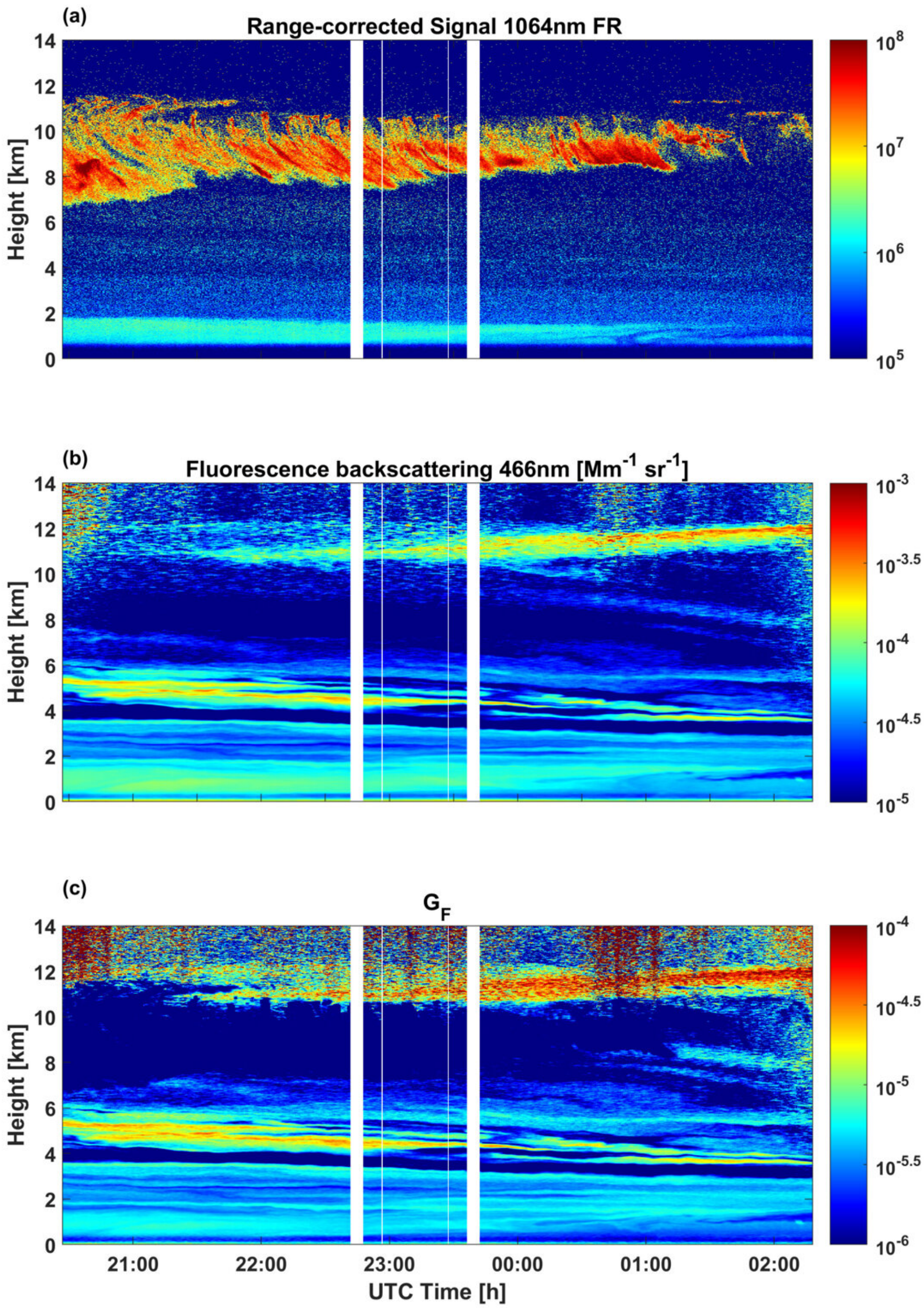
Smoke from Canadian wildfires has been hanging over Germany for weeks

June 29 2023


(a)
Range-corrected Signal 1064nm FR
Height [km]
(b)
Fluorescence backscattering 466nm [Mm^-1 sr^-1]
Height [km]
(c)
G_F
Height [km]
21:00
22:00
23:00
00:00
01:00
02:00
UTC Time [h]

Canadian smoke and cirrus clouds over Leipzig - observed with the fluorescence lidar MARTHA at TROPOS during the night of 29/30 May 2023. Credit: Benedikt Gast, TROPOS

Huge wildfires in Canada have destroyed millions of hectares of forest, displaced more than 100,000 inhabitants and affected the air quality of millions of people in North America. The traces of this ecological disaster can also be felt in the atmosphere over Germany.

Since mid-May, researchers at the Leibniz Institute for Tropospheric Research (TROPOS) have been recording thin layers of smoke at altitudes between 3 and 12 kilometers above Leipzig. The proof that the particles are smoke from wildfires was made possible by a new technique: smoke particles are of biological origin and glow when illuminated with UV light from a laser.

This allows them to be clearly distinguished from other particles such as volcanic particles or Sahara dust. The origin of the smoke layers could be traced back to North America using air currents. Related research has been published in three different articles, one on the *EGUSphere* pre-print server, one in *Atmospheric Measurement Techniques*, and one in *Atmospheric Chemistry and Physics*.

"It is impressive and frightening at the same time to see the dimensions these wildfires have reached in the meantime: When forests burn for weeks in Canada and the U.S., it is not only the people there who suffer from this disaster. The atmosphere over Europe is also affected: In the high, normally cloud-free air layers, thin veil clouds appear to form due to the smoke particles," reports Benedikt Gast from TROPOS, who is supervising and evaluating the current measurements as part of a doctoral thesis.

