



Early Results from a Joint Retrieval of Stratospheric Aerosol from SAGE III/ISS solar occultation and OMPS limb scattering

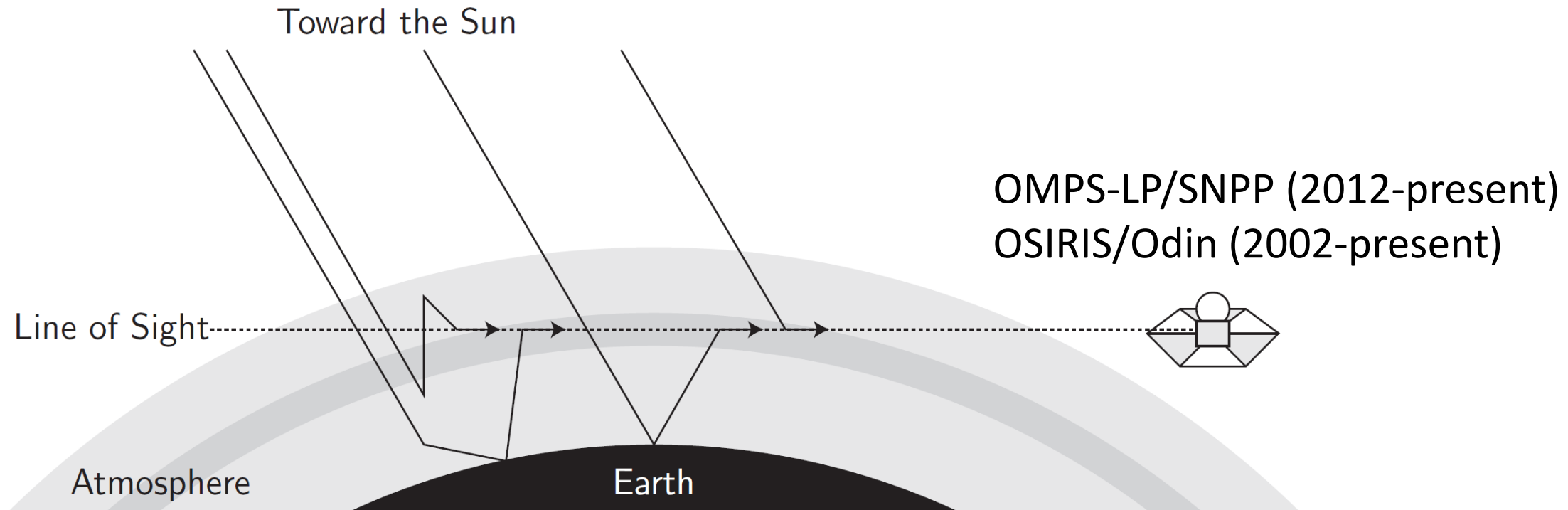
Adam Bourassa, Daniel Zawada, Landon Rieger,
Chris Roth, Doug Degenstein

Outline

- Stratospheric aerosol retrieval from OMPS limb scattering
 - The good side and the bad side
 - Radiative transfer and the scattering phase function
- Particle size distribution parameters from SAGE III/ISS
- Using SAGE III/ISS particle size in OMPS retrievals
 - Early results: encouraging and frustrating

The limb scattering measurement

Complex multiple scattering requires a forward model for retrieval of atmospheric parameters

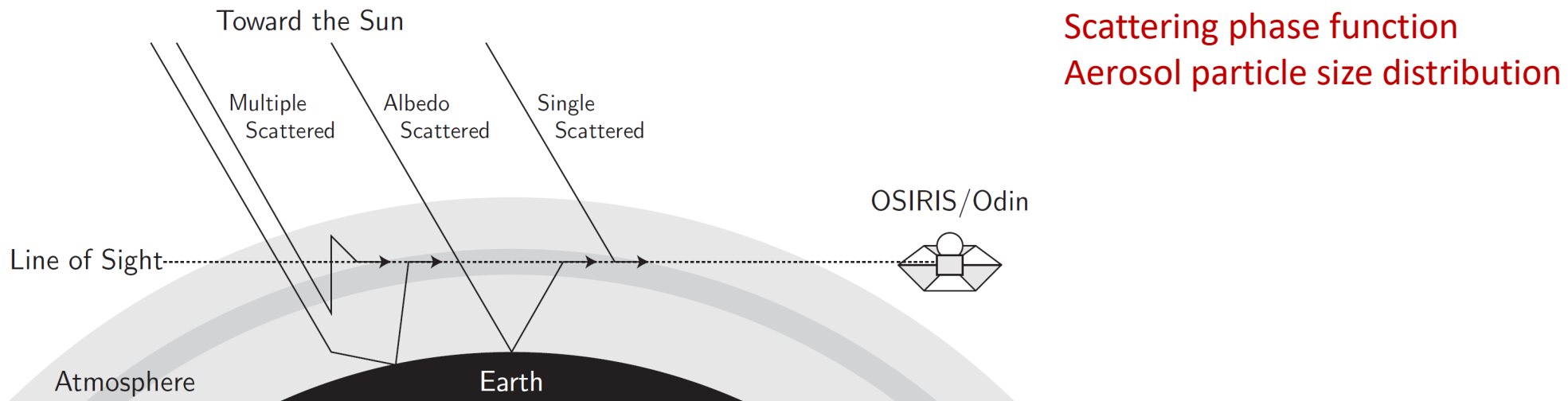


Radiative Transfer Modelling

Computationally challenging to estimate the source term in the integral radiative transfer equation in a spherical atmosphere: SASKTRAN

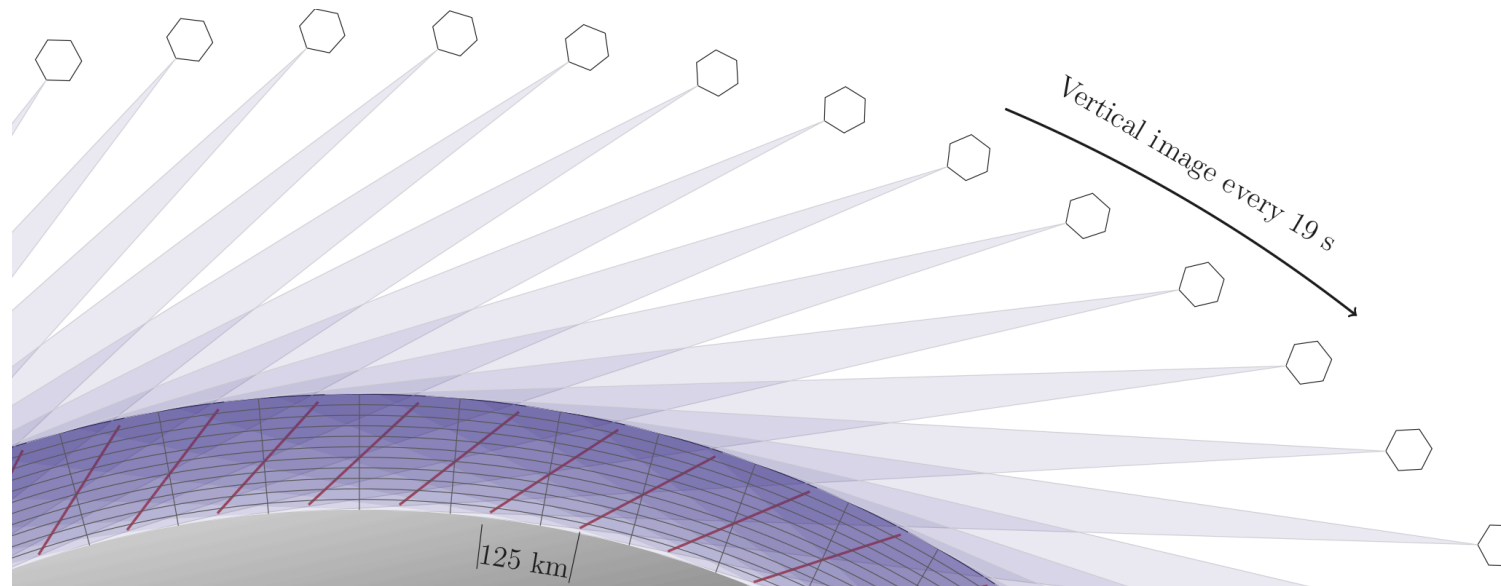
$$I(\mathbf{r}_0, \hat{\Omega}) = \int_{s_{\text{end}}}^0 J(s, \hat{\Omega}) e^{-\tau(s, 0)} ds + I_{\text{end}}(\mathbf{r}_{\text{end}}, \hat{\Omega}) e^{-\tau(\mathbf{r}_{\text{end}}, \mathbf{r}_0)}$$

$$J(s, \hat{\Omega}) = k_{\text{scat}}(s) \int_{4\pi} I(s, \hat{\Omega}') \underbrace{\bar{p}(s, \hat{\Omega}', \hat{\Omega})}_{\text{Scattering phase function}} d\hat{\Omega}'$$



The OMPS-LP USask-2D Aerosol Retrieval

- OSIRIS-like basic algorithm:
 - Effective surface albedo at 746 nm
 - Retrieve aerosol number density for assumed particle size distribution lognormal (80 nm, 1.6 mode width) → extinction
 - Single wavelength channel 746 nm
- Tomographic 2D retrieval grid; regularized in the horizontal dimension
- Developed in tandem with the ozone retrieval (Zawada et al., AMT, 2018)



OMPS-LP Aerosol extinction: The good

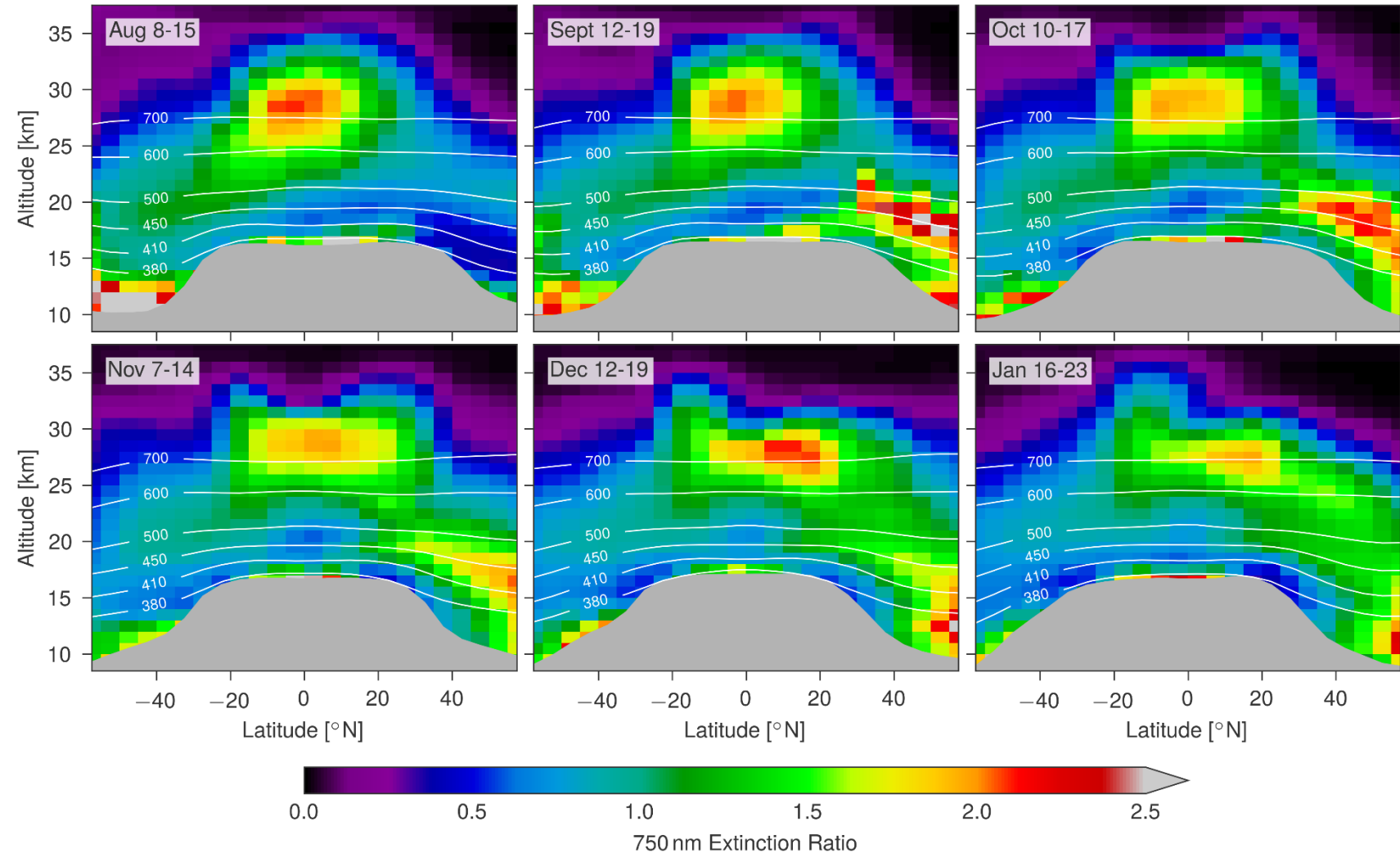
The 2017 Canadian forest fires Weekly zonal averages

