The importance of different global change processes for future air quality

- A STUDY OF EUROPEAN OZONE EXTREME EVENTS -

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WHY IS IT IMPORTANT ?

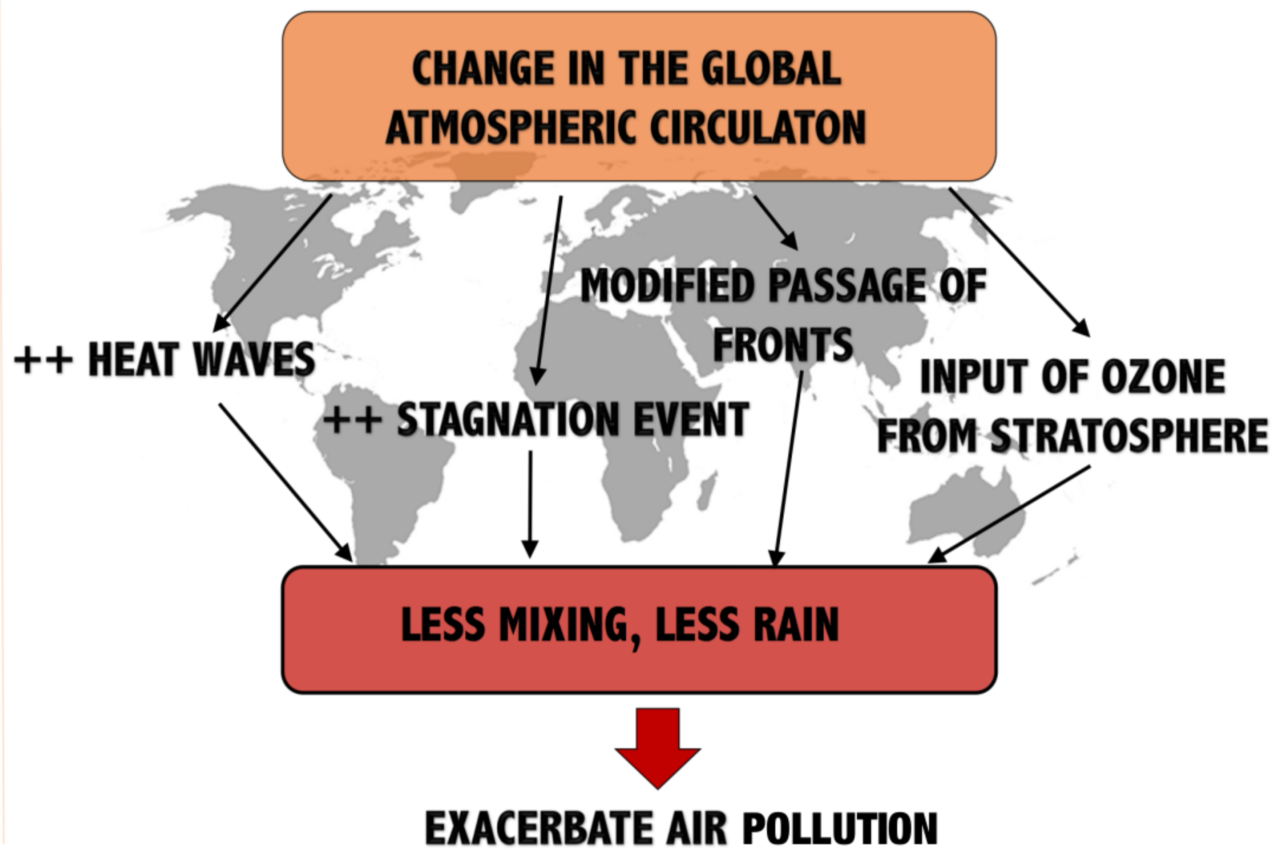
Poor air quality is a global threat for human and ecosystem health. **Over 4.2 million deaths each year result from air pollution**. Tropospheric **ozone is one of the major air pollutants**. When ozone concentration exceeds the exposure limit the impact on health can vary from minor to major health issue and even death.

Given that the climate change can impact air quality events it is important to **understand and describe how future climate change could influence the occurrence, time scale and the spread of air pollution events** for different future scenarios.

RCP : **Representative Concentration Pathway (RCP)** : wide range of greenhouse gas concentration (not emissions) trajectory adopted by the IPCC.

ODS : **Ozone depletion substances**

HOW CLIMATE CHANGE INFLUENCES AIR QUALITY ?



Understanding the future trajectory of AQ depends not only on projecting AQ pollutant emissions, but also on how climatic and meteorological factors will change. Factors Such as ventilation rates (wind speed, mixing depth, convection, frontal passages) and chemistry-climate interactions that control the residence time of pollutants in the atmosphere.

