Understanding the Impact of Biomass Burning on Ozone Conditions in the Arctic

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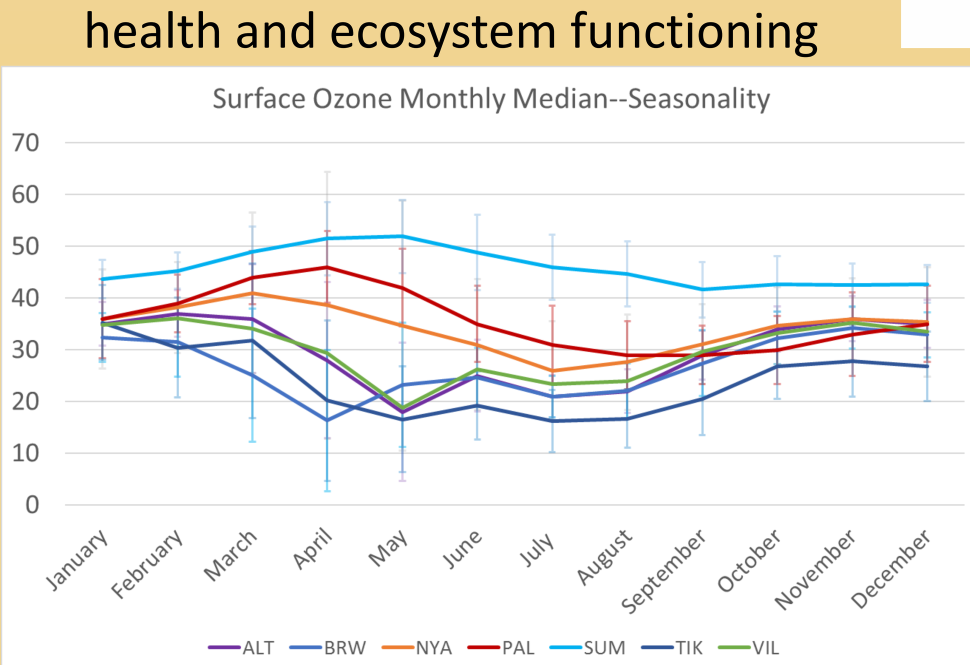
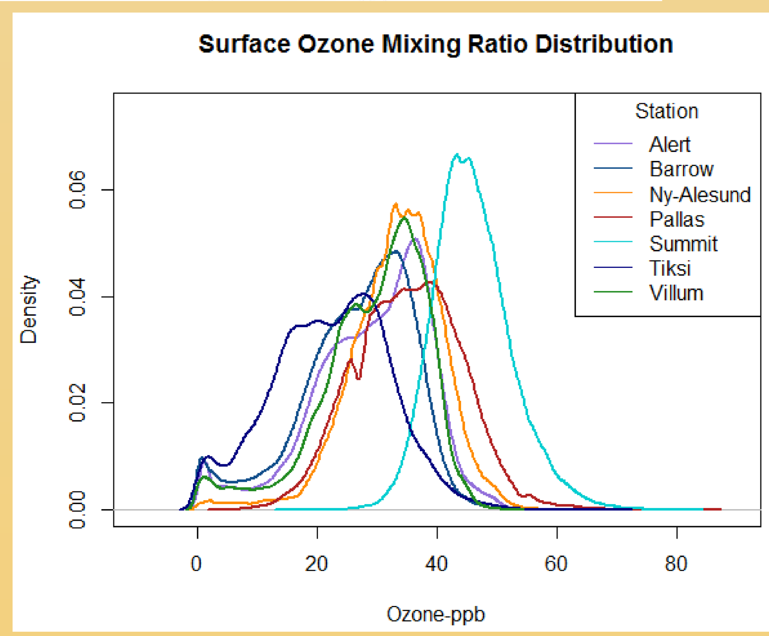
Ozone in the Arctic

