Climate Modelling with ALARO-Surfex

Royal Meteorological Institute of Belgium

Team Introduction and Research Overview

Kwinten Van Weverberg and many others (including CHMI) | 14 April 2026 | ACCORD 6th All Staff Workshop, 13-17 April Morocco

Royal Meteorological Institute Climate Modelling Team

Team:

- **Meteorological and Climatological Research** (led by Piet Termonia):
  - **Climatological Modelling and Impact studies** (led by Rafiq Hamdi):
    - 9 permanent researchers with foci on projections, urban climate, extremes, precipitation, land-atmosphere interactions, predominantly using ALARO-Surfex
    - 4 staff members with joint positions at universities (Ghent University, KULeuven, Liège University)
    - Synergies with many PhD and master students at universities

Vision:

Underpinning research to make climate science actionable

CORDEX-BE II – Climate Projections with ALARO-Surfex

Kobe Vandelanotte, Steven Caluwaerts, Bert Van Schaeybroeck, Nicolas Ghilain

Project Overview

- Belspo funded project (Sept 2022 – Dec 2026)
- High-resolution **CPM climate simulations** for Belgium using SSP scenarios (AR6) + **EURO-CORDEX** contribution
- Partners: RMI, KULeuven, UCLouvain, ULiège, UGent, VITO
- Models: ALARO-Surfex, COSMO-CLM, MAR
- Focus on extreme weather events & stakeholder dialogue

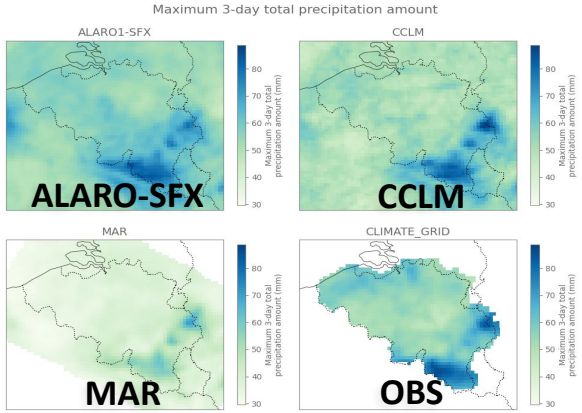
Simulation Status

https://cordex.meteo.be/simulations

- complete
- running
- planned

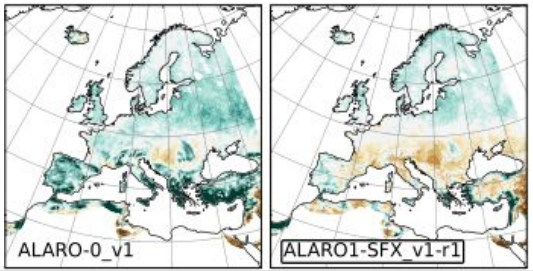
RCM	ALARO1-SFX	COSMO-CLMv6	MARv3.14
driving_GCM			
CMCC-CM2-SR5			SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist
CNRM-ESM2-1	SSP2-4.5, SSP5-8.5, SSP5-8.5, hist		
EC-Earth3-Veg	SSP2-4.5, SSP2-4.5, SSP5-8.5, hist	SSP2-4.5, SSP5-8.5, hist	SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist
ERA-5	evaluation	evaluation	evaluation
IPSL-CM6A-LR			SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist
MIROC6			SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist
MPI-ESM1-2-HR			SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist
NorESM2-MM		SSP3-7.0, hist	SSP1-2.6, SSP2-4.5, SSP3-7.0, SSP5-8.5, hist

Preliminary Results



CPMs: ERA5 driven evaluation run (1985-2014) extreme precip vs observations (CLIMATE_GRID)

RCMs: ERAint (CMIP5) and ERA5 (CMIP6) driven EURO-CORDEX. JJA precip bias vs EOBS

