Lightning Occurrence Prediction Model for Alberta

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Introduction:

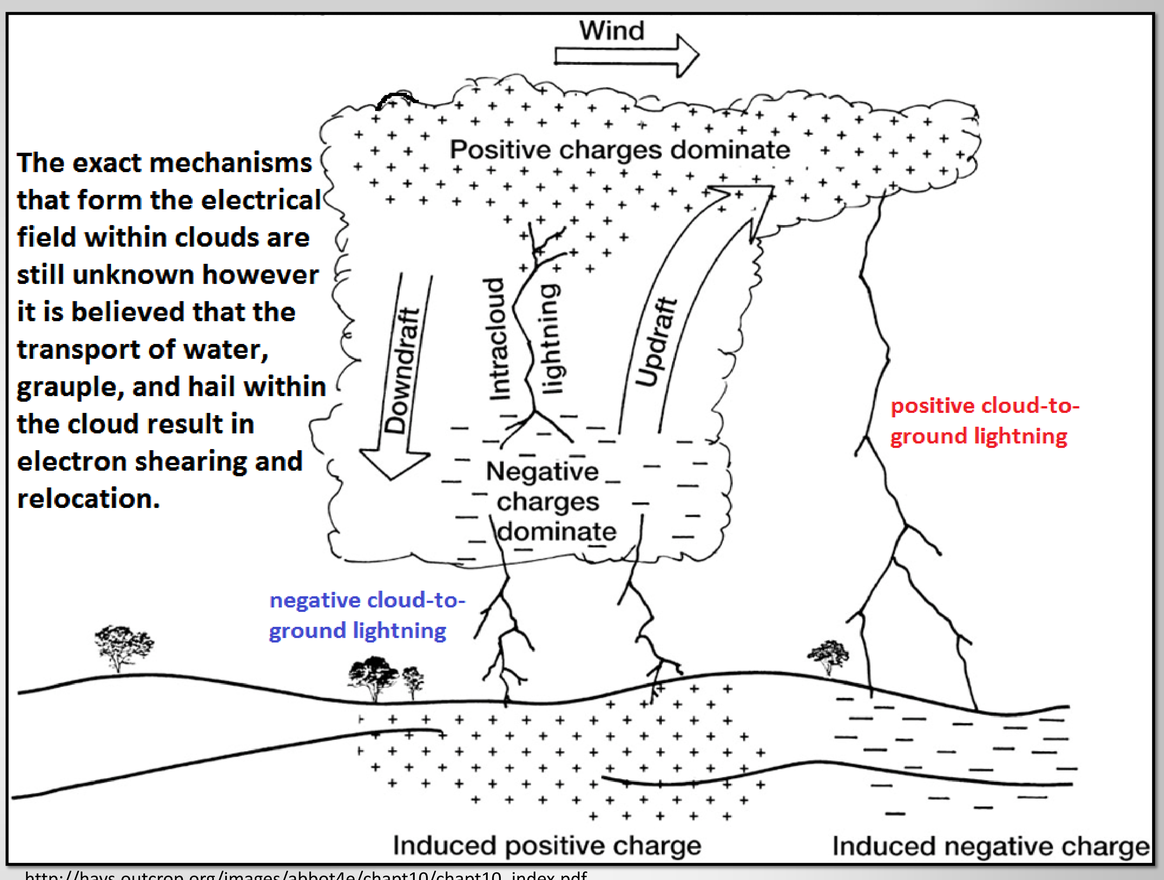
Wildland fires burn an average of 2.5M ha of Canada's forested area [1] with direct suppression costs ranging from CAD $500 million to $1 billion per year [2]. Although fire is a natural and necessary feature of our landscape, human development and valued resources inhibit our ability to allow fire to roam freely. Although human and lightning ignitions are near equal in number, lightning caused fire starts are responsible for ~80% of area burned in Canada [1]. Lightning fires are responsible for such a vast area burned due to two main factors:

1- Location: lightning can occur in remote areas making detection and response difficult thus increasing the chance of the fire escaping initial attack [3] (Photo courtesy of Stephanie Koroscil).

2- Concentration: lightning has a tendency to occur simultaneously in multiple locations and in large concentrations [3] (Photo courtesy of NOAA www.nws.noaa.gov)

Lightning Formation:

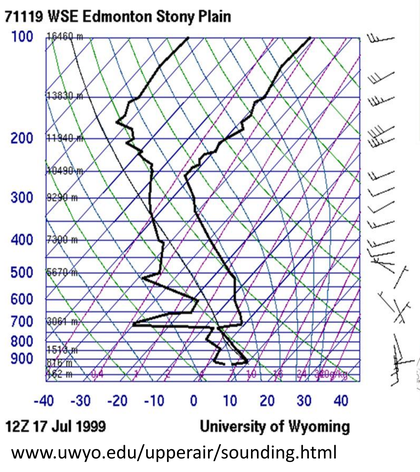
The exact mechanisms that form the electrical field within clouds are still unknown however it is believed that the transport of water, grauple, and hail within the cloud result in electron shearing and relocation.



http://hays.outcrop.org/images/abbot4e/chapt10/chapt10_index.pdf

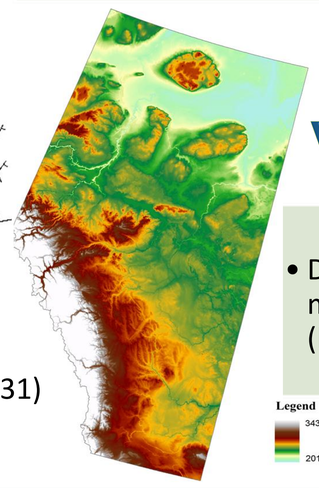
Methods:

21 variables are used to generate possible prediction algorithms via random forest (multiple decision trees).



www.uwyo.edu/upperair/sounding.html

- Temperature, dew point, winds, sea level pressure, geopotential height, etc.
- Atmospheric instability indicators (Showalter index, Lifted index, K Index, etc.)



