Statistical Downscaling for urban meteorology at hectometric scale

PhD student : Julia GARCIA CRISTOBAL. Supervised by Valéry MASSON, Olivier MESTRE and Jean WURTZ
Centre National des Recherches Météorologiques (CNRM)
CNRM/GMME/VILLE, Toulouse, France
julia.garcia-cristobal@meteo.fr

1.Context

Weather forecasting in urban environments is a complex task because of the highly heterogeneous nature of the urban structure. Nevertheless, many issues are inherent to urban meteorology, such as thermal comfort or energy consumption.

State-of-the-art **meteorological models at hectometric resolution**, like the Meso-NH research model [1], can provide accurate urban meteorology forecasts thanks to the urban schemes like TEB [2]. However, such simulations require **great computing power** due to its complexity. **Statistical downscaling** techniques are machine learning methods enabling the estimation of fine resolution fields from one or several low resolution fields. While enabling fine estimation of urban weather, these methods can significantly reduce computational costs compared to hectometric simulations.

2.Goal

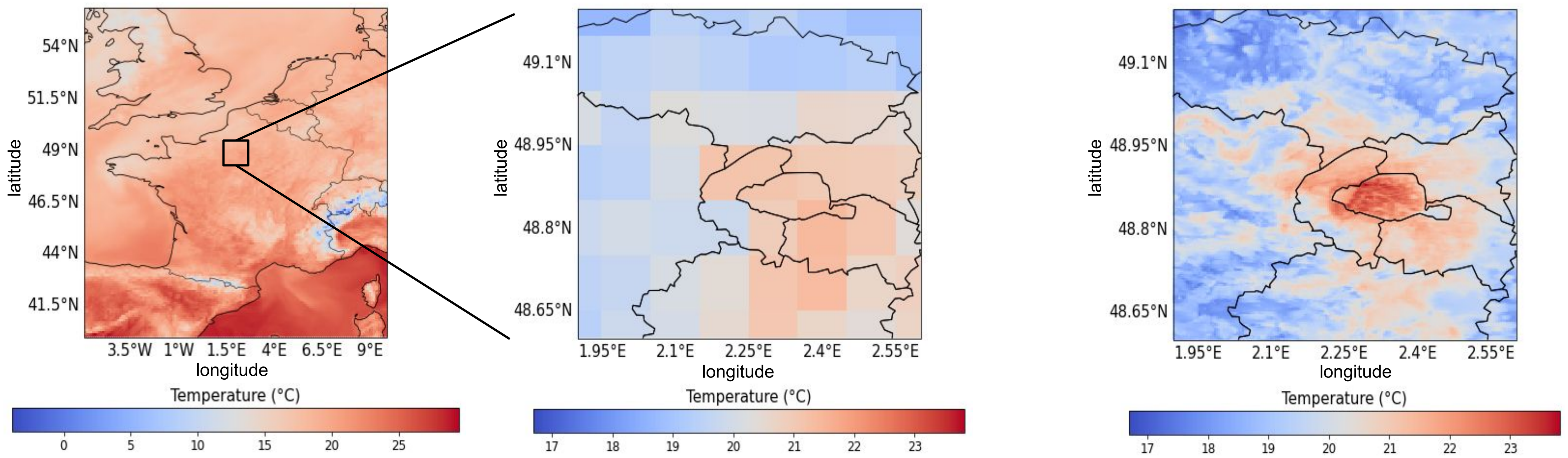
Given large scale simulations at coarse resolution, build an Artificial Intelligence downscaling emulator providing the 2 meters temperature at hectometric resolution.

3.Input for downscaling

GLOBAL MODEL : ARPEGE [3] (5km)
NWF deployed operationally at Météo France.

