Merging the SAGE II and OSIRIS Stratospheric Aerosol Records

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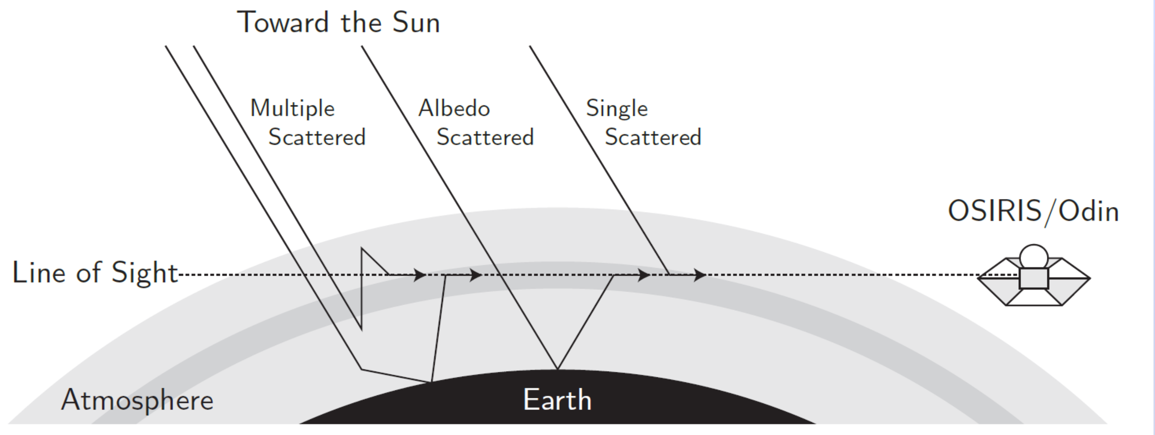
OSIRIS on Odin

The Canadian designed and built OSIRIS (Optical Spectrograph and Infrared Imaging System) instrument (1) was launched in 2001 onboard the Odin satellite and measures a single line of sight with wavelengths from the ultraviolet (275 nm) to the near infrared (815 nm). OSIRIS utilizes the limb geometry to measure sunlight that has been scattered into the instrument line of sight. By nodding the entire satellite OSIRIS collects information about the vertical profile of the atmosphere at a resolution of approximately 2 km, with daily, nearly global coverage. The 750 nm measurements are inverted to produce vertical profiles of aerosol extinction.



For this work the OSIRIS 750nm extinction profiles (2,3) are converted to 525nm extinction profiles. This is done assuming a lognormal particle size distribution with a mode radius of 80nm and mode width of 1.6, the same as used in the retrieval, yielding the conversion:

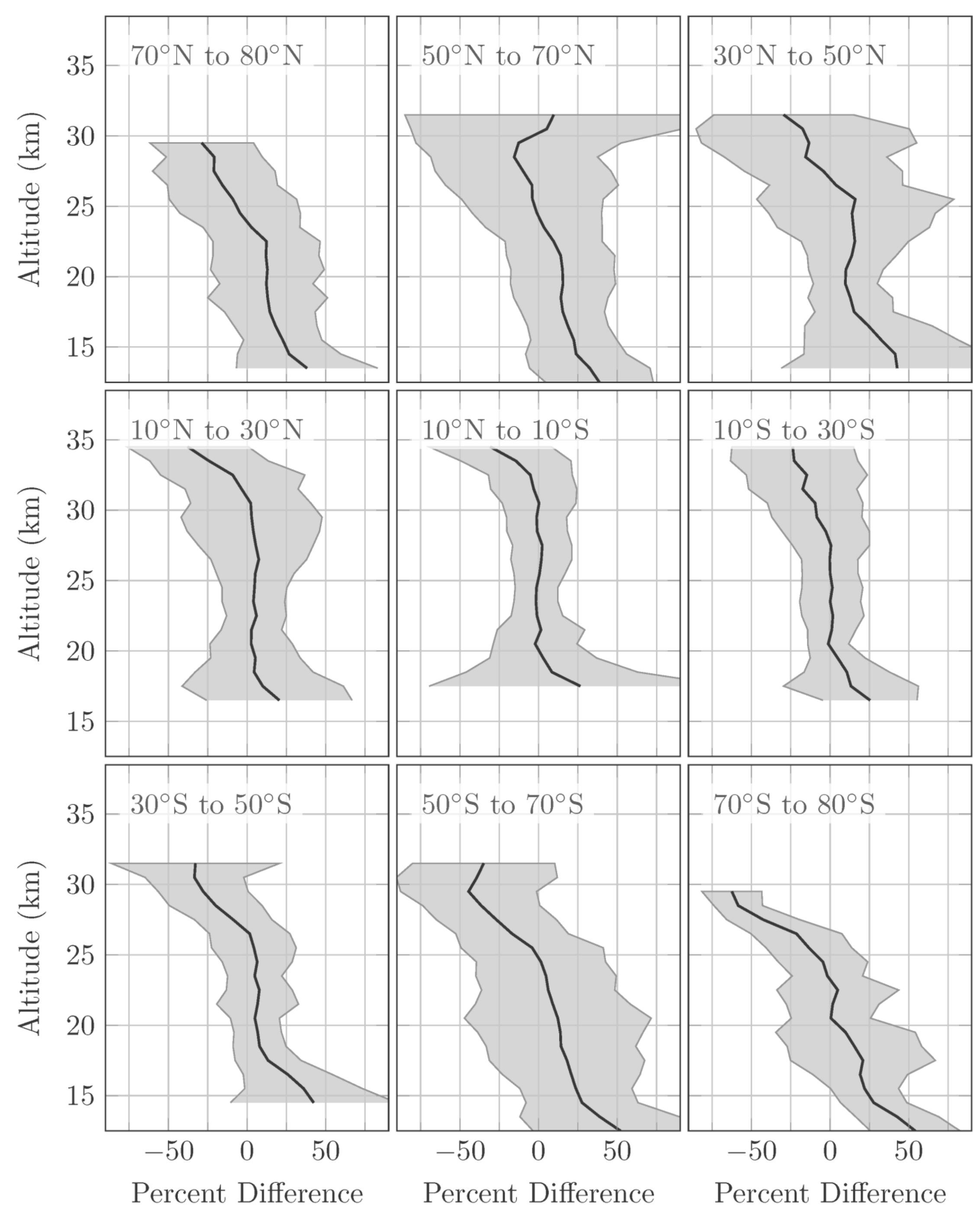
$$k_{525} = k_{750}\left(\frac{525}{750}\right)^{-2.33}$$

SAGE II

The Stratospheric Aerosol and Gas Experiment (SAGE) II [Russell and McCormick, 1989] was launched in 1984 onboard the Earth Radiation Budget Satellite (ERBS) and was operational until mid 2005 (4). ERBS had an orbit with a nominal altitude of 610 km and inclination of 57º. SAGE II is a 7-channel sun photometer with central wavelengths at 385, 448, 453, 525, 600, 940 and 1020 nm. Twice per orbit SAGE II scans the solar disc as it rises/sets through the atmosphere providing occultation measurements of atmospheric extinction with a vertical resolution of 1 km. For this study the SAGE II version 7 aerosol retrievals at 525 nm are used (5).

