Numerical modeling towards the sub-kilometer scale: The potential for regional reanalysis

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METEOROLOGIE

Introduction

The challenges of going towards sub-km resolution with LAM models

Goal: Assess the potential for a future reanalysis system at the sub-kilometer scale.

Important steps towards the **sub-kilometer** resolution:

1. Characterize the land surface heterogeneity;
2. Understand the urban climate representation;
3. Assess the added value of the increase in resolution;
4. Improve the processes representation.

Method
Area of Interest and test period

Area of interest:

Night image from NASA, zoom over Central Europe.

North Rhine-Westphalia: Densely inhabited, high data availability, tuned model

Test period: June 2019

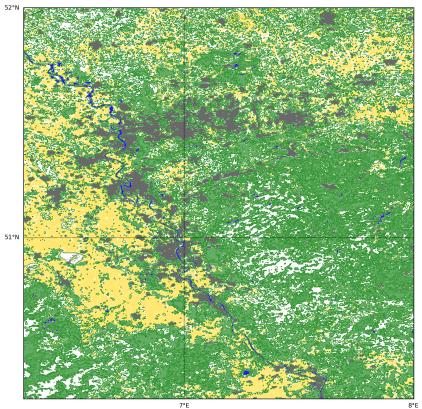
- Highest temperatures recorded in the region.
- Stress conditions for both humans and agriculture.
- Importance of correct representation for forecasting purposes.
- Followed by a second heat wave (July 2019).
- Strong media impact.

Experiments:

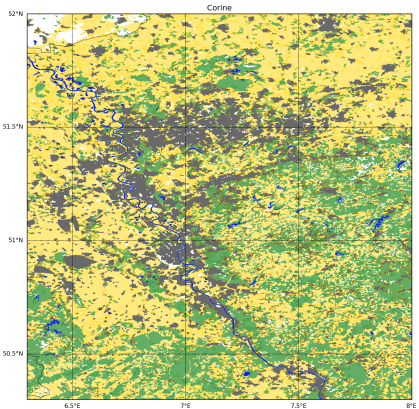
Acronym	$\Delta x/y$	Type	n^o days	Model specifics	Land use	Convection parametrization
OPS	2.1 km	Free run	30	no urban[a]	Globcover[a]	ON[a]
D2_CORINE	2.1 km	Free run	30	no urban[a]	Corine	ON[a]
D2_URB	2.1 km	Free run	30	Urban scheme	Globcover[a]	ON[a]
D2_CORURB	2.1 km	Free run	30	Urban scheme	Corine	ON[a]
GLC_D500	500 m	Free run	30	no urban[a]	Globcover[a]	OFF
COR_D500	500 m	Free run	30	no urban[a]	Corine	OFF

Table: [a] this is the default option.

Non-interpolated GlobCover and Corine datasets:



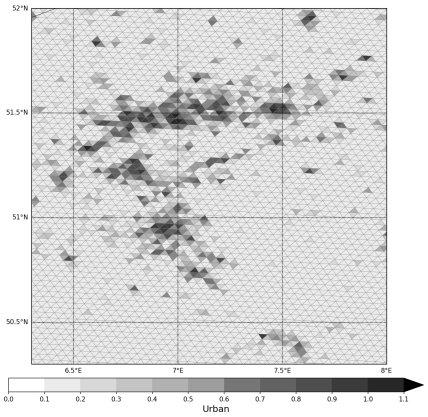
(a) Globcover



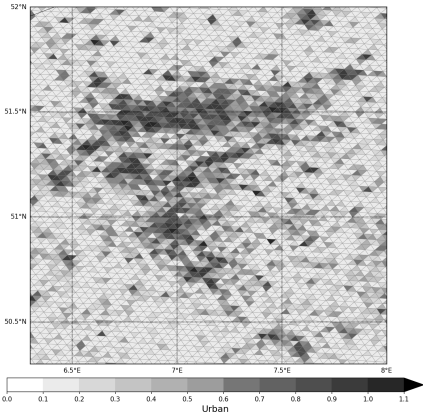
(b) Corine

Legend: (green) High rise vegetation, (yellow) low rise vegetation, (gray) urban/industrial areas

Land use fraction (within the grid-cell) for the 2.1 km resolution run, focus on North-Rhine Westphalia.

