First look at the influence of moisture scheme on long-term CPC simulations with RegCM

Michal Belda
Department of Atmospheric Physics, Charles University, Prague

In cooperation with Emanuela Pichelli (ICTP), Tereza Nováková and Tomáš Halenka

Ninth ICTP Workshop on the Theory and Use of Regional Climate Models, 2018

Convection permitting climate modeling

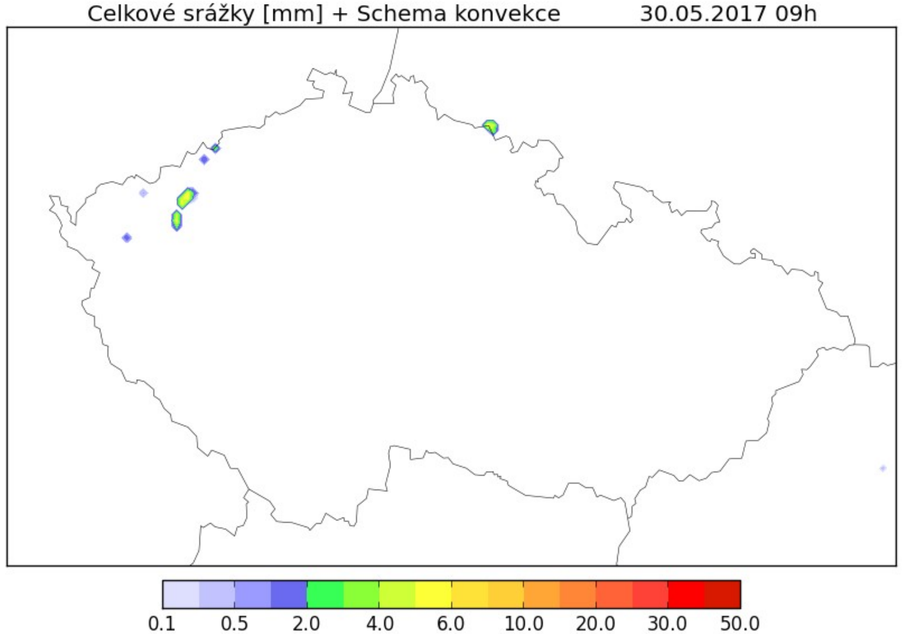
- Climate models run with a horizontal resolution in kilometer scale
- Better representation of local climate features
- Moving away from parameterized to explicit convection
- CPC FPS study within CORDEX initiative - multi-model convection permitting ensemble for investigating convective phenomena over Europe and the Mediterranean

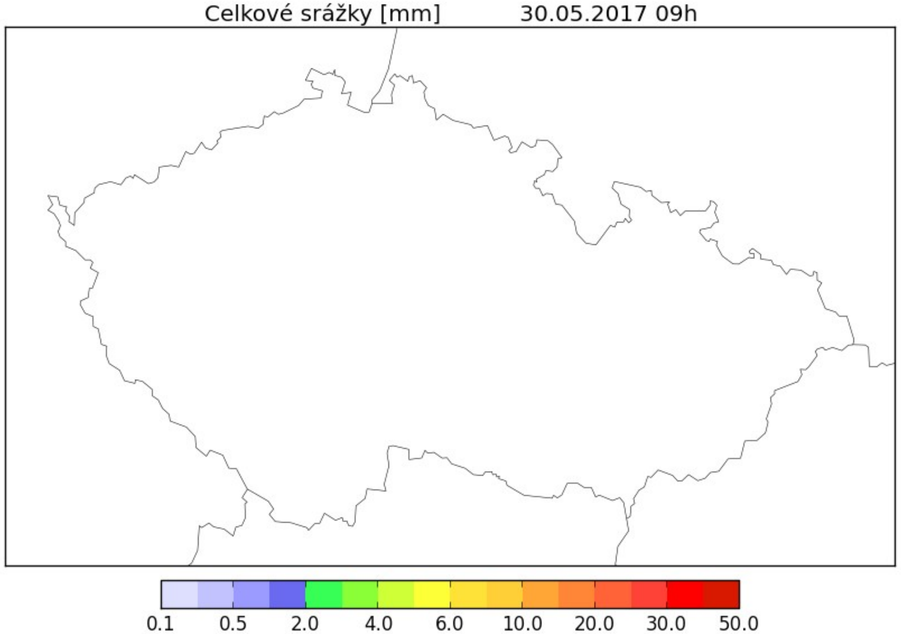
Case study with WRF

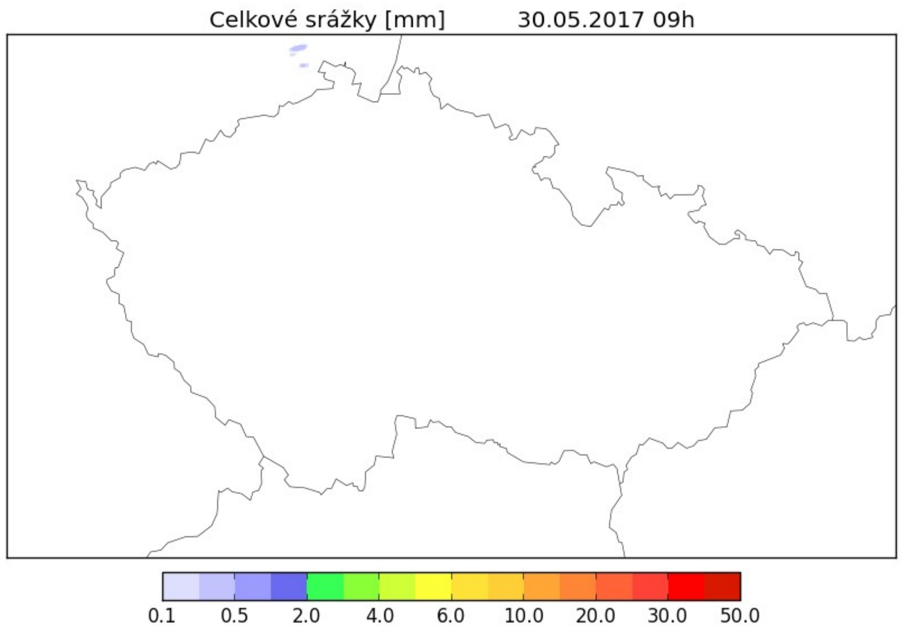
- WRF model in NWP mode
- Event: 30 May 2017
- Three simulations:

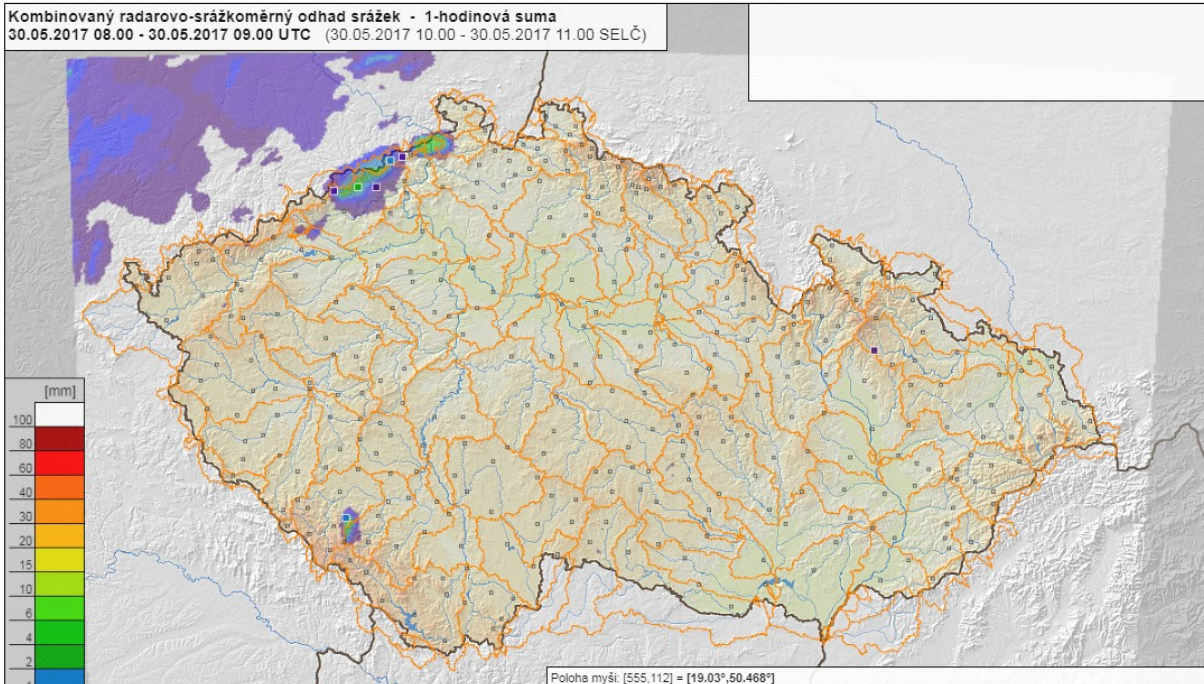
1. WRF in 3 km resolution with convection parameterization
2. WRF in 3 km resolution without convection param.
3. WRF in 1 km resolution without convection parameterization

