London Pilot Project Kick Starts a New Greenhouse Gas Emissions Measurement Service

The National Physical Laboratory's (NPL) Melanie Williams presents the results of a 2012 pilot study and outlines how it will form the basis of a new emissions measuring offer from Astrium.

The National Physical Laboratory (NPL) is partnering with Astrium Services to deliver a new emissions measurement service to enable countries and cities to better quantify their greenhouse gas (GHG) emissions.

"It is essential that we are able to assess and control GHG emissions at international, national and major city level, to both reduce the level of polluting emissions and to promote the uptake of new low carbon technologies."

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The new offer takes the learning from a pilot in London and uses it to complement the current 'inventory approach' models and validate national and international energy saving measures.

What makes the new service different is that it will use actual measurements of carbon dioxide and methane in the atmosphere, together with a bespoke atmospheric model, to provide a much greater level of accuracy than is available at present.

This article takes a preliminary look at the measurements which came from the successful pilot study in 2012 and outlines how these results will be taken forward to form the basis of the new service.

Establishing the Need

There is a global commitment to lowering GHG emissions. Countries have their independent plans to decarbonise their energy, transport and other industrial sectors and we are all encouraged to save energy in all that we do. In Europe and the UK measures have been made to incentivise the move to a low carbon economy and as other countries are added to this list, and put in place measures like biomass, nuclear energy, carbon capture and storage, they will want to see real local reductions in GHG concentrations in the atmosphere. This will see cities as well as nations looking at the GHG emissions and how they can provide evidence of lowering emissions.

Enhancing the Current Approach

Current emissions, whether national or local are calculated using the 'inventory approach'. This multiplies data –such as the number of miles driven by an average person– by 'emissions factors' to turn that activity data into the equivalent tonnes of carbon dioxide.

Astrium's new Emissions Measurement Service will complement and improve this approach by using actual concentration measurements. We are confident it will achieve this as parallels with 'traditional pollutants', such as acid gases, show that inventories often underestimates emissions.

The new service will take measurements from a range of sources. This will include permanent elevated sites round the country, as well as aircraft and eventually satellite measurements of carbon dioxide too. These will then be fed into the sophisticated model, and combined with inventories of natural and manmade GHG sources and sinks. By merging actual measurements with traditional modelling we will enable better validation of energy saving and decarbonising measures and be able to say with confidence if they are having the intended effect of reducing actual GHG emissions.

Data quality is essential when looking for small changes over a number of years so NPL will produce the highest-quality calibration gas standards to underpin the quality of the data used in the service.

The Initial Pilot

Over three months of the summer of 2012, Astrium and its partners NPL, Le Laboratoire des Sciences du Climat et l'Environnement (LSCE) and the National Centre for Earth Observation ran a pilot study in London to measure carbon dioxide, methane and carbon monoxide concentrations at four sites in or near the city. The objective was to predict and solve any practical issues before the launch of the full service in 2013 as well as answer some interesting scientific questions including:

1. How do concentrations of carbon dioxide and methane vary between rural, Outer London and London Centre sites?
2. How do meteorological conditions impact on these measured concentrations?
3. How do expected concentrations from known sources compare with the measured concentrations for this period?

Gases Measured by the London Pilot Study

Carbon Dioxide: in terms of tonnes emitted annually this is the most important GHG. It comes from burning fossil fuel in power generation, road and air transport and natural sources.

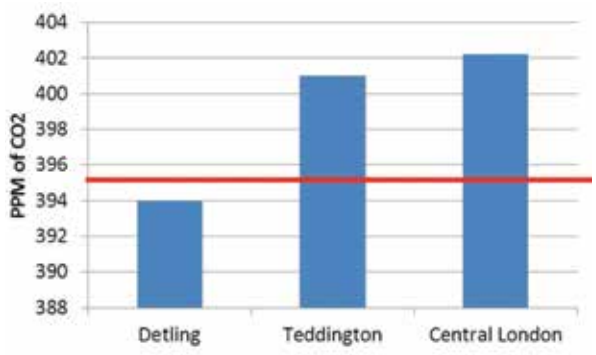
Methane: is emitted from waste management, agriculture, gas distribution, mining, aviation and road traffic. Also produced by natural sources. Methane is more potent than carbon dioxide as a GHG by a factor of twenty five.

