Predicting post-fire albedo under historical and future climate

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ABoVE Science Cloud Webinar

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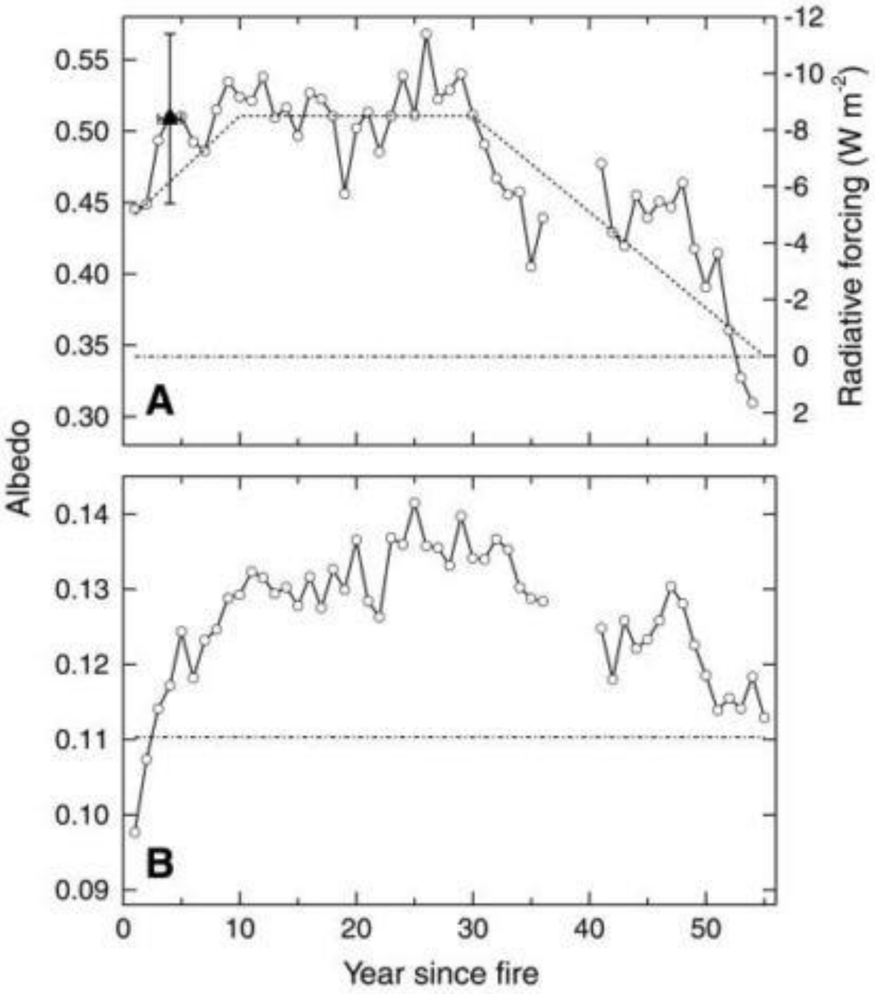
Importance of Fire in Boreal Forests

- Fire severity, frequency, and size have been increasing
- Dominant disturbance mechanism
  - Species composition
  - Carbon cycle
  - Surface energy exchange
    - Albedo
    - Black carbon aerosols

- Post-Fire Albedo Trajectories
  - Increases in Fall, Winter, and Spring
  - Decreases Immediately post-fire in the Summer
  - Winter and Spring albedo in particular can remain elevated leading to cooling

