VOC chemical climate and O_3 variation: Impact of emissions on regional O_3 increment

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Overview

- O_3 formation is a function of [NO_x] & [VOCs][1]
- VOCs each have distinct O_3 production potentials (POCP)
- Speciated European VOCs emissions in public databases (SNAP sectors and NFR code aggregations)
- 27 VOCs are measured at 2 rural UK EMEP supersites
- 38% by mass of 2011 UK VOC emissions emitted are measured

- UK emits majority of UK VOC emissions exposure.
  - E.g. Harwell 2011 average = 63% (July 2011 = 96%)
- **Ethene and m+p-xylene** biggest contributors to regional O_3 increment
- Smaller contributions from other VOCs: reduction in wide range of VOCs required
- Largest contribution to VOC emissions from ***solvent and product use*** sector
- Substantial advantages to gridded VOC emissions reporting in more disaggregated source sectors, i.e. **NFR codes more useful than SNAP sectors**
- VOC *O_3-impact* chemical climate determined by **cumulative emissions & meteorology**

VOC chemical climate analysis

Impact

Regional O_3 increment

Difference between hemispheric background and regional background O_3

Hemispheric = [O_3] during westerly conditions at Mace Head
Regional = *y*-intercept of OX (O_3 + NO_2) vs NO_x plot[4]

State

VOC diurnal photochemical depletion

$$\frac{POCP\ weighted\ [VOC]}{POCP\ weighted\ [ethane]}_{1am-5am} - \frac{POCP\ weighted\ [VOC]}{POCP\ weighted\ [ethane]}_{1pm-5pm}$$

Drivers

VOC trajectory emissions exposure

Monthly averaged estimate of the VOC hourly emissions along the 96 hour back trajectory pathway prior to arrival at the supersite.[5]

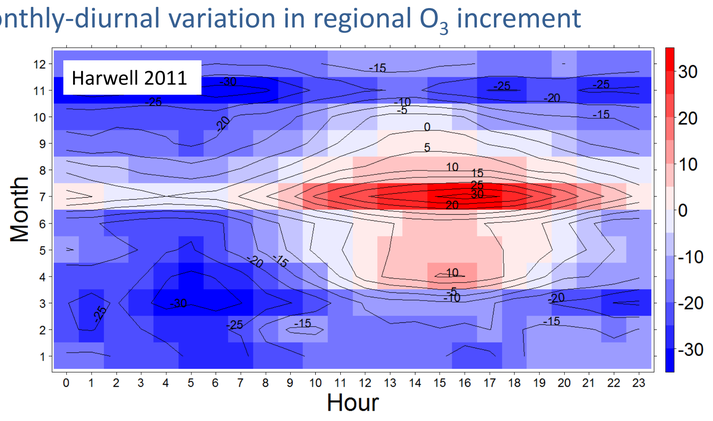
Study area and data

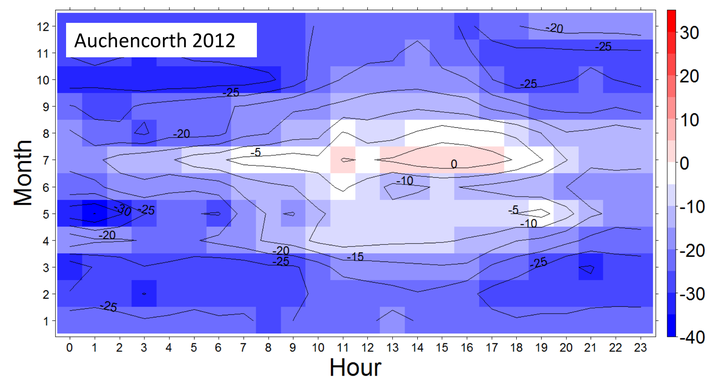
- Hourly measurements in 2011 and 2012 analysed
- NO_x
- O_3
- 27 VOCs

2-methylpentane
1-butene
1,3-butadiene
1,3,5-trimethylbenzene
1,2,4-trimethylbenzene
1,2,3-trimethylbenzene
trans-2-butene
toluene
propene
propane
o-xylene
n-pentane
n-octane
n-hexane
n-heptane
n-butane
m+p-xylene
isoprene
isopentane
isooctane
isobutane
ethyne
ethylbenzene
ethene
ethane
cis-2-butene
benzene

