Challenges of statistical-dynamical downscaling of EURO-CORDEX regional climate models for impact studies at the city scale

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Objectives of the study

Develop a methodology to conduct **impact studies** at the **city scale**

Produce **urban climate services** adapted to the needs of stakeholders

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Create a modelling methodology to evaluate different **urban planning scenarios** taking into account :

- The climate change signal
- The urban climate and its spatial variability up to the hectometric scale

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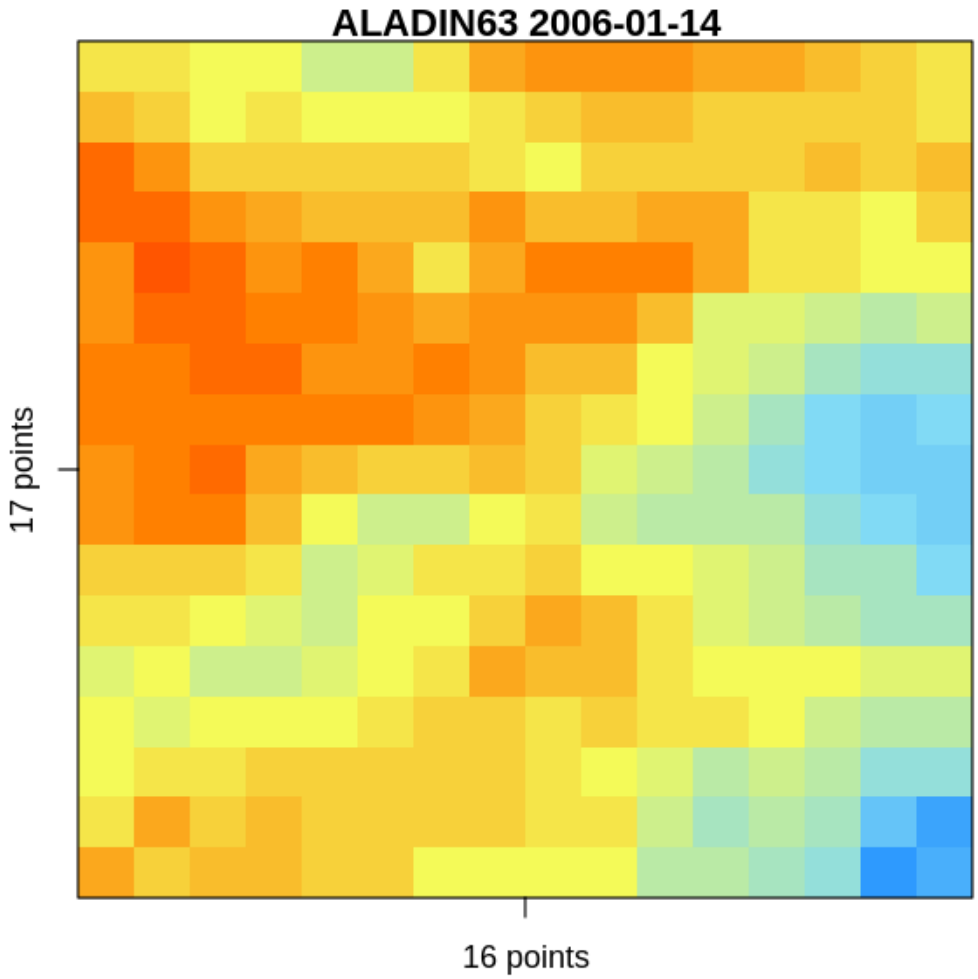
But to do so, they need **climatic fields**:

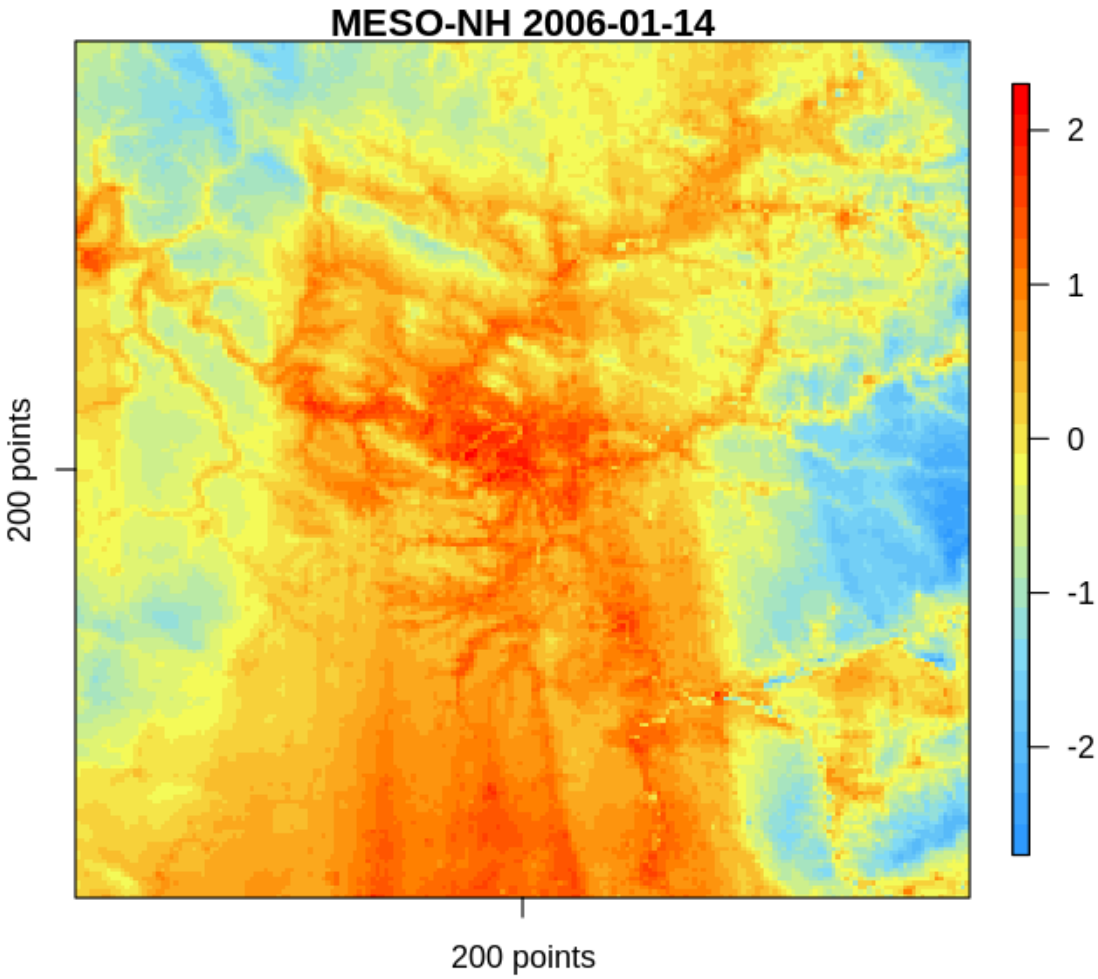
- Representative of **local conditions**
- Accounting for **city retroaction** on low atmosphere
- With temporal resolution adapted to capture the diurnal cycle of the **Urban Heat Island** (UHI)

Context

RCM 12 km over Paris



Mesoscale model 1 km over Paris



+ Time depth and climate trends
- No city, nor local specificity

+ Urban signal

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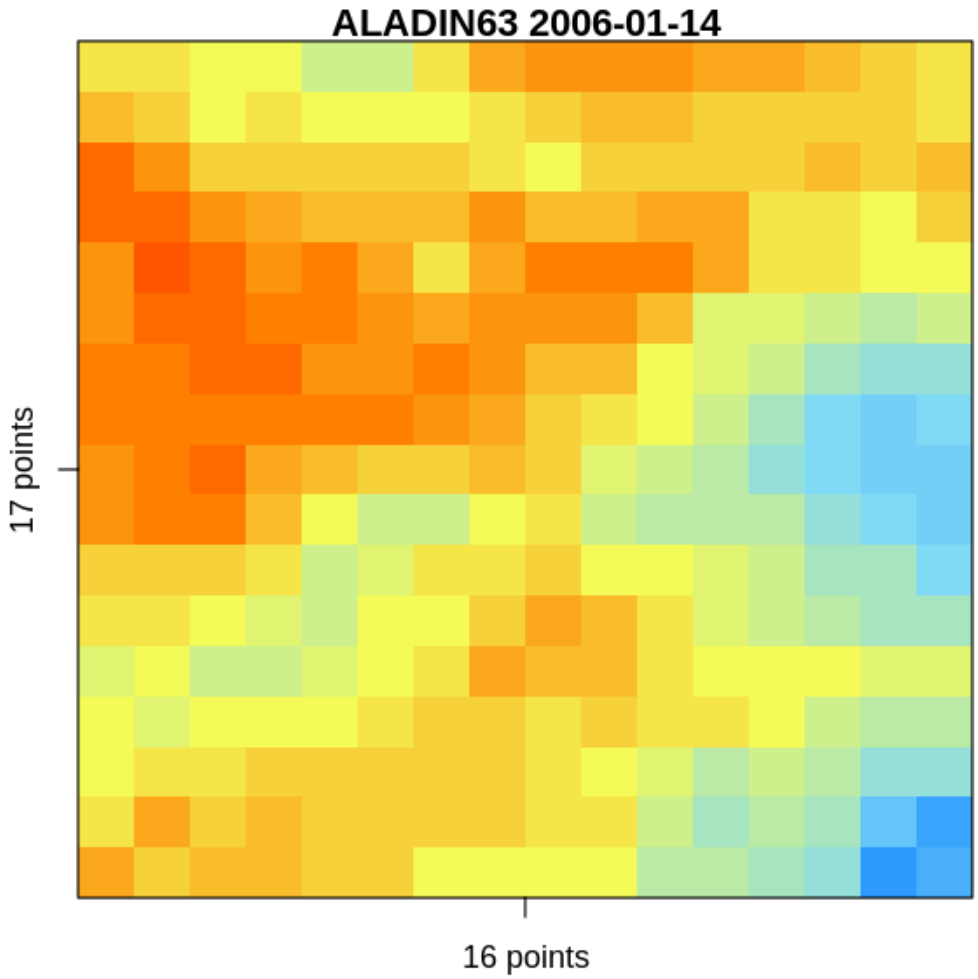