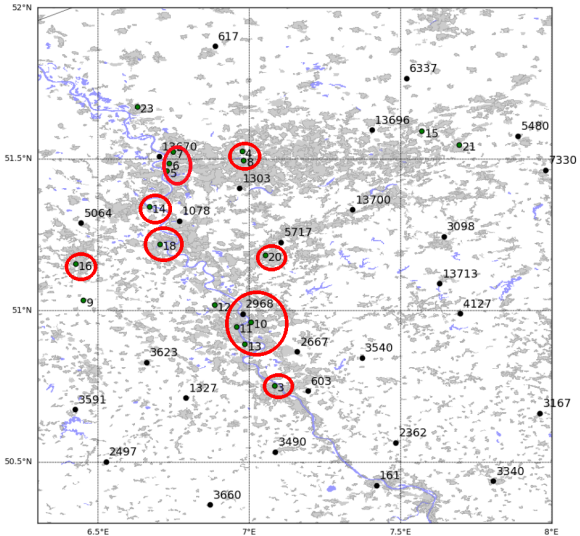


(c) Globcover



(d) Corine

Evaluation
Ground stations' networks

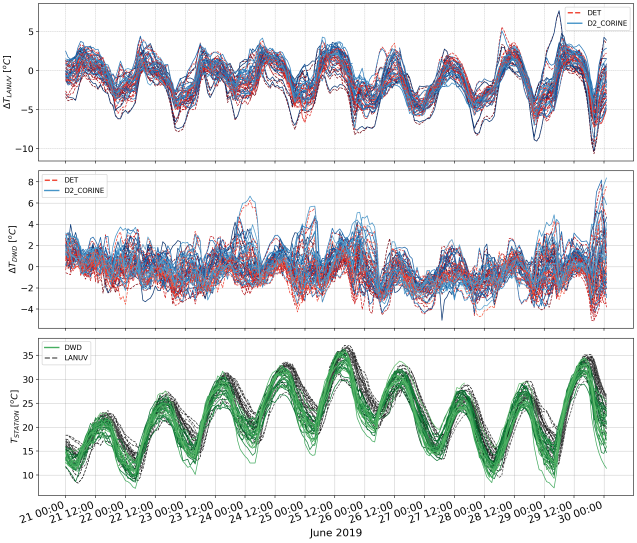


Stations:

- Black dots: **DWD**, this is the official network with quality controlled stations.
- Green dots: **LANUV**, this is the regional network, which has not been controlled yet.

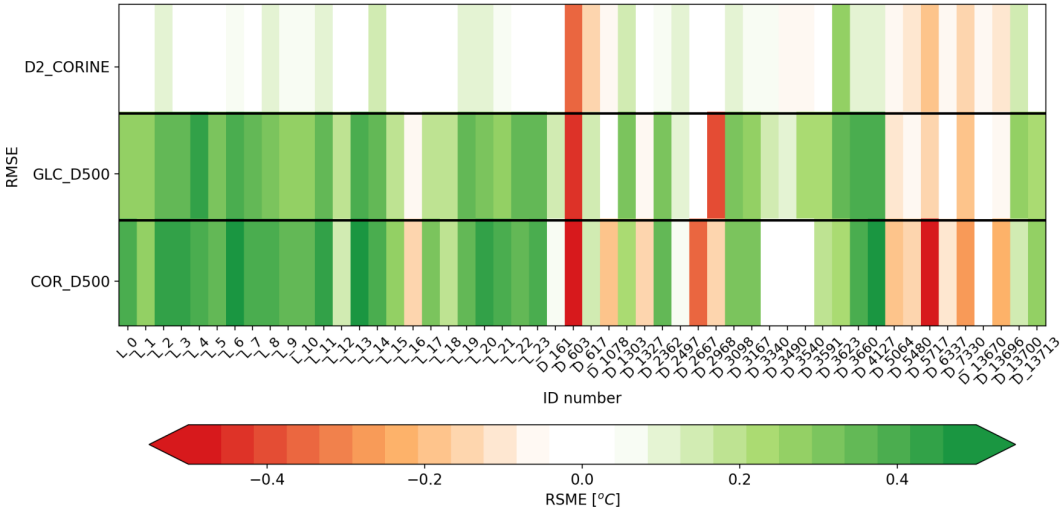
Urban stations are encircled in red.

