Mapping carbon emissions and other fire-climate forcings across Alaska and western Canada: An introduction and call for scientist and manager feedback

Brendan Rogers, Scott Goetz, Merritt Turetsky, and Sander Veraverbeke

ARCTIC BOREAL VULNERABILITY EXPERIMENT

ABoVE

NASA's Terrestrial Ecology Program, major field campaign

AK, western Canada. 8 - 10 years

Major goals:

(1) Gain a better understanding of the vulnerability and resilience of Arctic and boreal ecosystems

(2) Provide the scientific basis for informed decision-making to guide societal responses

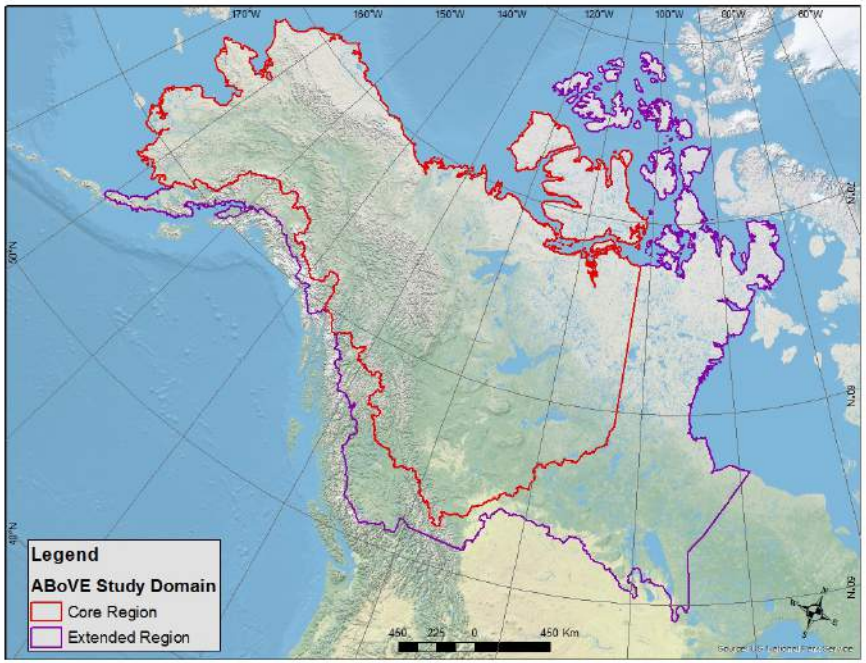
2009: Scoping study selected in 2009

2011: ABoVE selected for Field Campaign

2013: Science Definition Team announced

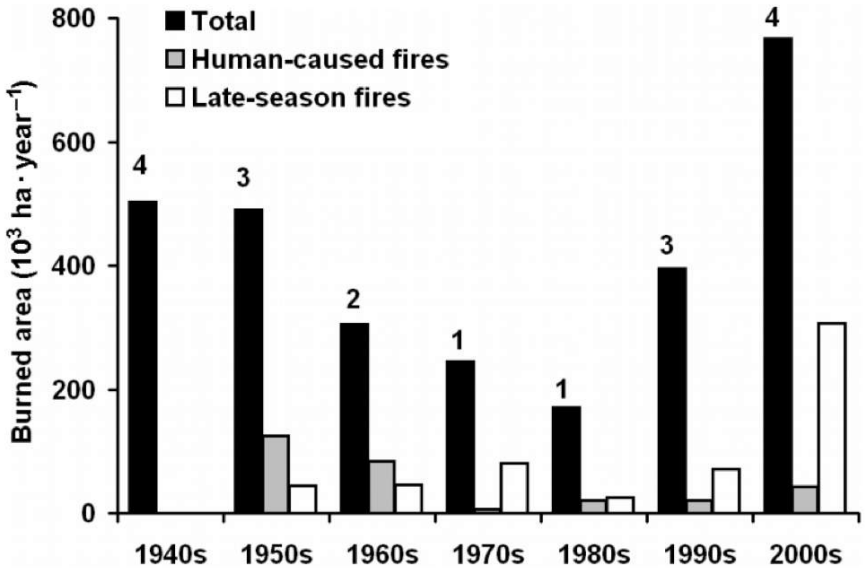
Aug 2015: Projects selected

21 new projects, 12 affiliated

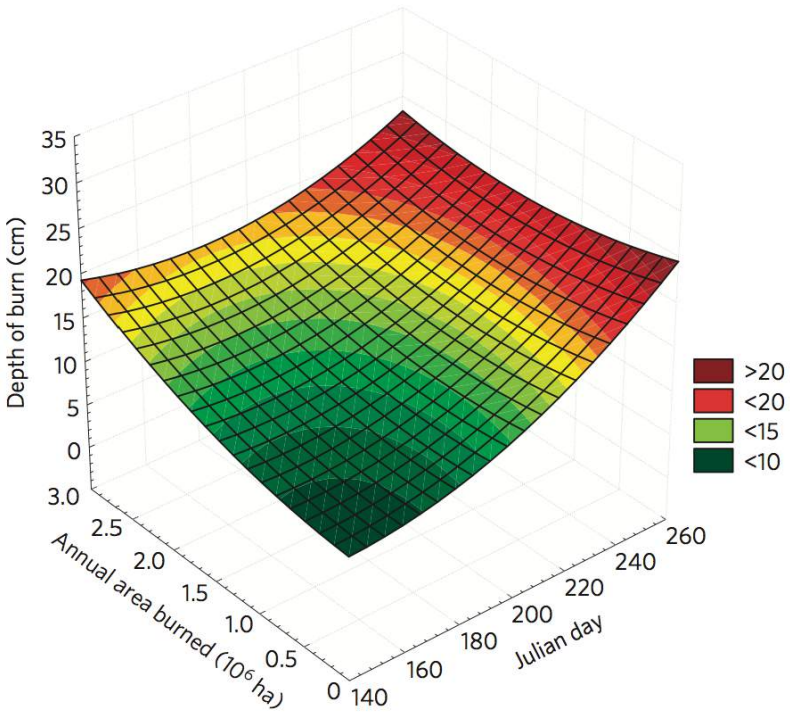


Project Motivation

Changing fire regimes



Kasischke et al. (2010)



Turetsky et al. (2011)

Changing fire regimes

2014 N.W.T. fire season report: What you need to know

Look back highlights need for better communication, more

By Garrett Hinchey, CBC News Posted: May 05, 2015 5:30 PM CT | Last Updated

Alaska's terrifying wildfire season and what it says about climate change

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By Chris Mooney July 26 Follow @chriscmooney

Alaska's wildfire season of 2015 may be the state's worst ever

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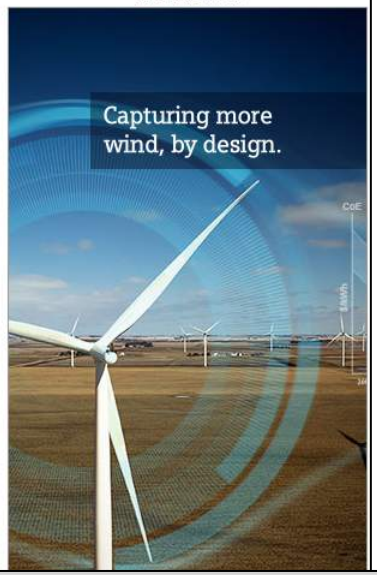


Alaska's permafrost threatened by intense fires, climate change

Trevor Hughes, USA TODAY 6:39 a.m. EDT August 14, 2015

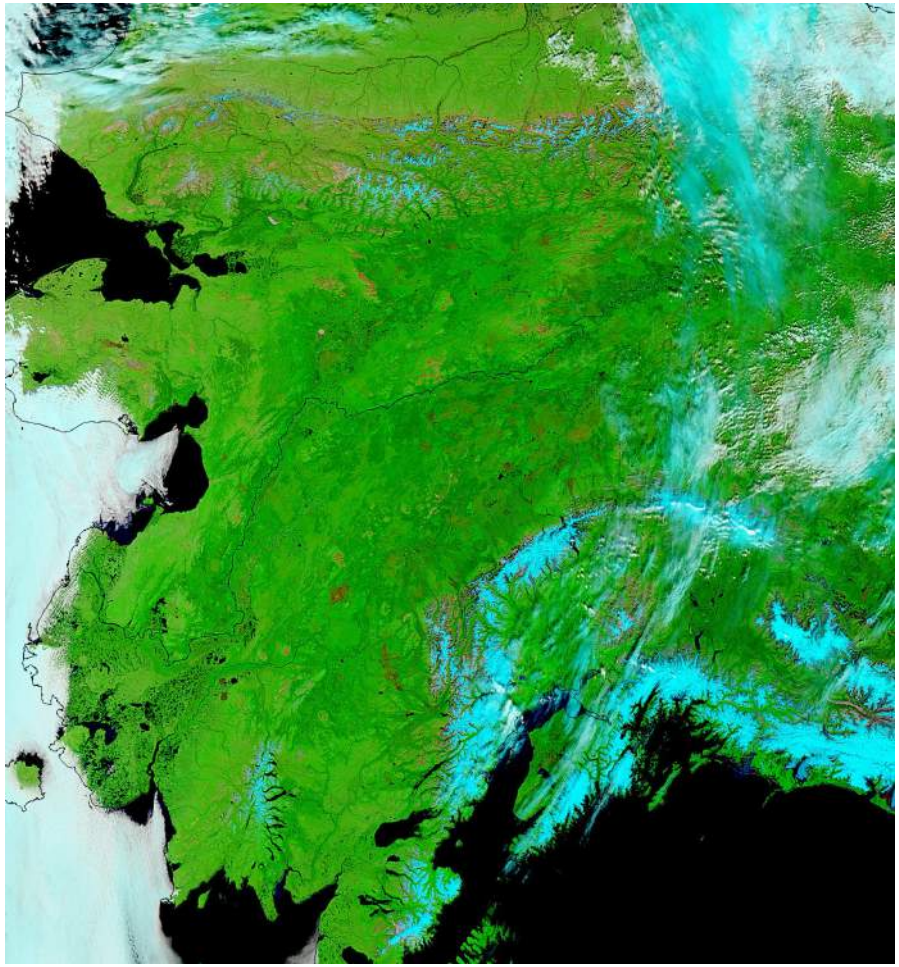
FREE RIDE
SALES EVENT

Climate-change predictions stoke wildfire fears in Alaska as the wildfire seasons in history. Trevor Hughes/USA TODAY

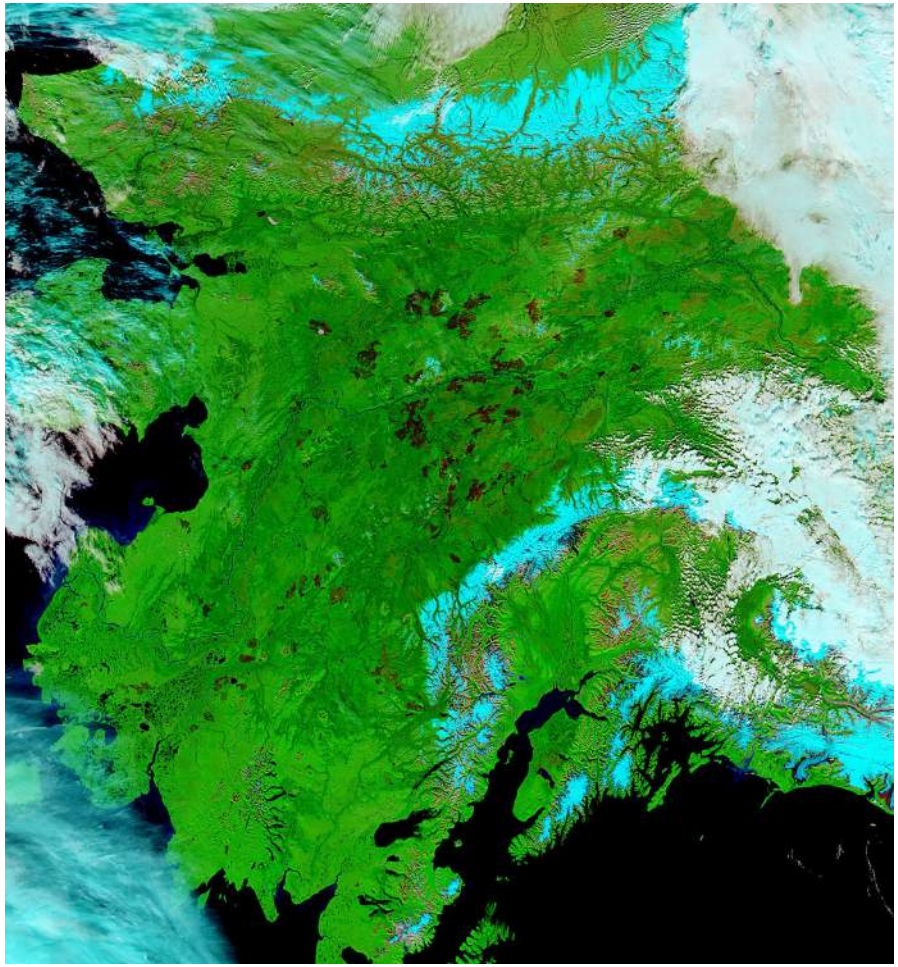
Russia Experiences Great Burning: Satellite Shots Show 'Sea of Smoke and Fire' Blanketing Russia