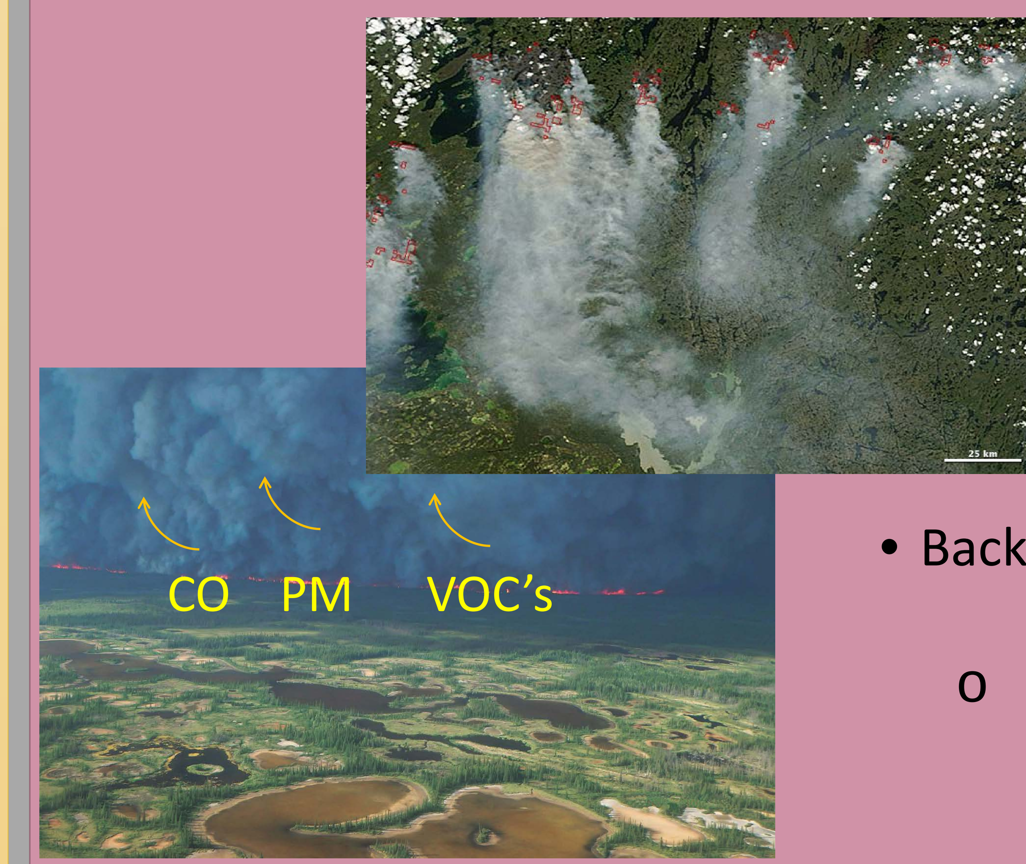
Ozone in the Arctic

- Central species in the photochemical oxidation and radiative forcing processes of the atmosphere
- Secondary Pollutant, formed from reactions of primary pollutants
  - Photochemical Smog
  - Greenhouse Gas
- High levels negatively impact human health and ecosystem functioning





Ozone and Biomass Burning



How are Episodes Identified?

