Measurements of light alkanes (C$_2$-C$_4$) in firn air at Summit, Greenland (2006) and West Antarctic Ice Sheet Divide, Antarctica (2005): Is there evidence for a recent decline in polar tropospheric levels?

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Acknowledgements: S. Montzka and J. Butler (NOAA/ESRL-GMD) – UCI flask data
Blake-Rowland Lab. (UCI) – surface flask data
E. Atlas (U. of Miami) – firn data
Todd Sowers (Penn State) – field
NSF/OPP – support
ICDS – drilling support
NMHC’s – light alkanes ($\text{C}_2\text{H}_6$, $\text{C}_3\text{H}_8$, $\text{n-C}_4\text{H}_{10}$)

Precursors of $\text{O}_3$ and $\text{CO}$ and a removal mechanism for $\text{OH}$

Summer $\text{OH}$ lifetimes: $\tau_{\text{ethane}} = 1$-2 months, $\tau_{\text{propane}} = 8$-20 days, $\tau_{\text{butane}} = 2$-10 days

**Anthropogenic sources**
- natural gas and oil leaks
- Automotive, biomass burning

**Natural sources**
- biomass burning
- oceanic, vegetative, soil emissions (smaller)

**Firn air records and modeling**

- Smoothed (low-pass filter) records
- Site characteristics impact smoothing
- Exact age calculation impossible
- All ages ($\text{CO}_2$, CFC-12, mean) represent an integrated average
- Summit and WAIS-D firn modeling with diffusivity tuning using $\text{CO}_2$ and CFC-12.
Summit surface measurements 1997-2007 and seasonality in Summit firn (Blake-Rowland and UCI)

- No clear long-term trend
- Mean levels
  - ethane: 1250-1500 ppt
  - propane: 400-600 ppt
  - n-butane: 150-250 ppt
- Annual mean signal observed in firn below 40 m
Summit UCI firn data (ethane, propane, \( n \)-butane)

Change in alkanes 1970-1990

<table>
<thead>
<tr>
<th></th>
<th>( C_2H_6 )</th>
<th>( C_3H_8 )</th>
<th>( n-C_4H_{10} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate</td>
<td>29 ppt/y</td>
<td>9 ppt/y</td>
<td>4 ppt/y</td>
</tr>
<tr>
<td>Overall</td>
<td>27%</td>
<td>27%</td>
<td>28%</td>
</tr>
</tbody>
</table>
Summit (UCI) and NGRIP (E. Atlas), Greenland data (depths > 40 m)

Similar trends at both sites:
1970s peak, decrease during 1980s and on

Apparent disagreement
- \( \text{C}_2\text{H}_6 \): bottom of the firn
- \( \text{C}_3\text{H}_8 \): shallow firn
- \( n-\text{C}_4\text{H}_{10} \): shallow firn
- No spatial variability, no clear long-term trend
- Mean levels
  - $\text{C}_2\text{H}_6$: ~200 ppt
  - $\text{C}_3\text{H}_8$: ~25 ppt
  - $n-\text{C}_4\text{H}_{10}$: ~8 ppt
- Annual mean below 40 m at WAIS-D (similar to Summit)
WAIS-D UCI firn data ($C_2H_6$, $C_3H_8$, $n-C_4H_{10}$)

**WAIS-D ethane**
- stabilization in 1980s
- drop in 1990s (~30%)

**WAIS-D propane and $n$-butane**
- More noise
- May be a similar drop in propane

Incorporation of atmospheric signal into firn

Ethane at WAIS-D (2005)
WAIS-D (UCI) and South Pole (E. Atlas) data (depths > 40 m)

- WAIS-D and SPO agree, trends from DML don’t (more/better data from Antarctica)

- SPO and WAIS-D data together suggest a ~30% decline in ethane
  - Roughly synchronous with changes at Summit, Greenland

- Fidelity of firn record still a question
WHY are NMHC’s decreasing at polar latitudes? (possibly globally!)
Sources: Fossil fuel consumption
Sink: OH, Cl

Sources: Hydrocarbon fuel use efficiency must have improved dramatically?

- Consumption/production going up
- Short lifetimes imply source loading must be continually dropping
- Both hemispheres (may be)

Source: Energy Information Administration, Office of Energy Markets and End Use
Can we trust the fidelity of the firn record?

**Surface air analysis:**
- Ongoing at UCI with NOAA flasks

**Firn air data – firn modeling:**
- back to Summit in 2008
- new SPO firn sampling in 08-09