Non-volcanic contributors to stratospheric aerosol load at northern midlatitudes: a multi-platform perspective on Asian pollution and forest fires

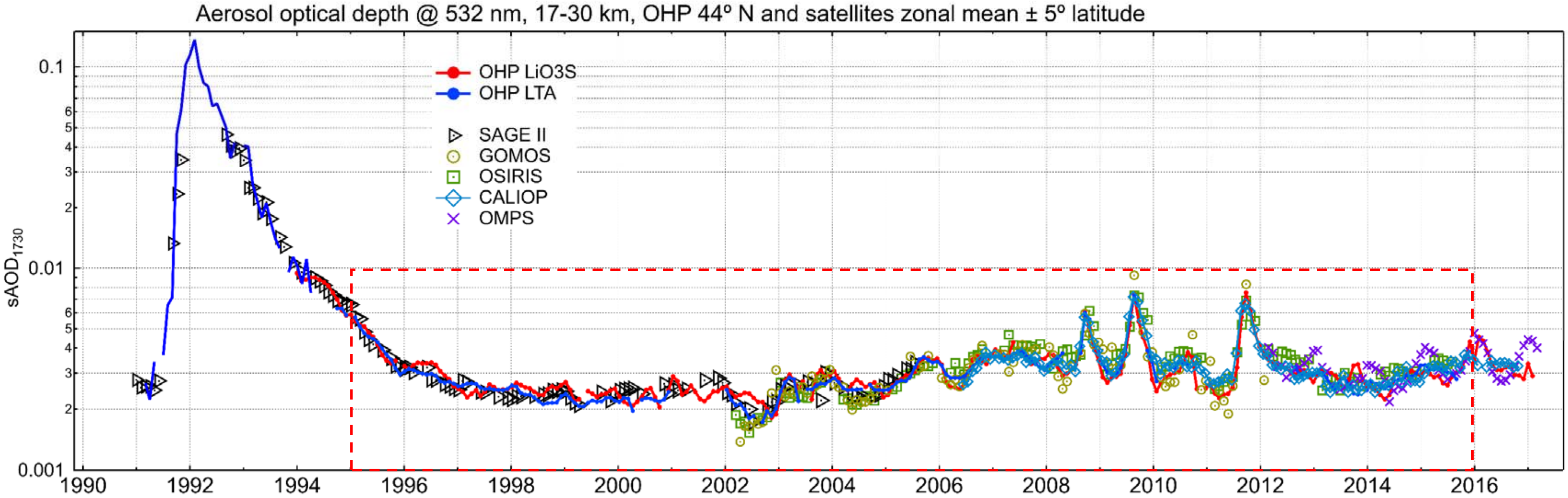
Sergey Khaykin[1], S. Godin-Beekmann[1], P. Keckhut[1], A. Hauchecorne[1]

1 LATMOS/IPSL, UVSQ , Sorbonne Universités, CNRS, Guyancourt, France.

With contributions from *J.-P. Vernier, A. Bourassa, C. Bingen, M. DeLand, P.K. Bhartia*

AGU Chapman conference “Stratospheric aerosol in the post-Pinatubo era: Processes, Interactions, and Importance”, Tenerife, 18-23 March 2018

OHP lidar observations: comparison with satellites



⇒ After a thorough reprocessing and quality control OHP lidars provide a benchmark-quality SA record

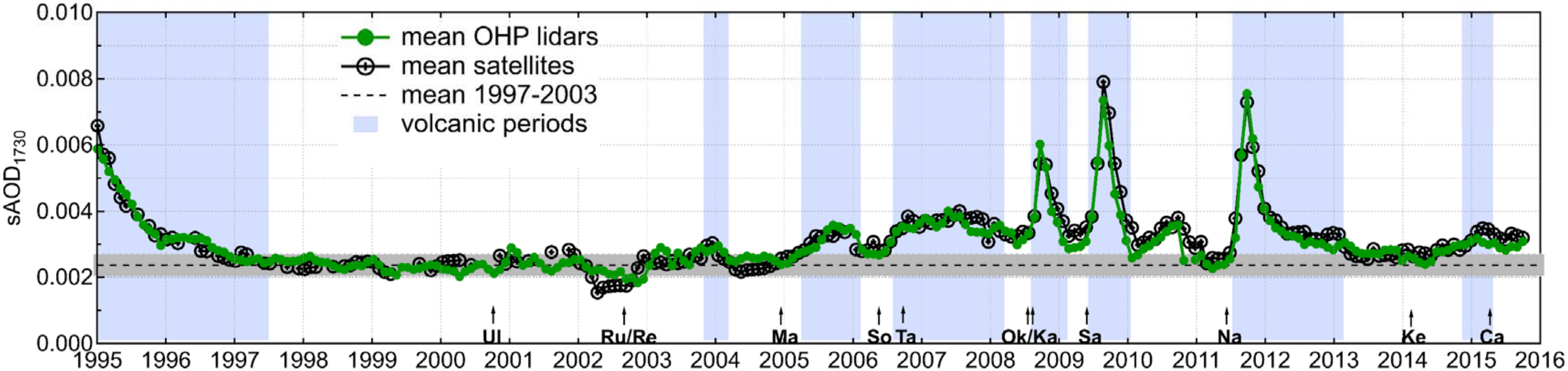
⇒ Excellent agreement between the two OHP lidars and satellite series

⇒ Long-term ground-based observations are indispensable for ensuring continuity and coherence of SA record bridging different satellite records

OHP lidar observations: detection of quiescent periods

Stratospheric Aerosol Optical Depth 17-30 km ($sAOD_{1730}$) @ 532 nm

Mean of **OHP lidars** and **satellites**

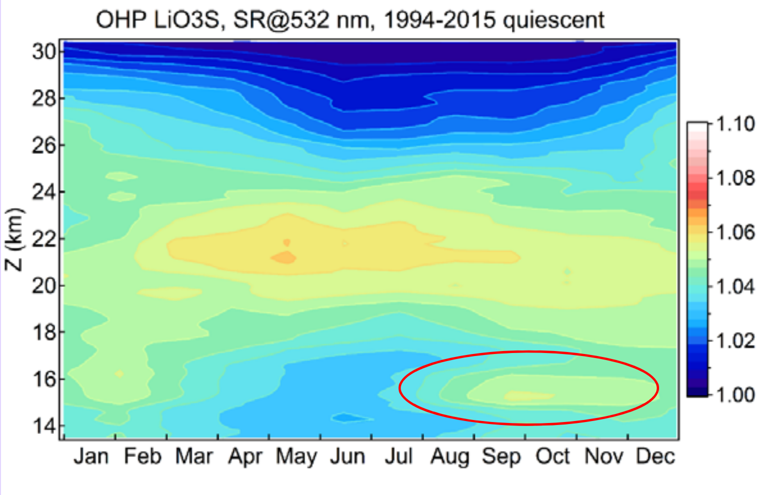


- ✓ “Reference” background level of sAOD at mid-latitudes accurately determined
- ✓ A combination of local and global observations was used to separate between volcanically-perturbed and quiescent periods
- ✓ Volcanically-perturbed periods identified using global satellite and OHP lidar data on the base of a set of criteria

