Observations of trace gases and methane at the Cape Verde Atmospheric Observatory

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Figure 1: The CVAO site, which was expanded in December 2014 to include new laboratory space and a permanent 10m tower.

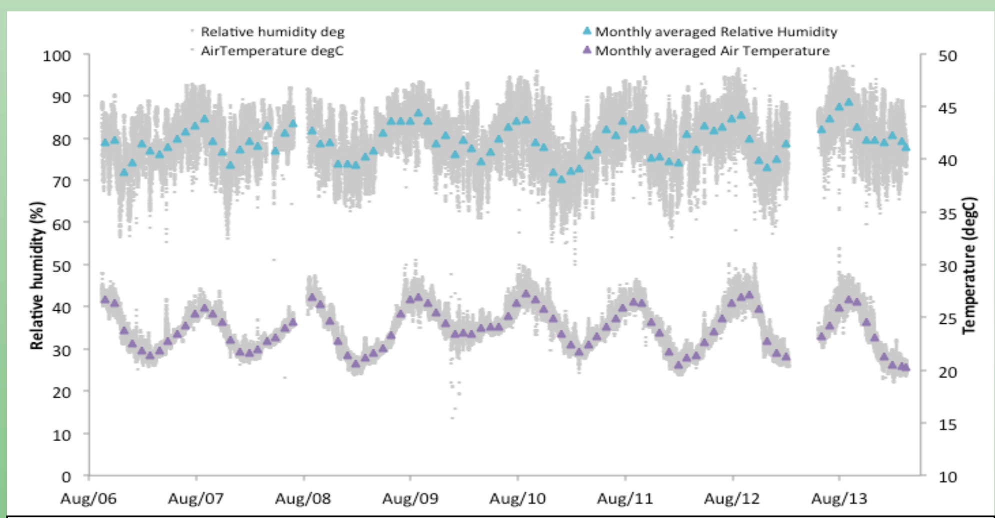


Figure 3: Temperature and relative humidity time-series' from the CVAO.

Introduction

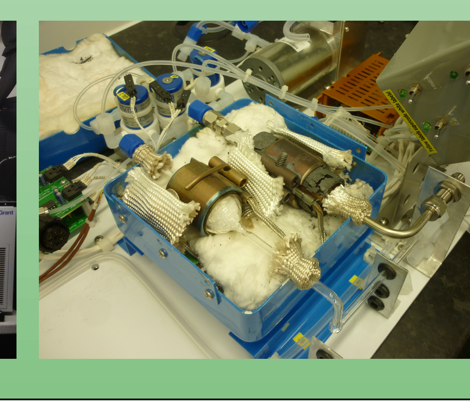
The Global GAW Cape Verde Atmospheric Observatory (CVAO) –Humberto Duarte Fonseca is situated in Calhau on the island of São Vicente in Cape Verde (16.848°N, 24.871°W). Measurements were started in October 2006 to further our understanding of atmospheric chemistry within the tropical marine boundary layer. Funding for the UK trace gases is through the Atmospheric Measurement Facility (AMF) which is a subsidiary of NCAS (National Centre for Atmospheric Science) in the UK. Staff are provided through the Instituto Naçional de Meteorologia and Geofisca (INMG), Cape Verde and other measurements (e.g. of greenhouse gases and aerosol) are supported by our partners at Leibniz-Institut fur Troposphärenforschung, Germany, Max-Planck Institut fur Biogeochemie, Germany,

Here we give an overview of the measurements and some of the science presently coming out of the Observatory.

