Revisiting Stratospheric Aerosol Climatology for the post-SAGEII era using Space-based Measurements

Mahesh Kovilakam[1] **(mmundakk@mail.nasa.gov), and Larry Thomason** [1] **(l.w.thomason@nasa.gov)**

[1]NASA Langley Research Center, Hampton, VA 23681

1. Introduction

A robust stratospheric aerosol climatology is important as many global climate models (GCMs) make use of observed aerosol properties to prescribe aerosols in the stratosphere. As a part of the Coupled Model Intercomparison project version 6 (CMIP6), a global space-based stratospheric aerosol climatology (GloSSAC) was recently created *[Thomason et al., 2017]*. Several space-based measurements were used to create GloSSAC, starting from 1979. These primarily constitute data from the Stratospheric Aerosol Gas Experiment (SAGE) series of satellites until the end of SAGE II measurements in August 2005. The measurements since August 2005 (post-SAGEII era), however, have been mostly depending on satellites that use the limb scatter (LS) technique. The stratospheric aerosol data in the post-SAGEII era in GloSSAC are represented by measurements from Optical Spectrograph and InfraRed Imager System (OSIRIS) and the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observation (CALIPSO). However, at the transition of SAGE II-OSIRIS data in August 2005, the two dataset tend to differ in the mid-high latitudes particularly following the Manam volcanic eruption in January 2005, where OSIRIS has overlap measurements with SAGE II. This enhancement of aerosol in the lower stratosphere seems persistent even years after the eruption in January 2005. Here, we revisit the aerosol climatology in the post-SAGEII era primarily by using OSIRIS level 2 and CALIPSO data.We also investigate for any cloud contamination in OSIRIS level 2 data in particular, which may have caused apparent enhancement in the aerosol extinction particularly near the tropopause. SAGEIII-ISS data is also used to extend the climatology to the present.

2. Methods

- OSIRIS level 2 data *[Bourassa et al., 2012; Rieger et al., 2015]* used in this study is first cloud cleared using a technique based on Interquartile range (IQR) to remove the outliers in the data at each altitude.
- For outlier detection, we only use positive tail of the probability distribution function (PDF). The threshold value is computed using lower quartile (Q1) and upper quartile (Q3) of the underlying distribution to compute IQR, which is defined as Q3-Q1and the extreme outlier as Q3+(3.0*IQR).

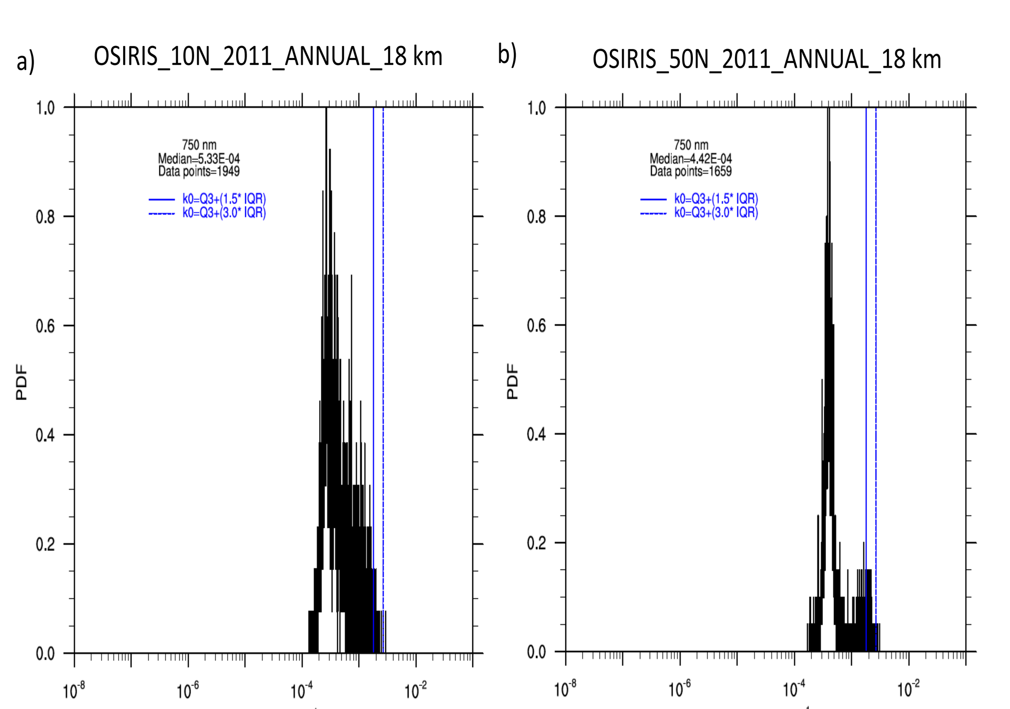

Figure 1: *Probability density function (PDF) of aerosol extinction at 750 nm. PDF is shown as number of events normalized to the maximum value. The solid blue vertical line represents upper outlier in the data while dashed blue vertical line represents extreme outlier.*