Case study with WRF

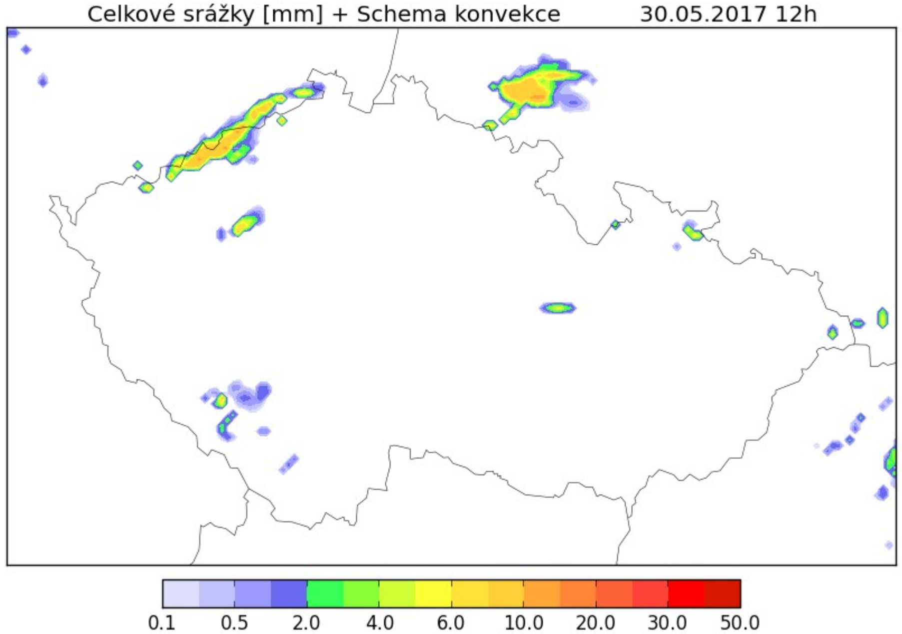


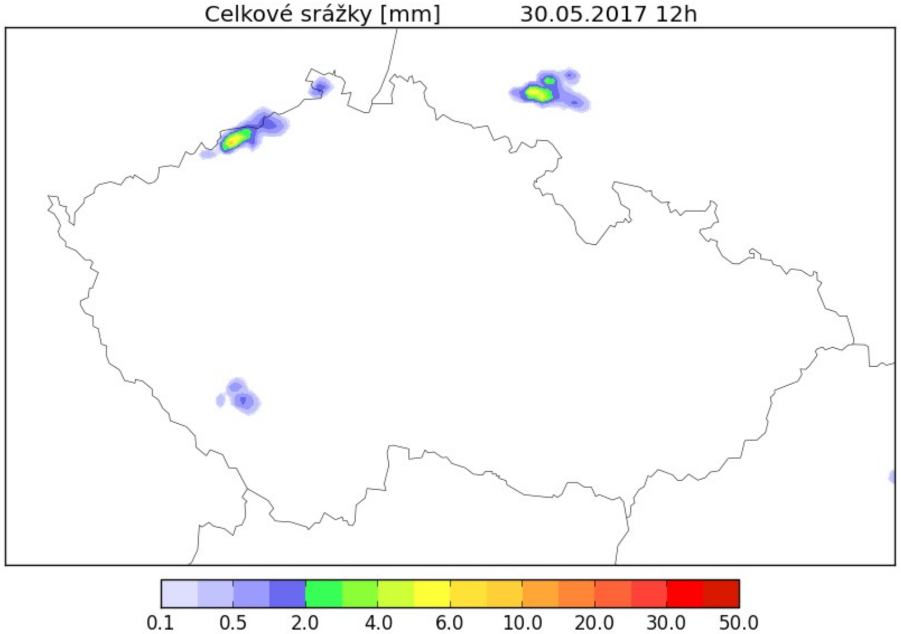


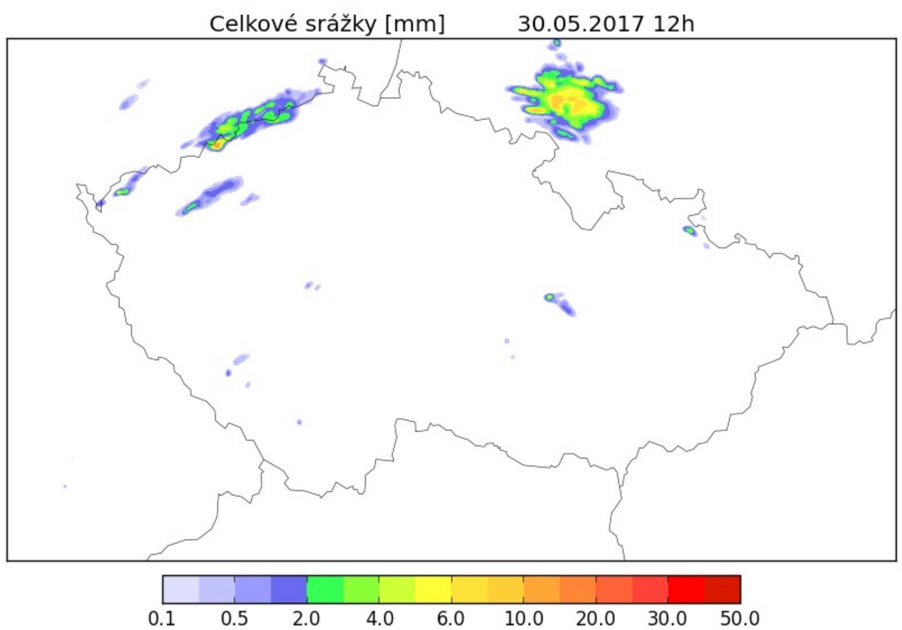


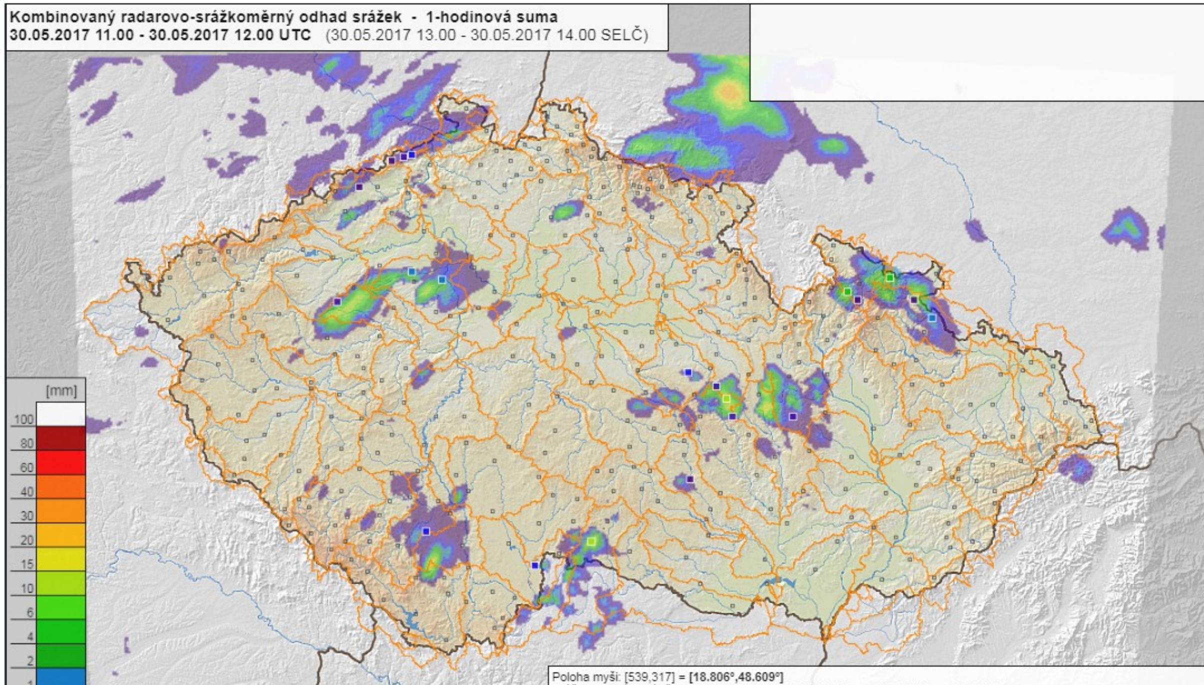


Case study with WRF

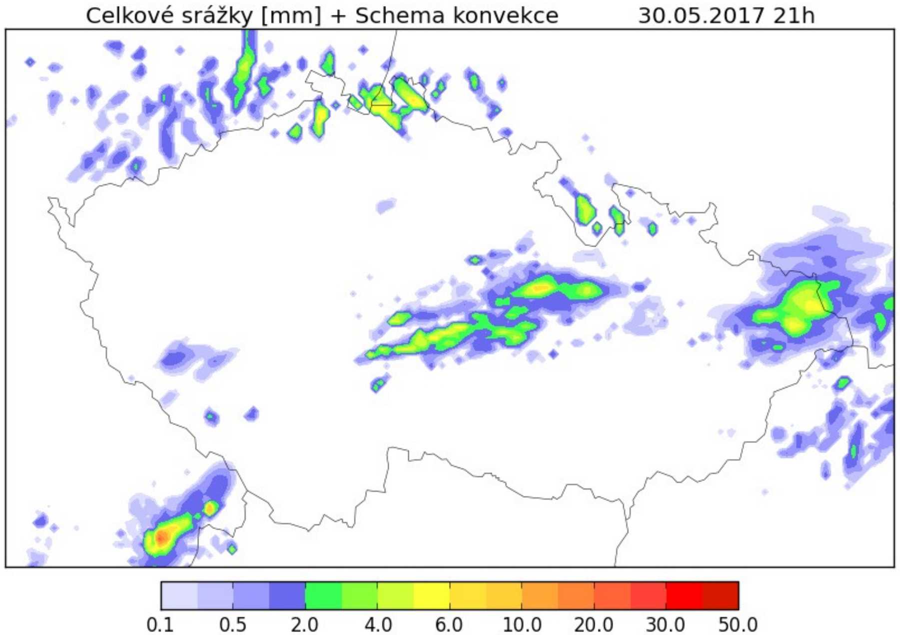


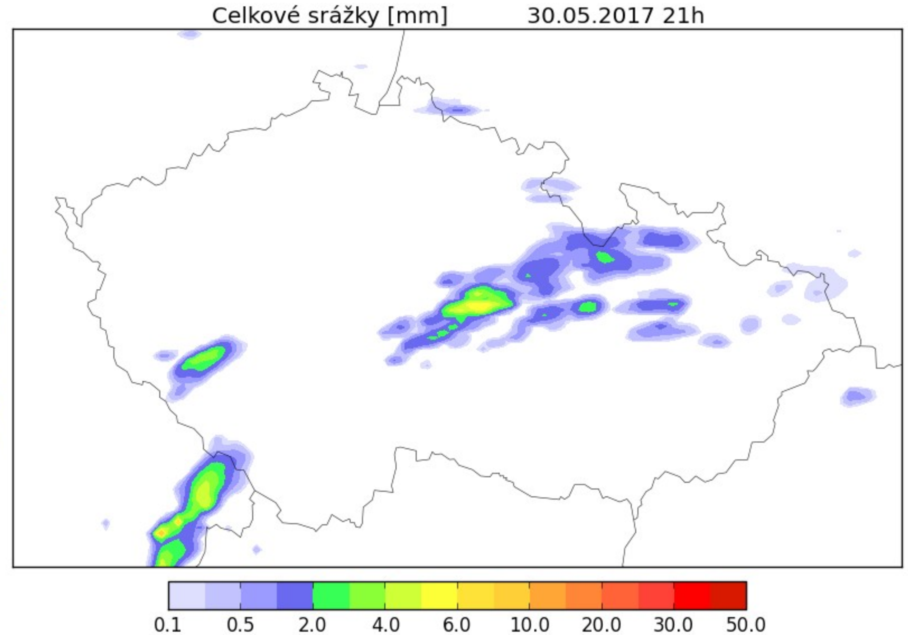


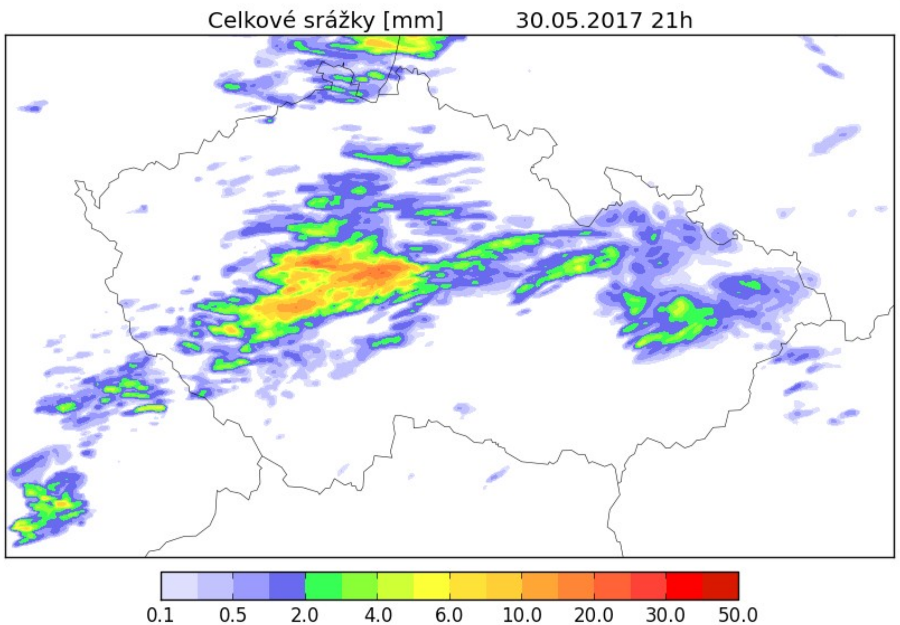


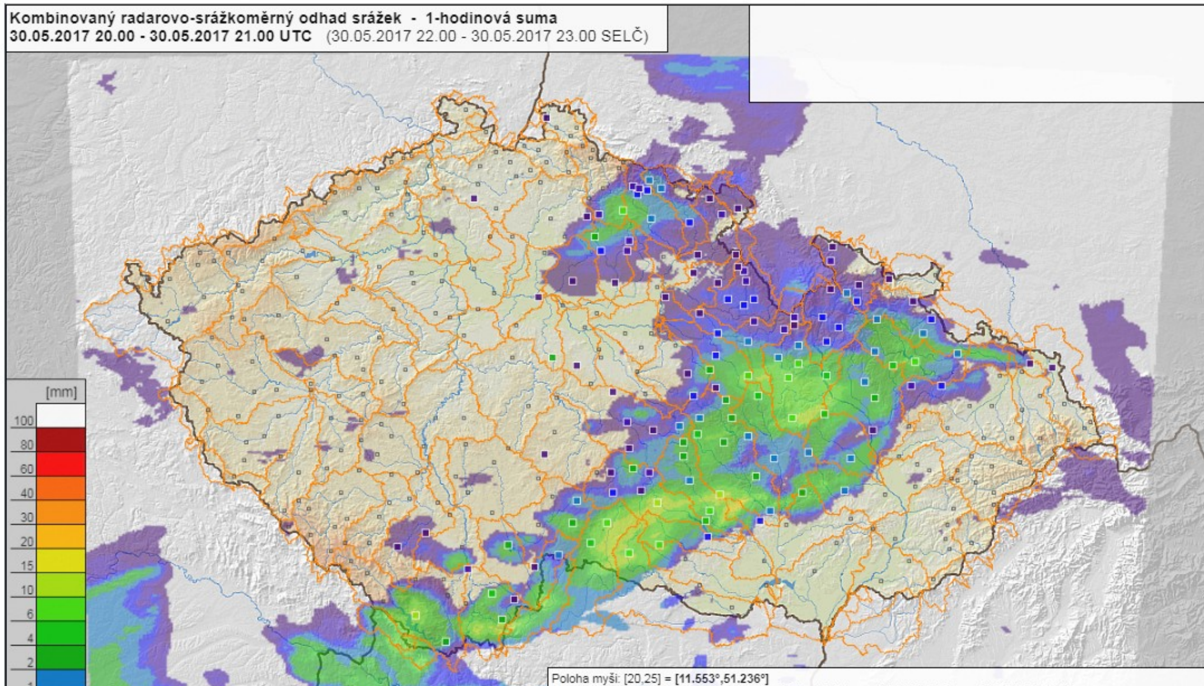


Case study with WRF









Convection permitting climate modeling

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Experiment design

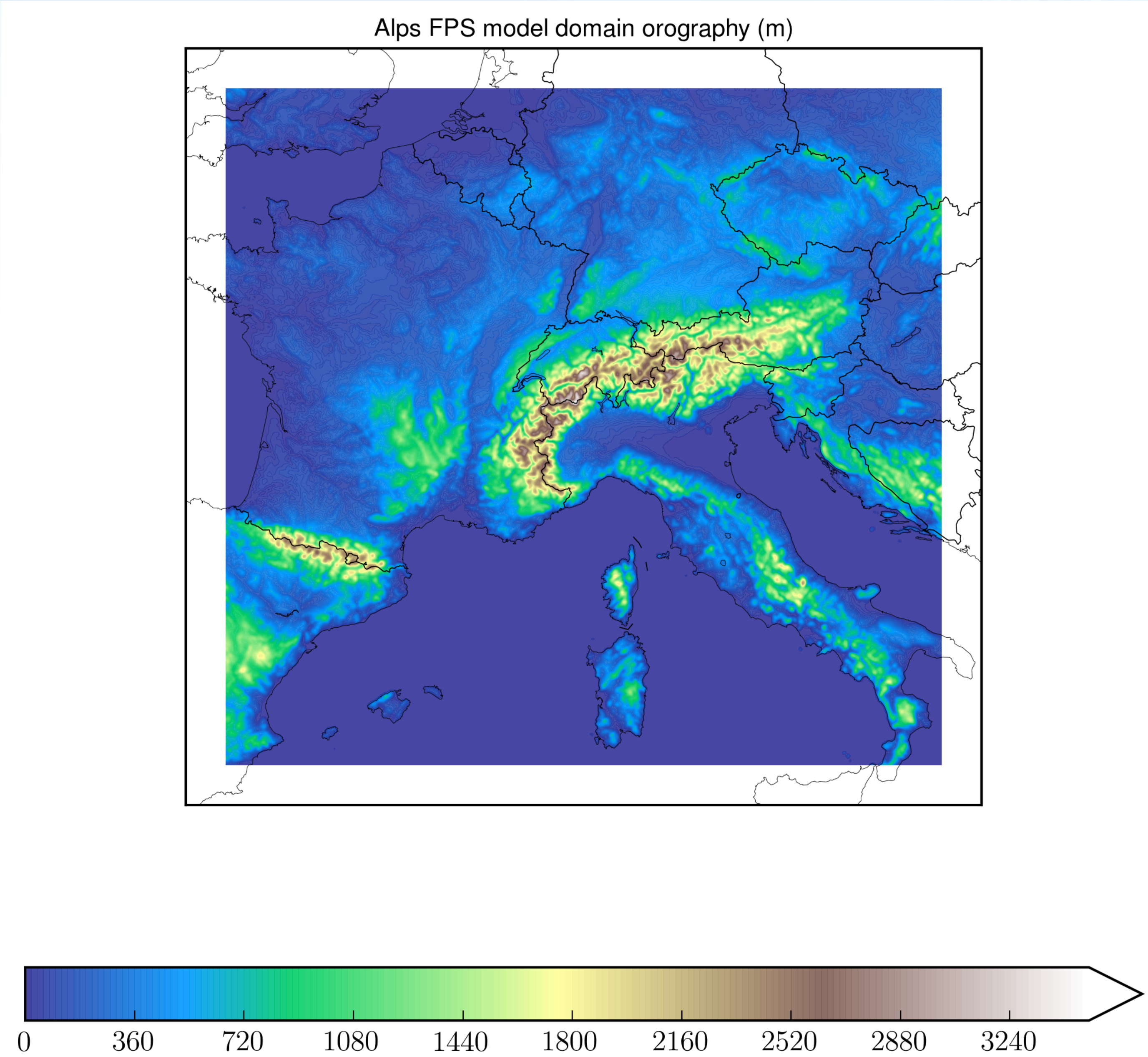
- Plan:
  1) case studies in weather-like (WL) and climate mode (CM) for short periods
  2) long-term evaluation simulations driven by ERA-Interim - 2000-2014
  3) scenario simulations for 10 year time slices

- Multi-model ensemble: RegCM, CCLM, WRF, REMO, HCLIM, AROME, MOLOCH, COSMO, UM...

- RegCM sub-group: ICTP, CUNI, DHMZ

- Comparing the ICTP and CUNI runs that use different moisture scheme: WSM5 vs. Nogherotto/Tompkins