Figure 2: The 29 Global GAW Stations http://www.wmo.int/pages/prog/arep/gaw/measurements.html








Understanding methane and ethane trends

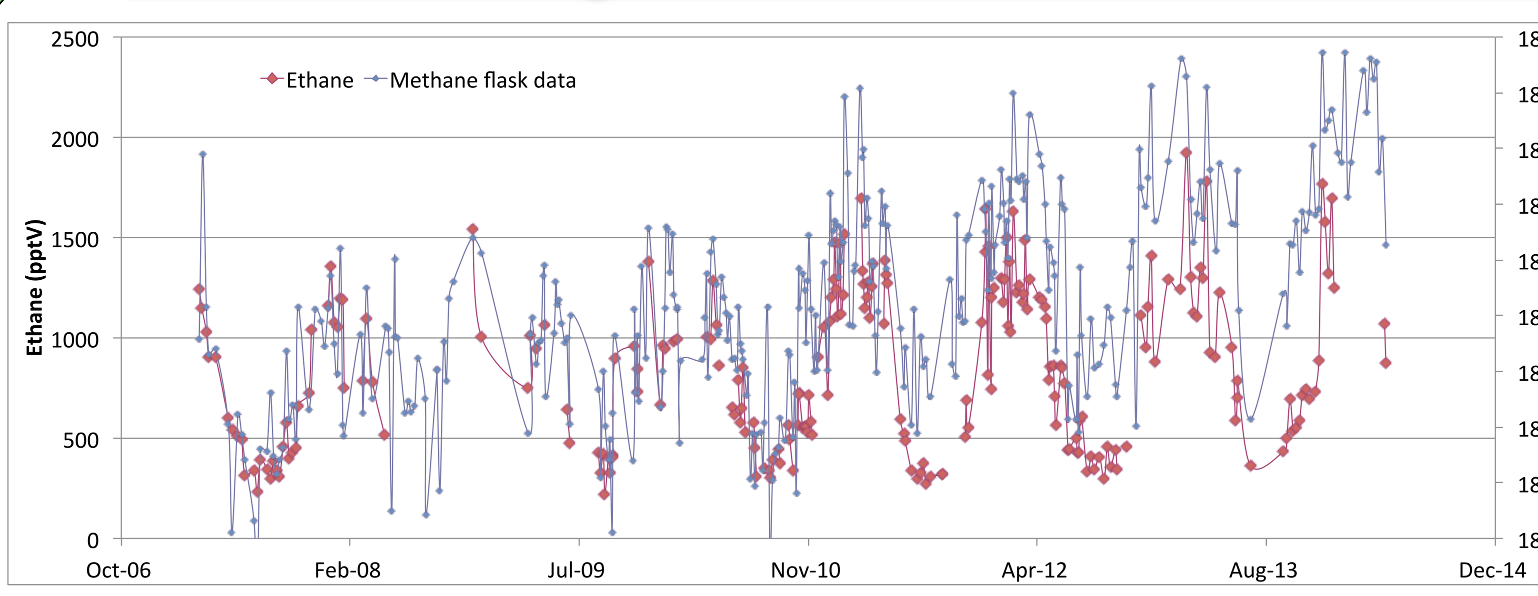


Figure 4: Time-series' of methane and ethane, ethane data is time-matched to the MPI methane flask data (~3 flasks per month).

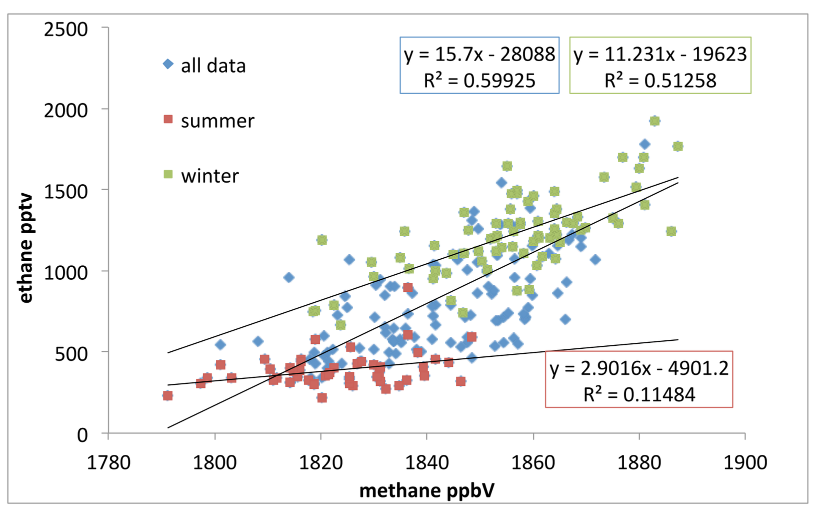


Figure 5: Monthly ethane versus methane, all data (blue), summer only (red) and winter only (green) data are plotted.

