A seven-year record (2006-2013) of nonmethane hydrocarbons (NMHCs) in the subtropical marine boundary layer at the Cape Verde Atmospheric Observatory (CVAO)

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A.C. Lewis - *NCAS, University of York*

Steve Arnold - *Earth and Environment, University of Leeds*

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NOAA ESRL GMAC
Boulder, May 21, 2014

THE UNIVERSITY of York

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National Centre for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

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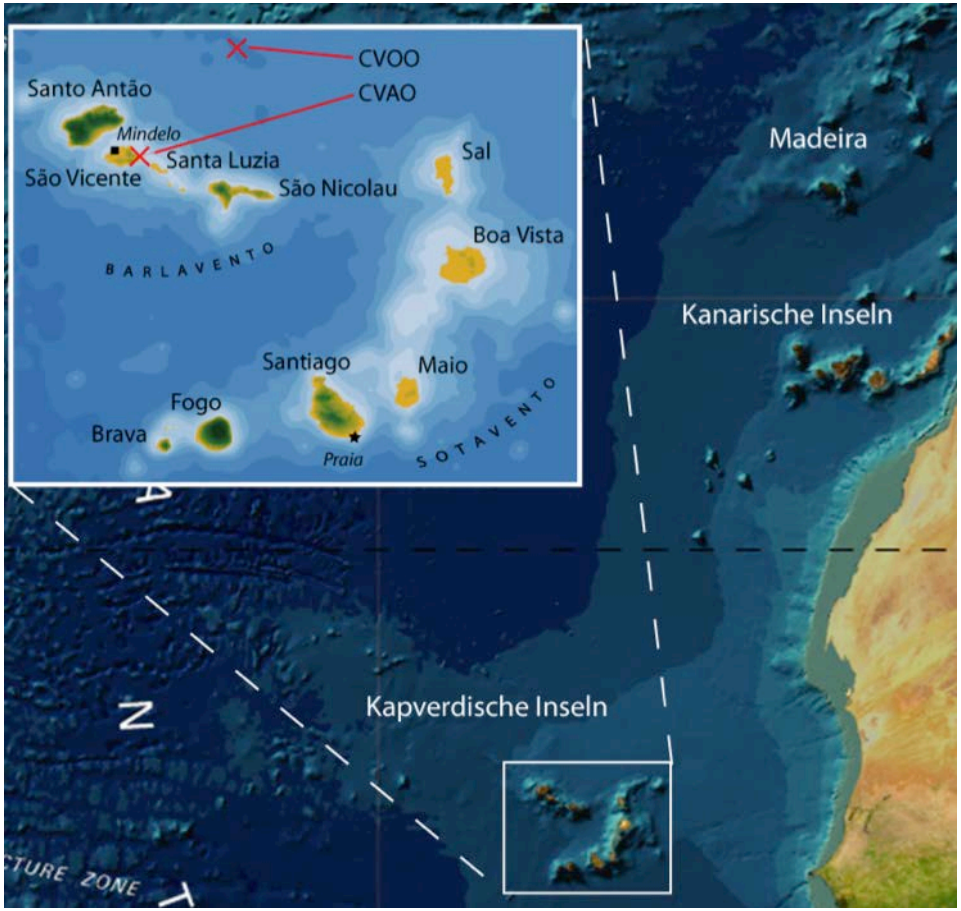
Cape Verde Observatory- A GAW Global status station



- Eastern tropical North Atlantic (ETNA)- 16° 52' N, 24° 52' W

- Long range transport and atmospheric - ocean exchange of trace chemicals

- Remote marine boundary location

- Measurement started Oct 2006

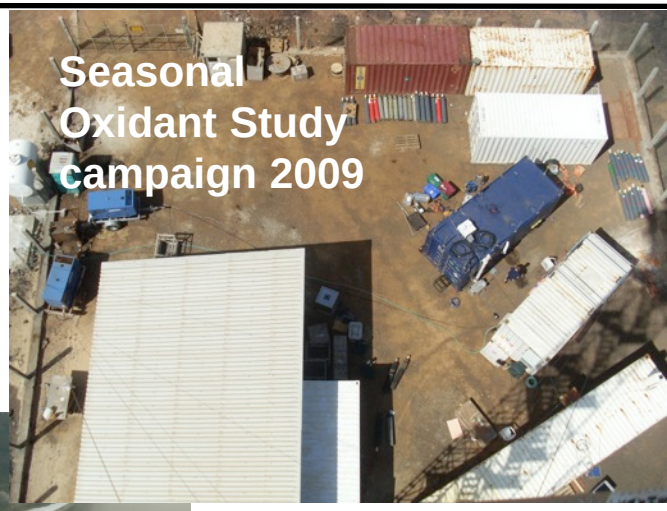
- Diverse trade winds arriving at site (North America, Arctic, European and African regions)

https://www.ncas.ac.uk/index.php/en/cvao-home

Measurements and campaigns at site

Ground based long term measurements
- Met data at 4m, 10m and 30m
- Solar radiation
- JO^1D
- O_3,
- *CO*
- *NO, NO_2,NOy*
- *C_2-C_8 NMHCs and DMS*
- *Methanol, acetone and acetaldehyde*
- *Halocarbons*
- *Mercury*

