Forest Fire and Weather in Alaska

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2013.7.4 Moon Lake Fire, TOK: Photo by H. Hayasaka

1. Forecast for wild fire occurrence

1-2. Prediction of wildland fire trend under the effect of global warming

Despite increasing temperatures since the end of the Little Ice Age (ca. 1850) , **wildfire frequency has decreased** as shown in many field studies from North America and Europe.

We believe that global warming since 1850 may have triggered decreases in fire frequency in some regions and future warming may even lead to further decreases in fire frequency.

Simulations of present and future fire regimes, using daily outputs from the General Circulation Model (**GCM**), were in good agreement with recent trends observed in fire history studies.

Flannigan, M.D, et al.: "Future wildfire in circumboreal forests in relation to global warming", Journal of Vegetation Science 9: 469-476, 1998

1 & 2. Forecast for wild fire occurrence

1-2. Prediction of wildland fire trend under the effect of global warming

Ignition probabilities may increase in a warmer world due to increased cloud-to-ground **lightning** discharges with warming (Price & Rind 1994).

The fire season will start earlier in the spring and extend longer into the autumn, yielding a **longer fire season** (Wotton & Flannigan 1993).

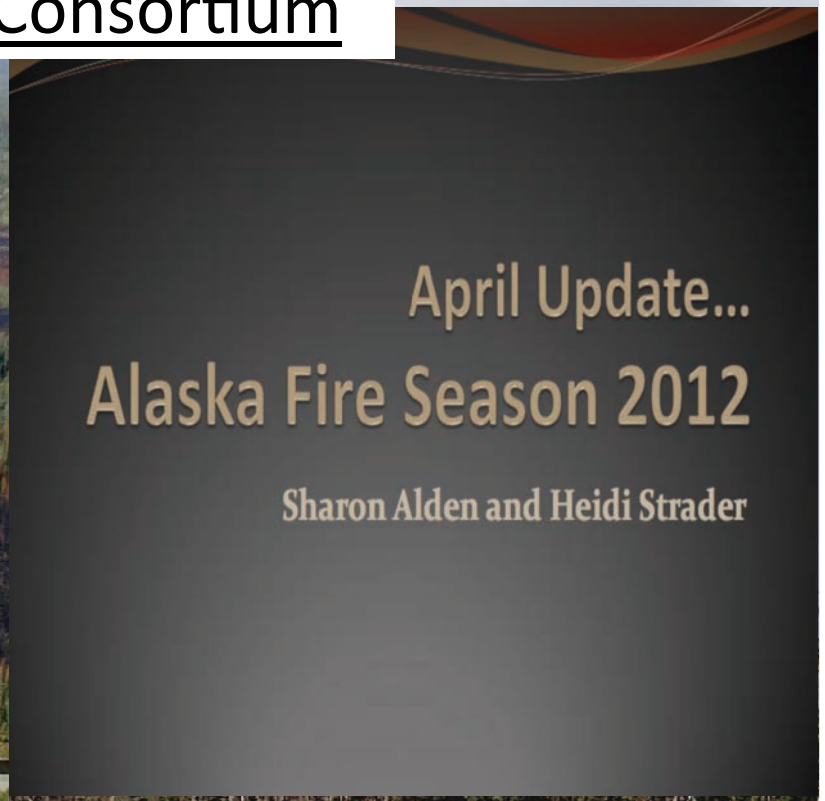
Flannigan, M.D, et al.: "Future wildfire in circumboreal forests in relation to global warming", Journal of Vegetation Science 9: 469-476, 1998.

