Reconstruction of Northern Hemisphere 1950 – 2010 Non-Methane Hydrocarbon Emissions

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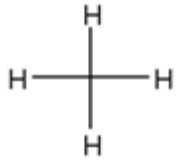
Non-Methane Hydrocarbons (NMHC)

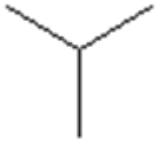


Methane (CH_4)

Ethane (C_2H_6)

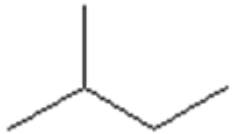
Propane (C_3H_8)

n-Butane (C_4H_{10})

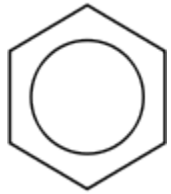


iso-Butane (C_4H_{10})

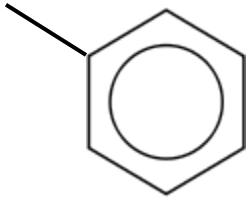
n-Pentane (C_5H_{12})



iso-Pentane (C_5H_{12})

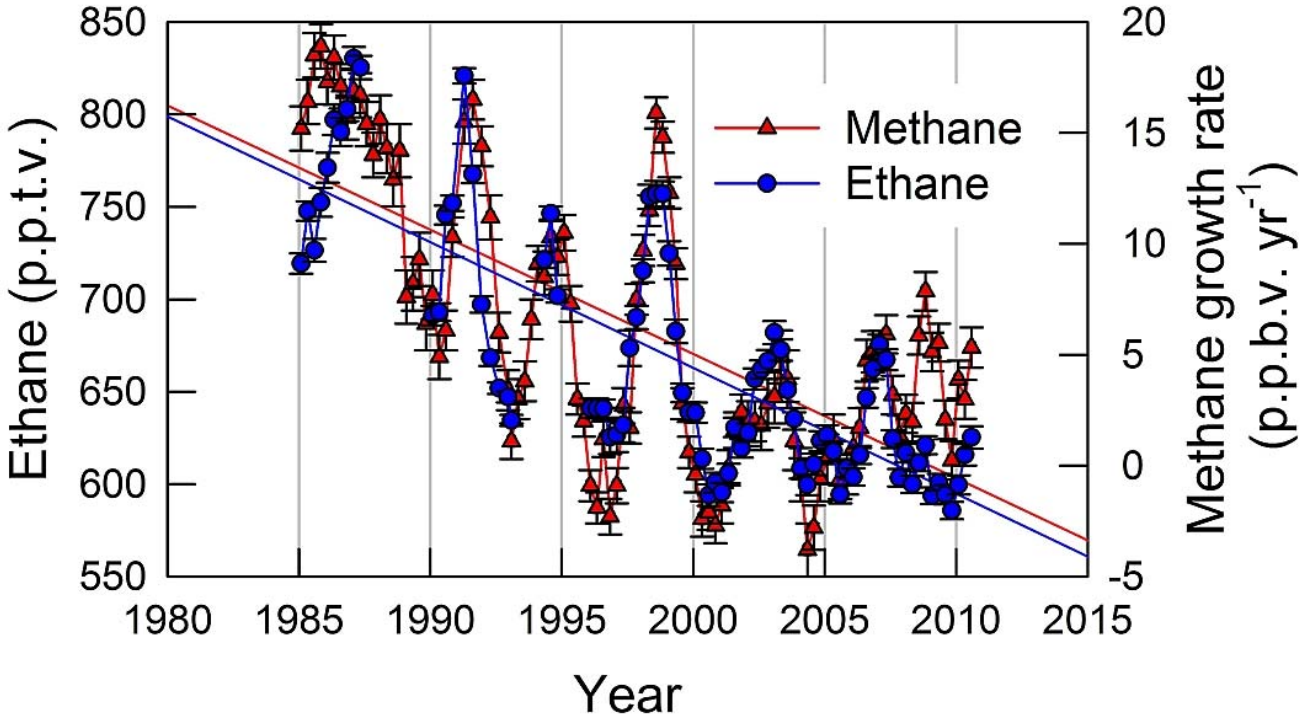


Benzene (C_6H_6)



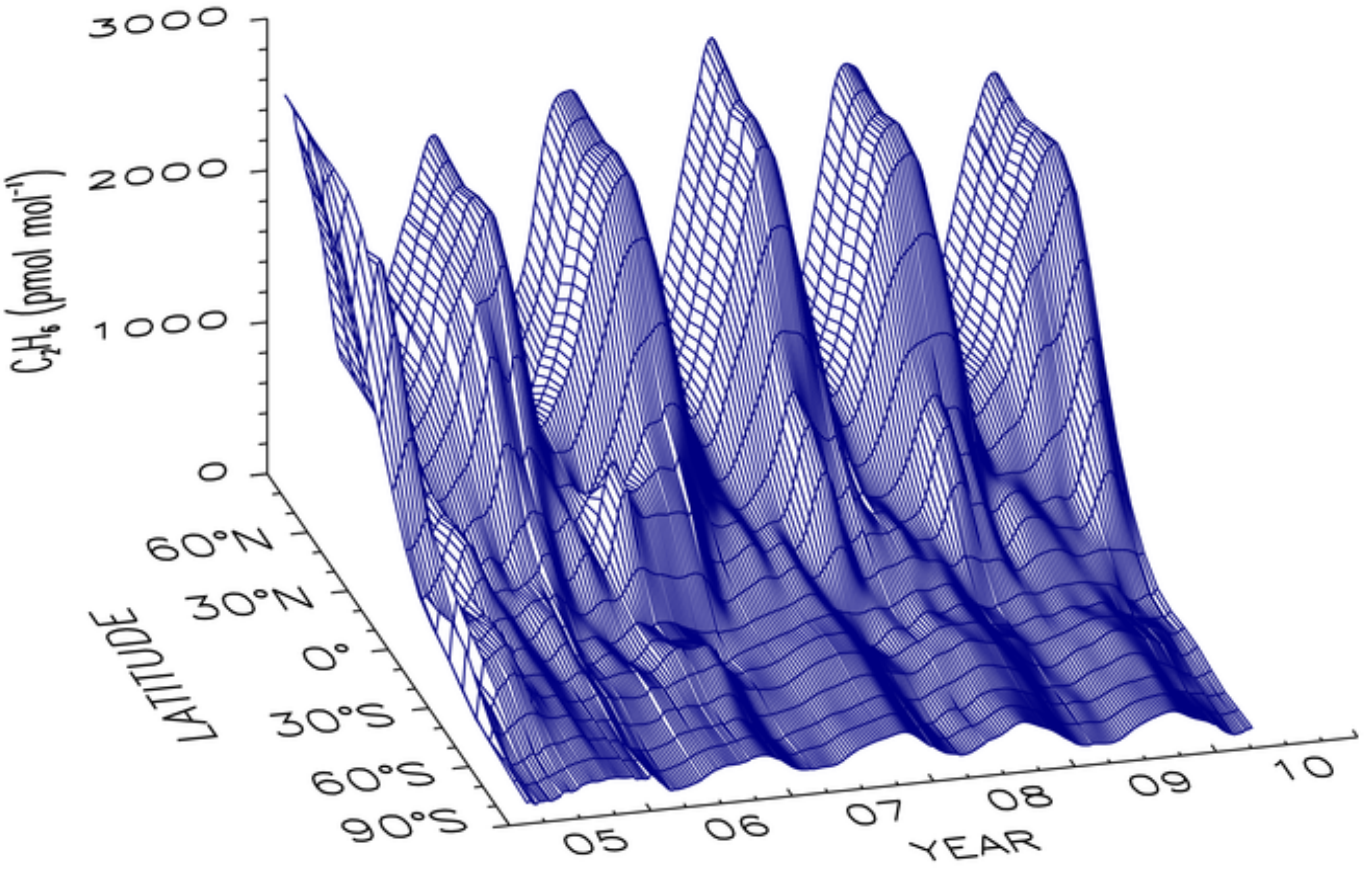
Toluene (C_7H_8)

