

Towards processing chains to estimate the urban heat island intensity using FOSS tools

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⁴ CNRS, CRENAU, UMR 1563, École Nationale Supérieure d'Architecture de Nantes - Nantes, France

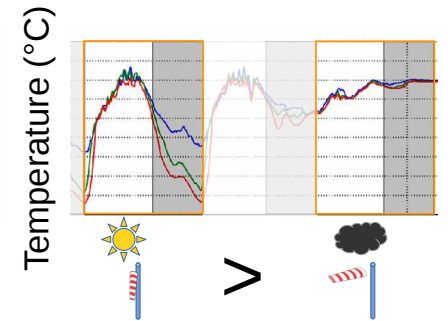
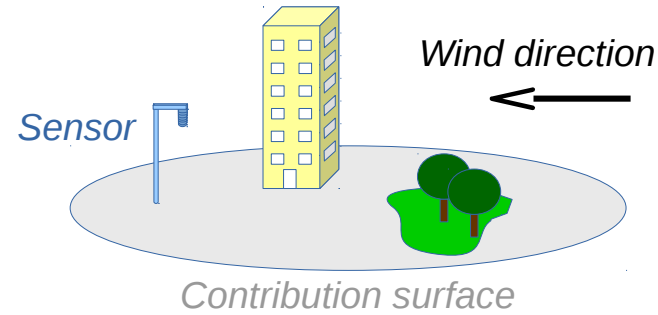
⁵ Cerema Ouest - Nantes, France



Context

Statement: UHI depends on

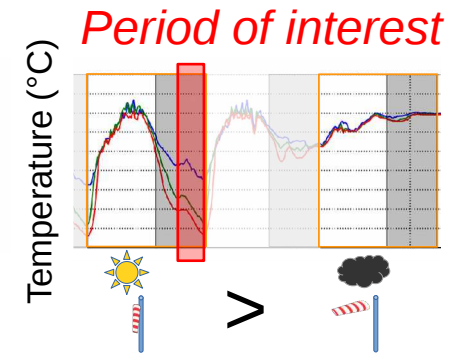
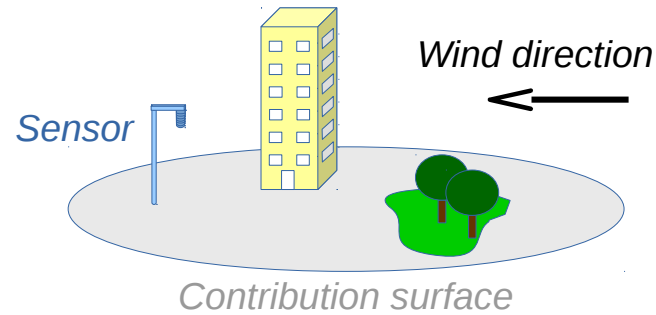
- x geographical context
- x meteorological conditions



Context

Statement: UHI depends on

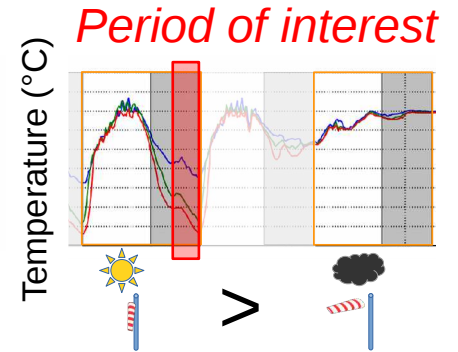
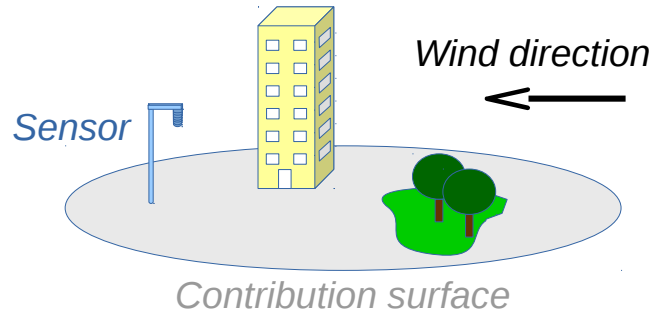
- x geographical context
- x meteorological conditions



Context

Statement: UHI depends on

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Objective: estimate the temperature of any point of an urban area from :

Data available and homogeneous

- 1 reference station for the temperature
- morphological and land cover data
- meteorological conditions

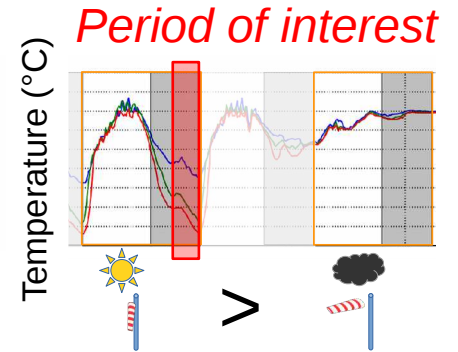
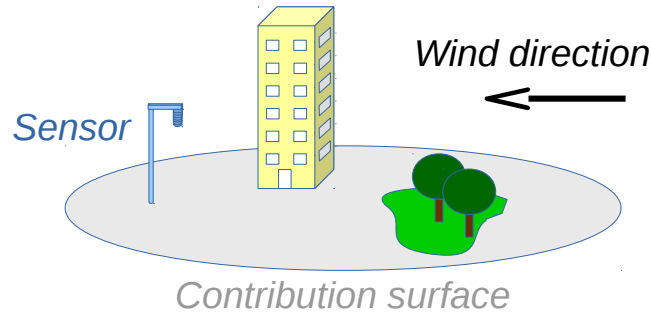
Softwares

- open and free tools
- using scripting

Context

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Objective: estimate the temperature of any point of an urban area from :

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Softwares

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Presentation content:

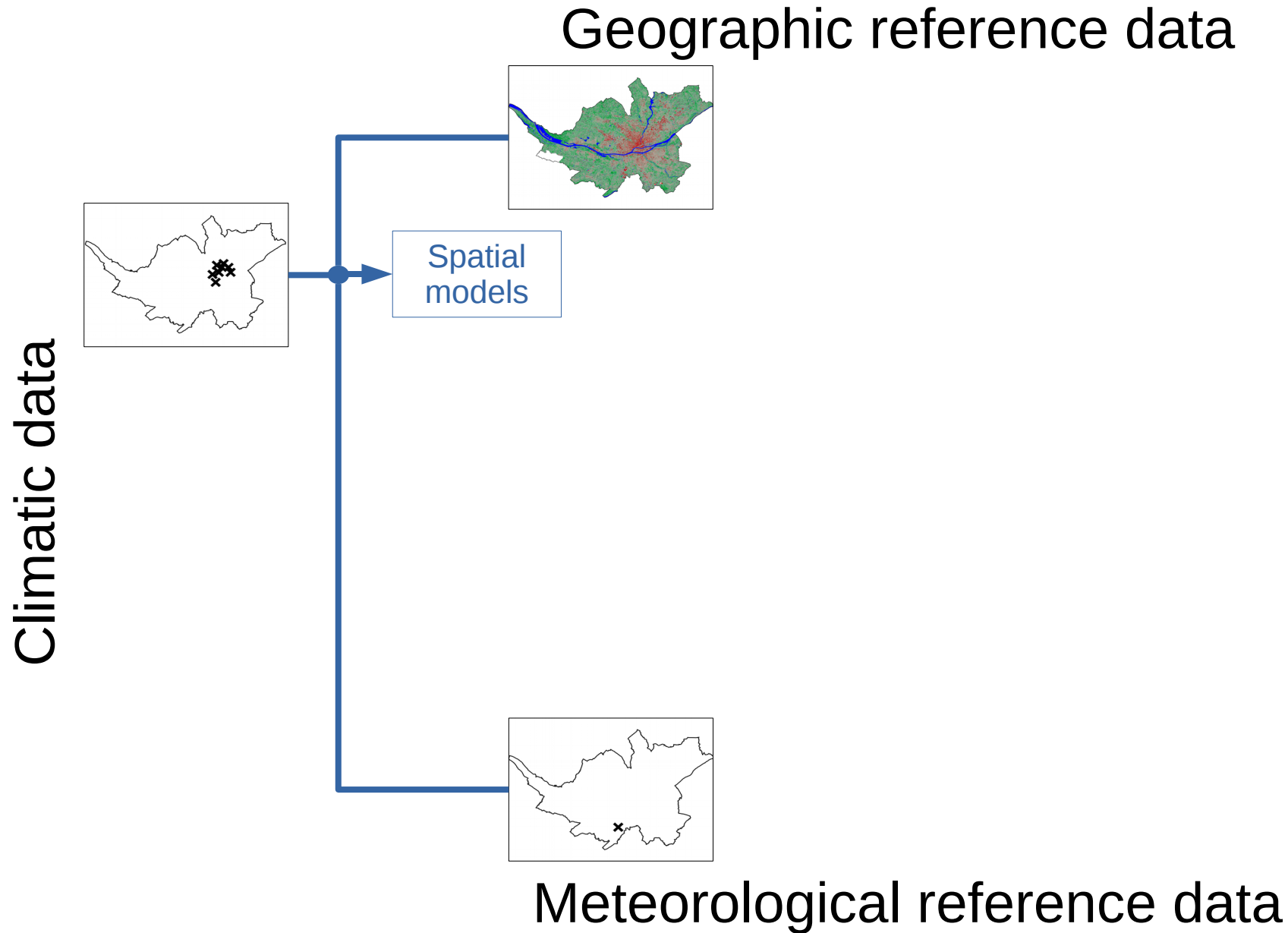
- x processing chain to calibrate the model
- x processing chain to verify or apply the model to any city

1st processing chain

Model calibration

1st processing chain

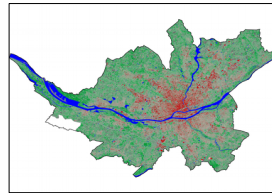
Model calibration



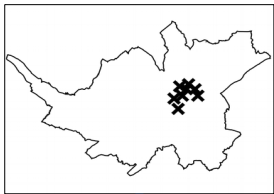
1st processing chain

Model calibration

Geographic reference data



Climatic data



Temporal models



Meteorological reference data

Spatial modelling

Geographic reference data

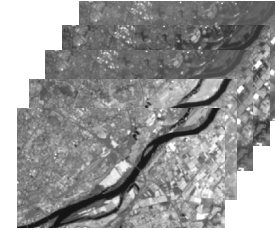
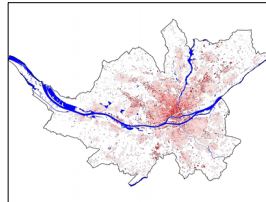
Climatic data

Meteorological reference data

Spatial modelling

Geographic reference data

French IGN
Vector database
Buildings and water



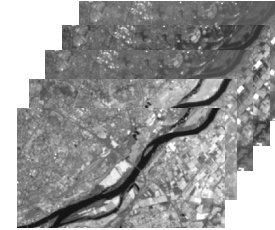
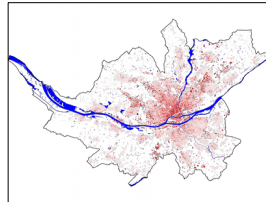
French IGN
Sat. Image (Rapideye)
Land cover

