High resolution carbon emissions estimates from boreal fires

Sander Veraverbeke, J. Randerson, E. Wiggins, B. Rogers

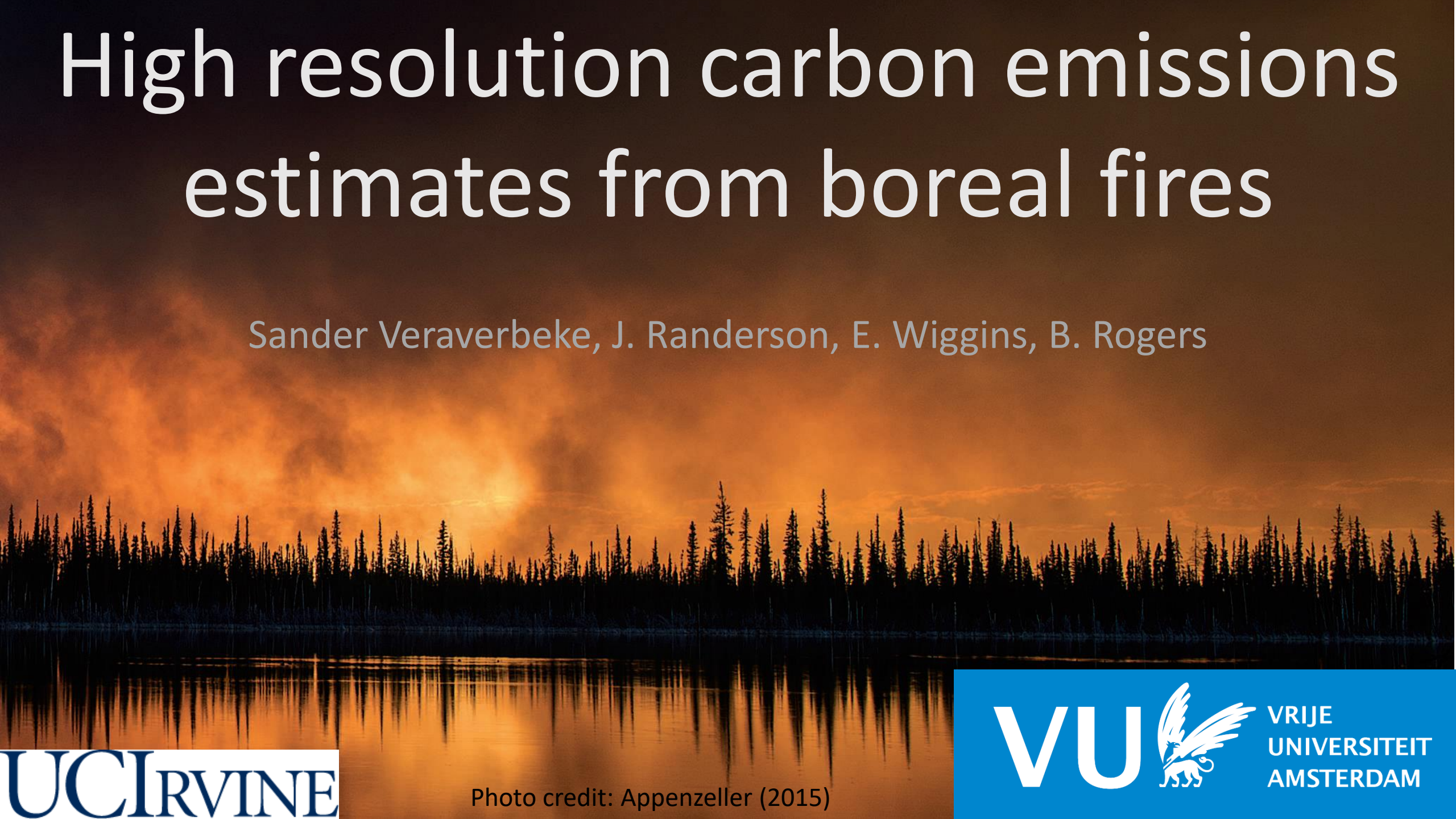

Photo credit: Appenzeller (2015)

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Forest Fires In Northwest Canada Burning At 'Unprecedented' Levels

Washington Post, July 2014

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

Washington Post, July 2015

'Almost biblical': Fort McMurray wildfire named biggest weather event of 2016

CBC News, December 2016

June 14, 2015

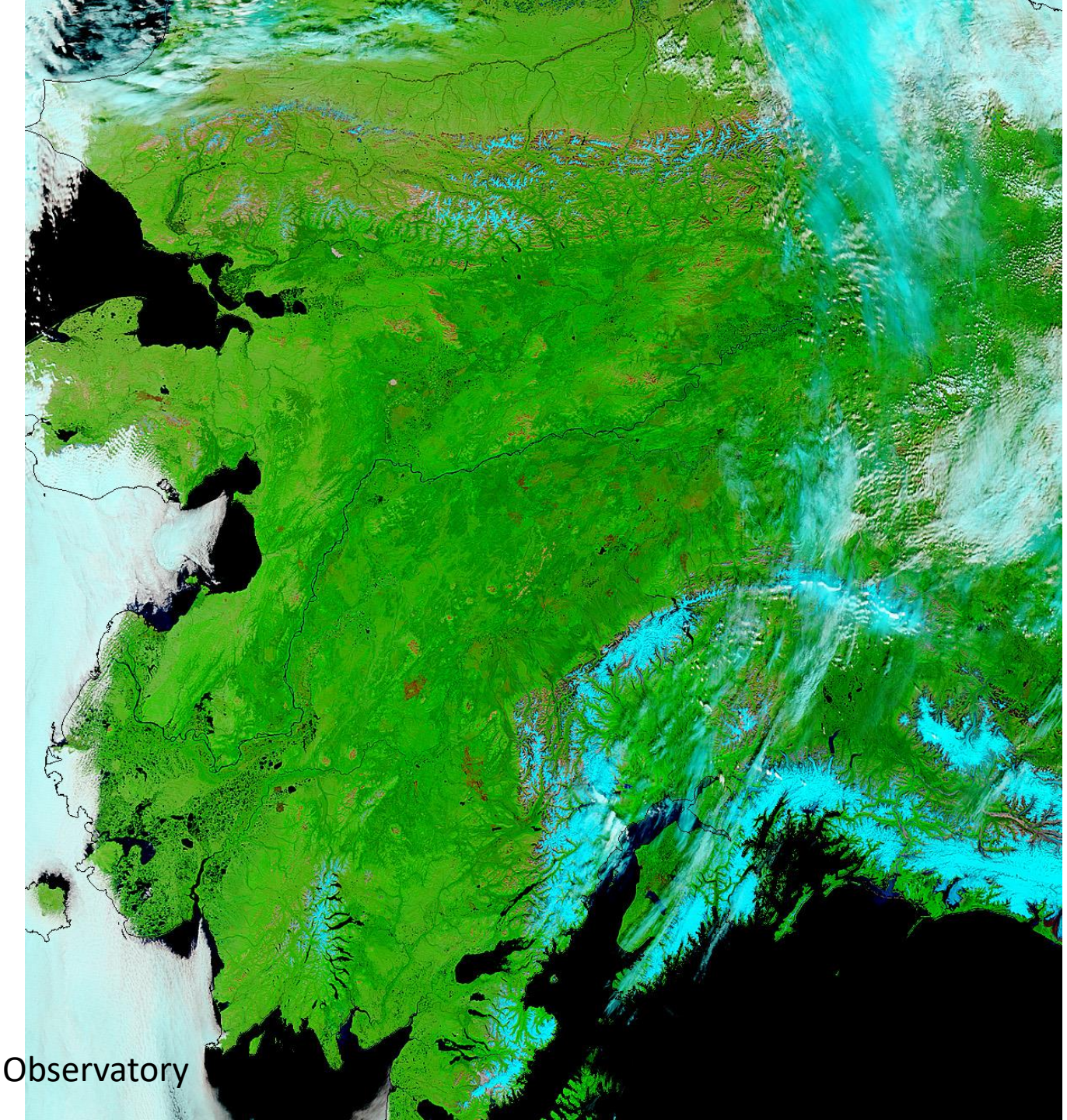
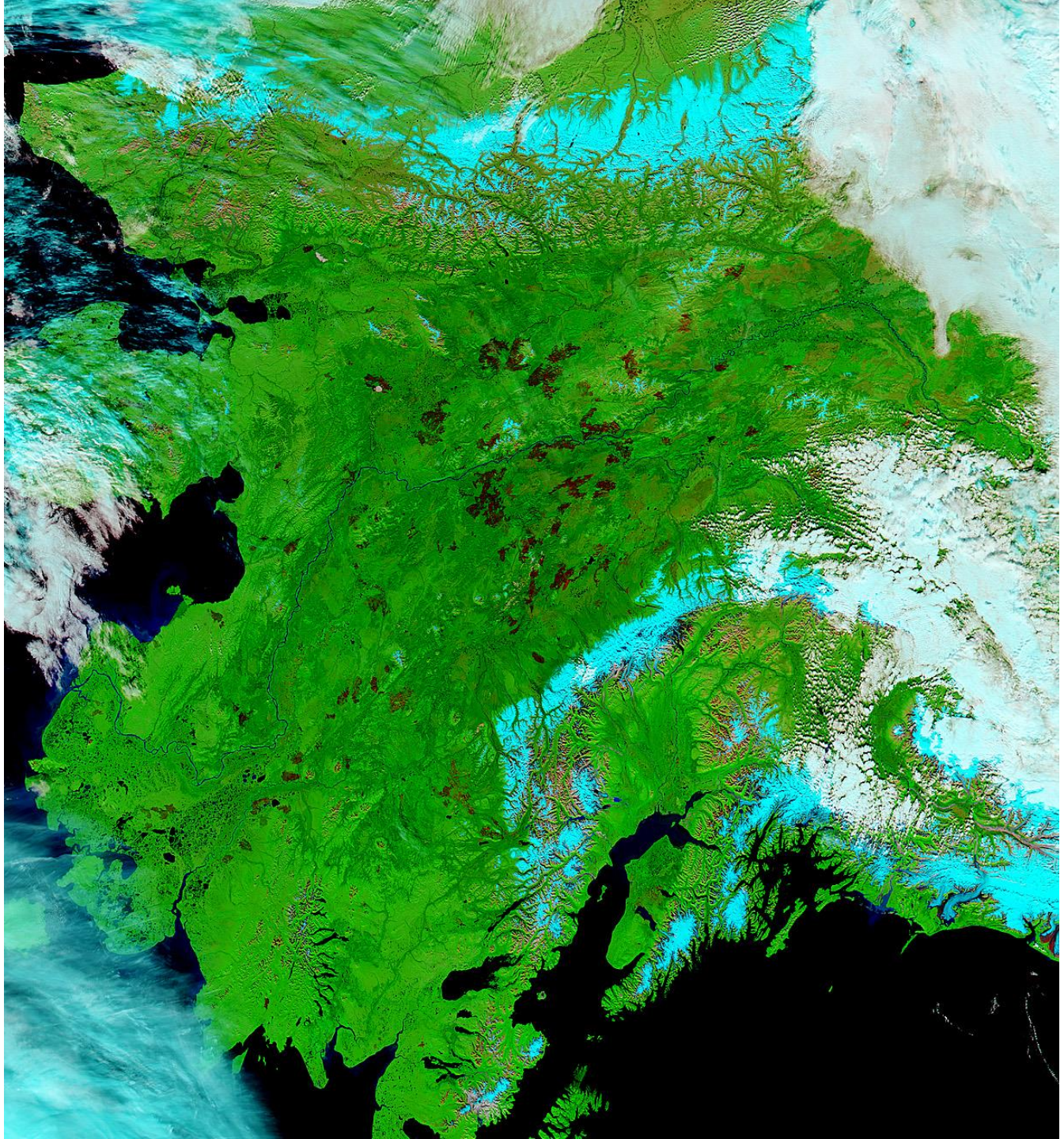


