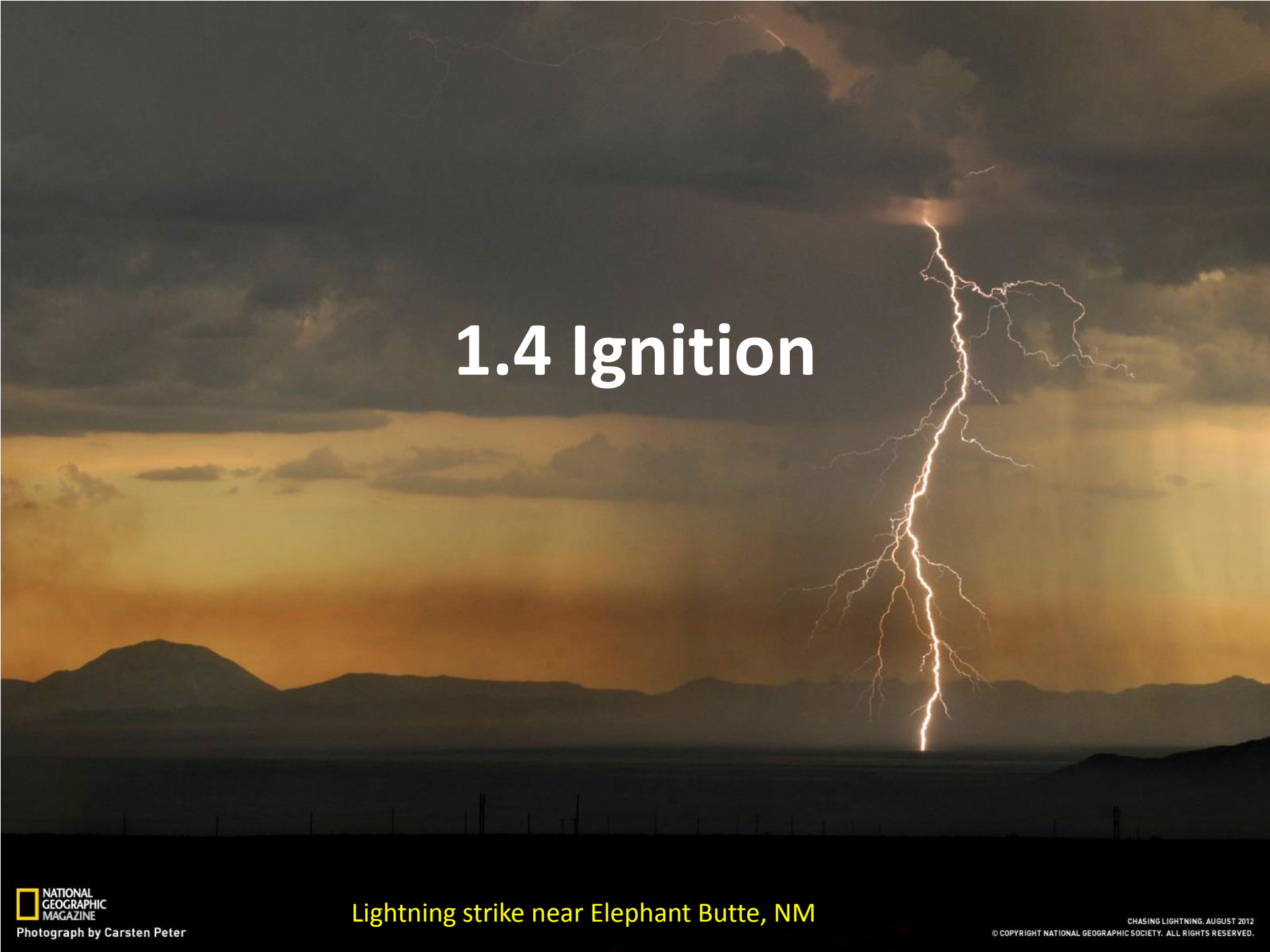
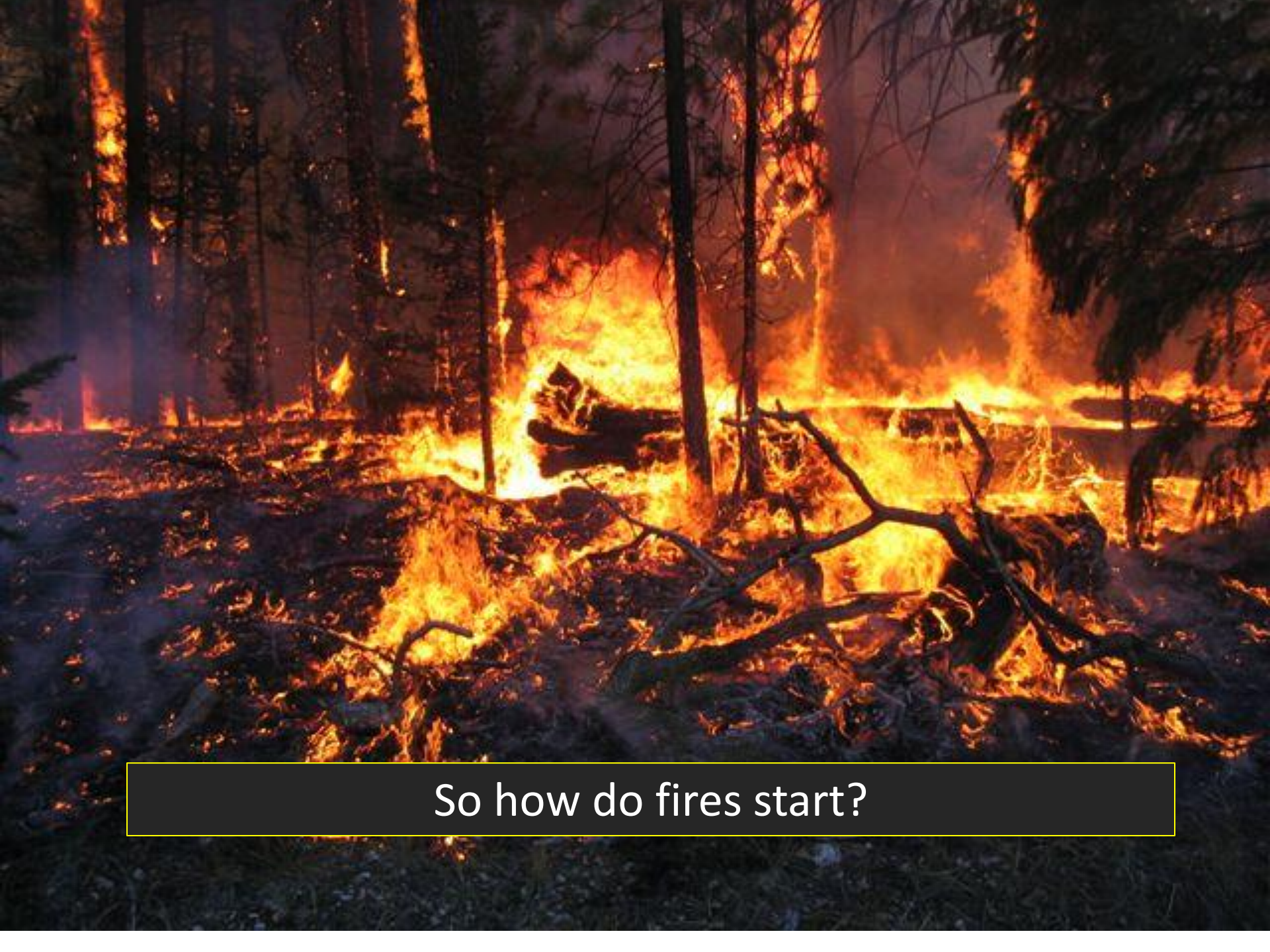

