Does the performance of different physical parameterizations in the WRF regional climate model depend on the synoptic weather pattern in the large-scale driving fields?

Ákos János Varga[1], Hajnalka Breuer[1]

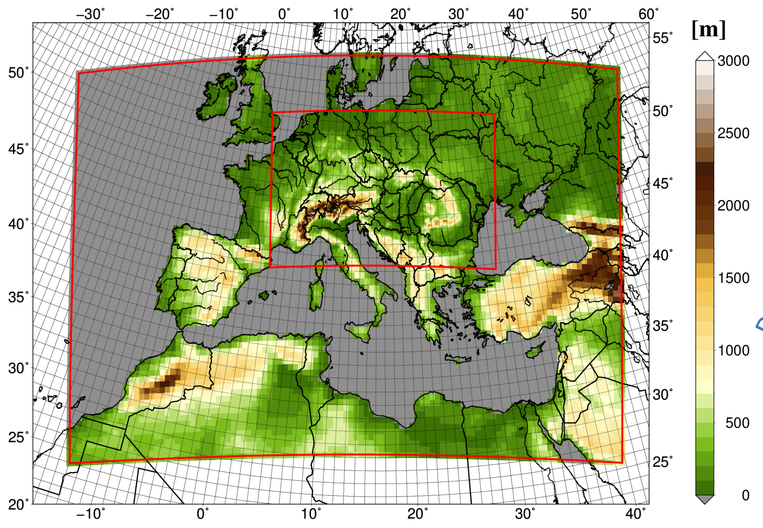
EMS Annual Meeting 2022 | 4–9 September 2022 | Poppelsdorf Campus, Bonn, Germany

(1) Department of Meteorology, Institute of Geography and Earth Sciences, ELTE Eötvös Loránd University, Pázmány Péter sétány 1/A, Budapest, 1117, Hungary (vakos94@staff.elte.hu)

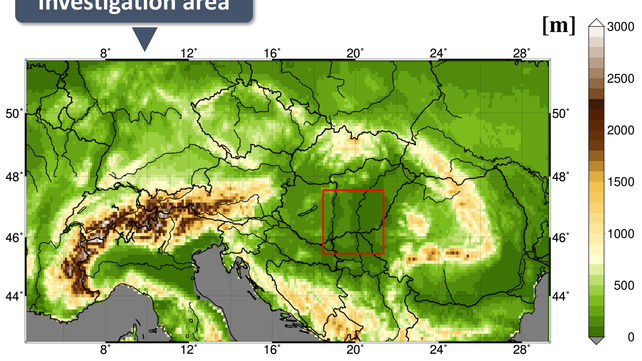
Model (WRFv4.2[1])

Domains

- One-way nesting.
- Outer grid: Δx=50 km
- Inner grid: Δx=10 km



Investigation area



Data

Input data

- **ERA5 reanalysis[2]** as ICBC (0.25° grid).
- Updated in WRF every 6 hours.

Observational data

- **E-OBS[3]** (v23.1e) daily observational dataset (0.1° grid).