Considering species such as ethane alongside methane can help interpret whether changes in CH_4 are due to natural factors e.g. wetlands, man-made effects e.g. fracking or a combination of the two.

Northern hemispheric CH_4 concentrations have been increasing steadily since 2009, a strong correlation with ethane (Figure 5) may suggest the cause is due to man-made effects. Due to a shorter atmospheric lifetime and lower concentrations, the summer ethane levels are more variable leading to a weaker correlation during the summer months.

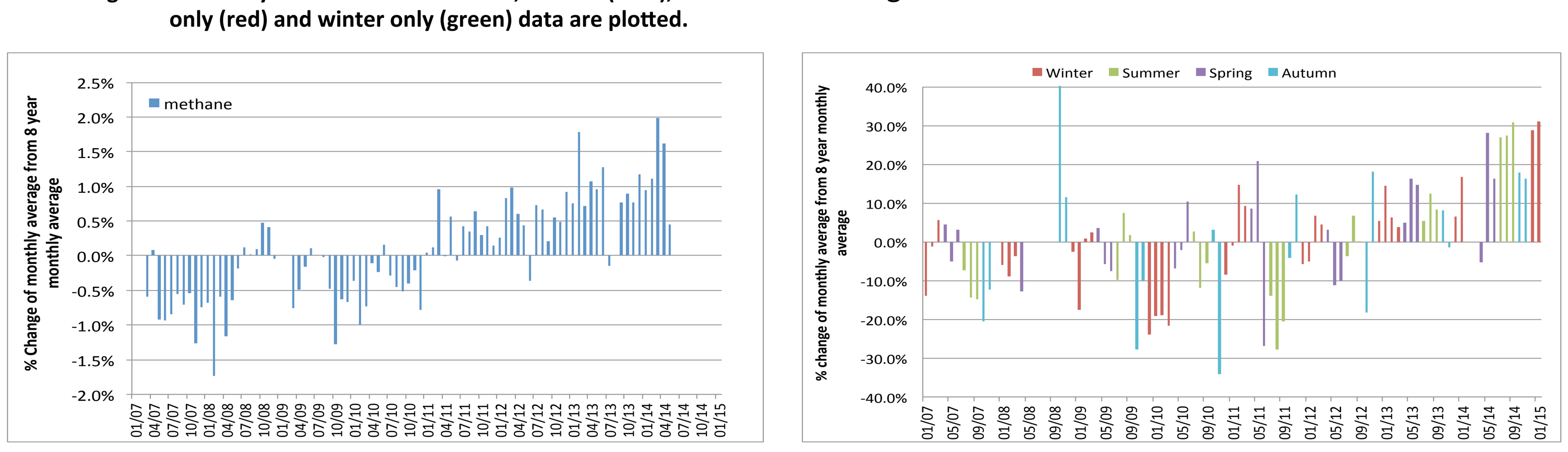


Figure 6a) left Percentage difference between the monthly methane concentrations and the average monthly methane over 8 years. b) right, as methane but for ethane and coloured by season.

