Seasonality and Trends of Non-Methane Hydrocarbons and Long-Range Transport at Summit, Greenland

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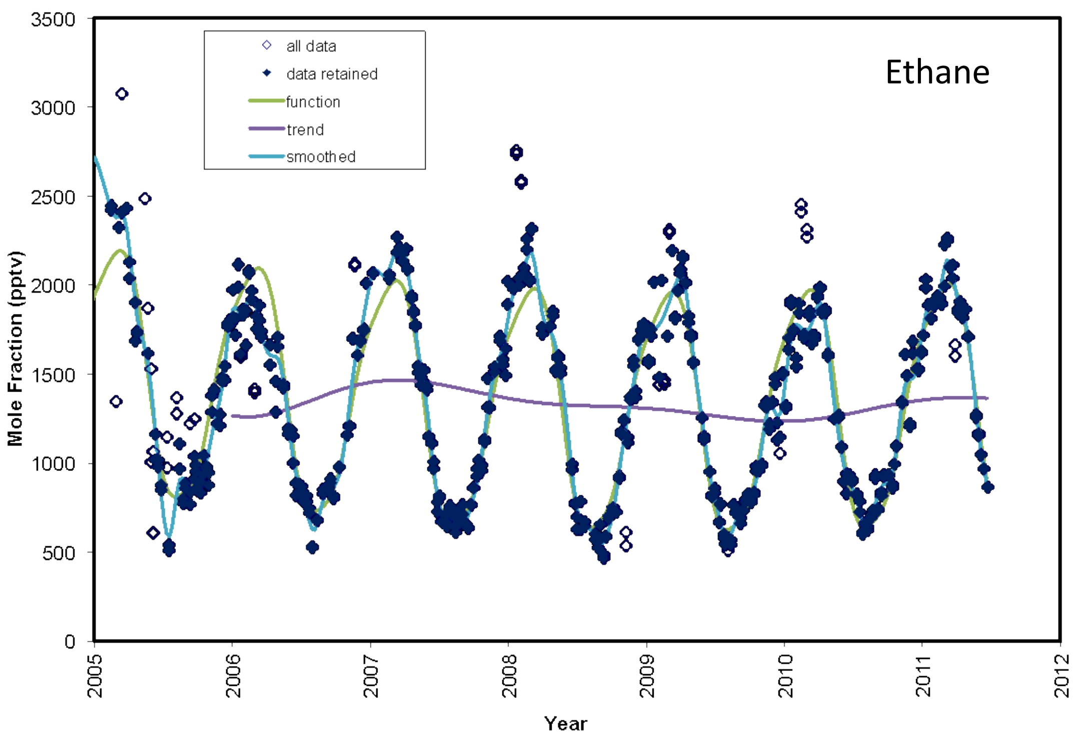
Summit, Greenland

72°34′46.50″N 38°27′33.07″W

Long-Term NMHC Monitoring at Summit

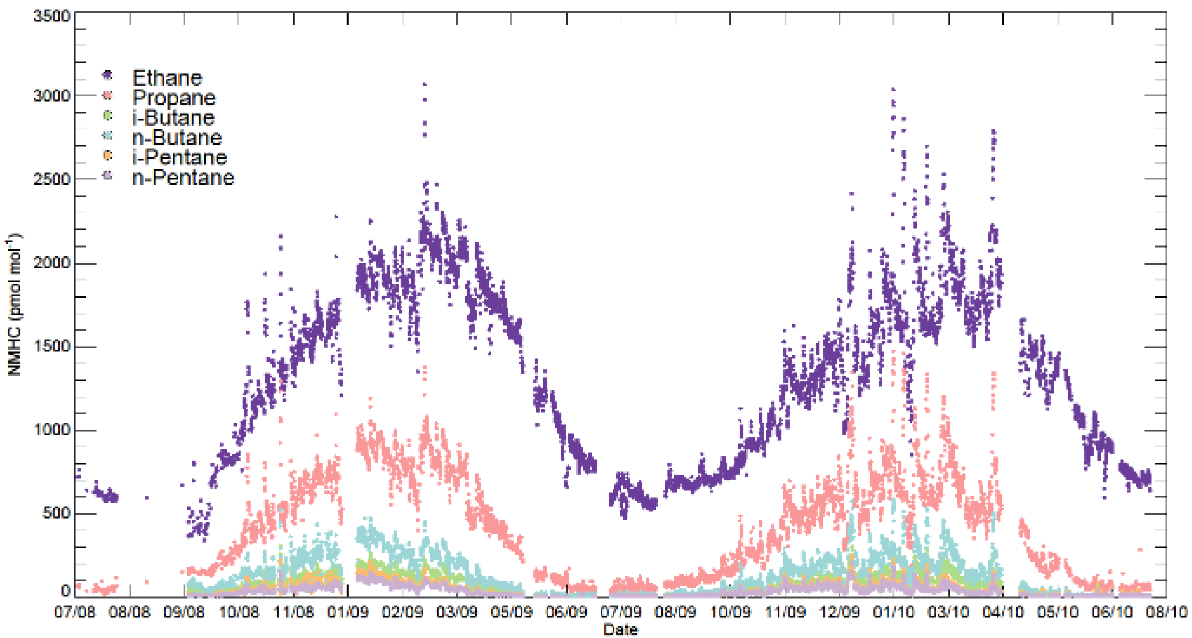
- Whole-air flask sampling as part of NOAA Cooperative Air Sampling Network with NMHC analysis since 2005