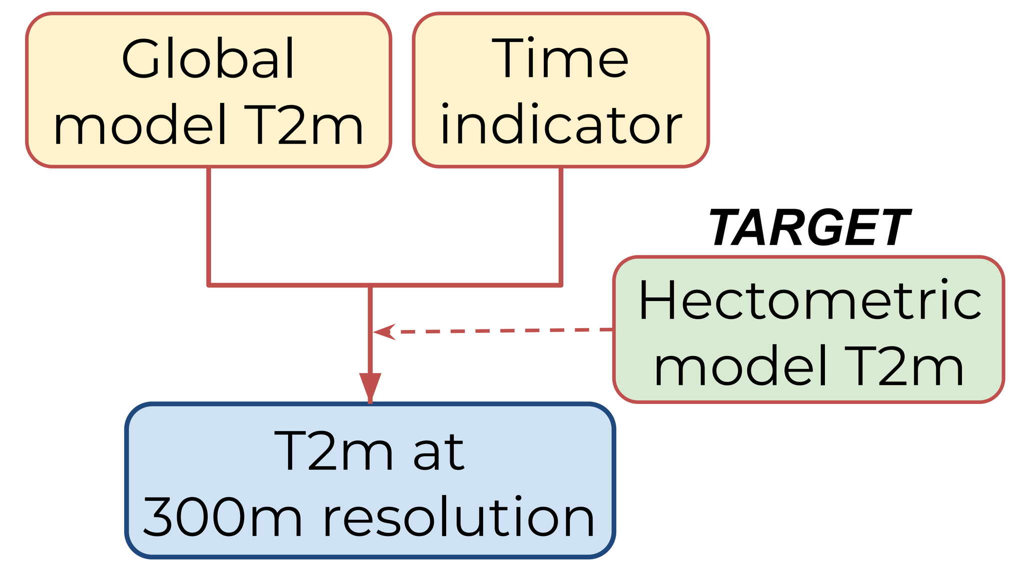
HECTOMETRIC MODEL : Meso-NH [1] (300m)

T2m simulations from ARPEGE (left panels) and Meso-NH (right panel), 3rd august 2022, 05:00 UTC



Dataset: Hourly 2 meters temperature (T2m) fields from ARPEGE and Meso-NH simulations during August 2022 over Paris region.