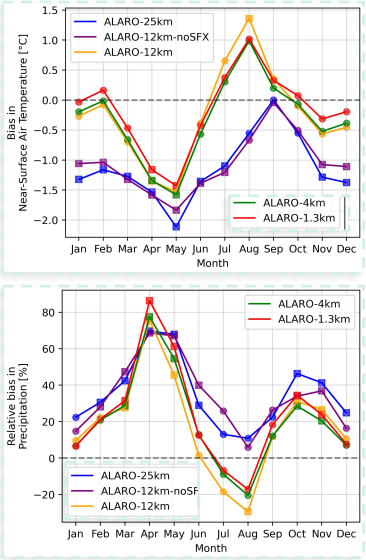


Case-Selective Downscaling with ALARO-Surfex

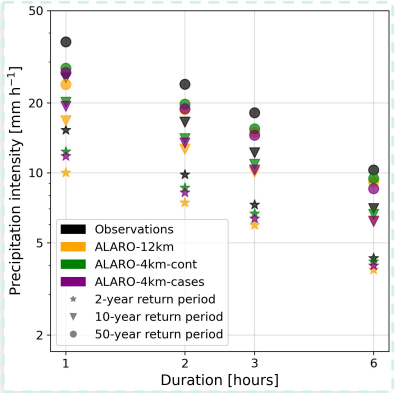
Wout Dewettinck, Hans Van de Vyver, Daan Degrauwe, Rafiq Hamdi, Michiel Van Ginderachter, Bert Van Schaeybroeck, Kwinten Van Weverberg, Kobe Vandelanotte, Steven Caluwaerts, and Piet Termonia

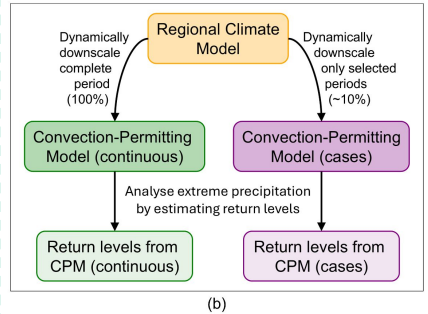
Multi-resolution validation of ALARO1-SFX over Belgium (*under review*)

- Climate simulations with ALARO1 (@ cy43t2) and SURFEX v8.0
- 31 years: 1992 - 2022
- Monthly bias over Belgium for temperature and precipitation
- Greater benefit from Surfex than from resolution
- ALARO reproduces (sub-daily) precip extremes better at high resolution



Case-Selective Dynamical Downscaling for Extreme Precipitation Statistics (*under review*)





(b)

CSDD reproduces rainfall extremes at 10 % of the cost!

Continental CPM scale runs with ALARO-Surfex

Leon Adriaensen, Steven Caluwaerts

Bridging gap from RCM to CPM:

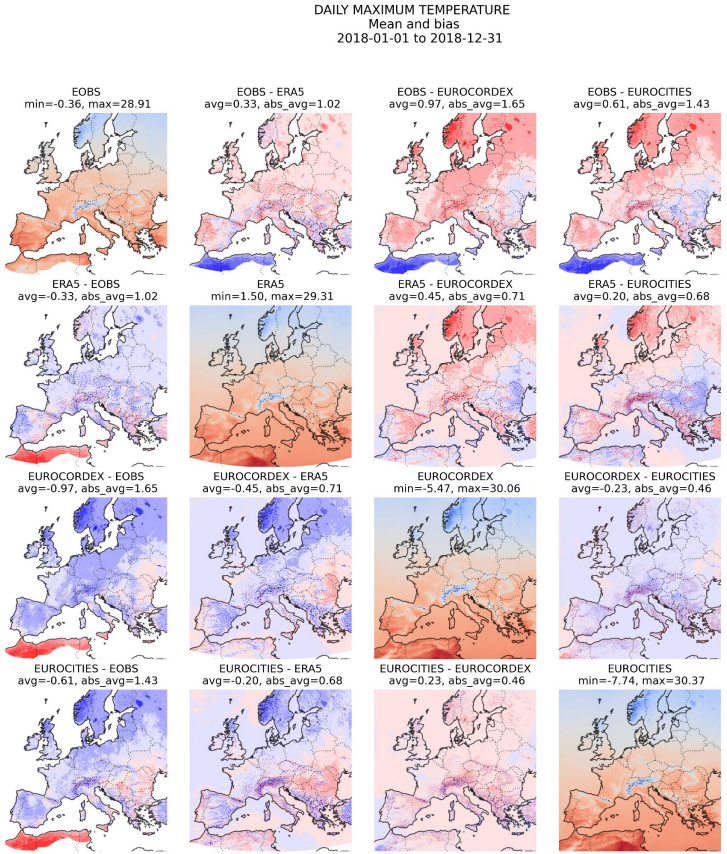
Using ALARO1-SFX @Cy43 with:

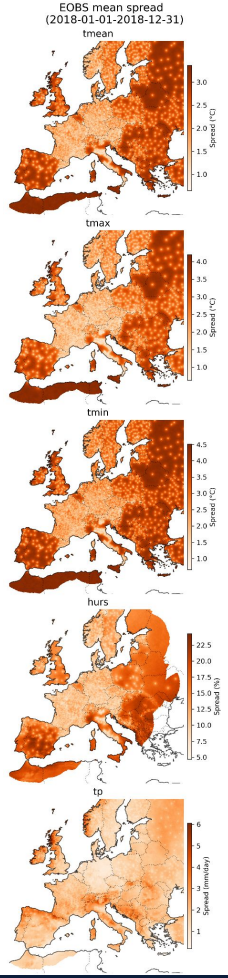
- multi layer soil scheme
- 3L-snow scheme
- Non-hydrostatic

Allows to resolve high resolution domain such as mountainous regions or cities.

Figure: comparison tmax between:

- EOBS = obs at 0.1°
- ERA5 = reanalysis at 25km
- EUROCORDEX = sim at 12.5km
- EUROCITIES= sim at 2.5km



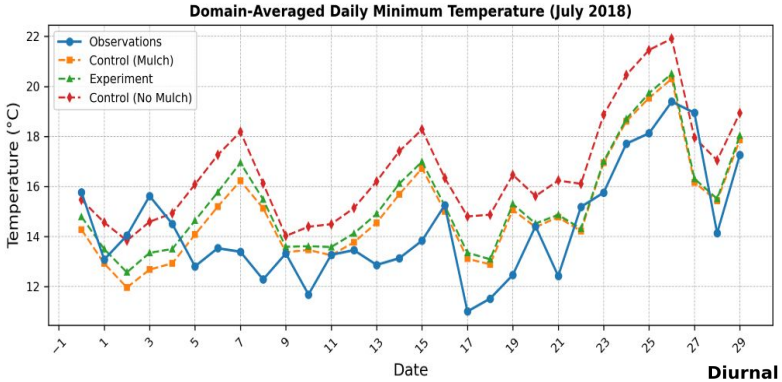


Heatwaves, Drought Dynamics and Vegetation Response

Sajjad Alghezi, Nicolas Ghilain, Kwinten Van Weverberg

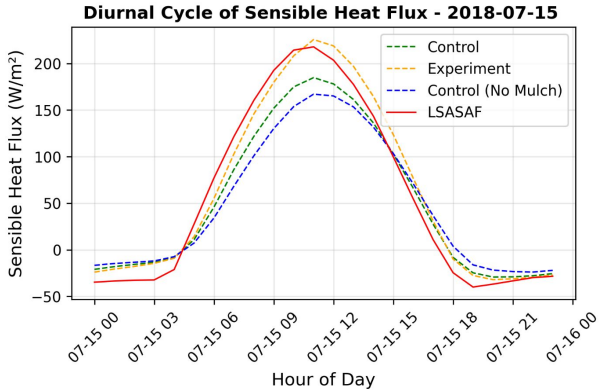
Research Focus

- Influence of satellite-observed biophysical parameters during heatwaves over Belgium using ALARO-Surfex @Cy46
- Land-surface feedbacks: soil moisture-temperature interactions during prolonged heat events
- Evaluation against in-situ observations and remote sensing products (ICOS, LSA-SAF; ESA-CCI)



Min temp overestimated during intense hot-dry month: bigger improvements from mulch than from using satellite-observed LAI/Albedo.