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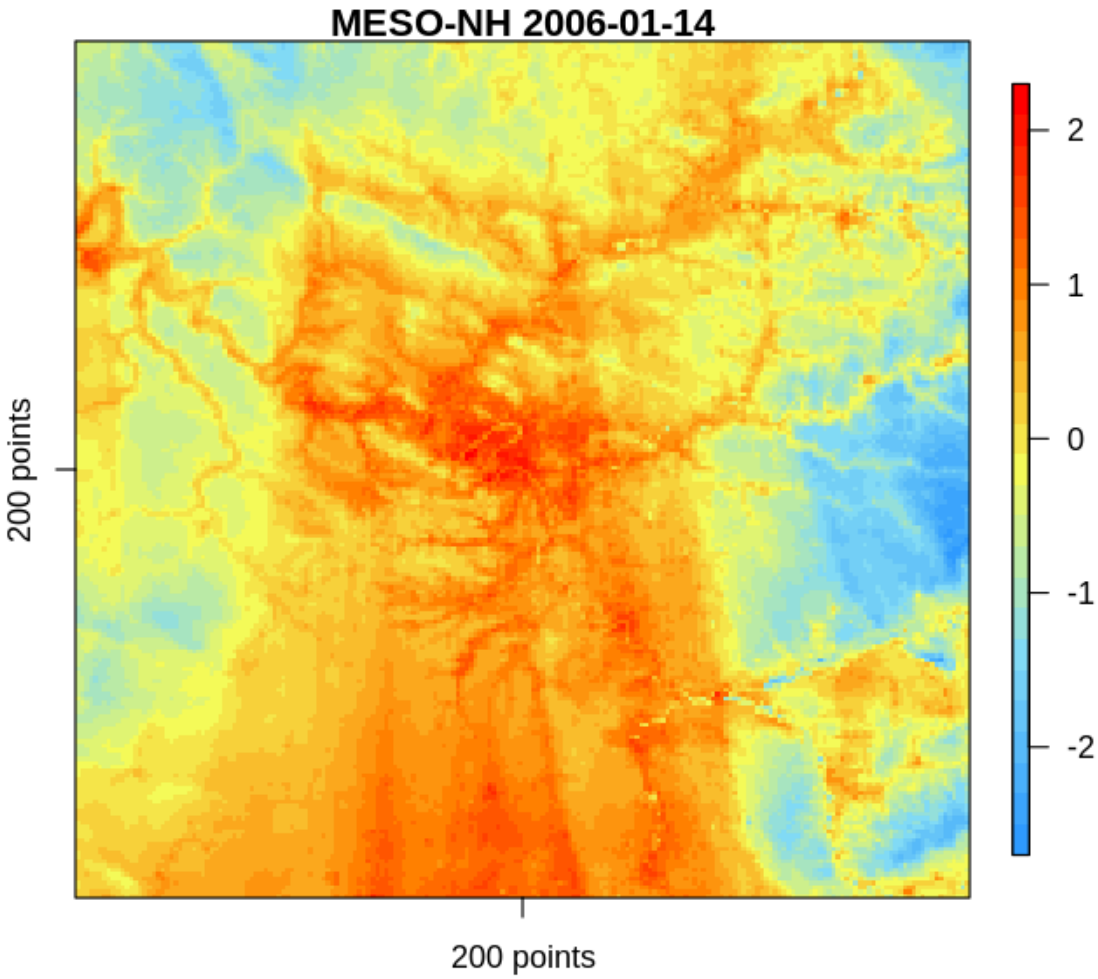

Some RCM now reach kilometric resolution but are computationally expensive

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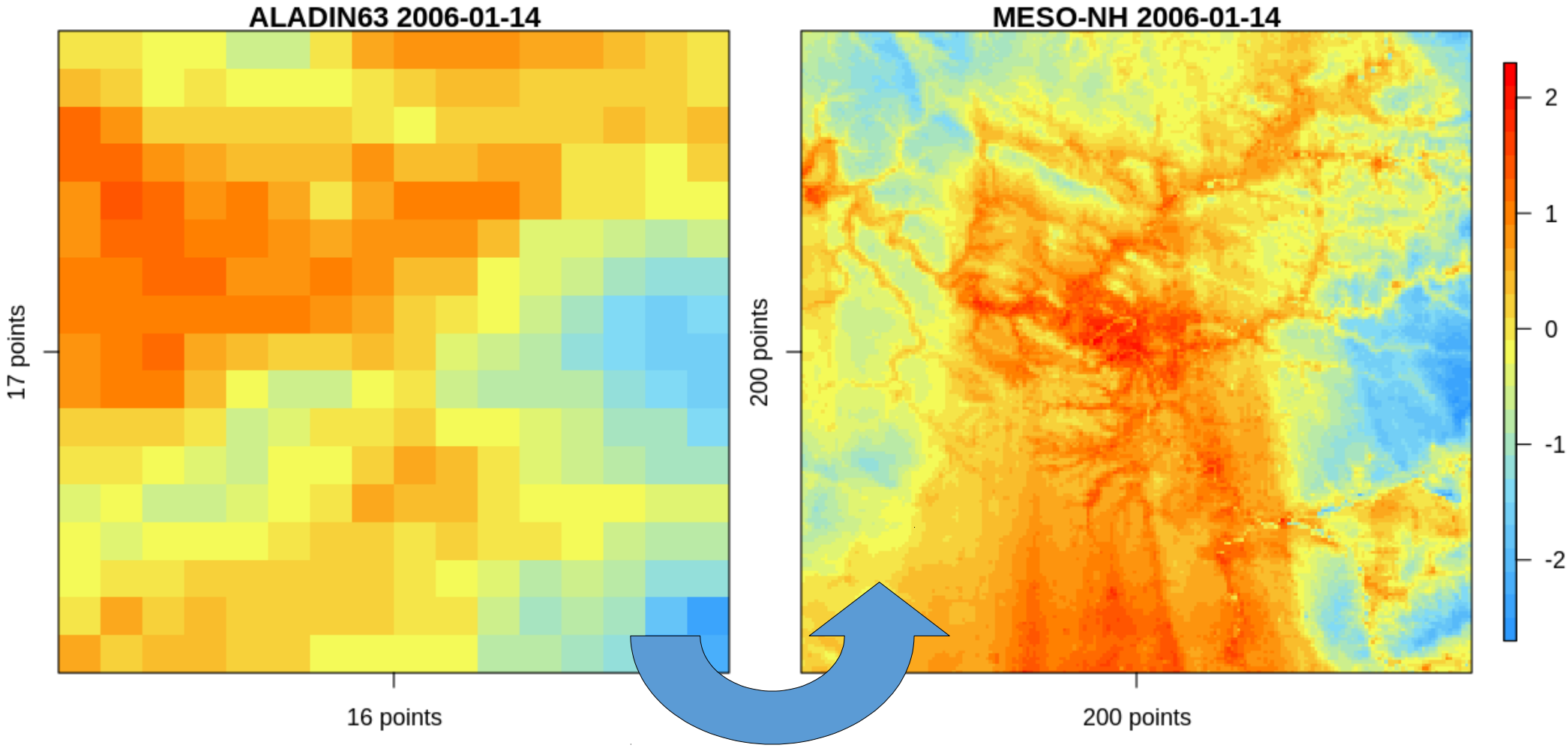

Statistical-dynamical downscaling of Regional Climate Model from EURO-CORDEX (over Paris)

Approach adopted

Because the **Urban Heat Island** is very variable from one day to another based on the local atmospheric conditions we chose to work with **Local Weather Types (WT)**

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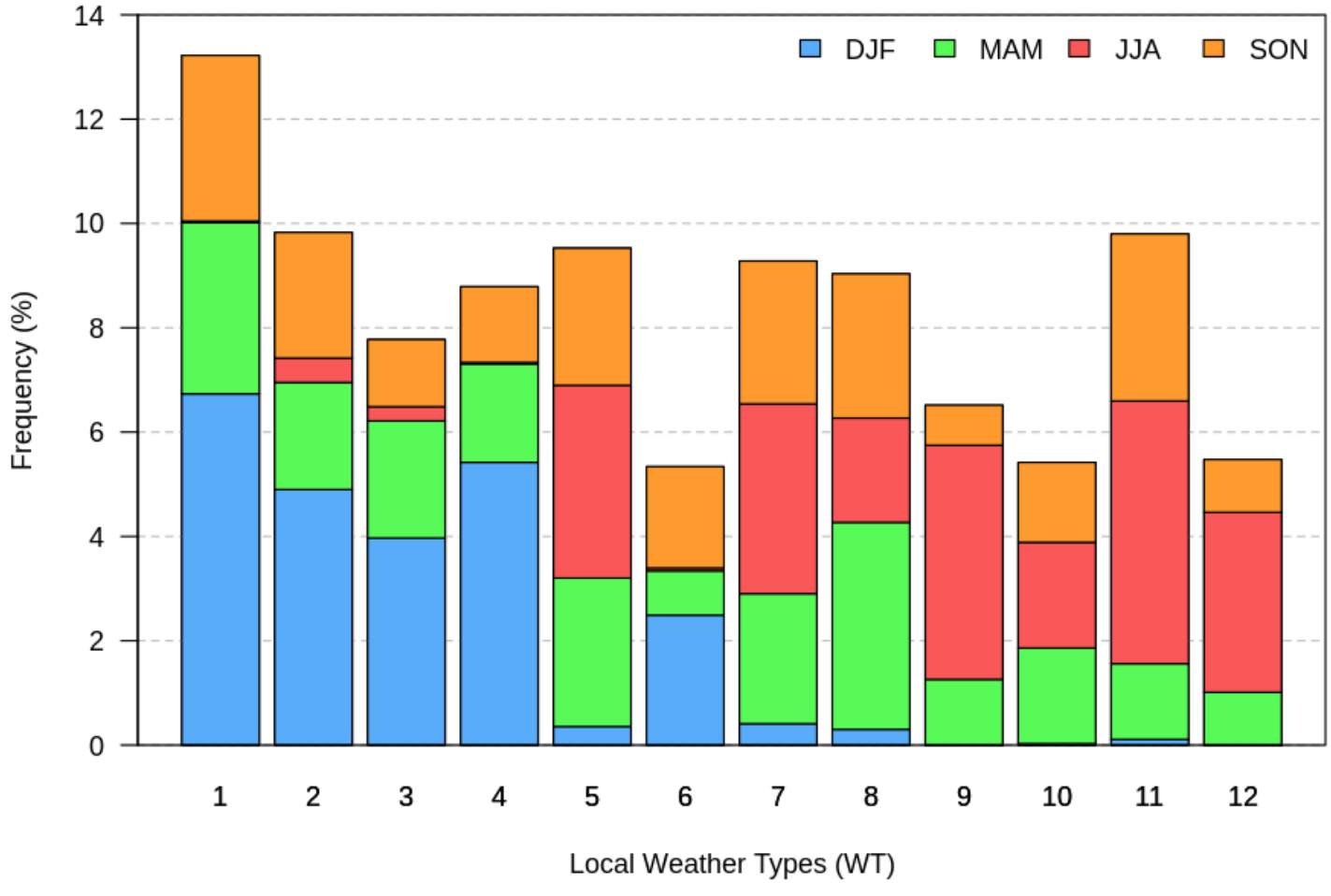
12 WT are found over Paris



