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Towards a long-term record of stratospheric aerosol extinction coefficients: comparison of data sets and conversion to other wavelengths

A. Rozanov[1], V. Sofieva[2], C. Arosio[1], E. Malinina-Rieger[1,*], M. v. Massenbach[1], A. Bourassa[3], L. Rieger[3], J.P. Burrows[1] and C. Retscher[4]

[1]Institute of Environmental Physics, University of Bremen, Germany
[2]Finnish Meteorological Institute, Finland
[3]University of Saskatchewan, Canada
[4]ESA-ESRIN
*Now at Environment Climate Change Canada

IUP

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Motivation

Long-term stratospheric aerosol records available so far:

- SAGE II – OSIRIS, 1984 - 2014 (Rieger et al., 2015)
- GloSSAC V1, 1979 - 2016 (Thomason et al., 2018)
  - 1979 – 1984: SAM, SAGE I, NASA Airborne Lidar, NASA 48-Inch LIDAR
  - 1984 – 2005: SAGE II, HALOE (1991 - 1993), CLAES (1991 - 1993)
  - 2005 - : OSIRIS, CALIPSO
- GloSSAC V2, 1979 - 2018 (Kovilakam et al., 2020)
  - Instruments in addition to GloSSAC V1: SAGE III/ISS

Specifics of GloSSAC:

- Strong focus on the global coverage
- Intentional use of the minimal number of instruments: data from all European sensors and OMPS-LP are not included

The new IUP-FMI long term aerosol record:

- Focus on the increased robustness of the data after 2000
- Instruments included: SAGE II, OSIRIS, GOMOS, SCIAMACHY, OMPS-LP, SAGE III/ISS

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Conversion between wavelengths: approach to estimate errors

Estimation of the error associated with the conversion of the aerosol extinction coefficient between different wavelengths

Particle size distribution PSD dataset to be used:

Mode radius and distribution width from SCIAMACHY stratospheric aerosol PSD dataset from 08.2002 to 04.2012 (tropical clear sky data)

Mie theory is employed to calculate the aerosol extinction time series at all required wavelengths:

- “True” time series is obtained using the PSD parameters from SCIAMACHY
- “Fixed PSD” time series is obtained by using the same PSD parameters (0.08 µm mode radius and 1.6 sigma) for all data points

Assessment of the “fixed PSD” approximation:

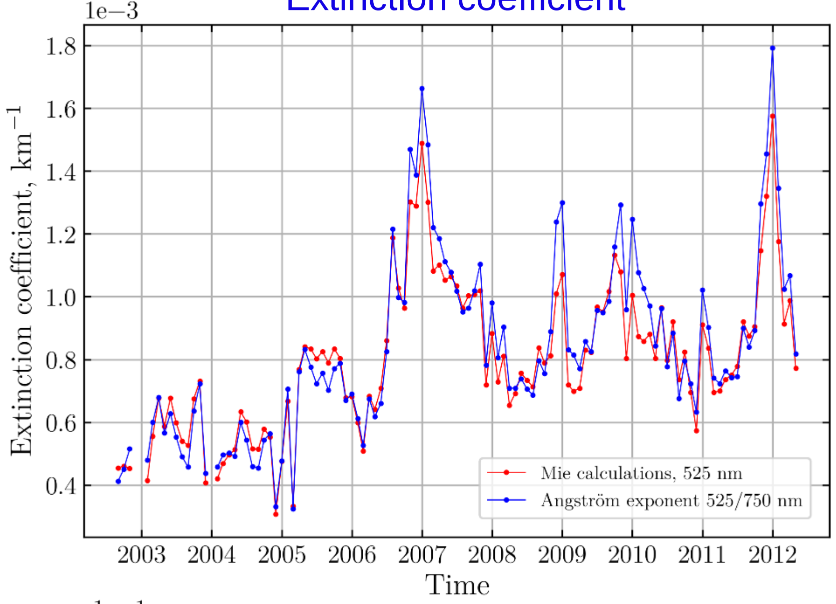
- Angstrom exponent for the selected wavelengths pair is calculated using the extinctions from the “fixed PSD” time series
- Conversion from the one wavelength of the pair to the other is done using the calculated Angstrom exponent
- Resulting extinctions are compared to the corresponding values from the “true” time series

Assessment of the conversion using the Angstrom exponents:

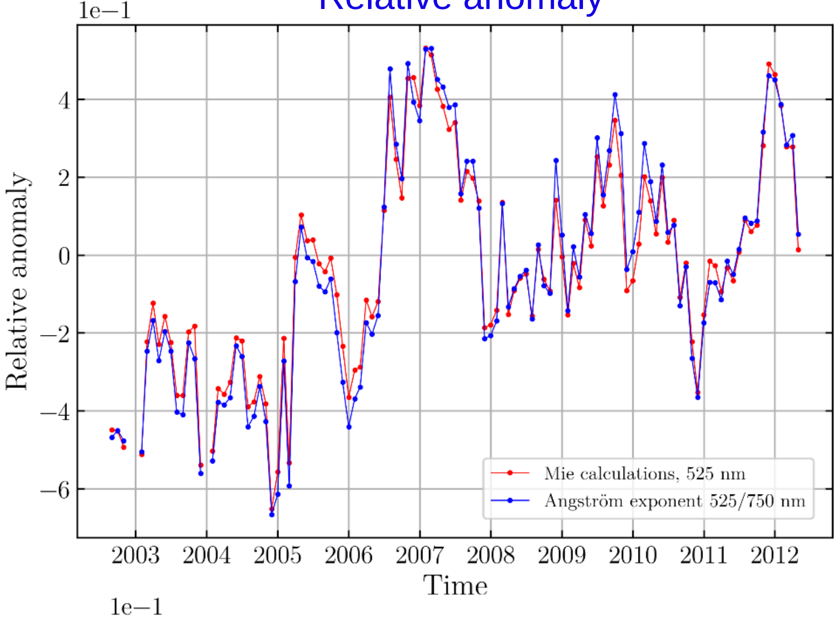
- Angstrom exponent for the selected wavelengths pair is calculated using the extinctions from the “true” time series
- Conversion between the wavelength (at least one of them does not belong to the pair) is done using the calculated Angstrom exponent
- Resulting extinctions are compared to the corresponding values from the “true” time series

