A sensitivity study with COSMO-CLM driven by ERA5 Reanalysis over Central Europe

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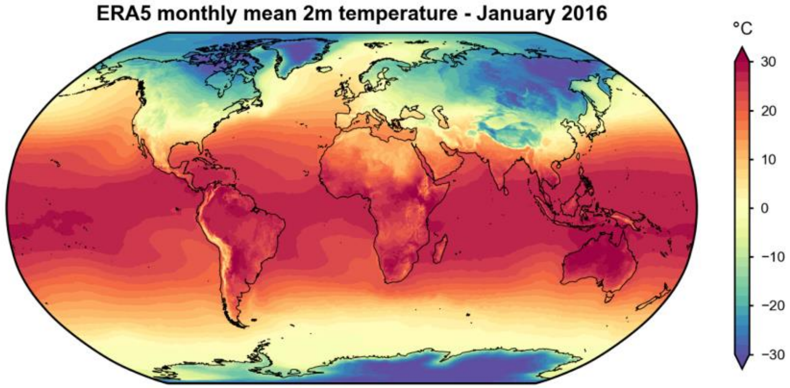
CLM-ASSEMBLY 2020
Web conference
September 17th 2020

Overview

- Motivations and scope of the work: a sensitivity analysis of RCM COSMO-CLM at convection permitting scale driven by ERA5
- Experiment setup

- Evaluation of total precipitation
    - Extremes analysis (95th and 99th percentiles)
    - Analysis at city scale: Copenhagen (DK) – Berlin (DE) – Koln (DE)
    - Sequence of precipitation events

- General remarks



https://climate.copernicus.eu/climate-reanalysis

Motivations and scope of the work

ERA5 is the latest climate reanalysis produced by ECMWF, replacing the ERA-Interim reanalysis, which stopped being produced on 31 August 2019.

Main features of ERA5:

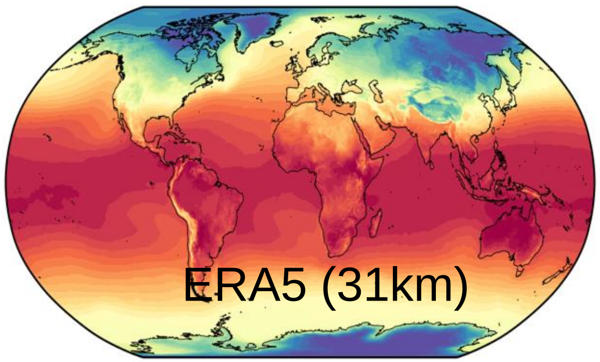
- ERA5 is available on regular latitude-longitude grids at 0.25° x 0.25° resolution, with atmospheric parameters on 37 pressure levels.

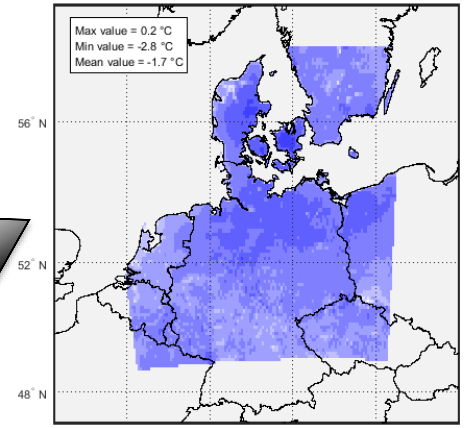
Compared to ERA-Interim,

- ERA5 has a higher spatial and temporal resolution;
- Improvement of the representation of troposphere and tropical cyclones;
- better global balance of precipitation and evaporation;
- additional differences to the computation of individual atmospheric parameters, due to the change in the assimilation systems.

In this work we performed a sensitivity study and evaluated the performances of COSMO-CLM model driven by this latest reanalysis to asset the basis of experimental setup, even in the frame of future climate studies.

Direct (1-step) or 2-step nesting strategy

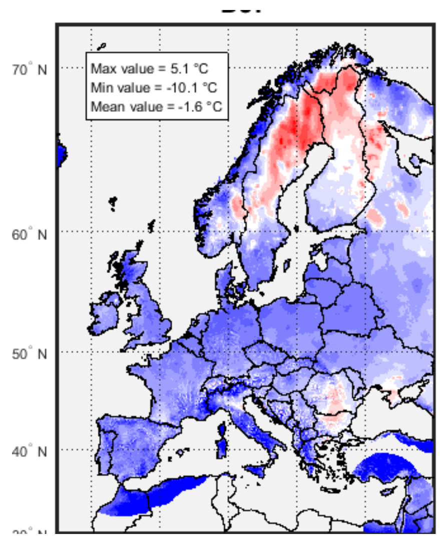




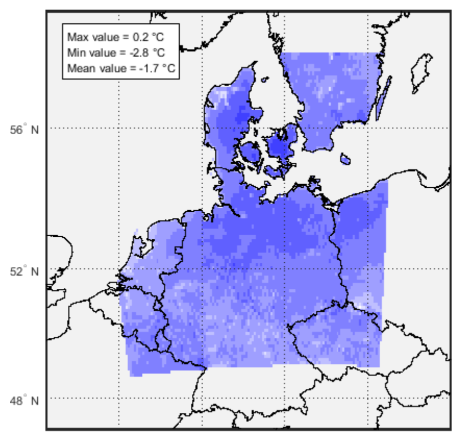
CCLM002 (2 km)

DIRECT

1:15 resolution jump



CCLM011 (12 km)



CCLM002 (2 km)

