Mitigating the Impact of Prescribed Burning in the Continental United States Using Trends in Synoptic Scale Transport to the Arctic Region

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Introduction (1 of 4)

- Arctic region warming at twice the rate of the rest of the planet (Zender, 2007)
- Arctic is susceptible to climate forcers (black carbon, carbon dioxide, methane)
- BC deposits on snow can alter the timing and quantity of annual snowmelt

Image source: NASA.

BC = black carbon

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Introduction (2 of 4)

- Emissions sources impacting the Arctic include fossil fuel combustion (70-90%) and biomass burning (up to 50% in peak years)
- Regulation of BC (and co-pollutants) suggested as short-term strategy to reduce warming because it has a short atmospheric lifetime (week or less) (Zender, 2007; Ramanathan, 2010)
- Implications for biomass burning that occurs in the United States—can we mitigate burning to benefit the Arctic region?

Image source: NASA.

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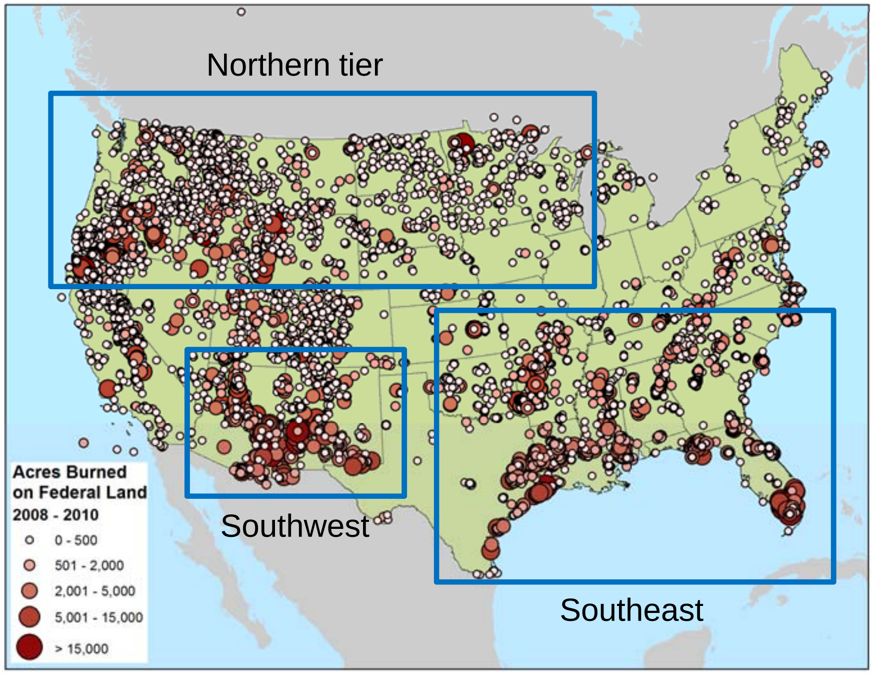
Introduction (3 of 4)

- Millions of acres of biomass burned in the United States each year
- Prescribed burning: intentional burning of forest, range, agricultural land
  - Utilized by agencies and private landowners
  - Primarily occurring in spring, fall, and winter



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Introduction (4 of 4)