HOW DO WE QUANTIFY THE CHANGE ?

The simulations we are using in this study were previously made using CESM a global chemistry-climate model.

Each simulation cover 10 years of data which are averaged to get "one-year" results dataset.

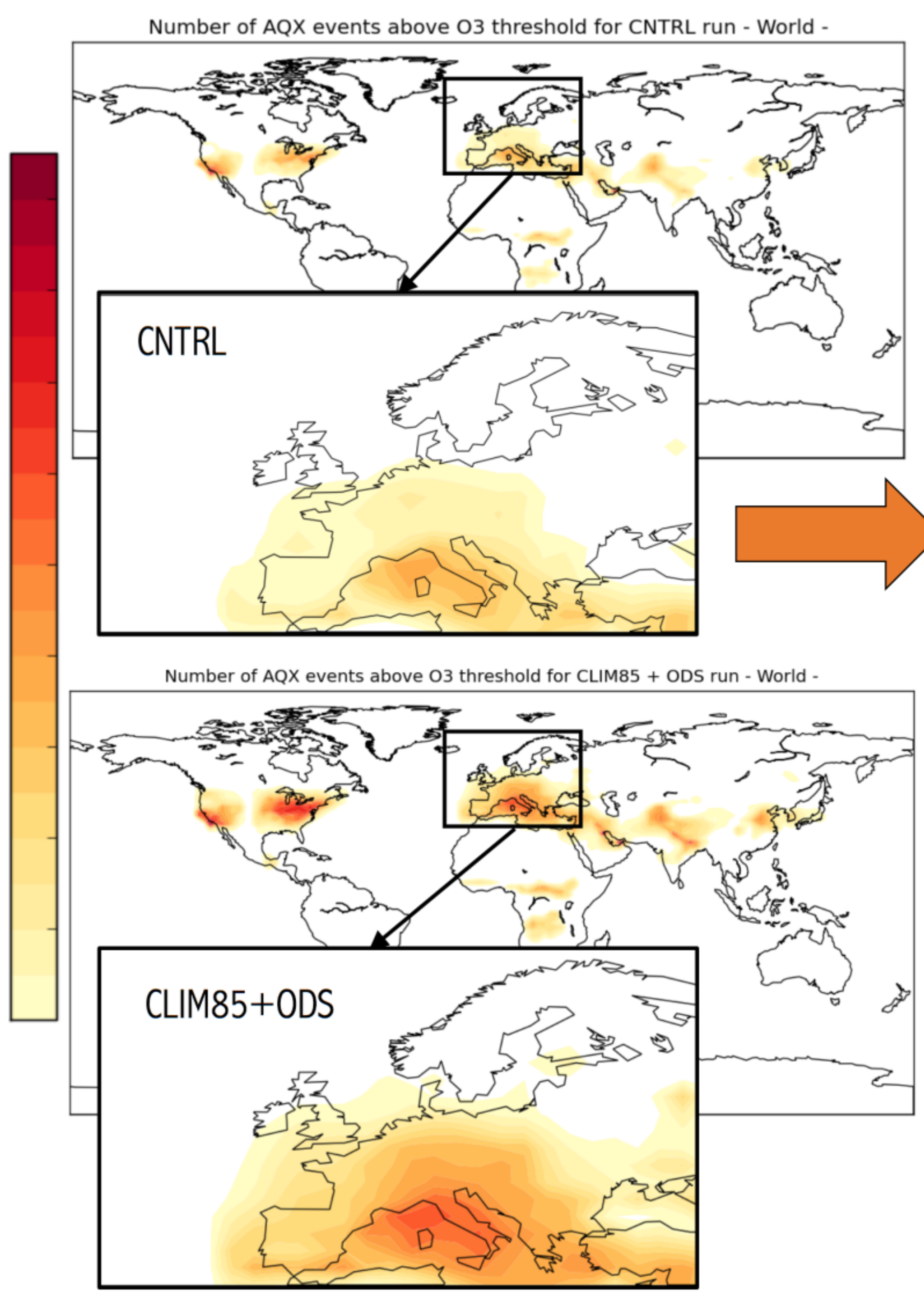
Different drivers of AQ change have been isolated and separately and conjointly studied

- **climate change based on different scenarios** (CLIM scenarios, RCP 8.5 and 4.5) to evaluate the direct effect of the increased temperature and thus modified wind, natural emissions (Wild fires, Lightening, isoprene…) and unchanged anthropogenic emissions.
- **Stratospheric ozone recovery** (ODS scenario, a scenario where the decrease in ODS concentrations induced by the Montreal Protocol is highlighted) to evaluate its impact on future AQ.

