COMPARISON OF HYDROSTATIC AND NON-HYDROSTATIC REGCM REGIONAL CLIMATE MODEL SIMULATIONS FOR THE CARPATHIAN REGION

Tímea KALMÁR[(1)], Ildikó PIECZKA[(1)], Rita PONGRÁCZ[(1,2)], Judit BARTHOLY[(1,2)]

(1) Eötvös Loránd University, Department of Meteorology, Budapest, Hungary

(2) Eötvös Loránd University, Faculty of Science, Excellence Center, Martonvásár, Hungary

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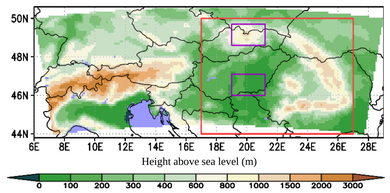
INTRODUCTION

An open-source regional climate model, namely, the RegCM (available from the ICTP, Trieste) is used to compare different approaches as well, as different moisture parameterizations. The main goal is to reconstruct the historical (recent past) regional precipitation characteristics (both mean and extremes) of the Carpathian region as reliable as possible. The current study focuses on the newest model versions of RegCM (RegCM4.5 and RegCM4.6) that are used to compare hydrostatic and non-hydrostatic approaches as well, as different moisture parameterizations. For validation purpose, RegCM simulation outputs are compared to the homogenized, gridded CarpatClim data (*Spinoni et al., 2015*), which are based on the measurements of regular meteorological stations.

DATA AND METHOD



The map on the right shows the topography of the integration domain. Validation is shown for the eastern half of the RegCM integration domain covering the CarpatClim domain (indicated by red rectangle on the map). In addition, two special geographical subregions with different climatic conditions are selected for more detailed validation: the purple rectangles indicate the Tatra mountain (the northern subregion - highland) and the Great Hungarian Plain (the southern subregion - lowland).

Summary of the simulation details

Name	Model version	ICBC	Dynamical core	Large-scale precipitation (LSP)	Convective precipitation (CP)	Closure
H_SUBEX	RegCM4.5	ERA Interim (0.75°)	Hydrostatic	SUBEX[1]	MIT-Emanuel / Grell[3]	FC[4]
H_NMIC	RegCM4.5	ERA Interim (0.75°)	Hydrostatic	**NMIC**[2]	MIT-Emanuel / Grell[3]	FC[4]
NH_SUBEX	RegCM4.5	ERA Interim (0.75°)	**Non-Hydrostatic**	SUBEX[1]	MIT-Emanuel / Grell[3]	FC[4]
NH_NMIC	RegCM4.5	ERA Interim (0.75°)	**Non-Hydrostatic**	**NMIC**[2]	MIT-Emanuel / Grell[3]	FC[4]
NH_NMIC_NC	RegCM4.5	ERA Interim (0.75°)	**Non-Hydrostatic**	**NMIC**[2]	MIT-Emanuel[3]	---
4.6_H_NMIC	**RegCM4.6**	ERA Interim (0.75°)	Hydrostatic	**NMIC**[2]	MIT-Emanuel / Grell[3]	FC[4]

Our simulation matrix contains 6 different model simulations

- *RegCM4.5 was run both in hydrostatic and non-hydrostatic mode*
- *The large scale precipitation scheme was tested: SUBEX and NMIC*
- *A simulation uded non-hydrostatic dynamics and NMIC, but the convective parameterizations were switched off*
- *RegCM4.6 was compared to RegCM4.5 in the case of the best performing model setup (hydrostatic, NMIC)*

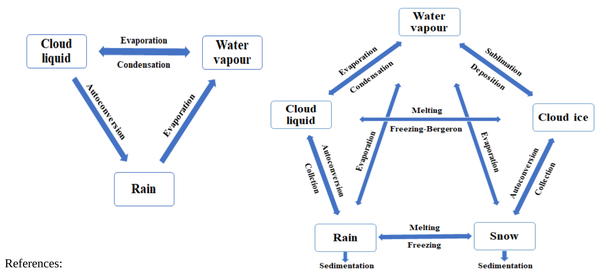
[1]SUBEX (Pal et al., 2000)