hosted international field projects
RHaMBLE 2007



Seasonal Oxidant Study campaign 2009

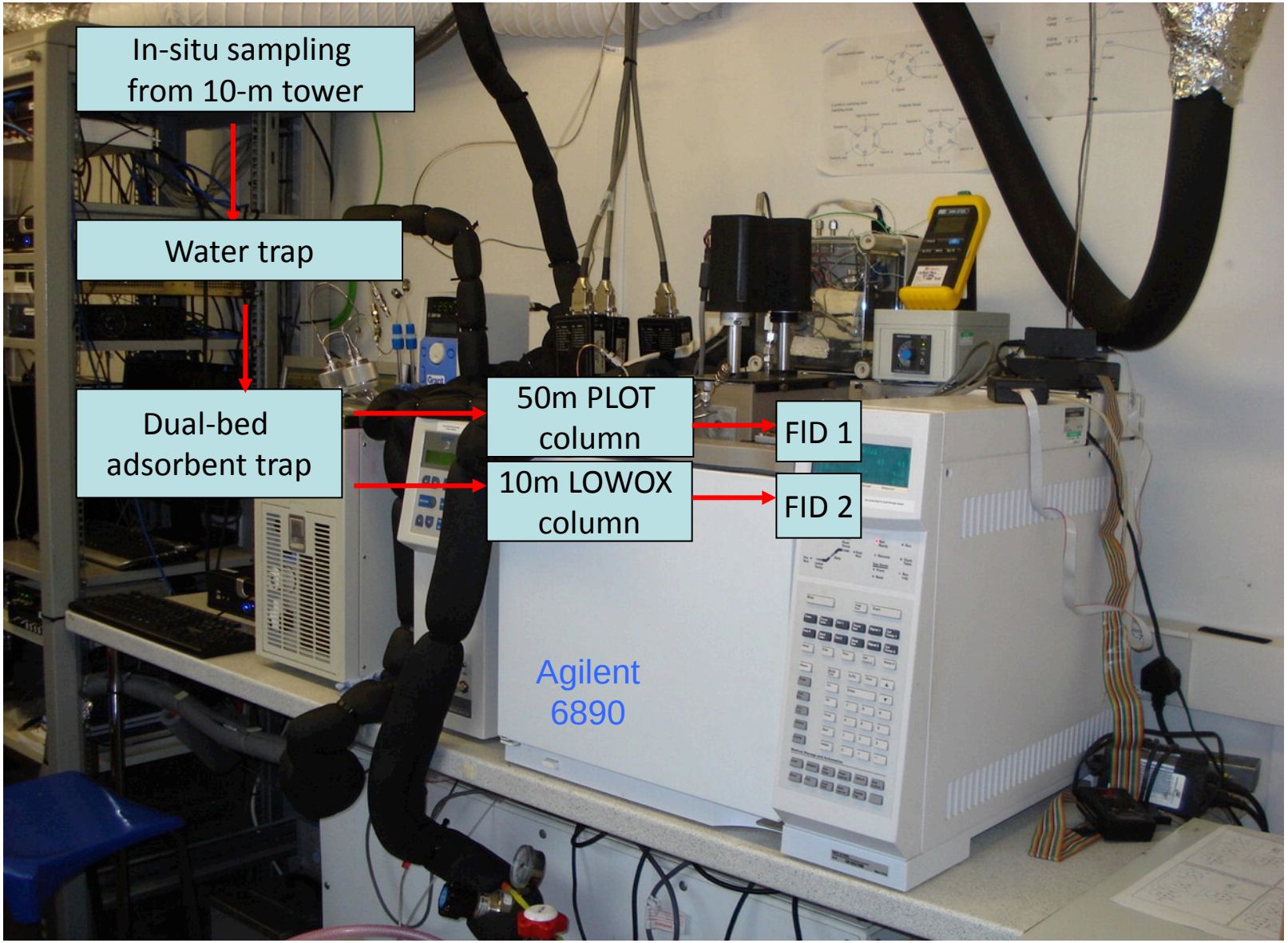
Oceanic Reactive Carbon[3] Project
June and Sep 2014

