# Fire in the Air: Biomass Burning Impacts in a Changing Climate

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ATMS 790: Atmospheric graduate seminar class

University of Nevada, Reno

February 12, 2018

# Journal Article: Overview, Discussion & Questions

## Fire in the Air: Biomass Burning Impacts in a Changing Climate

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# Outline

# Use of Biomass Burning

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# Susceptible fuel for Biomass Burning

Table 1: The global condition of biomass distributions

| | Global Land surface | C storage (globally) | Area covered |
|---|---|---|---|
| Forest | 30% -37% | | Globally |
| Boreal forest and Woodland | 6%-9 % | 30% | 9-14 $Mkm^2$ |
| Tropical Forest | 5% | | 49% America<br>34 % Africa<br>16 % Asia |
| Savana (tree and grasses) | 22% | | 33 $Mkm^2$ |
| Temperate Forest | 0.50% | | 0.75 $Mkm^2$ |

# Tools for Assessment of Biomass Burning products and impact

# Tools

## Observational tool

## Emission Factor estimates

## Earth system model

# Observational tools

## Ground based and aircraft measurements

Chemical composition, transport, and chemistry of the atmosphere.

## Satellite based measurements

Aquiring quantitative and spatial distribution of BB with fire activity.

# Observational tools

| | Satellite/Sensor | Coverage |
|---|---|---|
| Burned area products | | |
| Global Burned Area (GBA) 1982–1999[89] | Polar NOAA-AVHRR | Global 8 km weekly |
| GBA 2000[90] | Polar SPOT VEGETATION | Global 1 km monthly |
| GLOBSCAR 2000[91] | Polar European Remote Sensing Satellites (ERS) Along Track Scanning Radiometer (ATSR) | Global 1 km monthly |
| L3JRC 2000–2007[85] | Polar SPOT VEGETATION | Global 1 km daily |
| Global Fire Emissions Database version 2 (GFED v2)[81] | Polar MODIS (2001 onward), TRMM-VIRS and ATSR (for the pre-2001 period), and burned area (MODIS) | In 0.5 km monthly 1997–2006 |
| GFED v3[15] | | In 0.5 km monthly 1997–2009 |
| Global Carbon Burnt Area Estimate (BAE)[92] | VEGETATION, (A)ATSR and MERIS | Monthly 1998 to 2007 |
| Fire count products | | |
| TRIMM[93] | Polar Tropical Rainfall Measuring Mission (TRMM)—Visible and Infrared Scanner (VIRS) | 0.5° × 0.5°, between 38 °N and 38 °S since January 1998 |
| World Fire Atlas[94,95] | Polar European Remote Sensing Satellites (ERS) Along Track Scanning Radiometer (ATSR) | Global in 1 km × 1 km daily since July 1996 |
| MODIS[81] | Polar MODIS | In 1 km × 1 km on daily basis since 2001 |
| Fire counts and fire radiative power 2004[87] | Geostationary Spinning Enhanced Visible and Infrared Imager (SEVIRI) Meteosat-8 satellite | Africa 3 km in 15 minutes |

