



A New Stratospheric Aerosol Product from CALIPSO Lidar Measurements

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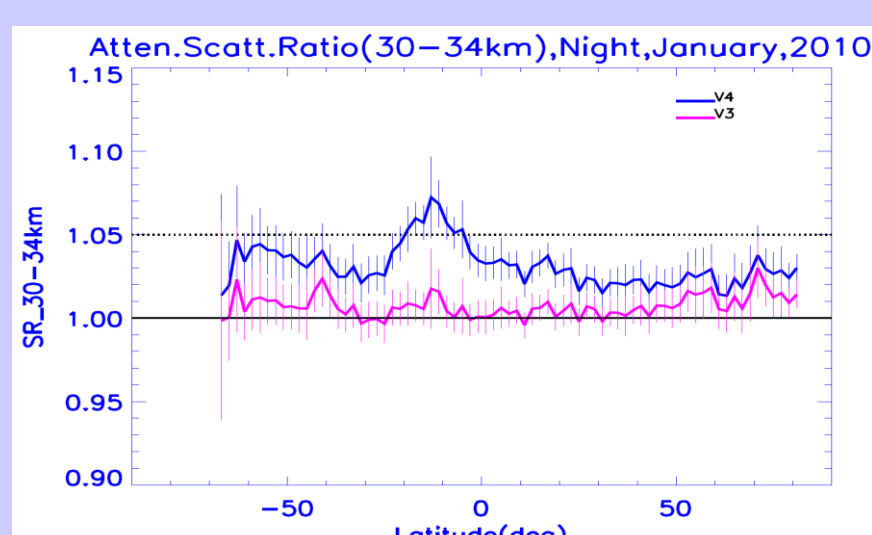


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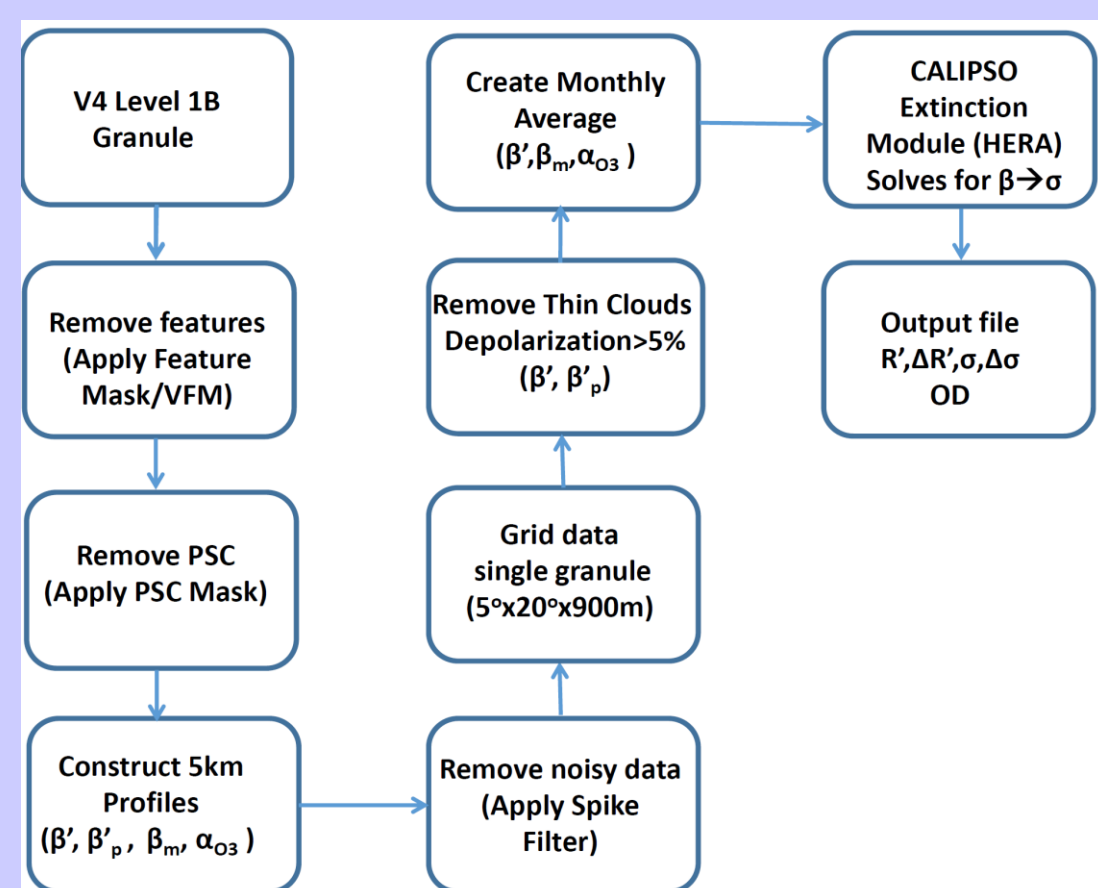
INTRODUCTION

