Quantifying the Radiative Impact of Albedo Changes Following African Landscape Fires

LEVERHULME Centre for Wildfires, Environment and Society

Michaela Flegrova[1-4], Helen Brindley,[1,3]

[1]Imperial College London
[2]Leverhulme Centre for Wildfires, Environment and Society
[3]National Centre for Earth Observation
[4]King's College London

Imperial College London

King's College London

National Centre for Earth Observation
NATURAL ENVIRONMENT RESEARCH COUNCIL

1. Project Objectives & Motivation

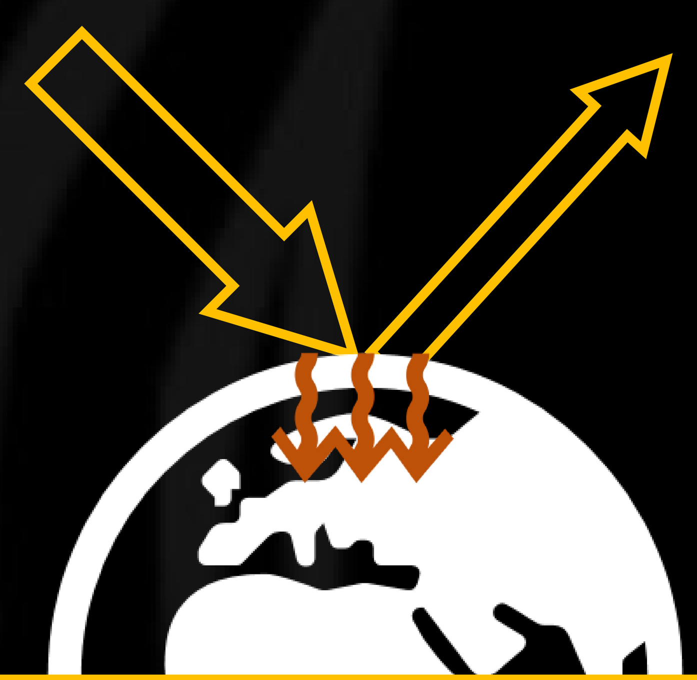
- PhD objective: Evaluate the effect of wildfires on surface radiation budget
  - a) Albedo changes (measure of heat in)
  - b) Emissivity changes (measure of heat out)
- Aim of this work: quantity & parametrise the fire effect on albedo, to help improve its representation in fire & climate models
  - Currently little/no consideration of surface changes following fires

2. Landscape Fires in Africa

- On average, 10% of land area in Africa burns every year, with burn locations typically experiencing fires every 2-6 years
- 70% of all landscape fires globally happen in Africa
- Strong annual and diurnal cycles

3. Albedo (α) and Fires

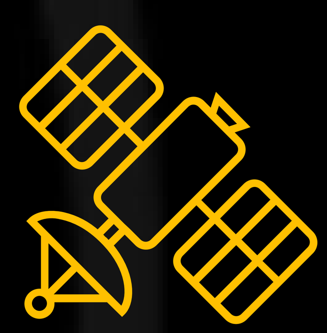
- Albedo: fraction of incoming radiation reflected from a surface
- Low albedo -> More radiation absorbed by surface -> More heat available at / near surface
- Ways fires affect albedo:
  1. Ash deposition & ground charring (darkening / albedo decrease)
  2. Removal of vegetation (brightening / albedo increase)



4. Remote Sensing Data Used

NASA's Moderate Resolution Imaging Spectroradiometer (MODIS)

