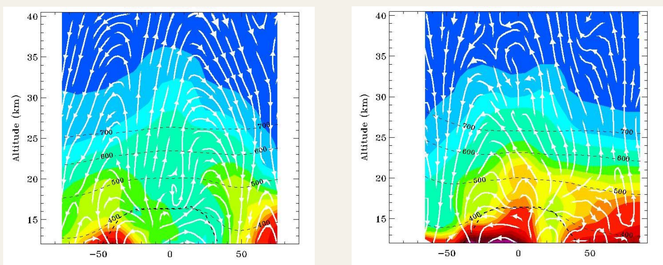

Figure 4: Monthly zonal plots of aerosol, with MERRA residual zonal winds superimposed. Black contour lines are potential temperature.

Comparison of OMPS LP with OSIRIS

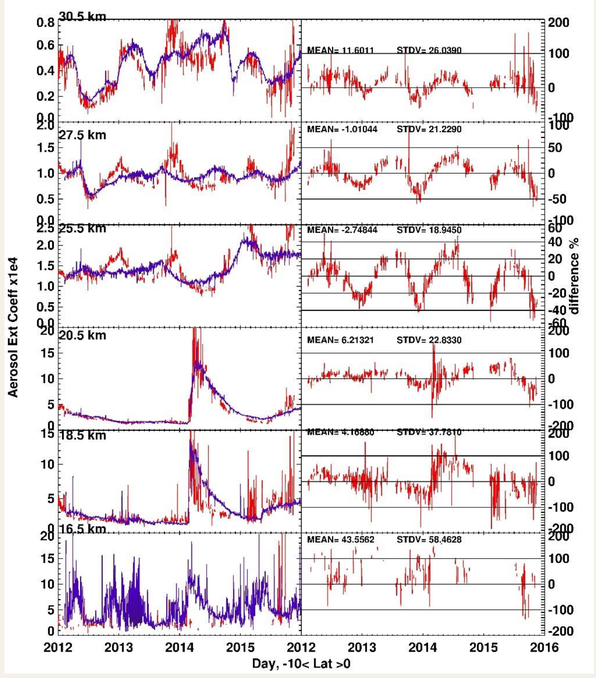

Figure 5: Left panel is aerosol extinction at selected altitudes for OSIRIS (red) and OMPS LP (blue) at 10S-0° latitude zone. Right panel is the percent difference between the two measurements.

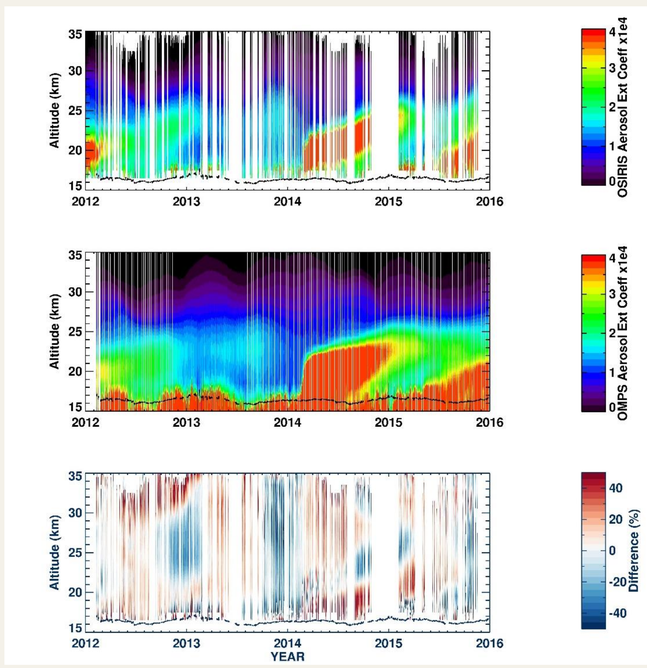

Figure 6: Zonal mean plot of the aerosol extinction profile at 10S-0° latitude for OSIRIS (top), OMPS LP (middle), and the difference in percent (bottom). Black line is the tropopause height.