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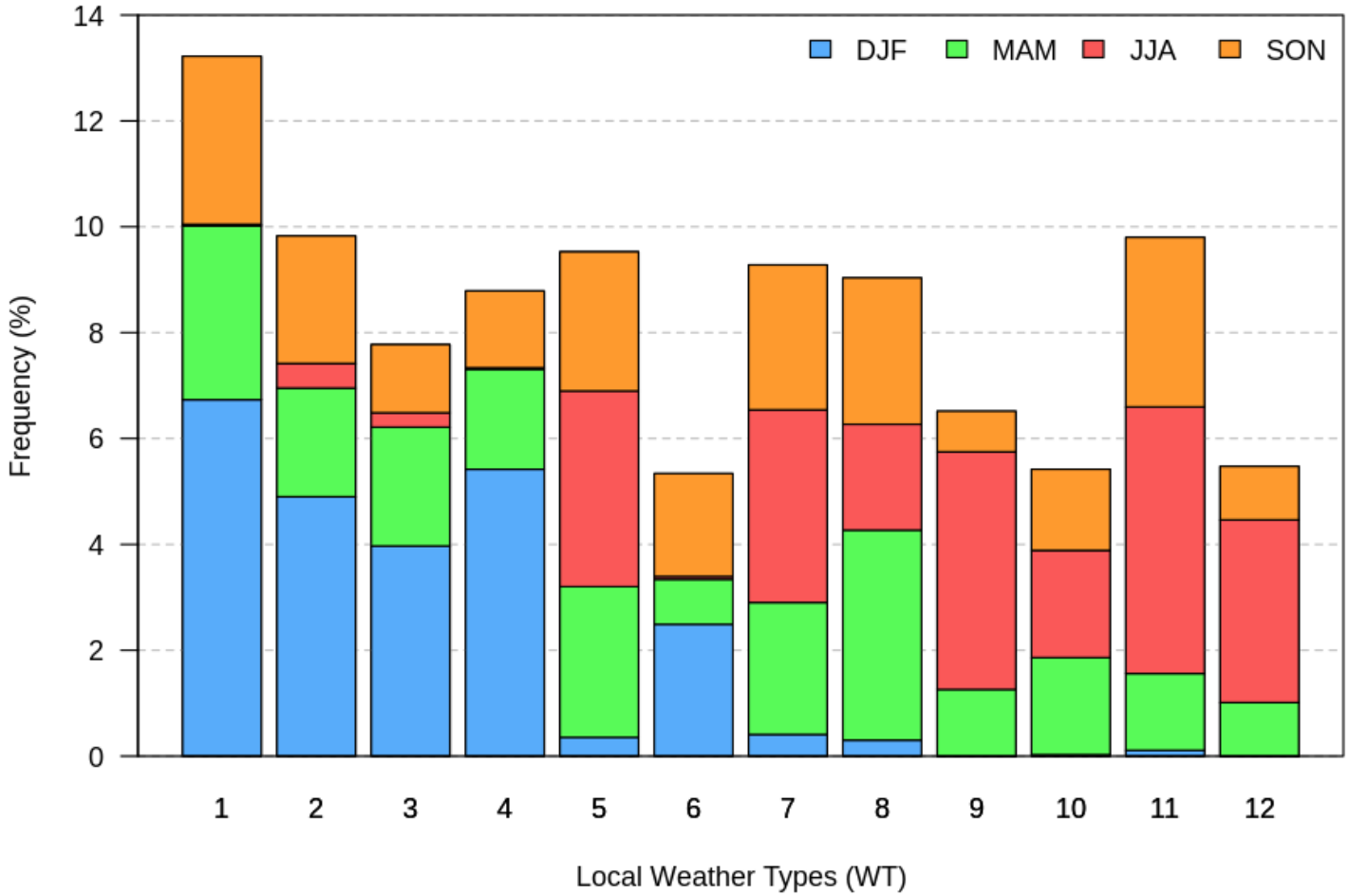
Each WT represents a different UHI:

- **Intensity**
- **Spatial extent**
- **Orientation**



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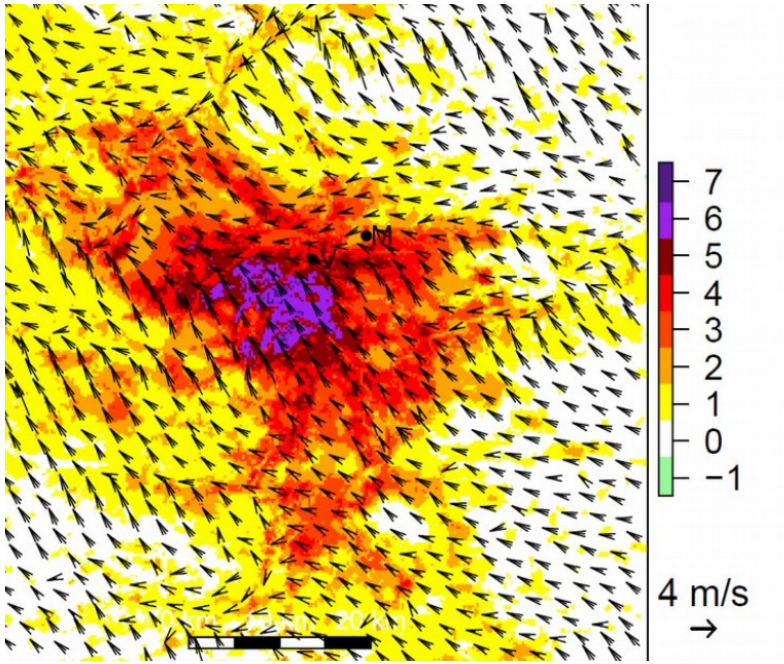
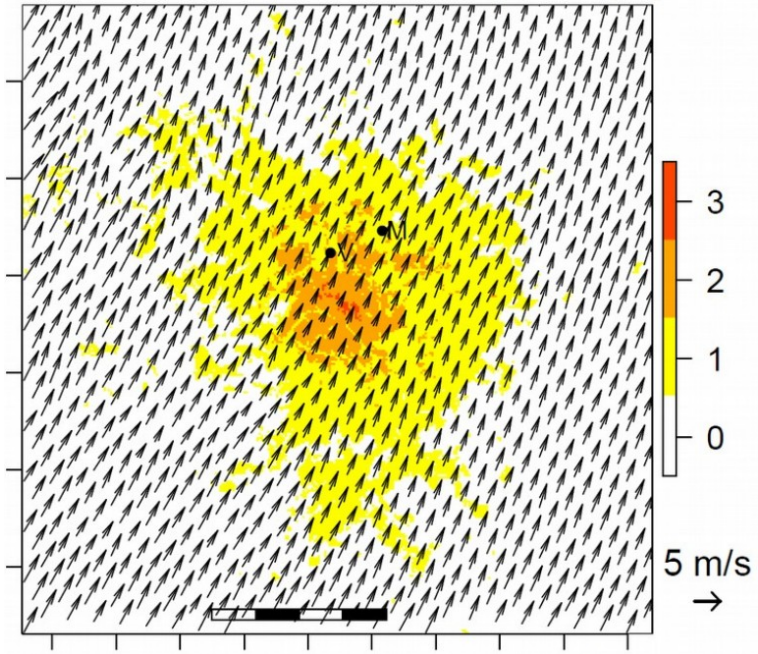
Urban signal for a WT with a **strong** UHI



Schoetter *et al*., (2019)

Urban signal for a WT with a **weak** UHI



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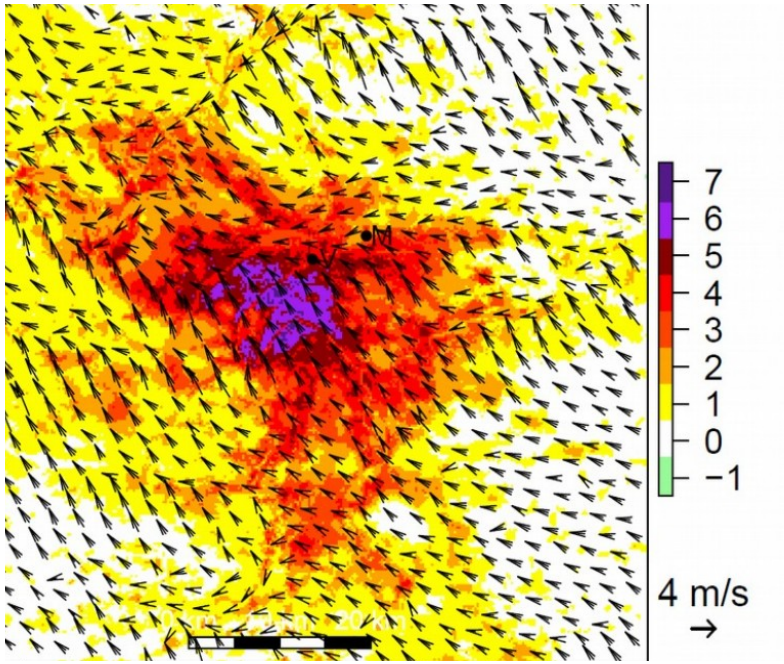

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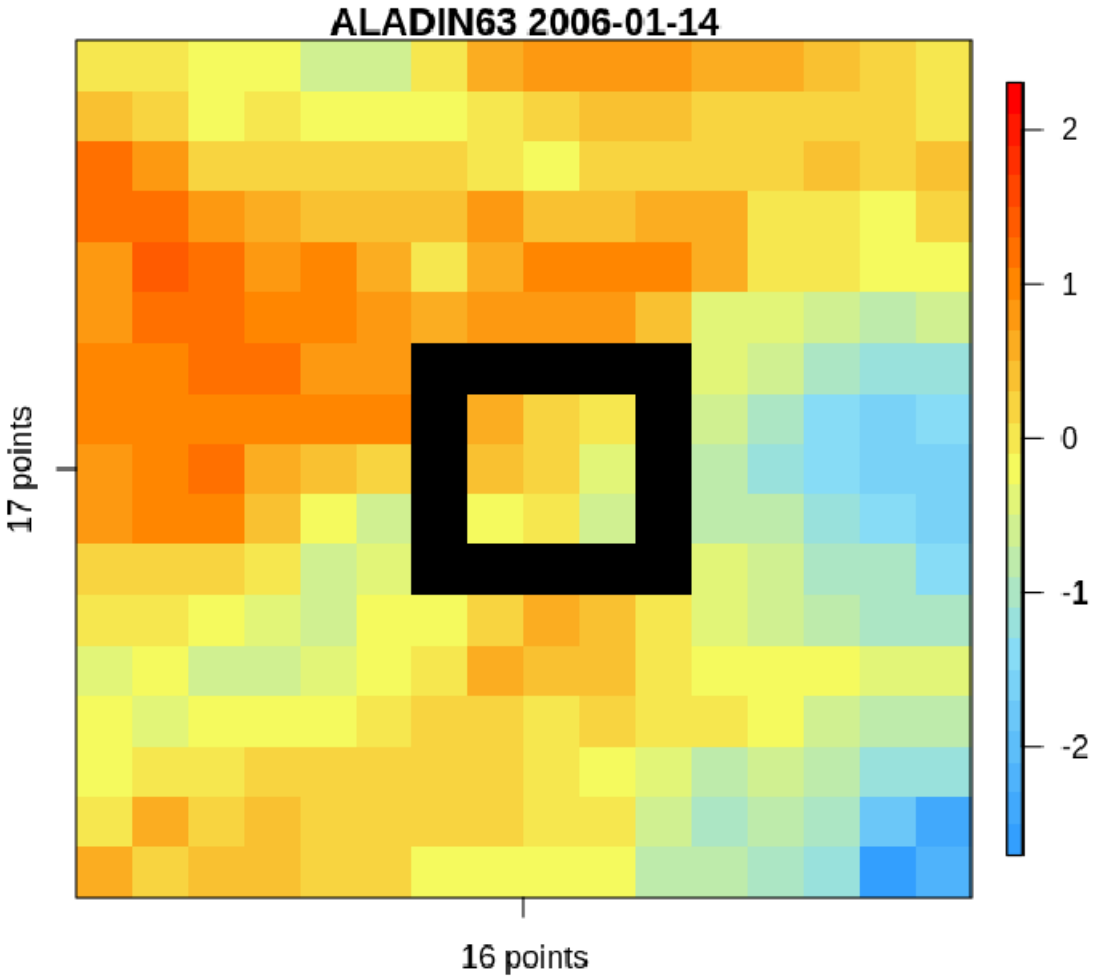
Meso-NH simulation evaluated against urban weather stations

