Overview of climate research with ALARO-0 at the RMI

Julie Berckmans, Lesley De Cruz, François Duchêne, <u>Rozemien De Troch</u>, 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

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5 Outlook

Multiscale feature 3MT: NWP



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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



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Multiscale feature 3MT: Climate



R. De Troch (RMI)

Climate and ALARO-0

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2 State-of-the-art

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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
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2005-2040	-	ο	ο	✓	1
		(2005-2015)			
2040-2070	-	-	✓	✓	1
2070-2100	-	-	✓	✓	1

Validation

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 @ Author(s) 2016. CC Attribution 3.0 License.





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

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Received: 29 July 2015 – Published in Geosci. Model Dev. Discuss.: 1 October 2015 Revised: 3 March 2016 – Accepted: 4 March 2016 – Published: 30 March 2016

Climate and ALARO-0

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:

- 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? \Rightarrow 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%
 K14 models RMIB-UGent

jackknife 95% confidence interval RMIB-UGent (top=.11; bottom=.44) white background: RMIB-UGent is in K14 green background: RMIB-UGent is not in K14, but better or not the worst yellow background: RMIB-UGent is not in K14 and the worst

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

Temperature

optimal score ja

jackknife 95% confidence interval

RMIB-UGent (top=.11; bottom=.44)

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R. De Troch (RMI)

Precipitation

optimal score K14 models jackknife 95% confidence interval

RMIB-UGent (top=.11; bottom=.44)

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

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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

National project: CORDEX.be



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

National project: CORDEX.be



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 (flexiblility required!)

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 (flexiblility required!)



- 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 (flexiblility required!)

- 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 (flexiblility 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]







2 State-of-the-art

3 Added value

4 Applications

5 Outlook

R. De Troch (RMI)

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

R. De Troch (RMI)

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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)



Temperature change 5°C 4°C 3°C 2°C 1°C

Winter

Summer

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.

Urban Climate 17 (2016) 176-195



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



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^b Department of Physics and Astronomy, University of Ghent, Ghent, Belgium

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Climate change impact on heat waves

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



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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)</p>
- Including SURFEX also affects the results, in particular for T2m

Thank you for your attention! Questions?