

Overview of climate research with ALARO-0 at the RMI

Julie Berckmans, Lesley De Cruz, François Duchêne, Rozemien De Troch, Olivier Giot, Rafiq Hamdi, Piet Termonia, and Bert Van Schaeybroeck

RMI

ALARO-1 Working Days
Brussels, 12-14 September 2016



- 1 Multiscale**
- 2 State-of-the-art**
- 3 Added value**
- 4 Applications**
- 5 Outlook**

1 Multiscale

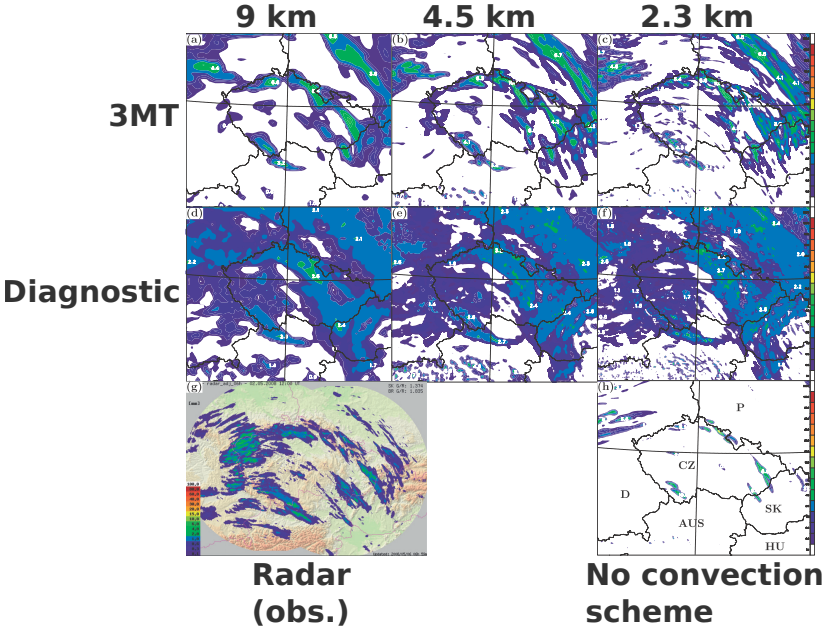
2 State-of-the-art

3 Added value

4 Applications

5 Outlook

Multiscale feature 3MT: NWP

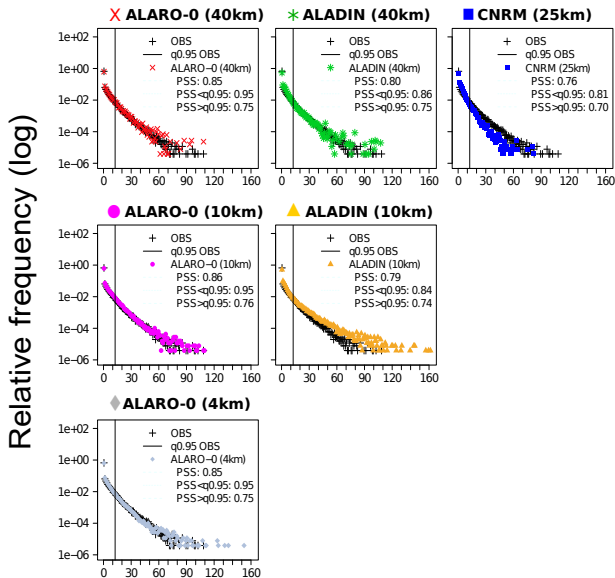


Climate with ALARO-0

Downscaling experiment by De Troch *et al.*, JoC, 2013:

- Evaluation of ALADIN and ALARO-0 at 40, 10 and 4 km:
 - cy36t1
 - ISBA
 - ACRANEB
- Initial and lateral boundary conditions: ERA-40 or model at 40km resolution (one-way nesting)
- 30-year run with daily reinitializations (summer)
- Reference: station observations 1961-1990 over Belgium