Current State of Fire Forecast in Alaska

Paul A. Duffy, UAF

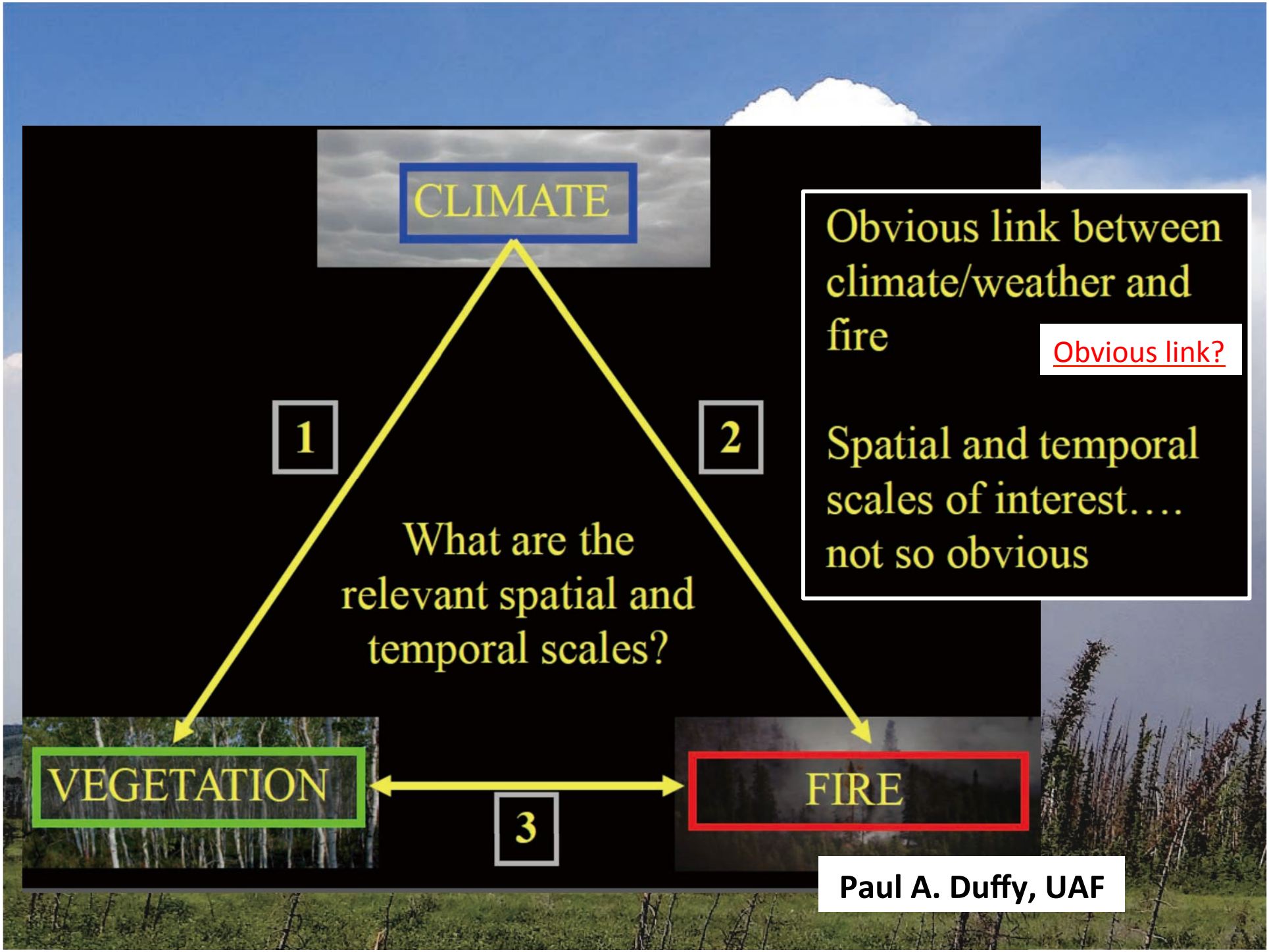
S. Alden & H. Strader, AFS

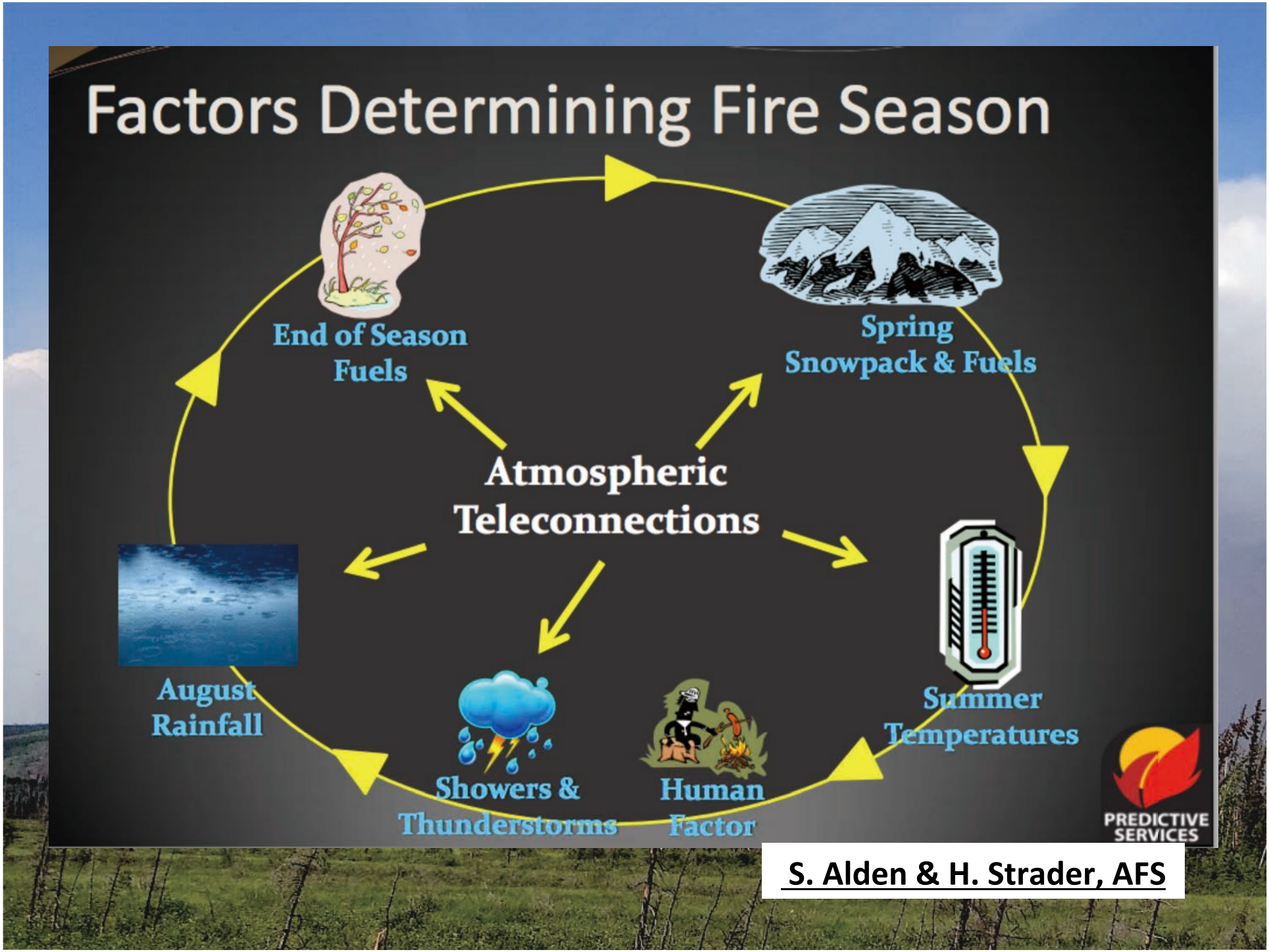
Alaska Fire Science Consortium



http://ine.uaf.edu/accap/documents/2009_05_FireTool_Duffy.pdf

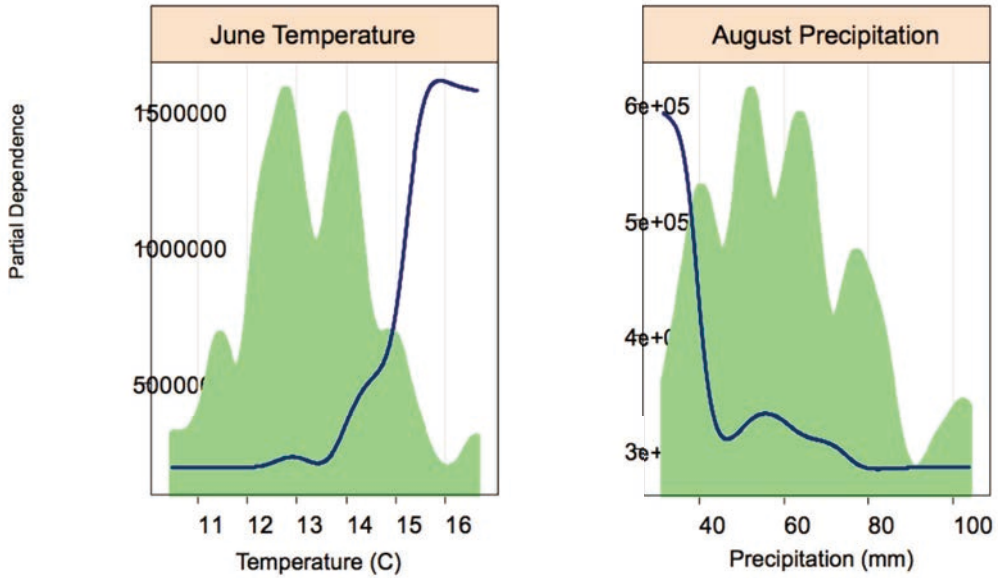
http://fire.ak.blm.gov/content/weather/outlooks/seasonal.pdf