Background stratospheric aerosols, modulated by major or even minor volcanic eruptions can exert a significant influence on the Earth's radiation budget over time scales relevant to climate change. Vernier et al.(2009) showed that with an adjustment of calibration altitude from 30-34 km (version 3) to 36-39 km, CALIPSO lidar data can give useful information on stratospheric aerosol. A significantly improved CALIPSO Lidar Version 4 Level 1 product has recently been released that has resulted in better calibrated lidar backscatter data. Based on this product, a new 3 dimensional gridded stratospheric CALIPSO aerosol product is under development that is planned for release in 2015. The primary products will be aerosol extinction and attenuated scattering ratio profiles binned into an equal angle grid of constant latitude and longitude with a vertical resolution of 900 m and averaged over a month's worth of data. We present the overall scheme of this product and preliminary comparisons with other stratospheric aerosol datasets.

OVERALL SCHEME OF CALIPSO STRATOSPHERIC AEROSOL PRODUCT



Motivation for a CALIPSO stratospheric aerosol product → Significant improvement in Version 4 level 1 data (captures the aerosol at 30-34 km).



Monthly mean gridded profiles of attenuated backscatter (β'), molecular backscatter coefficient (β_m) and ozone absorption coefficient (α_{O_3}) are used to solve for β_p (particulate backscatter) from (1) and (2):

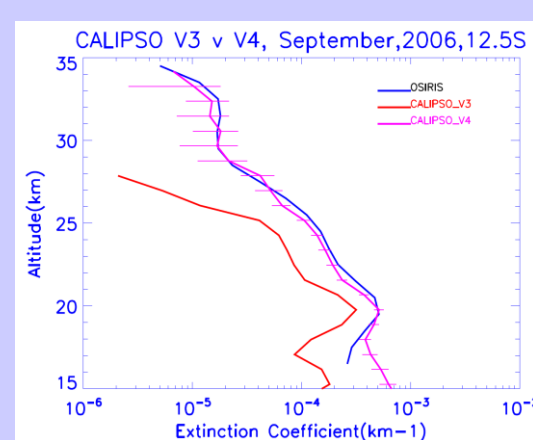
$$\beta_p(r) = \beta'(r) / T_m \cdot T_{O_3} \cdot T_p - \beta_m(r), \text{ ---(1)}$$

$$T_p^2 = \exp(-2 \cdot S \cdot \int_p^r \beta_p(r') dr'), \text{ ---(2)}$$

extinction coefficient: $\sigma_p = S \cdot \beta_p$, S being the stratospheric aerosol lidar ratio.

For this preliminary study we have used a lidar ratio of 50 sr and solved equations (1) and (2) using a simple iteration scheme.