Helmig et al., 2013

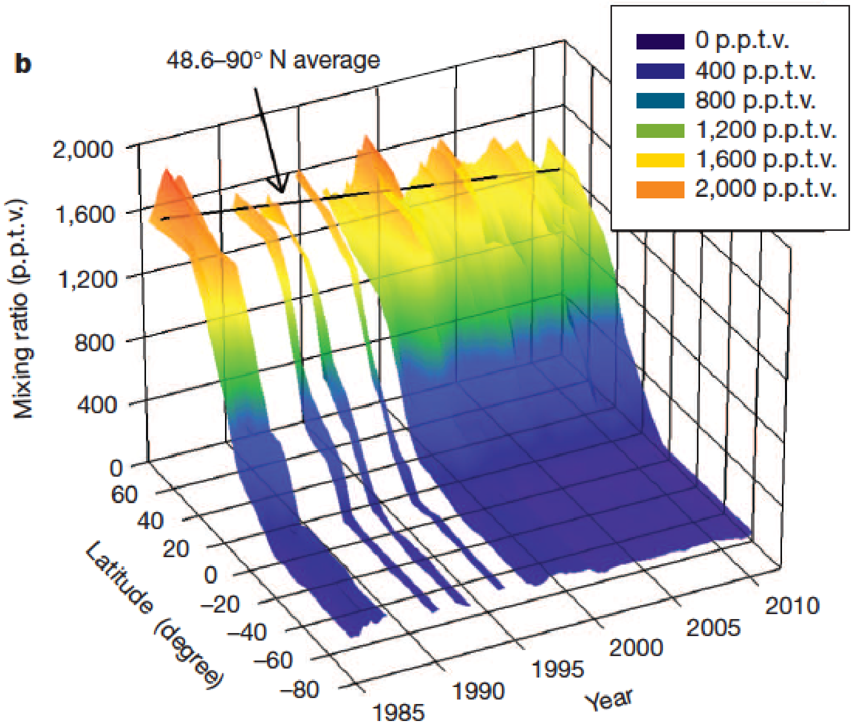
Long-Term NMHC Monitoring at Summit

- Continuous GC-FID measurements of C2-C5 NMHC and benzene from 2008-2010 (NASA)
- Continuous monitoring resumed in 2012 and is ongoing with addition of methane detection (NSF AON)
- Summit is one of only 4 stations with continuous background ethane measurements (Cape Verde, Hohenpeissenberg, Jungfraujoch)

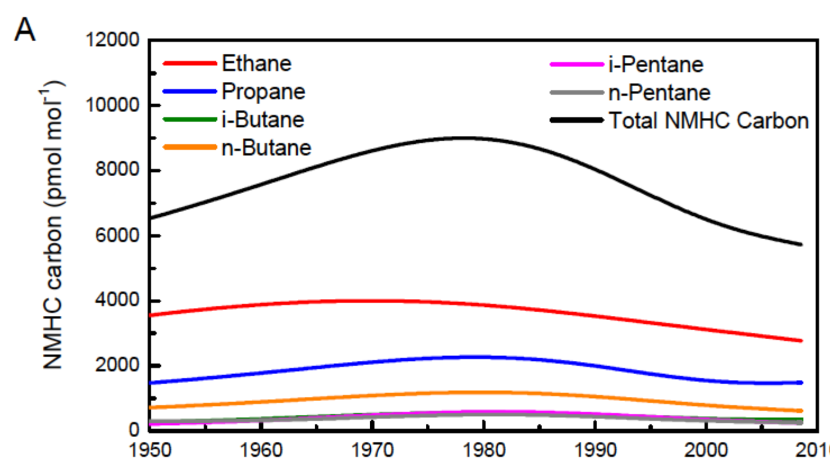


Trends in the Light Alkanes

- Recent studies have shown decreasing ethane trends in the Arctic and inferred decreasing anthropogenic emissions since ~1980s



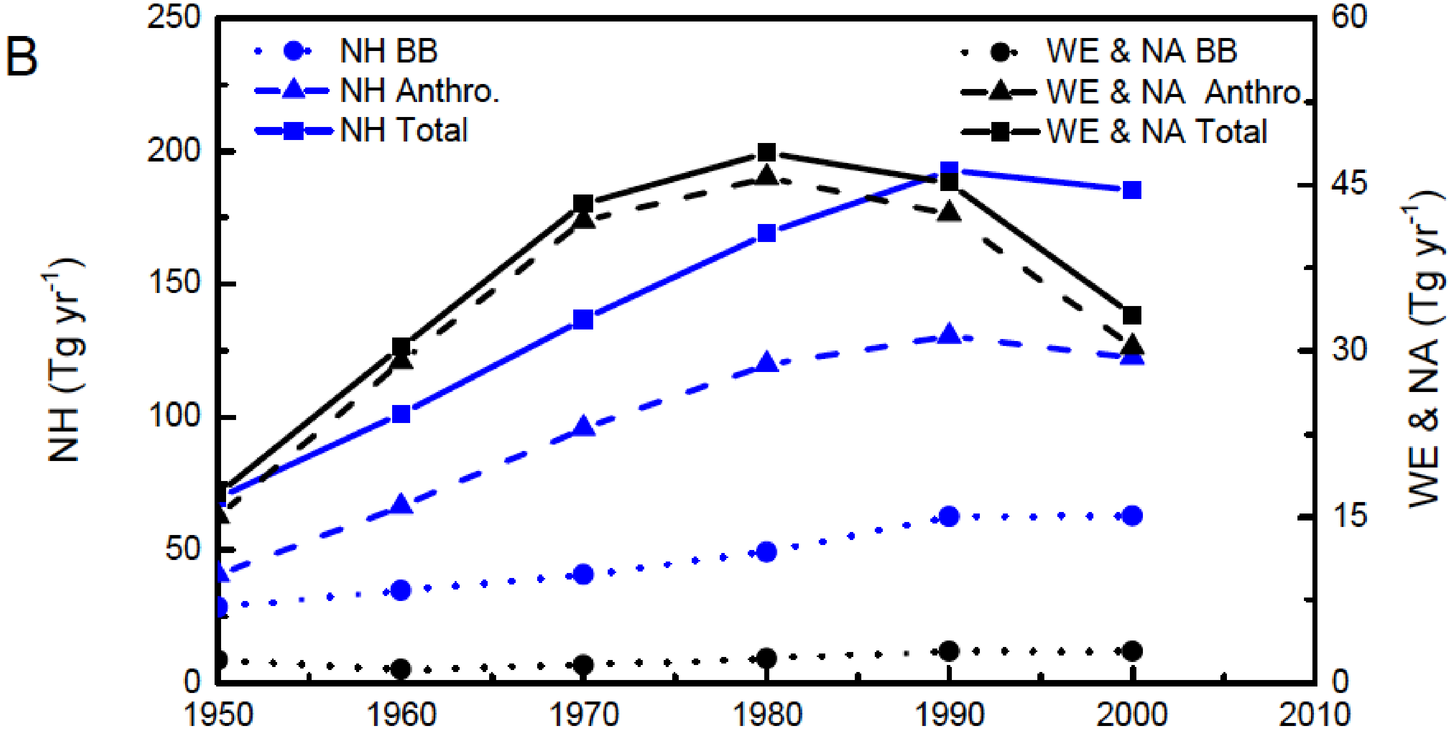
Simpson et al., 2012



Helmig et al., 2013

Trends in the Light Alkanes

Declining trends in light NMHC since 1980's is consistent with decreases in anthropogenic emissions in Western Europe and North America



