


ASSESSING THE EFFECTS OF NATURE ON FUTURE AIR QUALITY: PORTO CASE STUDY

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Motivation

72%

of the European population lives in urban areas

Increase of the extreme weather events (e.g., heat waves)

Increase of the NO_2 and PM10 annual concentrations

NBS provide sustainable, cost-effective, multi-purpose and flexible alternatives for various objectives

Goal

Investigate and quantify the effectiveness of different **green measures in improving air quality under a future heat wave** (medium-term future climate), in Porto urban area

Three main urban air pollutants were analysed:

PM10, NO_2 and O_3

Case study

Why Porto?

It is one of the European urban areas that most expanded in the last decades

- It is the Portuguese urban area with a lower proportion of green and blue areas
- It is expected an increase of the magnitude, duration and frequency of heat waves in a medium-term future
- It shows exceedances to the O_3 threshold value, to the PM10 daily limit value and to the NO_2 hourly limit value

Modelling setup

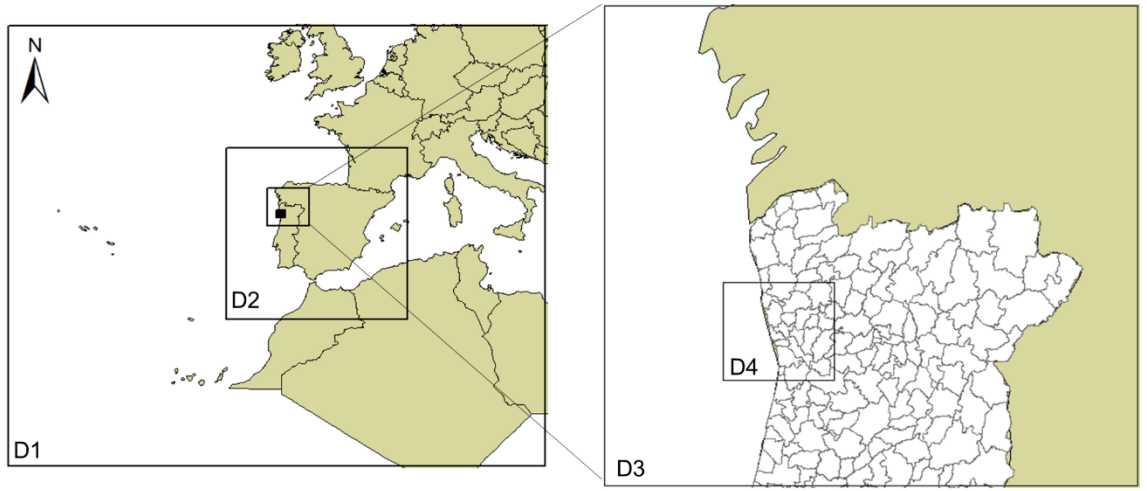
Models:

Weather Research and Forecasting Model (WRF - SLUCM) *

EMEP + MEGAN

Chemistry-transport model (CHIMERE v2016a1)

Domain:



Time period:

24-26 of July 2049

* Initial and boundary conditions were obtained from the Max Planck Institute Earth System Model – Lower Resolution (MPI ESM-LR)
* The Representative Concentration Pathway Scenario RCP8.5 was adopted