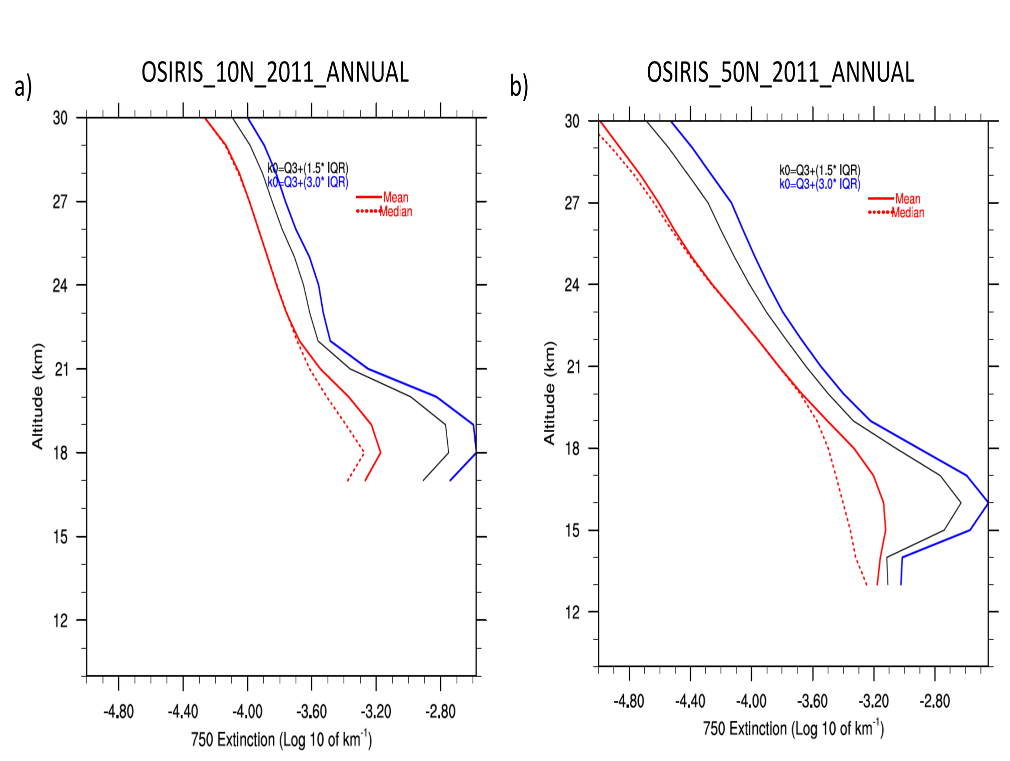

Figure 2: *The vertical profiles of OSIRIS level 2 extinction coefficient at 750 nm for the separation of aerosol from enhanced aerosol/clouds along with mean and median of extinction before cloud clearing for (a) 10N for the year 2011, and (b) 50N for the year 2011.*

3. SAGEII-OSIRIS Bias Correction

- OSIRIS extinction at 750 nm is converted to 525 nm extinction with a constant Angstrom coefficient.

$$k_{525} = k_{750}(\frac{\lambda_{525}}{\lambda_{750}})^{-2.33}$$

where, k_{525}, and k_{750} are extinctions at 525 nm and 750 nm respectively.

- A simple median based biased correction (SAGEII/OSIRIS) is applied for OSIRIS/SAGEII overlap period (2002-2005).