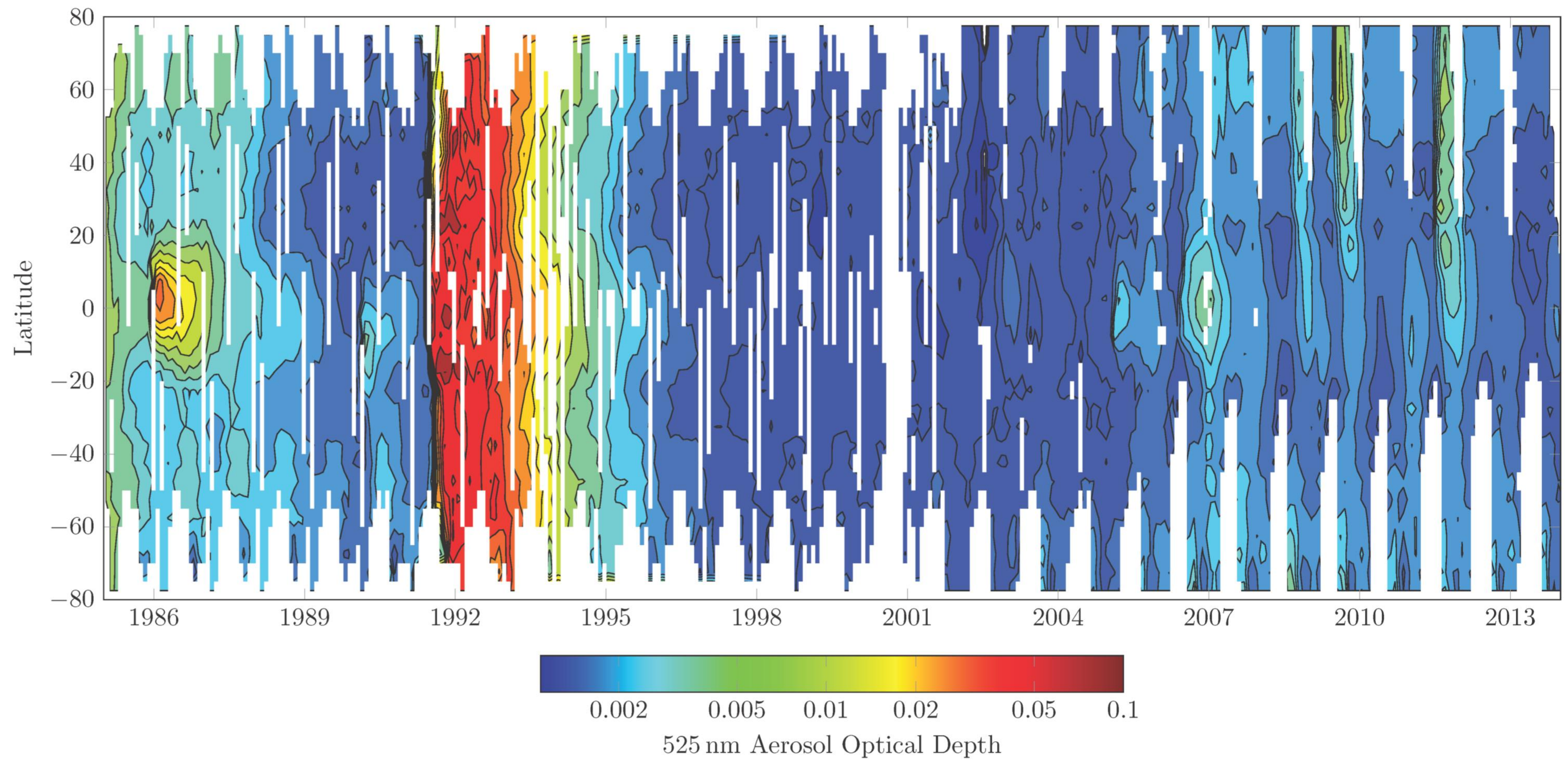
Coincident Comparisons

To test the agreement between SAGE II and OSIRIS 525nm aerosol profiles, coincident scans were compared using a criteria of 1º latitude, 1000 km, and 24 hours. Tighter criteria were also tested, but had very little effect on the outcome of the comparisons. The SAGE II profiles are convolved using a triangular filter with a FWHM of 1km to adjust the vertical resolution to that of OSIRIS which is approximately 2 km. This convolution has only a small effect on the mean differences, although does improve the standard deviations slightly. Results are shown below.