Climatic data

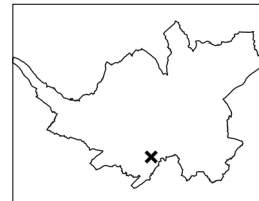
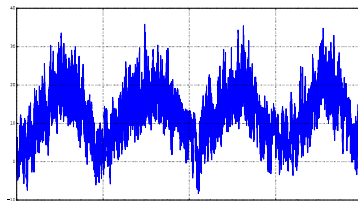
Meteorological reference data

Spatial modelling

Geographic reference data



Climatic data

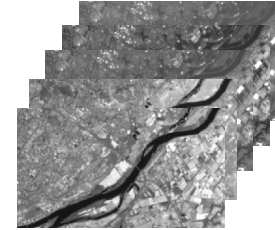
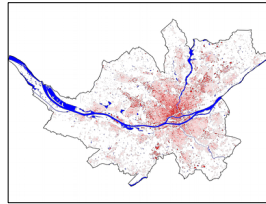


Météo-France
Air temperature

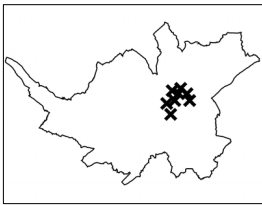
Meteorological reference data

Spatial modelling

Geographic reference data

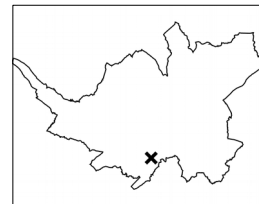
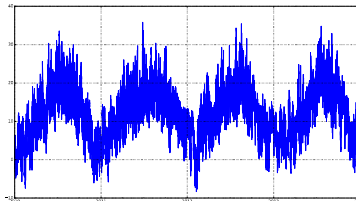
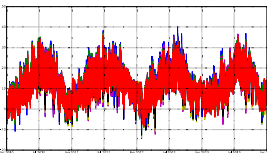


Climatic data



Stations i

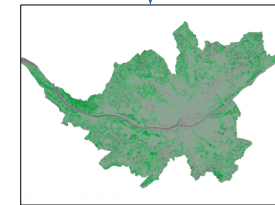
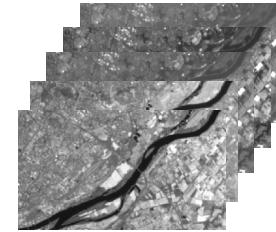
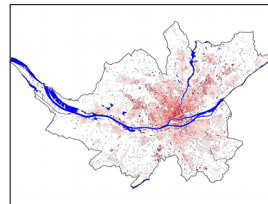
Days j



Meteorological reference data

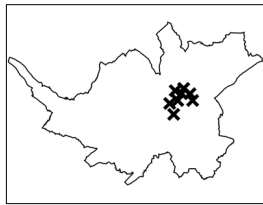
Spatial modelling

Geographic reference data



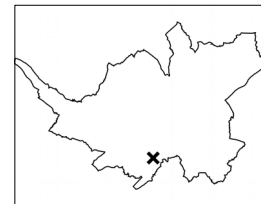
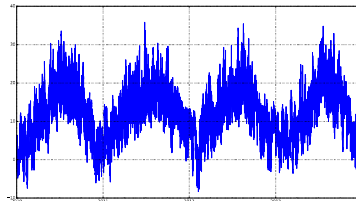
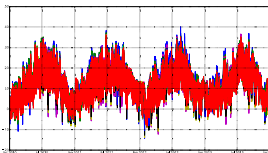
NDVI

Climatic data



Stations i

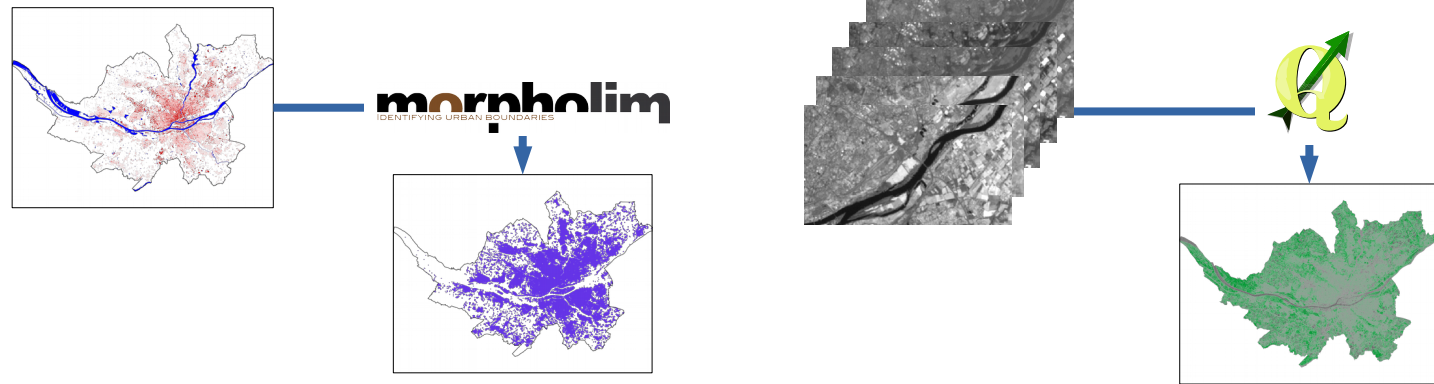
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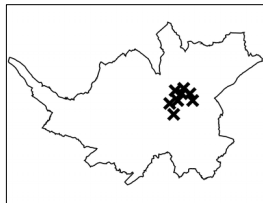
Meteorological reference data

Spatial modelling

Geographic reference data

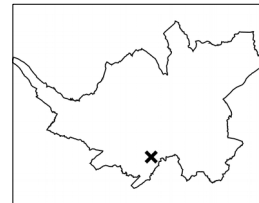
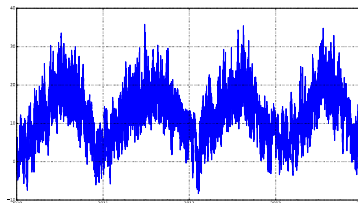
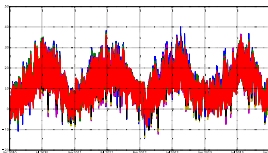


Climatic data



Stations i

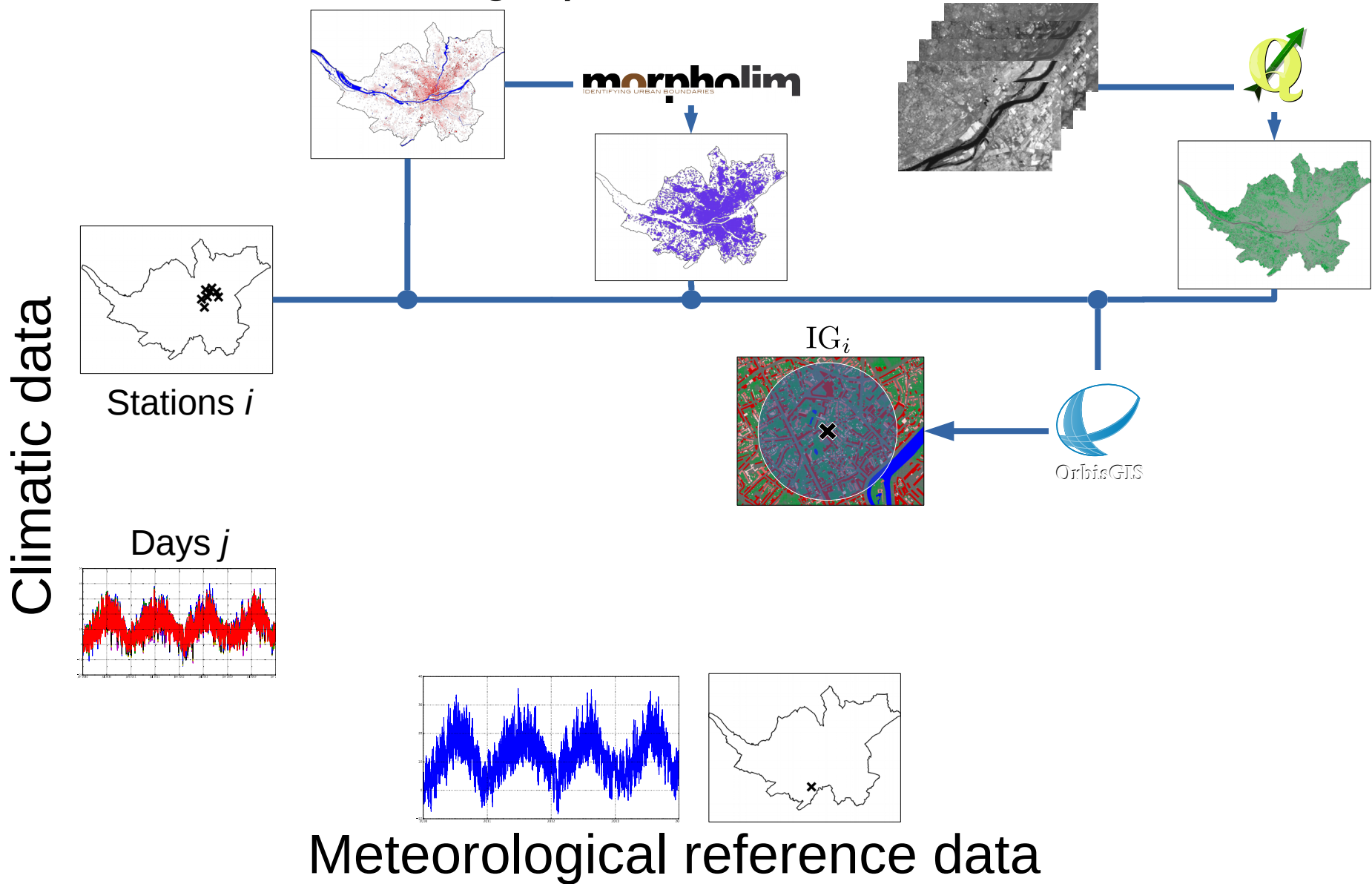
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Meteorological reference data