Changing fire regimes

June 14, 2015

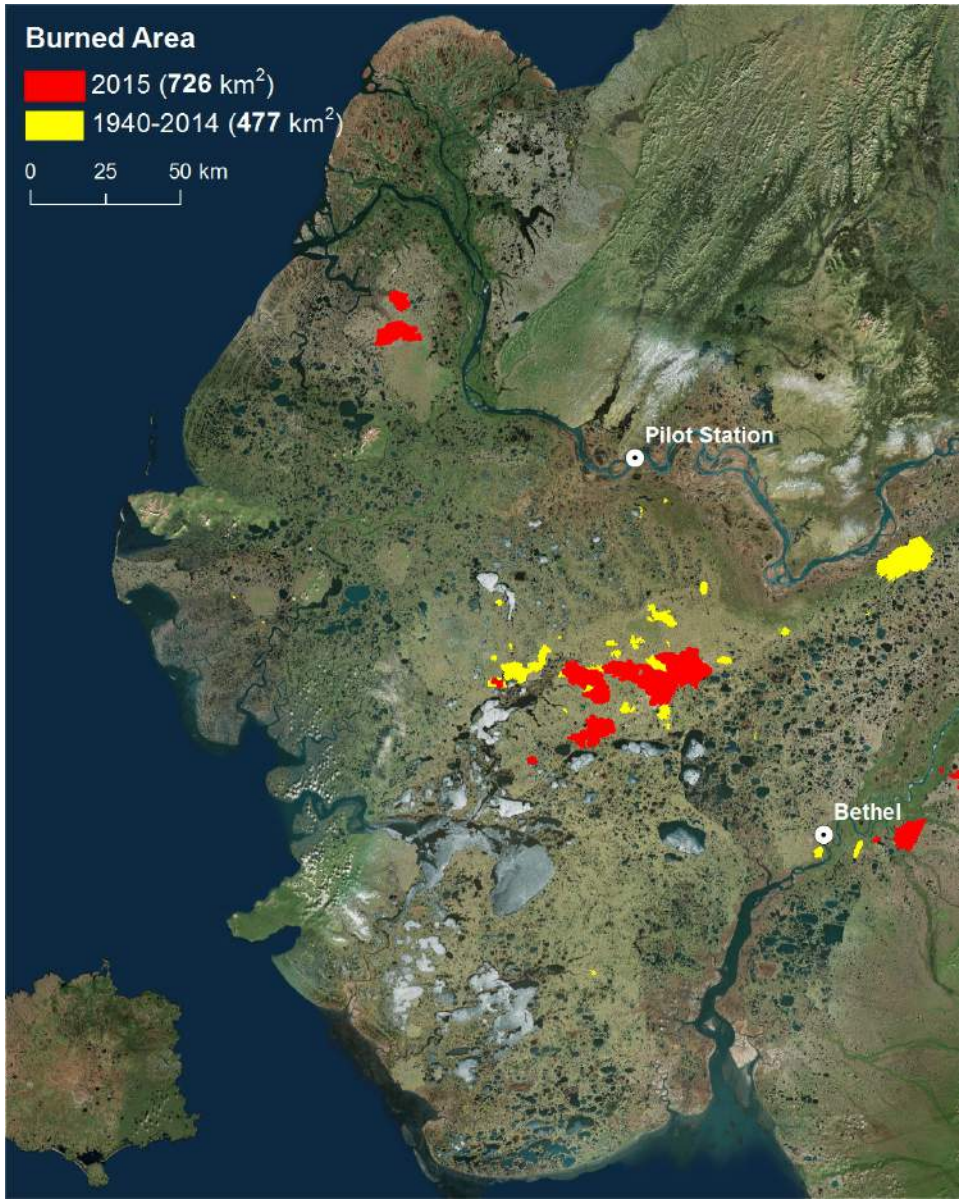


September 1, 2015

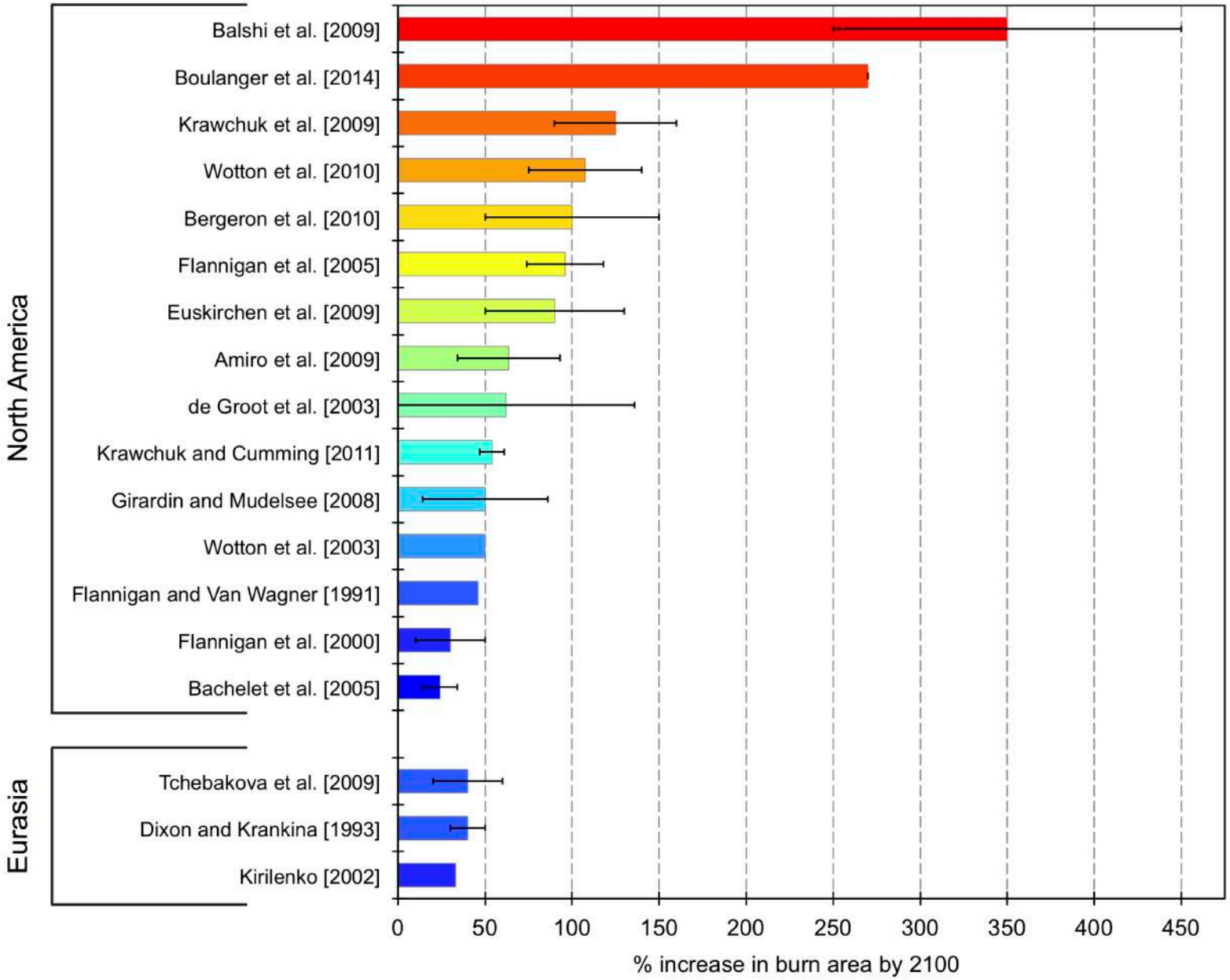


NASA Earth Observatory

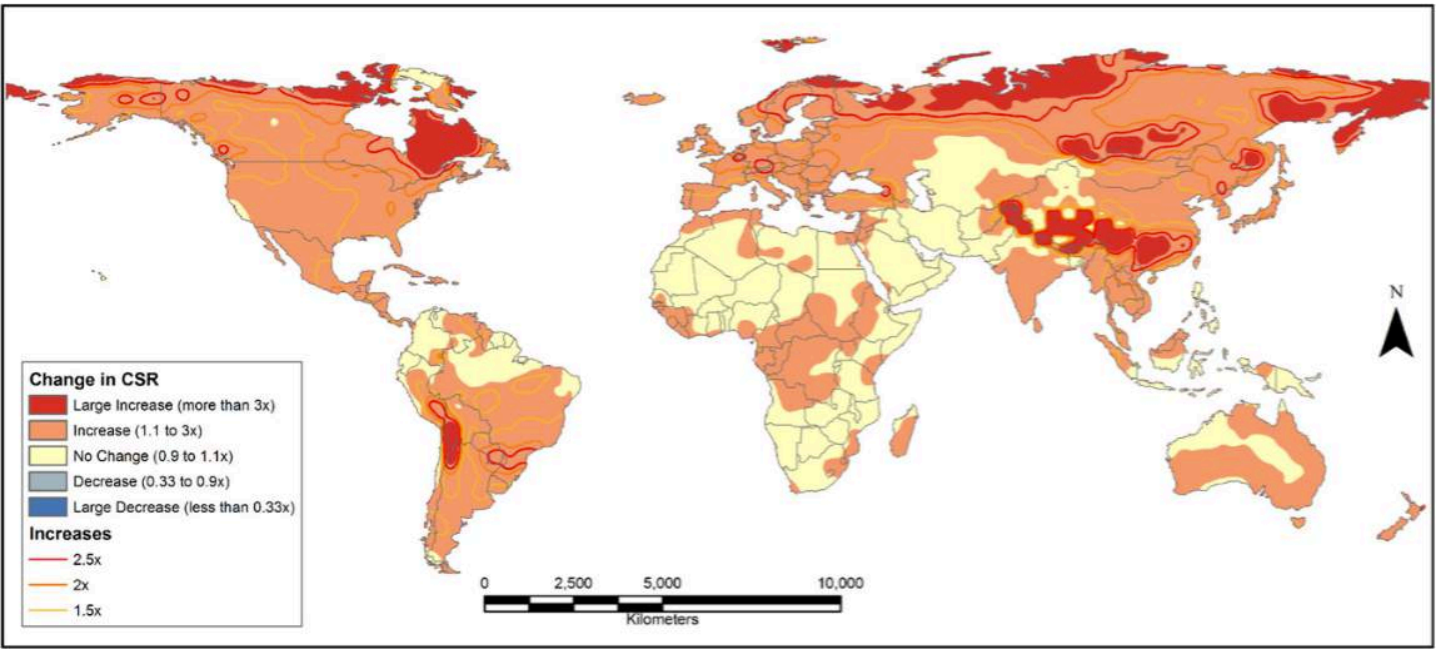
Changing fire regimes



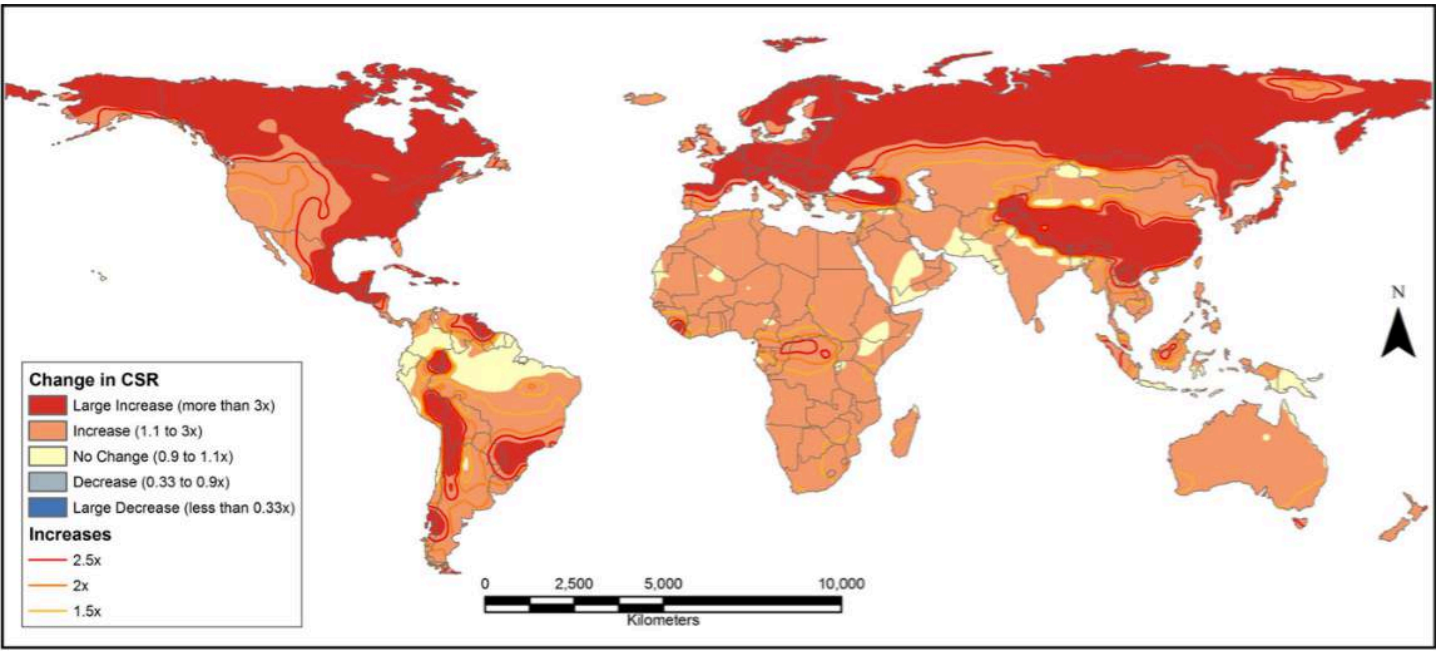
Changing fire regimes



Changing fire regimes



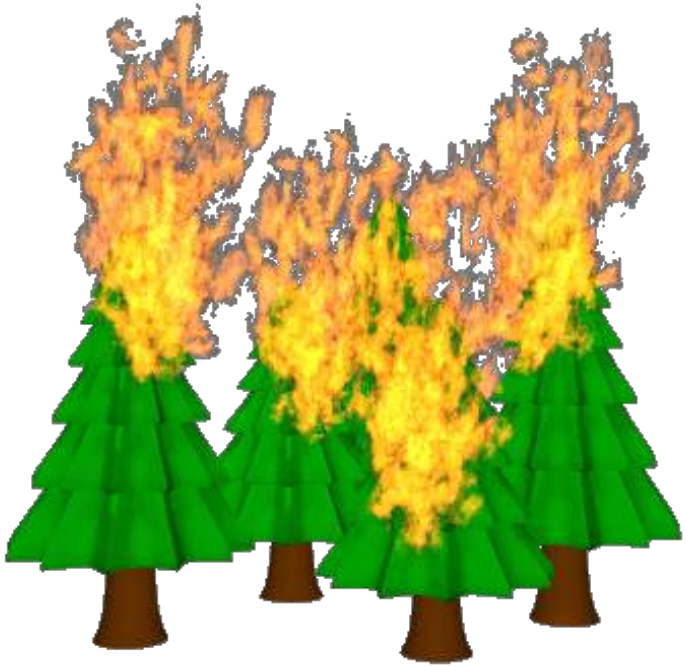
2041-2050



2091-2100

Flannigan et al. (2013)