staff at site

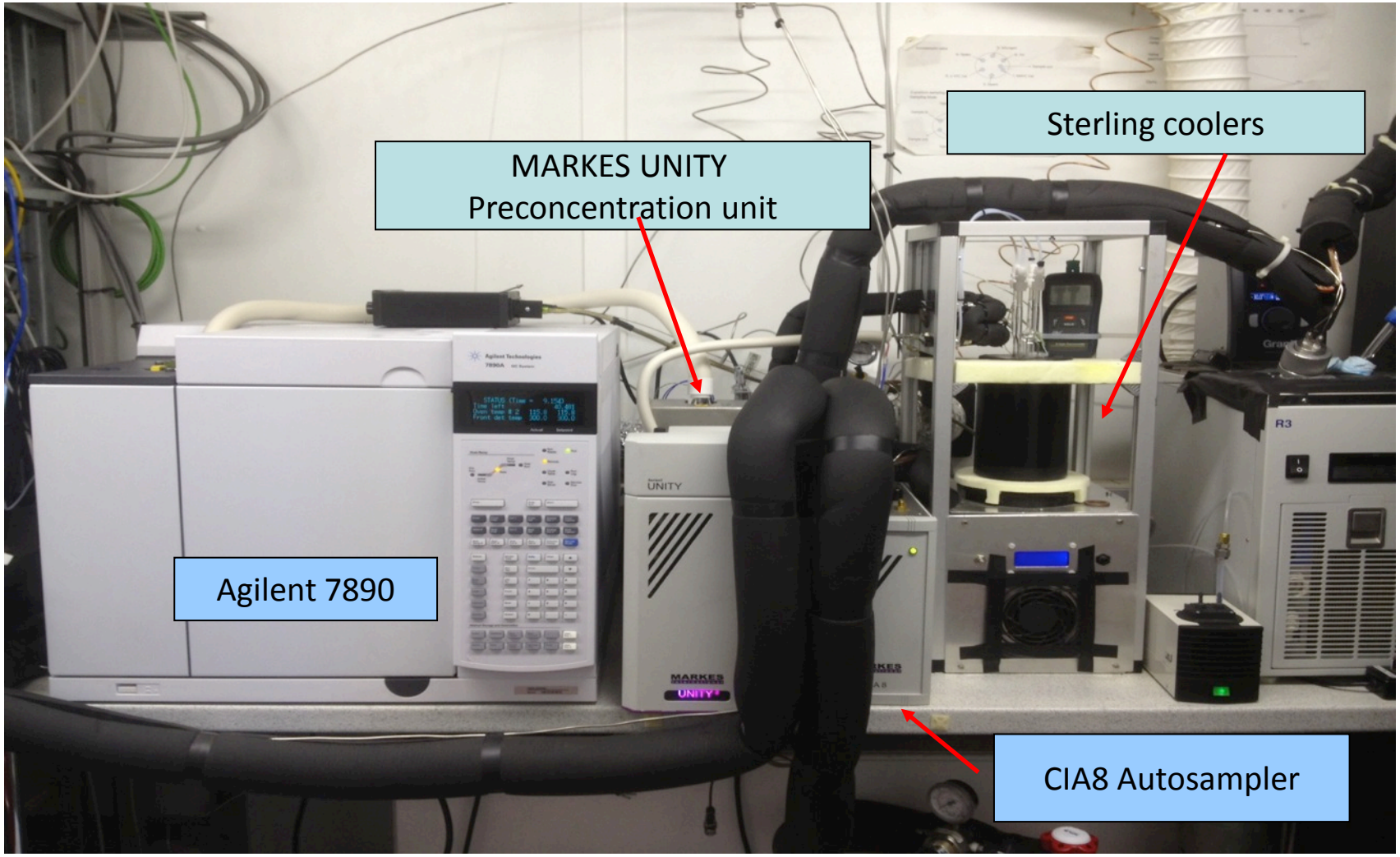
Met and data logger/server

Ship based measurements

Instrument involved during measurement period (Oct 2006- May 2013)