“Volcanic eruption”-like effect

Reaches altitudes of 22 km ($\Theta > 500$ K) at the edge of the tropics

Lasting stratospheric impact for
>5 months

Mid-winter transport out of the
deep tropics creates 2 layers



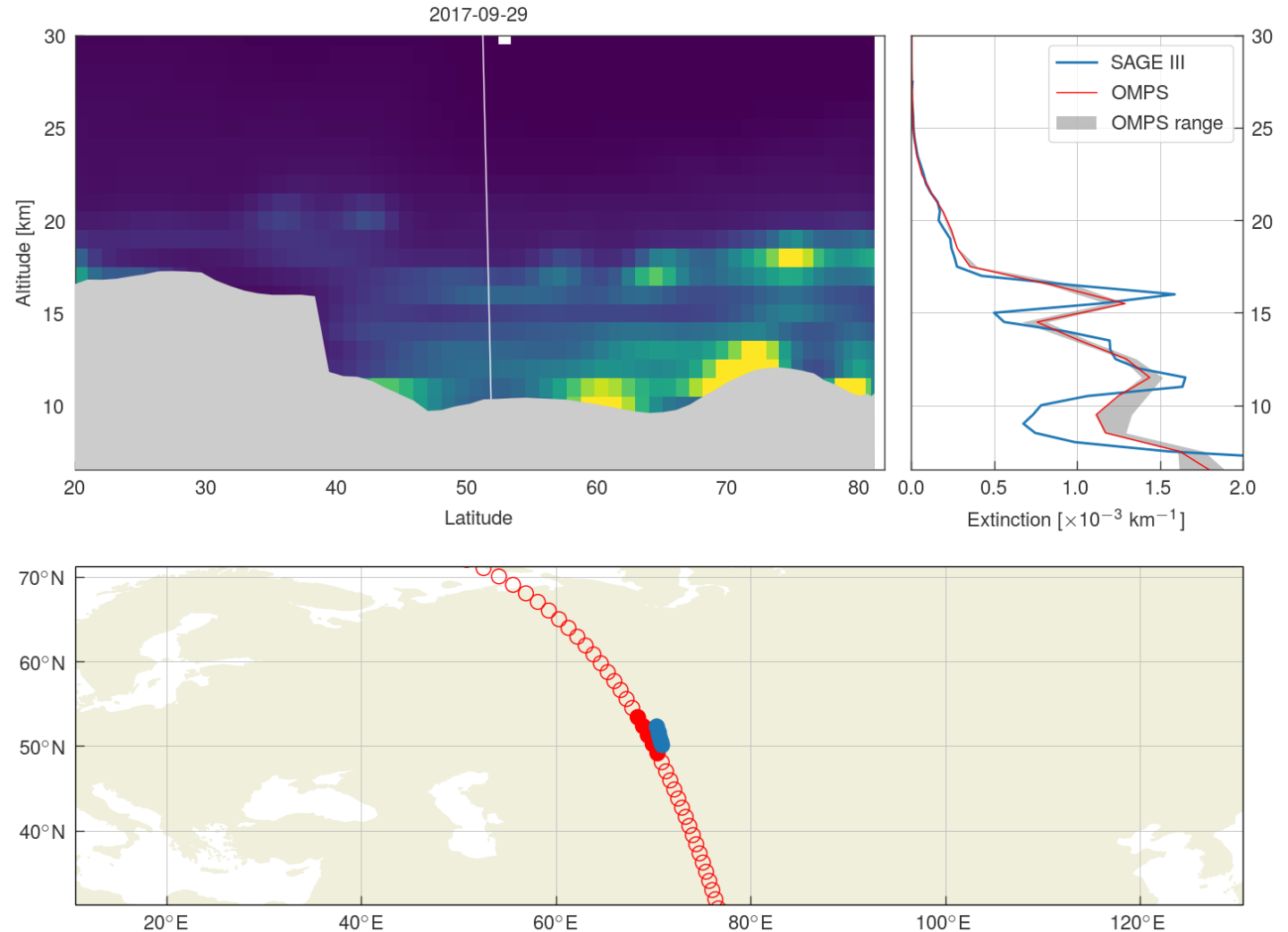
OMPS-LP Aerosol extinction: The good

Coincident OMPS-LP and SAGE III/ISS observations

Criteria: 6 hours, 3 degrees latitudes, 20 degree longitude

Huge variation in agreement in profile shape and magnitude

Highlights the usefulness of the limb scatter sampling and horizontal resolution of the 2D retrieval



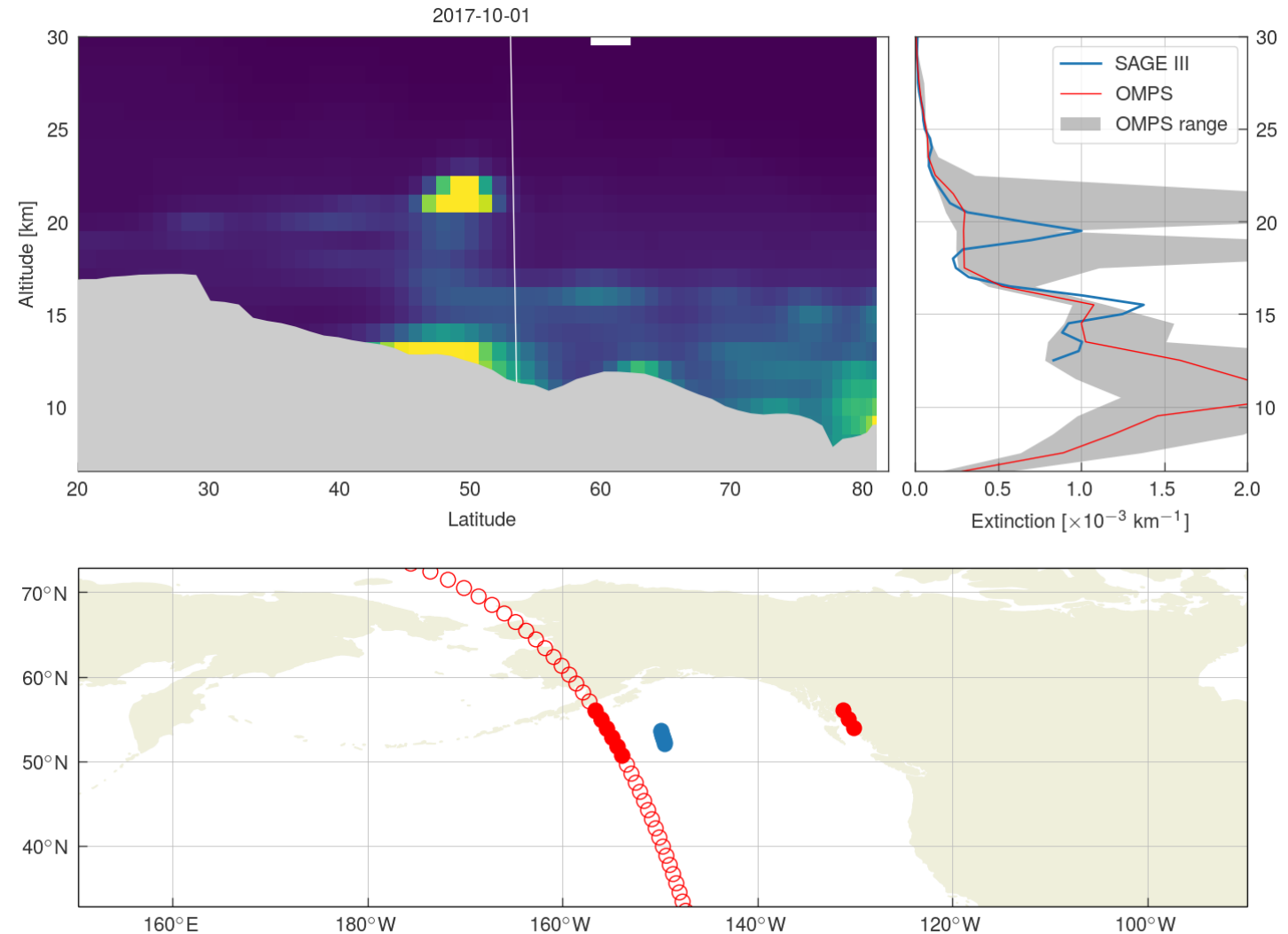
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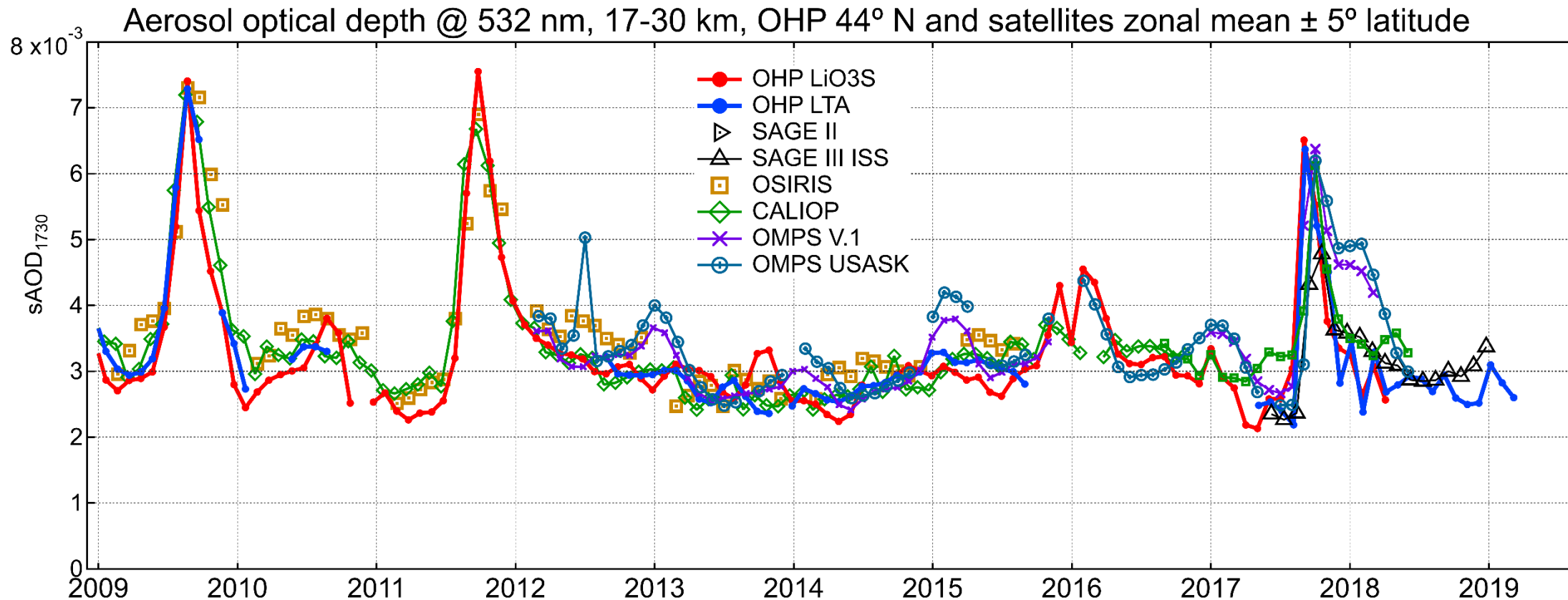
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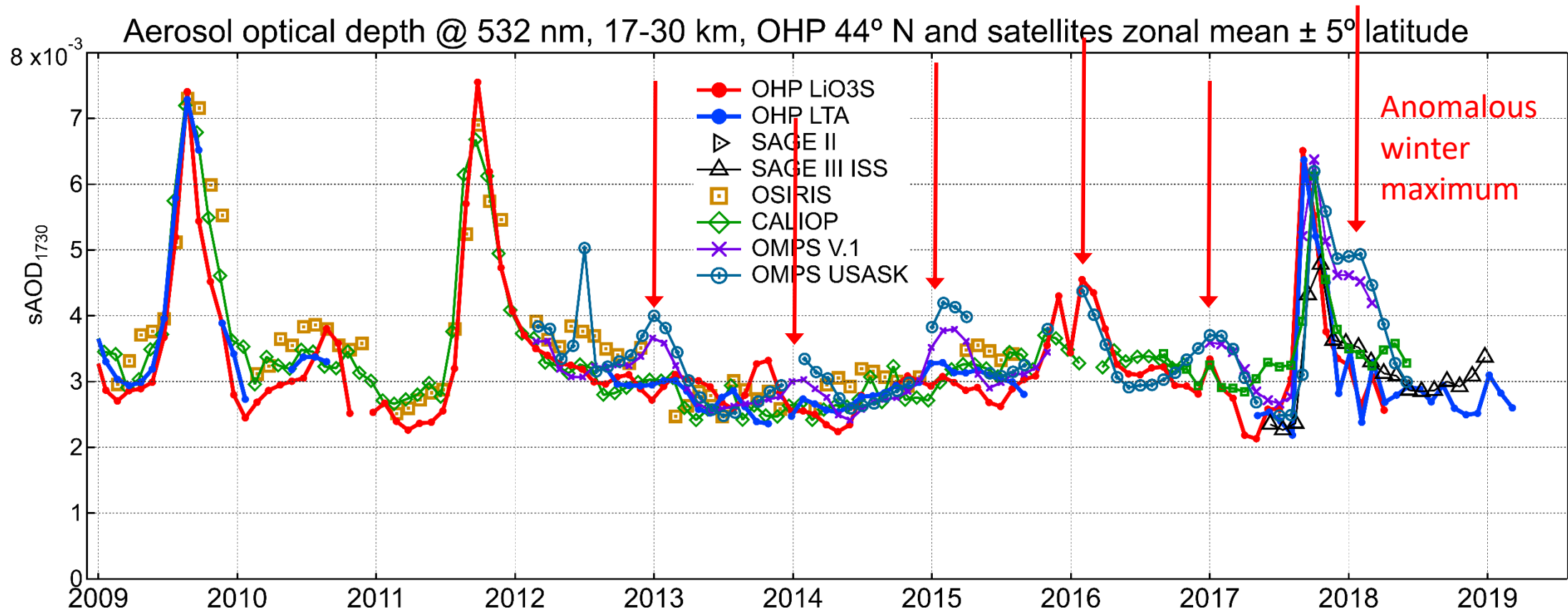
OMPS-LP Aerosol extinction: The bad