Green scenarios

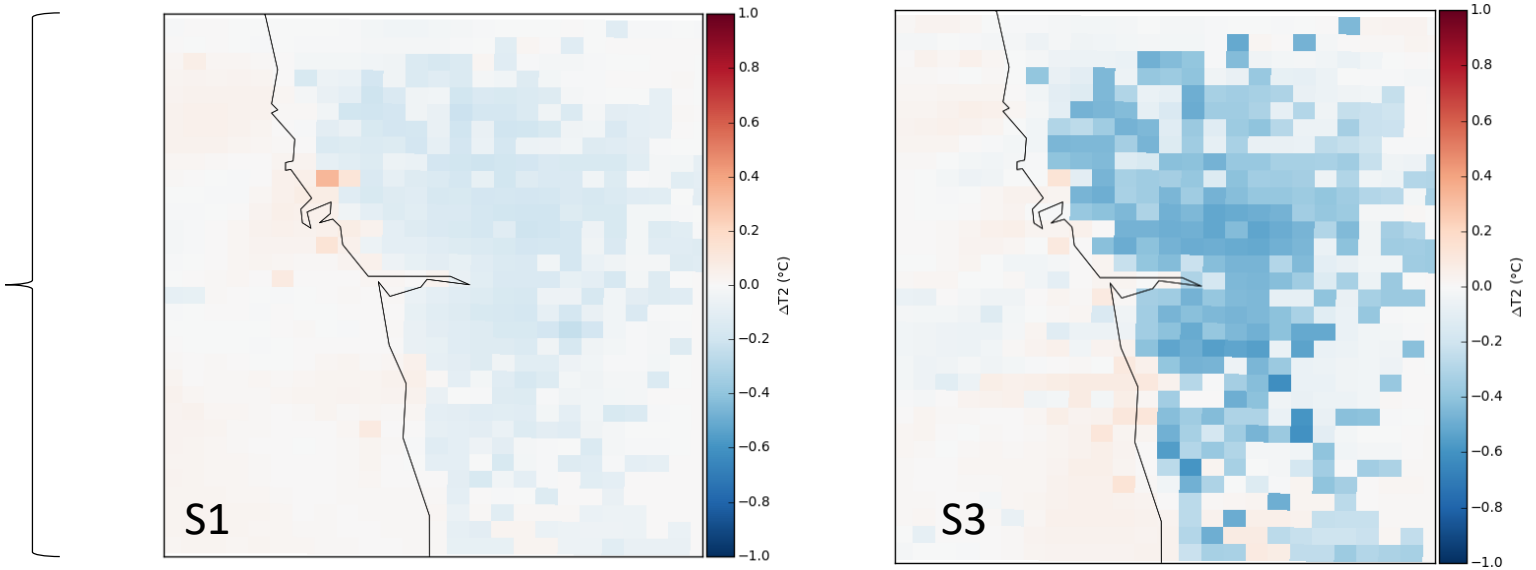
1	2	3	4
introduction of green roofs in areas classified as built-up area (by activating the “green roof option” available in the SLUCM)	introduction of white roofs in areas classified as built-up area (the roof surface albedo was defined as 80%)	application of white surfaces in areas classified as built-up area (surface albedo of roofs, facades and ground was defined as 80%)	duplication of existing green areas (by changing the land use classification)

* Baseline scenario, considering the current urban morphology

Results

Impacts on meteorology

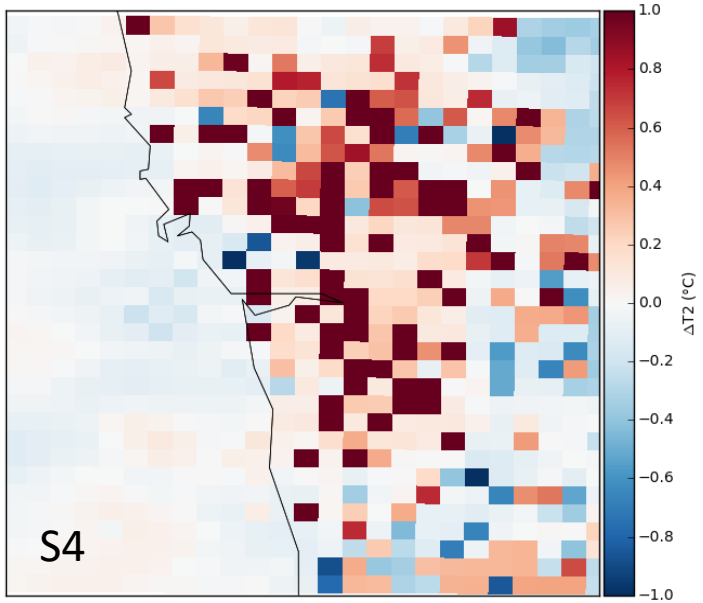
Spatial distribution of the absolute differences between implementation NBS and baseline scenario - mean of the modelling period



