Measurement Analysis of GC-FID Methane Network in East Anglia

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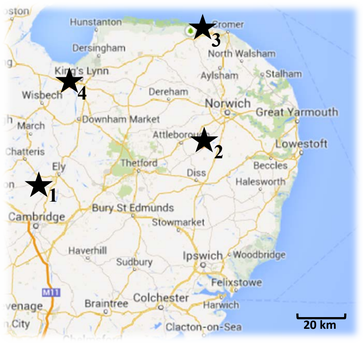
1. INTRODUCTION

Methane is the second most important anthropogenic greenhouse gas (GHG). The current UK emissions inventory for methane carries high uncertainty levels (20 % for the total emission but much higher on smaller, regional scales). The UK Climate Change Act (2008) states there should be a 80 % reduction in GHG emissions by 2050 (relative to the 1990 baseline). To accurately reduce our emissions this uncertainty must also be reduced.

The project aim is to develop a 'top-down' regional emissions estimate for methane to be used as a comparison to the current national emission inventory. Atmospheric measurements of methane are used in an Inversion model to achieve this. A measurement network of gas chromatographs coupled with flame ionisation detectors (GC-FID) have been installed around East Anglia (Figure 1) to monitor methane concentrations. This poster shows an analysis of the measurements to date.

Figure 1: *Locations of the 4 GC-FID machines*



	Site	Installation Date	Elevation (m)
1	Haddenham	July 2012	25
2	Tacolneston	July 2012	75
3	Weybourne	February 2013	15
4	Tilney	June 2013	25

5. SUMMARY

All four measurement sites can monitor both local, regional and far-field sources of methane depending on the elevation of methane above the baseline value and the duration of this rise.

A diurnal, weekly and annual cycle can be observed at all sites. Concentration variations show a large dependency on wind speed, wind direction and boundary layer height.

A one month period was analysed as a case study using measured methane data, modelled meteorological data from NAME and measured CO, CO_2, wind speed, wind direction and temperature from a SNAQ sensor installed at the Haddenham GC site.

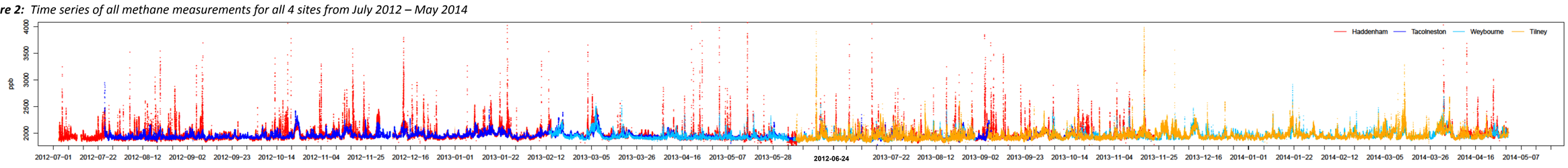
Both measured and modelled meteorological data were compared. All three variables were reasonably compared with the most weakly correlated being wind speed. It was deemed the modelled data was accurate enough to be used in further inversion analysis.

Finally, correlation analysis with CH_4, CO and CO_2 showed a strong positive relationship between CH_4 and CO. Boundary layer height was also found to effect concentrations of the three gases measured.

2. THE DATA SET

Measurements are recorded every 1-2 minutes. 1 year's worth of data has now been collected for all 4 sites, with almost 2 years of data being taken for both the Haddenham and Tacolneston sites. Figure 2 shows the raw data as a time series for all 4 sites. Periods of prolonged above-baseline concentrations of methane suggest sources from further outside the domain of interest. Short intensive periods of high methane concentrations imply nearby local sources.

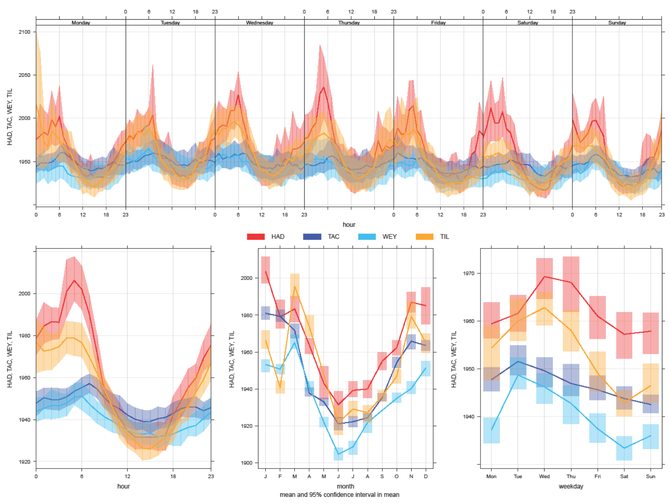
Figure 2: *Time series of all methane measurements for all 4 sites from July 2012 – May 2014*



3. ANALYSIS

The following analysis is with the entire dataset available. Figure 3 shows various time dependant statistical relationships derived from the 4 sites. All plots show the mean methane concentration (ppb) with the 95 % percentiles as the shaded area. No strong weekly cycle is observed however a large diurnal cycle can see been in the top and bottom-left plot where there is a peak in the early hours of the morning and a minimum during the afternoon. This corresponds to dispersion effect cause by boundary layer height change. A larger diurnal relationship is seen in Haddenham and Tilney particularly which could be the result of more local sources.