1.4 Ignition
NATIONAL GEOGRAPHIC MAGAZINE
Photograph by Carsten Peter
Lightning strike near Elephant Butte, NM
CHASING LIGHTNING. AUGUST 2012
© COPYRIGHT NATIONAL GEOGRAPHIC SOCIETY. ALL RIGHTS RESERVED.

# Recall the three basic modes of energy transfer work during fire:

**Conduction:** Heat passes through burning fuels (*e.g.* through a log or branch), driving off moisture and preparing it for burning; soil heating is mostly conductive

**Convection:** Heated air and gases rise above burning fuels into tree canopies, scorching and preheating them; smoke plumes are convective

**Radiation:** Heat radiated from a flaming front pre-heats grass, shrub, and tree fuels, causing the flaming front to move along


So how do fires start?

# Phase I: Pre-heating (pre-ignition)

- Fuels ahead of the fire are pre-heated by convection and radiation. This leads to:
  - Dehydration: Water is driven out of the fuel (so fuels become drier) ~ 100° C
  - Volatiles (extractives) evaporate into gas phase
  - Solid fuel breaks down into gaseous components
- This is called *pyrolysis* of solid fuels ~ 325° C
- These reactions are mostly *endothermic*
- Time: seconds

# Phase II: Gas (ignition) phase

- Volatiles generated in Phase I (by evaporation and pyrolysis) ignite and oxidize (finally!)
- This is when we start to see *flames*
- Phase II is *exothermic* – chemical bond energy is being released
- $H_2O$ and $CO_2$ released as by-products (right?)
- Time ~ minutes

# Phase III: Smoldering phase

- After the volatiles have ignited, what's left?
  - Un-pyrolized wood, esp. lignin component
  - Char
  - Tar
- Lower temperatures (300 – 400° C)
- Surface oxidation, heat travels by conduction (think of a glowing log)
- Time ~ hours to months!

# Fire is a chain reaction!

1. Initiation energy begins pre-heating and pyrolysis
2. Pyrolysis is exothermic (generates more energy than it consumes)
3. This released energy further pre-heats more fuel, keeps the reaction going
4. The reaction stops when one of the legs of the combustion triangle is no longer present

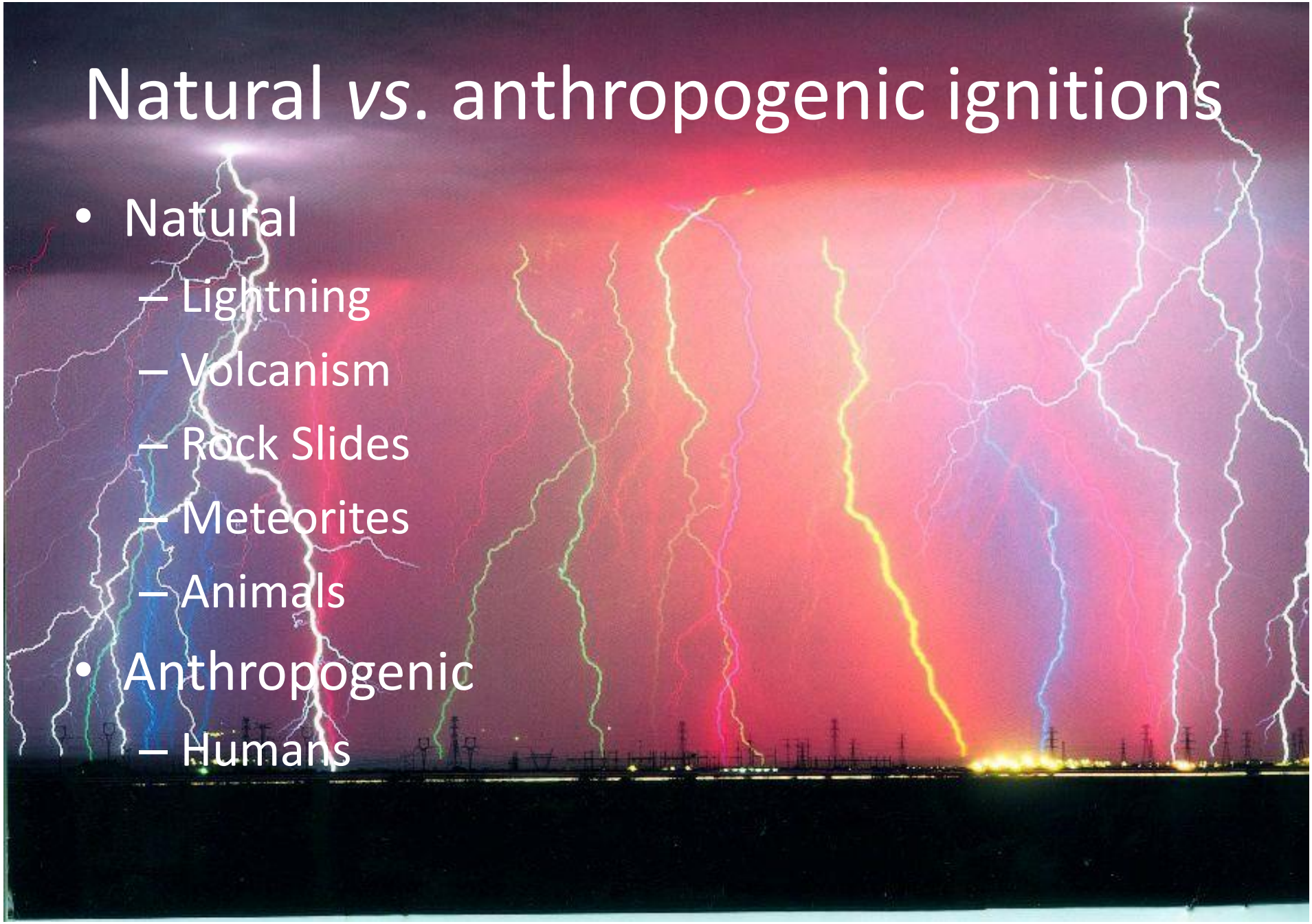
Instructor suggestion: Do the readings to learn more about the stages of combustion!

