IMPACT OF CLIMATE CHANGE ON OZONE RELATED MORTALITY IN LISBON, PORTUGAL A 2FUN CASE STUDY

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ABSTRACT

Short-term exposure to ozone (O3) is a public health concern worldwide. Tropospheric O3 is a secondary air pollutant, formed primarily through a complex series of photochemical reactions between nitrogen oxides and reactive hydrocarbons. Hot days with clear skies favor O3 production. Hence a warmer climate is likely to increase O3 ambient concentration and consequently the impact of ozone-related health effects.

In this paper we present a statistical modeling approach that estimates O3 concentrations based on ground level climate variables, O3 precursors and synoptic atmosphere variables. This model is used to estimate future O3 concentrations based on future climate and O3 precursor scenarios for Lisbon.

The impact of future climate change on O3 related mortality in Lisbon, the most urbanized city in Portugal is also presented.

METHODS

The study area is the city of Lisbon, the capital of Portugal. It is the largest urban area in Portugal with a population of about 0.5 million. Frequent exceedances of EU directive targets for air quality occur.

Daily local meteorology was collected from the European Climate Assessment & Dataset (ECA&D), while large scale synoptic climate data from the National Center of Environmental Prediction (NCEP). Hourly nitrogen dioxide (NO2) and O3 concentrations were obtained from four local monitoring stations (Restelo, Beato, Entrecampos and Olivais) located within the study area. Daily concentrations of O3 and NO2 were calculated for each monitoring station from an hourly dataset with more than 75% of the 24 hours values. To represent the air quality of the study area the daily results from all monitoring stations were averaged.

Generalized additive mixed modeling was chosen to build an O3 regression model taking into account ground level climate variables, O3 precursors and synoptic atmosphere variables for the Lisbon. Model calibration and validation were made for two different time periods, 2002 to 2007 and 2008 to 2009 respectively. Model selection was done taking into account the Akaike Information Criterion (AIC) and model variables were chosen based on the p-value at the 0.05 confidence level.

To estimate O3 concentrations until the end of XXI century the NCEP climate variables were interpolated to the same grid as the global circulation model (GCM) HadCM3 and local climate was downscaled from this GCM using a hybrid of stochastic weather generator with transfer function methods. In this case, large-scale circulation patterns and atmospheric moister variables were used to condition local scale weather parameters such as maximum and minimum temperature (Lopes, 2008).
Two future O3 scenarios (A2 and B2) were developed taking into account population growth and per capita NO2 emissions for the study area. These results were based on the work developed by Vuuren et al, 2006.

The impact of O3 concentrations on human mortality was calculated based on city specific relative risks presented by Garrett, et al, 2010. As a comparison the health impacts using WHO default relative risks are also presented.

RESULTS

Performance of the Ozone Model:

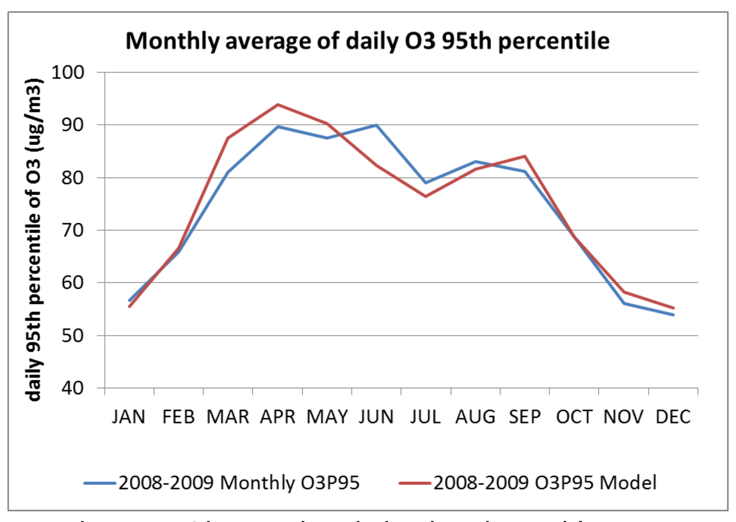

Figure 1- Observed and simulated monthly means of daily O3 95th percentile.