Simulation setup

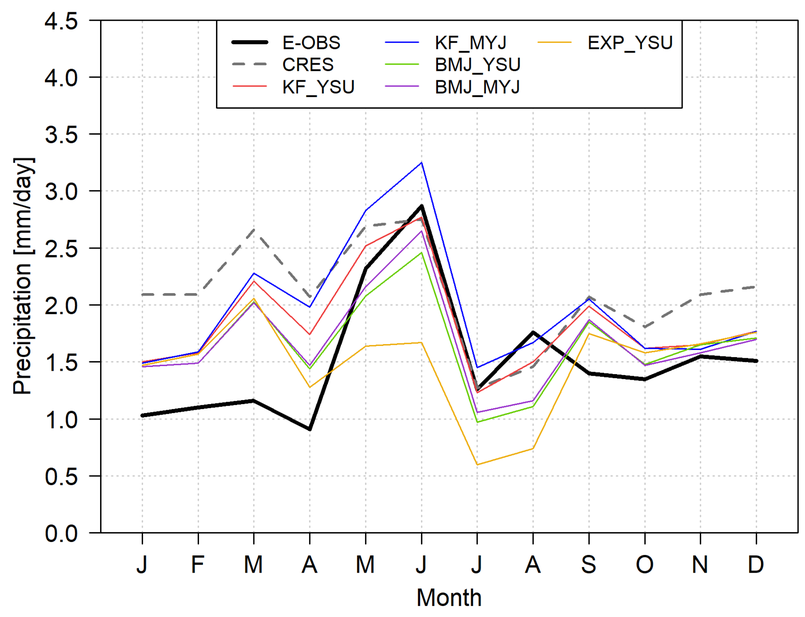
DOWNSCALING

Acronym	Δx	Microphysics	Cumulus convection	PBL, surface layer	Land-surface	SW, LW radiation
CRES	50 km	Thompson[4]	Kain–Fritsch (KF[5])	Yonsei University (YSU[7]), Revised MM5[8]	Noah–MP[9]	RRTMG[10]
KF_YSU	10 km	Thompson	KF	YSU, Revised MM5	Noah–MP	RRTMG
KF_MYJ	10 km	Thompson	KF	Mellor–Yamada–Janjic (MYJ[6]), Eta Similarity[6]	Noah–MP	RRTMG
BMJ_YSU	10 km	Thompson	Betts–Miller–Janjic (BMJ[6])	YSU, Revised MM5	Noah–MP	RRTMG
BMJ_MYJ	10 km	Thompson	BMJ	MYJ, Eta Similarity	Noah–MP	RRTMG
EXP_YSU	10 km	Thompson	Explicit (no cumulus scheme)	YSU, Revised MM5	Noah–MP	RRTMG
VAR	10 km	Thompson	Variable according to the synoptic weather situation (see below)	YSU, Revised MM5	Noah–MP	RRTMG

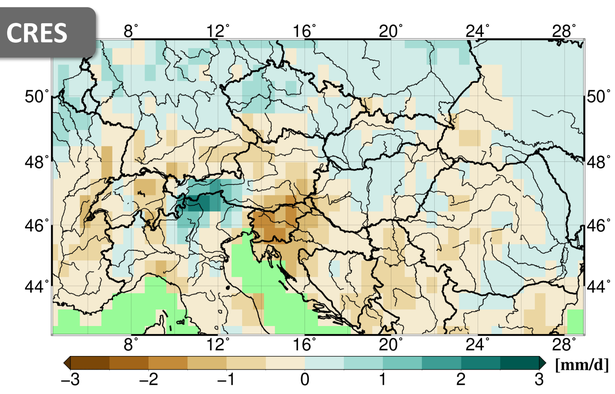
- Simulation start time: 01 July 2005, 0000 UTC; end time: 01 Jan 2011, 0000 UTC
- Non-hydrostatic dynamical core
- 61 model levels (σ–p)