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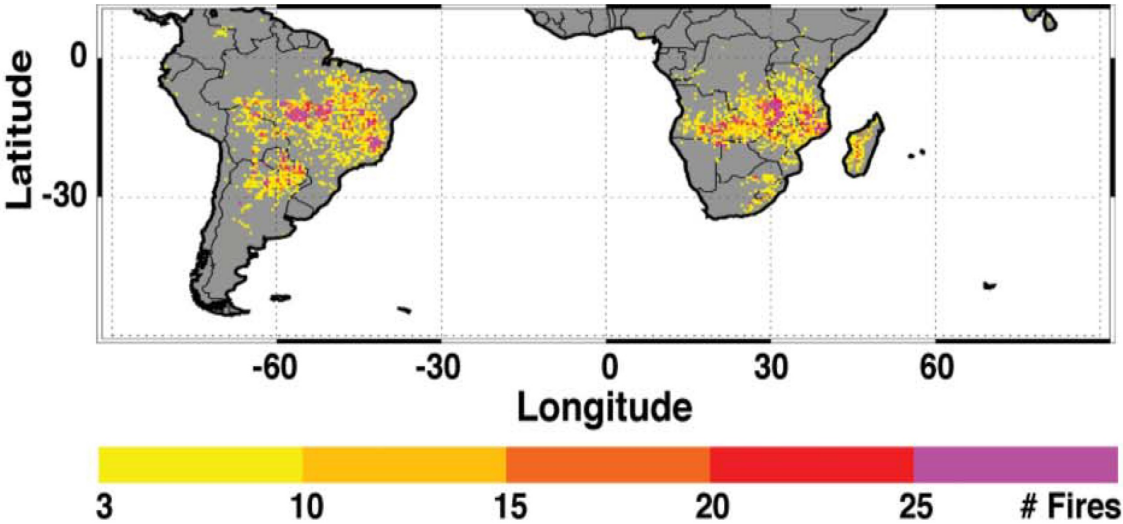
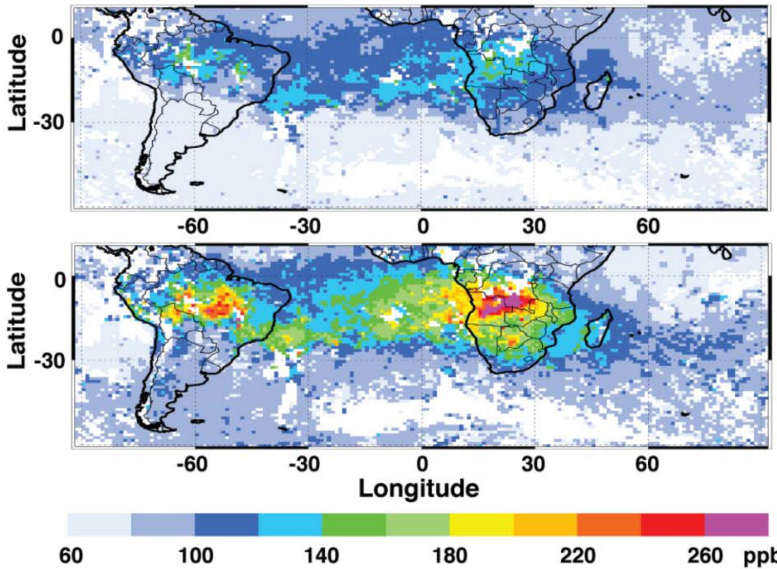
# MODIS fire counts: September 23–30, 2003



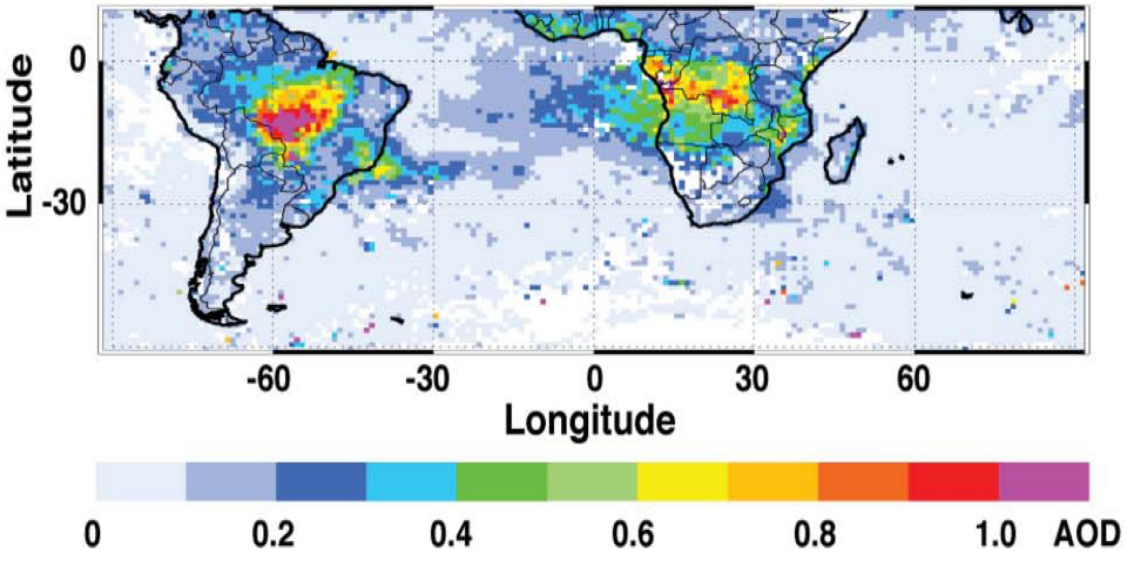
# MOPITT CO mixing ratio: September 23–30, 2003




