Evaluation of ALARO1-Surfex8 in climate mode over Europe and the Tropics

Kwinten Van Weverberg, Debasish Mahapatra, Emnet Negash, Sajjad Alghezi, Bo Van Wetter, Dries Keppens, Wannes Vandenhaute, Bert Van Schaeybroeck, Michiel Van Ginderachter

Who are we?

Climate and Earth Lab (Ghent University)

- Two assistant professors, 1 Postdoc, 7 PhD students
- Focus on geomorphology and climate in the Global South
- Climate studies:
  - Applying, evaluating and developing ALARO-Surfex
  - Novel observations
  - Land-atmosphere interactions

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Climate Research Team (RMI Belgium)

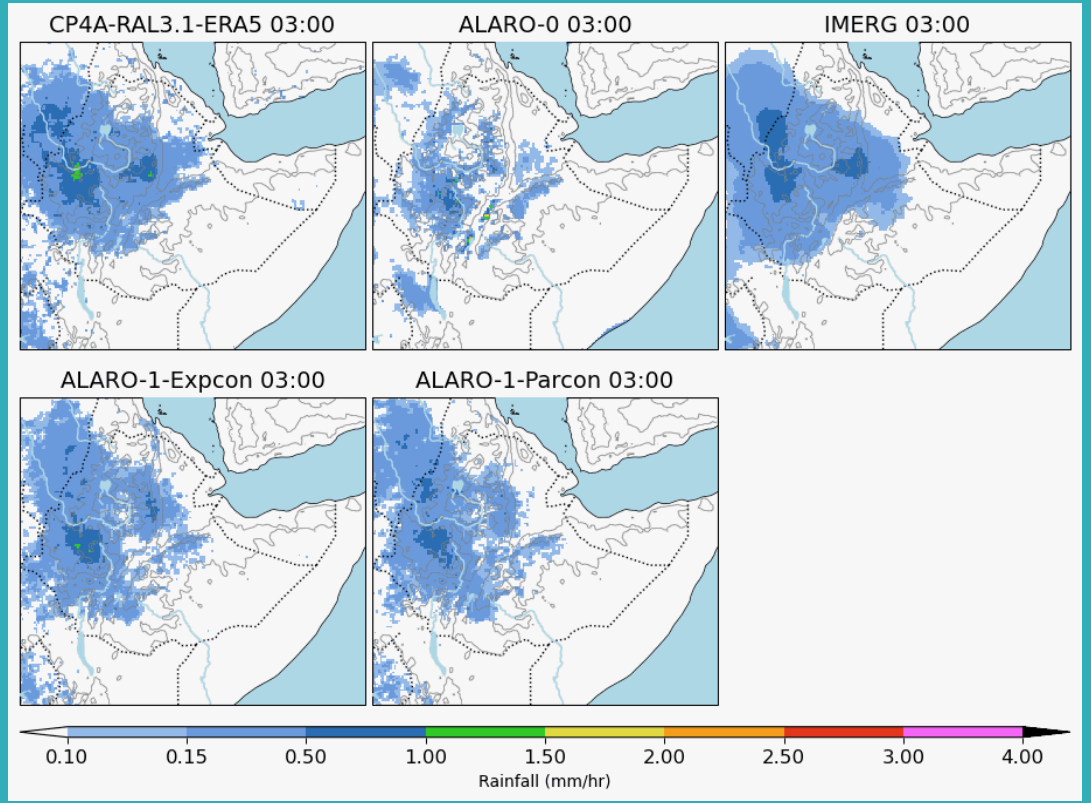
- About 10 researchers, all working with ALARO and/or Surfex
- Focus on urban climate, extreme value analysis, land-atmosphere interactions, regional climate projections

RMI

Orographic Rainfall in Ethiopia

How well does ALARO perform over tropical mountains?

- 3-year simulations
- driven by ERA-Interim/ERA-5
- Met Office UM, ALARO-0 and ALARO-1 (with and without deep convection parameterization)
- IMERG satellite rainfall



ALARO0-ISBA/ ALARO1-ISBA CY43T2

PhD Emnet Negash

Orographic Rainfall in Ethiopia

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RMI

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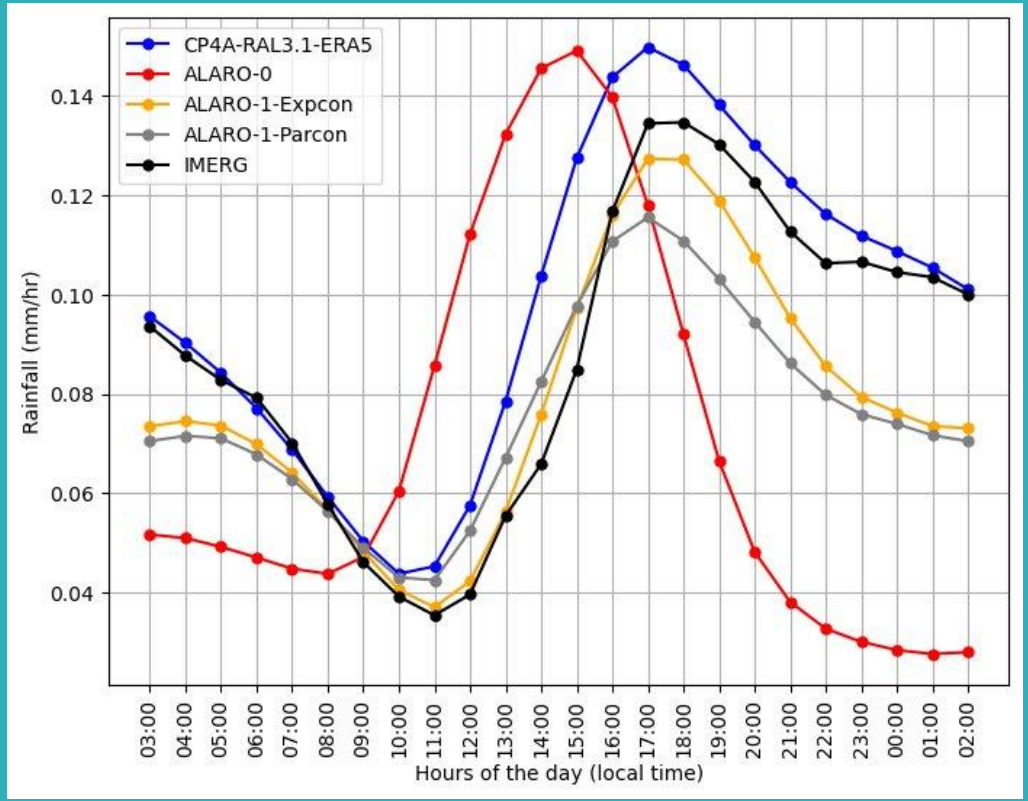
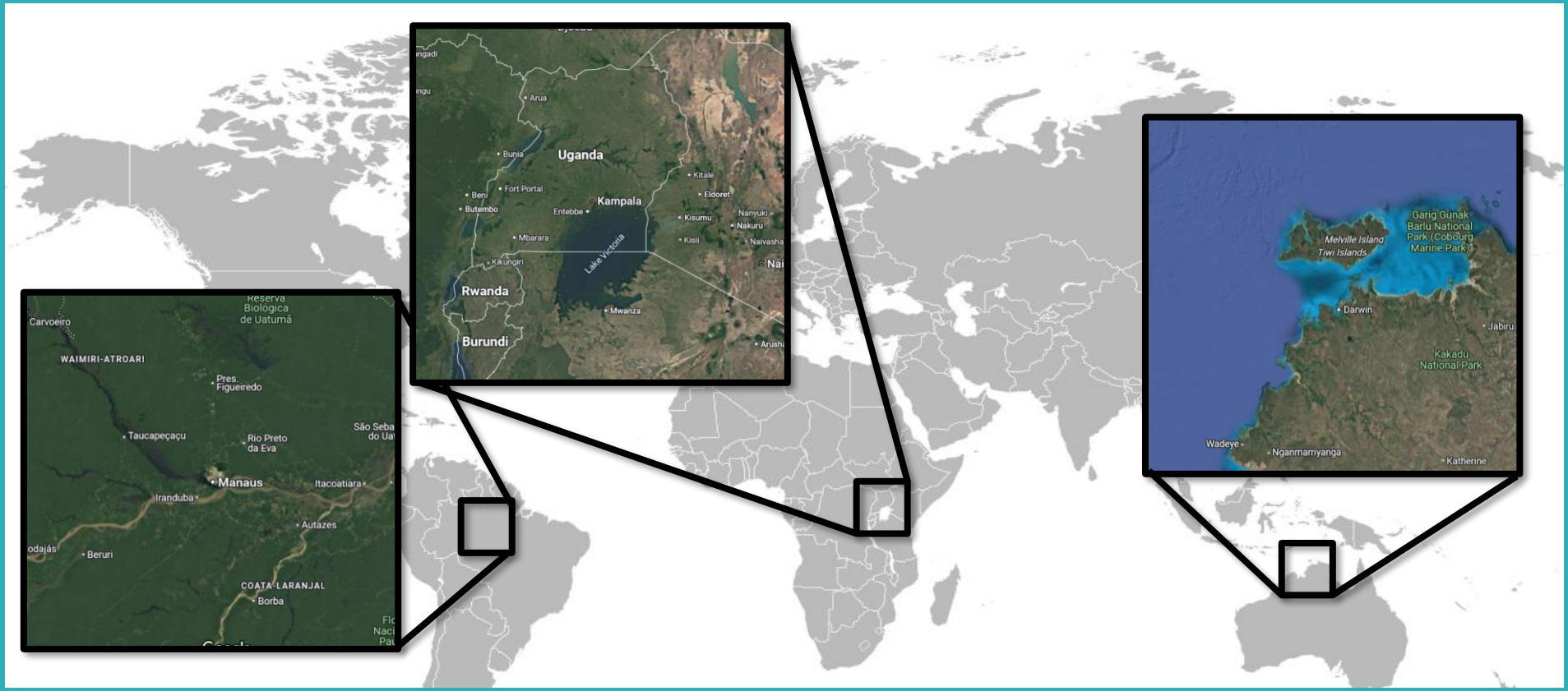


