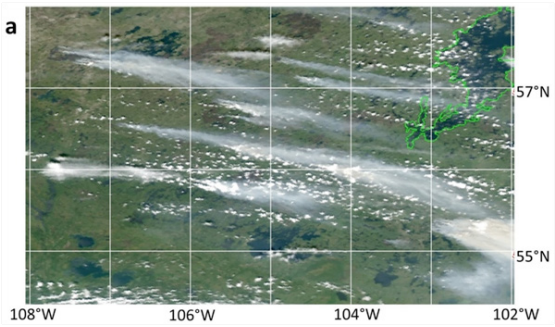
Cloud darkening: Impact of smoke from fires and pollution on the fate of clouds

....have you ever wondered why clouds are white and bright?
.....what might happen if the clouds suddenly turned smokey, gray and dull?
.....does forest fires have any connection to the fate of clouds?



Aerosols are tiny suspended particles released in the atmosphere from natural and anthropogenic emissions/processes such as dust storms, volcanic eruptions, forest fires, vehicular and industrial emissions, etc. Aerosol particles are a significant part of our weather and climate system, and due to their complex interactions with clouds and rainfall processes, these tiny particles (although emitted in large concentrations in the air), they pose a large uncertainty in our in depth understanding of clouds, rainfall, and the overall climate system. Aerosols scatter and absorb sunlight depending on their physical/chemical composition. For instance, smoke particles from forest fires, vehicular emissions, brick kilns and coal-fired power plants contain large concentrations of carbonaceous aerosols (e.g. soot or black carbon). Soot particles are widely known to cause significant absorption of the sunlight, thereby heating the atmosphere, which can perturb the weather and climate at regional-to-global scales.

Using airborne and satellite remote sensing data, our new study focuses on the light scattering and absorption characteristics of aerosols, and how these particles can affect clouds. We used measurements obtained from Cloud Absorption Radiometer (CAR), which flew on an aircraft, through thick smoke plumes of forest fires and clouds. At first, we were looking at the data for aerosols only, to quantify and characterise the light scattering. But the unexpected combination of smoke and clouds offered a whole new research opportunity. Clouds reflect sunlight back into space and have a net cooling effect on the climate. However, the significant absorption by soot particles was found to cause clouds to darken, which means less sunlight is being reflected back into space. That means more solar energy is being trapped between the clouds and the smoke; warming the air and affecting the local weather. The data from CAR made it possible to spiral down and circle around clouds from all angles - essentially providing a three-dimensional view.

This study in collaboration with NASA, showed a huge difference in the measured amount of light reflected from clouds interacting with the smoke and those far away from the smoke. When the clouds are embedded in smoke, heating occurs right around the clouds. This can accelerate the process of evaporation of existing clouds, causing them to burn-off faster, in turn reducing the cloud cover. However, when the smoke forms a layer above stratocumulus clouds (a certain type of extensive lower-level clouds), the air is warmed above the clouds, forming an inversion layer, like those that trap smog over a city. The inversion layer can cause the lower-level cloud cover to increase and spread out. So these heating effects of smoke can vary for different types of clouds, which add to the complexity of the impact of aerosols on the fate of clouds.

Although our new study sheds some light on the effects of smoke on clouds, whether the net cloud cover will increase or be reduced in response to heating due to smoke is still largely unknown. This makes it a highly intriguing research problem, which directly affects our weather and climate, especially in the scenario of climate change.

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