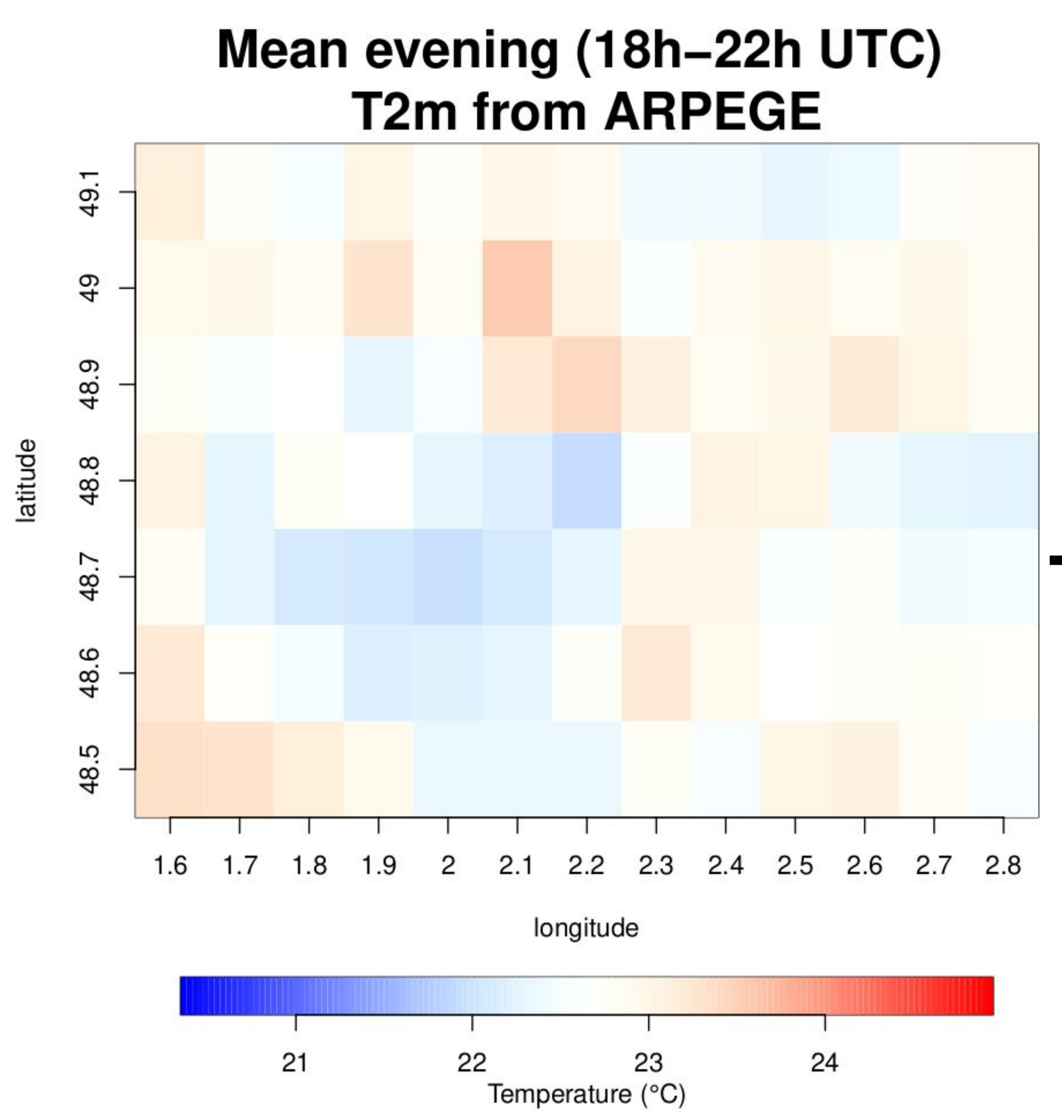
4.Training strategy



Estimation by **Vector Generalized Additive Models** (VGAM) [4].

