A note on SO_2 concentrations in London 22nd to 1st July 2009

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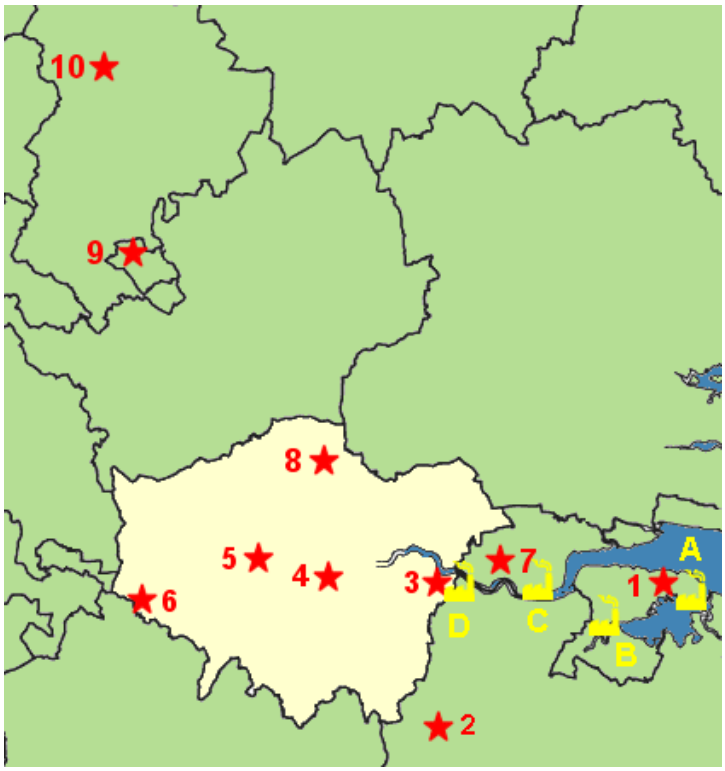
A series of elevated SO_2 events have been recorded across the London Air Quality Network in the past week. This note investigates the character, distribution and probable reasons for these concentration 'spikes'.

All data used were scaled and validated, but are provisional and subject to change during the ratification process. Source data were from the LAQN and the AURN.

Several 'events' have been detected causing brief periods of elevated SO_2 over most of London with one episode reaching across north London and into Bedfordshire and a further two 'events' affecting Sevenoaks. In all cases the concentrations have been modest, with concentrations not more than 60 ppb.

Four of these 'events' have been investigated in more detail; 22nd-23rd June, 25th June, 29th June and 1st July. 15 minute resolution SO_2 measurements were taken from ten urban background or rural monitoring sites in Kent, Essex, Greater London and Bedfordshire describing an east west transect, as shown in Figure 1. Measurements of wind direction were taken from Medway Stoke. The mostly likely sources of SO_2 are the Thames side oil and coal burning power stations. The location of these is also shown in Figure 1.



Monitoring sites
Medway Stoke (1)
Sevenoaks (2)
Bexley Slade Green (3)
Lewisham New Cross (4)
North Kensington (5)
Hounslow Cranford (6)
Thurrock (7)
Enfield Edmonton (8)
Luton (9)
Bedford (10)

Power stations
Grain (A)
Kingsnorth (B)
Tilbury (C)
Littlebrook (D)

Figure 1: Distribution of monitoring sites selected for study. Coal and oil fired power stations are also shown.

25th June and 1st July

Two events were measured at Sevenoaks. The event on the 25th June was perhaps the most straight forward of the events investigated. Elevated concentrations were initially measured around 09:00 GMT on 25th June with a second 'spike' in concentrations during the afternoon. As shown in Figure 2, the elevated concentrations were modest, being less than 30 ppb, when compared the Air Quality Strategy Objective concentration of 100 ppb. The elevated concentrations of SO_2 were clearly linked to elevated concentrations of NO_X as expected from a combustion source. The elevated SO_2 concentrations were measured during winds from the ENE. This wind direction points towards Grain and Kingsnorth power stations on the Medway estuary. Concentrations at Medway Stoke and Bexley show slightly elevated concentrations but no evidence of a distinct plume grounding.