ALARO0-ISBA/ ALARO1-ISBA CY43T2

PhD Emnet Negash

Process-based evaluation over various tropical domains



ALARO1-Surfex8.0+ CY46T1

PhD Debasish Mahapatra

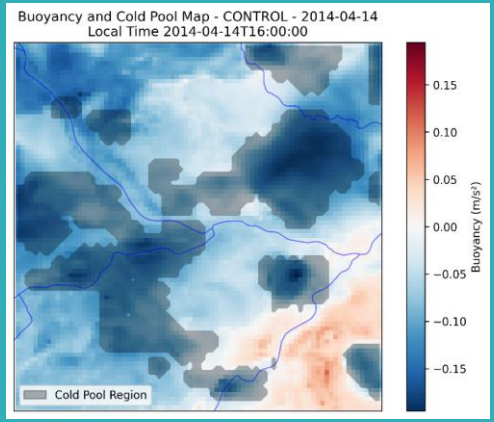
Process-based evaluation over various tropical domains

PhD Debasish Mahapatra, master Wannes Vandenhaute

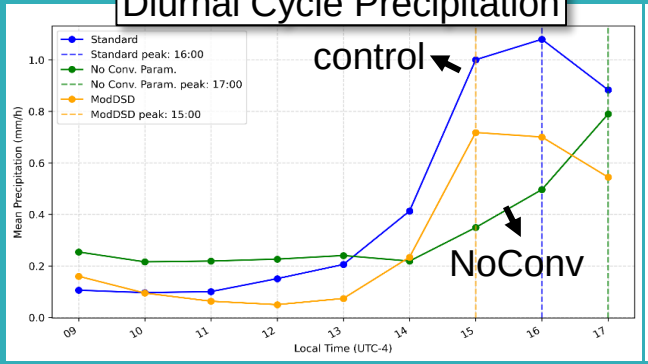
Sensitivity of ALARO1 to parameterizations

Single case, ERA5, 4 km resolution.
Very initial results.

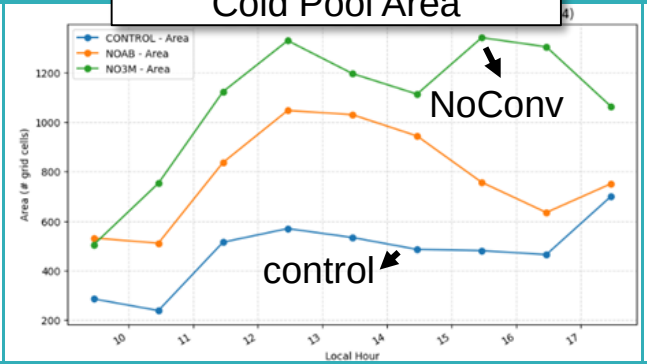
- Control (3MT, deep convection, Abel-Boutle scheme)
- No deep convection parameterization: fully explicit up- and downdraft → exaggerated vertical mass fluxes → larger, stronger cold pools??
- No Abel-Boutle rain microphysics adjustment (more drizzle → more evaporation → larger cold pools??



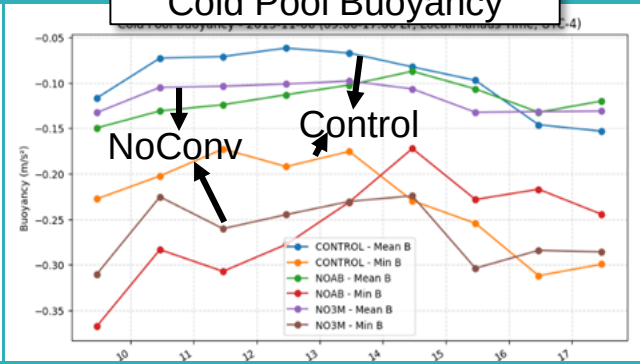
Diurnal Cycle Precipitation



Cold Pool Area



Cold Pool Buoyancy



ALARO1-Surfex8.0+ CY46T1

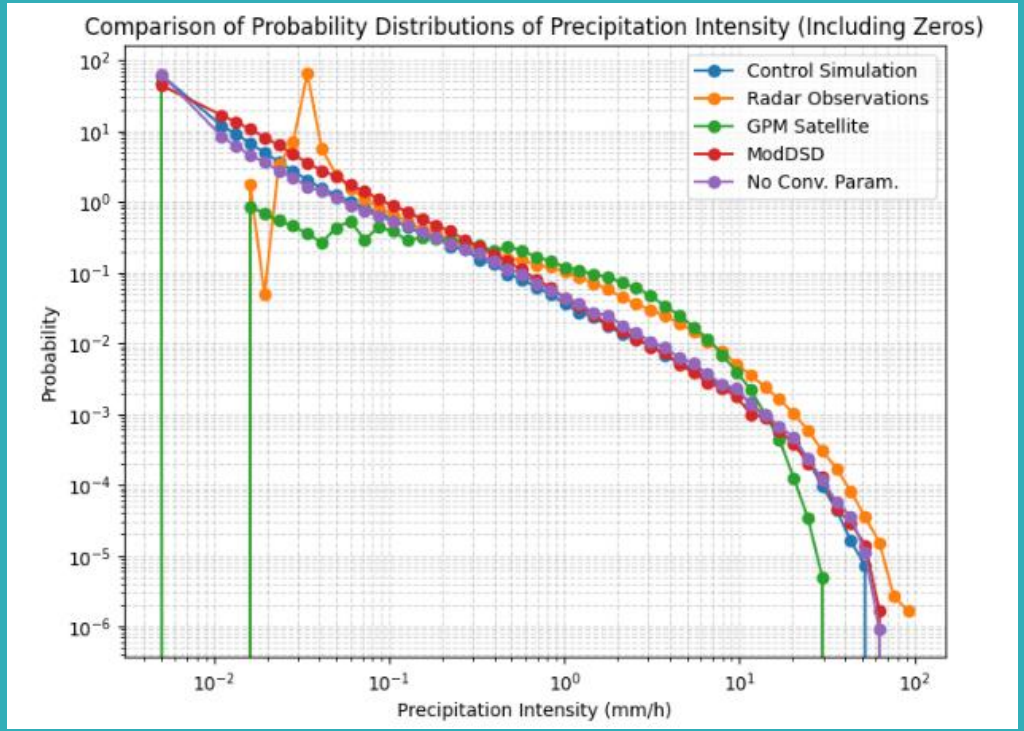
Process-based evaluation over various tropical domains

PhD Debasish Mahapatra, master Wannes Vandenhaute

Sensitivity of ALARO1 to parameterizations

Comparison of rain PDFs to radar and satellite retrievals for 5 most intense convective events in 2014:

- **Simulated extremes** between radar and satellite (~within observational uncertainty) for all experiments.
- **Intermediate rainfall** rates (and average rainfall accumulations) significantly underestimated.
- Switching off Abel-Boutle scheme gives more very **light rain**.