Ethane – Methane Growth Relationship

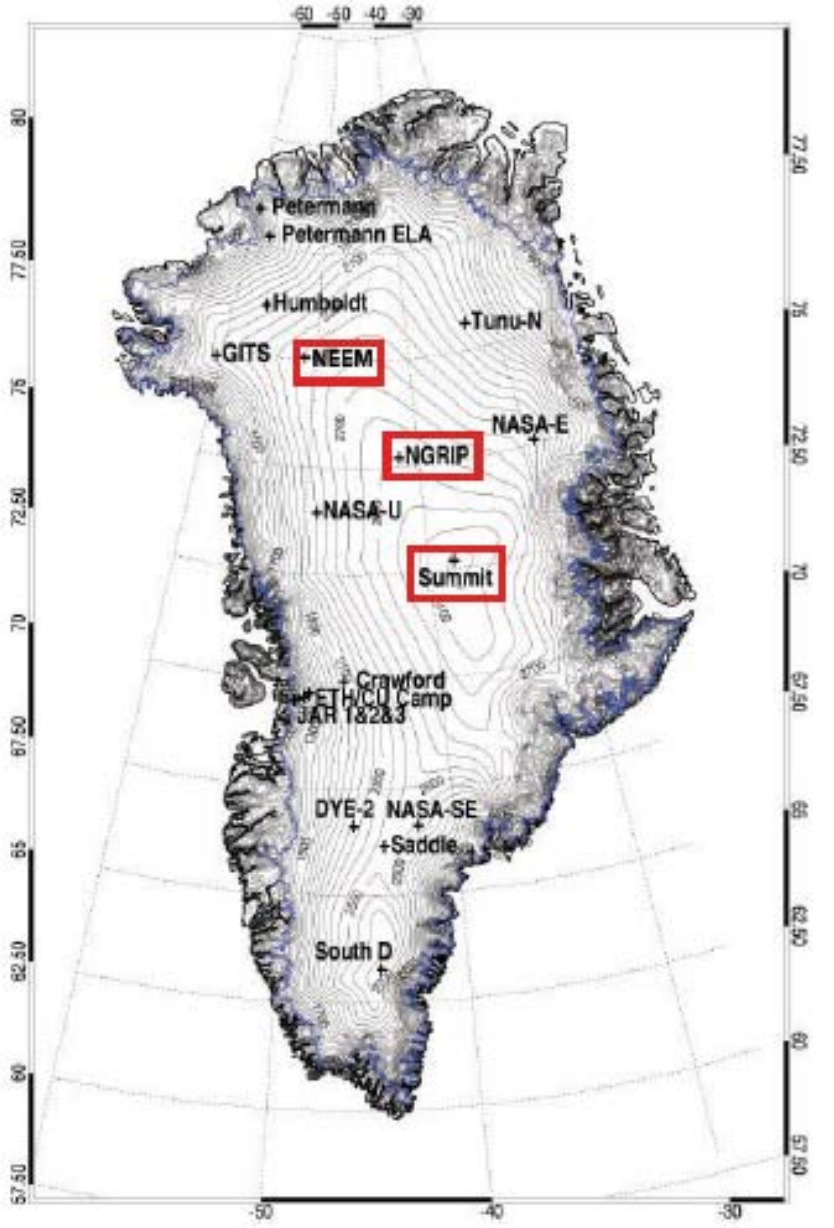


Simpson et al., 2012, submitted
Aydin et al., Nature, 2011

NOAA/GMD-INSTAAR Global NMHC Monitoring

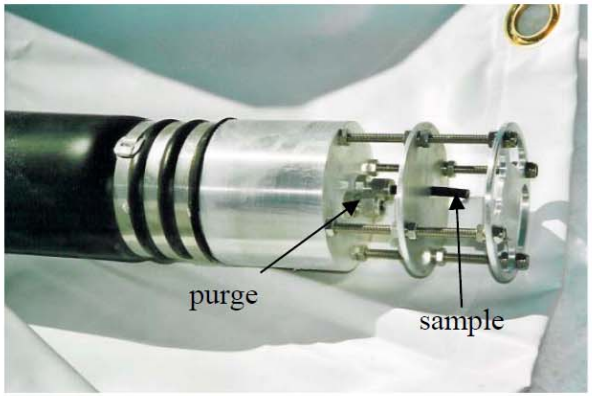


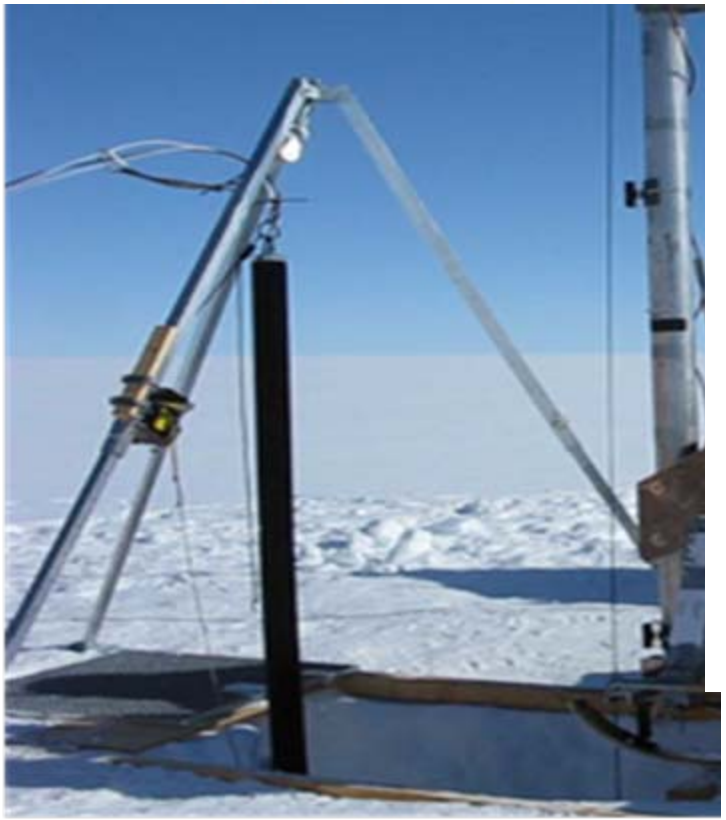
North Greenland Eemian Ice Drilling (NEEM)



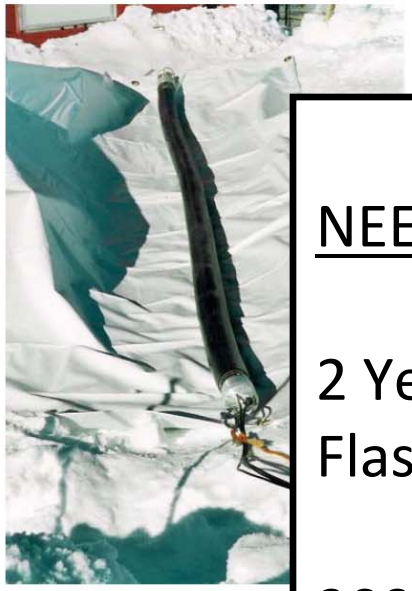
Map courtesy of Koni Steffen

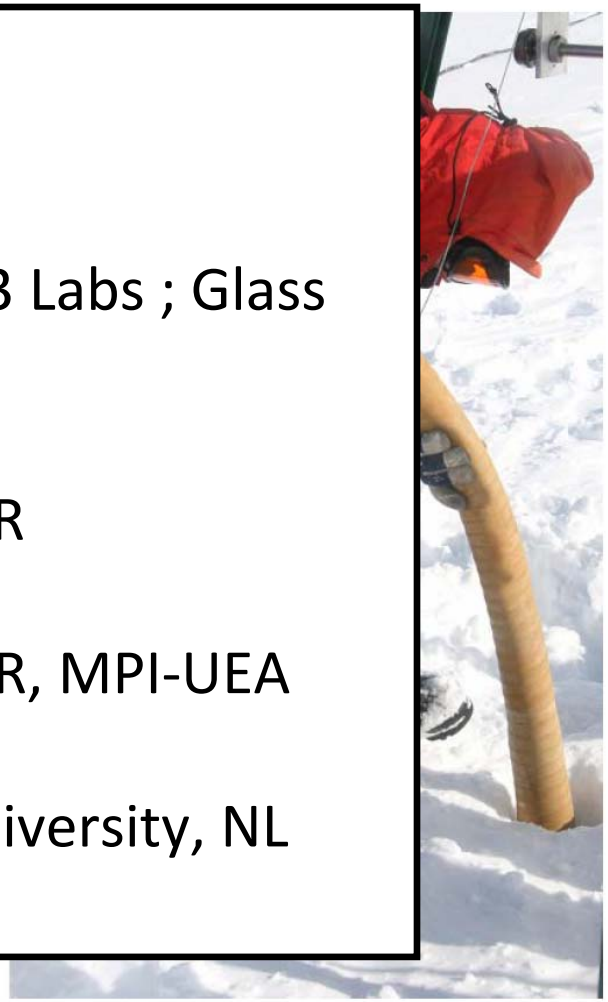
Firn Air Sampling





Firn Air Sampling





NEEM Firn Air Records:

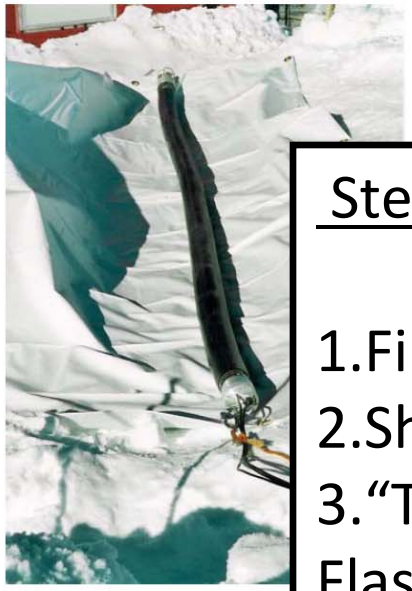
2 Years; 3 Firn Air Holes; 3 Drills; 3 Labs ; Glass Flasks and Steel Cans