Computational domain



iy = 575
jx = 605
kz = 41
ds = 3000

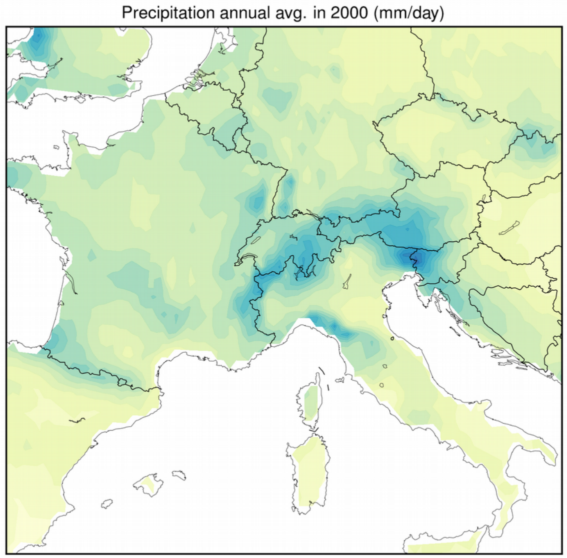
clat = 45.441
clon = 8.062

nspgx, nspgy = 30

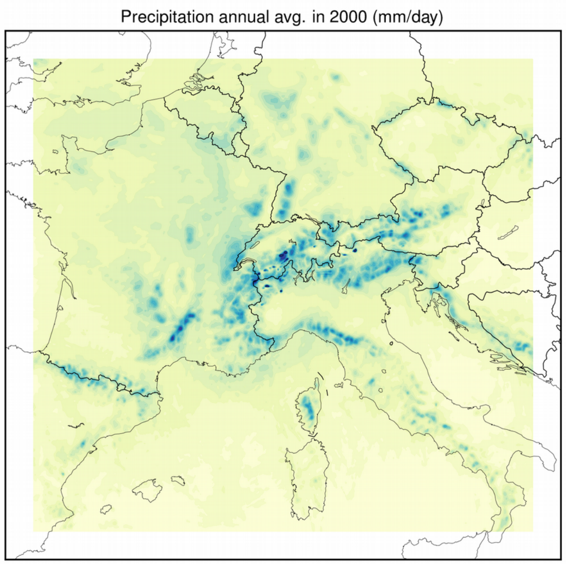
nested in ICTP
EUR-11 simulation

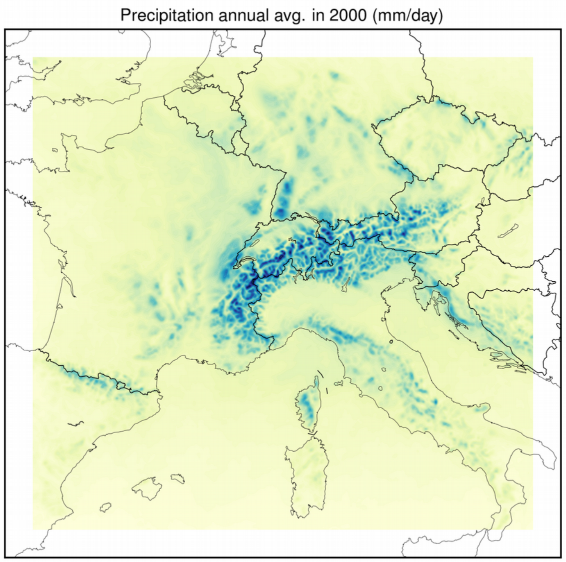
Precipitation - annual average 2000

E-OBS

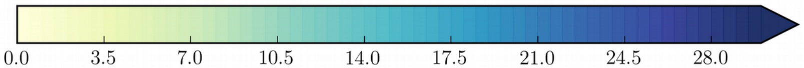


ICTP



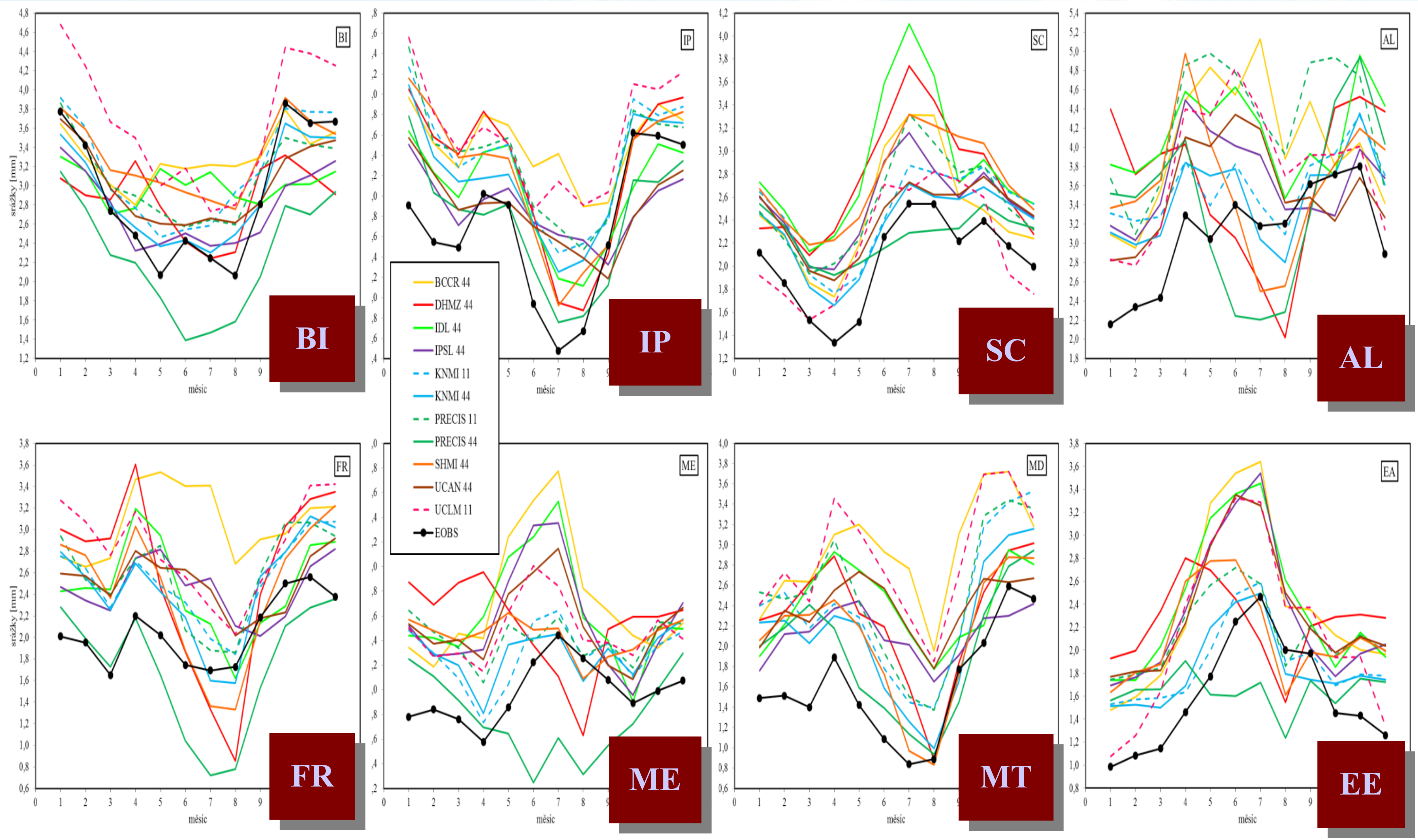


CUNI



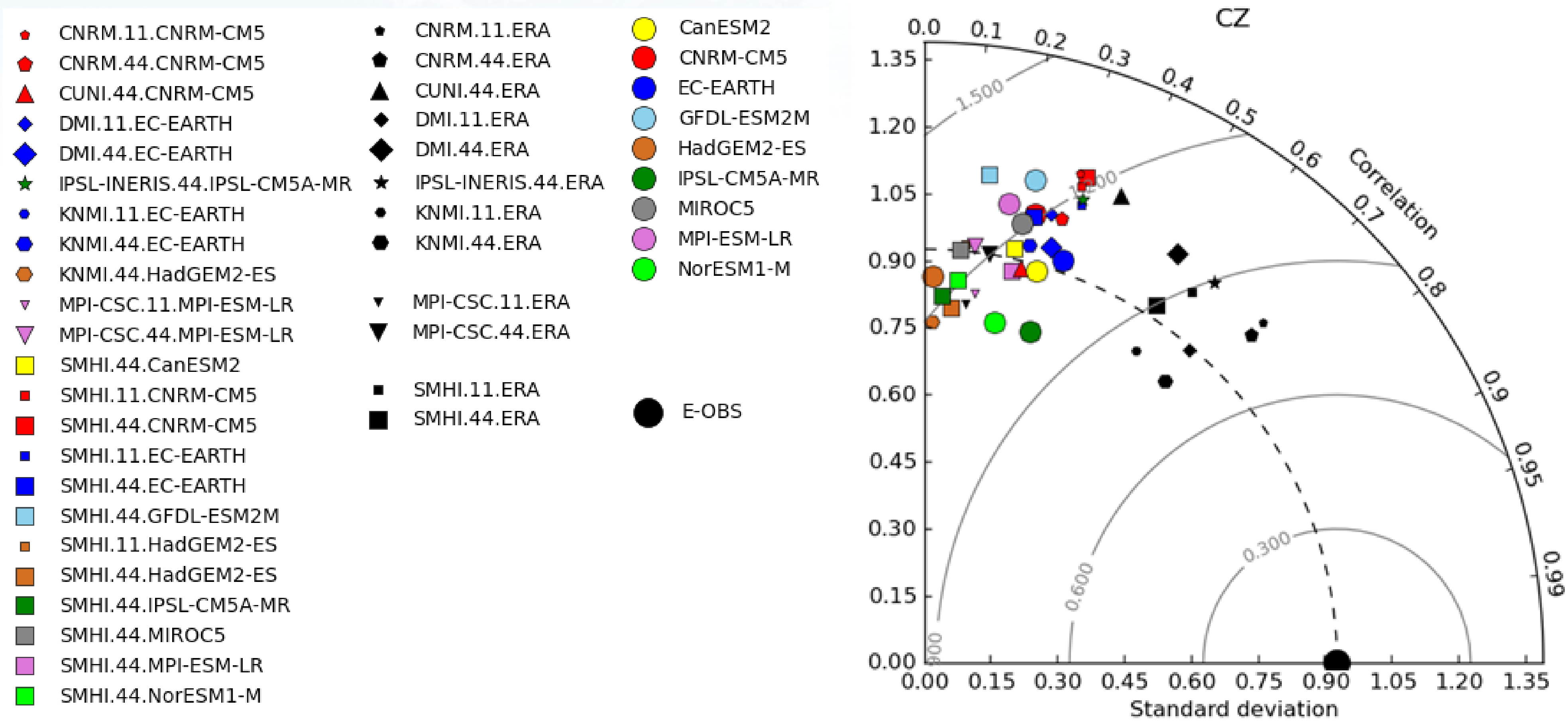
Annual cycle of precipitation

Reminder: CORDEX ERA-Interim simulations



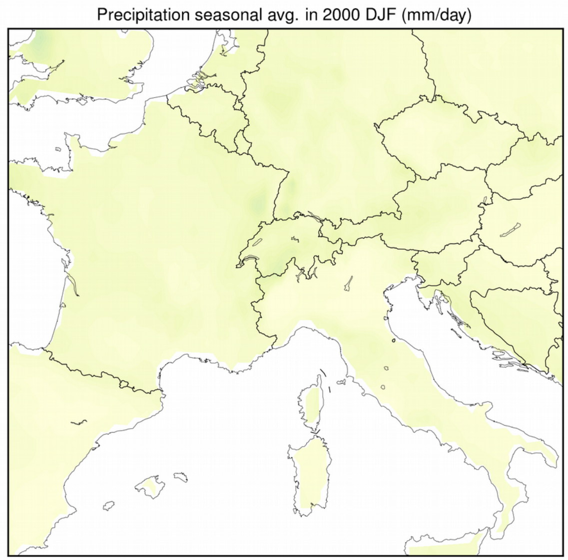
Annual cycle of precipitation