CLIMATE
1
2
What are the relevant spatial and temporal scales?
VEGETATION
3
FIRE
Obvious link between climate/weather and fire
Obvious link?
Spatial and temporal scales of interest…. not so obvious
Paul A. Duffy, UAF



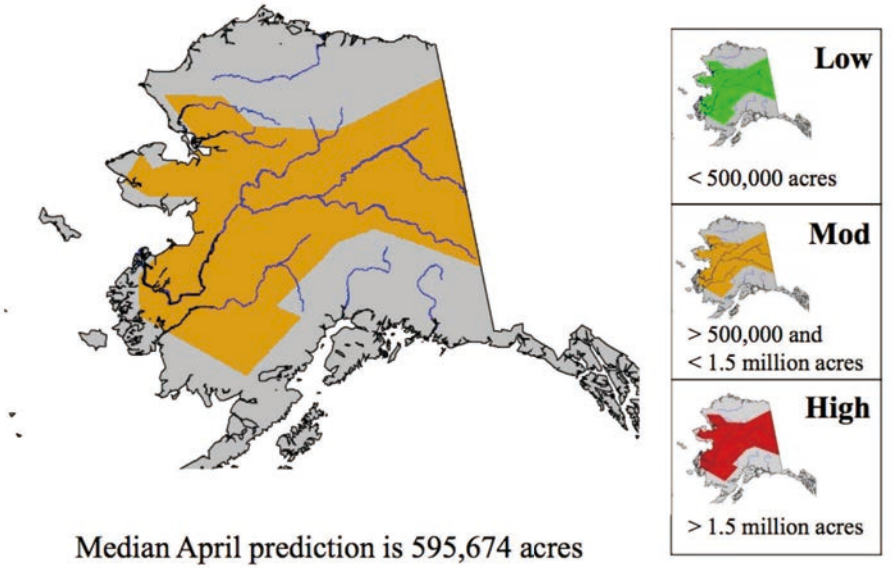
S. Alden & H. Strader, AFS

Partial Dependence Plots for GBM model



* Vertical axis shows expected hectares as a function of the explanatory variable

Forecast of Area Burned in 2009 Based on April Data

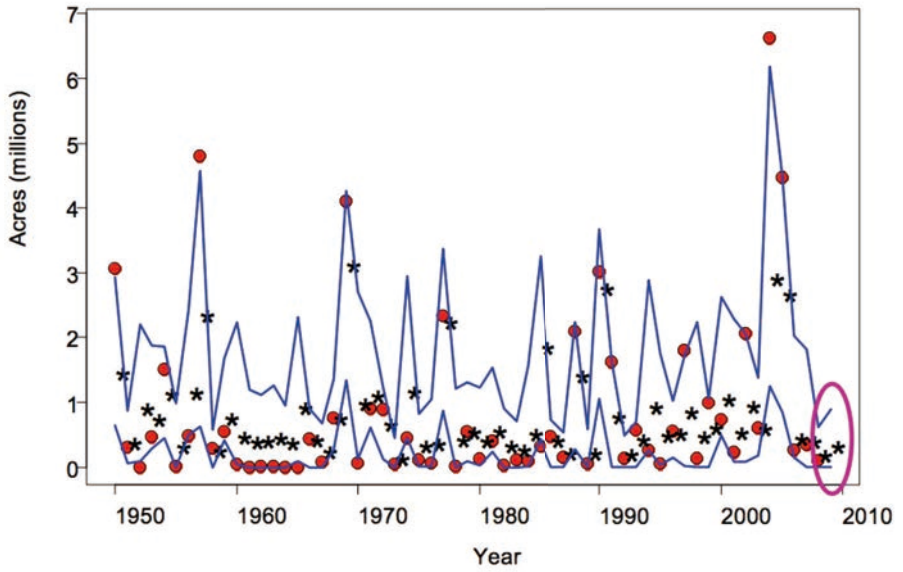


Median April prediction is 595,674 acres

Building Predictive Models

- Explanatory variables used
  - Polar (Jan, Feb avg)
  - East Pacific/North Pacific (Apr, Feb difference)
  - Pacific North American (Jan)
  - April precipitation

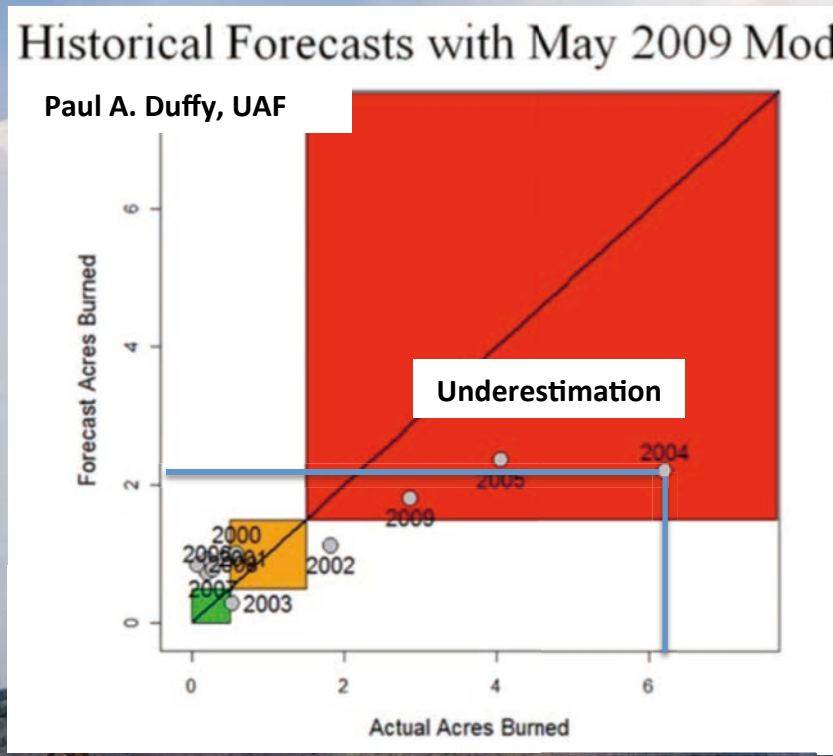
80% Uncertainty Intervals of Cross-Validated Predictions