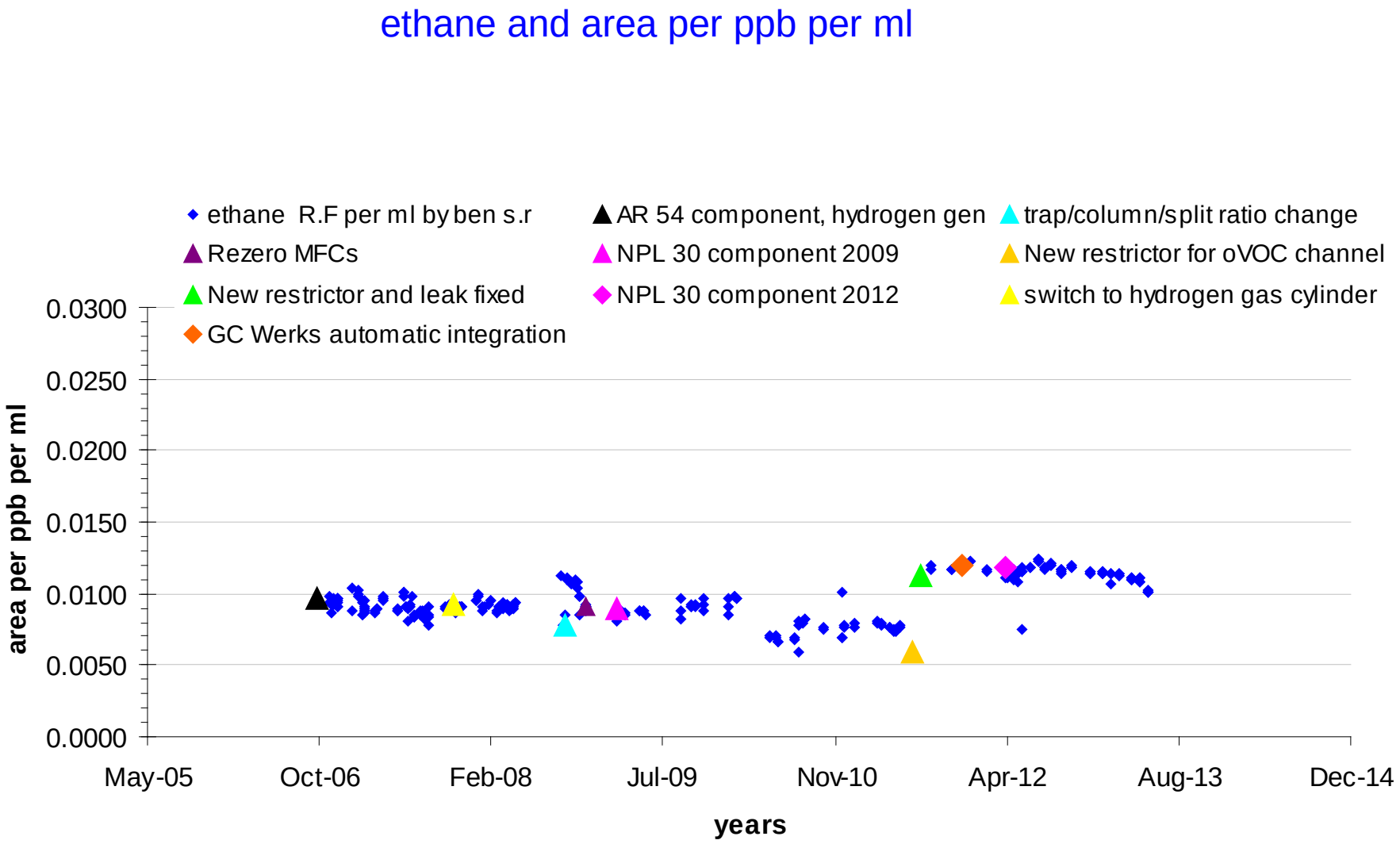


Since June 2013 instrument upgrade

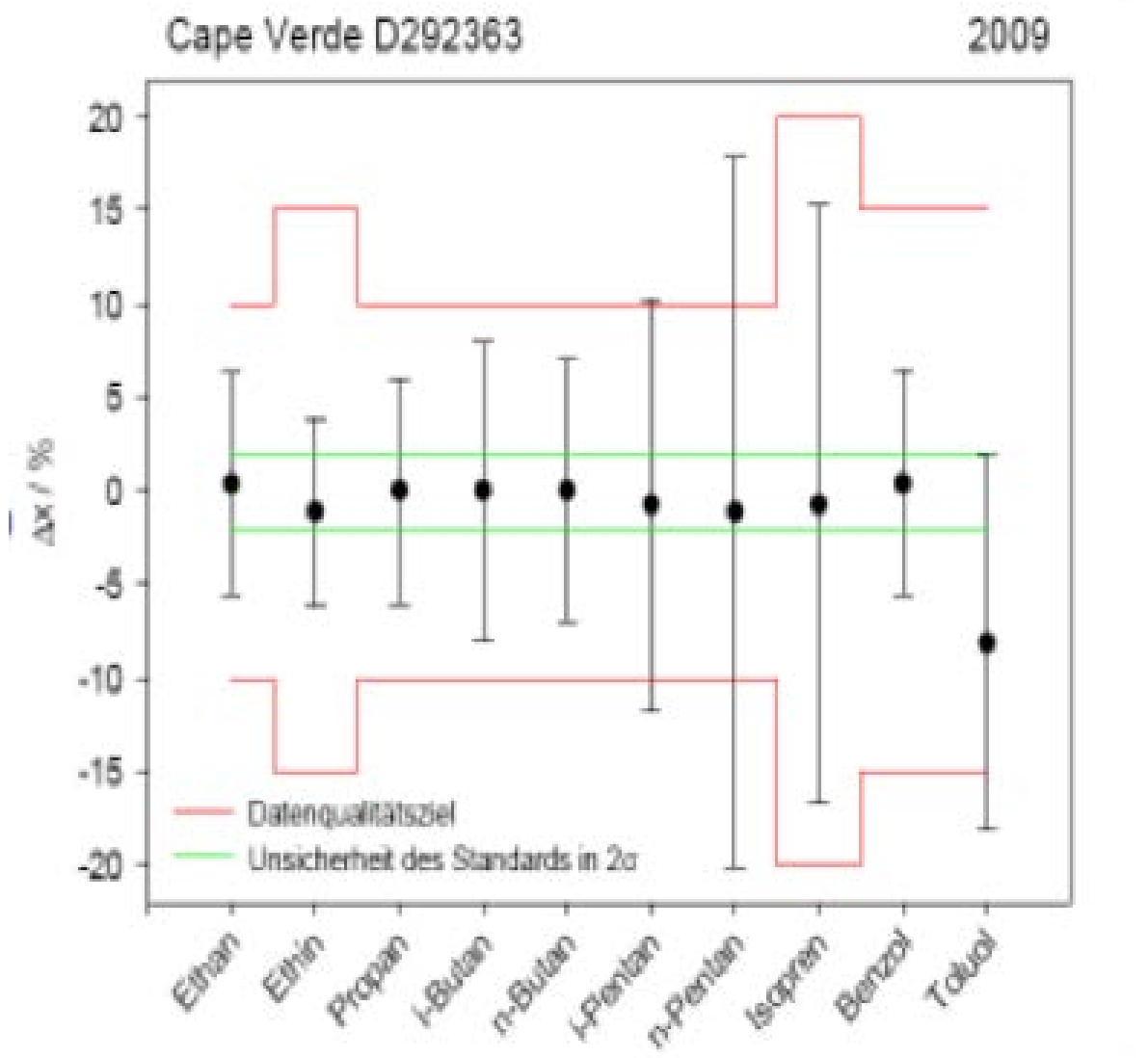


Commercial preconcentration and autosampler system : MARKES Thermal Desorbtion unit (TDU)