Reminder: CORDEX historical simulations

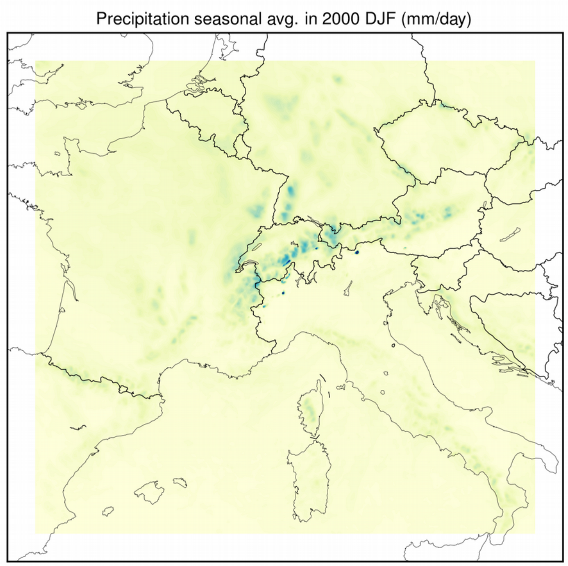


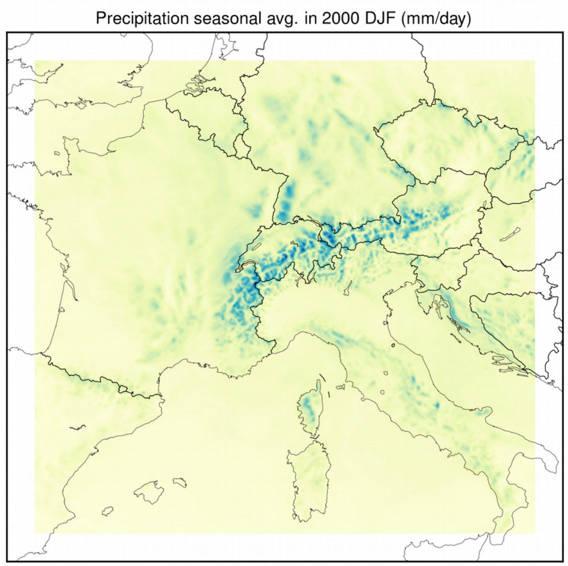
Precipitation – DJF average 2000

E-OBS

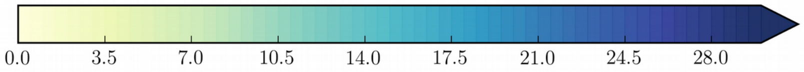


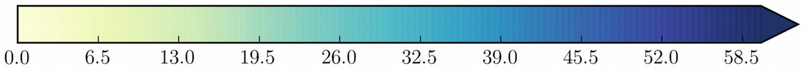
ICTP





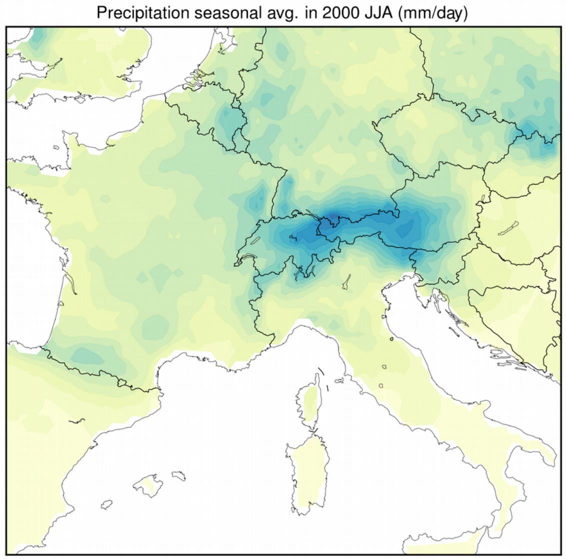
CUNI





Precipitation – JJA average 2000

E-OBS



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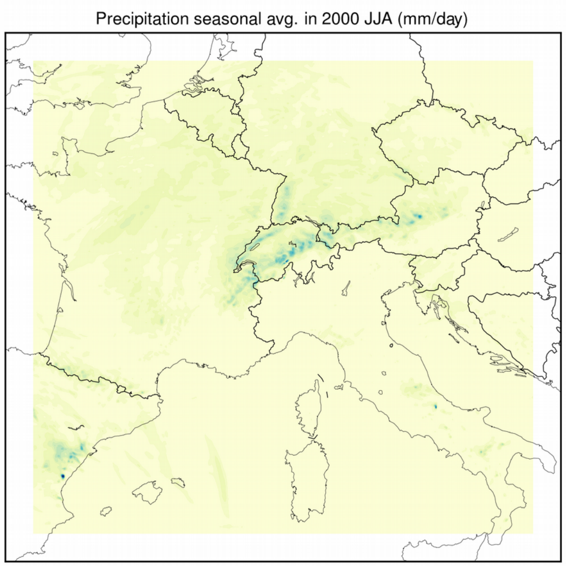
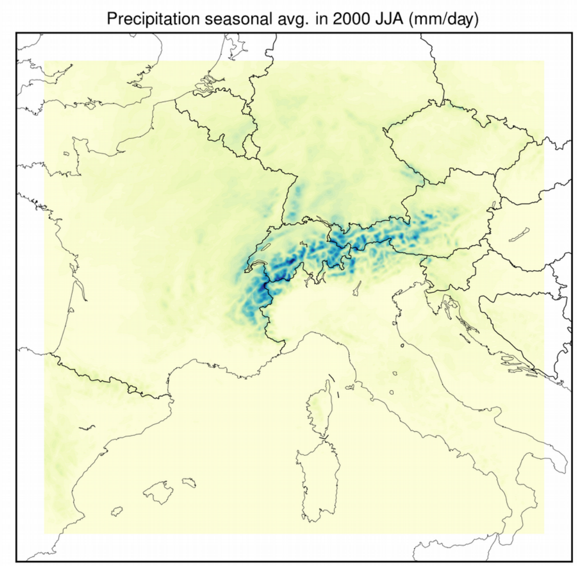
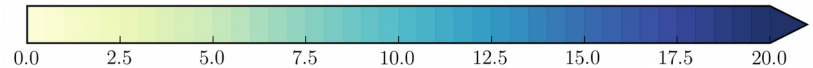
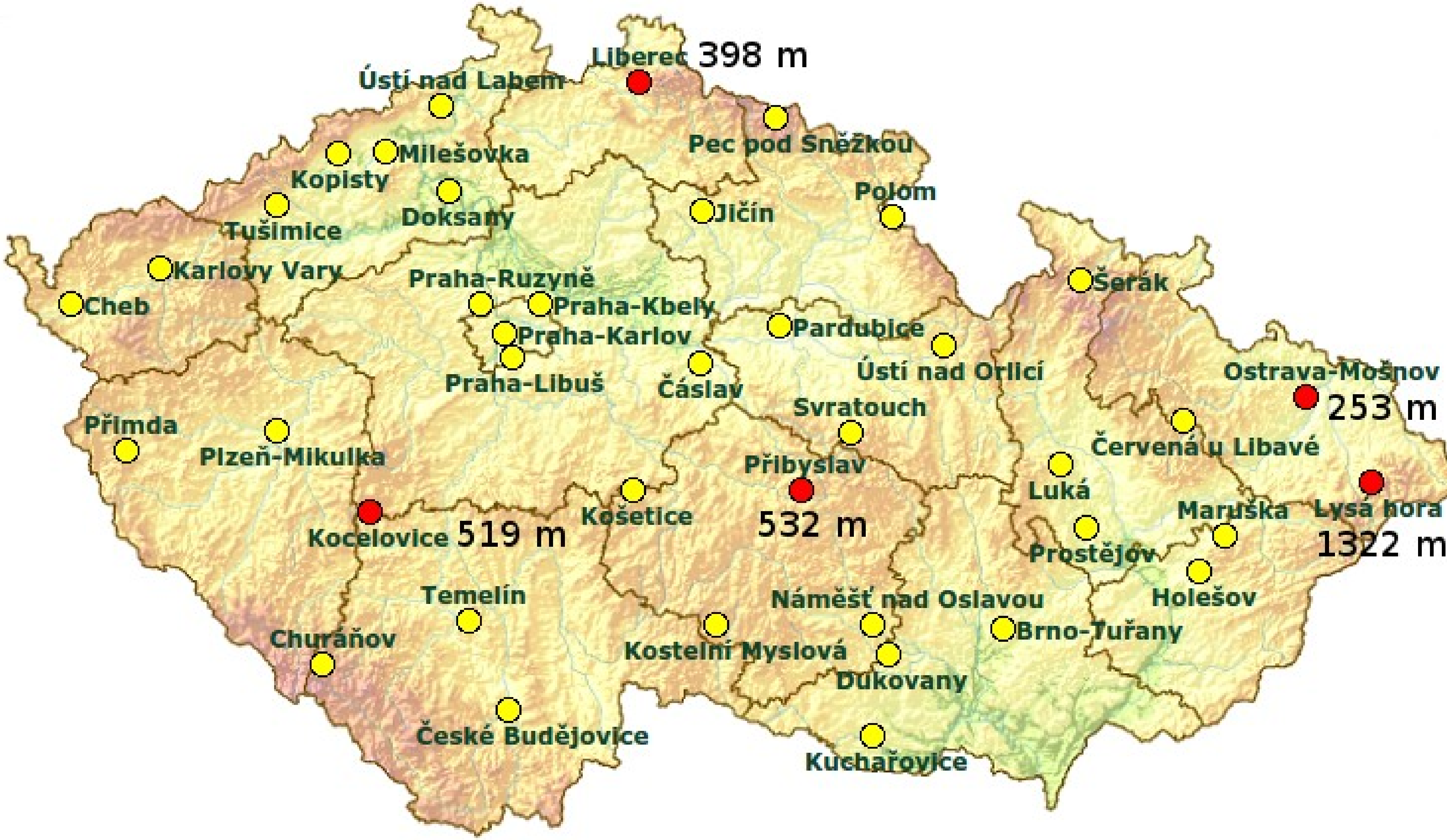