# Now that we understand how energy flows, and the stages of combustion

Some things we'd like to know:

- How does "ignition" work?
- What is an ignition source?
- What factors affect ignition probability?

# Natural *vs*. anthropogenic ignitions



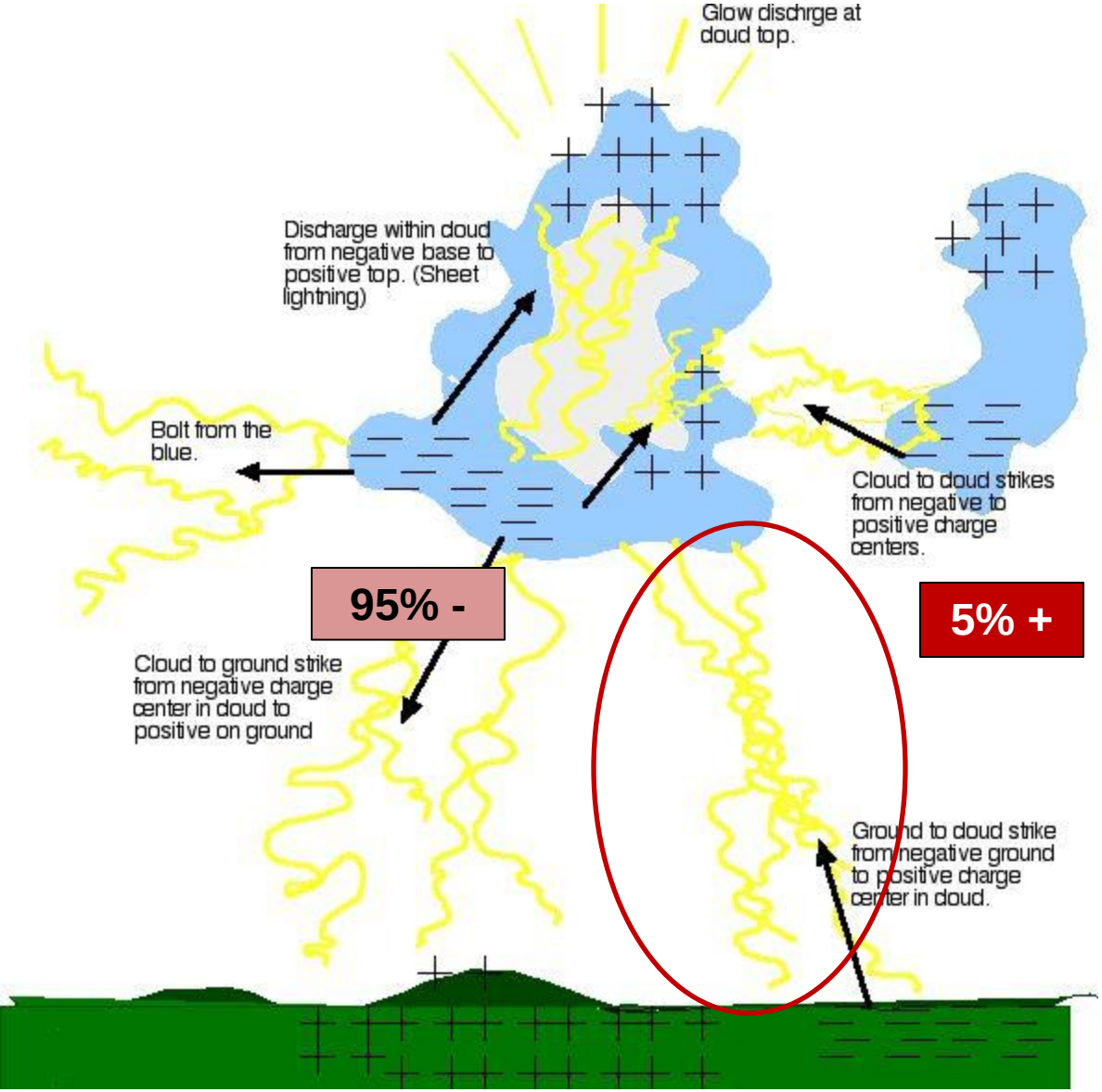
- Natural
  - Lightning
  - Volcanism
  - Rock Slides
  - Meteorites
  - Animals
- Anthropogenic
  - Humans

# Natural Ignition

- Lightning Ignition
  - Phases of Strike
    - Step Leader
      - Followed by pause
    - Return Stroke
      - Dart Leader
    - **Long Continuous Current (LCC)**
  - Ignition of forest fuels is most likely to occur when a discharge contains, in addition to one or more fast return strokes, a LCC, in which current flows continuously in the lightning channel for a relatively long duration (seconds)

http://www.metacafe.com/watch/1603707/lightning_strikes_tree_up_close/

http://www.metacafe.com/watch/1599423/slow_motion_lightning/




# What is lightning anyway?

- Atmospheric discharge of electricity
- Can travel 60,000 m/sec
- Heat up to 30,000 deg. C
- Within bolt, 10,000 degrees
- Surrounding air creates shockwave, known as thunder
- Average bolt size of 1 gigavolt, or 300 GJ (gigajoules)

## Types of Lightning

- Within cloud discharge
- Cloud-to-cloud
- Cloud-to-ground
  - Typically ground +
  - Unique ground –
- POSITIVE strikes start most fires