Fire effects on climate



smoke aerosols

biophysics

greenhouse gases

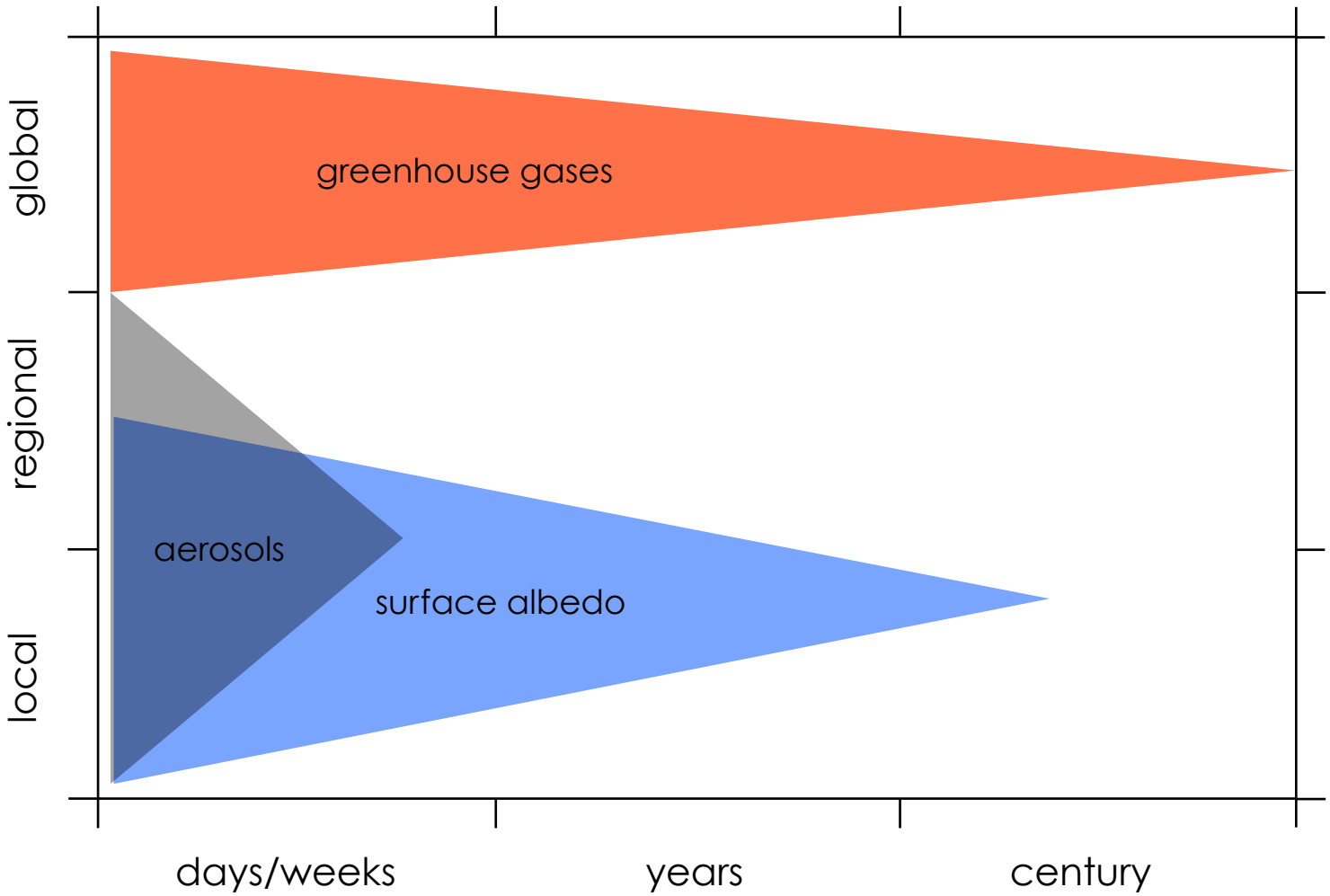
Forcing

direct

indirect

BC deposition

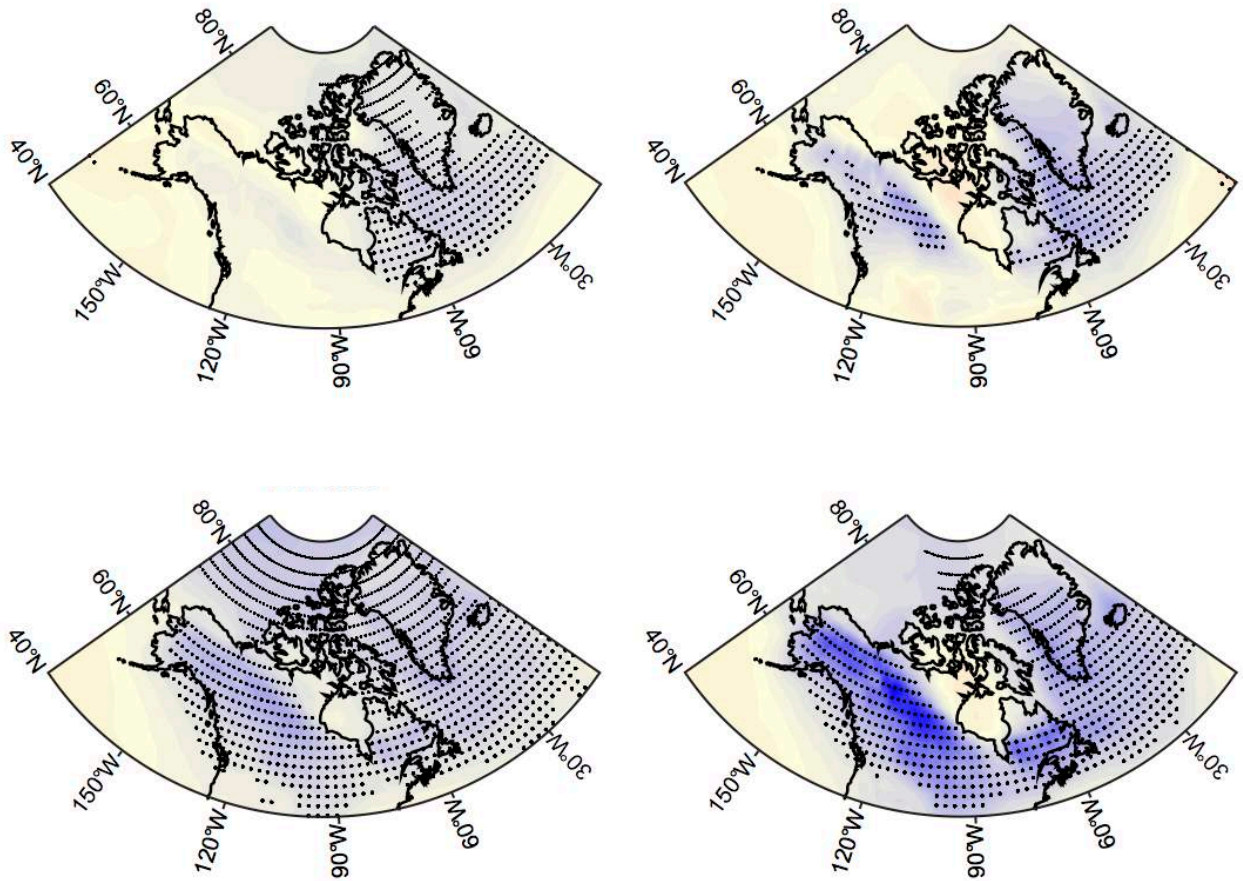
Fire effects on climate



Fire effects on climate

Annual

Feb - Apr



Burned area × 2

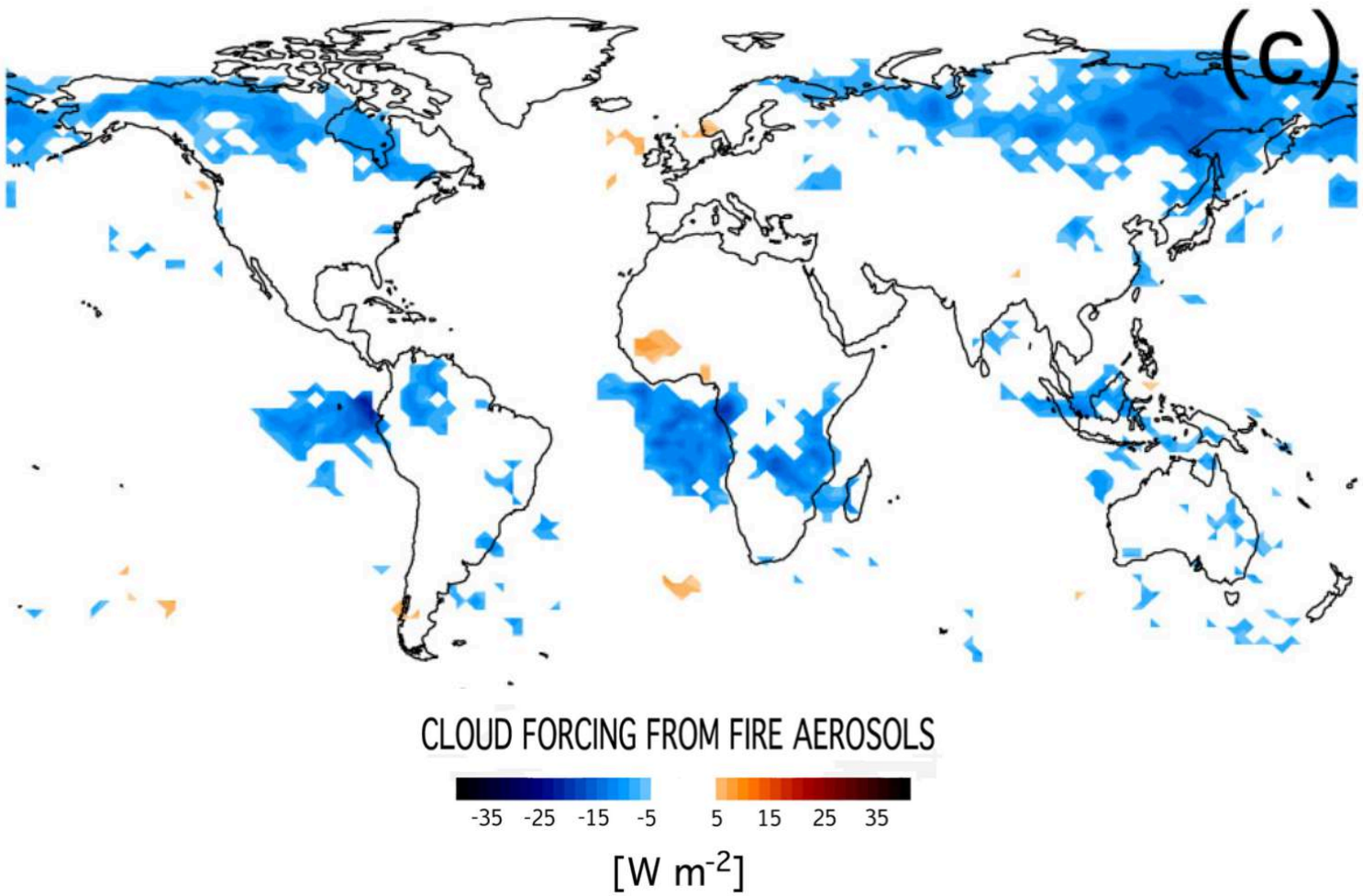
Burned area × 4

Δ surface air temperature (° C)

-3 -2 -1 0 1 2 3

Rogers et al. (2013)

Fire effects on climate

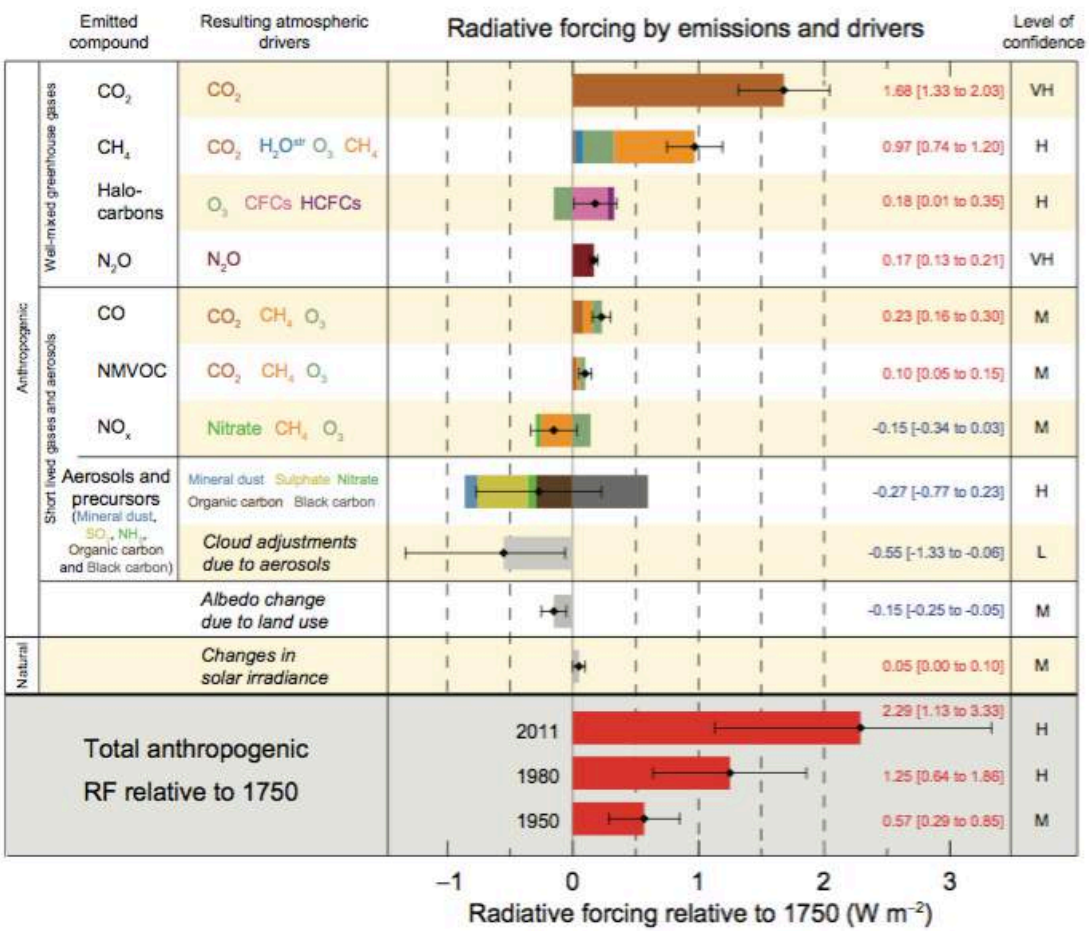