CUNI

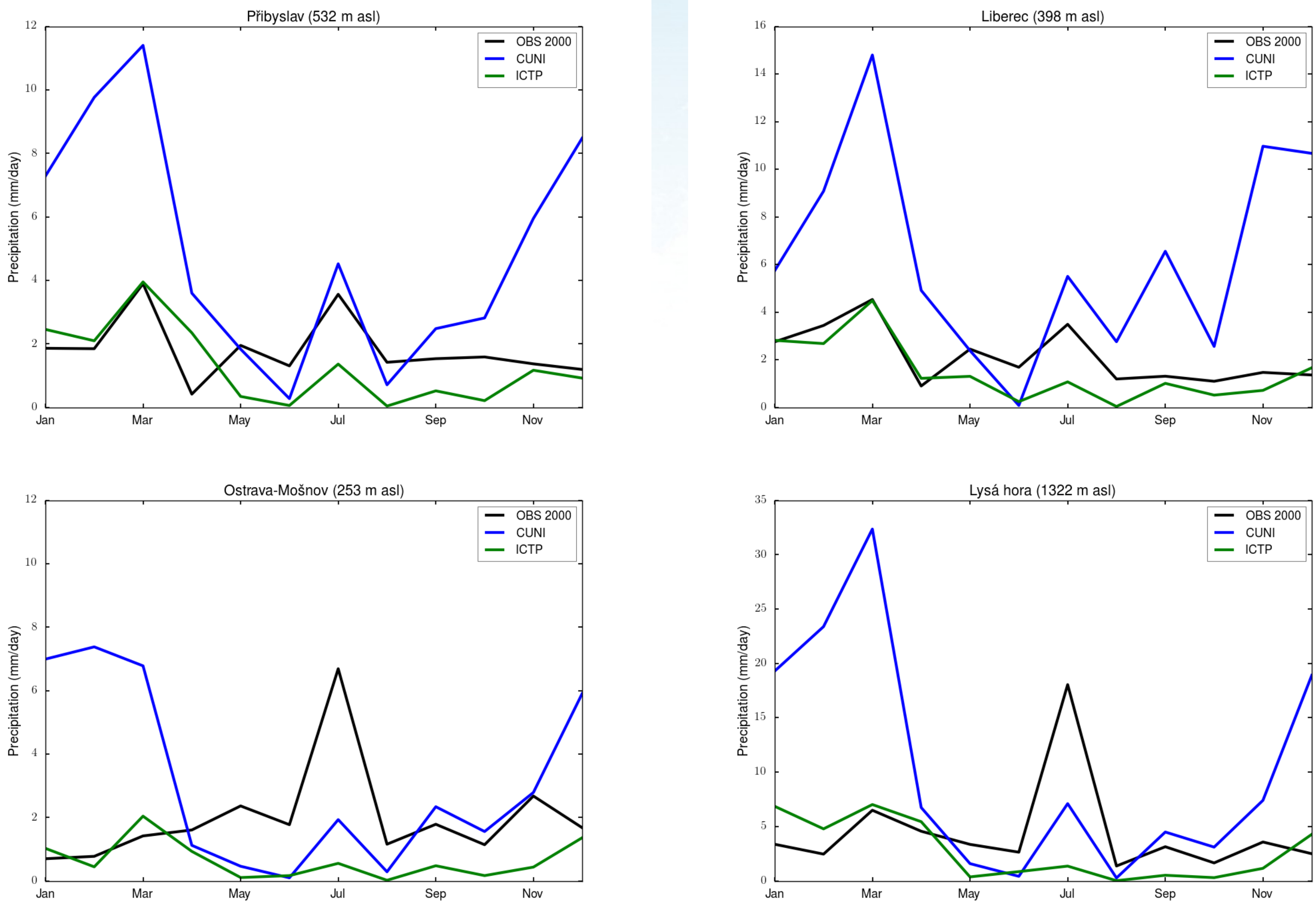


Evaluation stations



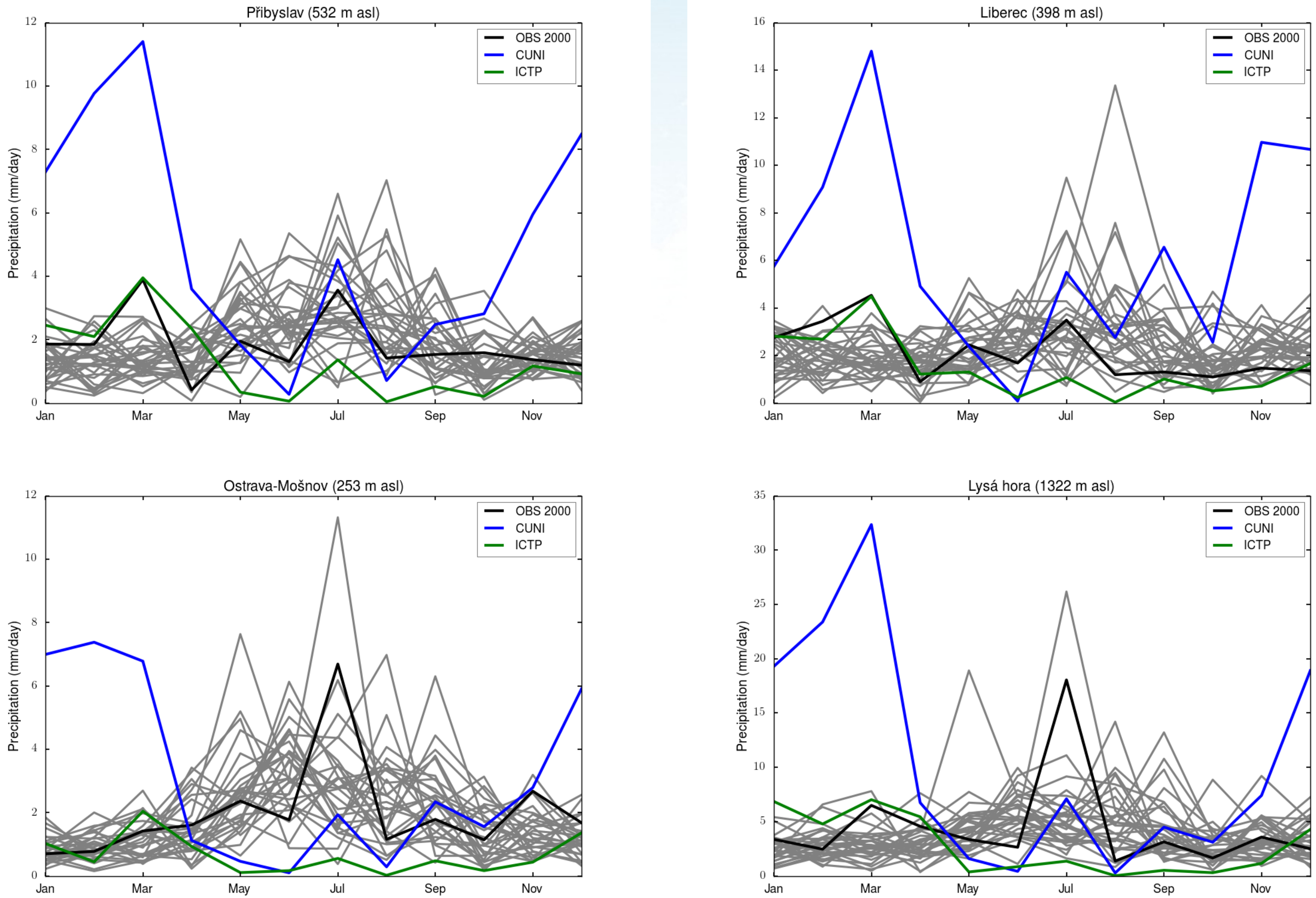
Precipitation station network of Czech Hydrometeorological Institute (professional stations)
red: used for this study

Annual cycle of precipitation



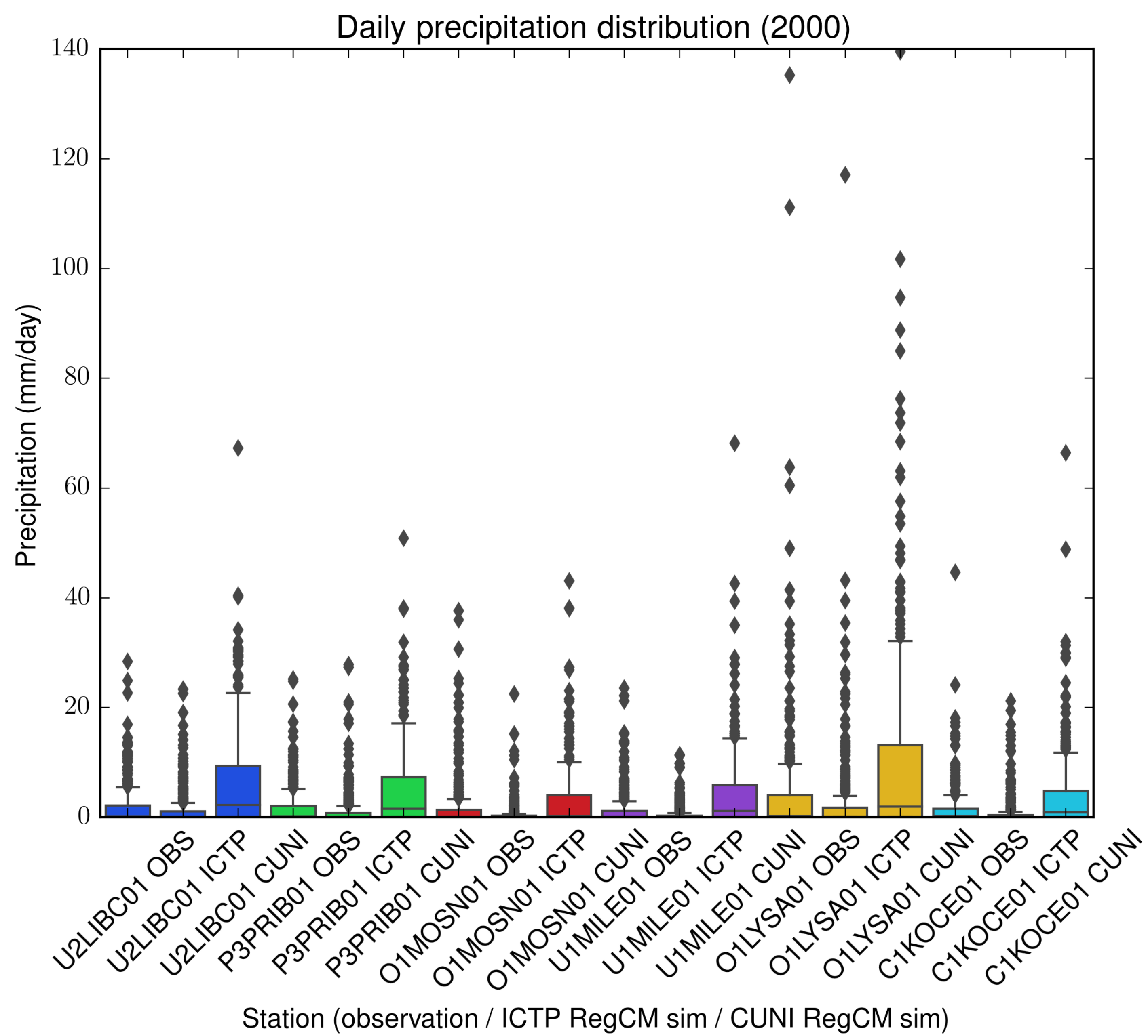
First look at the influence of precipitation scheme on long-term CPC simulations with RegCM

Annual cycle of precipitation

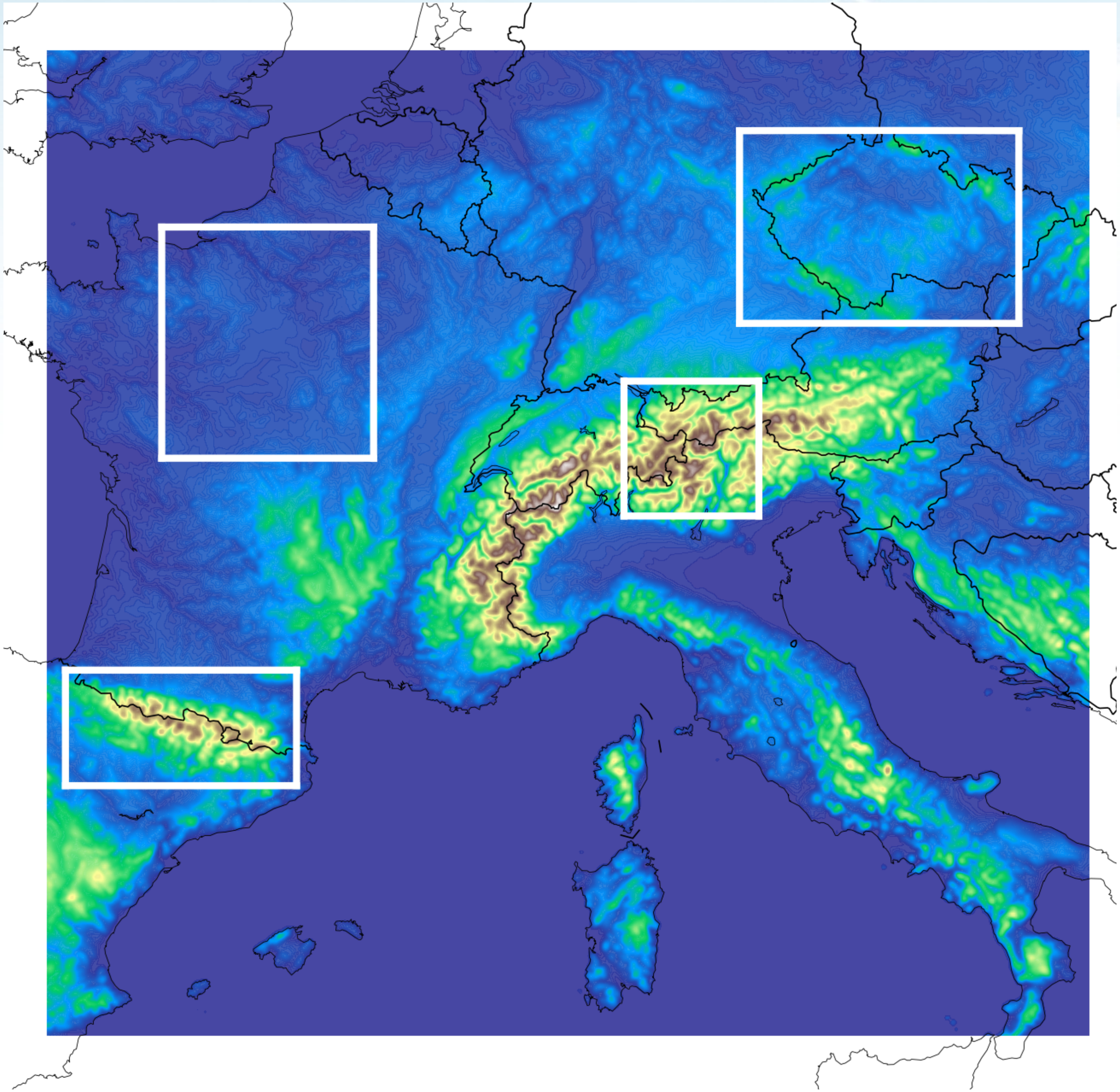


First look at the influence of precipitation scheme on long-term CPC simulations with RegCM

