Long-term measurements from the GAW Cape Verde Atmospheric Observatory (CVAO)

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Figure 1: The 31 Global GAW Stations http://www.wmo.int/pages/prog/arep/gaw/measurements.html

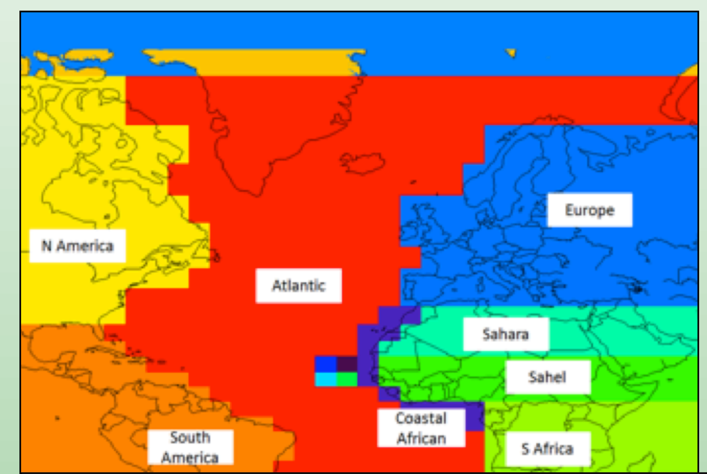

Figure 2: Boundary definition of the eight geographical regions, Coastal African, polluted Marine, Saharan Africa, Sahel Africa, North America, Atlantic marine South America, and, Tropical Africa

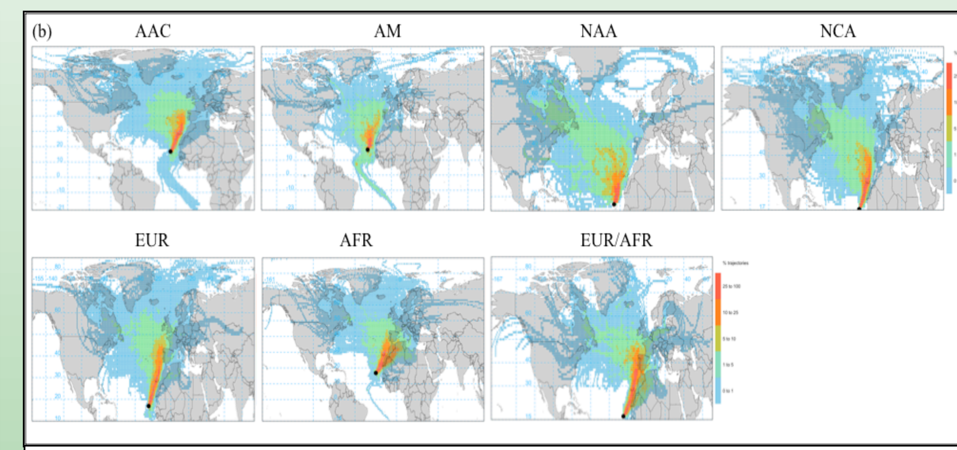

Figure 3: Trajectory frequency maps for each of the seven air mass types using HYSPLIT trajectories and Openair, AAC - Atlantic and African Coastal, AM - Atlantic Marine, NAA - North American and Atlantic, NCA - North American and Coastal African, EUR - European (with minimal African influence), AFR - African (with minimal European influence) and EUR/AFR - European and African.

Introduction to the CVAO

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. Our partners on the CVAO project are the Instituto Naçional de Meteorologia and Geofisca (INMG), Cape Verde, the Max-Planck Institut für Biogeochemie, Germany, and the Leibniz-Institut für Troposphärenforschung, Germany (TROPOS).