A figure from Sergey Khaykin at LATMOS, France



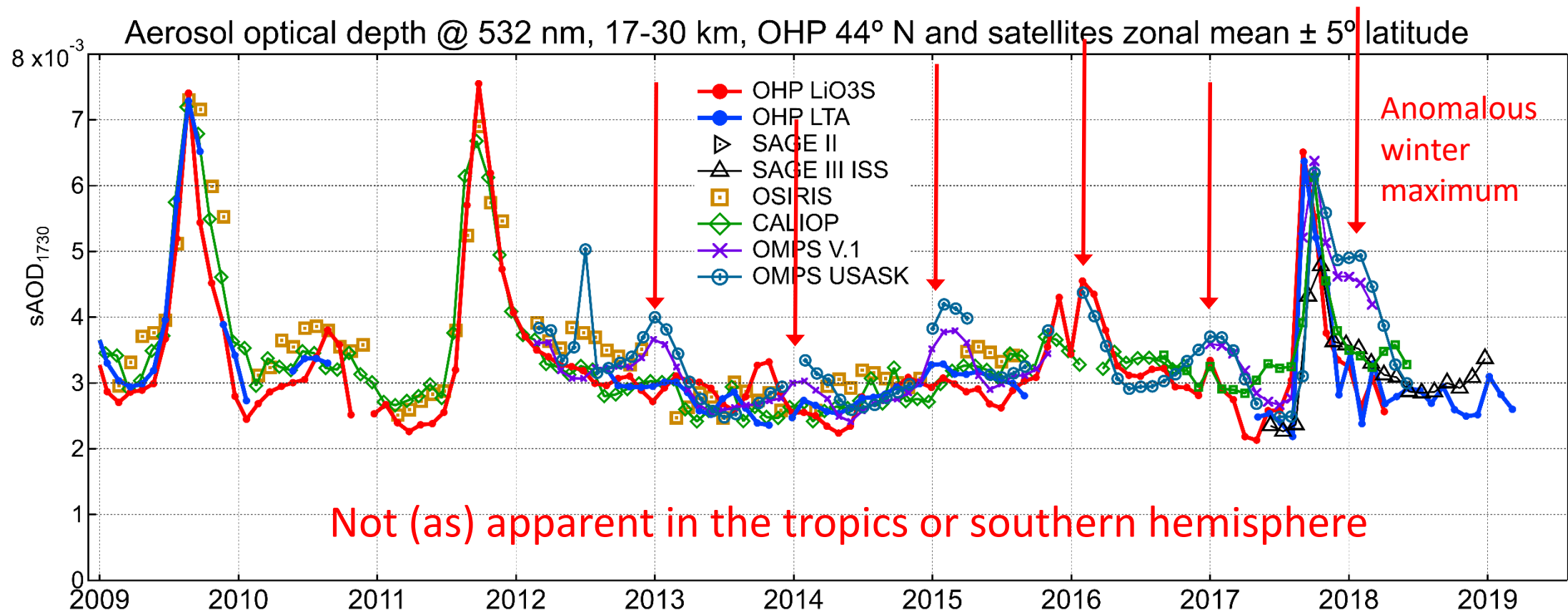
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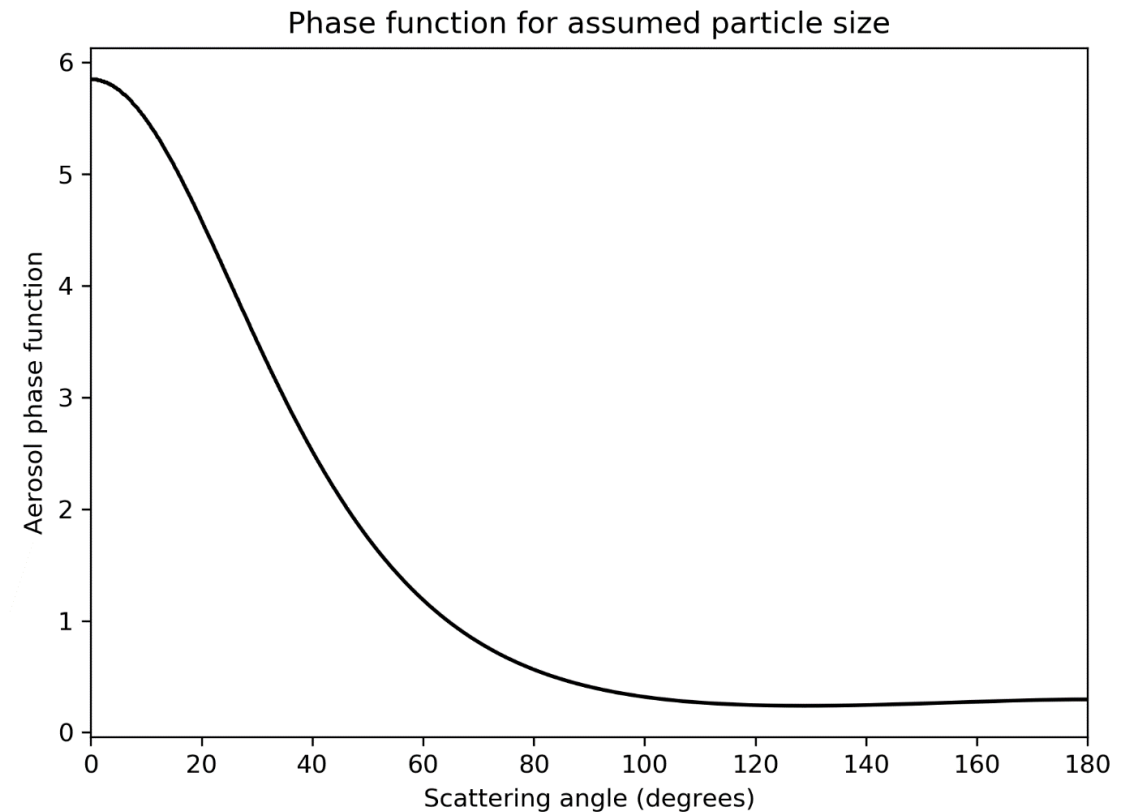
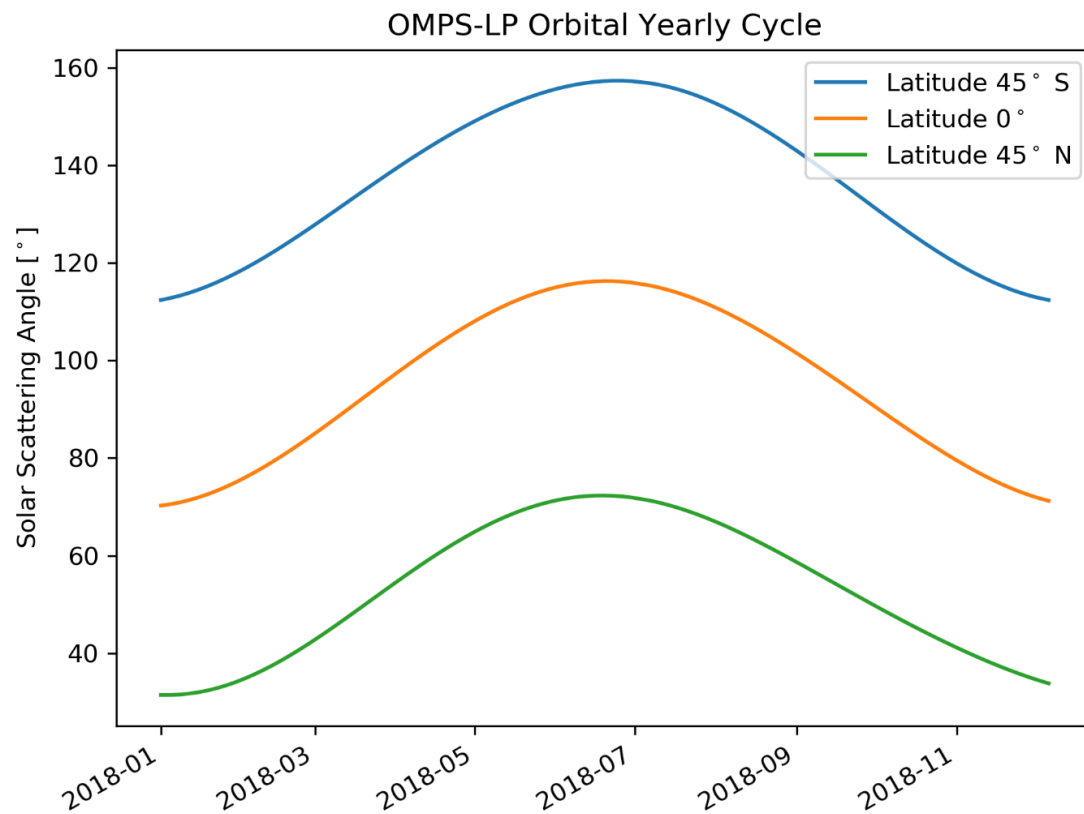
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OMPS-LP Aerosol extinction: The problem

