Climatology and Atmospheric Chemistry of Non-Methane Hydrocarbon Emissions over the North Atlantic

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Introduction

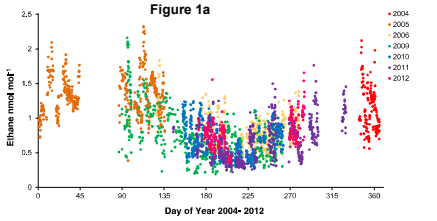
Non-methane hydrocarbons (NMHC) covering the C2 to C7 volatility range have been monitored at the Pico Mountain Observatory, Pico Island, Azores, Portugal, since 2004. The Observatory is located at 2225 m a.s.l. in the caldera of the Pico Mountain volcano, and during most times receives lower free tropospheric air that has been transported across the North Atlantic.

The 7-year NMHC record has been analyzed for seasonal behavior of photochemical processing, atmospheric transport time, and source region using ratios of NMHC species as indicators of photochemical aging and HYSPLIT model outputs. Transport conditions resulting in elevated and low NMHC conditions were specifically studied to investigate seasonal pollution transport in the North Atlantic region.

Methods

The NMHC data spanning these years have been analyzed for their seasonal cycles, short- and long-term variability, and photochemical processing. NMHC absolute mole fractions and the ln([propane]/[ethane]) ratio were used to identify periods with pollution impacts and fast transport to the station. Conversely, low values for these two indicators were tested for their representativeness for clean background air conditions. Transport time, and source region associated with these two conditions were investigated using HYSPLIT back-trajectory model outputs. HYSPLIT transport simulations were created in six hour increments for every month in the data set. Back trajectories were color-coded by the ln([propane]/[ethane]) seen in NMHC.

Results



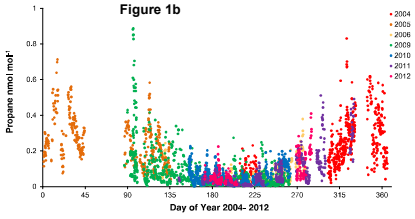


Figure 1
Composite of the ethane (**1a**) and propane (**1b**) results of in-situ air analysis at Pico Mountain during 2004-2012. Note that there are much more data available during the summer, stemming from the fact that the Pico Mountain Observatory has been operated during the winter only on two occasions.

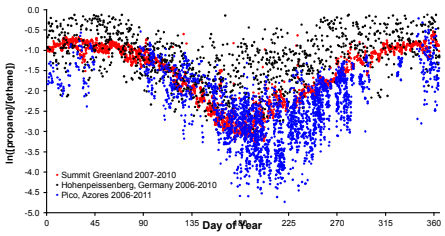


Figure 2
Seasonal cycle of ln([propane]/[ethane]) results in the Pico data in comparison with NMHC in-situ data from, Summit, Greenland, and Hohenpeissenberg, Germany.

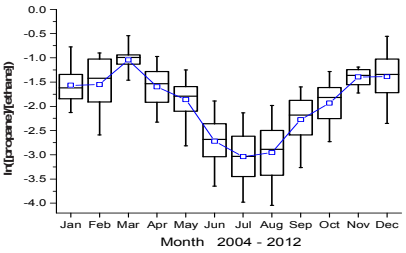


Figure 3
Whisker plots showing the seasonal distribution of ln([propane]/[ethane]) in the Pico NMHC data for the available 2004 -2012 measurements.

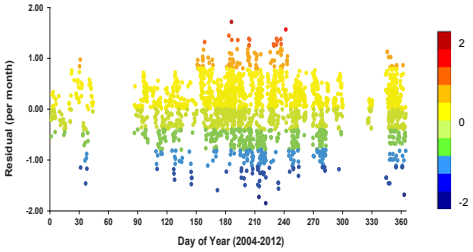
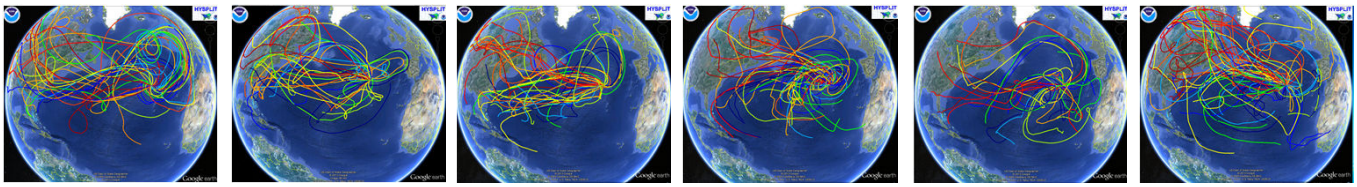


Figure 4
Residuals for the ln([propane]/[ethane]) data at Pico after subtracting the seasonal mean values shown in Fig. 3. Data are color-coded by the colors used for the back-trajectories in Figure 5.



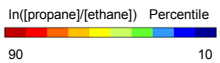


Figure 6
HYSPLIT back trajectory outputs for NMHC sample data at from Pico. The color scale represents the deviation of the ln([propane]/[ethane]) in each particular sample from the seasonal mean value shown in Figure 3. Trajectories closer to the red end of the color bar indicate young photochemical age, or strong pollution influence while those closer to blue represent are representative for well processed air or clean background conditions.

Conclusions

NMHC show a consistent seasonal cycle, with NNMHC maxima during the winter and much lower NMHC mole fractions during the summer. The ln([propane[/[ethane]), here used as an indicator of photochemical processing and/or atmospheric transport time, shows a higher variability during the summer months, indicating more variable transport conditions during that time of year. Emission from the North American continent are the dominating source of elevated NMHC in the Azores region throughout the year. The transport events frequently brought polluted air from urban areas in North America, not just from the East Coast, but also reaching further west into the continental U.S. and Canada. A second source of elevated pollution levels reaching Pico is Northern Canada, where biomass burning plumes are possibly contributing to high NMHC rations observed at Pico.

Future Investigations

Further NMHC measurements are planned for the 2013 and 2014 summers. The scarcity of late fall - spring observations limits a comprehensive evaluation of the seasonal signatures of transport patterns. HYSPLIT analyses of the relative impact of urban versus biomass burning influences are currently in progress.

Acknowledgments

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