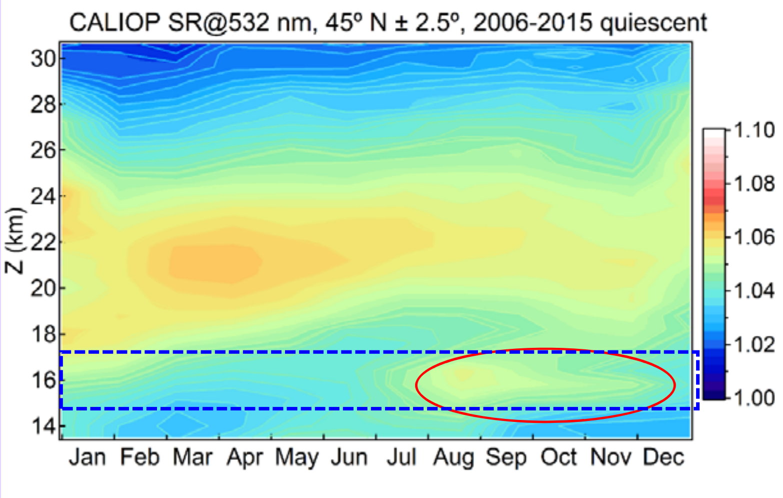
Khaykin et al., ACP, 2017

Background aerosol annual cycle

OHP lidar, volcanoes cleared

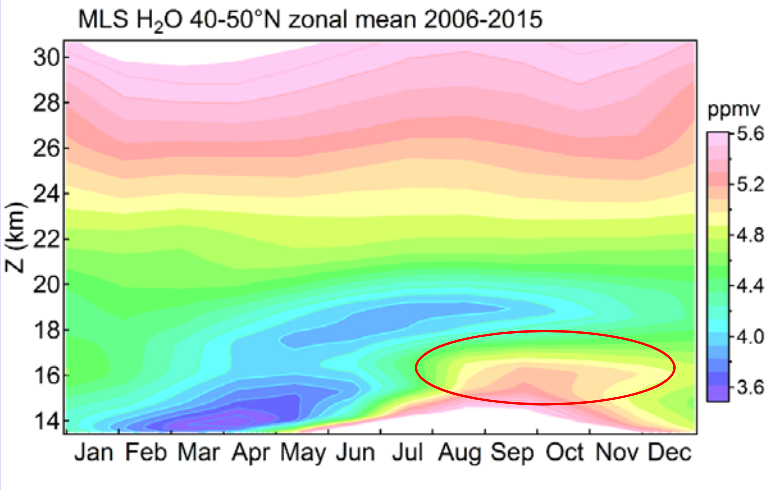


CALIOP, 40-50°N volcanoes cleared



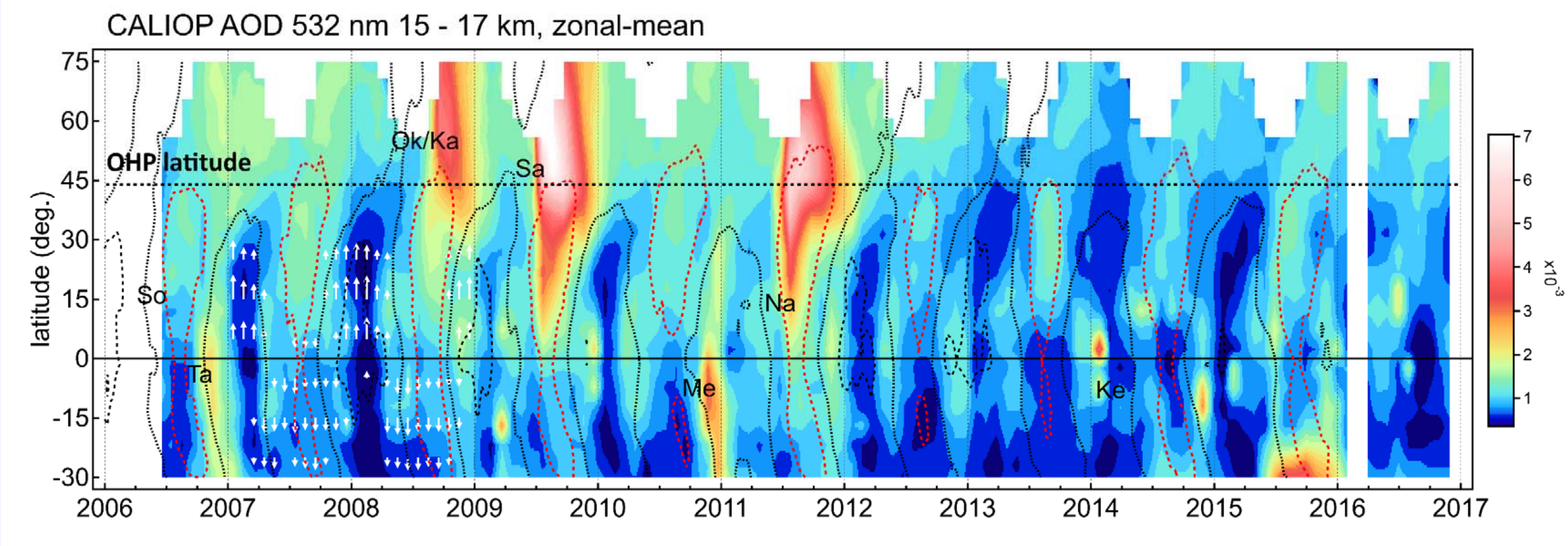
- ATAL signal at mid-latitudes (ex-ATAL)
- Influx of moist air from Asian monsoon UT/LS
- Similarity between water and aerosol annual cycle in the LS suggests that both of them are modulated by transport

MLS H_2O: 40-50°N 2006-2015



Khaykin et al., ACP, 2017

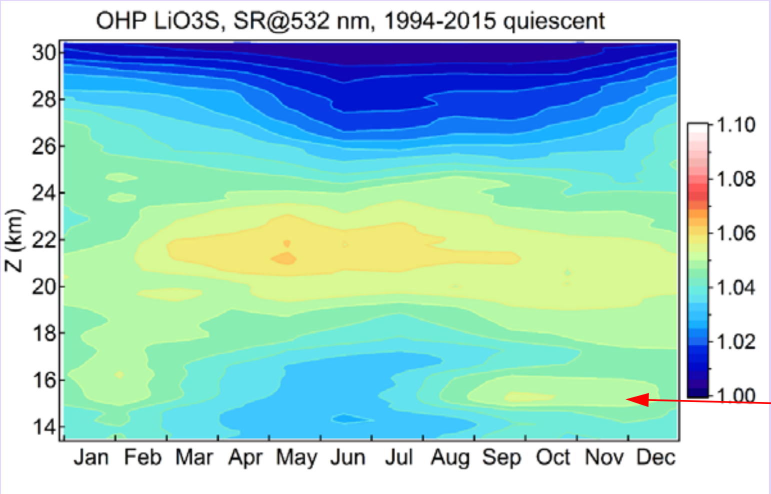
AOD within 15-17 km from CALIOP and MLS water vapour at 100 hPa



- Extension of ATAL to mid-latitudes during late summer
- AOD 15-17 km and water vapour (MLS, 100 hPa) reveal similar patterns
- Poleward transport of convectively-cleansed air from the deep tropics (Vernier et al., 2011)
- Non-volcanic aerosol annual cycle in midlatitude LS is modulated by quasi-horizontal transport from the tropics

Aerosol annual cycle and long-term change

OHP lidar, volcanoes cleared



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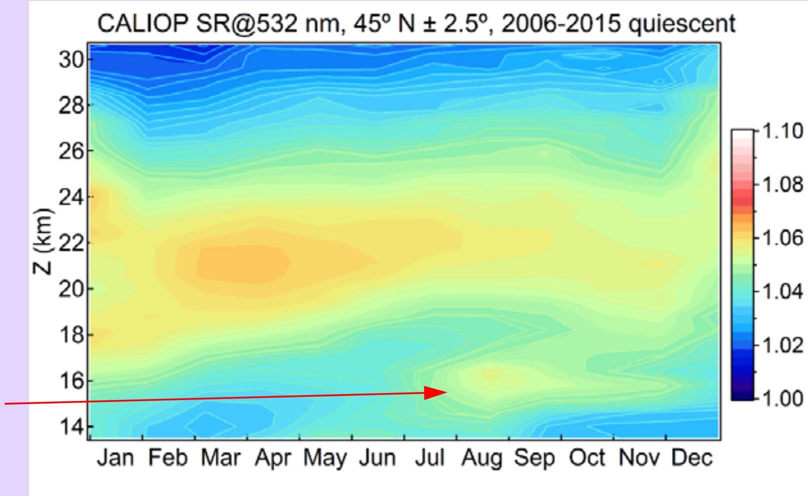
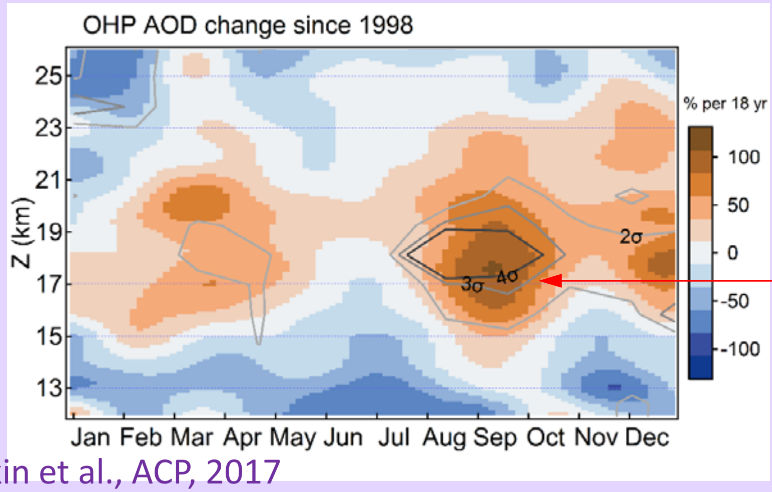
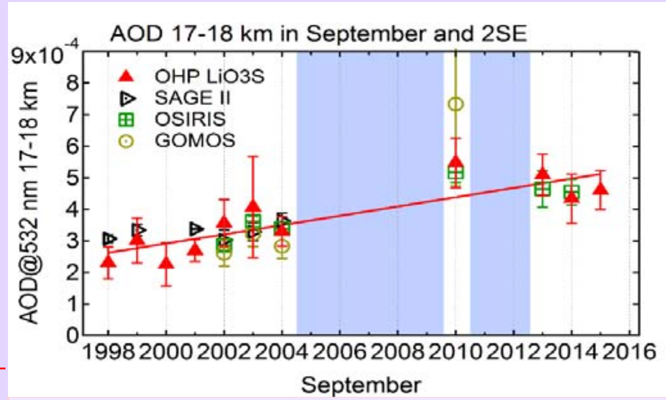


ex-ATAL

Background aerosol long-term change

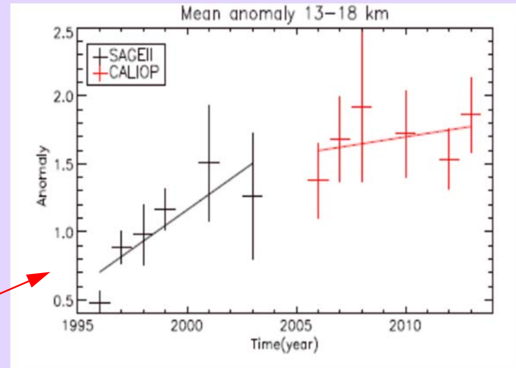




Statistically significant 2 times increase of midlatitudes LS AOD in early Fall

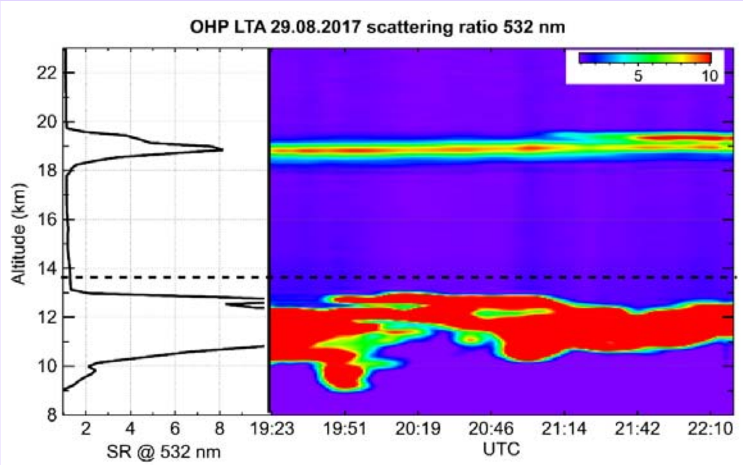
Consistent with 3 times increase of ATAL AOD reported by Vernier et al., 2015