Ward et al. (2012)

Radiative forcing

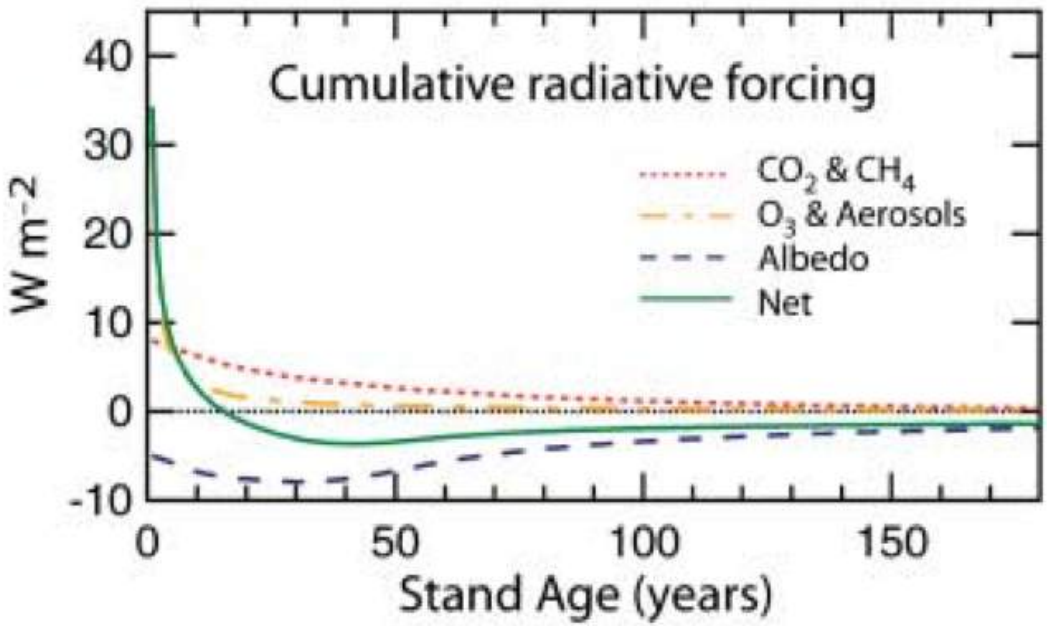
Radiative Forcing: The change in net irradiance at the tropopause…

$$\Delta T_s = \lambda \times RF \qquad \lambda \sim 0.8$$



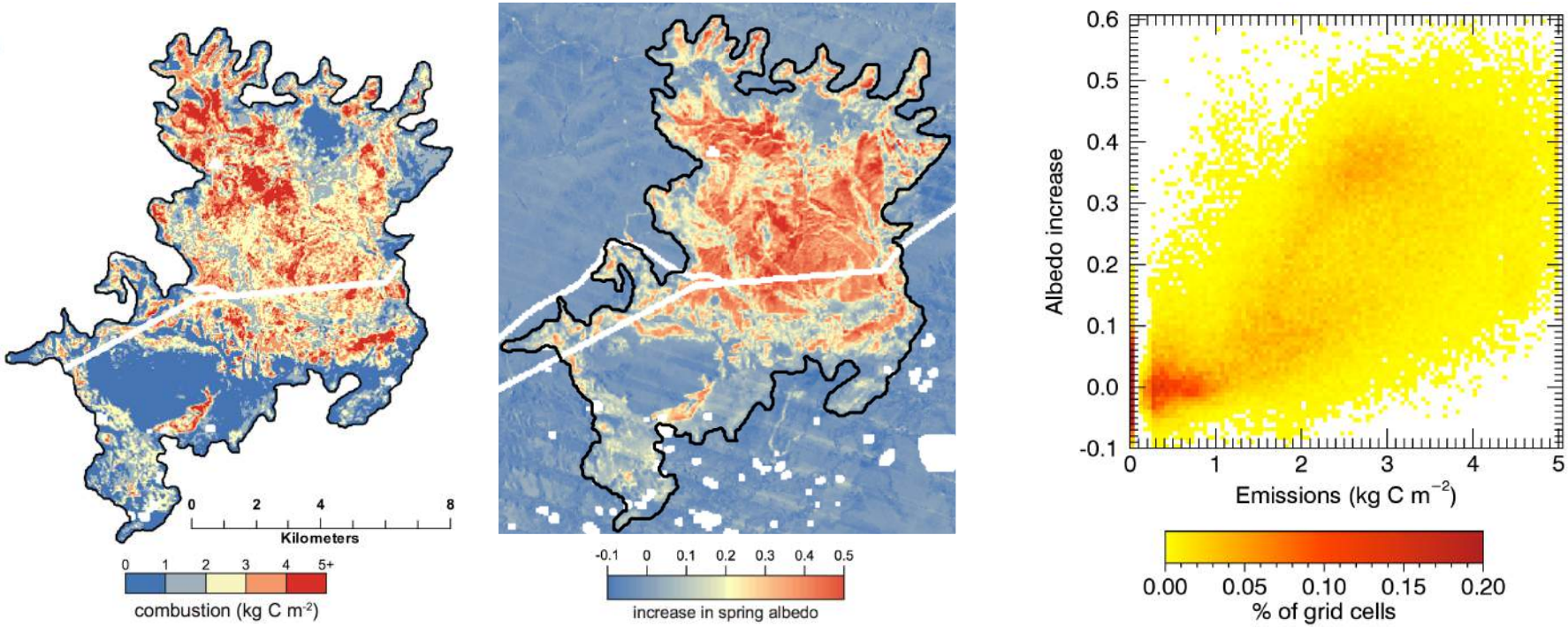
IPCC (2013)

Net forcings



Randerson et al. (2006)

Net forcings: spatial variability



Rogers et al. (2014)

Project goals

Main *Science* question: What controls the warming or cooling impact from fires in the ABoVE domain?