Station	RMSE	MAE
Paris-Montsouris	1.66	1.27
Belleville Park	1.70	1.28
Courbevoie	1.84	1.38
St-Maur	2.18	1.70
Mean	**1.84**	**1.41**

Approach adopted

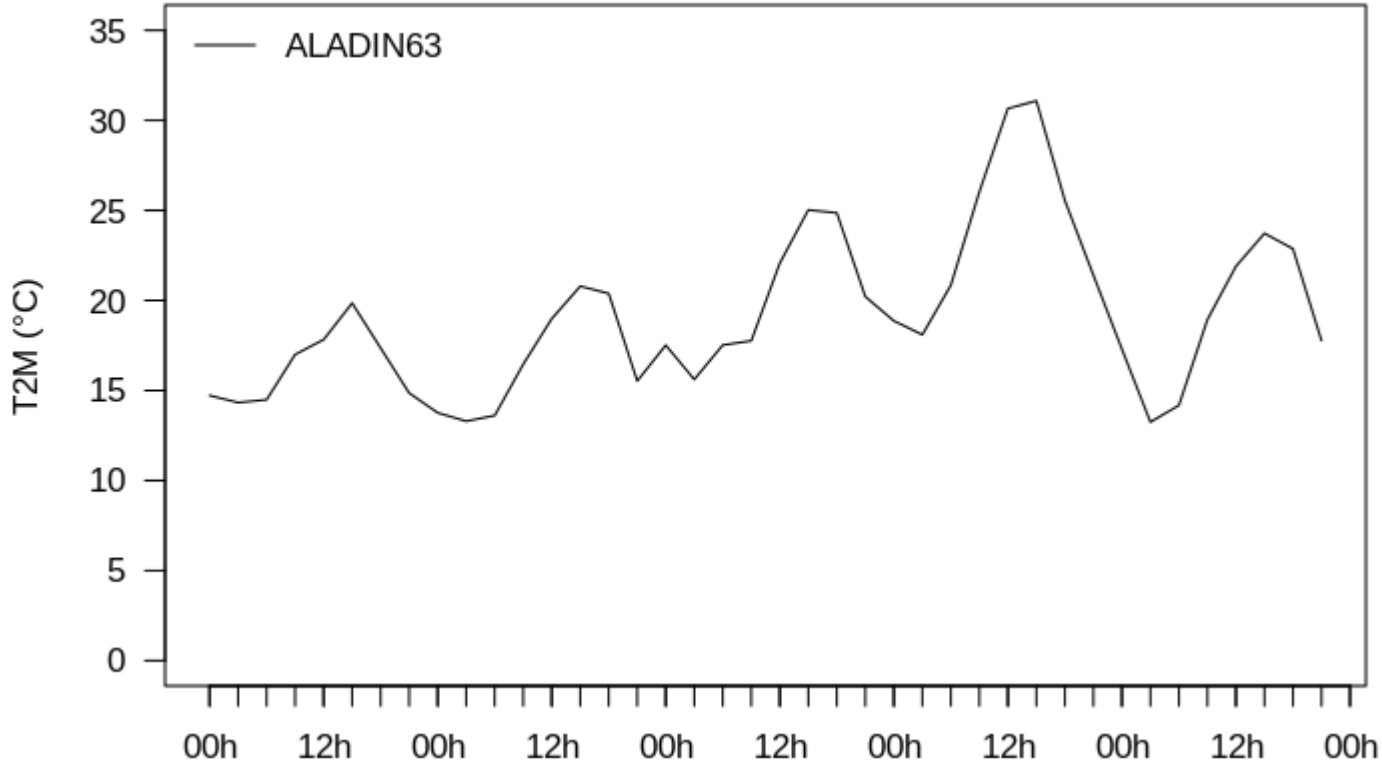


Focus on an outer ring to get the local climate without the city effect

→ Average of these points

Approach adopted

1. 3-hr time series of every variables are obtained from CORDEX EUR11



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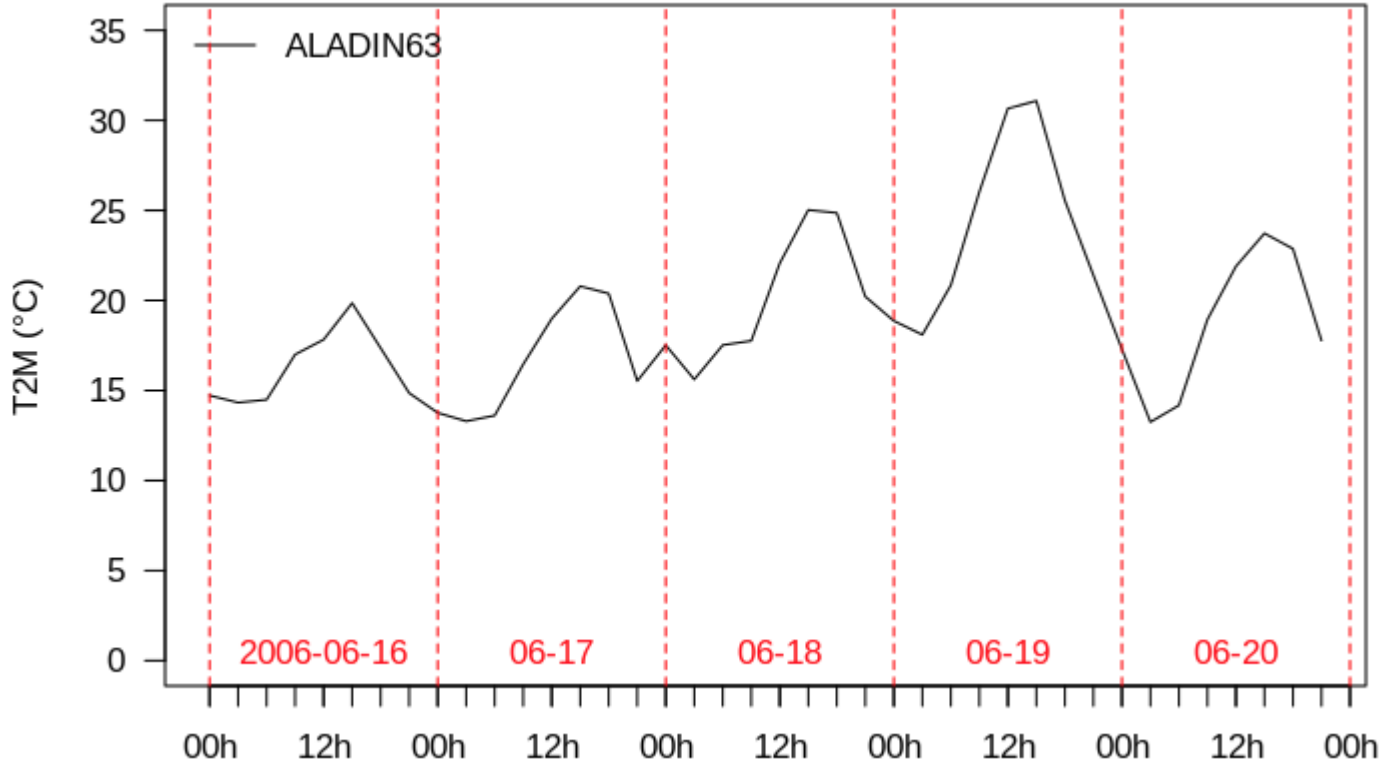

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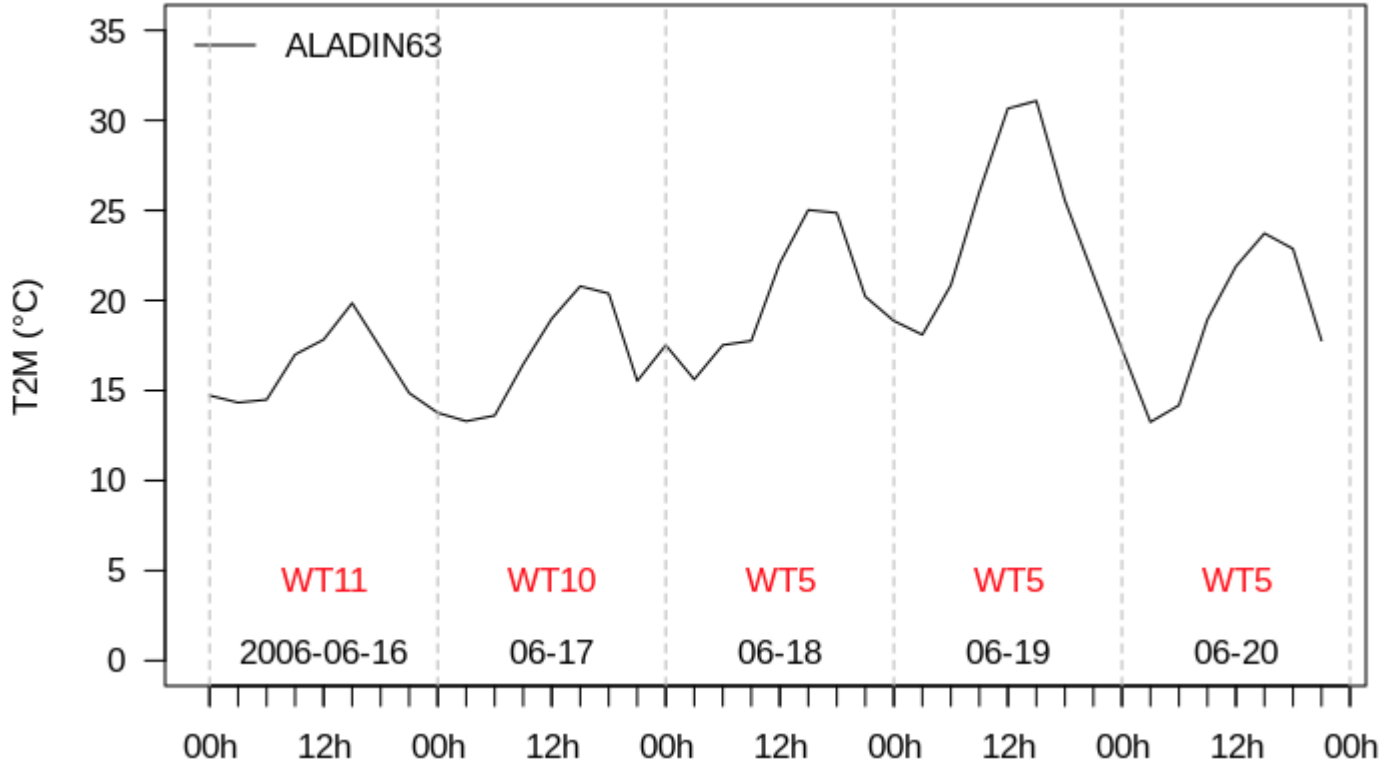