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

Four years of Total Gaseous Mercury measurements

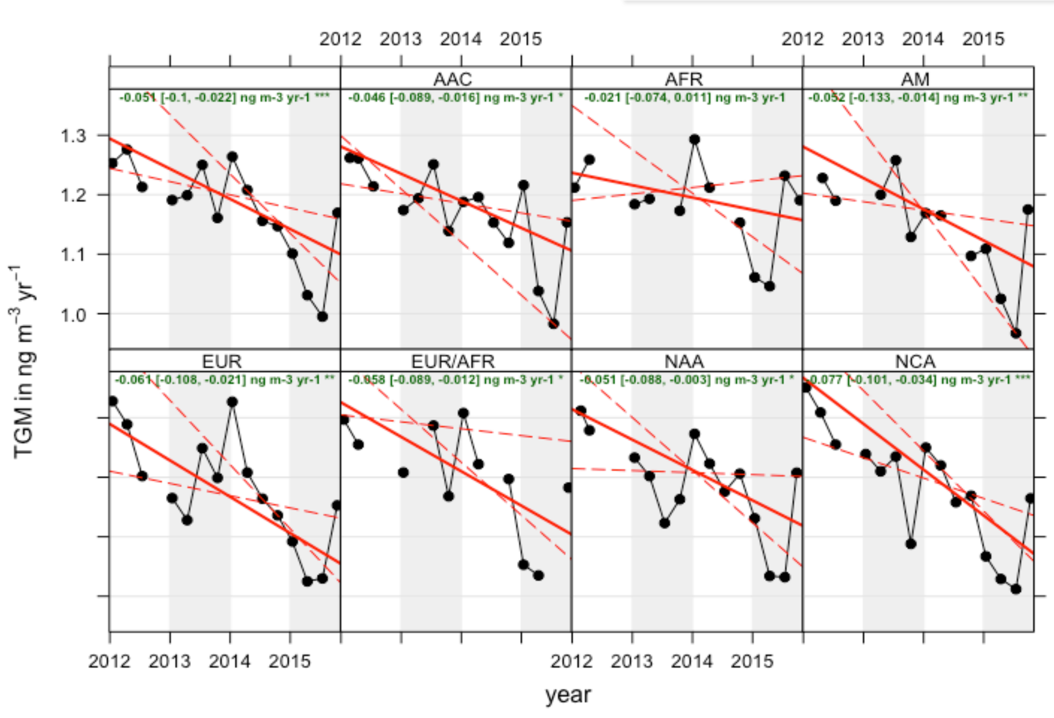

Figure 4: 4-year TGM trends using a Theil-Sen function based on seasonal TGM medians separated by air mass. The data for all air masses is shown in the top left panel with the rest of the panels showing the data separated by the 7 air mass classifications. The slope estimate and the 95% confidence intervals are in brackets (green). The solid red line shows the trend estimate and the dashed red lines show the 95% confidence intervals based on resampling methods.

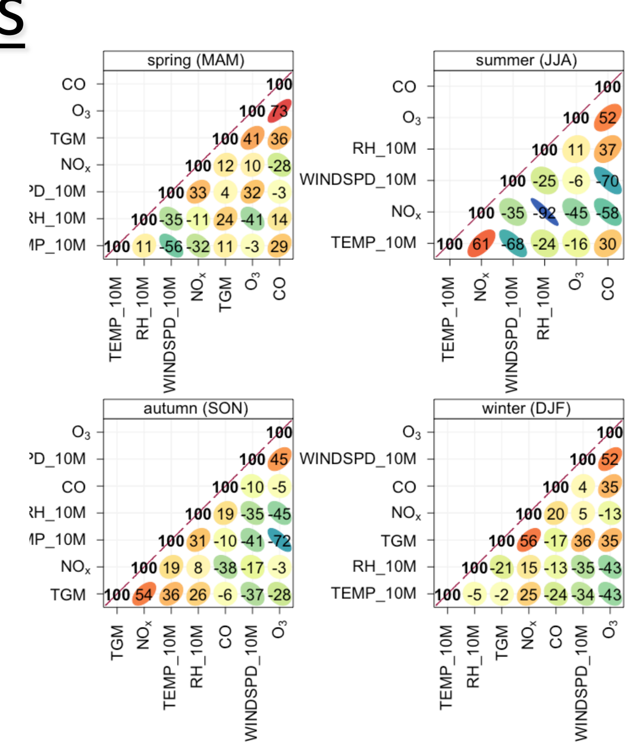

Figure 5: A correlation matrix separated by season to show the correlation between pairs of daily data (Carslaw D.C. and K. Ropkins, 2012). The ellipses are visual representations of a scatter plot. The colour scale highlights the strength of the correlation (red being the strongest and blue the weakest), and the number is the r^2 of the data.