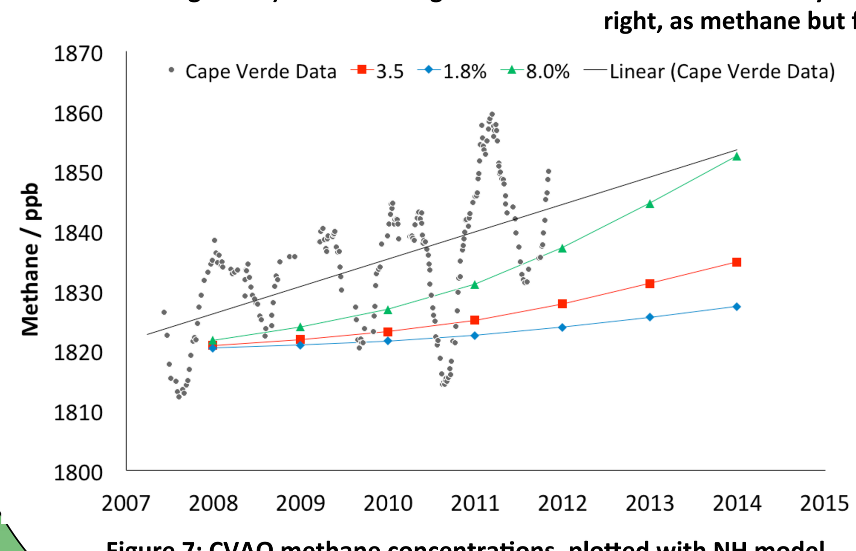


Figure 7: CVAO methane concentrations, plotted with NH model projections of cumulative methane based on emission data from the US Energy administration (1.8%) and from (Howard, 2011) (3.6-7.9%).

Figures 6a) and b) show the percentage difference between monthly concentrations and the average of 2007-2015. The increase is clearer to see in the methane (left) but in percentage terms the ethane (right) increase is more significant.

Figure 7 shows some modelled projections of fugitive shale gas emissions from the US. The Northern Hemispheric projections take into account mixing and decay but otherwise assume that the methane is a direct result of this source. These projections show that emissions from this source could explain some of the recent increases in methane and this could also explain the ethane increase too.