Science goals:

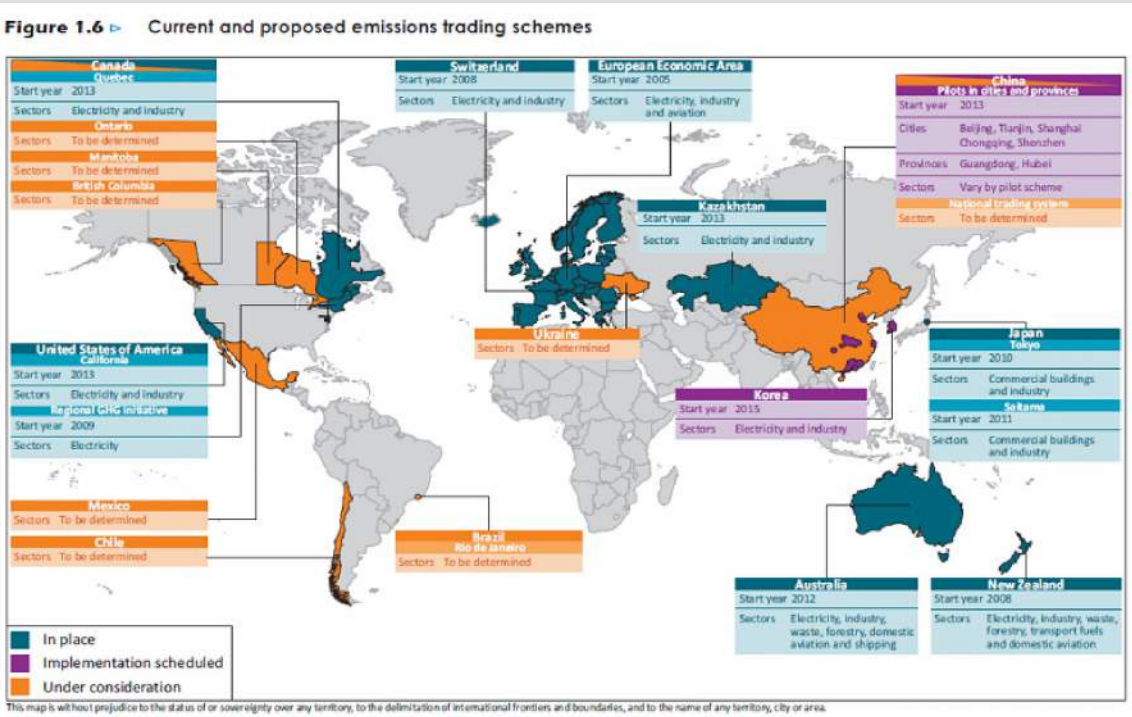
1. Quantify radiative forcing from all fires within ABoVE domain from 2002 – 2011 at 500m
2. Develop predictive models of forcing before the season and during

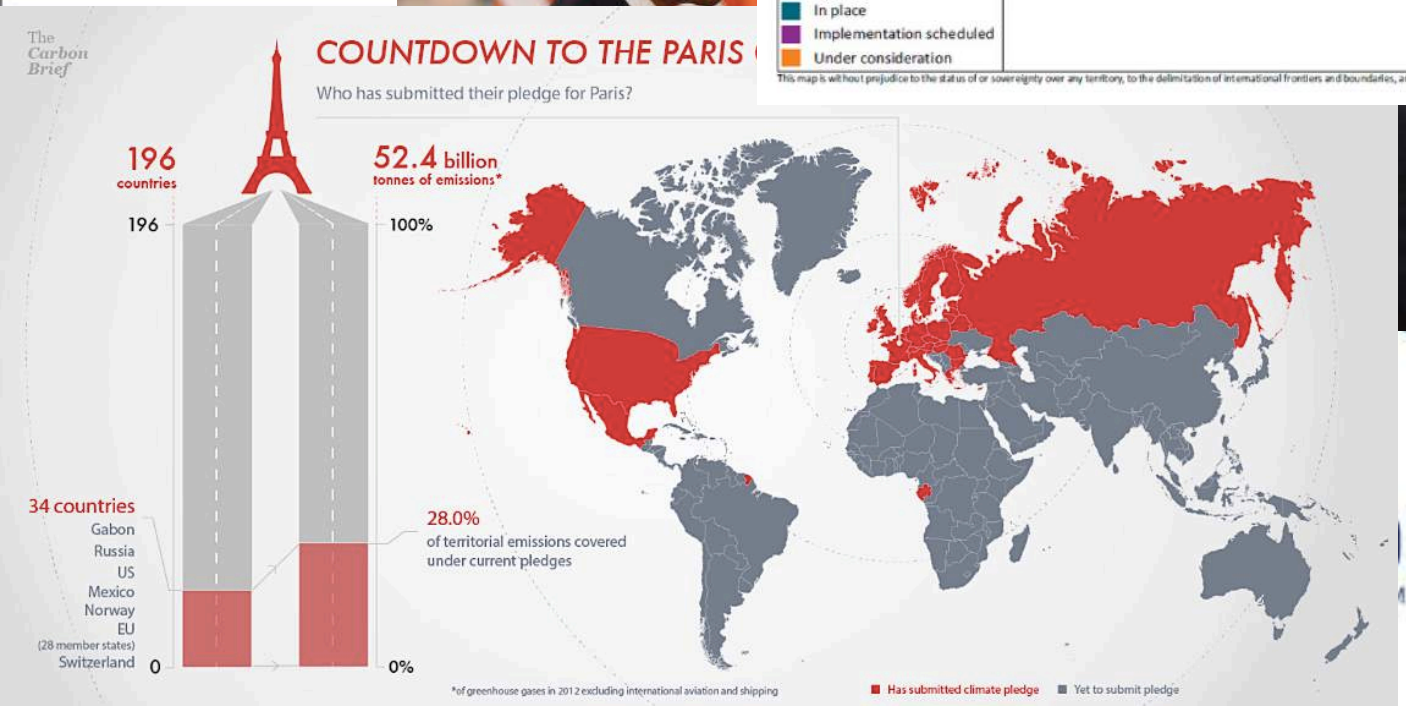
Main *management* question: How can fire management help mitigate fire-climate feedbacks?

Management goals:

1. Estimate how selective management could have reduced net forcing during this period
2. Communicate w/managers and explore the direct/indirect use of this information