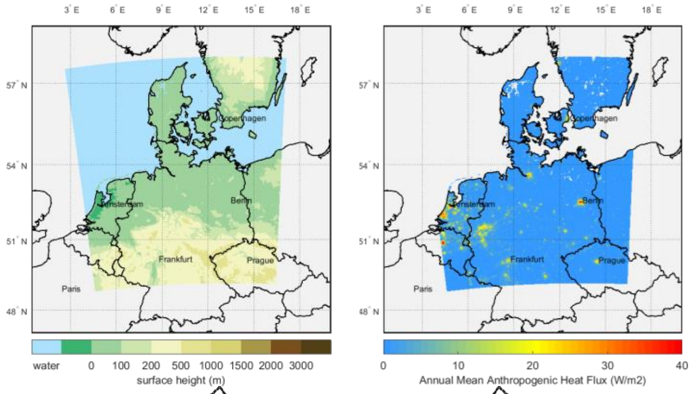
2-STEP

1:3:6 resolution jump

Experiment Setup

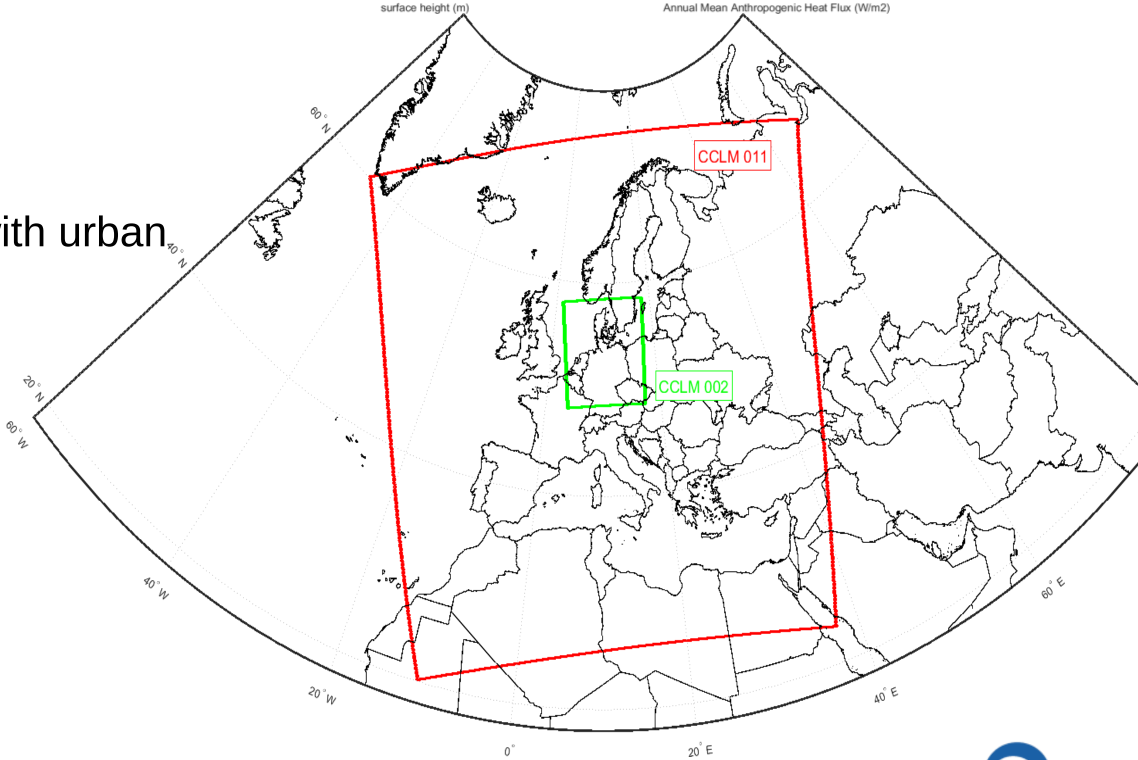
Experiment CCLM011

- RCM: COSMO-CLM v 5.00 clm9
- Nx=450, Ny=438, Nz = 40
- Euro-cordex 0.11 domain
- Resolution 0.11°, ~12 km
- Sponge zone: 30 grid points
- Period: (spin-up 2005) 2006-2011



Experiment CCLM002

- RCM: COSMO-CLM v 5.00 clm9 with urban parametrization TERRA-URB 2.3.1
- Nx=450, Ny=490, Nz = 50
- Resolution 0.02°, ~2.2 km
- Sponge zone: 25 grid points
- Period: (spin-up 2006) 2007-2011



Question: Which nesting strategy, Direct or 2-step ??

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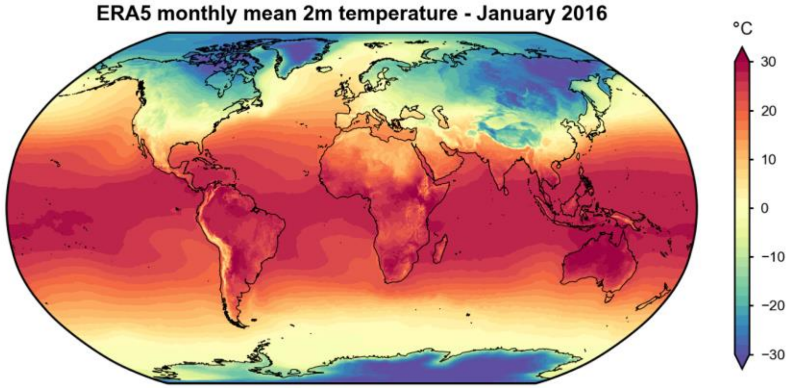

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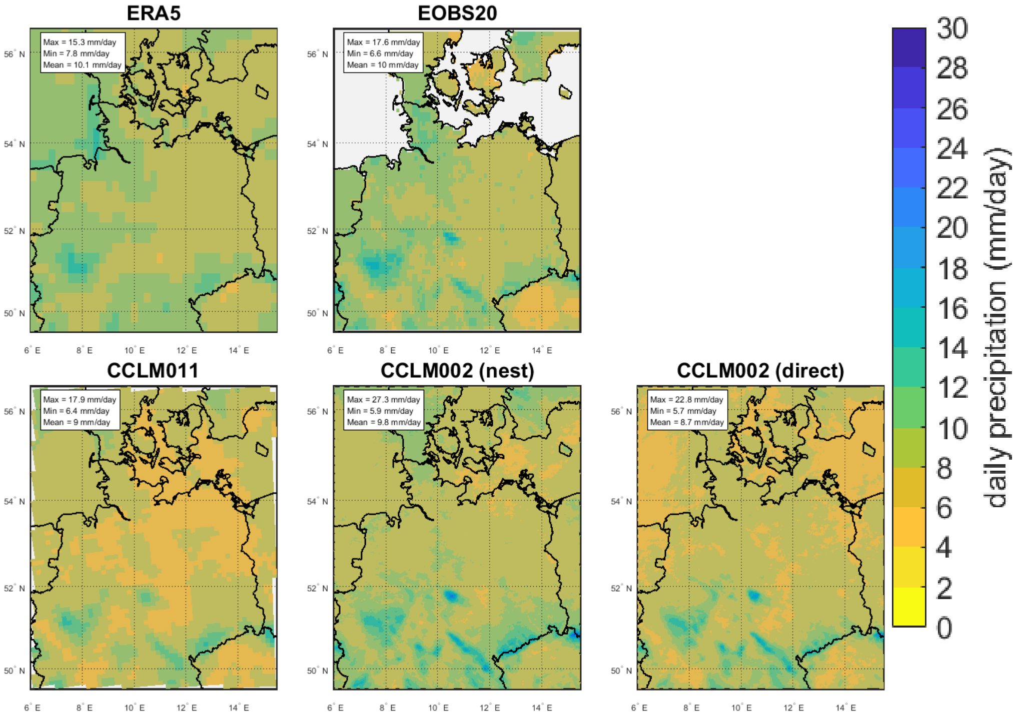
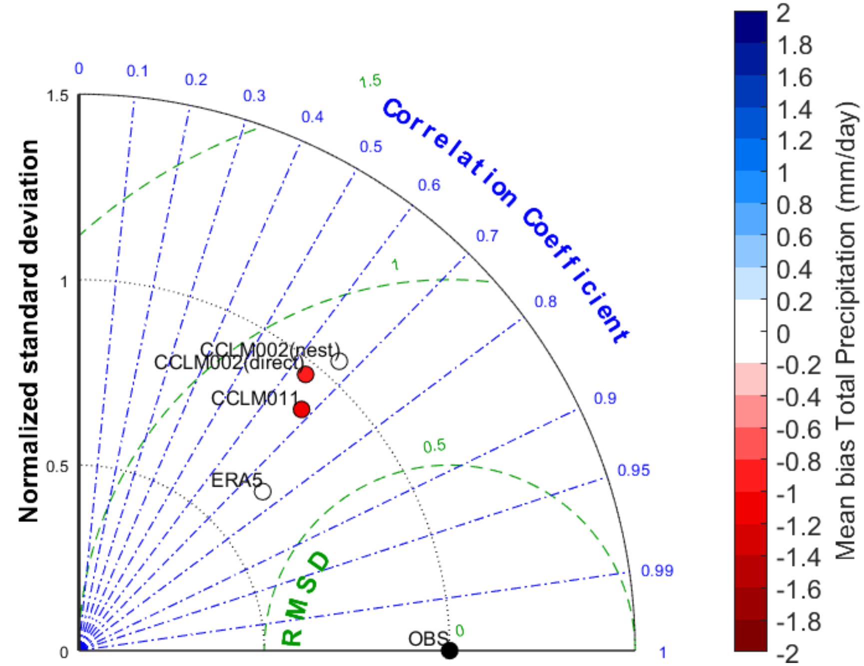
Evaluation: TOT_PREC: 95TH percentile