ALARO1-Surfex8.0+ CY46T1

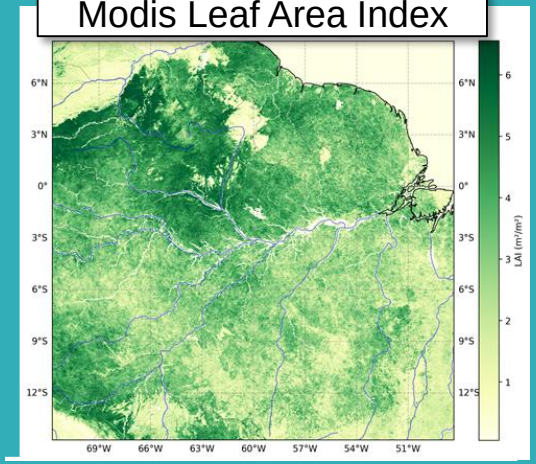
Process-based evaluation over various tropical domains

PhD Debasish Mahapatra

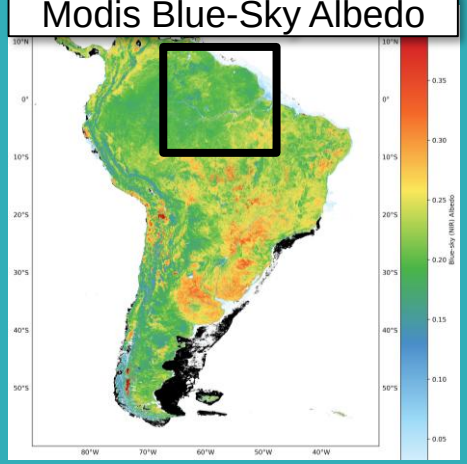
Further work:

- Longer climate simulations over well-observed site for 2 years (scanning radars, disdrometers, balloon soundings, GO-Amazon ARM DOE campaign).
- Improve land-surface representation (only Ecoclimap I available) with MODIS observed time-varying biophysical parameters (LAI, roughness, albedo).
- Evaluate new 2-moment microphysics scheme (David Nemec at CHMI)

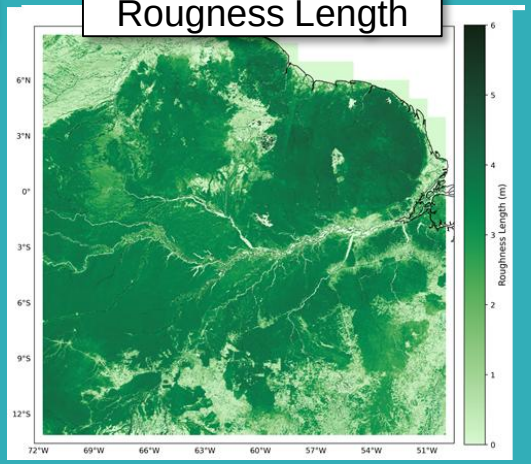
Modis Leaf Area Index



Modis Blue-Sky Albedo



Rougness Length



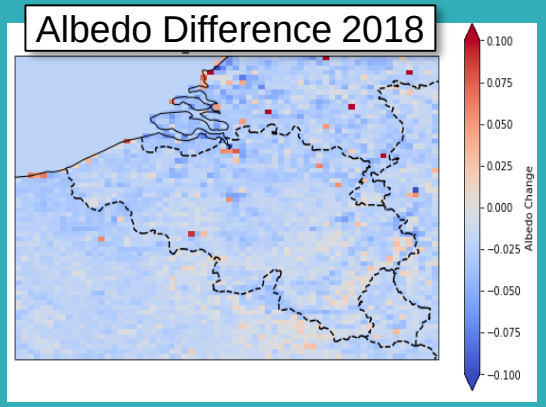
Heatwaves over Belgium: representation land surface

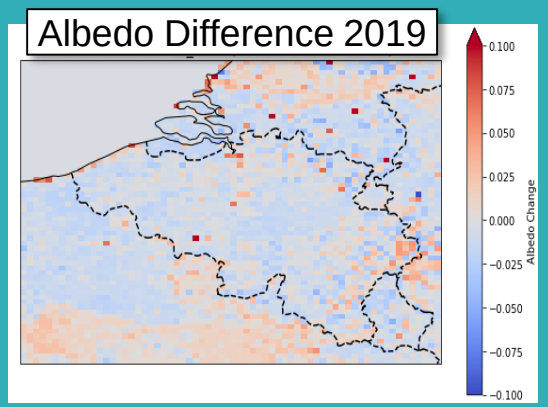
Master Sajjad Alghezi and Bo Van Wetter

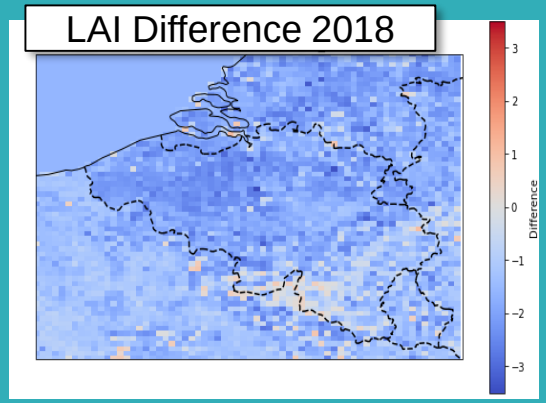
Two contrasting heatwaves with ALARO1-Surfex8.0+

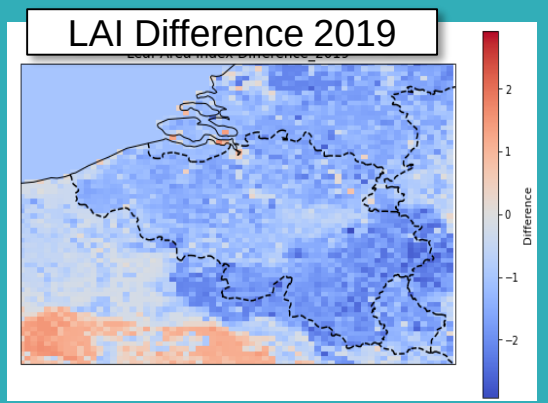
- **July 2018**: very dry year; long heatwave
- **July 2019**: less dry year; short, intense heatwave (highest temperature ever recorded in Belgium).

Impact of implementing MODIS-retrieved biophysical parameters in Surfex: **Lower albedo (2018) and LAI** than default Ecoclimap values









ALARO1-Surfex8.0+ CY46T1

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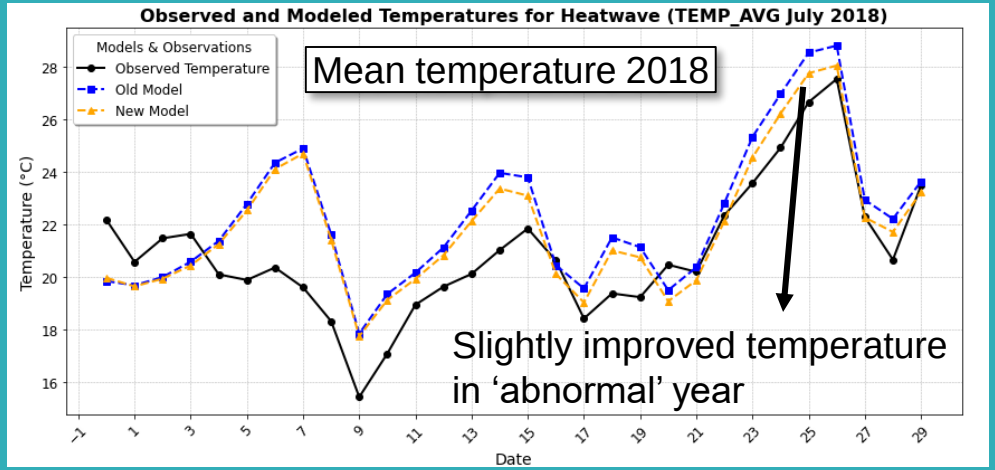
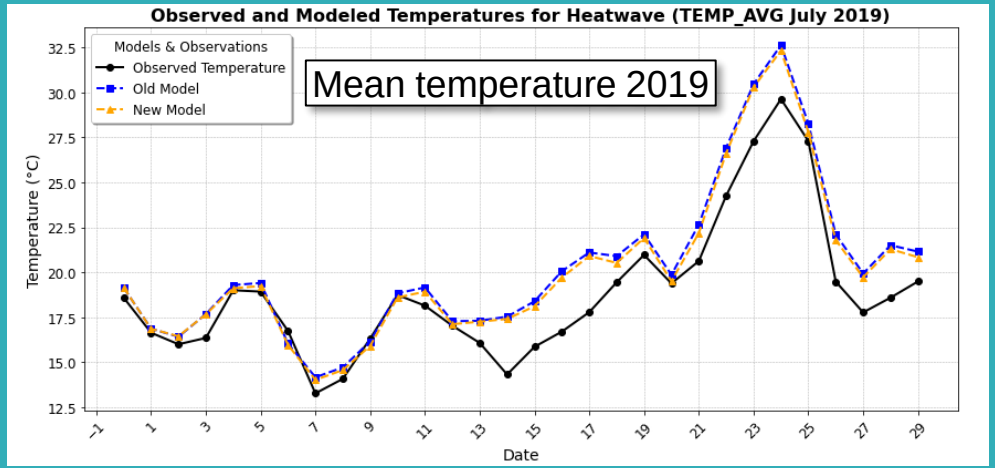
Slight improvement against gridded nationwide **temperature** observations with more realistic biophysical parameters in ‘abnormal’ year (2018)