Image credit: NASA Earth Observatory

September 1, 2015



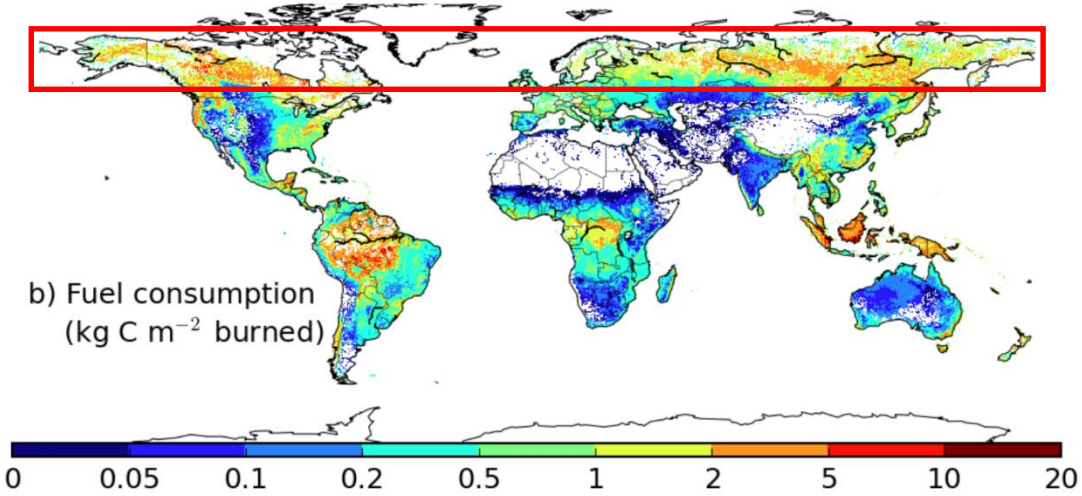
Carbon emissions from boreal fires

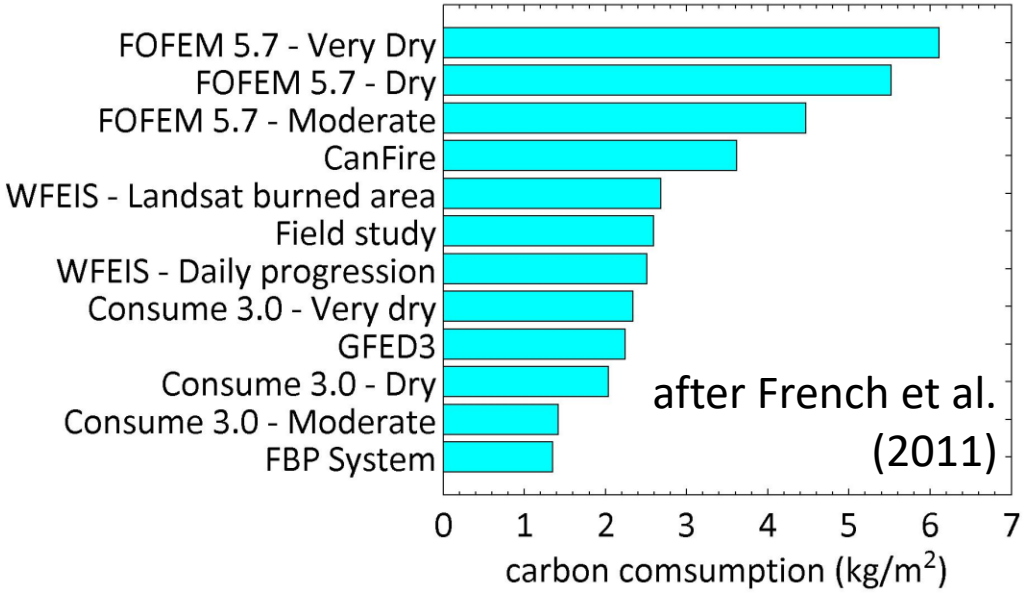
van der Werf et al. (2017)

- How much **carbon** do these fires release?
- *Northwest Territories 2014: 164 ± 32 Tg C*
- *Interior Alaska 2015: 55 ± 11 Tg C*

- **Fuel consumption**, primarily from **ground fuels**, among the highest on Earth

