How does climate change impact air quality ?

- A focus on ozone extreme events -

Suzanne VAN ZUIJLEN[1], Paul YOUNG[1], Oliver Wild[1], Rob Lamb[1,2]

1 Lancaster Environment Center, Lancaster University, 2 JBA Trust Limited, Skipton,

European Union
European Regional Development Fund

Centre for Global Eco-Innovation

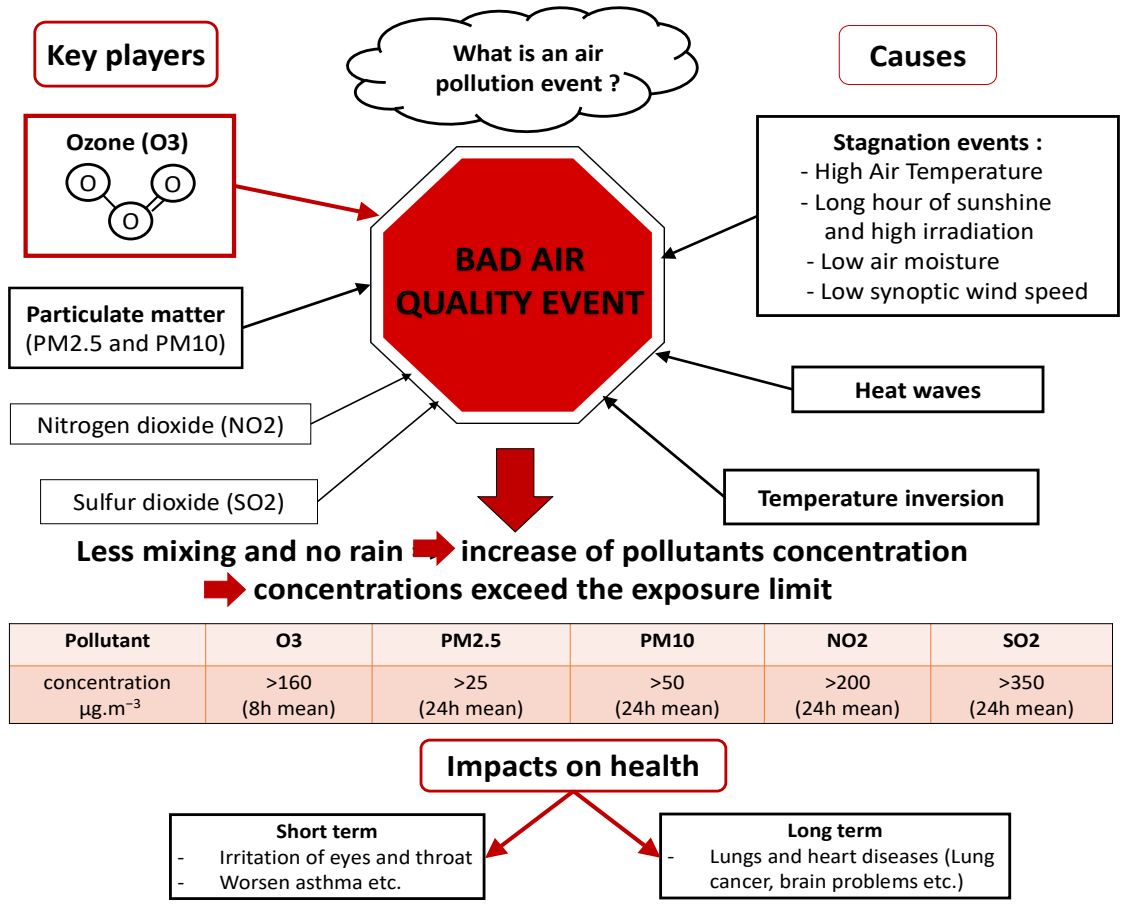
Introduction :

Poor air quality is a global threat to human and ecosystem health with climate change projected to exacerbate air quality problems through meteorological changes. Air quality is especially of most interest when pollution events are happening, these events, caused by specific meteorological configuration are likely to cause death when pollutants reach extreme concentrations.