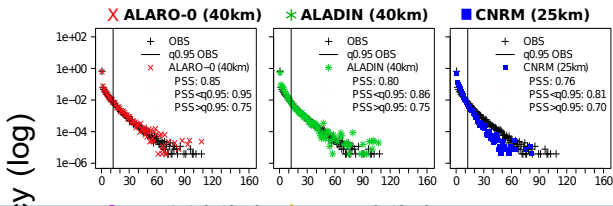
Multiscale feature 3MT: Climate



Precipitation (mm/day)

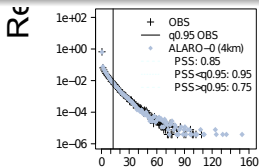
De Troch et al. (2013)

Multiscale feature 3MT: Climate



Conclusion

Thanks to the 3MT physics parameterization scheme, ALARO-0 generates consistent results across **multiple scales** and correctly represents extreme daily precipitation, up to resolutions of 4 km.



Precipitation (mm/day)

De Troch et al. (2013)

1 Multiscale

2 **State-of-the-art**

3 Added value

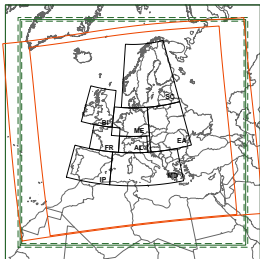
4 Applications

5 Outlook

CORDEX

Participation in the **Coordinated Regional Climate Downscaling Experiment (CORDEX)**:

- Runs are performed with **ALARO-0 cy36t1 (ISBA, ACRANEB)**
- Boundary conditions: ERA-Interim (evaluation) or CMIP5 GCM: CNRM-CM5 (historical and future)
- Run continuously (one month at a time) for a 31-year period
- Domain and resolutions: EUR-44 ($0.44^\circ \approx 50$ km) and EUR-11 ($0.11^\circ \approx 12.5$ km)



Current status of the runs

Runs are done on the Tier-1 supercomputer at Ghent University

✓: done | o: ongoing

	Analysis	Historical	RCP 2.6	RCP 4.5	RCP8.5
1950-1976	o (1957-1979)	o	-	-	-
1976-2005	✓	✓	-	-	-
2005-2040	-	o (2005-2015)	o	✓	✓
2040-2070	-	-	✓	✓	✓
2070-2100	-	-	✓	✓	✓

Validated using **state-of-the-art** performance metrics (Giot *et al.*, 2016).

Geosci. Model Dev., 9, 1143–1152, 2016

www.geosci-model-dev.net/9/1143/2016/

doi:10.5194/gmd-9-1143-2016

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Validation of the ALARO-0 model within the EURO-CORDEX framework

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Validation

Evaluation run:

- Lateral boundary conditions from the ERA-Interim reanalysis
- Continuous 31-year run (1979-2010)
- Reference: E-OBS 7 data set

Can ALARO-0 represent the most important features of the European climate?

In practice:

- 1 Is ALARO-0 competitive with other EURO-CORDEX ensemble members, using the **standardized performance metrics** as in Kotlarski *et al.*, 2014 [hereafter K14]?
- 2 Are these metrics **robust**?

Performance metrics

Scores are based on seasonal mean values of near-surface air temperature and precipitation.

- BIAS: mean bias
- 95%-P: 95th percentile of the absolute grid point differences
- RSV: ratio of spatial variability
- PACO: pattern correlation
- RIAV: ratio of interannual variability
- TCOIAV: temporal correlation of interannual variability

All scores except TCOIAV should be similar for reanalysis- and GCM-driven runs (if GCMs represent the climate well)

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Robustness

Are the scores **robust**, i.e. independent of the period used?