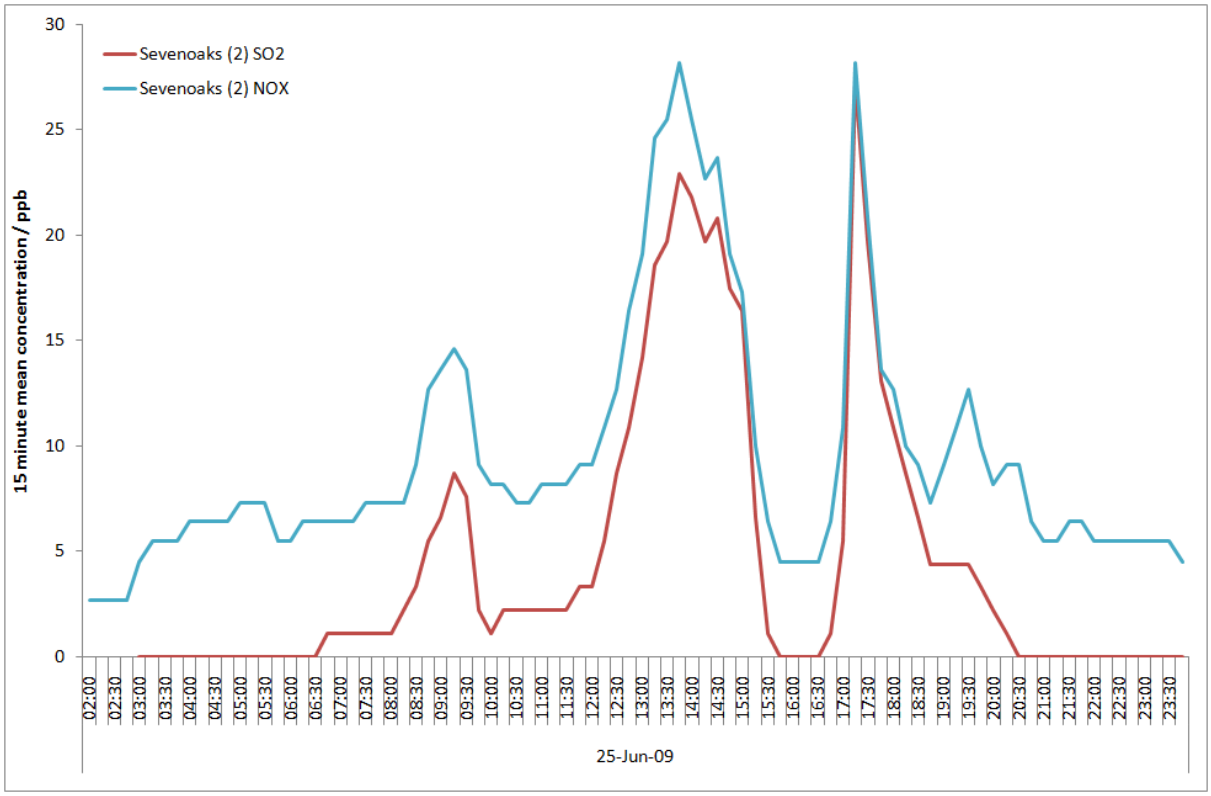


Figure 2 15 minute mean concentrations of SO_2 and NO_X at Sevenoaks on 25th June.

The second event at Sevenoaks, on 1st July, followed a similar pattern to that on the 25th June. Elevated SO_2 and NO_X were measured during wind directions of around ENE, as shown in Figure 4. Again this wind direction suggests either Kingsnorth or Grain power stations as the source. Importantly the peak concentration reached 60 ppb, approaching the AQS Objective concentration of 100 ppb. It is the greatest SO_2 concentration measured during the series of plume grounding events.