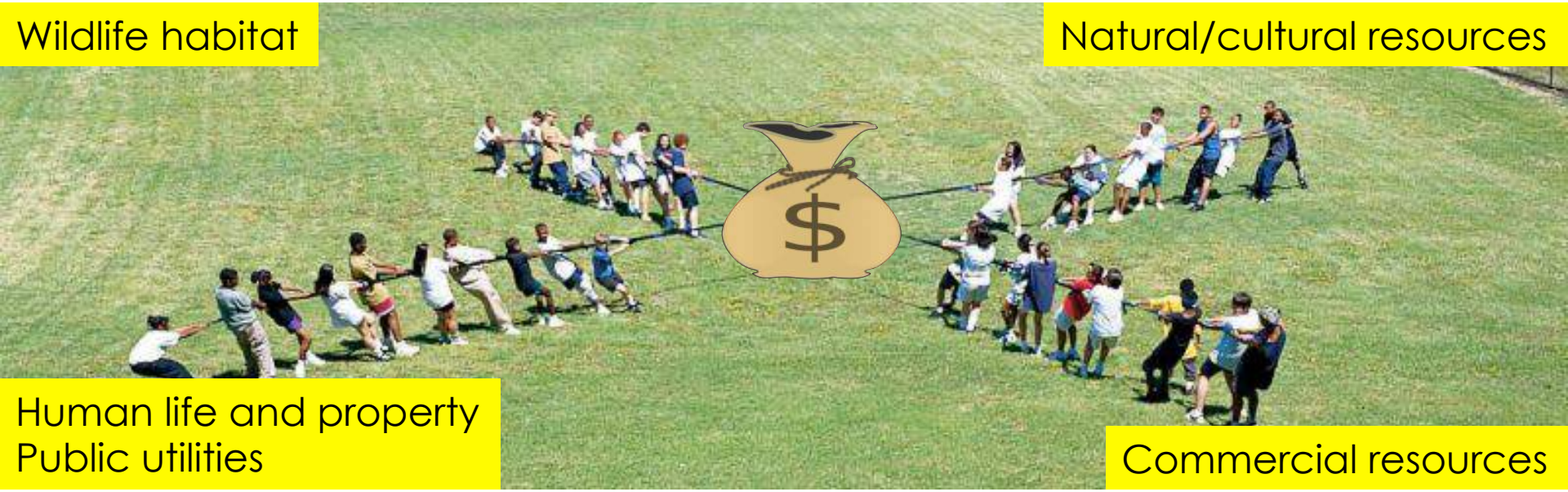
Political/global context





COP15
PENHAGEN
ATE CHANGE CONFERENCE 2009

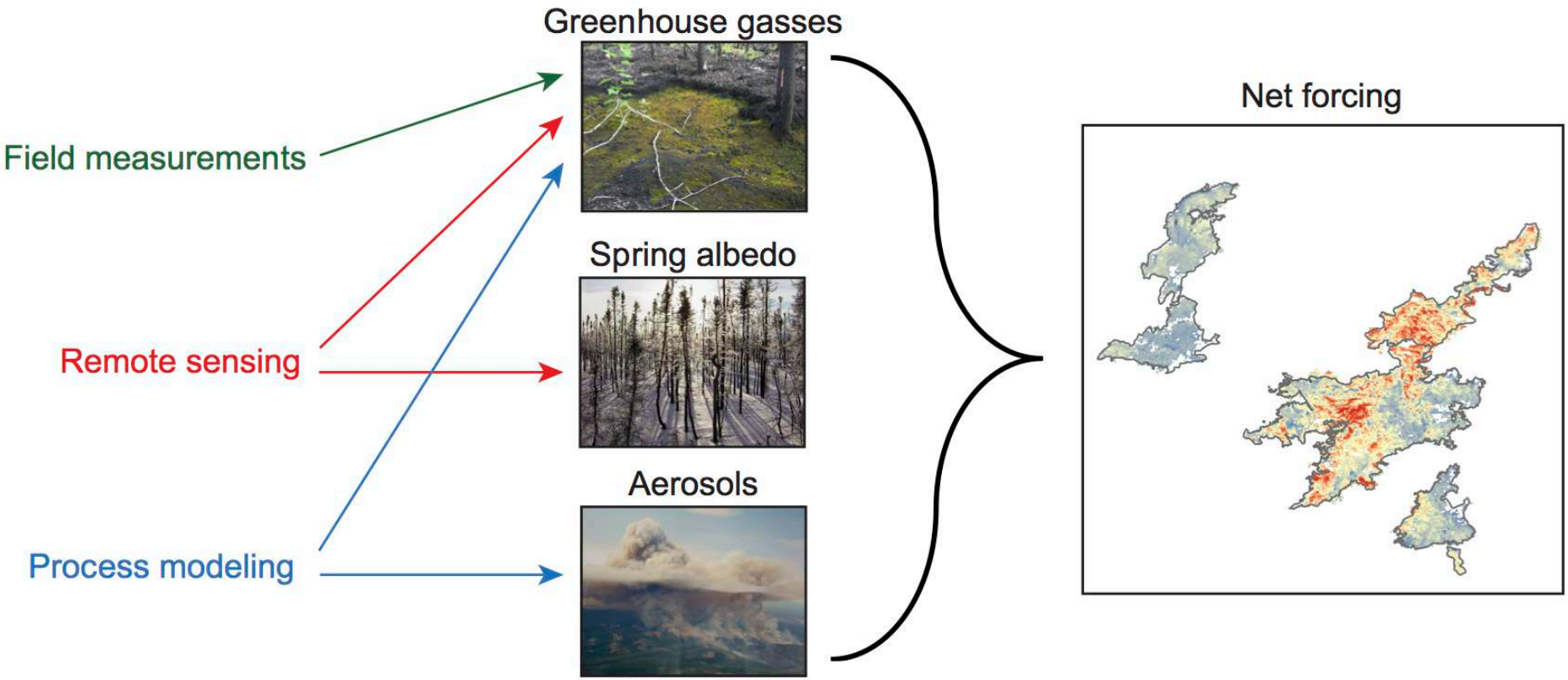
Management context



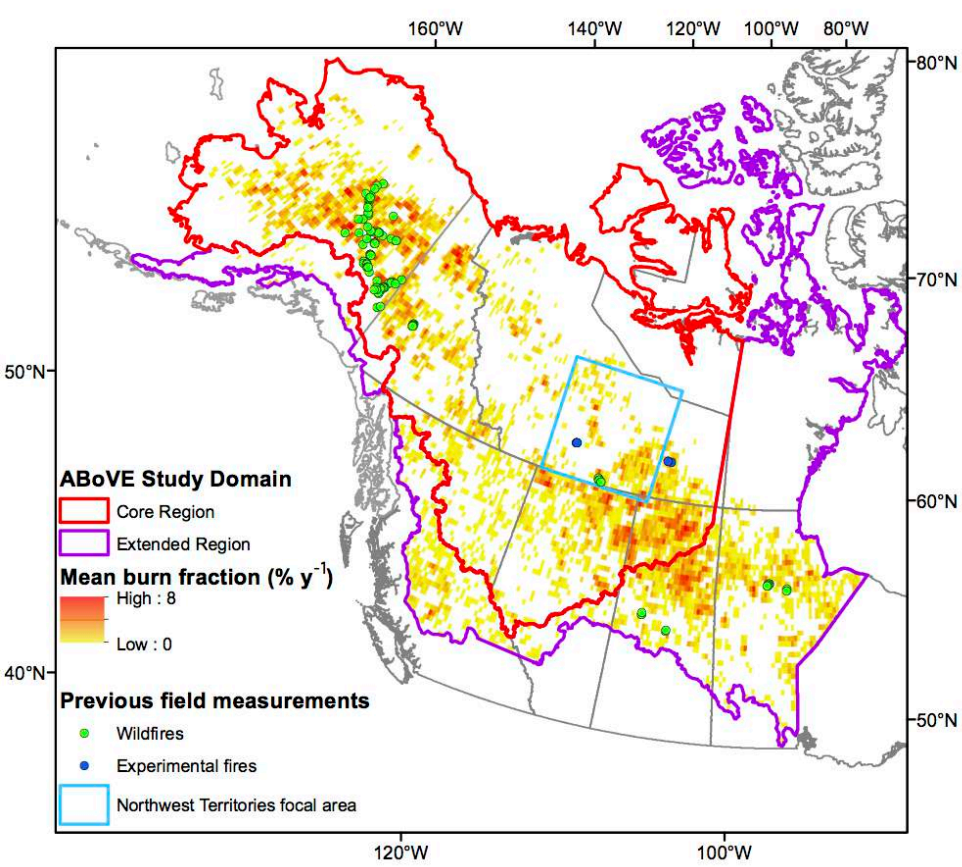
- How can we keep pace with climate change?
- Suppression vs. fuels treatments?
- How can/would climate impacts fit in?

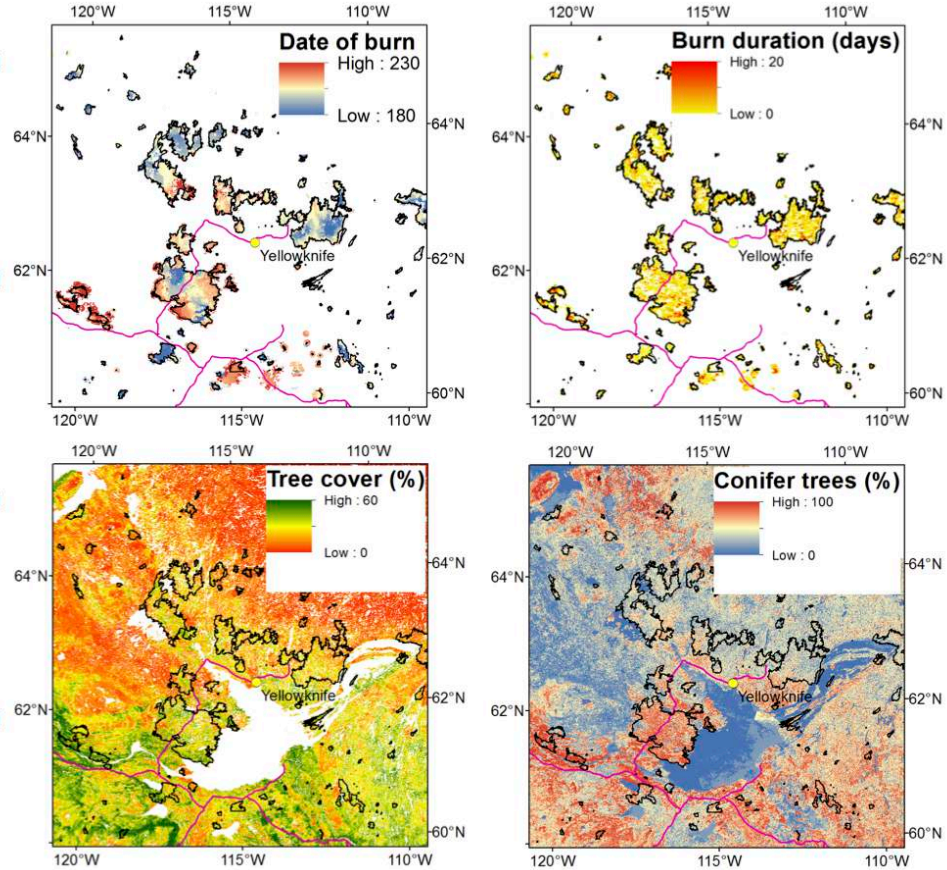
Project Specifics

Framework


Greenhouse gasses
Spring albedo
Aerosols
Field measurements
Remote sensing
Process modeling
Net forcing

Field campaign



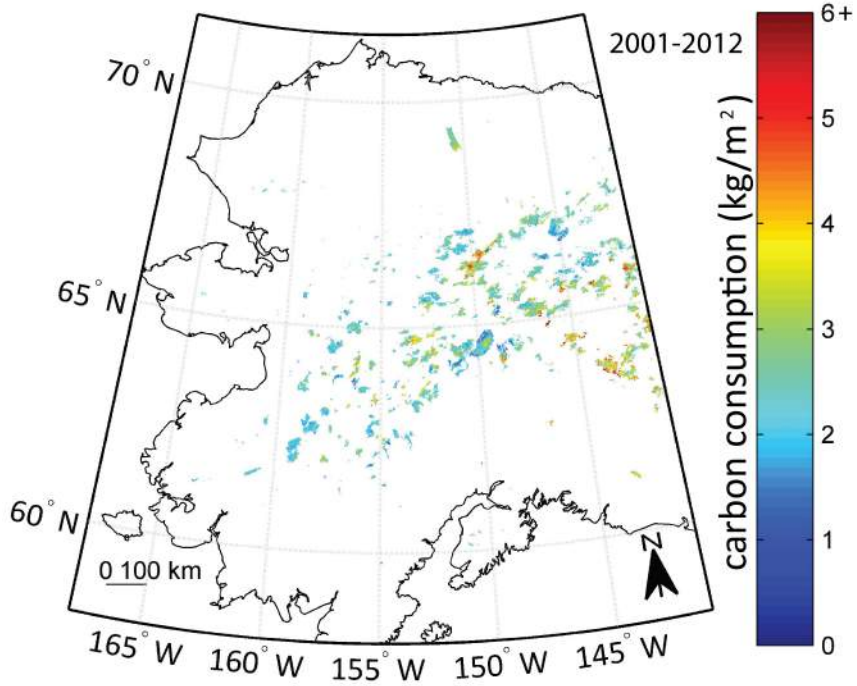


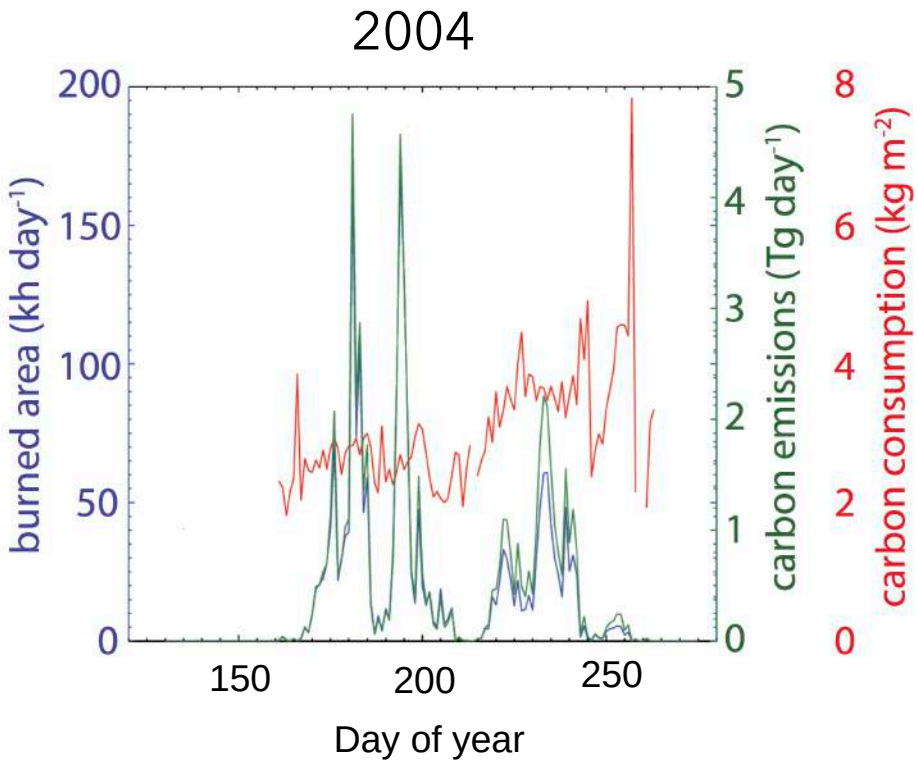
Limitations for current field database on combustion (324 sites, 30 fires):

- Most (63%) do not include aboveground
- Most (82%) are from black spruce forests
- Biased toward upland, early season fires
- Limited information on smoldering
- Only 27% from Canada

Modeling emissions

The Alaska Fire Emissions Database (AKFED)