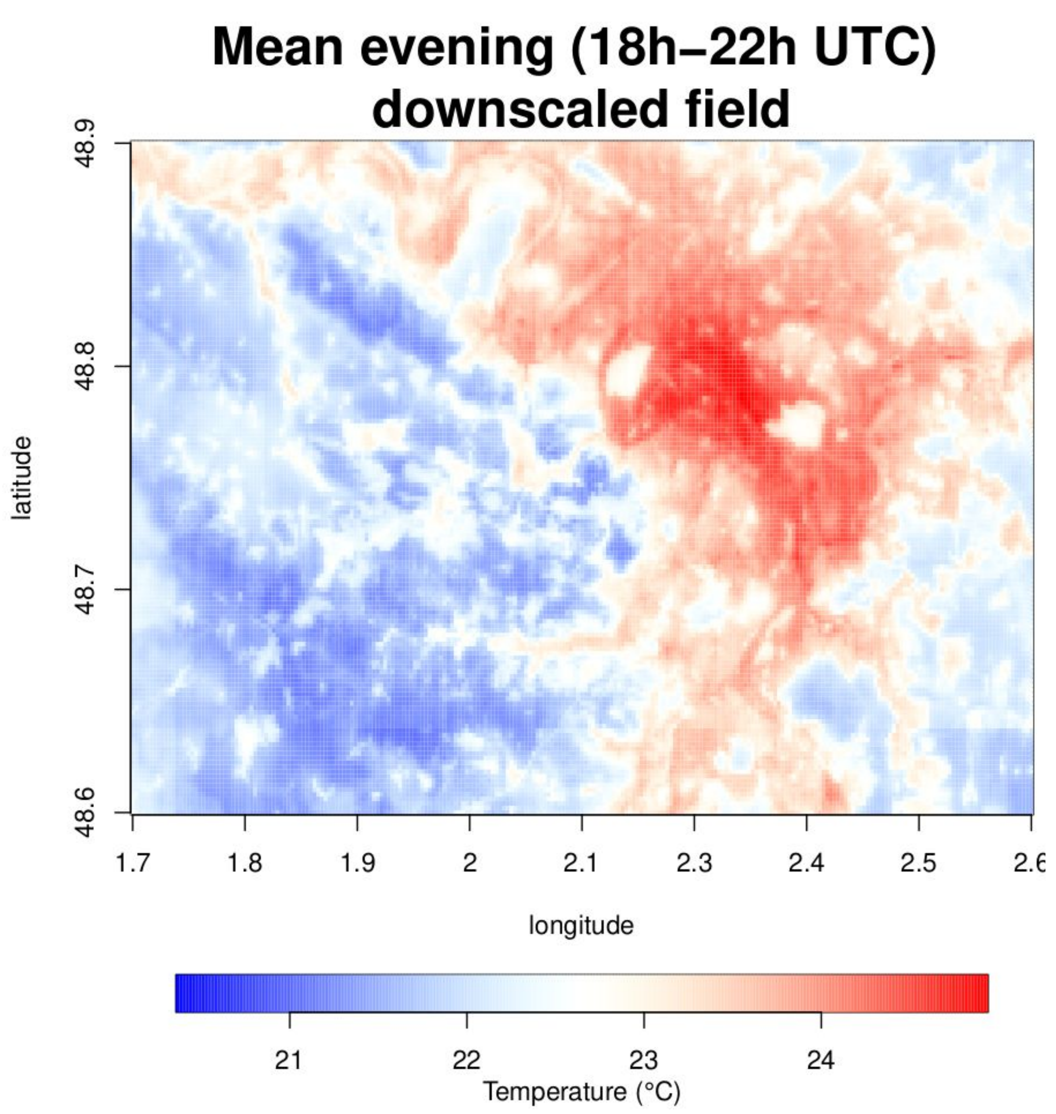
Training set: 25 days.
Test set: 5 days

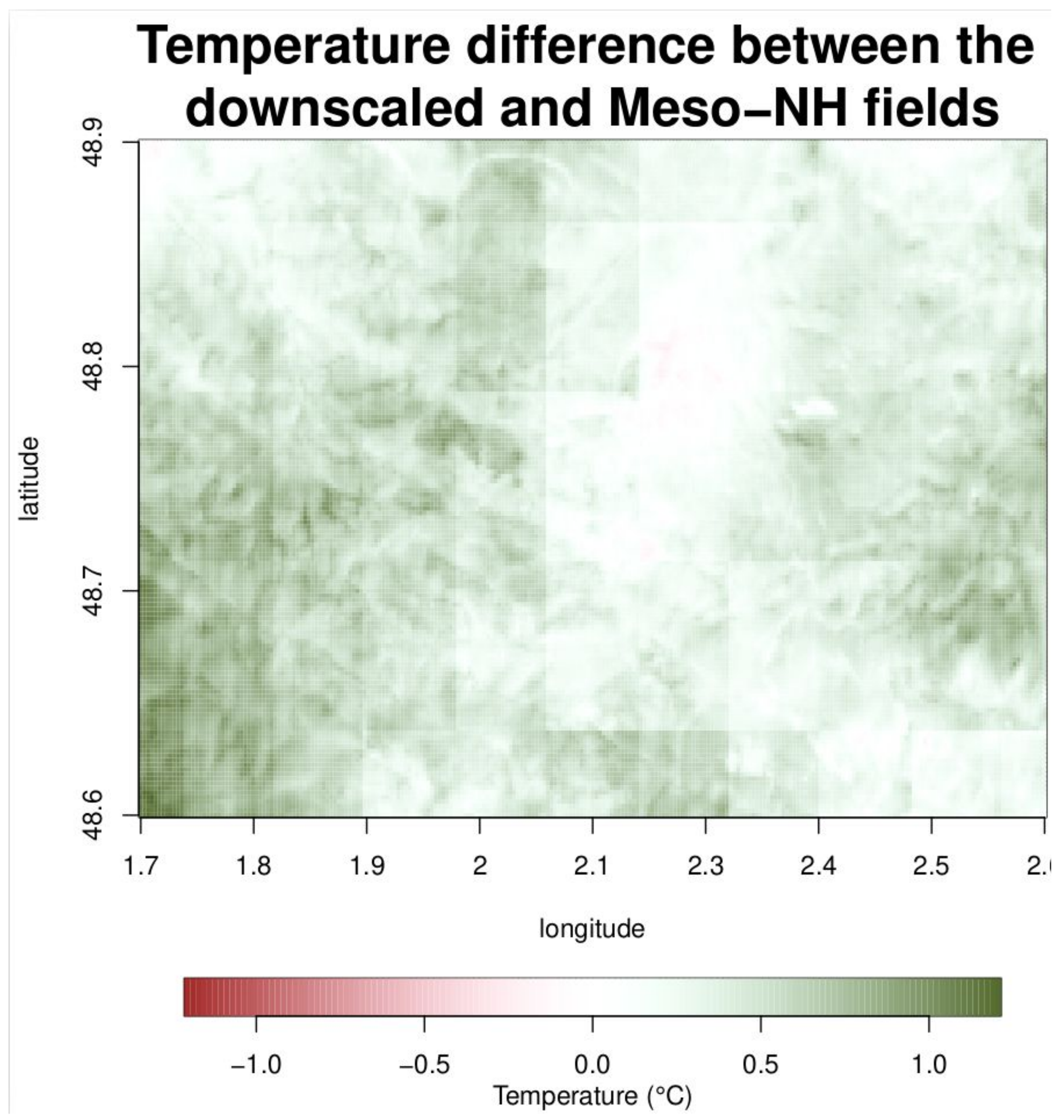
5.Downscaling results over test set



VGAM

ARPEGE T2m + Time ind.