Error assessment: “fixed PSD“ conversion from 750 to 525 nm

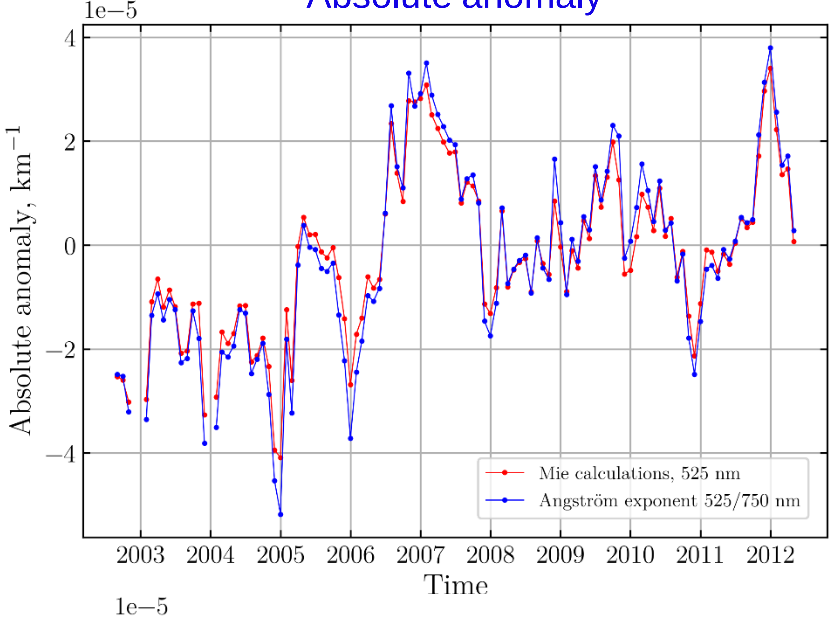
Extinction coefficient

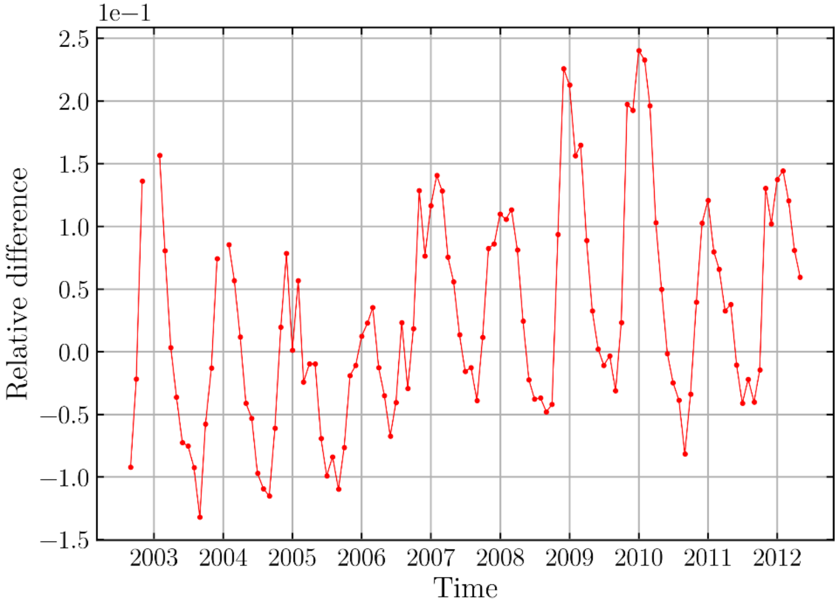


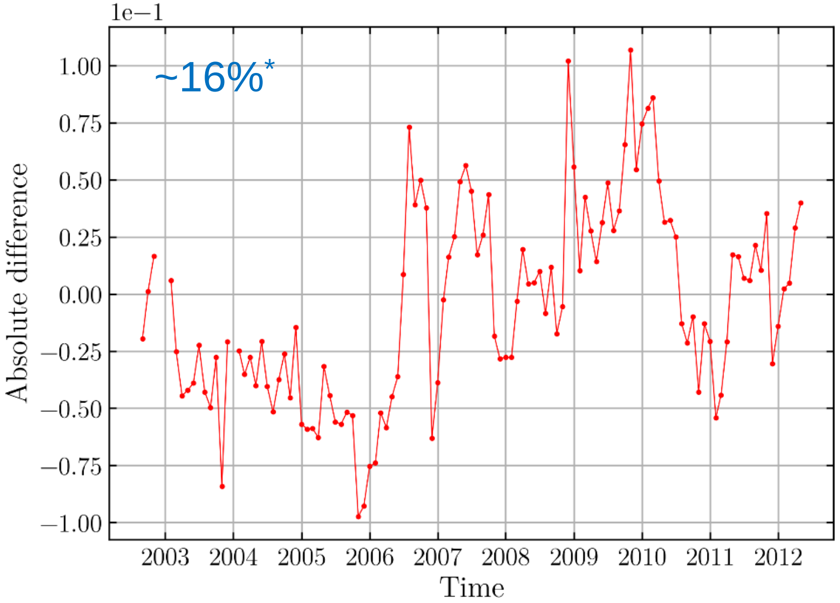
Relative anomaly

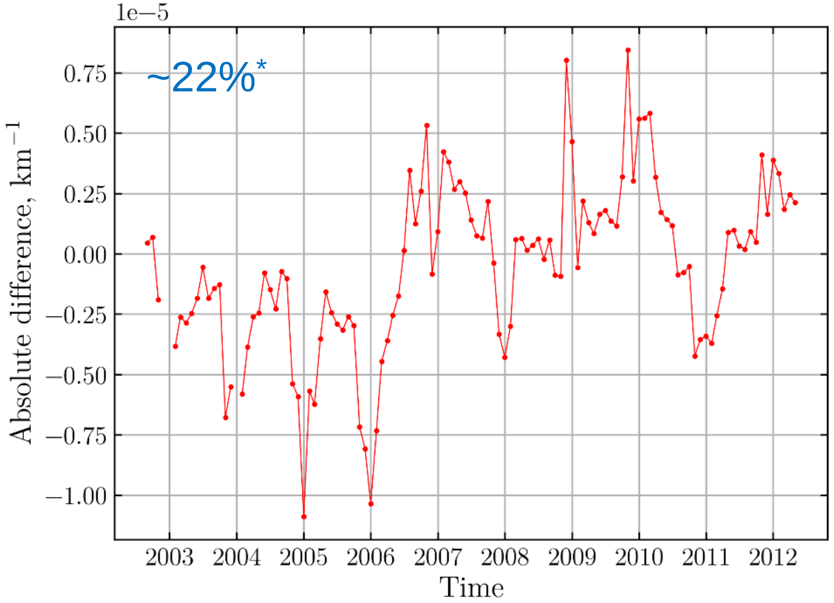


Absolute anomaly





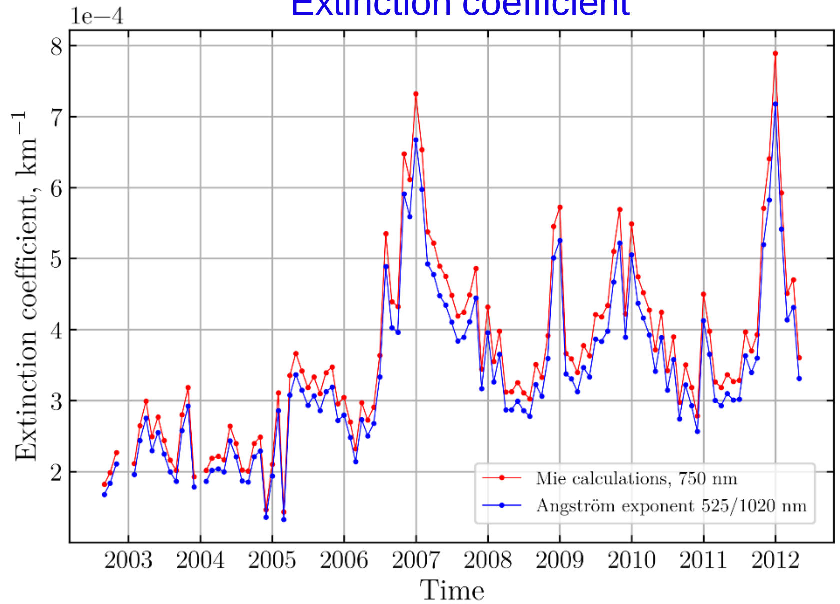




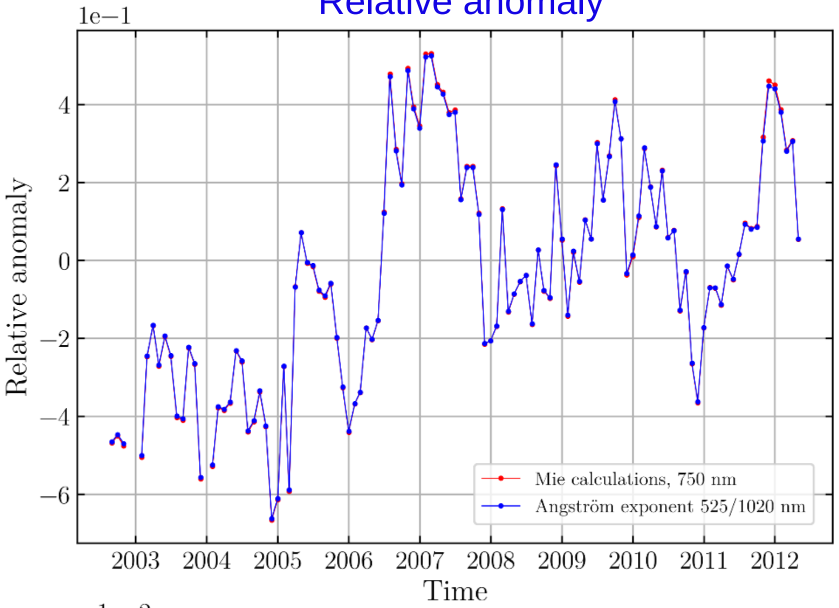
* Estimated as a ratio of the standard deviations of the time series shown in the lower and in the upper plots