250 hPa

700 hPa

# MODIS fine mode AOD: September 23–30, 2003



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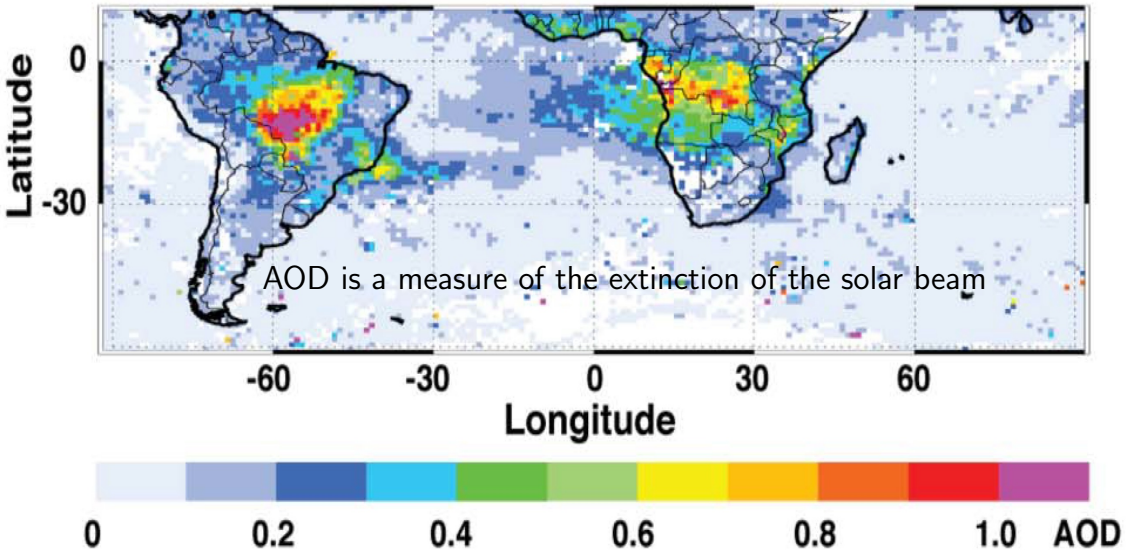
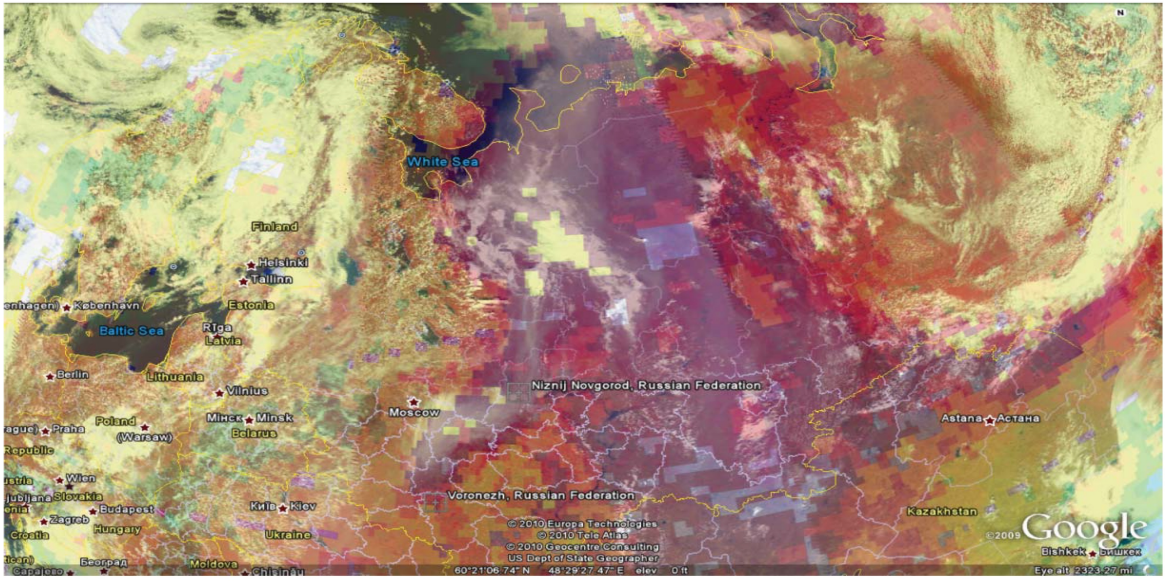