Background



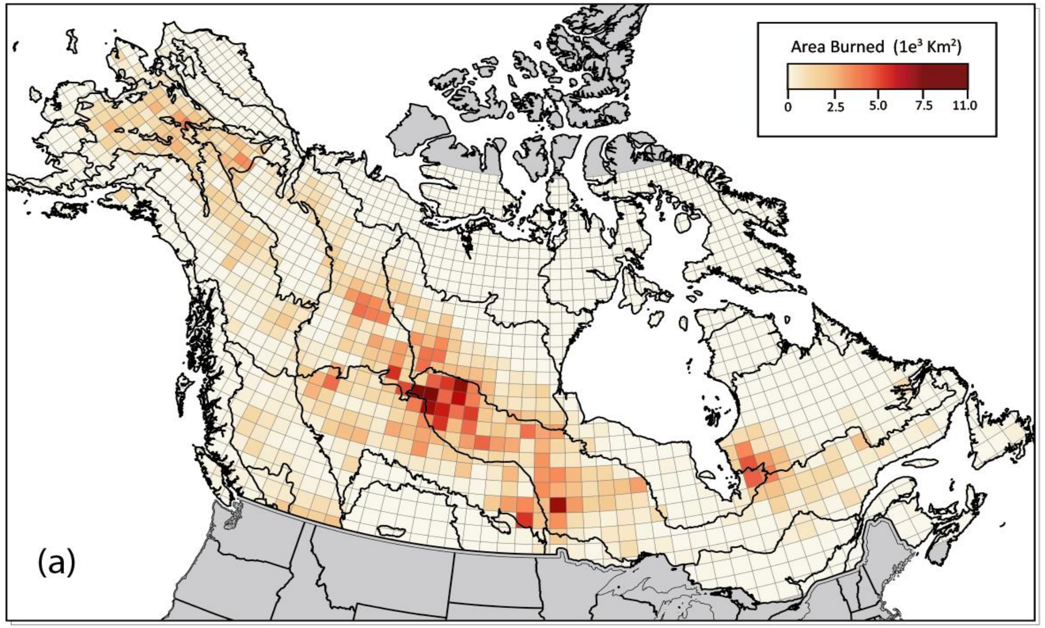
Forcing agent	Radiative forcing* [W (m^2 burned)$^{-1}$]	
	Year 1	Years 0 to 80 (mean)
Long-lived greenhouse gases (CH_4 and CO_2)	8 ± 3	1.6 ± 0.8
Ozone	6 ± 4	0.1 ± 0.1
Black carbon deposition on snow	3 ± 3	0.0 ± 0.0
Black carbon deposition on sea ice	5 ± 4	0.1 ± 0.1
Aerosols (direct radiative forcing)†	17 ± 30	0.2 ± 0.4
Impact at the surface: −90 W ± 35 m^{-2}		
Changes in post-fire surface albedo	−5 ± 2	−4.2 ± 2.0
Total‡	34 ± 31	−2.3 ± 2.2

Randerson et al., 2006

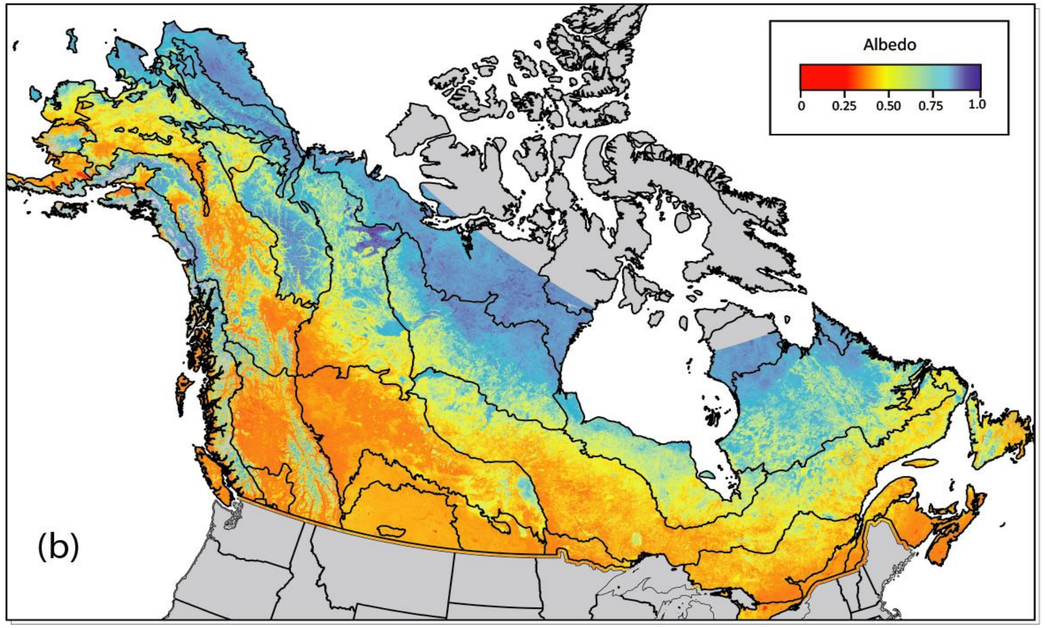
Research Goals

1. Identify the most influential variables that drive post-fire albedo in deferent seasons across boreal North America
2. Model long-term trajectories of post-fire albedo as a function of these drivers
3. Assess spatial variation in albedo trajectories, and the associated radiative forcing
4. Estimate how albedo driven radiative forcing may change under future climate scenarios (RCP 4.5 and 8.5)