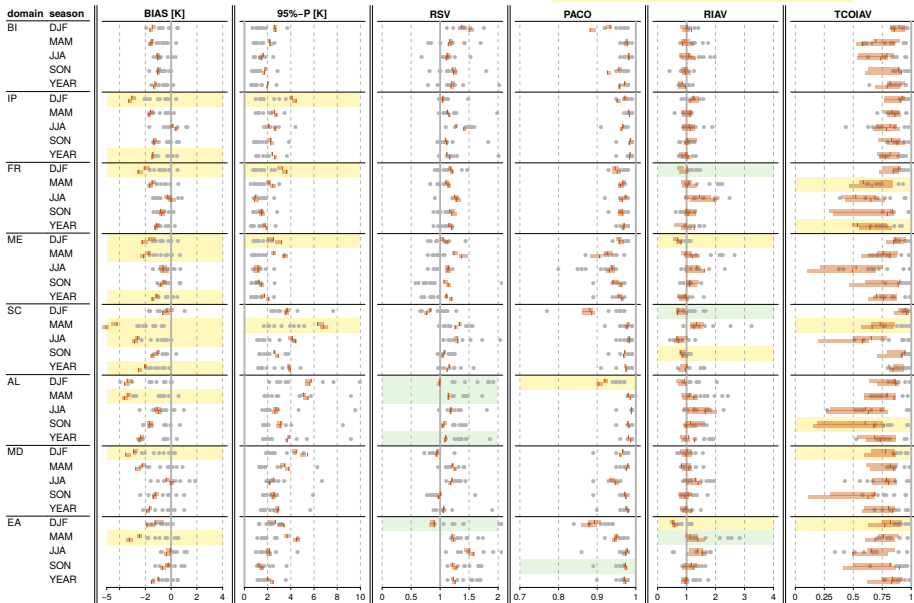
⇒ Jackknife procedure:

- Calculate all scores for 1000 random 20-year samples out of the 32-year period
- Construct 95% confidence intervals
- Compare interval width to the ensemble spread.

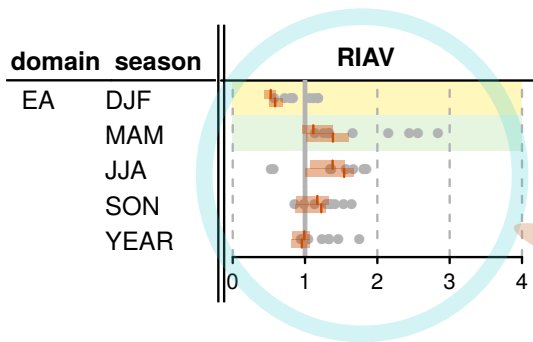
Temperature

● optimal score
 ■ jackknife 95% confidence interval
● K14 models
 ■ RMB-Ugent (top=-.11; bottom=-.44)

white background: RMB-Ugent is in K14
 green background: RMB-Ugent is not in K14, but better or not the worst
 yellow background: RMB-Ugent is not in K14 and the worst



| optimal score ■ jackknife 95% confidence interval
 ● ● K14 models | RMIB-UGent (top=.11; bottom=.44)