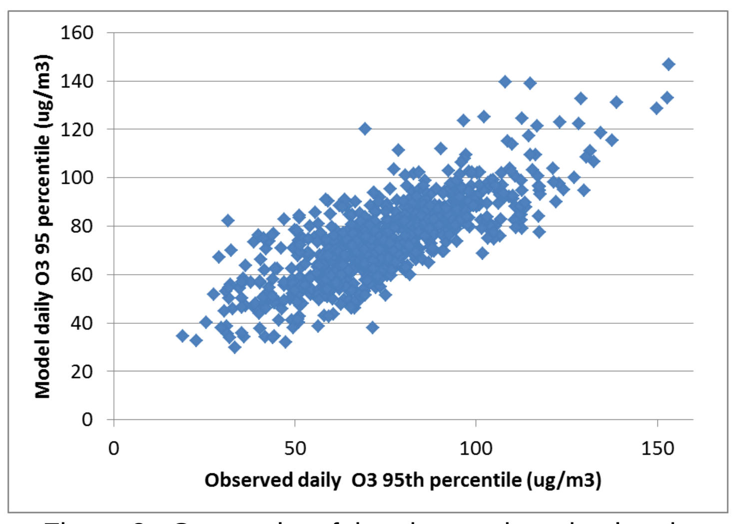

Figure 2 - Scatterplot of the observed vs simulated of daily O3 95th percentile for the 2008-2009

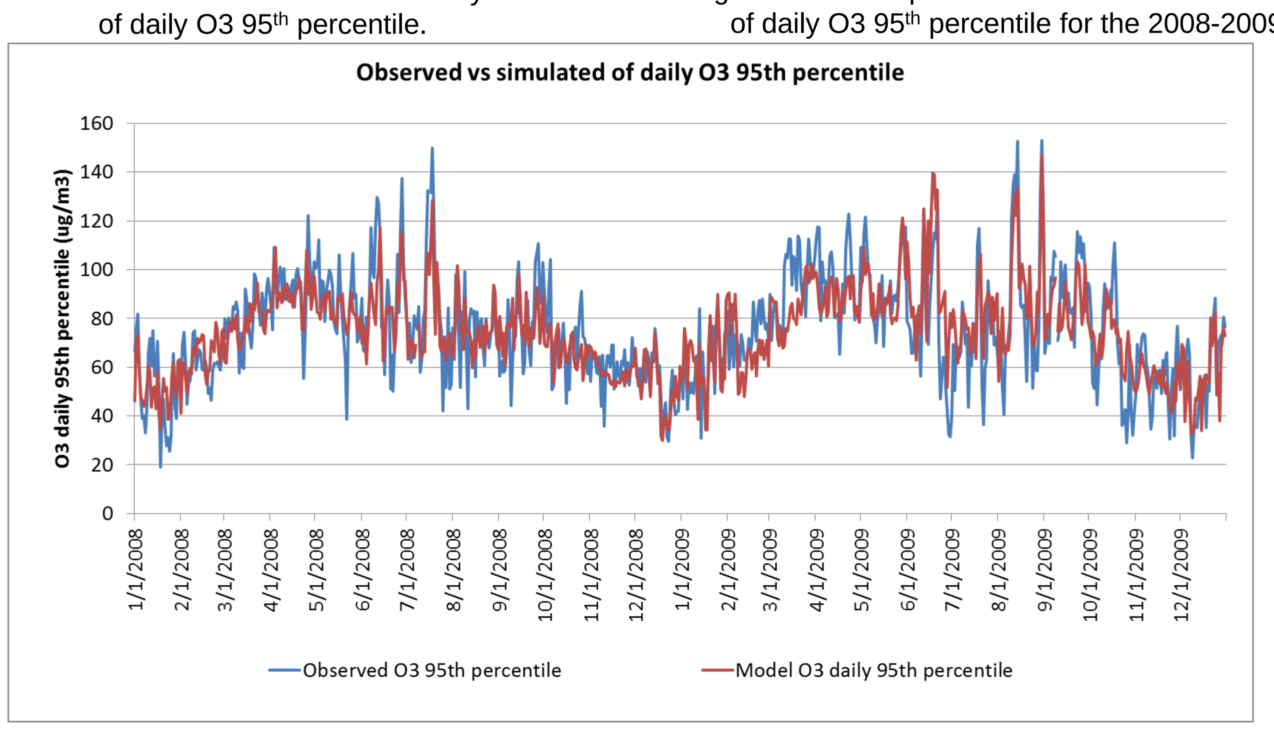

Figure 3 - Observed and simulated daily O3 95th percentile.