Helmig et al., 2013

Trends in the Light Alkanes

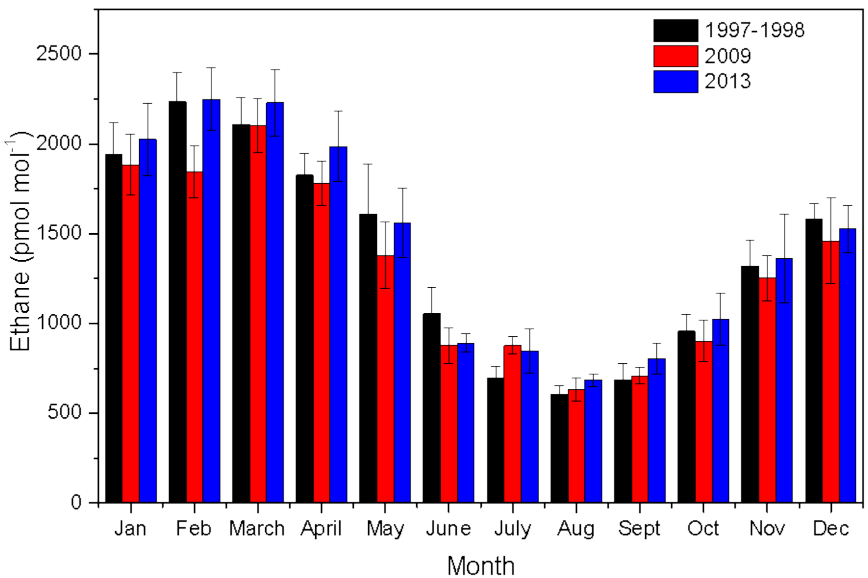
	1985–2000 reconstruction			2006–2011 ambient		Aydin et al. (2011)[a]	Simpson et al. (2012)[b]	Worton et al. (2012)[c]
	max (year)	$pmol\,mol^{-1}\,yr^{-1}$	% of max yr^{-1}	$pmol\,mol^{-1}\,yr^{-1}$	% of max yr^{-1}	$pmol\,mol^{-1}\,yr^{-1}$	$pmol\,mol^{-1}\,yr^{-1}$	$pmol\,mol^{-1}\,yr^{-1}$
Ethane	2000 (1979)	−20	1.0	−34 (±11)	1.7 (±0.6)	−25	−12.4 (±1.3)[b]	−47
Propane	764 (1980)	−17	2.2	−8.2 (±7.8)	1.1 (±1.0)			−17
i-Butane	142 (1980)	−2.9	2.0	−2.5 (±2.4)	1.8 (±1.7)			−3.8
n-Butane	296 (1980)	−6.3	2.1	−6.7 (±2.9)	2.3 (±1.0)			−8.0
i-Pentane	118 (1981)	−3.2	2.7	−5.8 (±1.3)	4.9 (±1.1)			−3.1
n-Pentane	101 (1981)	−2.5	2.5	−1.6 (±1.5)	1.6 (±1.5)			−2.8

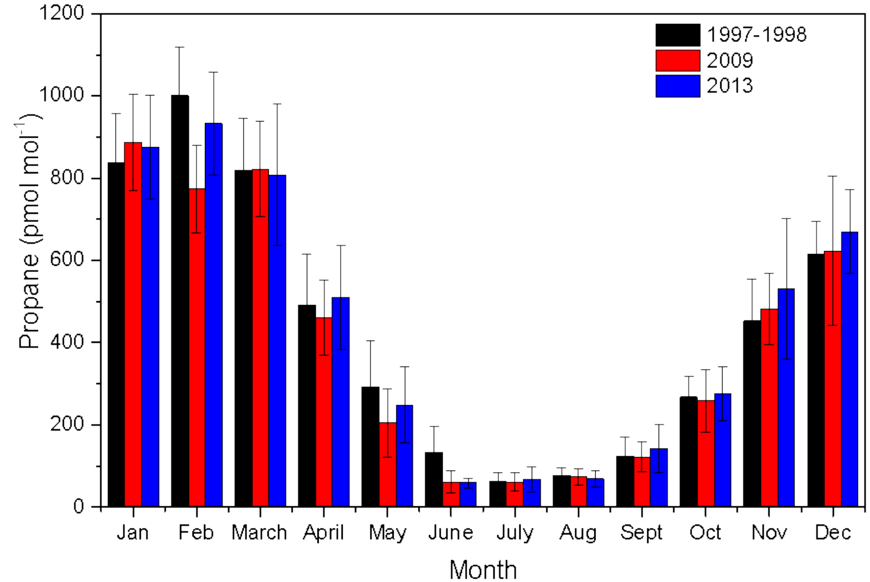
[a] 1980–2000; [b] 1984–2010; [c] 1985–2000, rates deduced from the graphs in Fig. 2 in Worton et al. (2012).

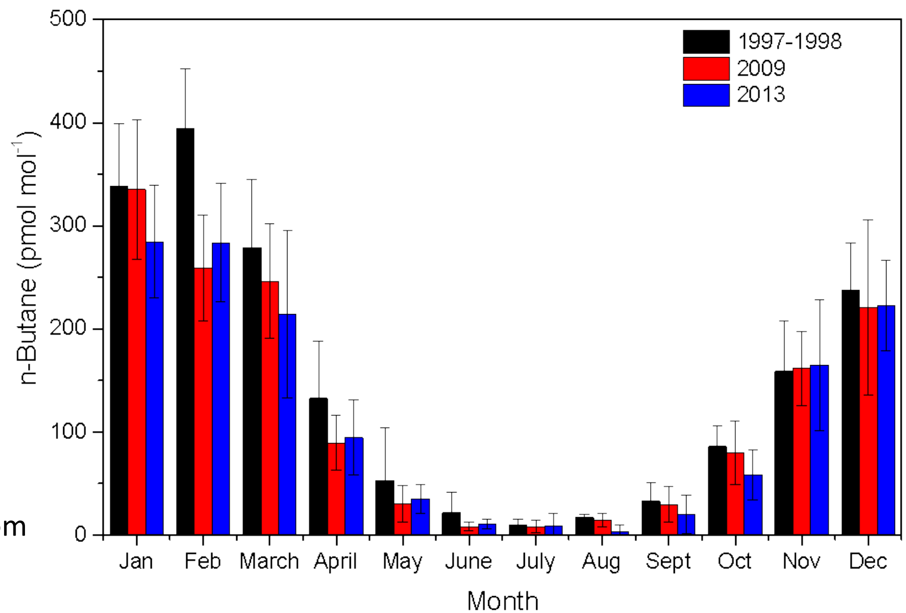
Helmig et al., 2013

- Some theorize that increased production of natural gas, especially in North America, may lead to reversal of the ethane trend in upcoming years.