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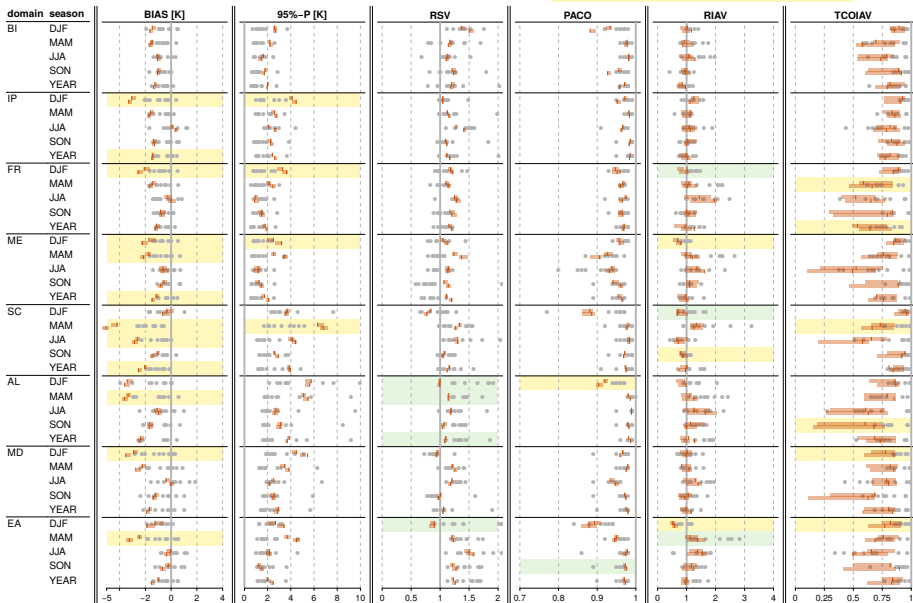
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Temperature

optimal score ■ jackknife 95% confidence interval
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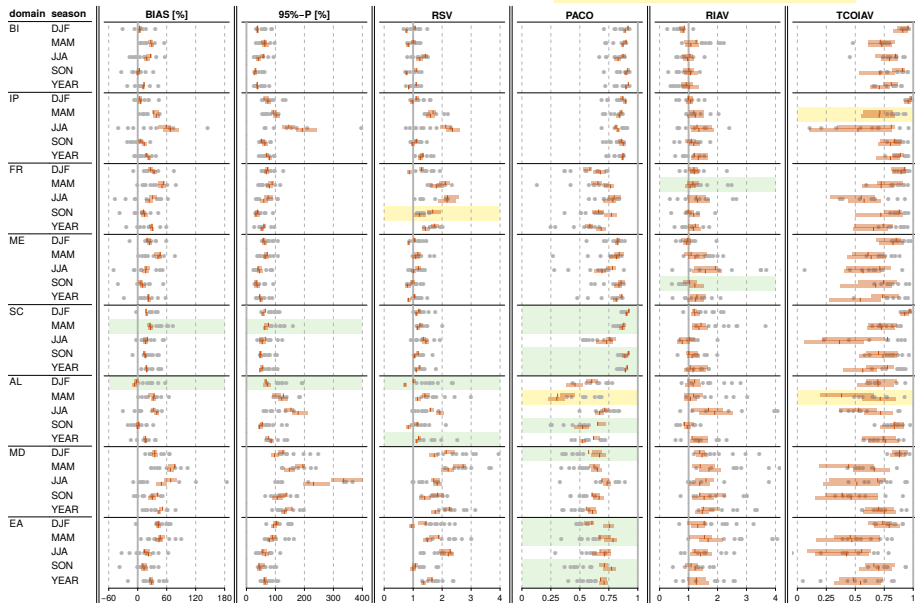
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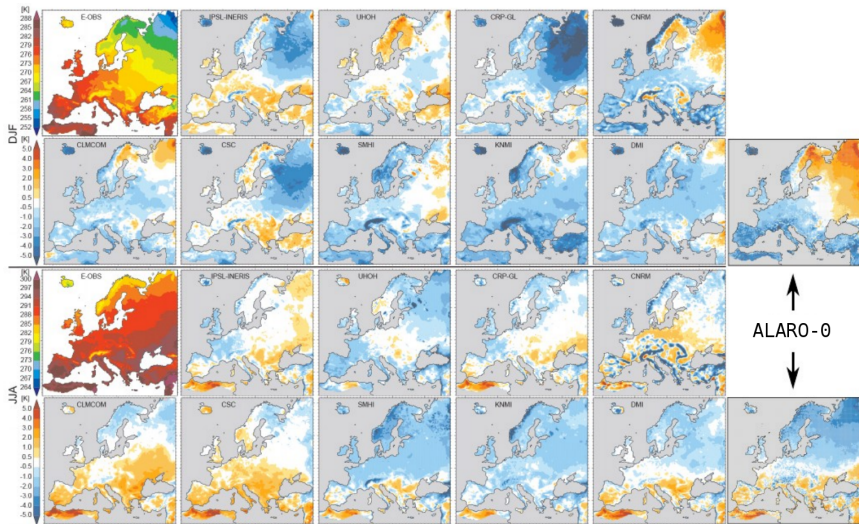
Precipitation