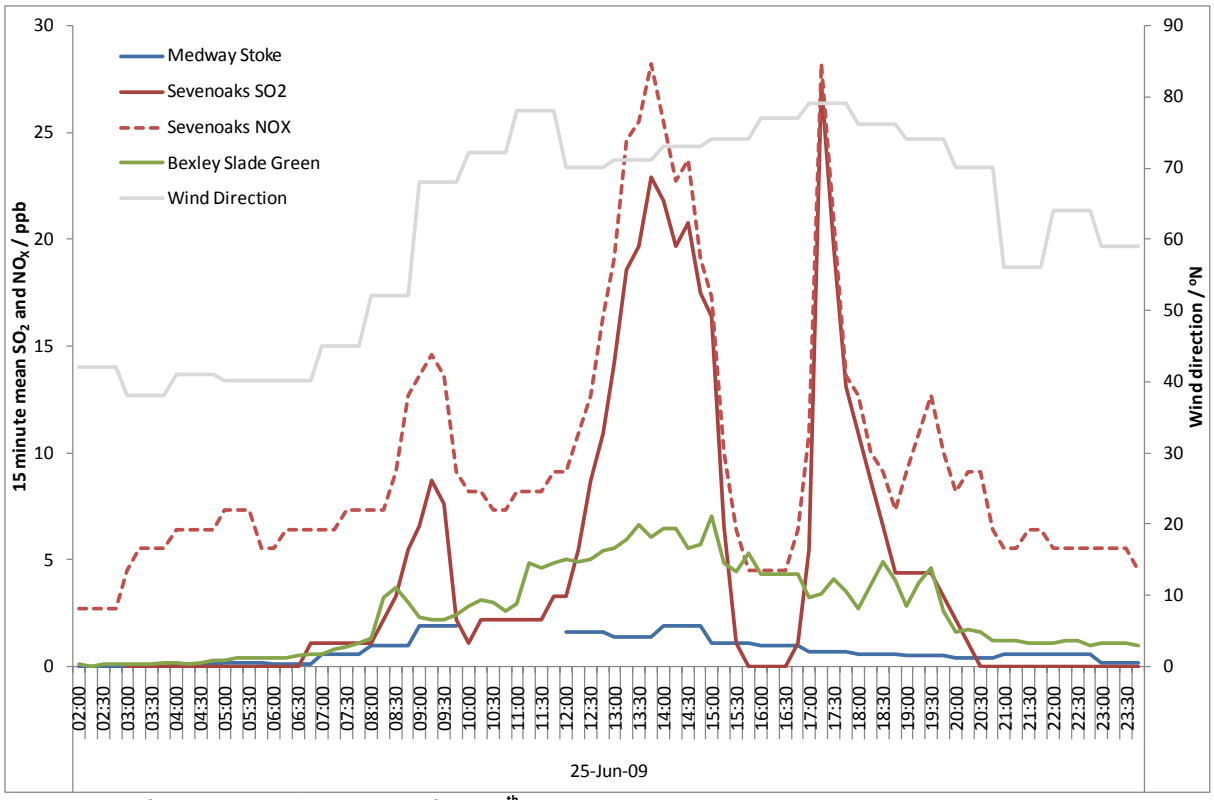


Figure 3: SO_2 and NO_X concentrations at Sevenoaks on 25th June 2009.