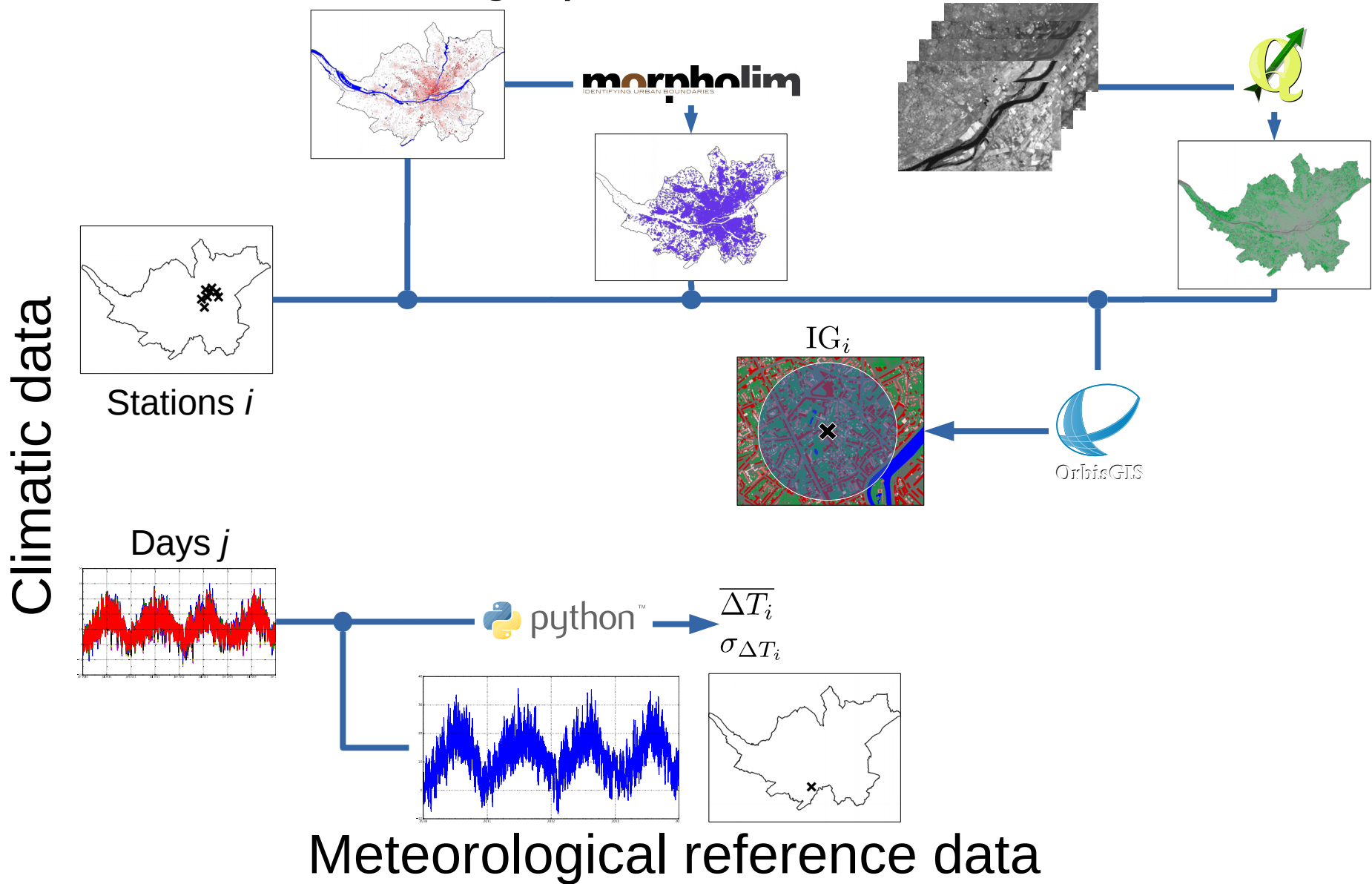
Spatial modelling

Geographic reference data

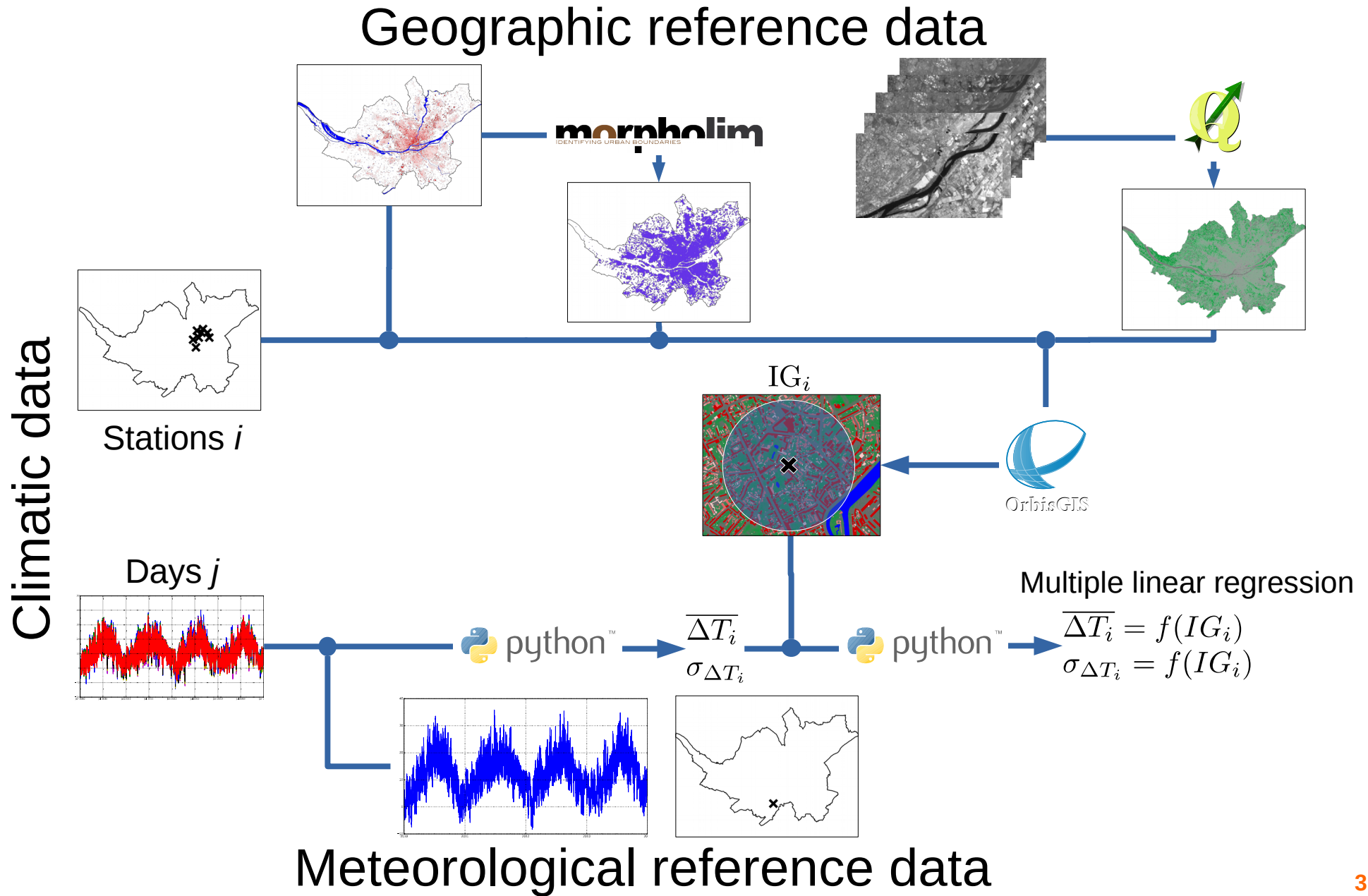


Spatial modelling

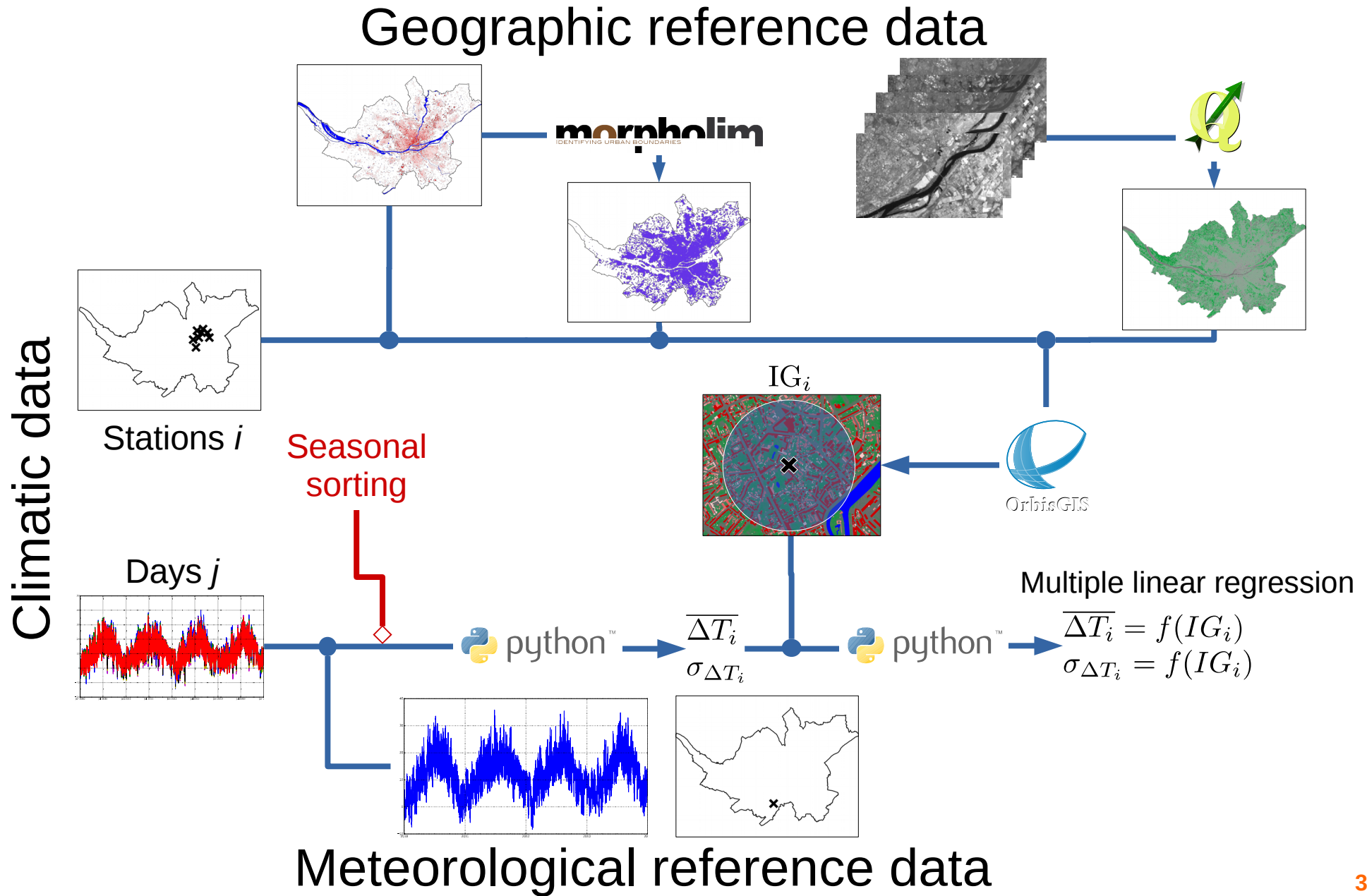
Geographic reference data



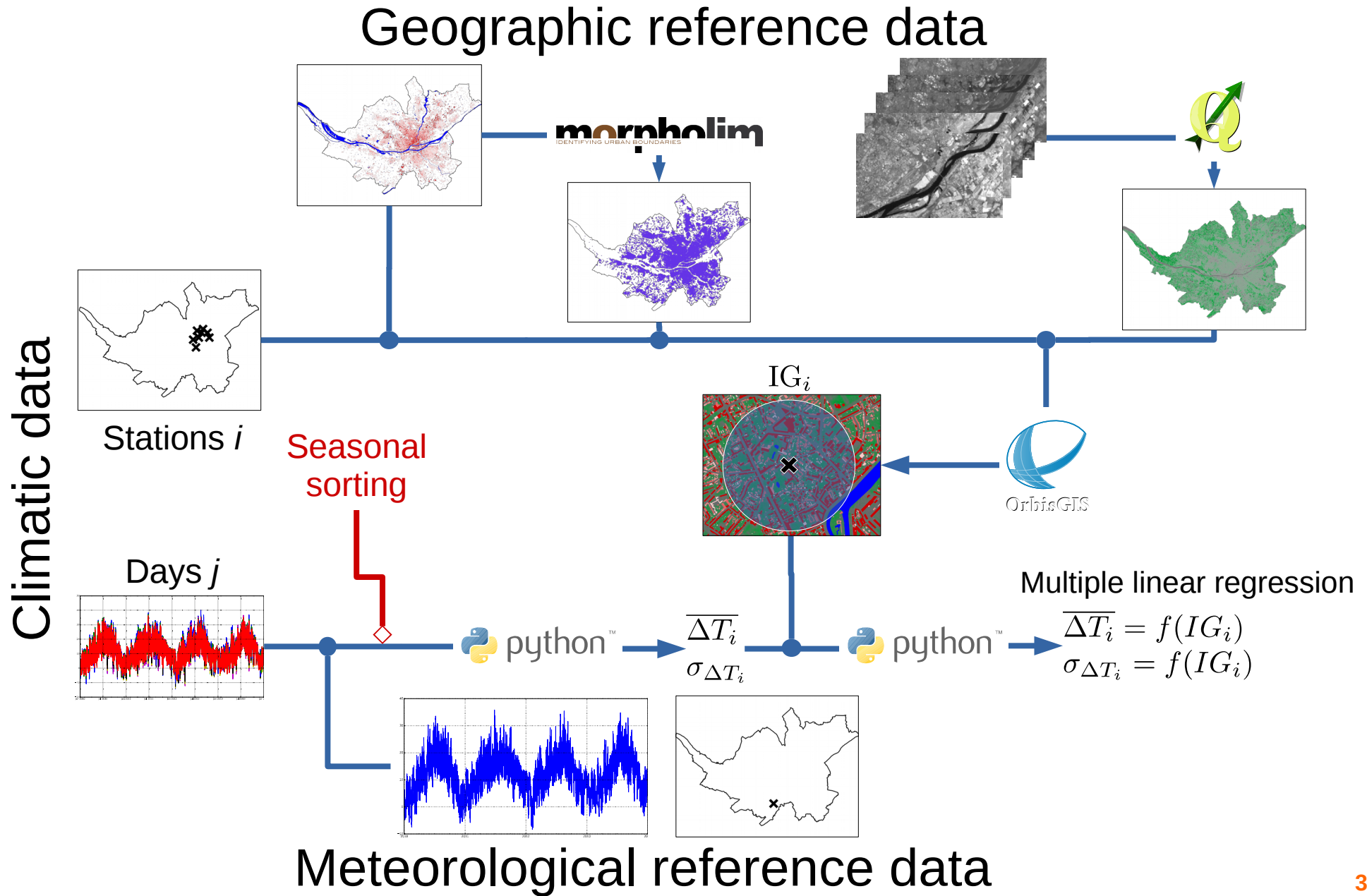
Spatial modelling



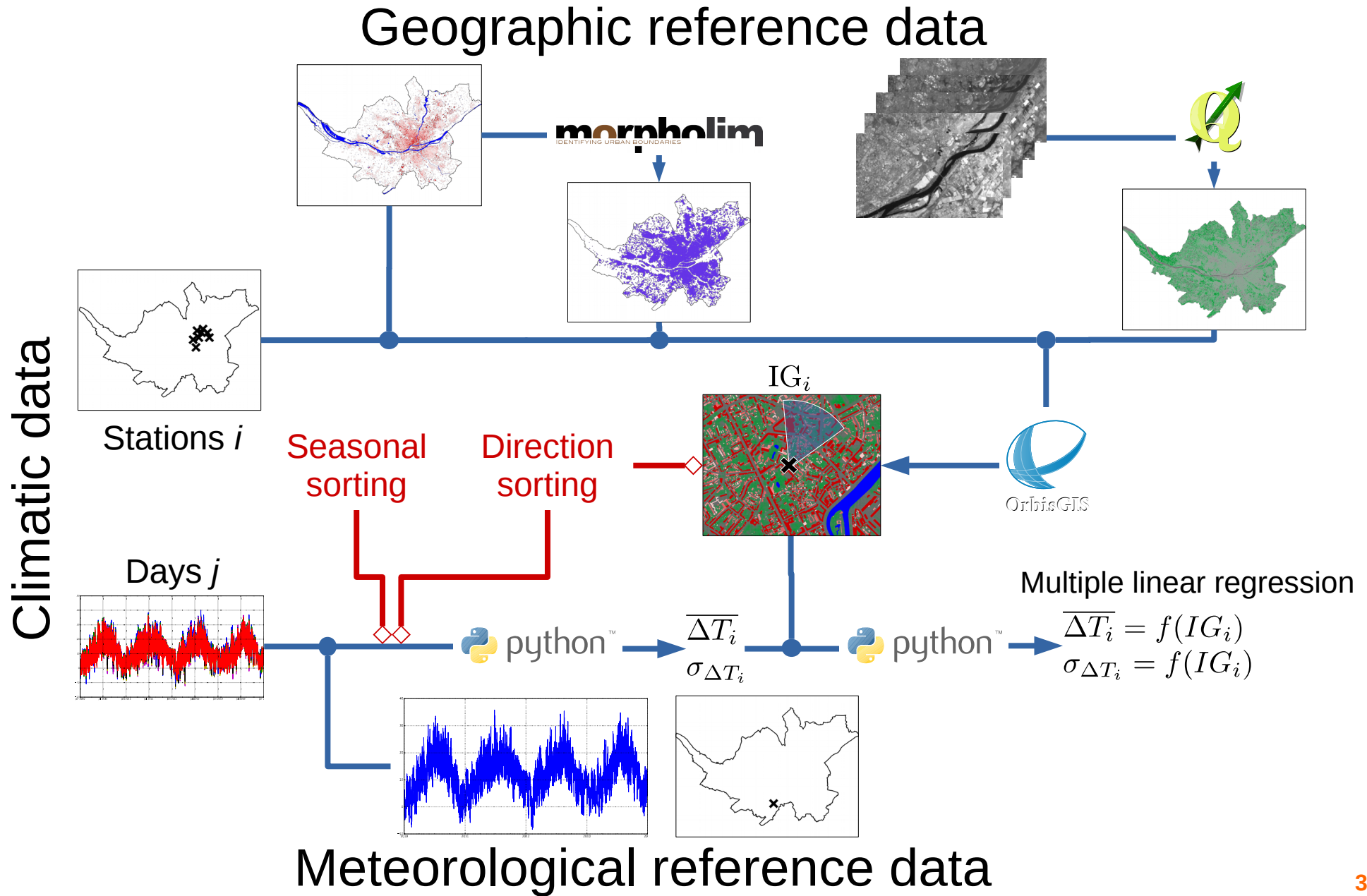
Spatial modelling



Spatial modelling



Spatial modelling



Resulting spatial models

$$\begin{aligned}
 \overline{\Delta T}^{(aut)} &= 5.3x_{D_f} && +0.15\ln(d_{op} + 1) - 5.7x_{NDVI} && -5.5x_{D_b} - 0.39 \\
 \overline{\Delta T}^{(win)} &= && 2.0x_{D_s} && +0.12\ln(d_{op} + 1) - 2.7x_{NDVI} && -4.0x_{D_b} - 0.2 \\
 \overline{\Delta T}^{(spr)} &= && && 3.3x_{D_w} && - 5.1x_{NDVI} && + 0.031 \\