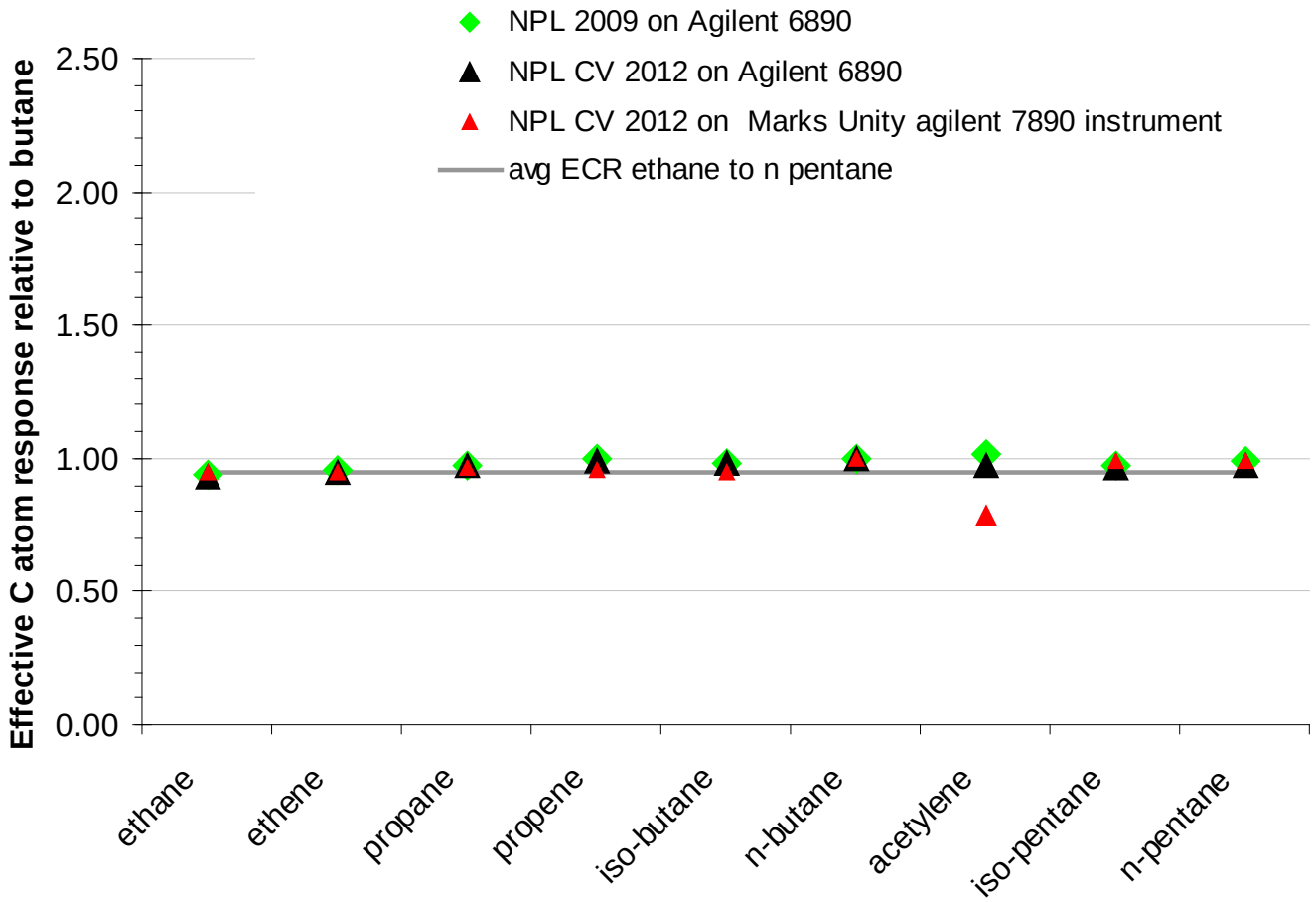
Calibration over time



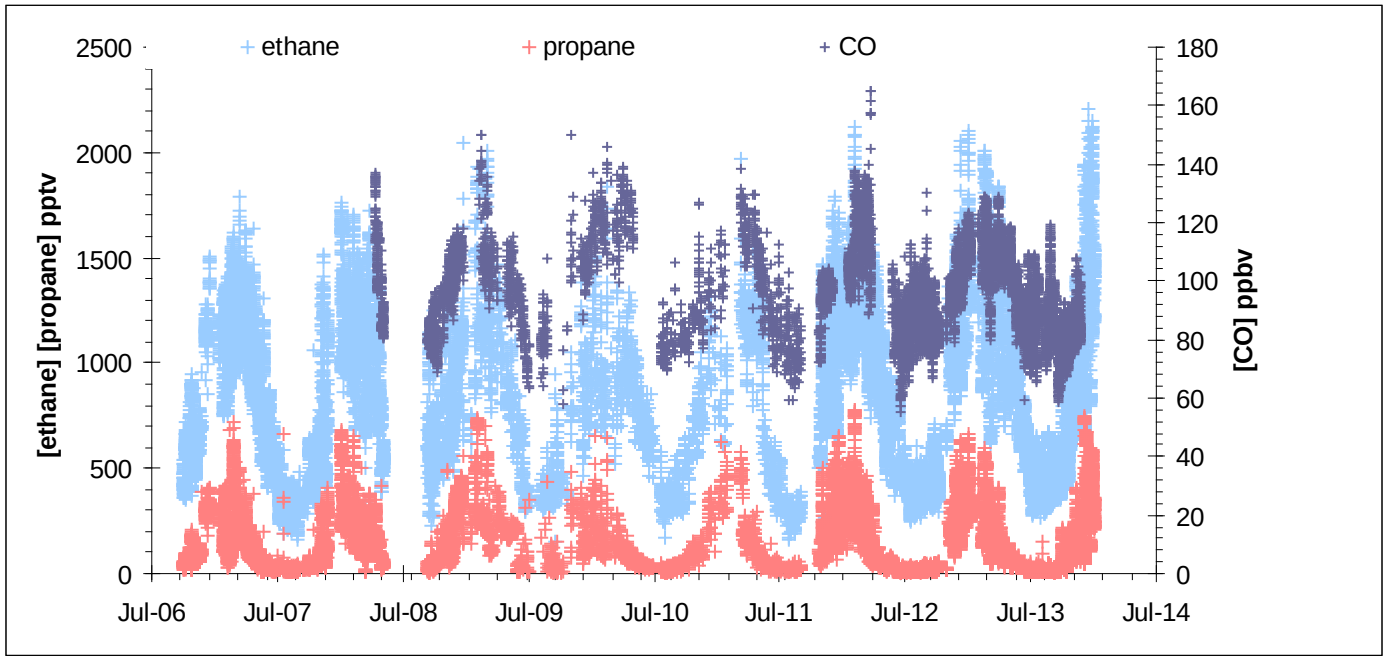
Results of WMO/GAW audit for VOC -2009



Comparison of calibration responses between old and new instrument



Data and time series



Spring maxima and summer minima : in line with the Northern Hemisphere observations

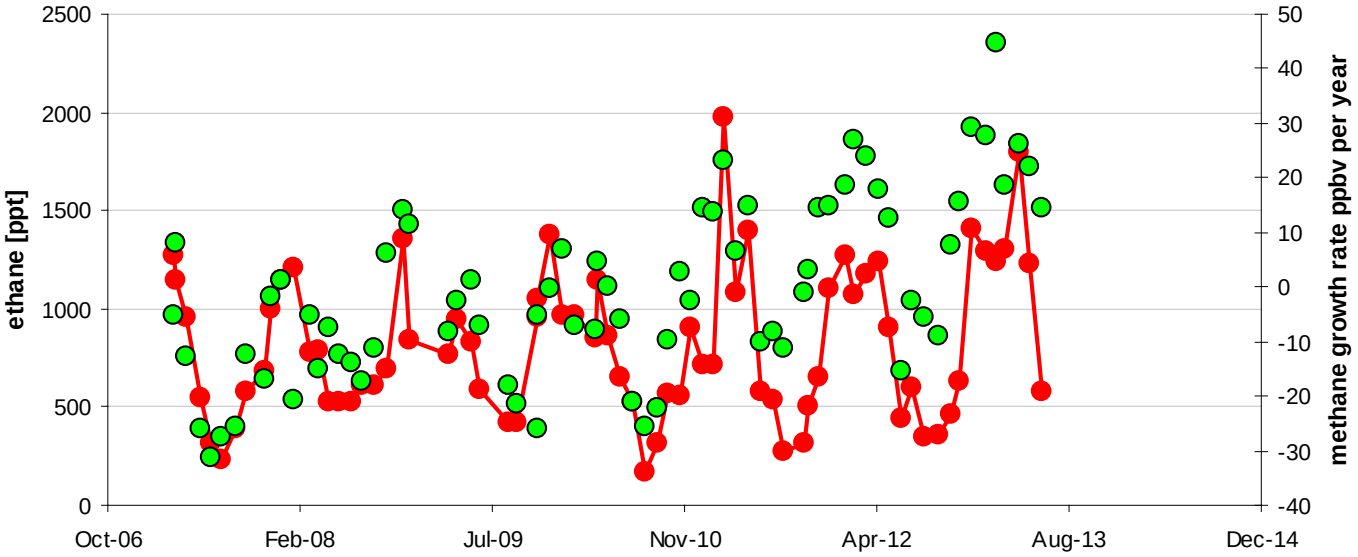
Rise in amplitude suggests a change in source strength or OH?