Historical Burn Area



Example Blue Sky Albedo Composite in April



Modeling Approach

Fire and Albedo Data

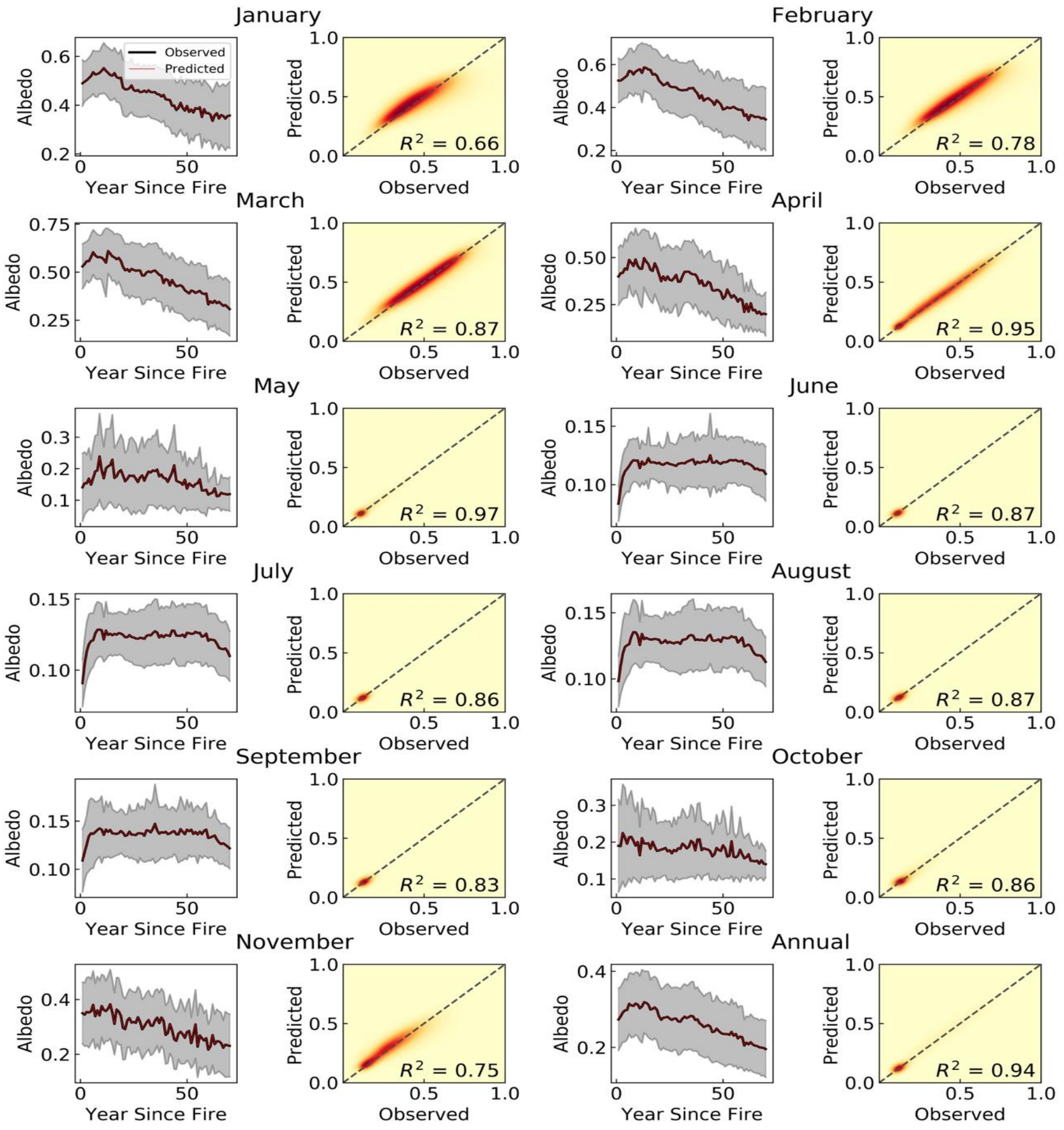
- Alaskan and Canadian Fire Databases
  - 1916 – 2013
- MODIS V006 blue-sky albedo product
  - Daily observations converted to monthly means

For any single month, once post-fire albedo chronosequences are built and associated predictor variables gathered the input file size is ~50 GB