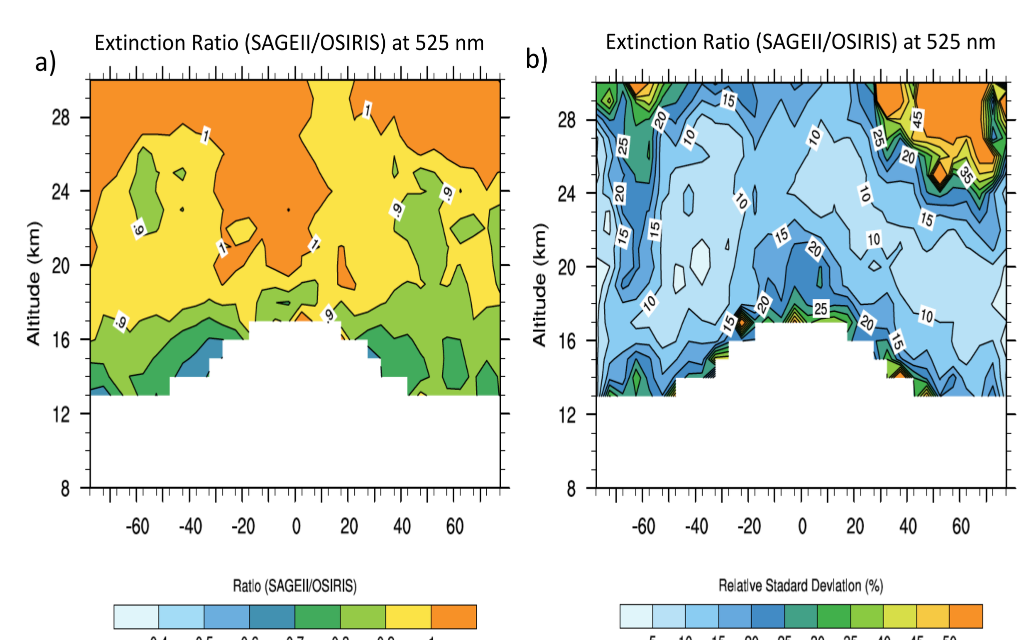

Figure 3: *(a) Altitude-Latitude dependence of median extinction ratio (SAGEII/OSIRIS) for the overlap period (2002-2005) (b) Relative standard deviation of (a) in percent.*

- OSIRIS extinction is then corrected at each latitude and altitude using

$$k_{525\_OSIRIS\_corrected} = k_{525\_OSIRIS}(\frac{k_{525\_median\_SAGEII}}{k_{525\_median\_OSIRIS}})$$

where, k_{525_OSIRIS} is uncorrected OSIRIS extinction at 525 nm, and $(\frac{k_{525\_median\_SAGEII}}{k_{525\_median\_OSIRIS}})$ is the median SAGEII/OSIRIS ratio at 525 nm respectively.

4. OSIRIS-CALIPSO Bias Correction

- Corrected OSIRIS level 2 data is used for the bias correction (OSIRIS 525 extinction/CALIPSO 532 backscatter coefficient). For lower stratosphere, particularly in the higher latitudes, a linear interpolation is performed to fill in missing data.