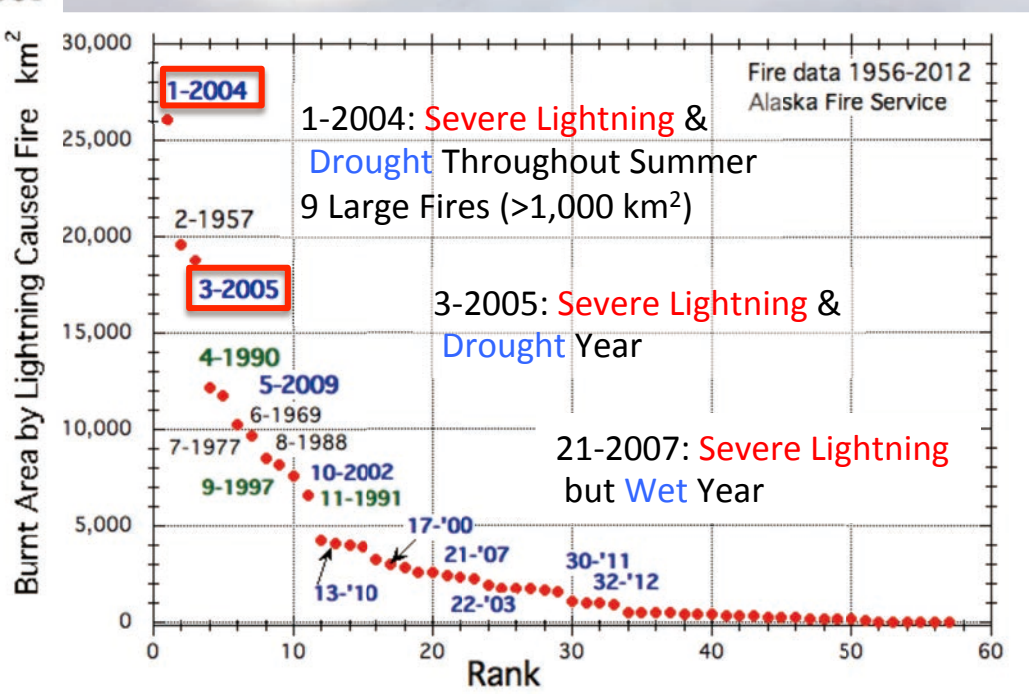


*Cross-Validation performed by re-fitting the model 5000 times, each time eliminating 20 years of data

Important factors for fire forecast

could be extracted from analysis results for extra severe fire years?





Ecological Applications, 15(4), 2005, pp. 1317–1330

IMPACTS OF LARGE-SCALE ATMOSPHERIC–OCEAN VARIABILITY ON ALASKAN FIRE SEASON SEVERITY

PAUL A. DUFFY,[1,5] JOHN E. WALSH,[2] JONATHAN M. GRAHAM,[3] DANIEL H. MANN,[4] AND T. SCOTT RUPP[1]

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…. Due to the strong dependence of area burned on weather, forecasts of area burned produced by the model are only as reliable as the forecasts for temperature and precipitation used in the model. Specifically, June temperature plays a critical role in the magnitude of area burned. Future attempts to forecast area burned in Alaska should focus on identifying those atmospheric mechanisms that most strongly influence June temperature.
…..

Obvious link?
between climate/ weather and fire

Alaskan Lightning History from 1986

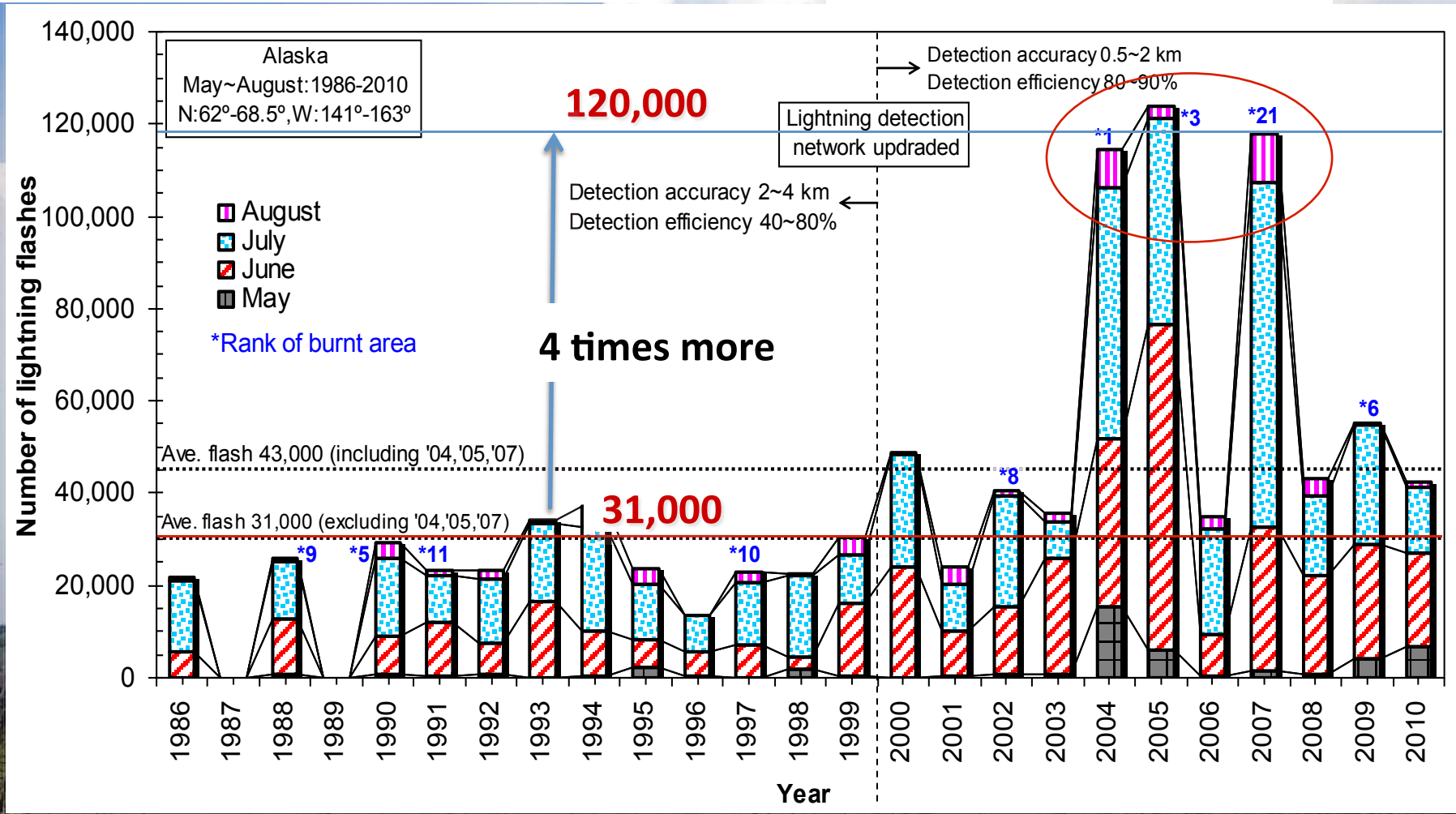
Burnt Area:

26,591 km² in 2004, 18,822 km² in 2005

2,389 km² in 2007, 11,715 km² in 2009

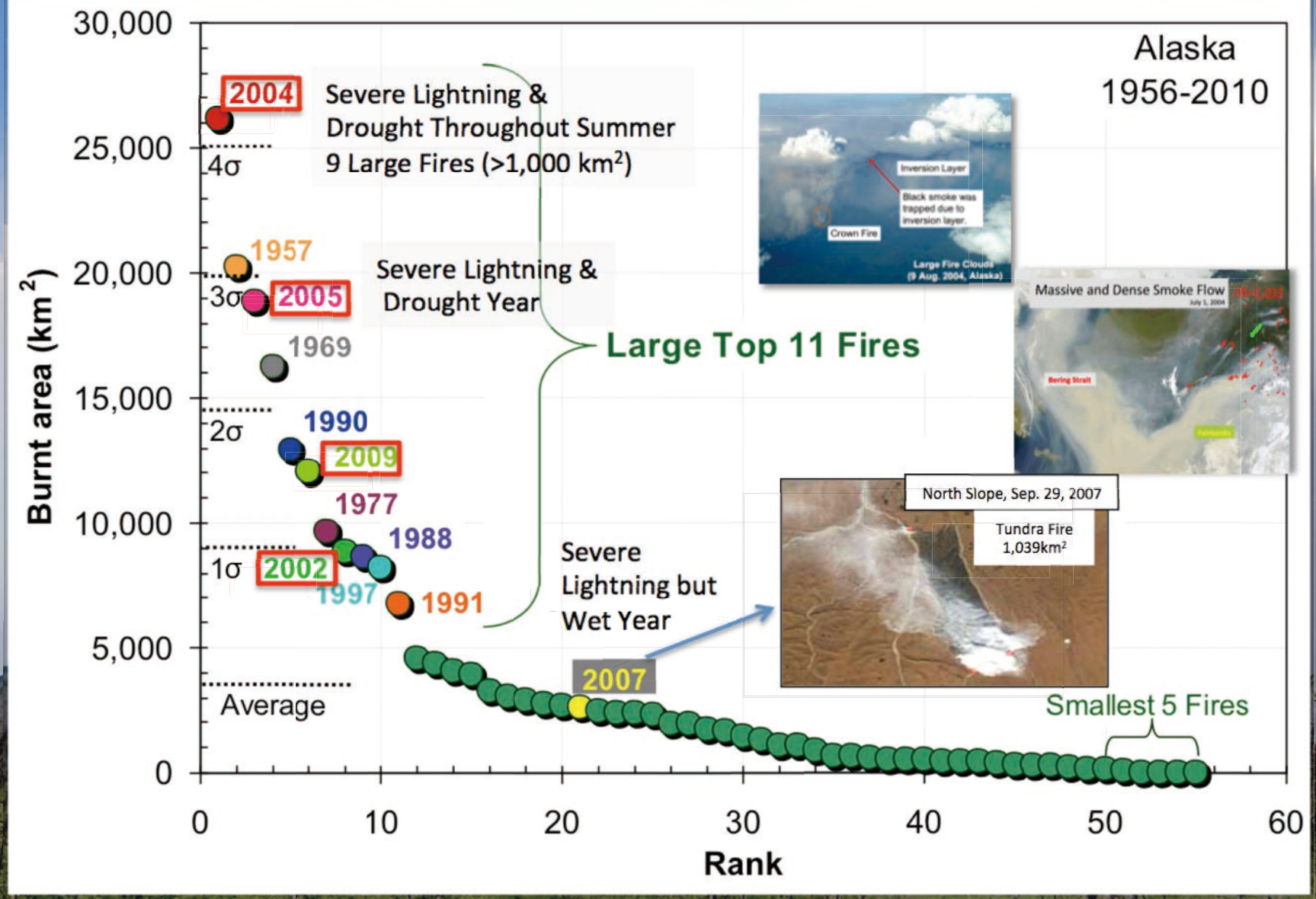
99% (May to August)

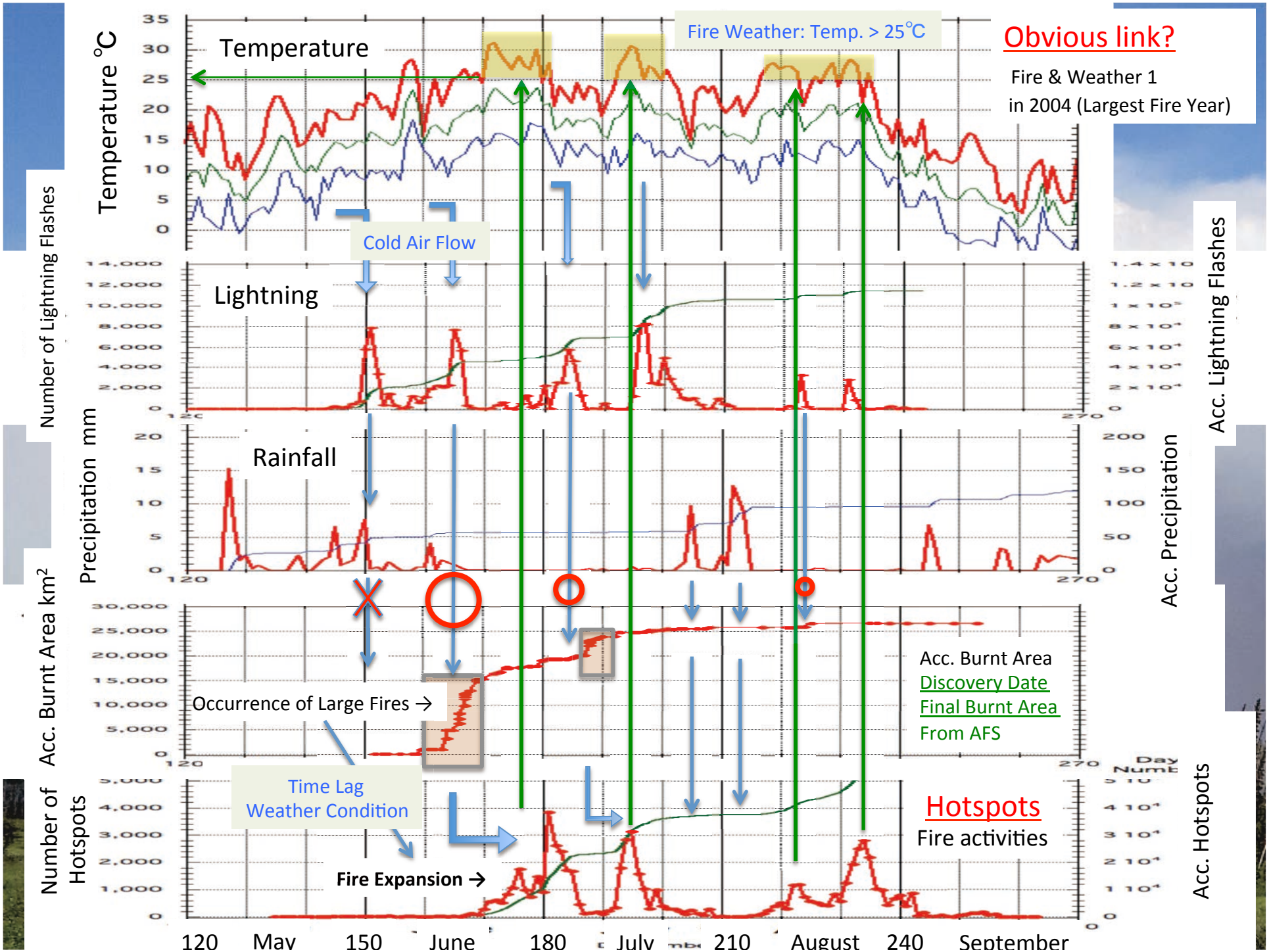
90% (June to July)

