What added value of CNRM-AROME CP-RCM compared to CNRM-ALADIN RCM for urban climate studies ? Evaluation over Paris area (France)

Aude LEMONSU[1], C. CAILLAUD[1], A. ALIAS[1], S. RIETTE[1], Y. SEITY[1], B. LE ROY[2], Y. MICHAU[1], P. LUCAS-PICHER[3]

[1]Centre National de Recherches Météorologiques, Université de Toulouse, Météo-France, CNRS, Toulouse, France
[2]Princeton University, Cooperative Institute for Modeling the Earth System, Princeton, USA & NOAA, Geophysical Fluid Dynamics Laboratory, Princeton, USA
[3] Département des sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, Montréal, Canada

***Convection-permitting regional climate models (CP-RCM) are promising tools for urban studies**, due to fine horizontal resolution, accurate land use mapping, and better resolved local-scale processes. Especially, some CP-RCMs run urban-canopy models inline to deal with surface-atmosphere exchanges in cities and to explicit interactions between urban and regional climate. Here, the added value of the CNRM-AROME (2.5 km) compared to CNRM-ALADIN (12 km) is evaluated for the Paris urban area (France).*

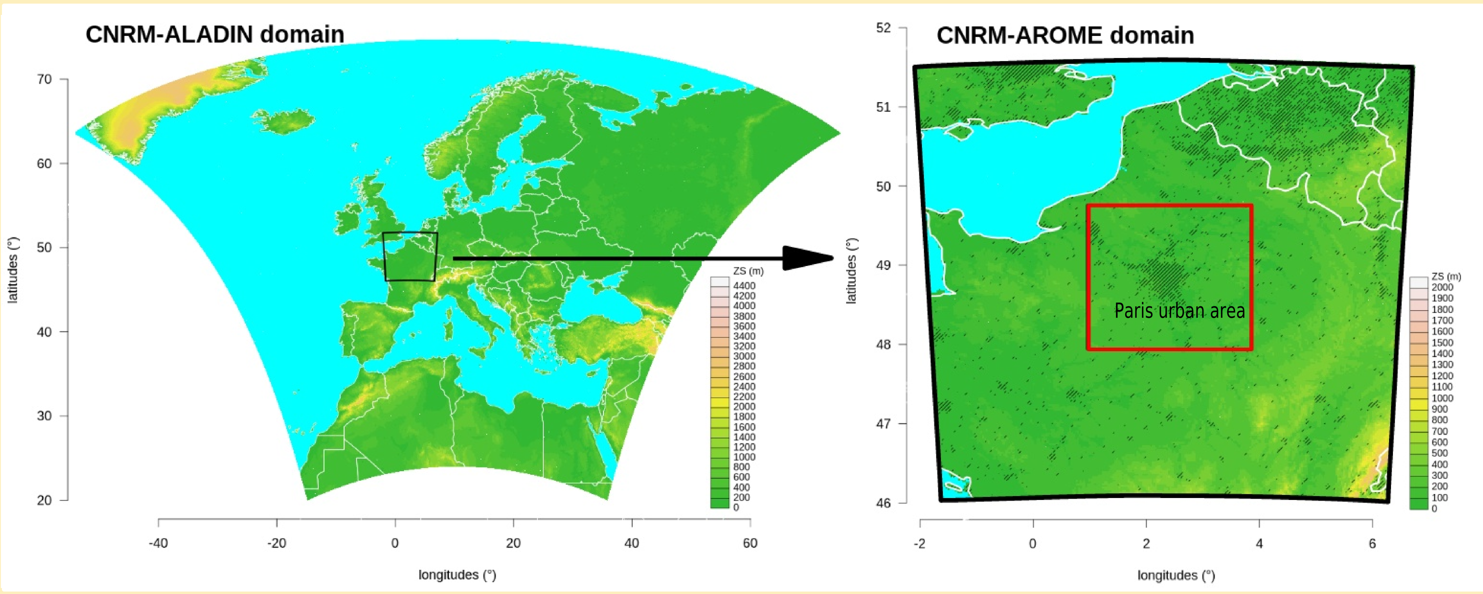

Fig 1 - Simulation domains for CNRM-ALADIN (left) and CNRM-AROME (right, the red rectangle indicates the boundaries of the study area centered on Paris)

1. Configuration for climate simulations

CNRM-AROME simulations were performed at 2.5-km resolution over northern half of France with:

- Global ERA-Interim reanalyses to provide large-scale conditions (evaluation configuration)
- Intermediate domaine over Europe with CNRM-ALADIN (12 km, Fig 1)
- Simulation time period covering 2000-2017

CNRM-AROME coupled to SURFEX land surface modelling system including:

- **ISBA** soil-vegetation-atmosphere transfer model for natural soils and vegetation
- **TEB** urban canopy model for urban areas (based on "urban canyon" concept, Fig 2)

CNRM-ALADIN with more roughly description of urban areas, as rocky surfaces with high roughness

2. Radiation and Precipitation

Long-term observations were used to evaluate precipitation (1-km resolution COMEPHORE precipitation analysis) and radiation (three flux stations). Contrasted performances are noted with **no so clear added-value of CNRM-AROME compared to CNRM-ALADIN** (Tab 1)

> **Too much precipitation for both models** (whether for daily rainfall or number of wet days) particularly in spring
BUT emphasized bias in CNRM-AROME, probably resulting from an overly active deep convection

> Too much incoming shortwave radiation in summer in CNRM-ALADIN (due to cloud-cover underestimation)
BUT **significant reduction of bias in CNRM-AROME** through cloud scheme tuning

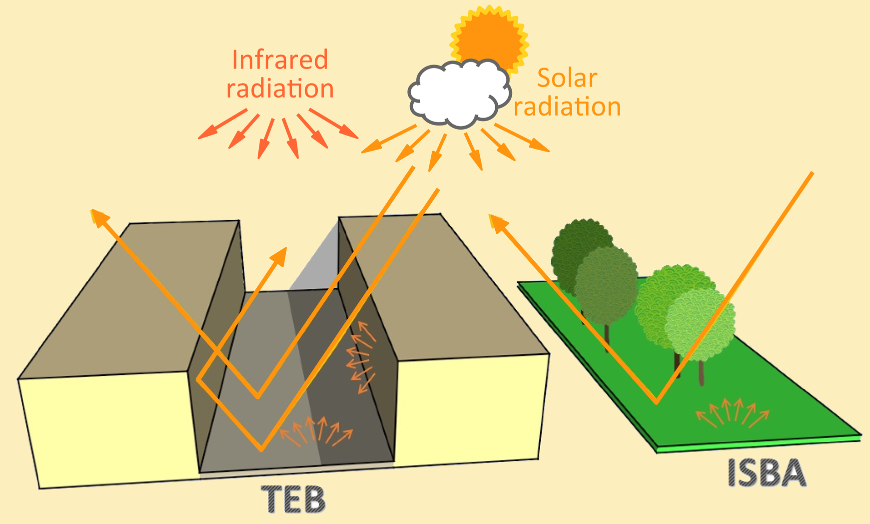

Fig 2 - Combination of TEB and ISBA models for grid cells composed of pervious and impervious covers

	Bias RR24 (mm day-1)				Bias SWD (W m-2)			
	DJF	MAM	JJA	SON	DJF	MAM	JJA	SON
CNRM-AROME	+0.7	+1.1	0.	+0.6	-2.4	-7.6	+4.5	-0.7
CNRM-ALADIN	+0.5	+0.7	-0.4	+0.2	+7.8	+18.0	+34.6	+14.8

Tab 1 - Mean seasonal bias in daily rainfall and incoming solar radiation for both models over 2000-2017 (values highlighted when CNRM-AROME performs better than CNRM-ALADIN)

3. Near-surface temperatures

Minimum (TN) and maximum (TX) daily temperatures simulated by CNRM-AROME and CNRM-ALADIN were both compared to a 1.25-km resolution gridded observation product (Fig 3).

> **Differences in TX between models mostly driven by atmospheric forcing**:

- Summer TX (JJA) much warmer in CNRM-ALADIN simulation due to excess in solar radiation
- Spring TX (much colder in CNRM-AROME simulation as a response of too wet conditions

> **Differences in TN mostly related to surface properties and surface models**:

- Spatial variability related to the relief more finely represented in CNRM-AROME
- Systematic cold bias over the city in CNRM-ALADIN due to the lack of urban-dedicated model