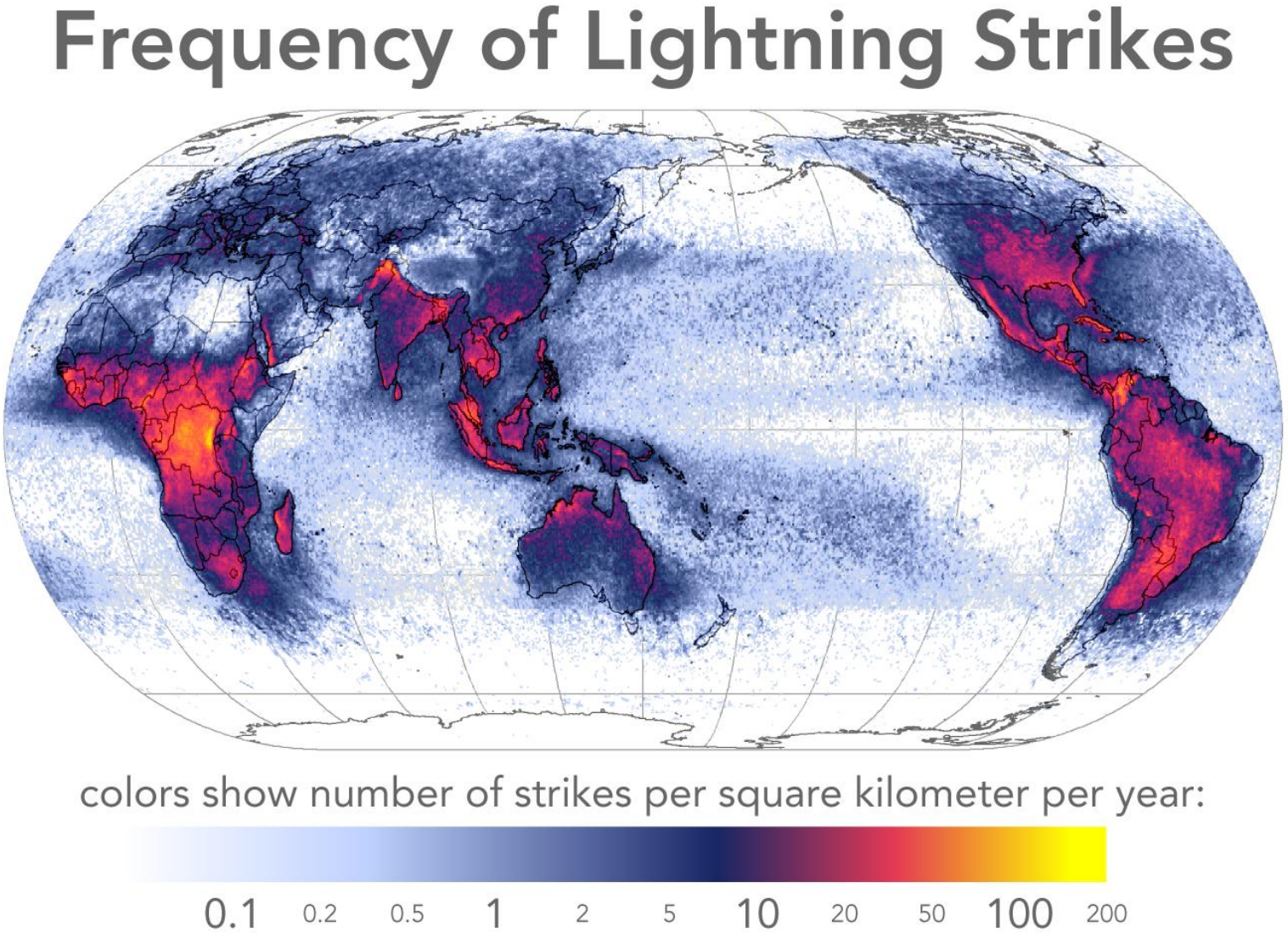
CentennialofFlight.gov

# Lightning energy

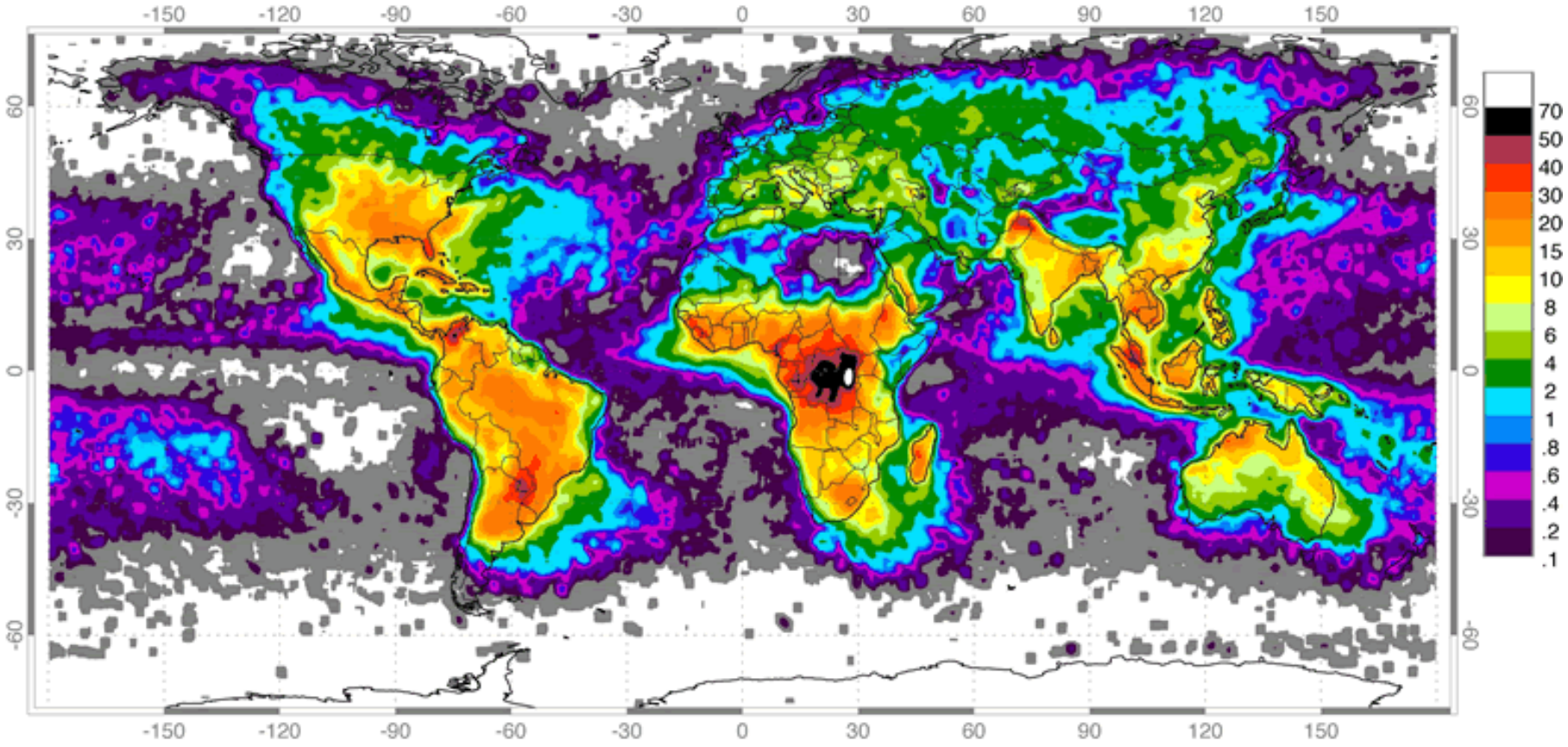
- Typical lightning bolt ~ 5 km long
- Contains ~ 1 to 10 billion joules of energy
- Lightning is actually a fourth form of energy transfer, *electrostatic discharge*
- Temperatures can exceed 20,000 °C (compares favorably with the core temperature of our Sun, ~5,800 °K)