- **Yet, uncertainties** remain very large

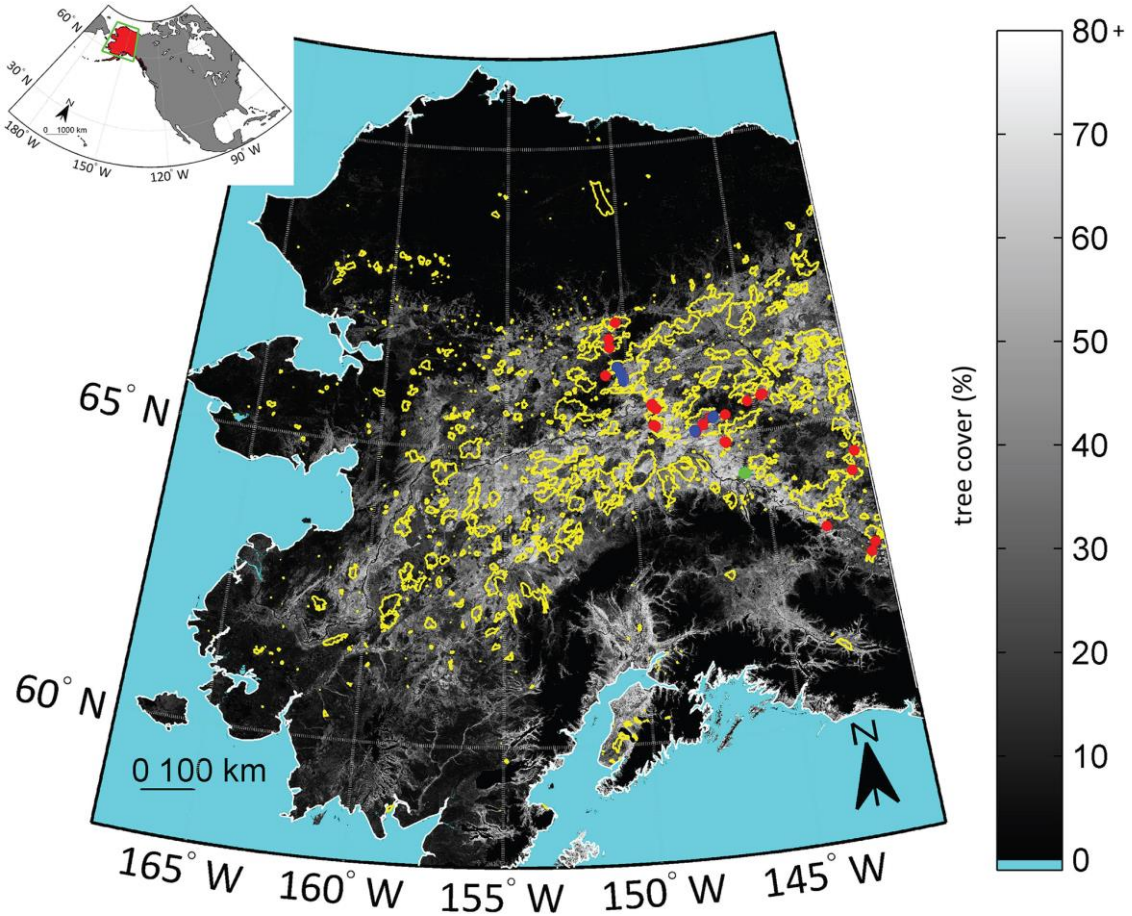




Carbon emissions from boreal fires: Motivation

- We need *better* boreal fire emission estimates:

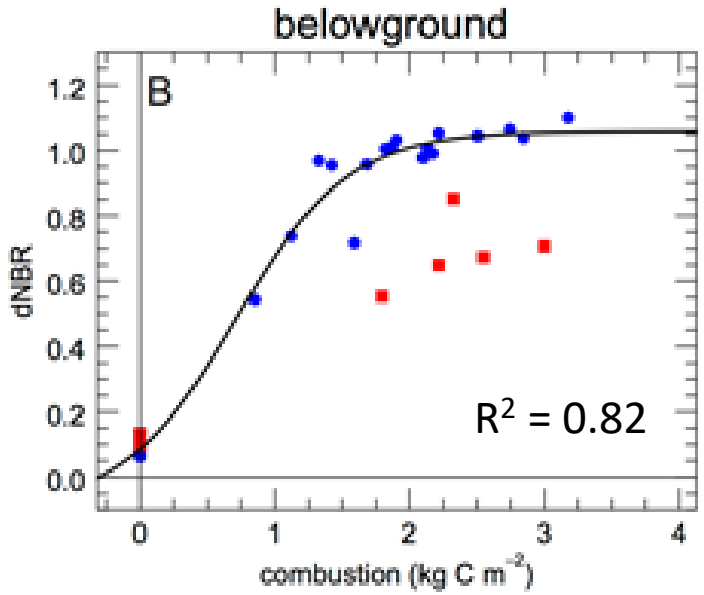
- Higher spatial resolution
- Higher temporal resolution
- Calibrated and validated with field measurements
- Inclusion of remotely sensed severity
- Quantified uncertainty

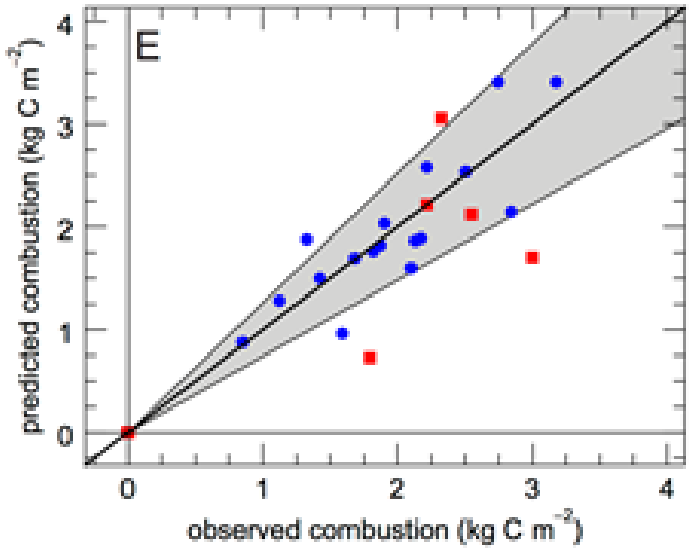


Colored dots: location of field plots

Carbon emissions from boreal fires: Inclusion of remotely sensed burn severity

The differenced Normalized Burn Ratio (dNBR) has potential as indicator of depth of burn and C consumption





Rogers, Veraverbeke et al. (2014). *JGR*

Carbon emissions from boreal fires: Methods

- Field work

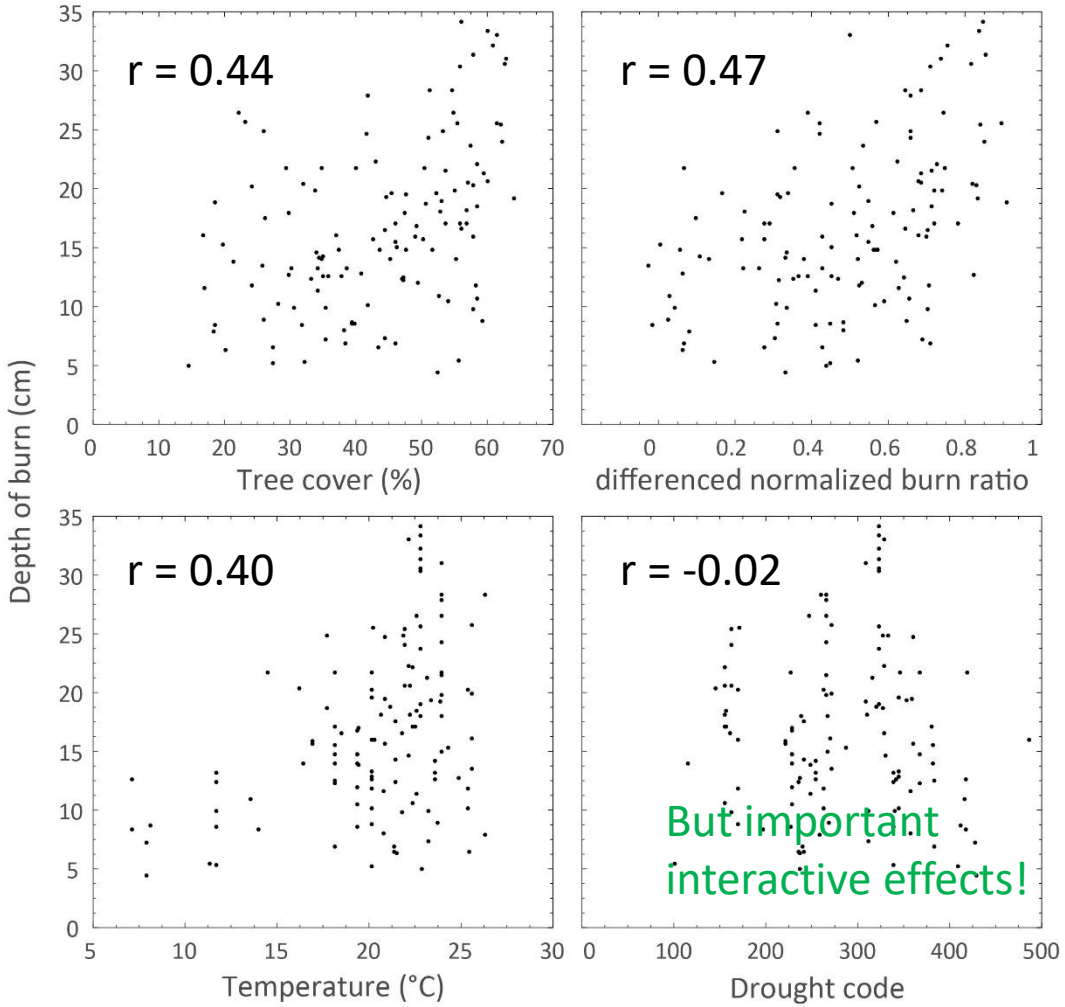
https://www.facebook.com/nasaearth/videos/10154328509597139/