Predictor Variables

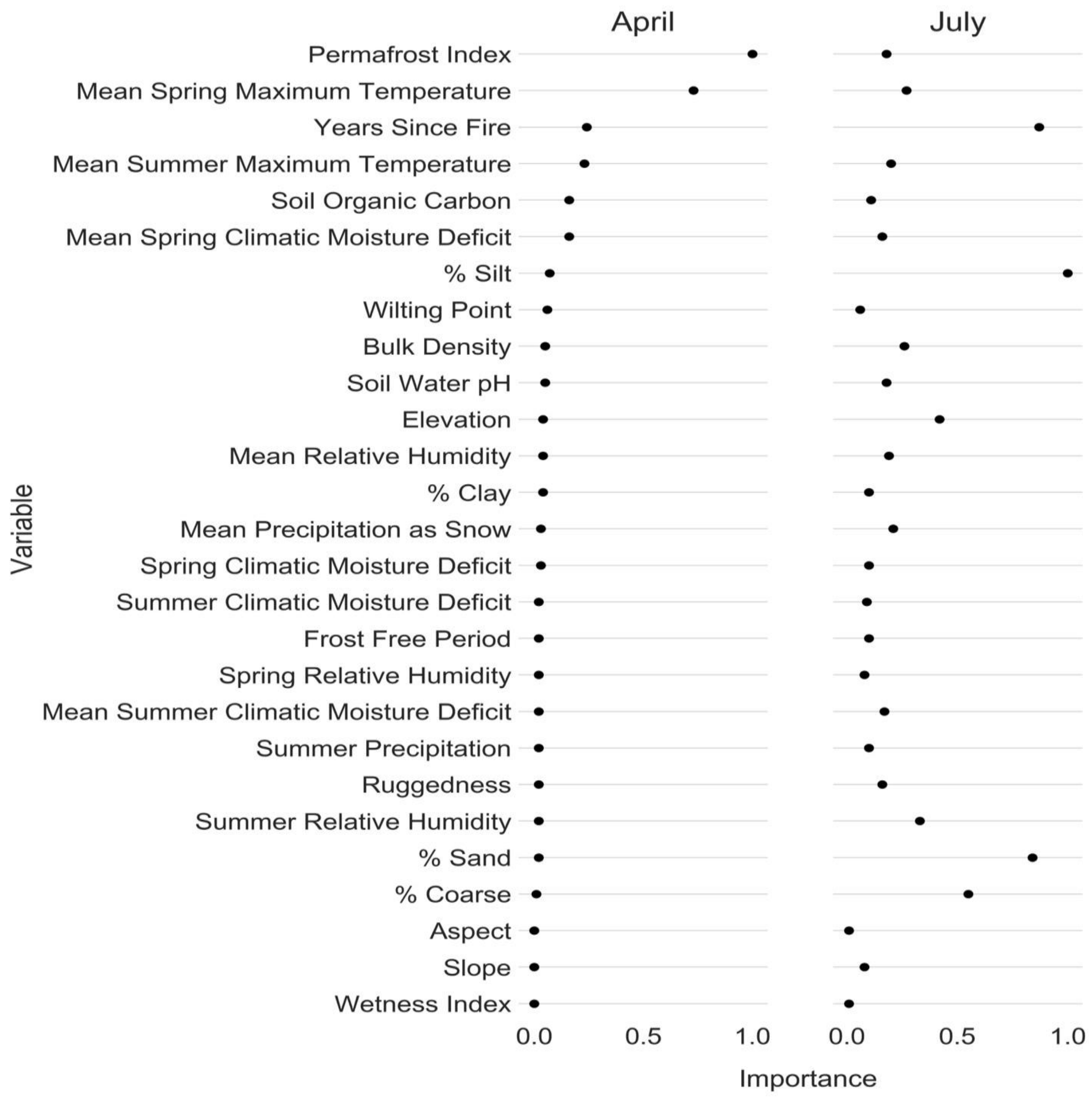
- Soils – SoilGrids
- Historical and Projected Climate – ClimateNA
  - Year of burn
  - Long term mean
- Permafrost and Ruggedness – Gruber, 2012
- Topographic variables – GMTED2010 7.5 arc seconds