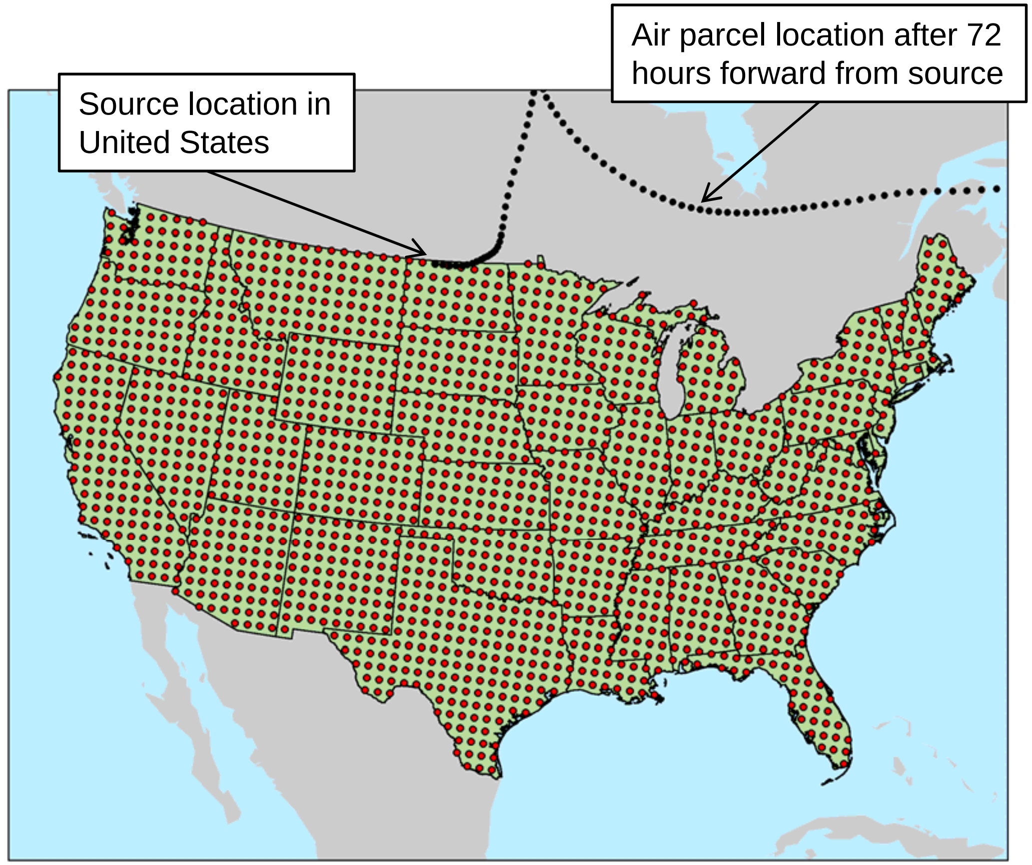
- Is modifying prescribed burning a useful mitigation strategy?
  - Need information on transport characteristics from the United States to the Arctic to inform policy decisions
- Conducted a transport analysis to investigate likelihood of transport from the United States to the Arctic Circle
  - Spatial
  - Temporal
  - Other (altitude, time to Arctic)

Methods (1 of 3)

- 30-year climatological trajectory analysis
  - Jan. 1979–Dec. 2009
  - Forward trajectories modeled from sources in the United States
  - NOAA's Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model
  - Two gridded meteorology data sets (NARR and NCAR/NCEP) that were nested for our domain

Methods (2 of 3)

- 1,926 source locations across the United States (every other NARR grid cell)
- Trajectories initialized every six hours (0000, 0600,1200,1800 UTC)
- Trajectories initialized at seven vertical levels (500, 1000, 1500, 2000, 2500, 3000, 5000 m agl)
- Modeled forward for 10 days



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Methods (3 of 3)

- Modeled nearly 600×10^6 individual trajectories
- Stored 1.4×10^{11} individual trajectory locations
- Developed a "trajectory system" to maximize multiprocessing computing platforms
- Developed a new data format to make data retrieval as efficient as possible (HYSPLIT's native ASCII storage format is an inefficient storage and retrieval mechanism)