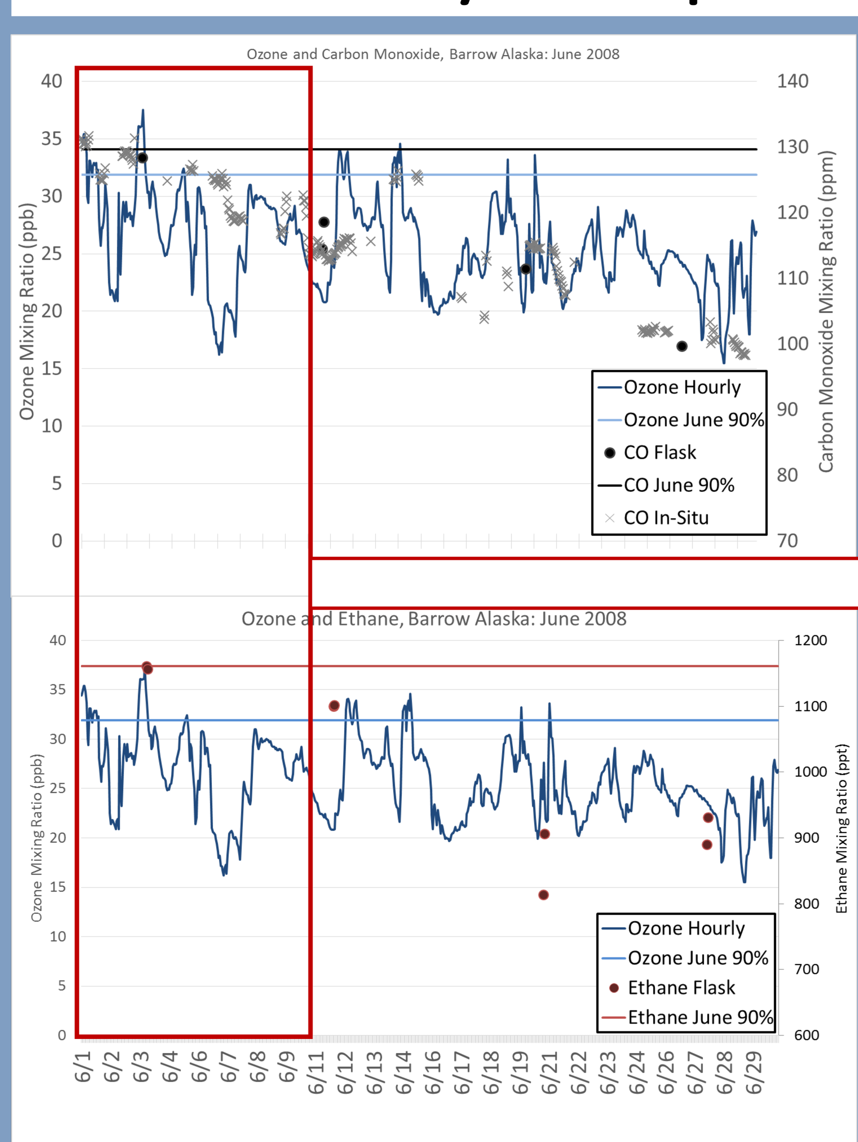
- Co-Located Measurements
  - Carbon Monoxide
  - Acetylene
  - Ethane
- Aerosol Properties
- Satellite Imagery
- Back-Trajectory Analysis (NOAA ARL Hysplit)
- Models
  - NCAR Community Earth System Model
  - MERRA, FINN, MEGAN 2.0