Ethane and CH_4 growth rate

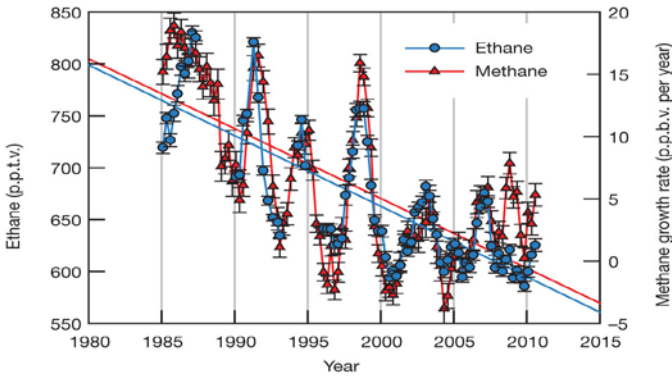
Ethane

ΔCH_4 (Monthly mean - 5 year running mean)

Methane data from
M. Heimann, Jena



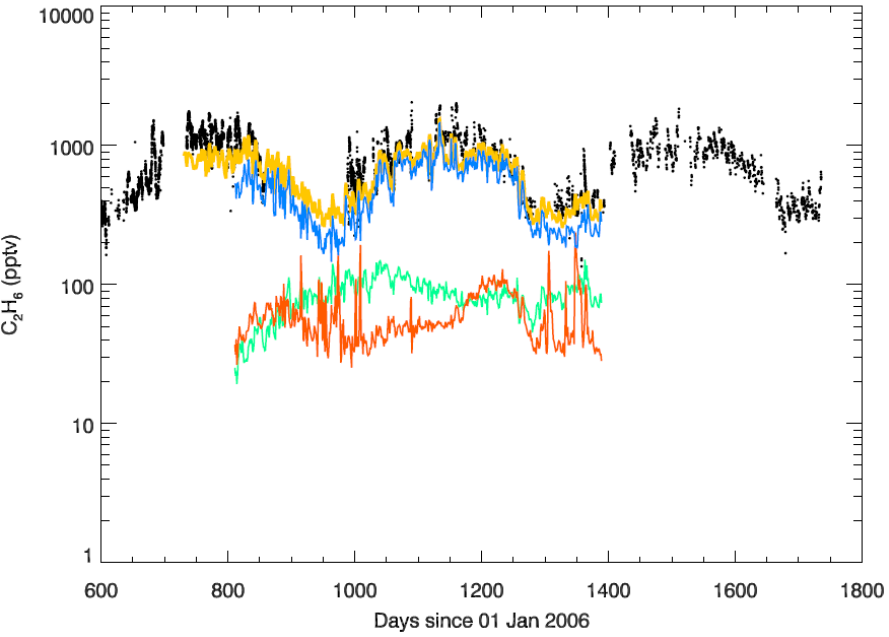
- Methane atomspheric growth rate is a sensitive indicator of fluctuations in methane's emissions.
- 1985-2010 saw global ethane decline of 190 pptv (24%) (Simpson et al., Nature, 2012)
- Declining fugitive fossil fuel emissions

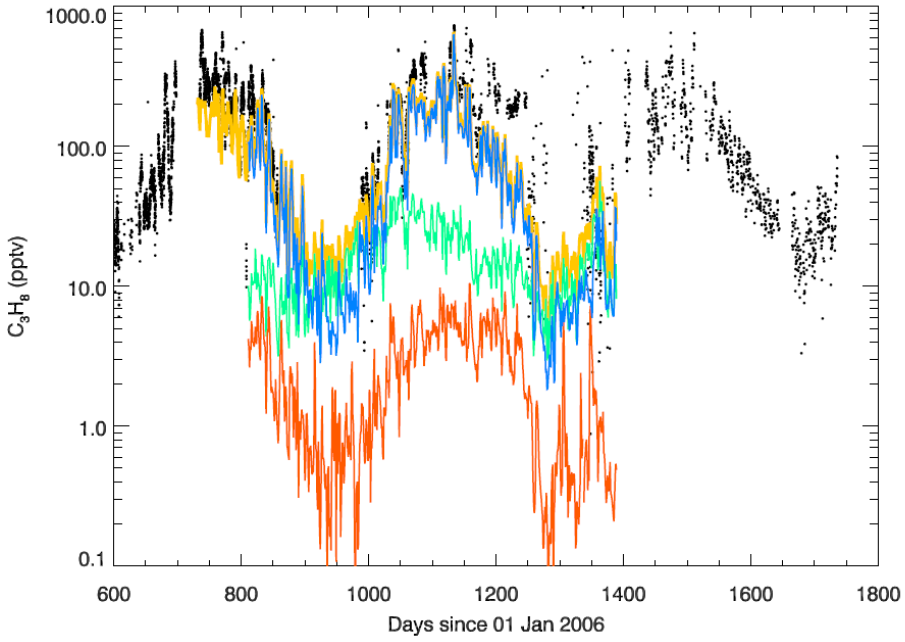


Long-term decline of global atmospheric ethane concentrations and implications for methane , Simpson et al , *Nature* **488**, 490–494 (23 August 2012) doi:10.1038/nature11342