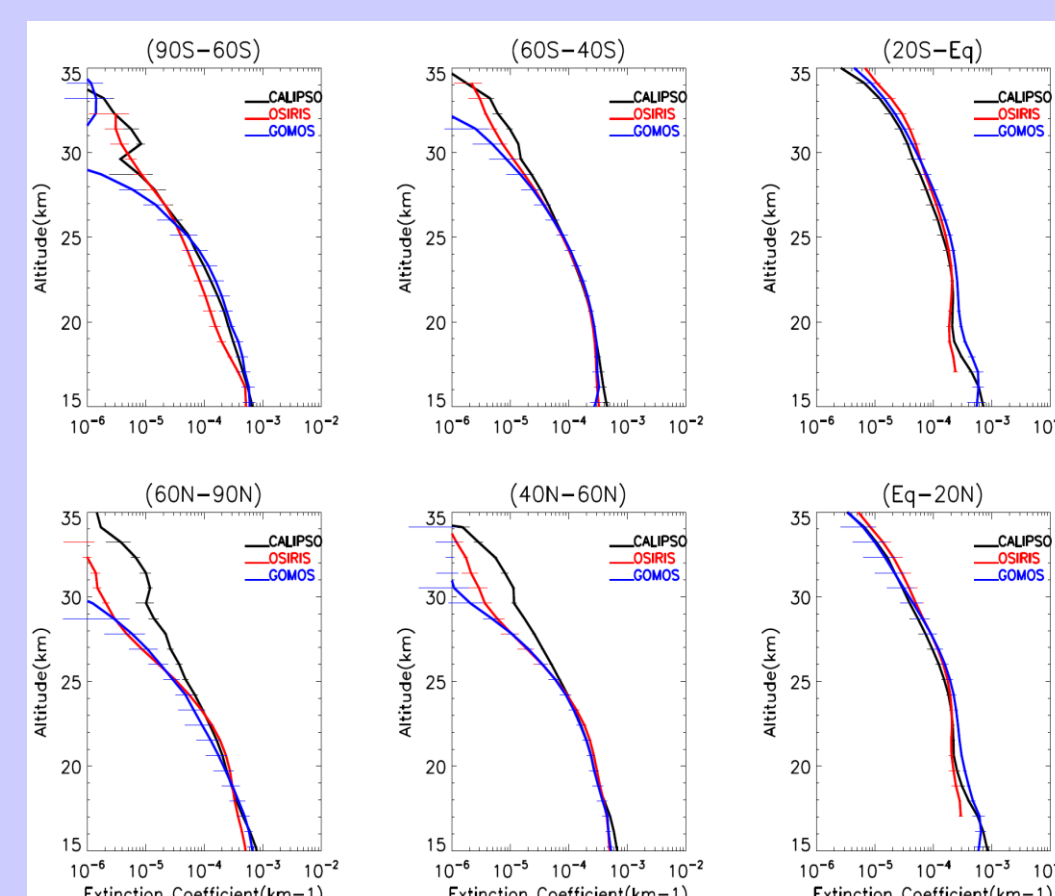
Example of retrieved extinction coefficients from CALIPSO lidar data. Improved calibration in version 4 data shows up in the extinction profile retrieved using V4 data—the profile closely matches OSIRIS extinction in shape and magnitude. The error bars reflect the computed uncertainties.



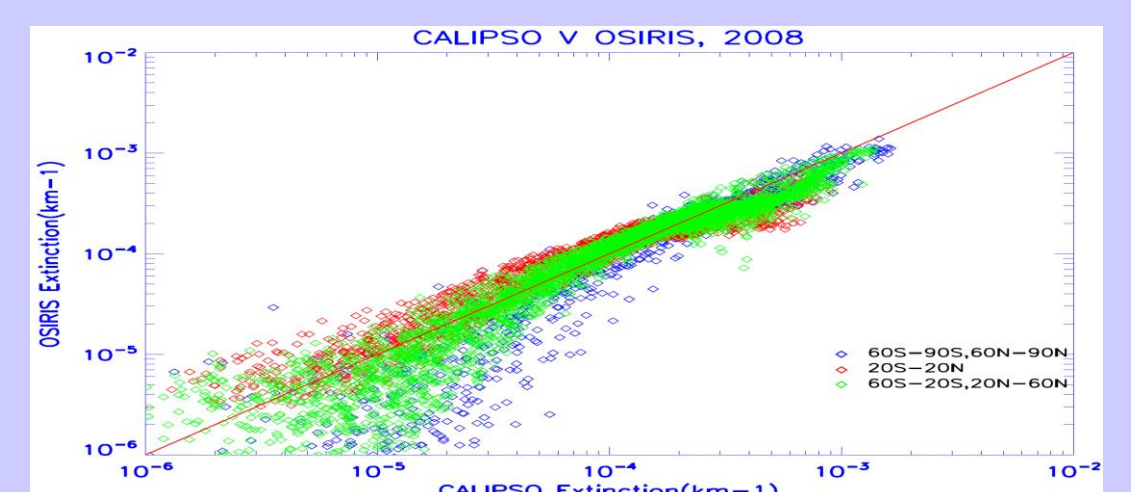
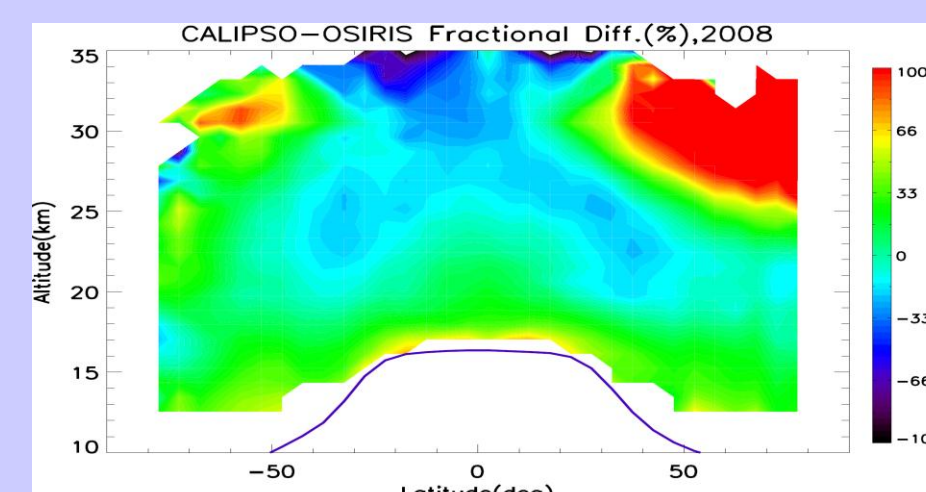
DATA