 \overline{\Delta T}^{(sum)} &= && && 12.0x_{D_w} && - 4.5x_{NDVI} && + 0.23
 \end{aligned}$$

$$\begin{aligned}
 \sigma_{\Delta T}^{(aut)} &= 3.2x_{D_f} && && +0.06\ln(d_{op} + 1) - 2.7x_{NDVI} && -2.9x_{D_b} + 0.38 \\
 \sigma_{\Delta T}^{(win)} &= -3.0x_{D_f} && +1.4x_{D_s} && +0.065\ln(d_{op} + 1) && && + 0.5 \\
 \sigma_{\Delta T}^{(spr)} &= && && 1.7x_{D_s} && +0.12\ln(d_{op} + 1) - 2.9x_{NDVI} && -3.4x_{D_b} + 0.41 \\
 \sigma_{\Delta T}^{(sum)} &= -6.4x_{D_f} && +3.0x_{D_s} + 4.8x_{D_w} && +0.15\ln(d_{op} + 1) && && + 0.86
 \end{aligned}$$

Temporal modelling

Climatic data

Meteorological reference data

Temporal modelling

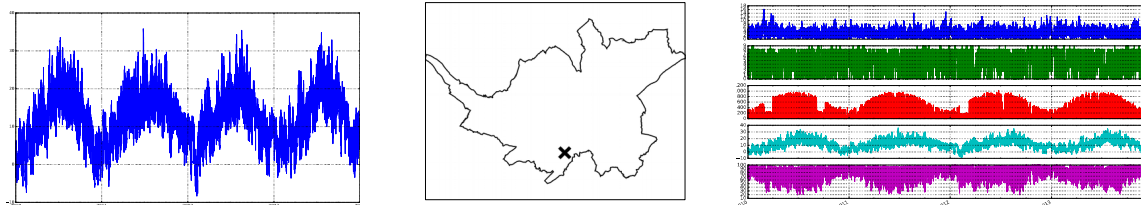
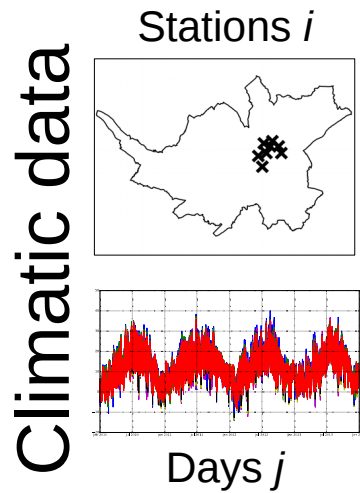
Climatic data