# Atmospheric Infrared Sounder visible wavelength radiance



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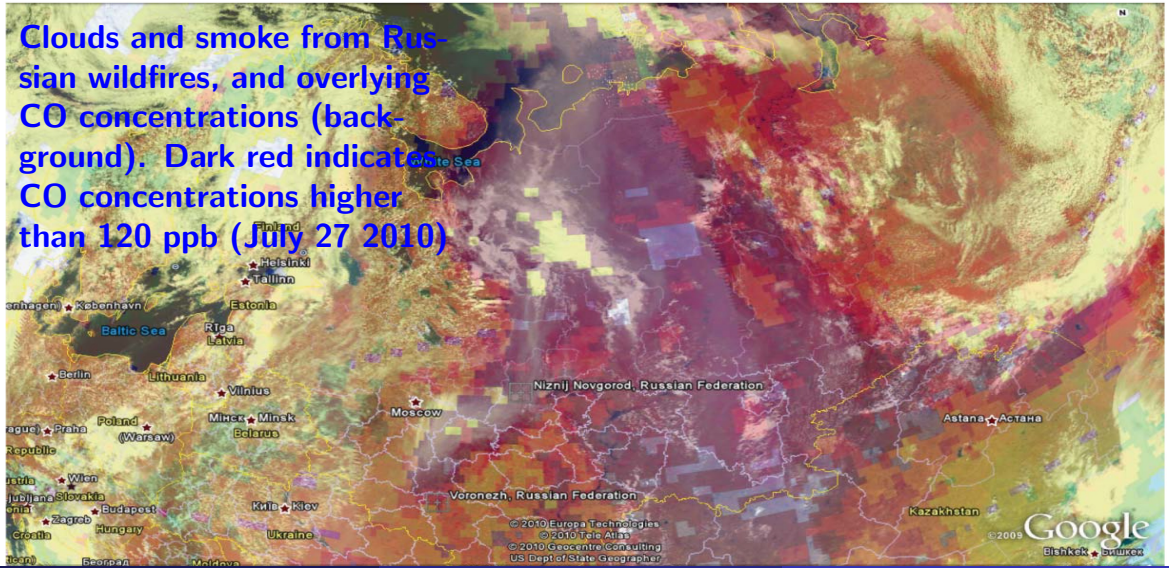
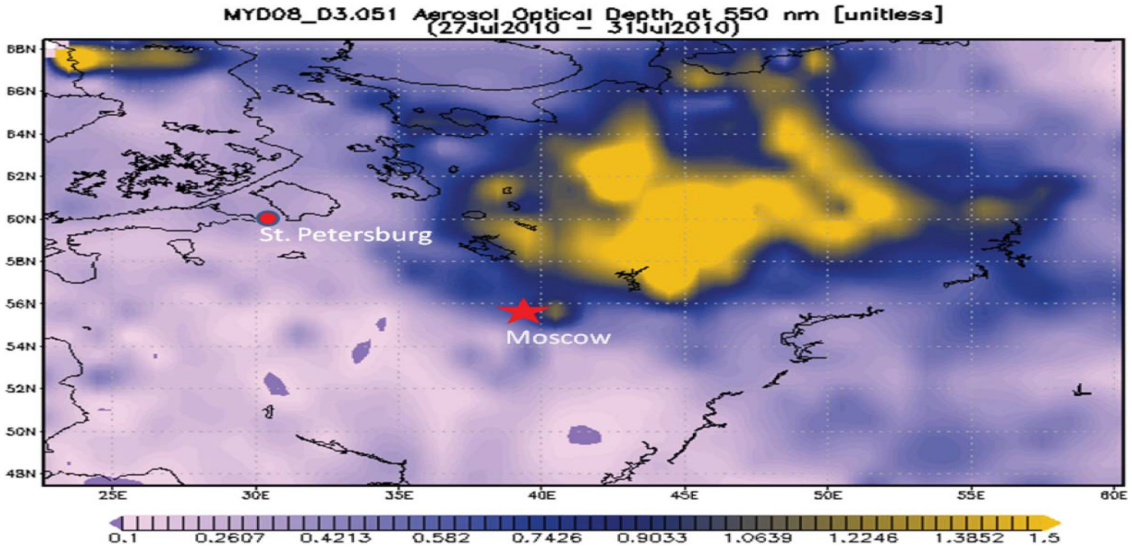