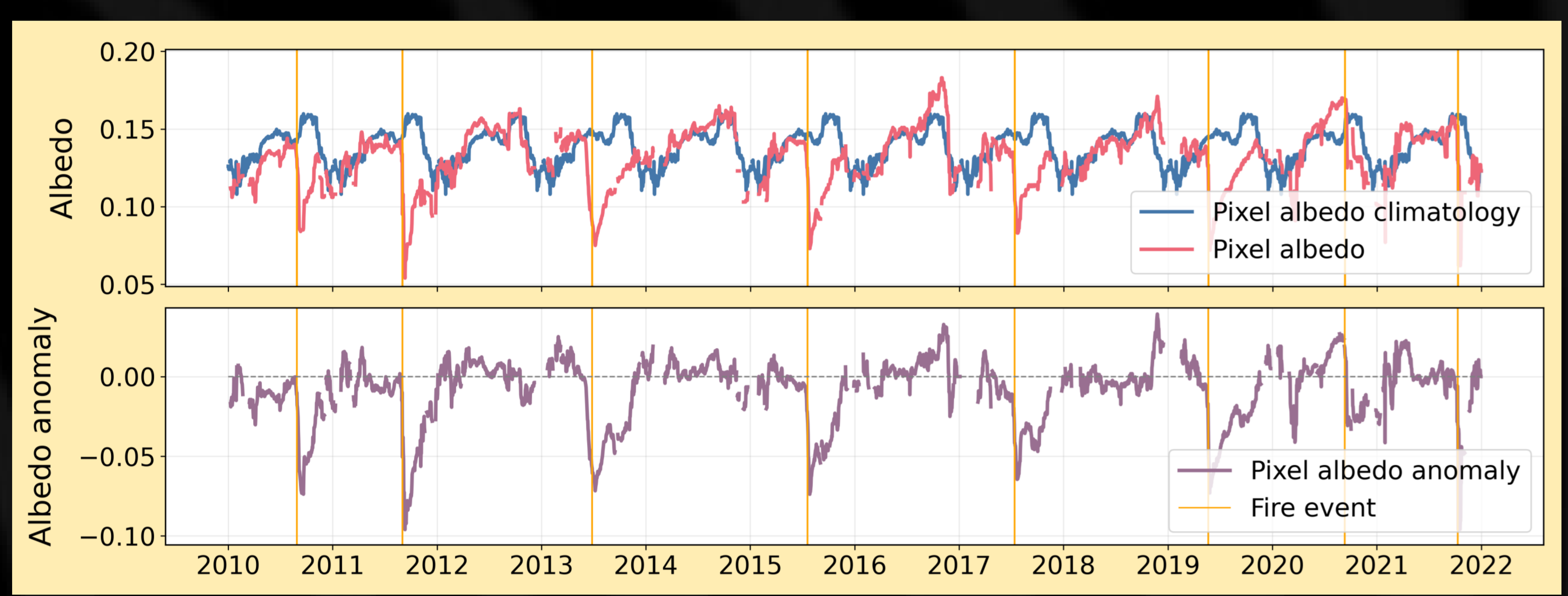
- MODIS Albedo (here: black sky albedo)
- MODIS Burned Area: all fires in 2001-2021
- MODIS Land Cover Type (IGBP classification)
  - Focusing on Savannas (46% of all fires), Grasslands (34%), Forests (7%) and Woody Savannas (6%)



5. Albedo Change: Method

Goal: isolate effects of fire on otherwise natural annual albedo cycle

1. Find "climatology" – expected annual cycle of albedo when not affected by fire, for each pixel in dataset
2. Identify fire events in each pixel
3. Calculate "Albedo anomaly": difference between pixel albedo values post-fire and pixel albedo climatology
4. Look at albedo 60 days before and 300 days after fire
5. Average over all pixels investigated