Simulation results – precipitation

Monthly total precipitation



CRES

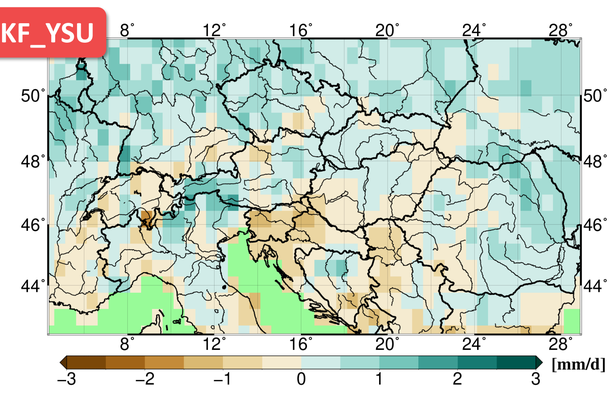


Summer (JJA) precipitation bias

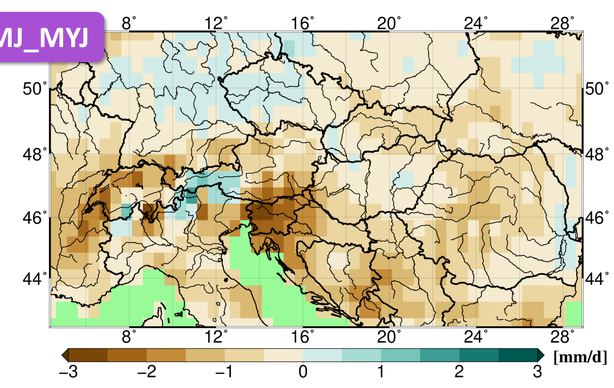
Δx=50 km -> Δx=10 km

- The resolution refinement mitigates the dry bias in summer and the wet bias in winter in most areas

KF_YSU

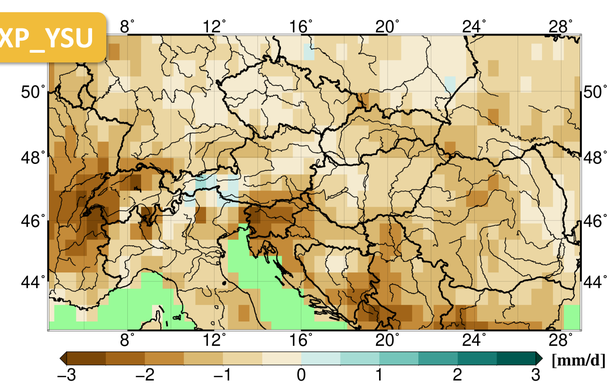


BMJ_MYJ

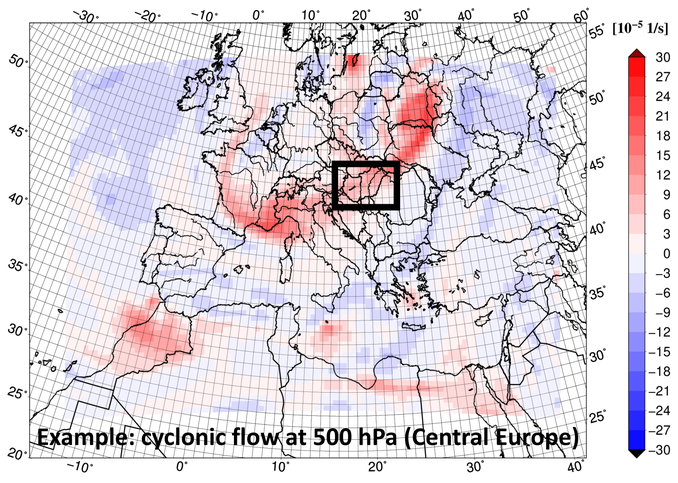


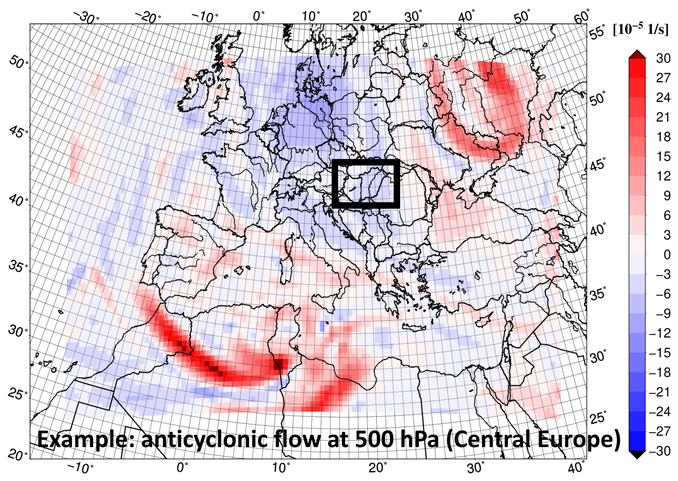
- Turning off the cumulus scheme at Δx=10 km leads to a significant precipitation deficit in summer
- Using the BMJ scheme instead of KF also results in an extensive dry bias