- Version 4 level 1 CALIPSO lidar data for night time.
- Version 5.07 aerosol extinction product from OSIRIS at 750 nm. These extinction profiles agree within 10% with coincident SAGE III data between 15-25 km, but may have increasing differences at higher altitudes (Bourassa et al., 2012).
- Version 2.0 OMPS LP aerosol data at 745 nm. The extinction profiles agree within 5% with OSIRIS data but have poor quality at low latitudes (D. Rault, private communication).
- Version 1 GOMOS aerosol product with extinction coefficients agreeing within 10-20% between 10-25 km with SAGE II, SAGE III, and POAM III (Vanhellemont et al., 2010).
- Version 7 SAGE II aerosol extinction product.

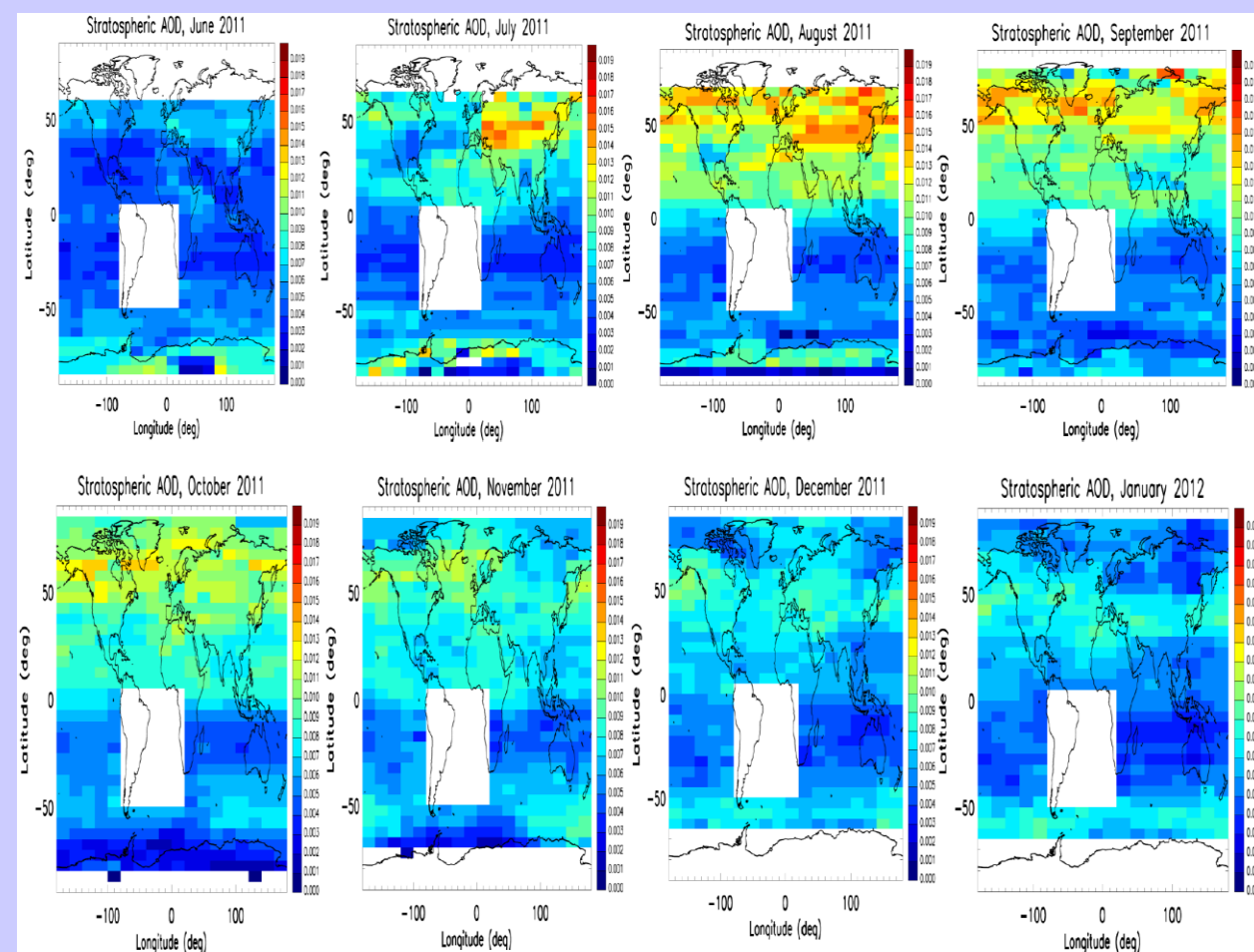
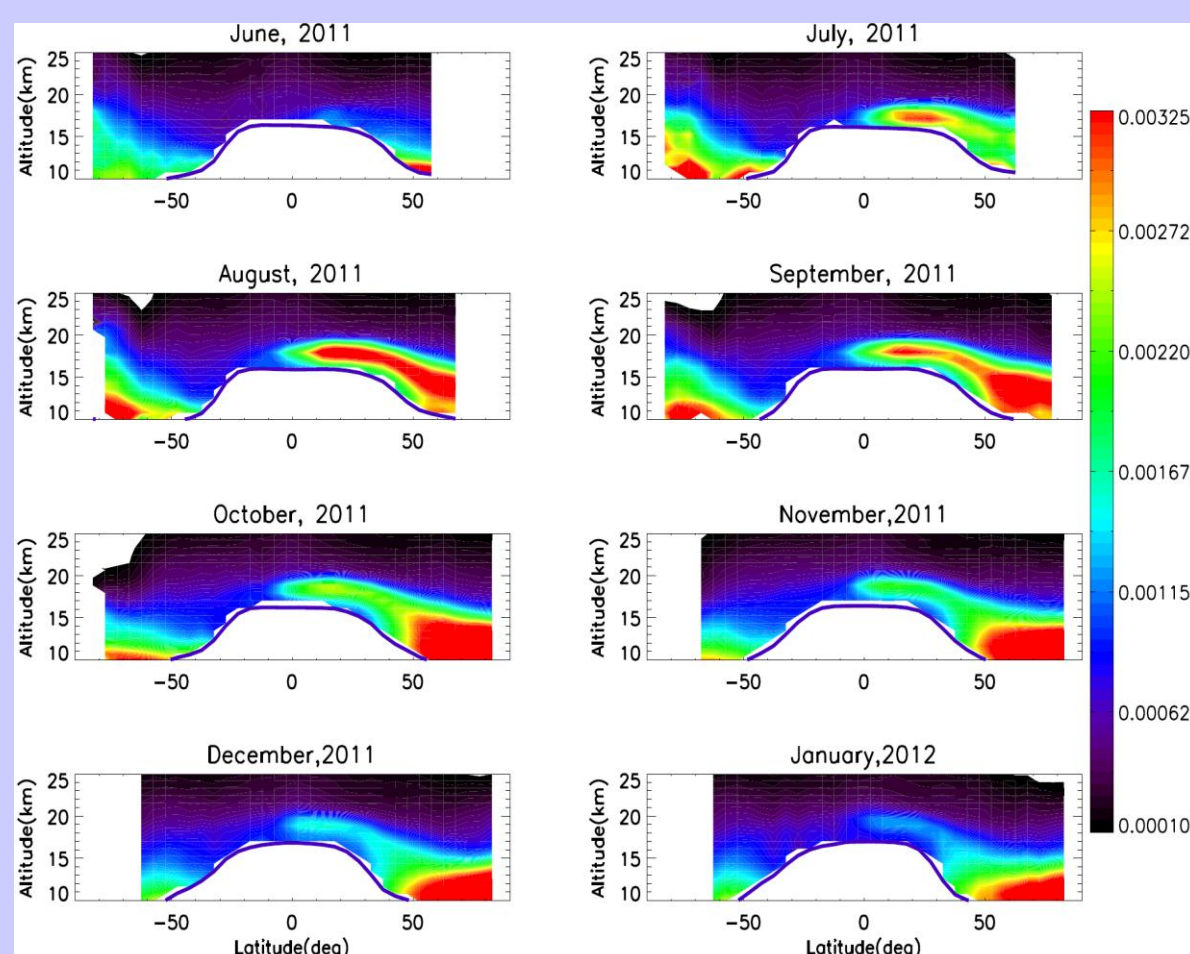
COMPARISONS BETWEEN CALIPSO OSIRIS AND GOMOS, 2008