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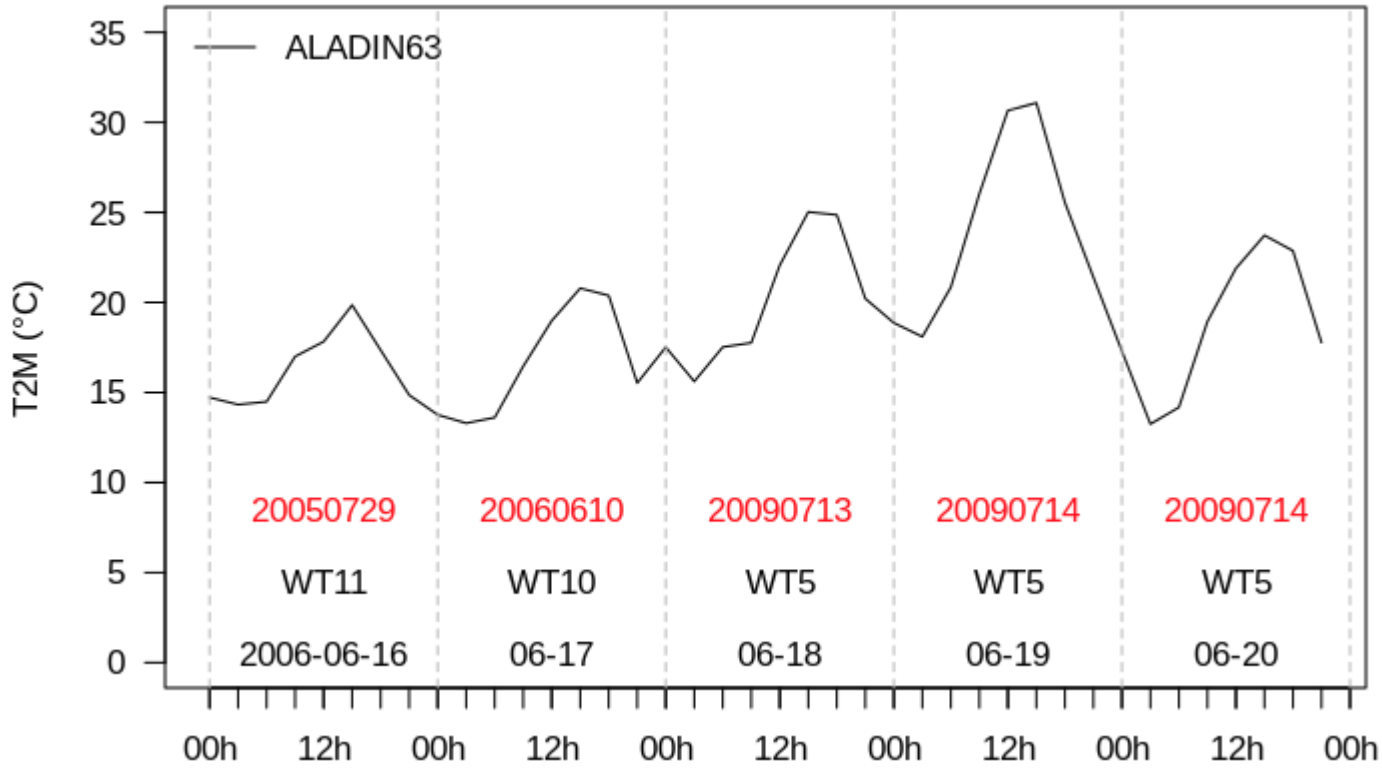

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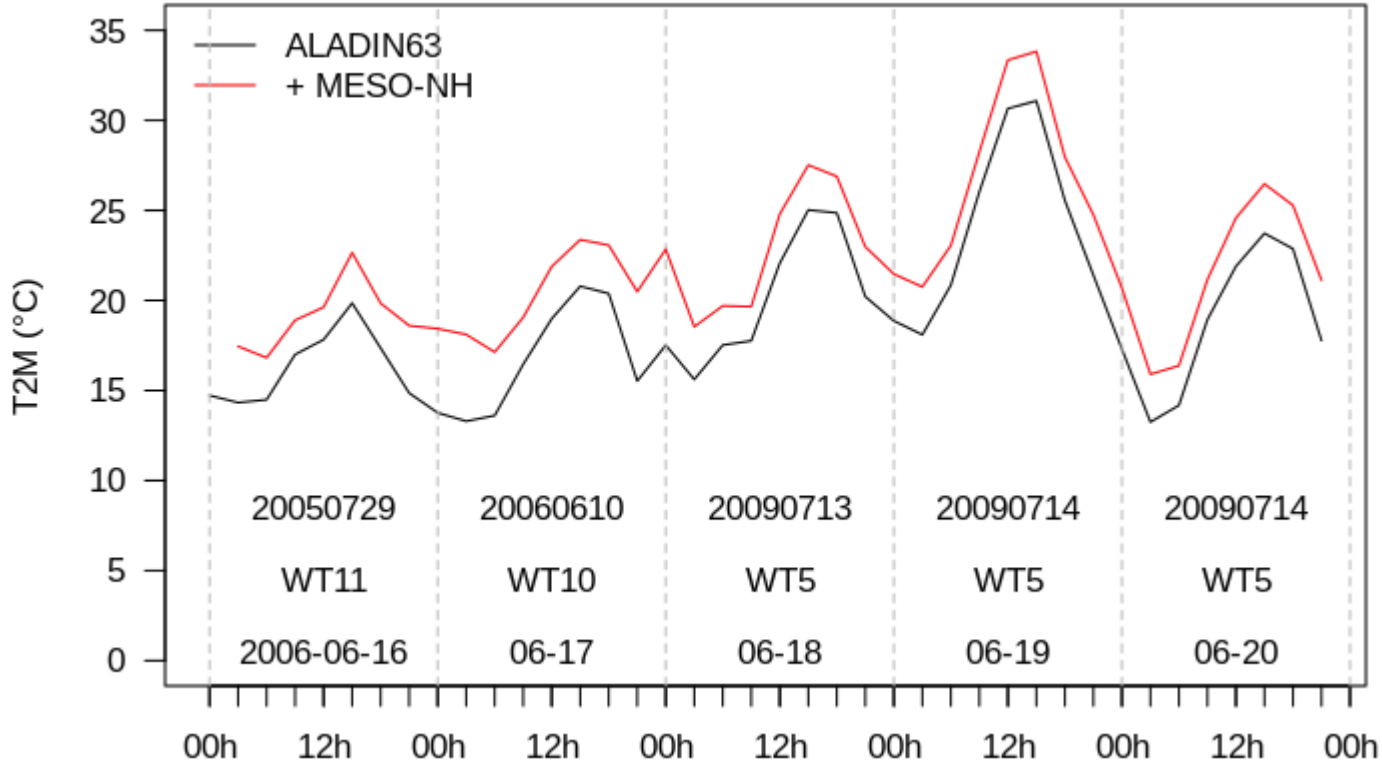
5. The urban signal from Meso-NH is added to the RCM field



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RCM 12 km
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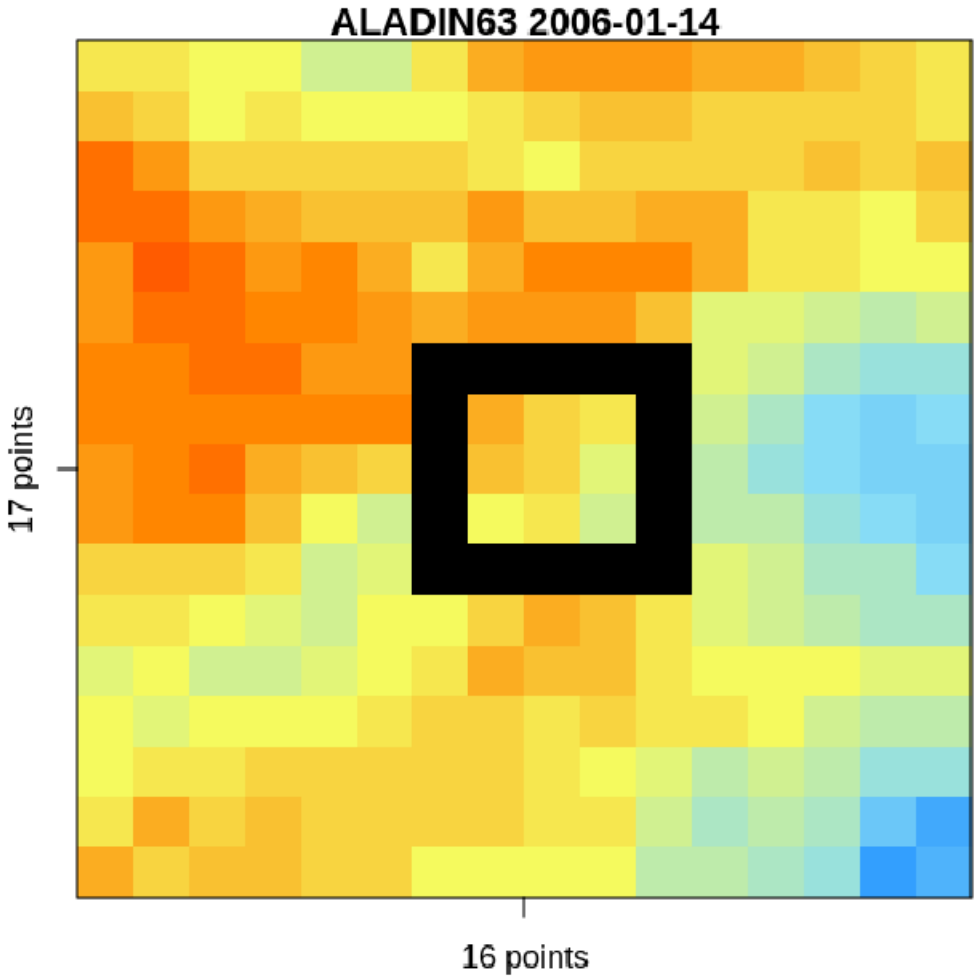