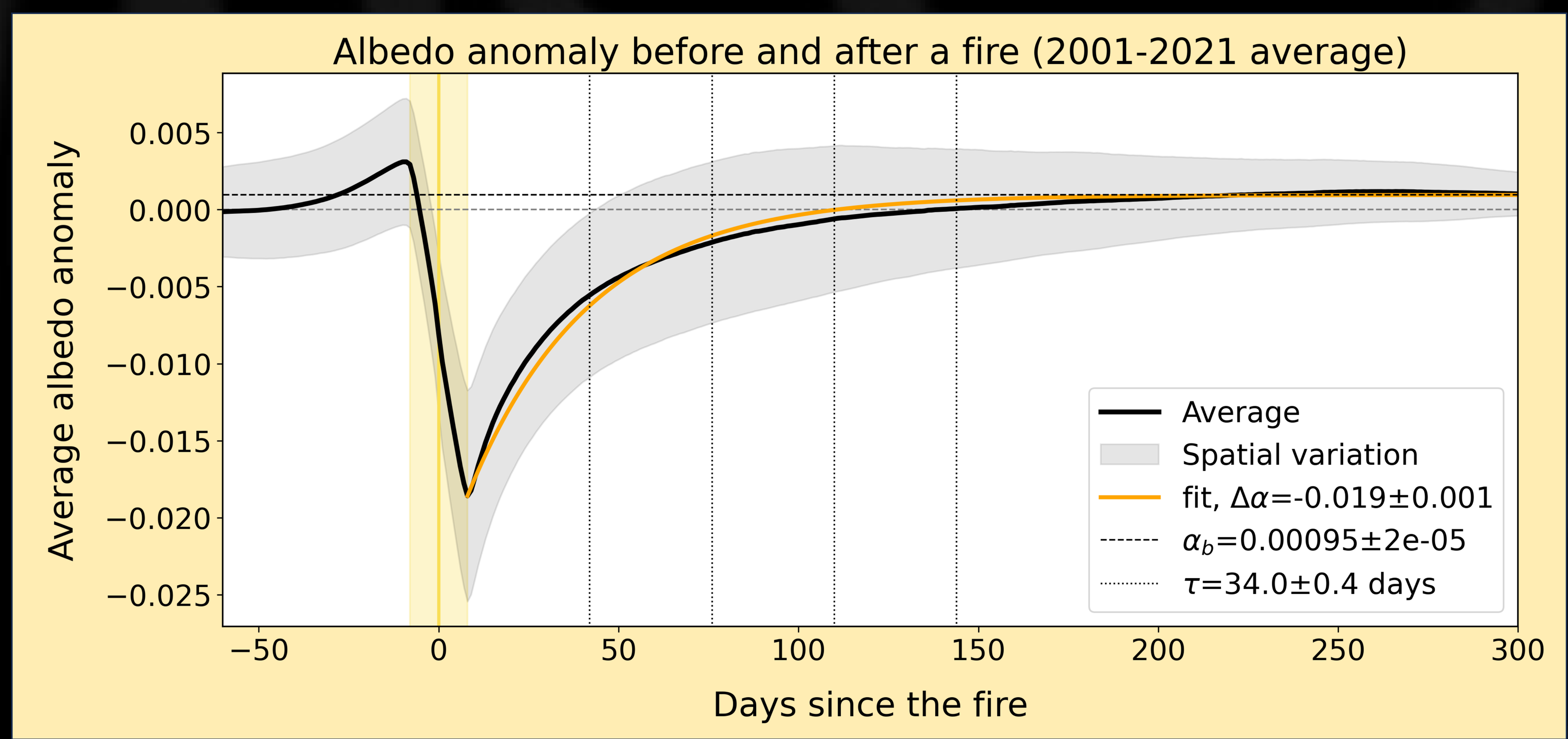
Find Out More

References

1. Giglio, L., Randerson, J. T. and van der Werf, G. R. (2013), 'Analysis of daily, monthly, and annual burned area using the fourth-generation global fire emissions database (gfed4)', Journal of geophysical research. Biogeosciences 118(1), 317–328.
2. Roberts, G., Wooster, M. J. and Lagoudakis, E. (2009), 'Annual and diurnal african biomass burning temporal dynamics', Biogeosciences 6(5), 849–866.
3. Teixeira, J., Folberth, G., O'Connor, F., Unger, N. and Voulgarakis, A. (2021), 'Coupling interactive fire with atmospheric composition and climate in the uk earth system model'

6. Results

- Analysis of 163 million fires between 2001 and 2021
- Key takeaways:
  - a) Albedo decreases immediately following a fire
  - b) Recovery follows exponential decay
  - c) Albedo "overshoots", ending on a higher-than-expected value
  - d) Significant spatial and temporal variations



- Albedo can be parametrised as:

$$\alpha(t) = (\Delta\alpha - \alpha_b) \times e^{-\frac{t}{\tau}} + \alpha_b$$

- $\Delta\alpha$ albedo anomaly (from climatology) at t=0, or 8 days after the fire
- τ recovery time constant (same units as t)
- α_b albedo brightening constant; a measure of the longer-term brightening (the value $\alpha(t)$ settles on towards the end of the observed period)