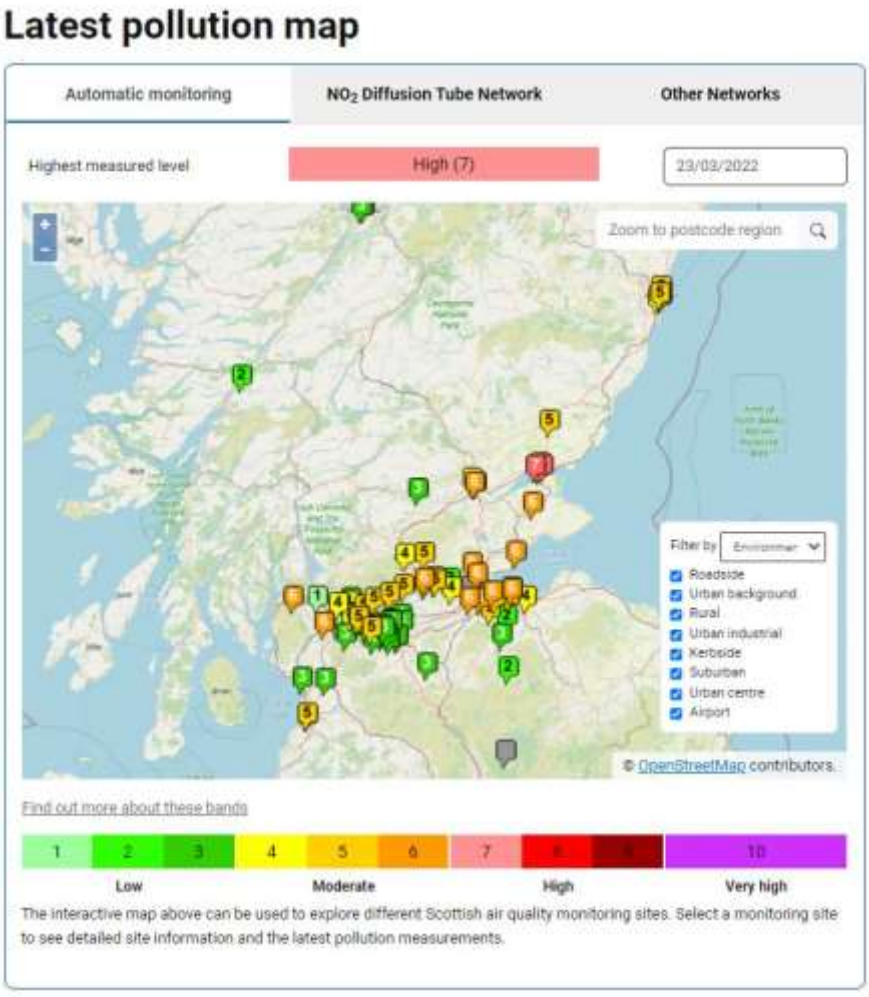
The Current Transboundary Pollution Episode and its Impact on Scottish Air Quality

Scotland is currently experiencing a Particulate Matter pollution episode, with concentrations in the "Moderate" banding (51- 75 μgm^{-3} for PM_{10}) seen across the central belt and up the East coast. Measurements in the "High" band (76- 100 μgm^{-3} for PM_{10}) are also currently being recorded at monitoring stations in Dundee, as shown in Figure 1. While these concentrations are unusual, it is not uncommon for these type of events to occur, with a similar even occurring between the 22nd and 26th of March 2020. Warm, calm conditions means that there is little dispersion of locally emitted pollutants, (such as industrial, transport and agricultural emissions) which is added to by emissions blown in from continental Europe. Please carry on reading below for an explanation of how Transboundary pollution can affect Scottish air quality and the causes of this specific event.

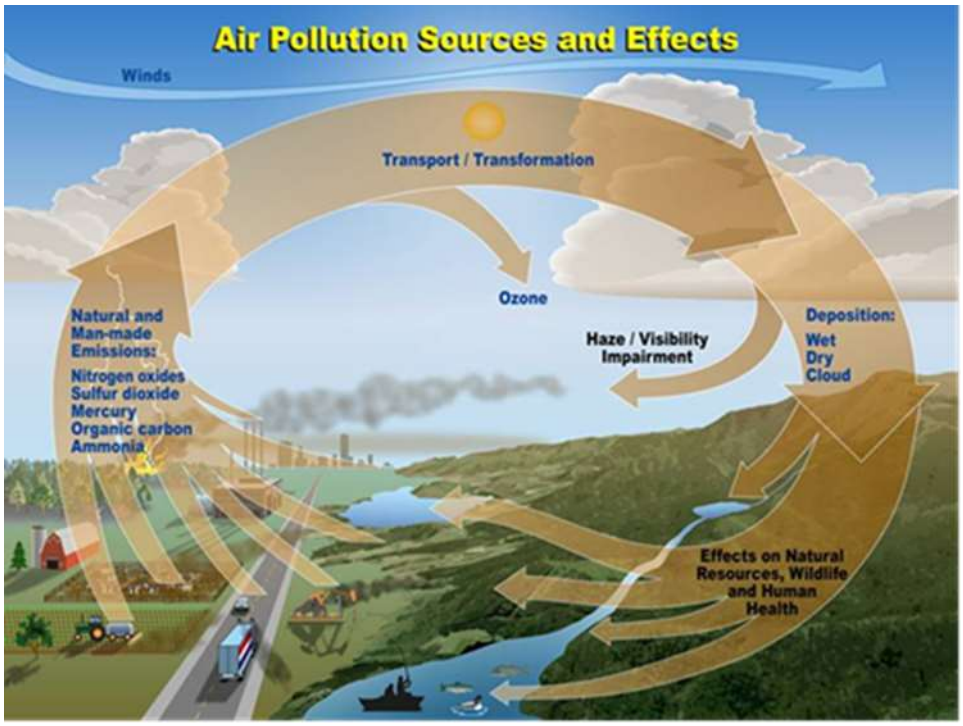
Figure 1: Pollution bands for Scottish monitoring sites on Wednesday the 23rd March 2022