Meteorological reference data

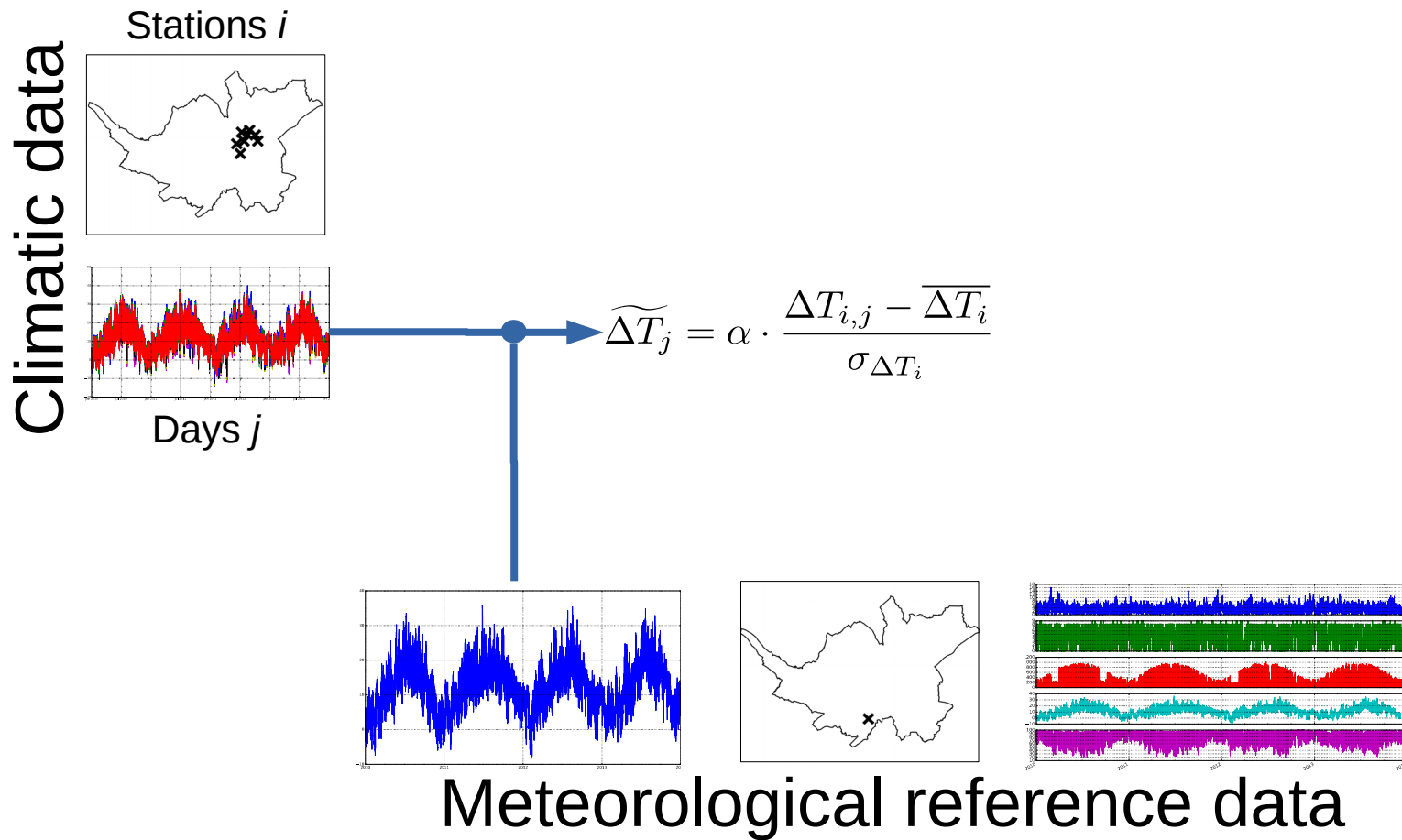
Météo-France
*Air temperature and
other weather variables
(RH, U, K, N)*

