Measurements of Light Alkanes (C_2-C_4) in Firn Air at Summit, Greenland and West Antarctic Ice Sheet Divide, Antarctica: Is there Evidence for a Recent Decline in Polar Tropospheric Levels?

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Light alkanes are an important part of the tropospheric photochemical system, acting as precursors for ozone (O_3) and carbon monoxide (CO) and as a removal mechanism for the hydroxyl radical (OH.) In this study, we report measurements of ethane (C_2H_6), propane (C_3H_8), and n-butane (n-C_4H_{10}) in firn air collected at Summit, Greenland (May-June 2006) and West Antarctic Ice Sheet Divide (WAIS-D) (Dec-Jan 2005-2006.) C_2H_6, C_3H_8, and n-C_4H_{10} levels in Summit firn were in the 1.5-2.0 ppb, 400-600 ppt, and 150-250 ppt range, respectively. These levels are within the range of modern mean annual levels in surface air. C_2H_6, C_3H_8, and n-C_4H_{10} mixing ratios measured in the WAIS-D firn were much lower than the Summit values, ranging from 200-300 ppt, 20-40 ppt, and 10-20 ppt, respectively. This is consistent with expectations from the interhemispheric differences in the distribution of sources for these short-lived gases.

The reliability of firn air as an archive for tropospheric levels of light alkanes was assessed by comparison of firn air records to surface air flask measurements. If the firn air alkane data are interpreted as atmospheric histories, the depth profiles suggest that there has been a decline on the order of 25-30% in annual mean levels over Greenland between 1970 and 1990. WAIS-D data suggest steady C_2H_6 levels over the West Antarctic Ice Sheet in 1980s, followed by a 25-30% decline in the 1990's. Trends in C_3H_6 and n-C_4H_{10} data from WAIS-D are harder to interpret due to higher noise in the measurements resulting from lower background levels.

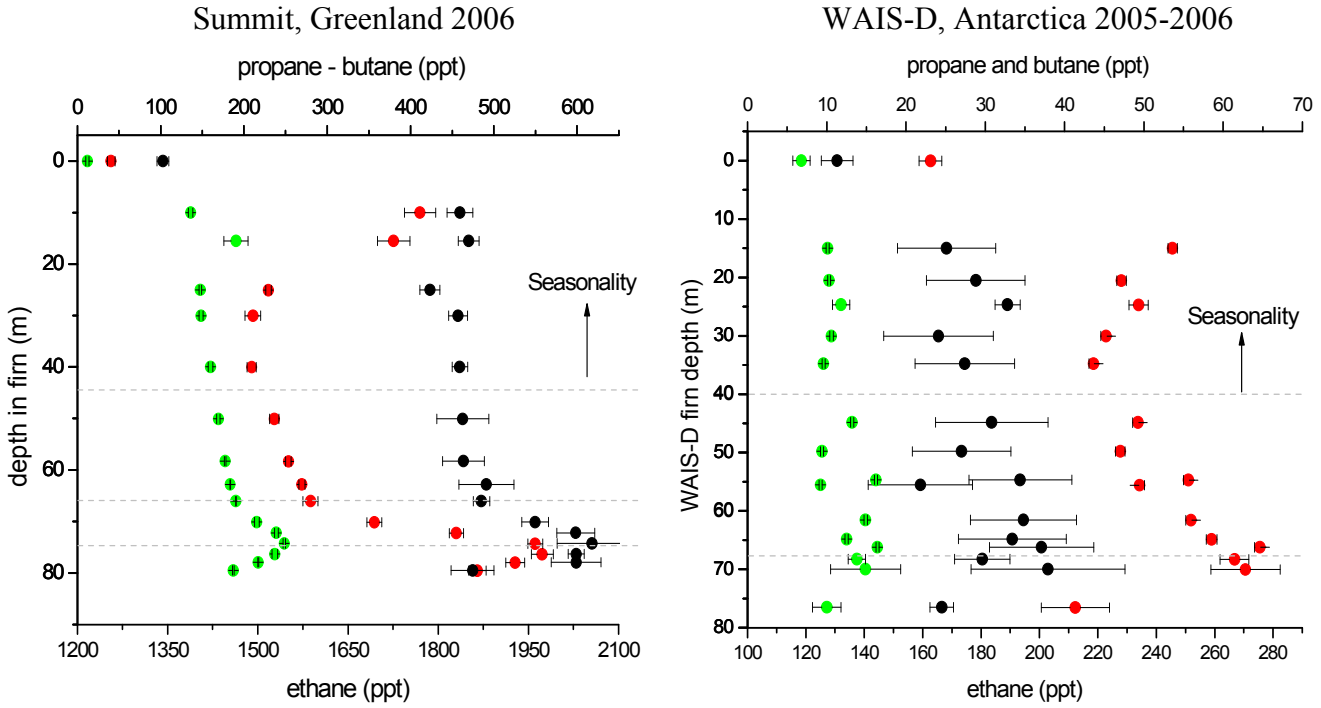

Figure 1. Depth profiles of ethane (red), propane (black), and n-butane (green) measured in firn air from Summit, Greenland (left) and West Antarctic Ice Sheet Divide, Antarctica (right). Light alkanes display strong seasonality in polar latitudes because their primary sink is OH oxidation. Modeling experiments suggest that the effects of this seasonality do not penetrate to depths deeper than 40m.