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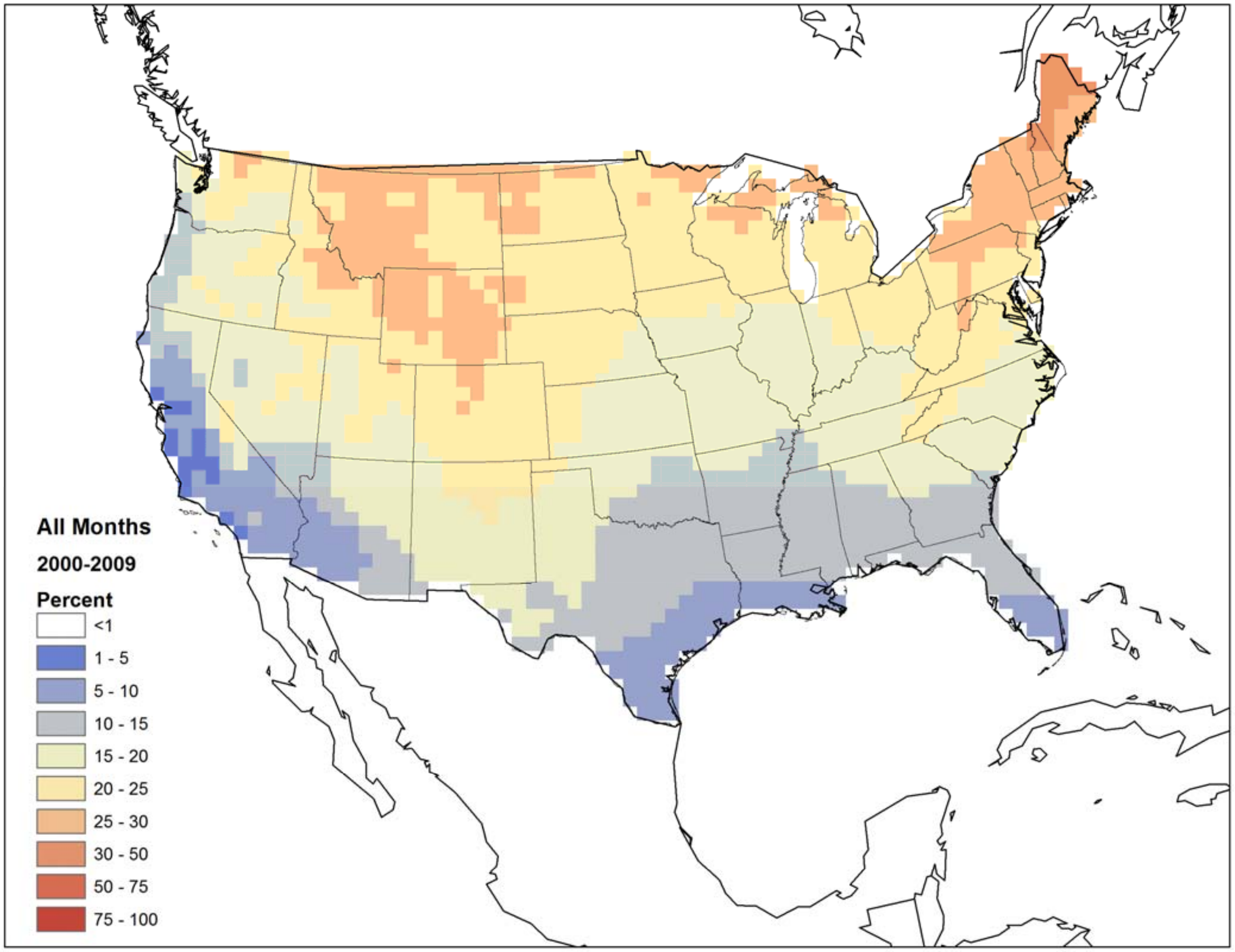