Input Variables

- Digital elevation model Location (latitude)

13 fire seasons (April 1 – Oct 31) from 1999 to 2011

Probability of Cloud-to-Ground Lightning Occurrence

http://www.srh.noaa.gov

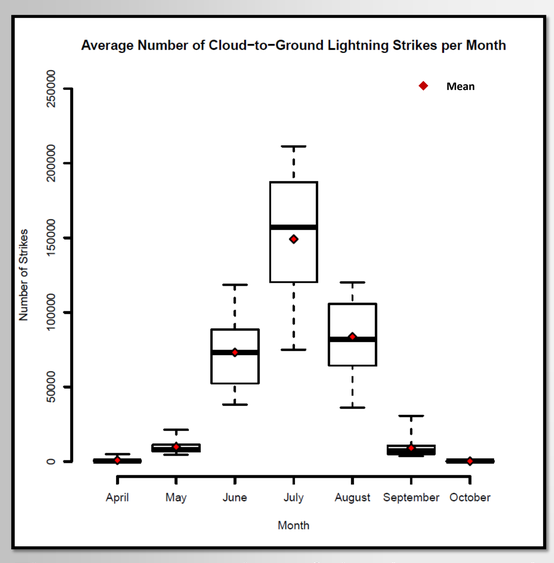
http://www.onlyhdwallpapers.com

Phase 1- Diagnostic Model: Create diagnostic model to predict the occurrence of lighting given a certain set of conditions.

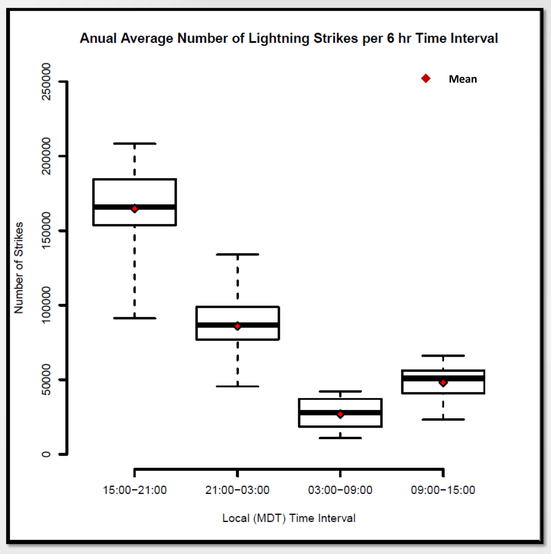
Phase 2- Forecast Model: Create model to forecast lightning occurrence out to 4 days using current and forecasted conditions.

Model Outputs: Probability of lightning occurrence and predicted frequency of strikes for each cell (50x50km) at 6 hour time intervals.

Preliminary Results:

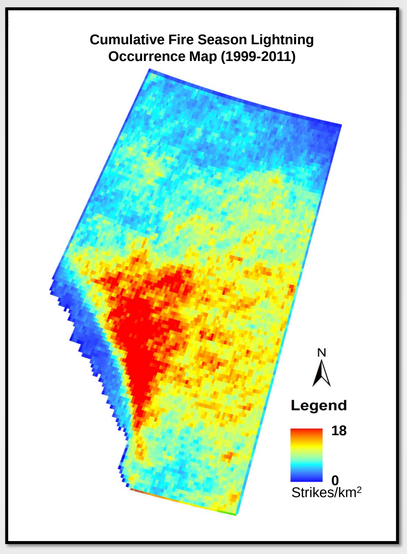


The greatest number of cloud-to-ground lightning strikes in Alberta occur in June, July and August. On average, there are ~326,000 strikes per fire season with ~149,000 occurring in the month of July alone.



A diurnal trend in lightning occurrence is shown with the peak number of cloud-to-ground lightning strikes occurring between 3pm and 9pm local time. This anticipated trend corresponds with typical peak temperature and atmospheric instability.

Boxplots: The box encompasses the 1st and 3rd quartiles with the median indicated by a heavy center line. Whiskers extend to the minimum and maximum values. The plots represent 13 years of data.



Cumulative strikes range from 0 to 18 per square km. A maximum value of 18 corresponds with a frequency of ~1.4 strikes/km^2 per year. The greatest concentration of strikes typically occur leeward of major topographic features.

Looking Forward:

- Determine key atmospheric indicators for predicting lightning location and frequency in Alberta.
- Forecast lightning location and frequency in Alberta out to 4 days.
- Possible adaption of model for other regions.
- Potential prediction of lightning variations (positive vs. negative strikes, dry lighting and long continuous current).

An accurate, medium range lightning prediction model could greatly aid the effort to responsibly manage Alberta's forests, improve allocation of resources and increase preparedness of fire managers and communities alike. The incorporation of this lightning occurrence prediction model with the Fire Weather Index and a Vegetation Index could produce extended lighting ignition risk forecast maps.

Photo courtesy of D'arcy Norman

Photo courtesy of Stephanie Koroscil

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References: [1] Stocks, B.J., et al., Large forest fires in Canada, 1959-1997. Journal of Geophysical Research 2002. 107/108(D1): p. 8149.1-8149.12.; [2] Flannigan, M.D., et al., Impacts of climate change on fire activity and fire management in the circumboreal forest. Global Change Biology, 2009. 15: p. 549-560.; [3] Martell , D.L. and H. Sun, The impact of fire suppression, vegetation, and weather on the area burned by lightning-caused forest fires in Ontario. Canadian Journal of Forest Research, 2008. 38: p. 1547-1563.

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