We start from several points in the RCM

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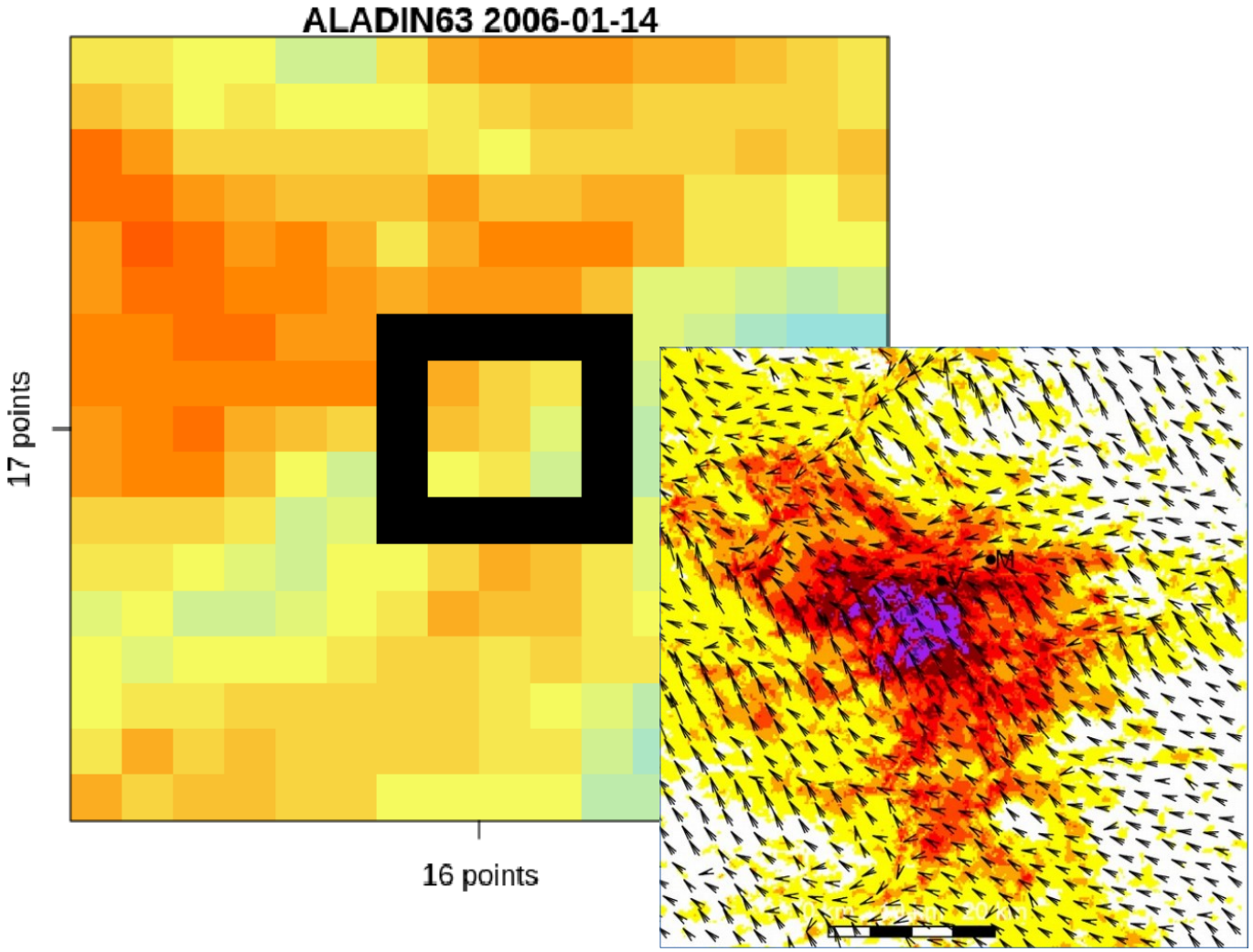

We add the urban signal

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Mesoscale model 1km
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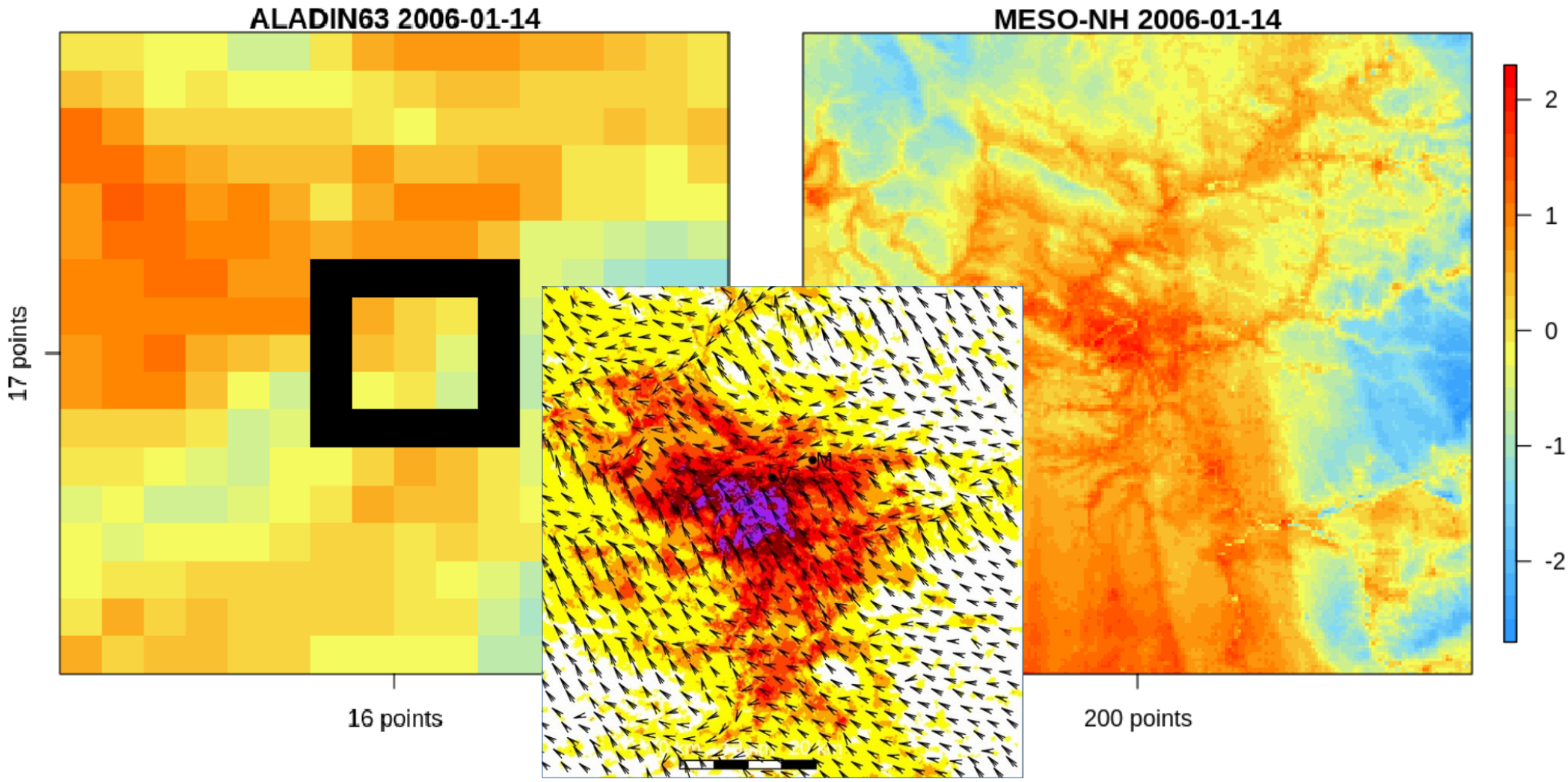


We reconstruct a **2D field** from 1 point in the RCM and the urban signal

Evaluation

Evaluation of the reconstruction methodology:

- Are the RCM able to reproduce **Local Weather Types**?
- Does the reconstructed urban signal match observations ?

Evaluation

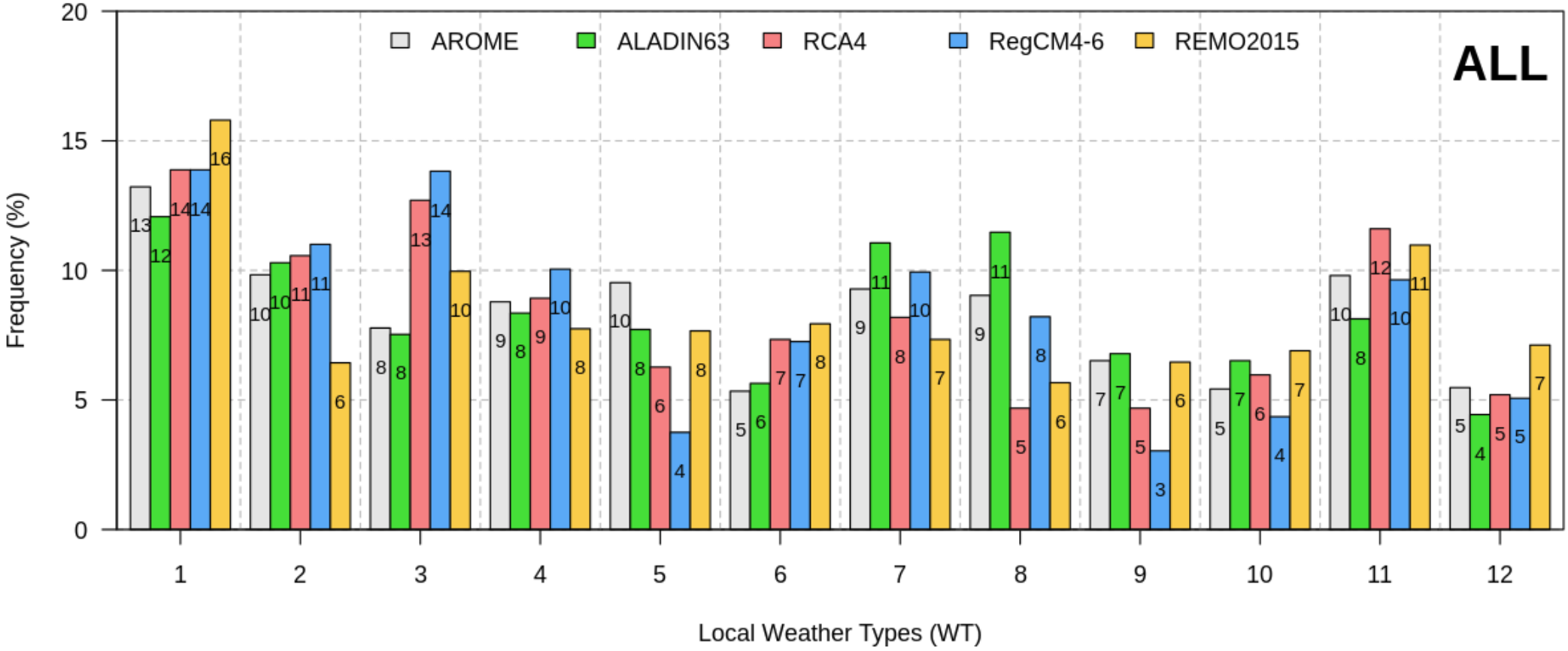
For the moment 9 couples of GCM / RCM have been downloaded from the ESGF portal :

ALADIN63, RCA4 (x5 GCM), RegCM4-6 and REMO2015

- **EVALUATION** (2000-2009) simulations

- **AROME** reference reanalysis used for the WT classification
- **T2M interpolated** at 1.25 km over the Paris area
- **Daily RR reanalysis** interpolated at 1 km over France

Are the WT frequencies produced by the RCM correct?