The assumed particle size distribution defines the scattering phase function

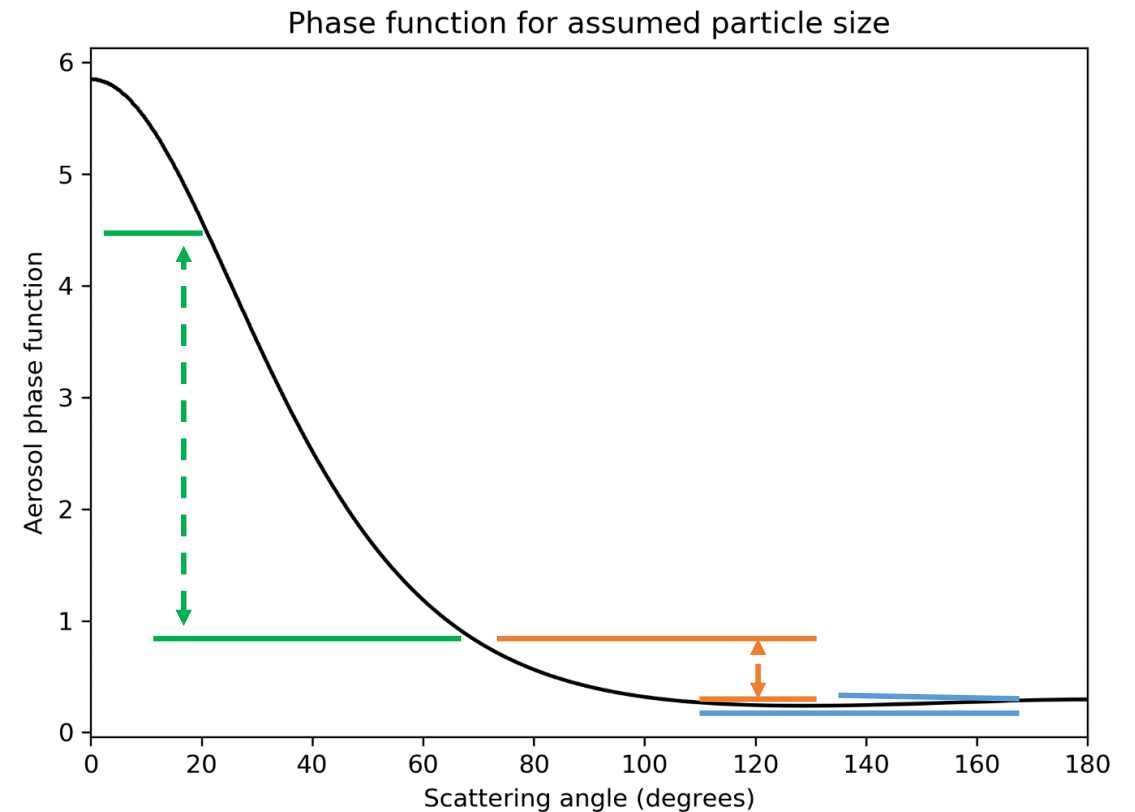
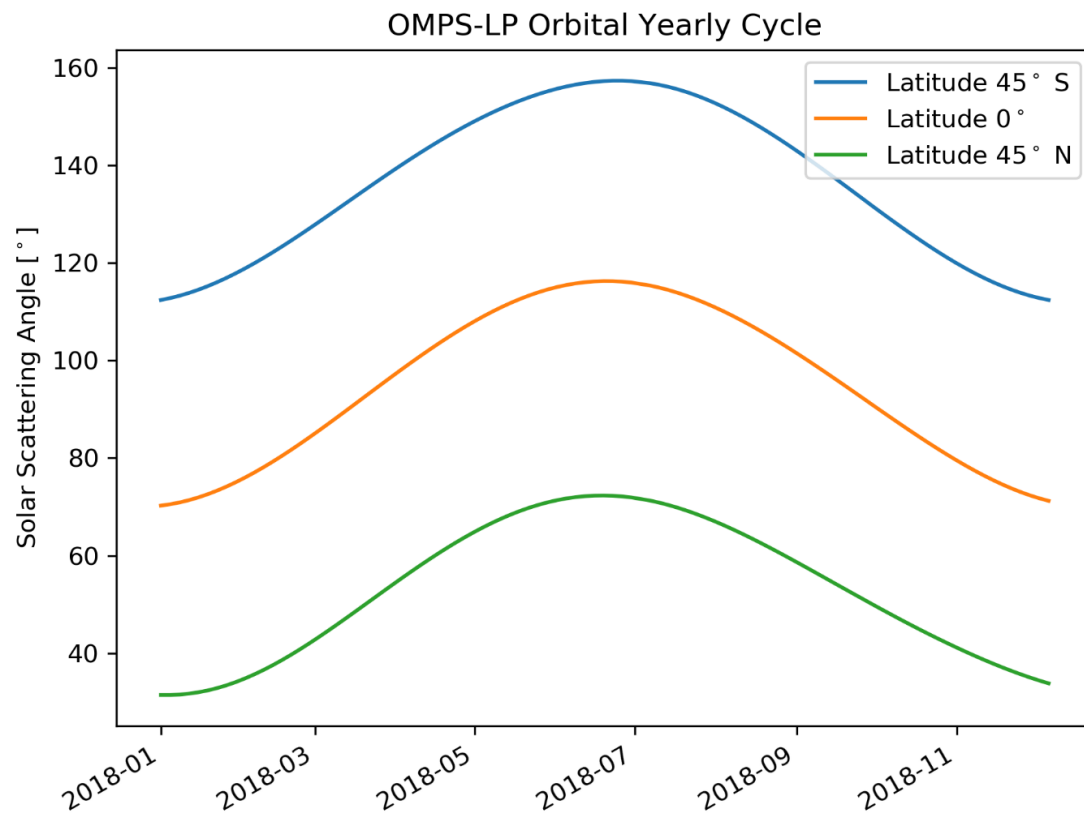
The OMPS-LP orbital geometry has yearly cycle, with forward scattering in the Northern Hemisphere



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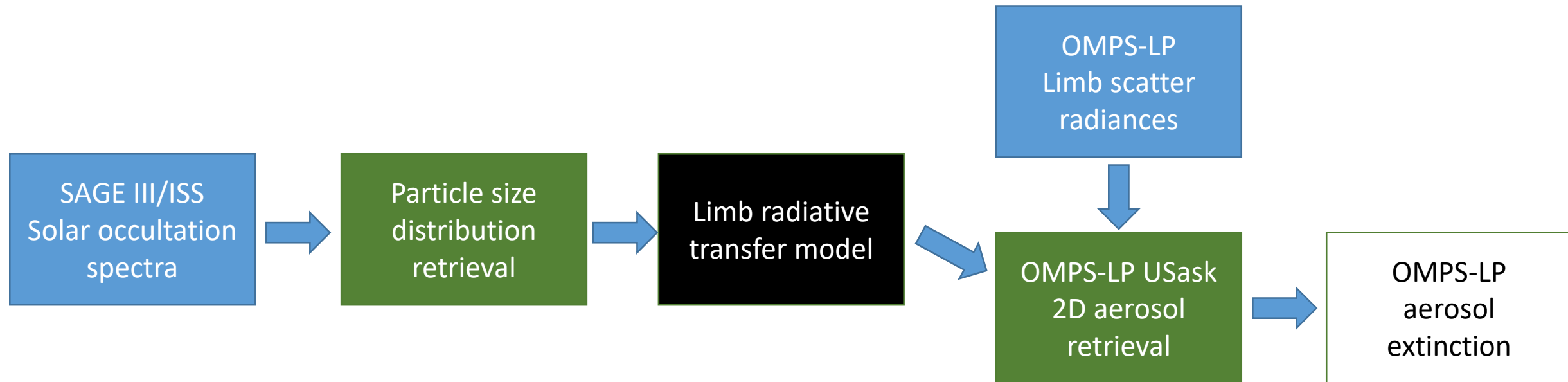
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The joint retrieval idea

Use SAGE III/ISS solar occultation to derive particle size distribution parameters

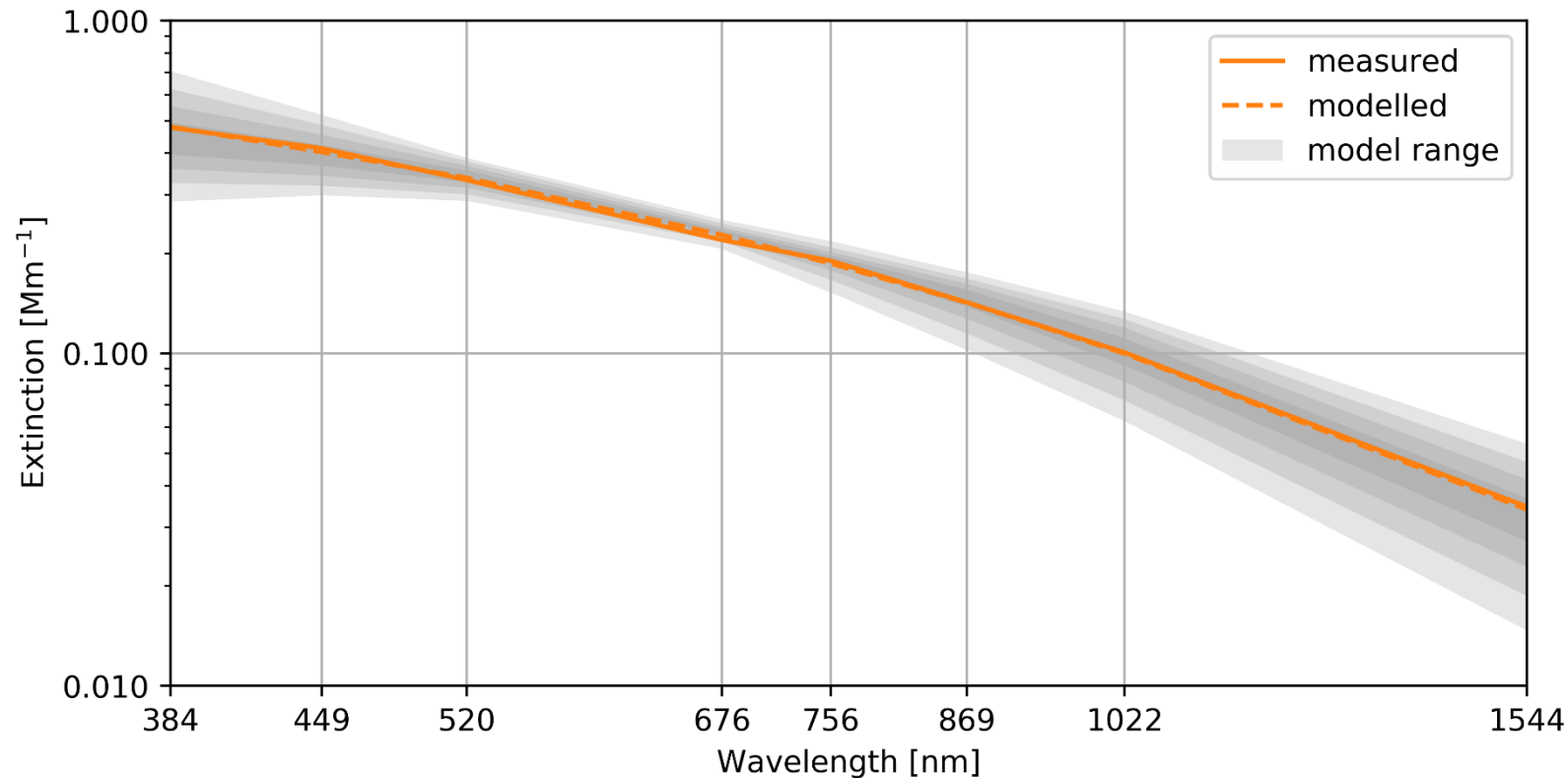
Use these particle size parameters in the forward model for the OMPS-LP aerosol extinction retrieval



Idea credit to Rob Loughman
and maybe others?

