Spatiotemporal surface shortwave forcing from fire-induced albedo change in interior Alaska

AGU Fall Meeting, December 10, 2013, San Francisco, CA, USA

Presented by:
Dr. Shengli Huang
ASRC Federal USGS  Earth Resources Observation and Science (EROS) Center
Email: shuang@usgs.gov

U.S. Department of the Interior
U.S. Geological Survey
* Extensive fires in Alaska change the climate

* Fire impact on climate is determined by:
  a) albedo change
  b) greenhouse gas emission
  c) aerosol emission
  d) energy partitioning
  e) photosynthesis
  f) soil respiration

* Alaskan fires may cool climate over an 80-year fire cycle due to large effect of surface albedo (Randerson et al., 2006). The albedo effect can be quantified as:
  surface shortwave forcing = albedo change * solar radiation
How does fire-induced albedo change affect climate?

Surface becomes black for 1-2 years, albedo decreases $\rightarrow$ Warm Earth

There is a successional stage of deciduous vegetation, albedo increases $\rightarrow$ Cool Earth

More winter snow is exposed, albedo increases $\rightarrow$ Cool Earth
Challenges

- The conclusions of “boreal fires lead to climate cooling” came from a single fire event, but there are many fires in boreal fires.
- The surface shortwave forcing (SSF) of Alaskan fires is heterogeneous, but it is not well explored.

Questions

- What are the spatiotemporal patterns of surface shortwave forcing caused by fires in Alaska?
- What are their implications in climate change?
Overall Hypothesis
- Cooling and warming caused by boreal fires can co-exist on landscape
- The magnitude depends on local environmental factors

Surface Shortwave Forcing Hypothesis
- There is strong spatial and temporal variability in surface shortwave forcing

Objective
- Reveal the spatiotemporal surface shortwave forcing of Alaskan fires during 2001-2010 and its implication on climate change
Method of SSF modeling

Flowchart of surface shortwave forcing (SSF) due to fire-induced albedo change.

Results: spatial variation (1)

Monthly products
(Winter Feb 2010 shown in the figures)

- Albedo change ranging from -12.5% to 17.5%
- 77% increased (albedo change > 2.5%)
- 12% neutral (-2.5% < albedo change < 2.5%)
- 11% reduced (albedo change < -2.5%)
- Significant spatial variation of SSF: most positive SSF but negative SSF exists

* Most postfire albedo increases during snowy seasons
* Postfire albedo could decrease during snowy seasons
(see next slide for the magnified portion)
Findings

- “Postfire winter albedo reduced” was detected by our approach
- These areas (with albedo decrease) have thin or even no snow cover in winter

Possible Reasons

- Leaves were not burned
- Snow melts very fast
Results: temporal change

Surface Shortwave Forcing:
-1.30, -4.40, -3.31, -4.00, -3.42, and -2.47 W m$^{-2}$ from 2005 to 2010

* In early successional years, Surface shortwave forcing (SSF) is negative and the magnitude is large
  
  **Reason:** Winter albedo increase after 2005

* SSF may not be significant during the first postfire year
  
  **Reason:** Summer albedo decrease in 2005
Results: positive and negative SSF

Averages over 2005-2010 for 2004 fire scars

- Despite the dominance of negative SSF, about 16% of pixels had positive SSF
- These pixels are deciduous forests/shrubs, which can be identified from high-resolution aerial photos or land cover products

* SSF of boreal deciduous fires may be positive and contribute to climate warming
Findings and next steps

<table>
<thead>
<tr>
<th>Previous Findings</th>
<th>Our New Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postfire albedo increases in snowing seasons</td>
<td>Postfire albedo could decrease during snowy seasons</td>
</tr>
<tr>
<td>Surface shortwave forcing (SSF) is largely negative in early successional years</td>
<td>SSF may not be significant during the first postfire year</td>
</tr>
<tr>
<td>SSF of boreal fires over multiple decades is negative and contributes to climate cooling</td>
<td>SSF of boreal deciduous fires may be positive and contribute to climate warming</td>
</tr>
</tbody>
</table>

Next Steps

- SSF over a full fire cycle (e.g., 80 years in Alaska)
- Quantify all forcing agents to fully understand climatic impact
THANK YOU