Frequency of every Local Weather Type (WT) found for every RCM against AROME as a reference.

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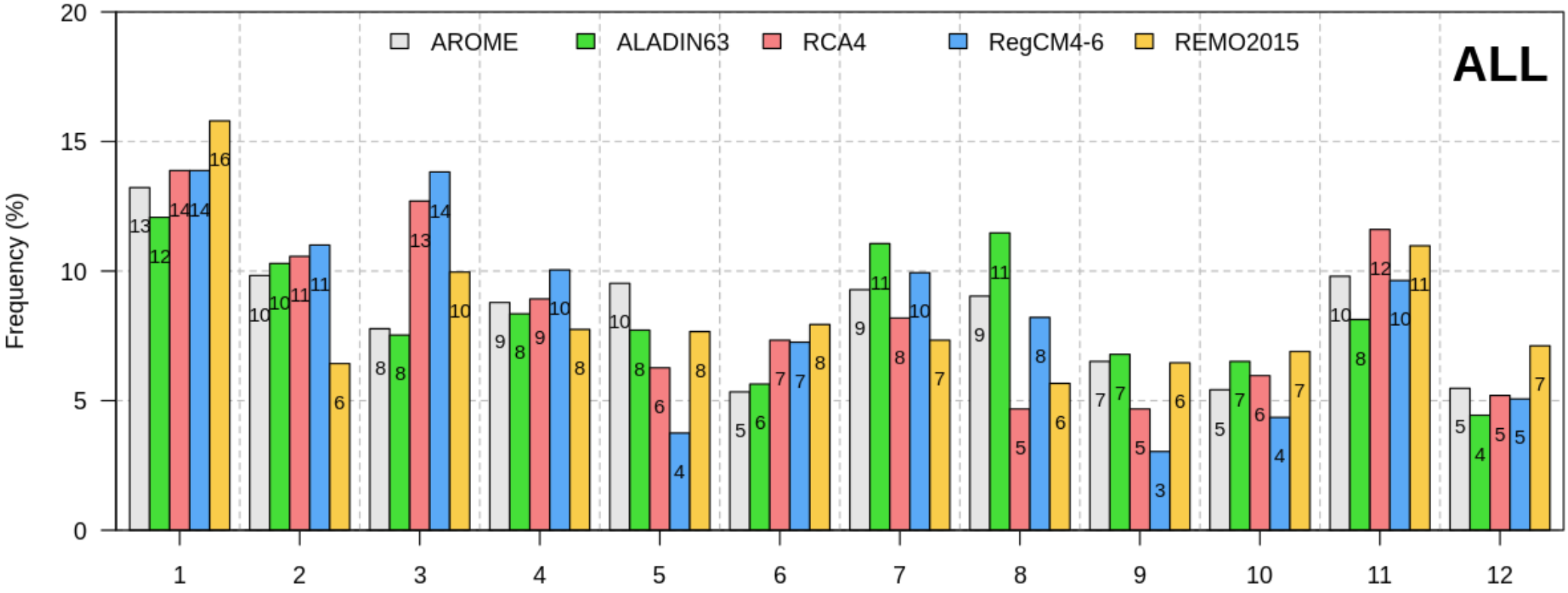
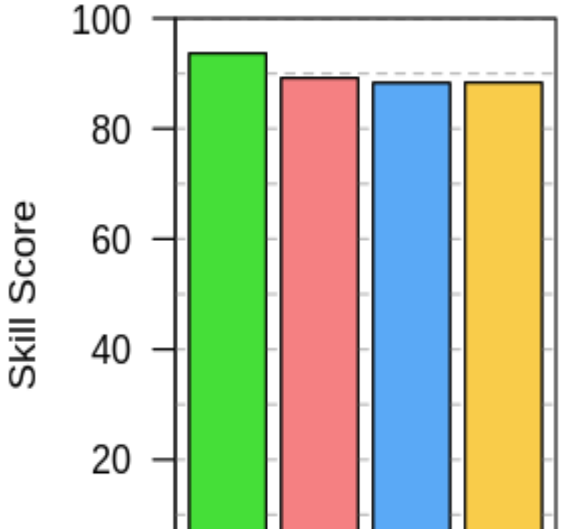


Perkins *et al.*, (2007) skill score with AROME as the reference

$$S_{score} = \sum_{WT\,1}^{WT\,12} minimum\left(f_{AROME}, f_{RCM}\right)$$



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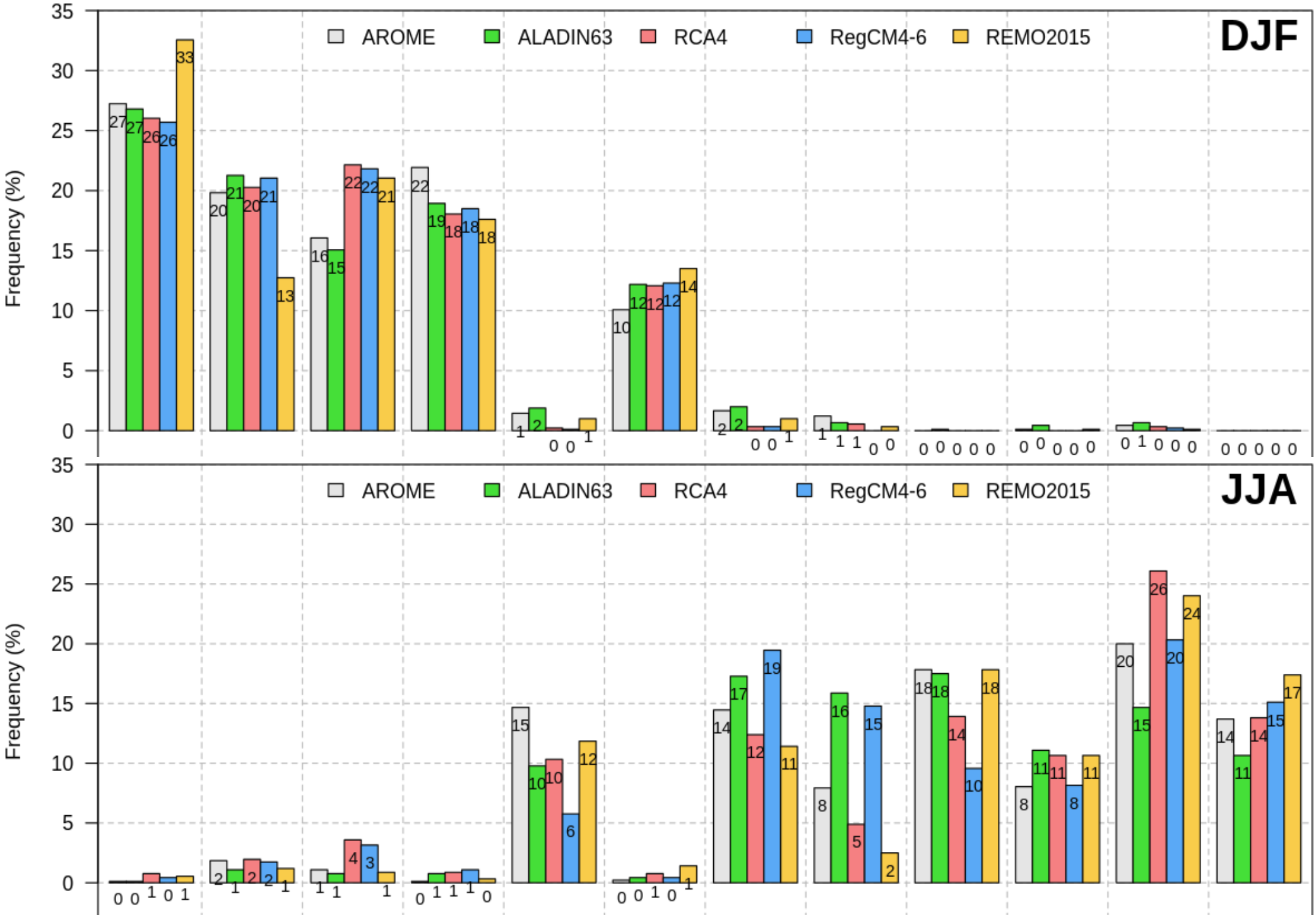

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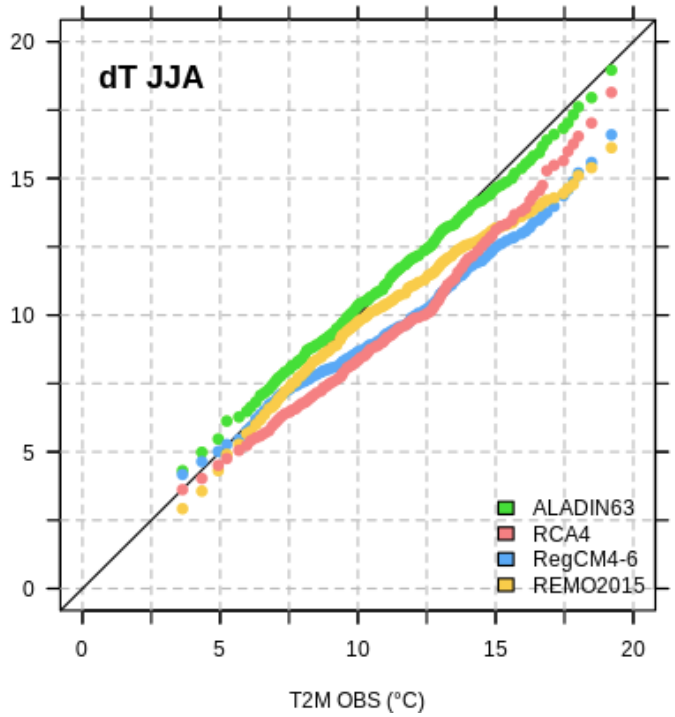
Daily Thermal amplitude



Systematic bias on the thermal amplitude

Daily Precipitation

MODEL / OBS	% days ≥ 0.1 mm
OBS	**53.08**
ALADIN63	60.85
RCA4	72.11
RegCM4-6	67.01
REMO2015	62.88

