JÜLICH FORSCHUNGSZENTRUM

ALFRED-WEGENER-INSTITUT
HELMHOLTZ-ZENTRUM FÜR POLAR- UND MEERESFORSCHUNG

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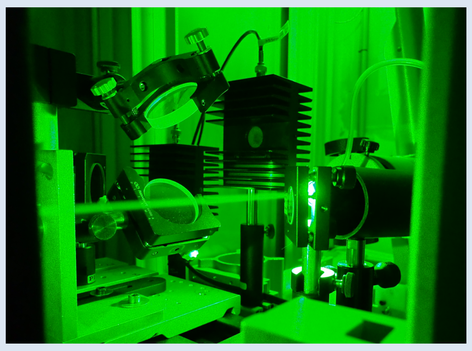
Tropical Aerosol in the Arctic?

Ny-Ålesund and Koldewey Aerosol Raman Lidar (KARL)



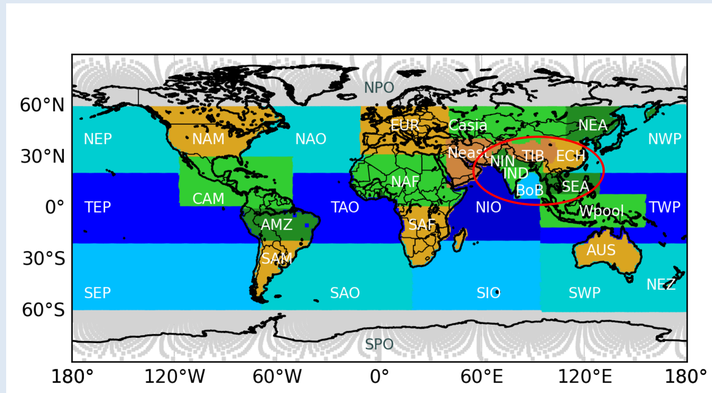
Laser beam shortly after production

The Koldewey Aerosol Raman Lidar KARL emits in the wavelengths 355nm, 532nm and 1064nm a laser signal to investigate the properties of aerosols, water vapor and cloud particles. Due to the Raman effect in total seven wavelengths are recorded, most of them with different polarization. For stratospheric applications a resolution of 150m and 600s was chosen to increase SNR.

The measurement sight Ny-Ålesund (78.92°N, 11.92°E) is located at the west coast of Svalbard in the European Arctic. It is a super-sight for environmental research with contributions of many inter-national institutes.

Lidar measurement during polar night

Chemical Lagrangian Model of the Stratosphere (CLaMS)



AMZ	Amazonia
AUS	Australia
BoB	Bay of Bengal
CAM	Central America
Casia	Central Asia
ECH	Eastern China
EUR	Europe
IND	Indian Subcontinent
NAF	Northern Africa
NAM	Northern America
NAO	Northern Atlantic Ocean
NEA	Northern Eastern Asia
NEP	Northern Eastern Pacific
NEZ	New Zeeland
NIN	Northern India/Pakistan/Himalayan foothills
NIO	Northern Indian Ocean
NPO	North Polar Region
NWP	Northern Western Pacific
Neast	Near East
SAF	Southern Africa
SAM	Southern America
SAO	Southern Atlantic Ocean
SEA	Southeast Asia
SEP	Southern Eastern Pacific
SIO	Southern Indian Ocean
SPO	South Polar Region
SWP	Southern Western Pacific
TAO	Tropical Atlantic Ocean
TEP	Tropical Eastern Pacific
TIB	Tibetan Plateau
TWP	Tropical Western Pacific
Wpool	Warm Pool

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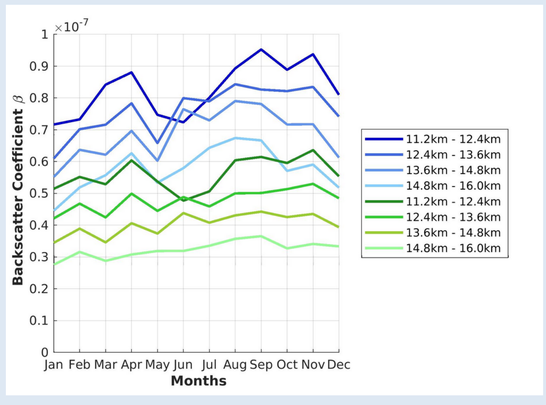
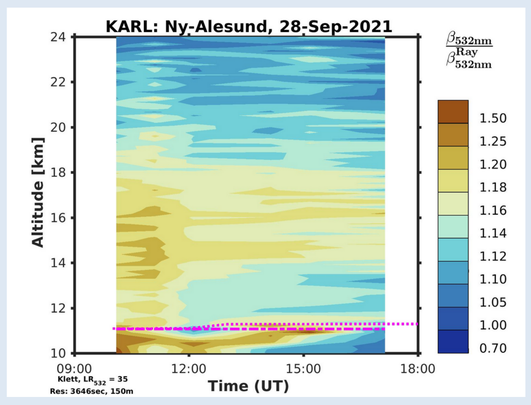
The Chemical Lagrangian Model of the Stratosphere (CLaMS) covers the entire monsoon season 2021. The world is divided into 32 different regions. The model uses horizontal winds from ERA5 reanalysis with a resolution of 1° x 1° and a 6h time resolution. Vertical velocities are calculated following diabatic heating rate on isentropic coordinates above 300hPa. The Lyapunov exponent is used as a proxy for wind shear as well as for mixing.
To depict all processes associated with the Asian monsoon, on 1 May 2021 artificial tracers were introduced 2-3km above the surface. They are released every 24 hours and further transported to the free atmosphere.