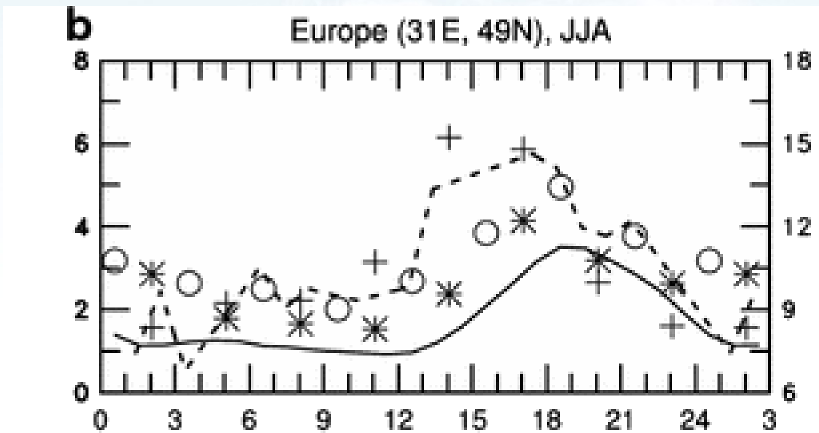
Daily precipitation distribution



Diurnal cycle of precipitation



Diurnal cycle of precipitation

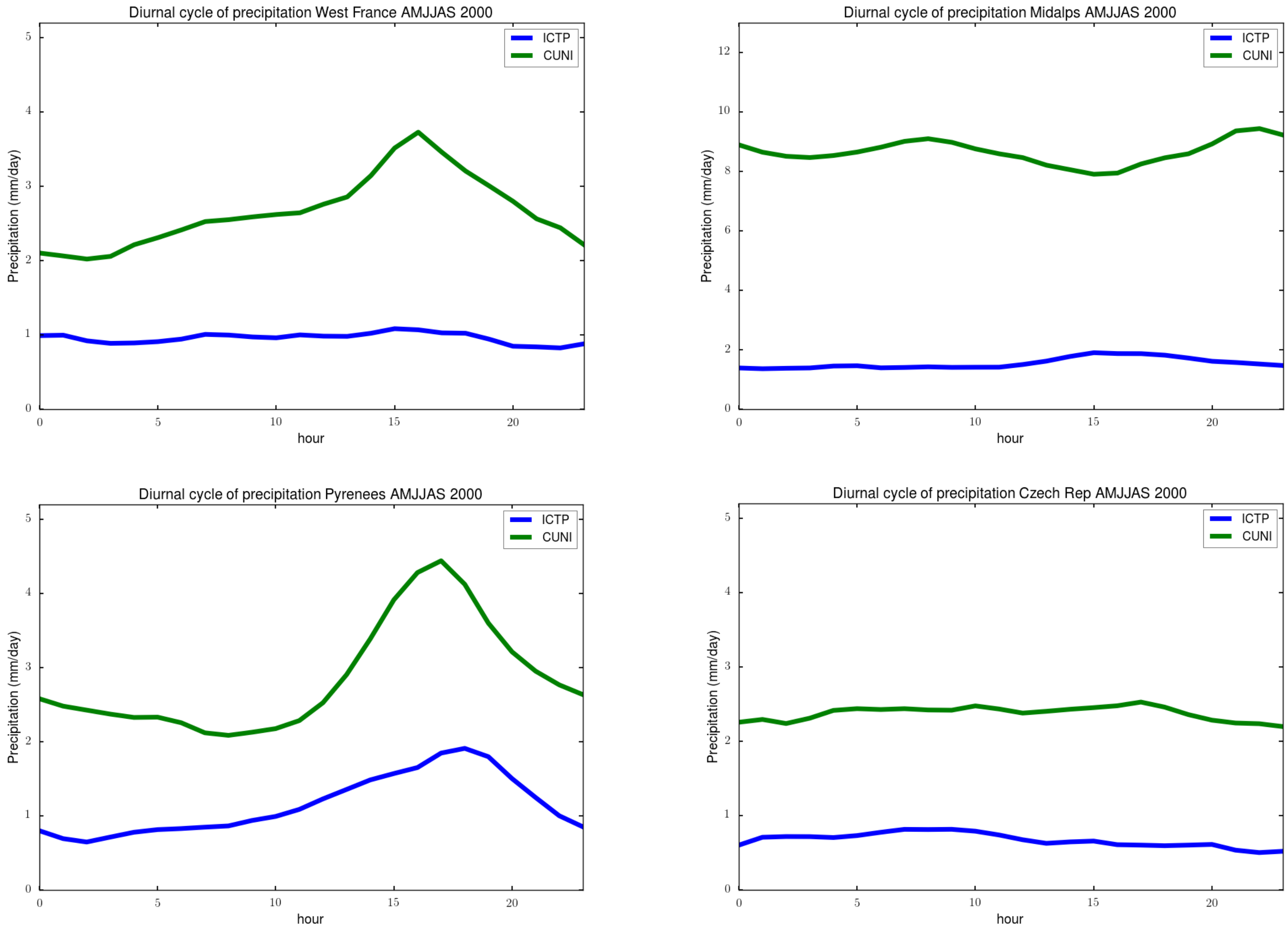


Dai, A., Lin, X. & Hsu, KL. Clim Dyn (2007) 29: 727. https://doi.org/10.1007/s00382-007-0260-y

Fig. 4

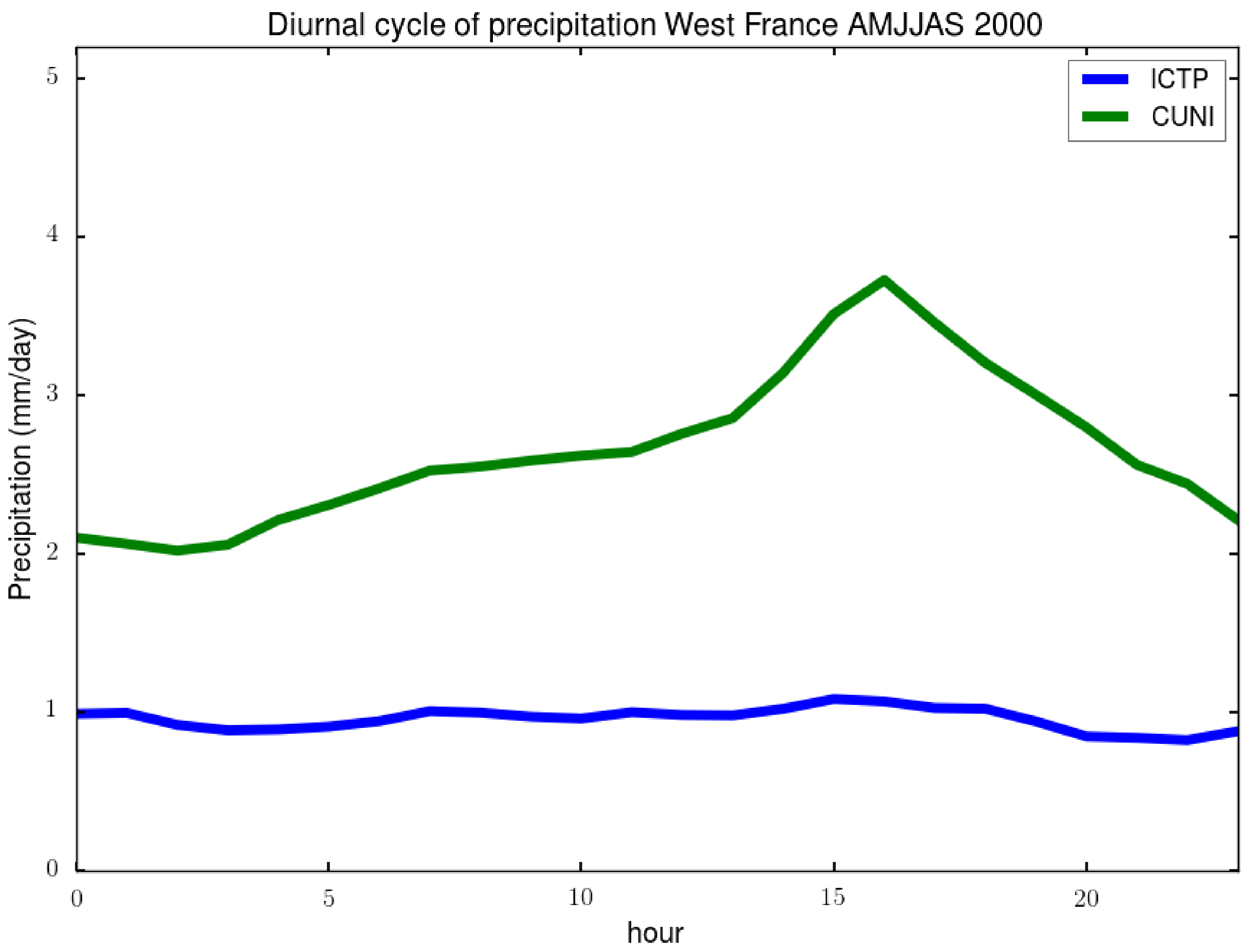
Mean diurnal cycle of summer precipitation at ten selected 2° × 2° boxes from surface weather reports (*plus* indicates frequency in % on the *right-hand ordinate*, 1975–1997 mean), CMORPH (*open circle* indicates 2003–2005), TRMM 3B42 (*asterisks* indicates 1998–2005), PERSIANN (*thin solid lines* indicates 2002–2005), and MI (*dashed lines* indicates 1998–2005). Also shown in the *top-left panel* (*thick solid line*) is rain-gauge hourly data (for 1963–1993).

Diurnal cycle of precipitation

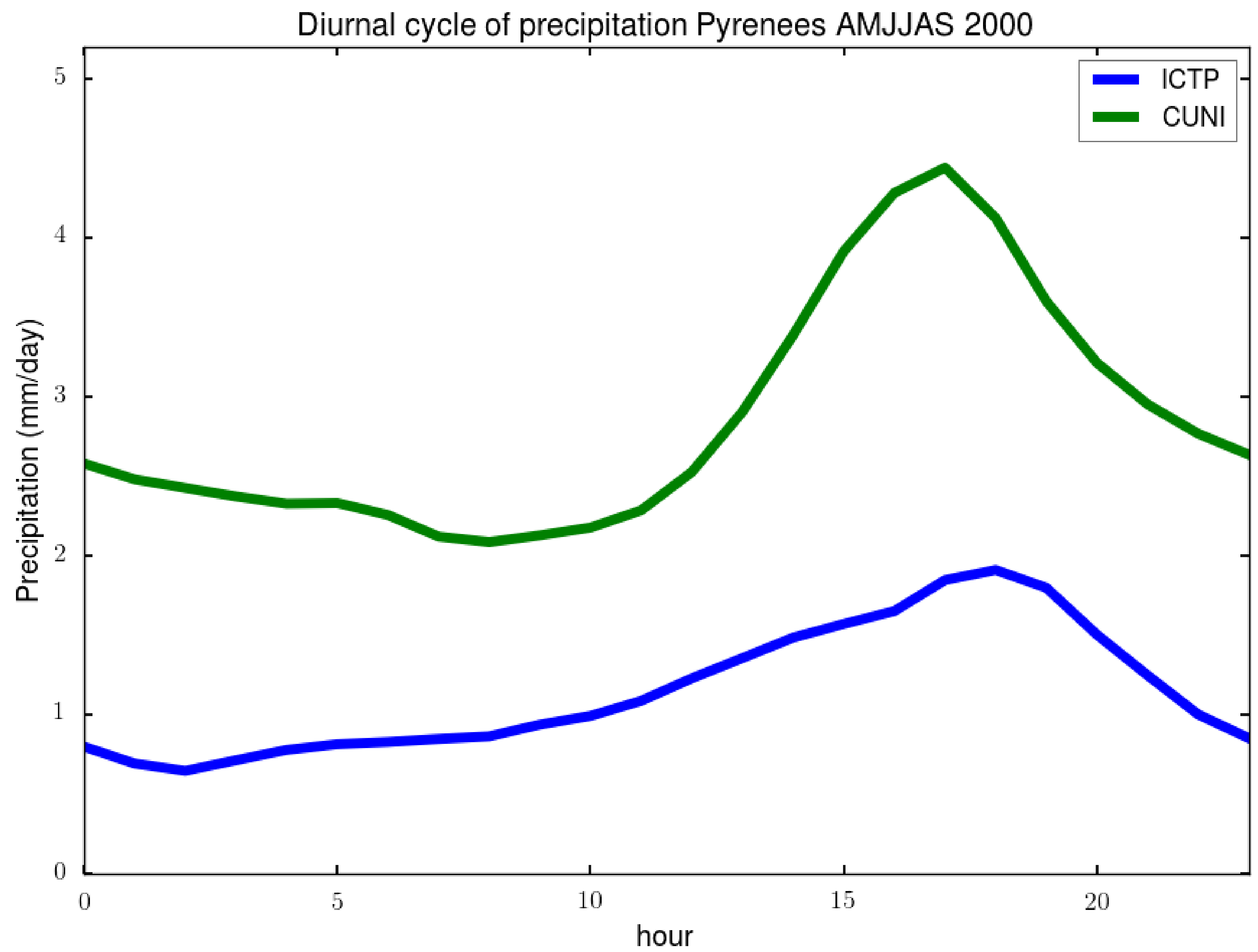


First look at the influence of precipitation scheme on long-term CPC simulations with RegCM