Wikipedia

# Natural Ignition




MODIS 2008



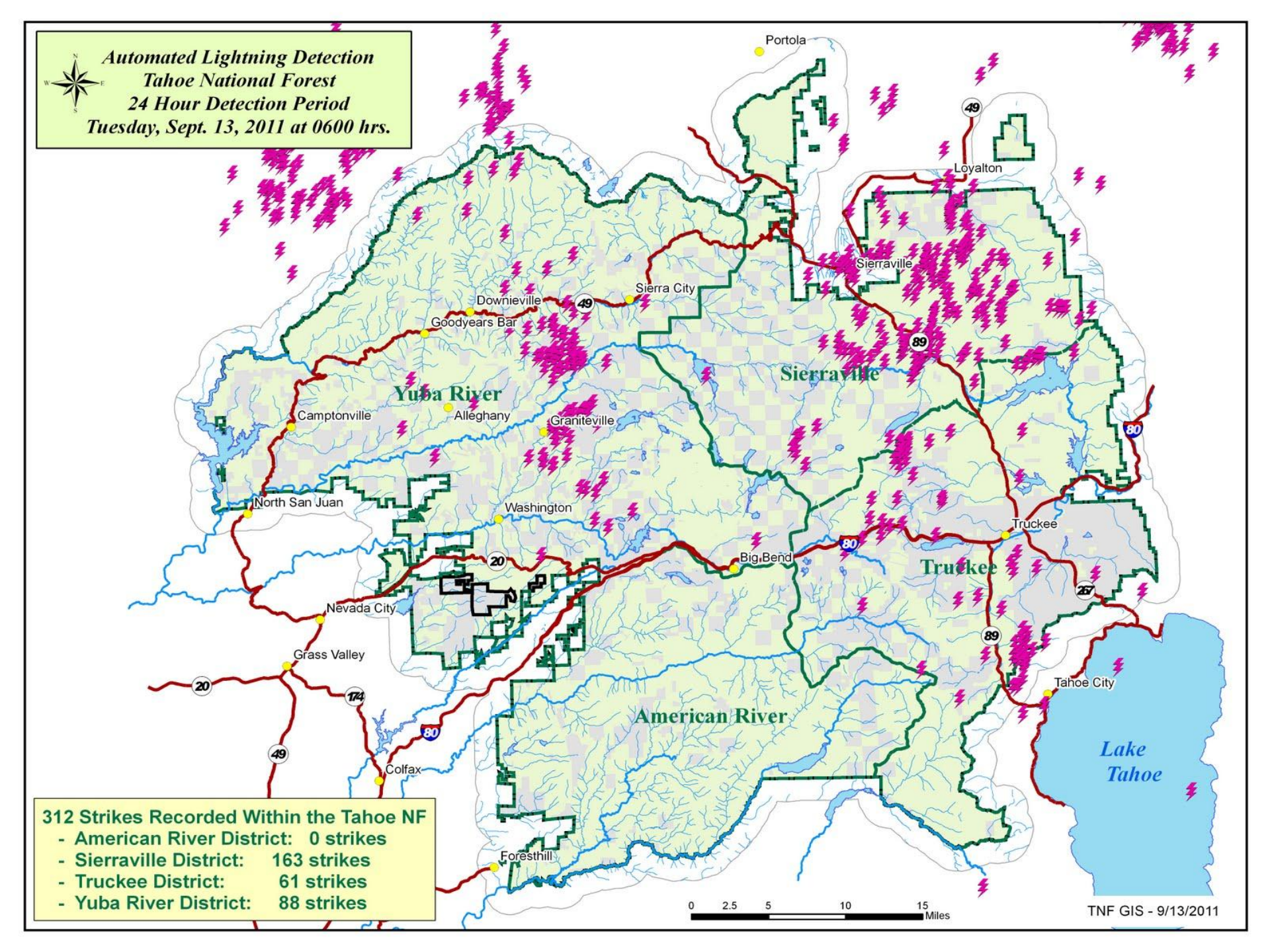

**Low Resolution Full Climatology Annual Flash Rate**

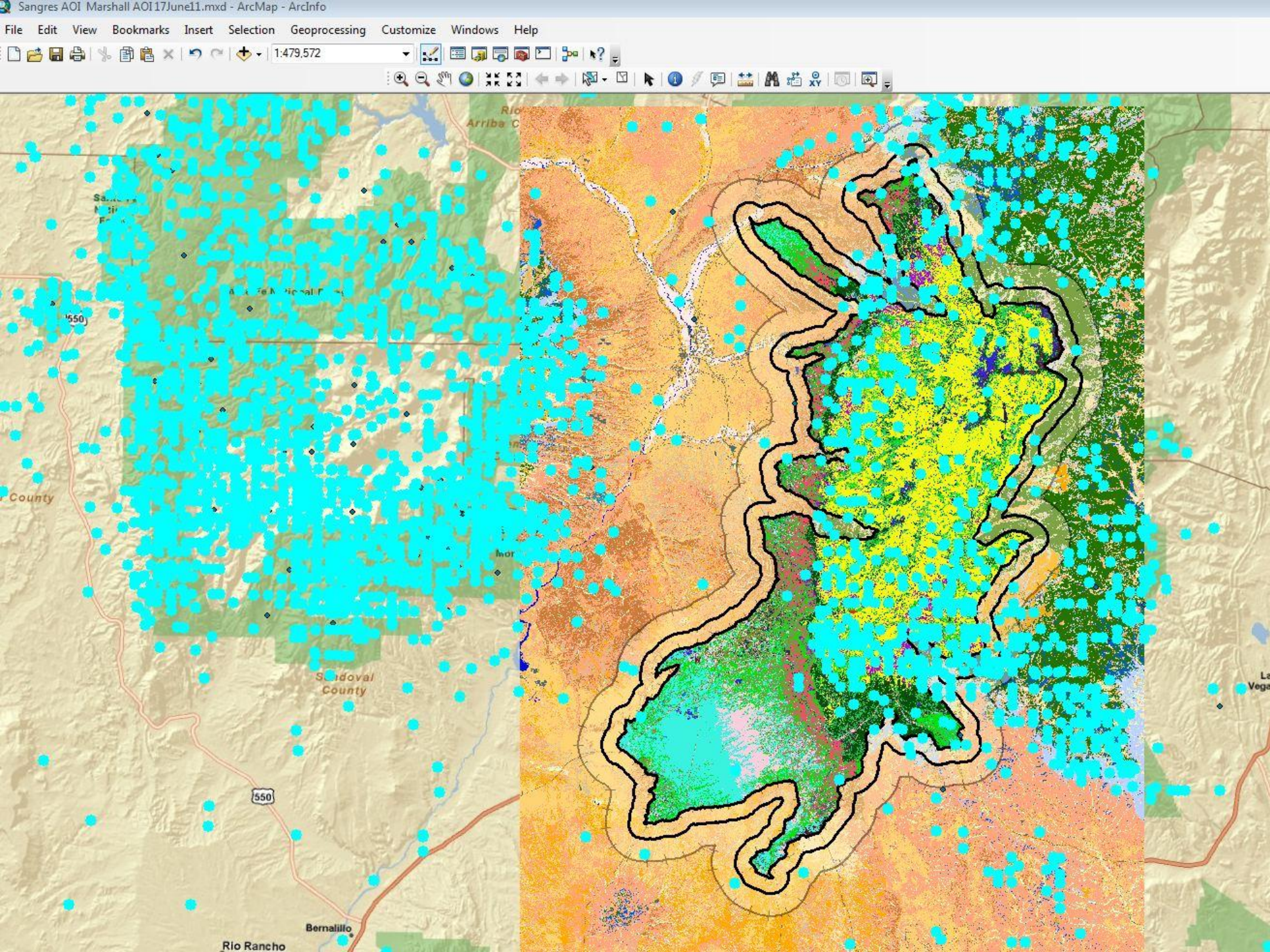
Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments.