Summer/winter ratio of AOD 13-18 km above Eastern Mediterranean



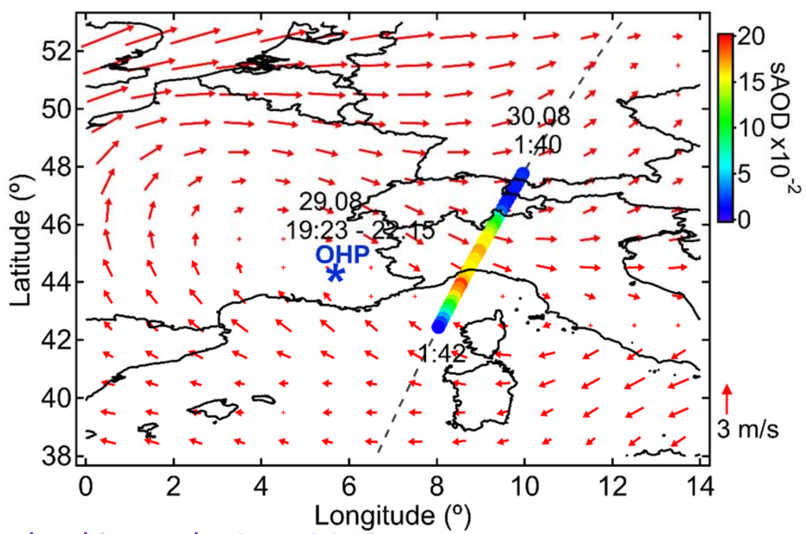
Khaykin et al., ACP, 2017

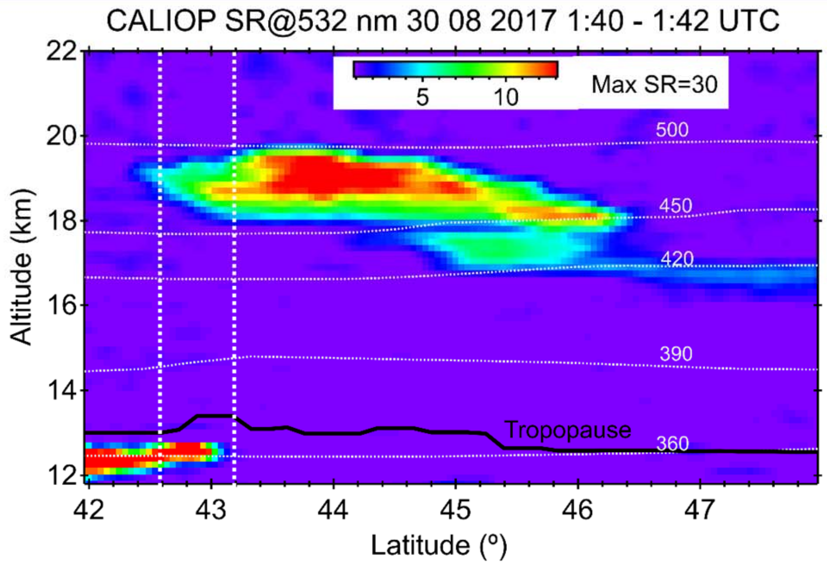
Impact of August 2017 NA wildfires on stratospheric aerosol load

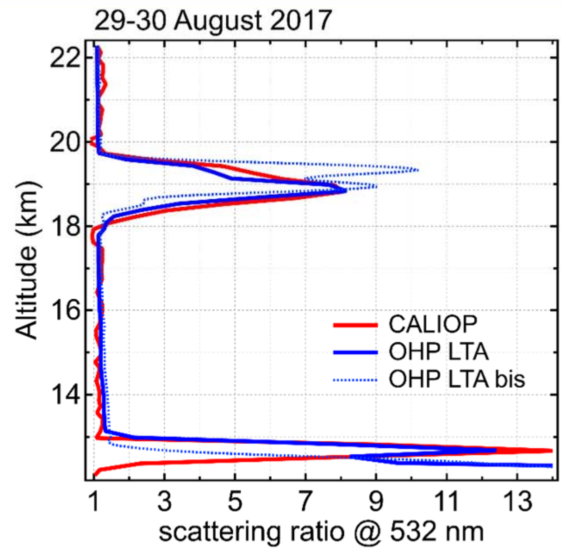


- Stratospheric smoke plumes with unprecedentedly high SR detected at OHP in August-September 2017
- Plumes are traceable to PyroCBs in North America
- Smoke plumes at different levels above OHP through November

- Cross-sampling of the same smoke cloud by OHP lidar and CALIOP
- Excellent agreement between GB and space lidars



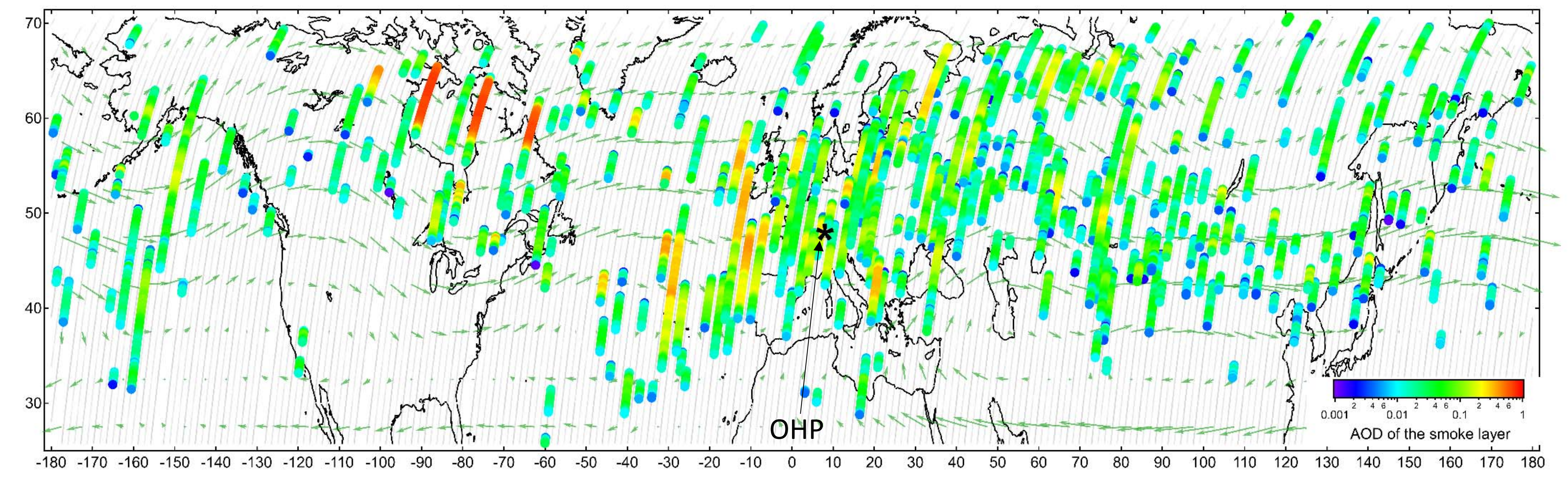




Khaykin et al., GRL, 2018

Impact of August 2017 NA wildfires on stratospheric aerosol load

Locations of stratospheric smoke layer detected by CALIOP nighttime observations (16 Aug – 03 Sep)

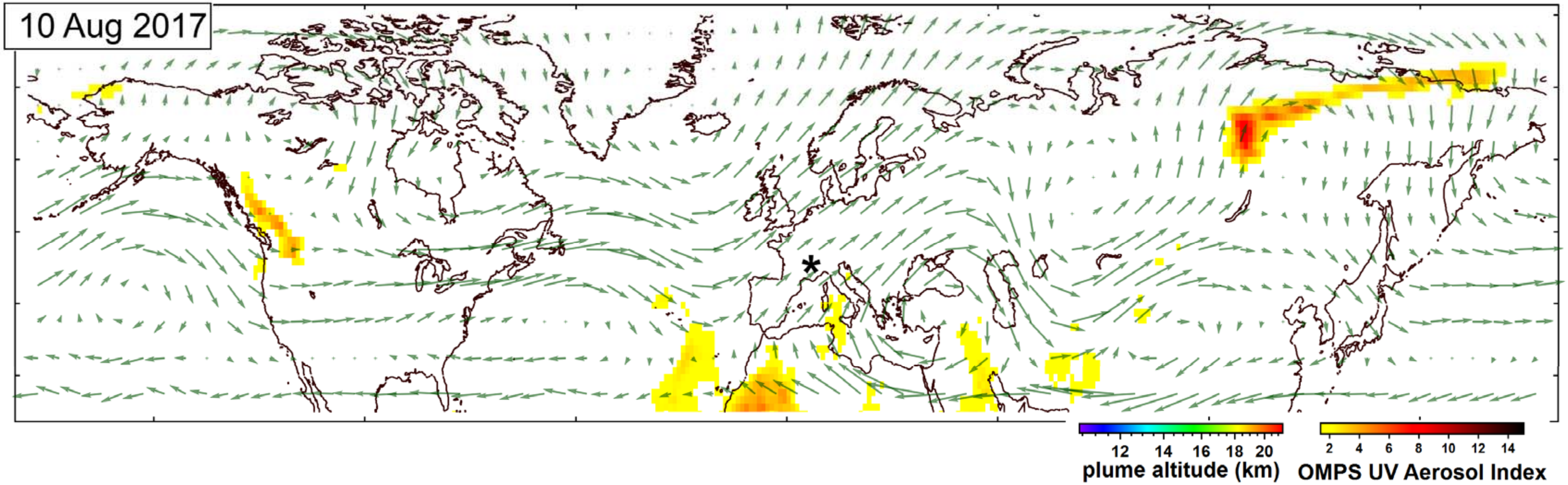


- AOD of the stratospheric smoke plume reaching 0.7 (0.21 above Europe)
- Rapid hemispheric dispersion and entrainment by Asian monsoon