Trends in the Light Alkanes





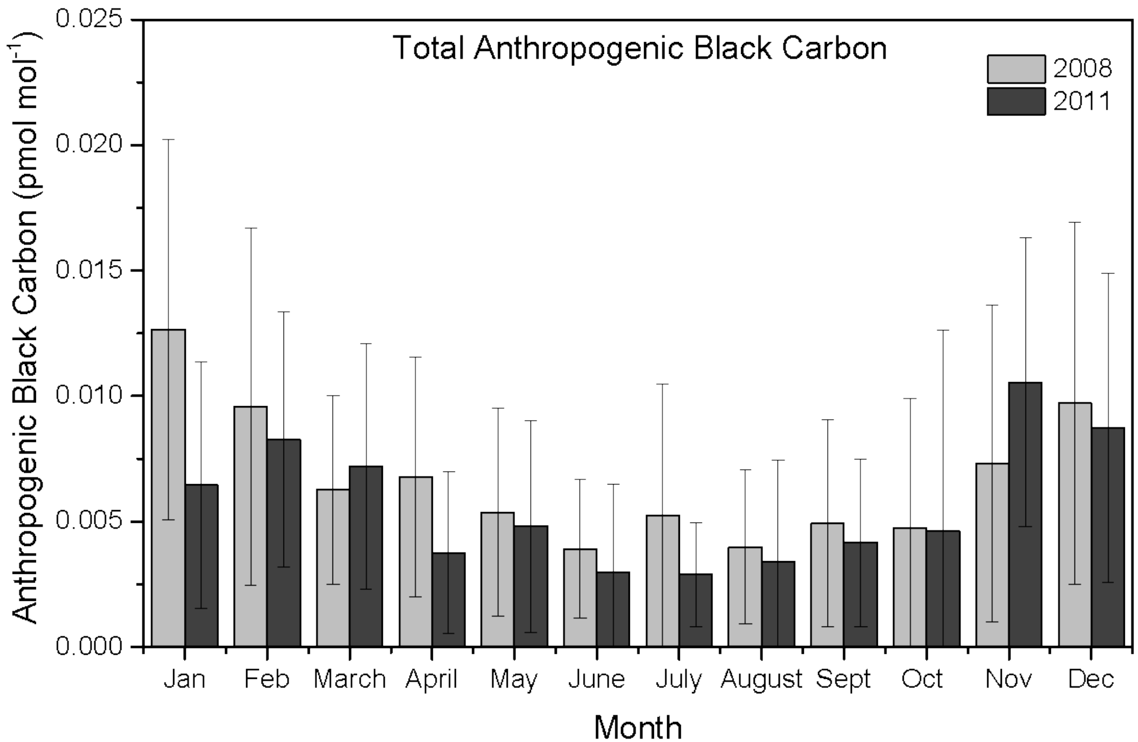


- Some apparent decreases in the winter and spring between 1998-2009
- Ethane and propane show increases again in 2013
- Butane still has lower levels in 2013 than 2009, especially Jan-April

1997-1998 NMHC data from Swanson et al., 2003

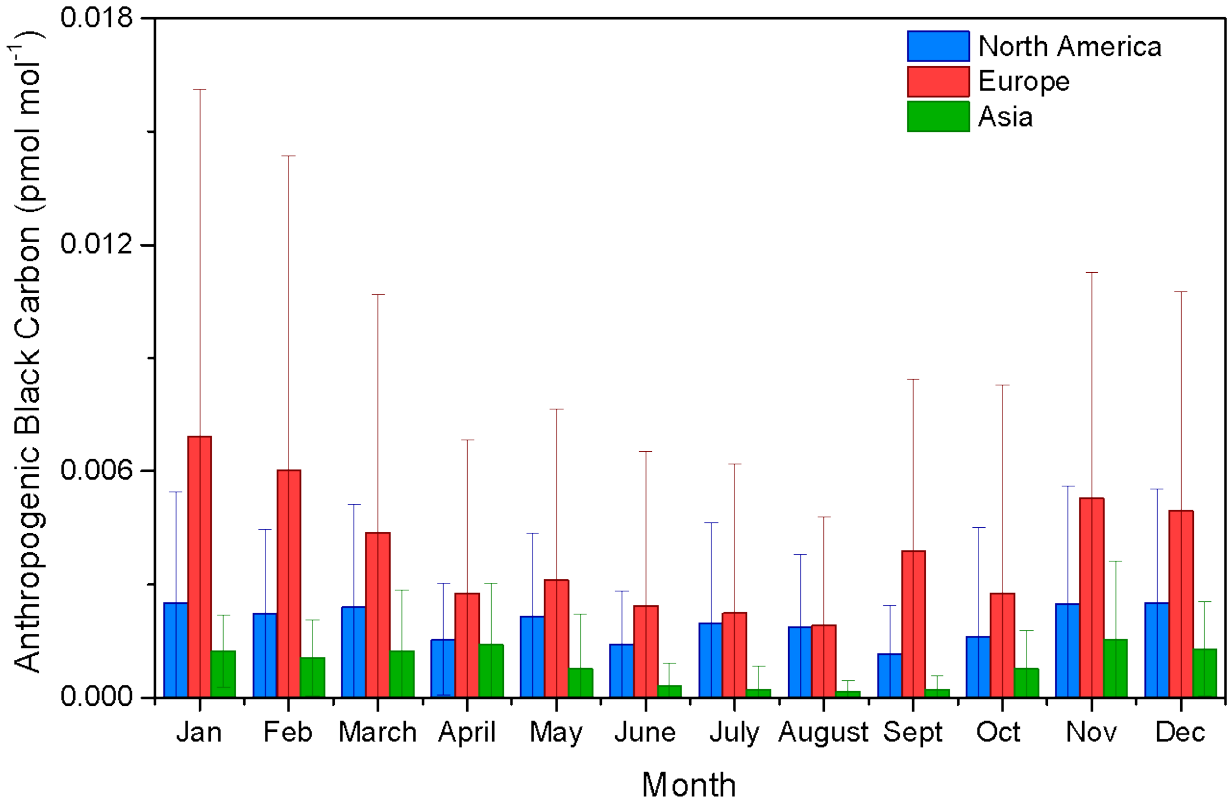
Anthropogenic Black Carbon Transport

- FLEXPART retroplume analysis using anthropogenic black carbon tracer
- Anthropogenic transport events primarily in winter/spring when Polar Front extends down over Eurasia