Conversion from 525 to 750 nm using SAGE II Angstrom exponent

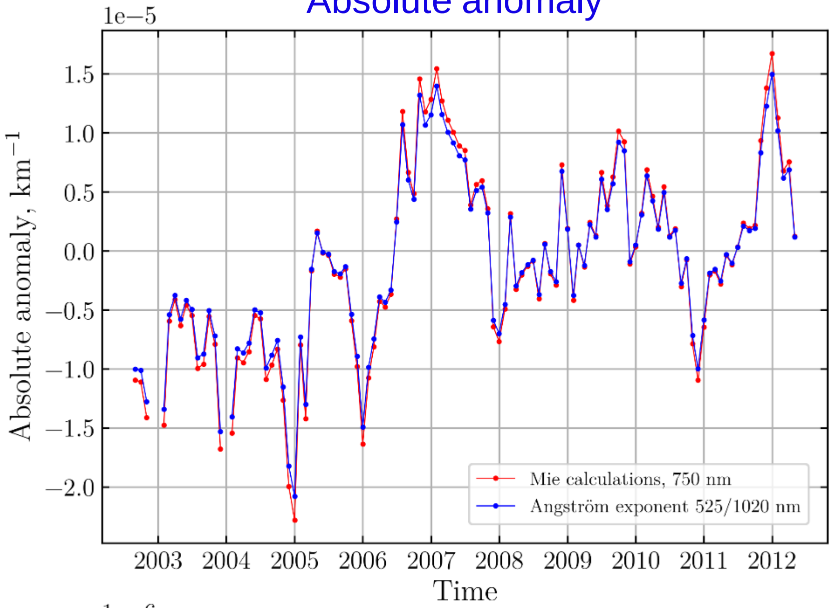
Extinction coefficient

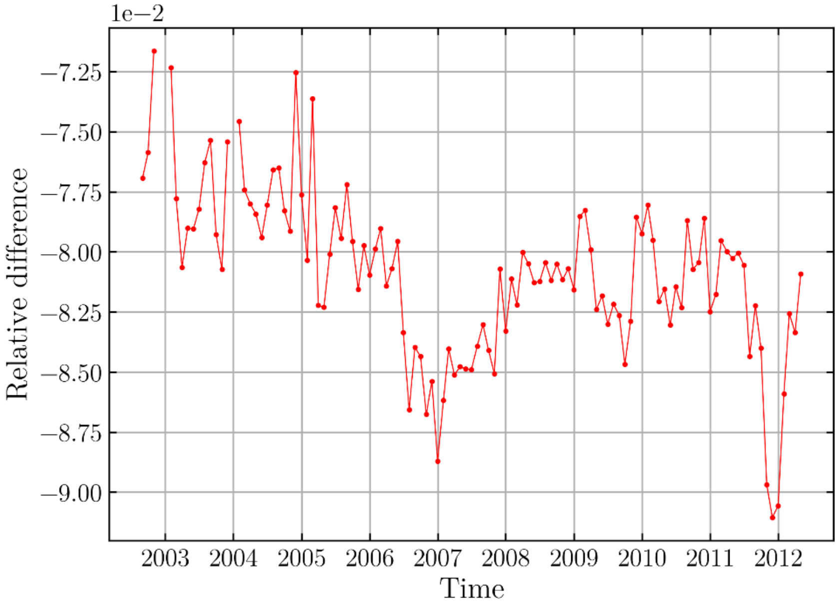


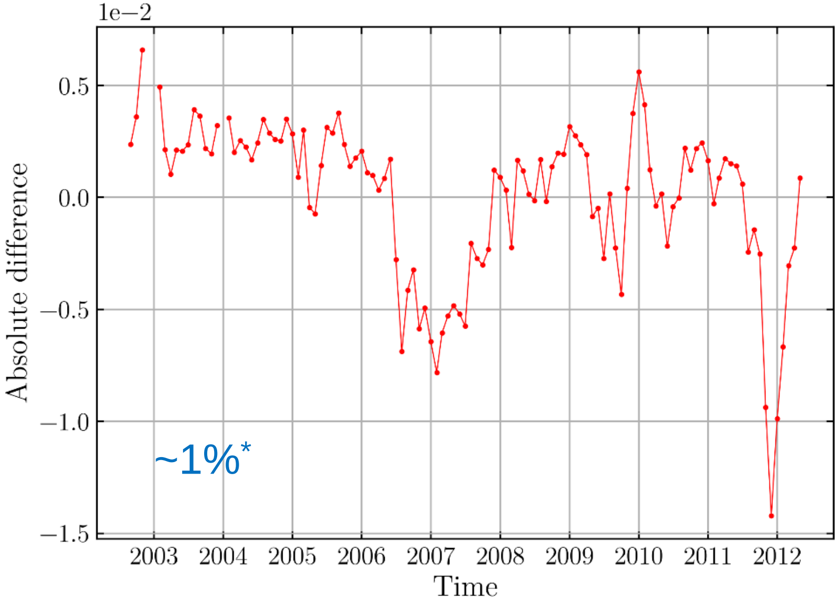
Relative anomaly

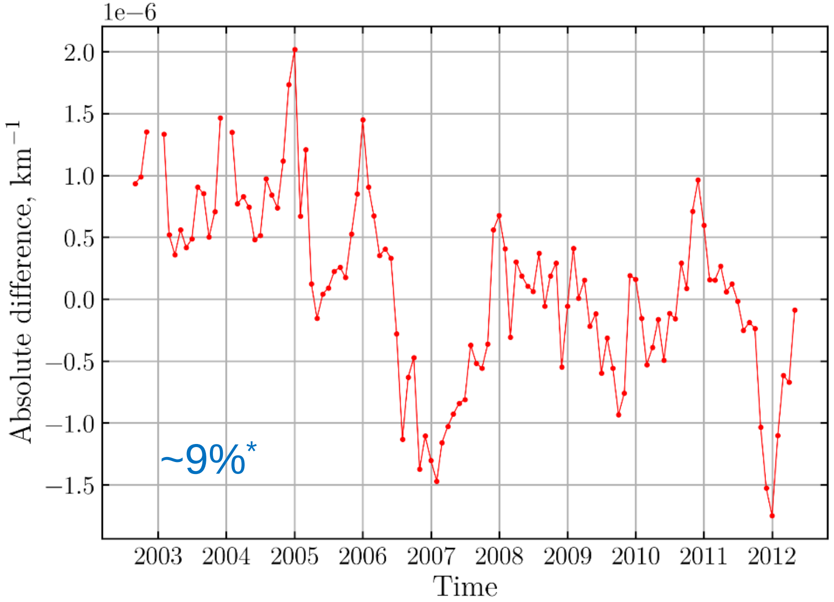


Absolute anomaly





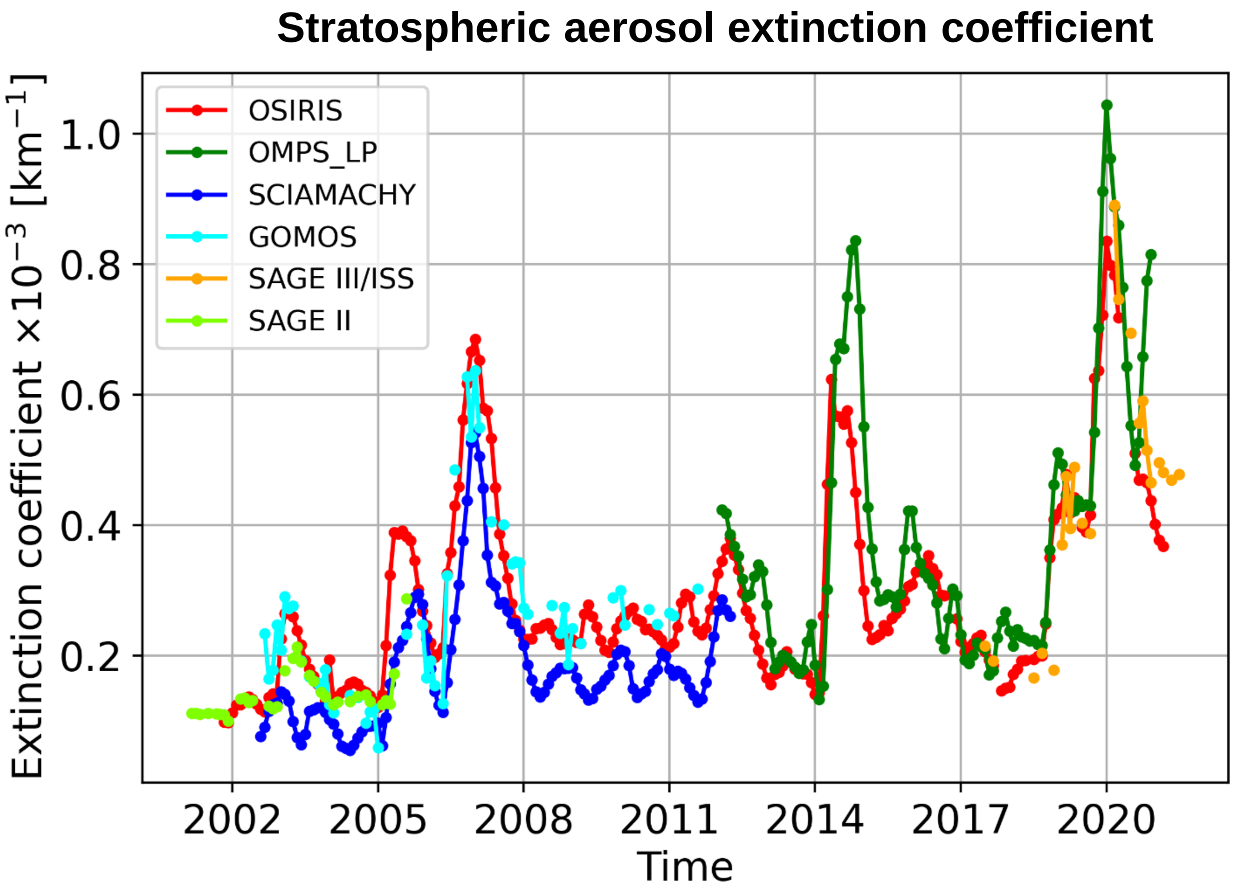