- Decrease of -0.051 ng m^{-3}/yr in the TGM over 4 years suggesting controls on anthropogenic emissions are having an effect.
- AFR air shows the smallest decreasing trend suggesting an influence from an un-regulated/natural source.
- Strong correlation of TGM with CO and O_3 in Spring suggests a shared anthropogenic source.
- No correlation of TGM and CO in autumn suggests biomass burning is not a source for TGM.
- Strong correlation of TGM with NOx in Autumn suggests anthropogenic pollution sources within closer proximity.
- Highest TGM is observed in AFR and EUR/AFR air and may suggest a source from small scale-artisanal gold mining.

K.A. Read, et al., : Four years (2011–2015) of total gaseous mercury measurements from the Cape Verde Atmospheric Observatory, Atmos. Chem. Phys., 17, 5393-5406, doi:10.5194/acp-17-5393-2017, 2017.

Evidence for renoxification in the tropical marine boundary Layer

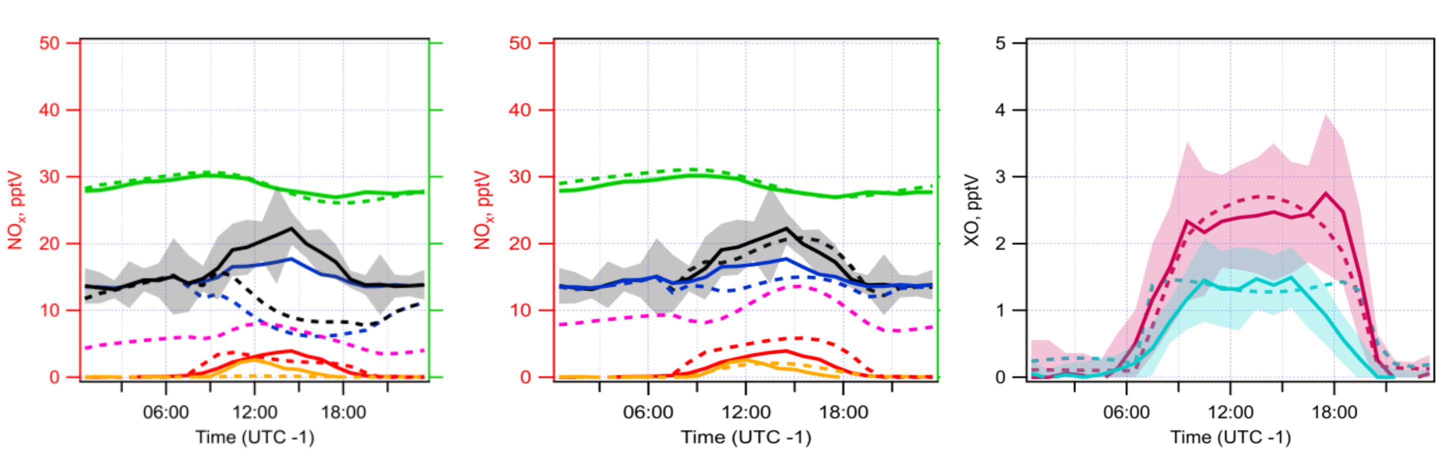

Figure 6: Left plot shows the measurements with original model output, middle plot is the model including nitrate aerosol and halogen chemistry. Colour key: O_3 – green; NO_x – black; NO_2 – blue; NO – red; HONO – yellow; PAN – pink; IO – turquoise; BrO – purple , model-dashed line, measurements-solid line.

- NOx concentrations peak at midday but we expect NO_2 to photolyse and so be at a minimum. Typical box model therefore predicted a minimum at midday (plot far left).
- Measurements of HONO suggest that the daytime source of NOx is likely from the rapid photolysis of nitrate aerosol which produces HONO and NO_2.
- The middle plot shows the model with the inclusion of HOBr+NO3 chemistry and HOI+NO3
- The right plot shows the modelled and measured HOI and HOBr.

C. Reed et al., : Evidence for renoxification in the tropical marine boundary layer, Atmos. Chem. Phys., 17, 4081–4092, 2017 www.atmos-chem-phys.net/17/4081/2017/doi:10.5194/acp-17-4081-2017

- 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).