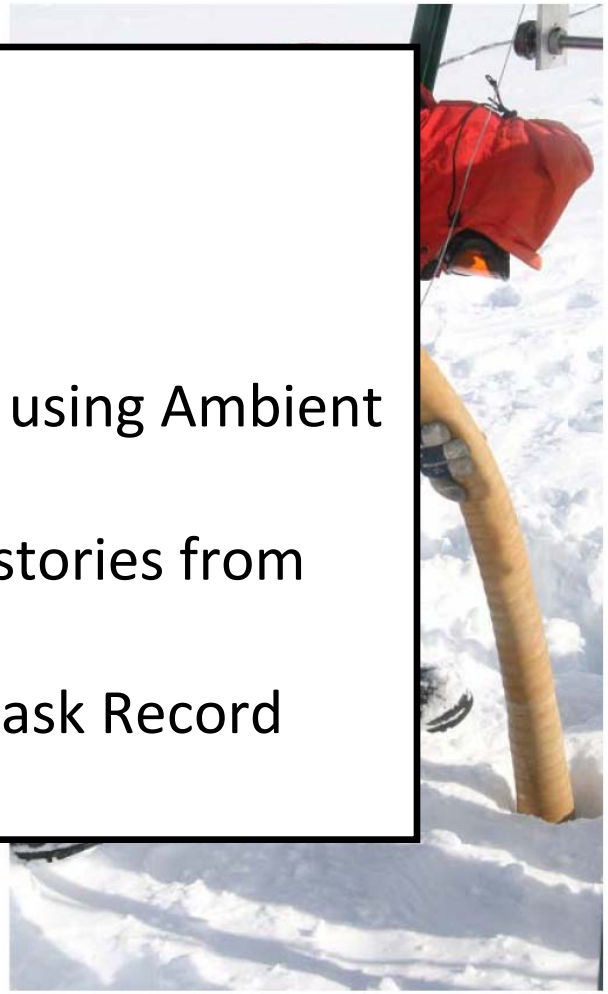
2008 US Hole – NMHC by INSTAAR

2008 EU Hole – NMHC by INSTAAR, MPI-UEA

2009 Hole – NMHC by Utrecht University, NL

Firn Air Sampling

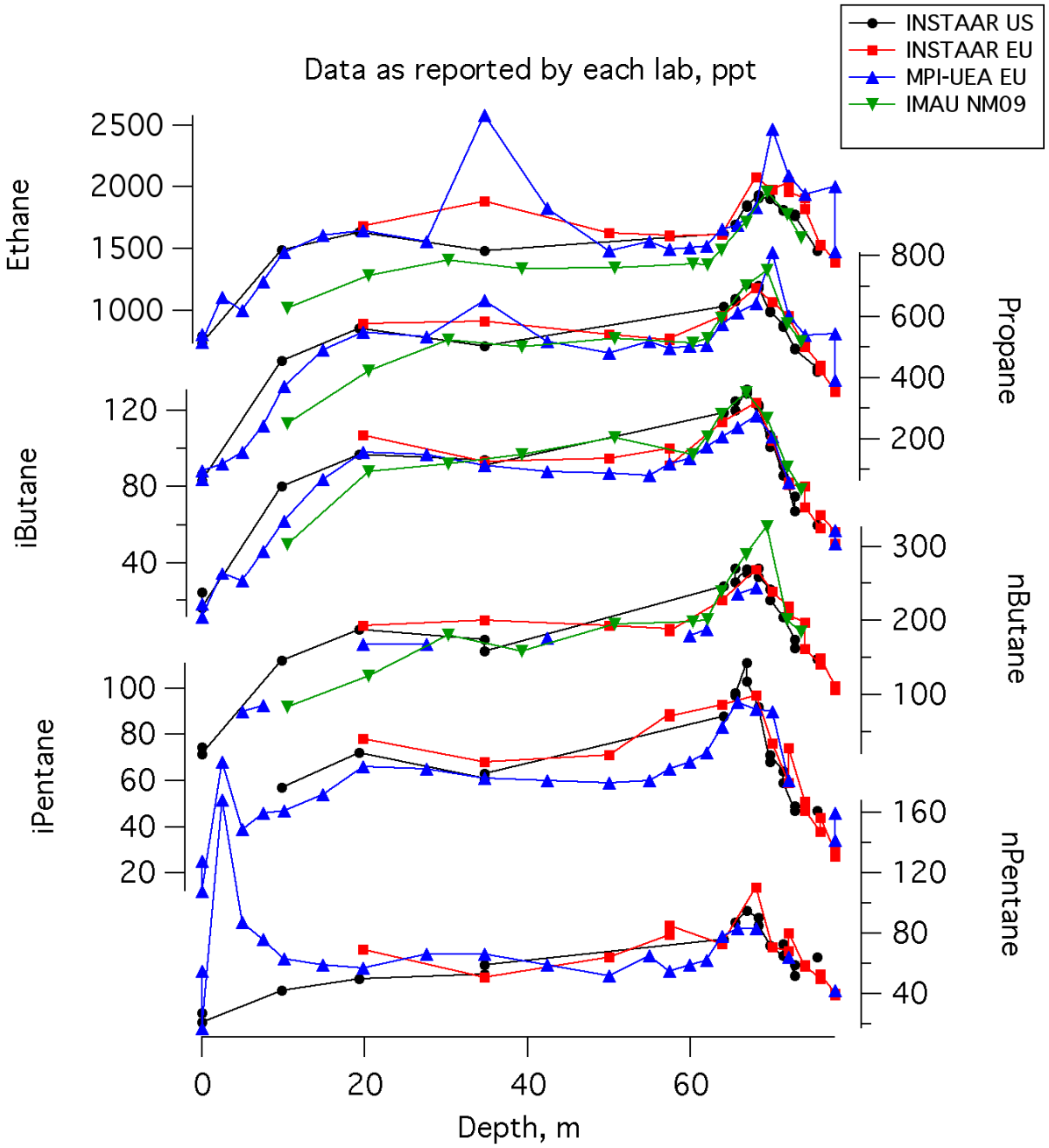




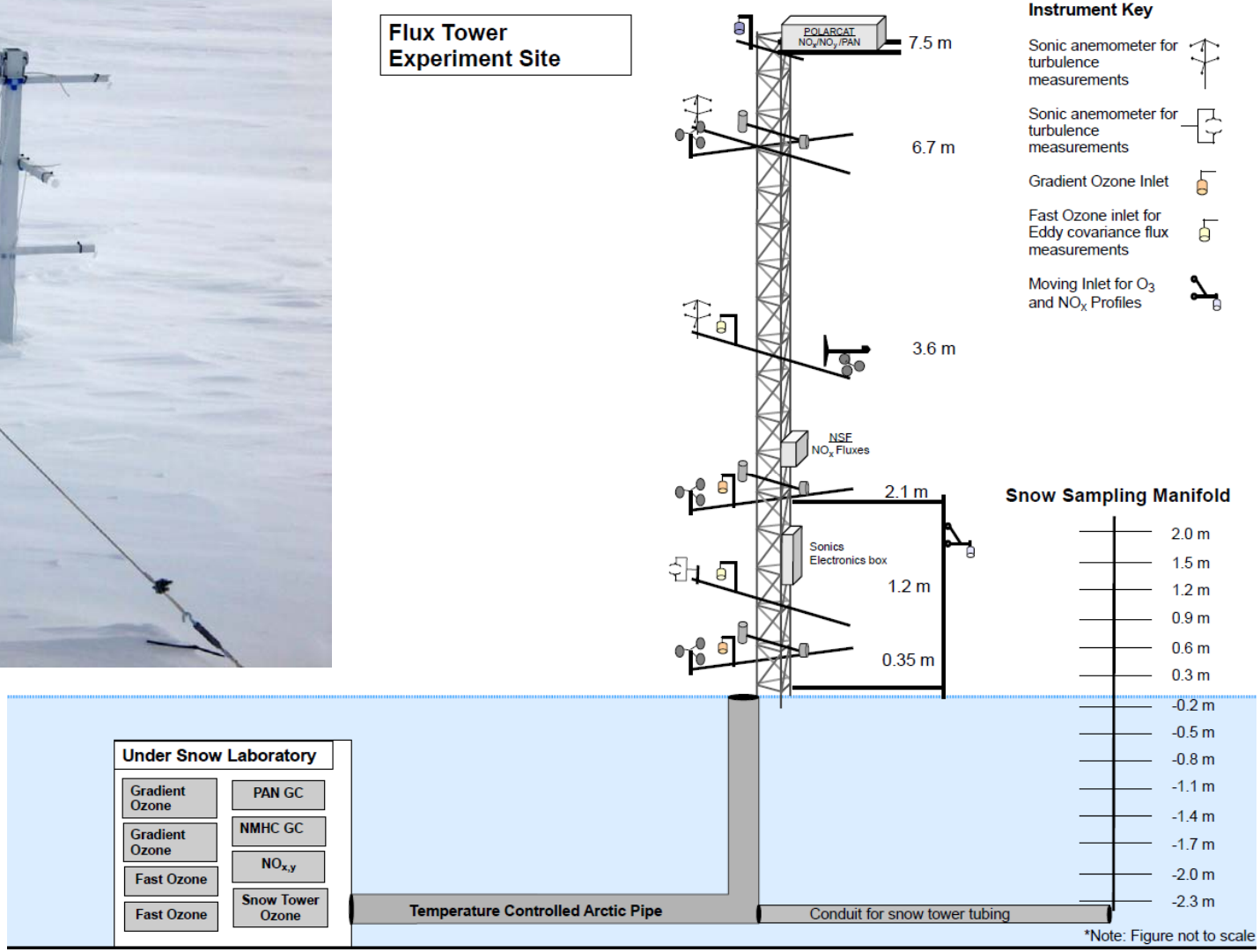
Steps:

1.Firn Air NMHC Profiles
2.Show that NMHC are Preserved
3.“Tune” Firn Air Diffusion Model using Ambient Flask Data
4.Produce NMHC Atmospheric Histories from Firn Air Diffusion Model
5.Evaluate Findings with NMHC Flask Record