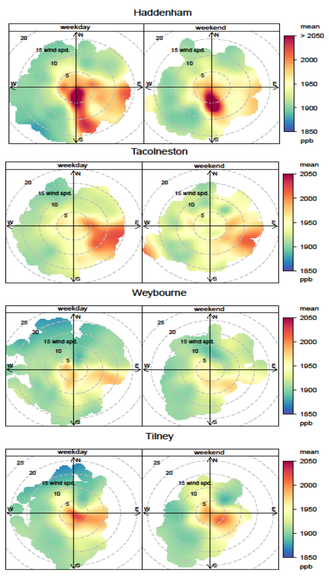
Figure 3: *Statistical time dependant analysis of methane data. Plots made using the R 'Openair' package.[2]*



A clear annual cycle can be been in all sites. Tilney appears to have a decrease in Dec and Jan. Figure 2 shows very few anomalies occurring during those months which will lower the mean concentrations. The bottom-right plot suggests a slight weekly cycle with all data sets with a maximum early to mid week and minimum in the weekend.

This cycle is studied further in figure 4 which shows polar bivariate plots for each site split into weekday and weekend values. A Mann-Whitney-Wilcoxon statistical significance test (U test - 95 % confidence) was used to assess if this observed cycle was significantly different. Each site was split into four wind quadrants and the results are shown in the table below.

Figure 4: *Polar Bivariate plots, separated by weekday and weekend. Plots made using the R 'Openair' package.[2]*

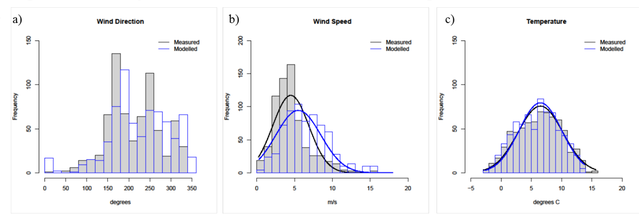


	North	South	West	East
HAD	X	X	✓	✓
TAC	✓	X	✓	✓
WEY	X	✓	✓	✓
TIL	✓	✓	X	X

4. HADDENHAM CASE STUDY

Between November 2012 – December 2012 a SNAQ (Sensor Network for Air Quality) sensor was installed at the Haddenham site. Concentrations of carbon dioxide, carbon monoxide were measured along with the meteorological variables wind speed, wind direction and temperature. A comparison between these variables and the ones produced by the Met Office's model NAME (Numerical-Atmospheric Dispersion Modelling Environment – used in future Inversion analysis) is shown in figure 5. All variables show reasonable to good correlation. It appears NAME appears to over-estimate wind speed (or the sensor underestimates). The measured wind direction has very few northerly recordings due to an obstruction NW of the site.

Figure 5: *PDFs of measured and modelled meteorological data*



$R^2 = 0.743$ $R^2 = 0.777$ $R^2 = 0.933$

Figure 6: *Anomaly time series plot of CH_4, CO and CO_2 concentrations. Windrose[1] plots corresponding to the numbered periods indicate wind speed and wind direction for specific periods of time.*

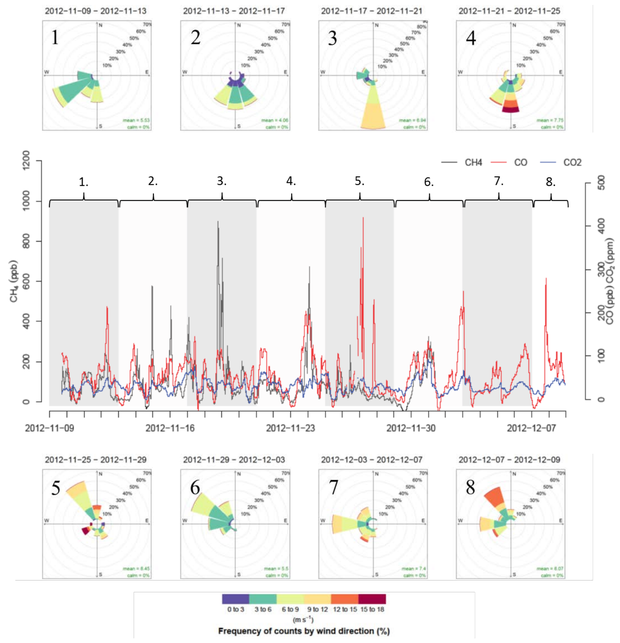
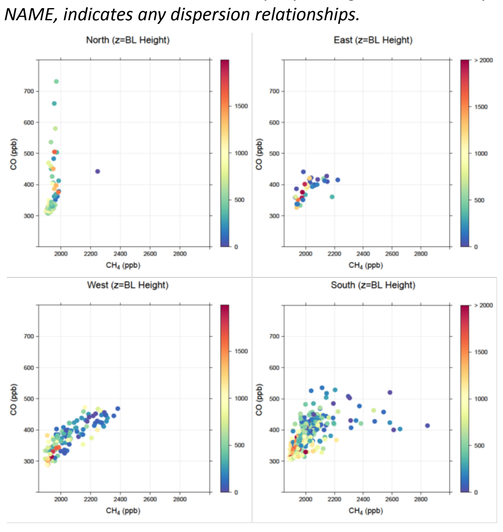


Figure 6 shows an anomaly time series of the measured CH_4, CO and CO_2 with windrose plots using modelled met data which correspond to the labelled subsections. Figure 7 shows correlations of CH_4 and CO subdivided by wind direction. The south and west panels show a clear dependency on boundary layer height with the high CH_4 values due to the local sources at Haddenham. The north panel indicates a nearby CO source but no CH_4.

Figure 7: *Correlation plots of CH_4 and CO split into four wind directions. Z axis shows boundary layer heights modelled by NAME, indicates any dispersion relationships.*



References:

[1] – Carslaw, David, Ropkins, Karl, 2012. Openair: Open-source Tools for the Analysis of Air Pollution Data. R Package Version 3.05.0.

[2] – Mead, M. I., et al, 2013. The use of electrochemical sensors for monitoring urban air quality in low-cost, high-density networks, Atmospheric Environment 70 (2013) 186e203.