Khaykin et al., GRL, 2018

Impact of August 2017 NA wildfires on stratospheric aerosol load

OMPS UV aerosol index and CALIOP smoke detections



- Several patches of plumes at different levels travelling at different speed
- Forefront plume reaches Europe in a few days
- Smoke plume crossed the globe in about two weeks and dispersed at hemispheric scale
- Additional injections by PyroCbs in Northwest USA in late August

Impact of August 2017 NA wildfires on stratospheric aerosol load

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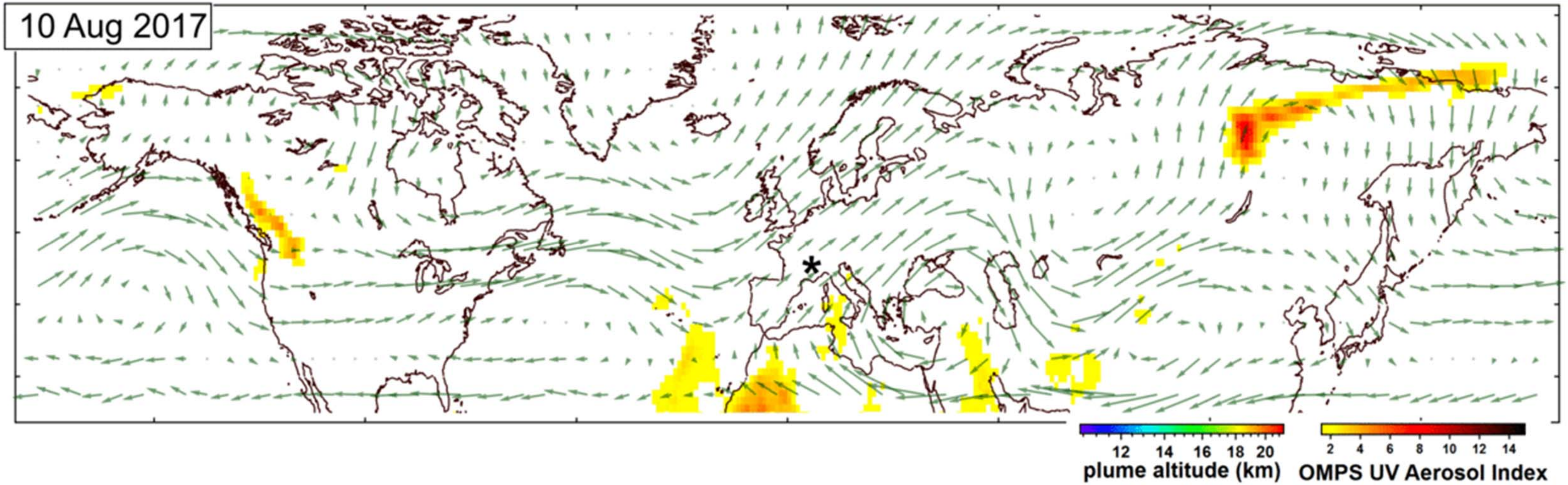

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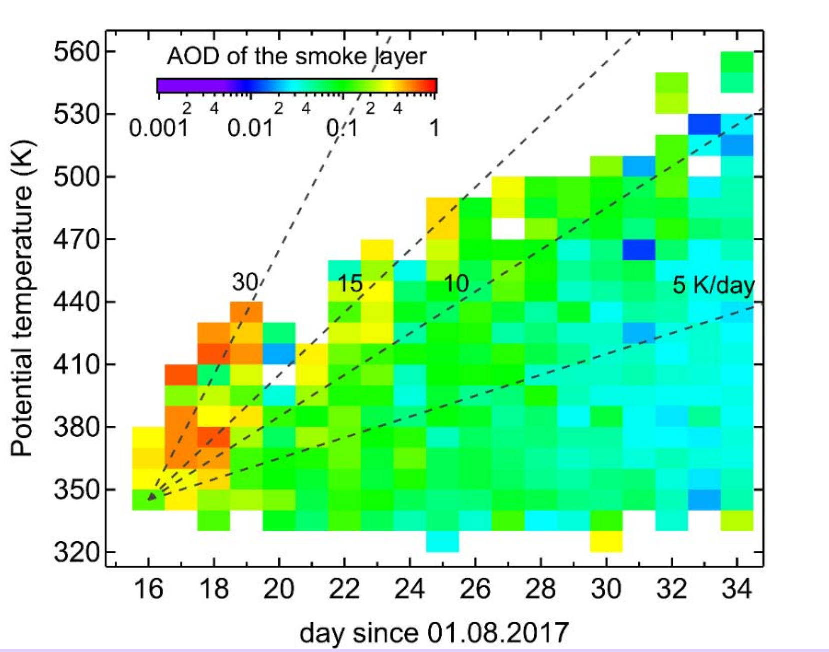
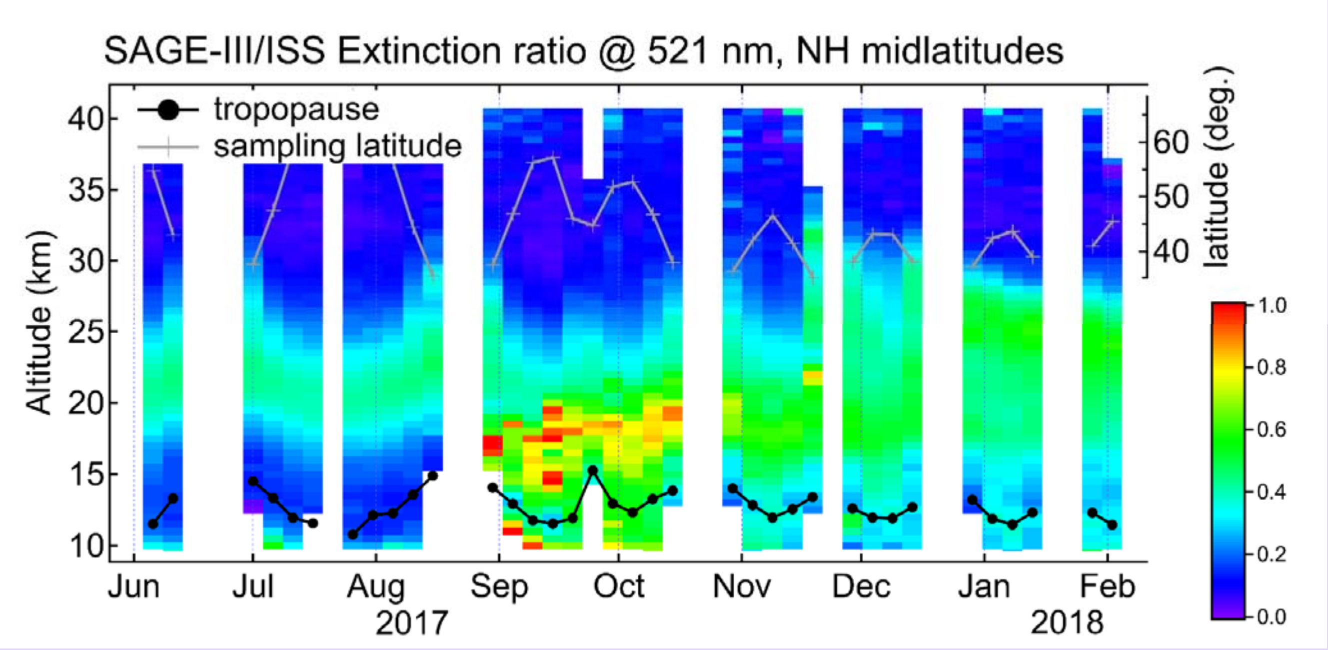
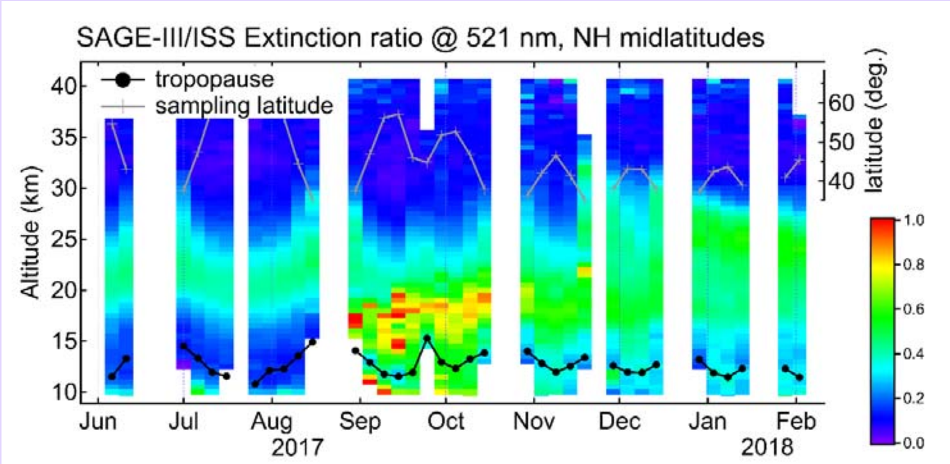
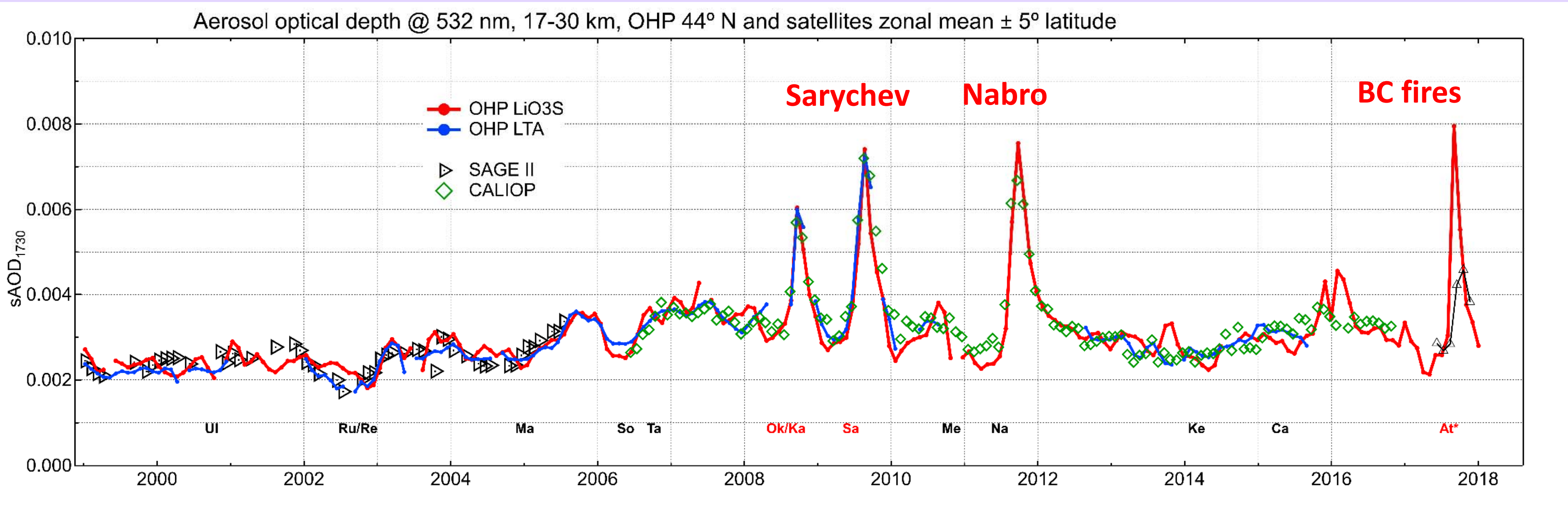