ALARO1-Surfex8.0+ CY46T1





Heatwaves over Belgium: evaluation of energy balance

Master Sajjad Alghezi and Bo Van Wetter

Two contrasting heatwaves with ALARO1-Surfex8.0+

- **July 2018**: very dry year; long heatwave
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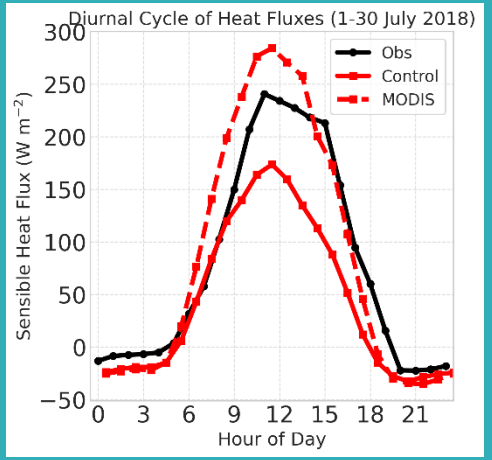
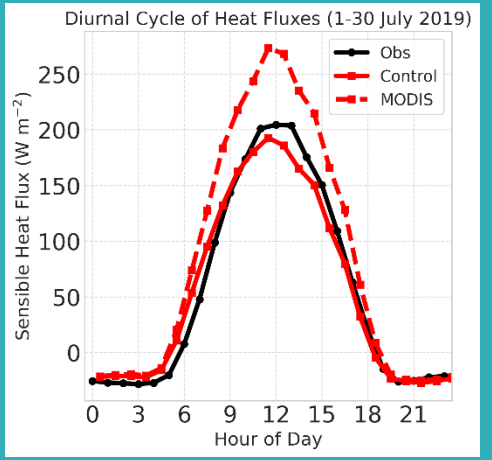
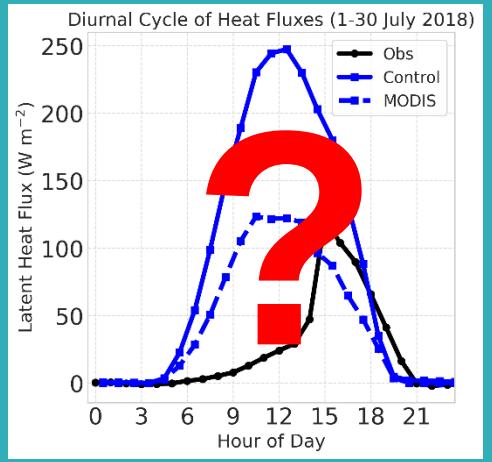
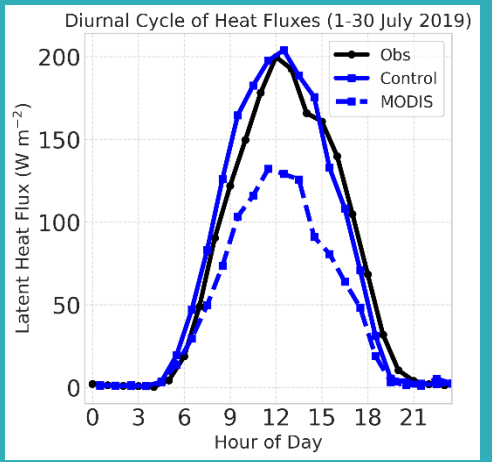
Also monthly average sensible heat flux better captured in 2018, but not in 2019 – Likely mainly caused by lower LAI (less transpiration)

ALARO1-Surfex8.0+ CY46T1









Heatwaves over Belgium: urban heat island

Master Dries Keppens

Two contrasting heatwaves with ALARO1-Surfex8.0+

- **July 2018**: very dry year; long heatwave
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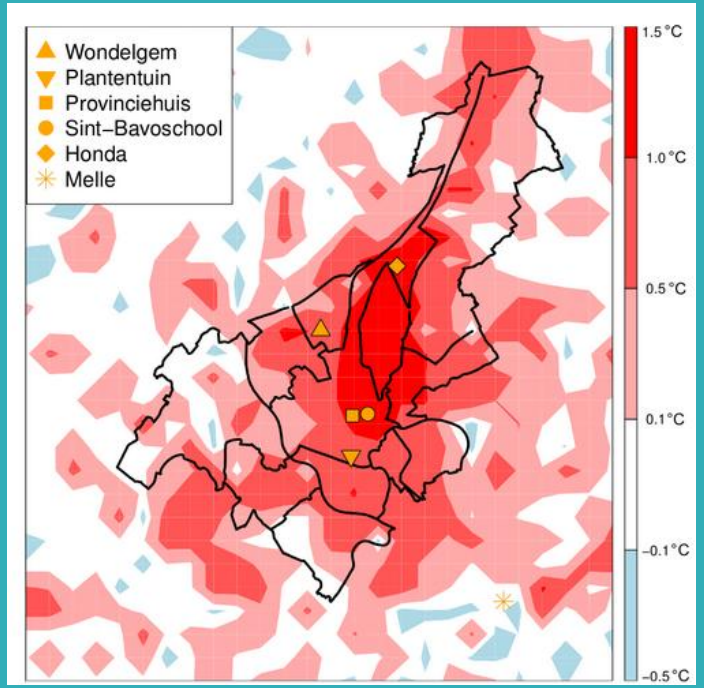
How well does ALARO-Surfex **capture the Urban Heat Island** of Ghent with two version of the Ecoclimap?
Do impacts of **mitigation measures** depend on the land cover maps used?



MOCCA network in Ghent (Caluwaerts et al. 2018)

ALARO1-Surfex8.0+ CY46T1

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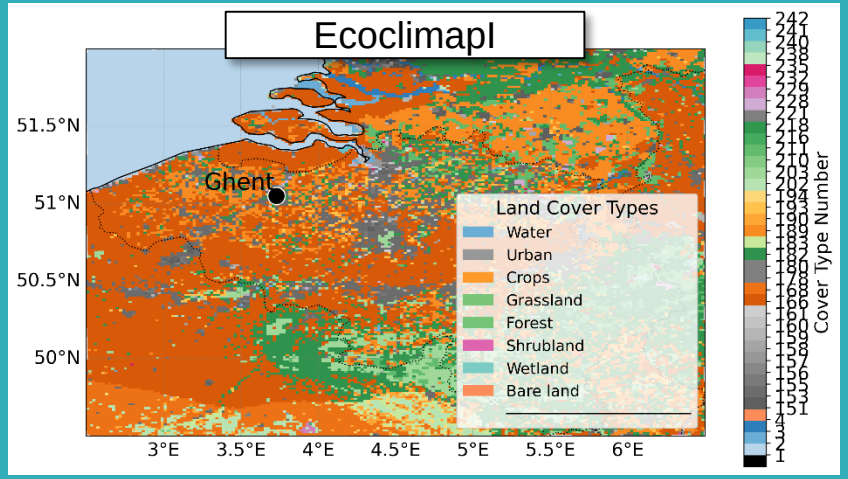