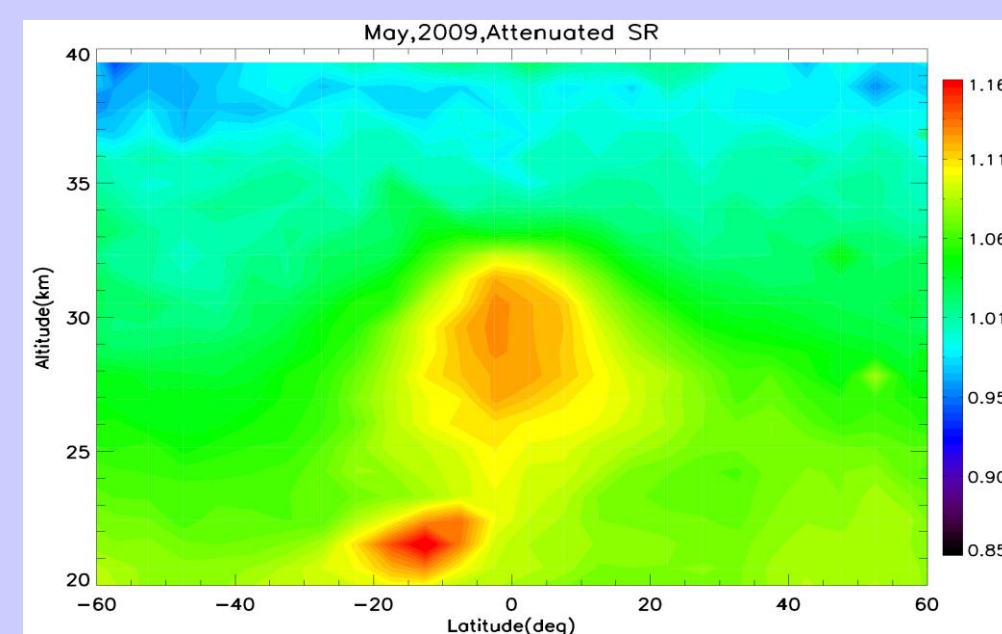
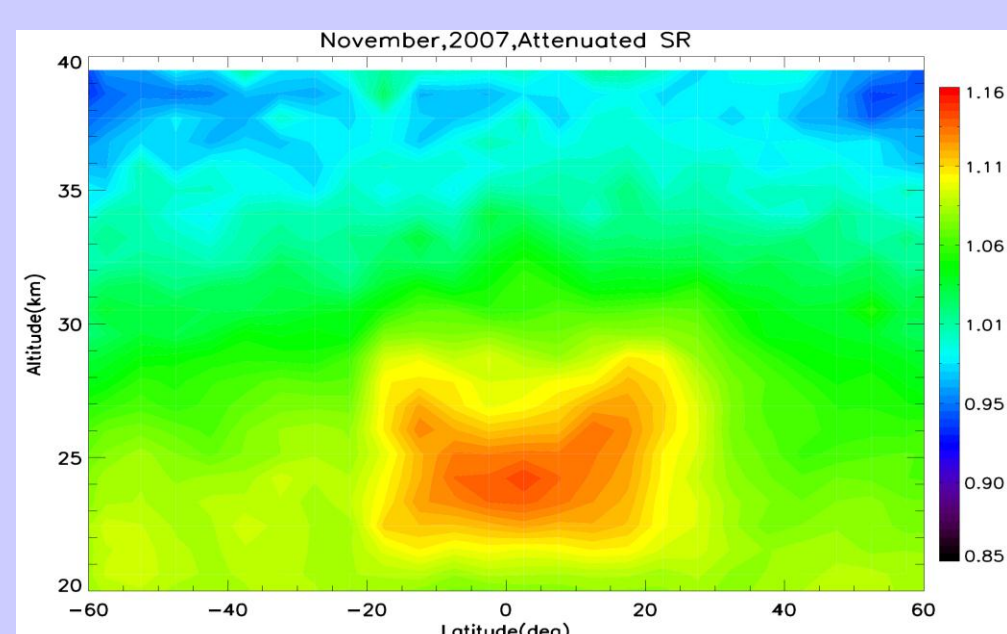
All comparisons done at 750 nm. CALIPSO (532 nm) and GOMOS (500 nm) extinction data were converted to 750 nm using the climatological Angstrom coefficients derived from SAGE II data between 1998 and 2005 at 525 nm and 1020 nm. CALIPSO zonally averaged profiles agree with OSIRIS and GOMOS profiles within ~20-30% between 15-30 km and ~50S-50N, but have a significant high bias at high latitudes and high altitudes.