- The implementation of green roofs and white roofs promoted an average temperature reduction of -0.5°C
- The white surfaces scenario showed a more pronounced temperature reduction (-1°C, on average)
- White roofs are a viable and cost-effective approach to reduce temperature during extreme events

Results

Impacts on meteorology



Spatial distribution of the absolute differences between implementation NBS and baseline scenario – mean of the modelling period

The increase of green urban areas promoted differences in the temperature fields between -1°C and +1°C

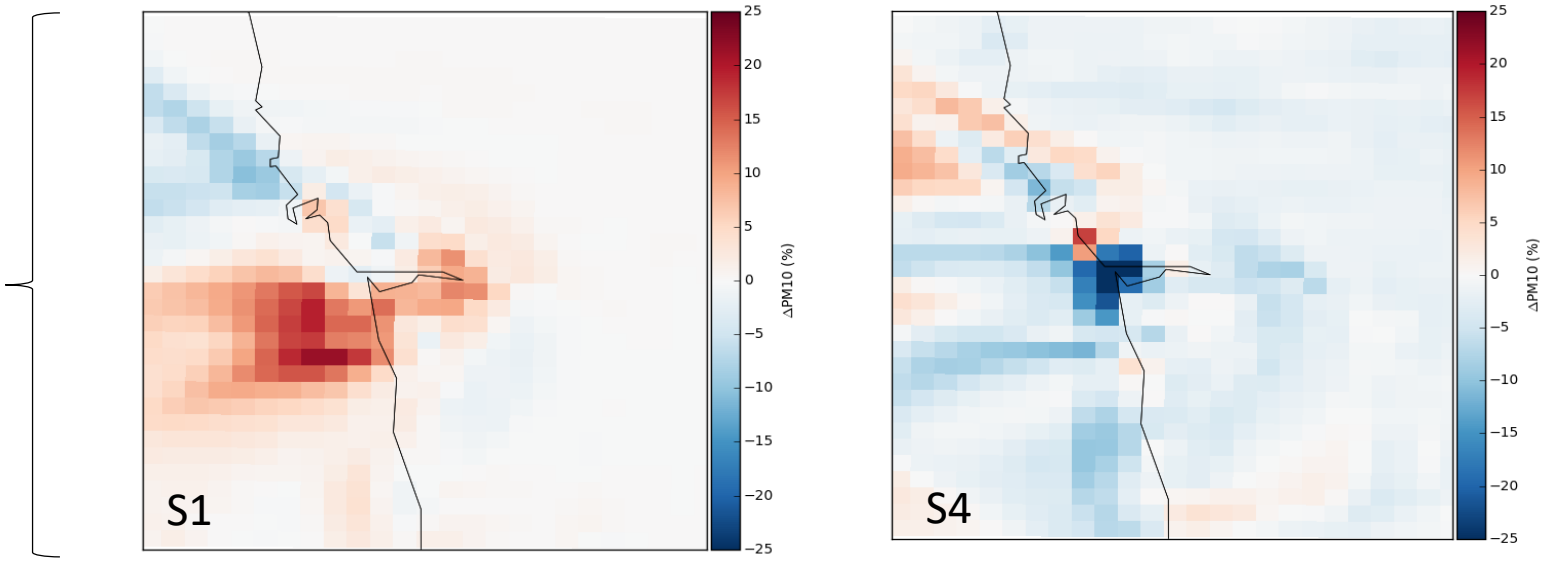
The temperature differences between the green area (cooler) and its urbanized surroundings (warmer), leads to a cold air advection from the park to the built-up areas - **park cool island effect**

The convergence of warmer air above the park, promoted a localized temperature increase in the parks

Results

Impacts on air quality | primary pollutants | e.g. PM10

Spatial distribution of the absolute differences between implementation NBS and baseline scenario - 12 a.m.