Random Forest Model Fits



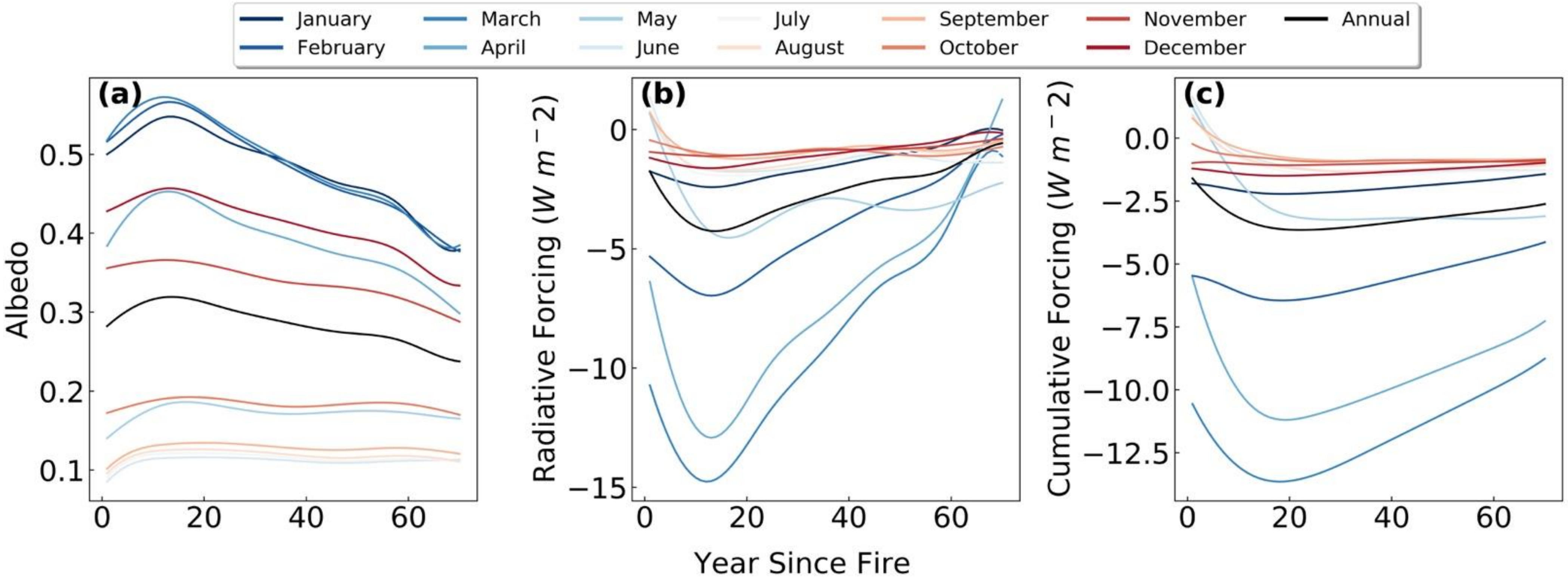
Mean observed post-fire albedo compared to mean predicted albedo (left panels) and density plots of observed vs predicted values and associated R^2 (right panels). R^2 are based on fits in the test set during cross validation.

1. Identify the most influential variables that drive post-fire albedo in deferent seasons across boreal North America



Feature importance of predictor variables used in the random forest model for the months of April and July.

2. Model long-term trajectories of post-fire albedo as a function of these drivers

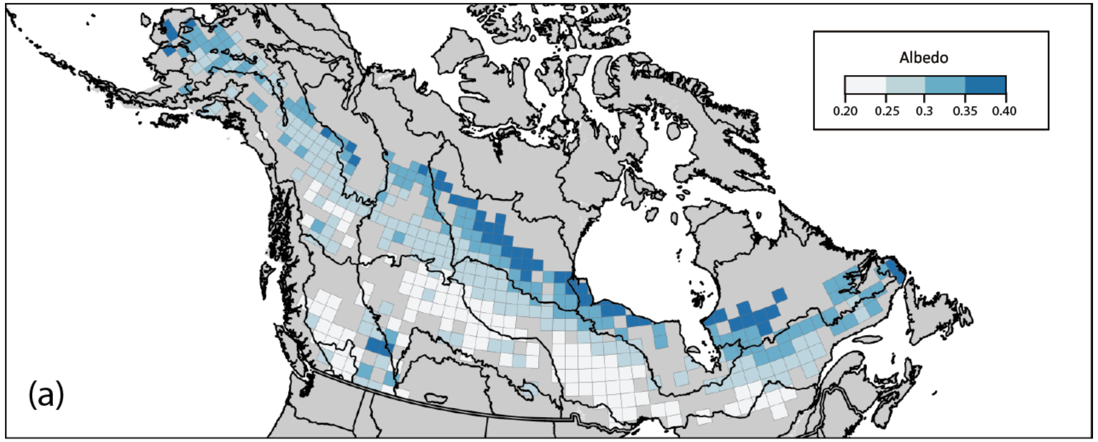


Monthly and annual modeled post-fire albedo (a), radiative forcing (b) and cumulative mean forcing (c) for a sample of 10,000 pixels which burned in the MODIS era.