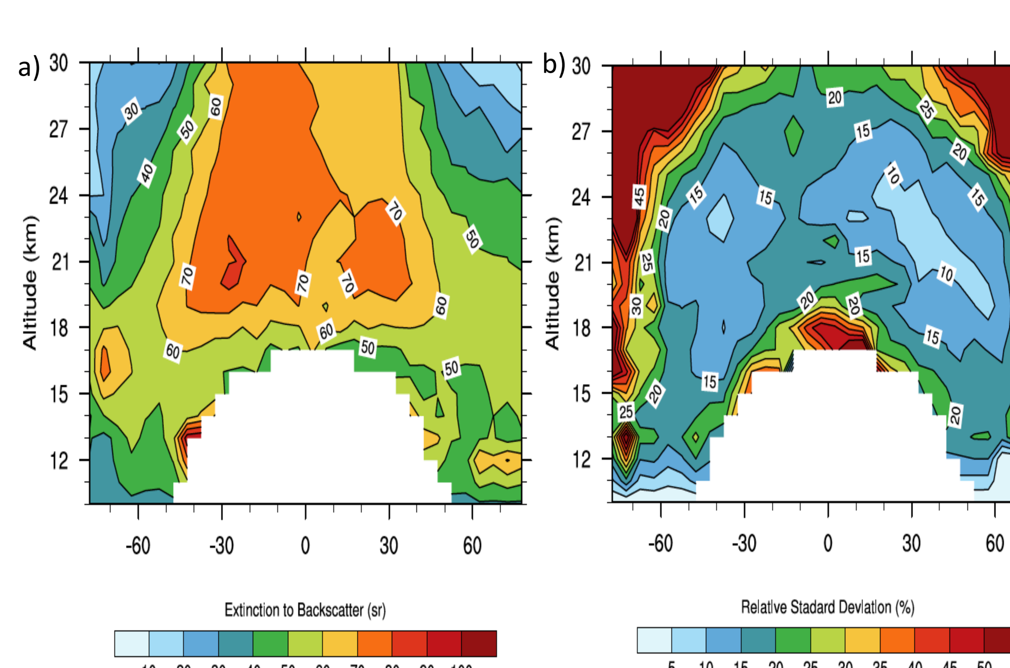

Figure 4: *(a) Altitude-Latitude dependence of median extinction to backscatter ratio (OSIRIS/CALIPSO) for the overlap period (2006-2016) (b) Relative standard deviation of (a) in percent.*

- A similar median based bias correction is then used to compute CALIPSO extinction.

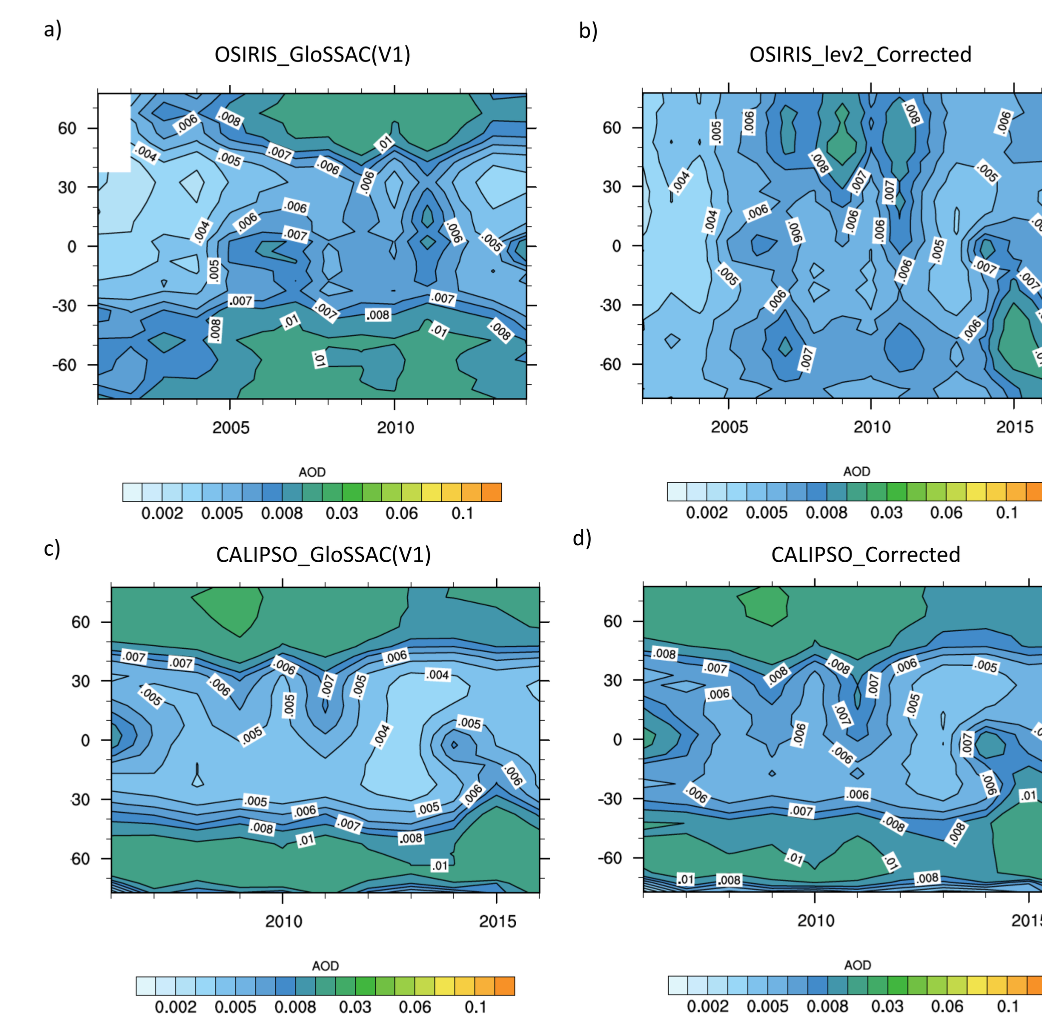

Figure 5: *AOD distribution. (a) OSIRIS AOD from GloSSAC V1, (b) Corrected OSIRIS AOD from level 2 data, (c) CALIPSO AOD from GloSSAC V1, and (d) Corrected CALIPSO AOD using corrected OSIRIS level 2 data.*