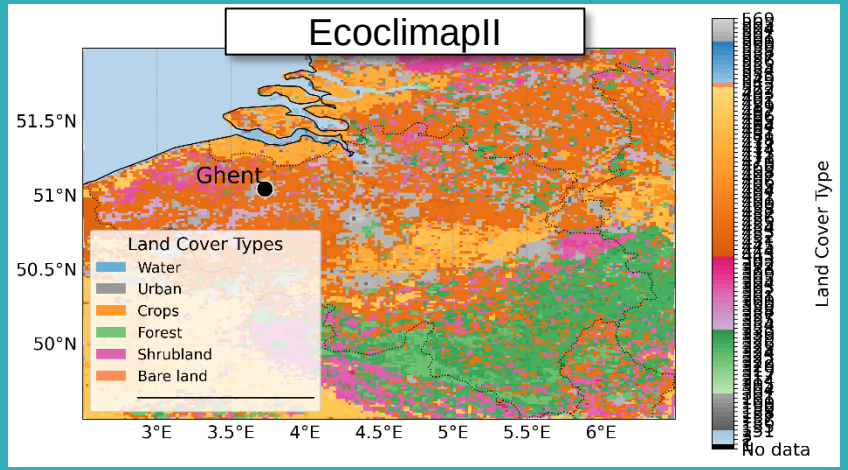

ALARO1-Surfex8.0+ CY46T1

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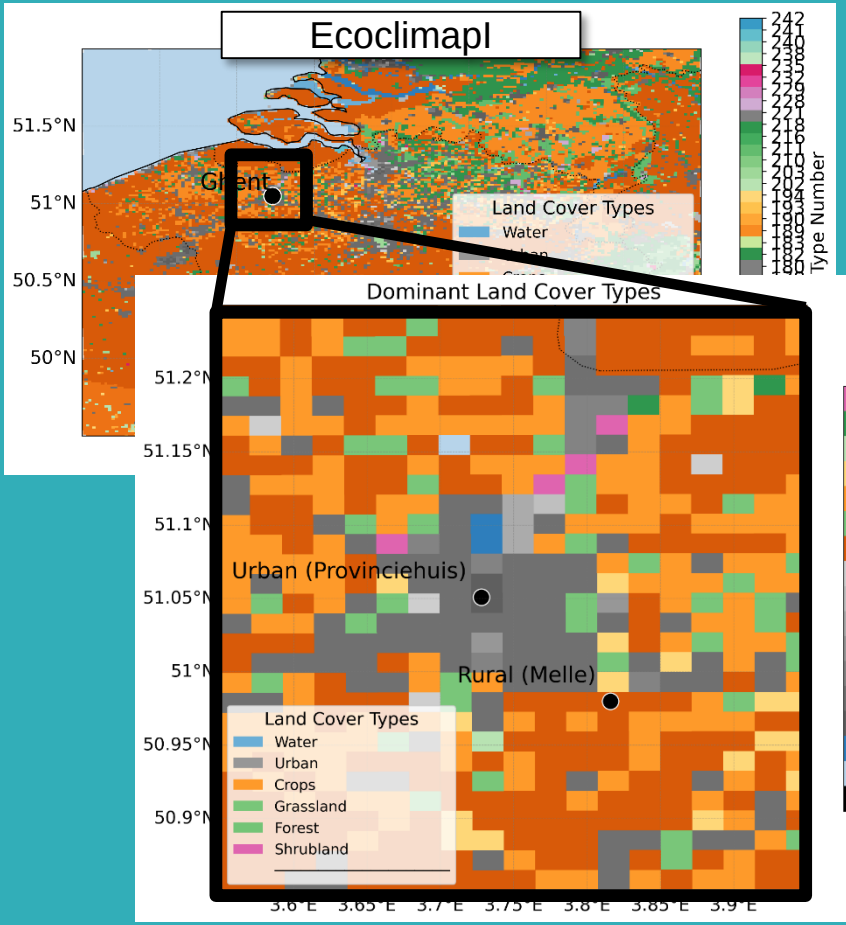
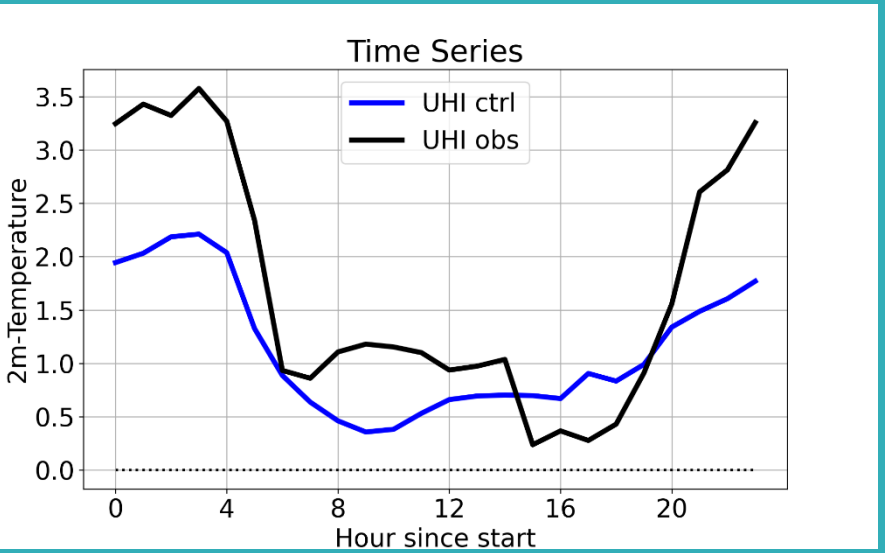
Urban heat island not well captured in default configuration with EcoclimapI