https://www.youtube.com/watch?v=7NduFdTYglo

- Remote sensing

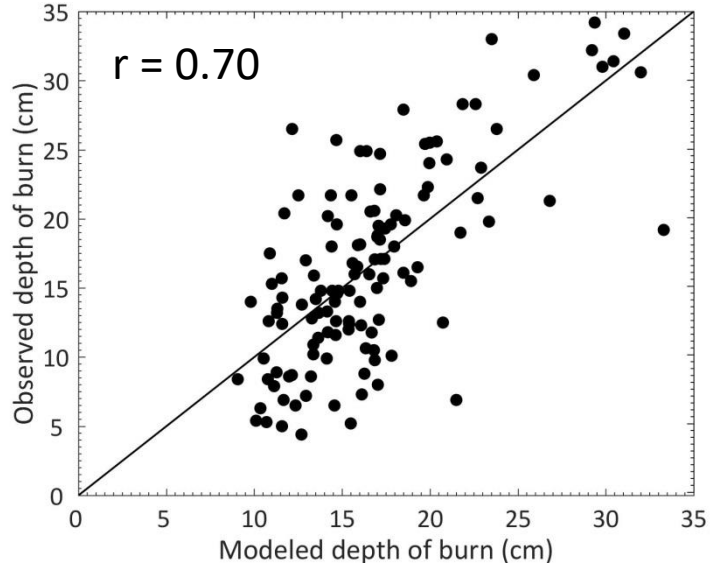
- Statistical modeling

Carbon emissions from boreal fires: Methods



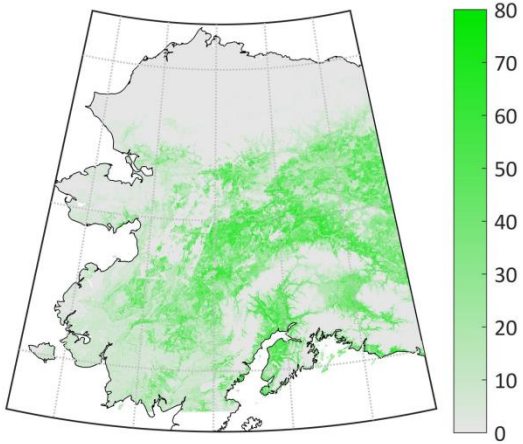
But important interactive effects!

Depth of burn = f(TC, dNBR, T, DC)
C = f(TC, dNBR, T, DC)

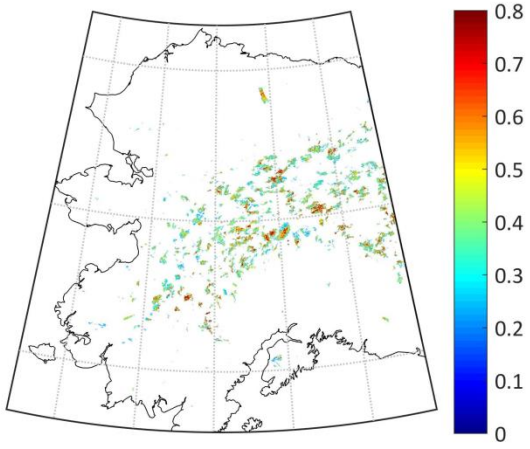


Carbon emissions from boreal fires: Methods

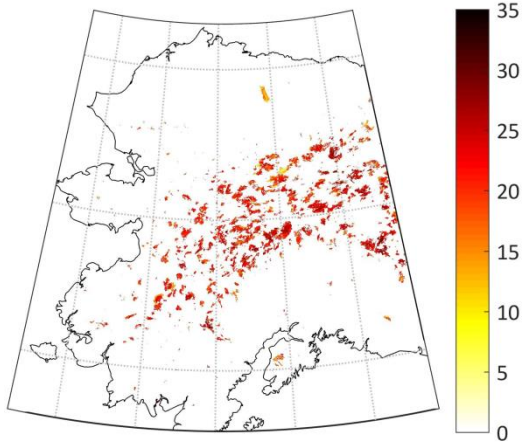
Tree cover (%)



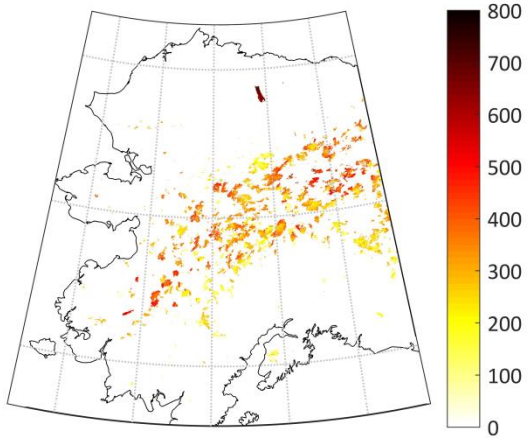
dNBR



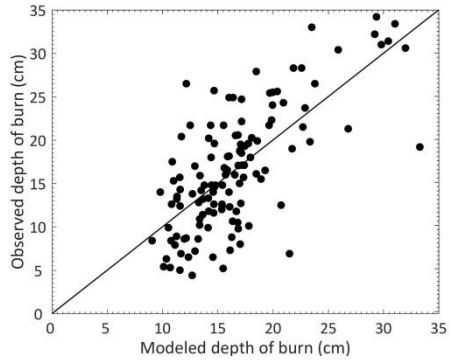
Temperature



Drought code

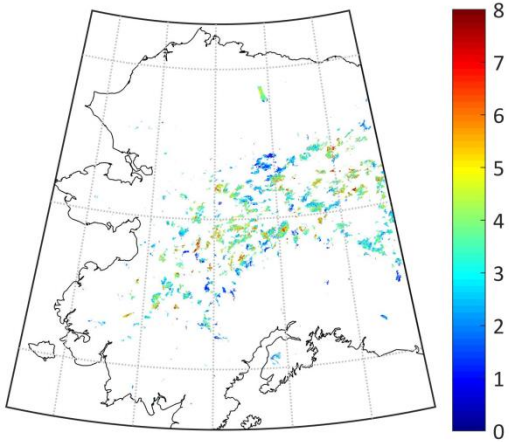


Environmental variables derived from remote sensing and reanalysis



Statistical predictive model (based on field data)