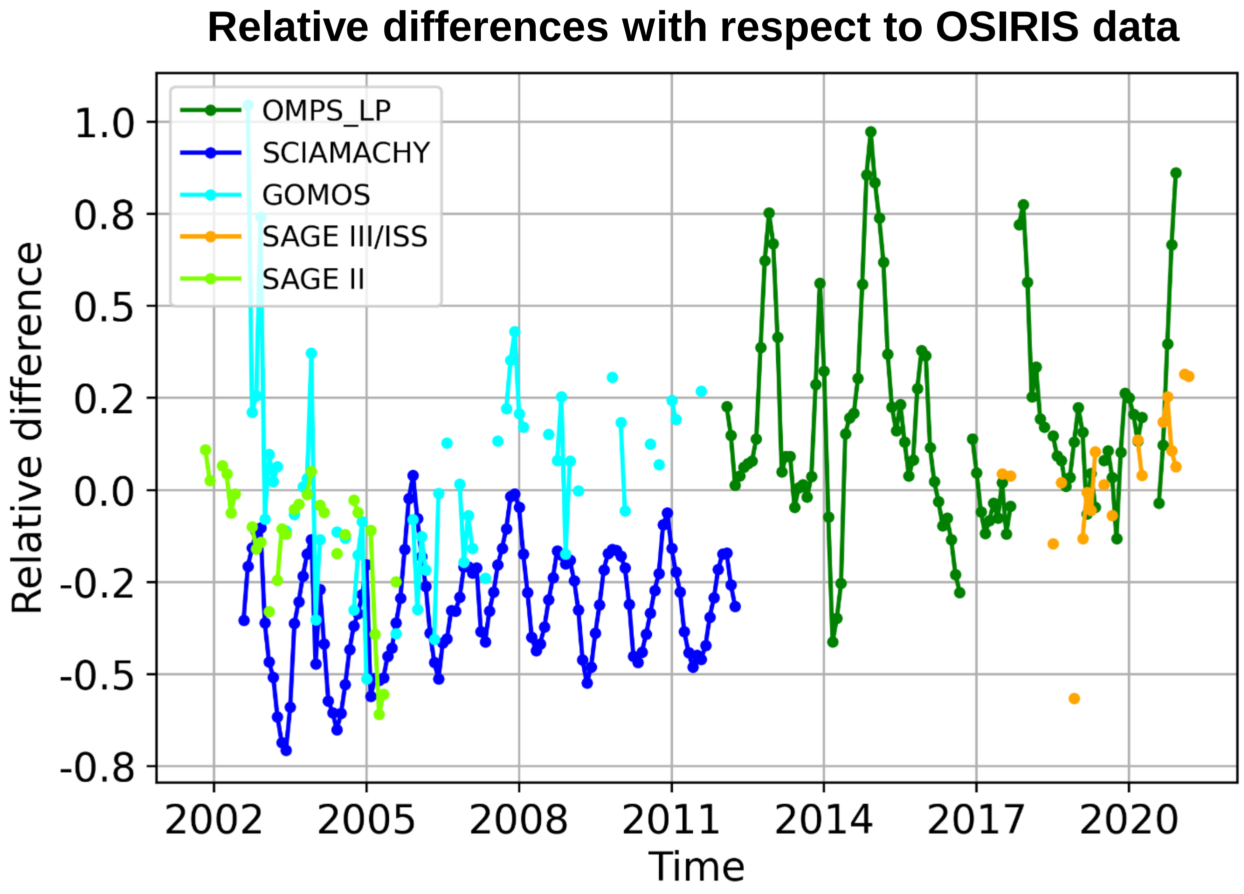


* Estimated as a ratio of the standard deviations of the time series shown in the lower and in the upper plots

Towards the long-time record: original data sets

Comparison of the original data sets at 750 nm at an altitude of 21.7 km in tropics (5°N)