Model (CAM- Chem) and measurment comparison and emission contributions

Obs
Model
Biogenic
Anthropogenic + biofuel
Fire



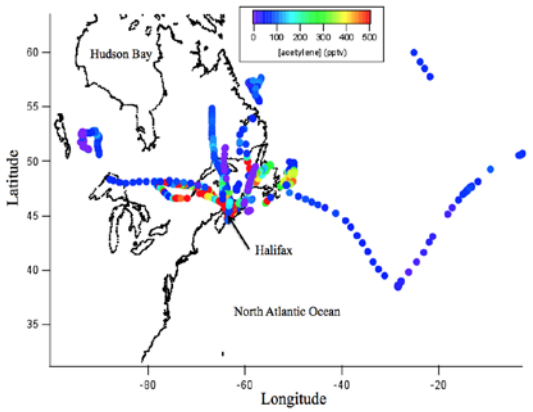


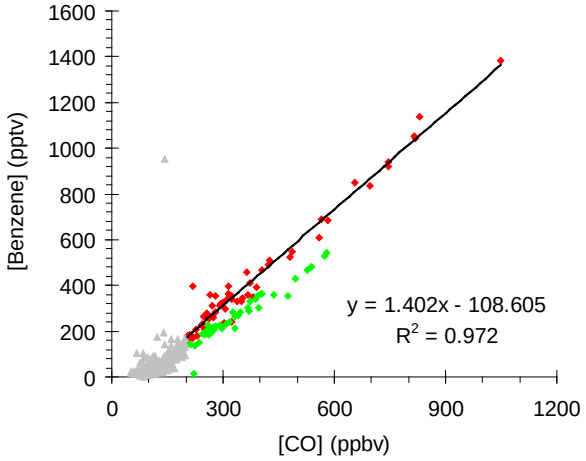
The model suggests that alkanes at Cape Verde are dominated by the anthro + biofuel sector (bioethanol is widely used in USA)

Courtesy: Steve Arnold

Read K.A; Carpenter L.J; Hopkins J.R; Lewis A.C; Lee J.D; **Arnold S.R**; Pickering S.J; Beale R; Nightingale P.D; Mendes L (2012) Multiannual observations of acetone, methanol, and acetaldehyde in remote tropical Atlantic air: Implications for atmospheric OVOC budgets and oxidative capacity, *Environmental Science and Technology*, **46**, pp.11028-11039. doi: 10.1021/es302082p

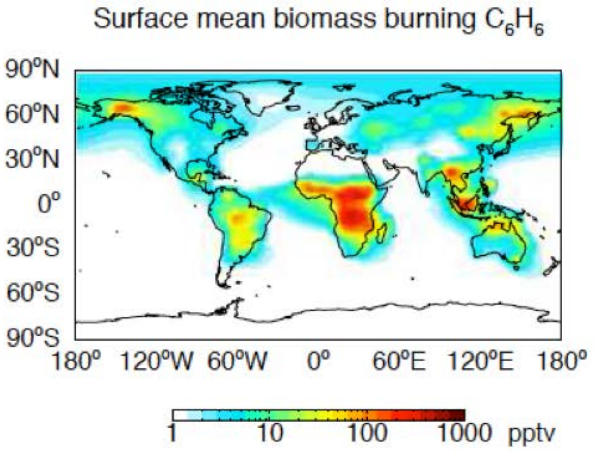
Constraining global benzene emissions using Cape Verde

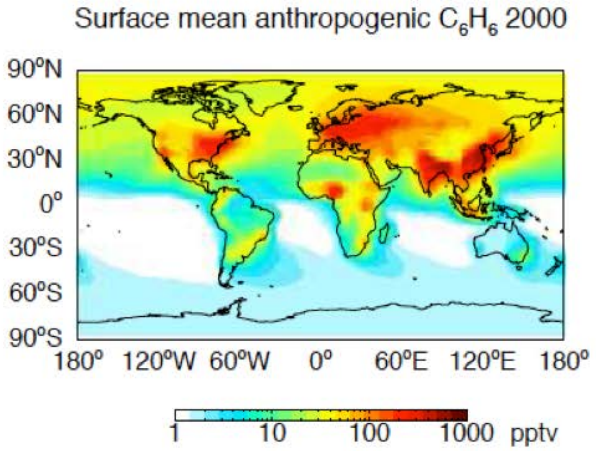




Starting point – boreal plume observations from aircraft

Derive Emission Ratios of benzene to CO (plus use literature values)