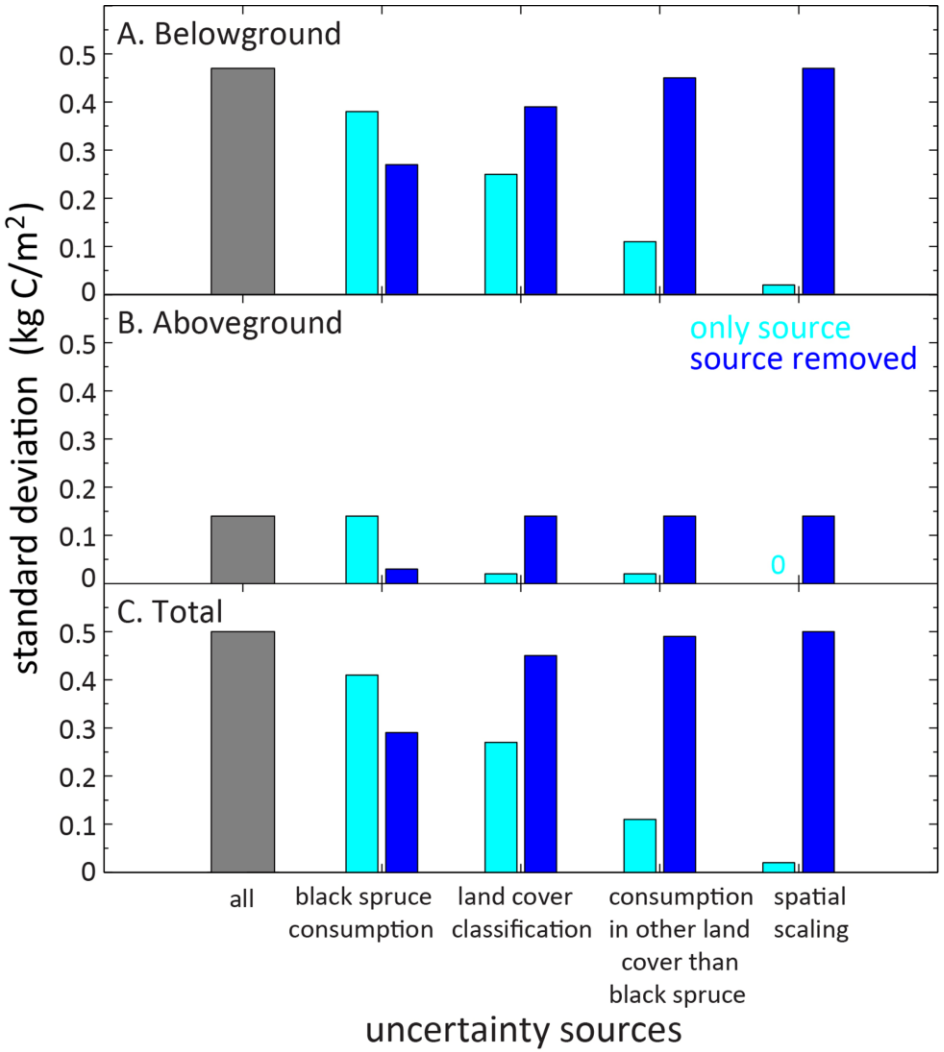
C consumption (kg/m^2)



Spatially and temporally explicit C emissions

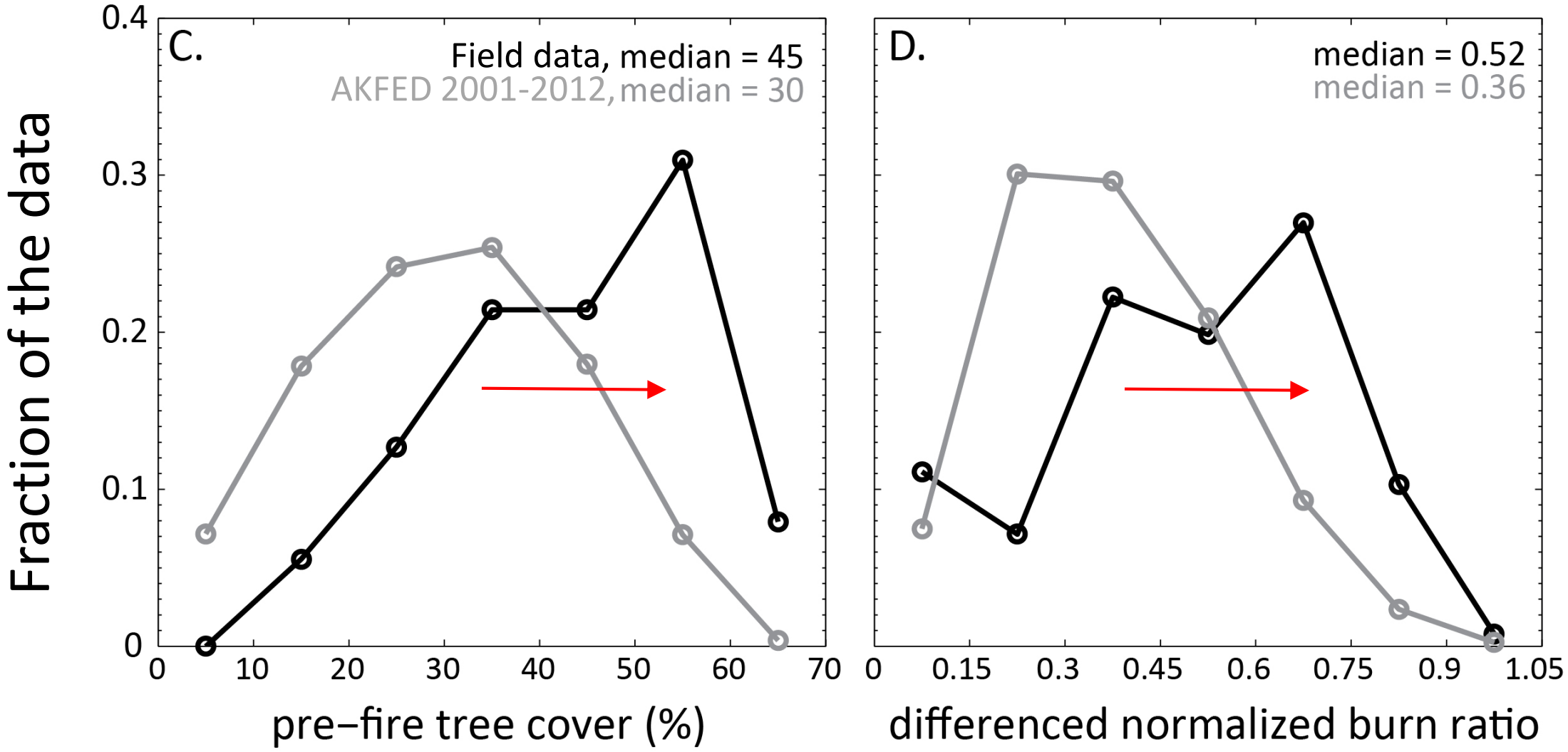
Carbon emissions from boreal fires: Uncertainties

- Approximately **20 %** of the estimates
- Largest uncertainty comes from **belowground consumption**
- The main source of modeling uncertainty is from the **regression models** for consumption



Carbon emissions from boreal fires: Bias in field data

Field data are biased toward **high tree cover** and **high severity** sites



Carbon emissions from boreal fires: Data availability

- Data available for Alaska 2001-2013 at the ORNL DAAC

DAAC Home > Get Data > Field Campaigns > CARVE > Data Files

CARVE: Alaskan Fire Emissions Database (AKFED), 2001-2013

Download Data

Data Set Overview

Data set	CARVE: Alaskan Fire Emissions Database (AKFED), 2001-2013
DOI	10.3334/ORNLDAAC/1282
Release date	2015-09-17
Project	Carbon in Arctic Reservoirs Vulnerability Experiment
Time Period	2001-01-01 to 2013-12-31

Veraverbeke et al. (2015). Biogeosciences.