K.A. Read et al., Extensive halogen-mediated ozone destruction over the tropical Atlantic Ocean. Nature, 453, 2008, 1232-1235

Long-term datasets

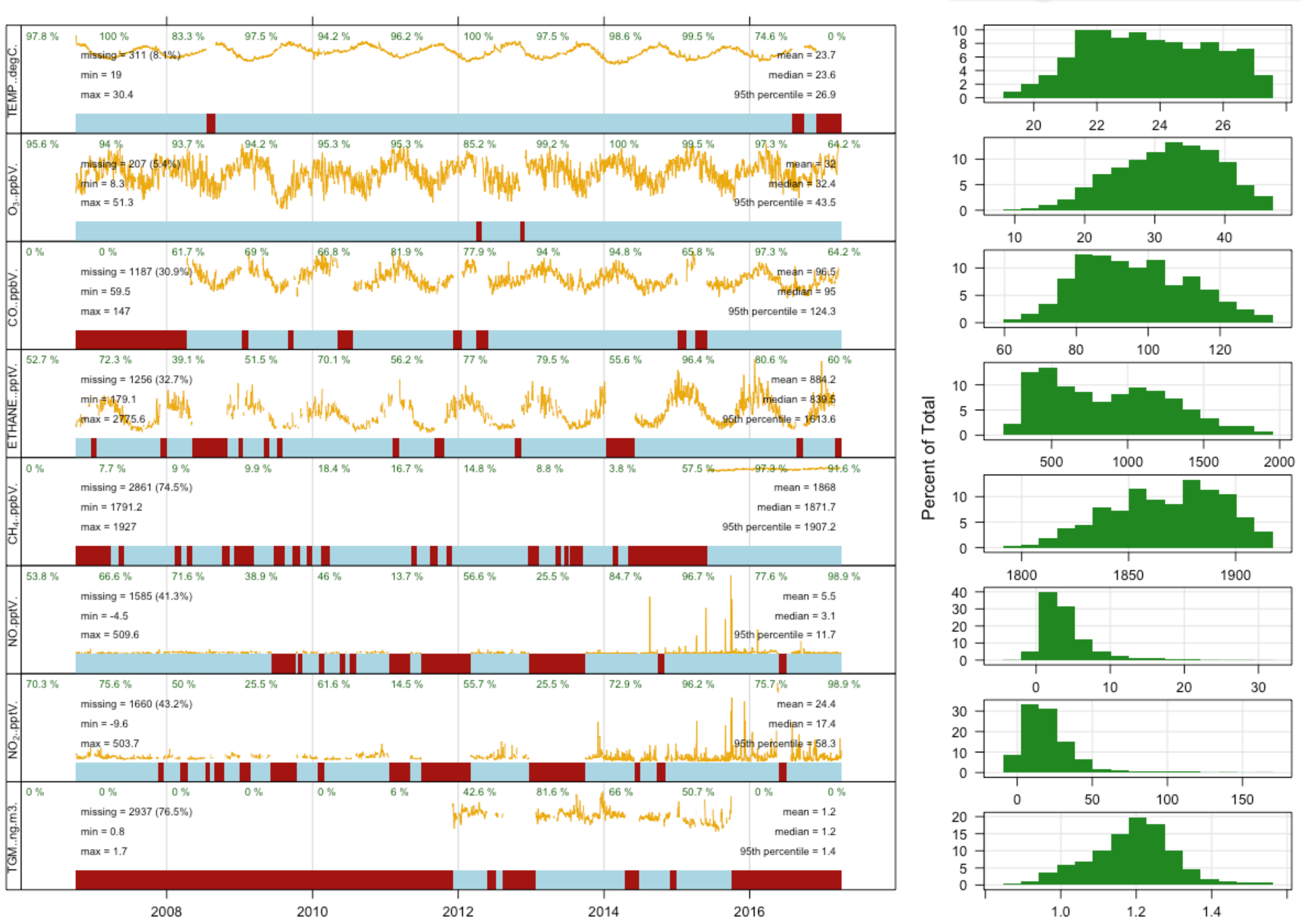

Figure 7: Summary plot of selected CVAO data. The plots in the left panel show the time-series data, where blue shows the presence of data and red missing data. The daily mean values are in yellow scaled to cover the range in the data from zero to the maximum daily value. Percentage data capture is shown in green and the distribution of the data is shown as a histogram plot.