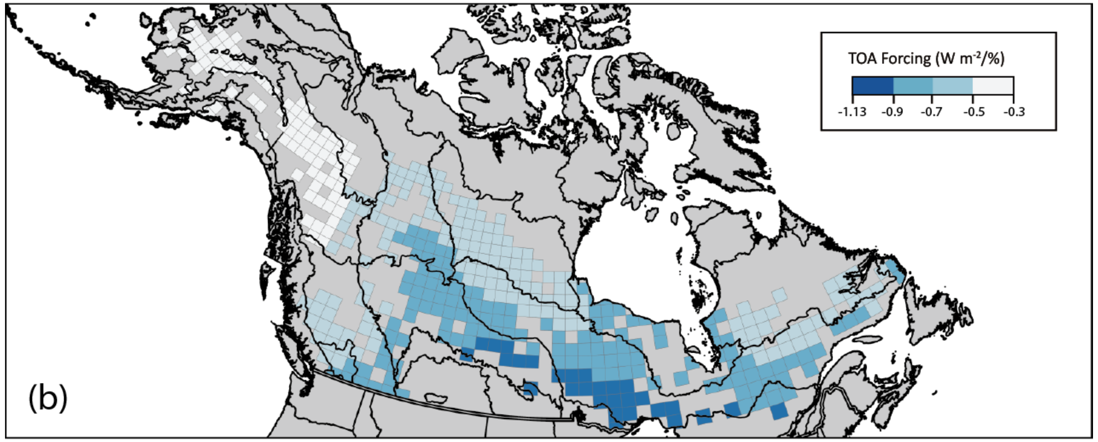
Our mean annual estimate: -2.53 +/- 1.61 W m^{-2}
Randerson et al., 2006: -4.2 +/- 2.00 W m^{-2} in interior Alaska
O'Halloran et al., 2012: -4.5 W m^{-2} in central Canada