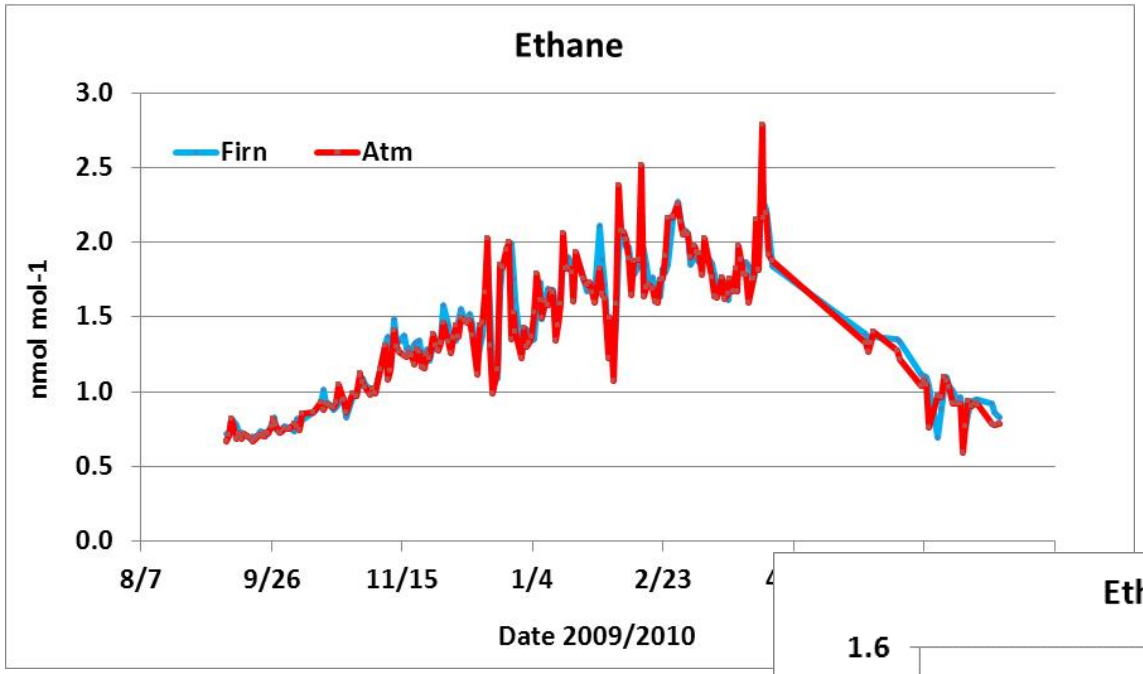
1. NEEM Firn Air NMHC Results

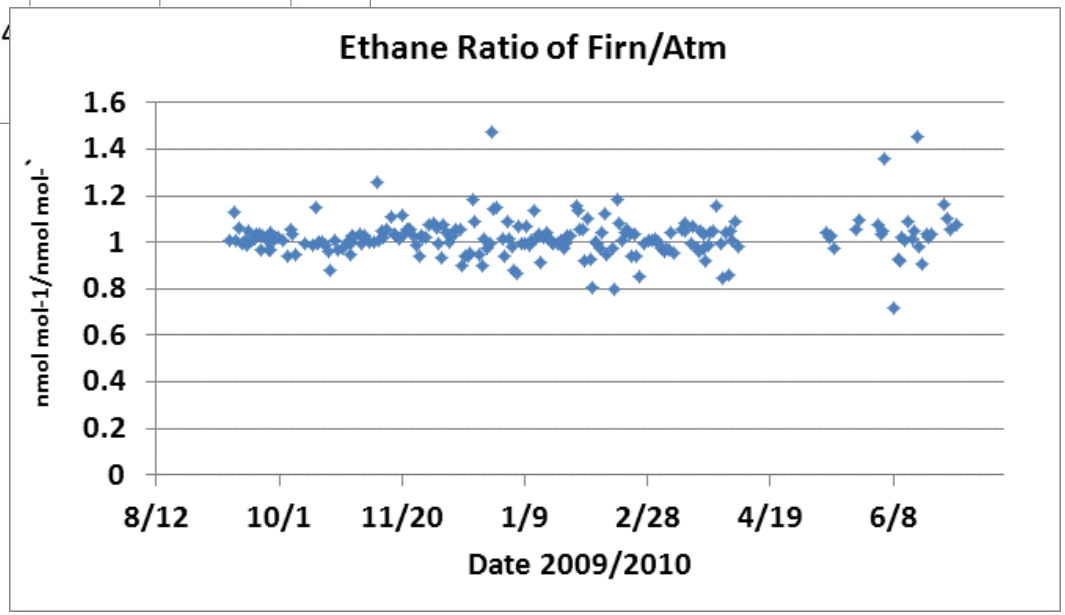


2. INSTAAR Year-round Firn Air Monitoring at Summit

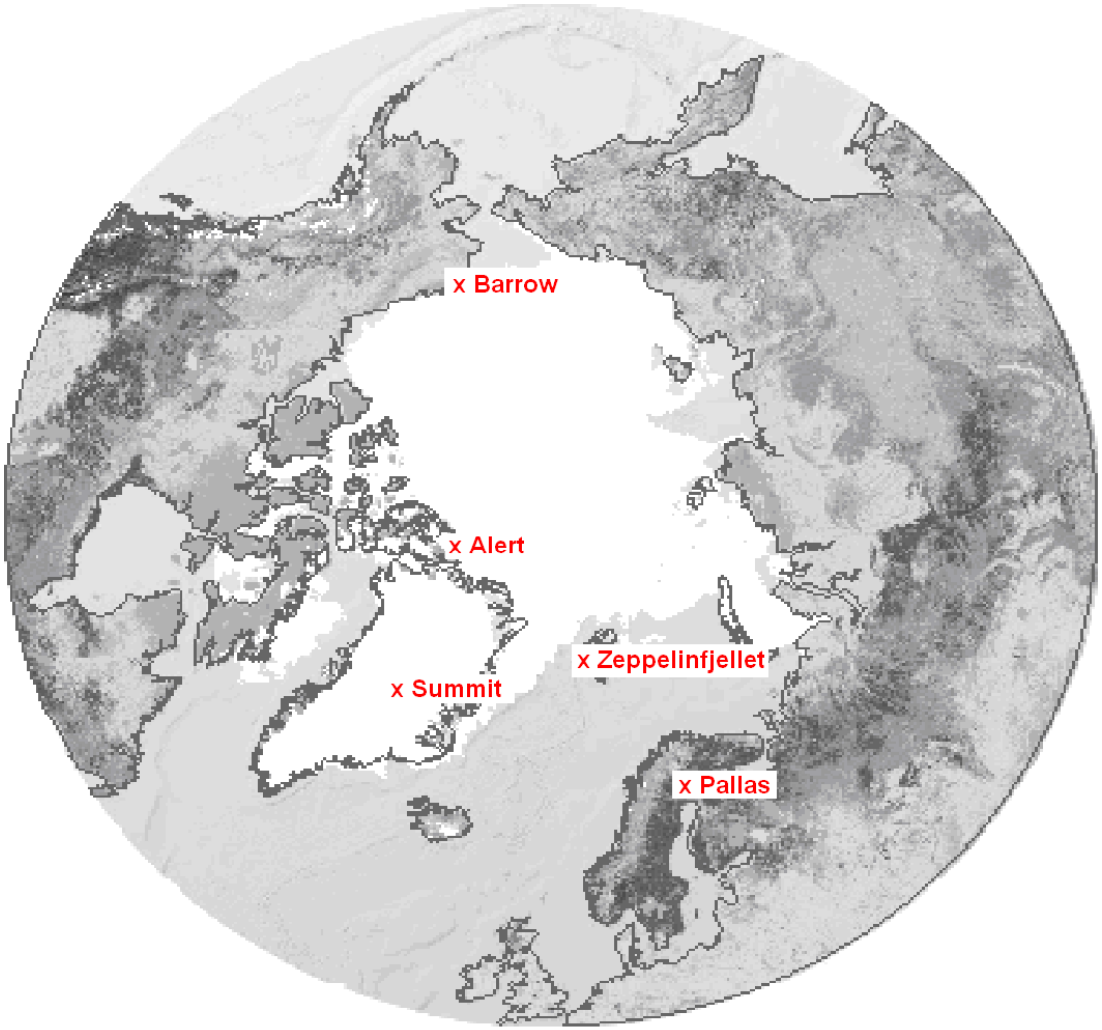


Summit Firn Air Monitoring Results

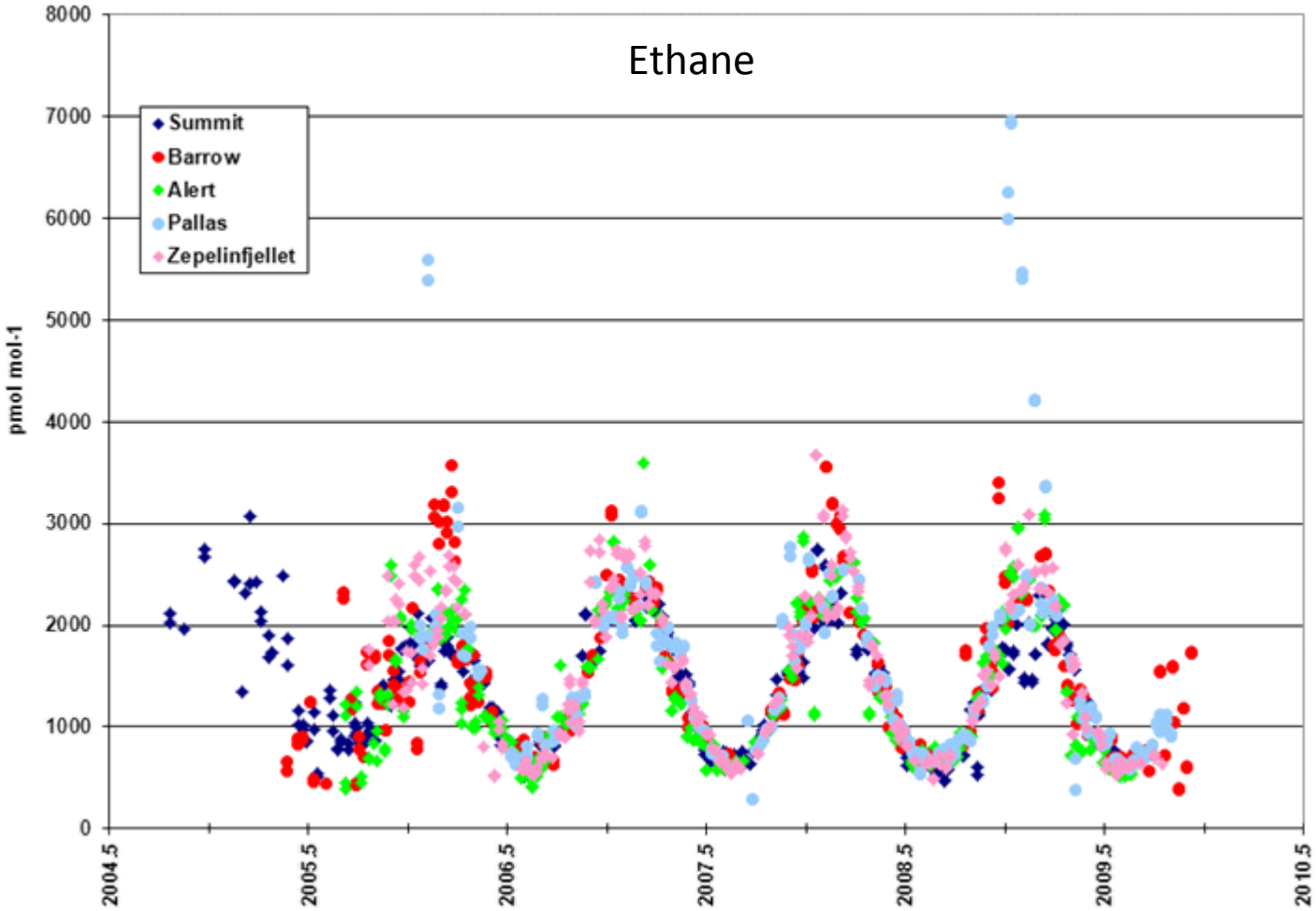




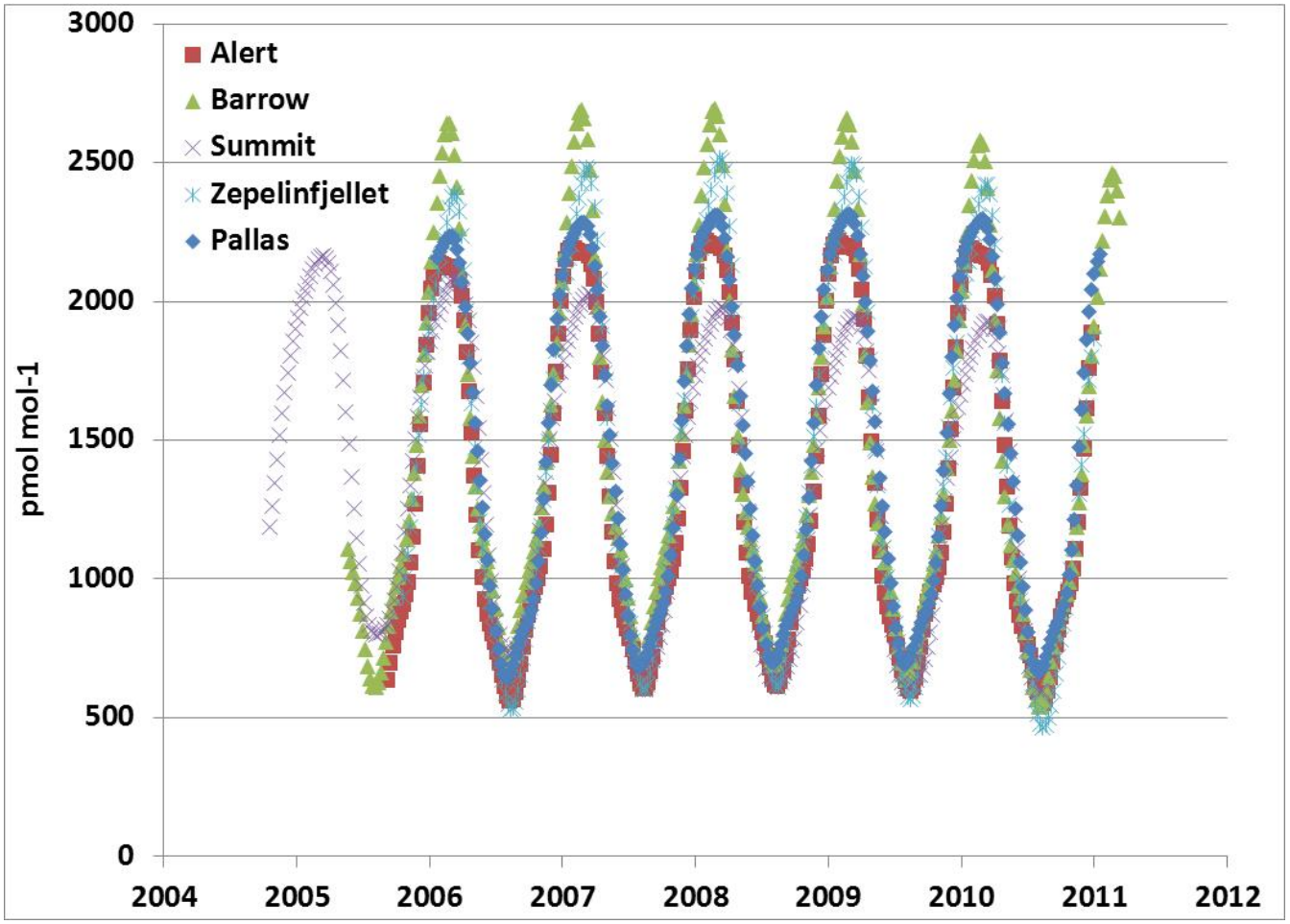
3. Data from NOAA/GMD – INSTAAR Arctic NMHC Flask Monitoring Sites