Carslaw, D.C. and K. Ropkins, (2012). openair — an R package for air quality data analysis. Environmental Modelling & Software. Volume 27-2

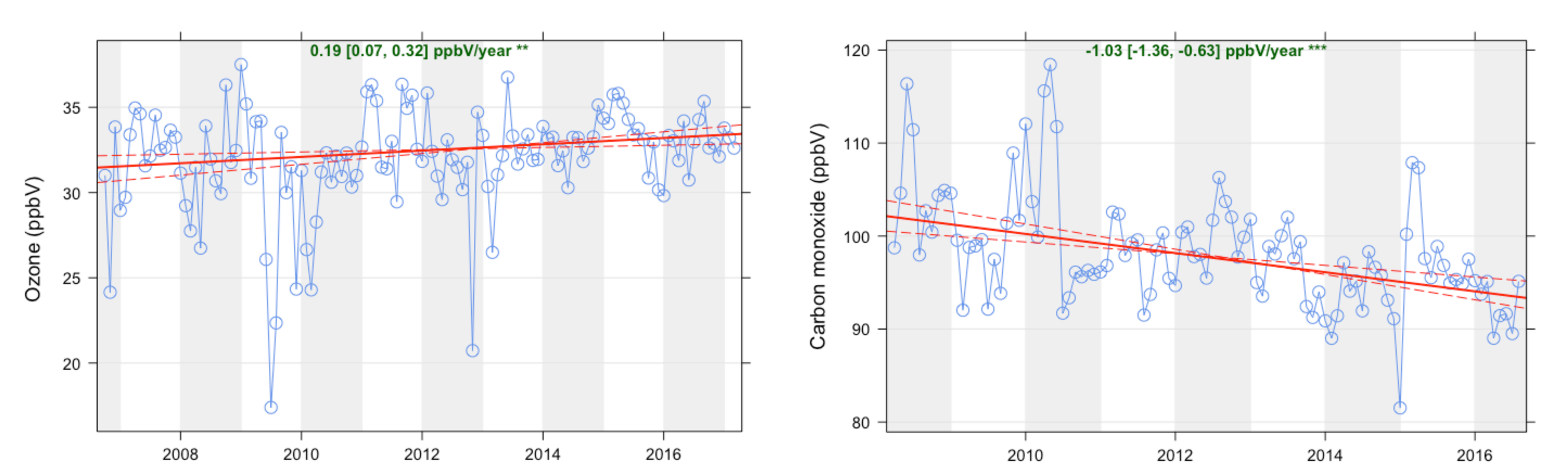

Figure 8 and Figure 9 : Ozone and Carbon Monoxide trends calculated using a Theil-Sen function based on de-seasonalised monthly O_3 means. The green text shows the slope estimate and the dashed red lines show the 95% confidence intervals for the trend based on resampling methods (Carslaw D.C. and K. Ropkins, 2012).

- Ozone is observed to be slowly increasing in the northern hemisphere due to increasing emissions of trace gases. Carbon monoxide is observed to be decreasing at a rate of 1 ppbv yr^{-1}. These data will feed into the ACSIS project*.
- Methane and Carbon dioxide are measured continuously and in flasks by MPI, Jena and these data are not shown here, however we have recently started duplicate measurements of these with our Picarro G3201 Analyser.
- A more comprehensive analysis of our VOC data is shown on another poster (S. Punjabi et al).
- NO and NO_2 data spikes may yet be removed, we have recently changed our processing methods which has led to less removal of these potentially real spikes and installed an SO_2 instrument to determine whether they originate from shipping emissions.
- TGM measurements were restarted in April 2017.

* The North Atlantic Climate System Integrated Study (ACSIS), is an ambitious 5-year multicentre (NCAS, NOC, BAS, NCEO,CPOM, PML) program which aims to use the long-term atmospheric data and aircraft measurements together with measurements of the climate, ocean and cryosphere to evaluate the state of the North Atlantic climate system. The aim of the project is to enhance the UK's capability to detect, attribute and predict future changes.

Data quality and archiving: CEDA and WDCGG/WDCRG

Data is submitted regularly on daily, monthly and yearly timescales to the World Centre for the Greenhouse Gases (WDCGG/WDCRG) http://gaw.kishou.go.jp/wdcgg/, http://www.gaw-wdcrg.org/ and to the Centre for Environmental Data Analysis CEDA (formerly 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/

Acknowledgements

Thanks to our CVAO Partners: Instituto de Naçional de Meteorologia and Geofisca (INMG), Rep of Cape Verde, Max-Planck-Institut für Biogeochemie, Jena, Germany, Leibniz-Institut für Troposphärenforschung, Germany.

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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