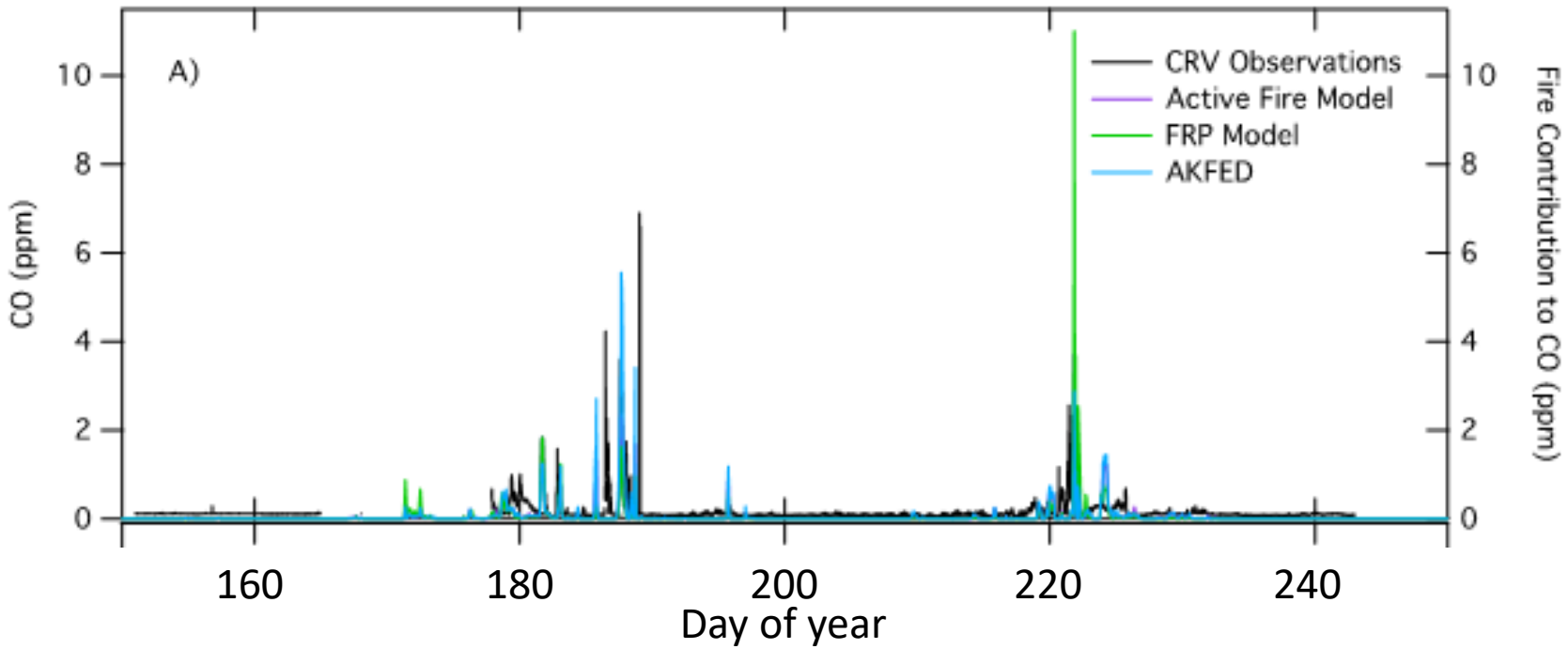
- We are currently updating the database till 2015, and to include the Yukon and Northwest Territories

Carbon emissions from boreal fires: Opportunities

Hi-res (spatially and temporally) fire progression and emissions enable a better understanding of:

- Fire behavior (e.g. fire growth)
- Aerosol composition (e.g. emission factors of flaming/smoldering fires)
- Air pollution and exposure
- Boreal forest carbon balance and climate feedbacks

Carbon emissions from boreal fires: 2013 season



- Showed influence of daily weather on emissions, and extracted emissions factors
- Modeled emissions were in close agreement with tower observations

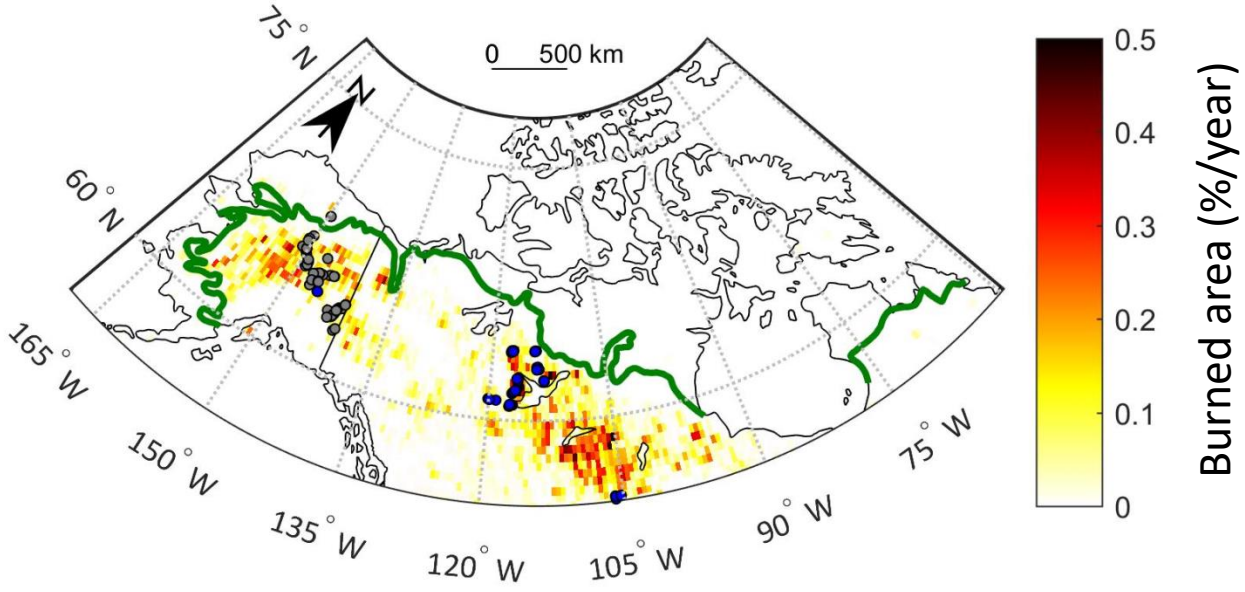
Wiggins, Veraverbeke et al. (2016). JGR.

Carbon emissions from boreal fires: Ongoing efforts

- Collaborative effort as part of the Fire Disturbance Working Group of NASA ABoVE
- An expected field database of **400+ plots**

- Goals:

1) Integration of new field measurements
2) Extension of model over entire boreal North America