# AOD at 550 nm data from the MODIS



# Emission Estimates

## Emission Factors

$$EF = \frac{\text{mass of pollutent}}{\text{Mass of dry fuel consumed}}$$

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New algorithms quantify fire radiative power (directly related to fuel consumption by fire) from satellite data, which reduces uncertainty associated with fuel load and combustion completeness

# Earth System Model

## Inclusion of Fire in Model

Satellite product: Area of burn, fire counts, emission estimates are the proxy for time dependent BB emission inventories (used in large scale CTM)

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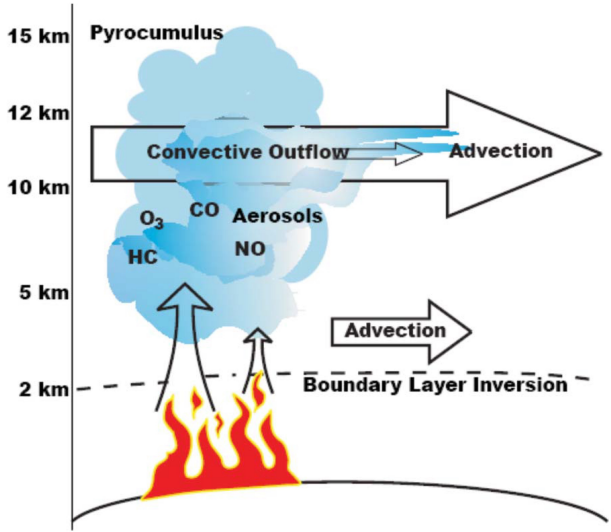
## Challenge

Estimation of fire activity : topsoil moisture and dead fuel amount and source of ignition or fire danger index

# Impact of Fires in the Present Climate

# Injection of Aerosol in different layer of atmosphere



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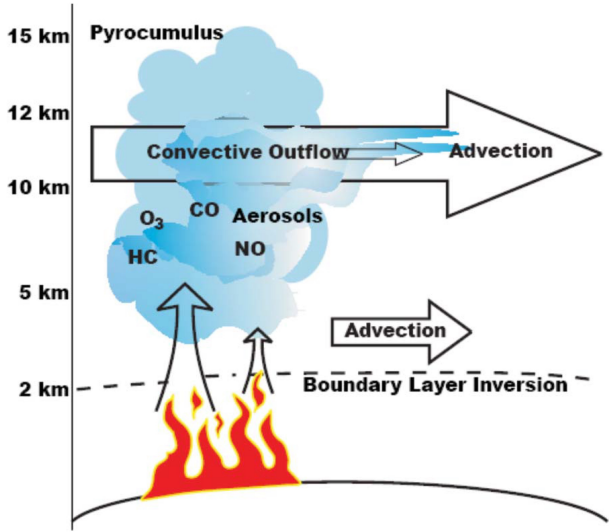



- African fire can transported to Indian ocean, all the ways to Australia in 8-13 days
- Aerosols from the Russian/China fire might transported to USA in a week
- Aerosols from India can get deposited in high mountain ranges (Nepal)
- `Current model does not capture Pyroconvention`

# Short term effect of BB emission


Clear day view of the downtown Reno

# Short term effect of BB emission


During air pollution event on October 24, 2013

# Air Quality and Long Range Transport


Mountain View from the Zippelin Station in clear condition on 26 April, 2006

# Air Quality and Long Range Transport

a) 26 April 2006

b) 2 May 2006

Mountain View from the Zippelin Station during air pollution event on May 2

# Atmospheric chemistry

- About 10-25% of the tropospheric ozone is estimated to be from BB (during dry seasons with concentrations being three times higher than background conditions)
- Formation secondary pollutants from BB emission along with ozone, $NO_x$ and more oxygenated species (Aged smoke particles show enhanced cloud condensation activity due to coating by water soluble material)
- BB emissions affect the oxidants in the troposphere (OH radical that is central to the lifetime of CH4, tropospheric ozone, and halogens, thus impacting stratospheric ozone)

# Radiative forcing

- GHG emissions from forest fires are suggested to have a positive feedback on climate leading to enhanced global warming via modifications to weather and vegetation types (Post fire: land albedo changes, BC deposition on snow increases RF of the climate)