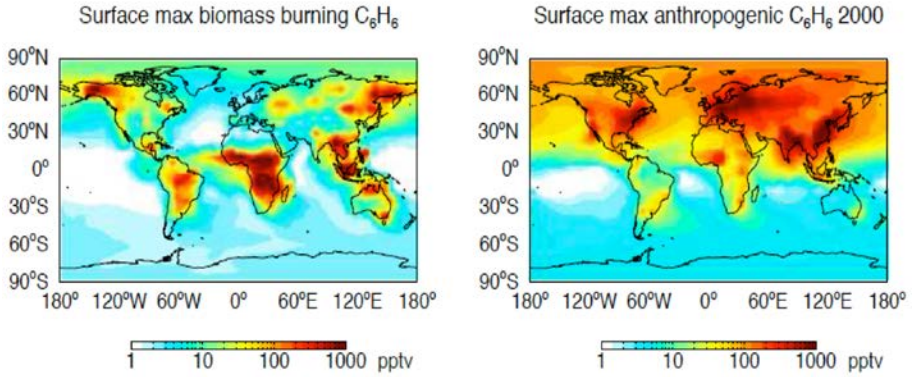


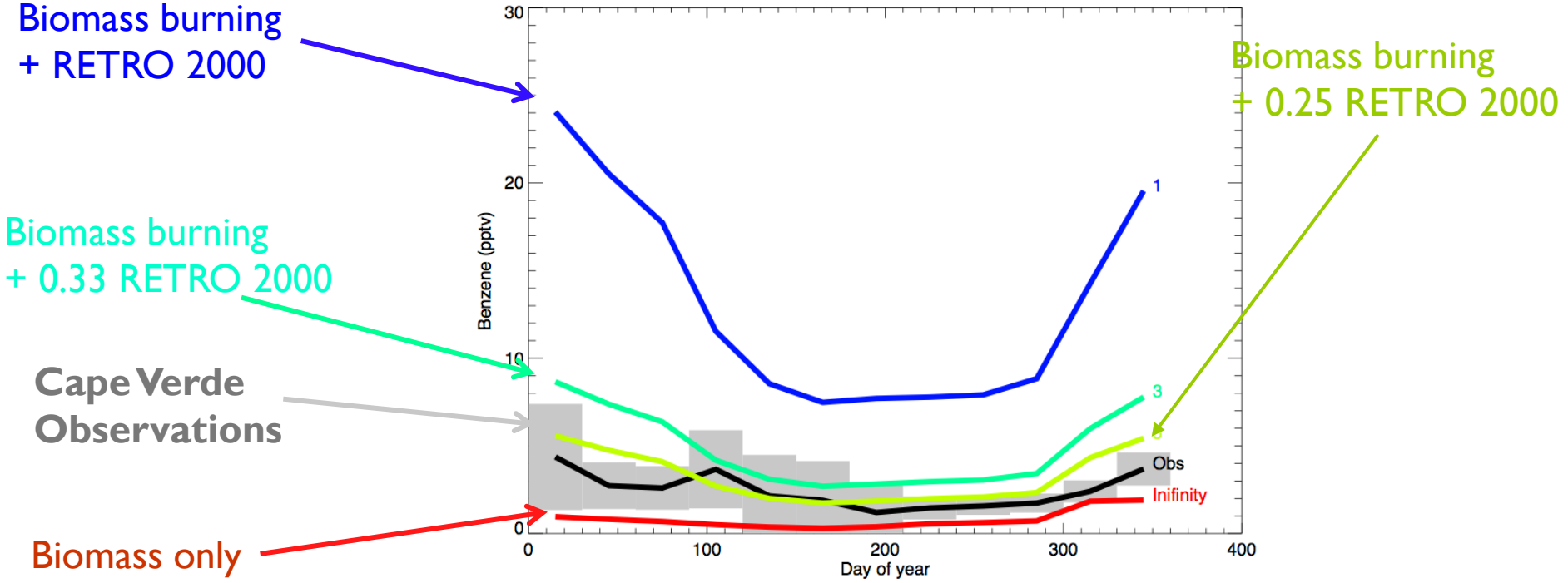
GEOSChem Model – Tagged benzene (scaled to GFED3 CO) + RETRO anthropogenic benzene

The influence of biomass burning on the global distribution of selected non-methane organic compounds, Lewis , A..C et al
Atmos. Chem. & Phys. **13**, 851-867, 2013

Constraining global benzene emissions using Cape Verde

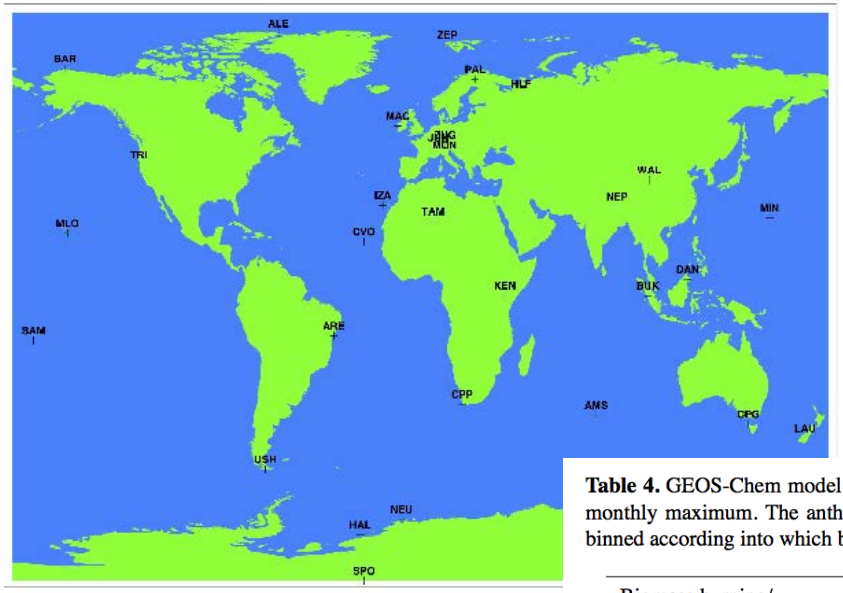
- Cape Verde influenced by both biomass burning and anthropogenic benzene.
- Model / measurement comparison shows overestimation.
- Better fit using RETRO x 0.33 or 0.25
- Reducing RETRO is consistent with major reduction in fuel benzene since 2000.





The influence of biomass burning on the global distribution of selected non-methane organic compounds, Lewis , A.C et al *Atmos. Chem. & Phys*. **13**, 851-867, 2013

Impact of biomass burning on GAW stations



- Estimated fraction of benzene from biomass burning / anthropogenic arriving at 27 GAW Global stations is calculated.
- Most GAW stations affected significantly in at least one month of the year, biomass influence becomes more pronounced as anthropogenic emissions of benzene decline.

Table 4. GEOS-Chem model estimated fraction of annual benzene associated with biomass burning, given as the annual mean and as the monthly maximum. The anthropogenic emissions used are that of RETRO and 0.33 × RETRO. GAW sites (see Table 3 and Fig. 7) are binned according into which biomass burning fraction range they lie.

Biomass burning/ anthropogenic benzene fraction	Annual Mean	Annual Mean (RETRO · 0.33)	Monthly Maximum	Monthly Maximum (RETRO · 0.33)
0.0–0.2	TAM CVO KEN IZA WAL MIN DAN NEP MLO ARE TRI PAL ZUG MAC MON JUN HLF	IZA WAL NEP PAL ZUG MAC MON JUN HLF	NEP ZUG MON JUN	ZUG MON JUN
0.2–0.4	AMS CPP CPG LAU SAM USH ALE BAR ZEP NEU SPO HAL	TAM CVO KEN MIN DAN MLO ARE ALE TRI ZEP	IZA	NEP
0.4–0.6	BUK	CPP CPG LAU USH BAR	TAM CVO WAL ARE	
0.6–0.8		AMS BUK SAM NEU SPO HAL	KEN CPP MIN DAN SAM TRI PAL MAC NEU SPO HAL HLF	TAM IZA WAL ARE
0.8–1			AMS CPG BUK LAU MLO USH ALE BAR ZEP	CVO AMS KEN CPP CPG BUK MIN DAN LAU MLO SAM USH ALE BAR TRI PAL MAC ZEP NEU SPO HAL HLF

The influence of biomass burning on the global distribution of selected non-methane organic compounds, Lewis , A.C et al
Atmos. Chem. & Phys. **13**, 851-867, 2013

Further plans

- Continuing with long-term measurements programme
- Rigorous checks to ensure data quality