Carbon Monoxide: is almost exclusively produced by incomplete combustion of fossil fuels and will be used in the Emissions Measurement Service as a marker for manmade sources of GHG emissions.

Four state-of-the-art GHG sensors were installed at sites in and around London. One was sited to the west of London in the suburbs at Teddington. The second was at Poplar and the third was at a site in Hackney. The final sensor was placed in Detling, in the countryside to the east of London (see map below).

The sites were chosen to be on an approximate west -east transept across London, using existing air quality measurement infrastructure and every site was elevated at 10 m above ground level to ensure the measurements were not too dominated by local sources. The predominant wind direction is from the west.

The measurements needed to be made to the highest accuracy so the sensors were calibrated throughout the measurement campaign with synthetic gas standards, produced gravimetrically to have the same isotopic composition as that of naturally occurring carbon dioxide in the atmosphere.



395ppm, Baseline UK CO_2, concentration for 2011

Sensors were first characterised in the laboratory for their linear response and stability, so the uncertainty of the final measurement could be quoted. The measurements and instrument diagnostics were continuously sent to the control centre. This helped to ensure that the equipment was operating correctly and the immediate availability of carbon dioxide concentrations.

Measurements began in June and finished at the end of September and the results are shown below in the context of the three questions stated above.

1.How do concentrations of carbon dioxide and methane vary between rural, Outer London and London Centre sites?

An increase in average concentrations over the measurement period was seen for all species between the rural site at Detling and the Outer London site in Teddington.

The average increase was 7.2 ppm for CO_2. There was a further increase in average concentrations between Teddington and the average of the Inner London sites of 1.04 ppm. The red line in the graph below shows the baseline CO_2 concentration for 2011 for the UK of 395 ppm, according to Met. Office and DECC measurements.

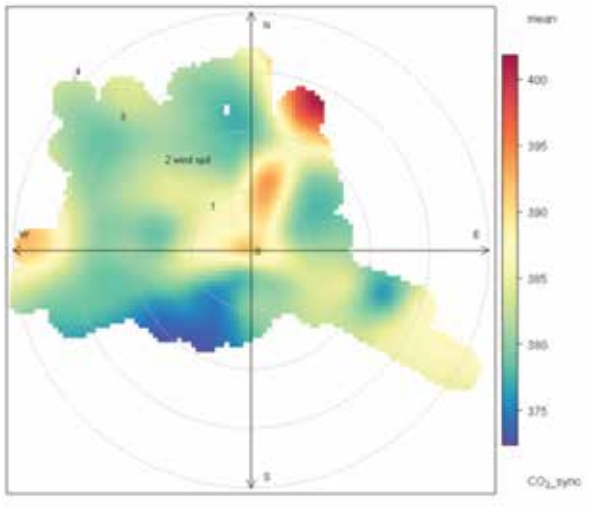
It is difficult to make a comment about the magnitude of concentration increases but they are in line for that seen from other pollutants e.g. Nitric Oxide (NO) from combustion processes. This increase was due to emissions from local traffic and fossil fuel fired heating.

2.How do meteorological conditions impact on these measured concentrations?