Impact: Regional O_3 Increment

Monthly-diurnal variation in regional O_3 increment

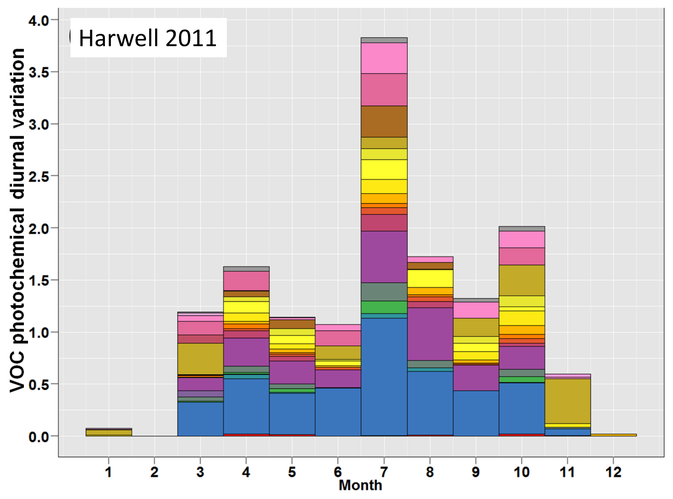


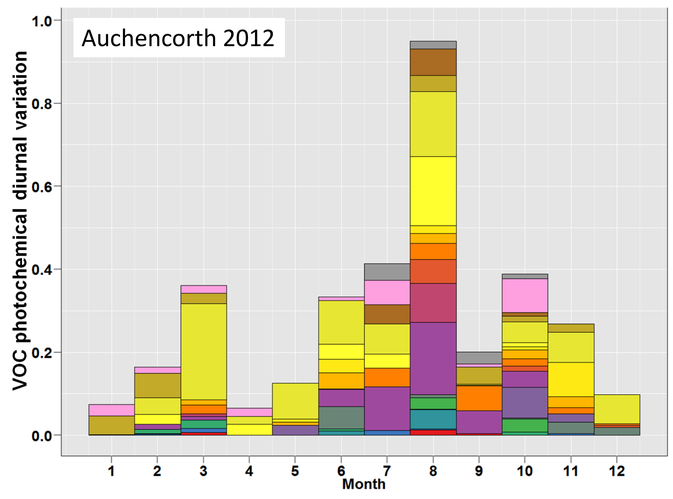


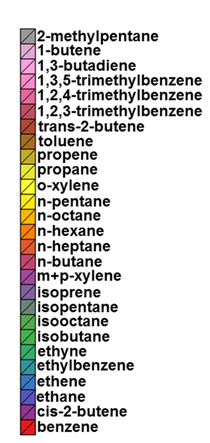
Harwell 2011: Two regional O_3 increment max: April (+11 µg m^{-3}) & July annual max (+32 µg m^{-3})
Auchencorth 2012: Annual max in July 2012 (+4 µg m^{-3}) lower regional O_3 increment

State: VOC photochemical reactivity

Monthly variation in VOC diurnal photochemical depletion



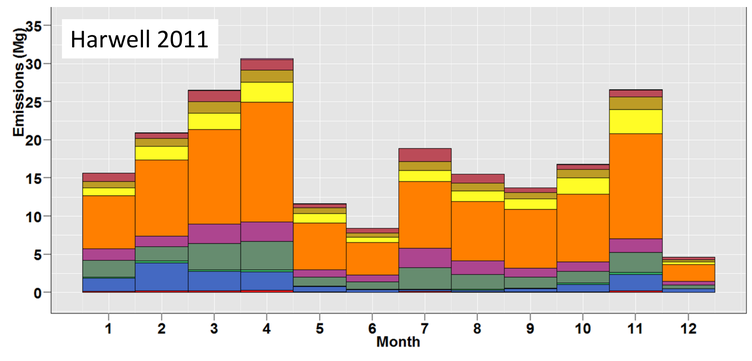


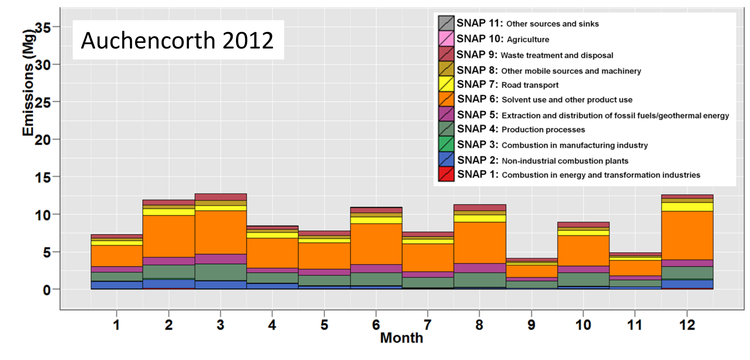


Harwell 2011: Ethene and m+p-xylene largest contributors in maxima months April and July
Auchencorth 2012: Substantially lower VOC diurnal photochemical depletion

Drivers: Total trajectory path emissions

Total monthly averaged 4-day back trajectory VOC emissions cumulative exposure (Mg of VOC), disaggregated into 11 SNAP source sectors





Harwell: April 2011: VOC emissions exposure annual max
June-July 2011: 123% increase in emissions exposure.
July 2011: Higher temperature and solar intensity produce **annual max**
VOC photochemical depletion and regional O_3 increment

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