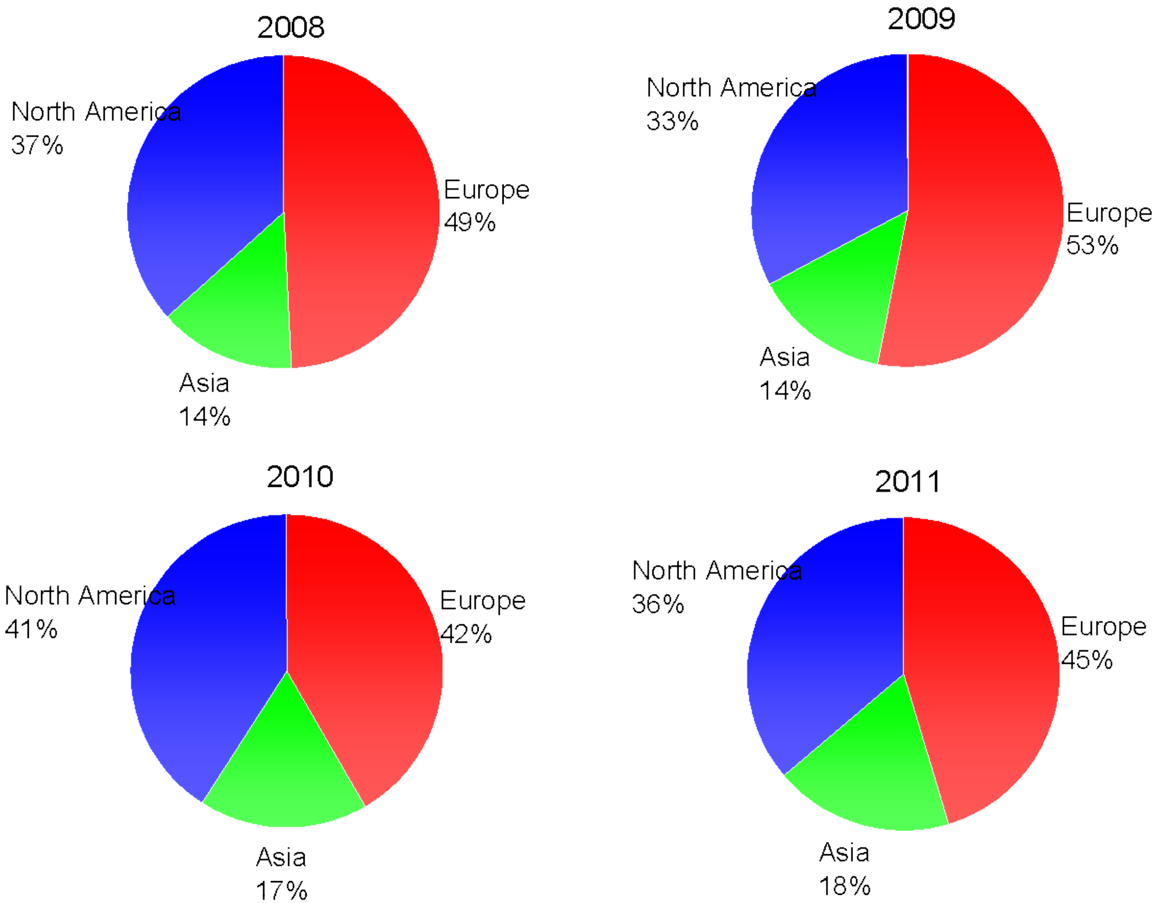
- FLEXPART simulations indicate less anthropogenic pollution to Summit in 2011 compared to 2008, notably Jan, Feb, and April, generally consistent with previous NMHC observations

Anthropogenic Black Carbon Sources



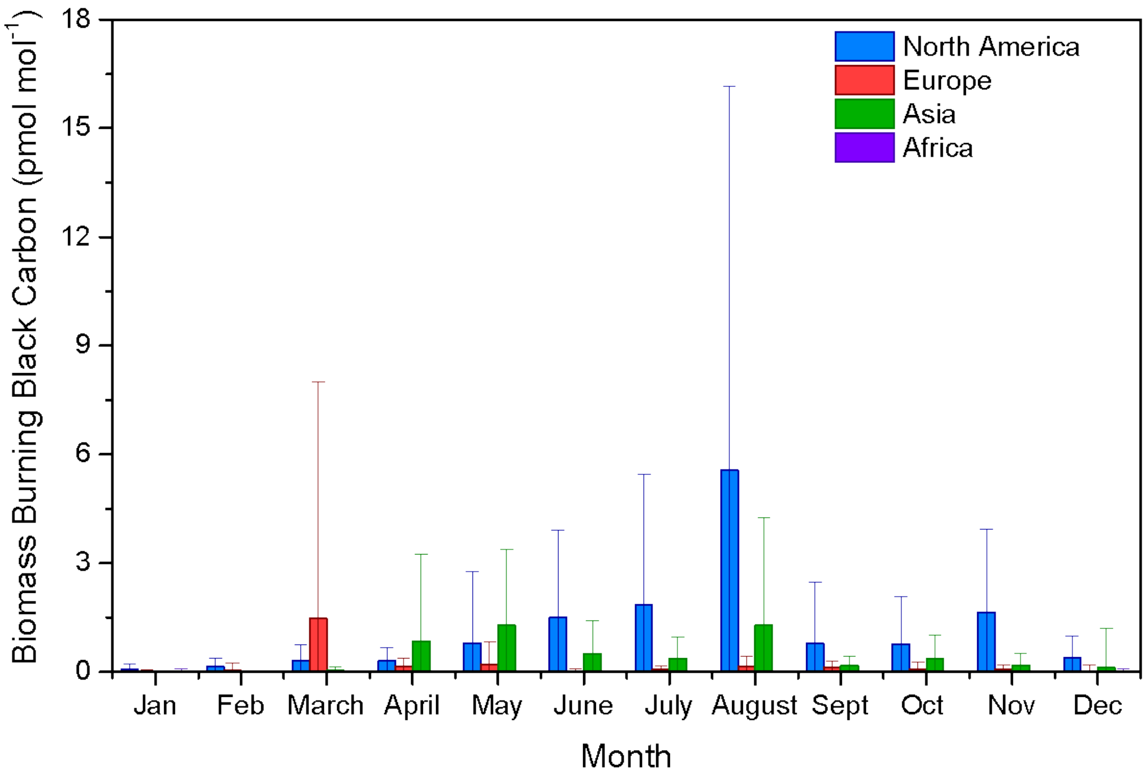
- Europe is the primary source of anthropogenic pollution, especially during winter/spring months, when fast transport events (~3-6 days) are more common
- Typical mean transport times 10-12 days from Europe, 12-16 days from North America, and 15-19 days from Asia