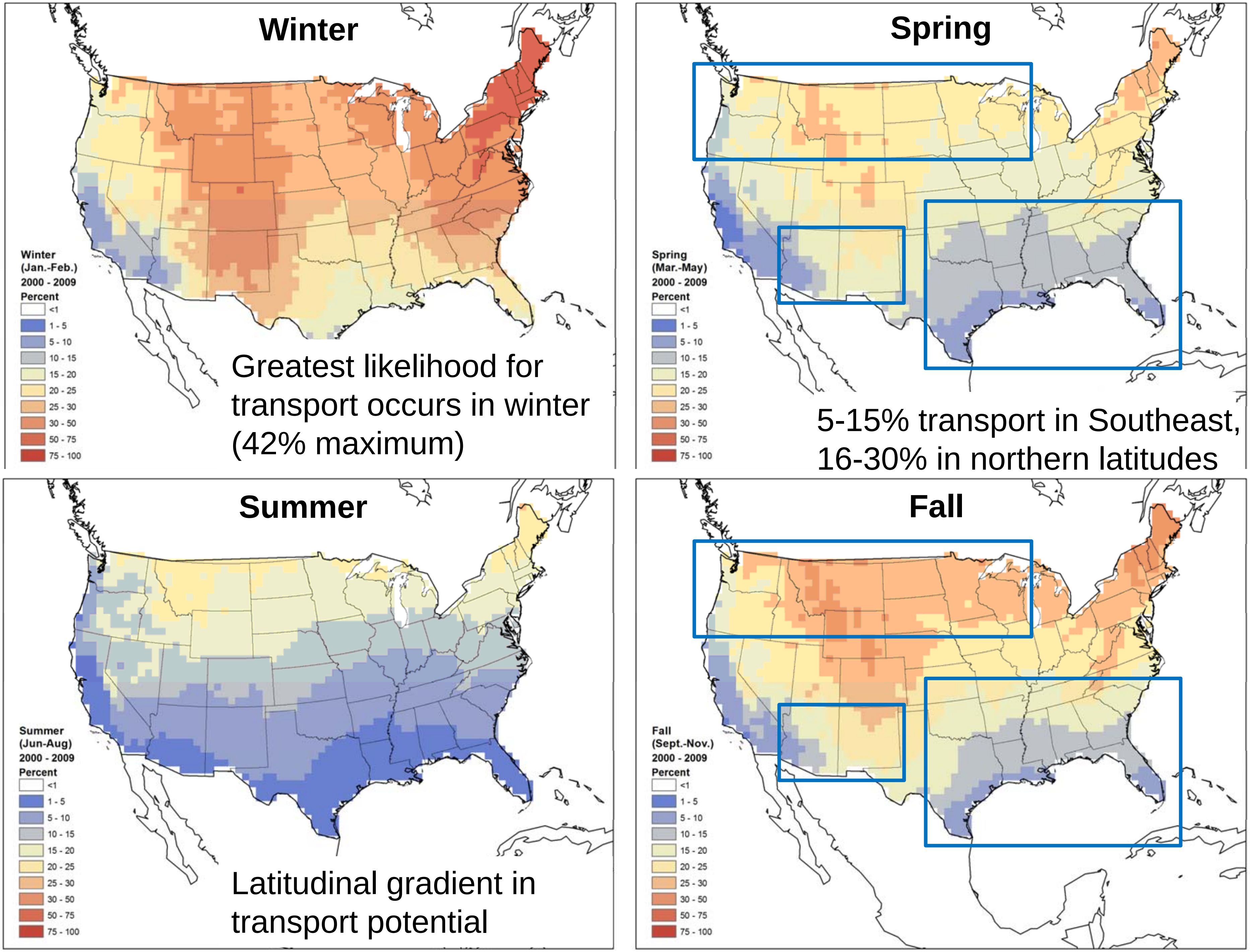
Results (1 of 4)

