# Volatile Organic Compounds and Their Oxidation Chemistry in the Arctic Troposphere

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## Summary

Atmospheric lifetimes of Volatile Organic Compound (VOC) depend on their chemical structure and therefore vary by molecule. Consequently, analyses of a series of VOC can be applied as a powerful tool for assessing impacts and transport times of polluted air to remote sites. The series of short chain atmospheric non-methane hydrocarbons (NMHC) is particularly valuable. Their lifetimes span days (hexane) to several months (ethane), thereby providing a wide dynamic range for studying atmospheric processes. NMHC have been measured since 2004 in flask samples collected bi-weekly at five arctic sites (i.e. north of the arctic circle) at Barrow, AK; Alert, Nunavut; Svalberg (Zeppelinfjellet), Spitzbergen; Pallas, Finland, and Summit, Greenland, within the NOAA greenhouse gas and VOC monitoring program. These data are providing new insights into atmospheric transport into the Arctic, and seasonal and latitudinal trends of the oxidation behavior of the arctic atmosphere. Despite the fact that sources of VOC are small in the arctic environment, ambient background levels and seasonal cycles are larger than in any other remote environment on Earth. This behavior is a result of a) the atmospheric import of lower Northern Hemisphere air into the Arctic, and b) from the stark contrast in the seasonal oxidation capacity of the arctic troposphere. At Summit, in-situ VOC measurements began in 2008. These much higher time resolution data (~ 3 hours) allow identification of occurrences and transport times of events bringing air with elevated VOC concentrations to the center of Greenland. Combined, these data provide convincing evidence that VOC in the high Arctic atmosphere are determined by anthropogenic and biomass burning emissions originating from lower latitude regions of the Northern Hemisphere.

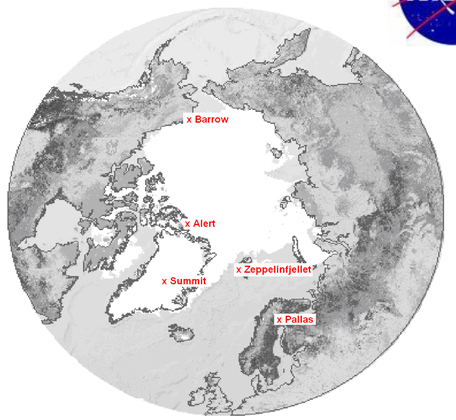
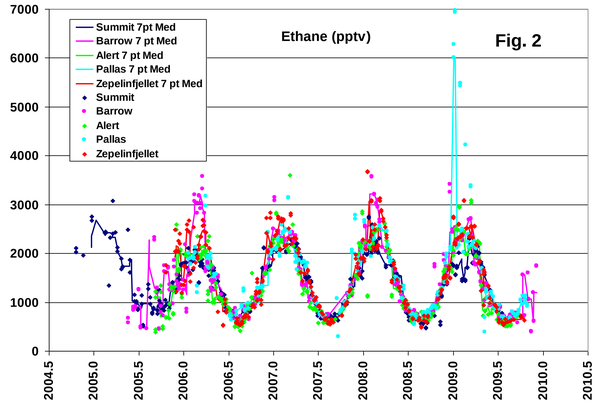
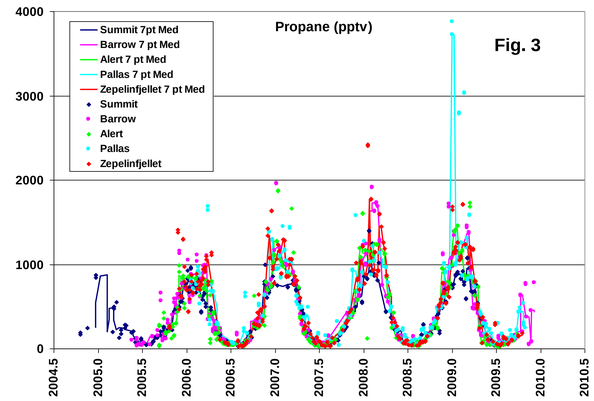
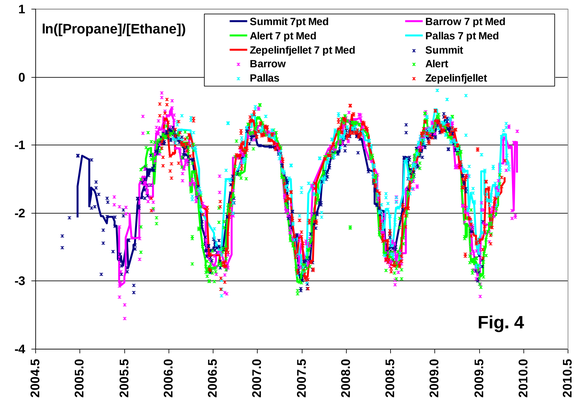