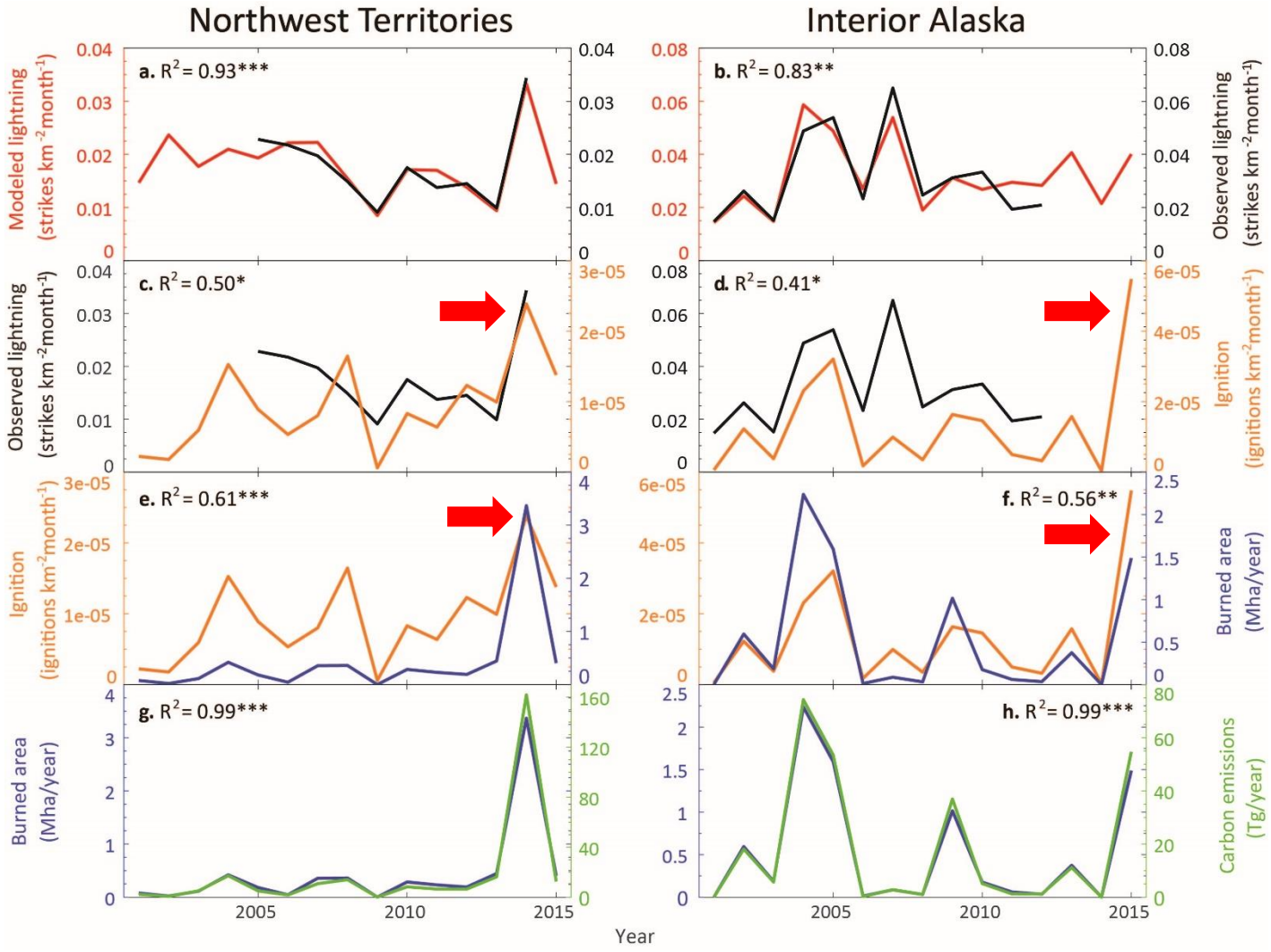


Existing field plots

New field plots under NASA ABoVE

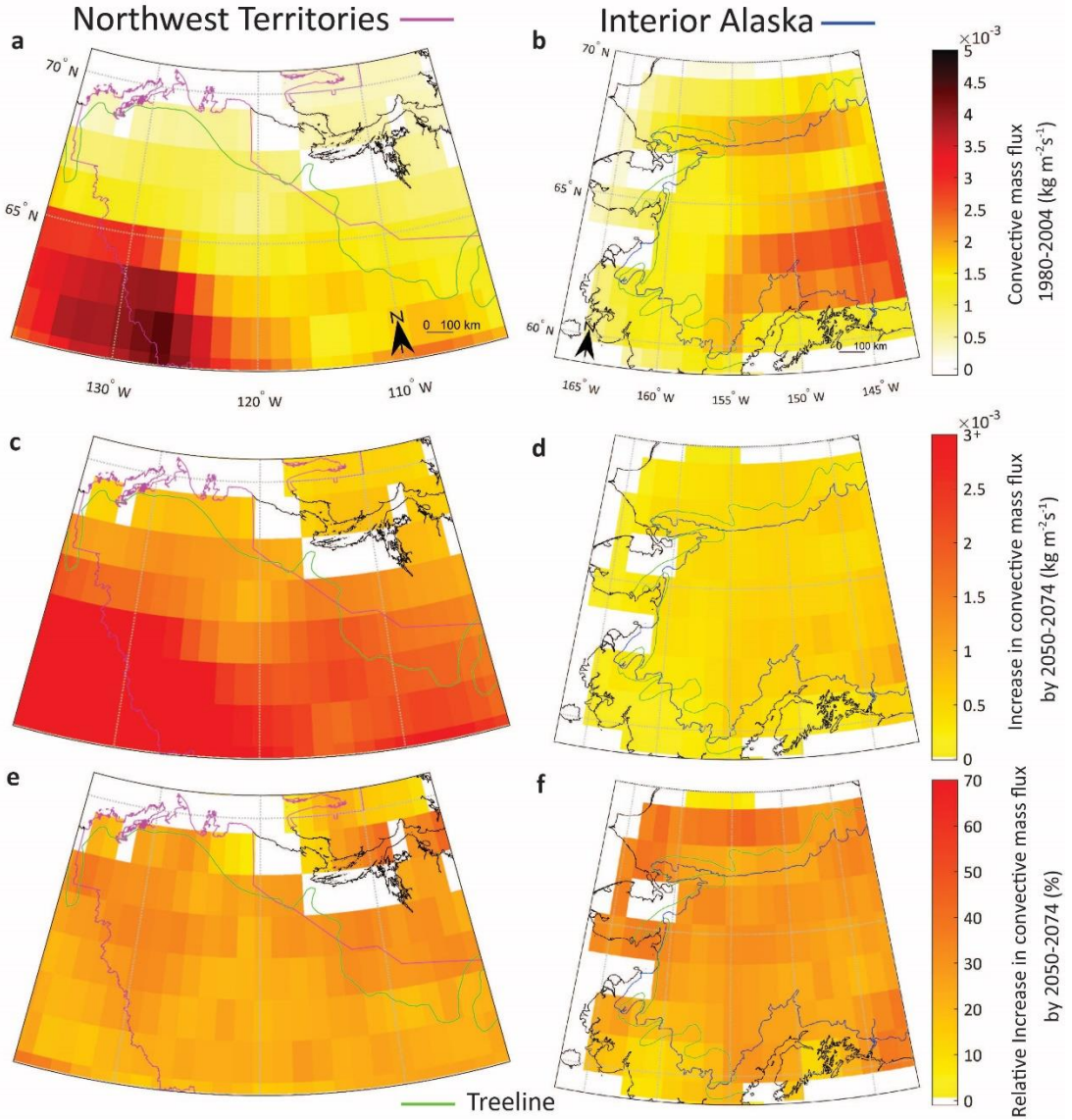
Climate-induced lightning, fire and carbon

- We found a direct cascade from climate-induced lightning to fire emissions
- Extreme **lightning was a driver** of the large fire seasons in the **Northwest Territories in 2014** and in **Alaska in 2015**



Climate-induced lightning, fire and carbon

- **Increases** in lightning are expected **with climate change**
- This will lead to increases in burned area and fire emissions