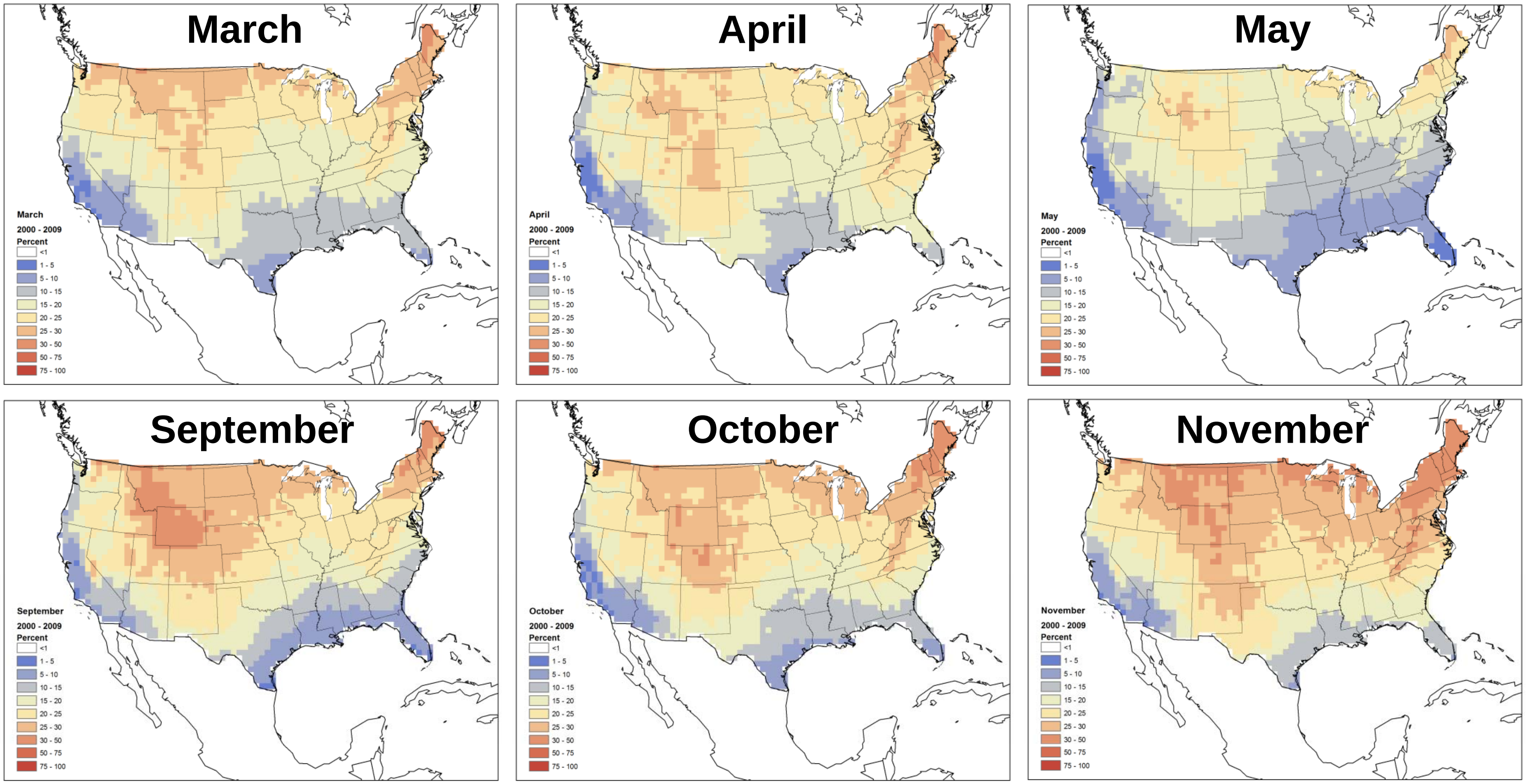
Fraction of trajectories that reach the Arctic (as a percent of possible trajectories) over the past ten years (2000-2009), at heights below 2,000 m agl, and in seven days or less.