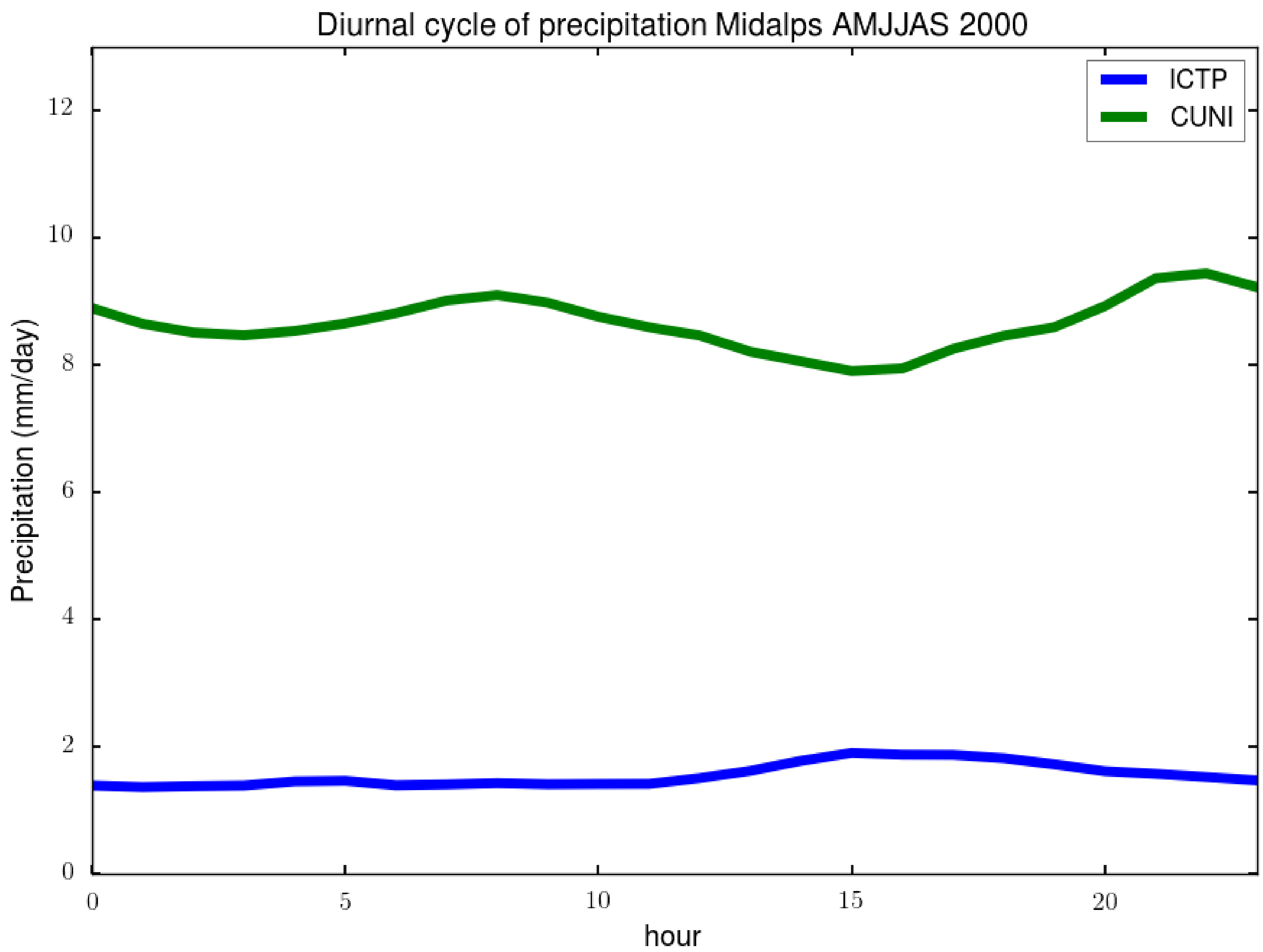
Diurnal cycle of precipitation



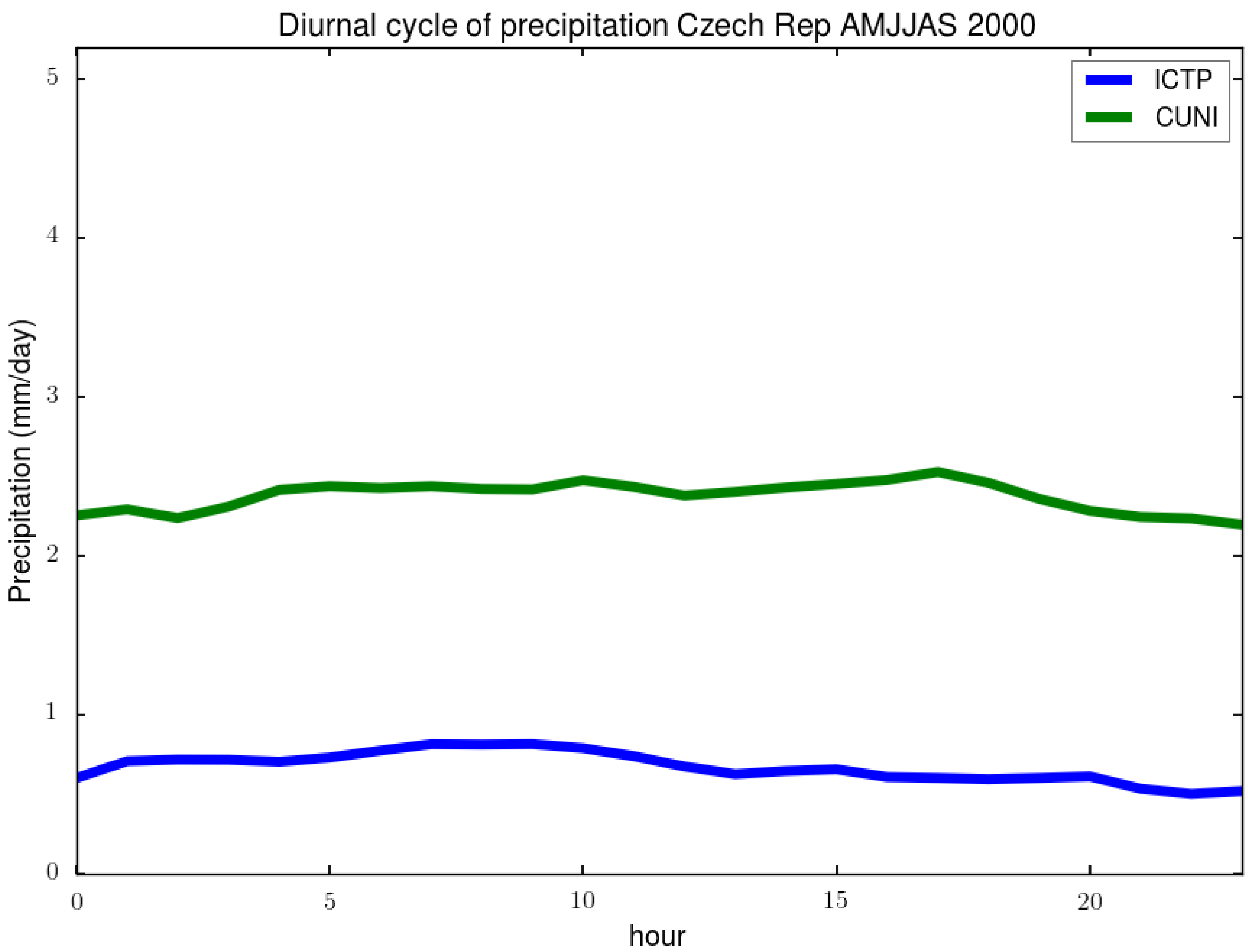
Diurnal cycle of precipitation



Diurnal cycle of precipitation



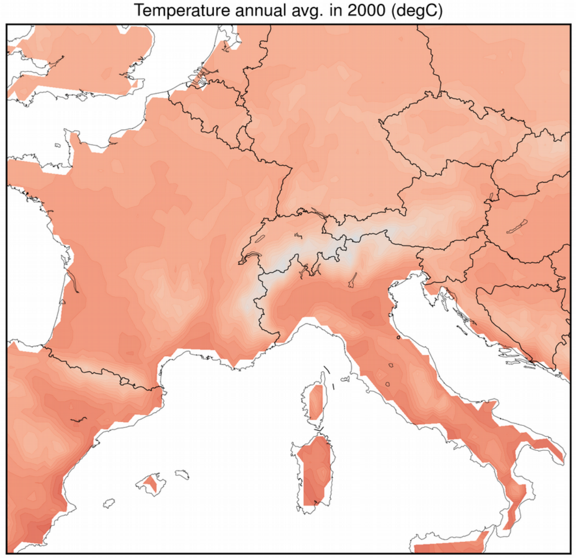
Diurnal cycle of precipitation



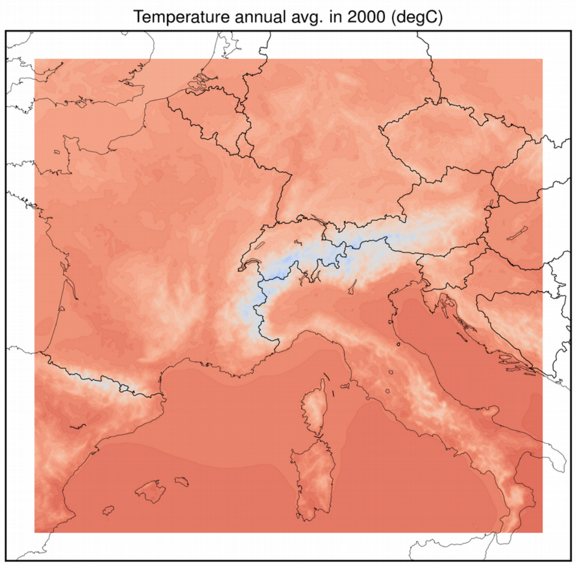
Influence on surface temperature

2m temperature – annual average 2000

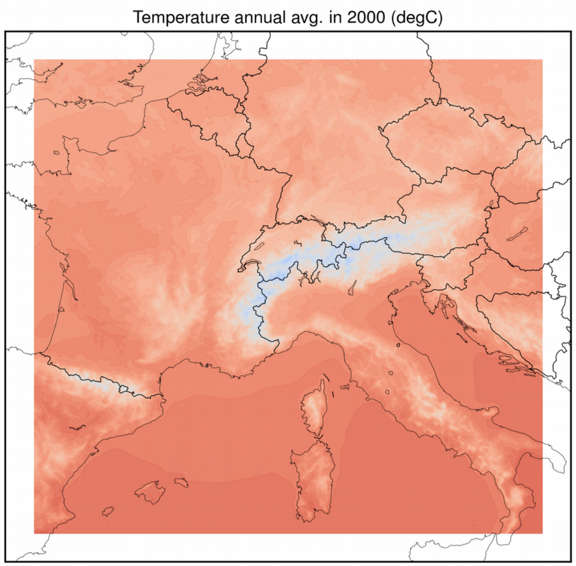
E-OBS

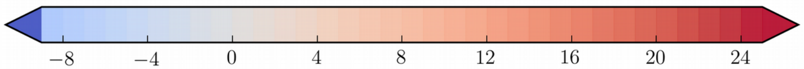


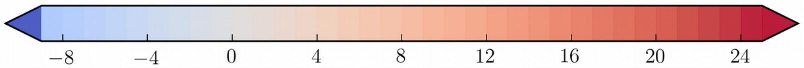
ICTP



CUNI

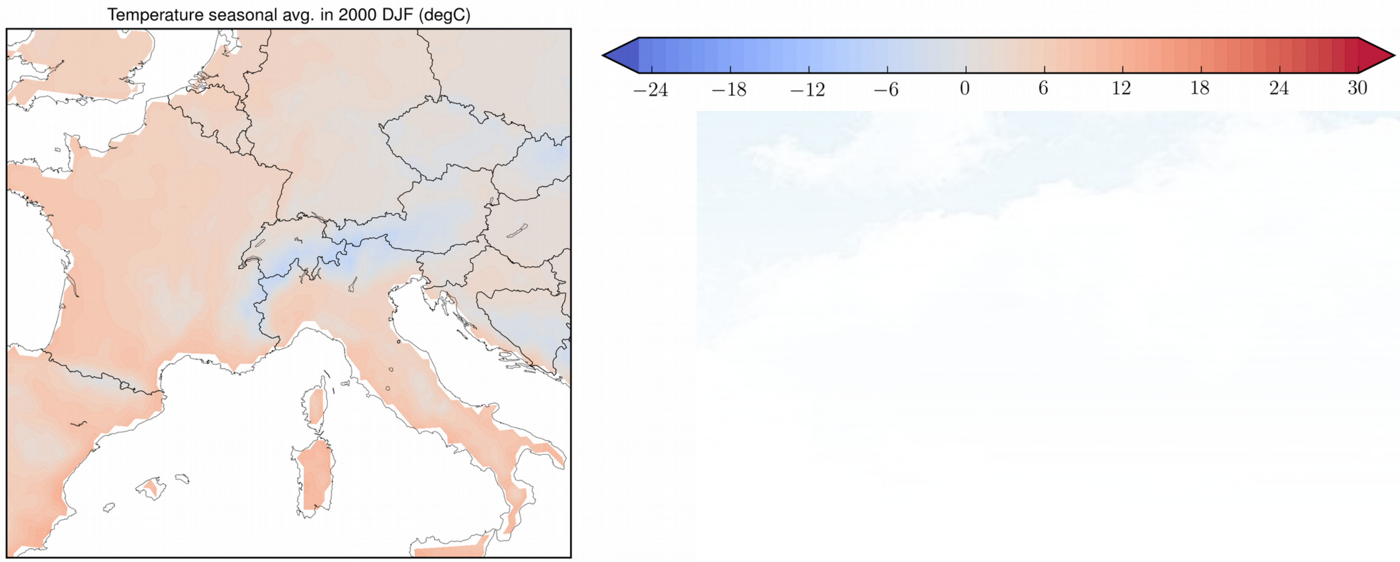






2m temperature – DJF average 2000

E-OBS



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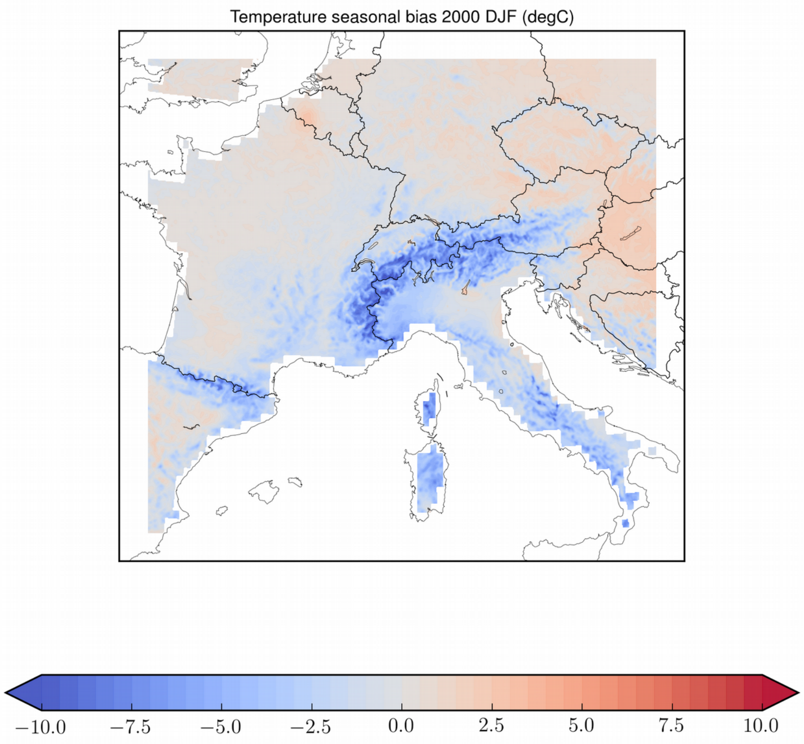
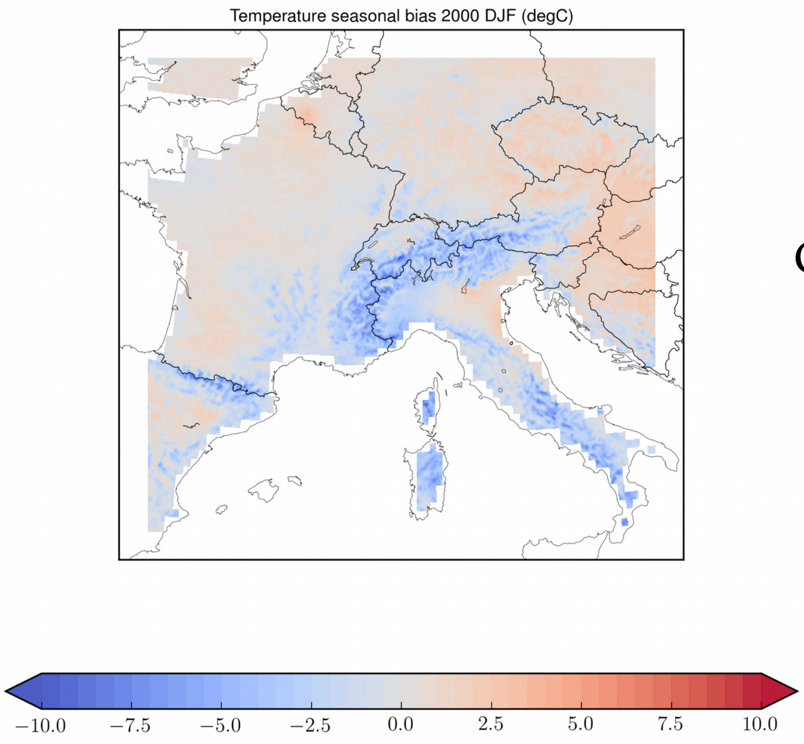
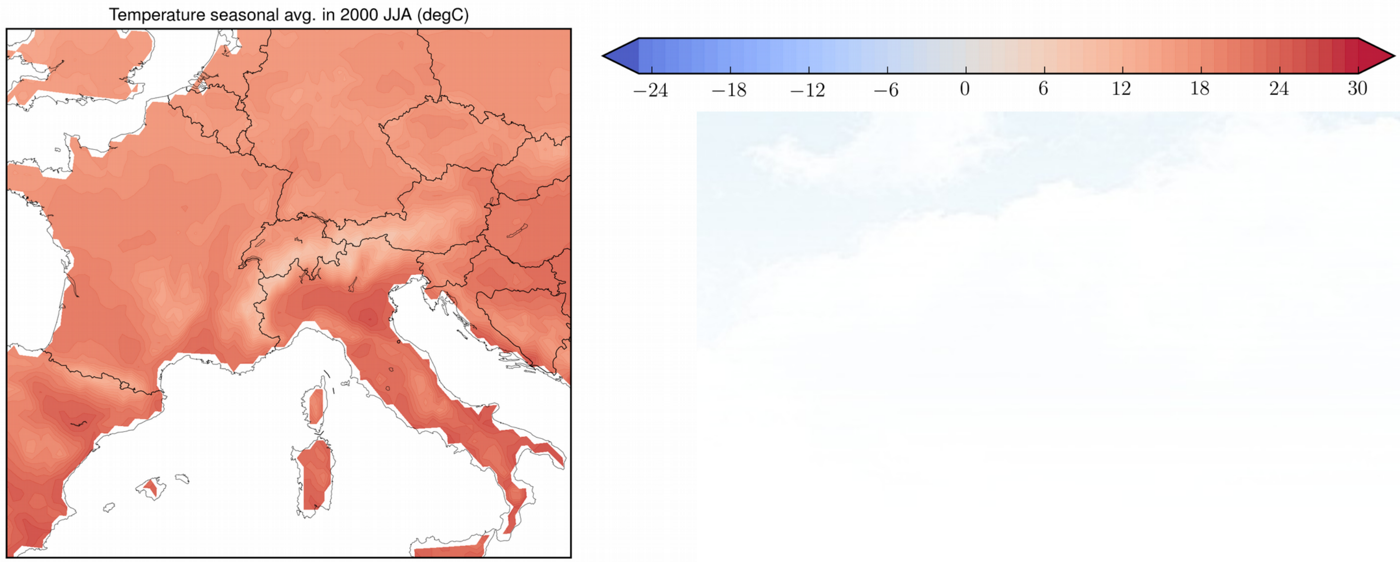




CUNI

2m temperature – JJA average 2000

E-OBS



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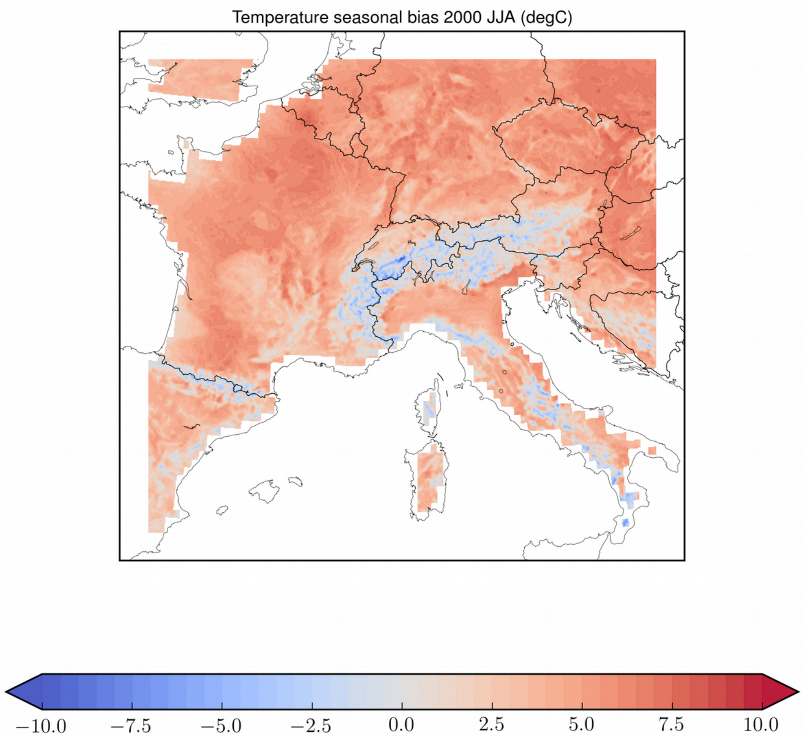

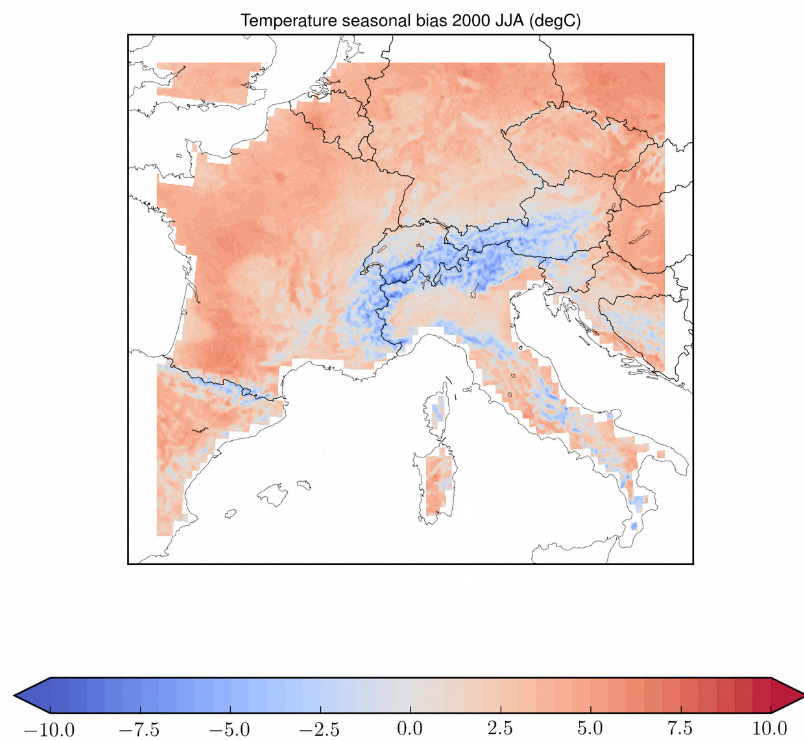

CUNI

Computational costs

- RegCM model in 50x50 km resolution for Europe (144x144 grid boxes): 1 year long simulation ~ 1 day on 24-core computer (AMD Opteron 6140 @ 2.6 GHz); typical output data volume ~ 35 GB/1 year of simulation
- RegCM in 12x12 km resolution for Europe (530x530 grid boxes): 1 month long simulation ~ 2.5 days; 400 GB/1 month of simulation
- RegCM in 3x3 km resolution for the Alps domain (575x605 grid boxes): 1 month long simulation ~ 2.5-5 days on 384 cores (salomon.it4i.cz, Intel XEON E5-2695 @ 2.3 GHz, 16 nodes); 850 GB/ 1 month of simulation
- NWP and climate models not very efficient in using computational power of massive parallel clusters – up to 5% of the peak
- Two main bottlenecks: node-node and processor-memory communication – do we need a different computer architecture?

Summary

- Case studies for individual convective events
  - sim with convection parameterizations in 3km resolution comparable to 1km sim without parameterization
  - time shift of the event
- Long-term simulations:
  - Overall large bias with N/T scheme
  - Inverse behavior in annual cycle – large positive bias in winter with N/T scheme, underestimation with WSM5 scheme
  - Comparable in diurnal cycle shape – captured only in some regions
  - Need more tuning – requires a lot of computational resources