CARVE

Carbon in Arctic Reservoirs Vulnerability Experiment

ABoVE

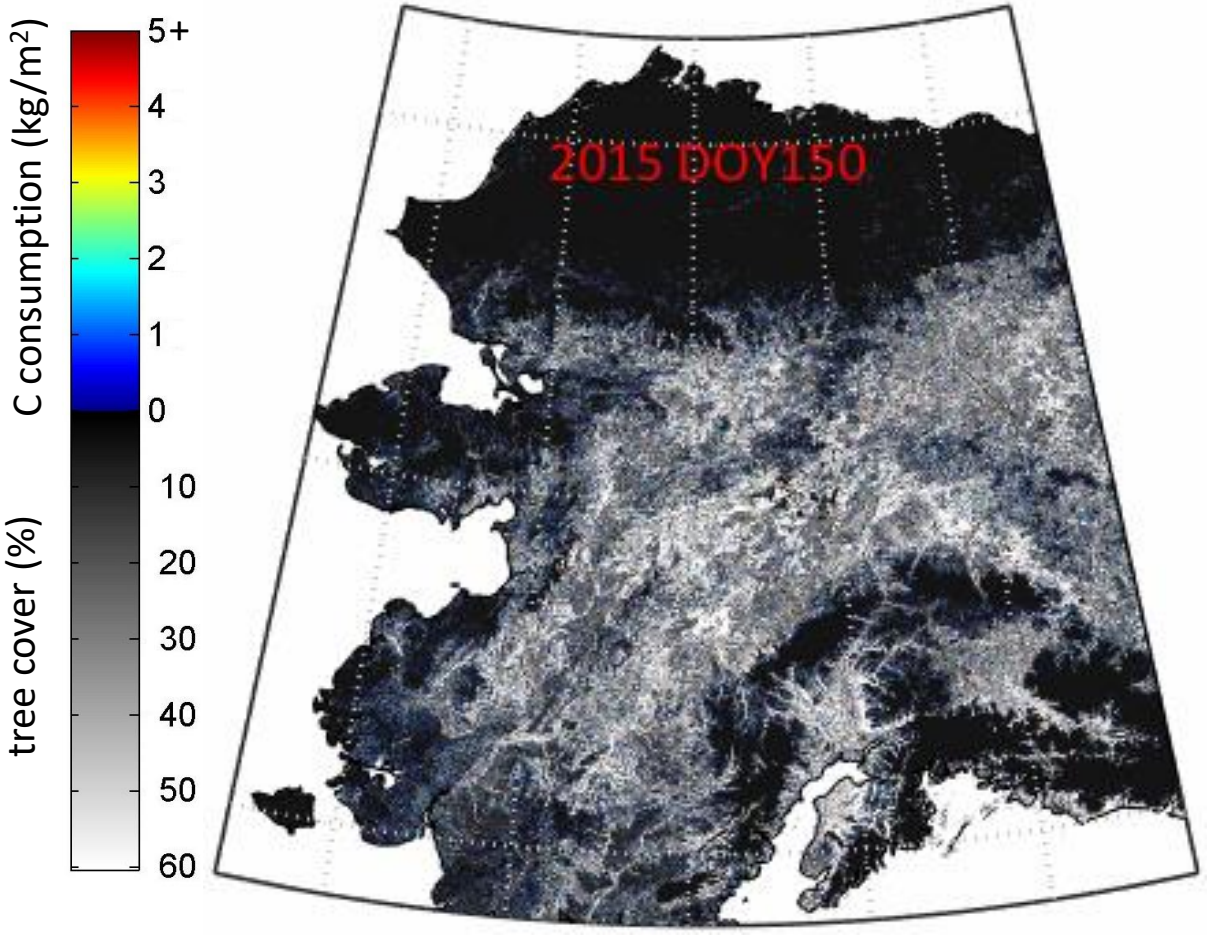
ARCTIC BOREAL VULNERABILITY EXPERIMENT

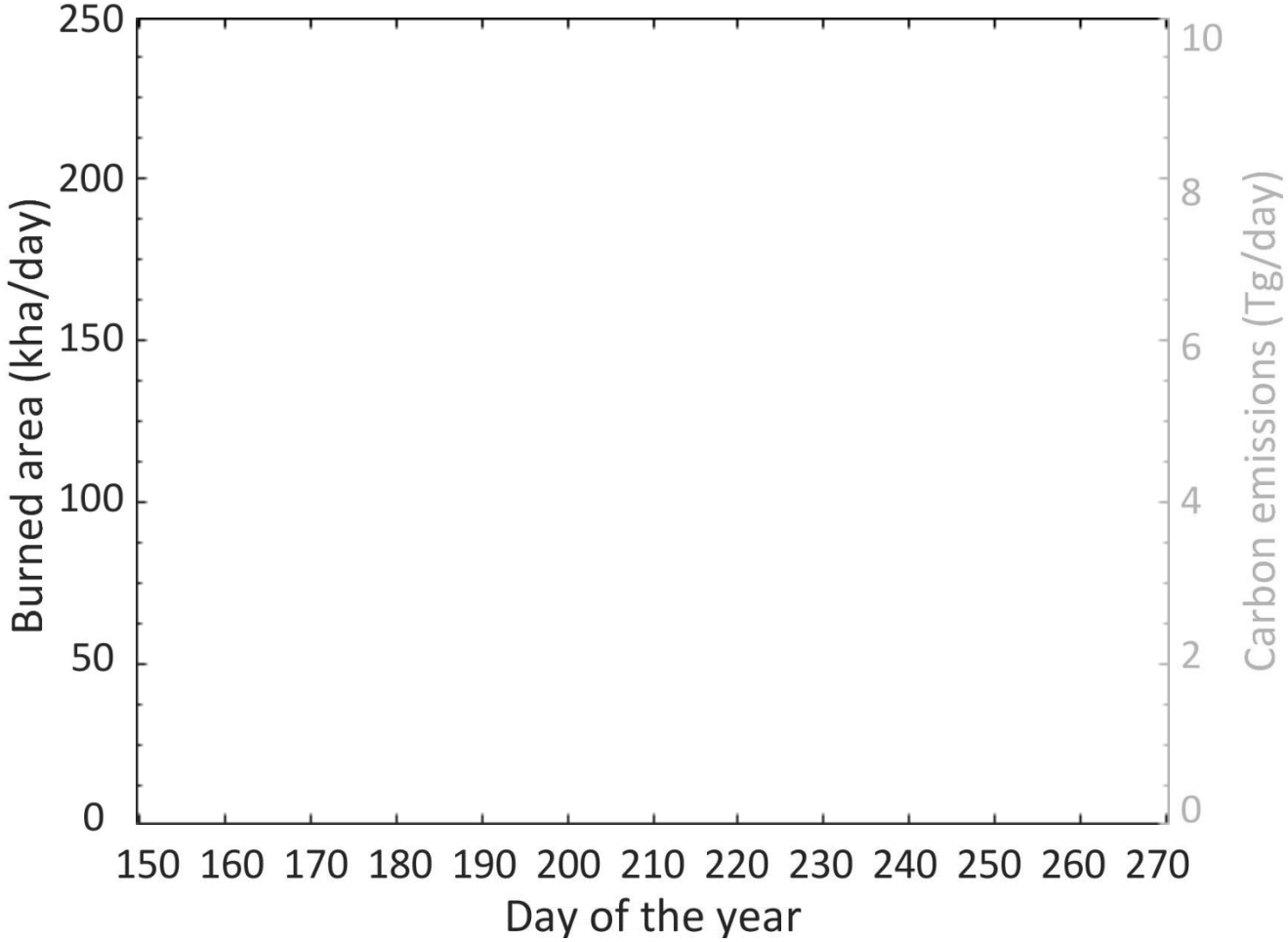
NASA

s.s.n.veraverbeke@vu.nl

THANK YOU!!

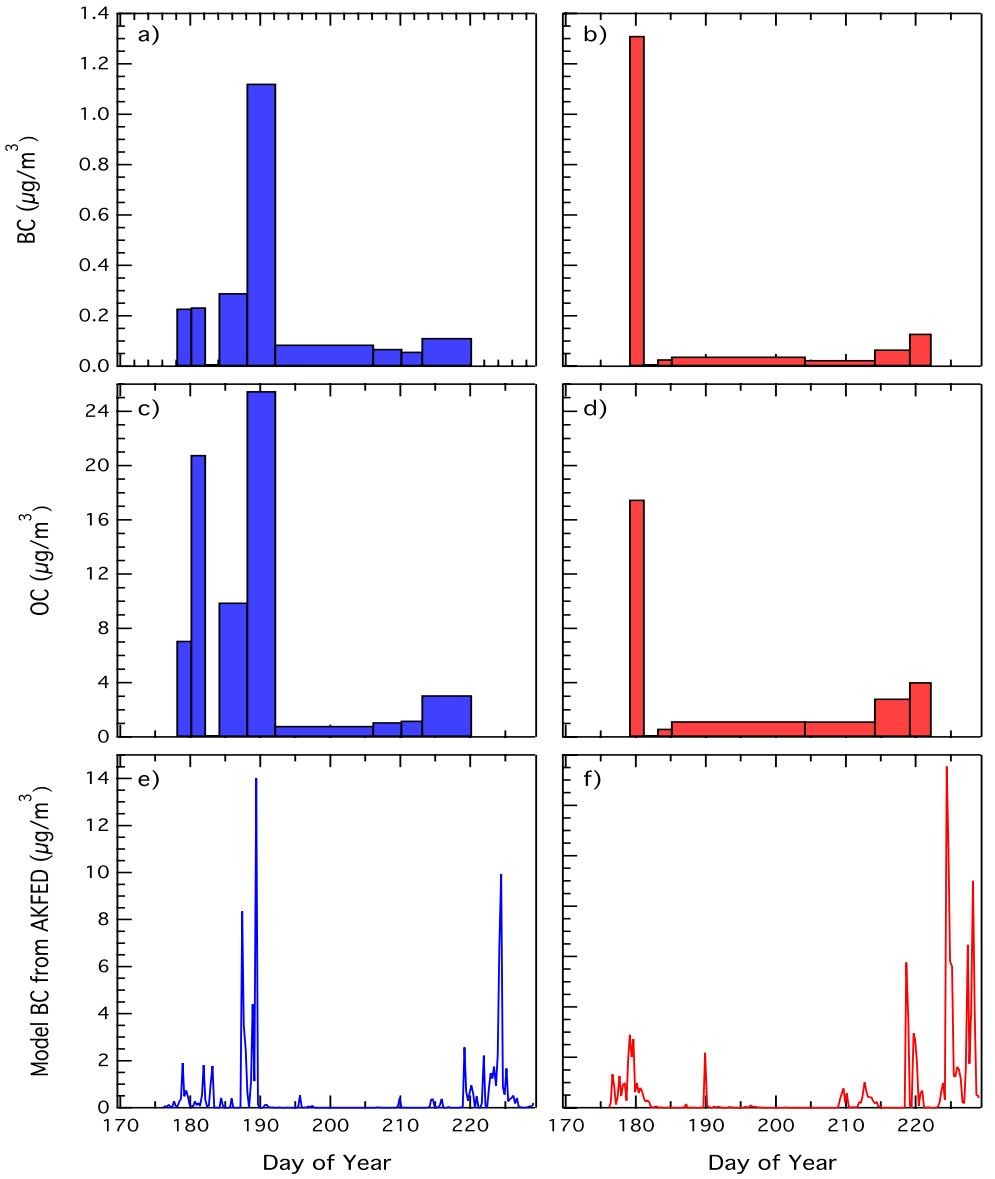
Carbon emissions from boreal fires: 2015 season





Carbon emissions from boreal fires: 2013 season

- Showed black carbon aerosols dynamics during the fire season
- Used AKFED-WRF-STILT to independently verify high fire periods at measurement locations
- Radiocarbon measurements were consistent with a mean depth of burn of 20 cm and fuel age of 20 years



Mouteva et al. (2015). *GBC.*