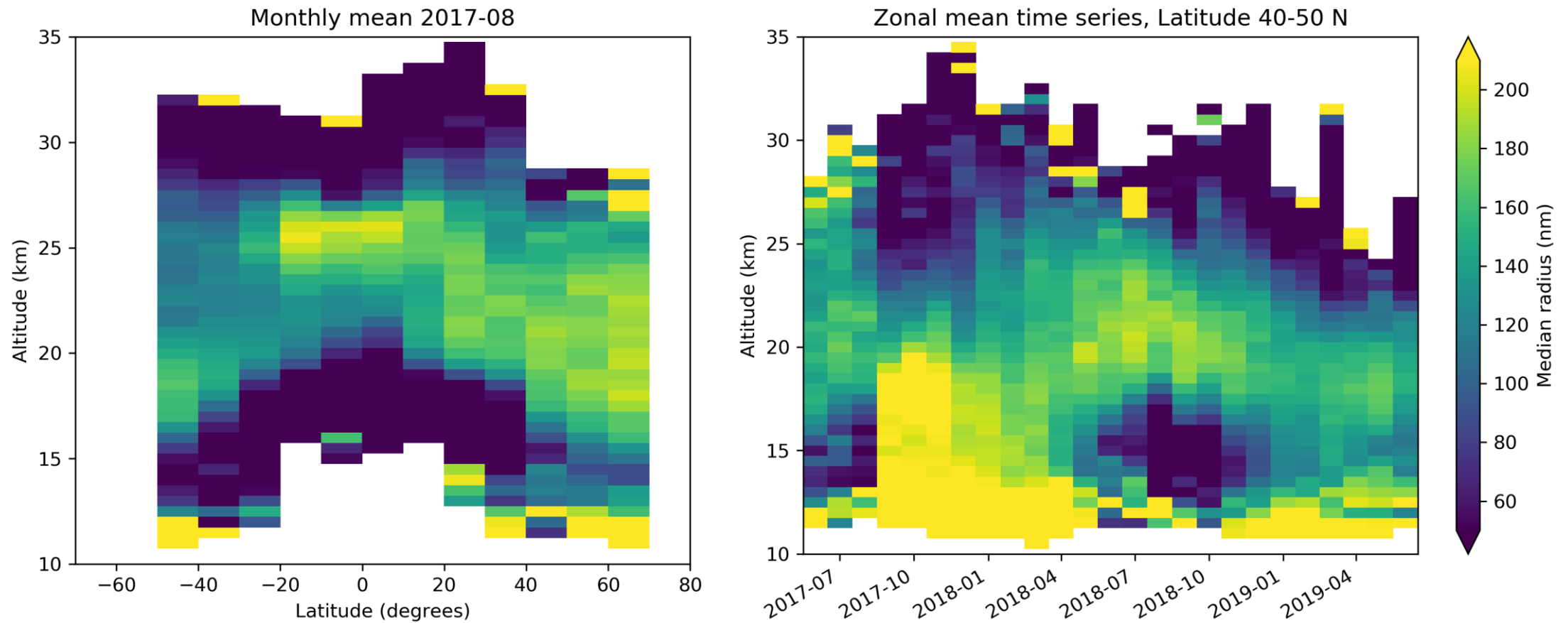
SAGE III/ISS: Particle size retrieval

Single mode log-normal size distribution (median radius and width)
Minimize fit between Mie solution and SAGE III/ISS extinction spectra
All channels from 384 to 1545, excluding 600 nm
Performed on monthly 10-degree latitude binned extinction



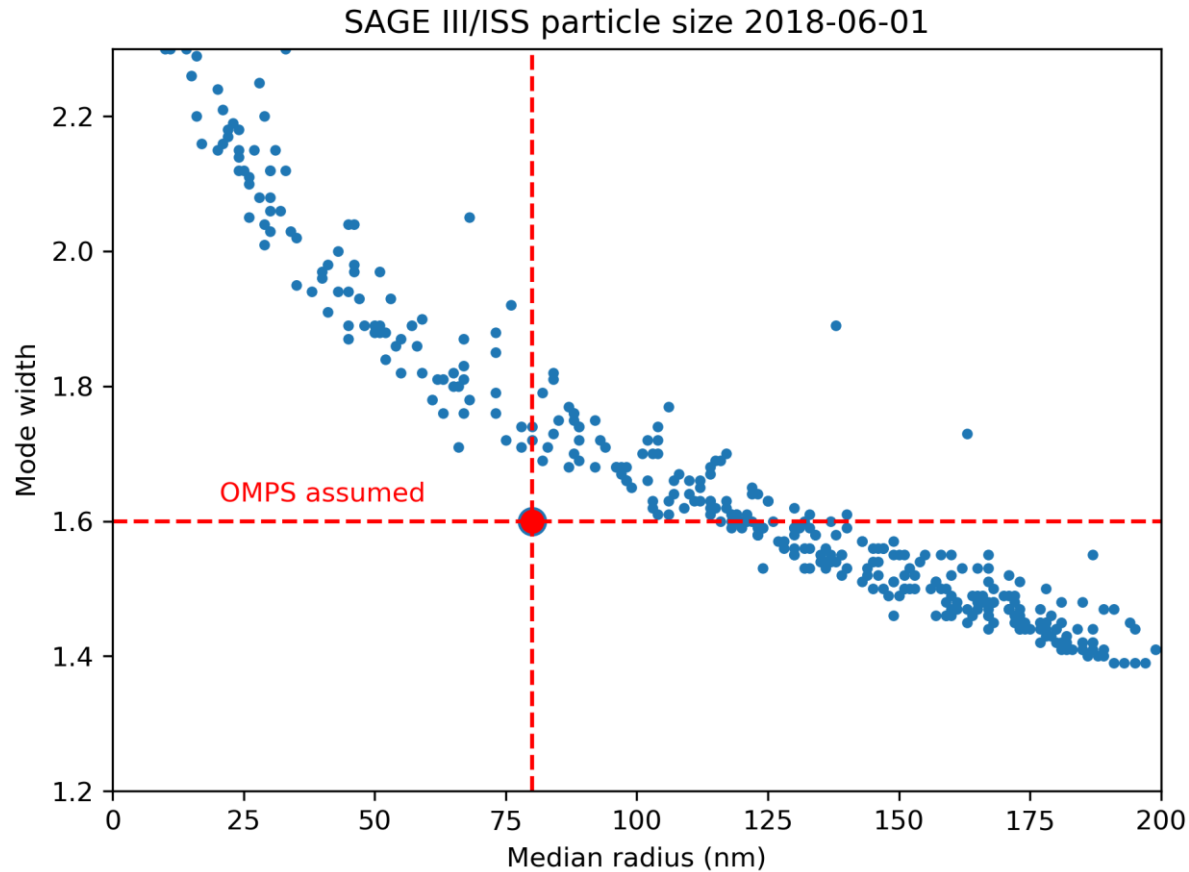
SAGE III/ISS: Particle size retrieval results

Monthly zonal average median radius (width not shown)



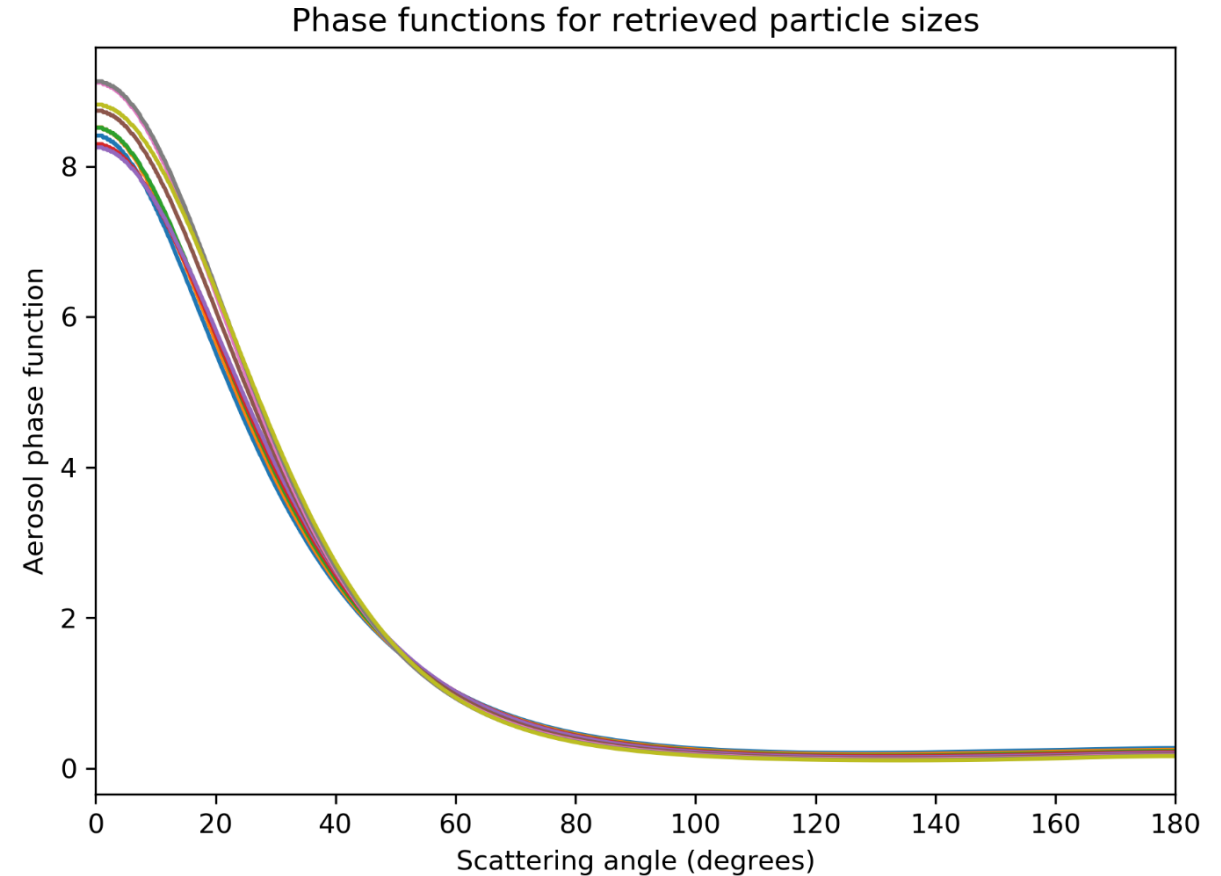
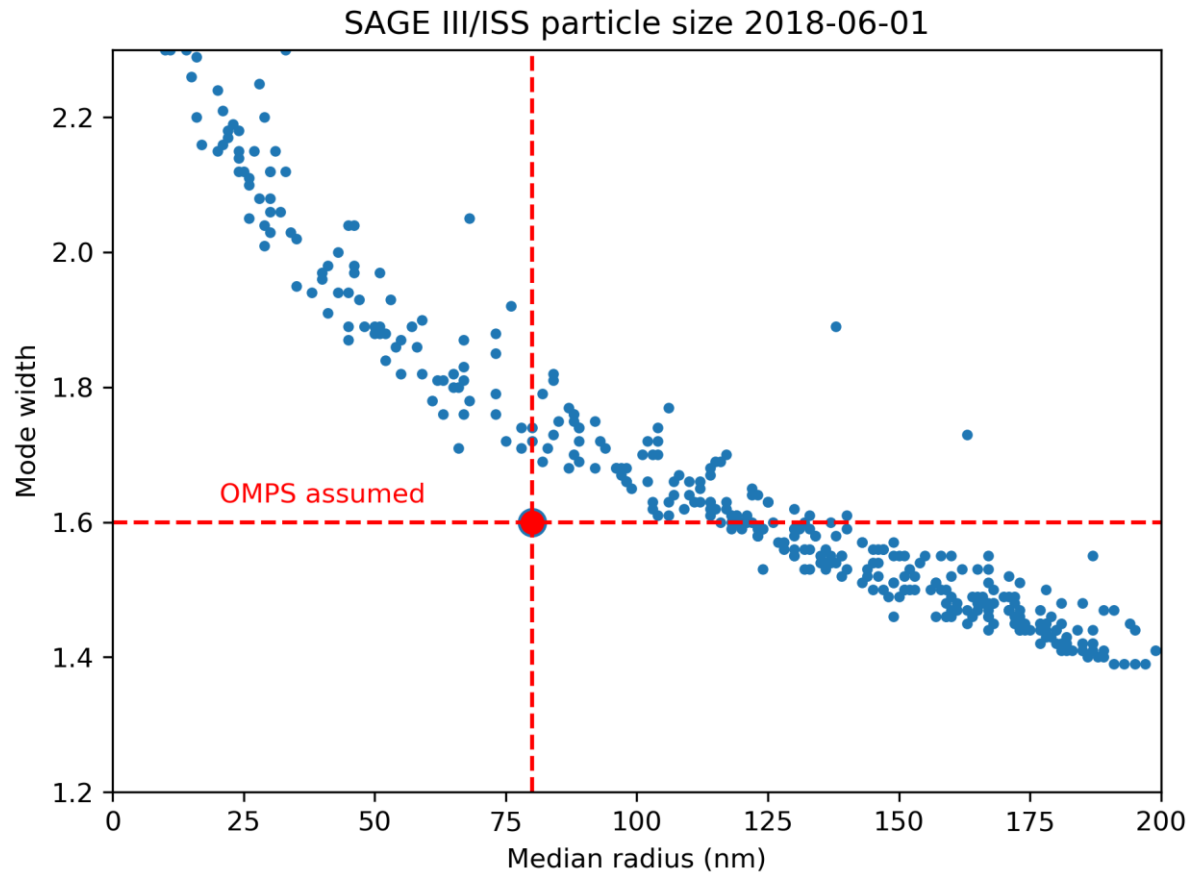
SAGE III/ISS: Particle size retrieval results