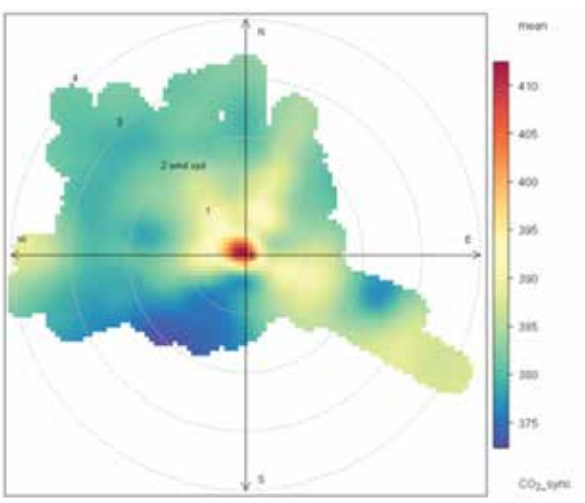
The variation in the concentrations of CO_2, with wind speed and direction, are best understood from polar plots, where the colour represents the measured concentration at a specific wind direction and speed. The distance from the centre of the plot corresponds to wind speed, i.e. colours close to the origin are concentrations measured at very low wind speeds whilst colours further from the origin represent concentrations measured at higher wind speeds.

The angular position represents the wind direction. The white areas represent wind directions and speeds that did not occur due to the short nature of the measurement campaign (3 months).

Detling CO_2



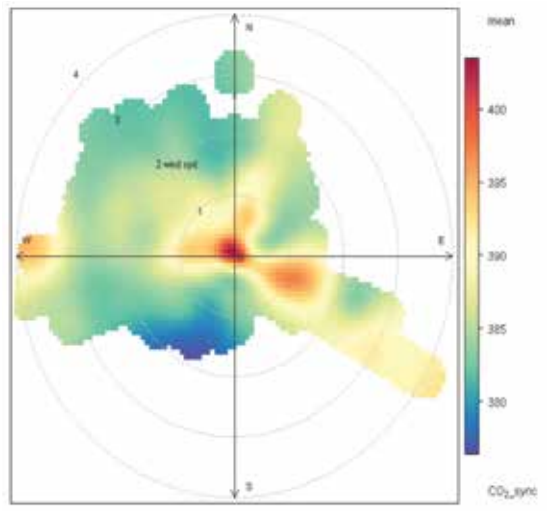
At Detling, high levels (red and yellow) were expected in the NW if CO_2 from London is the main source detected. We observed raised concentrations from the NNE, likely to be from Kingsnorth Power Station.



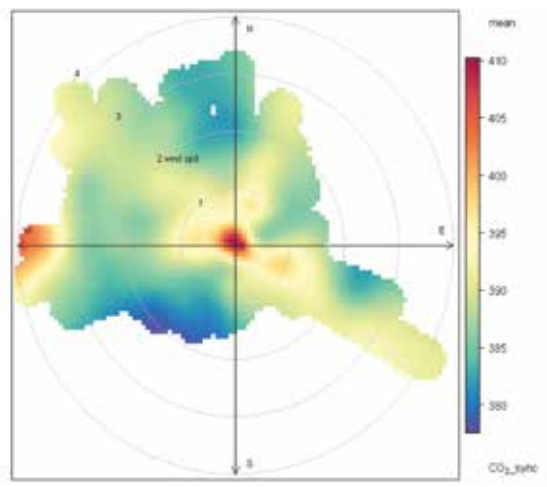
Teddington CO_2

Teddington's high levels of CO_2 (red and yellow) were to be expected from the NE if CO_2 from London was the main source detected. Raised concentrations in the middle suggest CO_2 from local sources at low wind speeds dominated. There was poor dispersion of locally generated CO_2 under these conditions.