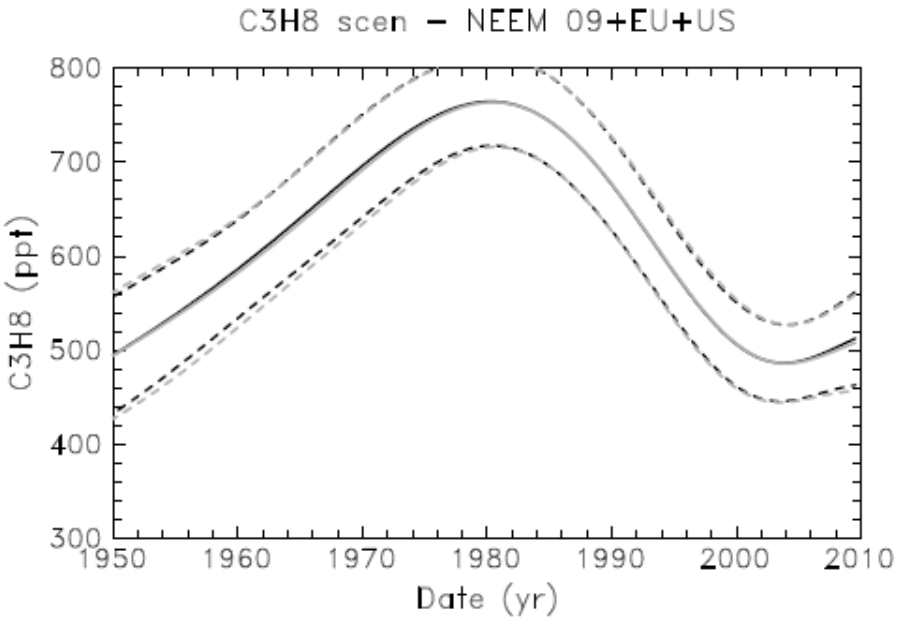
Arctic Site NMHC Flask Data

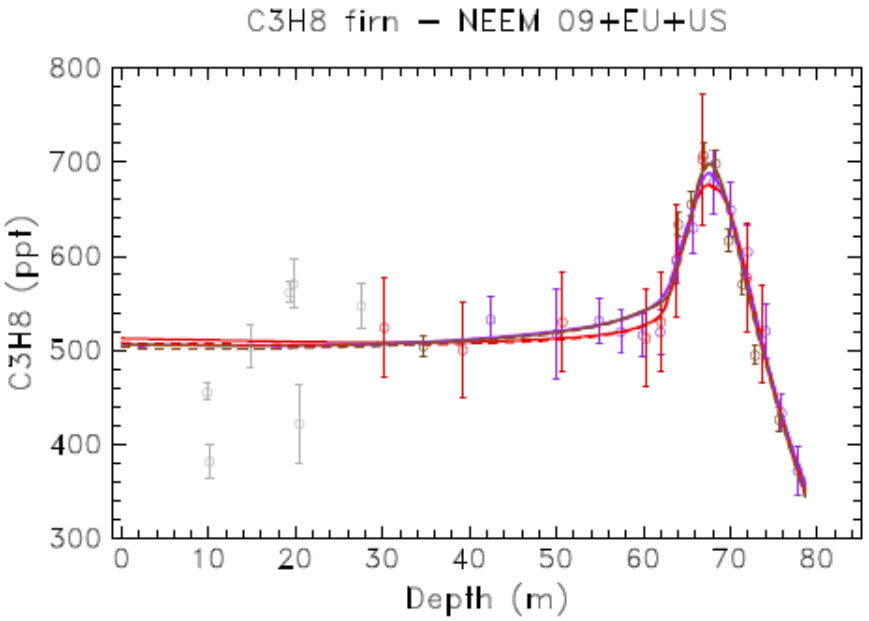


Harmonic Fit to NMHC Flask Data

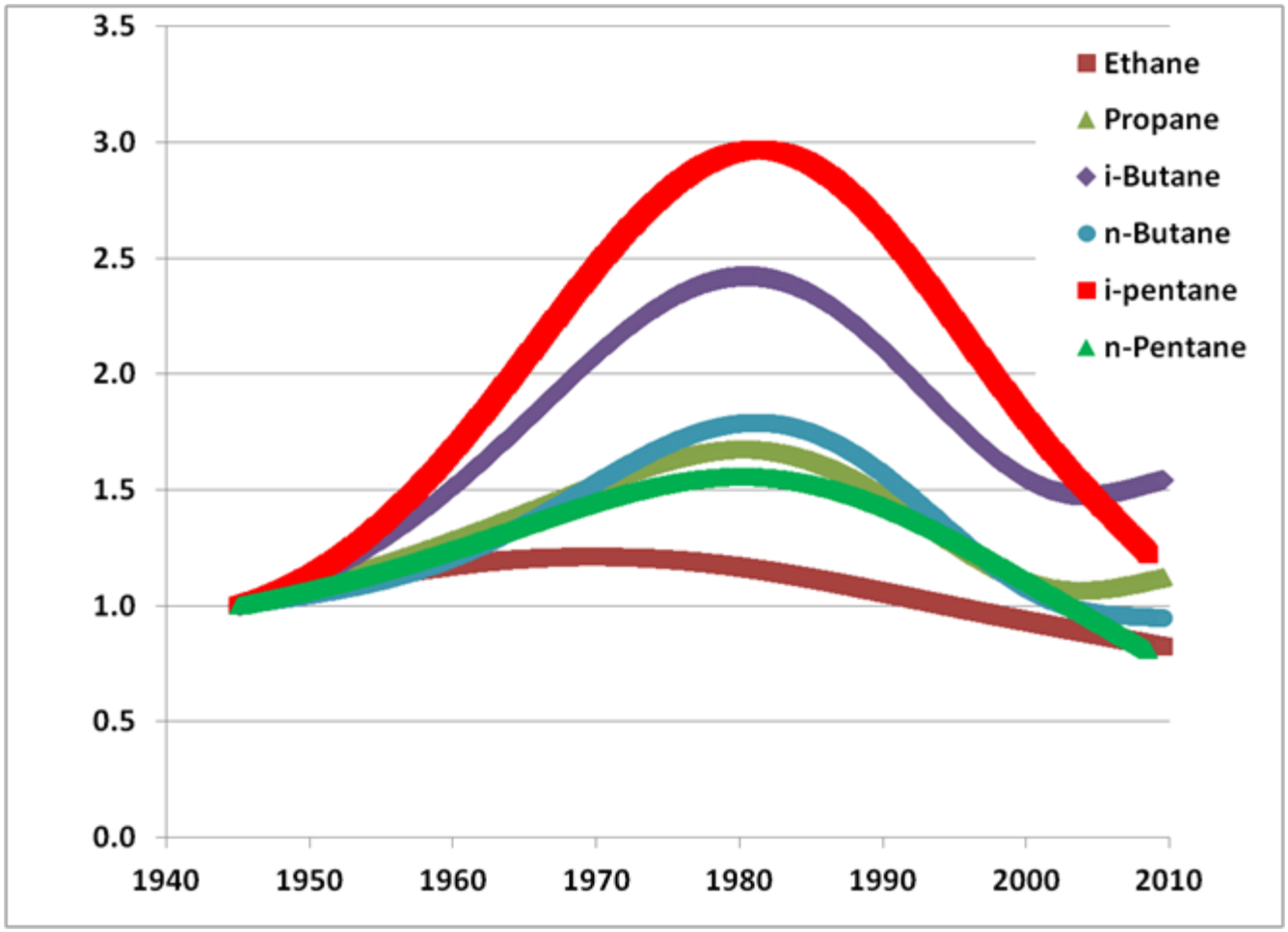


4. Atmospheric Concentration Reconstruction from Firn Air Diffusion Model - Propane

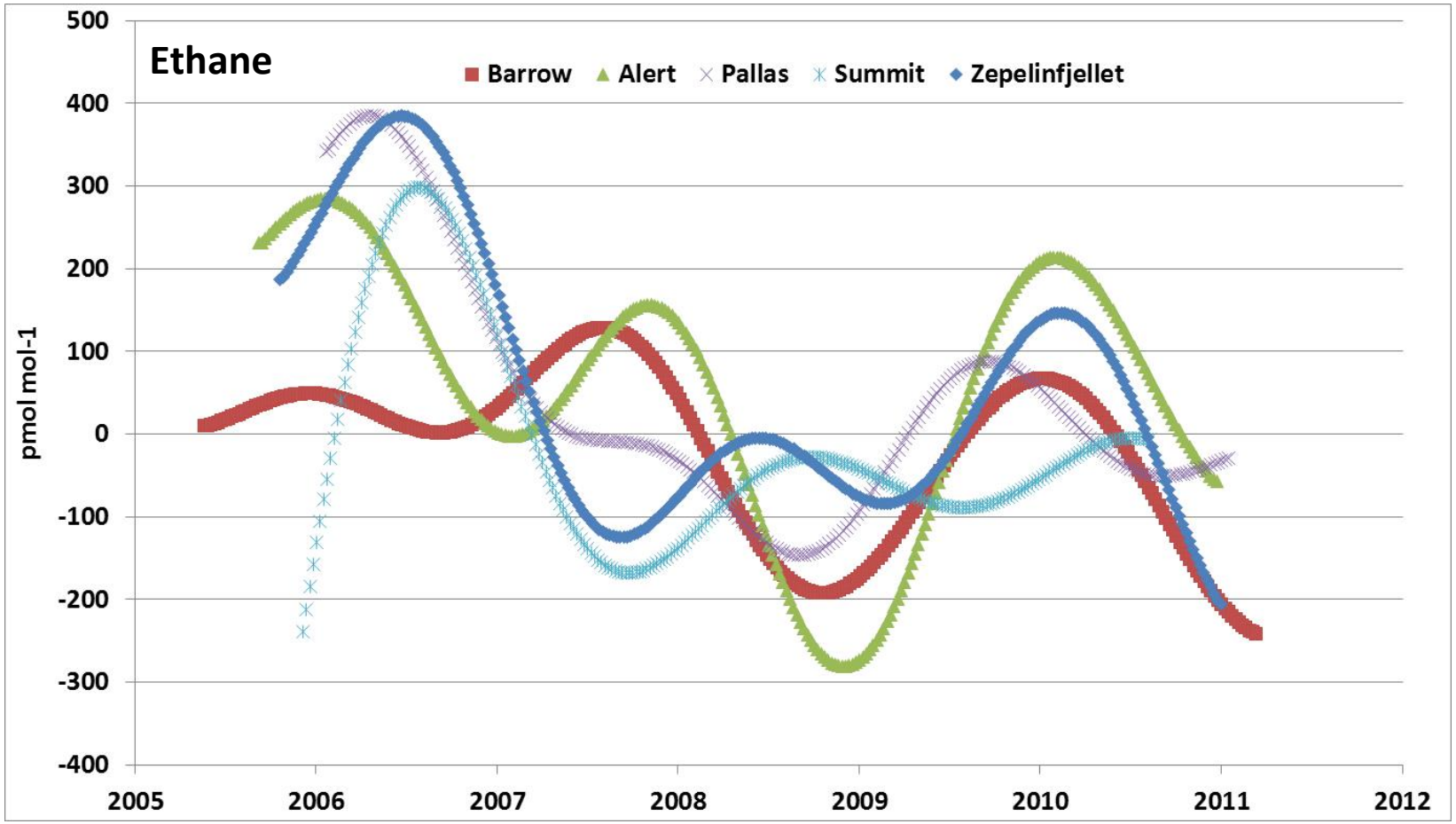




4. NMHC Trend Reconstruction from Firn Air Model



5. Evaluate Results – Comparison of Firn Air Trends with Ambient Flask Data Results



Summary

- Results from three firn holes/three labs gave consistent results for 6 NMHC depth profiles.