optimal score ● K14 models jackknife 95% confidence interval
 | RMIB-UGent (top=.11; bottom=.44)

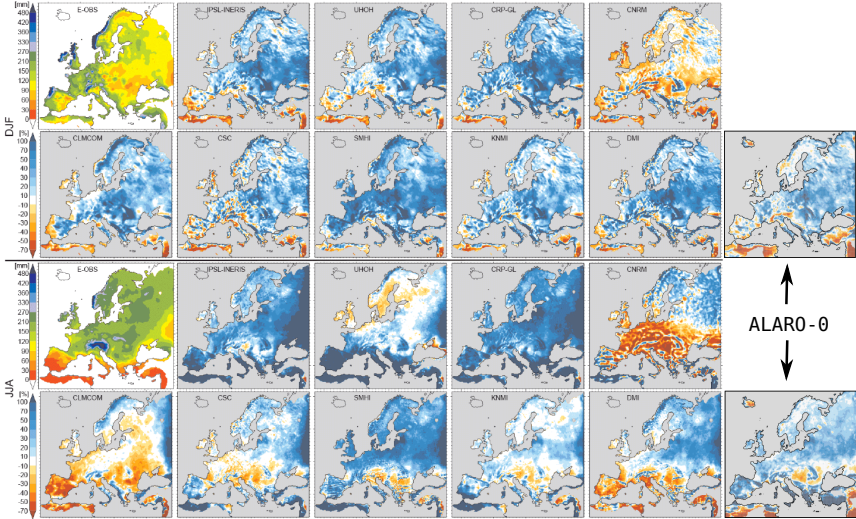
white background: RMIB-UGent is in K14
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Temperature bias patterns



Precipitation bias patterns



Conclusions

A **state-of-the-art** validation was performed of the ALARO-0 evaluation run of RMIB-UGent, following standardized metrics.

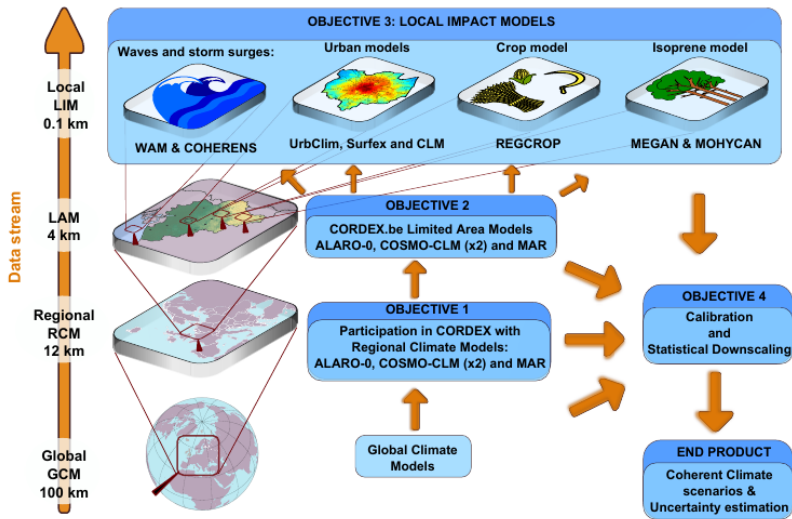
- ALARO-0 performs well, despite not being tuned for climate: cfr. white/green backgrounds
- Temperature biases persist in Scandinavia / Eastern Europe (same spatial pattern as ARPEGE)
- For precipitation, ALARO-0 often outperforms all other models!