From geology.com: http://geology.com/articles/lightning-map.shtml

# Why is lightning concentrated in certain areas?

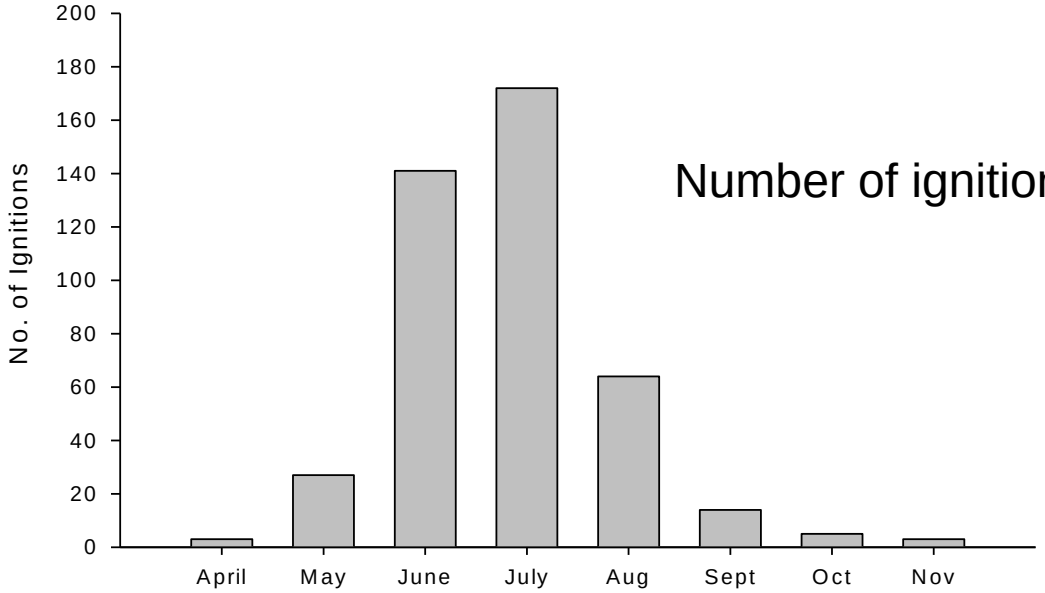
- Lightning is associated with areas where air rises rapidly, either by topographic forcing, surface heating, or other mechanisms.
- More lightning occurs over land than ocean because solar flux heats up the land surface faster than the ocean. More hot air leads to stronger convection, thunderstorms, and lightning.
- Much more lightning occurs in equatorial areas than near the poles. The equator is warmer than the poles, and convection, thunderstorms, and lightning are widespread across the tropics every day due to concentration of solar heating.
- Lightning rarely occurs in Arctic or Antarctic regions for the same reason (no mechanism for rising air).


Automated Lightning Detection
Tahoe National Forest
24 Hour Detection Period
Tuesday, Sept. 13, 2011 at 0600 hrs.
Portola
Loyalton
Sierraville
Sierra City
Downieville
Goodyears Bar
Yuba River
Camptonville
Alleghany
Graniteville
Sierraville
North San Juan
Washington
Truckee
Big Bend
Truckee
Nevada City
Grass Valley
Tahoe City
American River
Lake Tahoe
Colfax
Foresthill
312 Strikes Recorded Within the Tahoe NF
- American River District: 0 strikes
- Sierraville District: 163 strikes
- Truckee District: 61 strikes
- Yuba River District: 88 strikes
0 2.5 5 10 15 Miles
TNF GIS - 9/13/2011


Sangres AOI Marshall AOI17June11.mxd - ArcMap - ArcInfo
File Edit View Bookmarks Insert Selection Geoprocessing Customize Windows Help
1:479,572
Sandoval County
550
Bernalillo
Rio Rancho