Observation with KARL

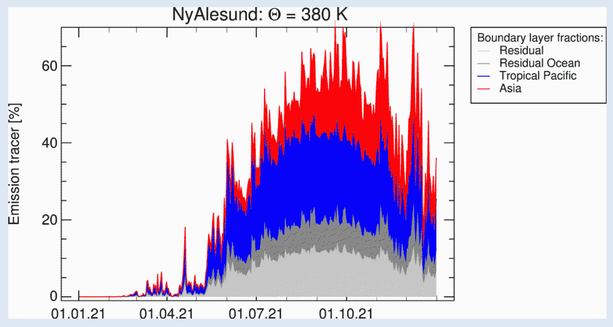
Most of the variability of stratospheric aerosol load happens in the UV spectrum, which leads to the conclusion that smaller particles are more present in the lower stratosphere. Mie scattering strongly depends on the particle diameter. A typical effective radius of 70nm to 90nm was found. In general, the aerosol load becomes more and more homogeneously with increasing height. It can be seen that the overall backscatter coefficient in creases throughout the year and decreases in winter times.
On the exemplary day of 28 September 2021 an increased backscatter ratio was found in the lower stratosphere. This layer remains in the stratosphere but becomes weaker and weaker throughout the rest of the year.



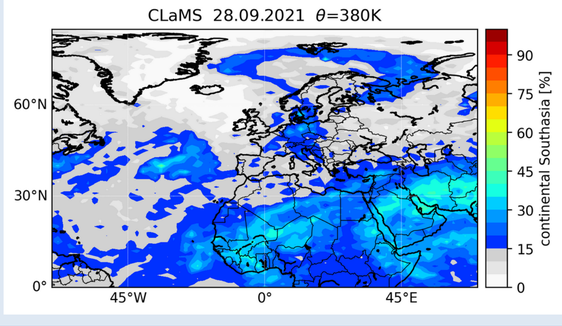


Observations with CLaMS

The aerosol layer, which was seen by KARL can also be found in some cases by CLaMS advected in filaments to the Arctic at an altitude of about 13.5km.



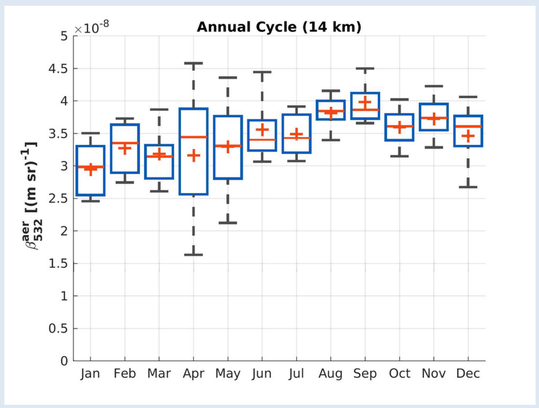
The before mentioned annual trend, which was seen by KARL, can also be found by CLaMS. The red area marks the contribution of Asian aerosol, which comes from the selected area, to the overall aerosol load in Ny-Ålesund.

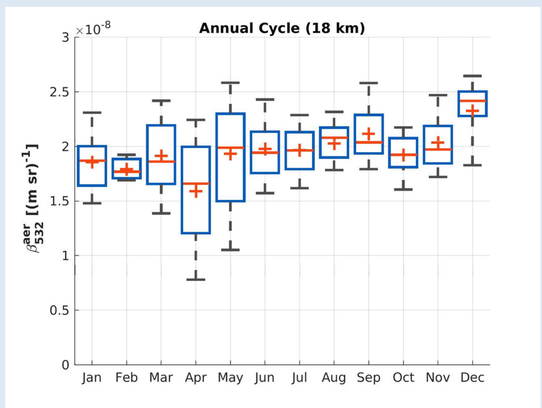


Annual Cycle of Stratospheric Aerosol

An annual trend can be found in the lower stratosphere (14km). While the backscatter coefficient, β, is lowest in the first part of the year, it increases in August and shows a clear maximum in September, after which it slowly decreases. Contrary to the aerosol backscatter coefficient, the variability decreases with increasing aerosol load. This trend can not be found in 18km altitude.

The same annual cycle can also be seen for the emitted laser beam with 355nm but with smaller variability in the first half of the year.





Conclusion

1) The Asian monsoon can not be directly identified by KARL in the Arctic
2) The contribution of aged wildfire aerosol can not be distinguished from the Southeast Asian monsoon
3) We found a weak signal of background aerosol in the lower stratosphere, which changes its concentration and / or composition during the year

Further Process and Outlook

1) Calculation of backward trajectories from Ny-Ålesund to find the probable source regions
2) Satellite measurements to exclude the contribution of wildfires
3) Does other Lidar observation sights see the Asian monsoon in their data?
4) When comparing the data with FTIR (Fourier-Transform Infrared Spectroscopy) measurements, is there also an annual trend in the concentration and composition of trace gases?

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