Robustness test: all scores except RIAV and TCOIAV are robust



- Dynamical downscaling of EURO-CORDEX 12.5km or 50km runs on a high-resolution $\mathcal{O}(4\text{km})$ domain over Belgium [on new HPC @ RMI]
- In addition to our contribution with ALARO-0, partner institutes use e.g. COSMO-CLM, MAR
- \Rightarrow **Ensemble** of high-resolution climate runs **for local impact modellers**

National project: CORDEX.be



Technical challenges

- Creating netCDF files that conform to the CORDEX **archive specifications**
- Processing 100s of TBs of historical files to extract TBs of data
- ... in R: new R package CordextractR (flexibility required!)

Technical challenges

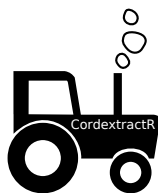
- Creating netCDF files that conform to the CORDEX **archive specifications**
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separate spacetime netCDF files for each variable

variable 1



variable n



All variables in one FAfile per model output time interval

variable 1
variable n



FA file 1



FA file 2



FA file 3



FA file 4

Technical challenges

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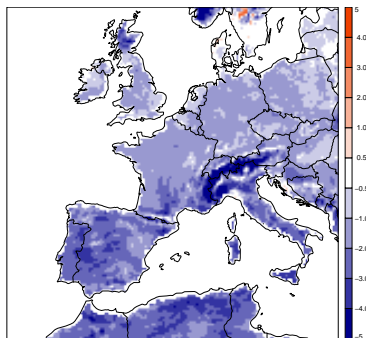
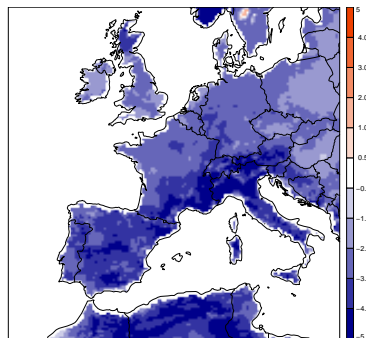
Technical challenges

- Creating netCDF files that conform to the CORDEX **archive specifications**
- Processing 100s of TBs of historical files to extract TBs of data
- ... in R: new R package CordextractR (flexibility required!)
- Submitting data to the ESGF nodes (many of which have been down for a while...)

ALARO-0 with SURFEX in climate mode

Improved DJF bias (1991-2000) 2m-temperature for ALARO-0 + SURFEX

- ALARO-0 + ISBA [left]
- ALARO-0 + SURFEX [right]