Evaluation
Comparison with ground stations



Evaluation

Root Mean Square Error improvement w.r.t. default D2.1



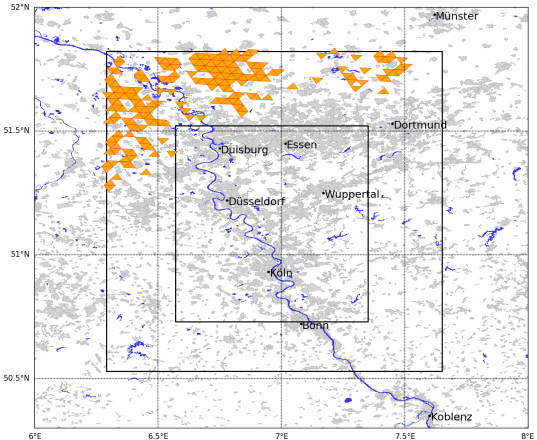
urban: DWD 2968 and LANUV 3-8,10,11,13,14,16,18,20

Baseline process:

1. Urban core and rural area extension: black boxes;
2. Select **no** urban grid-points;
3. Orography constrain: Rural points have **similar** altitude to the urban core;
4. Rural points and urban core must have roughly the same size

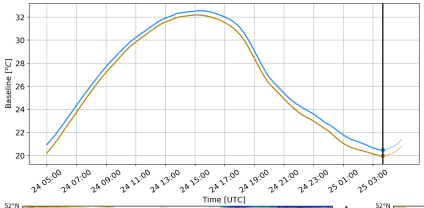
↓

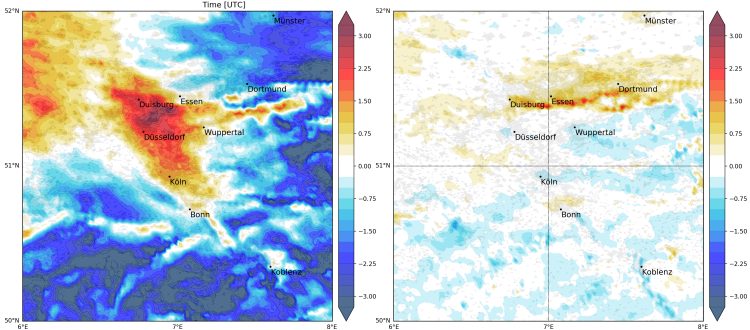
Use the spatial average value as subtraction baseline



Results D2.1

UHI results: 25 June 03:40 UTC



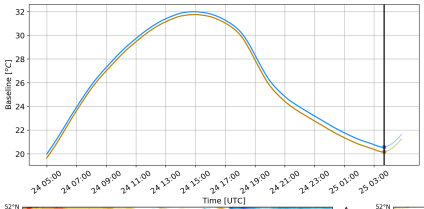


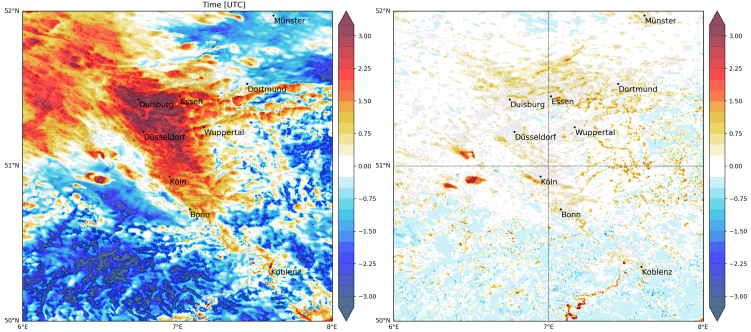
Baseline timeseries: COR_D2 (blue) has a warmer baseline than the OPS (yellow) for the whole period.