- ➢ Rapid ascent of the smoke plumes through radiative heating by up to 30 K/day
- ➢ Vertical excursion of up to 12 km (340 to 560 K)
- ➢ Hemispheric dispersion and ascent of the smoke evidenced by SAGE III
- ➢ Aerosol load remained elevated for several months

Impact of August 2017 NA wildfires on stratospheric aerosol load





Summary

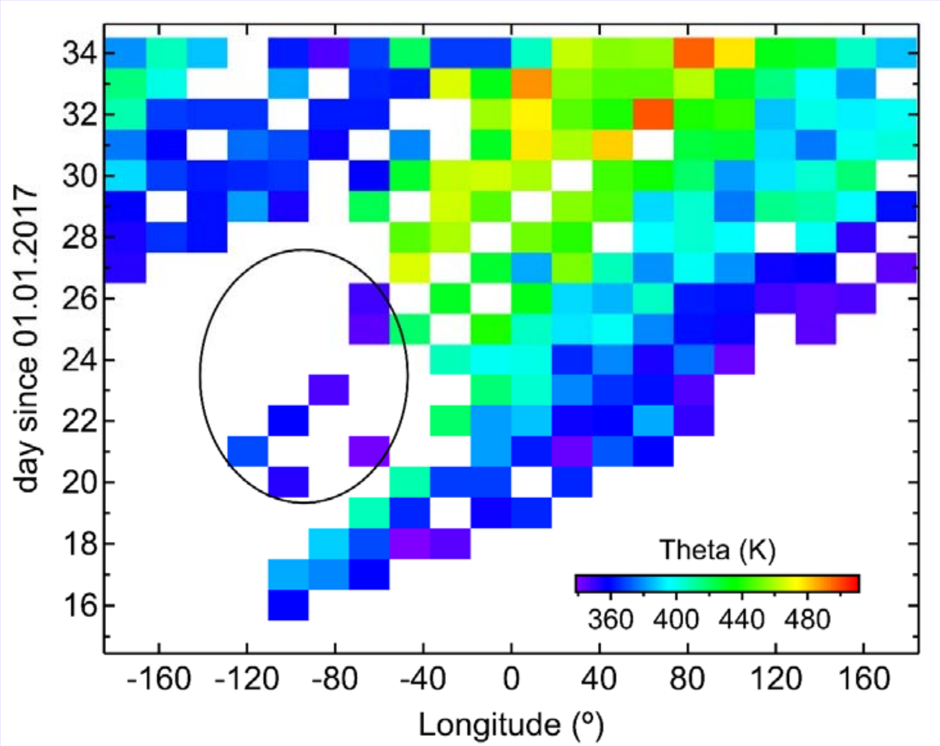
- ✓ **Combination of GB lidar and satellite observations allowed identifying the drivers of background SA and its long-term evolution**
- ✓ **Annual cycle of LS mid-latitude background SA is modulated by poleward transport of clean air from the deep tropics and polluted air from ASM**
- ✓ **Doubling of ex-ATAL AOD detected by OHP lidars**
- ✓ **Summer 2017 wildfires had a hemisphere-scale impact on SA load similar to that of moderate volcanic eruptions**
- ✓ **Stratospheric smoke plumes detected by ground-based and spaceborne lidars featured unprecedentedly high backscatter and aerosol optical depth**
- ✓ **Long-term lidar observations by ground-based are crucial for ensuring the continuity of stratospheric aerosol climate record**

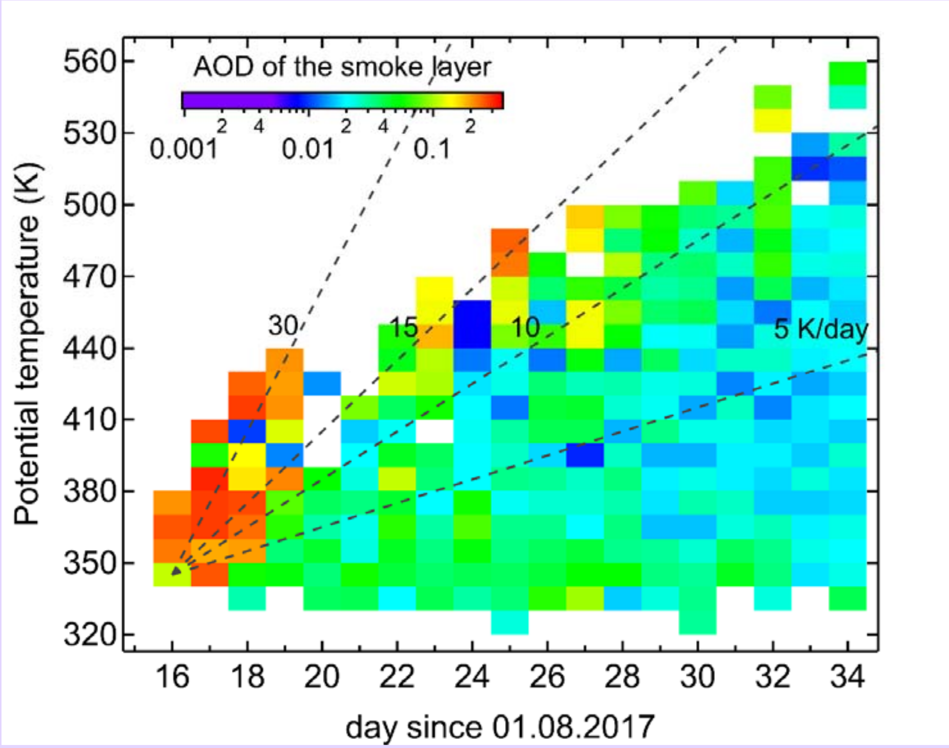
Further information:

Khaykin et al., *Variability and evolution of the midlatitude stratospheric aerosol budget from 22 years of ground-based lidar and satellite observations*, Atmos. Chem. Phys., 2017

Khaykin et al., *Stratospheric smoke with unprecedentedly high backscatter observed by lidars above southern France*, Geophys. Res. Lett., 2018

Supplementary material





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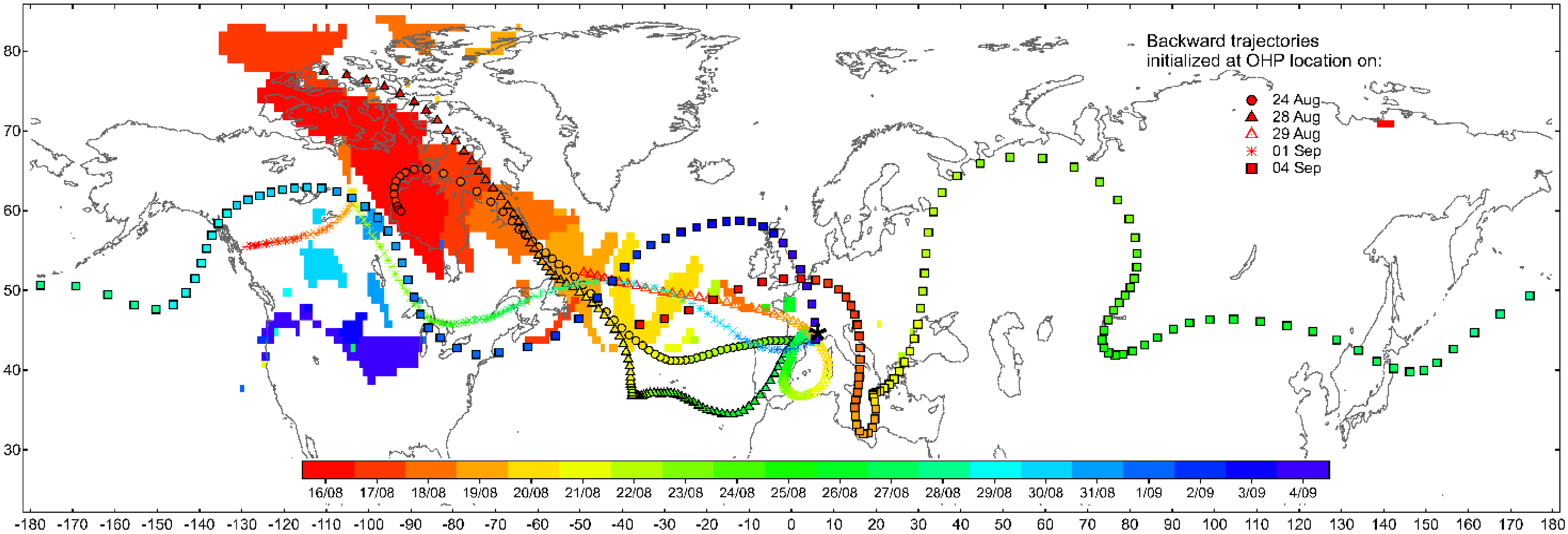

. Backward trajectories initialized at OHP (black asterix) on the dates of lidar detections of stratospheric smoke at the level of layer's SR maximum. Shaded areas indicate the locations where OMPS recorded AI exceeding 7. Trajectories and AI>7 areas are color–coded by date.