How Transboundary Pollution can affect Scottish Air Quality

The majority of the UK and Europe's air quality issues are derived from a variety of local emissions, point sources (e.g. factories), area sources (e.g. many smaller point sources) or mobile sources (e.g. road traffic). However, once pollutants have been emitted and are airborne they are subject to a variety of chemical and physical forces. Atmospheric chemical reactions between these primary pollutants and sunlight (UV radiation) and other substances in the atmosphere can cause the formation of secondary pollutants. For gaseous pollutants an example would be, UV light causing nitrogen oxides, released from vehicles, to react with hydrocarbons, from industrial activity, to produce secondary ozone. Fine particulate matter ($PM_{2.5}$ and smaller) is mainly formed by gas to particle conversions, such as the oxidisation of precursor gasses within the atmosphere. Both of which are harmful to humans and the natural environment. These pollutants, both primary and secondary, can also be "picked up" into parcels of air by the wind and transported to other areas. Depending on their chemical and physical properties the pollutants can remain airborne for significant periods of time. Figure 2 (http://cpcbenvis.nic.in/air_pollution_control.html) illustrates the sources, movement and effects of air pollution.

Figure 2:- Air pollution sources, transportation and deposition



Depending on the strength and direction of the wind pollution can be distributed locally or transported to locations large distances away. This is known as transboundary pollution. Certain areas of continental Europe, such as the highly urbanised and industrialised areas of Paris (in France), Ghent (in Belgium) and the Ruhr valley (in Germany), especially in combination, emit many primary pollutants. In addition, during the spring period ammonia emissions from the agricultural areas of Europe are believed to be the prime cause of secondary PM pollution episodes. The calm and warming weather is seen as a good opportunity for intensive fertiliser spreading however temperatures are low enough that particulate nitrate can be formed and transported (in higher temperature it volatises). If certain local weather conditions prevail, these pollutants can be transferred higher into the troposphere and picked up by weather fronts heading towards the UK. When these polluted air parcels reach the UK, they increase the background concentrations and combine with locally sourced pollution to create regional pollution episodes.

The Current Pollution Event, Concentrations and Causes

The current pollution event saw levels of Particulate Matter at some stations in Scotland move into the "moderate" banding on the 22nd March, with many more in "moderate" and some in "high" on the 23rd. Figures 3 and 4 below shows provisional PM_{10} and $PM_{2.5}$ data respectively. The thick blue line shows the mean of all sites. Over the period in question there is a small but significant rise above normal levels. With no known increase of PM source that would affect the entire country, this increase was highly unlikely due to local sources. However, when you look at the air mass trajectories above Scotland at the time the increase in concentrations makes more sense and an explanation can be found.

Figure 3: Provisional data for PM_{10} at Scottish sites (The Green spikes are currently under investigation, but are believed to be roadworks)