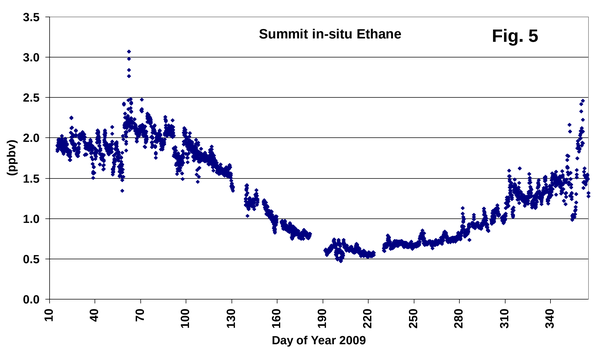

**Figure 1.** Location of the five sites north of the arctic circle that participate in the NOAA-INSTAAR atmospheric VOC monitoring program.

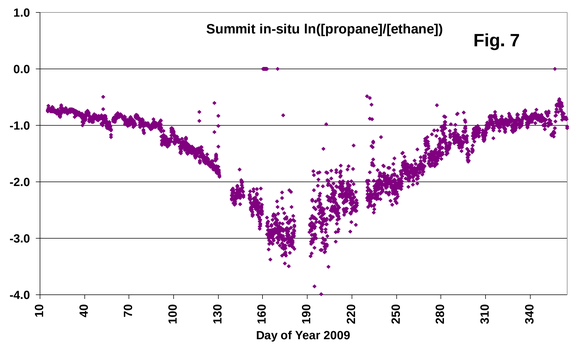
**Figures 2-4 (right):**
Five years (2005 – 2010) of data from NMHC monitoring in flask samples collected within the NOAA Cooperate Greenhouse Gas Sampling Network. All five sites show similar behavior in ethane and propane concentrations and seasonal cycles, despite their far geographical separation. The natural logarithm of [propane]/[ethane] is a sensitive indicator of photochemical aging of air masses. Again, data from these sites show very similar absolute values and seasonal behavior. The lack of stark gradients and the similarity in these data are indicative of the fast air transport and deep circulation of the lower arctic troposphere.

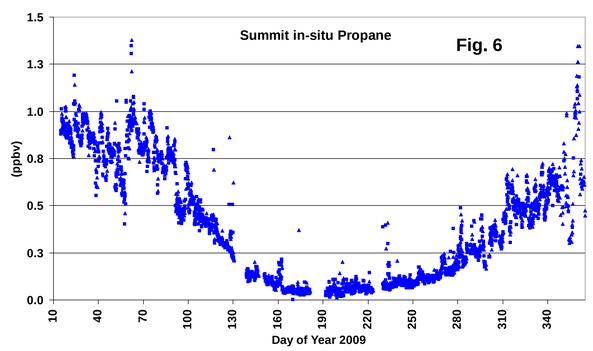


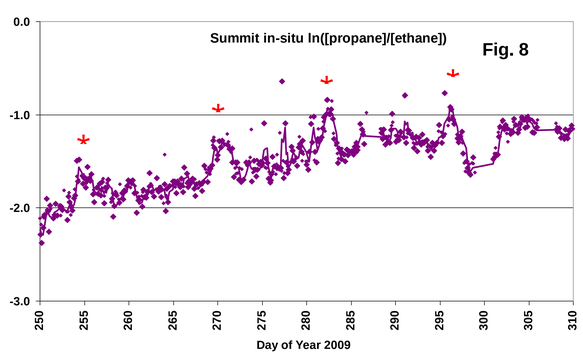




**Figures 5-8 (left):**
One year of ethane and propane data from in-situ monitoring of NMHC by a gas chromatography system operated at the FLUX facility at Summit. These data show the same absolute concentration ranges and seasonal cycle as seen in the flask data (Figs 2-3). The ln([propane]/[ethane]) ratio minimizes in July, indicating that during this time air encountered at Summit has been subjected to the seasonal maximum of photochemical processing. The much higher temporal resolution in these data allows identification of transport of air with pollution signatures to Summit. These events are characterized by increases in ambient VOC concentrations, with relative enhancements increasing with decreasing molecule atmospheric lifetime. Enhancements of ln([propane]/[ethane]) are frequently observed superimposed on the seasonal cycle. At least four major events, each lasting 3-4 days are observed during the 60-day window enlarged in Fig. 8 (events marked by red asterisks). These data are currently subjected to back trajectory and FLEXPART analyses to decipher the contributions of different source regions, as well as boreal biomass burning emissions, to the observed pollution transport events to the center of Greenland.

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