- Continuous firn air sampling showed no evidence for NMHC changes in snowpack.

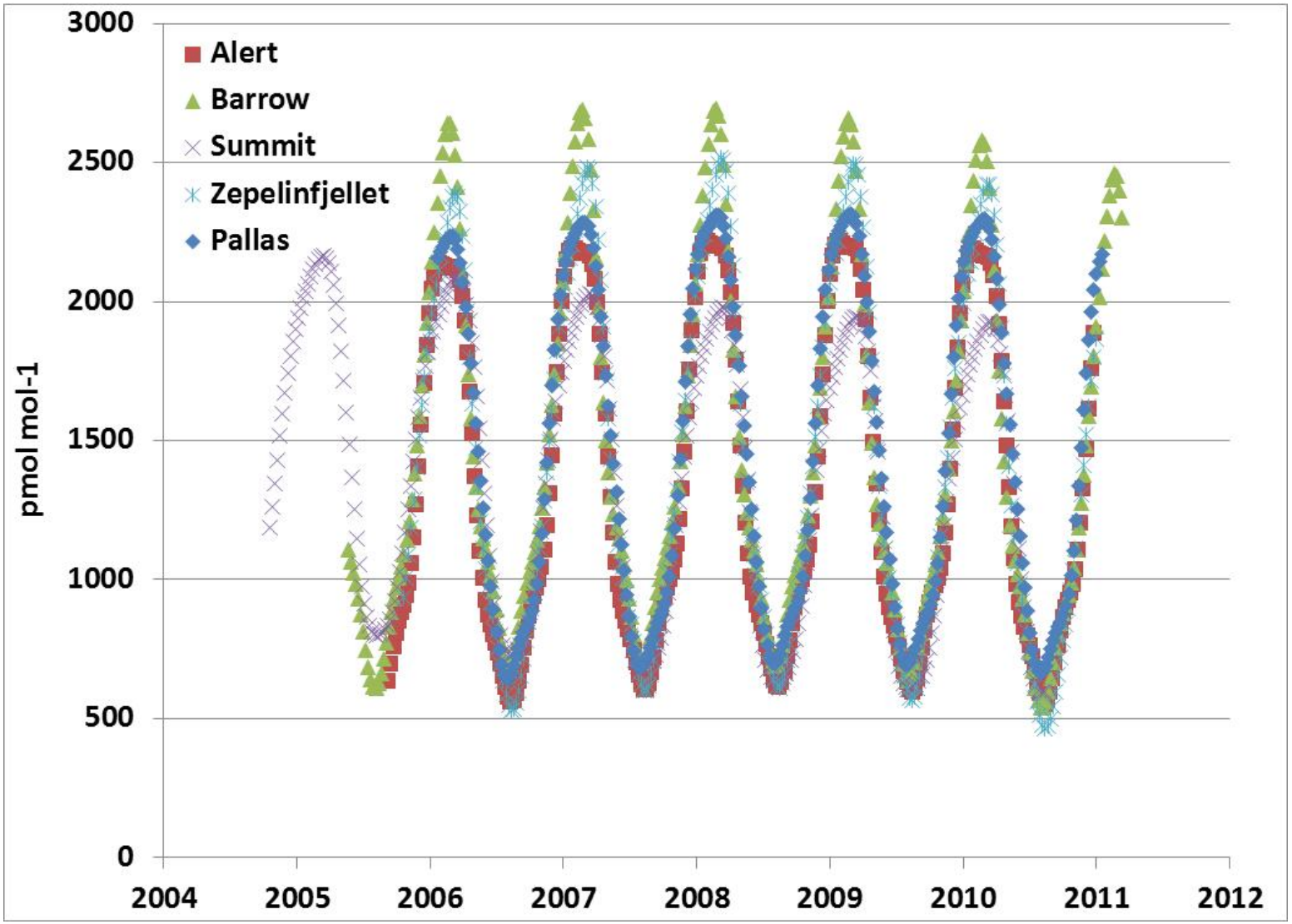
- All NMHC show peak concentrations during 1960-1980, with ethane preceding other NMHC by ~ 15 years.

- Total NMHC carbon emissions have declined by ~50% since peak in 1975-1980.

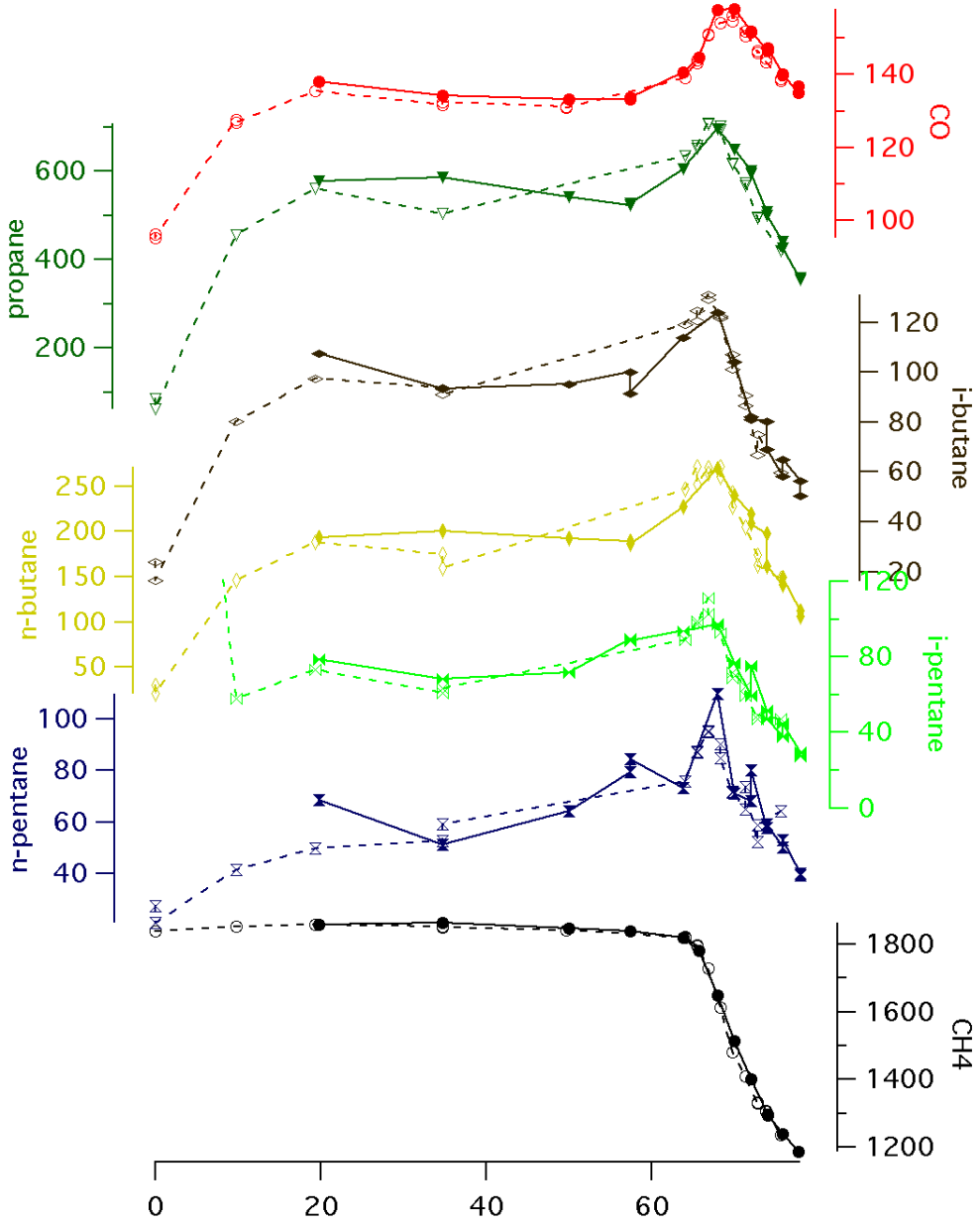
- Ongoing NOAA/GMD-INSTAAR global sampling program shows tentative agreement with firn hole results.

- NMHC data will help for further constraining fossil fuel emissions changes and global methane sources.