EXP_YSU



Variable parameterizations according to the large-scale weather situation





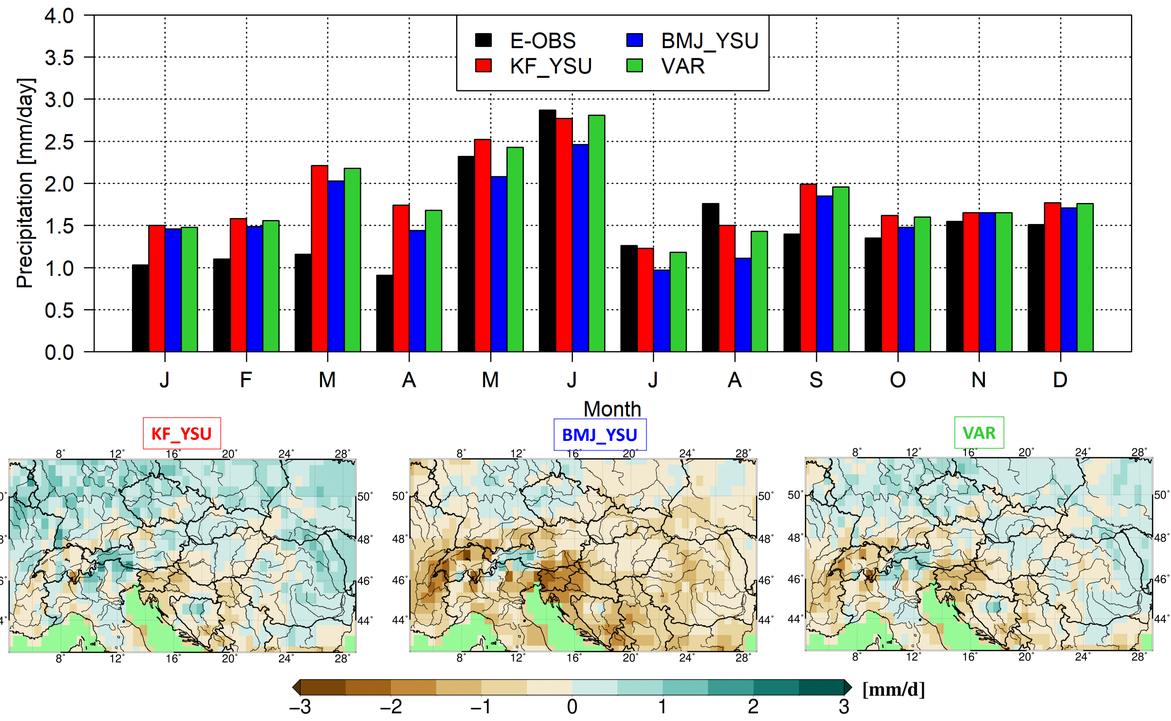
1. Categorizing each day into cyclonic/anticyclonic flow pattern at two atmospheric levels
   - Based on relative vorticity at 950 and 500 hPa
   - Calculated from the CRES run over Central Europe
2. Calculating statistical measures (R, ME, MAE, RMSE) for each large-scale flow pattern separately
3. Evaluating WRF simulations conditioned on the weather patterns – is there a scheme that performs systematically better in a particular synoptic situation?

Mostly no

Slight differences in R (Pearson's correlation) for the case when anticyclonic flow dominates both at 950 and 500 hPa:

	KF_YSU	KF_MYJ	BMJ_YSU	BMJ_MYJ	VAR
R	0.28	0.27	0.32	0.31	0.32

Slightly better correlation in the case of the BMJ cumulus scheme for anticyclonic flow



There is no cumulus or boundary layer parameterization that systematically performs better under a given large-scale flow pattern (cyclonic/anticyclonic)

Model run „VAR" initialized with the BMJ scheme for days with anticyclonic flow at both the 950 and 500 hPa levels, KF otherwise

Funding

The research leading to this poster was supported by the Hungarian Scientific Research Fund under the grant FK132014. Hajnalka Breuer's work was additionally financed by the János Bolyai Research Scholarship of the Hungarian Academy of Sciences.