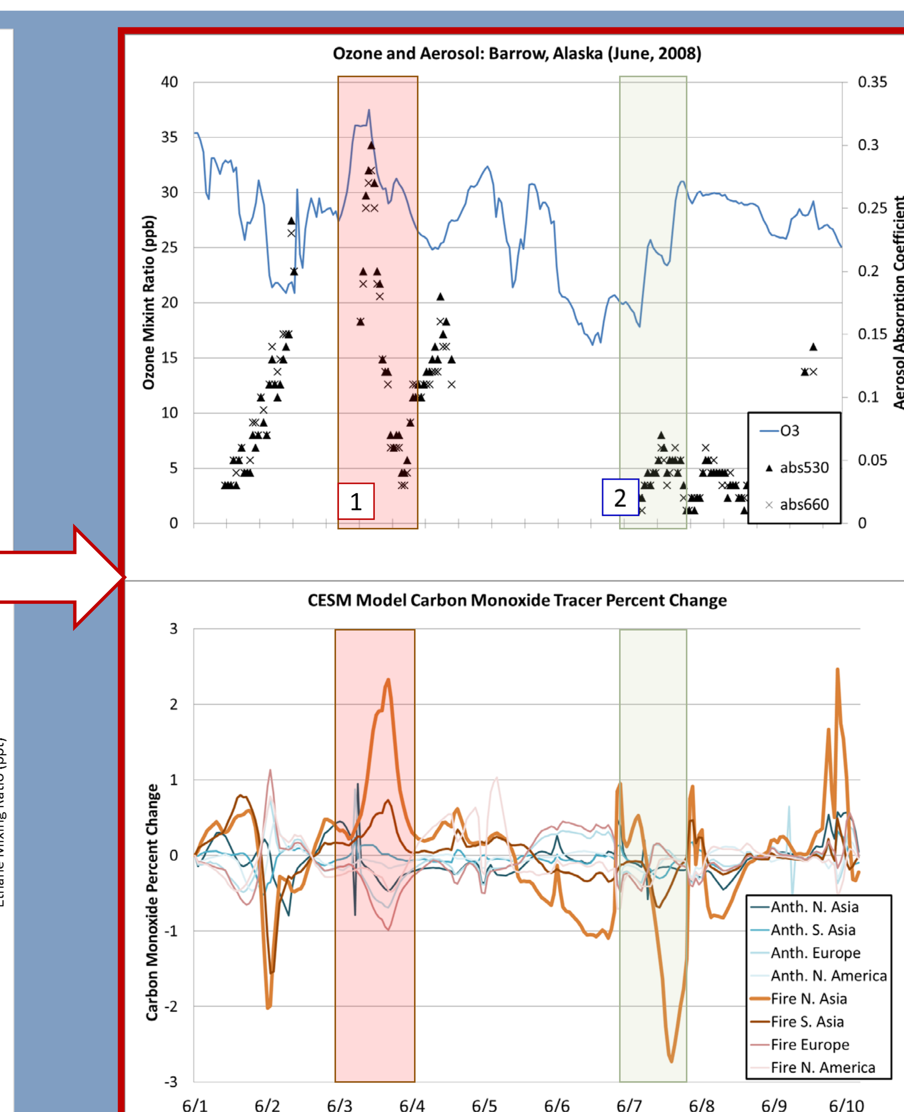
Biomass Burning and Ozone

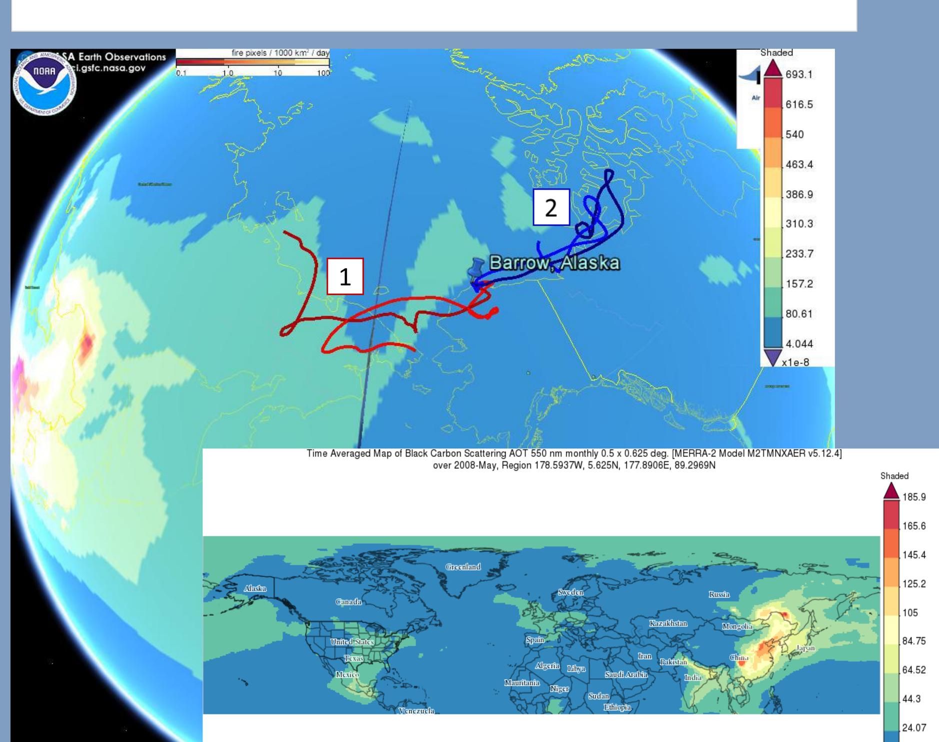
- Biomass burning releases a suite of compounds into the atmosphere—many of which are ozone precursor pollutants *(Andrae and Merlet, 2001)*
- Fire Emissions are different for each fire and stage of the fire
- Climate patters impact biomass burning and transport of pollutants to the arctic.