Poplar CO_2



Hackney CO_2

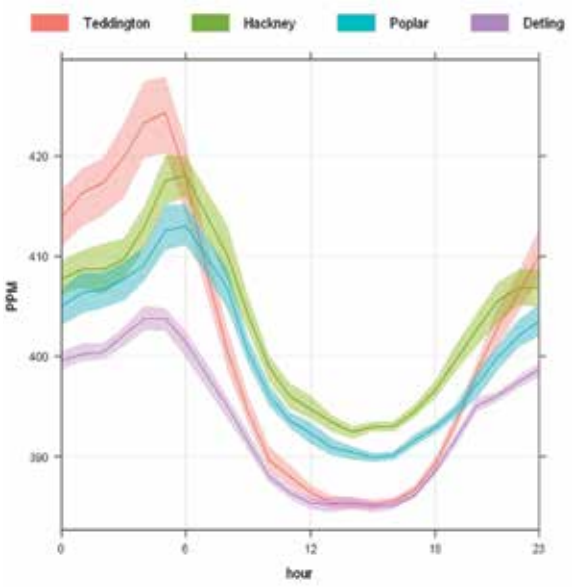


Raised concentrations in the middle of the plot for Poplar and Hackney suggested that CO_2 from local sources at low wind speeds dominated the measurements. Higher concentrations from the SE at Poplar were believed to be from traffic from the Blackwall Tunnel.

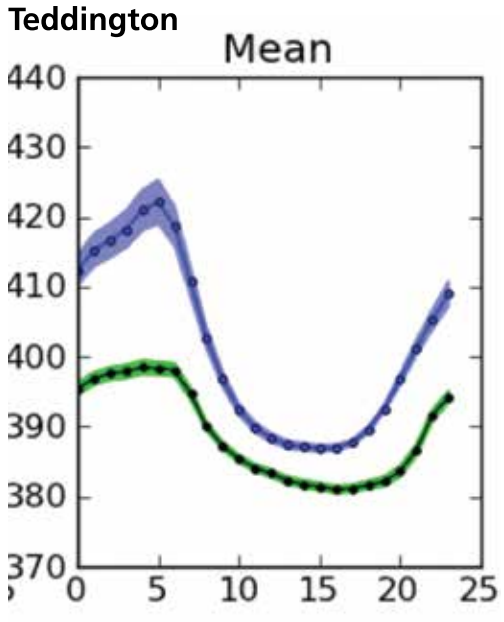
One thing the results showed us was that concentrations were affected by wind conditions. At times of low wind speed, the concentrations were higher as a result of poorer dispersion of local emissions. Concentrations as high as 520 ppm CO_2 were seen at Teddington, Poplar and Hackney compared with the average peak in the daily value of 412ppm to 424ppm. The dominance of local sources was expected as the measurements were taken at the relatively low heights of 10-15m.

3.How do expected concentrations from known sources compare with the measured concentrations for this period?

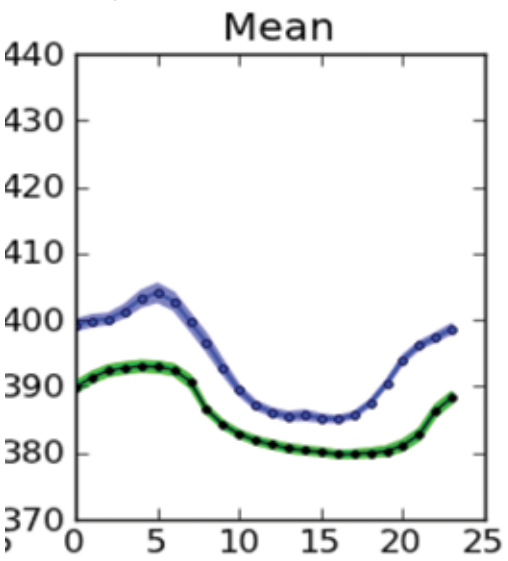
The average variation in measured CO_2 concentration during a day is shown for each site below; the y-axis the shaded area represents the uncertainty in the mean y-value due to the standard deviation of the results over that averaging