3. Assess spatial variation in albedo trajectories, and the associated radiative forcing

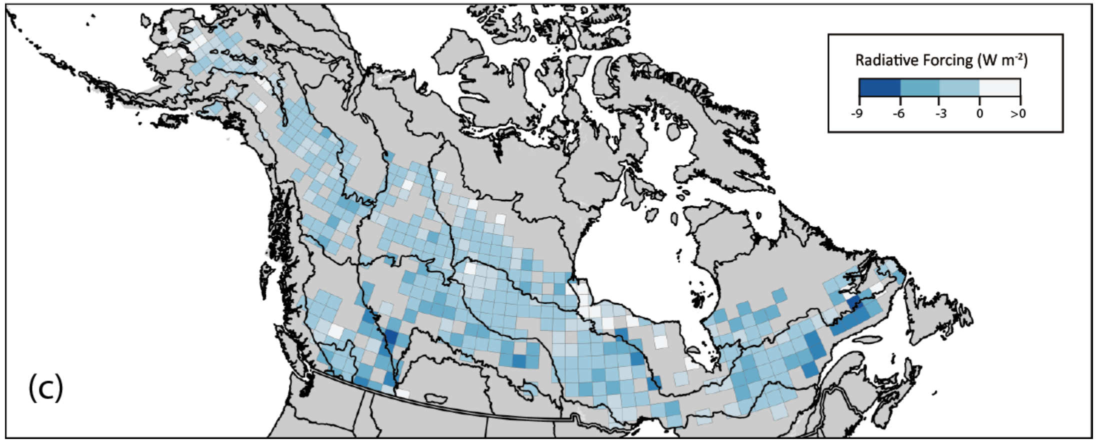
Modeled Historical Albedo



Spatial Variation in Radiative Kernels



Albedo converted to Radiative Forcing

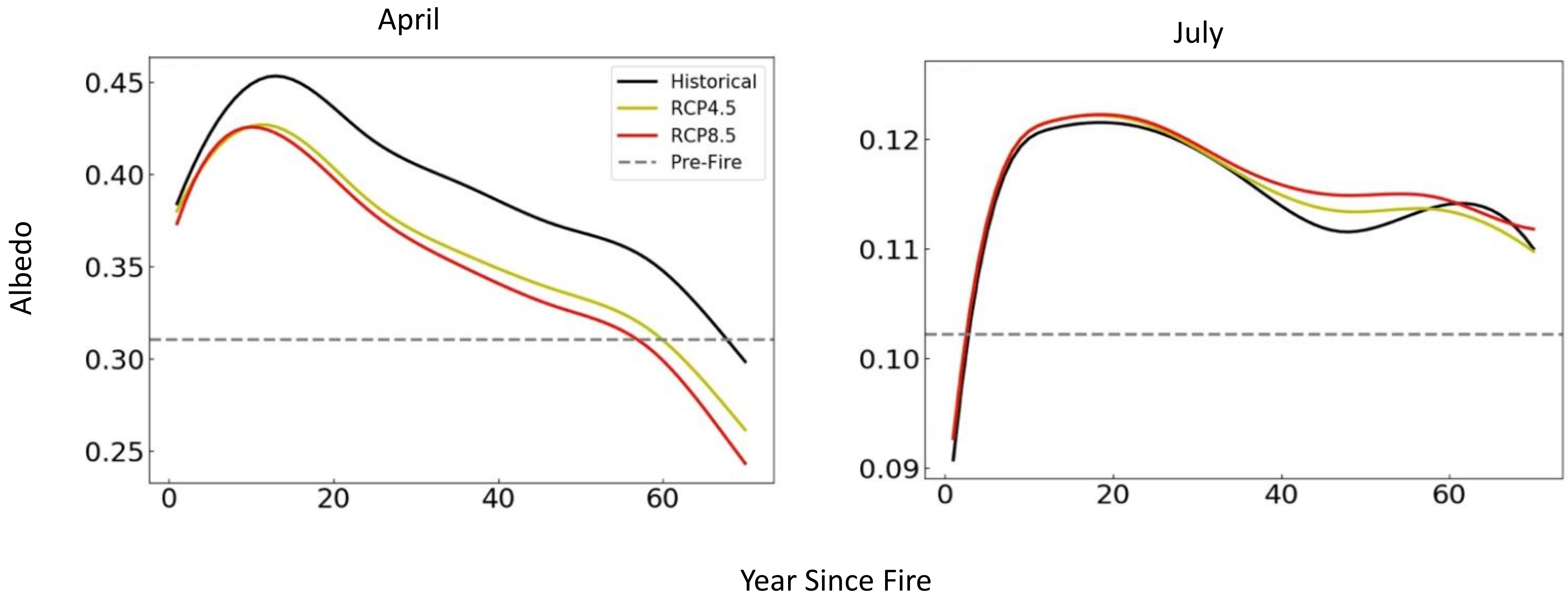


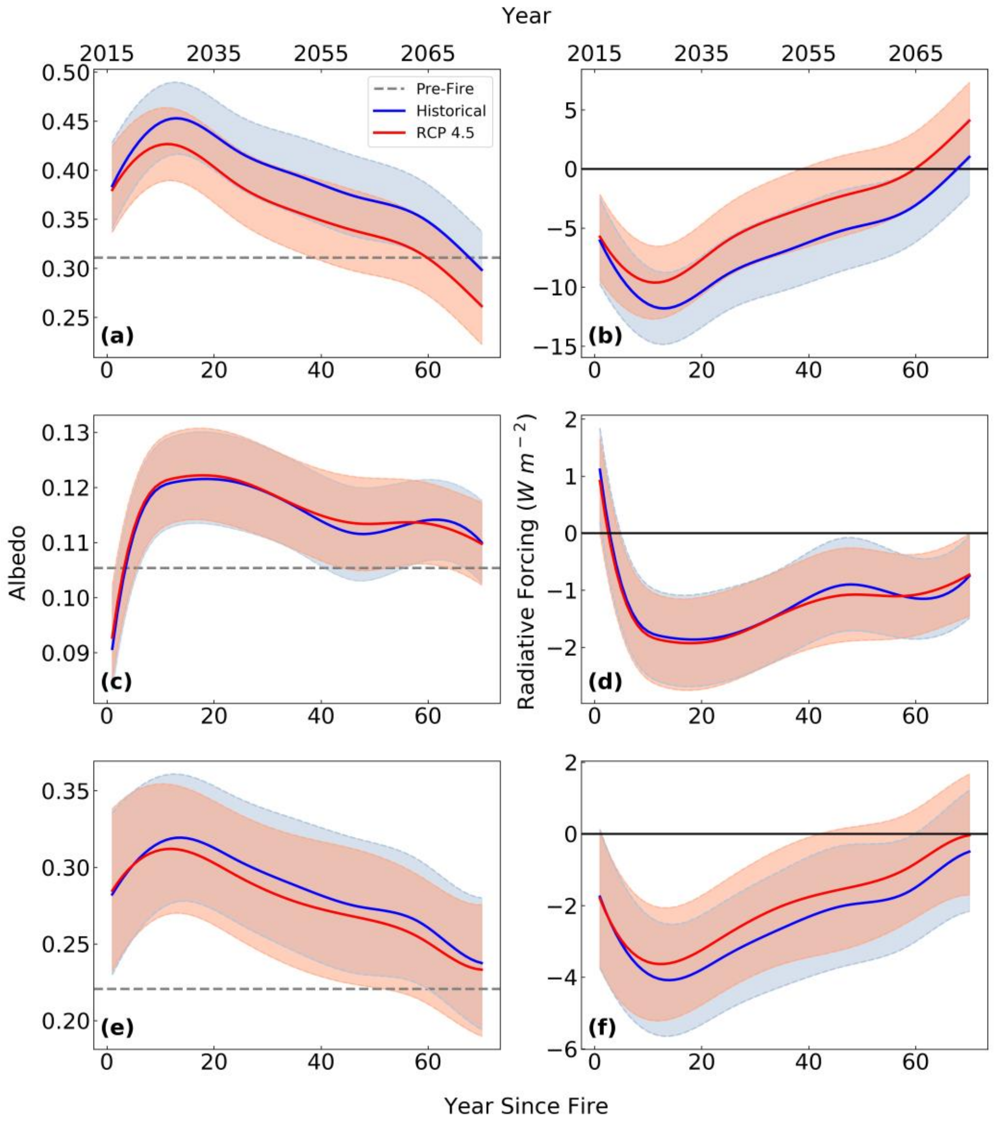
Future Climate Scenarios

- ClimateNA provided modeled climate variables under two future scenarios
  - RCP 4.5
  - RCP 8.5
- Each RCP centered around three different time periods
  - 2025 (2010 – 2039)
  - 2055 (2040 – 2069)
  - 2085 (2070 – 2099)

- 10,000 pixels which burned in the MODIS era were randomly selected and modeled 70 years post-fire using e.g. 2016 - 2085

Predicted Future Climate





Modeled trajectories of post-fire albedo (a, c, e) and radiative forcing (b, d, f) under a historical climate and RCP 4.5 April (a, b), July (c, d), and annual mean (e, f). Grey dotted line indicates pre-fire albedo for modeled pixels. Shading indicates the root mean square error from the cross validated test set.

4. Estimate how albedo driver radiative forcing may change under future climate scenarios (RCP 4.5 and 8.5)

Conclusions

1. In the summer soil properties are more important drivers of post-fire albedo while in the winter permafrost and temperature are
2. Under historical climate we estimate that fires generate an annual mean cooling of -2.53 +/- 1.61 W m^{-2}
3. Post-fire albedo increases from south to north wile solar radiation declined across the same gradient resulting in no distinct spatial patterns.
4. Climate change lead to notable increases in mean annual post-fire radiative forcing (warming effect)
4. Depending on scenario and uncertainty estimates, the cooling effect from post-fire albedo will be reduced by 20-38% due to seasonal effects of climate change

Additional Resources

ABoVE-Maintained ASC Website with setup instructions and useful links:

https://above.nasa.gov/sciencecloud.html

NCCS-Maintained ADAPT Website with FAQs:

https://www.nccs.nasa.gov/services/adapt/

Help Tickets: support@nccs.nasa.gov

https://www.nccs.nasa.gov/nccs-users/instructional/adapt-instructional

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Everything you need to know about using ADAPT:

- ADAPT's Virtual Machine Environment
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  - Software