(Eckhardt et. al, 2003 and Stohl et. al, 2007)

Case Study #1: Episode Identification Methods

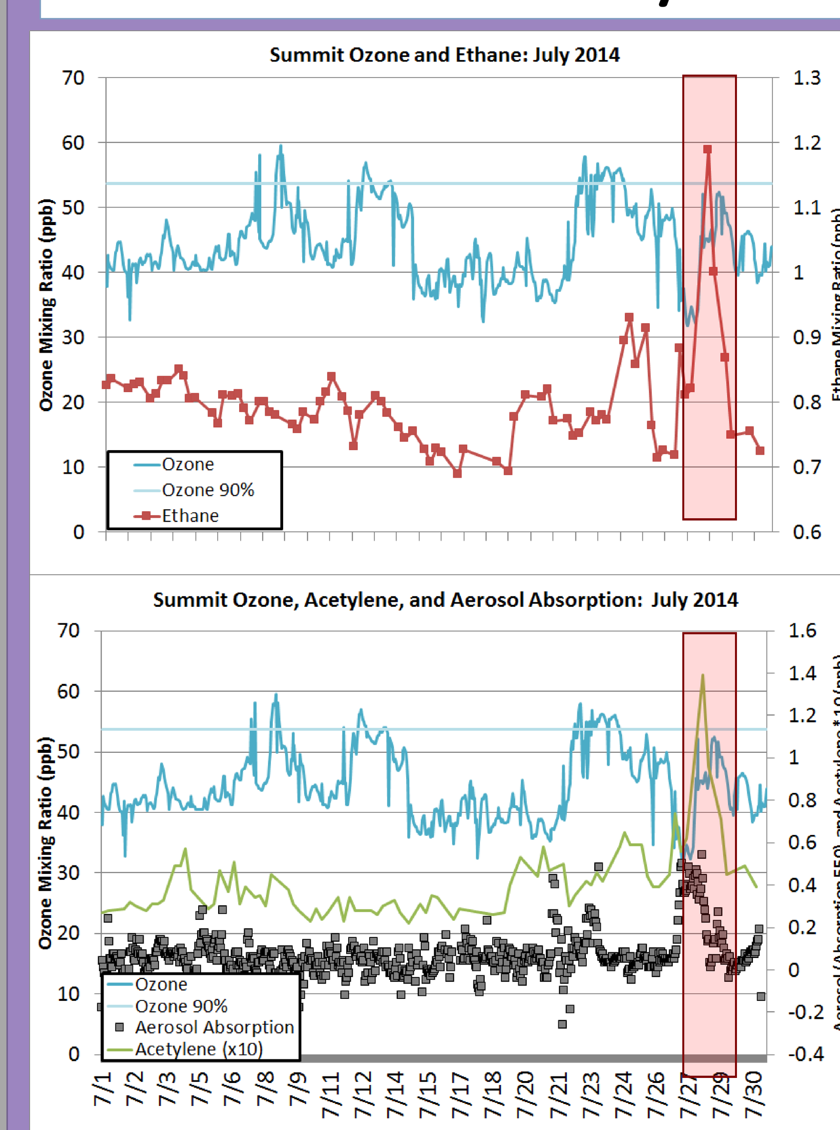


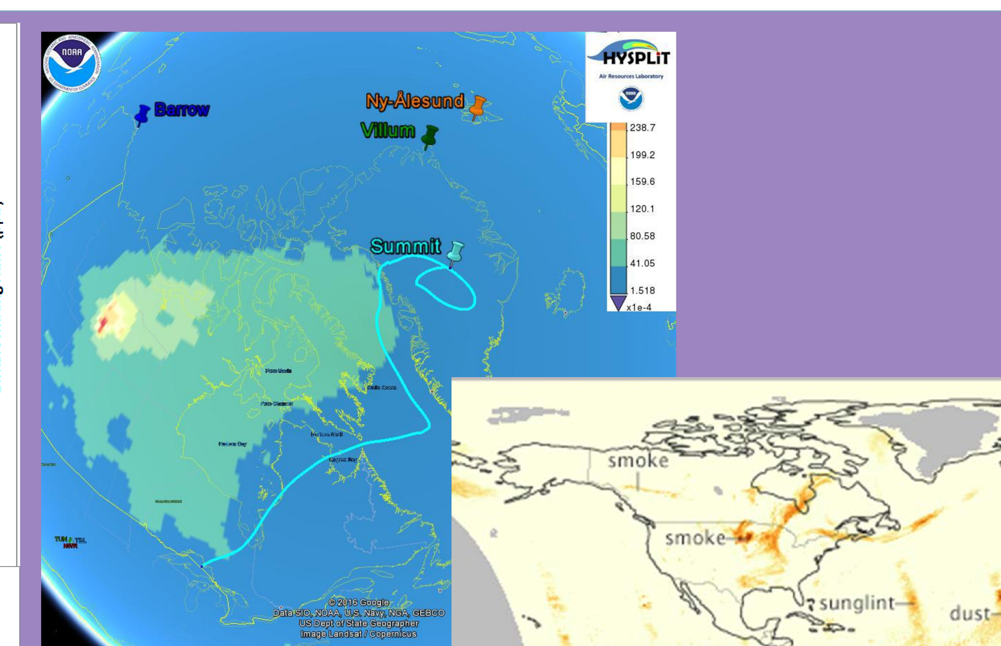




Co-located measurements of Carbon Monoxide, Ethane, and Aerosol Absorption help to distinguish influences on ground-level ozone conditions. These species are elevated at the same time as the enhanced ozone episode which indicates influence from biomass burning. The NCAR CESM Carbon Monoxide Tracers reveal a dominant source of carbon monoxide from fires in North and South Asia. MERRA-2 black carbon over lay and NOAA HYSPLIT Back-Trajectory analysis provide a visualization of what has been detected in the model results. The air mass was likely influenced by biomass burning in Asia.

