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Wildfire smoke triggers cirrus formation: Lidar observations in the Arctic (MOSAiC expedition) and Eastern Mediterranean (Cyprus)

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We observed wildfire smoke layers in the Arctic and over the Eastern Mediterranean in the upper troposphere with lidar. Cirrus layers formed in these smoke layers. This indicates that smoke particles (organic aerosol particles) can be efficient ice-nucleating particles (INPs) at temperatures from -50 to -70°C. The Arctic lidar observations were conducted aboard the German icebreaker Polarstern in the framework of the one-year MOSAiC expedition. The Polarstern drifted with the pack ice at latitudes of 85°-88.5°N from October 2019 to March 2020. A persistent Siberian smoke layer in the upper troposphere and lower stratosphere covered the entire central Arctic during the winter half year 2019-2020 and permanently triggered cirrus formation.

From 27 October to 1 November 2020 we observed aged Californian wildfire smoke layers between 10 and 11.5 km height with a Raman lidar at Limassol, Cyprus, continuously over 6 days. Again, ice nucleation was initiated in the smoke layers at temperatures around -50°C. In all cases, ice crystals grew fast and formed long virga in clean air below the smoke layers.

The aerosol influence on ice nucleation is described in climate models by the aerosol-type-related INP concentration (INPC). In the case of smoke, appropriate INP parameterization schemes are available to retrieve INPC from lidar observations. In these INPC retrievals, the particle surface area concentration is the aerosol input parameter. The relationship between the particle extinction coefficient measured with lidar and the smoke particle surface area concentration, required to convert the optical into the needed microphysical property, was derived from AERONET sunphotometer observations during pure smoke situations. We will show how we derived the AERONET-based smoke extinction-to-surface-area conversion factors. Furthermore, we will discuss several measured cases of smoke-cirrus interaction.

Keywords: aerosol, clouds, aerosol-cloud interaction, lidar, AERONET