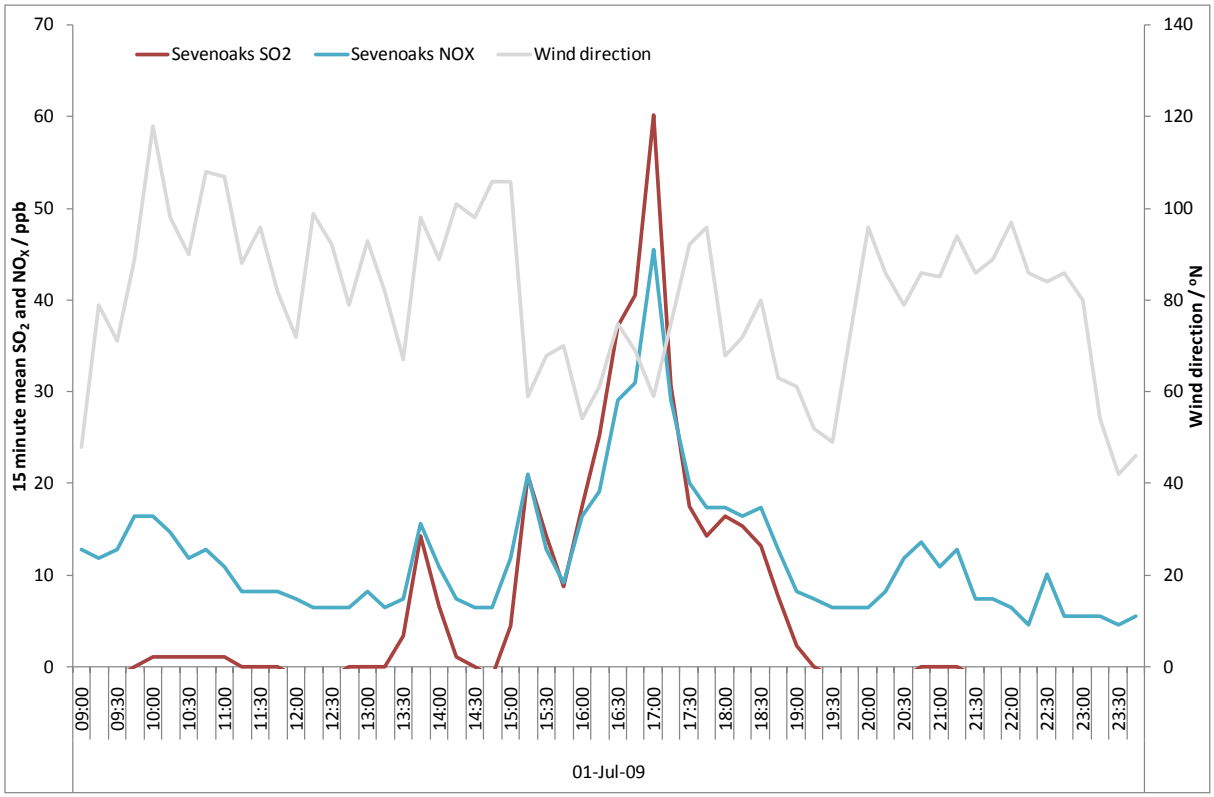


Figure 4: Wind direction, SO_2 and NO_X concentrations at Sevenoaks on 1st July 2009

29th June

Figure 5 shows SO_2 concentrations recorded at six monitoring sites on 29th June and shows a more complex situation when compared with the events at Sevenoaks. The event of 29th June shows clear progression of a plume across London from east to west. Light easterly winds were present throughout the day. Elevated SO_2 concentrations were first recorded at Bexley Slade Green at 14:30 GMT peaking at 35 ppb with a second spike of 30 ppb at 18:00. There then followed a 'classic' plume progression from east to west across London with corresponding spikes at Lewisham at 15:30, Kensington at 16:00 and Hounslow at around 17:00. As the plume progressed peak concentrations decreased and were only just above background at Hounslow (6 ppb) in the west.

No elevated concentrations were recorded at Medway Stoke to the east or at Sevenoaks to the south. This progression of elevated SO_2 across London accompanied by decreasing peak concentrations is typical of industrial plume grounding. Furthermore, the lack of signal at the Medway Stoke site suggests that the source may have been between Stoke in Kent and Slade Green in Bexley. Littlebrook and Tilbury power stations are located in this area. However, it is also possible that the plume simply missed Stoke and that the source was to the east of Stoke, possibly Grain power station or Kingsnorth to the south of the Stoke site.