Winter
Winter
(Jan.-Feb.)
2000 - 2009
Percent
<1
1 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 50
50 - 75
75 - 100
Greatest likelihood for transport occurs in winter (42% maximum)
Spring
Spring
(Mar.-May)
2000 - 2009
Percent
<1
1 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 50
50 - 75
75 - 100
5-15% transport in Southeast, 16-30% in northern latitudes
Summer
Summer
(Jun-Aug)
2000 - 2009
Percent
<1
1 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 50
50 - 75
75 - 100
Latitudinal gradient in transport potential
Fall
Fall
(Sept.-Nov.)
2000 - 2009
Percent
<1
1 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 50
50 - 75
75 - 100

Results:

Transport frequency more similar between fall and spring if May is excluded.



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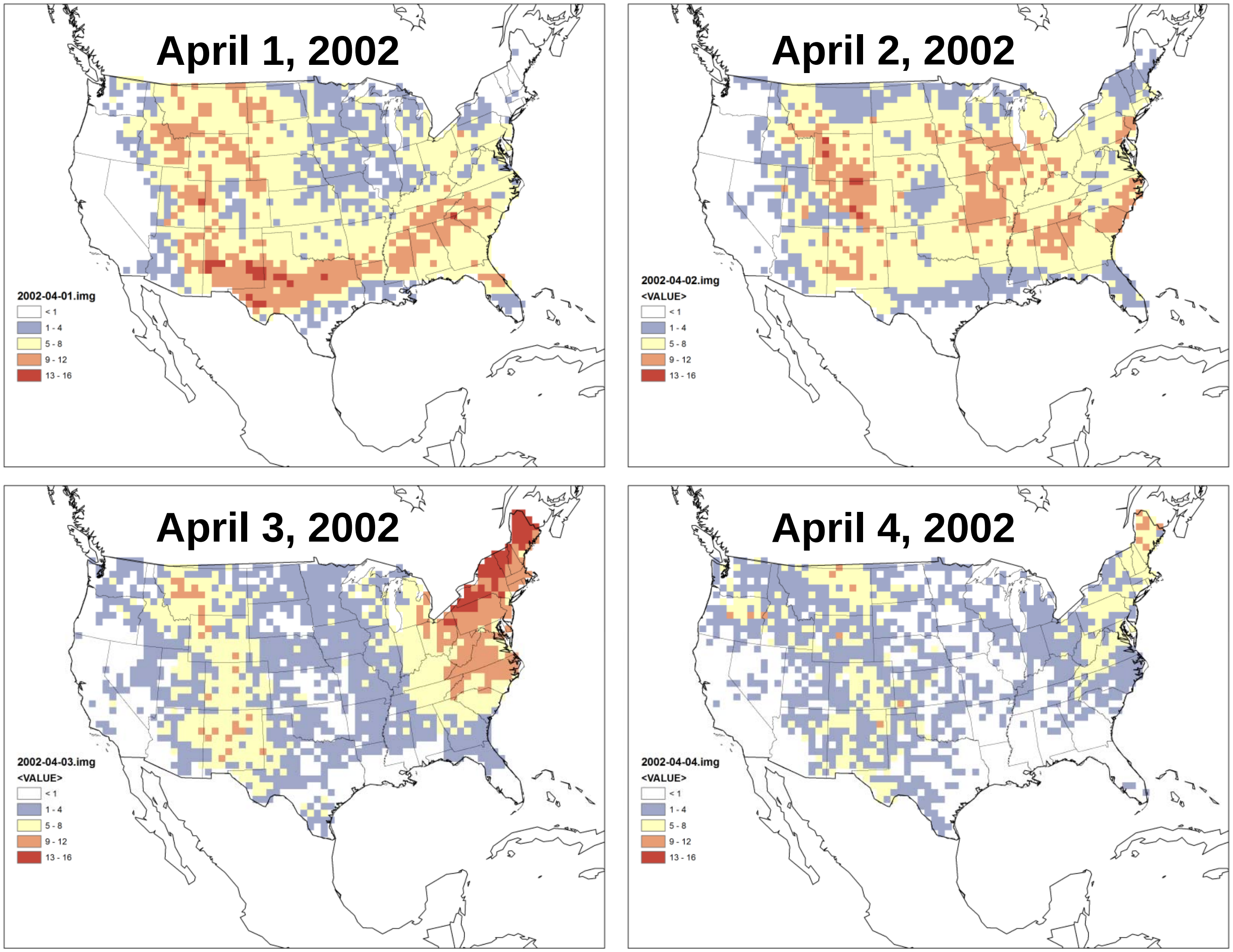
Results: Potential transport to the Arctic varies daily and by region.



Summary

- What is the likelihood of transport from the United States to the Arctic? How does this likelihood vary regionally?
  - *Transport is possible (up to 42% in winter) at altitudes typical of prescribed fire injection (< 2,000 meters)*
  - *Transport is more likely at northern latitudes (varies regionally)*
- Is transport more likely during certain seasons or months?
  - *Transport is more likely during spring, fall, and winter*
  - *Seasonal, monthly, and daily variability due to synoptic patterns*

Conclusion

- Is modifying prescribed burning a useful mitigation strategy?
  - *Restricting seasonal/monthly prescribed burning does not meet land management strategies*
  - *Arctic impact could occur during all seasons (consider sub-monthly time scales)*
- Impacts in the Arctic (of BC, gases from burning) could be reduced by:
  - *Burning in locations and during time periods when impact is lower (but must balance local/regional/Arctic impacts)*
  - *Using trajectory modeling to forecast days with higher/lower potential Arctic impact*

Further Applications

- Benefits of prescribed burn regulation need to be further assessed for certain months using meteorological and chemical modeling
- Robust climatological data set is available for assessing the potential impacts of emissions on sensitive regions (Arctic Circle)
  - Modeling domain spans the United States at 64 km resolution
  - Modeled at 7 altitudes and 4 times per day
  - 30 years of trajectory results

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