Data quality and archiving: BADC and WDCGG

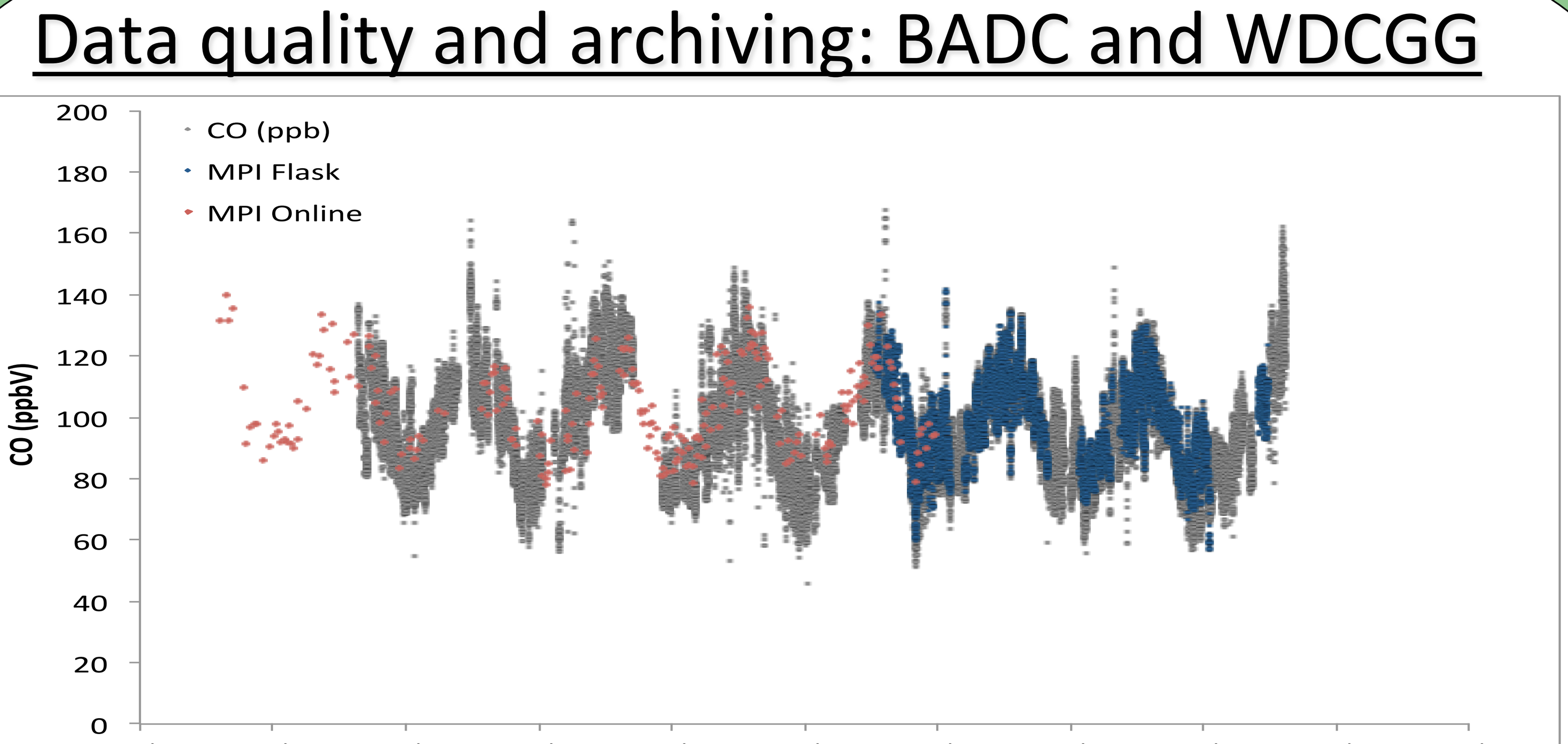


Figure 8: CO measurements using three techniques, Aerolaser VUV-Fluorescence (grey), LGR Off-axis ICOS (blue), flask and subsequent GC analysis (red).

Data is submitted regularly on daily, monthly and yearly timescales to the World Centre for the Greenhouse Gases (WDCGG) http://gaw.kishou.go.jp/wdcgg/ and to the British Atmospheric Data Centre (BADC) http://badc.nerc.ac.uk/home/index.html along with associated instrument metadata. Through GAW the CVAO O_3 and CO data is submitted to the MACC (Monitoring atmospheric composition and climate) project. Data is submitted in near-real-time and global modelled gas concentrations are validated with this data: http://www.gmes-atmosphere.eu/d/services/gac/verif/grg/gaw/

The CVAO performed well in a GAW audit for CO, O_3 and the greenhouse gas species (CVO_2012.pdf) and this and other relevant reports (in particular Nos 171, 195) are available at http://www.wmo.int/pages/prog/arep/gaw/documents/