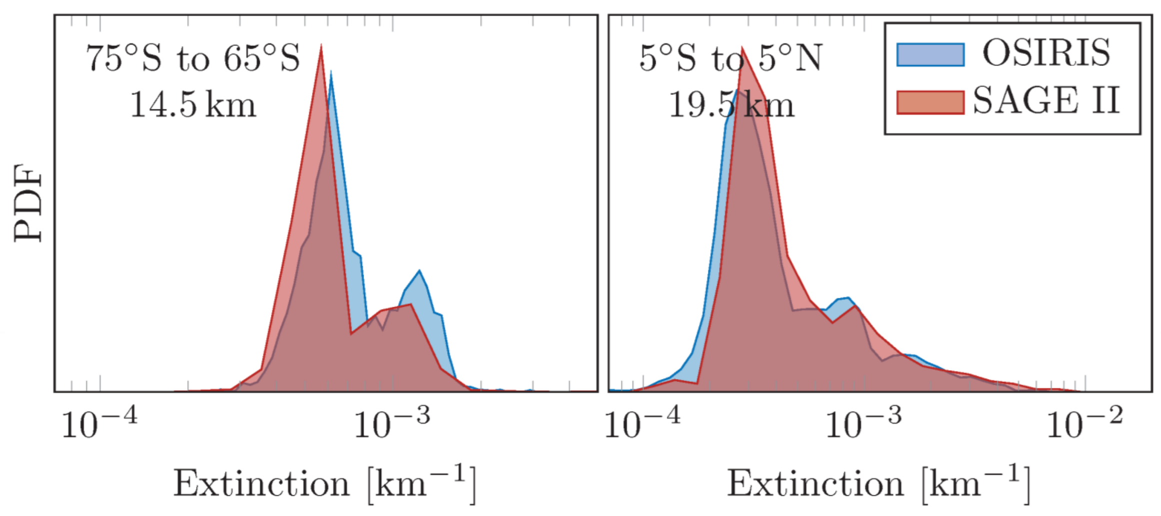
Merged Aerosol Optical Depth

The figure below shows the aerosol optical depth as calculated from 2 km above the 380 K tropopause up to 35 km altitude. Two large volcanic eruptions are evident; the Nevado del Ruiz eruption in 1985 and Mount Pinatubo in 1991. Several smaller eruptions in the last decade including Manam (2005), Kasatochi (2008), Seryachev (2009), Merapi (2010) and Nabro (2011) are also visible.



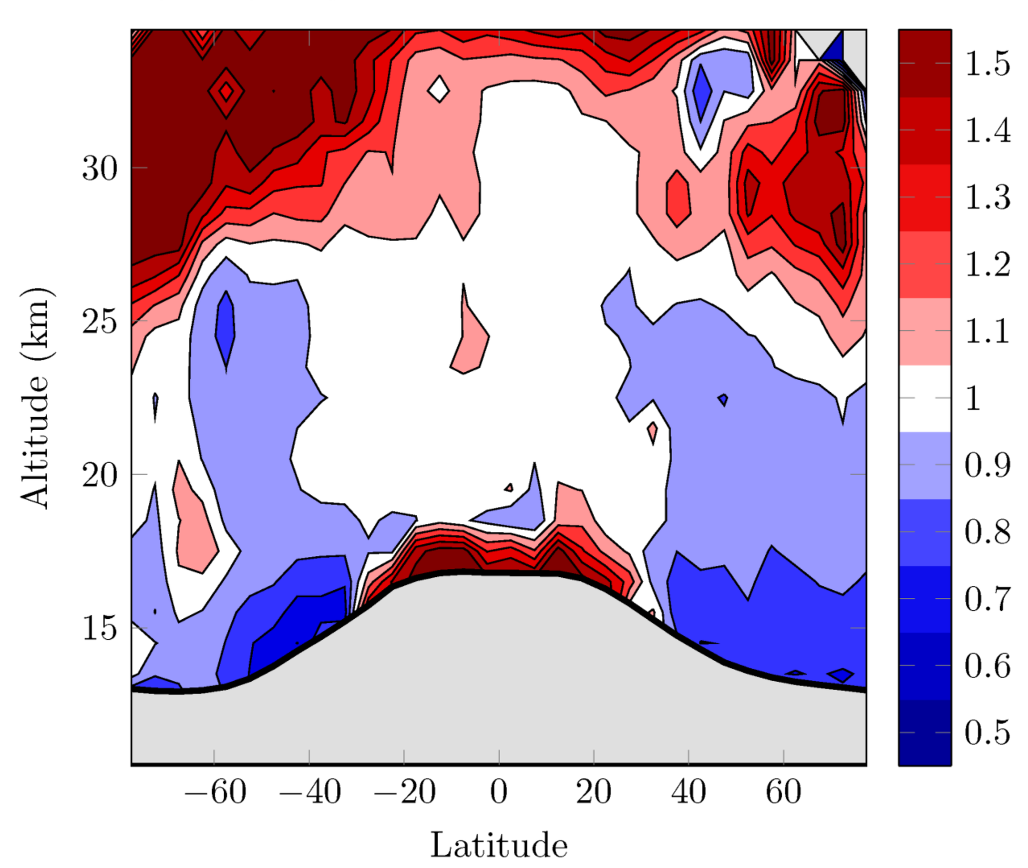
Zonal Comparisons

it is difficult to investigate possible problem regions with coincident scans alone due to the limited number of measurements. Expanding comparisons to latitude regions provides a much greater number of observation, with 10º latitude bands providing several hundred to several thousand measurements from both instruments. However, the temporal sampling in each latitude bin is still quite different between the two instruments. To avoid temporal biases the measurements are weighted so that both OSIRIS and SAGE have the same number of weighted samples in each one month period. Probability density functions of the measurements can then be constructed from summing the weights in each bin. Two typical measurement distributions are shown in the figure below.