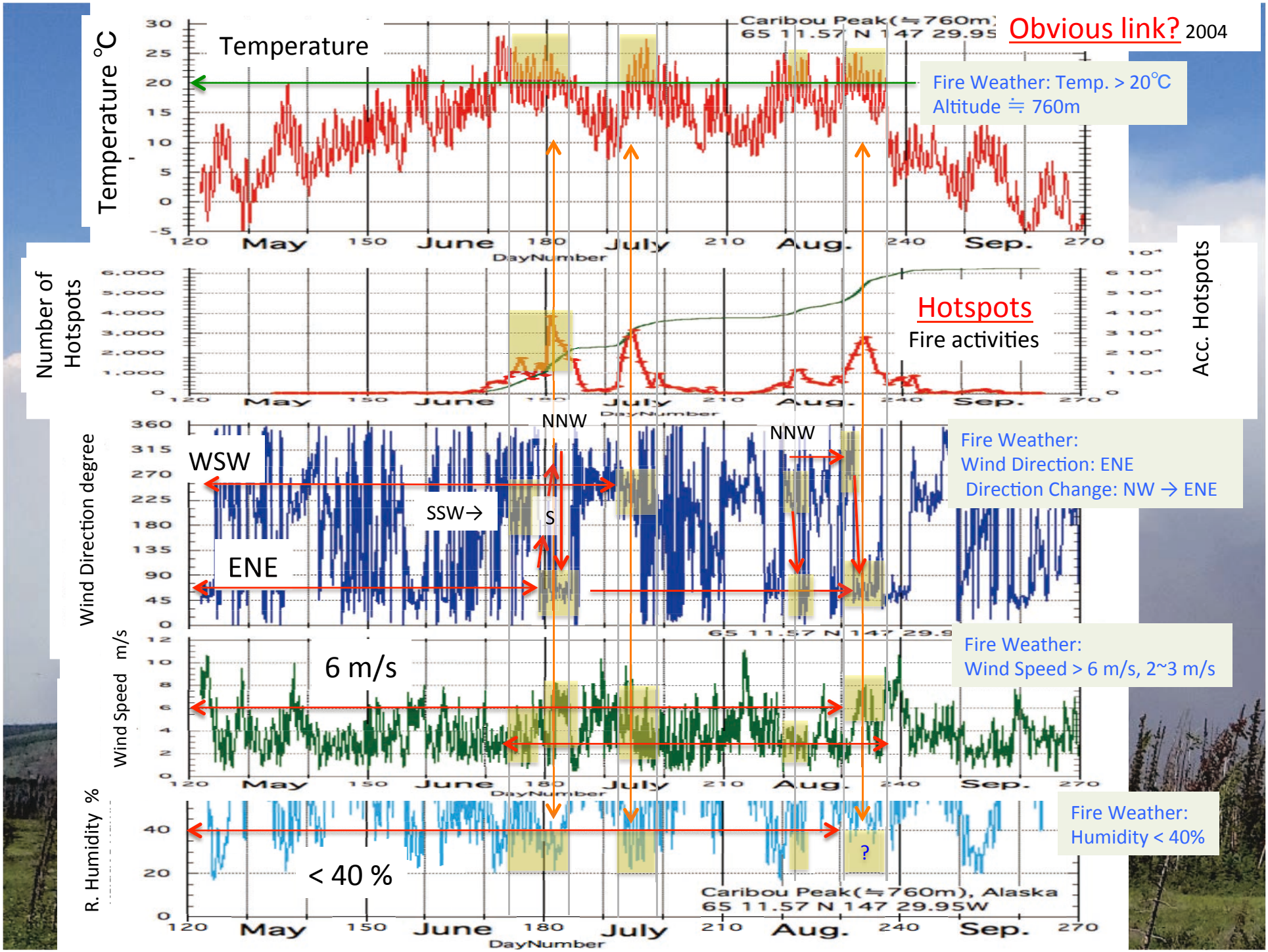


Lightning in Alaska is mainly from "Ordinary Cell Thunderstorm"