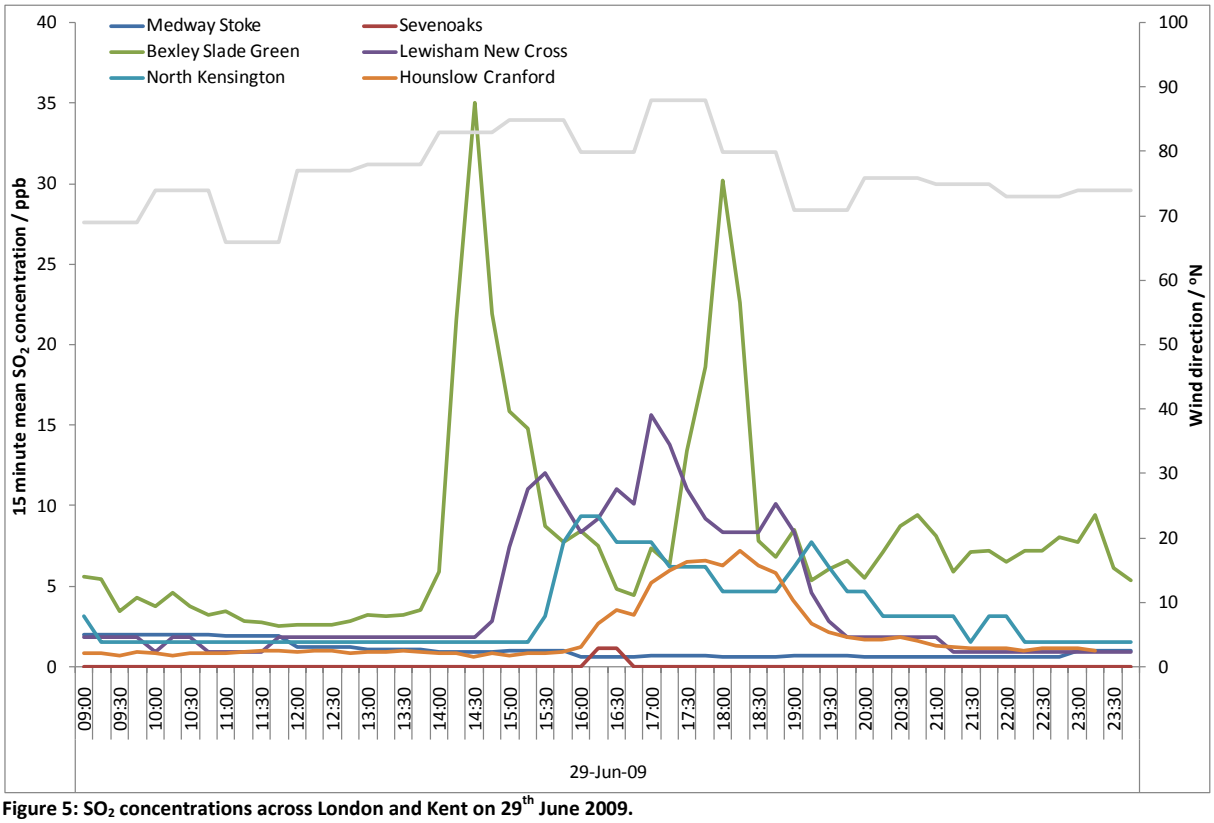


Figure 5: SO_2 concentrations across London and Kent on 29th June 2009.

22nd and 23rd June

The most complex pattern of plume grounding occurred on the 22nd and 23rd June. During both events the plume grounding followed 'classical' spatial progression with wind direction; from Bexley in the east, westwards along the line of the Thames through Lewisham, Kensington and finally to Hounslow in west London as shown inFigure 6. However, the event on 22nd was preceded by a grounding at Medway Stoke as wind direction backed from around 150° to around 90° (classic grounding conditions). It is possible in this circumstance that the source was close to Medway Stoke; most likely Grain power station which is nearby at a bearing of around 120°.