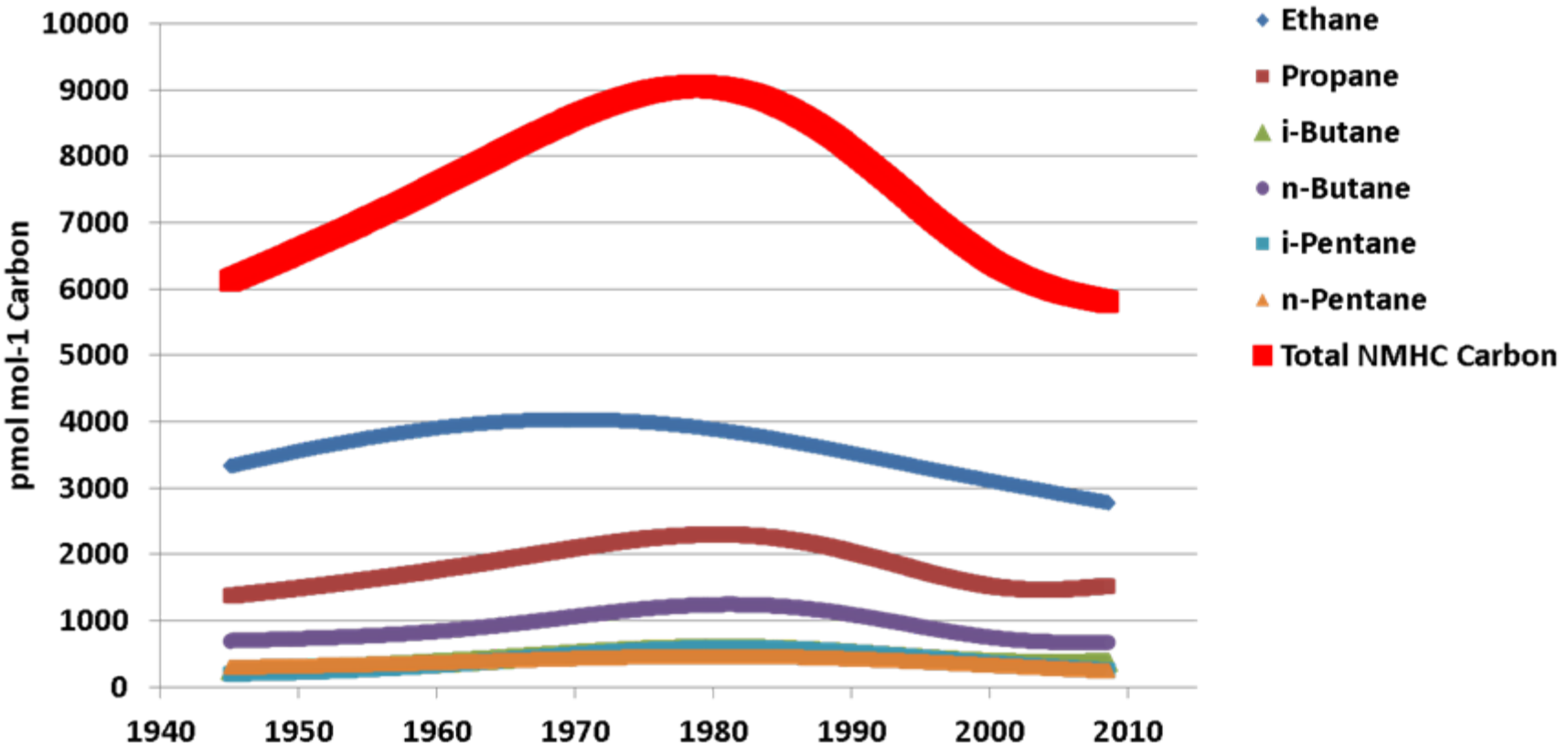
5. Evaluate Results using Fit Curves to Flask Data

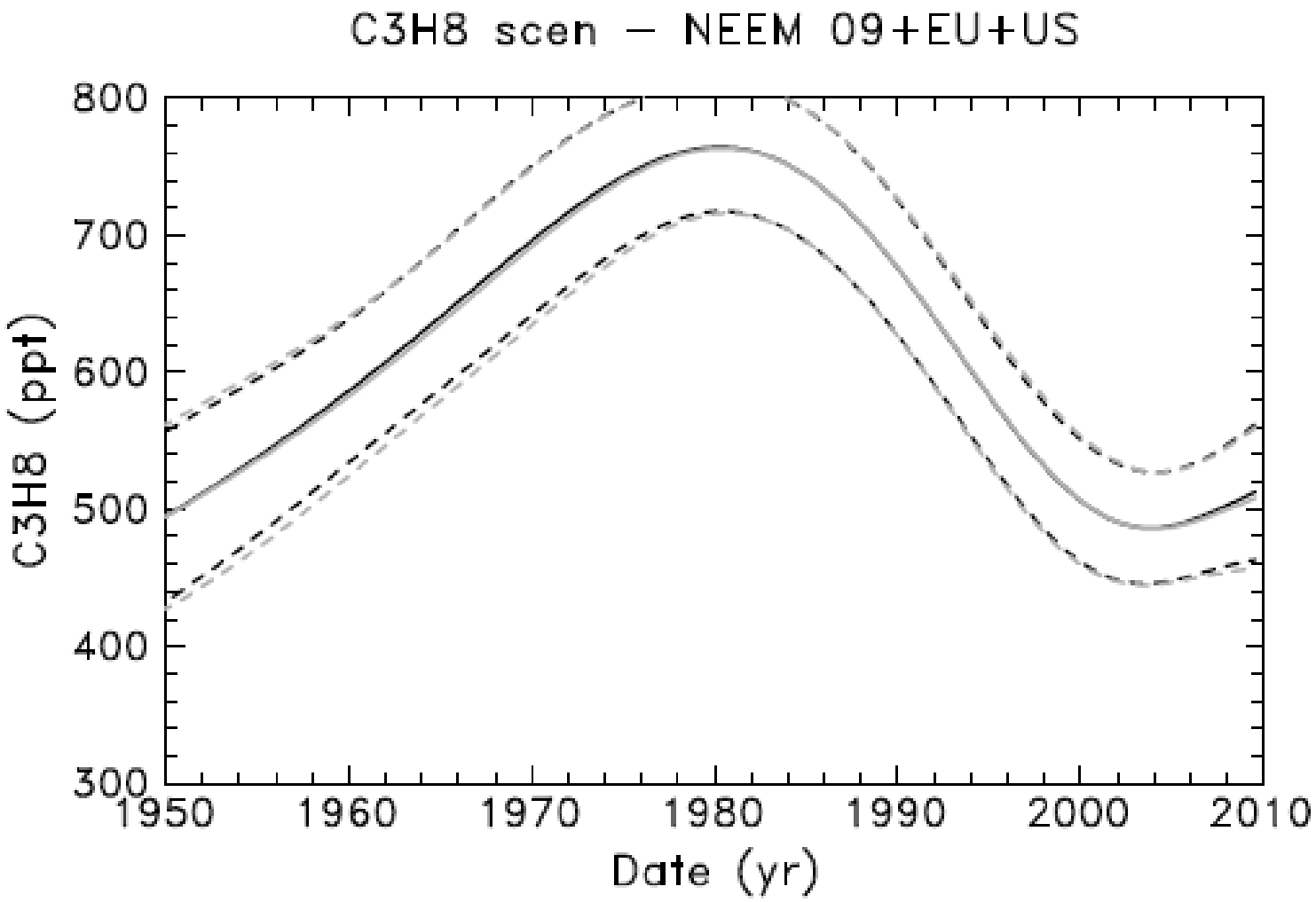


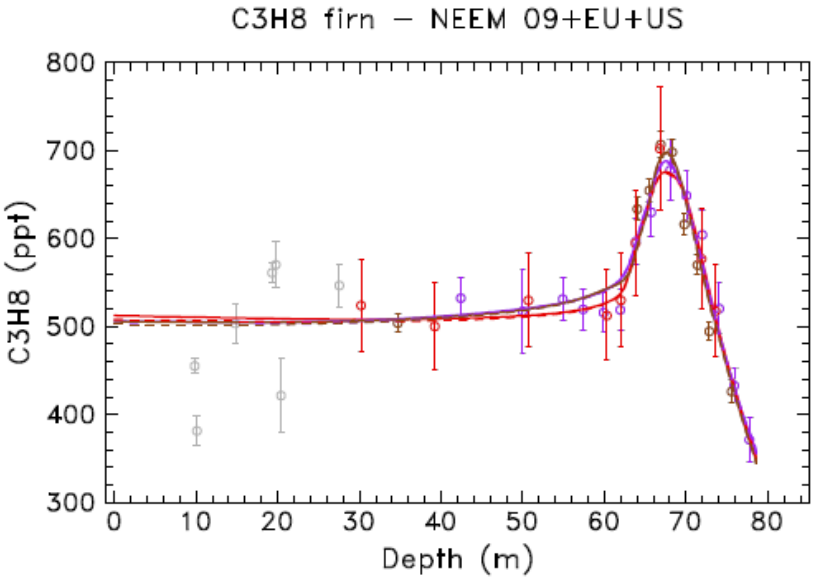
NEEM Firn Air Hole NMHC and Methane Results