1 Multiscale

2 State-of-the-art

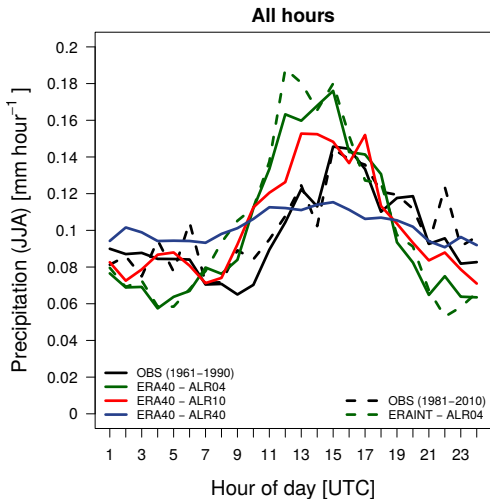
3 Added value

4 Applications

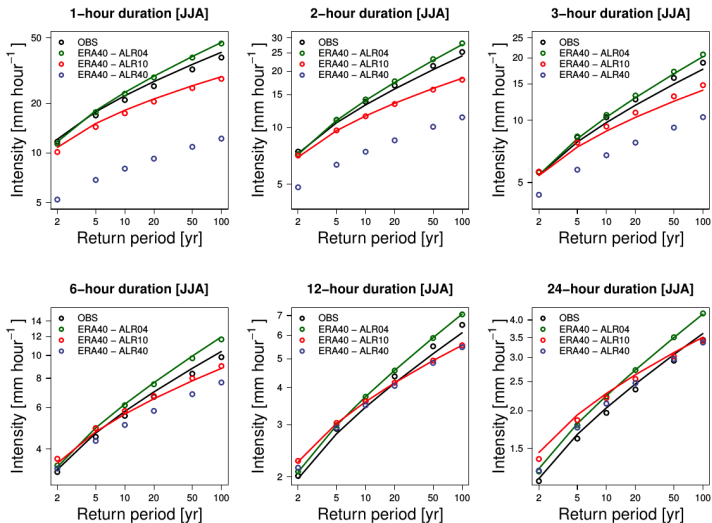
5 Outlook

Diurnal cycle Uccle

High resolution: improvement in onset and peak of convective activity



Subdaily precipitation - IDF curves

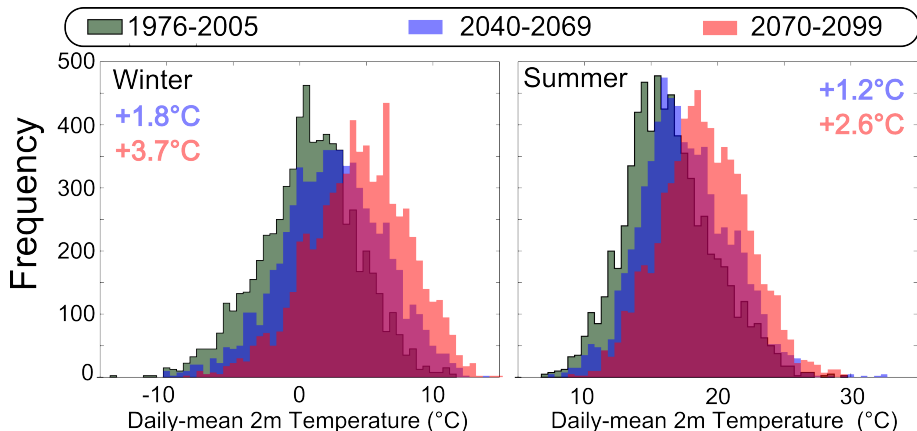


OBS: "centennial" 10-minute precipitation observation series in Uccle

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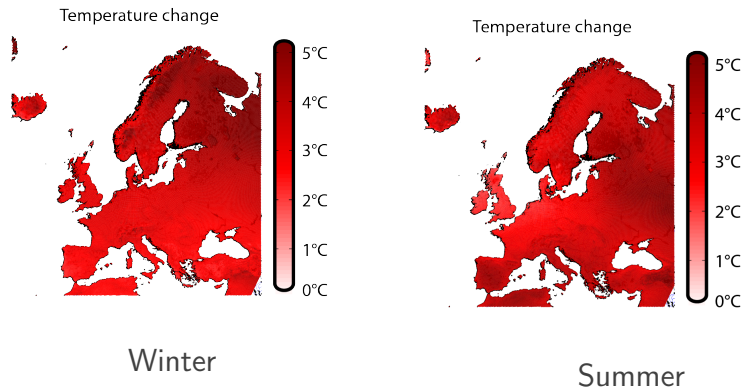
Climate projections: change in T2m, Uccle