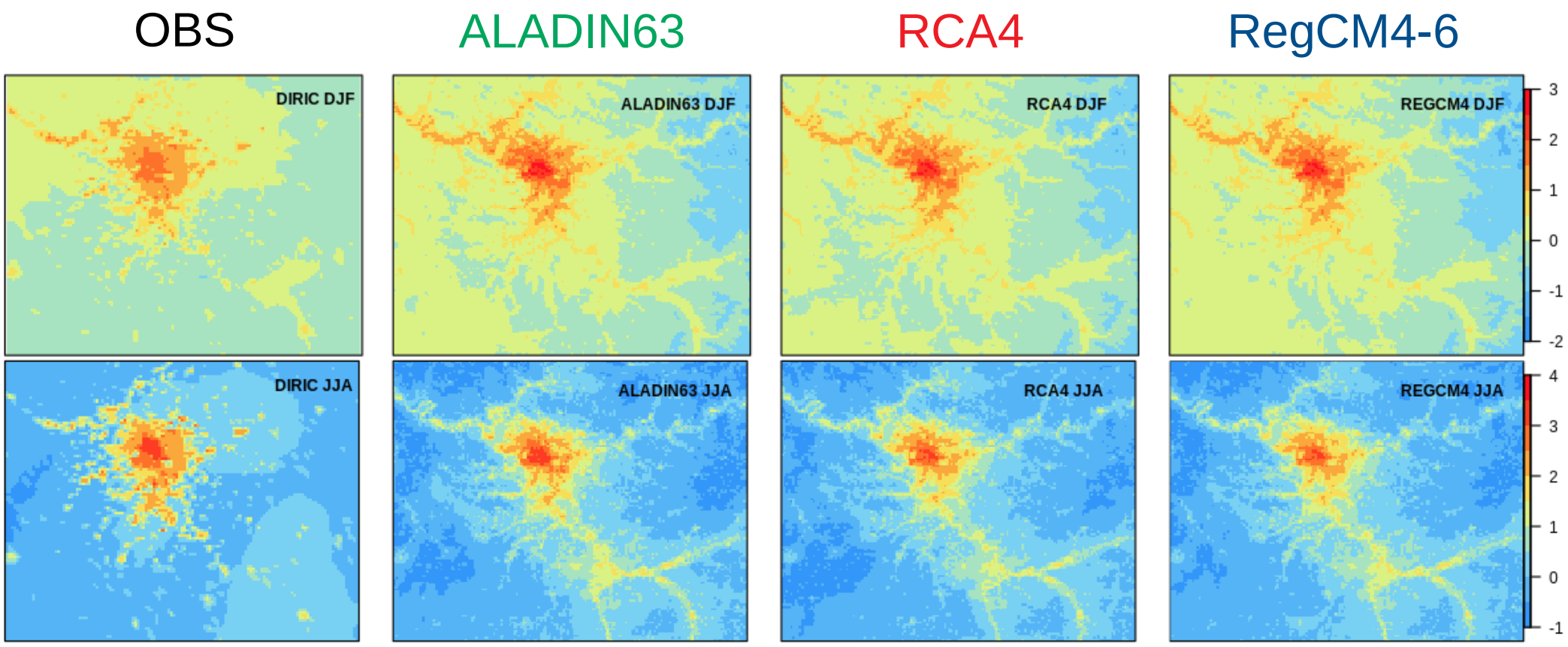
Too much precipitation → overestimation of rainy WT

Daily Mean Wind Direction

Differences in wind direction → change the WT

Does the reconstructed urban signal match observations?

Night-time Urban Heat Island ($TN - \overline{TN}_{rural}$)



The **shape** and **extent** of the UHI are **well reconstructed**
The **intensity** in the inner-city might be slightly **overestimated**

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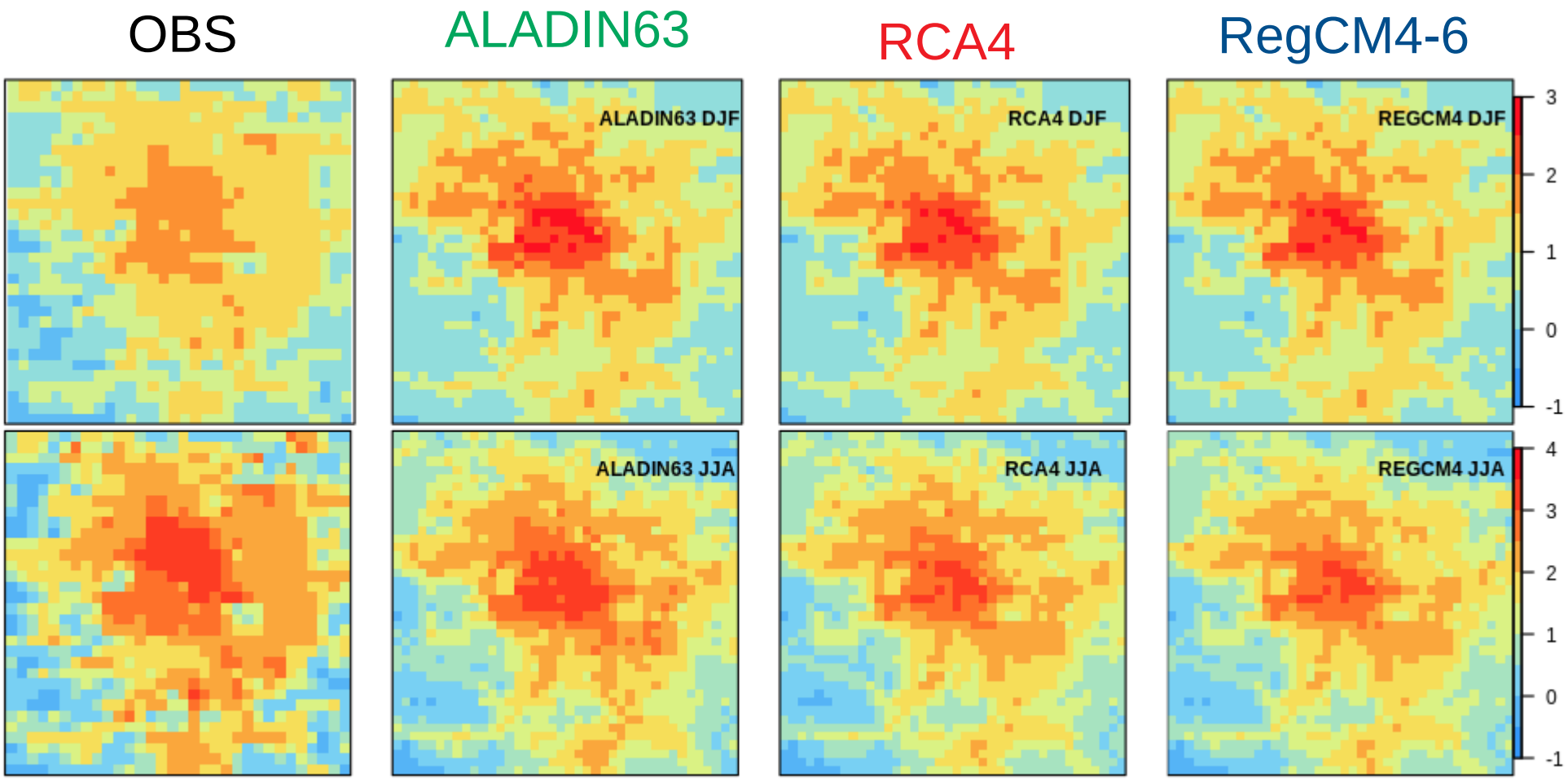
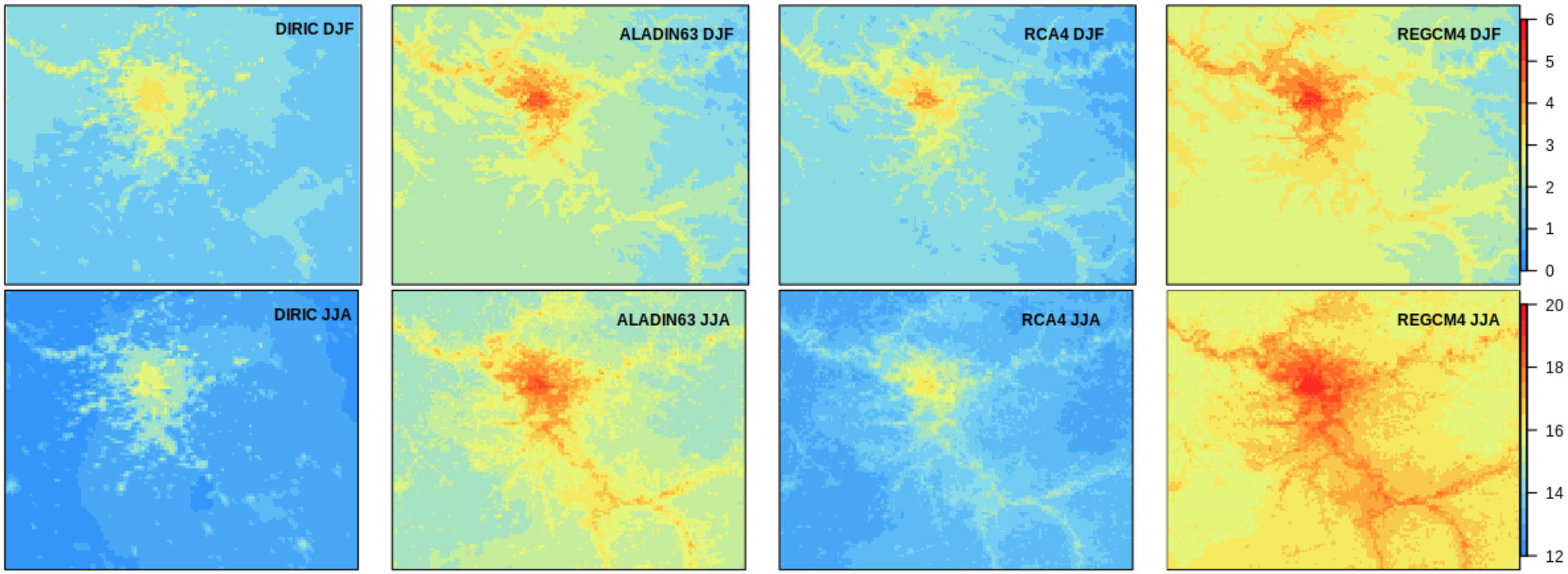


RCM are in **agreement** in DJF when the WT frequencies are similar
More differences in JJA, for example **ALADIN63** shows a greater extent and intensity

Does the reconstructed urban signal match observations?

Night-time reconstructed TN

OBS | ALADIN63 | RCA4 | RegCM4-6



Hypothesis that no RCM **correction** was necessary

→ No problem on the UHI reconstruction
→ But the **bias** could be **problematic** for some **impact studies**

Conclusion

The methodology seems **well suited** to recreate **night-time UHI**
Which is very interesting for our future impact studies

Some methodological questions remain regarding the **RCM bias**.
Should we **correct** them? And if so, how?

More scientific questions will also be investigated such as:

- Will the WT frequency be the same on the **HISTORICAL** simulations?
- And how will it evolve under climate change (**RCP 8.5**)?

Limitations of the methodology:

- Classification is made on the present and applied in the future, we hypothesize that the WT and the UHI will not change.

The whole methodology will be compared to a Dynamical Downscaling CNRM-ALADIN63 by CNRM-AROME.

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