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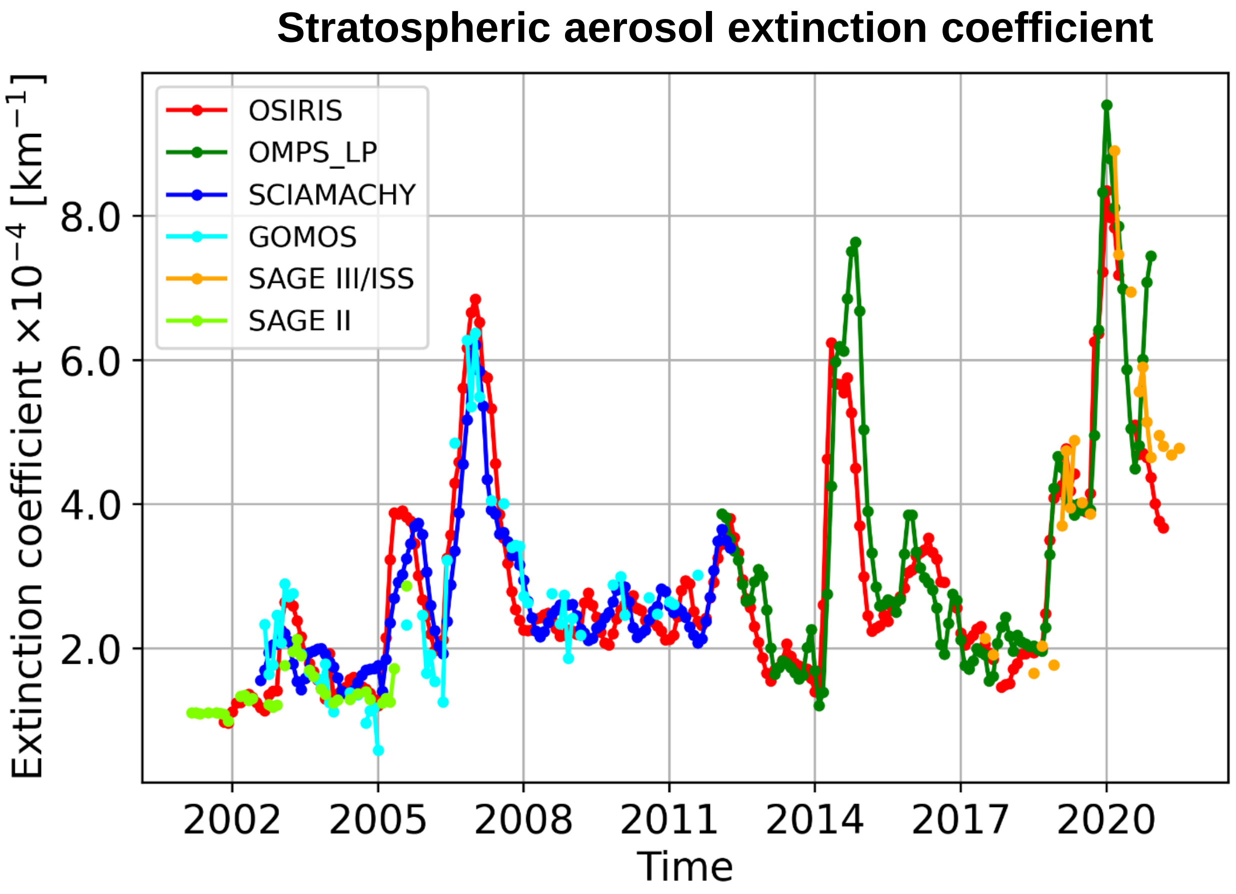
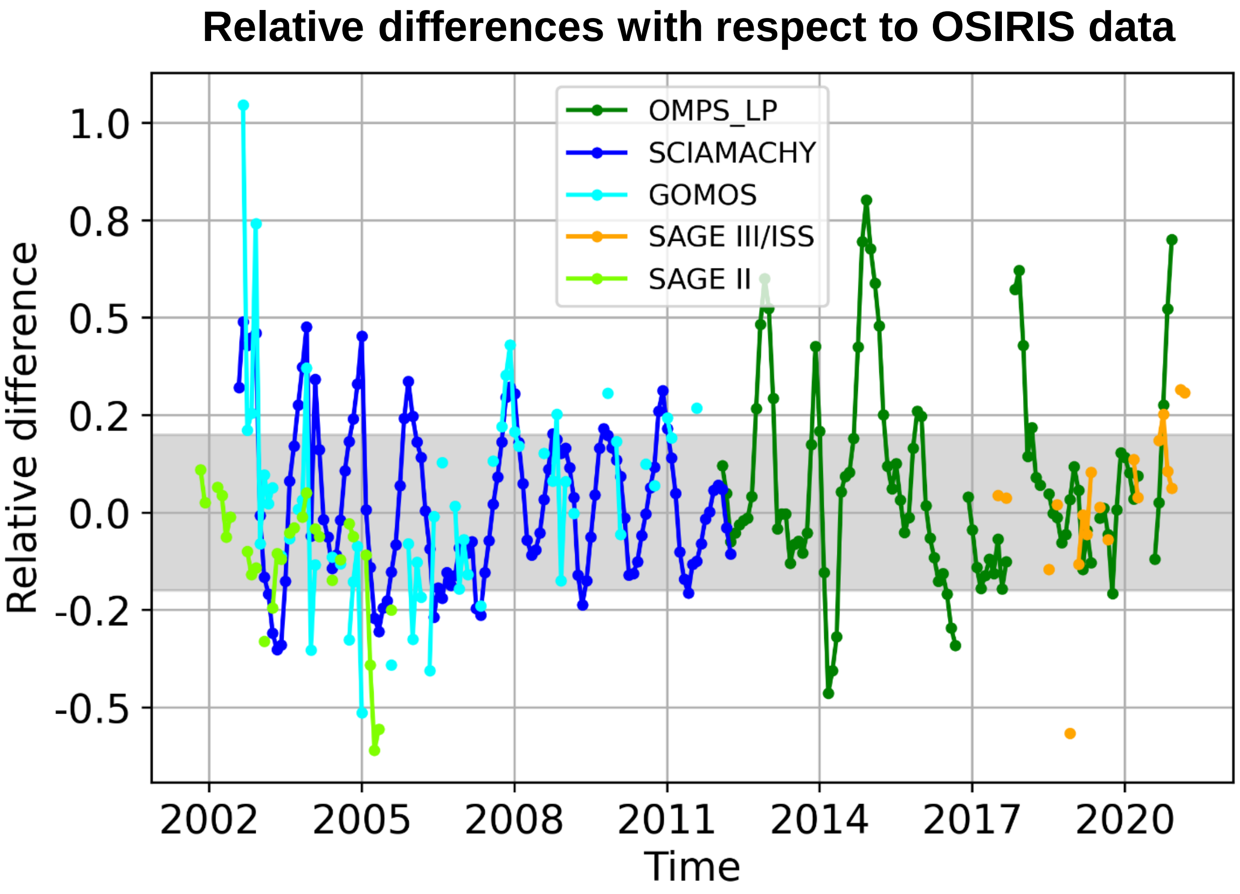
Towards the long-time record: corrected data sets

Comparison of the corrected data sets at 750 nm at an altitude of 21.7 km in tropics (5^{o}N)