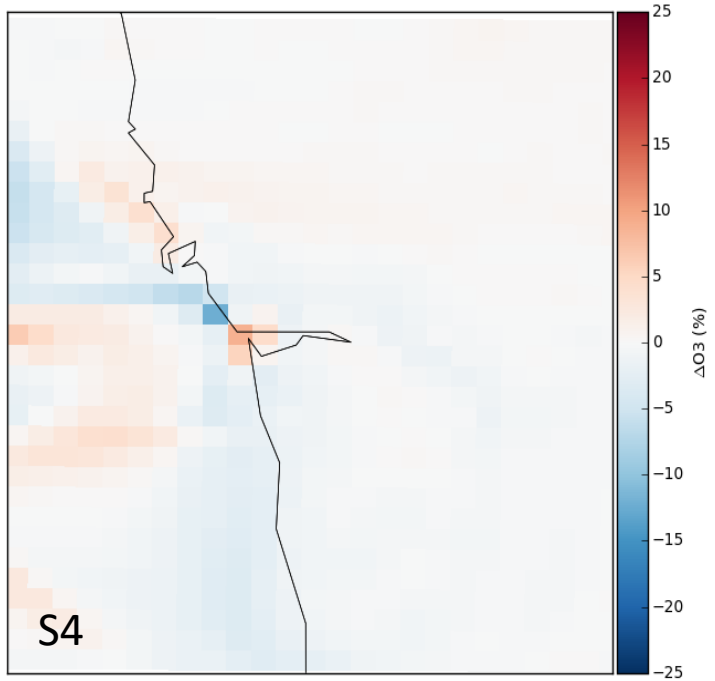


The implementation of green roofs, white roofs and white surfaces, promoted an overall increase of PM10 and NO_2 concentrations, which are closely related to a decrease of vertical mixing in the urban boundary layer

The increase of green urban areas promoted an overall decrease of both PM10 and NO_2, by around -1% and -3%, respectively

Results

Impacts on air quality | secondary pollutant | O_3



Spatial distribution of the absolute differences between implementation NBS and baseline scenario – 12 a.m.

Due to the chemical coupling of O_3 and NO_2, the reduction of NO_2 concentrations promoted by the implementation of green areas is followed by an increase in the atmospheric concentration of O_3

The obtained results highlight the need of analyse these pollutants in an integrated way, since changes in NO_2 concentrations can induce secondary impact on O_3 concentrations via chemical reactions.

Results

Summary

	"Green" measures			
	Implementation of green roofs (S1)	Implementation of white roofs (S2)	Implementation of white surfaces (S3)	Implementation of parks (S4)
T	↓	↓	↓	↓↑
PM10	↑	↑	↑	↓
NO_2	↑	↑	↑	↓
O_3	↓↑	↓↑	↓↑	↑

Positive benefits in temperature

Negative impact in **primary pollutants** with S1-S3

Urban parks promotes **positive** impacts in primary pollutants and **negative** impacts in secondary pollutants

Main findings

1. To make cities sustainable and resilient to air pollution is one of the 2030 sustainable development goals. There is a growing recognition that the implementation of options that go further than the typical technological measures is crucial to achieve this goal;

2. The modelling results suggest **overall benefits** for all the analysed measures in the mitigation of heat waves effects, by **reducing the air temperature**; **both positive and negative impa**cts were found for **air quality**, depending on the measures adopted and on the pollutants;

3. The obtained results highlight the importance of investigating the secondary effects of any kind of urban planning measures in the mitigation of climate change impacts, namely its impacts on the urban air quality; **decision making should be supported based on a multicriteria analysis of different variables**


THANK YOU!

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