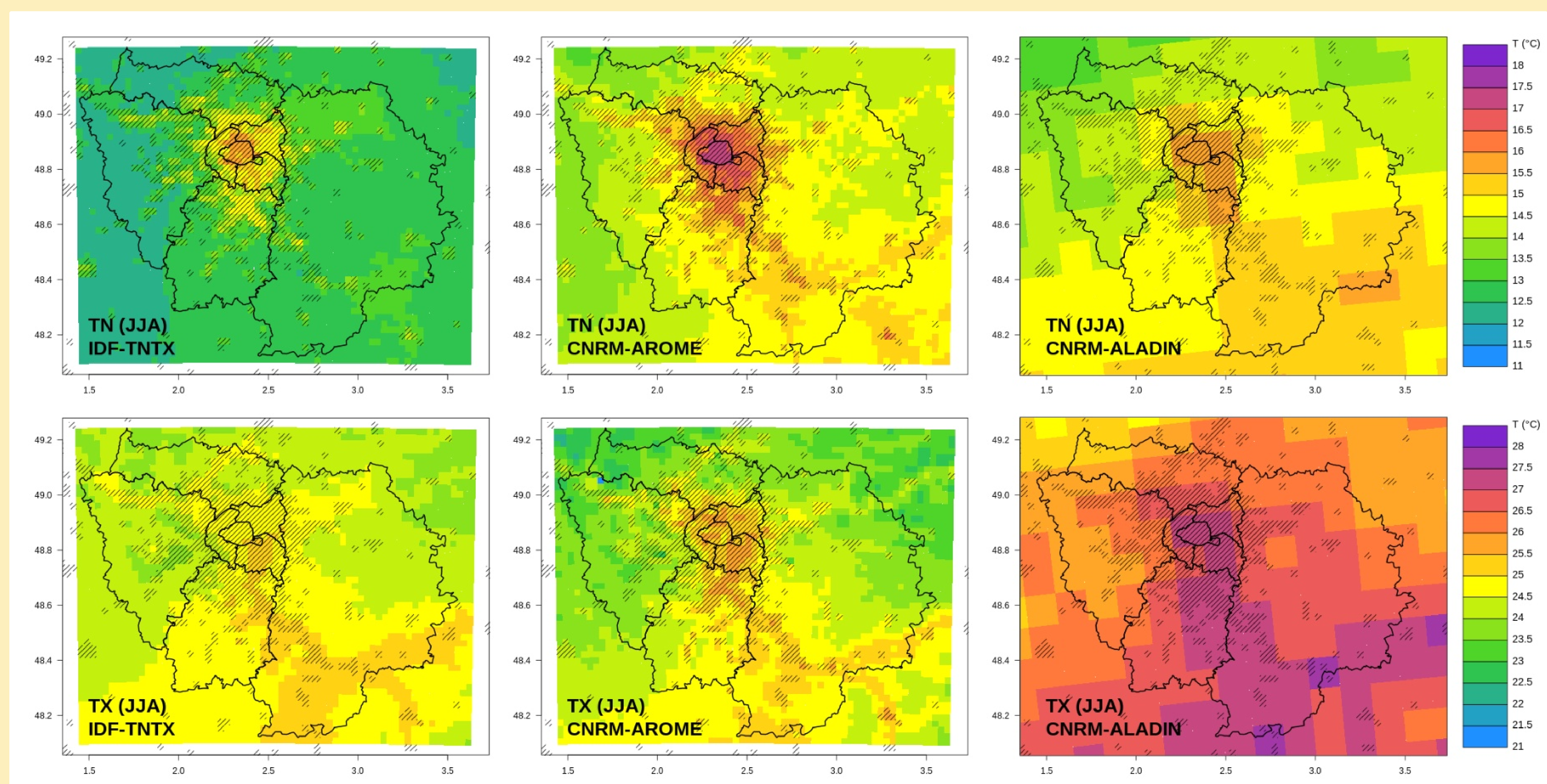

Fig 3 - Averages summer TN/TX over 2000-2017 for observations (left), CNRM-AROME (middle) and CNRM-ALADIN (right) simulations. Hatching represents the extent of Paris urban area.