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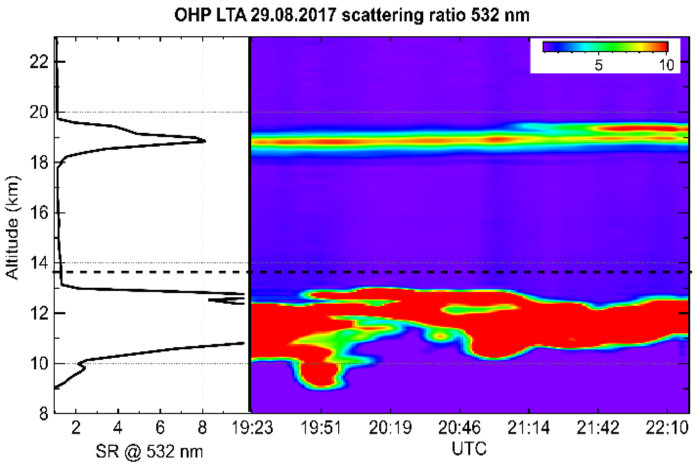

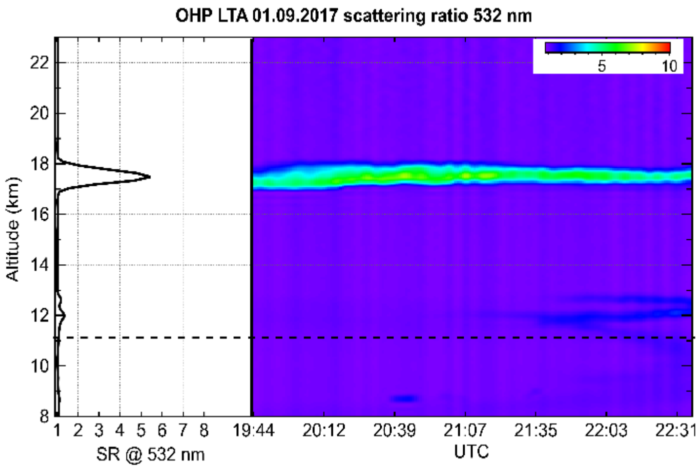

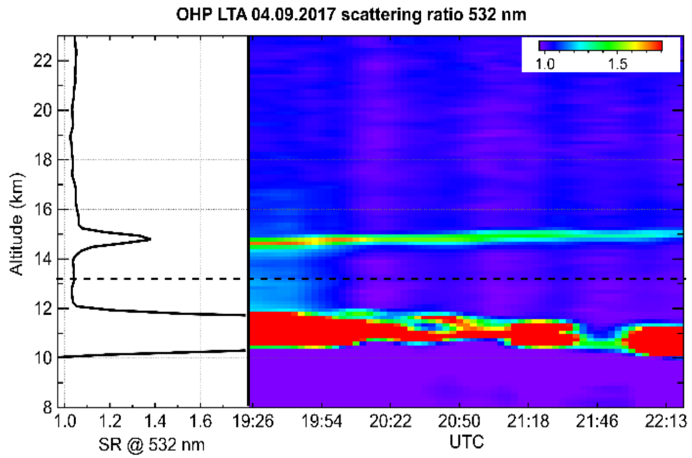

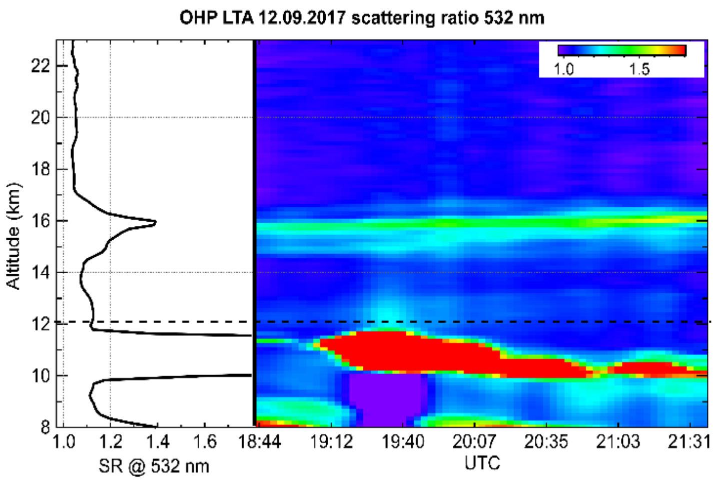

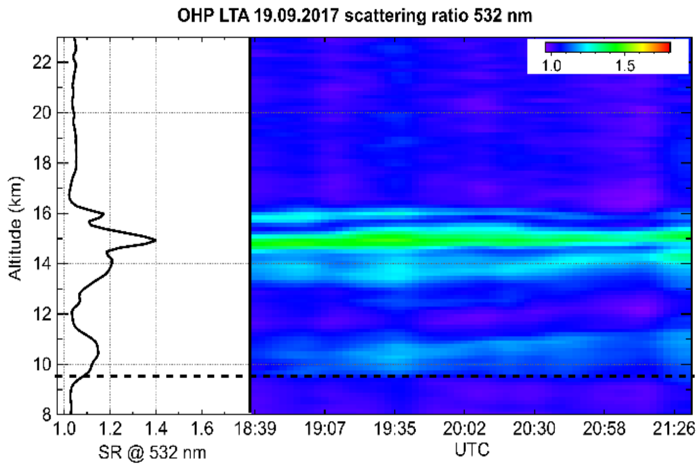

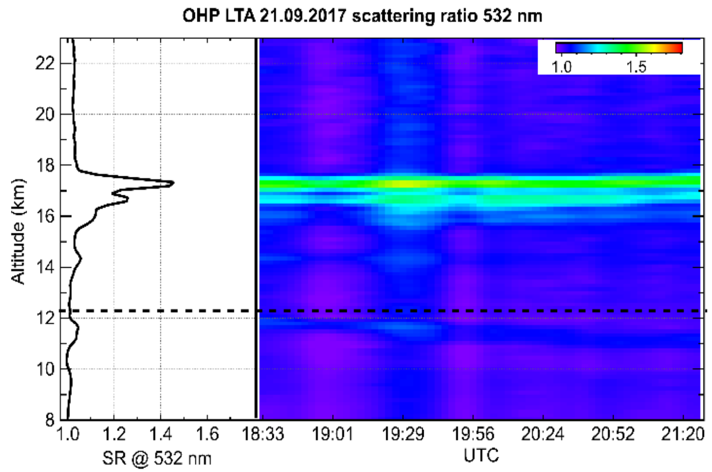

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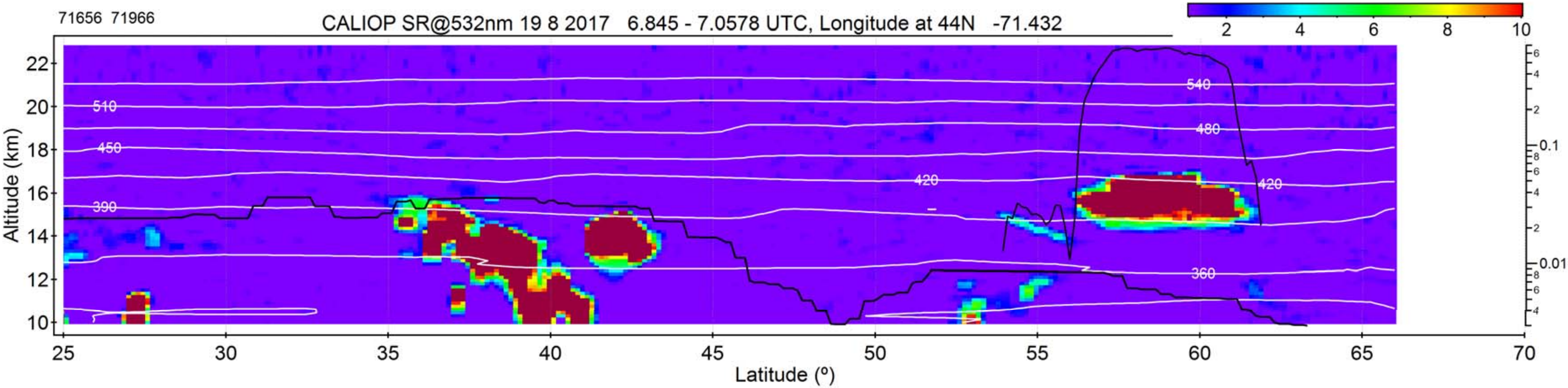

