A 20th Century Atmospheric History of Ethane and Implications for the Methane Budget

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Atmospheric ethane is an abundant non-methane hydrocarbon derived primarily from fossil fuels, biofuel use, and biomass burning. The primary loss pathway is through reaction with hydroxyl radical, which controls the lifetime and seasonality of ethane in the troposphere (~1-2 months during summer). Firn air results from South Pole and West Antarctic Ice Sheet-Divide, Antarctica show that ethane mixing ratios in the high southern latitudes increased from ~80 ppt in 1920 to ~280 ppt in the 1980s, then declined to the present day level of ~210 ppt over the last 20 years. Firn air measurements at Summit, Greenland are consistent with the timing of this increase, stabilization, and decline. At Summit, ethane levels increased from ~1.7 ppb to 2 ppb between 1950-1980, followed by a decline to the present day level of about 1.4 ppb between 1980-2000. The ramp-up and decline in atmospheric ethane was about 8-10 times larger in the northern hemisphere than in the southern hemisphere, indicating the observed variability is largely driven by changes in fossil fuel emissions. Interestingly, the late 20th Century decline in ethane coincides with a decrease in the atmospheric growth rate of methane, suggesting a common cause. The most likely explanation is a reduction in hydrocarbon emissions during the production, transport, storage, and/or use of fossil fuels. Assuming a fixed methane to ethane ratio for the fossil fuel source, the reduction in fossil fuel emissions required to explain the 1980-2000 ethane decline is much larger than that needed to explain the observed decline in the methane growth rate over the same period. Possible alternative explanations include changes in the ratio of methane/ethane emitted from fossil fuels or changes in the atmospheric abundance of chlorine atoms, which preferentially oxidize ethane relative to methane compared to their respective reaction rates with hydroxide.

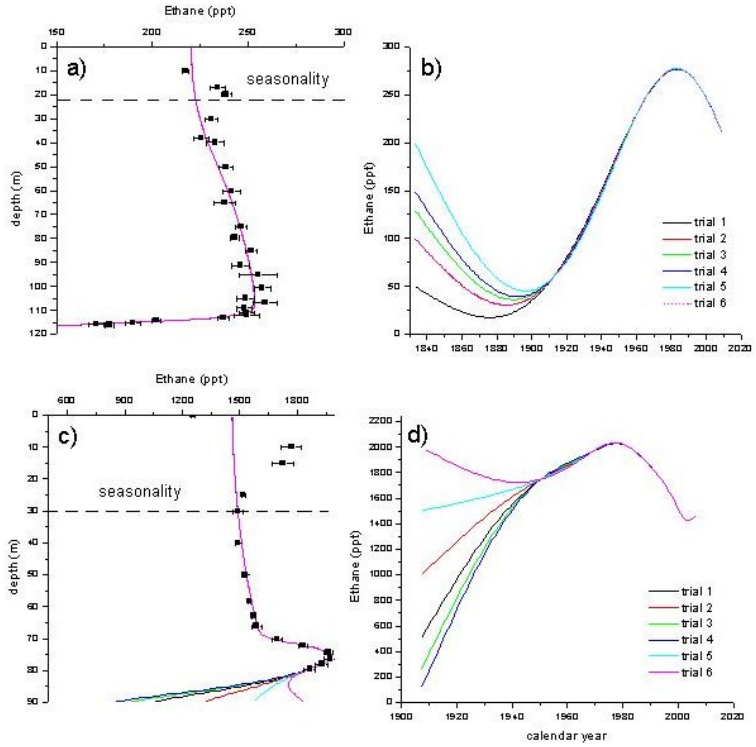

Figure 1. Atmospheric ethane histories for the past century derived from firn air measurements at South Pole (a and b) and Summit, Greenland (c and d). Fits to the firn air measurements were determined using a 1-D firn diffusion model (figures a and c for South Pole and Summit, respectively). The various curves show optimized fits using different starting conditions (see legend, trials 1-6 in panels b and d). At South Pole, all the fits converge from 1920 onward, indicating that the atmospheric history from 1920-present is insensitive to assumptions about preindustrial ethane levels (figure b). The Summit firn data constrain the ethane variability between 1950-2000 (figure d).