Alaskan Fire History by Size

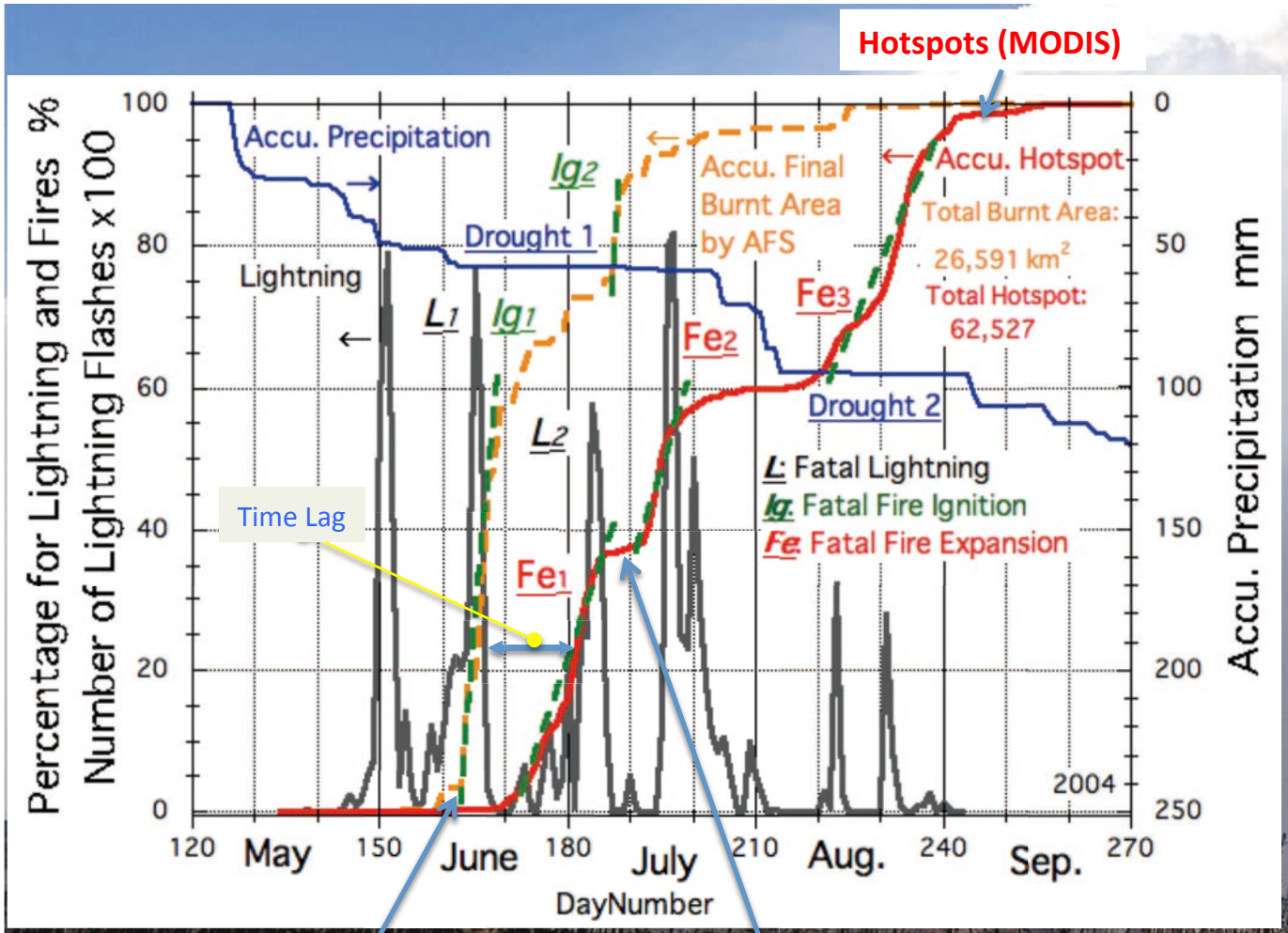



Temperature
Temperature °C
Fire Weather: Temp. > 25°C
Obvious link?
Fire & Weather 1
in 2004 (Largest Fire Year)
Cold Air Flow
Lightning
Number of Lightning Flashes
Acc. Lightning Flashes
Rainfall
Precipitation mm
Acc. Precipitation
Acc. Burnt Area km²
Occurrence of Large Fires →
Acc. Burnt Area
Discovery Date
Final Burnt Area
From AFS
Time Lag
Weather Condition
Fire Expansion →
Hotspots
Fire activities
Number of Hotspots
Acc. Hotspots
120
May
150
June
180
July
210
August
240
September


Obvious link? 2004
Temperature °C
Temperature
Caribou Peak(≒760m)
65 11.57 N 147 29.95
Fire Weather: Temp. > 20℃
Altitude ≒ 760m
Number of Hotspots
Hotspots
Fire activities
Acc. Hotspots
Wind Direction degree
WSW
SSW→
ENE
NNW
S
NNW
Fire Weather:
Wind Direction: ENE
Direction Change: NW → ENE
Wind Speed m/s
6 m/s
Fire Weather:
Wind Speed > 6 m/s, 2~3 m/s
R. Humidity %
< 40 %
?
Fire Weather:
Humidity < 40%
May
June
July
Aug.
Sep.
DayNumber

Important Factors for Alaskan Fires

Analysis Results Based on Satellite Observation



Obvious link?

Fire & Weather 1
in 2004 (Largest Fire Year)

2004: Largest Burnt Area
Rainfall before (or after) lightning may control ignition of vegetation.
Lightning under drought condition could ignite vegetation. → Dryness of vegetation
Fire expansion will occur under fire favorable condition. → weather and fuel condition.
August fires under drought condition could become severe.

Fire data from AFS is not sufficient

for "Advanced New Fire Forecast"?

Fire Name
Number of Fires △
Estimated Acres: Final Burnt Area △
Latitude, Longitude
Discovery Time: Date & Time △
Out Date: Date & Time ✕
Fire Cause :Lightning, human, etc.

Fire perimeter (kml file): Fire Map

Treatment of small fires?
Overestimation ?
Observation flight?
No observation data

Obvious link between climate/weather and fire

Obvious link?

Spatial and temporal scales of interest…. not so obvious

Paul A. Duffy, UAF

Proposal for Improvement:

Advanced New Fire Forecast Based on

Satellite Observation =

Spatial and temporal information on fire = Fire behavior

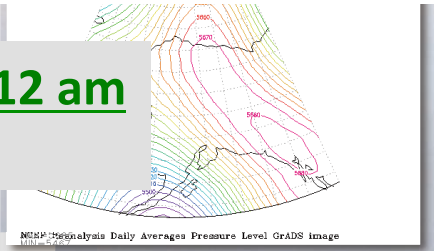
1 & 2. Forecast for wild fire occurrence

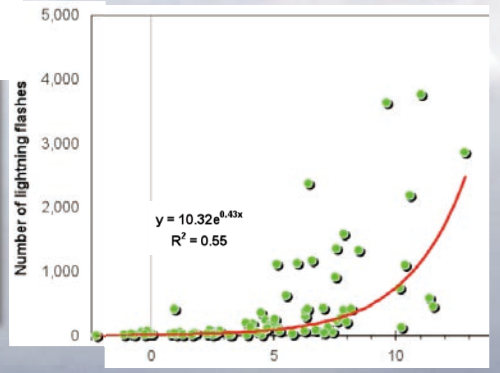
1-1. Prediction of wild (tundra) fires = forecast of lightning occurrence

Forecast: Daily→ Weekly→ Monthly→ Seasonally

A1. Check weather and fuel conditions: ~12 am

(Temp., Rainfall, weather maps….)