Temporal modelling

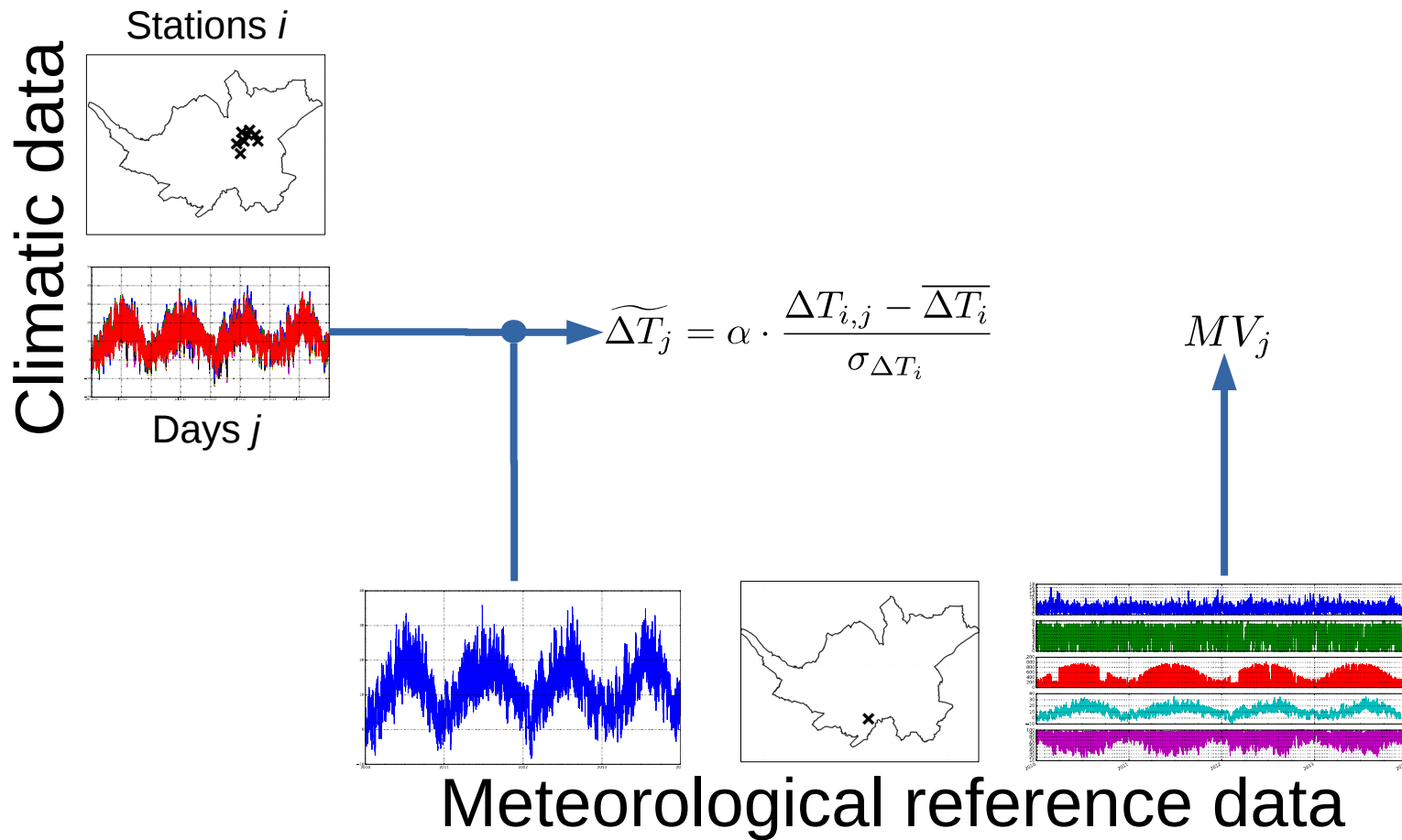


Meteorological reference data

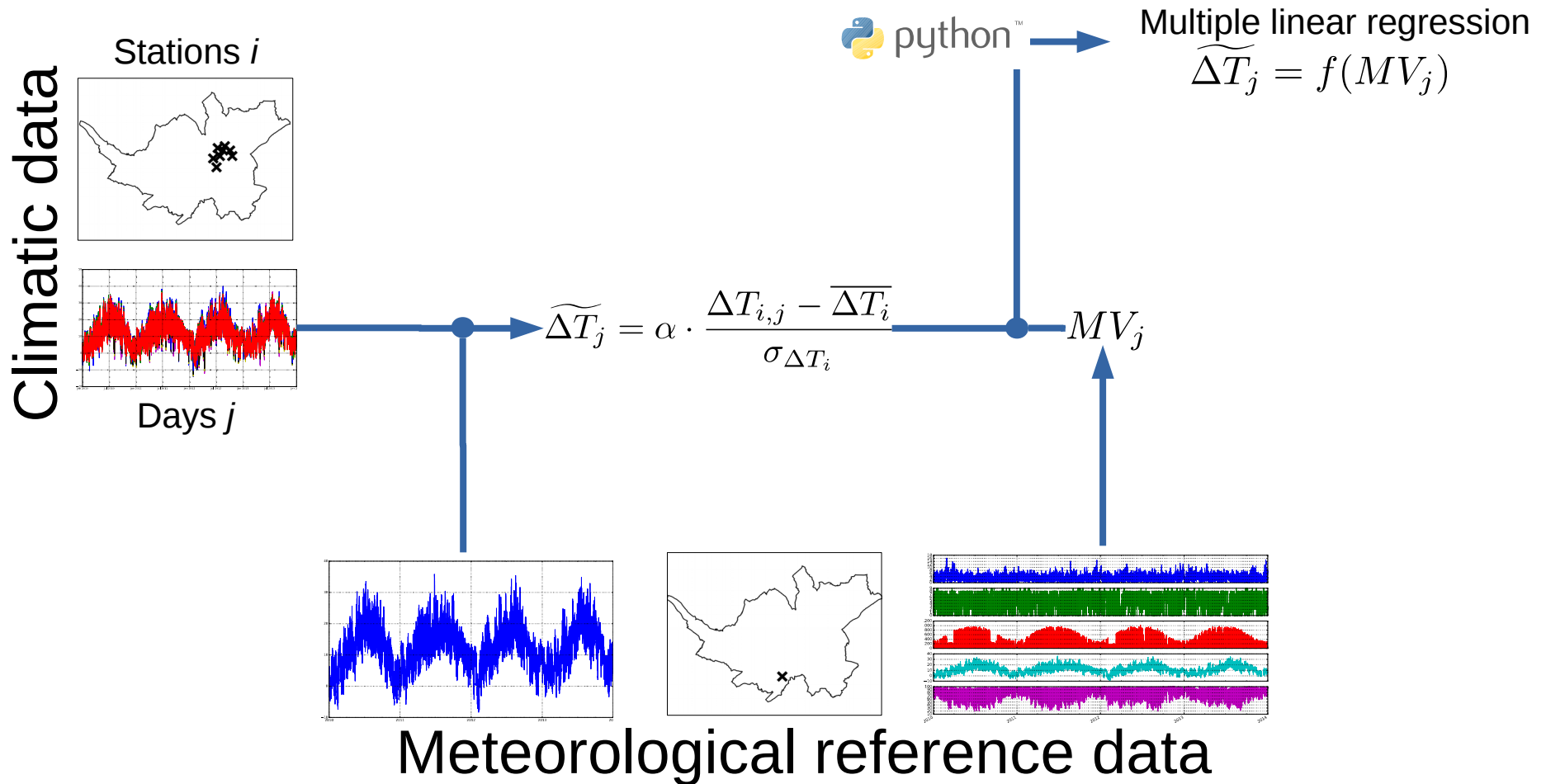
Temporal modelling



Temporal modelling



Temporal modelling

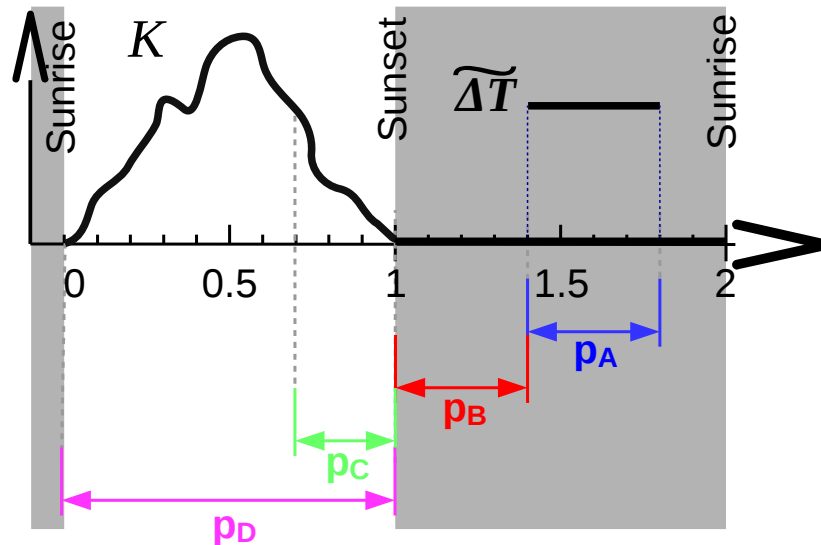


Resulting temporal models

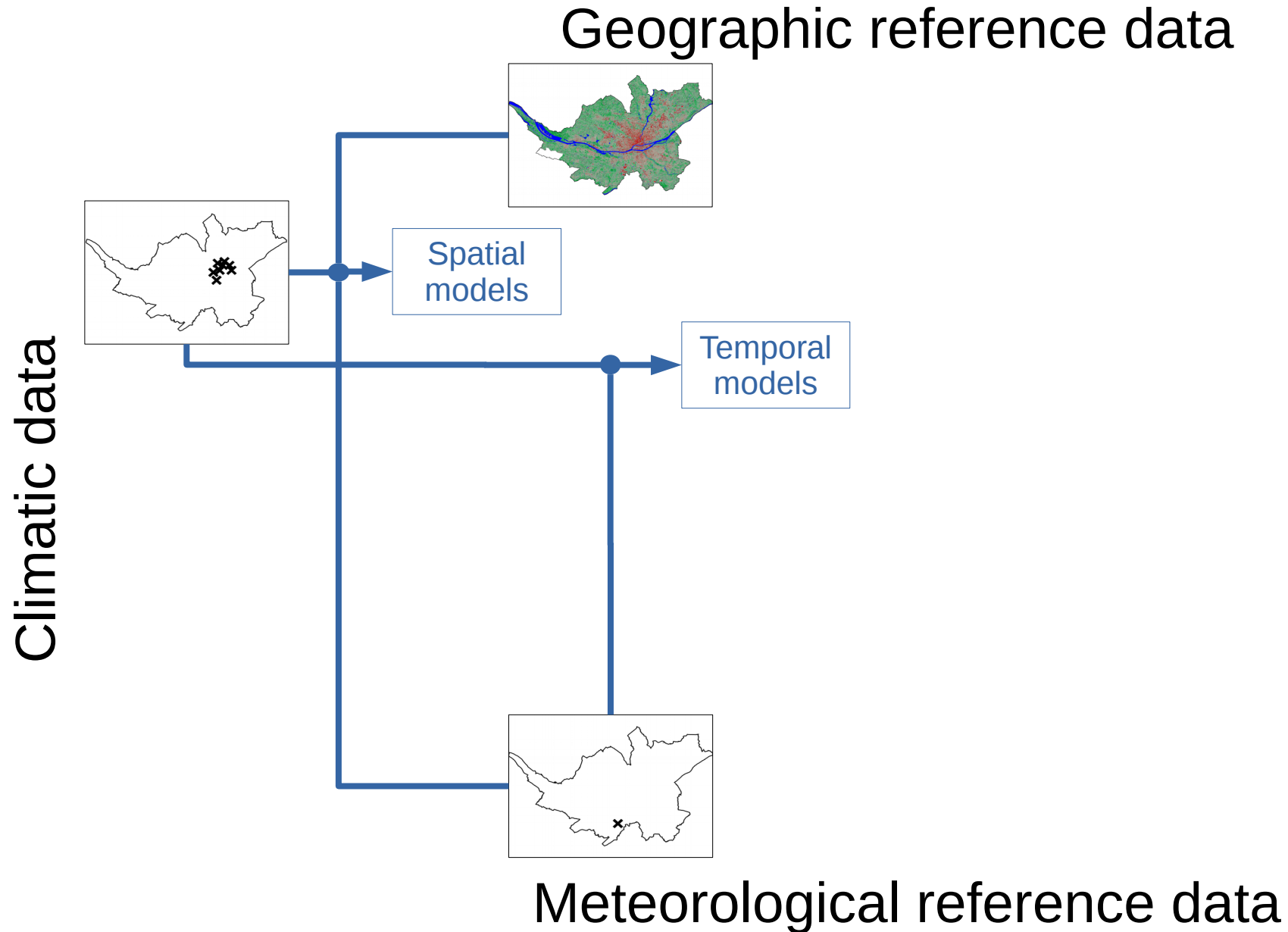
$$\begin{aligned}
 \widetilde{\Delta T}^{(aut)} &= 0.0016K(p_C) & + 6.3 \frac{1}{U(p_A) + 3.0} & + 0.01T(p_C) - 0.095 \exp\left(\frac{N(p_B) - 6}{6}\right) & -1.1 \\
 \widetilde{\Delta T}^{(win)} &= & 0.081 \exp(-U(p_B) + 3) & - 0.12N(p_A) & +0.64 \\
 \widetilde{\Delta T}^{(spr)} &= 0.0011K(p_C) & + 11.0 \frac{1}{U(p_A) + 3.0} & + 0.033T(p_D) - 0.12N(p_A) & -2.3 \\
 \widetilde{\Delta T}^{(sum)} &= & -0.0083RH(p_D) - 0.36U(p_A) & - 0.13T(p_A) & +3.2
 \end{aligned}$$

Resulting temporal models

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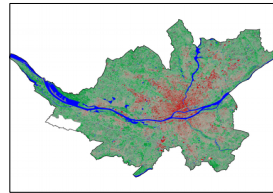


2nd processing chain: *Model verification and application*



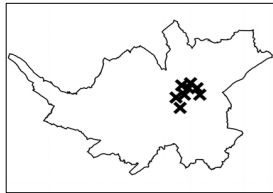
2nd processing chain: *Model verification and application*

Geographic reference data



Spatial models

Temporal models

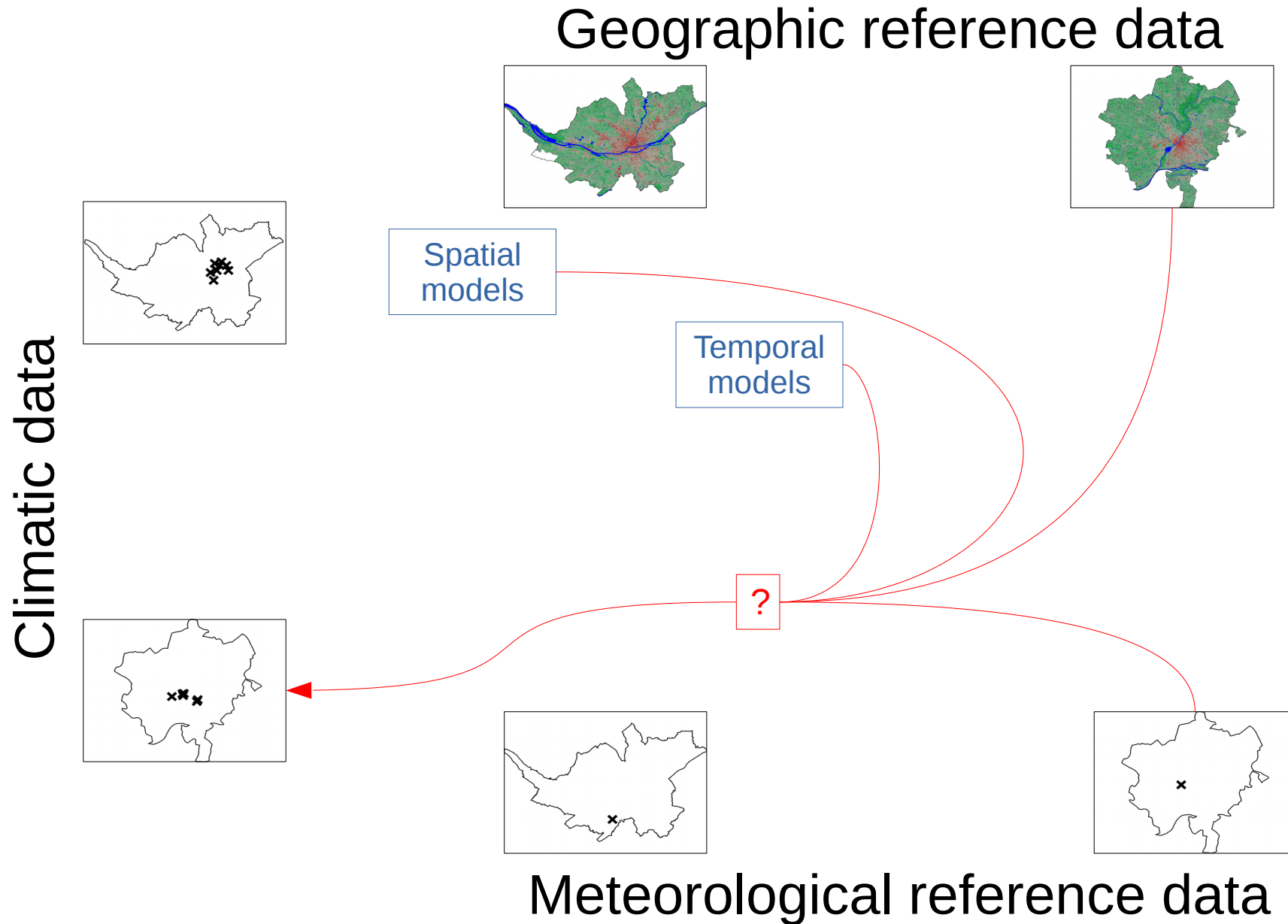


Climatic data



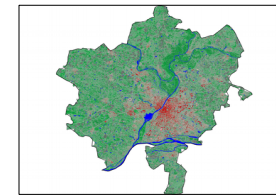
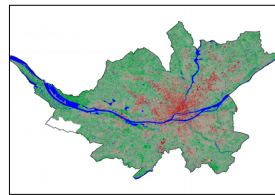
Meteorological reference data