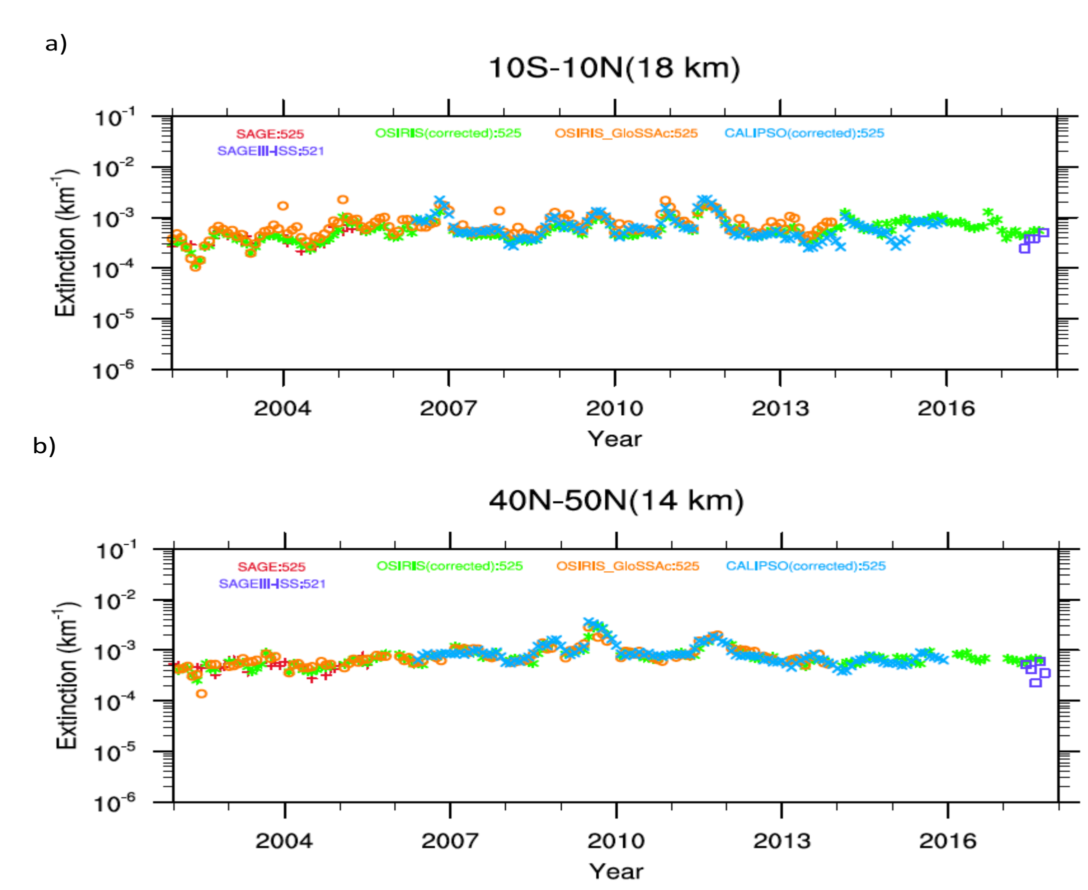

Figure 6: *Monthly zonal mean time series of 525 nm extinction. (a) for 10S-10N at 18 km, and (b) for 40N-50 N at 14 km.*

5. Summary and Conclusions

- The median based OSIRIS bias correction improves the agreement with SAGEII and SAGEIII-ISS. SAGEIII-ISS can be used to verify OSIRIS and CALIPSO as they have overlap measurements with SAGEIII-ISS.
- The bias correction of OSIRIS and CALIPSO results in considerable improvement particularly in the higher latitude following moderate volcanic events that occurred in post-SAGEII period.
- Overall, corrected OSIRIS extinction at 525 nm is in reasonably good agreement with SAGEII/SAGEIII-ISS and CALIPSO. However, CALIPSO lower stratospheric extinction at higher latitudes tend to still overestimate.
- Future work includes further study of lower stratospheric CALIPSO data to better represent/match SAGEIII-ISS measurements and addressing issues with conversion of 525 nm to 1020 nm extinction.

6. Acknowledgements

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7. References

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