Corine UHI (COR_D2, left) and difference between UHI (OPS-COR_D2, right): COR_D2 captures higher temperatures differences (w.r.t. rural areas) in the eastern part of the urban agglomeration (Dortmund, Essen).

Results D500

UHI results: 25 June 03:40 UTC



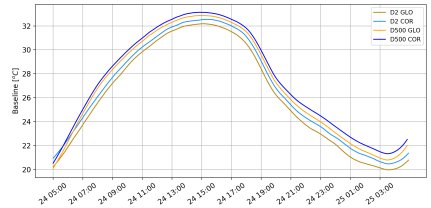


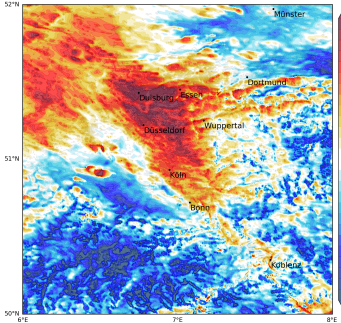
Baseline timeseries: COR_500 (blue) has still a warmer baseline than GLC_500 (yellow) in the 500-m resolution

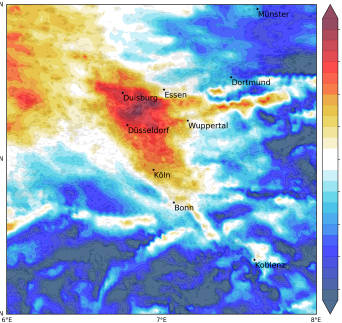
Corine UHI (COR_D500, left) and difference between UHI (GLC_D500-COR_D500, right): better LU representation in corine: e.g. smaller rivers are included (bottom right warm part), slightly higher temperatures in the new urban areas.

Results: comparison between resolutions

Qualitative comparison of the UHI results







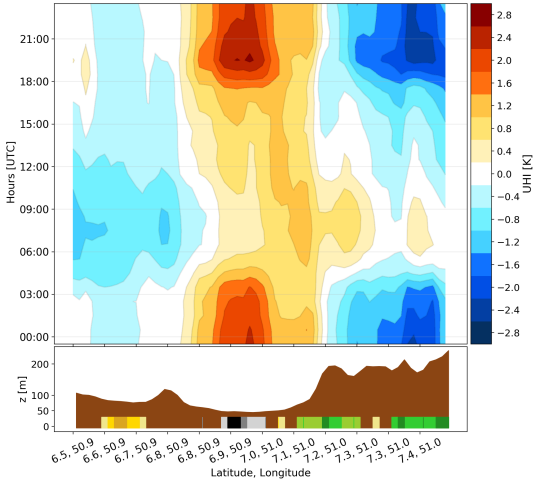
Baseline timeseries: warmer baselines w.r.t. the operational settings (OPS), up to 1.5 ^{o}C. The maxima is during nighttime.

500-m Corine UHI (COR_D500, left) and 2-km Corine UHI (COR_D2, right): higher UHI values in the 500-m resolution, despite the increase in the baseline w.r.t. 2-km; better representation of the smaller UHI in the smaller towns/cities of the region (e.g. Koblenz, lower right).