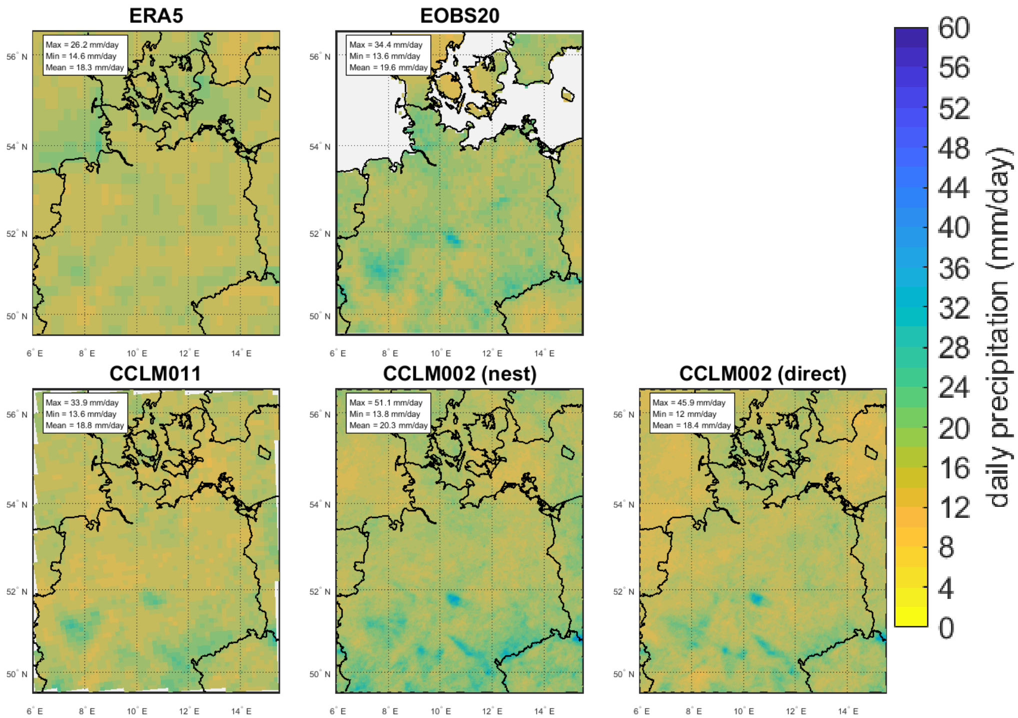


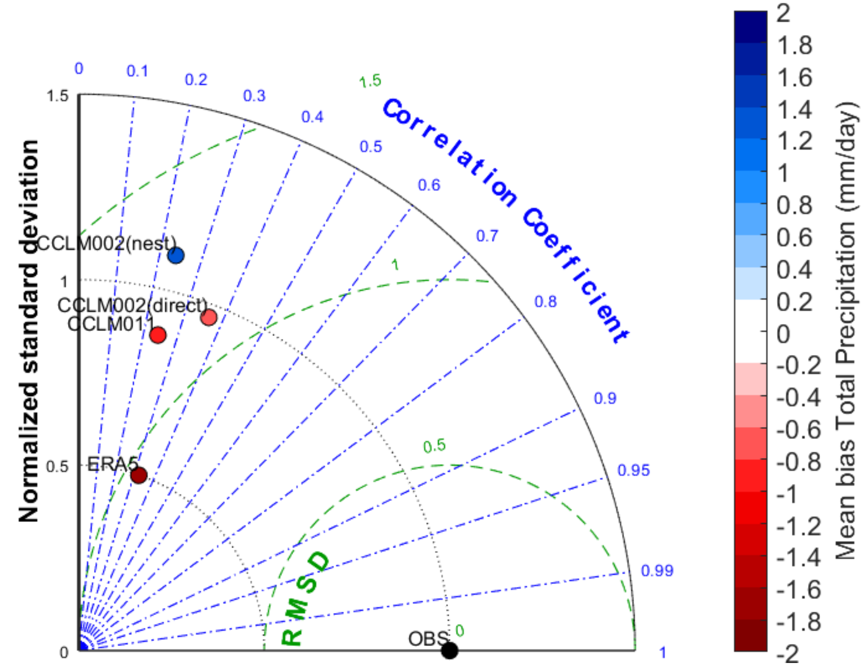


- CCLM011 decreases the magnitude of 95th percentile of daily precipitation compared with the forcing ERA5 and both CCLM002 nest and direct have similar performances in terms of magnitude and pattern of extreme precipitation.
- Both CCLM002 direct and nest generally agree with observations (similar RMSE). Nest has a slightly higher correlation with OBS (E-OBS as reference) and more variability (std >1)

	E-OBS	ERA5	CCLM011	CCLM002 nest	CCLM002 direct
mean error	0	**0.0841**	-1.0985	0.1586	-0.9090
standard deviation	1	0.6554	0.8850	**1.0495**	**0.9635**
root mean square error	0	**0.6618**	0.7632	0.8350	0.8399
correlation	1	**0.7565**	0.6784	0.6690	0.6346

Evaluation: TOT_PREC: 99TH percentile





- Direct downscaling performs the 99th percentile of daily precipitation better than 2-step, in terms of mean error and RMSE, with the highest value of standard deviation and spatial correlation.