- Satellite-observed LAI/Albedo improves sensible heat flux (but not latent heat flux).
- Work in progress: To be complemented with offline Surfex and dedicated online simulations (separate LAI/Albedo)



Orographic precipitation in the Ethiopian Highlands

Emnet Negash, Bert Van Schaeybroeck, Kwinten Van Weverberg

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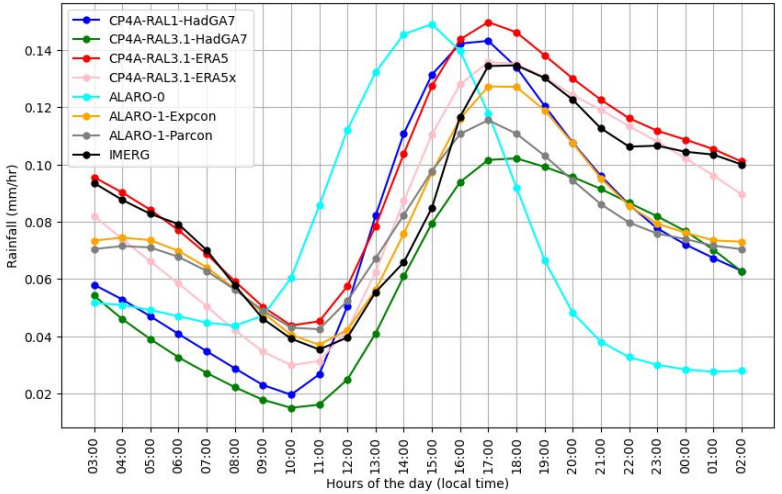
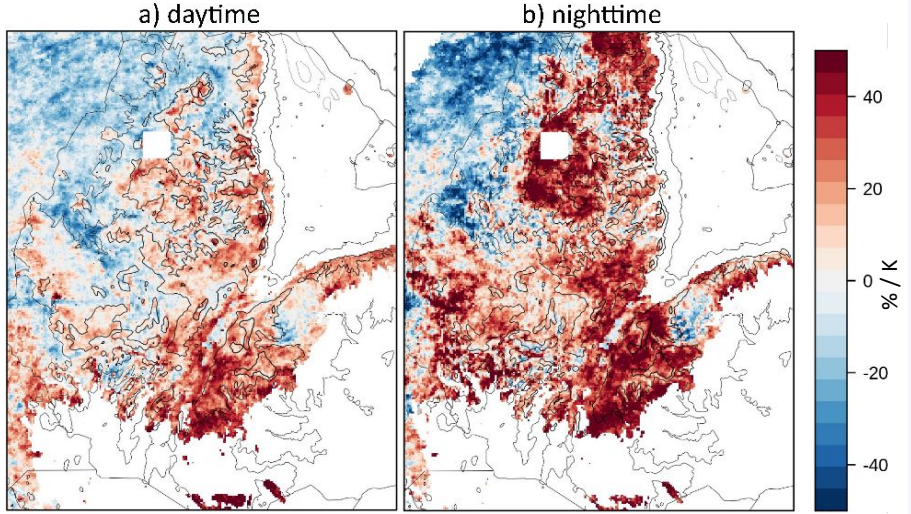
Diurnal Cycle Comparison

- ALARO1-Surfex vs UK Met Office model (Unified Model)
- Timing and intensity of afternoon convective peak
- Impact of orography on diurnal cycle representation