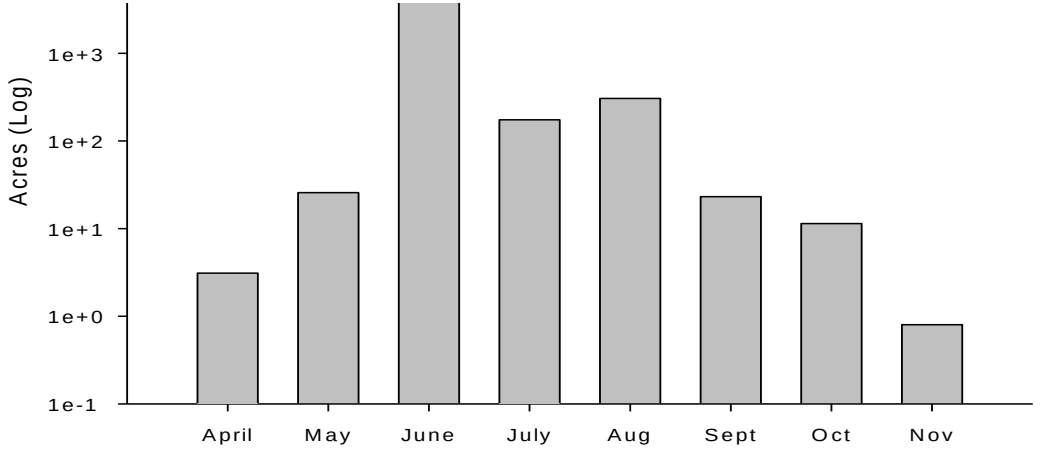
# Lightning is highly seasonal

Fire ignitions 1970-2006




Number of ignitions

Area burned

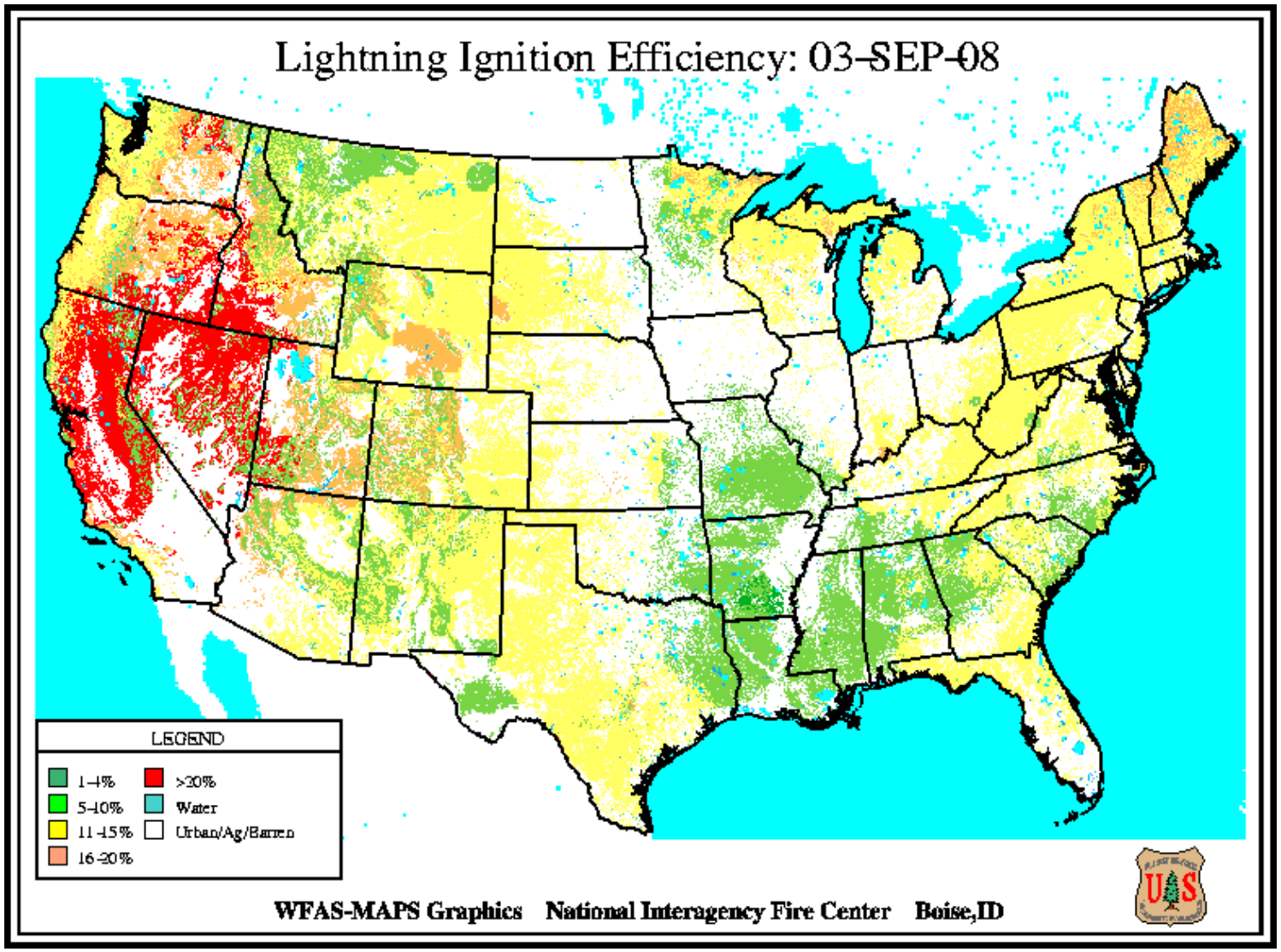


# “Ignition efficiency”

Number of strikes / Number of starts

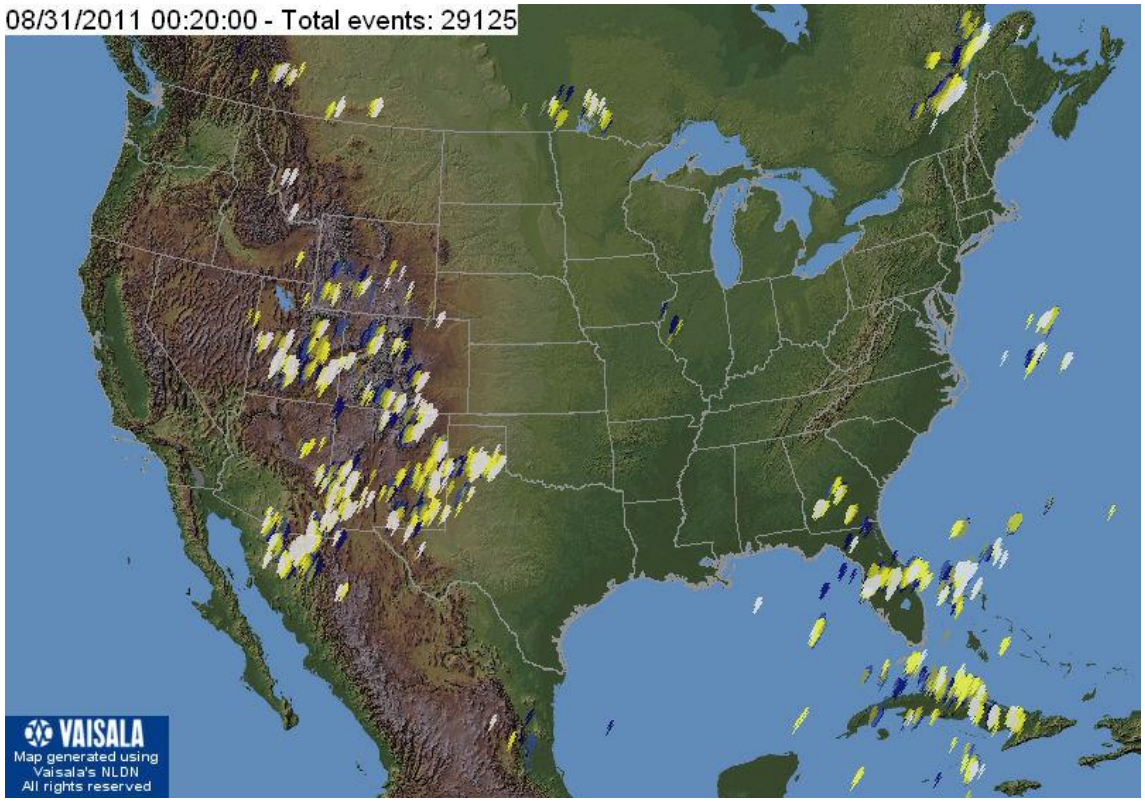
(so, a dimensionless ratio)