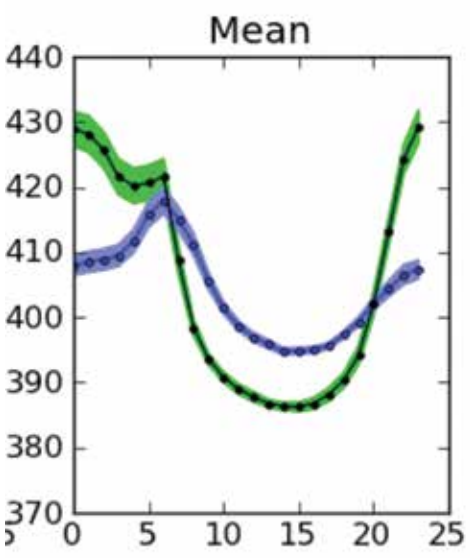
Teddington



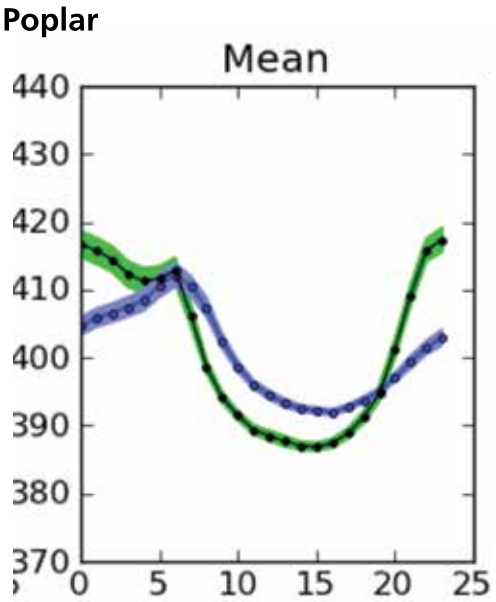
Detling



Hackney



Poplar



Blue =observations, green=model

period, so as to cover 95% of the variation. It is not the overall measurement uncertainty.

The variations of carbon dioxide concentrations over the day largely reflect the normal diurnal cycle. The trial was undertaken over the summer, so photosynthesis from vegetation reduces CO_2 concentrations during the daytime. Higher peaks in the morning and evening are seen at Teddington, Hackney and Poplar compared with Detling, which is most likely down to the effect of local traffic, such as that from the Blackwall Tunnel.

These diurnal variations were compared with modelled data from LSCE using the most recent GHG inventory for London (2010) – comparisons are shown below. A direct comparison was difficult to make because inventory data for 2012 will only be published in 2014. However, our comparison indicated that measured CO_2 concentrations over the period were mainly higher than predictions based on the inventories available.

Impact of the pilot

It is essential that we are able to assess and control GHG emissions at international, national and major city level, to both reduce the level of polluting emissions and to promote the uptake of new low carbon technologies. Rising populations will only enhance this need, as it will increase emissions, so nations will need to implement thorough and robust ways of reporting how they reduce their carbon footprint.

The pilot study in London 2012 showed the viability of the GHG Emissions Measurement Service being developed by Astrium Services and its partners. Further pilots are currently being carried out in Paris and Rotterdam.

What is next?

A long term site is now installed at Divis, IN Northern Ireland sampling the same species at ground level, 50m and 100m. Boundary layer and other meteorological measurements are being made at this site.

By sampling at 100m we can provide measurements of CO_2 concentrations that are not overly influenced by local sources, which is a lesson from the London campaign. When these measurements are combined with modelling, then a comparison with concurrent, UK wide, GHG emissions inventories will be carried out.

The site will also be used to test different calibration protocols, using NPL gas standards, to maximise the accuracy of the measured CO_2 concentrations. In addition, sampling will be carried out at 50m and 10m, to gain information on the concentration gradient of CO_2.

The site will be a critical component of the full Emissions Monitoring Service. This will be rolled out for cities and countries aiming to monitor and verify their GHG emissions reductions over a period of time.

For more information on the London Pilot or the Astrium Emissions Measurement Service go to http://event.astrium.eads.net/en-london-pilot/ or email Jane.burston@npl.co.uk or christele.donadini@astrium.eads.net