RCP 8.5 vs historical T2m



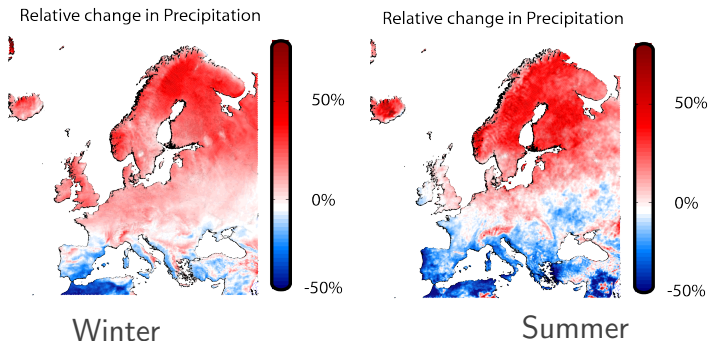
Climate projections: change in T2m, EUR-11

RCP 8.5 (2070-2100) vs historical (1976-2005)



Climate projections: change in precipitation, EUR-11

RCP 8.5 (2070-2100) vs historical (1976-2005)

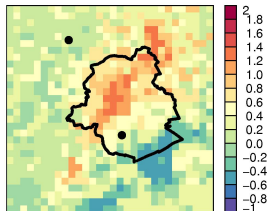


Urban climate

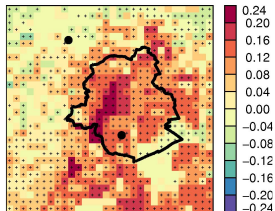
- 1-km urban dynamical downscaling technique over the Brussels Capital Regional
- Output from ALARO-0 cy36t1 + TEB + SURFEX inline is used for SURFEX offline at 1 km

Climate change impact on Urban Heat Island

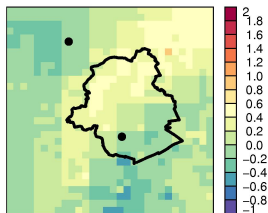
ARP_PC, Winter, UHI_N



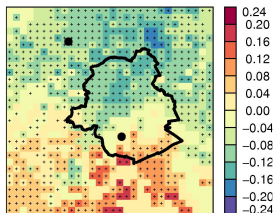
ARP_A1B-ARP_PC, Winter, UHI_N



ARP_PC, Summer, UHI_D



ARP_A1B-ARP_PC, Summer, UHI_D



Climate change impact on heat waves

UHI during HW and their interactions under present and future conditions.

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Evolution of urban heat wave intensity for the Brussels Capital Region in the ARPEGE-Climat A1B scenario



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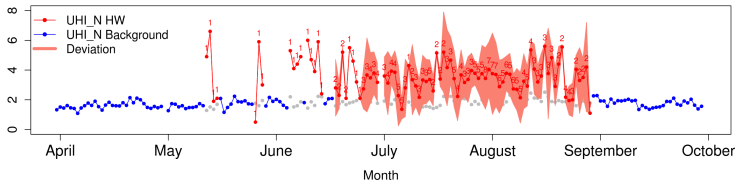
^c Centre of Excellence Plant and Vegetation Ecology (PLECO), University of Antwerp, Antwerp, Belgium

^d Belgian Interregional Environment Agency, Brussels, Belgium

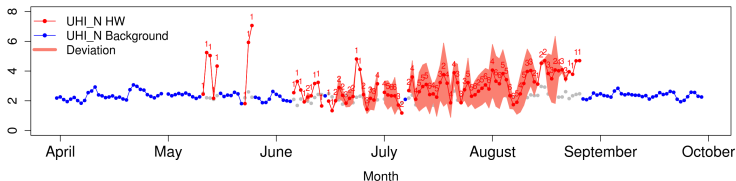
Climate change impact on heat waves

UHI: temperature difference between station of Molenbeek and Brussegem from April to October

(a) UHI_N Observed



(b) UHI_N Simulated



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Climate with ALARO-1

- Were we 'lucky'? Will our positive results hold?
- cy36t1 vs new cycle (e.g. ACRANEB vs ACRANEB2, TOUCANS, increase resolution < 4 km)
- Including SURFEX also affects the results, in particular for T2m

Thank you for your attention!
Questions?