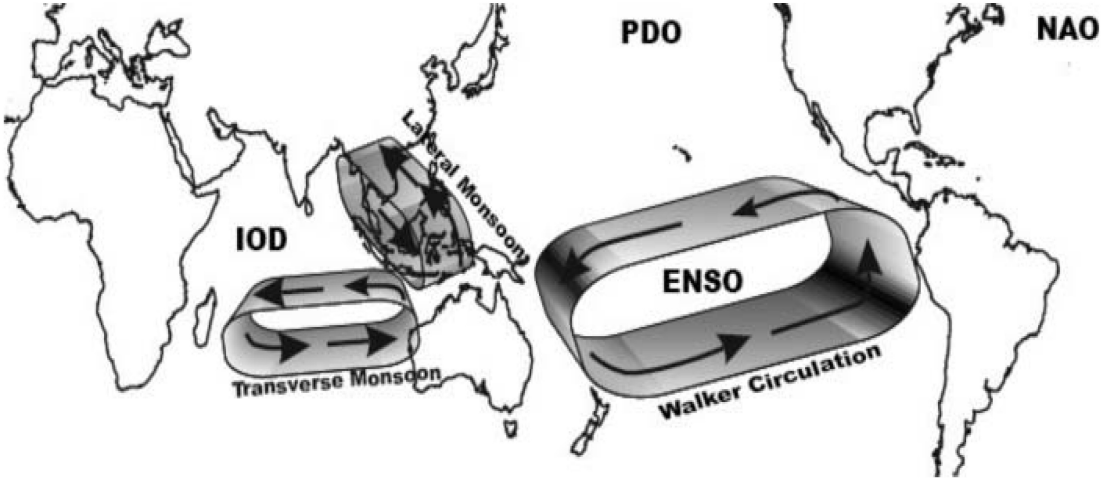
- Study on the top of the atmosphere(TOA) at Alaska, over different fire years, demonstrated higher TOA radiative cooling associated with fires.

- Boreal forests emits VOC which form SOA (act as CCN) and change in radiative forcing -1.8 to -6.7 W $m^{-2}$.

# Impact of climate change on biomass burning

# Short term

The principal atmospheric circulation patterns affecting tropical fires.



# Short term

- Open vegetation fires and climate variability associated with sea surface temperature anomalies and extended droughts (i.e. demonstrated by the most studied low-frequency climate cycle, the globally significant ENSO, shown to impact fires in South East Asia, Central and South America, and boreal regions of Eurasia and North America.)

# Short term

- Synergistic impact of the large-scale and regional climatic phenomena can enhance fires, leading to exceptionally intensive biomass burning (example 1997/1998 Indonesia fires as a consequence of combined strength of the El Nino and the IOD)

# Short term

- A nonlinear link between drought and fire emissions

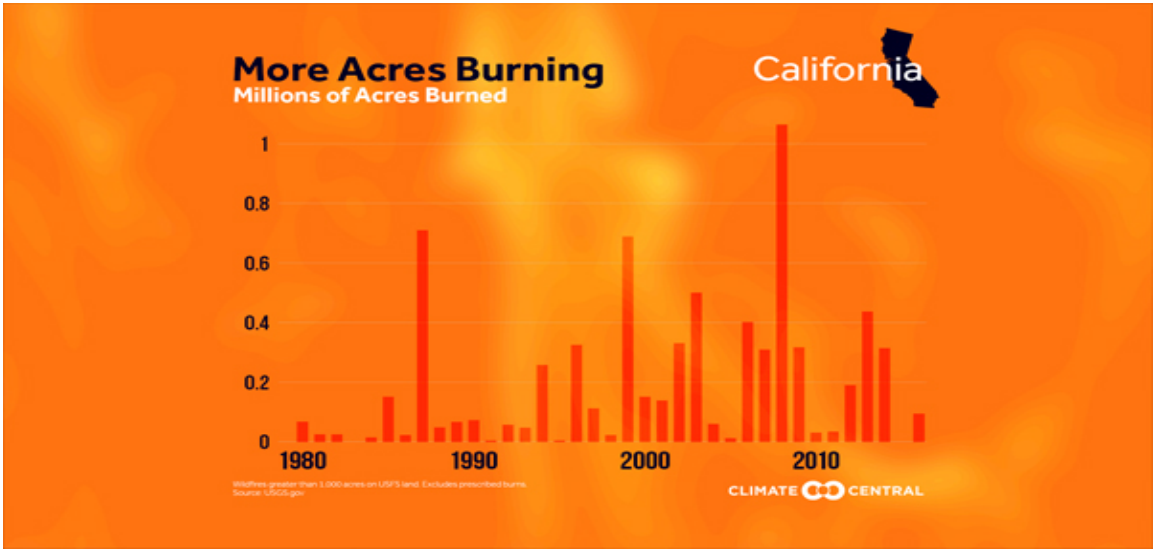
# Short term

- The strong correlations of fires with climate parameters, and the predicted changes in these parameters due to climate, also suggest significant future change of fires.