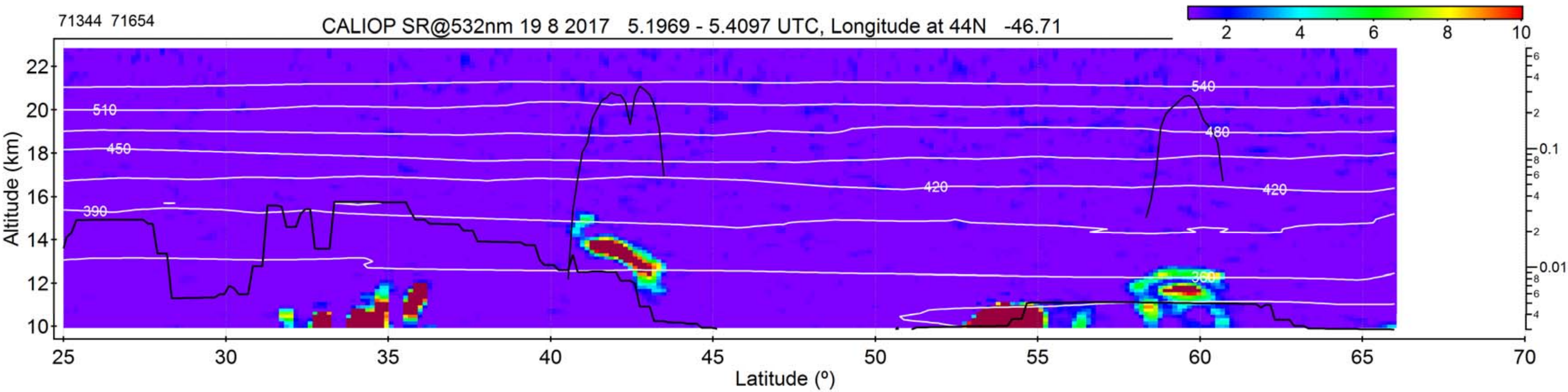

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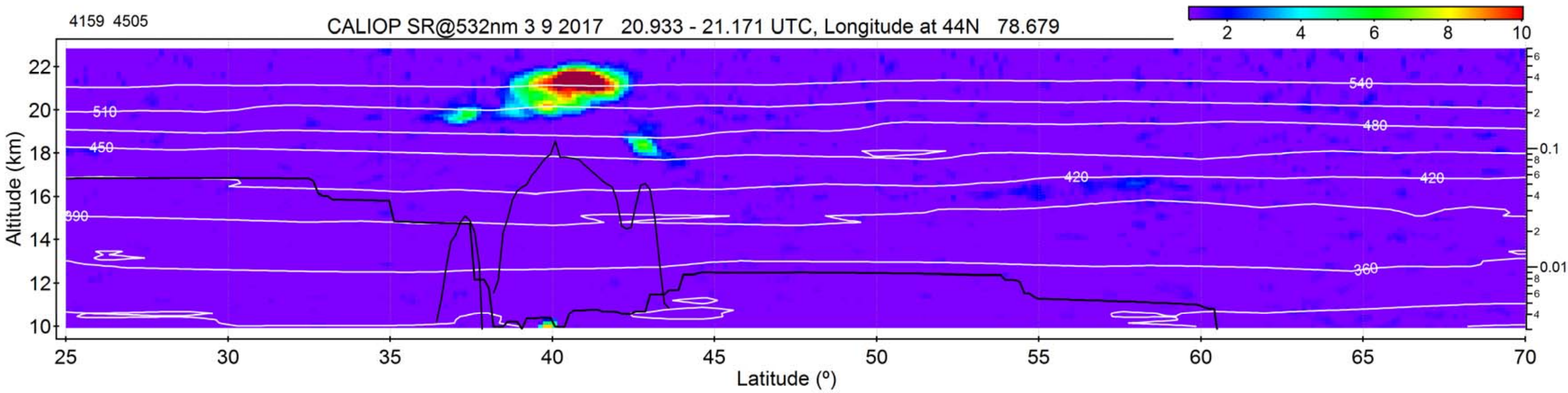

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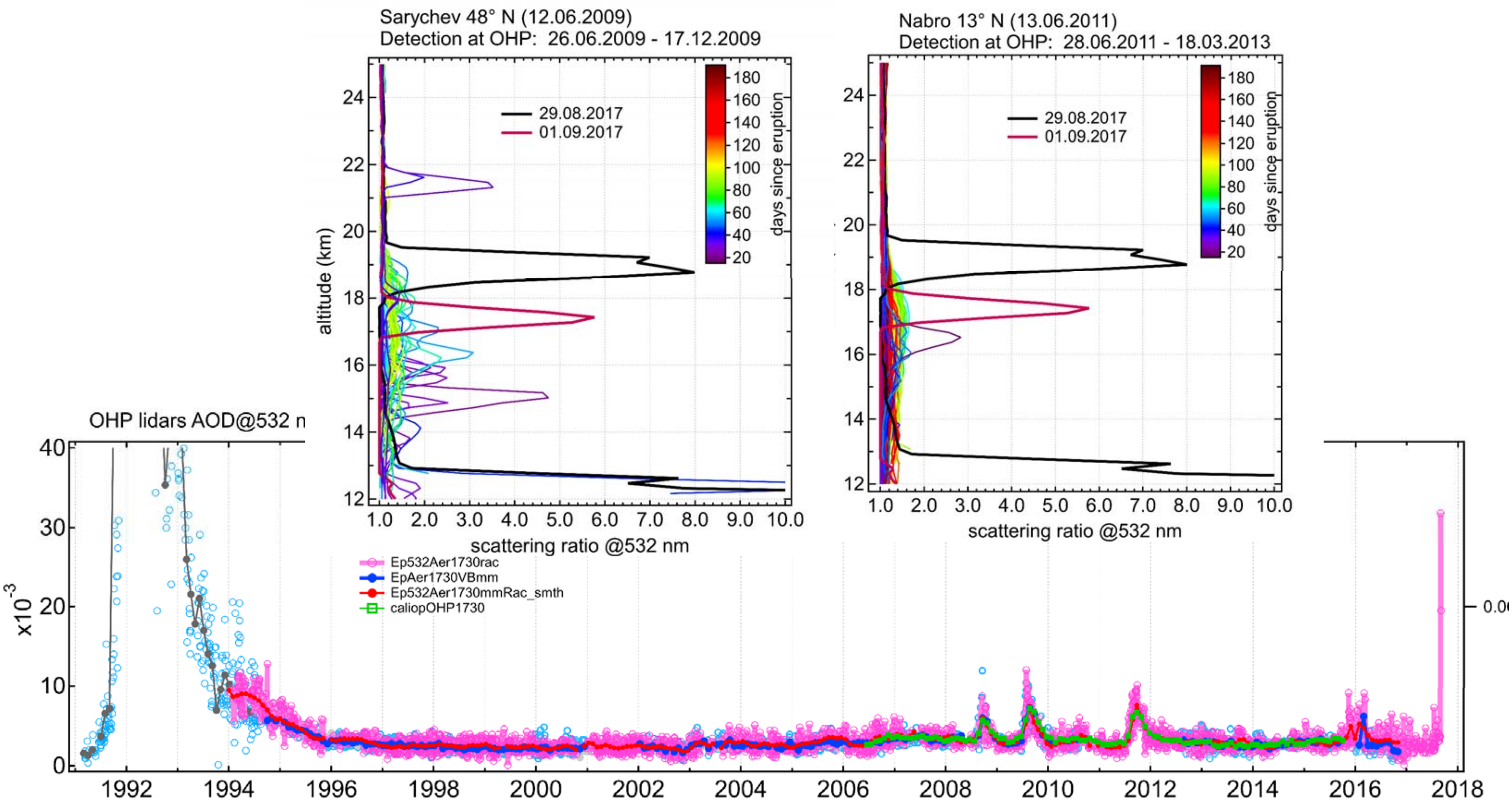

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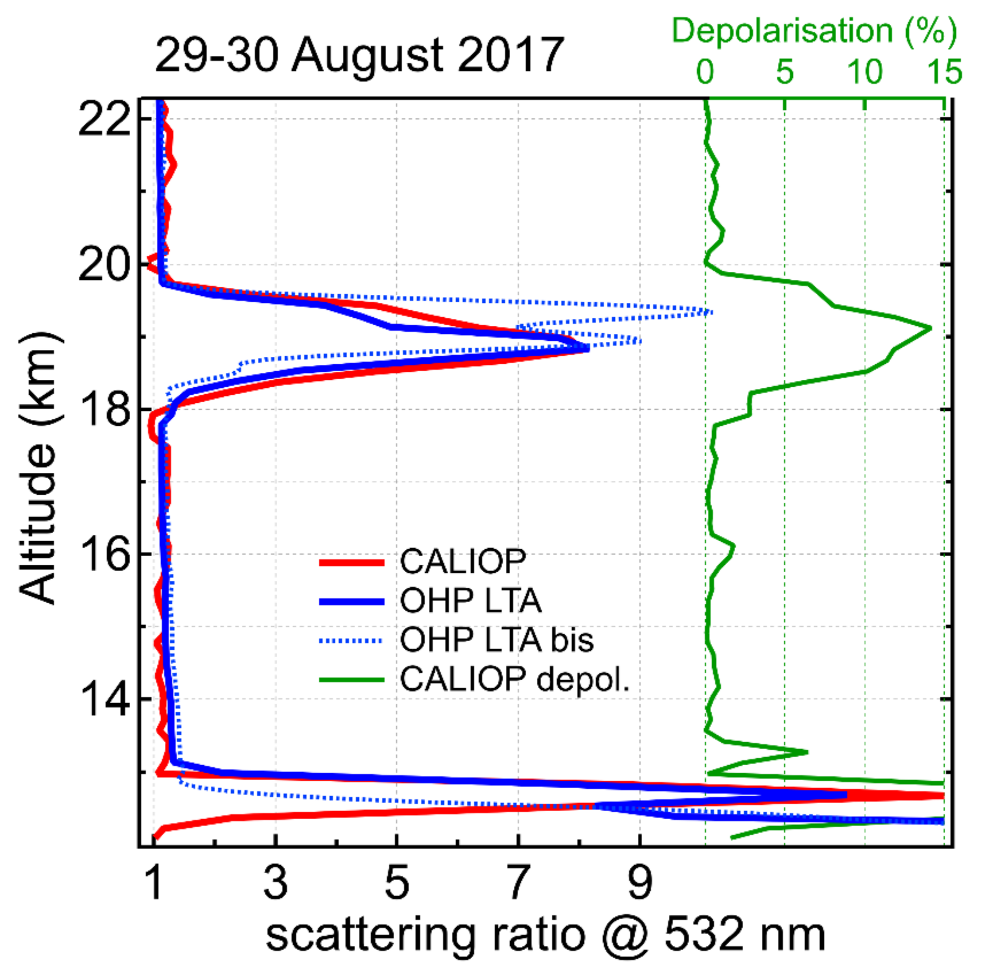