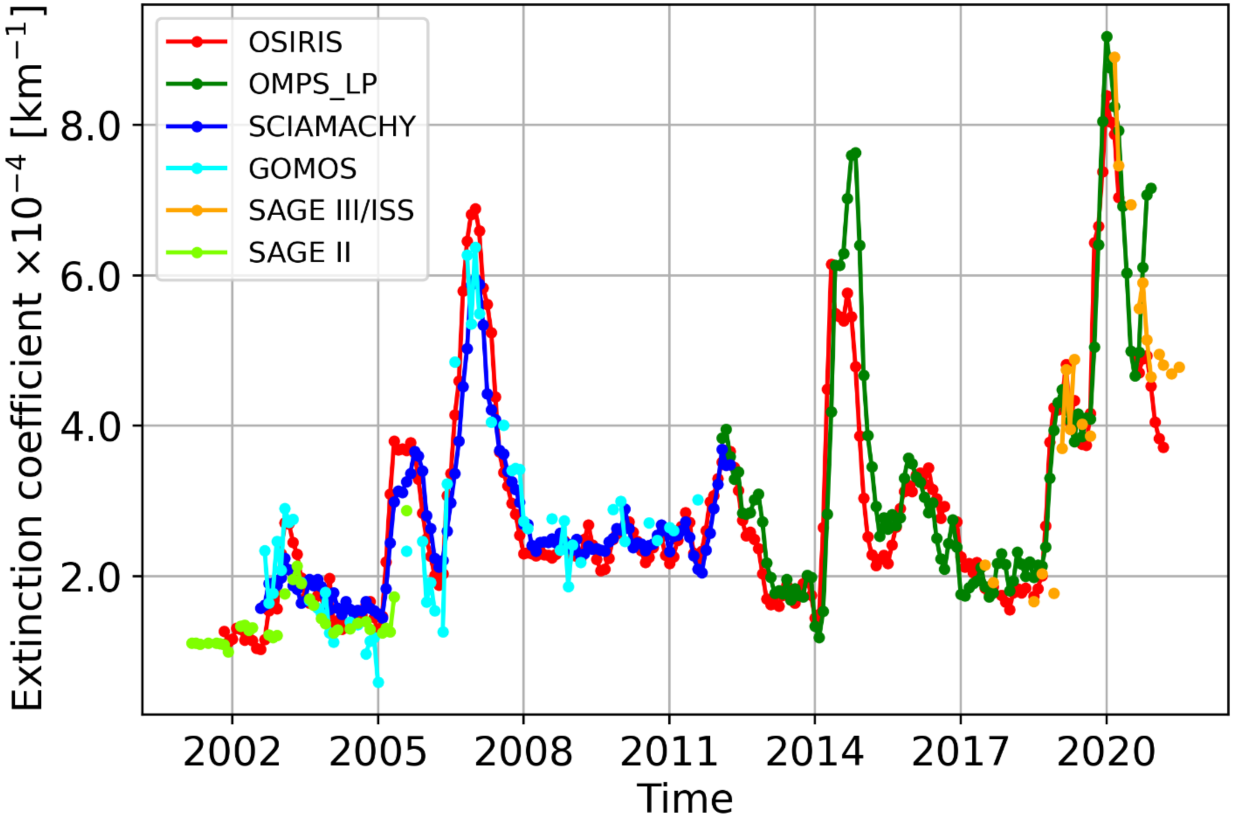


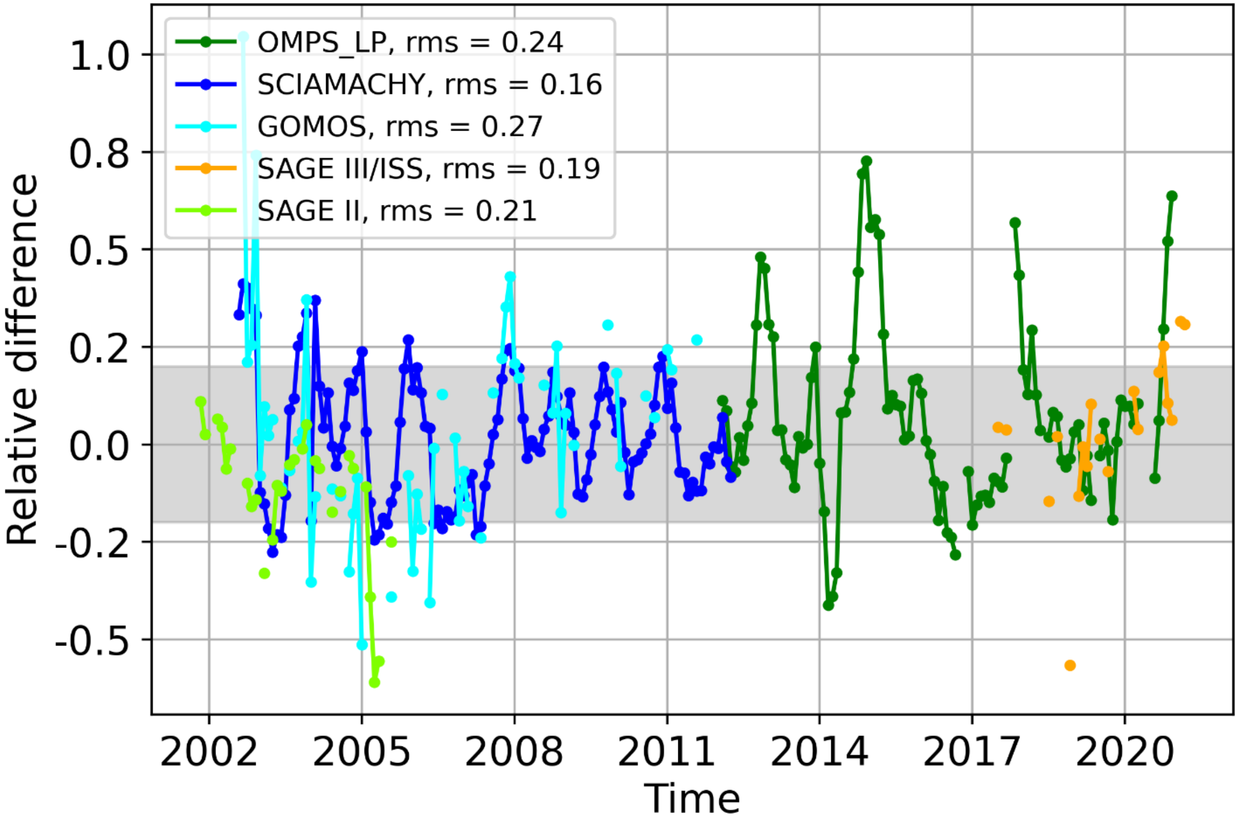


SCIAMACHY: additive correction. OMPS-LP: multiplicative correction. Data above mean + 2*std were not considered for the correction.

Corrected and deseasonalized data sets

Comparison of the corrected and deseasonalized data sets at 750 nm at an altitude of 21.7 km in tropics (5°N)

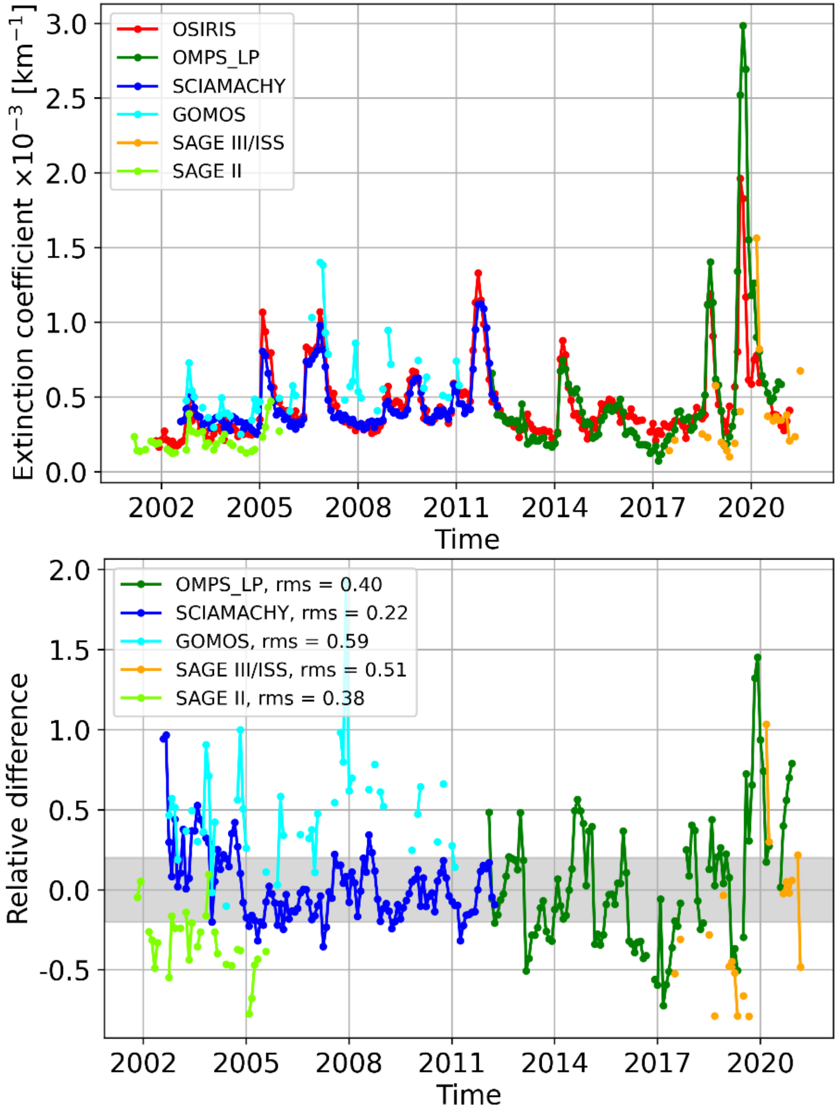




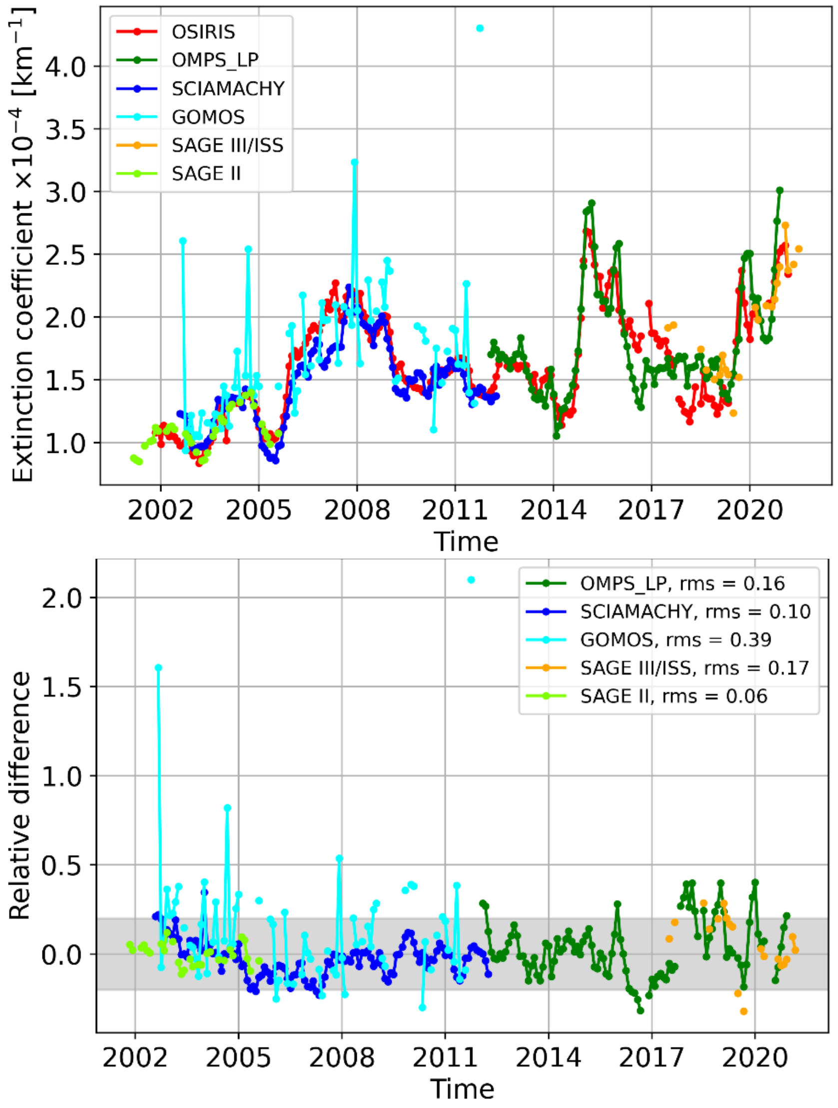
Only OMPS-LP, OSIRIS and SCIAMACHY data are deseasonalied, it is to be investigated how to do it for GOMOS, and SAGE III/ISS
Data above mean + 2*std were not considered in the deseasonalising procedure.