	E-OBS	ERA5	CCLM011	CCLM002 nest	CCLM002 direct
mean error	0	-1.7215	0.9682	1.2836	**-0.6806**
standard deviation	1	0.4995	0.8769	1.0969	**0.9641**
root mean square error	0	0.9623	1.1587	1.2963	**1.1084**
correlation	1	0.3237	0.2431	0.2383	**0.3635**

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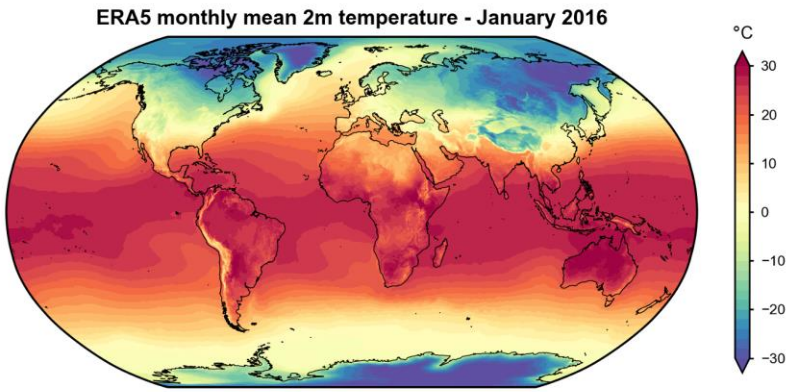

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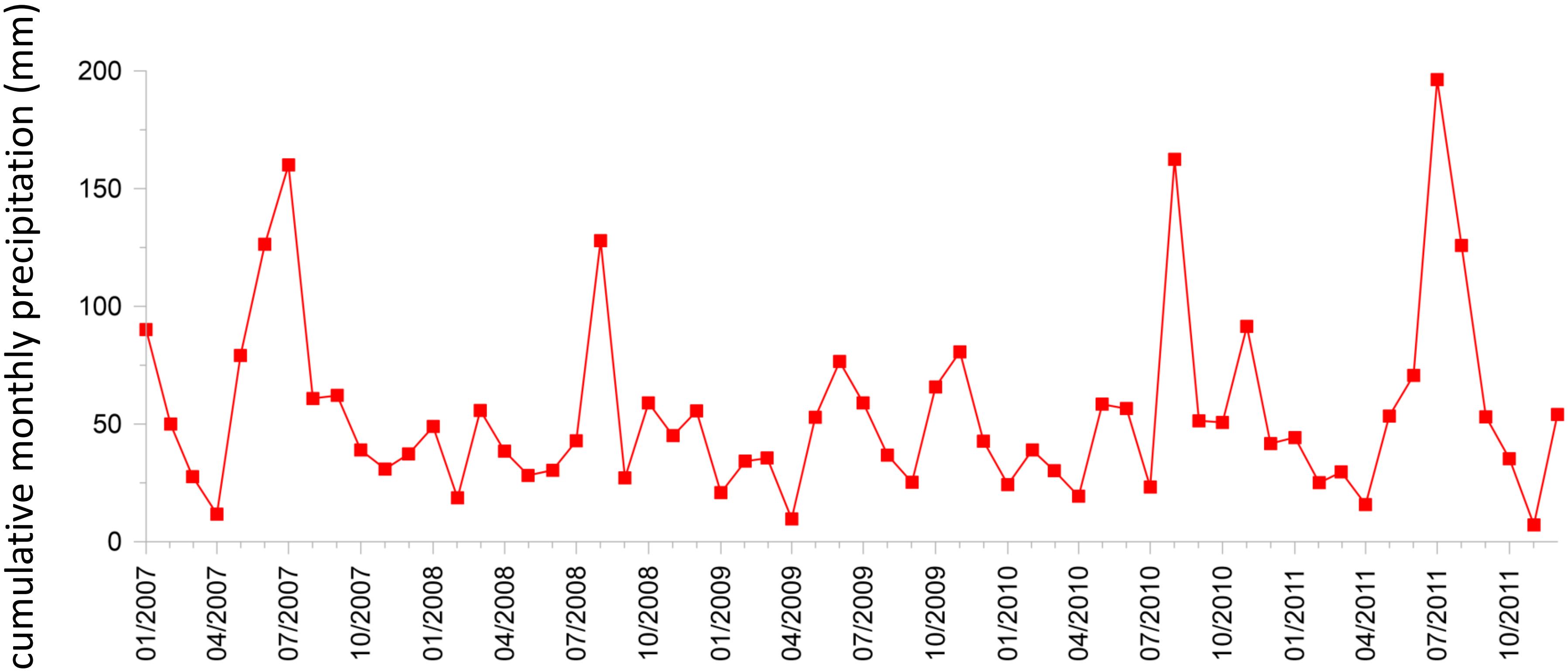
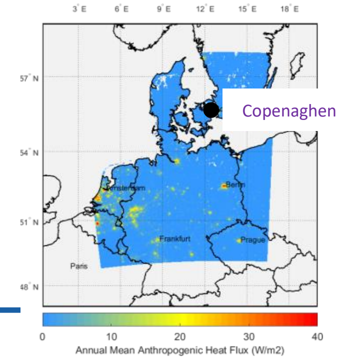
Evaluation at city scale: Copenhagen (DK)
Time-series of monthly prcptot (2007-2011)

E-OBS





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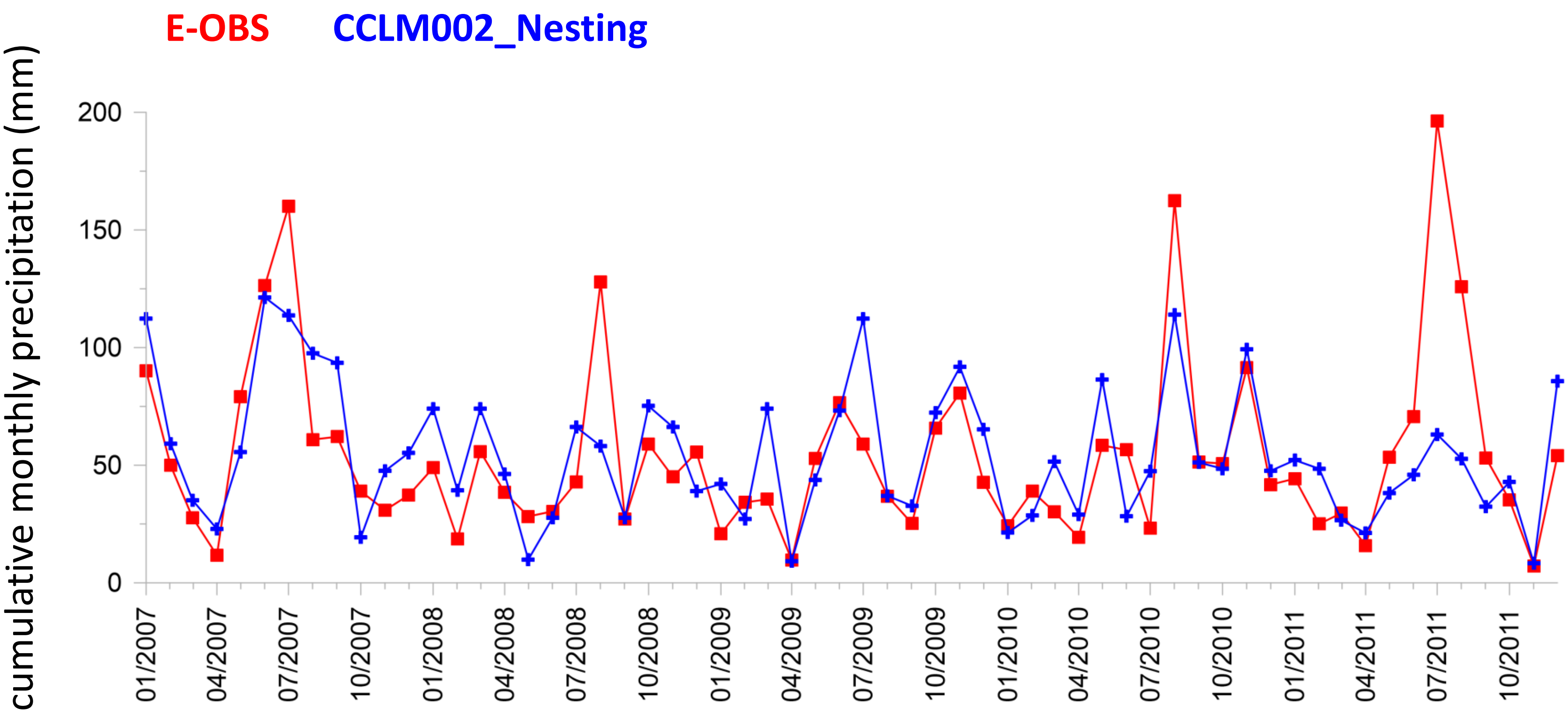