In contrast to North America, where in June the metropolises of the East Coast, among others, were covered in smoke for days and a fine dust alarm was issued, the smoke from North America certainly does not represent a health risk in Europe. The smoke layers at high altitudes and are now highly diluted. But it does affect the atmosphere and the climate: solar radiation is scattered by the particles and the light is thus slightly dimmed.

Similar to Saharan dust, the sky can also look slightly cloudy. In addition, the smoke could influence cloud formation in higher layers of the atmosphere. At least that is what recent research suggests: during the MOSAiC expedition in the Arctic in 2020, TROPOS researchers were able to measure an unusually large amount of smoke in the atmosphere around the North Pole and observe the formation of cirrus clouds in those smoke environments.

A recent study from Cyprus shows that smoke particles can act as nucleation nuclei for the formation of ice crystals under certain conditions. For this purpose, researchers from the Eratosthenes Center of Excellence, the Cyprus University of Technology and TROPOS analyzed data from Limassol in autumn 2020, when smoke from severe wildfires in North America was transported to the whole Mediterranean region from Portugal to Cyprus.

The measurements at that time provided clear evidence that aged smoke particles at around -50°C triggered ice formation at the transition between the humid troposphere and the dry stratosphere, leading to the formation of ice clouds.

"Our current observations over Leipzig also show indications of such connection. During several measurements in the last few weeks, we were able to observe smoke layers, and ice clouds (also known as cirrus clouds) in its surroundings at altitudes from 10 to 12 km. Such smoke layers in the strong presence of cirrus clouds were observed not only in Leipzig but also in various stations in Europe: From the southwest in Evora (Portugal), through Warsaw (Poland) to Kuopio (Finland) in the northeast.

"The smoke causing more clouds, could open a new impact-pathway in the context of climate change, since clouds can have a cooling or warming effect, depending on their optical thickness, phase, and microphysical properties. The more intense and more frequent wildfires are potentially affecting atmospheric radiation budget at a still unknown extent. This potential motivates us to further investigate the interplay of forest-fire smoke and cloud formation," says Benedikt Gast from TROPOS.

Due to climate change, the number and intensity of wildfires are increasing, and with it the amounts of aerosol that are released into the atmosphere when biomass is burned. These aerosol particles can not only be distributed in the troposphere, but can even reach the stratosphere above and influence the Earth's radiation budget and cloud cover over long periods and large areas.

"Since the start of the 2023 wildfire season in the northern hemisphere, we have seen smoke in almost every layer of the atmosphere, including the lower stratosphere. From an atmospheric science perspective, this is a worrying trend: global warming does not only seem to be causing the burn of large forests around the Arctic Circle, but those fires are more sever and frequent. It is also significantly changing our atmosphere and in turn influencing the climate. In addition, there is new evidence suggesting that the smoke is also disrupting the ozone layer and thus posing a health risk to millions of people," explains Dr. Albert Ansmann from TROPOS.

In order to fully understand and quantify the effects of aerosols on climate, accurate aerosol typing is crucial. Multi-wavelength polarization lidars, such as those operated by TROPOS at various locations, are very powerful tools in this respect for the detection and classification of aerosol with parameters such as the lidar ratio, the depolarization ratio and the Ångström exponent. However, it has been difficult to distinguish stratospheric smoke from volcanic sulfate aerosol.

Recent studies have shown that fluorescence lidar has great potential to improve aerosol classification because it provides another parameter—the so-called fluorescence capacity (ratio of fluorescence backscatter to elastic backscatter coefficients). The researchers have therefore expanded their large, stationary atmospheric lidar at TROPOS in Leipzig: the Multiwavelength Atmospheric Raman Lidar for Temperature, Humidity, and Aerosol Profiling (MARTHA) received an additional receiving channel in August 2022 that can measure fluorescence backscatter in the spectral range of 444–488 nanometers.

The experience gathered with the fluorescence observations at TROPOS, shows that it has great potential not only for aerosol typing, but also for finding smoke layers in the first place. "Since the new channel is only sensitive to particle scattering, it is perfectly suited for aerosol profiling. Several cases have proven this. A fluorescence channel in the lidar is like a having a loupe for aerosol layers," reports Dr. Cristofer Jimenez from TROPOS. "Especially at low particle concentrations, the new approach could provide interesting and completely new results. There is much to explore and expect from the technique."

A more powerful laser, which can also be used to study even higher layers of the atmosphere and lower concentrations, is to follow in the next few months. Both the station in Leipzig and the one in Limassol belong to PollyNet, a network of lidar systems that use laser beams to study the atmosphere from the ground. It is part of the European research infrastructure ACTRIS, which studies aerosols, clouds and trace gases.

More information: Rodanthi-Elisavet Mamouri et al, Wildfire smoke triggers cirrus formation: Lidar observations over the Eastern Mediterranean (Cyprus), *EGUSphere* (2023). DOI: 10.5194/egusphere-2023-988

Athena Augusta Floutsi et al, DeLiAn—a growing collection of depolarization ratio, lidar ratio and Ångström exponent for different aerosol types and mixtures from ground-based lidar observations, *Atmospheric Measurement Techniques* (2023). DOI: 10.5194/amt-16-2353-2023

Igor Veselovskii et al, Fluorescence lidar observations of wildfire smoke inside cirrus: a contribution to smoke–cirrus interaction research, *Atmospheric Chemistry and Physics* (2022). DOI: 10.5194/acp-22-5209-2022

Provided by Leibniz-Institut für Troposphärenforschung e. V.