stratospheric column

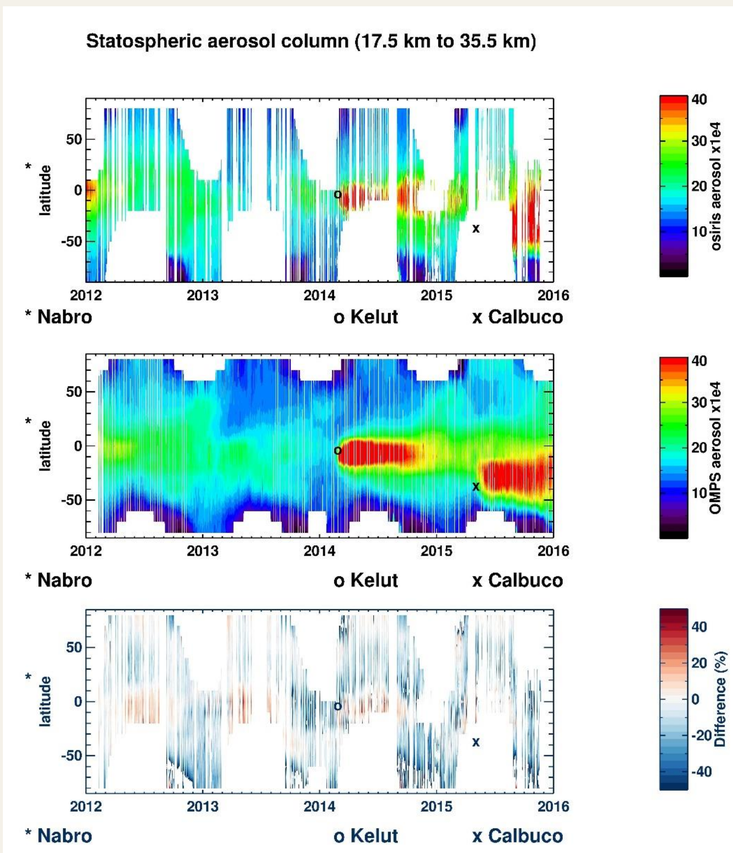

Figure 7: Aerosol stratospheric column for OSIRIS (top), OMPS LP (middle) and percent difference (bottom). The symbols in each plot indicate volcanic eruptions (Nabro; June 2011, Kelut; February 2014, Calbuco; April 2015.

Global observations of Kelut volcanic eruption (20 km)

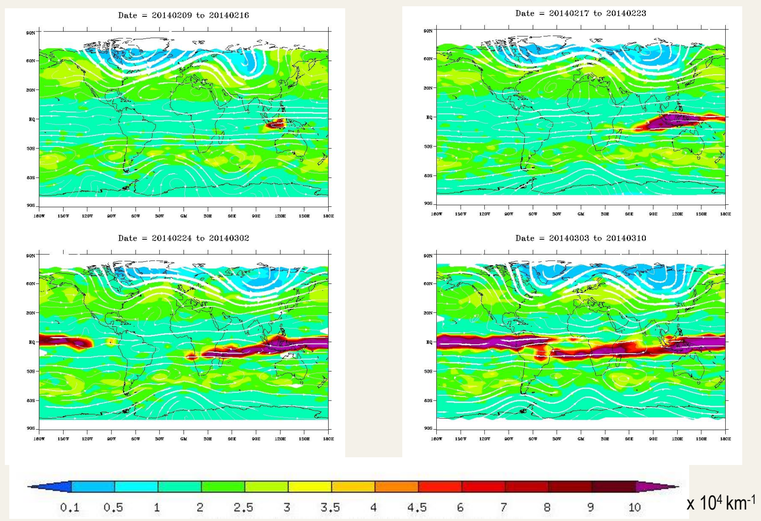

Figure 8: Global weekly maps of OMPS LP aerosol extinction, tracking Kelut volcanic eruption at 20.5 km altitude. Superimposed MERRA Winds.

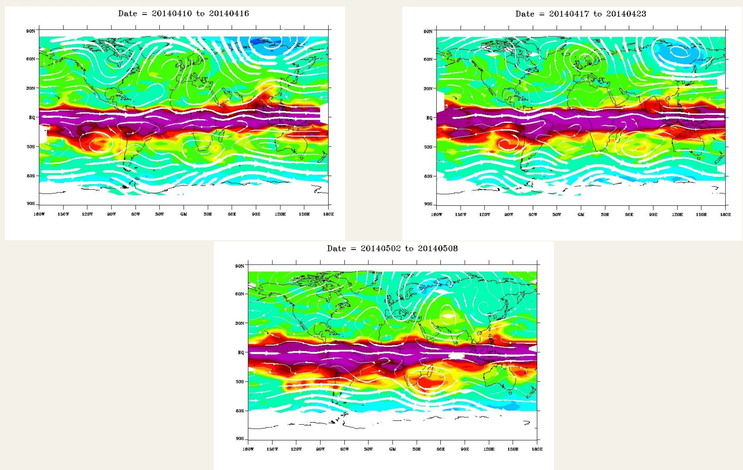

Figure 9: Weekly maps illustrating Kelut aerosol plume transport poleward in synoptic scale tongue of air (NH) and by anticyclone (SH) where the aerosol plume is trapped inside for weeks.