Anthropogenic Pollution Source Distribution: Yearly Average



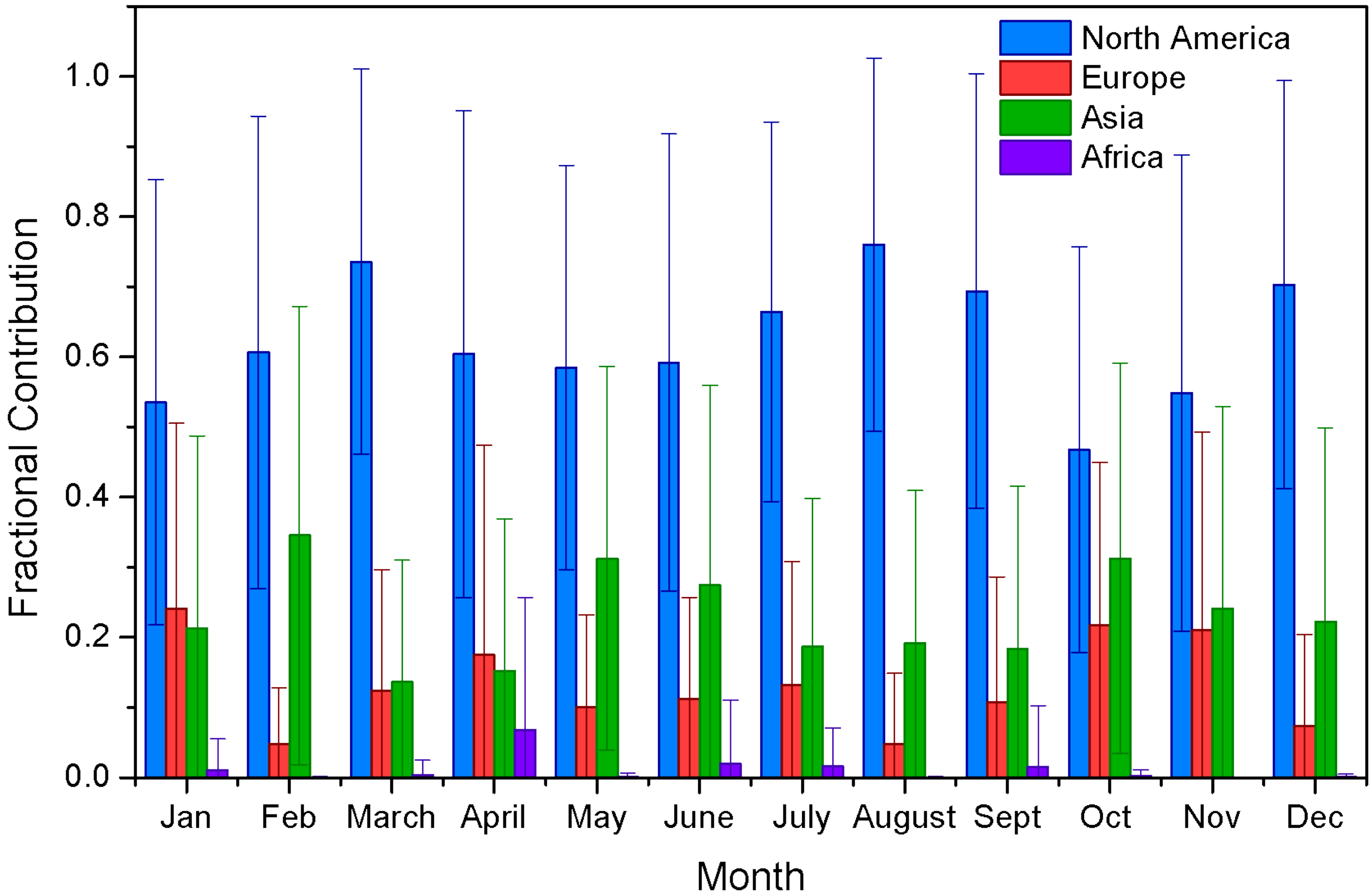
- Europe contribution between 42 – 53% yearly average, but can be up to 65% considering winter/spring months alone
- Asian contribution potentially trending upwards in more recent years?

Biomass Burning Influences

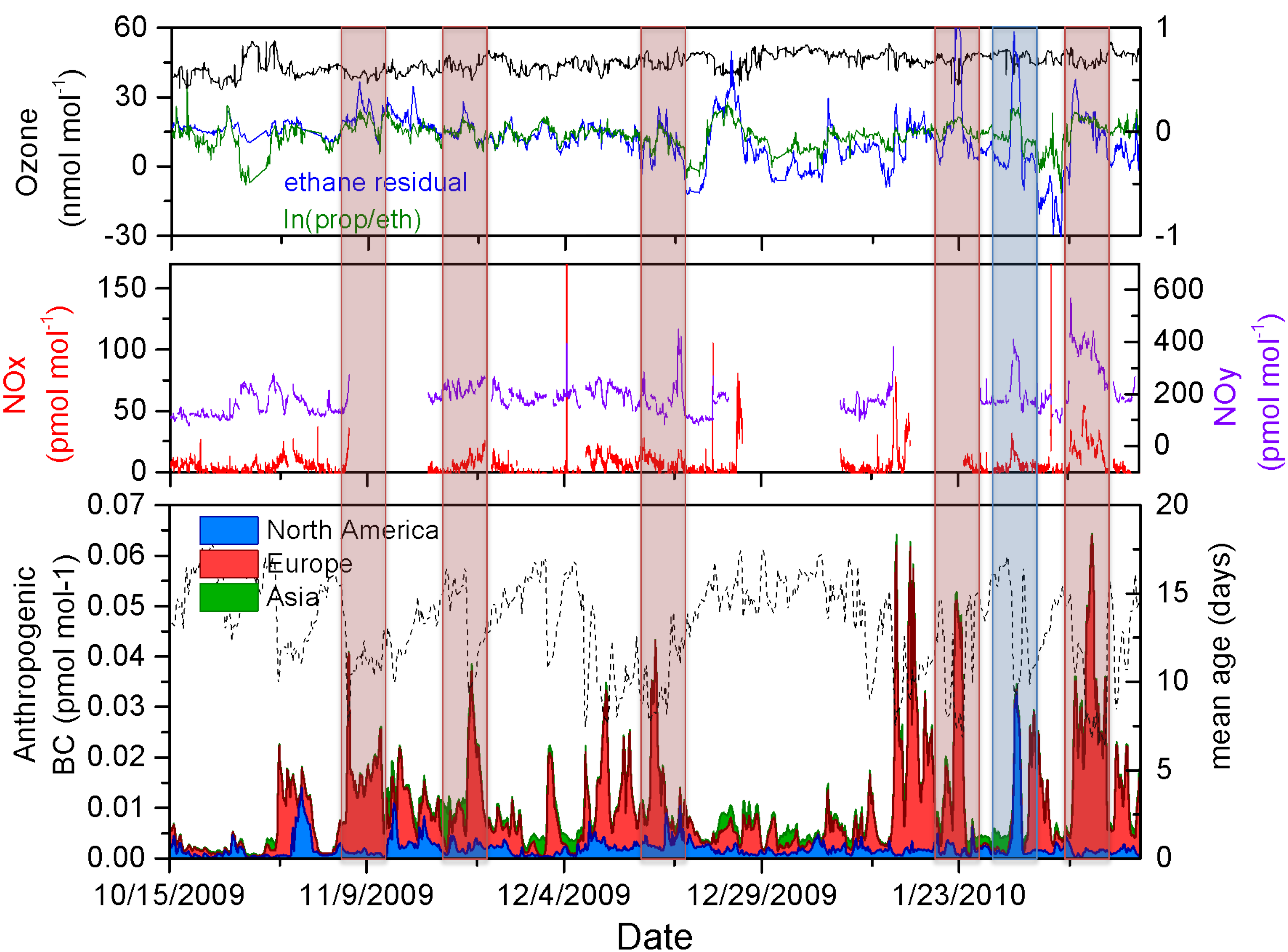


- Biomass burning emissions peak in August during summer fire season
- North America is primary source of biomass burning emissions, followed by boreal Asia
- Typical mean transport times ~14 days for biomass burning plumes

