Proposal for PhD-Thesis

Subject:
"Study of urban climate: in-line modeling, downscaling methods and uncertainties evaluation"
36 months, starting in October 2017 at the earliest (funding secured)

Deadline for application: ***15 June 2017***

Host laboratory:
Météo France / National Center for Scientific Research (CNRS), National Center for Meteorological Research (CNRM), Toulouse, France

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Summary of phD proposal

The modeling of urban climate and associated impact studies, facing combined effects of climate change and evolution of cities themselves [1], requires modeling tools and climatic scenarios adapted to the relevant study scales. Issues of adaptation and/or mitigation in urban areas cover various topics as mitigation of urban heat island, improvement of thermal comfort for inhabitants, energy efficiency, or urban vegetation and water resources management [2,3,4].

To address these issues and effectively assist public actors in urban policies management, we need to use modeling tools capable of simulating adaptation strategies from the city scale (kilometric resolution) to the neighborhood scale (100 meters), of quantifying their effects, and of assessing the associated uncertainties. In addition, climatic forcings must themselves be adapted to the urban issue in terms of (1) spatial resolution (e.g., spatial variability of precipitation fields over the study area), (2) temporal resolution (diurnal cycle of atmospheric conditions required to reproduce the dynamics of urban climate).

Most of previous studies carried out by the team on adaptation of cities to climate change have been performed on the basis of off-line simulations by forcing the urban climate model TEB [5,6] by spatially disaggregated climate scenarios using different statistical approaches [7,8,9] in order to account for local climate variability. We have been recently oriented towards a dynamical downscaling approach, by running the urban model in-line in climate simulations, so that the surface-atmosphere interactions and the potential feedback of the city on the local climate are explicitely simulated in climate modeling.

The atmospheric model AROME [10] is currently used at Météo France for the numerical weather prediction over France with a 1.3 km spatial resolution, and soon in climate modeling mode. Within the framework of Maxime Daniel's thesis (GMME / GMGEC), AROME simulations were carried out for a past time period covering the CAPITOUL urban measurement campaign (Toulouse, France) in order to evaluate the model and to quantify the real contributions of the urban model TEB and of its recent developments [11]. Future scenarios are also planned by the end of the thesis to study the evolution of urban climate taking into account urban expansion and climate projections by the end of the century.

The phD-thesis subject is in the line of this work. The objective is to define downscaling methods adapted to impact studies of climate change for cities, with Paris as study area. This involves combining coupled dynamic downscaling techniques (that enable modeling city's retroactions on the local climate) and less time consuming methods based on statistical downscaling approaches or off-line modeling (that enable the evaluation of a large number of scenarios).

1. The first part of the phD-thesis will be dedicated to the study of Paris climate for a reference time period (from 1979 to today) based on observations and AROME modeling.

To identify and characterize urban phenomena, different observation data will be used : surface network of meteorological stations (air temperature and humidity, wind), network of rain gauges and re-analysis of COMEPHORE radar, MODIS satellite imagery for surface temperatures.

AROME simulations over the same time period will be performed and analyzed to evaluate the capability of the model to simulate the different patterns of Paris urban climate, such as:

- Occurrence and intensity of urban heat island
- Occurrence and distribution of precipitation
- Spatial fields of surface temperature

2. The second part will be devoted to the analysis of uncertainties in the coupled modeling chain from regional climate models to impact models.

In future climate, a simulation based on a dynamical spatial downscaling approach will be performed: ALADIN-climate will be run with a 12 km spatial resolution, to provide boundary conditions and forcing to AROME-climate model which will be run at 2.5 km spatial resolution over France. In turn, these simulations will make possible to force the Meso-NH model for hectometric simulations over the city of Paris. This modeling methodology, which is computationally expensive but allows to explicitly model all physical and dynamic processes and their interactions, will be a reference framework for the analysis and evaluation of downscaling methods tested afterwards.

Different spatial downscaling techniques (less accurate but less time-consuming) will have to be defined on the basis of a literature review and previous works carried out by the team. They will be implemented and evaluated using the reference simulation. The uncertainties associated with each method will be quantified.

Depending on the progress of the phD-thesis work, an analysis of the uncertainty associated with the choice of scenarios of urban expansion and urban planning over the century could be conducted.

Planned work & expected skills

The student must cover several aspects during the phD:

- Literature review of existing spatial downscaling techniques, and of uncertainty assessment methods
- Processing and analysis of experimental data of several natures that require to use specific tools for data extraction and processing (especially for satellite imagery) and analysis softwares (e.g., Python or R)

- Numerical modeling using ALADIN, AROME and Meso-NH atmospheric models, and urban climate modeling with the SURFEX land surface modeling system (including the TEB urban model)

The student must have an academic background in atmospheric physics and/or surface processes and surface/atmosphere interactions. He or she will have to become familiar with the urban climate topic, and to be trained more specifically in the modeling and data processing tools used in the laboratoy (Meso-NH, SURFEX, R trainings planned during the thesis).

Bibliography

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