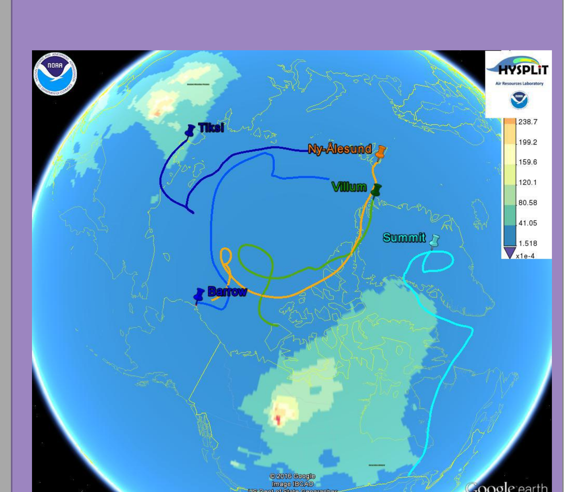
Case Study #2: Long Range Transport

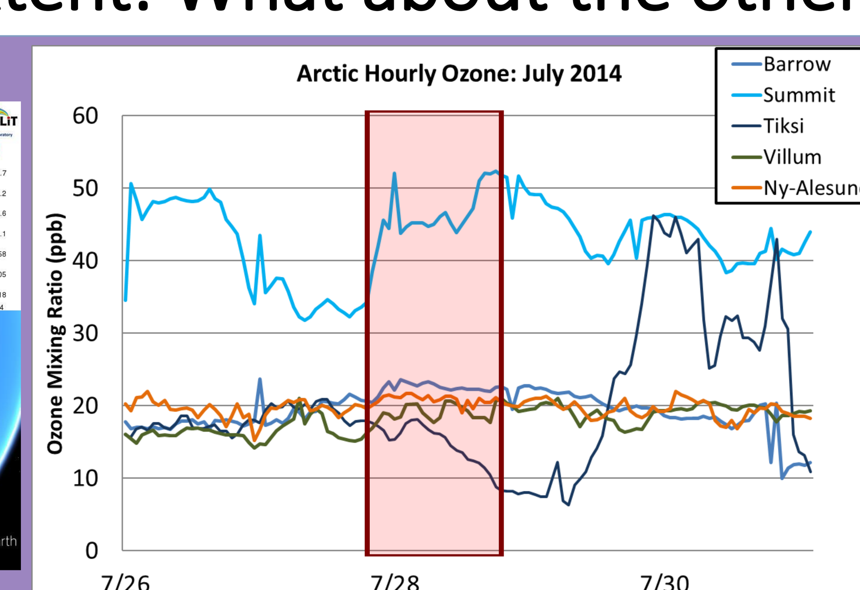




High ozone which was influenced by biomass burning pollutants was detected at Summit Greenland on July 28, 2014. The co-location and coincident elevation of Ethane, Acetylene, and Aerosol Absorption as well as the back trajectory analysis indicates that the air mass sampled at the station interfered with and was impacted by a biomass burning smoke plume which originated from fires in North America.

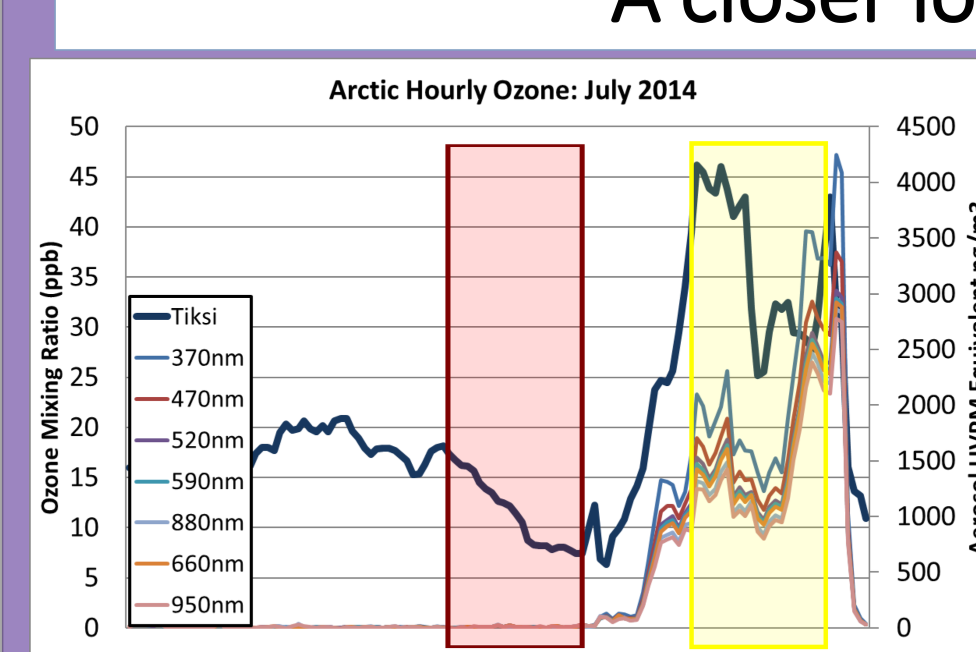
Spatial Extent: What about the other Stations?