References

1. Skamarock, W. C., Klemp, J. B., Dudhia, J., Gill, D. O., Liu, Z., Berner, J., Wang, W., Powers, J. G., Duda, M. G., Barker, D. M., Huang, X.-Y., 2019: A Description of the Advanced Research WRF Model Version 4. NCAR Tech Note NCAR/TN-556+STR, Mesoscale and Microscale Meteorology Division, Boulder CO, USA, 162 p. https://doi.org/10.5065/1dfh-6p97
2. Hersbach, H., Bell, B., Berrisford, P., Hirahara, S., Horányi, A., Muñoz-Sabater, J., Nicolas, J., Peubey, C., Radu, R., Schepers, D. et al., 2020: The ERA5 global reanalysis. Quarterly Journal of the Royal Meteorological Society, 146(730): 1999-2049. https://doi.org/10.1002/qj.3803
3. Cornes, R. C., van der Schrier, G., van den Besselaar, E. J., Jones, P. D., 2018: An ensemble version of the E-OBS temperature and precipitation data sets. Journal of Geophysical Research: Atmospheres, 123(17): 9391-9409. https://doi.org/10.1029/2017JD028200
4. Thompson, Gregory, Paul R. Field, Roy M. Rasmussen, William D. Hall, 2008: Explicit Forecasts of Winter Precipitation Using an Improved Bulk Microphysics Scheme. Part II: Implementation of a New Snow Parameterization. Mon. Wea. Rev., 136, 5095–5115. https://doi.org/10.1175/2008MWR2387.1
5. Kain, John S., 2004: The Kain–Fritsch convective parameterization: An update. J. Appl. Meteor., 43, 170–181. https://doi.org/10.1175/1520-0450(2004)043<0170:TKCPAU>2.0.CO;2
6. Janjic, Zavisa I., 1994: The Step–Mountain Eta Coordinate Model: Further developments of the convection, viscous sublayer, and turbulence closure schemes. Mon. Wea. Rev., 122, 927–945. https://doi.org/10.1175/1520-0493(1994)122<0927:TSMECM>2.0.CO;2
7. Hong, Song–You, Yign Noh, Jimy Dudhia, 2006: A new vertical diffusion package with an explicit treatment of entrainment processes. Mon. Wea. Rev., 134, 2318–2341. https://doi.org/10.1175/MWR3199.1
8. Jimenez, Pedro A., Jimy Dudhia, J. Fidel Gonzalez–Rouco, Jorge Navarro, Juan P. Montavez, Elena Garcia–Bustamante, 2012: A revised scheme for the WRF surface layer formulation. Mon. Wea. Rev., 140, 898–918. https://doi.org/10.1175/MWR-D-11-00056.1
9. Niu, Guo–Yue, Zong–Liang Yang, Kenneth E. Mitchell, Fei Chen, Michael B. Ek, Michael Barlage, Anil Kumar, Kevin Manning, Dev Niyogi, Enrique Rosero, Mukul Tewari, Youlong Xia, 2011: The community Noah land surface model with multiparameterization options (Noah–MP): 1. Model description and evaluation with local–scale measurements. J. Geophys. Res., 116, D12109. https://doi.org/10.1029/2010JD015139
10. Iacono, M. J., J. S. Delamere, E. J. Mlawer, M. W. Shephard, S. A. Clough, W. D. Collins, 2008: Radiative forcing by long–lived greenhouse gases: Calculations with the AER radiative transfer models. J. Geophys. Res., 113, D13103. https://doi.org/10.1029/2008JD009944