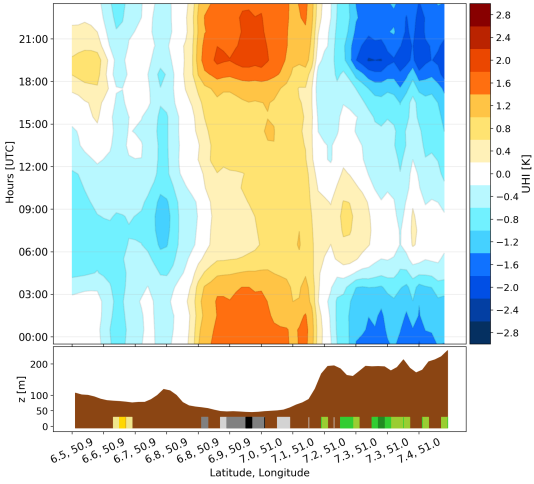
Results D2.1

Diurnal evolution of UHI: Hovmöller diagram

Globcover

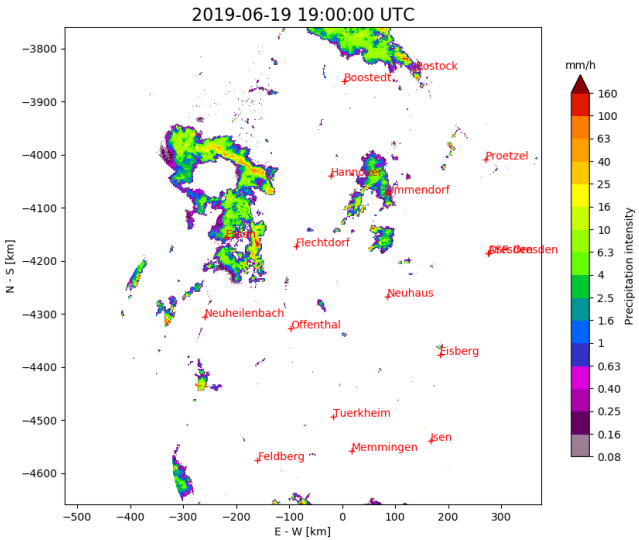


Corine



Work in progress

RADOLAN: 19 June 2019, 19 UTC Convective event



Snapshot of the radar composite (first 5 mins):
intense organized precipitation moving north-eastward.

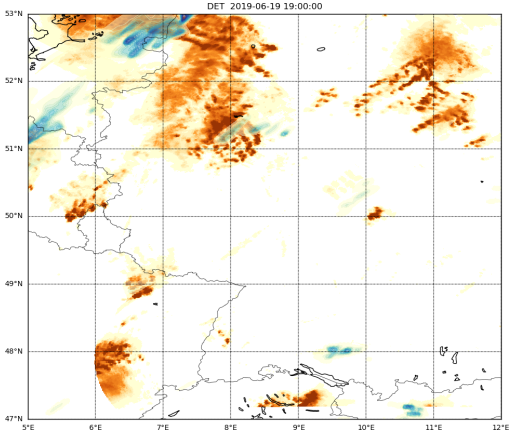
NB. 19 days into the simulation (which is continuous).

Work in progress

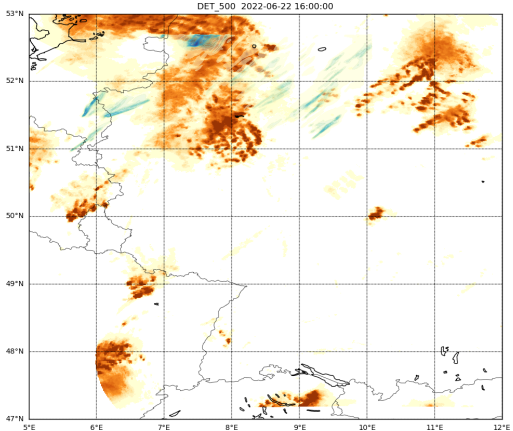
Qualitative comparison with radar composite:19 June 2019, 19 UTC

No improvement with increase in resolution: focus on the precipitation **location** (.. no need for the quantity as we are far off from reality)

OPS (2km)



GLC_500 (500 m)



the scales are similar in the colors (brown: radar, blue:model)

Conclusions and look ahead

Conclusions:

- Generally, resolution improves the RMSE during the heat-wave period, especially in the LANUV network (mostly urban) and some of the DWD stations (mainly east and south west).
- UHI with corine is wider than with globcover, but the magnitude is similar. The UHI magnitude increases with the resolution, despite also the increase in the baseline.
- Corine baseline is consistently higher that globcover one.
- A better representation of the urban heat island (UHI) is still needed, as both globcover and corine peaks at sunset.

To **improve** our results and the urban representation, we look at:

1. increasing the spatial (and temporal) resolution;
2. improving the physical parameterizations of the urban areas.
3. running data assimilation with conventional observation and additional ones.

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