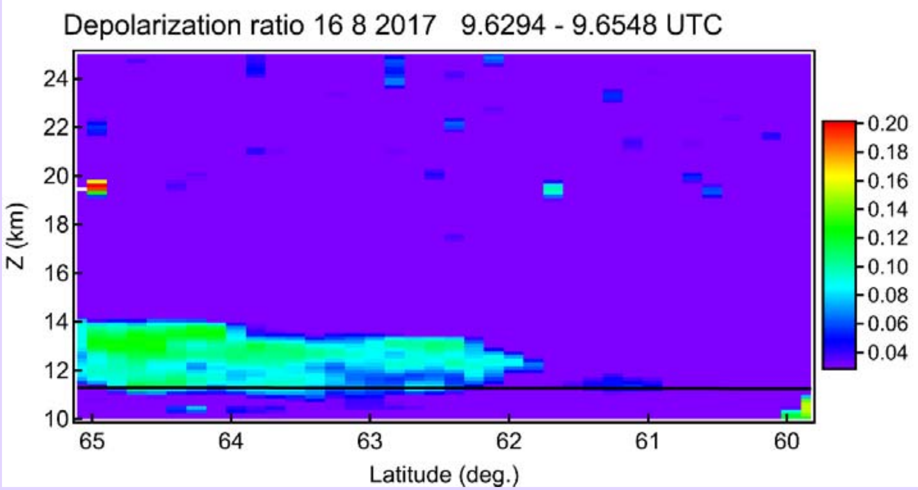

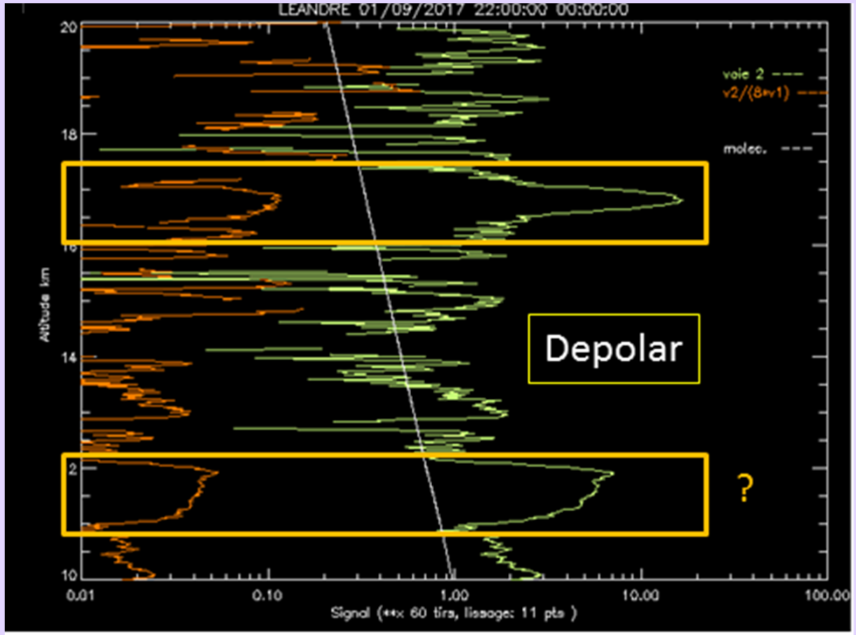

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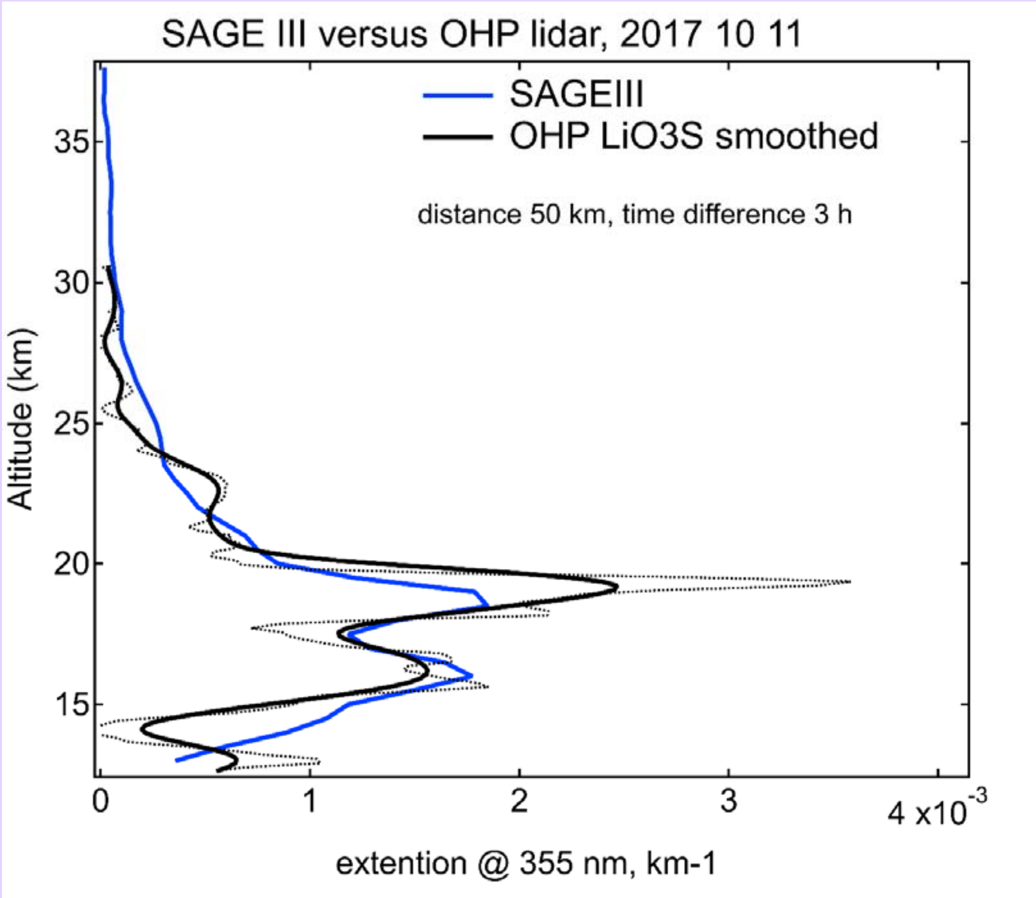

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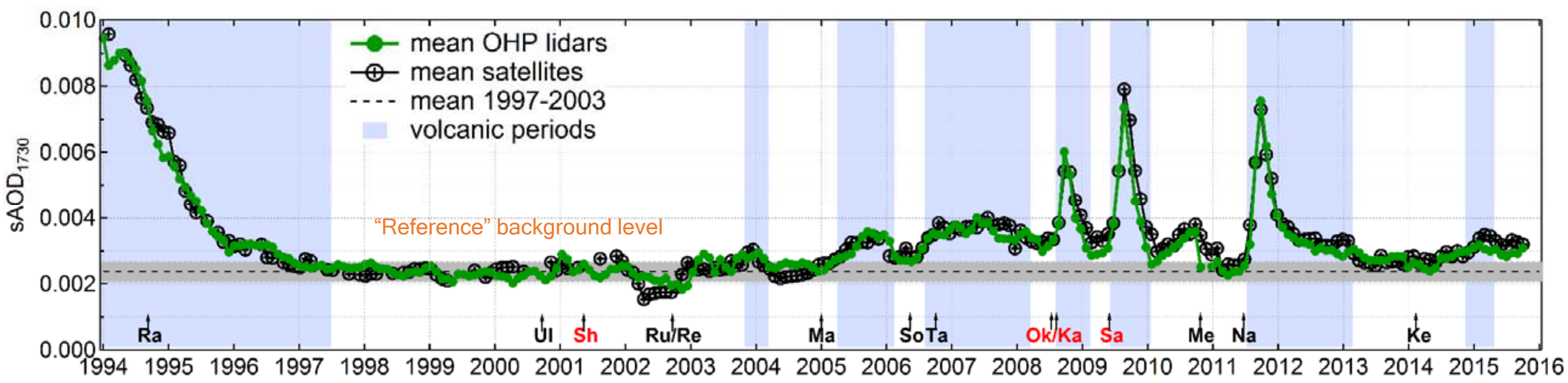

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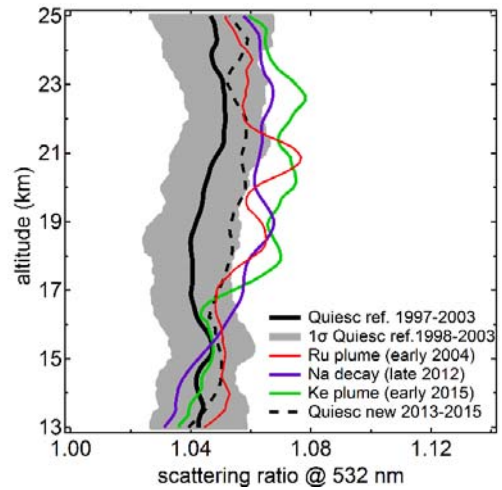

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