SIGNATURES OF VOLCANOES AND QBO

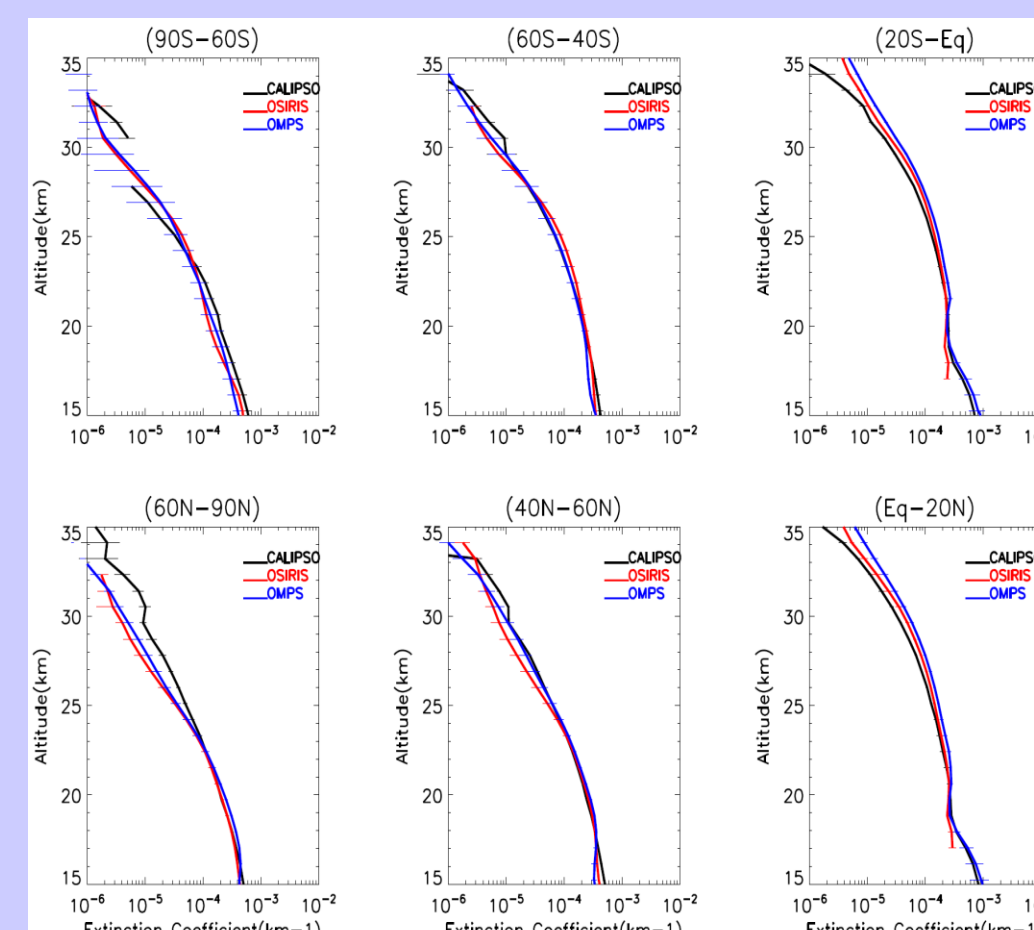


Evolution of the Nabro (June 2011) volcanic plume as captured in the retrieved stratospheric aerosol extinction profiles from CALIPSO 532 nm measurements (left). The right panel shows the spatial distribution of the stratospheric aerosol optical depth (above 380 K). The initial confinement of the plume in the Asian summer anticyclone and subsequent dispersal is well captured in the AOD data.