Retrieved size distribution parameter space and the scattering phase functions



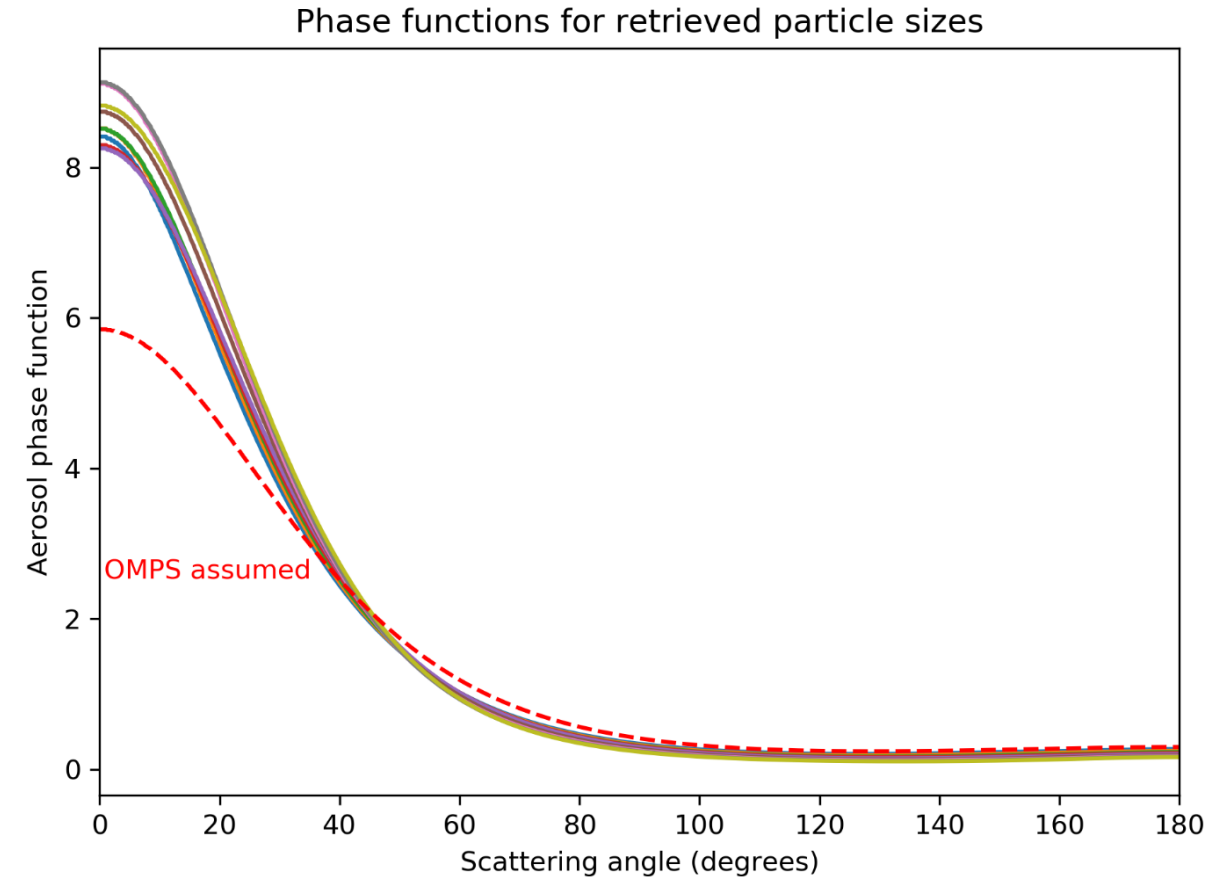
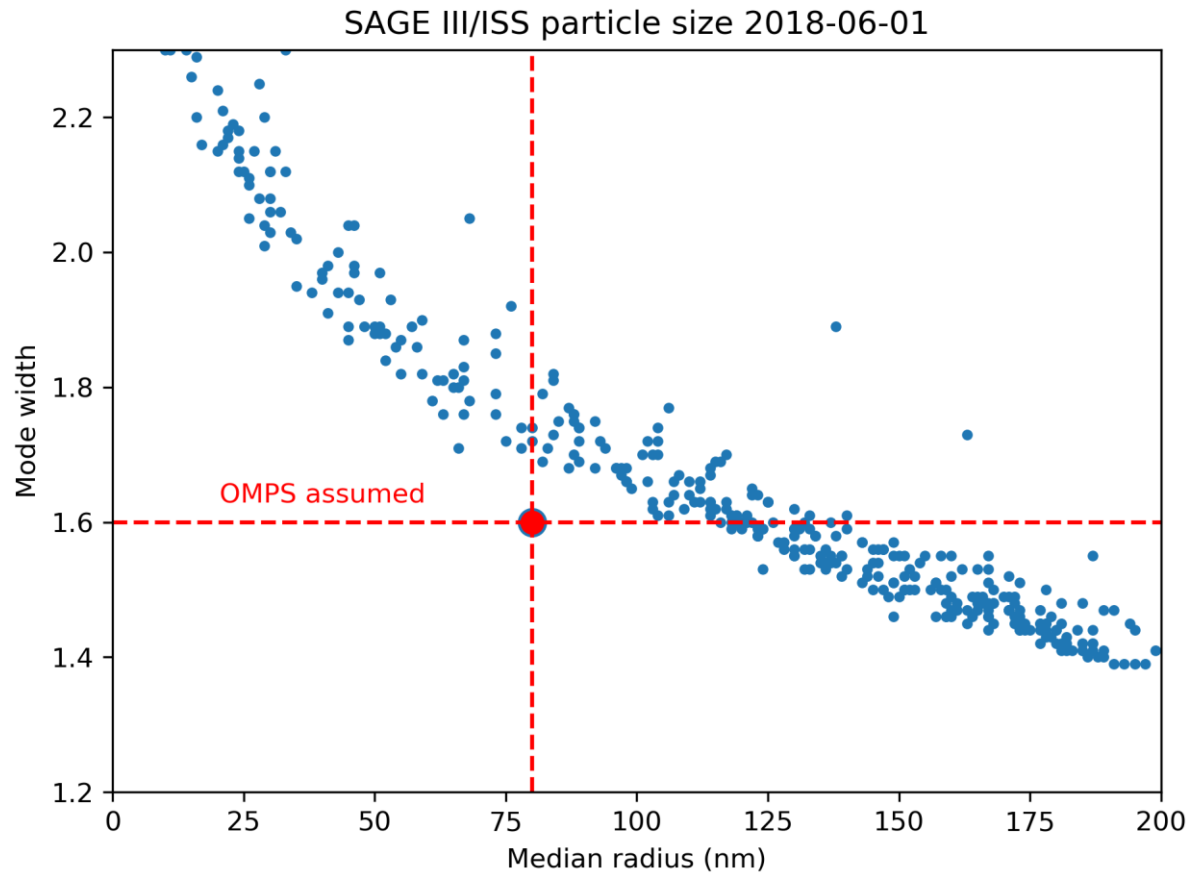
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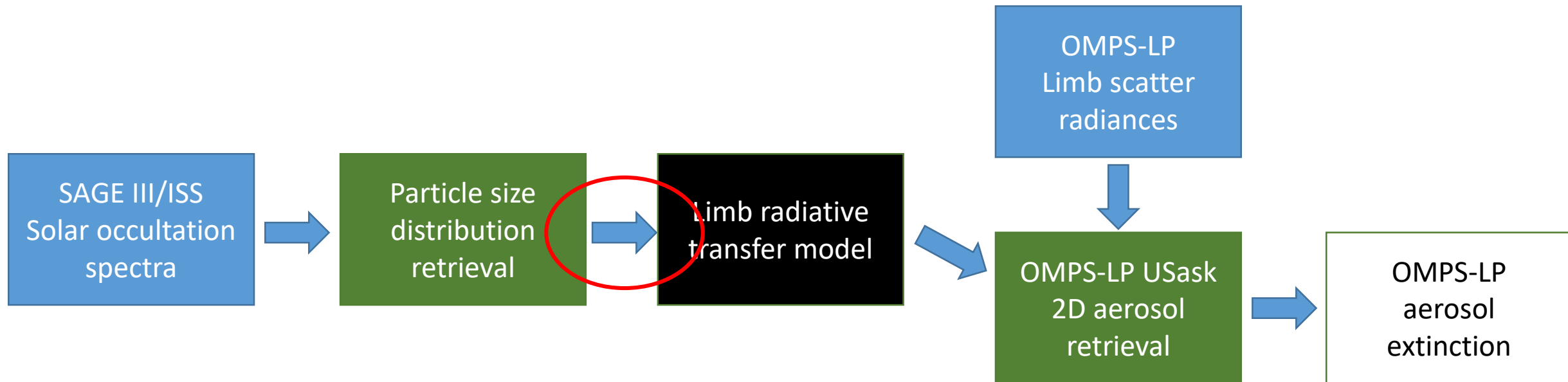
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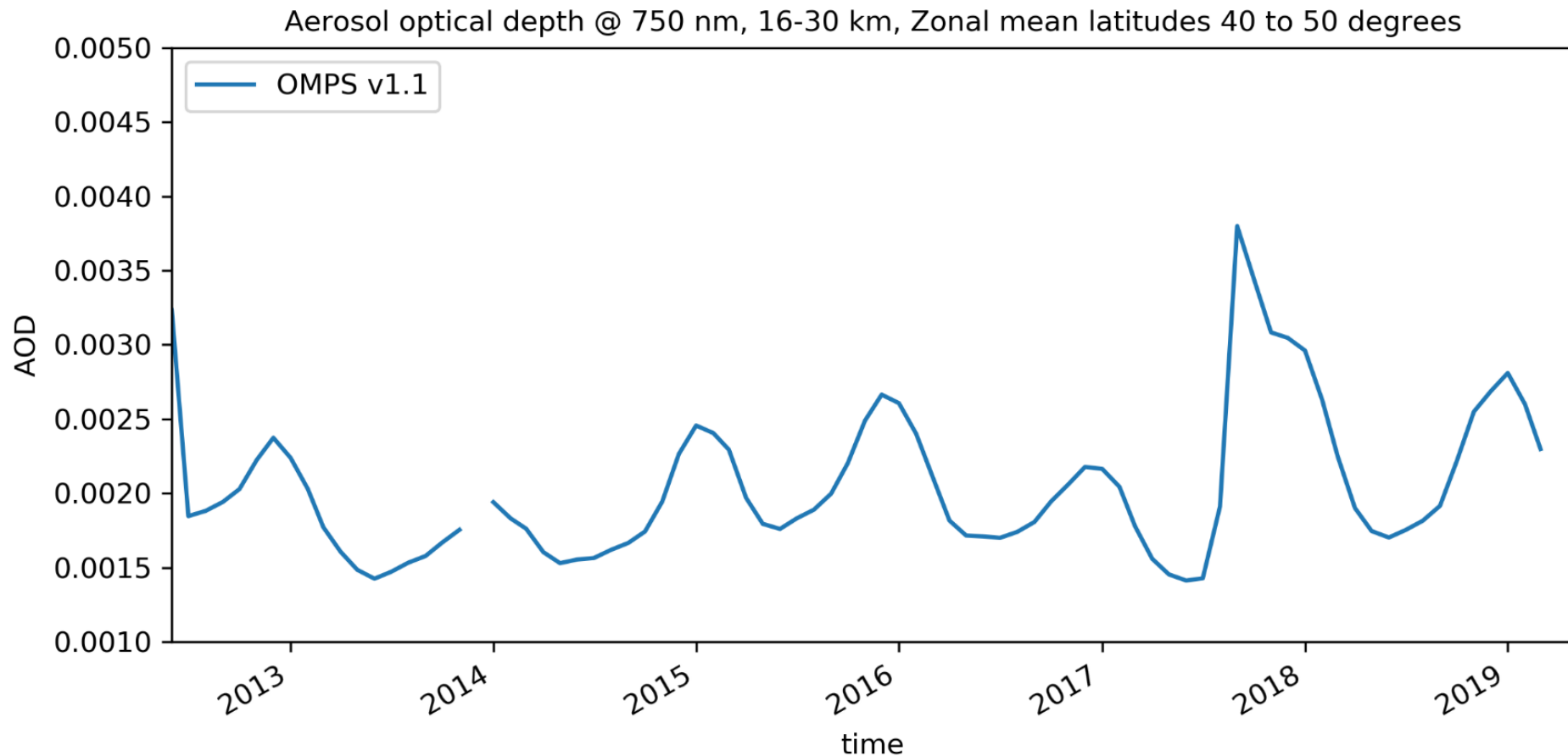
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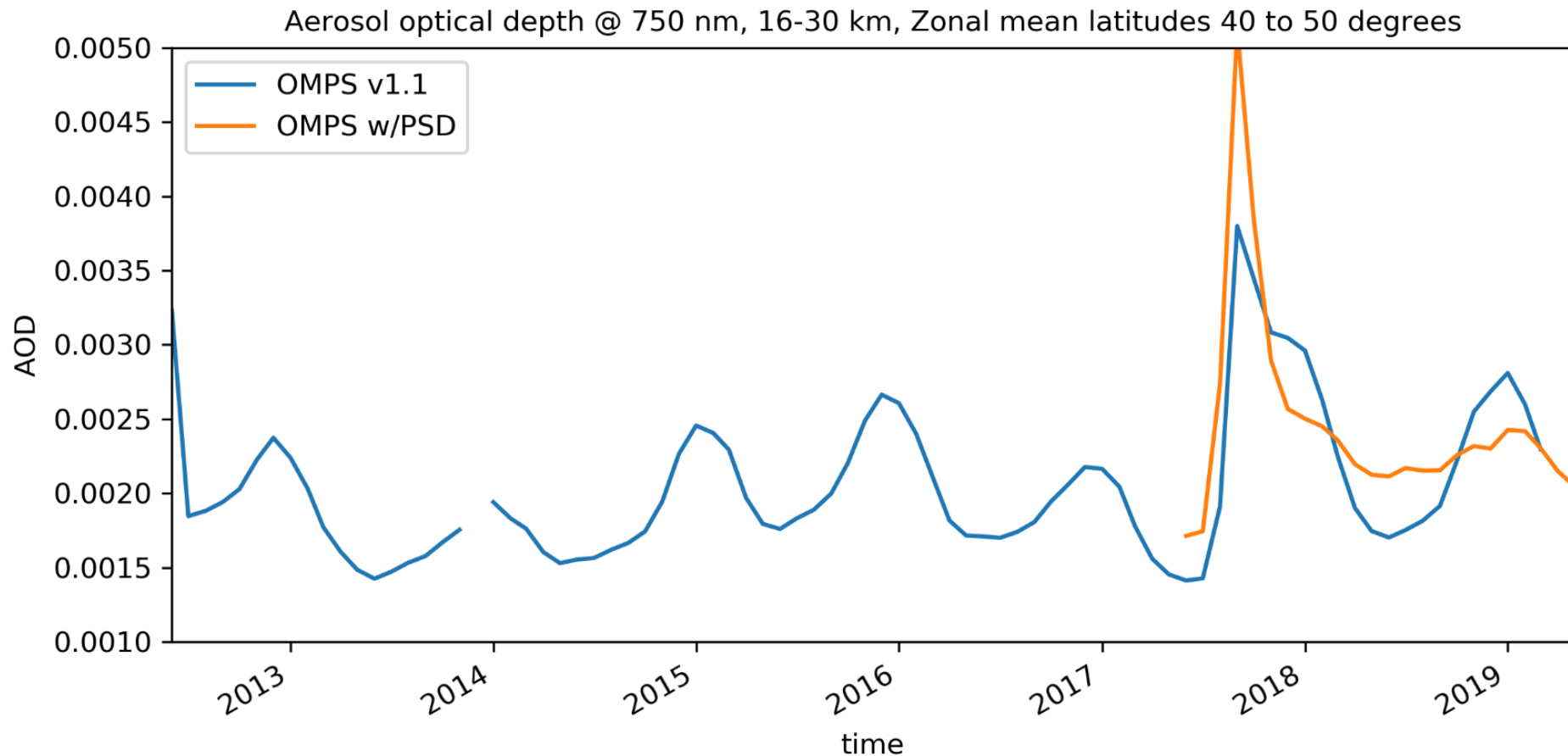
OMPS-LP extinction (recreating Sergey's figure)