6.Perspectives

DATA SET

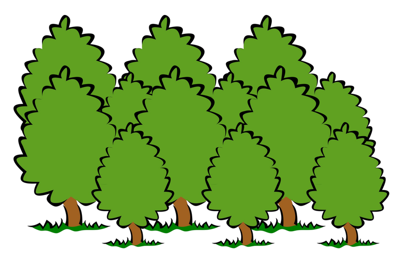
Extend temporally the data set : one year of ARPEGE and Meso-NH simulations.

ADD PREDICTORS

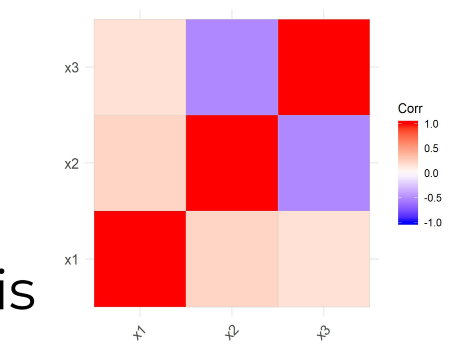
Test the prediction when adding other meteorological variables: humidity, solar radiation, wind direction/speed...

Explore the emulation of other meteorological variables.

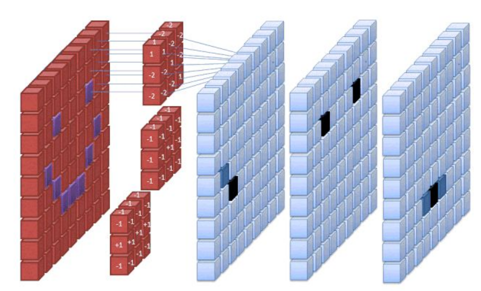
EXPLORE OTHER TECHNIQUES



Random Forests



Canonical Correlation Analysis



Deep Learning: Convolutional Neural Networks

ACKNOWLEDGMENTS

The thesis work of J. Garcia Cristobal under the supervision of V. Masson and J. Wurtz receives a doctoral research grant from the Occitanie Region (N°23002916) in the context of the METURBIA project, and from Météo France (N°2330C0021). Special thanks to V. Masson, J. Wurtz and O. Mestre, as well as to the VILLE team at CNRM.

REFERENCES

[1] Lac, C., Chaboureau, J.-P., Masson, V., Pinty, J.-P., Tulet, P., Escobar, J., Leriche, M., Barthe, C., Aouizerats, B., Augros, C., Aumond, P., Auguste, F., Bechtold, P., Berthet, S., Bielli, S., Bosseur, F., Caumont, O., Cohard, J.-M., Colin, J., Couvreux, F., Cuxart, J., Delautier, G., Dauhut, T., Ducrocq, V., Filippi, J. B., Gazen, D., Geoffroy, O., Gheusi, F., Honnert, R., Lafore, J.-P., Lebeaupin Brossier, C., Libois, Q., Lunet, T., Mari, C., Maric, T., Mascart, P., Mogé, M., Molinié, G., Nuissier, O., Pantillon, F., Peyrillé, P., Pergaud, J., Perraud, E., Pianezze, J., Redelsperger, J.-L., Ricard, D., Richard, E., Riette, S., Rodier, Q., Schoetter, R., Seyfried, L., Stein, J., Suhre, K., Taufour, M., Thouron, O., Turner, S., Verrelle, A., Vié, B., Visentin, F., Vionnet, V., and Wautelet, P. (2018). Overview of the meso-nh model version 5.4 and its applications. Geoscientific Model Development, 11(5) :1929–1969. [2] Masson, V. 2000. A physically-based scheme for the urban energy balance in atmospheric models. *Bound.-Layer Meteor.* 94:357–397.
[3] Déqué M., Dreveton C., Braun A., Cariolle D. (1994) : The ARPEGE-IFS atmosphere model : a contribution to the French community climate modelling. Climate Dynamics 10:249-266. [4] Yee, T. and Moler, C. (2023). Vector Generalized Linear and Additive Models.