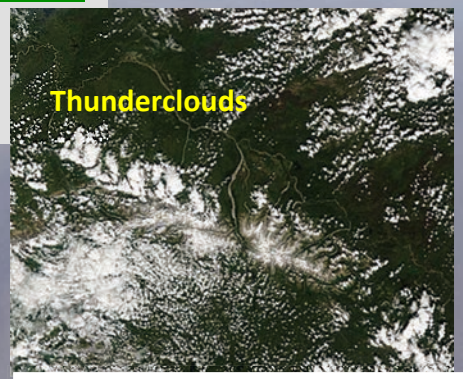


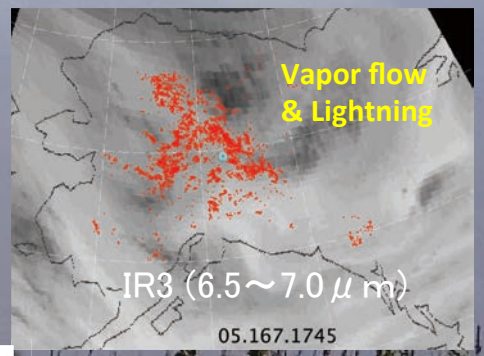


A2. Check Lightning Forecast Index:~12 am

$$LFI_{(N)} = 0.7*Te_{850,(N-1)} - LIFT_{(N)}$$

(N=day number)

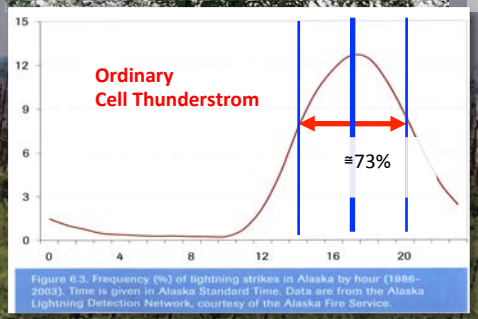




A3. Check satellite images: ~12 am

MODIS, GEOS…. IR3 (6.5～7.0μm)

Thundercloud, vapor flow,….



B. Prepare lightning or fire occurrence: 13~ pm

Conclusions

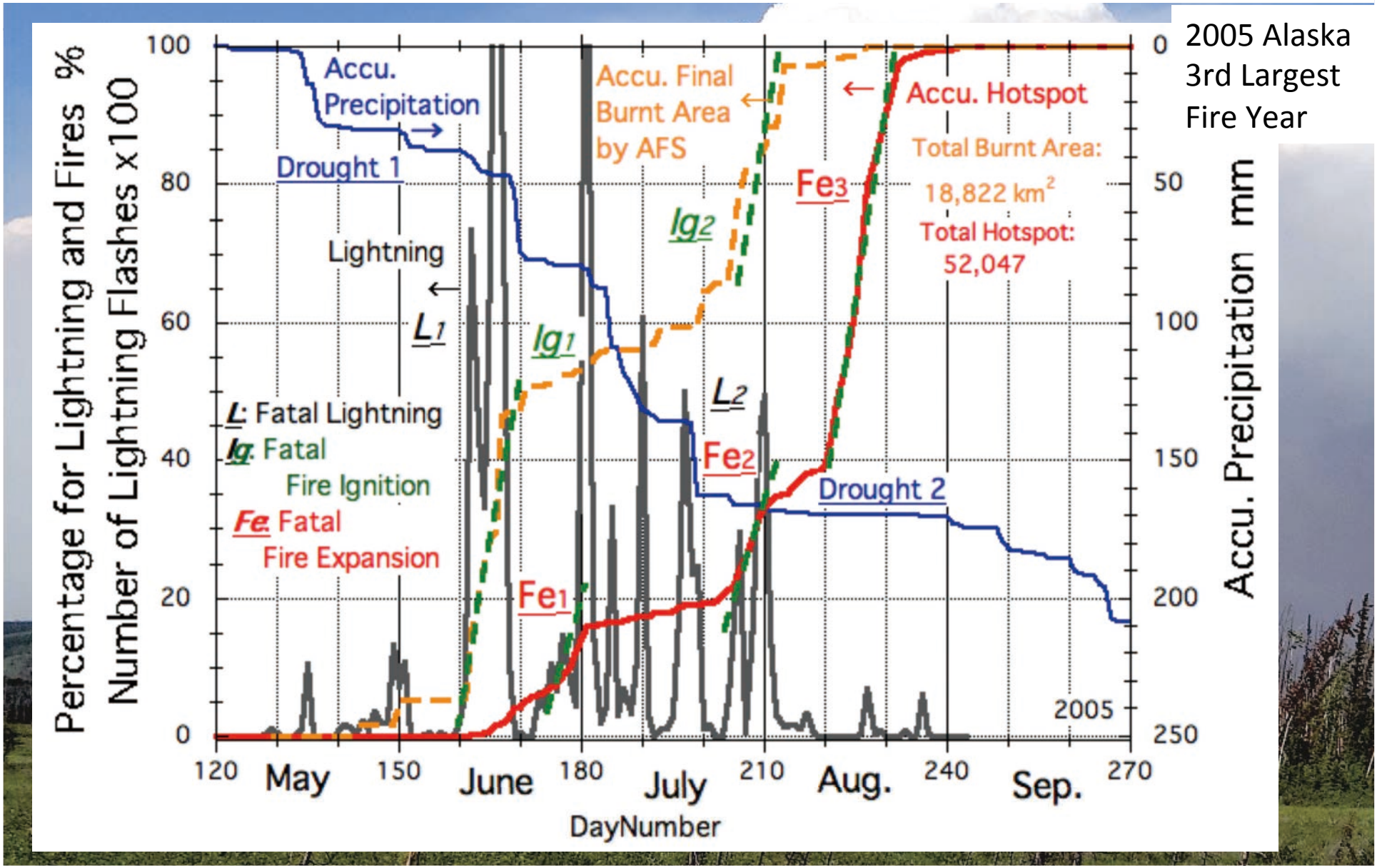
Obvious link?
between climate/ weather and fire

Satellite observation (MODIS daily hotspot) and lightning data were successfully used to show "obvious link" in Alaskan fires. Analysis results for largest fire year (2004) allowed following conclusions:

1. **Occurrence of large fire may be closely related to not only the amount of rainfall during lightning period but also forest conditions (dryness of vegetation).**
2. **There was a time lag (about several days or more) between fire discovery date and fire expansion date (period) due to weather condition (change from cold air flow condition to warm condition or from lightning weather to fire weather).**
3. **Analysis results using daily hotspot data could explain activity of spatial and temporal fires. This implies "Advanced New Fire Forecast".**
4. **Fire weather conditions near Fairbanks were confirmed: temperature > 25 ℃, wind direction = ENE & WSW, wind direction change from NW to ENE, wind speed > 6 m/s, 2~3 m/s, relative humidity < 40 %.**

Important Factors for Alaskan Fires

Analysis Results Based on Satellite Observation



2005 Alaska 3rd Largest Fire Year