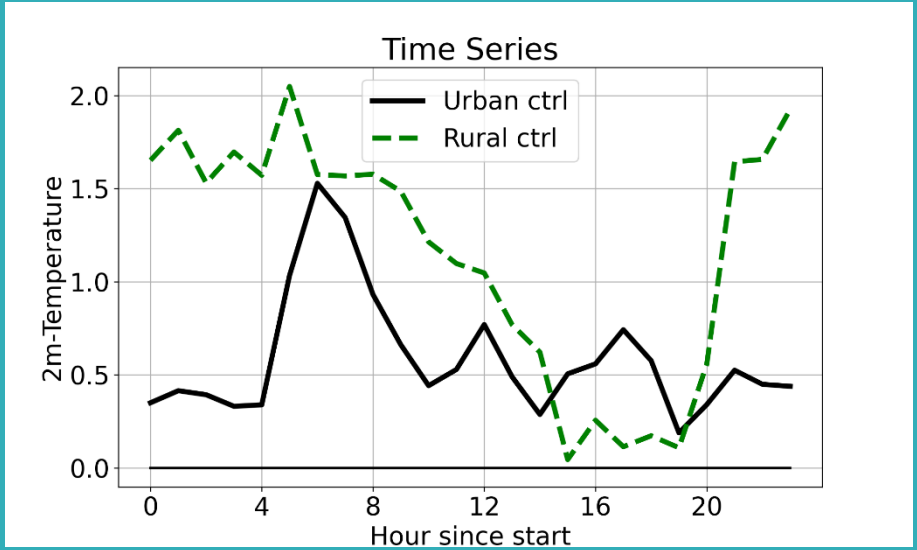


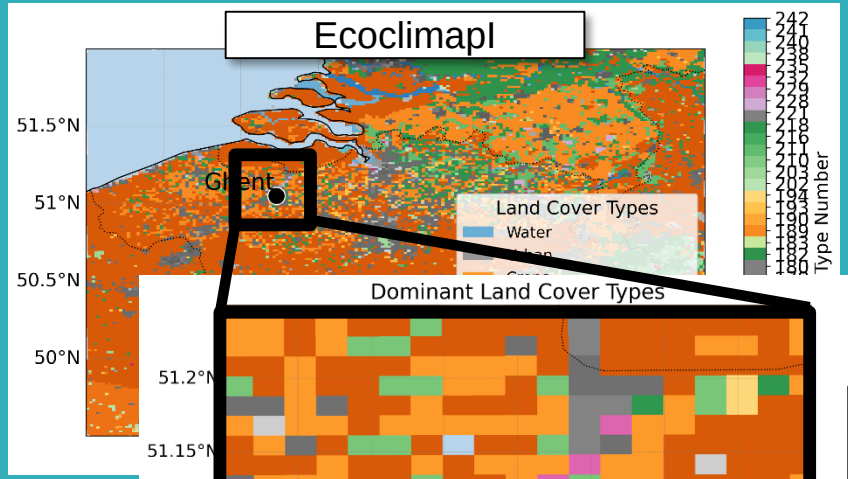
ALARO1-Surfex8.0+ CY46T1

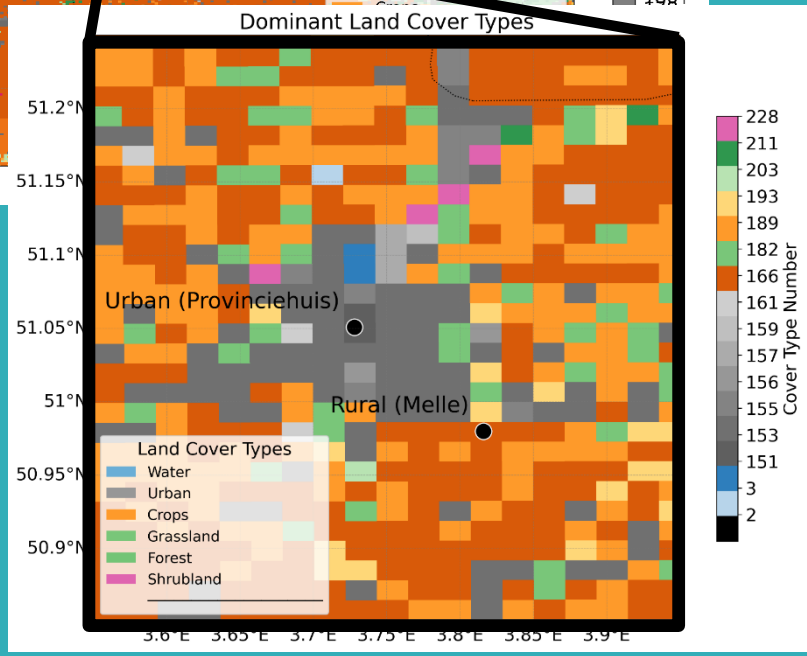
Heatwaves over Belgium: urban heat island

Master Dries Keppens

Mainly due to warm bias in rural stations at night, masking out the UHI.





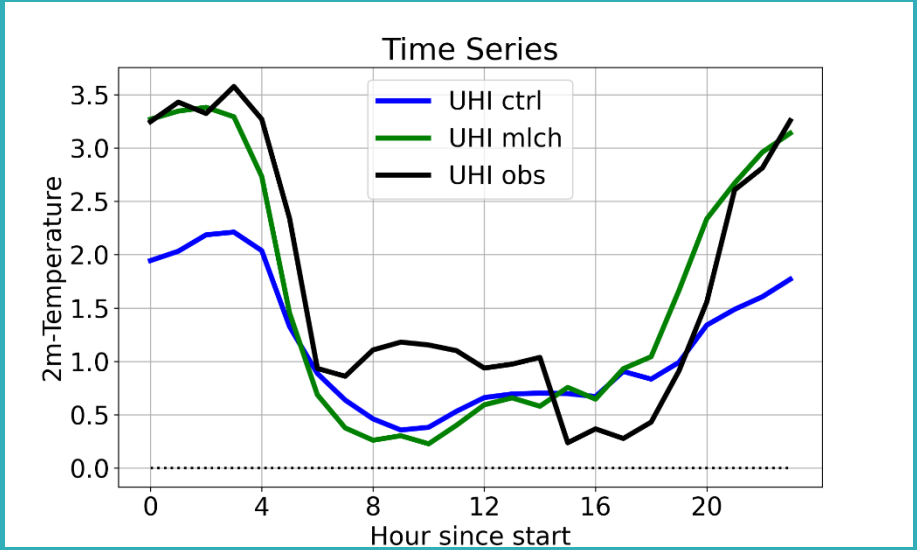


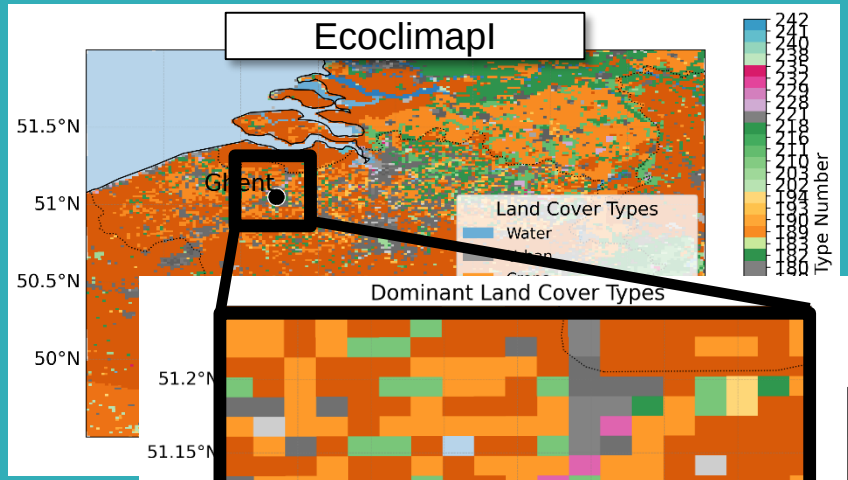
ALARO1-Surfex8.0+ CY46T1

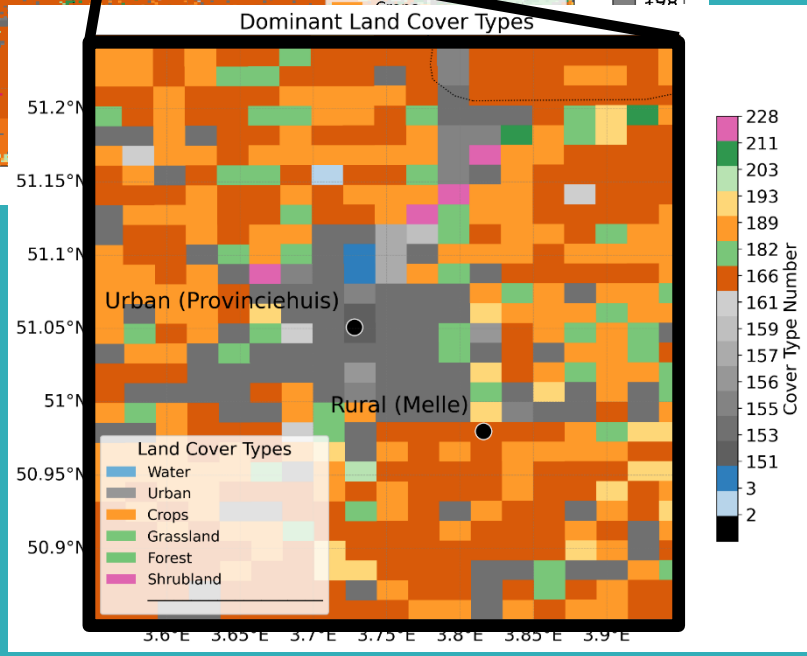
Heatwaves over Belgium: urban heat island

Master Dries Keppens

But much better captured when switching on ‘mulch’ option, decoupling the soil and the atmosphere under vegetation