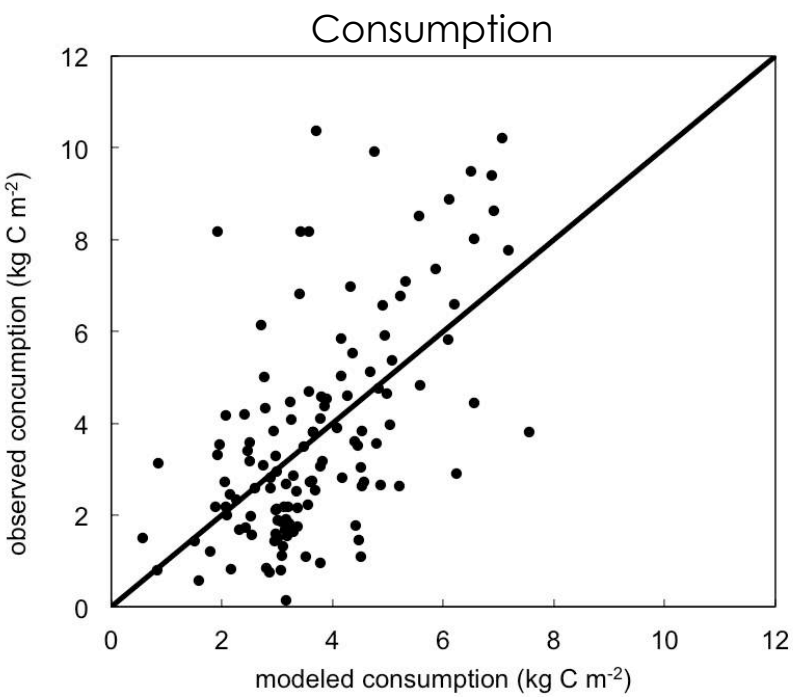
Veraverbeke et al. (2015)

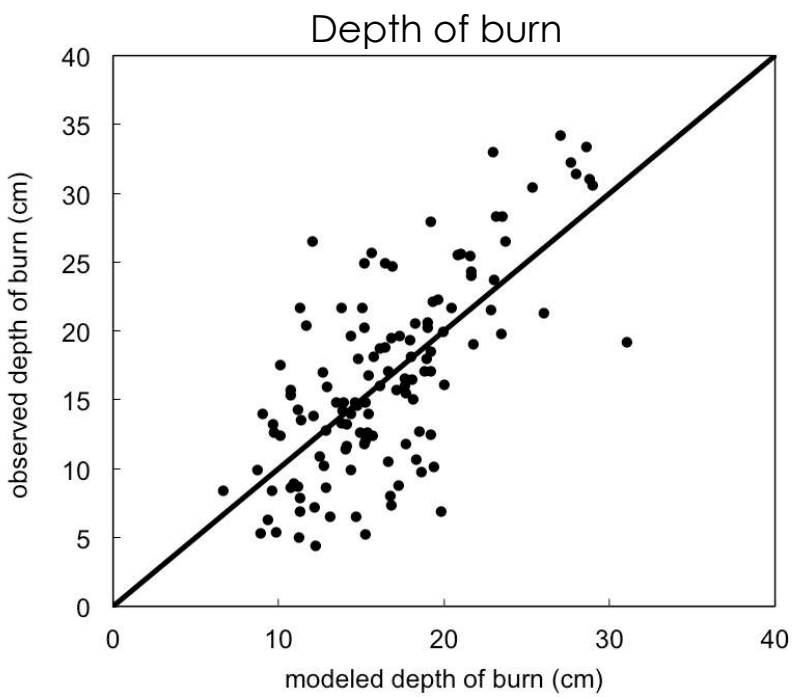
- AKFED incorporates field observations, remote sensing, and related geospatial data:
  - Fire perimeters, MODIS active fires, dNBR, day of burning, tree cover, elevation, slope, aspect, fuel type
- Estimates burned area, carbon emissions, and uncertainty at 500 m across Alaska from 2001 - 2013.
- Estimates are provided for aboveground and belowground combustion.

Modeling emissions

The Alaska Fire Emissions Database (AKFED)

Now incorporating fire weather



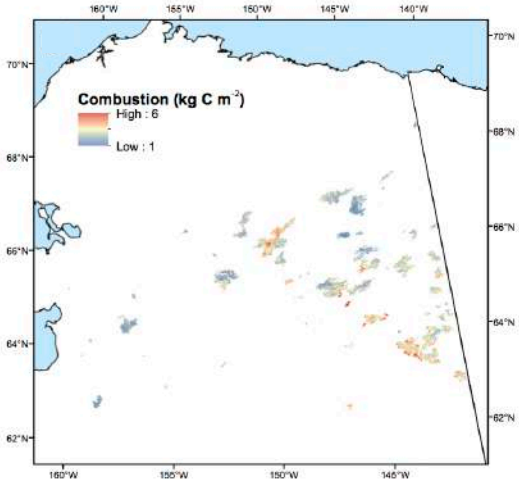


Greenhouse gas RF

new field measurements

new fuel types map prior data from Canada

AKFED

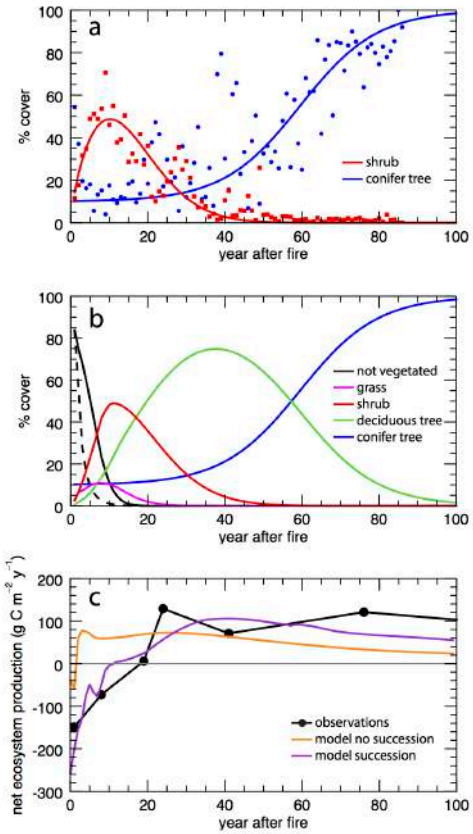


FWIs

Lidar retrievals expanded domain

smoldering combustion

Land model

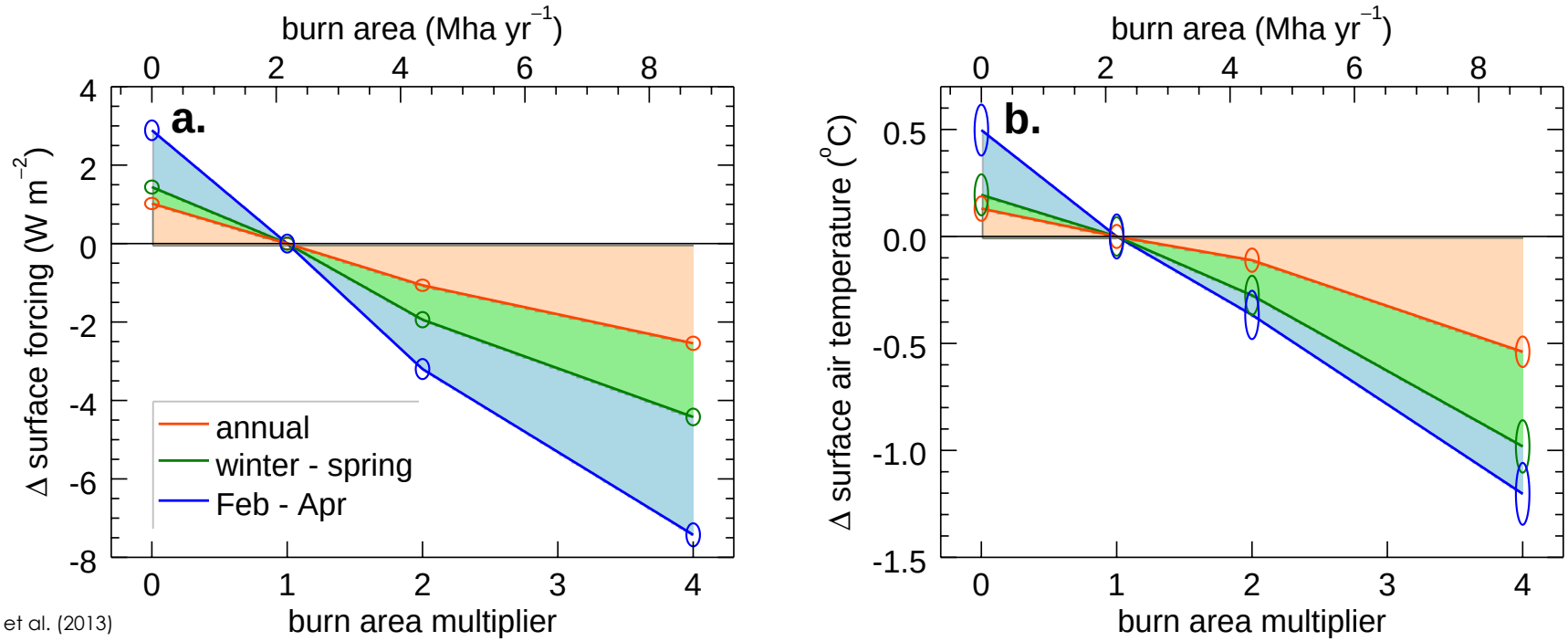


CO_2 impulse response functions

Box models of N_2O, CH_4 lifetime

RF equations

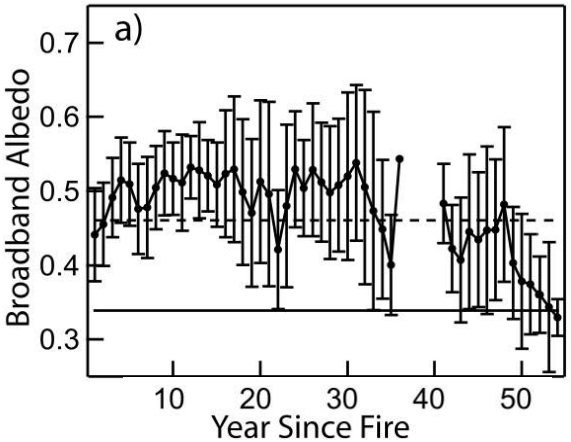
Spring albedo RF



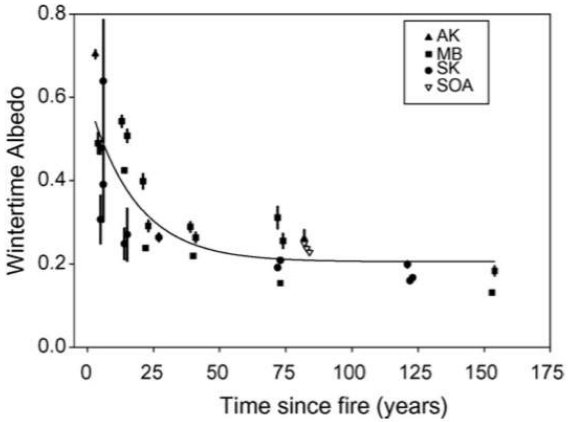
Rogers et al. (2013)

Spring albedo RF

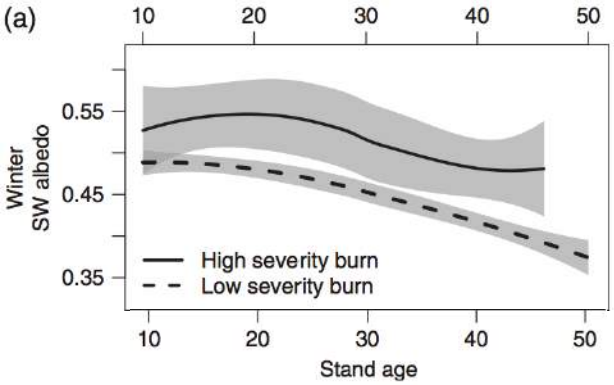
Randerson et al. (2006)



Lyons et al. (2008)