Baseline USask retrieval with assumed particle size distribution



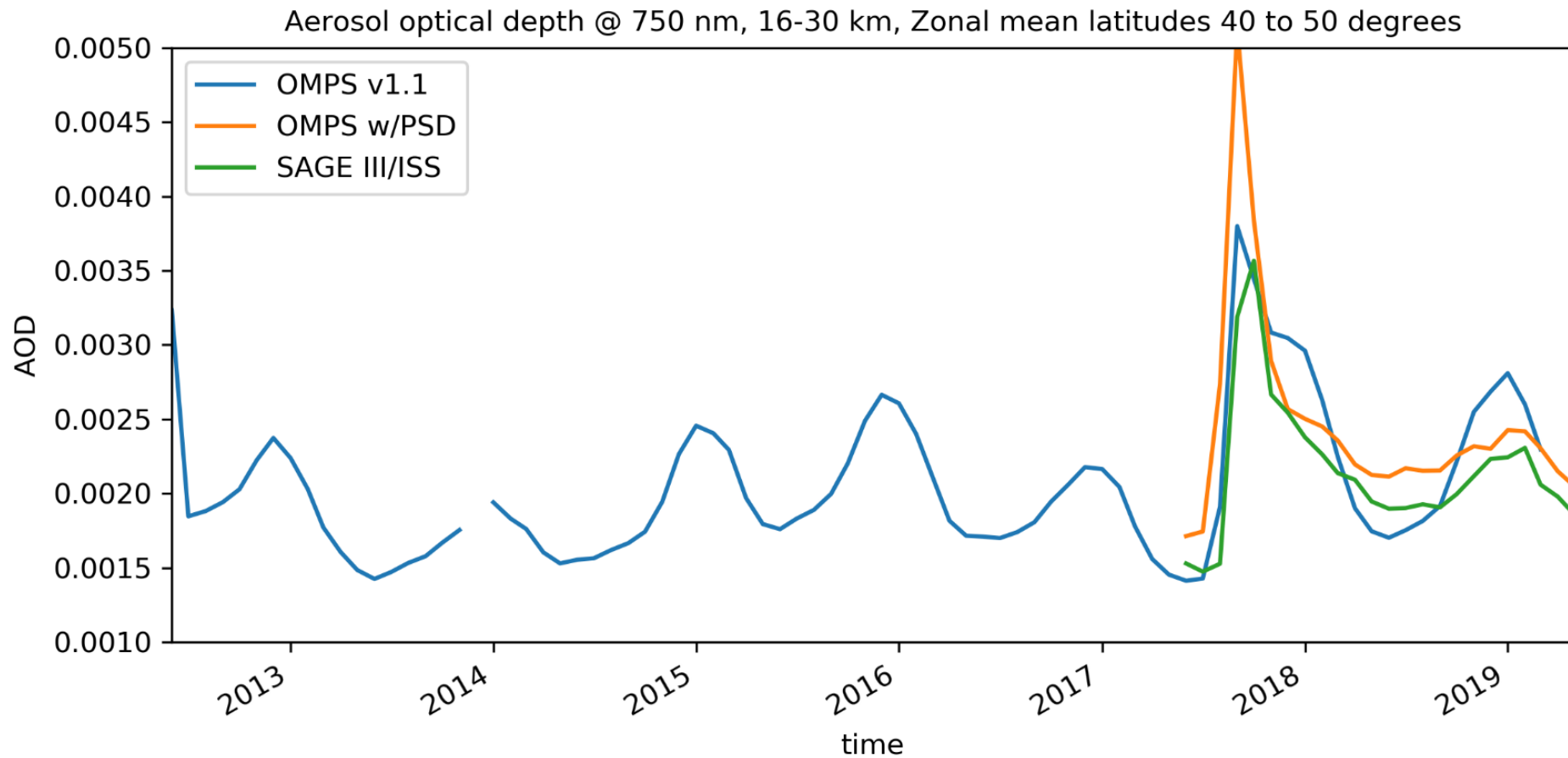
OMPS-LP extinction with SAGE III particle size

Particle size parameters linearly interpolated in time and latitude for each OMPS orbit