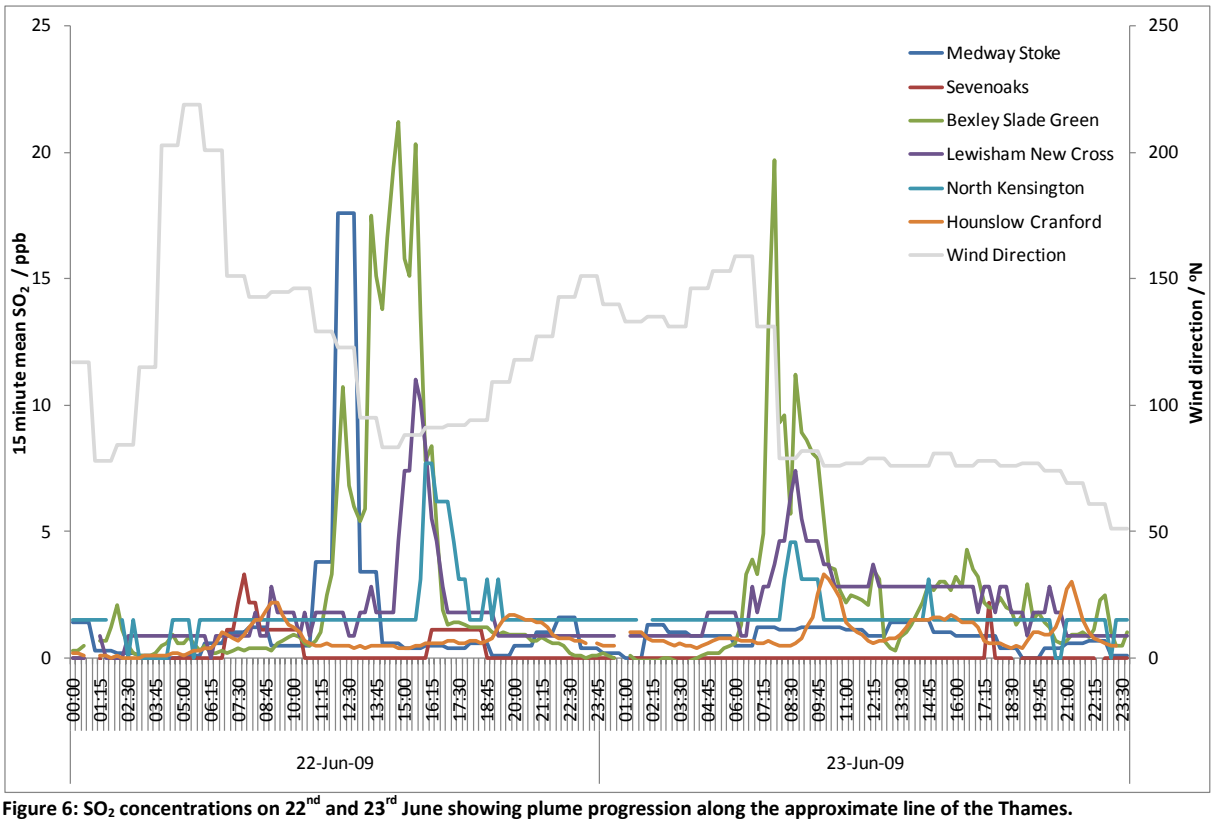


Figure 6: SO_2 concentrations on 22nd and 23rd June showing plume progression along the approximate line of the Thames.

A separate plume appears to have affected the north side of the Thames on 22nd June. Figure 7 shows the SO_2 concentrations at Medway Stoke and Bexley (as shown inFigure 6) however a second later plume can also been seen. Initially affecting Thurrock in south Essex, this plume then grounded in Enfield in north London before progressing northwards across Bedfordshire affecting Luton and finally Bedford overnight. Whilst it is possible that the plume that grounded along the line of the Thames and the plume the grounded across the northern part of London as simply different ground contacts from the same plume, the different profile at Thurrock with a slow increase in concentrations during the early afternoon is very different to the distinct peak measured at Bexley some 9 km to the south suggesting two different plumes.

