Long-term measurements of atmospheric trace gases (CO₂, CH₄, N₂O, SF₆, CO, H₂), O₂, and δ¹³CH₄ isotopes at Weybourne Atmospheric Observatory, UK: past, present and future.

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Introduction
The Weybourne Atmospheric Observatory (WAO) is a WMO GAW regional station and a component of the National Centre for Atmospheric Science (NCAS) Atmospheric Measurement Facility (AMF). WAO is located on the north Norfolk Coast (52.977°N, 1.137°E) in the UK and is run by the University of East Anglia with support from NCAS. Since 2008 we have been collecting high-precision long-term measurements of atmospheric carbon monoxide (CO), molecular hydrogen (H₂), carbon dioxide (CO₂), oxygen (O₂) and δ¹³CH₄ isotopes. In March 2013, the measurement of atmospheric methane (CH₄) commenced, and nitrous oxide (N₂O) and sulphur hexafluoride (SF₆) began in October 2014. In 2016, WAO will become a part of the EU ICOS network.

Long-term measurements

<table>
<thead>
<tr>
<th>Species</th>
<th>Instrument</th>
<th>Scale</th>
<th>Calibration Range</th>
<th>Data coverage period</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>Siemens NOIR</td>
<td>WMO CO₂ X2007</td>
<td>388.5 to 426.6 ppm</td>
<td>2008 – present</td>
</tr>
<tr>
<td>O₂</td>
<td>Osylia II</td>
<td>Scripps</td>
<td>-811 to -426 ppm</td>
<td>2008 – present</td>
</tr>
<tr>
<td>CH₄</td>
<td>GC-FID</td>
<td>WMO CH₄ X2004</td>
<td>1753 to 2495 ppb</td>
<td>2013 – present</td>
</tr>
<tr>
<td>CO</td>
<td>RGA3</td>
<td>WMO CO X2004</td>
<td>61 to 503 ppb</td>
<td>2008 – present</td>
</tr>
<tr>
<td>H₂</td>
<td>RGA3</td>
<td>WMO H₂ X2009</td>
<td>375 to 1182 ppb</td>
<td>2008 – present</td>
</tr>
<tr>
<td>N₂O</td>
<td>GC-ECD</td>
<td>WMO N₂O X200A</td>
<td>314 to 345 ppb</td>
<td>2013 – present</td>
</tr>
<tr>
<td>SF₆</td>
<td>GC-ECD</td>
<td>WMO SF₆ X200E'</td>
<td>7.5 to 15.9 ppb</td>
<td>2014 – present</td>
</tr>
<tr>
<td>δ¹³CH₄</td>
<td>GC-IRMS</td>
<td>NIWA/NISTAR</td>
<td>-57 to 47 ‰</td>
<td>2013 – present</td>
</tr>
</tbody>
</table>

Table 1. Summary of long-term measurements made at Weybourne Atmospheric Observatory

Annual variations - CO₂, H₂, CH₄, CO₂ and O₂

Figure 2. Annual cycles of CO₂, H₂, CH₄, CO₂ and O₂ for WAO.

Data availability and submission
Data are available from BADC and are updated on a biannual basis.
All data will shortly be submitted to both WMO/GAW WDCGG and EU ICOS repositories.
Near Real Time H₂, CO and CH₄ mole fractions are displayed at http://inigos-atm.lcse.ipsl.fr/WAO-NRT...

δ¹³C in CH₄

Figure 4. Plotting for all samples collected for δ¹³CH₄.

NAME atmospheric transport model as a tool to identify trace gas origins

The NAME model uses UK Met Office Unified Model meteorological data (25 km resolution) to simulate the backward movement of tracer particles according to atmospheric conditions and turbulence. For this study, 30,000 theoretical air particles are released at WAO (here 25 m above ground level). These particles are followed as they spread backwards in time over a 10-day period. The residence of these particles within the 0-100 m surface layer reflects the probable pathways the air passed over at surface level which would influence the emissions (i.e. footprint).

Measurement support: past, present and future

- EUROHYDROS – a EUROpean network for HYdrogen Observations and Studies (EU project).
- MAMM – Methane and other Greenhouse Gases in the Arctic: Measurements, Process Studies and Modelling (NERC project).
- NERC’s National Centre for Atmospheric Sciences (NCAS) through the Atmospheric Measurement Facility (AMF).