Tropospheric ozone and other trace gases

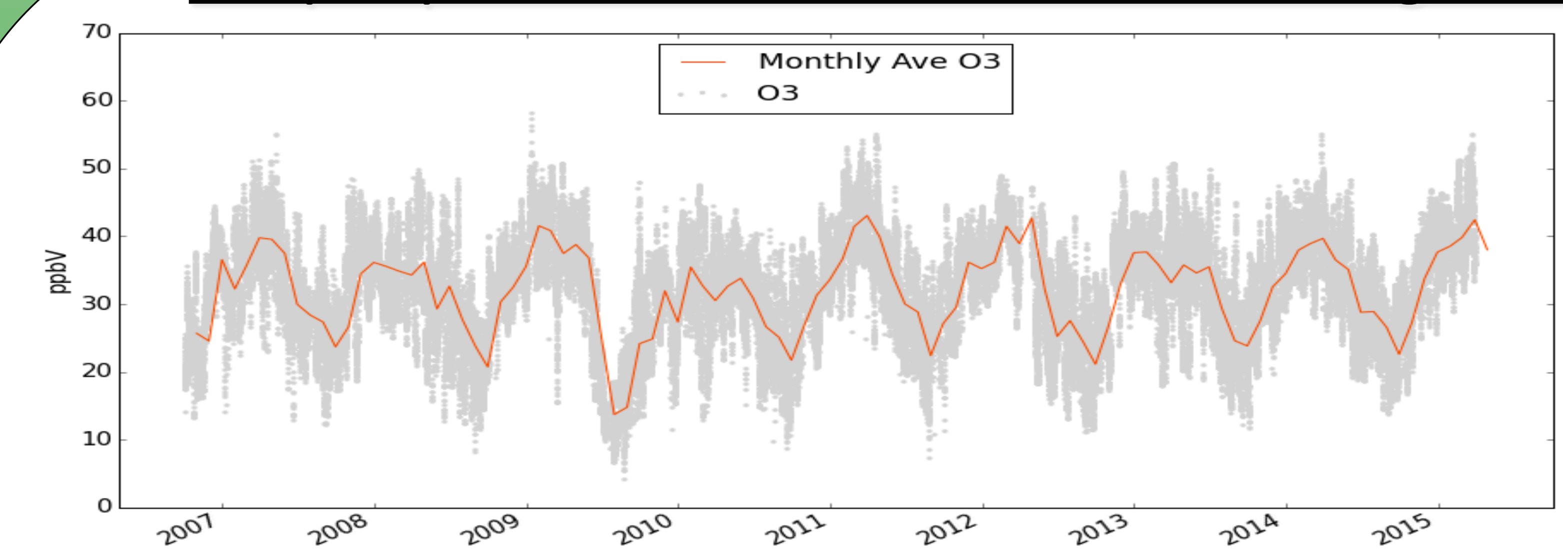


Figure 9: Time-series of ozone, hourly (grey), monthly (red).

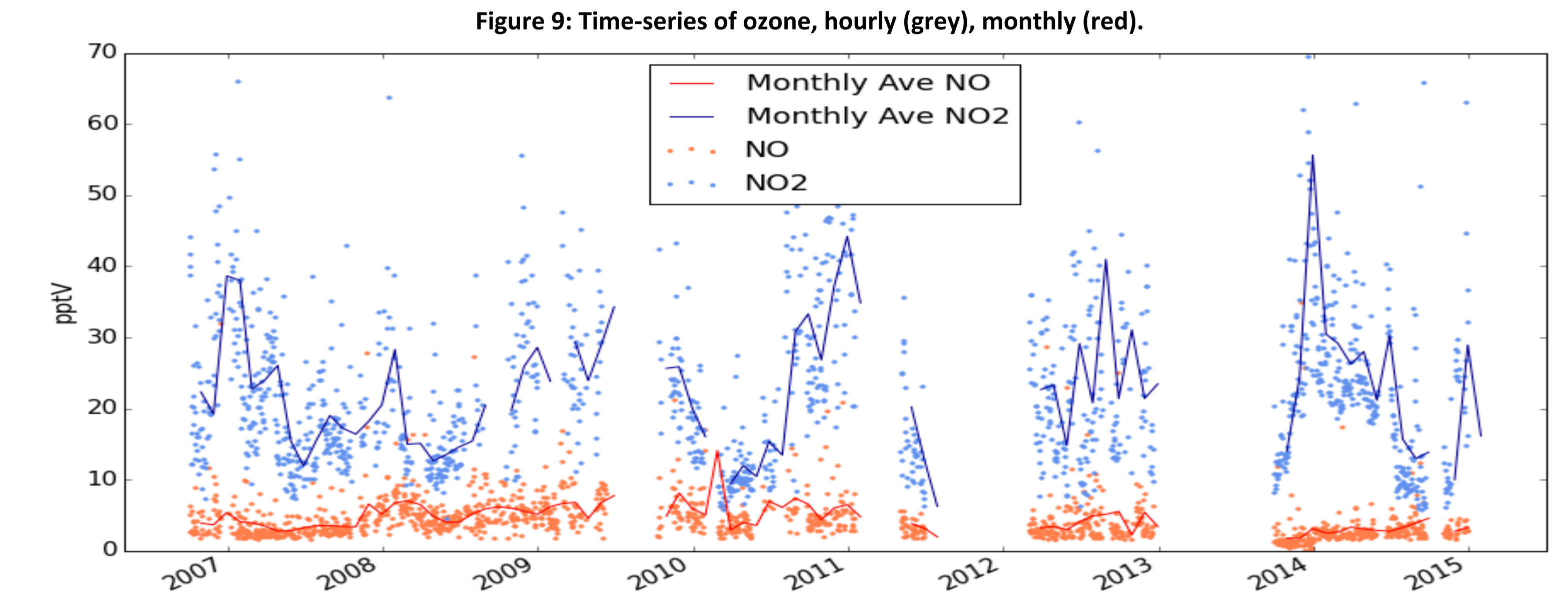


Figure 10: Time-series of NO daily (red dot), monthly (red line) and NO2 daily (blue dot), monthly (blue line).