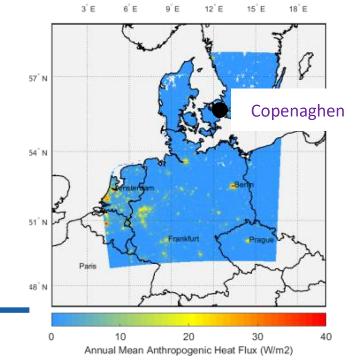

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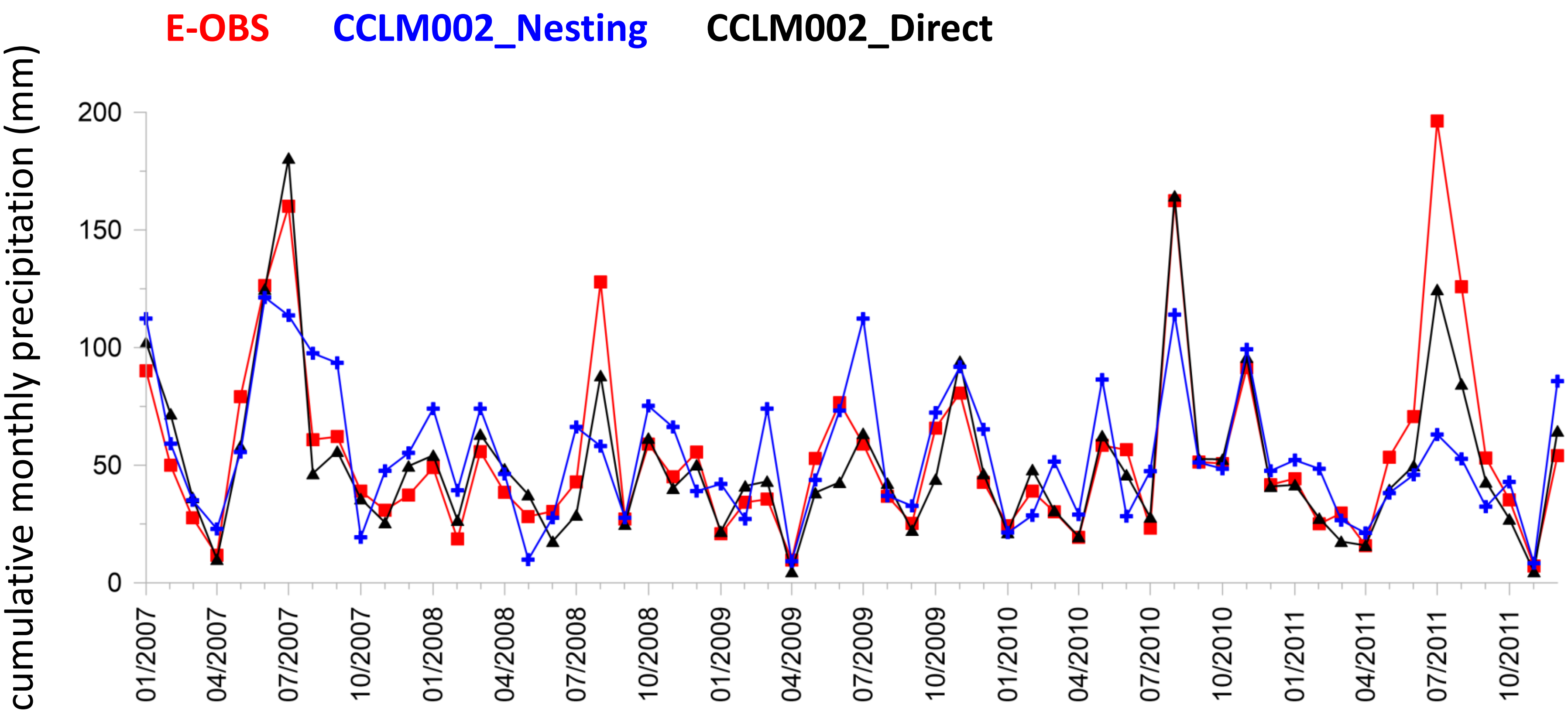
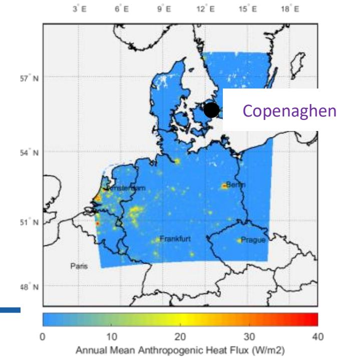
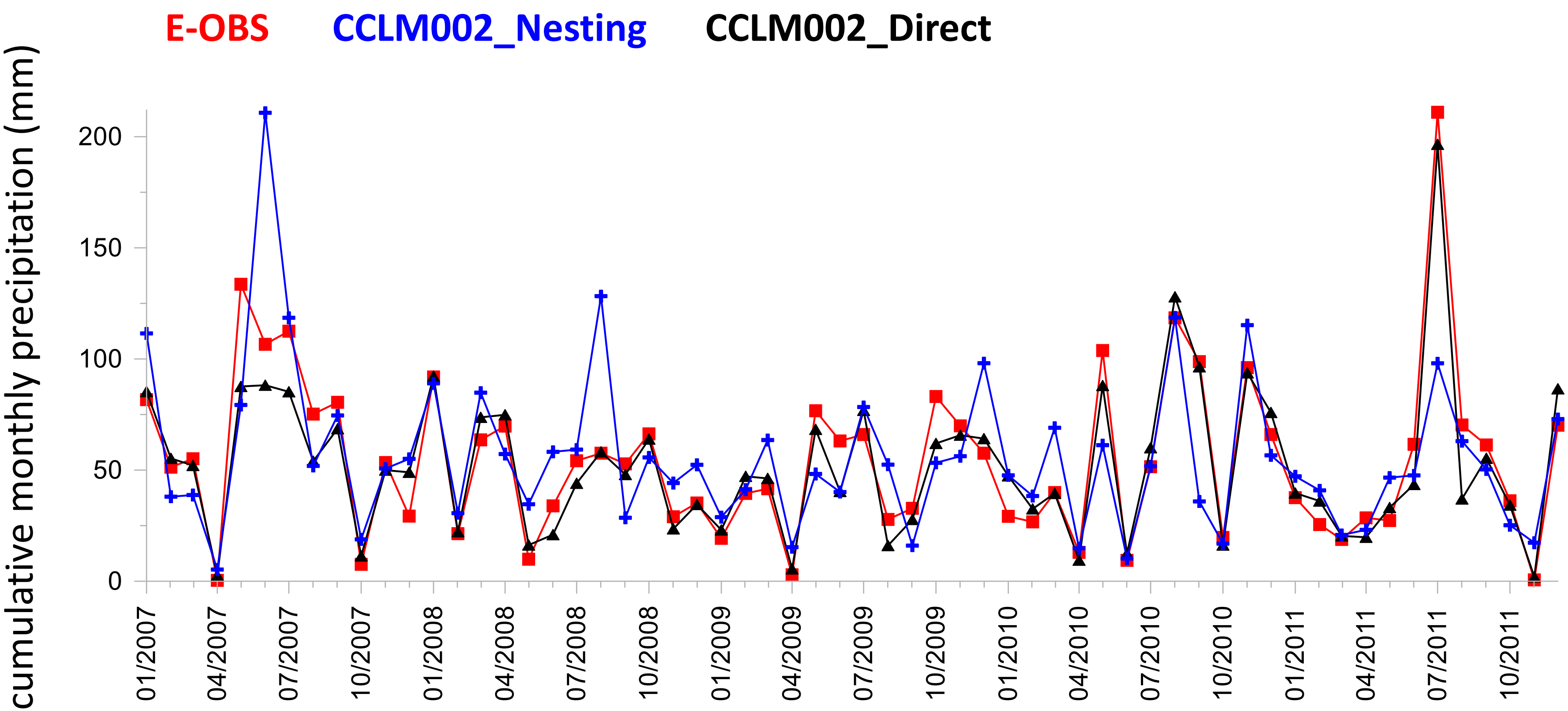