# Natural Ignition



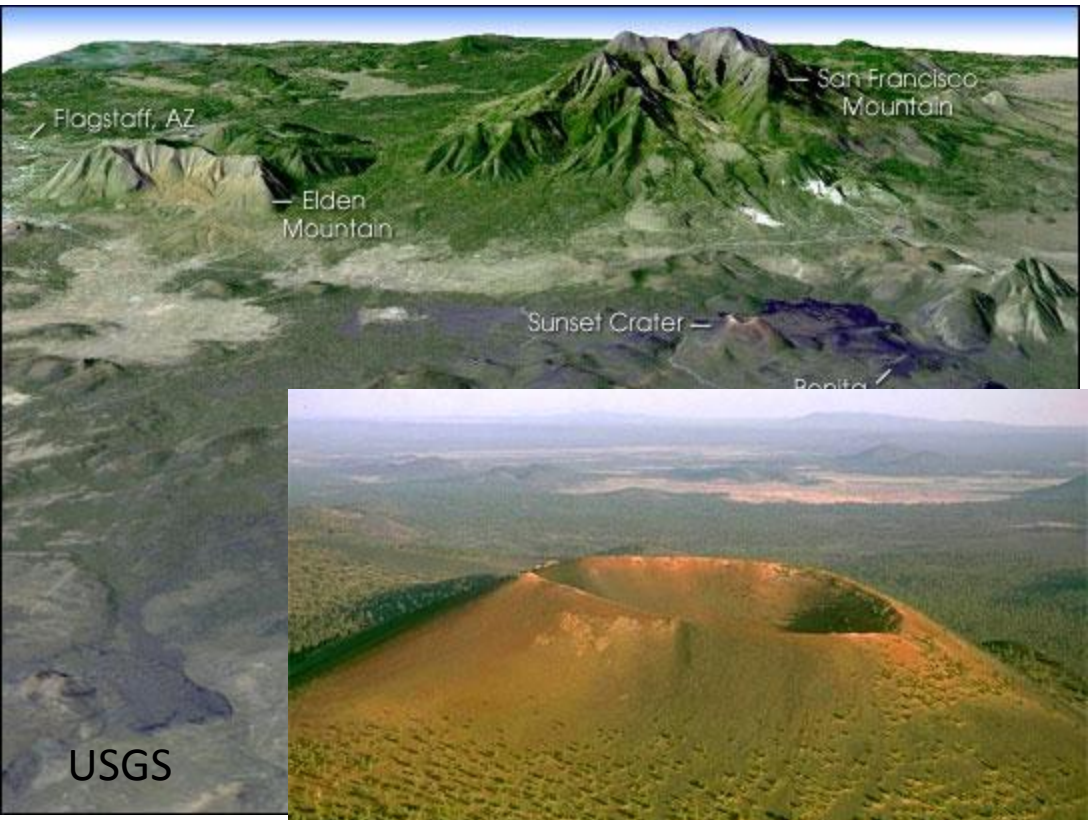
# Where to find good lightning data

- http://thunderstorm.vaisala.com/explorer.html
- National Lightning Detection Network



# Other (less common) sources of natural ignition

– Volcanoes







Hawaii, Kalapana

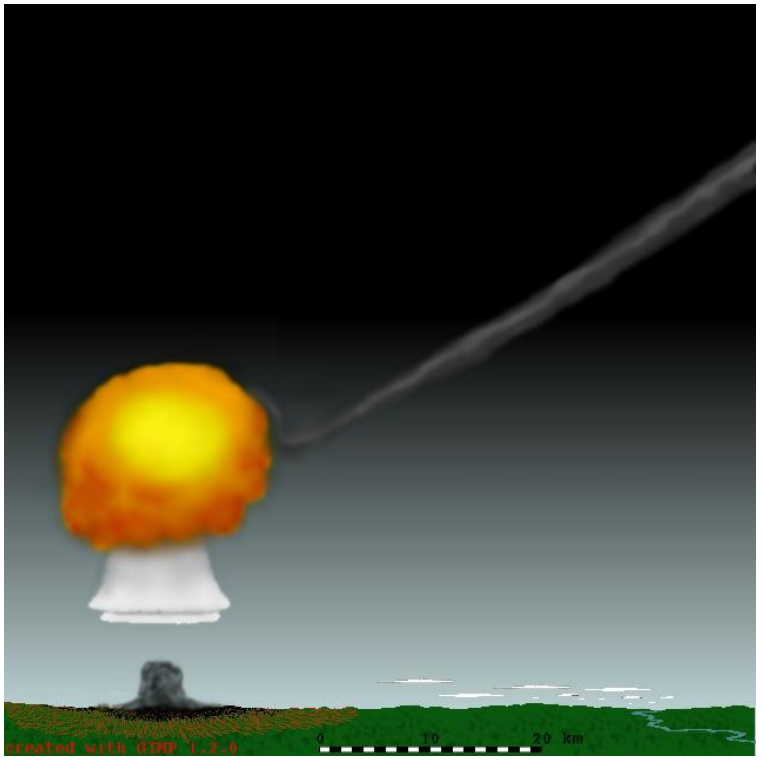
Honolulu Advertiser, 2008

# Natural Ignition

- METEORITES!

Tunguska, Siberia 1903

- 60 million trees across an area of 2000 square kilometers (850 square miles)
- Estimated equivalent 5 to 30 megatons




*Diane Neisius*

# Natural Ignition

- Animals as secondary sources
  - Birds of Prey
    - Brown Falcon, Arnhem L
  - Arizona Southwest?
    - White Tail Hawks

Billy Yalawanga

"They peered into the fire and looked for all the world like a host of soot-darkened devils."

Pete Dunne, David Sibley

# Anthropogenic Ignitions

- Aborigines
  - First form of landscape scale manipulation by Humans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EDITORS' BLOG

Last Updated: Thursday, 29 April 2004, 18:01 GMT 19:01 UK

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## Early human fire skills revealed

By Paul Rincon
BBC News Online science staff

**Human-like species migrating out of their African homeland had mastered the use of fire up to 790,000 years ago, the journal Science reports.**

The excavations uncovered numerous flint artefacts

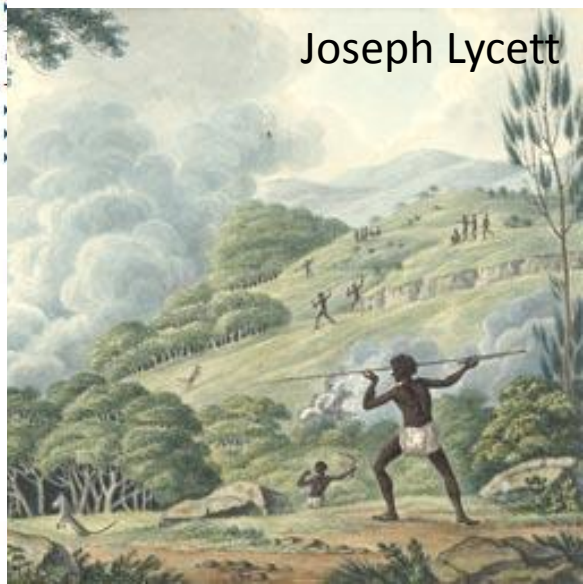
The evidence, from northern Israel, suggests species such as *Homo erectus* may have been surprisingly sophisticated in their behaviour.

The find links earlier evidence of controlled fire from Africa with later discoveries in Eurasia, scientists say.

The researchers say that a wildfire is unlikely to be the cause.

Researchers from the Hebrew University in Jerusalem and Bar-Ilan University in Ramat-Gan excavated a waterlogged site at Gesher Benot Ya'aqov.

In 34m-thick ground deposits, they found numerous flint implements belonging to the so-called Acheulean tradition of tool manufacture. Some of these were burnt, while other were not.



# People still contribute a lot to ignitions

- Pastoralists, ranchers
- Farmers (shifting cultivation)
- Arson, curiosity
- Probably some religious practices
- Careless behavior (origins of Rodeo-Chediski, Wallow Fires, the two largest in AZ history)

# Looking ahead:

Friday: 1.5, Smoke and incomplete combustion

Monday: Holiday

Wednesday: Unit 1 Quiz