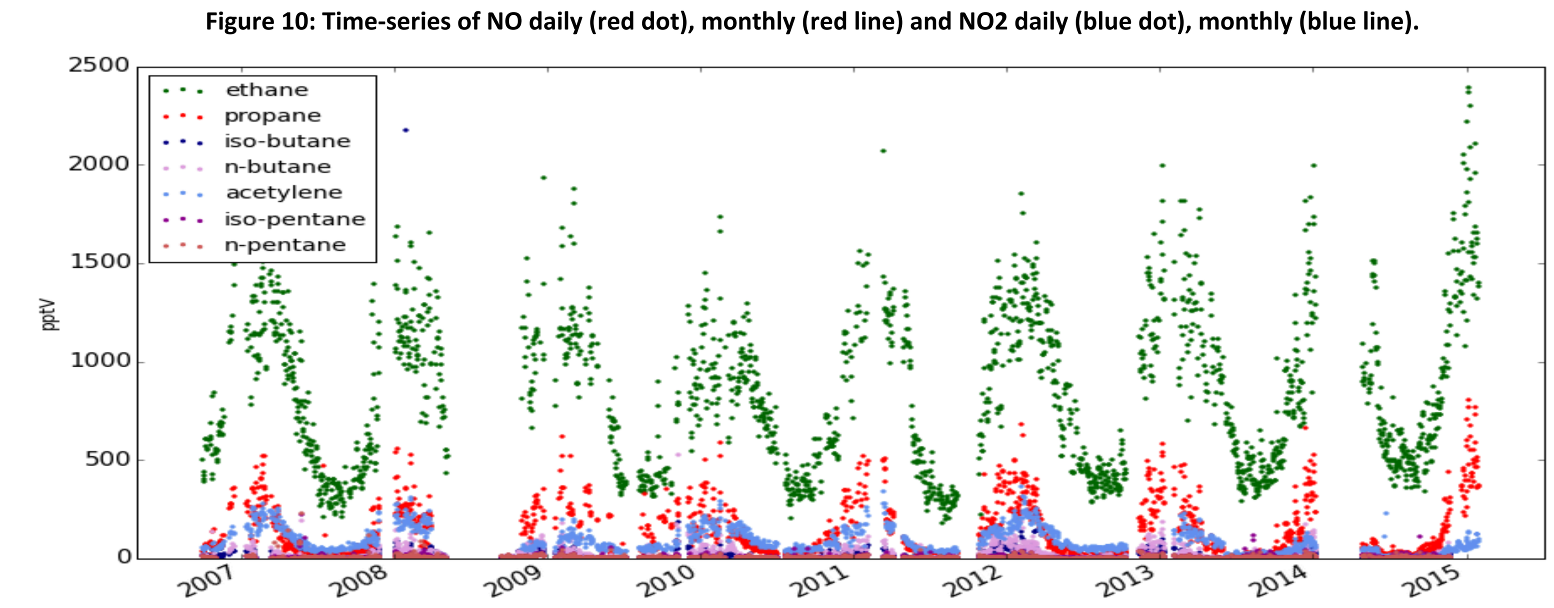


Figure 11: Daily average NMHC measurements.