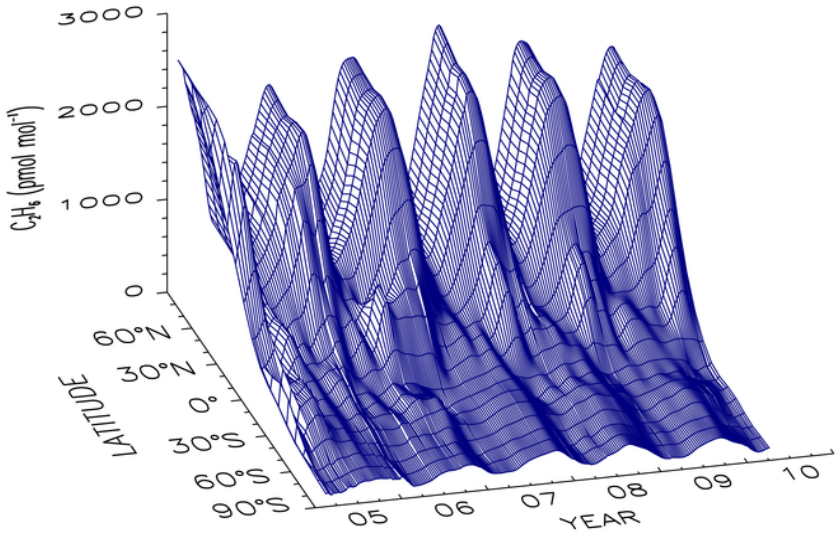
Total Carbon Trends from Firn Air Data

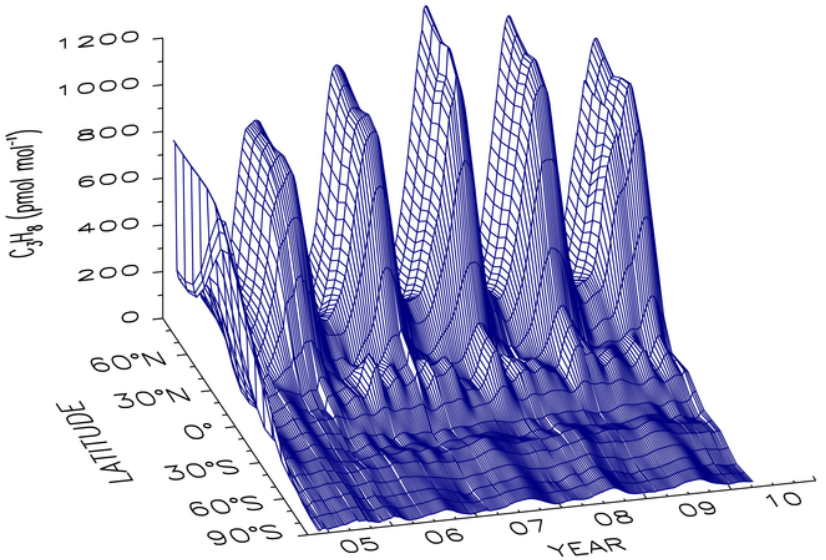


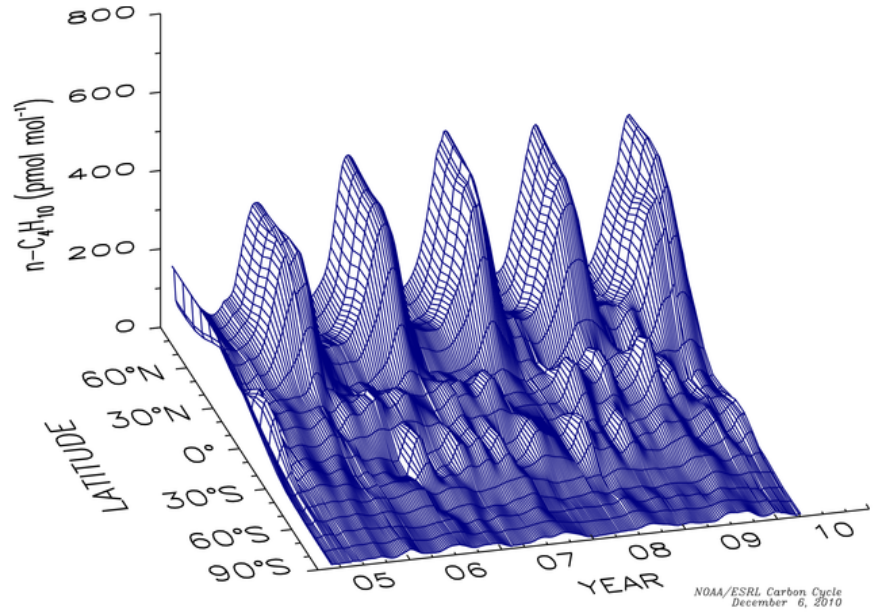

C3H8 scen – NEEM 09+EU+US
C3H8 (ppt)
800
700
600
500
400
300
1950
1960
1970
1980
1990
2000
2010
Date (yr)

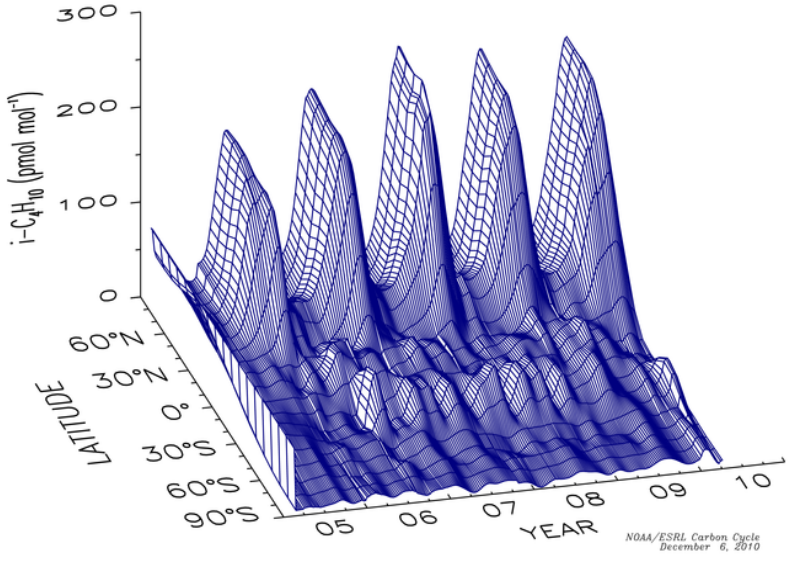

C3H8 firn – NEEM 09+EU+US
C3H8 (ppt)
800
700
600
500
400
300
0
10
20
30
40
50
60
70
80
Depth (m)

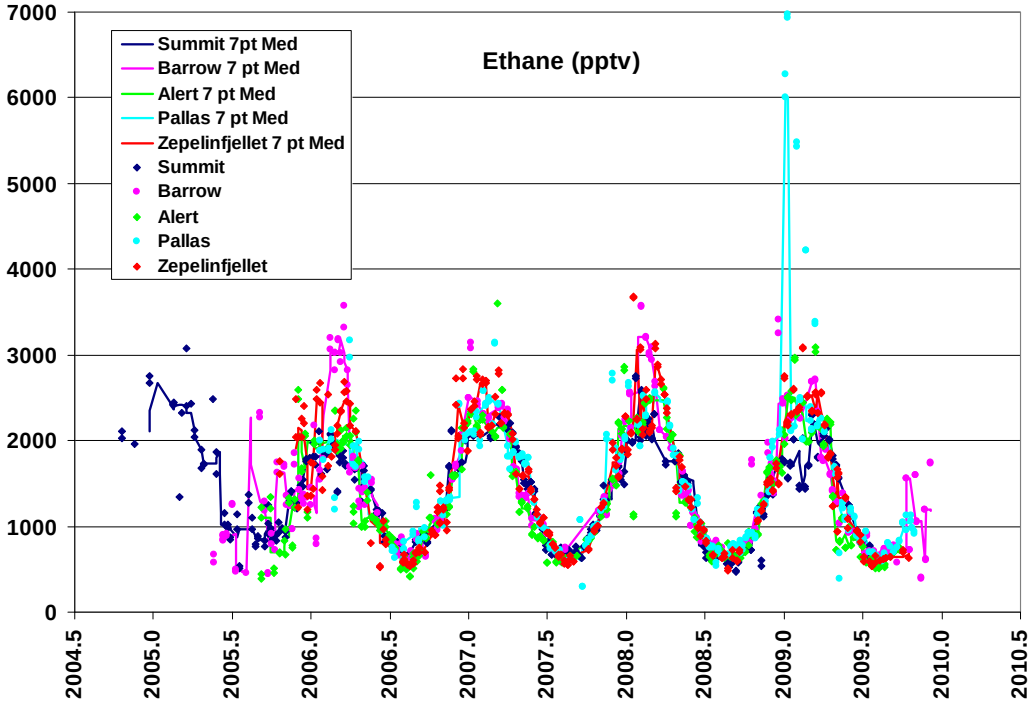
Ethane, Propane, *n*-Butane, *i*-Butane Comparison

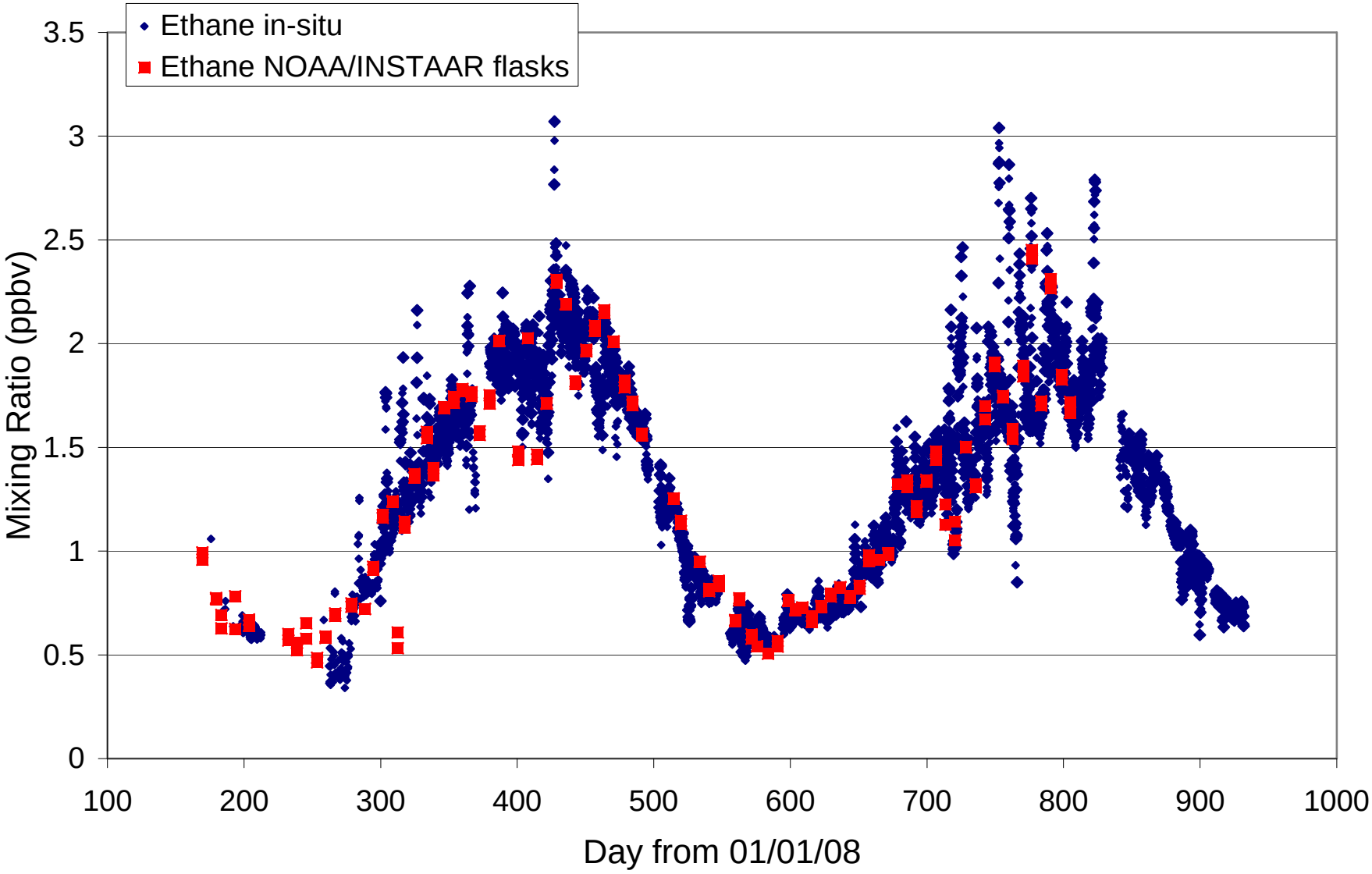









Ethane (pptv)
Summit 7pt Med
Barrow 7 pt Med
Alert 7 pt Med
Pallas 7 pt Med
Zepelinfjellet 7 pt Med
Summit
Barrow
Alert
Pallas
Zepelinfjellet
7000
6000
5000
4000
3000
2000
1000
0
2004.5
2005.0
2005.5
2006.0
2006.5
2007.0
2007.5
2008.0
2008.5
2009.0
2009.5
2010.0
2010.5


Ethane in-situ
Ethane NOAA/INSTAAR flasks
Mixing Ratio (ppbv)
3.5
3
2.5
2
1.5
1
0.5
0
100
200
300
400
500
600
700
800
900
1000
Day from 01/01/08