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  - Instructional Video
  - Linux
  - Windows/Guacamole
- Tools
- Data Collections
- Shared Directories
- ABOVE users

Orthorectifying Imagery Using PGC Tools

https://www.nccs.nasa.gov/nccs-users/instructional/above-orhtorectify-digitalglobe

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// PARALLEL ORTHORECTIFICATION OF DIGITALGLOBE IMAGERY USING POLAR GEOSPATIAL CENTER TOOLS ON THE ABOVE SCIENCE CLOUD - LINUX ENVIRONMENT

OVERVIEW

High-resolution DigitalGlobe imagery is available on the ABoVE Science Cloud (ASC) for approved ABoVE Science Team members. Request access here. Most of the DigitalGlobe imagery on the ASC is Basic (1B) imagery. DigitalGlobe describes this type of imagery in this way:

> "**Basic (1B) Imagery** is the least processed of the Core Imagery product series and is corrected for radiometric distortions, internal sensor geometry, optical distortions, and sensor distortions. Basic Imagery is neither geo-referenced nor mapped to a cartographic projection. Basic Imagery is provided with sensor models and is intended for sophisticated photogrammetric processing such as orthorectification. Basic Imagery is a scene-based product."
>
> ~DigitalGlobe Core Imagery Product Guide

Depending on your use case, Basic (1B) imagery may require orthorectification in order to be used for location analysis. This guide describes the use of the Polar Geospatial Center's "Imagery Utils" to orthorectify these data.

Approval for Public Release of DG Data

- In 2017, the National Geospatial-Intelligence Agency (NGA) issued a policy for NextView-licensed imagery in coordinated public releases.
- You *must* get approval from NGA to publish that imagery (which is licensed under the NextView license) in publicly-accessible materials. Approval is required for, but not limited to:
  - Academic Journals (any access)
  - Posters and Presentations
  - Websites, Blogs, and Social Media
  - Any other format with public access

Announcements

- Success stories you would like to share? Email Liz Hoy elizabeth.hoy@nasa.gov
- How do I cite the ASC in my publications? Use language similar to:

“Resources supporting this work were provided by the NASA High-End Computing (HEC) Program through the NASA Center for Climate Simulation (NCCS) at Goddard Space Flight Center.”