[2]NMIC: New cloud microphysics scheme (Nogherotto et al., 2016)

[3]MIT-Emanuel (1991) over sea and Grell (1993) over land

[4]FC: Fritsch and Chappell (1980)

The comparison of the tested large scale precipitation schemes

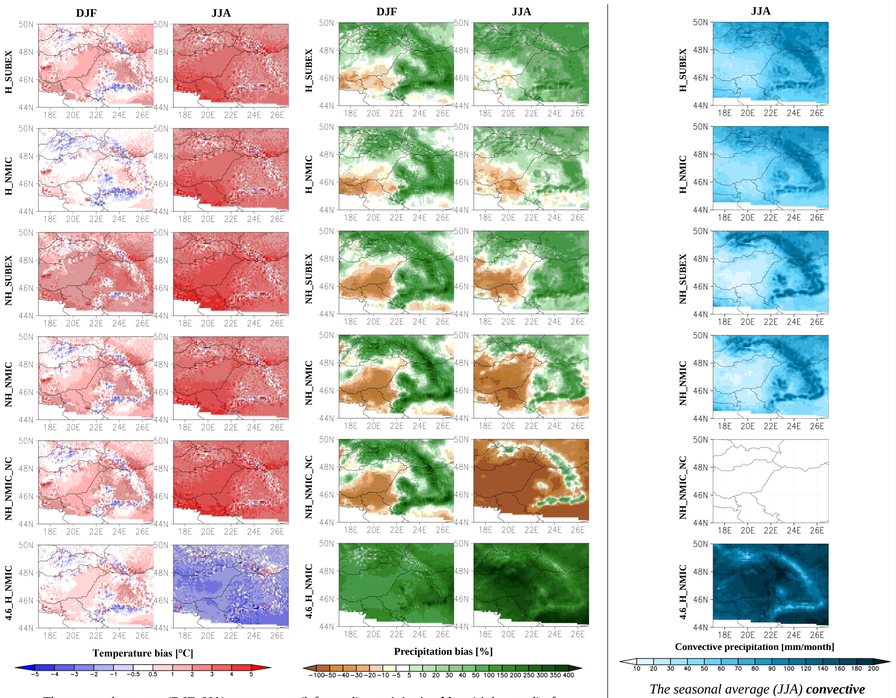


References:

SUBEX (Pal et al., 2000)

NMIC: New cloud microphysics scheme (Nogherotto et al., 2016)

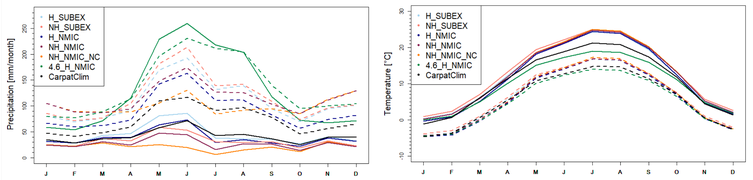
GENERAL RESULTS – ENTIRE DOMAIN



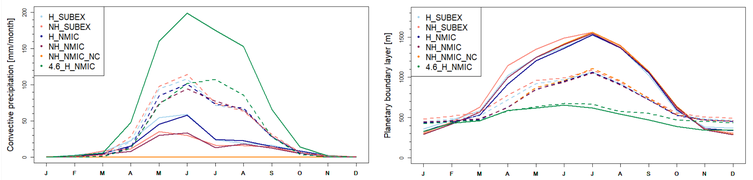
*The seasonal average (DJF, JJA) temperature (left panel), precipitation **bias** (right panel) of the 10-km horizontal resolution RegCM4.5 and 4.6 simulations, 1981–1990. Validation data: CarpatClim, Spinoni et al. (2015)*

*The seasonal average (JJA) **convective precipitation** of the 10-km horizontal resolution RegCM4.5 and 4.6 simulations, 1981–1990.*