A pollution event can be established considering the EPA(Environmental Protection Agency) or WHO(World Health Organisation) limits. As this study is focused on ozone concentration, this results is a maximum 8h mean concentration of ozone. If the value is exceeded, this period is considered to be an air pollution event. The interest of this work is to identify how climate change can influence the trend of air quality extreme events.

To do this, the results of the large-scale model CESM are used, the objective is to understand and describe how climate change can influence the occurrence, time scale and the spread of air pollution events for different future scenarios and for different locations using the ozone concentration calculated by the model.

Abbreviations :
CLIM85: Simulation with the climatology from the RCP8.5 scenario described in the last IPCC
CNTRL: Control simulation, all forcings set to year 2000 cyclical (meteorology, emissions...)
AQX: Bad air quality extreme event



Pollutant	O3	PM2.5	PM10	NO2	SO2
concentration $\mu g.m^{-3}$	>160 (8h mean)	>25 (24h mean)	>50 (24h mean)	>200 (24h mean)	>350 (24h mean)

Impacts on health

Short term
- Irritation of eyes and throat
- Worsen asthma etc.

Long term
- Lungs and heart diseases (Lung cancer, brain problems etc.)

Results and discussion

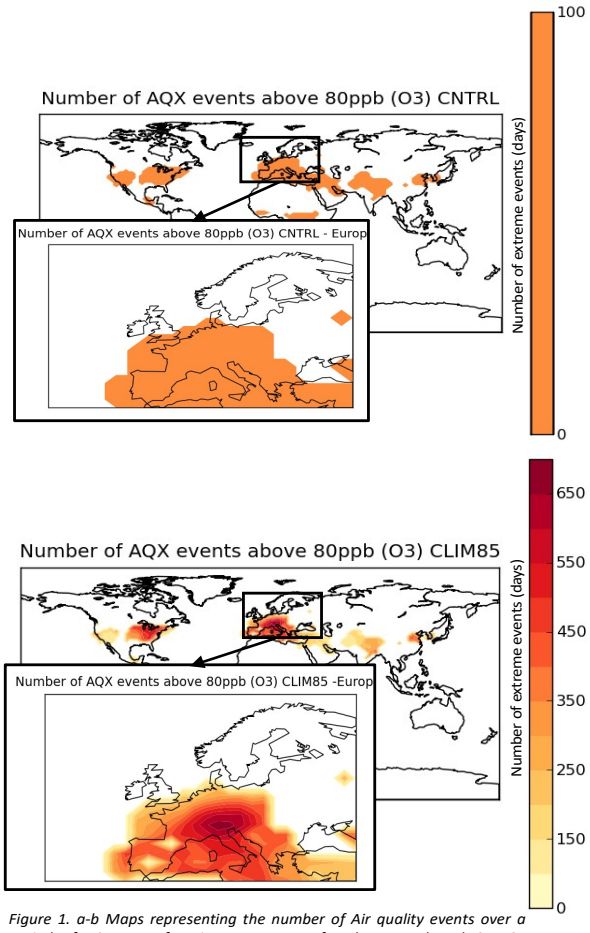


Figure 1. a-b Maps representing the number of Air quality events over a period of 10 years, focusing on Europe, for the control and CLIM85 simulation, respectively.

Occurrence of extreme events

The map on the figure 1-a represent the number of extreme event (days) over 10 years for the control simulation, considering the hypothesis that for one year, 10 extreme events of pollution are observed.

This assumption is used to calculate a new threshold as the model CESM used is biased. Indeed, ozone concentrations at the surface level seem to be overestimated.