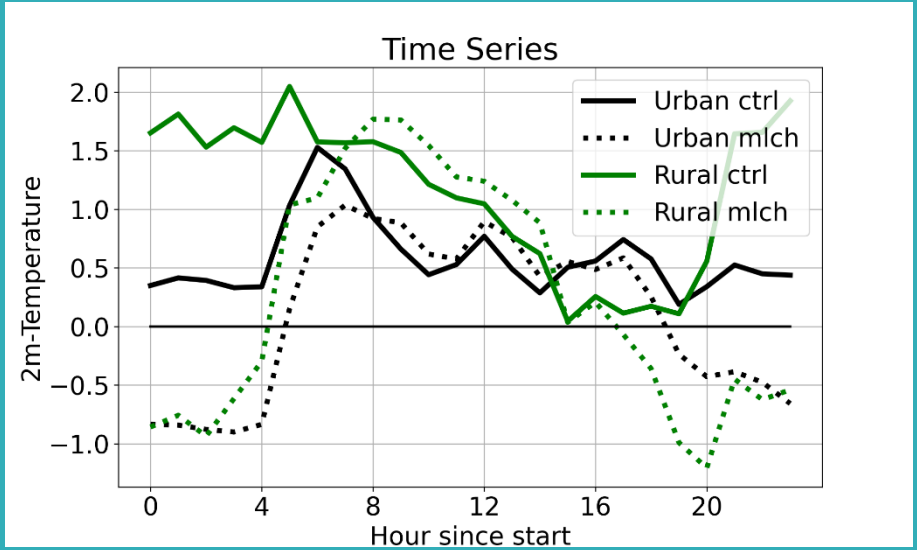


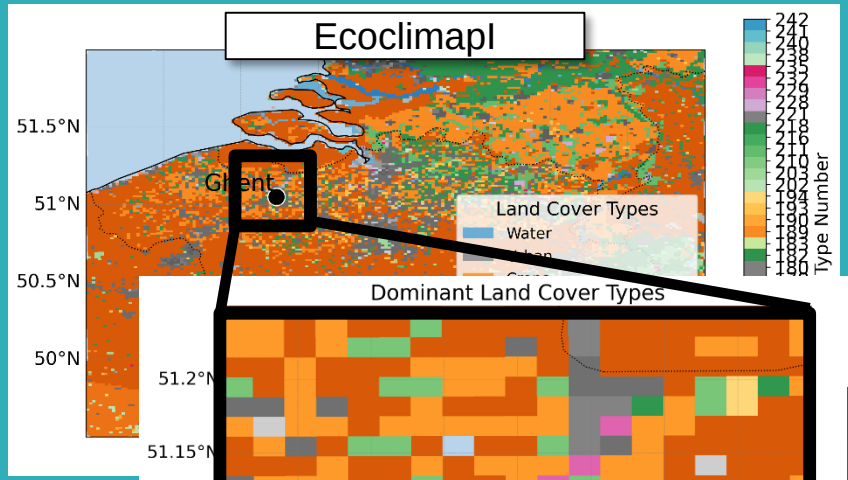
ALARO1-Surfex8.0+ CY46T1

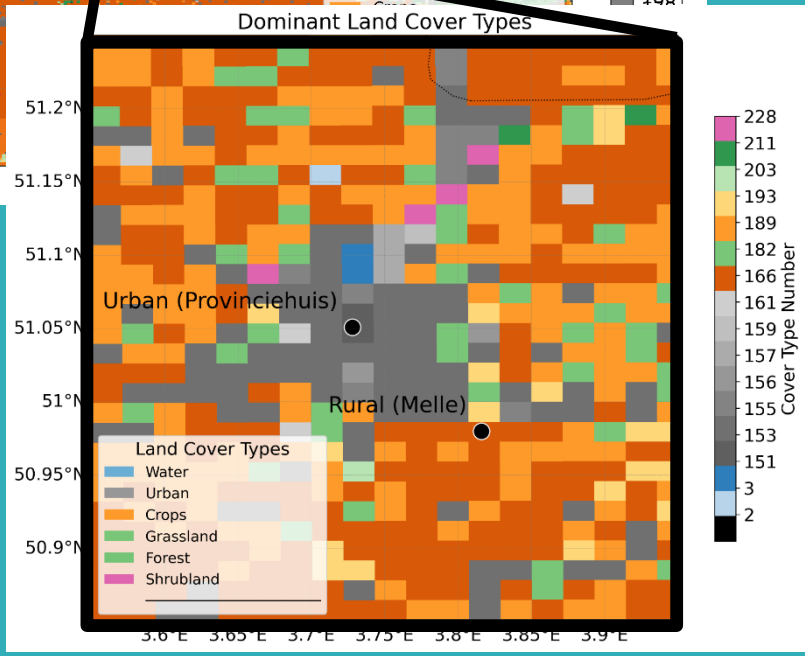
Heatwaves over Belgium: urban heat island

Master Dries Keppens

Due to a similar cold bias at night in rural and urban stations, no longer ‘masking’ the UHI.





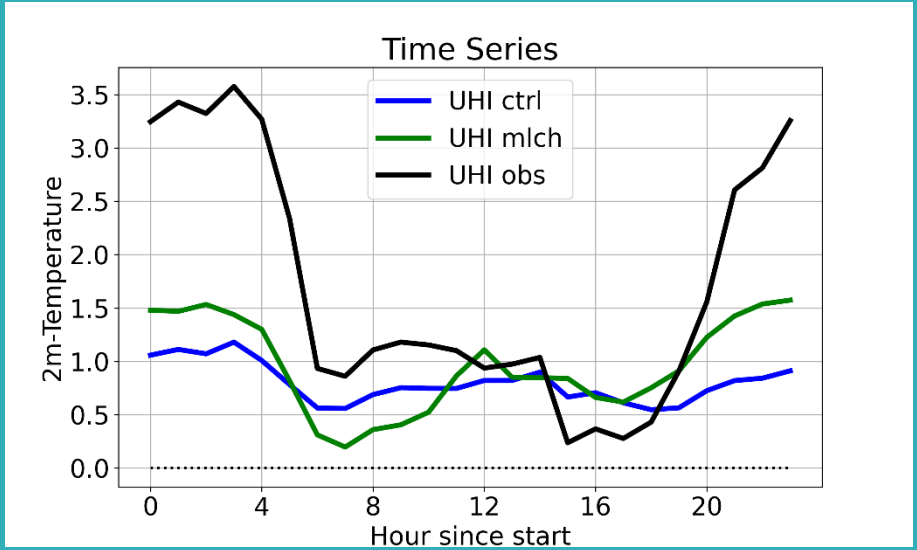


ALARO1-Surfex8.0+ CY46T1

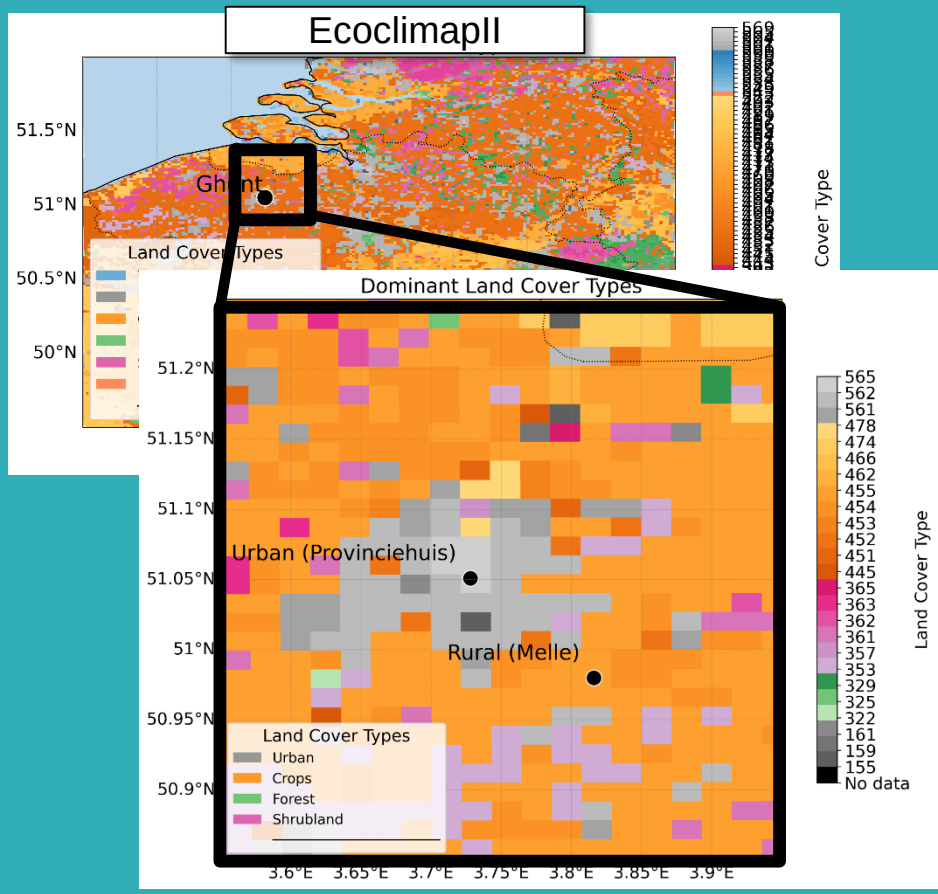
Heatwaves over Belgium: urban heat island

Master Dries Keppens

Mulch does not seem to help in EcoclimapII, though!