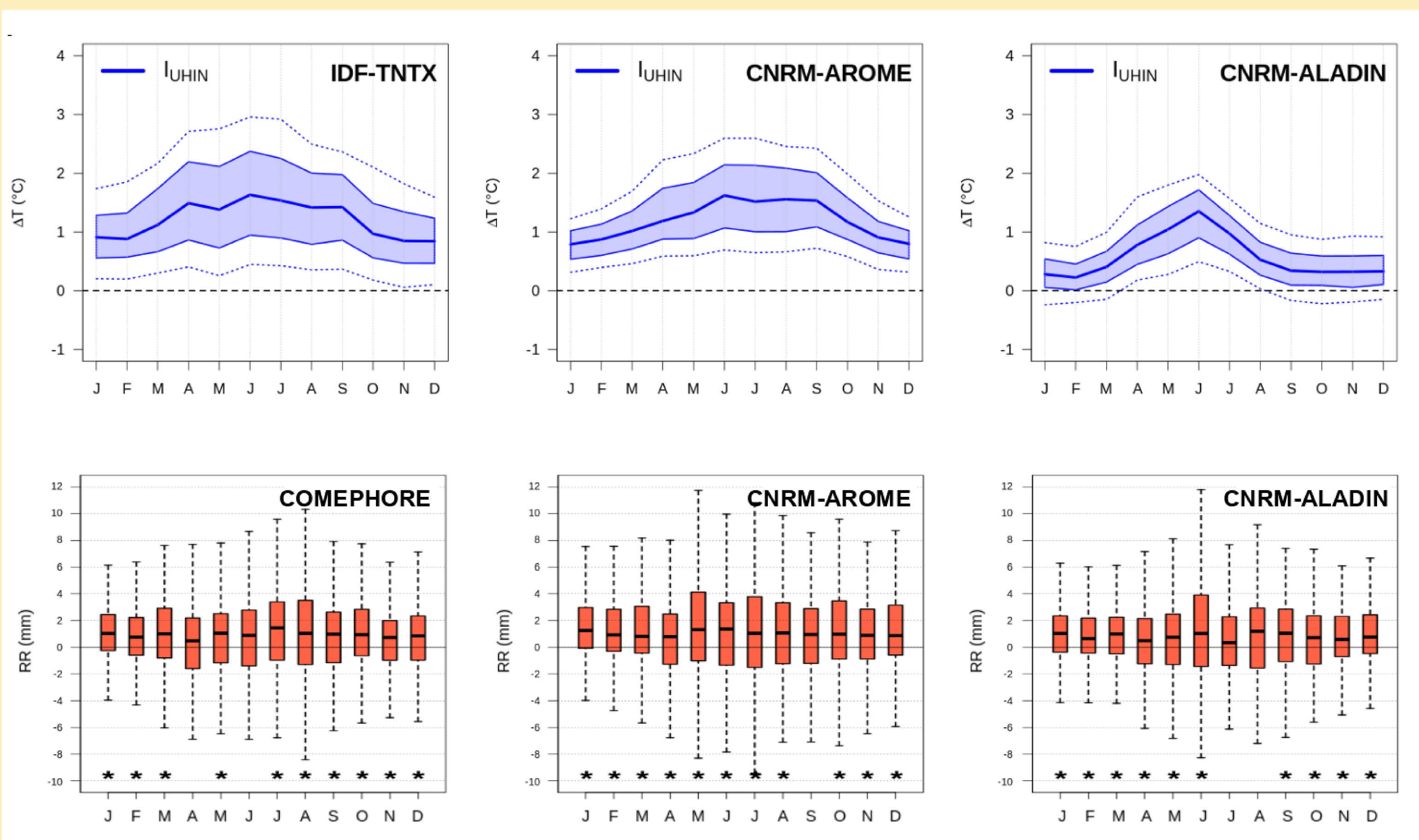

Fig 4 - Top: Comparison of monthly urban heat island calculated from IDF-TNTX observations (left) and from CNRM-AROME (middle) and CNRM-ALADIN (right) simulations for 2000-2017. Bottom: Monthly averages of daily precipitation rate differences between downwind and upwind areas of the city, calculated from COMEPHORE observations (left) and from CNRM-AROME (middle) and CNRM-ALADIN (right) simulations for 2000-2017 (asterisks indicate significant differences)

4. Urban effects

A specific analysis of urban effects highlights the added-value of CNRM-AROME compared to ALADIN-CNRM through running TEB inline (combined with the better resolution) for:

> **Simulating nighttime urban heat island** (Fig 4 top)
with more realistic spatial patterns and higher intensities, as well as a better seasonal variability

> **Mapping heat-wave warning areas** (not shown here)
on the condition that the model is debiased if epidemiological temperature thresholds are applied

> **Capturing the intensification of daily precipitation downwind the city** (Fig 4 bottom)
with more realistic intensity and seasonal variability

Conclusions and Perspectives

A high-resolution regional climate model such as **CNRM-AROME, with specific modeling of urban surface processes, is a promising tool to diagnose climatic and impact indicators at the city scale, and their evolutions in a changing climate**. Nevertheless, some ways remain to be investigated to improve the simulations and diagnose additional impacts:

> Physical parameterisations of CNRM-AROME, especially for microphysics, radiation, and shallow-convection
> More sophisticated versions for both TEB and ISBA surface models, especially for modeling urban vegetation and building energy functioning

REF: Lemonsu A, Caillaud C, Alias A, Riette S, Seity Y, Le Roy B, Michau Y, Lucas-Picher P: What added value of CNRM-AROME convection-permitting regional climate model compared to CNRM-ALADIN regional climate model for urban climate studies ? Evaluation over Paris area (France). Climate Dynamics, under review

__Contact__: Aude Lemonsu, Météo-France, CNRM/GMME/VILLE, 42 avenue G. Coriolis, 31057 Toulouse cedex, France - Email: aude.lemonsu@meteo.fr