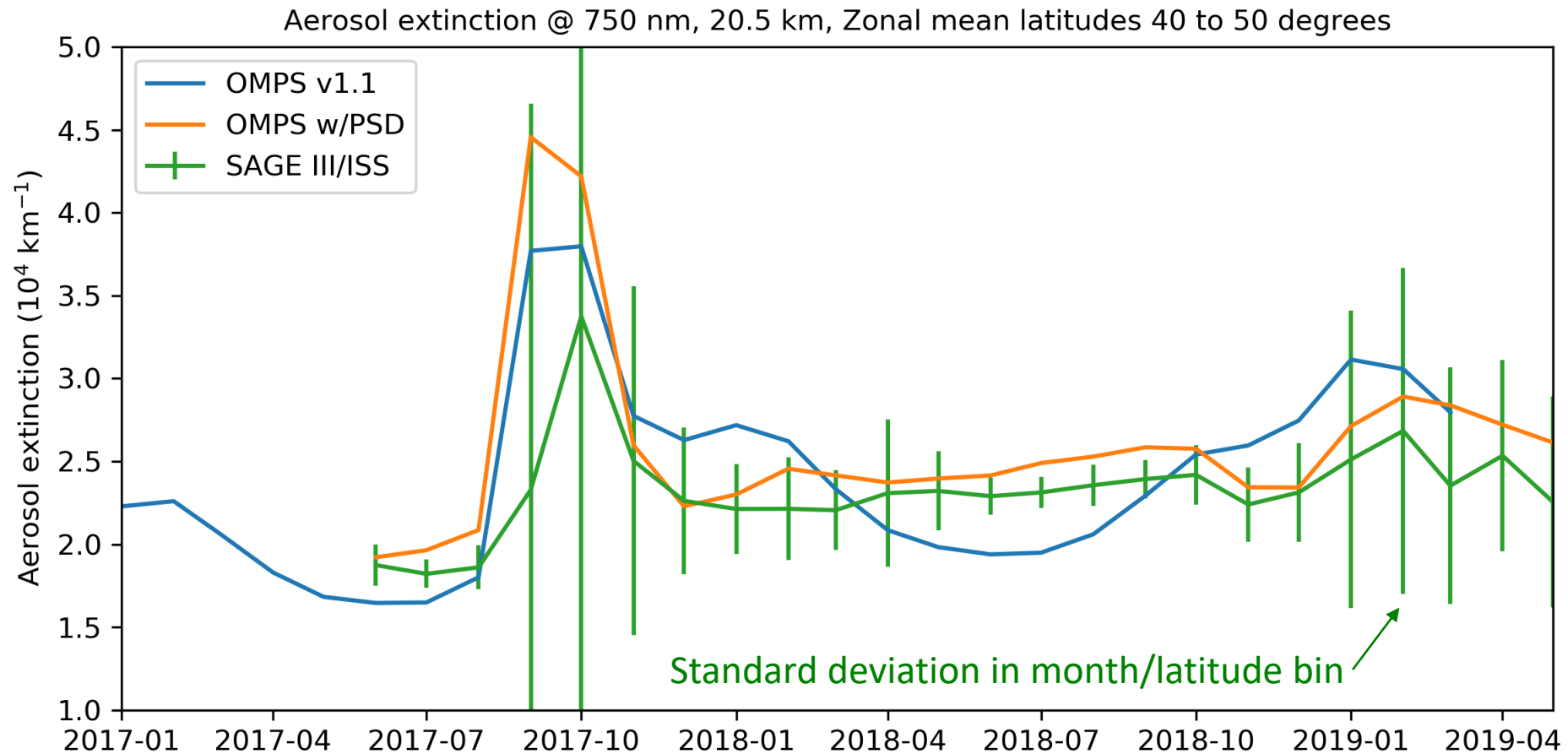
OMPS-LP extinction with SAGE III particle size

Add SAGE III/ISS AOD for reference



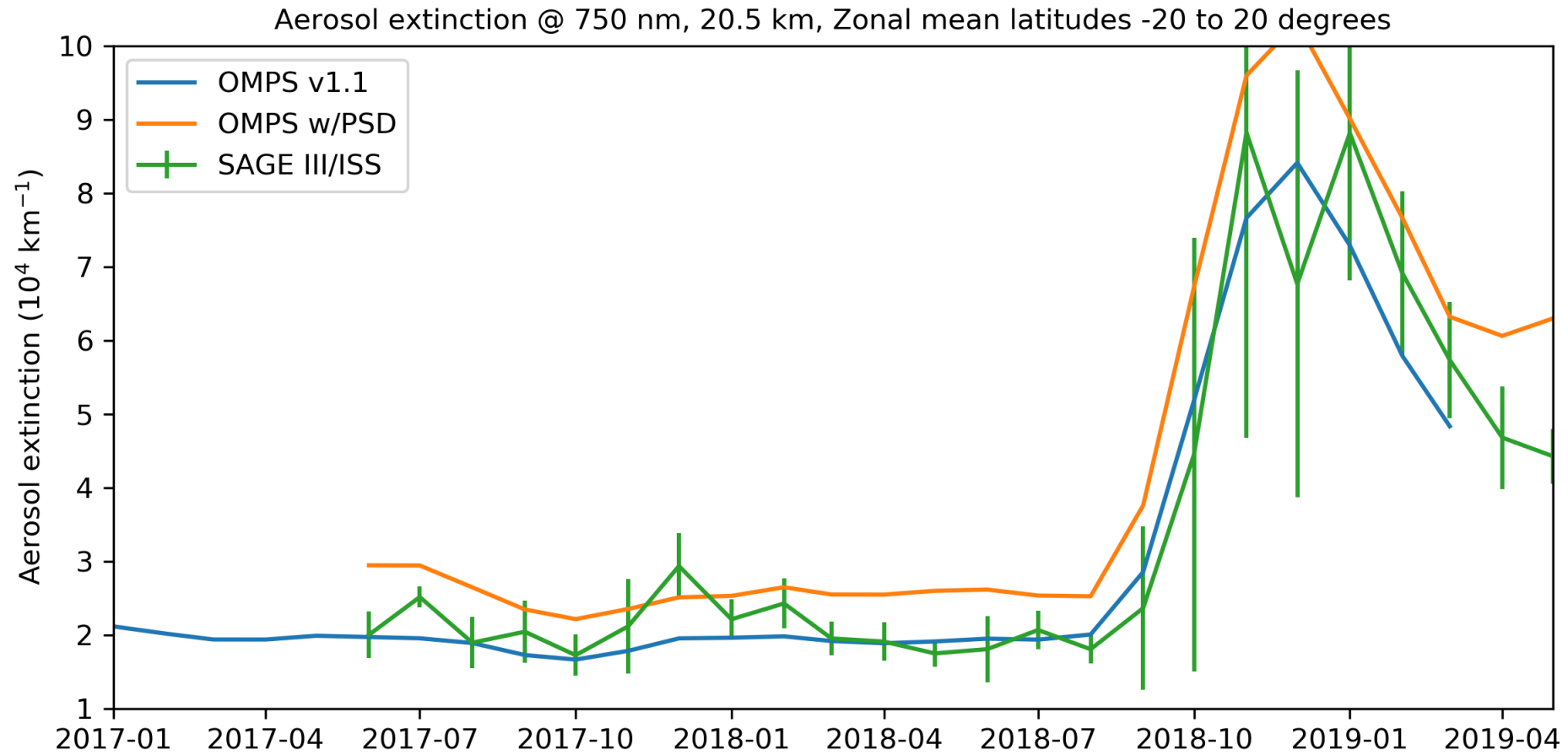
OMPS-LP extinction with SAGE III particle size

Aerosol extinction at 750 nm during SAGE III/ISS mission time period: northern mid-latitude



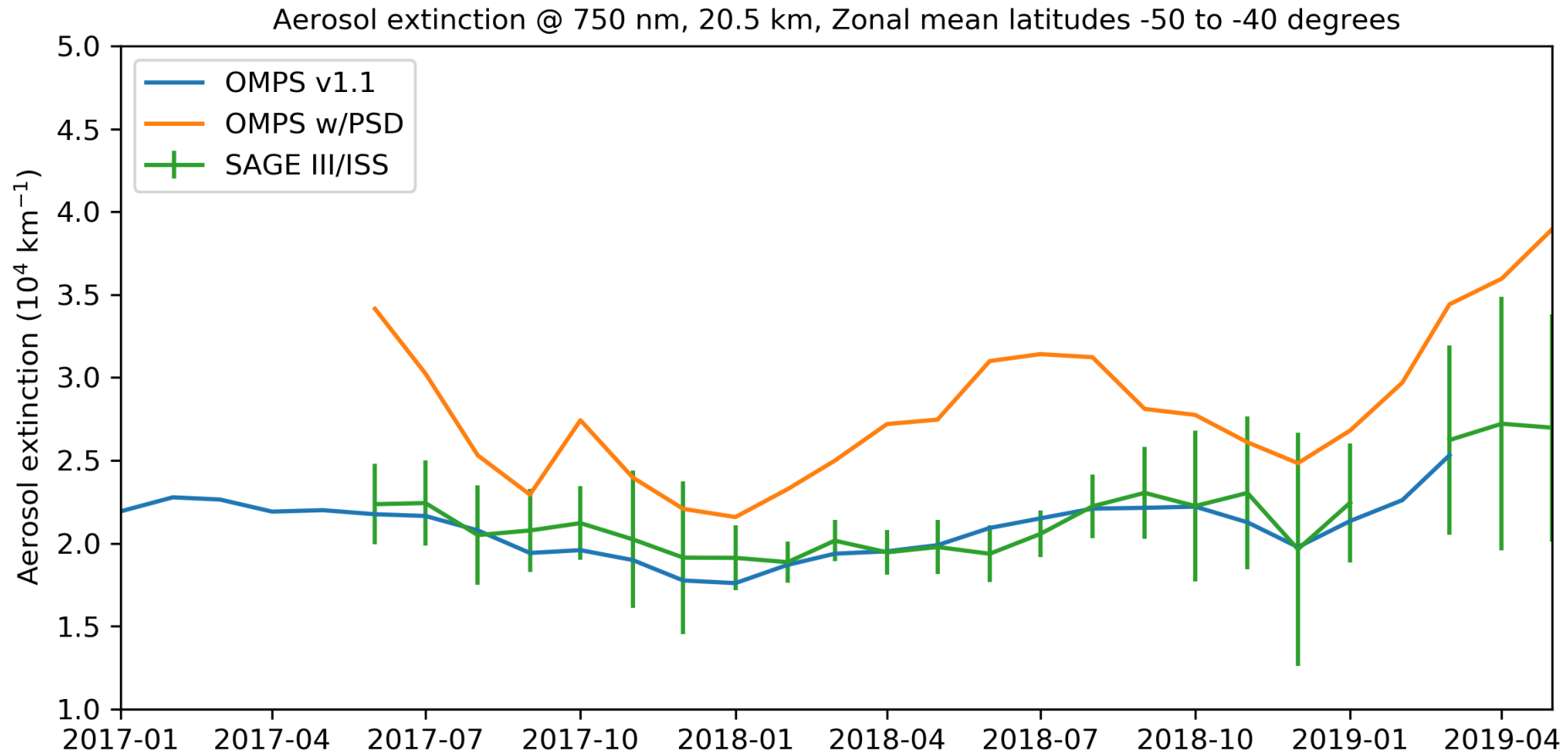
OMPS-LP extinction with SAGE III particle size

Aerosol extinction at 750 nm during SAGE III/ISS mission time period: Tropics



OMPS-LP extinction with SAGE III particle size

Aerosol extinction at 750 nm during SAGE III/ISS mission time period: Southern mid-latitudes



Conclusions

- Particle size distribution parameters from SAGE III/ISS
 - Coherent and geophysical
 - Can be used to derive scattering phase functions for OMPS aerosol extinction retrieval
- Results from OMPS retrievals with SAGE III/ISS particle size
 - Improvement of the “anomalous cycle” in northern hemisphere
 - Introduces a systematic bias at other latitudes
- Occultation + limb scatter as a feasible way forward?

This episode is brought to you by SASKTRAN

- SASKTRAN model developed for OSIRIS; fully spherical geometry
 - “Fast” successive order of scattering; “slow” Monte Carlo
 - Optional 2D, 3D, and polarized (vector) modes
 - Built-in cross sections, climatologies, phase functions
 - Easy to use Python installation