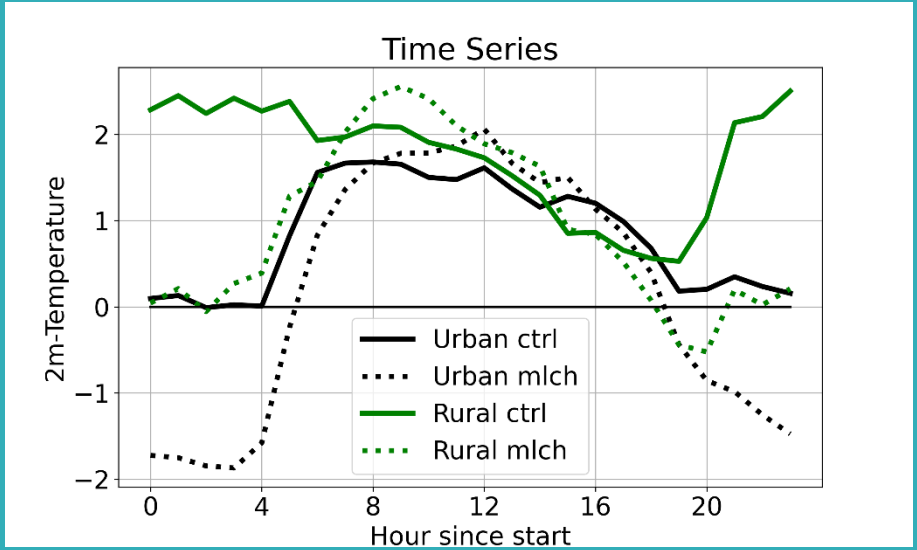
ALARO1-Surfex8.0+ CY46T1

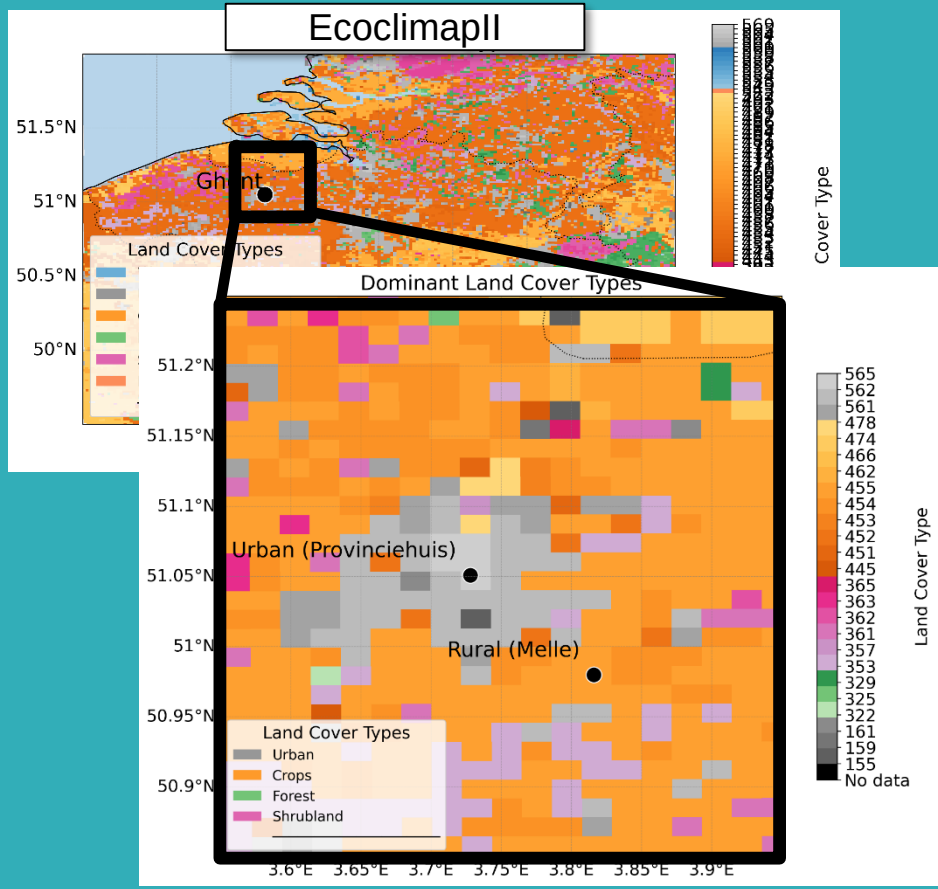


Heatwaves over Belgium: urban heat island

Master Dries Keppens

Mulch equally **cools** rural and urban station at night. Choice between cold urban bias or warm rural bias...



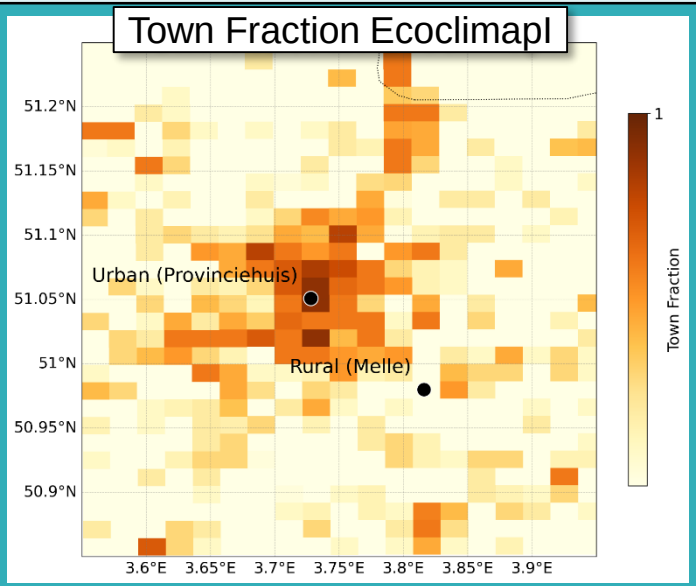


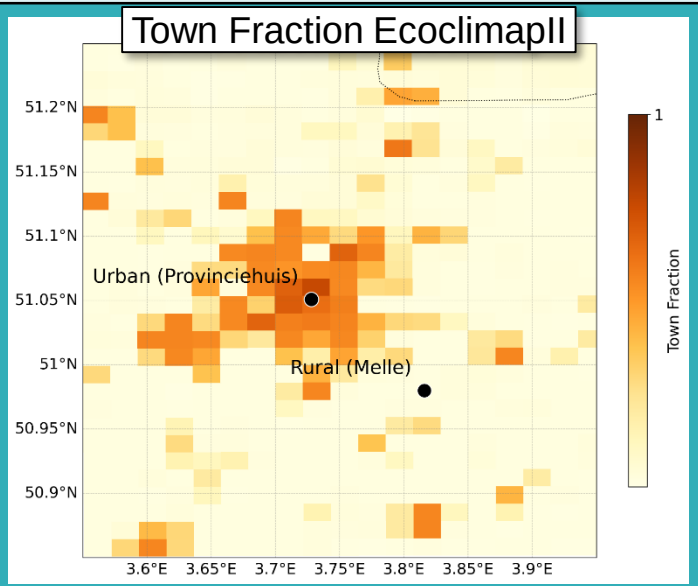
ALARO1-Surfex8.0+ CY46T1

Heatwaves over Belgium: urban heat island

Master Dries Keppens

Possibly related to smaller urban density in Ecoclimap II (63%) than in Ecoclimap I (90%) for our urban site. Mulch also acts to cool the city in Ecoclimap II.
→ May need other solutions (move to Surfex8.1 with LCZs, Soil Organic Carbon options mentioned by Patrick Samuelsson yesterday)

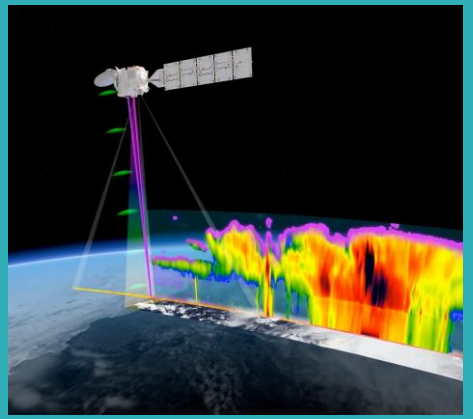


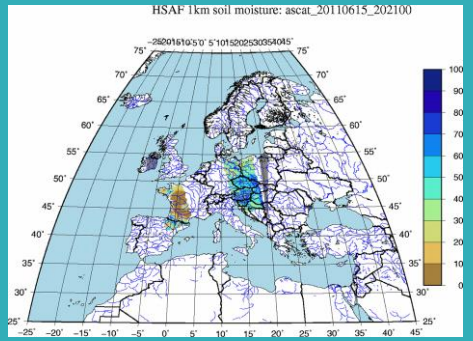


ALARO1-Surfex8.0+ CY46T1

Future

- **Perform process-based evaluation** of ALARO-Surfex for:
  - **Tropical convection** (US Atmospheric Radiation Measurement (ARM) facility tropical supersites, new geostationary (Meteosat Third Generation) and low-earth orbit (EarthCARE) satellites.
  - Compound **hot-dry events in Belgium** (EUMETSAT and ESA satellite products): errors in model dry-down, soil-moisture, flux partitioning and boundary-layer.
- Use ALARO-Surfex to study **the impact of global warming, land-use change and aerosol** changes on tropical convection and droughts.
- Contribute **to further developments** of ALARO-Surfex (e.g. cloud-radiation-microphysics coupling; interactive vegetation in Surfex).





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Questions?

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