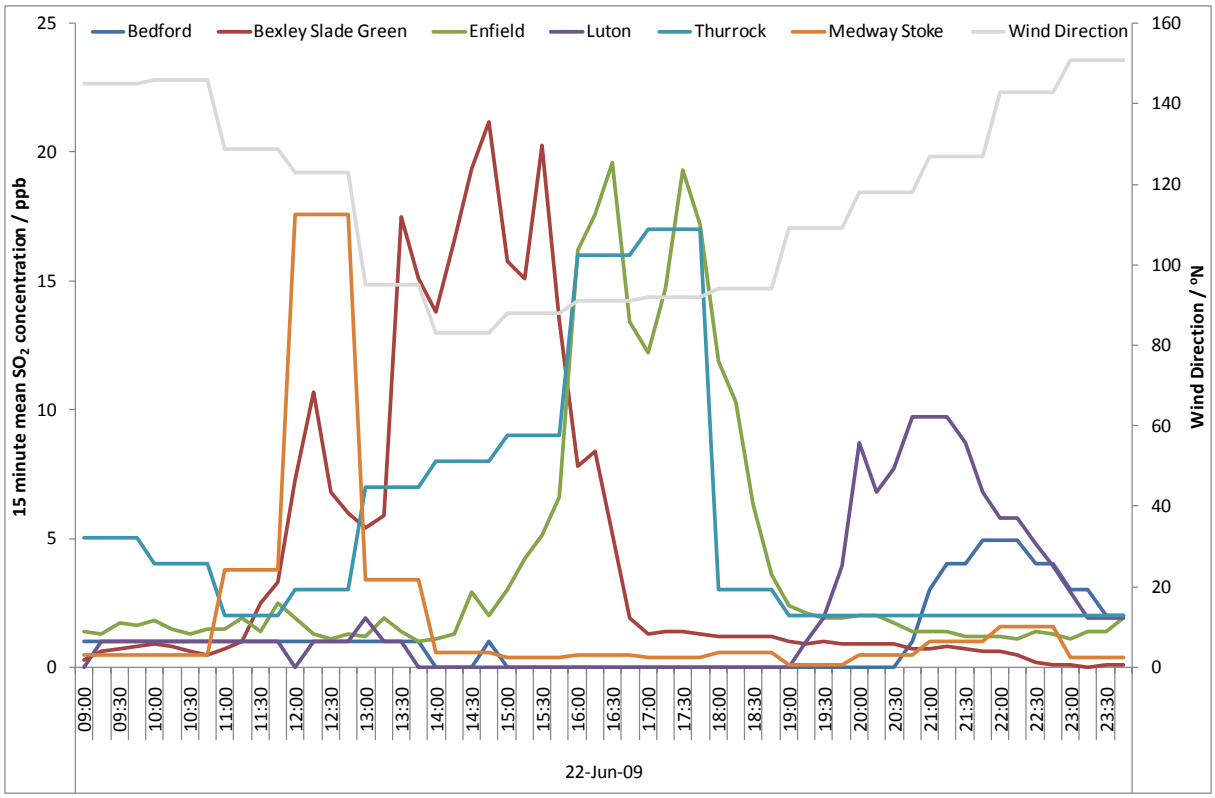


Figure 7 SO_2 concentrations of 22nd June showing a plume spreading across north London and into Bedfordshire.

Conclusions

It must be emphasised that the SO_2 concentration peaks measured during these events have been modest, not more than 60% of the AQS 15 minute objective concentration. However the concentration of 60 ppb, measured at Sevenoaks on 1st July, some 43 km from the source raises the possibility of a breach of the AQS Objective concentration closer to the source.

During the 2006 heat wave a combination of power demand in London and maintenance at several north England power stations lead to Littlebrook being used as reported in the Financial Times newspaper. During July 2006 a pattern of SO_2 plume grounding was seen in London including a breach of the AQS objective concentration in west London around Teddington and Richmond.

As with most plume grounding events in London it is hard to determine which Thames side power station is responsible:

- Grain power station was almost certainly the source of the grounding event measured at Medway Stoke.

- Each of the episodes with clear tracks across London have very much greater concentrations at Bexley than sites further east, such as Lewisham only 14 km away. The concentration decrease between Lewisham and Kensington a further 14 km is much smaller than that between Bexley and Lewisham. This suggests that the source was very much closer to Bexley than it was to Lewisham. Grain and Littlebrook are unlikely to be the source of these plumes being around 31 km from Bexley and a similar 45 km from Lewisham. Instead it is likely that Littlebrook or Tilbury was the source of these plumes.

- Wind directions suggest that either Grain or Kingsnorth was the source of the plume grounding events at Sevenoaks. The ratio between SO_2 and NO_x, about 1:1 during the first episode and 1:1.6 during the second may be of use to station regulators to distinguish between Kingsnorth, which burns coal and Grain which burns oil.

- The complexity of the plume grounding on 22nd June with two apparent plumes spreading across London shows the area affected by such plume groundings. The southerly plume was tracked over 40 km westwards across London and the more northerly plume was tracked over 87 km from Thurrock to Bedfordshire. These events also point to at least two sources operating at the same time. It is known that Grain was one of the sources. The event suggests that Littlebrook and / or Tilbury were also sources of plume grounding on this day.

Data on detailed power station use is regarded as commercially confidential and we do not receive such information. However following the incident of 29th June we requested that our own staff and local authority colleagues look out for evidence that Littlebrook was in operation (it can be clearly seen from most of east and north London). A start up was witnessed late morning on the 30th. Electricity demand on the 30th was likely similar to the previous warm afternoons.

Oil fired power stations such as Littlebrook and Grain are not utilised often. However they can be started quickly to respond to diurnal or unexpected demand peaks. Littlebrook occupies an important place in the grid system being close to London.

For the most part the concentrations, even close to the source have been far less than the AQS Objective concentration. However, the concentration of 60 ppb at Sevenoaks is more concerning. The recent plume grounding events and the breaches of the AQS objective concentration in 2006 confirm the need to maintain a good spatial distribution of SO_2 monitoring in the LAQN.

Further information

Further information about sites and access to measured data can be found on the network websites:

www.londonairorg.uk

www.hertsbedsair.org.uk

Addendum

At the time of release of this note, a further plume grounding was being detected in east London exceeding 60 ppb. Updates will be released over the next few days as necessary.