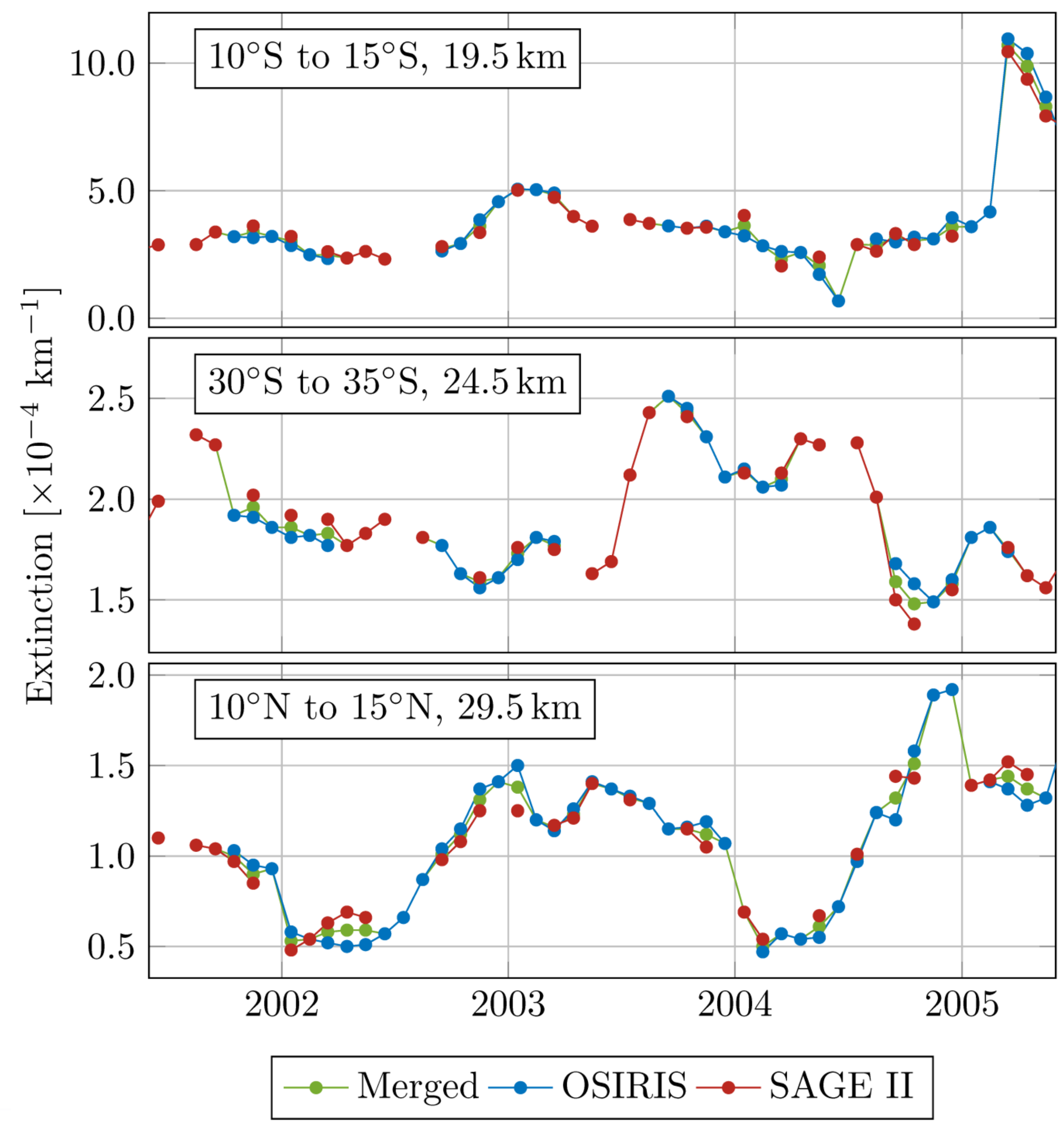
Merging Approach

Based on the relatively good agreement between measurement histograms the OSIRIS data is scaled at each latitude and altitude bin so that the average monthly means are equal. The figure below shows the scale factor applied to the OSIIRS data at each latitude and altitude. The 380K Tropopause is shown as the solid black line. For the bulk of the aerosol layer scale factors between 0.8 and 1.2 are required except near the tropical Tropopause where OSIRIS retrievals can saturate due to high aerosol loading and cirrus clouds, requiring larger scale factors.



Merged Extinctions

Comparisons of the extinction time series after OSIRIS data has been scaled is shown in the figure below for the 4 years of mission overlap. Overall, agreement between the two instruments is very good with both instruments measuring volcanic enhancements and the quasi-biennial oscillations.



References

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