2nd processing chain: *Model verification and application*



2nd processing chain: *Model verification and application*

Geographic reference data

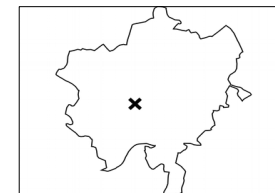
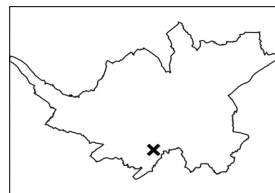
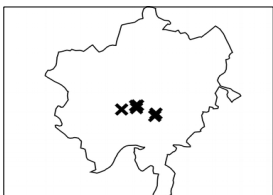
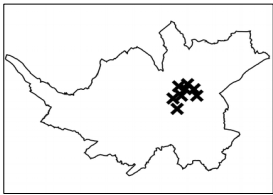


IG

Spatial
models

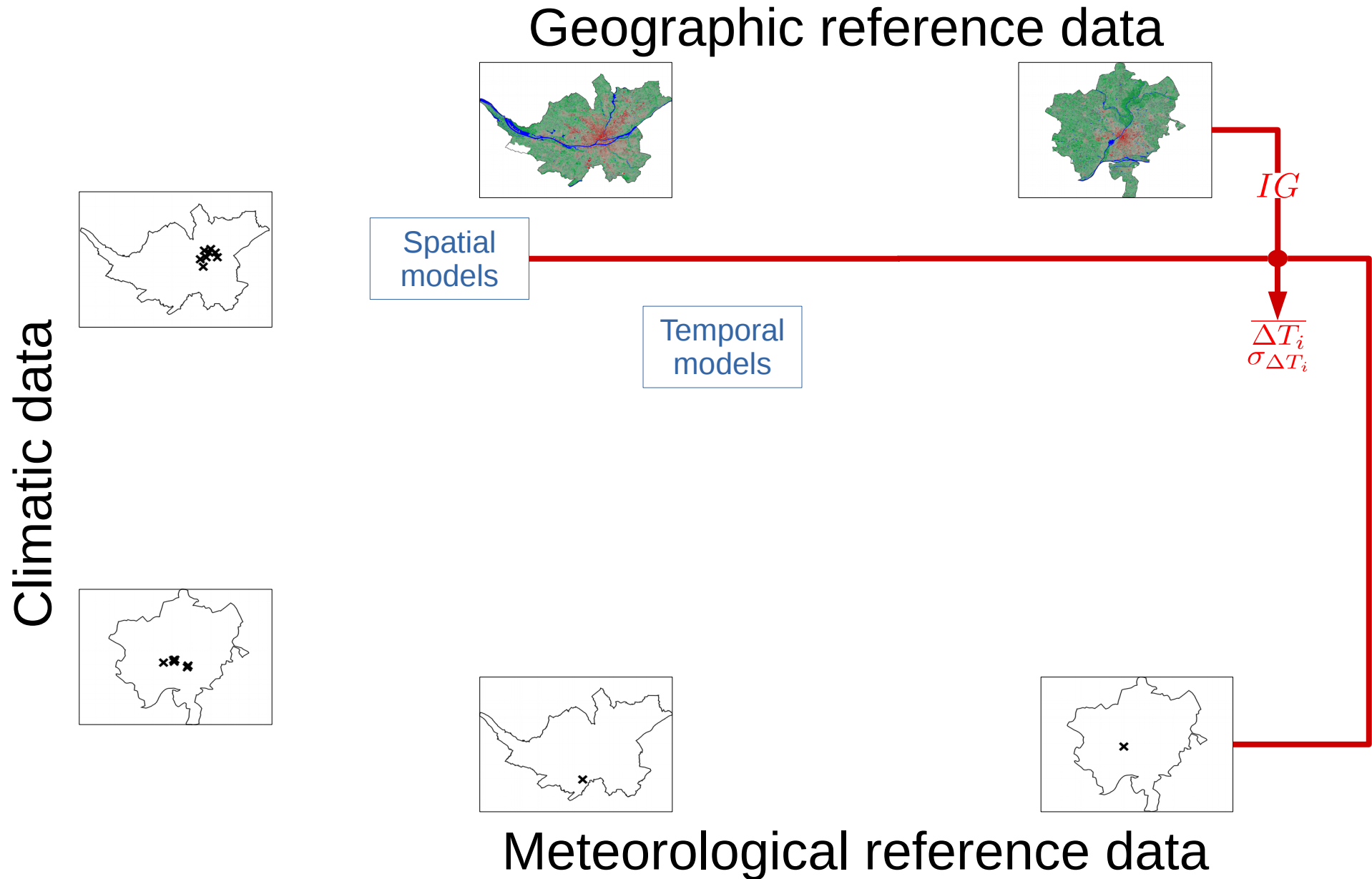
Temporal
models

Climatic data



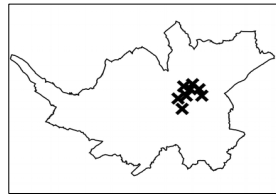
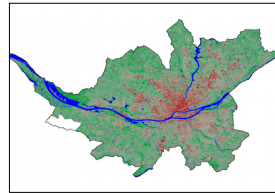
Meteorological reference data

2nd processing chain: *Model verification and application*



2nd processing chain: *Model verification and application*

Geographic reference data

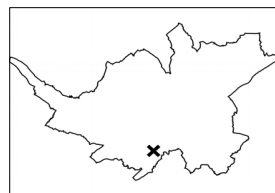
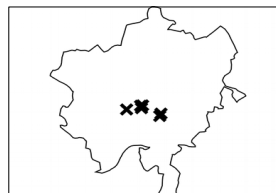


Spatial models

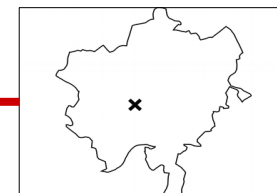
Temporal models

$$\frac{\overline{\Delta T_i}}{\sigma_{\Delta T_i}}$$

Climatic data

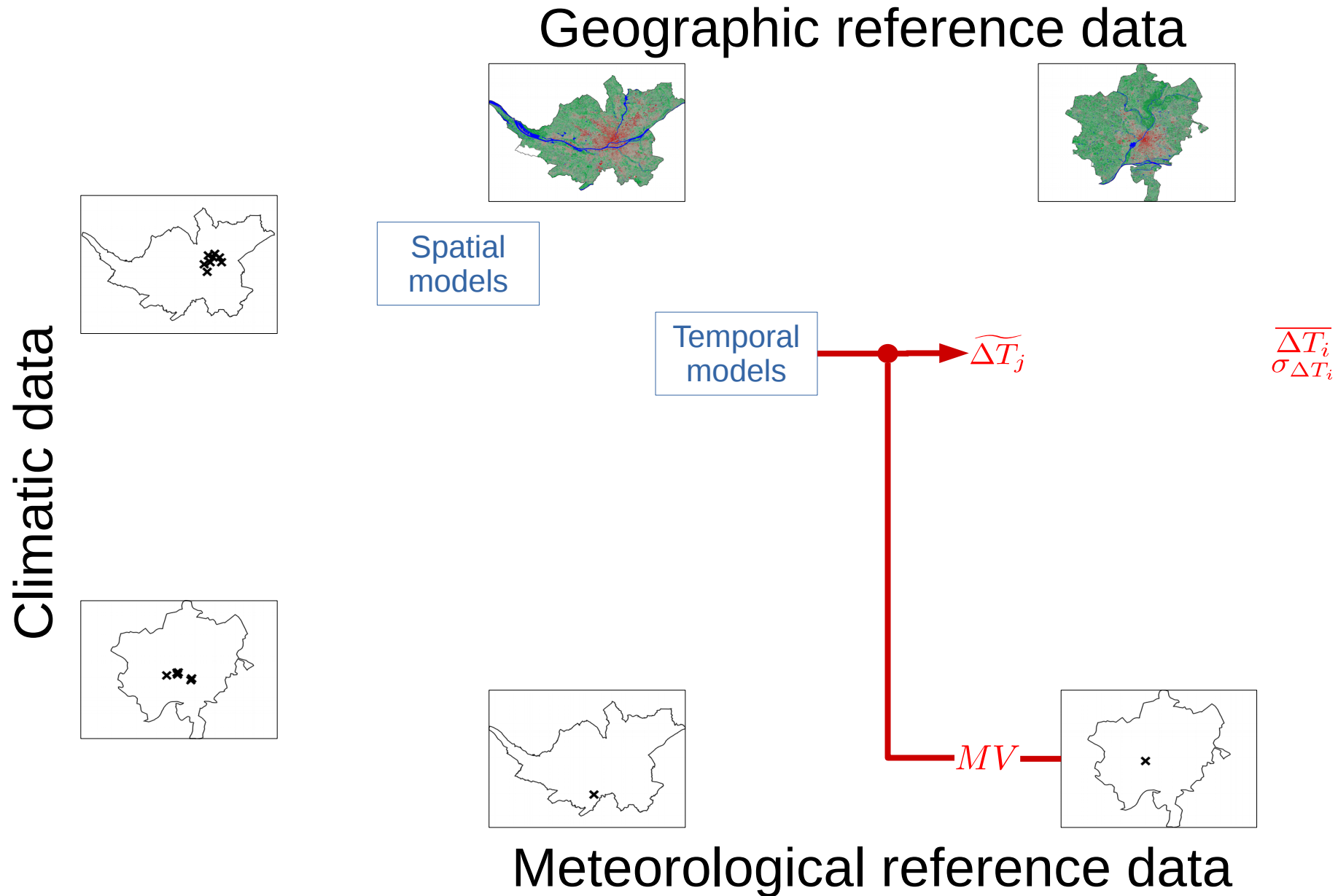


MV —



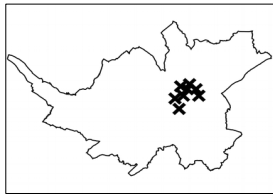
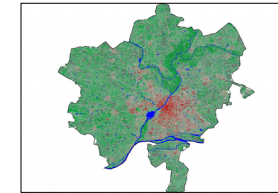
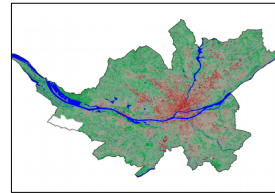
Meteorological reference data

2nd processing chain: *Model verification and application*



2nd processing chain: *Model verification and application*

Geographic reference data



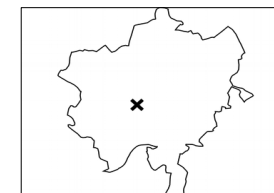
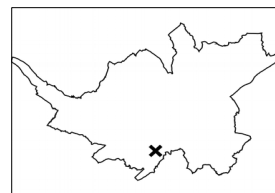
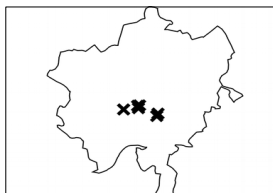
Spatial models

Temporal models

$$\widetilde{\Delta T}_j \text{ --- } \bullet \text{ --- } \overline{\Delta T}_i$$

$$\downarrow$$

$$\Delta T_{i,j}^{rest} = \frac{\widetilde{\Delta T}_j \cdot \sigma_{\Delta T_i}}{\alpha} + \overline{\Delta T}_i$$