As our simulations are not specific to past episodes, this solution helps to mitigate these bias. In addition to the threshold calculated considering the 10 episodes a year hypothesis, we decided to select areas where the calculated threshold is above 80ppb (160 $\mu g.m^{-3}$), as those concentrations have a direct impact on human health. The map on the figure 1-b represent the number of extreme event days over 10 years for the RCP8.5 scenario. The threshold calculated using the control run is kept to observe how much days of extreme event are observed with the RCP8.5 inputs in the model for the year 2100 with the current limits. The observation is clearly visible, the RCP8.5 scenario which represent a non-modified emission of pollutants and a modified climatology based on the impact of climate change tend to show an increasing number of extreme events by up to 7 times over 10 years in Europe compared to the control simulation.

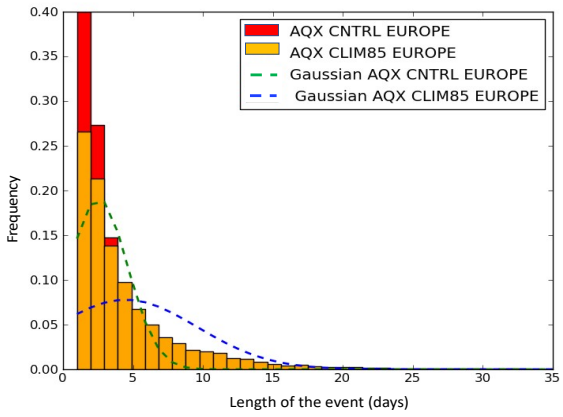


Figure 2. Histograms and Gaussian representing the length frequency of the events happening over 10 years in Europe for both simulation, CNTRL and CLIM85

Expansion of the event

The graph on the figure 3 two events for the control and the RCP8.5 scenario over the European area. As it is clearly visible, the RCP8.5 scenario seems to get events with an expansion greater in time (number of days of the event for the area) and also in terms of surface. Indeed, for the first event represented on the graph, the surface covered by the event has more than doubled for the RCP8.5 simulation. This is what we expected from the graph as the figure 1-b and 2 showed similar results. This means that the event will be more intense if the future climatology tend to look like the one implemented in the model for the RCP8.5 scenario.

Curious to see what does an event spread look like?

Length of the event

Figure 2 represents the length frequency of all the events happening over 10 years for the European area. Those histograms and Gaussian helps to identify how much differences, in terms of duration of the events, can be identified when comparing different simulations. The CLIM85 simulation seems to show longer episodes of pollution, indeed, as the Gaussian curve shows it, the peak is shifted and less high than the one for the control run. This explains that the simulation following the RCP8.5 climatology is likely to get more events with a greater length than the simulation from the control run. This increase of length is harmful for human health as the more you are exposed to high ozone concentration, the more it will affect your health.

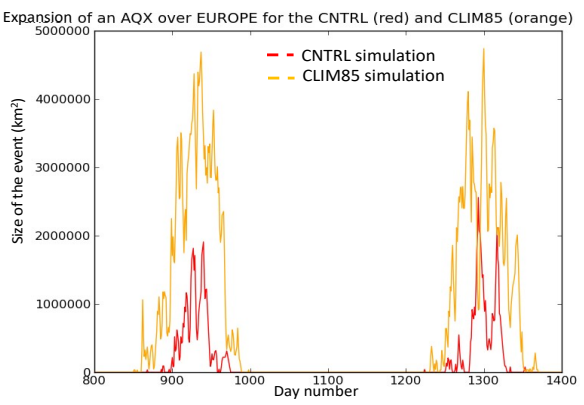


Figure 3. Spatial expansion of two AQX events in Europe for both simulation, CNTRL and CLIM85

Conclusion and perspectives

This study shows how much changes would be linked to climate change if the forecasted climatology scenario following the parameters of the RCP8.5 scenario happens to be similar to the observed climatology in the future. The results shown for each sections highlight the idea that bad air quality events would be more frequent, spread over greater areas but would also last longer. This last parameter is of most importance as the time of exposure to high concentration of pollutants can greatly threaten the health.

Beside the research aspect, a strong link with risk management is expected as this PhD project is done in partnership with JBA trust, an independent charity that supports research and promotes the growth of knowledge and skills in environmental risk management. The following steps of this study will be to link the results with the population vulnerability all over the world, creating an index of risk levels.