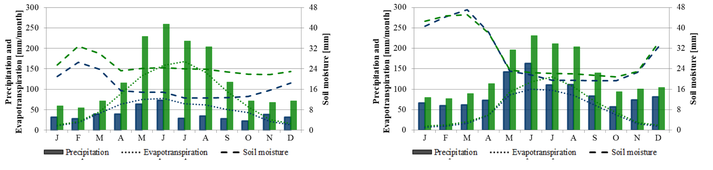
SPECIFIC RESULTS – SELECTED SUBREGIONS



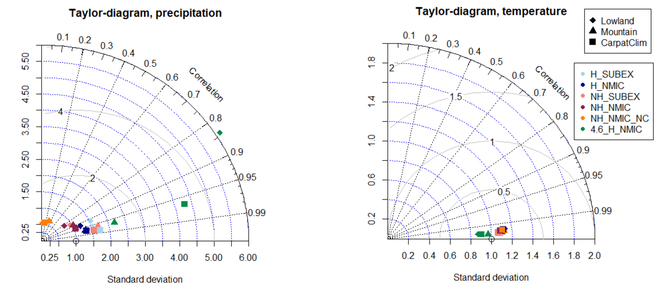
*Annual distribution of monthly mean **precipitation totals** (mm/month, left) and **temperature** (°C, right) over the selected subregions (Hungarian Great Plains – solid line , Tatra – dashed line). (Reference data: CarpatClim – black line), 1981-1990.*



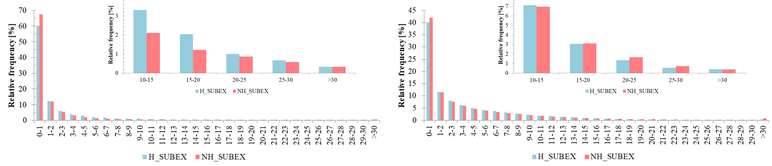
*Annual distribution of monthly mean **convective precipitation** (mm/month, left) and the height of **planetary boundary layer** (m, right) over the selected subregions (Hungarian Great Plains – solid line , Tatra – dashed line), 1981-1990*



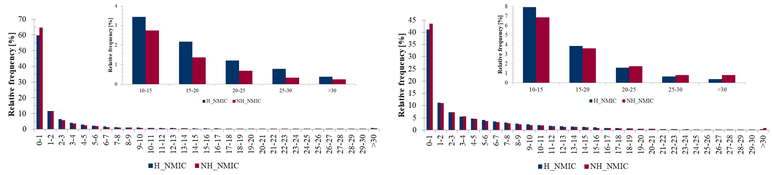
*Comparison of H_NMIC (blue) and 4.6_H_NMIC (green): annual distribution of monthly mean simulated **precipitation totals**, **evapotranspiration** and **soil moisture** over the selected subregions (left: lowland – Hungarian Great Plains; right: mountainous area – Tatra), 1981-1990.*



***Taylor diagram** of the mean annual cycle of temperature (left) and precipitation (mm/month, right) over the two subregions (lowland – Hungarian Great Plains; mountainous area – Tatra) and the entire CarpatClim domain simulated by the 6 simulations (Reference data: CarpatClim), 1981-1990.*



*The **frequency distribution** of daily convective precipitation in RegCM simulations (H_SUBEX, NH_SUBEX) for selected subregions (left: Hungarian Great Plains, right: Tatra), summer (JJA), 1981–1990.*



*The **frequency distribution** of daily convective precipitation in RegCM simulations (H_NMIC, NH_NMIC) for selected subregions (left: Hungarian Great Plains, right: Tatra), summer (JJA), 1981–1990.*

MAIN CONCLUSIONS

- The largest differences between simulated and observed temperatures occur in summer.
- The 4.6_H_NMIC is the least acceptable simulation: it overestimates precipitation and underestimates temperature.
- The NH_NMIC_NC does not calculate convective precipitation at all.
- After comparing the simulations, the H_NMIC seems to be the most promising over Hungary, however, it underestimates temperature in the Carpathian Mountains.
- More extreme convective precipitation occurs in the Carpathian Mountains than in the lowlands.
- The largest positive precipitation biases are found over the Carpathian Mountains, except with 4.6_H_NMIC.
- Question unsolved: Although the setups of H_NMIC and 4.6_H_NMIC are identical (stored in a separate file called namelist), unexpectedly large differences can be recognized between the simulations with the two model versions.

ACKNOWLEDGEMENTS

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