A2 and B2 SRES scenario to calculate NO2 emissions:

(A) (B)

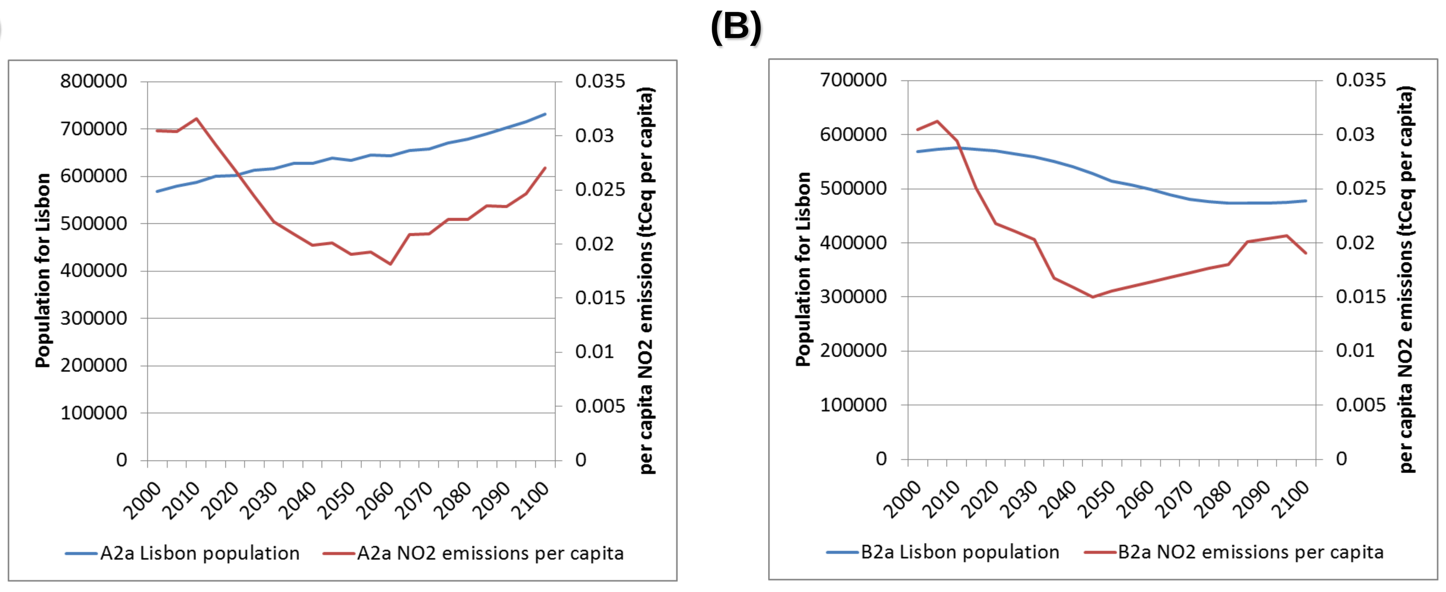

Figure 4 - A2a (A) and B2a (B) SRES scenario up to the end of the XXI century for the population in Lisbon and the NO2 emissions per capita

A2a O3 projections:

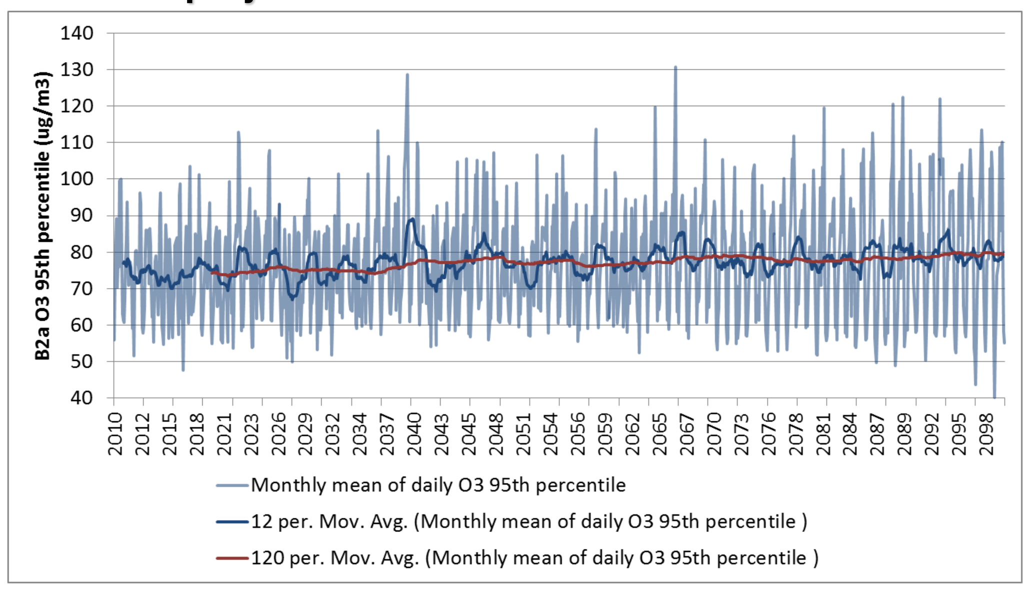

Figure 5 - Monthly average of daily 95th percentile of O3 for the A2a SRES scenario and the one and ten years trend lines from 2010 to 2099

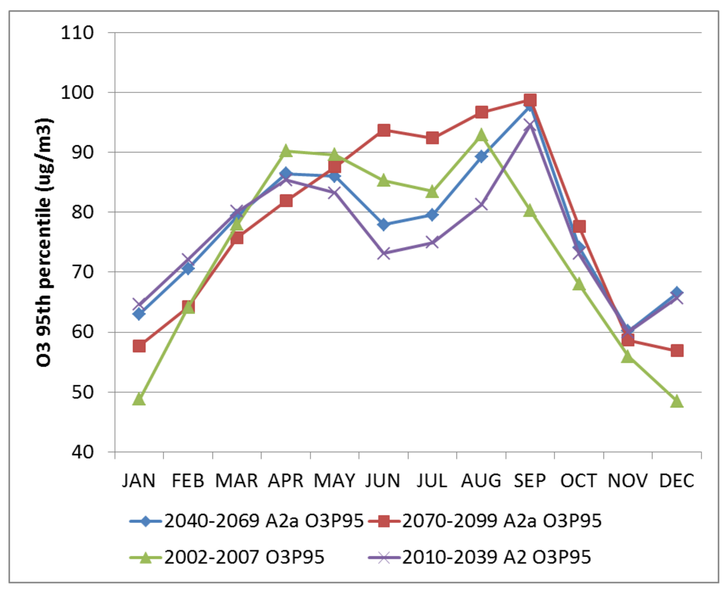

Figure 6 - 30 years monthly average of daily 95th percentile of O3 for the A2a SRES scenario

B2a O3 projections:

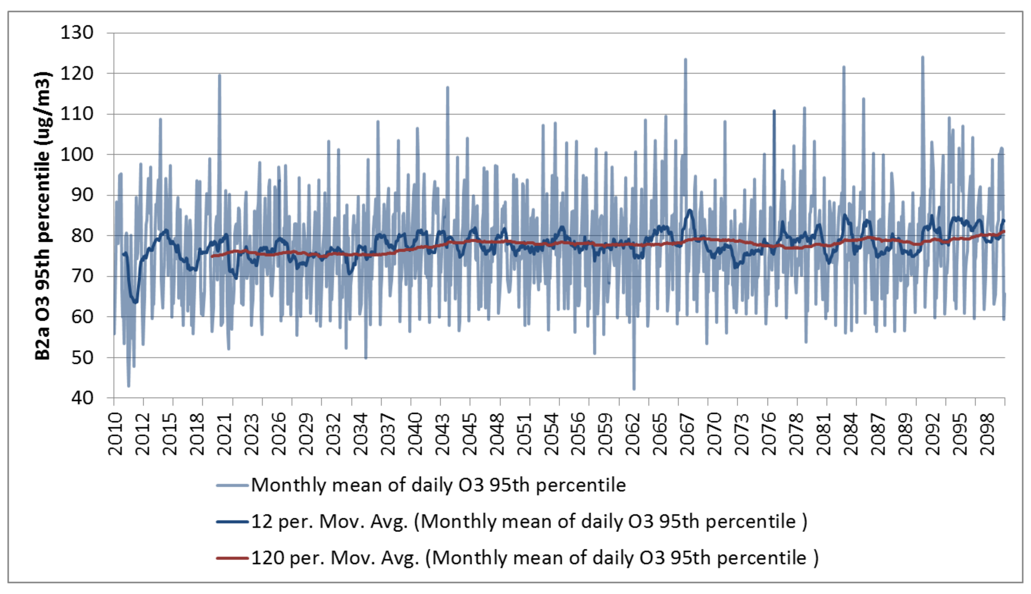

Figure 7 - Monthly average of daily 95th percentile of O3 for the B2a SRES scenario and the one and ten years trend lines from 2010 to 2099

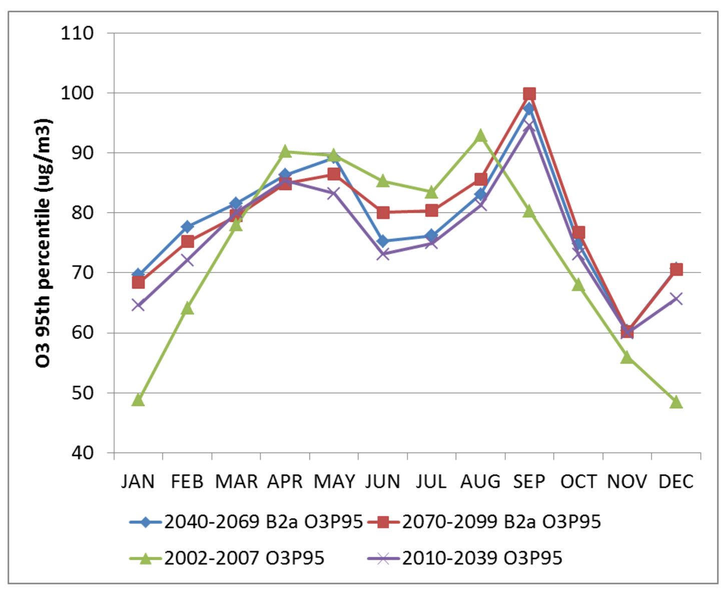

Figure 8 - 30 years monthly average of daily 95th percentile of O3 for the B2a SRES scenario

Impact of O3 concentrations in mortality for the B2a scenario:

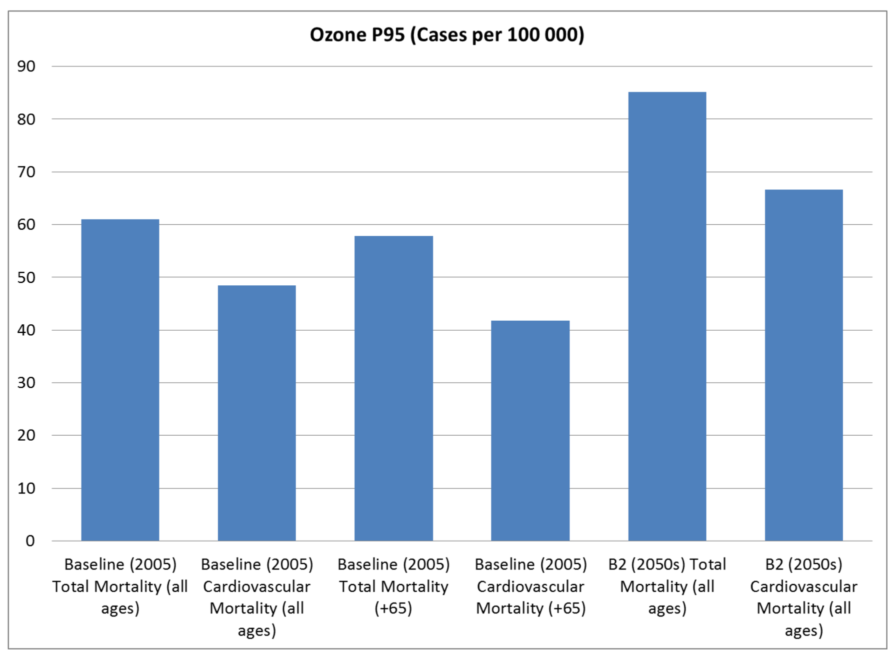

Figure 9 - Number of deaths associated with ozone concentrations for 2005 and B2a 2050s using a Relative Risk of 1.0096 calculated from the daily 95th percentile of O3 (Pedro Garrett et al, 2010)

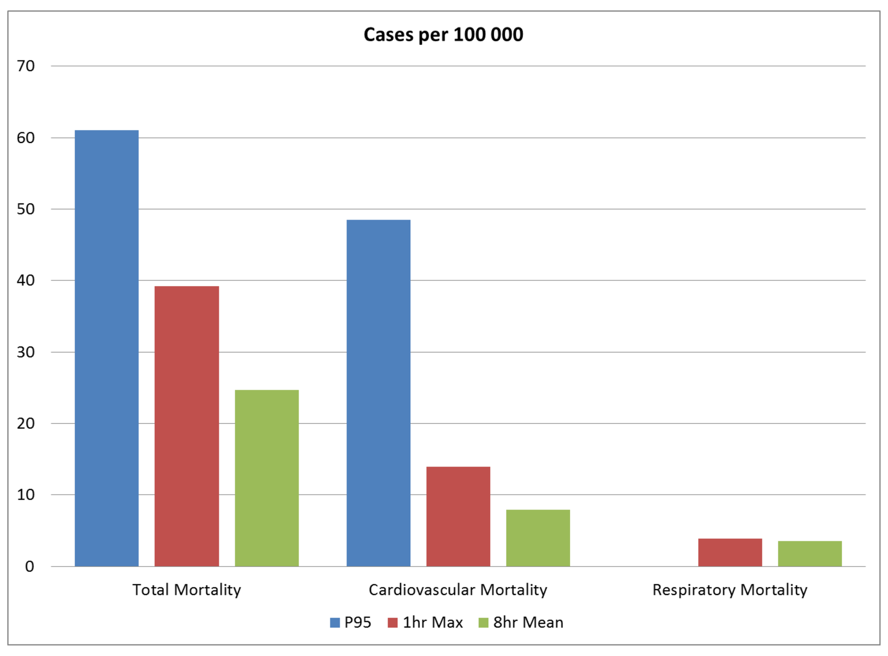

Figure 10- Comparison of the number of deaths associated with ozone concentrations using WHO Relative Risk for daily max and 8h mean of O3 and the one calculated by Pedro Garrett et al, 2010 using daily 95th percentile of O3. O3 concentrations are observed for Lisbon during 2005.

CONCLUSION

Model validation of O3 shows a similar trend when compared with the daily and monthly observed dataset describing not only extreme values but also its seasonality (figures 1-3).

Concentrations of O3 are dependent on emissions and climate. Model results clearly shows increasing trends of high O3 concentrations up to the end of the XXI century with a possible change of seasonality (figures 5-8). In both scenarios higher concentrations are likely to appear in September. The B2a scenario also shows higher concentrations of O3 during winter.

Results shows that for the B2a scenario the number of premature total deaths increases from about 60 cases per 100 000 inhabitants in 2005 to about 85 cases per 100 000 inhabitants at mid century (Figure 9).

For future work is important to take further analysis on uncertainties and how these can be reduced.

REFERENCES

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Vuuren DP van ; Lucas PL ; Hilderink HBM, 2006. Downscaling drivers of global environmental change. Enabling use of global SRES scenarios at the national and grid levels. Report number: 550025001. Netherlands Environmental Assessment Agency.

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