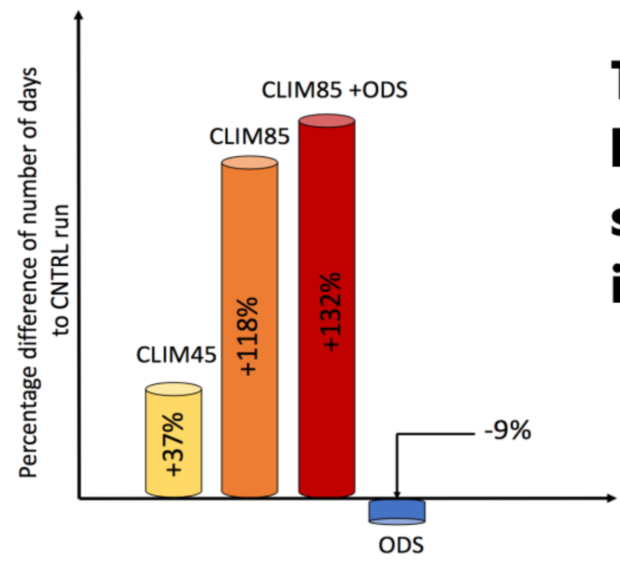
SETTING UP A SPECIFIC THRESHOLD

Large scale models are often biased in concentration they simulates, considering a specific EPA or WHO ozone limit was not the best choice. A new threshold has been calculated following the assumption that 10 events of bad air quality happen every year. **The new threshold has been calculated for the control run and applied to every simulation.**

IN THE FUTURE, MORE DAYS OF OZONE CONCENTRATION EXCEEDANCE



Climate change scenarios tend to increase the number of days with a concentration of ozone above the threshold



The combination of the RCP8.5 and the ODS scenario gives the greatest increase.

THE OZONE LAYER RECOVERY : AN INTERESTING RESULT…

The simulation with the ozone layer recovery shows a **decrease of the number of days with ozone concentration above the threshold**. More ozone in the stratosphere mean less UV in the troposphere which reduces tropospheric ozone production. **This is the opposite when stratospheric ozone recovery scenario is combined with the RCP8.5 scenario** the number of days with an excess of ozone is greater than for the RCP8.5 scenario alone.

CHARACTERISTICS OF AN AVERAGED LARGE AQX EVENT IN EACH SIMULATION

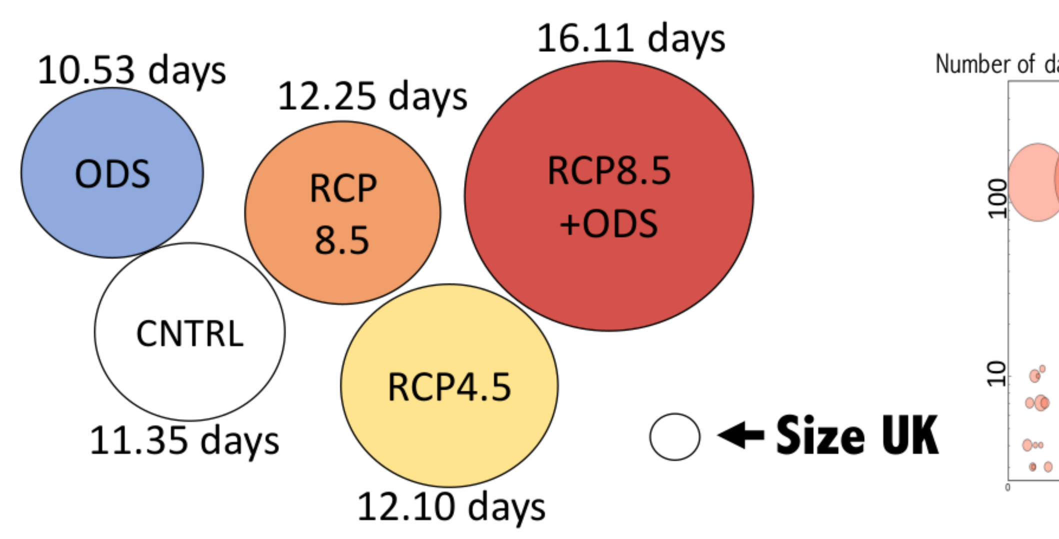
	Ozone concentration (ppb)	Surface Temperature (°C)	Cloud coverage (%)	Isoprene concentration (ppb)	Pm2.5 (ppb)
CNTRL	83	30.6	26.4	0.64	13.7
RCP8.5	86	30.9	27	1.1	13.3
RCP8.5 + ODS	86.1	30.9	27.4	1.13	13.3
RCP4.5	83.1	30.6	28	0.84	12.9
ODS	81.9	30.6	24.8	0.61	13.2
Averaged	83.8	30.8	26.7	0.86	13.27