Comparison of satellite records: tropics

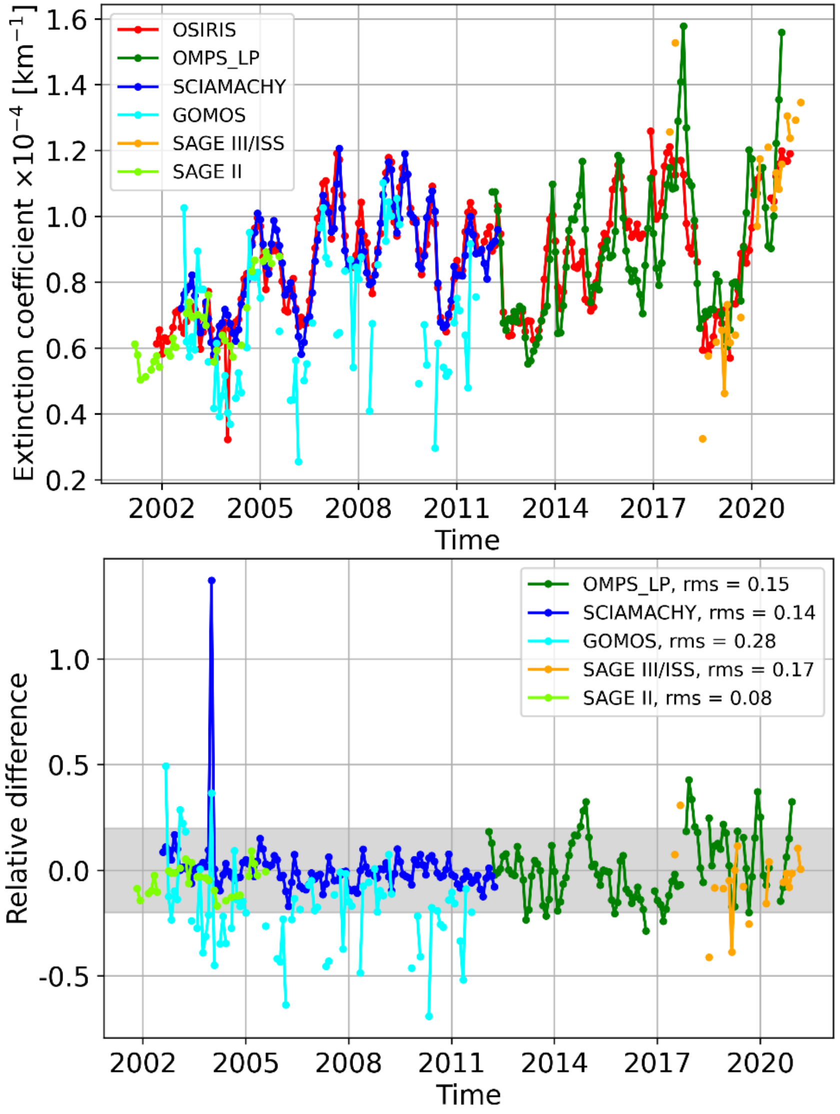
18.4 km



25.0 km

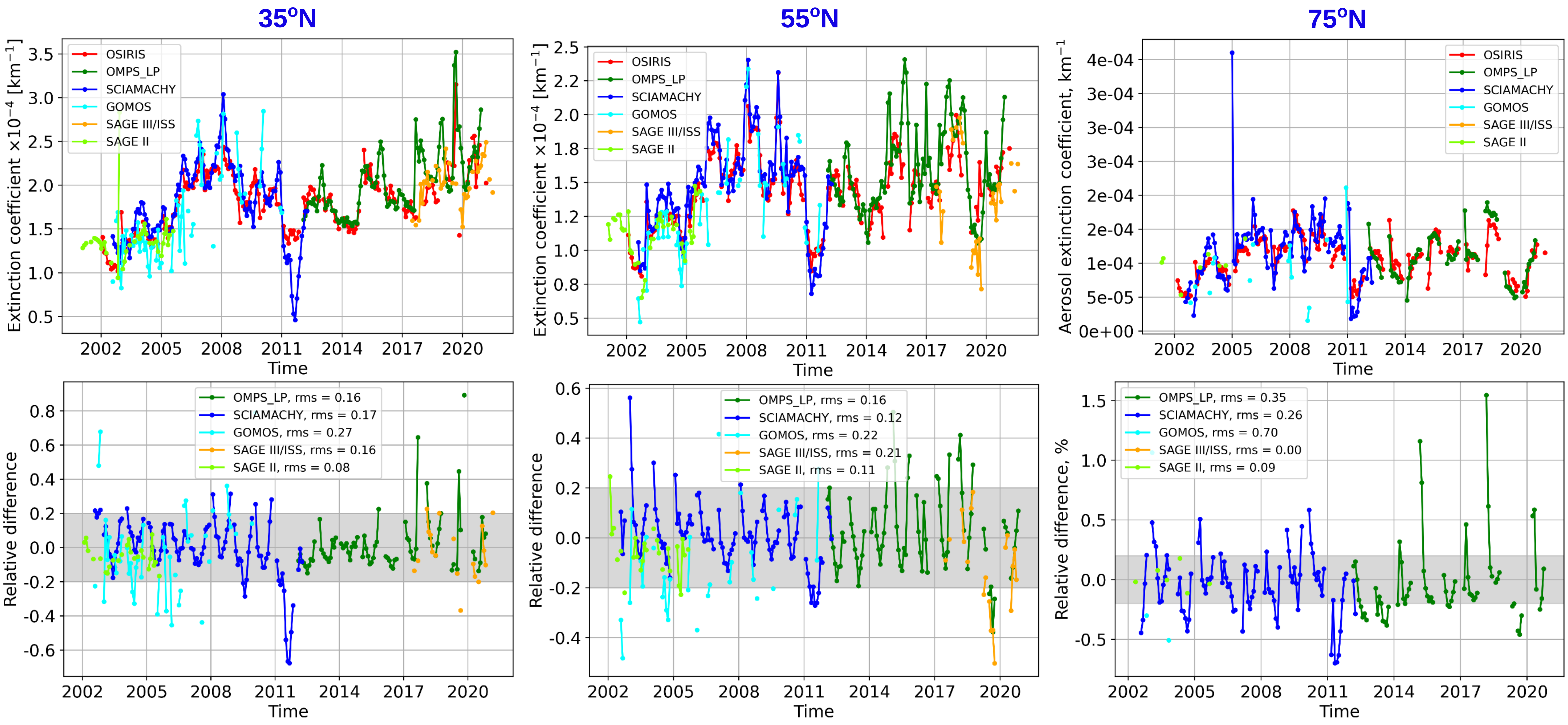


28.3 km



Deseasonalized data. Relative differences are calculated with respect to OSIRIS data

Comparison of satellite records: northern hemisphere, 21.7 km



Deseasonalized data. Relative differences are calculated with respect to OSIRIS data