Clausius-Clapeyron Scaling

- Precipitation extremes scaling with temperature
- Super-CC scaling behaviour in CPM runs
- Implications for future extreme precip projections



Two-Moment Microphysics and 3MT over the Tropics

Debasish Mahapatra, David Nemec, Michiel Van Ginderachter, Kwinten Van Weverberg

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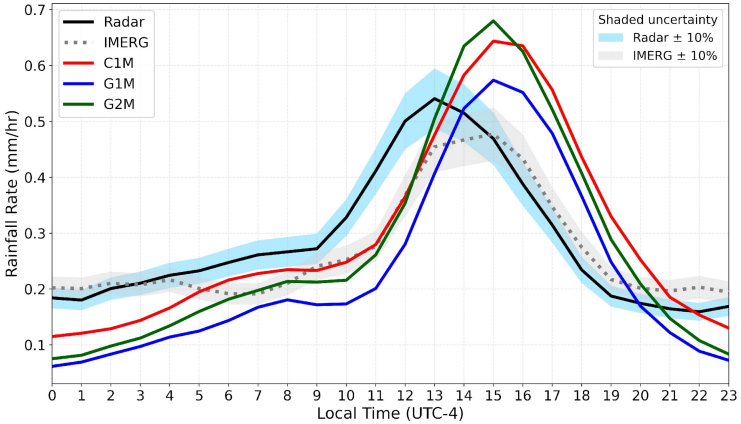
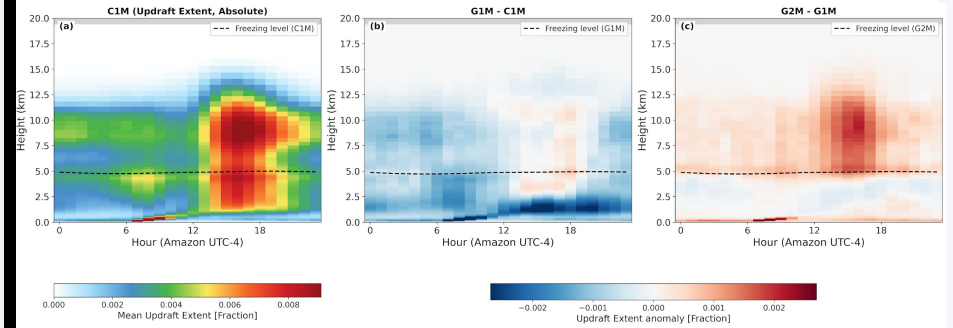
Convective Dynamics

- 2-moment microphysics scheme coupled with 3MT convection parameterisation in ALARO-Surfex @Cy46
- Focus on Amazon (testbed for tropical deep convection)
- Convective organisation, lifecycle, precip efficiency



Updraft properties



Adding graupel weakens and 2-mom intensifies updrafts

Next

- Evaluate impact of 3MT at 4 and 1 km resolution
- Evaluate storm track statistics
- Repeat analysis for other tropical areas (Central Africa and Maritime Continent)

Future Outlook

Upcoming projects

- Ongoing projects on climate projections (CORDEX-Be), downscaling and evaluation over Belgium.
- ANVIL (African Convective Systems in a Changing Climate): In-depth evaluation of ALARO-Surfex, ICON and UM over East Africa using Meteosat Third Generation (MTG) and EarthCare satellite data: improve aerosol-cloud-precipitation coupling.
- Using ALARO-Surfex to study irrigation impact on regional water balance in Xinjiang province, China.

Strategy for coming years

- Focus on urban climate, land-atmosphere interactions during heat and drought stress, and extreme precipitation in Europe and Africa.
- Keep working with ALARO-Surfex for fundamental and applied studies, and aim to contribute to model development where possible. Focus on Europe and Africa.
- AI-based approaches will be explored alongside physical model applications.
- We are interested in seeking closer alignment and finding synergies with HCLIM.