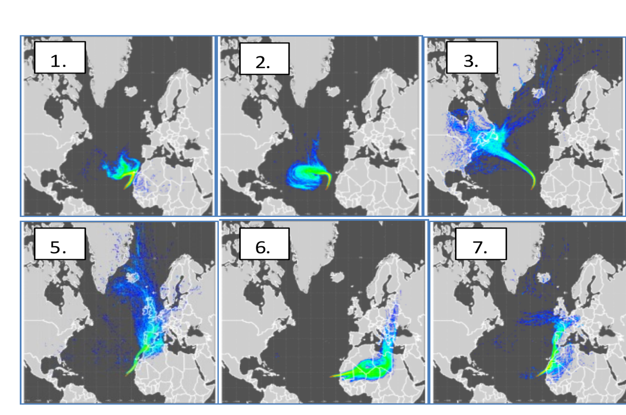


Figure 12: Air mass classifications using the NAME model (L.J. Carpenter et al., J. Atmos. Chem, 2010)

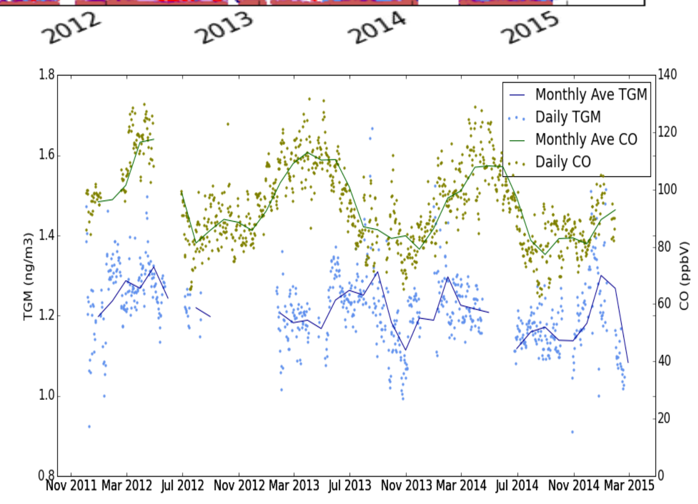


Figure 13: Time-series' of Total Gaseous Mercury (TGM) and Carbon Monoxide.

Delta ozone filtered by air mass shows a negative correlation with the NO 12pm peak in mixing ratio (Figure 14) consistent with its role in the formation of tropospheric O_3. Modelling suggests that a persistent concentration of 17-34 pptV NO could push the region into a net O_3 producing regime (perhaps 5-10 years away) (Lee et al, 2009).

Modelling of the O_3 diurnal suggests that in addition to low NO, halogen oxides may play a major role in the removal of tropospheric O_3 in the wider marine environment (since the CVAO provides data considered by GAW to be representative of at least the North Atlantic ocean if not of the global ocean). (Read et al., 2008, Nature)

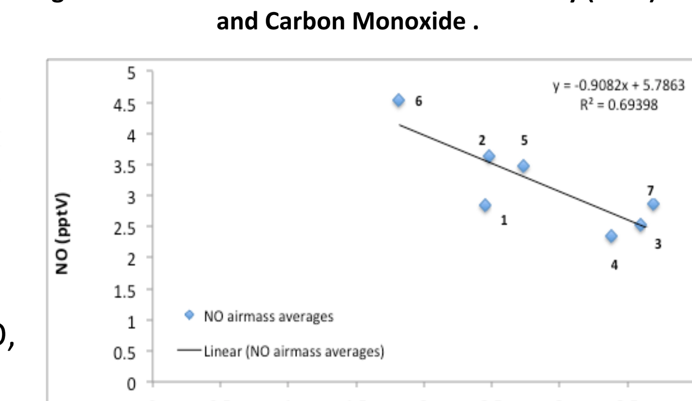


Figure 14: NO (pptV) at 12pm against delta O_3 (9am-6pm). The numbers correspond to the air mass classifications in Figure 12.

Future plans

- An interferometer will be installed in June to make upper atmosphere wind measurements (NCAR).
- The Ice in Clouds Experiment-Dust (ICE-D) flying campaign is taking place around the Cape Verde islands in July-August 2015. The aircraft will be based on Praia but will do some flights around the CVAO. A bio-aerosol spectrometer will be installed at the CVAO.
- HONO will be measured during a short campaign in the Autumn to try and understand some of the NOy questions.
- Investigation of NOy speciation and NOx budget.

Acknowledgements

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http://ncasweb.leeds.ac.uk/capeverde/

For access to the CVAO please go to: https://www.ncas.ac.uk/index.php/en/amf-menu