Scientist seeing clearly the effects of pyrocumulonimbus

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Smoke from wildfire blocks out the sun at Yellowstone National Park -- Terrace Spring (1988). Credit: US National Park Service

Wildfires can wreak widespread havoc and devastation, affecting environmental assets lives, property and livelihoods. Meteorologist Mike Fromm of the Naval Research Laboratory, in collaboration with several national and international laboratories, is now discovering that changes in the frequency of occurrence and intensity of wildfires has substantial consequences for a variety of important problems including atmospheric change.

Superimposed on this important topic is a relatively new discovery, forest fire smoke in the stratosphere, an area of the atmosphere that begins nearly 38 thousand feet above the Earth's surface.

As a result, a poorly understood aspect of wildfire behavior - pyrocumulonimbus firestorm dynamics and atmospheric impact - is becoming the focus of increasing attention. Pyrocumulonimbus (pyroCb) is a fire-started or augmented thunderstorm that in its most extreme manifestation injects huge abundances of smoke and other biomass burning emissions into the lower stratosphere. The reason is a particularly energetic form of 'blowup' caused by pyroCbs. Although known to form naturally and through anthropogenesis, attention to this topic has heightened with growing concern regarding anthropogenic climate forcing and the apparent increase of fires in the wildland/urban interface.

Global and regional warming trends have long been identified and associated with exacerbated wildfire occurrence but extreme injection by thunderstorms was previously judged to be unlikely because the tropopause, a transitional zone from the troposphere to the stratosphere, is considered to be a strong barrier to convection. This view is reflected in many instances in which mystery clouds in the stratosphere were attributed to volcanic eruptions, although volcanic evidence was lacking.

"Direct attribution of mysterious stratospheric aerosols has only occurred in the last decade," said Fromm. "While pyroconvection and pyrocumulus are well known, the peculiar vertical extent of the impact potential of pyrocumulonimbus escaped our attention."

That is, until it was discovered that pyroCbs from Canada wildfires had injected smoke (and other related emissions) well beyond the tropopause and into the stratospheric "overworld."

In 2002, survey of the Canada/USA fire season identified 17 pyroCb occurrences associated with newsworthy fires such as the Hayman, Rodeo/Chediski, and Biscuit fires. Data from these fires indicated pyroCbs injected smoke into the lowermost stratosphere offering a plausible alternate explanation for phenomena that were previously assumed to involve volcanic aerosols.

As such, two recurring themes have developed as pyroCb research unfolds. First, some "mystery layer" events - puzzling stratospheric aerosol-layer observations - and other layers reported as volcanic aerosol, can now be explained in terms of pyroconvection. Secondly, pyroCb events have been found to occur surprisingly frequently and are likely a relevant phenomenon of many wildfires.

"These findings will lead to a re-analysis of climatologies related to volcanic effects on the stratosphere and a 'new' climatology and geography of pyroCb occurrence worldwide," added Fromm.

Reports of pyroCb are increasing in science literature but are still rare. However, the hemispheric spread of smoke and other biomass burning emissions in the stratosphere due to pyroCbs will now be looked at as an impact having important climate consequences, likely resulting in improved models on air quality, thermo-chemical effects of smoke pollution and global pollution transport.

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