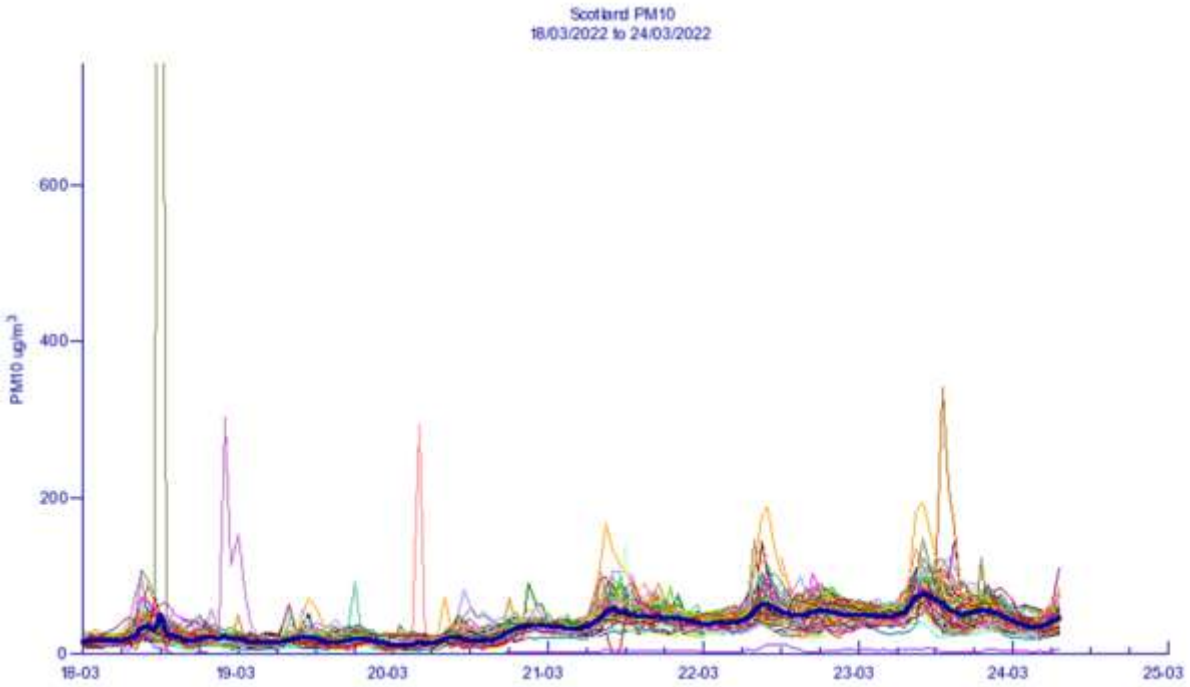
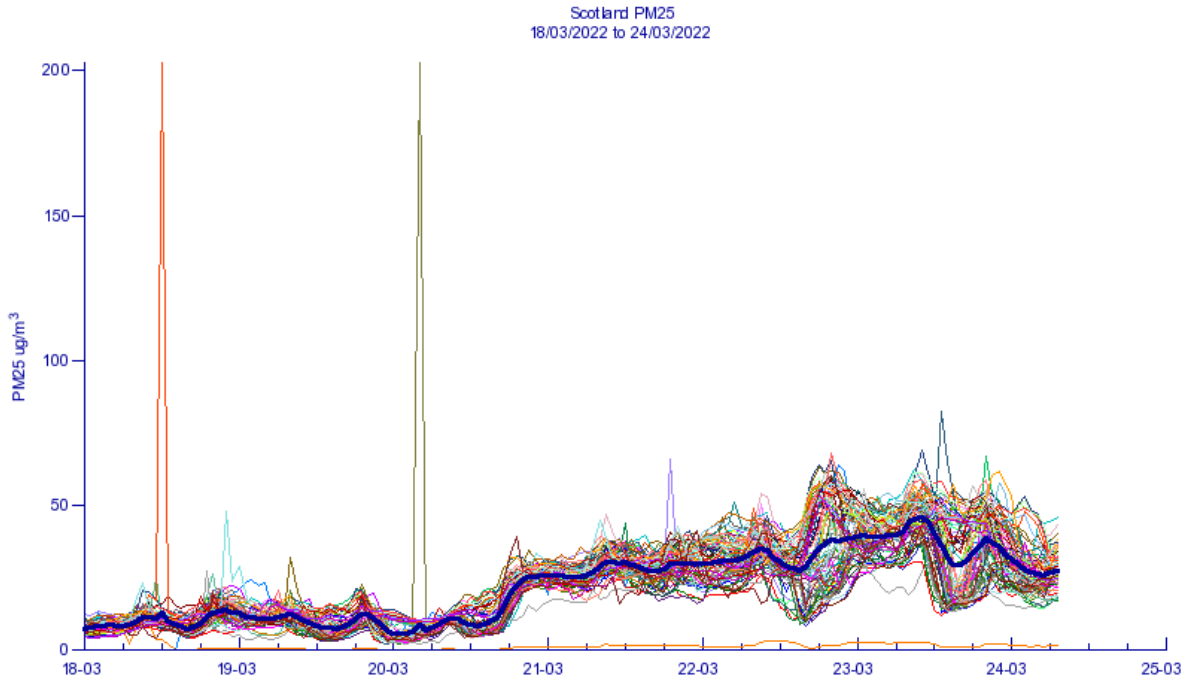


Figure 4: Provisional data for $PM_{2.5}$ at Scottish sites (The Black spikes are currently under investigation, but are believed to be roadworks)



Each coloured line on Figure 5 represents a different air parcel arriving at different locations within the UK. The lines are produced using the HYSPLIT model which accurately predicts how these parcels of air moved over the 96 hours before mid-day on Wednesday the 23rd of March this year. As can be seen, air parcels have moved over urban and industrial areas of continental Europe, while there the air parcels would have picked up the pre-cursor emissions needed to form transboundary pollutants such as PM_{10} and $PM_{2.5}$. This air mass then travelled across the UK where it will have continued to pick up pre-cursor emissions with further transboundary pollutant formation before arriving in Scotland causing the measured elevated PM levels.

Figure 5: Trajectory plot for air parcels in Scotland on Wednesday the 23rd March 2022