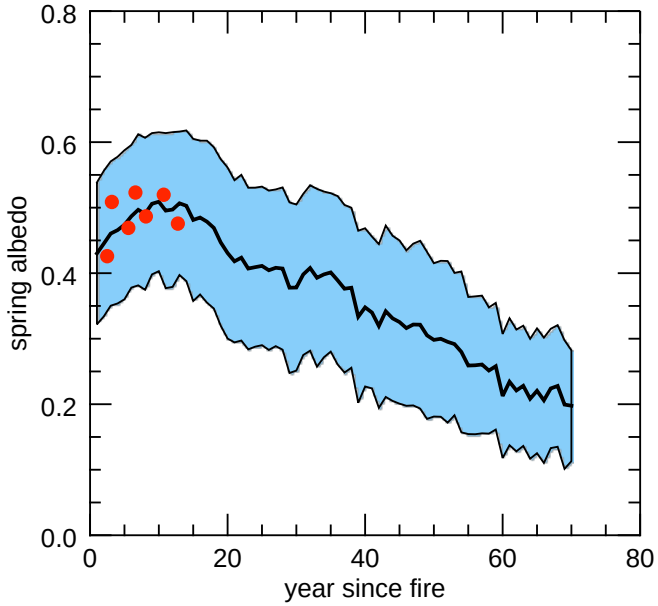
Amiro et al. (2006)



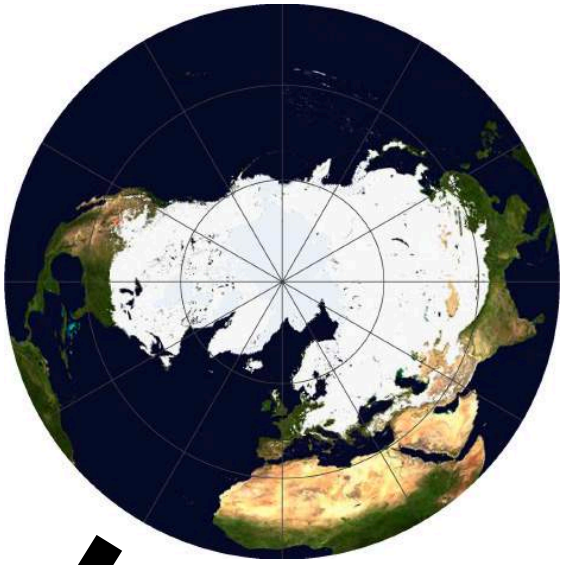
Beck et al. (2011)

Spring albedo RF

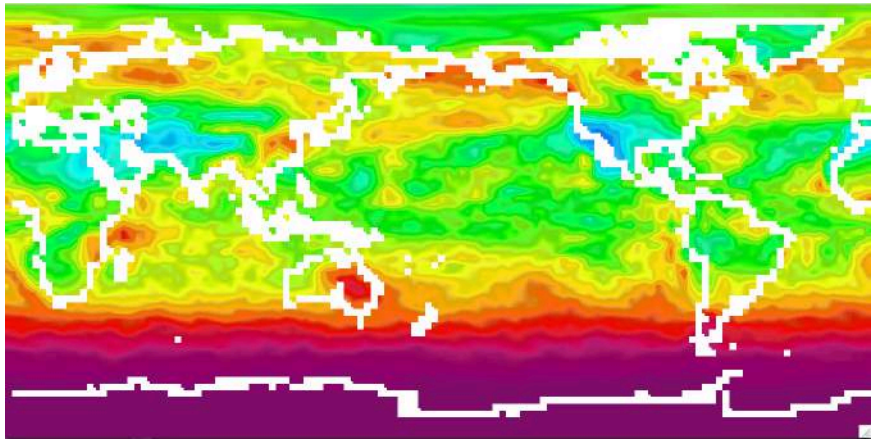
Post-fire albedo trajectories



Current & projected snow cover

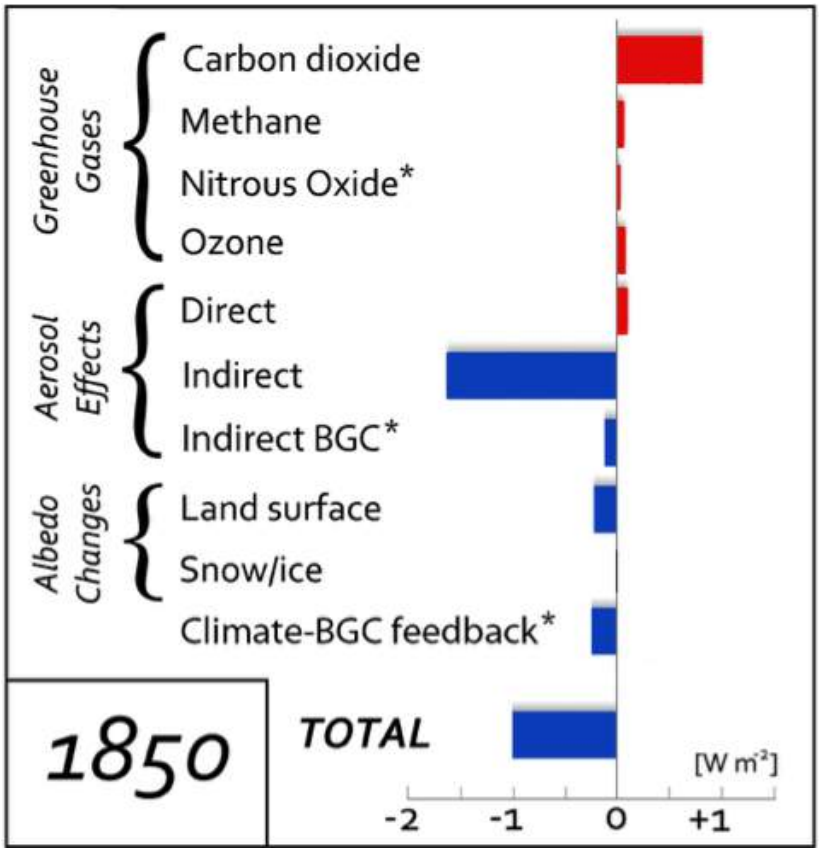


Radiative kernels



Shell et al. (2008)

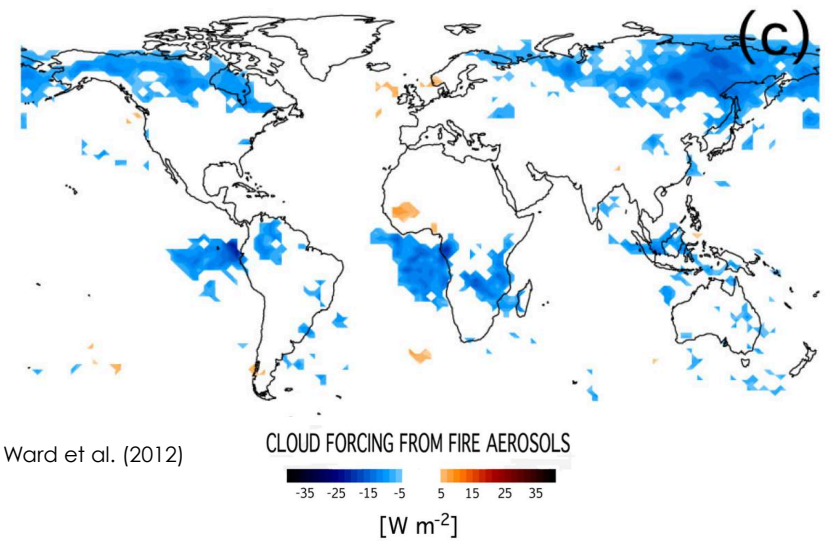
Smoke aerosols



Ward et al. (2012)

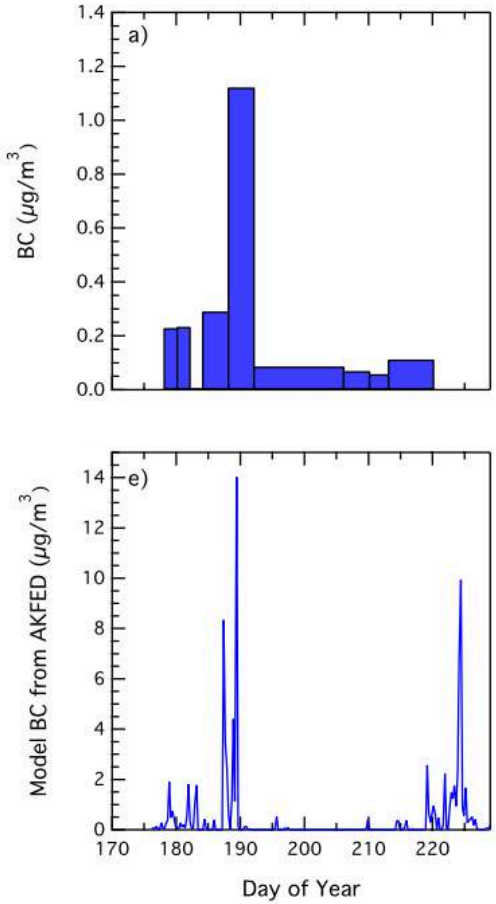
Smoke aerosols

Combustion + Emission factors -> ESM



Ward et al. (2012)

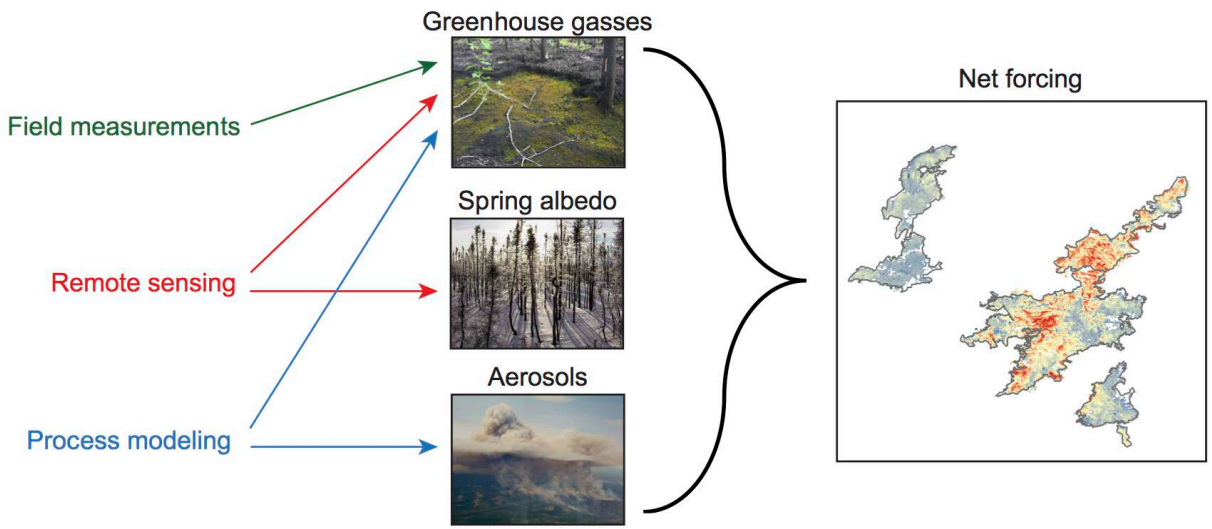
Finer-scale WRF-STILT model



Mouteva et al. (in press)

- Injections every 3 days to capture seasonality
- Quantify forcing from:
  - Direct
  - Indirect
  - Semi-direct
  - BC deposition

Final products



Project deliverables (relevant to management):

- Daily 500 m net and component RF from 2002 - 2013 (at least)
- Predictive models of net RF (i) before the fire season, (ii) seasonal progression, (iii) and at the time of fire
- Estimated warming avoidance from targeted management (W m^{-2}, $)
- Focused analysis for one agency (e.g., AK DOF)
- Identification of places particularly amenable to prescribed burning (i.e., cooling in spring, warming in summer)

Management questions

- Is there currently interest in this information?
- If so, how could it be used? What activities?
- Can we tie into existing prescribed burns or other fuels treatments?
- Are there feasibly resources available to devote to warming/cooling effects?

Looking for feedback

- Field campaign locations and measurements
- Scientific direction/management relevance
- Linking to current or expected management activities
- Other!

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photo credit: Dennis Quintilio