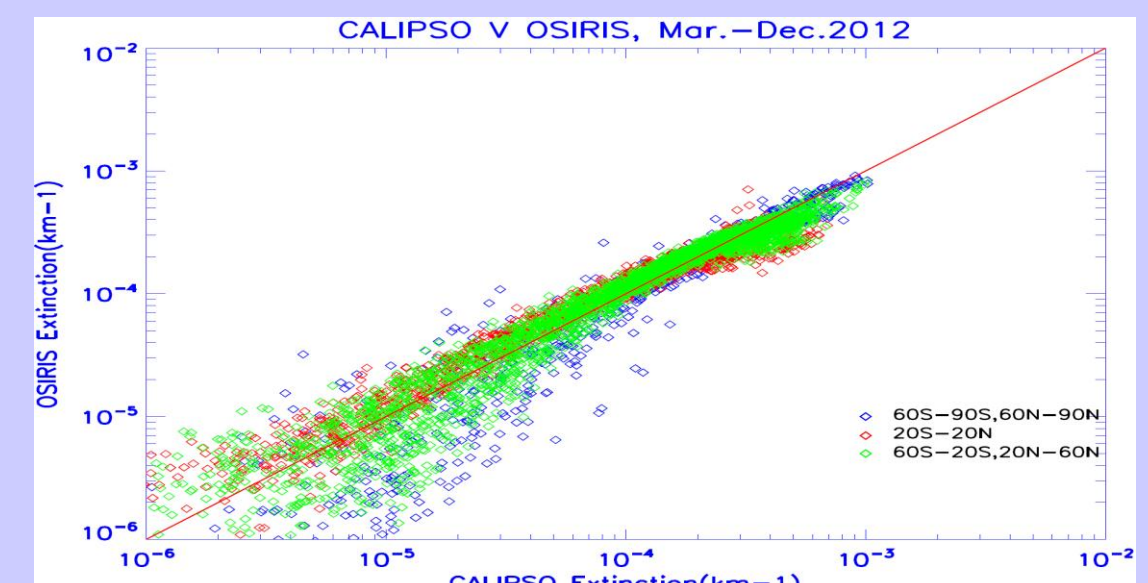
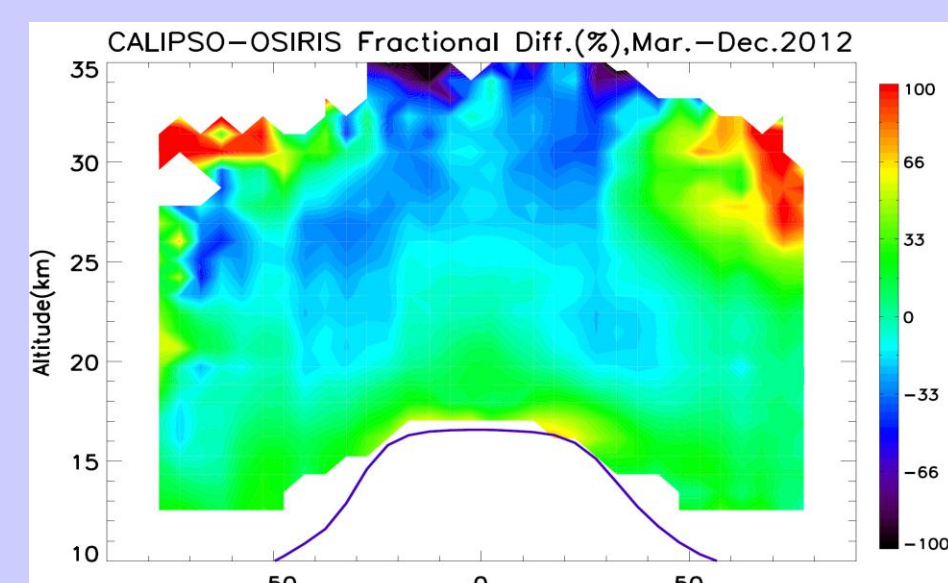


Quasi Biennial Oscillation (QBO) as seen in the attenuated scattering ratio data from CALIPSO—the double horn structure (Trepte and Hitchman, 1992) in November 2007 occurs during a period of westerlies in the stratosphere (left) and aerosol lofting occurs during the easterlies in May 2009 (right).

COMPARISONS BETWEEN CALIPSO, OSIRIS AND OMPS, 2012



CALIPSO (532 nm) extinctions were converted to 750 nm (for comparison with OSIRIS) and 745 nm (for comparison with OMPS) using the climatological Angstrom coefficients derived from SAGE II data between 1998 and 2005 at 525 nm and 1020 nm. Once again, the CALIPSO zonally averaged profiles agree with OSIRIS within ~20-30% between 15-30 km and 50S-50N. The differences are higher when compared to OMPS profiles. However, note that OMPS data in the southern tropics may have quality issues (D. Rault, private communication)



References

- Bourassa. A. E. et al., ACP, 12, 605-614, 2012.
Trepte, C. R and Hitchman, M. H, Nature, 355, 626-628, 1992.
Vanhellemont, F. et al., ACP, 10, 7997-8009, 2010.
Vernier, J.-P. et al., JGR, 114, D00H10, doi:10.1029/2009JD011946, 2009.

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Conclusions:

- With improved calibration in Version 4, CALIPSO lidar data can be used effectively to retrieve stratospheric aerosol extinction profiles.
- The preliminary results indicate that CALIPSO stratospheric product captures well the signatures of stratospheric transport processes like the QBO as well as volcanic effects.
- Comparison with stratospheric extinction profiles retrieved from occultation and limb scatter measurements indicate differences ~ 20-30% between 15-30 km within 50S-50N but can be significantly higher at high altitudes and high latitudes.