Compared to the CNTRL simulation, two notable differences are apparent with the RCP8.5 scenario: average ozone and isoprene concentration. **During an AQX event the surface temperature is high and the cloud coverage is low which tend to correlate with more stagnant weather** leading to a higher residence time of pollutant in the atmosphere; **these characteristics are favorable for the creation of ozone.**

BAD AIR QUALITY EVENTS (AQX)

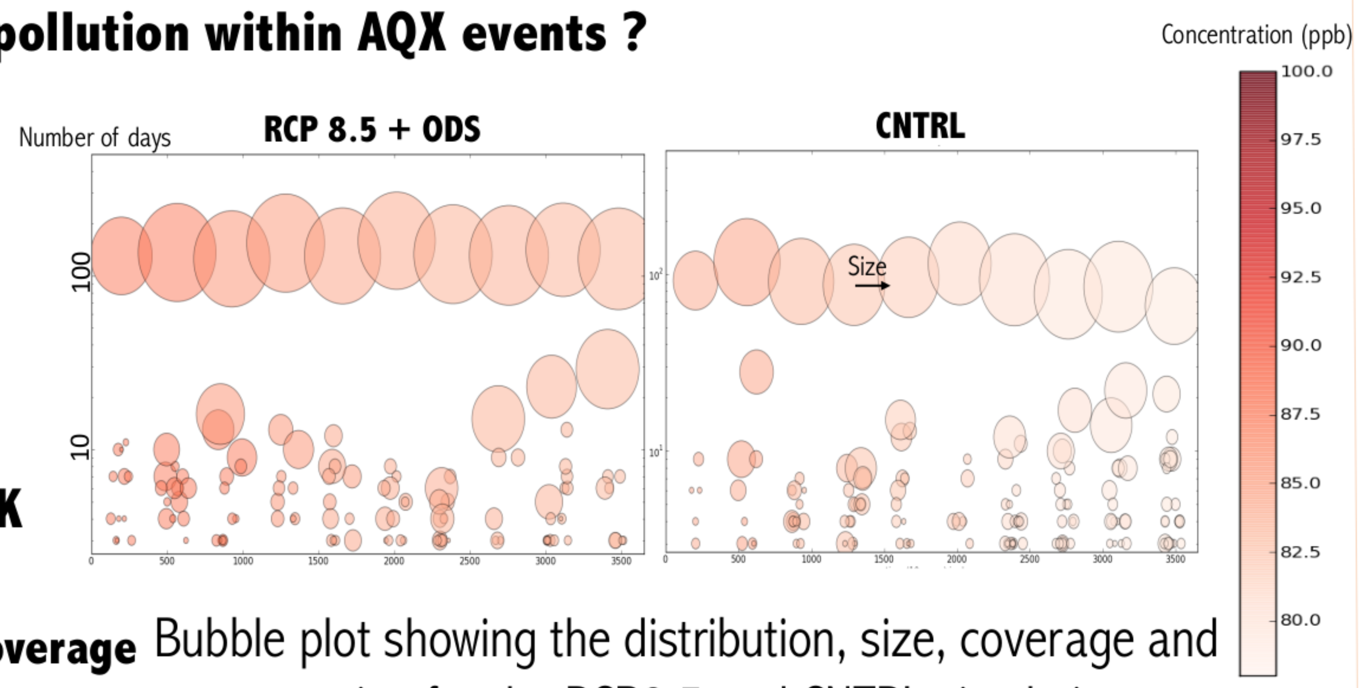
Bad air quality events in the simulation are categorized using a clustering algorithm that helps to identify the length and the spreading of an event. In our analysis we exclude events of less than 3days to restrict our analysis to the more notable events.

How are distributed these extra days of pollution within AQX events ?



Smallest to biggest, diameter represent the coverage

The length and the spreading tend to increase for future RCP scenario.



Bubble plot showing the distribution, size, coverage and concentration for the RCP8.5 and CNTRL simulation.

CONCLUSION

According to these results, **large scale bad air quality events will be more frequent, spread over greater areas and would also last longer with climate change**. The magnitude of these increases varies for different future climate. Changes in these characteristics are important as the increase of time of exposure to high concentration of ozone will greatly threaten human and ecosystem health.

WHAT'S NEXT ?

These AQX event characteristics are what we saw during the 2018 European heatwave. As such events are projected to increase in frequency in the future, the next phase of my work is to use the 2018 heatwave as a case study. **I will conduct simulations of this event with scenarios of future pollutant emissions to evaluate whether these scenarios lead to reductions or increases in air pollution.**

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