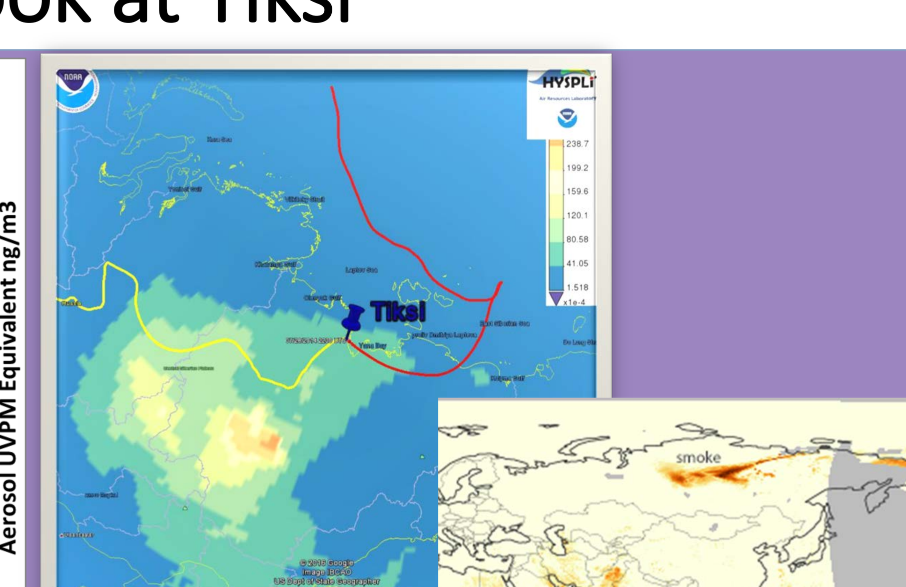


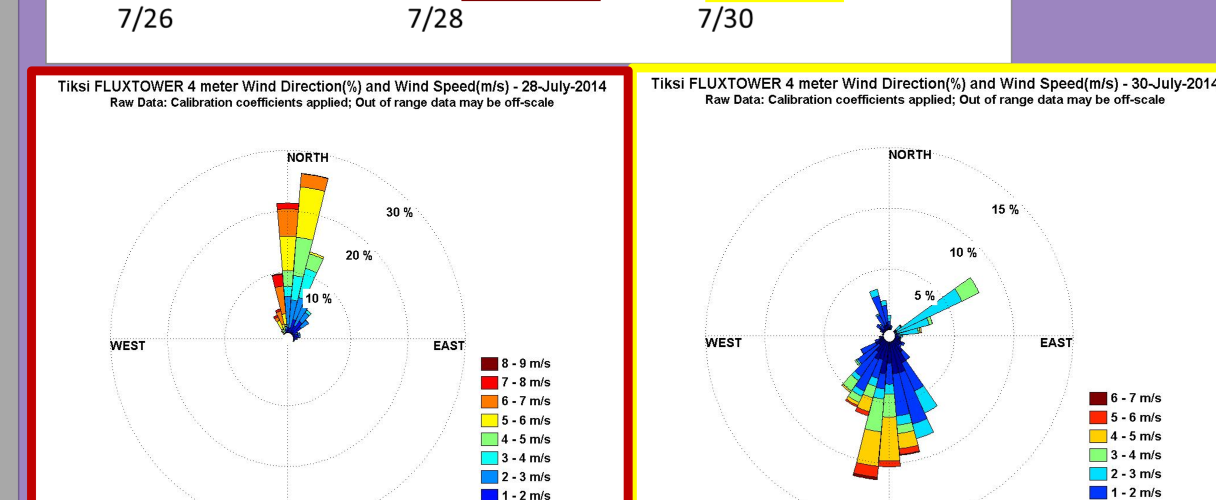


4 Arctic surface ozone measurement locations were measuring ozone at this time, they did not observe elevated ozone during the time when Summit observed the biomass burning influenced air mass. HYSPLIT Back Trajectories with MERRA 2 Black Carbon overlay provides a visualization of how the other stations in the arctic observed different conditions than the air mass measured at Summit Station.

A closer look at Tiksi







During the time period where Summit was observing elevated ozone, Tiksi remained relatively "clean". However, the next day, Tiksi observed high ozone- that was related to a different biomass burning plume. Wind direction data collected at 4 meters shows how the source region and meteorological conditions differ.

Conclusions

- Co-located measurements of VOC's, Meteorology, Aerosols, and model results are essential for determining the impact of biomass burning on ozone conditions
- Biomass burning episodes are variable in space and time, generalized (ex. Monthly) studies are often not sufficient to identify the influence

Future Research

- Apply the methods defined to investigate long term variation in frequency of biomass burning related high ozone events for each station
- Spatial analysis including all arctic ozone measurement sites
- Long-Term research:
  - Given the Arctic is warming at a rate faster than the rest of the world, How are circulation and transport patterns to the arctic impacted?
  - What are the implications of climate change on biomass burning (fuel, emissions, length, size) in the Arctic?

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NOAA HYSPLIT: Reanalysis