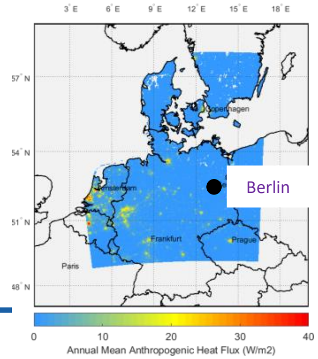
Correlation EOBS vs CCLM002_Nesting = 0.64

Correlation EOBS vs CCLM002_Direct = 0.92



Evaluation at city scale: Berlin (DE)
Time-series of monthly prcptot (2007-2011)

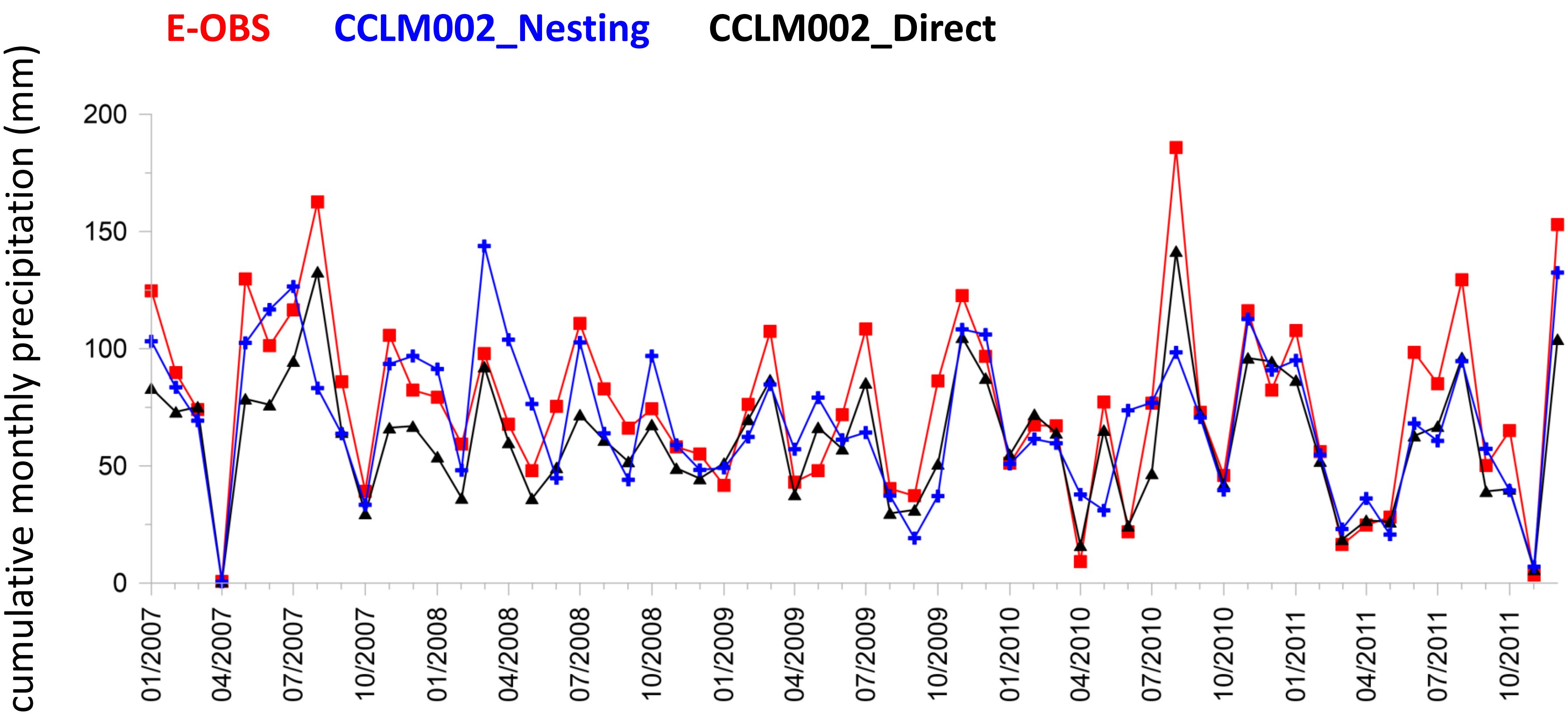




Correlation EOBS vs CCLM002_Nesting = 0.67

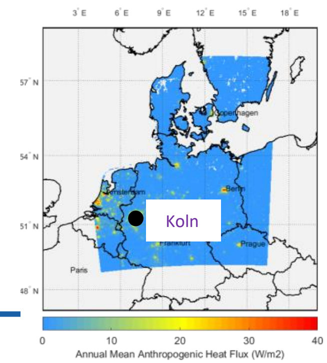
Correlation EOBS vs CCLM002_Direct = 0.95

Evaluation at city scale: Koln (DE)
Time-series of monthly prcptot (2007-2011)