Global observations of Calbuco volcanic eruption

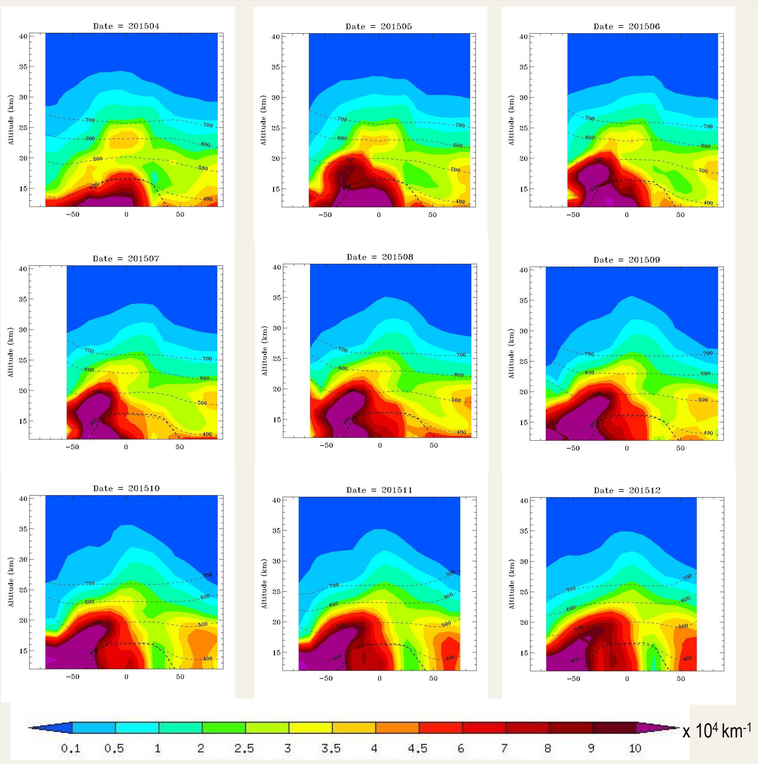

Figure 10: OMPS LP aerosol extinction monthly zonal means plots from April to Dec 2015, tracking Calbuco volcanic eruption and the transport of volcanic plum inside the polar vortex.

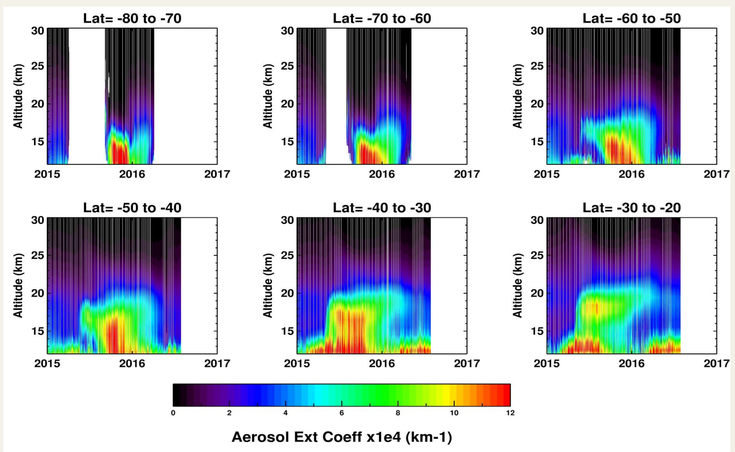

Figure 11: Aerosol daily zonal means in SH (01/2015-07/2016).

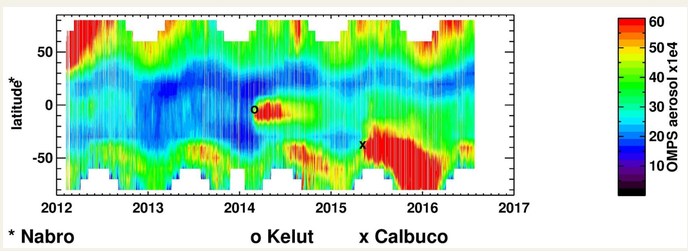

Figure 12: Total stratospheric aerosol column (01/2015-07/2016).