# Long term

- Under climate change, warmer temperatures and precipitation changes are expected to be the main climate drivers for fires by changing the frequency and the intensity of fires
- Canada and Alaska the average area burned per decade is expected to double by 2041-2050 (relative to 1991-2000) and increase on the order of 3.5-5.5 times by the last decade of the 21st century
- A number of climate scenarios indicate shifts in the precipitation patterns

# Long term


More Acres Burning
Millions of Acres Burned
California
1
0.8
0.6
0.4
0.2
0
1980
1990
2000
2010
Wildfires greater than 1,000 acres on USFS land. Excludes prescribed burns.
Source: USGS.gov
CLIMATE CENTRAL

# Policy Prospective

# Local Fire Management

## Fire suppression

Complete prevention and extinguishing of any fire. However, it increases probability of a catastrophic fire (fuel accumulated under suppression)

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deliberate ignition of fire in a specified and controlled area. Sometime this controlled fire undergone accidental wildfire and massive destruction.

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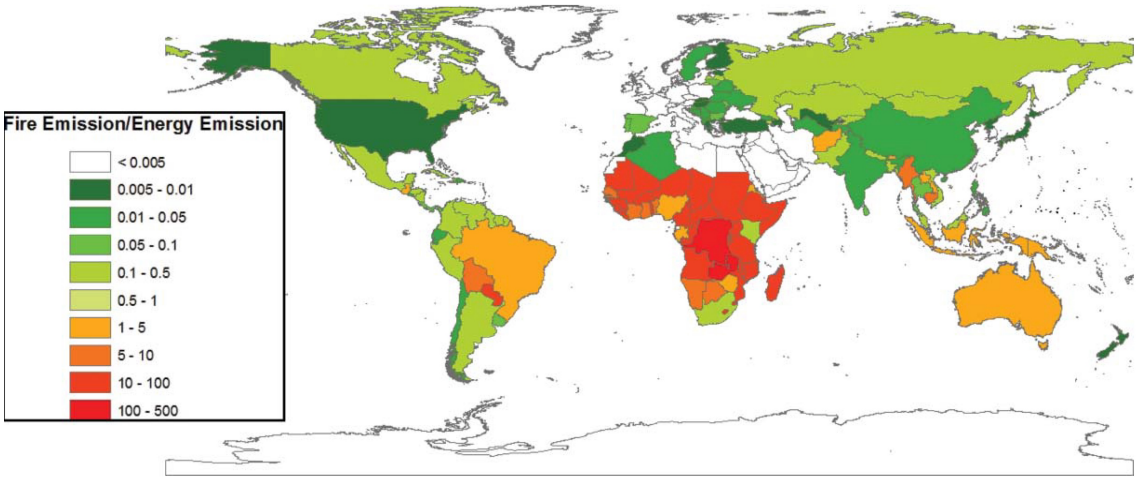
## Other policy

Forest thinning and natural wildfires

# Global policy



# Summary

- Fire emit large amount of pollutent in atmosphere
- Fire has both positive and negative radiative forcing of Atmosphere
- Changing climate influences frequency and intensity of fire increases
- Unintentional forest fires will be difficult to avoid completely

# References




Melita Keywood, Maria Kanakidou, Andreas Stohl, Frank Dentener, Giacomo Grassi, CP Meyer, Kjetil Torseth, David Edwards, Anne M Thompson, Ulrike Lohmann, et al.
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A Stohl, T Berg, JF Burkhart, AM Fjraa, C Forster, Andreas Herber, Ø Hov, C Lunder, WW McMillan, S Oltmans, et al.
Arctic smoke–record high air pollution levels in the european arctic due to agricultural fires in eastern europe in spring 2006.
*Atmospheric Chemistry and Physics*, 7(2):511–534, 2007.

**THANK YOU !!!**

**ANY QUESTIONS ??**