Biomass Burning Fractional Contribution



Transport Events of Anthropogenic Pollutants



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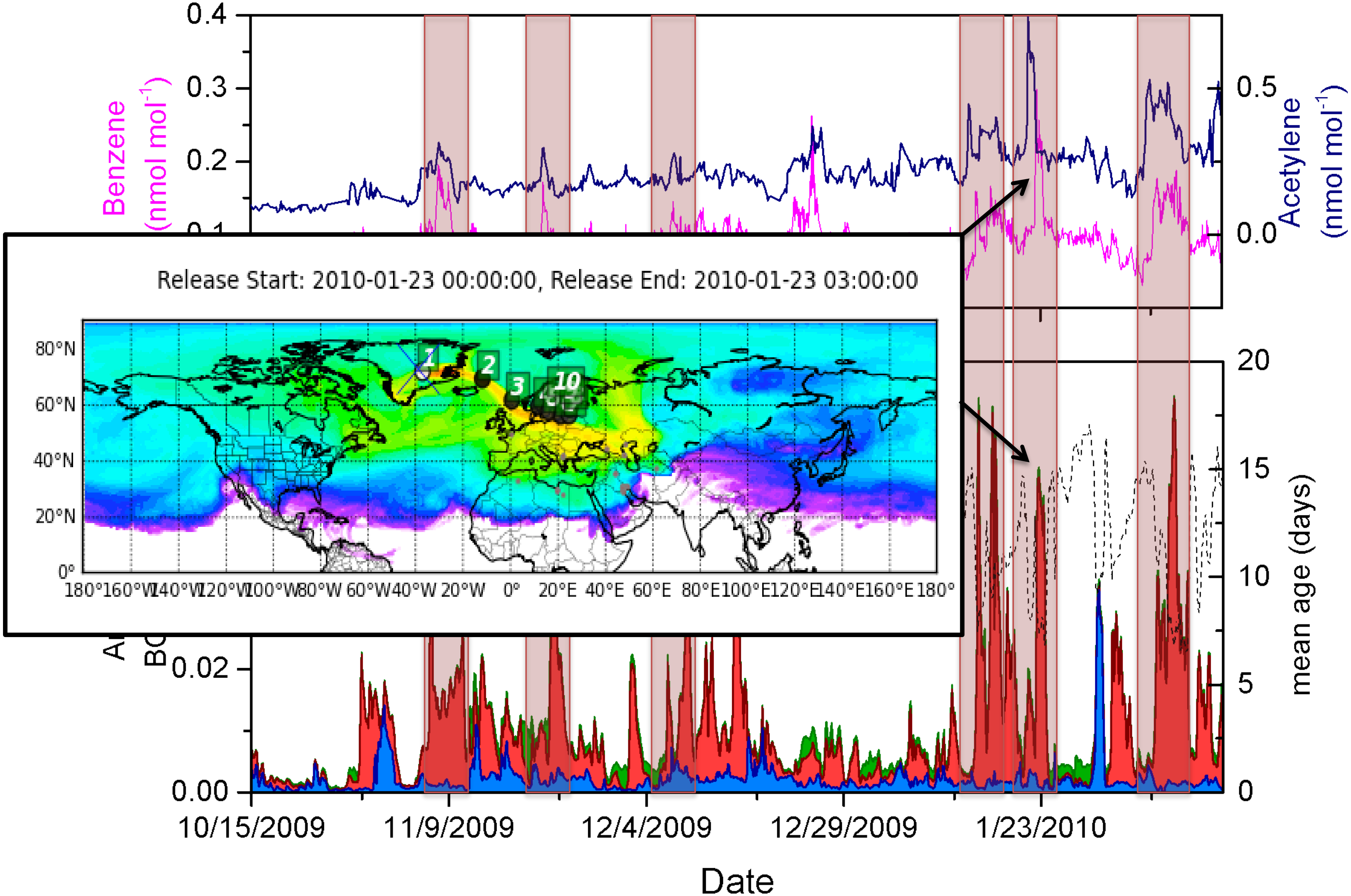
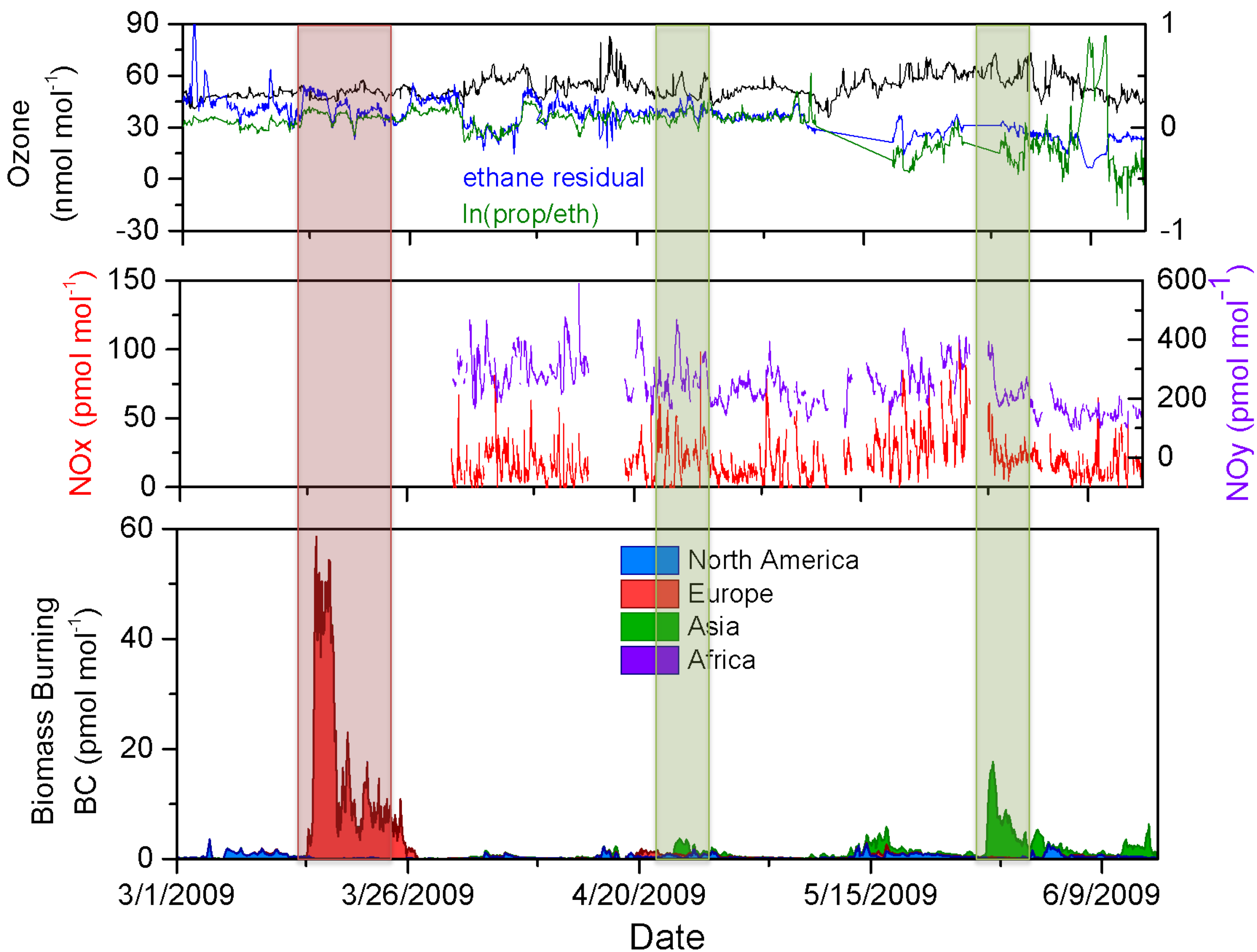
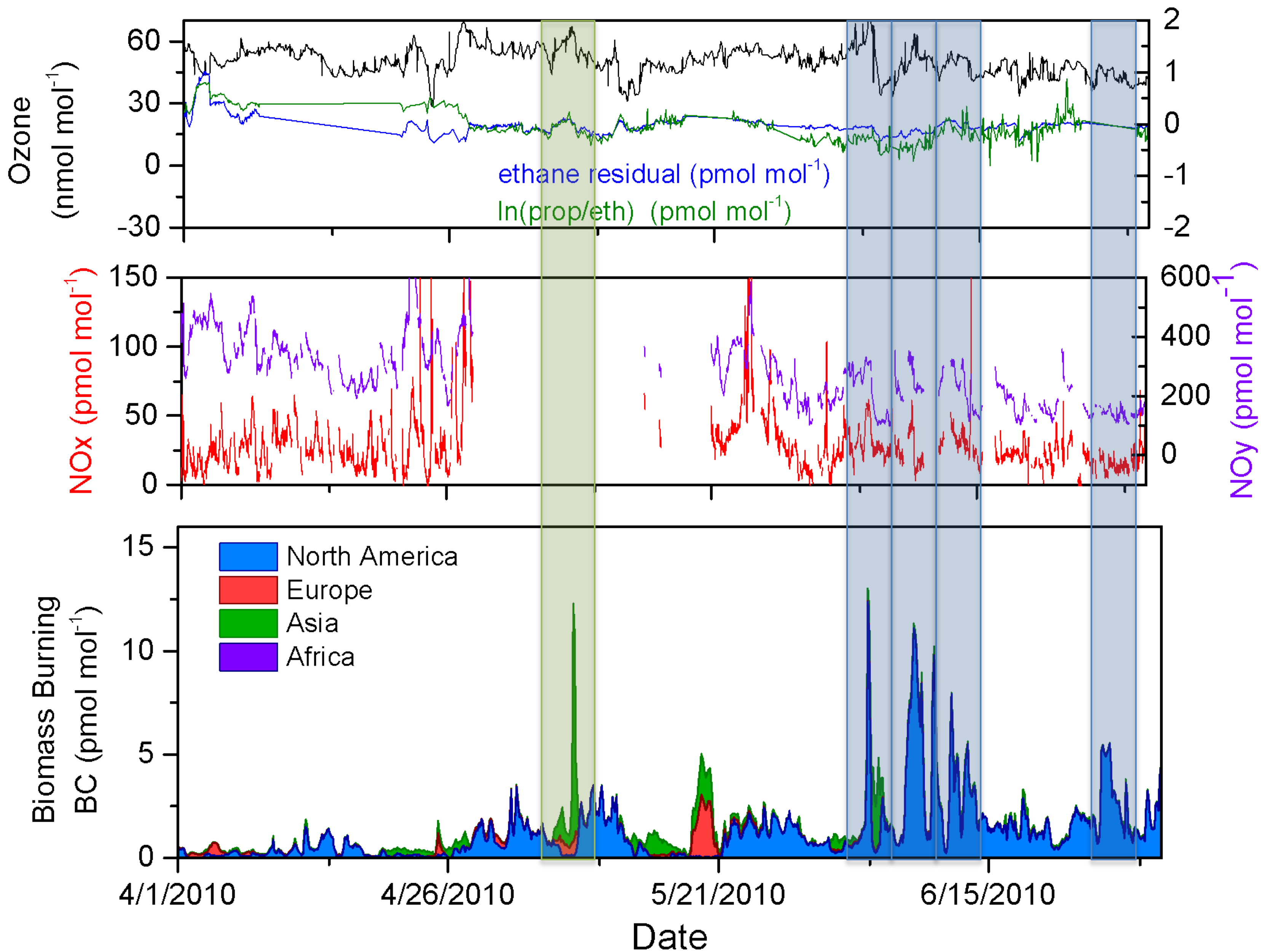


Transport Events of Biomass Burning Pollutants



Transport Events of Biomass Burning Pollutants



Some preliminary results…

- NMHC levels at Summit reveal declines of -34 pmol mol^{-1} ethane, -8.2 pmol mol^{-1} propane, and -6.7 pmol mol^{-1} n-butane between 2006-2011 (NOAA flask data), and 19%, 52%, and 63% for ethane, propane, and n-butane respectively between 1998 – 2009
  - However, 2013 data reveals some increases…too soon to determine if trend is reversing
- FLEXPART retroplume analysis shows that European sources dominate anthropogenic pollution, especially in winter/spring
  - Anthropogenic events show obvious increases in NMHC, including alkanes, benzene, and acetylene
  - Increases in NOx and NOy species
  - Some ***decreases*** in ozone associated with these events
- North America and Asia contribute majority of biomass burning emissions, but these events are less frequent
  - Some increases in NMHC
  - Typically also associated with ***increases*** in ozone

Acknowledgements

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- Long-term flask samples provided through the NOAA Cooperative Air Sampling Network

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