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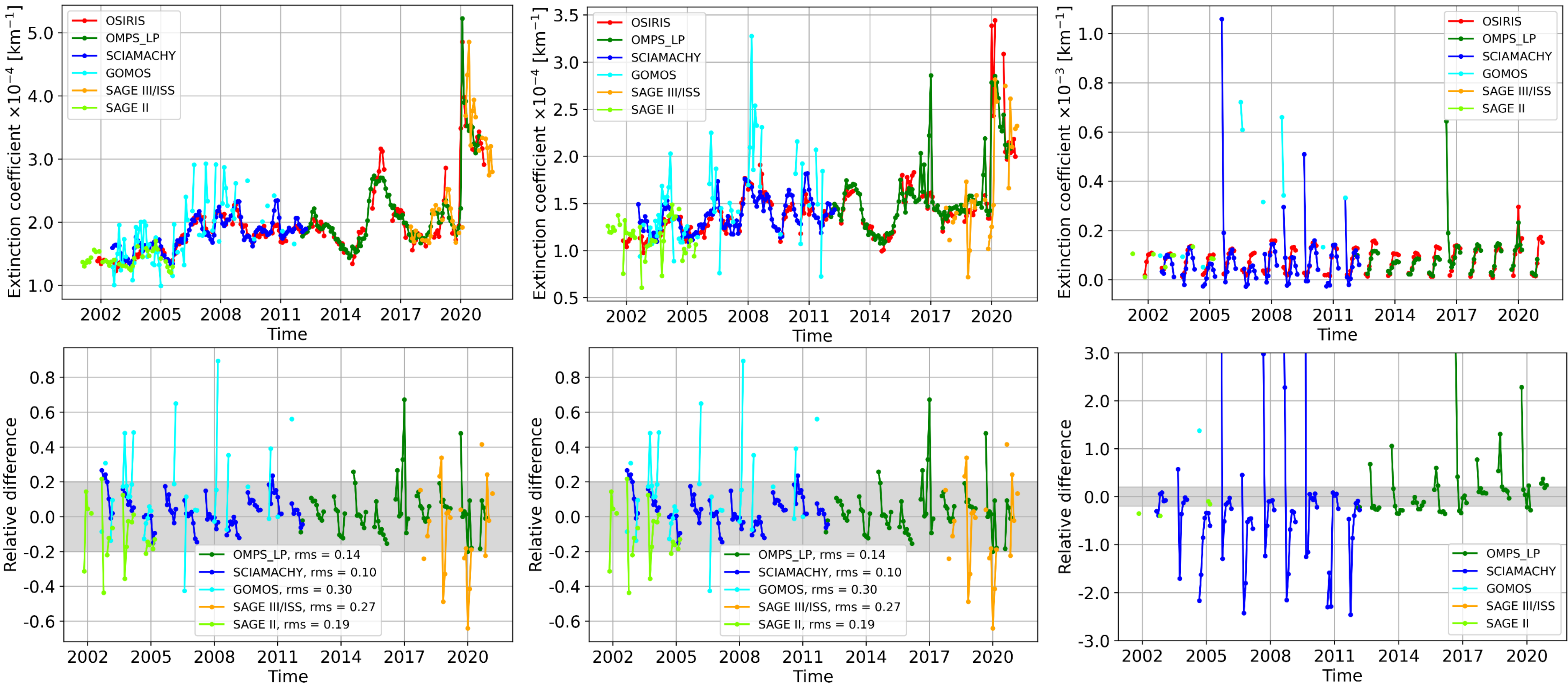
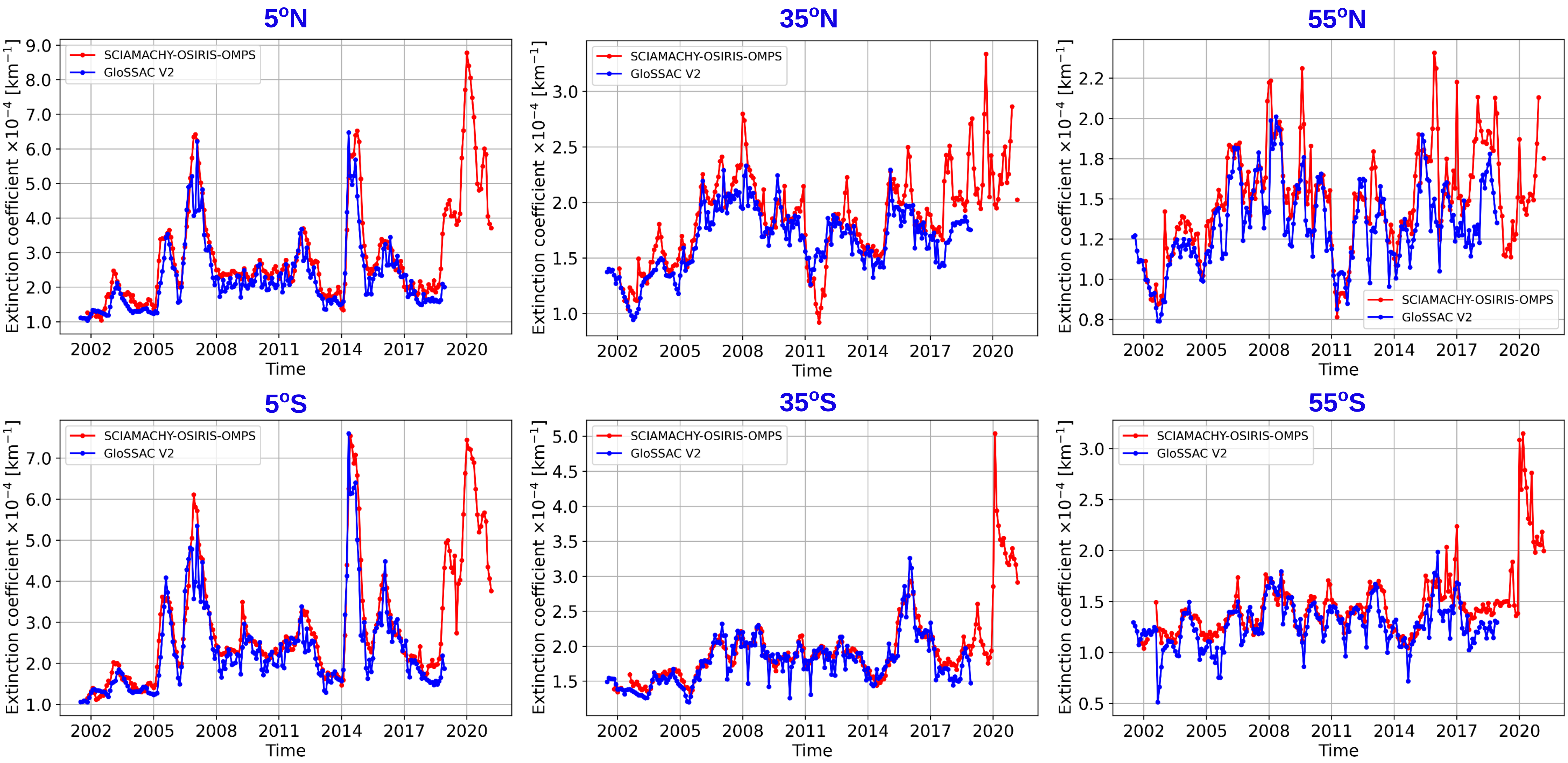
Comparison of satellite records: southern hemisphere, 21.7 km

35°S **55°S** **75°S**



Deseasonalized data (with exception of 75°S) . Relative differences are calculated with respect to OSIRIS data

Comparison to GloSSAC V2: 21.7 km



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Comparison of satellite records: Summary

- Mostly a good agreement between the long-term time series from SCIAMACHY, OMPS and OSIRIS instruments (SAGE II, GOMOS and SAGE III/ISS are out of focus so far).
- Characteristic volcanic features are seen by all instruments.
- No apparent drifts could be identified
- De-biasing of the time series from SCIAMACHY and OMPS-LP are need to match that of OSIRIS
    - Additive correction works better for SCIAMACHY
    - Multiplicative correction works better for OMPS-LP
- Deseasonalising helps to reduce differences due to too strong pronounced seasonal cycle in SCIAMACHY and OMPS-LP observations than in those from OSIRIS.
- A method to recover the seasonal cycle needs to be elaborated
- Some outliers are still seen requiring an additional filtering (in all instruments).
- Negative values are present in SCIAMACHY data at high southern latitudes
- Generally a good agreement with GloSSAC V2 is found, larger deviations are seen after 2017 (most probably due to inclusion of SAGE III/ISS, which is often lower than OSIRIS)