Correlation EOBS vs CCLM002_Nesting = 0.75

Correlation EOBS vs CCLM002_Direct = 0.93



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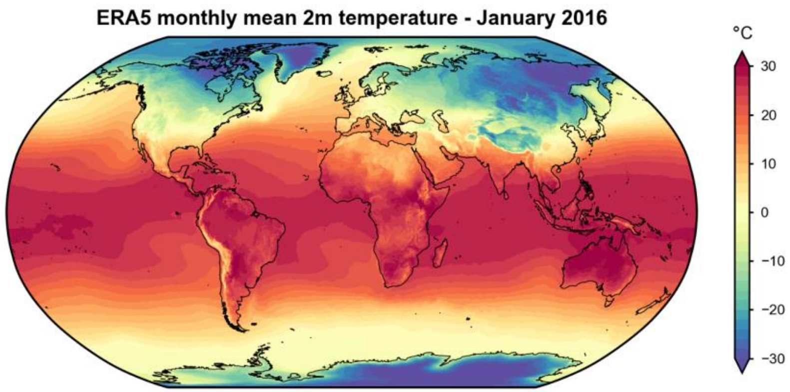

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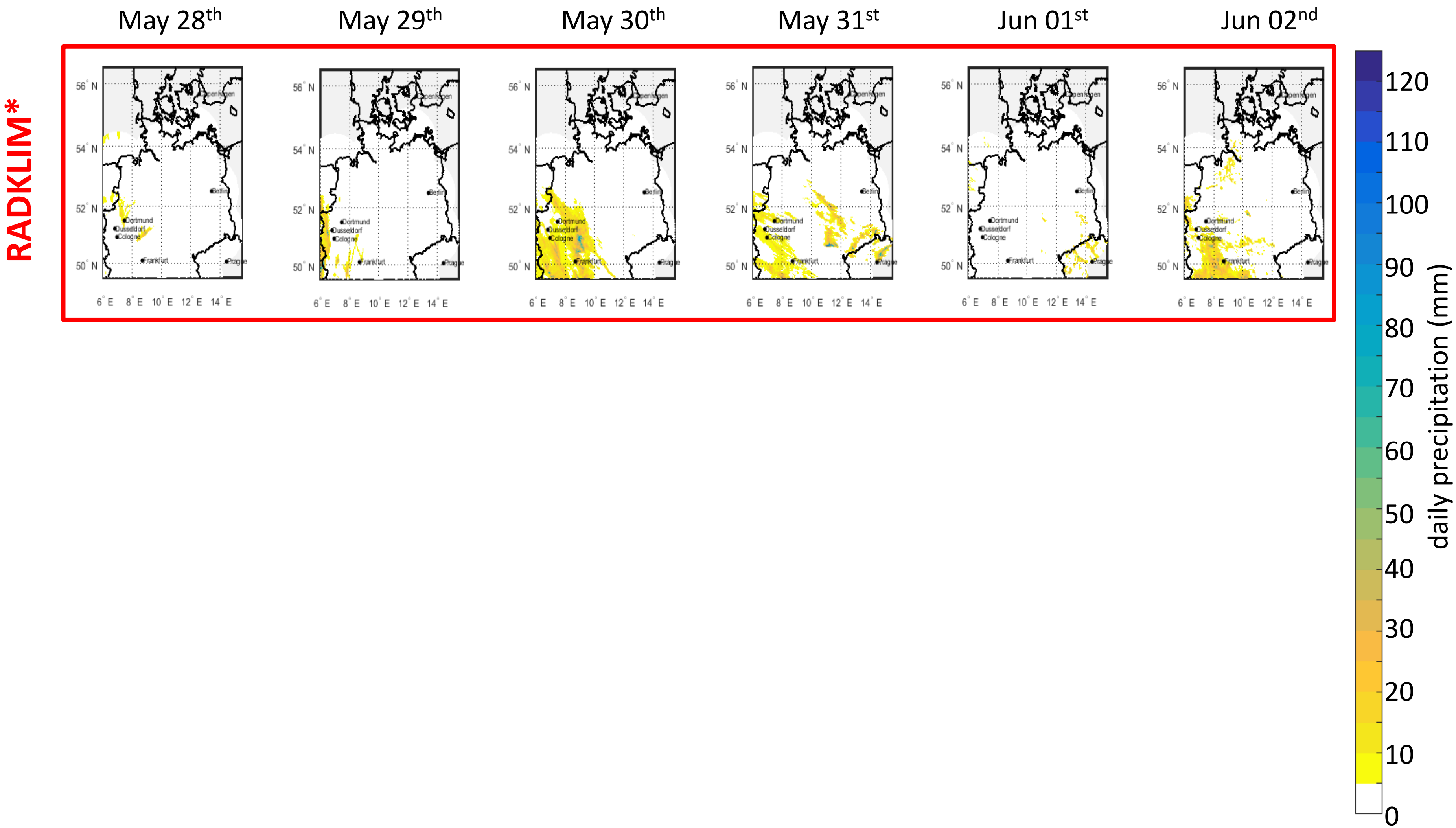
Sequence of precipitation events 28/May/2008 – 02/Jun/2008