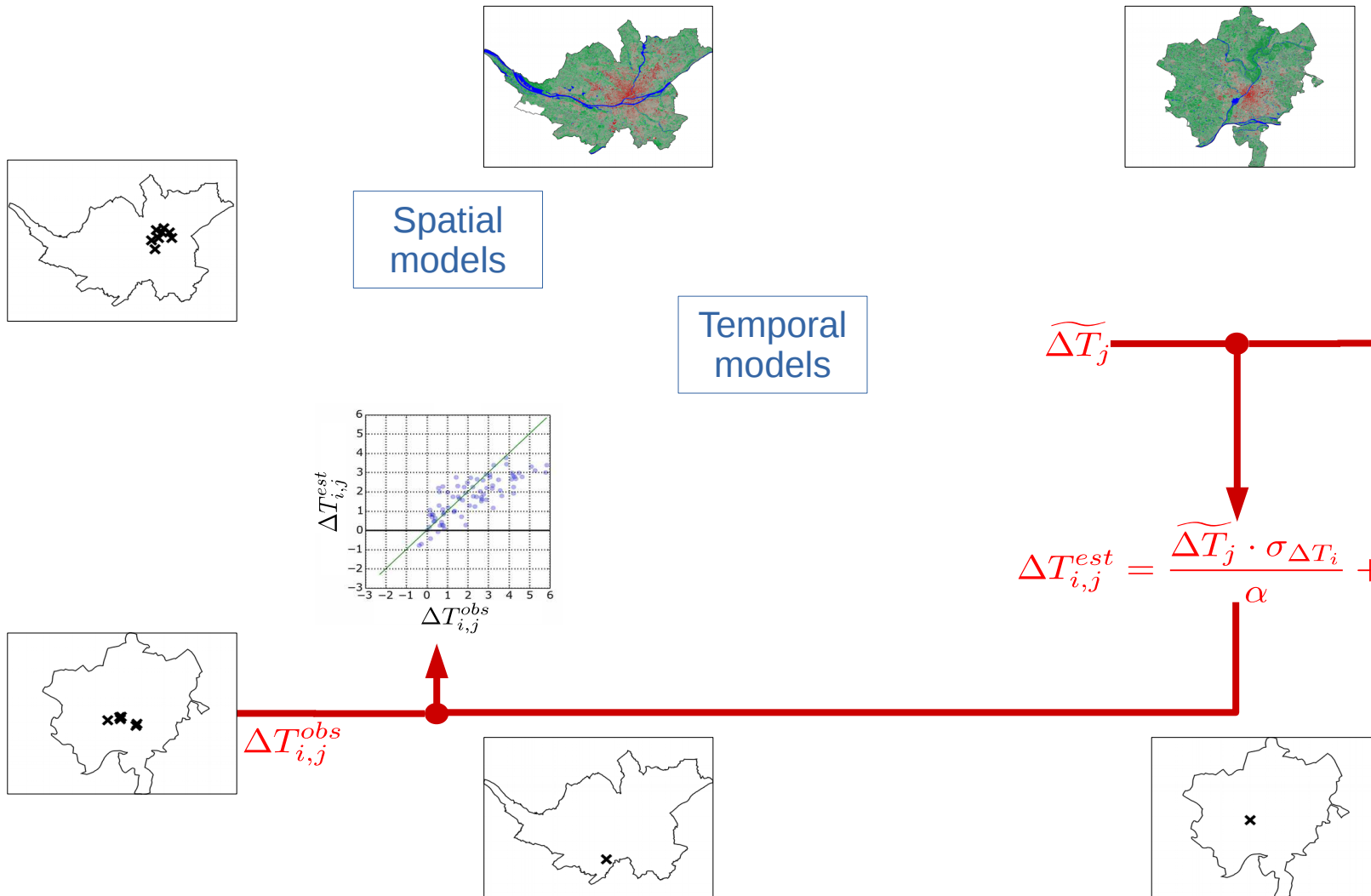
Meteorological reference data

Climatic data

2nd processing chain: Model verification and application

Geographic reference data

Climatic data

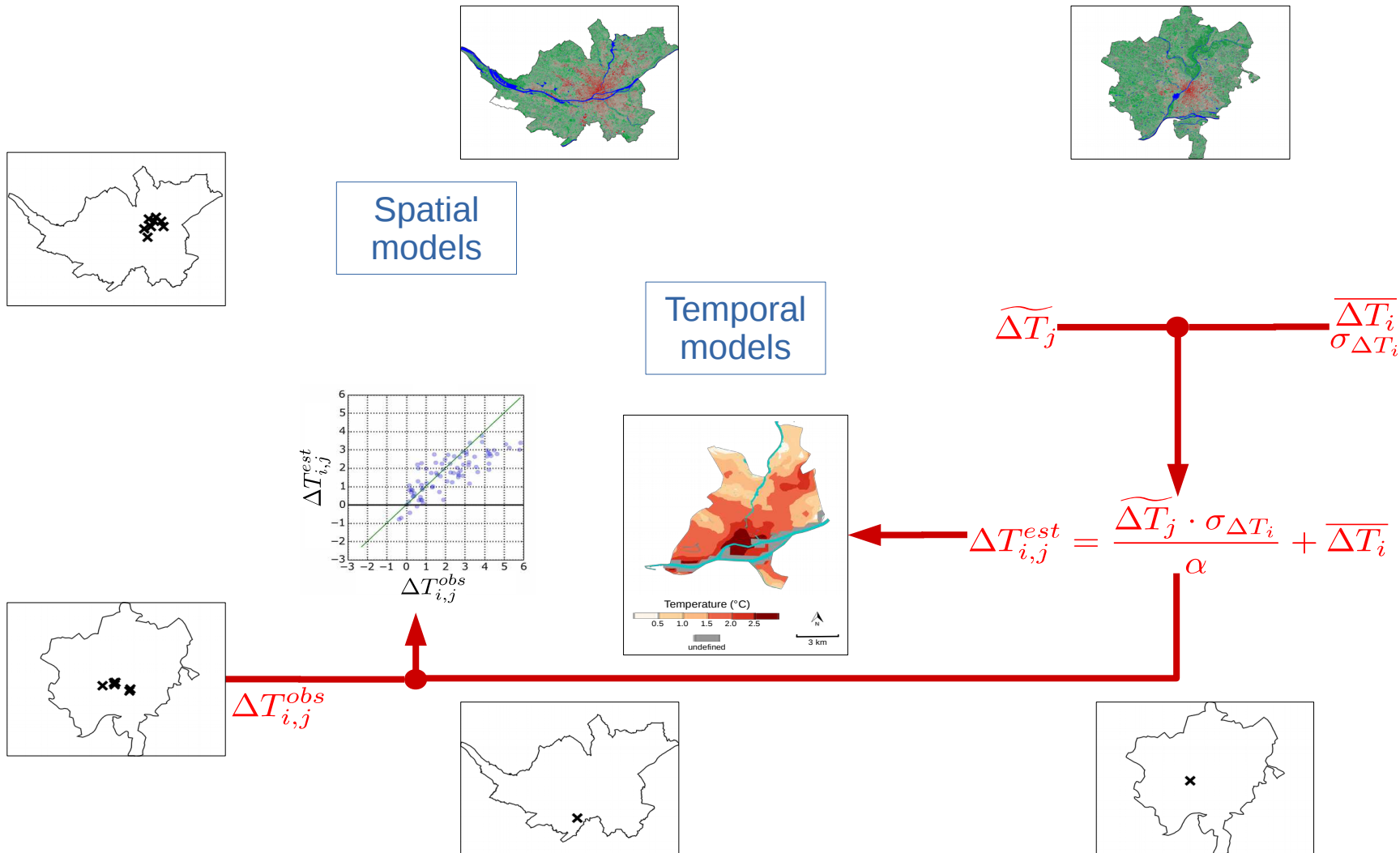


Meteorological reference data

2nd processing chain: Model verification and application

Geographic reference data

Climatic data



Meteorological reference data

Conclusion and improvements

Conclusion:

We proposed a method to estimate the night-time UHI for:

- x any day
- x any location of any French city

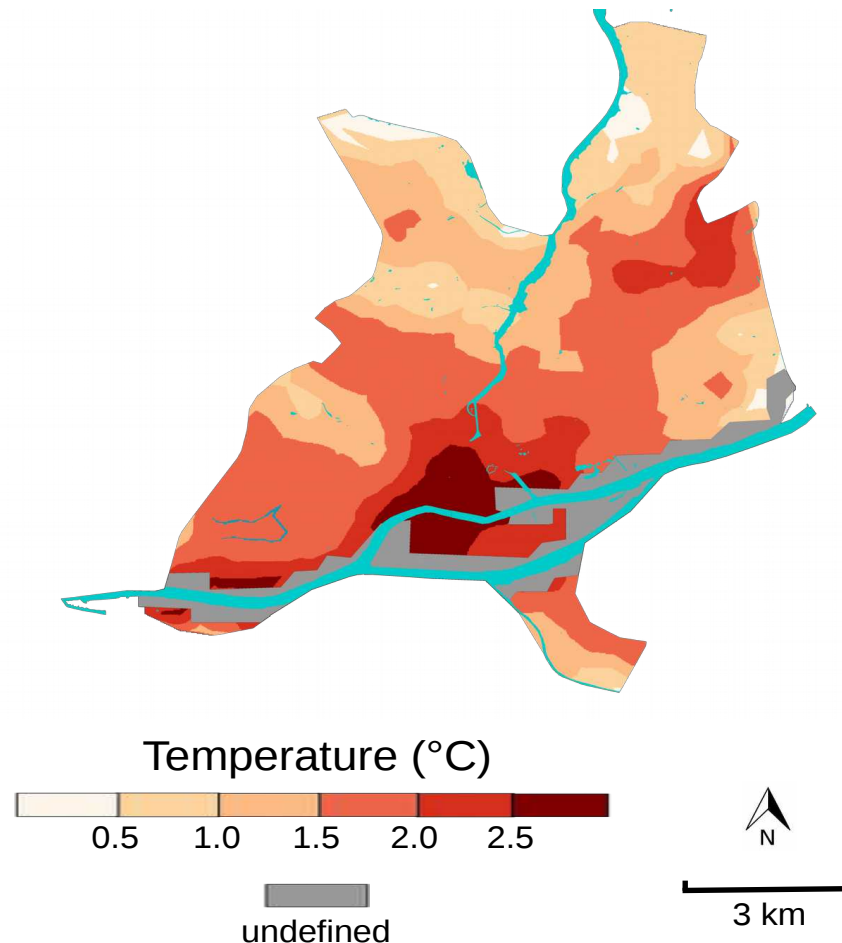
Improvements:

- x Scientific improvements
 - x data for calibration (amount of data, OSM)
 - x method : buffer size
- x Technical improvements
 - x replace QGIS and MorphoLim steps by scripts
 - x plug-in development

Any question, suggestion, comment ?

For further details concerning the method, please refer to :

Jérémy Bernard, Marjorie Musy, Isabelle Calmet, Erwan Bocher, Pascal Kéравec. *Urban heat island temporal and spatial variations : empirical modelling from geographical and meteorological data*, Building environment, Elsevier (accepted)



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