On the ability of convection permitting models for capturing the urban- rural contrasts over selected cities in South America

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1. The problem

Cites are particularly vulnerable to climate change. Considering that a large part of the population lives in cities, there is an urgent need for building useful climate information for adaptation needs. In this work we demonstrate that regional climate models operating at convection permitting resolution (CPRCM) are a powerful tool for capturing the urban-rural contrasts of temperature, humidity and winds over large cities in South America.

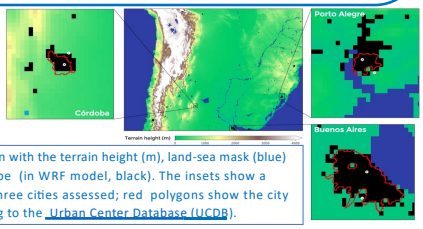

Figure 1: SESA-4i domain with the terrain height (m), land-sea mask (blue) and urban land-use type (in WRF model, black). The insets show a zoomed view of the three cities assessed; red polygons show the city center extent according to the Urban Center Database (UCDB).

2. The methods and the data

A set of coordinated convection permitting simulations operating at 4km horizontal resolution centered over subtropical South America developed in the framework of the **FPS-SESA** was used to simulate a 3-year period (October 2018-September 2021) to assess city footprints in three major South American cities: Buenos Aires and Córdoba in Argentina and Porto Alegre in Brazil.

Differences between the urban and rural surrounding environment have been computed for identifying the city signal on temperature, referred to the urban heat island (UHI), relative humidity and wind intensity.

The analysis also includes the response of the urban environment to extreme conditions such as heat waves. Simulated data has been compared against observed hourly station data from the National Weather Service of Argentina and Brazil.

CPRCMs:

USP-RegCM471; ICTP-RegCM5pbl1; ICTP-RegCM5pbl2; WRF-UCAN433

3. Results: Daily cycles of contrasts between the urban and rural environment

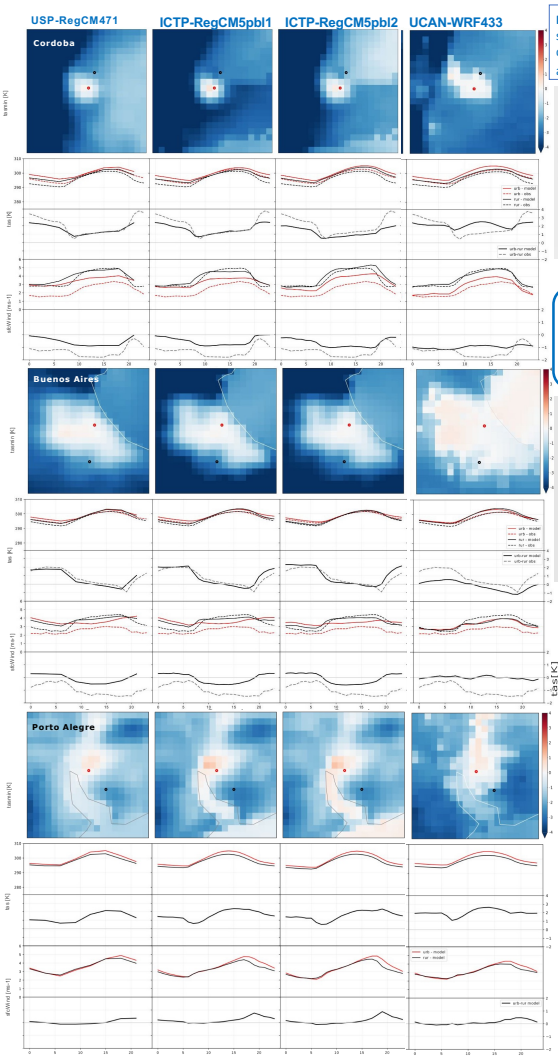

Figure 2: Spatial distribution of the difference between the daily minimum temperature (tasmin) in the city and the rural environment and the daily cycles (DC) of near-surface air temperature (tas) and wind speed (sfcWind) during the austral summer (DJF) examined at two separate locations: within the city center (red dots in the top panels) and in the rural outskirts (black dots in the top panels). To represent the urban area in the models, an average anomaly of the minimum temperature (tasmin) compared to the closest CPRCM grid cell to the city center is utilized as a proxy.

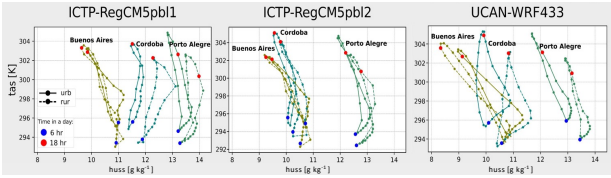

Figure 3: Daily cycles of near-surface specific humidity (huss) in relation to tas from the simulations over all analyzed cities (colors), for grid cells representing urban (solid lines) and rural areas (dashed lines). Dots indicate the local time during the day. 6 (blue) and 18 (red) are highlighted. Evolution is in clockwise direction.

Heat waves (HW)

HWs are defined when the maximum daily temperature is above the 90th percentile in the summer season (DJF) for at least 3 consecutive days in both urban and rural areas.

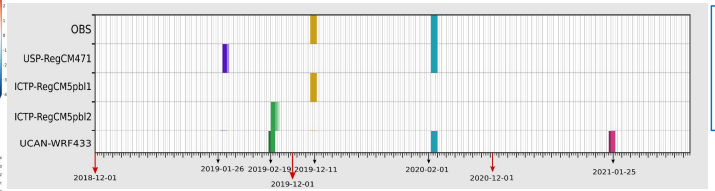

Figure 4: HWs in Buenos Aires during the analyzed period. HW occurrence is not concurrent in observations and across all models.

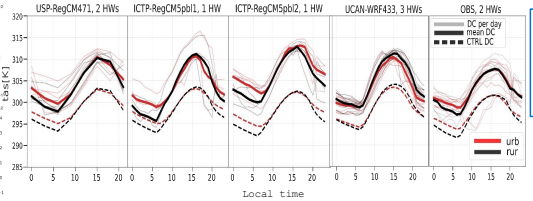

Figure 5: Daily cycles of tas during each HW (lighter shades) in urban (red solid lines) and rural (black solid lines) grids. Mean daily cycles for both urban and rural grids are shown in bold lines. As a reference, the average diurnal cycles for DJF are presented as dashed lines (as in Figure 2).

4. Concluding remarks

- CPRCMs reproduce the UHI signal in terms of both timing and magnitude, with the largest UHI signal occurring during nighttime hours and with a magnitude of around 2^{O}C, in agreement with the observations.
- Dryer nighttime conditions (up to 10%) over the cities are well captured by the models, probably associated with the UHI, though models tend to overestimate the cities' drying effect.
- The intensity of the wind is weaker over cities and models reproduce this effect, though the magnitude of the difference is overestimated.
- The results are sensitive to the model and to the choice of PBL scheme in RegCM5
- During heat waves, CPRCMs are able of capturing the exacerbated warming effect of cities.

Acknowledgements

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