Winterrath at al., 2018a, b

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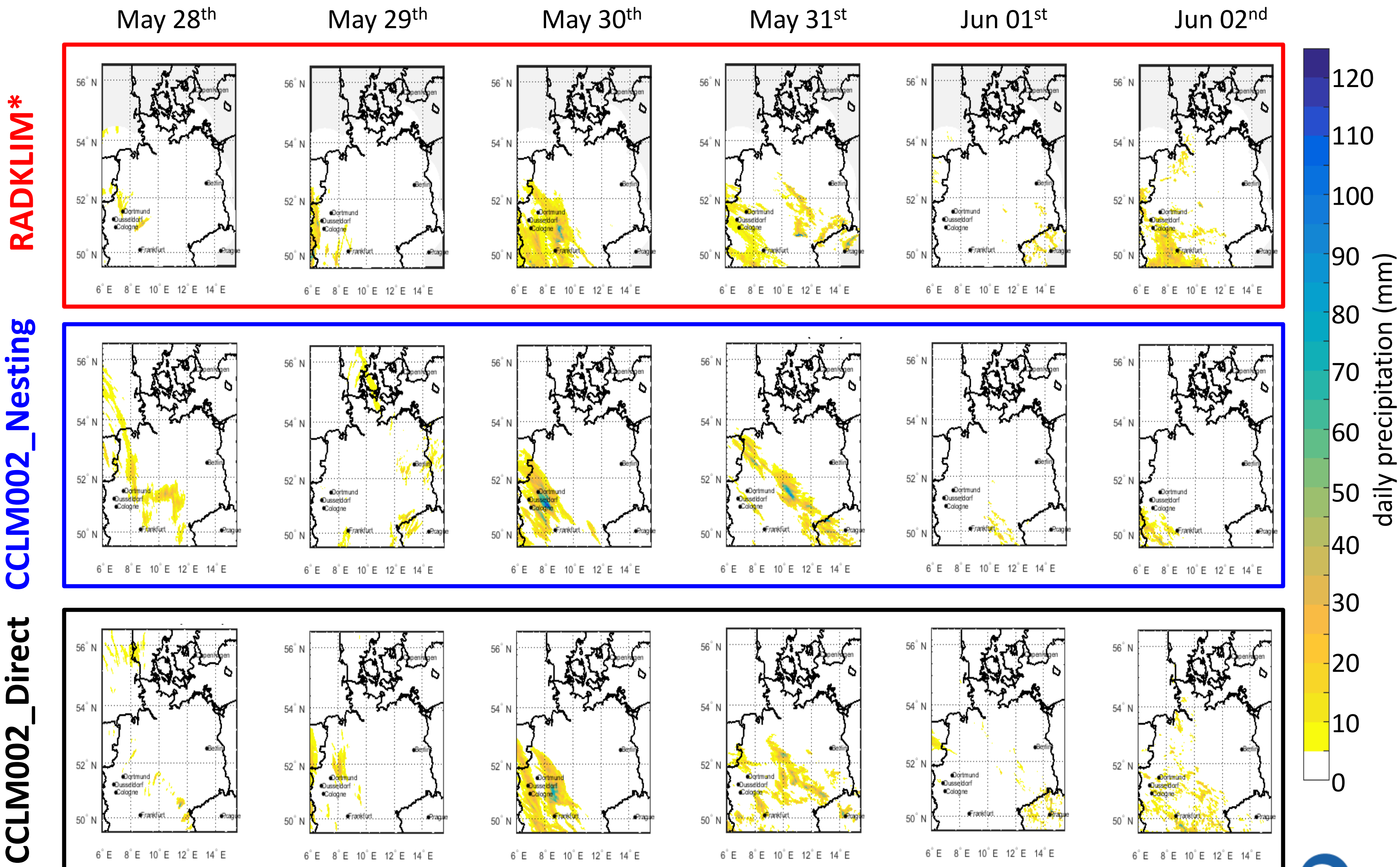
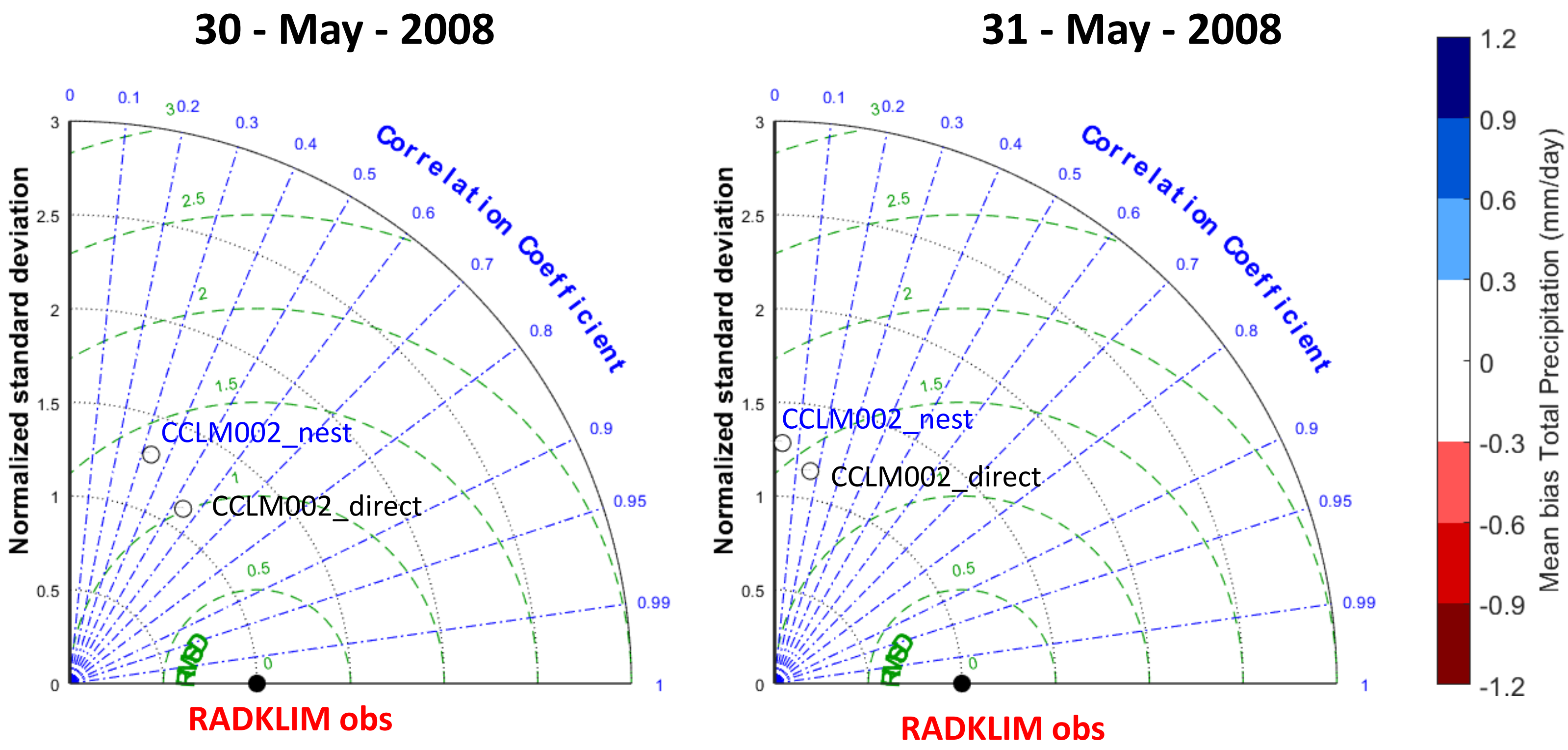


*Winterrath at al., 2018a, b

Sequence of precipitation events: statistics



- For both days, direct downscaling performs better than 2-step, in terms of RMSE and standard deviation. It's evident an improvement of the correlation, especially on 30 May when the peak of precipitation occurred.

General remarks

In this work, we presented a sensitivity analysis of COSMO-CLM driven by ERA5, at convection permitting scale (0.02°).

The configuration has been tested through a pilot experiment aimed at:

- evaluating reliability and robustness of the nesting strategies;
- evaluating the coherence and consistency of the ERA5 downscaling at VHR, in comparison with observational datasets in terms of extremes of precipitation.

MAIN RESULTS

Generally, these preliminary results highlight that ERA5 directly downscaled with CCLM at 0.02° shows better performances in the most of analysis:

- **Extremes**: 99th percentile of daily precipitation is better performed from direct nesting strategy
- **At city scale:** The direct downscaling provides coherent and reliable results with respect to the observations, capturing trend and peaks of monthly precipitation
- **Sequence of precipitation events**: The investigated event of precipitation is better localized by the direct downscaling.

Thanks

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Acknowledgments

The ongoing activity is performed using the COSMO model in CLimate Mode (COSMO-CLM). We acknowledge the members of the CLM-Community for their common efforts to provide the reference model setup, the forcing data and maintain the codes.

A special acknowledgment to Burckhardt Rockel (HZG) for the great effort to pre-process the ERA5 data for all CLM-Community