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Future Fire Regime in Alaska: a Look at the Role of Lightning

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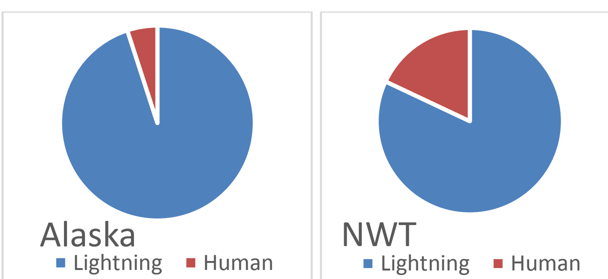
Lightning and boreal fire

Sander Veraverbeke, professor at Vrije Universiteit Amsterdam, published a new study in Nature Climate Change showing that big lightning storms linked to hotter summers were key drivers of recent large fire seasons in Alaska and Canada. The importance of lightning trends to changes in fire regime and ecosystem balance is a concept which we have not given much thought to heretofore. In fact, some previous thought among fire ecologists has been that yearly burn extent in Alaska was not limited by ignition sources, but more correlated with weather and fuel conditions that allowed for large increases in fire size after the inevitable ignitions came. The role of ignitions as a *driver* of fire regime changes may have been underestimated.

Veraverbeke, *et al*. (2017) analyzed satellite imagery and data from ground-based lightning networks in Alaska and northern Canada back to 1975 and compared lighting occurrence to annual burn extent. The vast majority of acreage burned is a result of lightning igntions.



Percent of burned acreage attributable to lightning in Alaska and NWT (2001-2015), Veraverbeke *et al.* 2017.

Because there have been changes and upgrades in the lightning detection system over time, the authors used time periods which would be reasonably comparable, and detrended the data (see Fig. 1 -- Supplementary Information). They also used an independent lightning data set from NASA's spaceborne Optical Transient Detector for comparisons. The data indicate that lightning ignitions in Alaska are increasing at a rate of about 5% *a year* on average and 2% in NWT over the last 40 years.

Climate change fuels convective storms

In Alaska most convective storms develop in mid- to late-afternoon, driven by intense solar heating. The reason for this timing is that most of these storms in Alaska are *airmass* thunderstorms, so not dependent on frontal activity (Clay 2017, Farukh and Hayasaka 2011). The more the heating, the more potential for orographic lifting and static instability to build a thunderhead. As firefighters know, sometimes large fires even heat the airmass enough to generate their own lightning storms. Veraverbeke developed regression equations using weather variables to "predict" the number of lightning strikes in past summers and discovered that CAPE (*convective available potential energy)* plus precipitation used in temperate North America were not optimal for Alaska. However, an equation using temperature, precipitation, and convective precipitation provided an excellent fit for the Alaska lightning data (R^2 = .83).

Pyrocumulus cloud over Fire 043 (Photo: Rod Dow, 1988).

The next logical step was to predict how lightning trends might change into the future using standard climate projections. Here they used a "business as usual" option—no concerted effort to reduce global anthropomorphic emissions (RCP 8.5). Fire managers take note: the results indicate increased lightning strikes to the tune of 25% more for NWT and *59% for Alaska by 2050*! Using their previously-developed equations tying lightning to burned area, that would translate into a 35% increase in NWT and a 55% in Alaska. There are a number of caveats with these conclusions that the authors explore, including the potential negative feedback of more deciduous forest on the landscape. The magnitude of such an effect is not known (but see *Barrett et al. 2016* for their findings of apparent increased deciduous burning in Alaska during periods of high fire weather indices). There are also potential positive feedbacks if fire size increases (they assume it does not in the analysis) or the fire season gets longer (they assumed a "status quo" season length).

> "These trends are likely to continue. We expect an increasing number of thunderstorms, and hence fires, across the high latitudes in the coming decades as a result of climate change." *Brendan Rogers, co-author, Woods Hole Research Center*

More burning at the forest/tundra ecotone

Another potential source of positive feedback to the future burning estimates is the northern march of treeline. Interestingly, Sander's team documented a higher-than-expected proportion of burned acreage was near the forest/tundra ecotones during these large fire seasons. Burning can provide seedbeds for colonization of trees and large shrubs.

This isolated white spruce tree in Seward Peninsula tundra exemplifies fire-aided treeline migration. The tree dates from a 1977 fire (Imuruk Lake) and other forested areas are many miles distant (Photo: C. Racine, 2009)

Putting It All Together

Previous analysis of ground-based lightning detection data has hinted that warming across Alaska is driving increased lightning (Farukh and Hayasaka, 2011). In the continental US, it has been estimated that lightning may increase 11% for every 1^{o} C increase in temperature (Romps, et al. 2014). Veraverbeke expands on this by showing how important lightning is to burned area dynamics in boreal North America. The future ignition increases they predict may increase carbon loss as well as accelerating the northward expansion of boreal forest.

Read the article: Veraverbeke, S., B.M. Rogers, M.L. Goulden, R.R. Jandt, C.E. Miller, E.B. Wiggins and J.T. Randerson. Lightning as a major driver of recent large fire years in North American boreal forests. *Nature Climate Change* 7: 529–534 (2017). DOI: 10.1038/nclimate3329

CITATIONS

Barrett, K., T. Loboda, A.D. McGuire, H. Genet, E. Hoy, and E. Kasischke. 2016. Static and dynamic controls on fire activity at moderate spatial and temporal scales in the Alaskan boreal forest. *Ecosphere* 7(11):e01572. 10.1002/ecs2.1572

Clay, Matthew. 2017. ACCAP Webinar: A Five-Year Study of Lightning Patterns Across Southcentral Alaska

Farukh, M.A., H. Hayasaka and K. Kimura. 2011. Recent anomalous lightning occurrences in Alaska - the case of June 2005. Journal of Disaster Research 6(3):321-330.

Romps, D.M., J.T. Seeley, D. Vollaro, and J. Molinari. 2014. Projected increase in lightning strikes in the United States due to global warming. Science 346(6211):851-854.

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