Performance of CMIP6 GCMs ensemble in the coupling zone for the RCM simulations in the PERUN project

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INTRODUCTION

- **Dynamical downscaling using regional climate models (RCMs) is a common solution to assess climate features on regional and local scales.**
- **Nevertheless, RCMs outputs are influenced by the lateral boundary conditions provided by global climate models (GCMs) [1]. The magnitude of this influence depends on various aspects including the geographical region, temporal scale, climatic variable, etc.**
- **This study is divided in two parts: i) to validate two reanalyses with radiosondes at different vertical levels and ii) to evaluate GCMs from the Coupled Model Intercomparison Project phase 6 (CMIP6), both in the lateral boundary region of ALADIN-CLIMATE/CZ domain [2]. The goal is to evaluate the CNRM-ESM2-1 ensemble performance as also of one of its members, since this model will be used as boundary conditions for the ALADIN-CLIMATE/CZ convection-permitting simulations for PERUN Project [3].**

DATA AND METHODS

Period 1990-2014	Validation	Boundary analysis
Data basis	ERA5 and CFSR reanalyses; four radiosondes (Fig. 1); 0000 and 1200 UTC	monthly data from ERA5; CMIP6: GCM ensemble (60 models), CNRM-ESM2-1 ensemble (10 members) and CNRM-ESM2-1 (PERUN driving simulation)
Variables/levels	ta, hus, ua, va, hgt at 850, 500, 300, 200 hPa	ta, hus, ua, va at 850, 500, 300 hPa
Method of analysis	Spearman correlation (s) and mean absolute error (MAE)	Model performance index (RK Index) [4]: $e^2_{svm} = \sum_{i=1}^{n} \frac{\left(\bar{s}_{svmi} - \bar{o}_{svi}\right)^2}{\sigma^2_{svi}}$

RESULTS

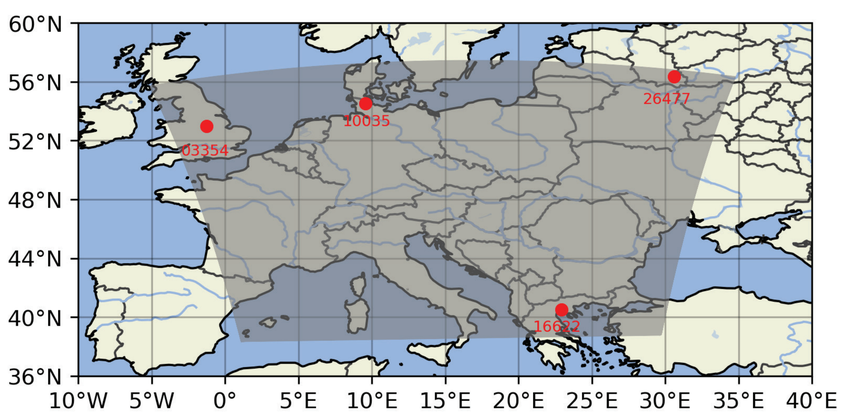
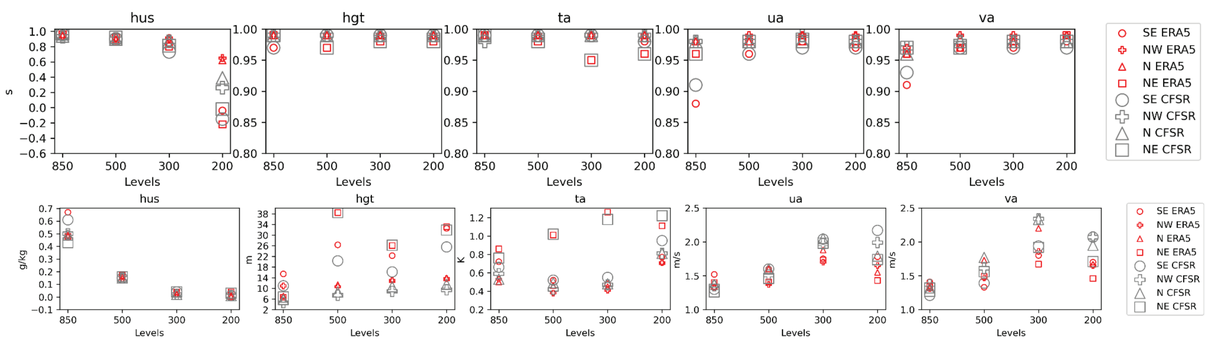


Fig 1. Integration domain of ALADIN-CLIMATE/CZ (shaded in grey) and the selected stations with available radiosondes (red dots) for the period 1990-2014: 03354 (hereafter NW), 10035 (N), 26477 (NE) and 16622 (SE).



Parameter/ variable	hus	hgt	ta	ua	va
S	above 0.75 for all levels except for 200 hPa, where there are also negative values; highest correlation at 850 hPa	high correlation (above 0.97) for all levels; lower correlations at 850 and 500 hPa for SE and NE, respectively	high correlations (above 0.95); the lowest is at 300 hPa in NE	correlations in general above 0.95, except at 850 hPa in SE location	similar to ua
MAE	higher error in SE in ERA5; lower errors at upper levels	higher errors towards upper levels and in NE and SE locations (in SE ERA5 has higher error); NW presents lower errors in all levels	higher errors in NE, especially at 300 (in ERA5) and 500 hPa; most locations showing higher errors at 200 hPa; lower errors at 850 hPa	higher errors at upper levels (300 and 200 hPa), especially in CFSR; at 200 hPa SE and NW have higher errors	similar to ua; NW and N having higher errors in CFSR

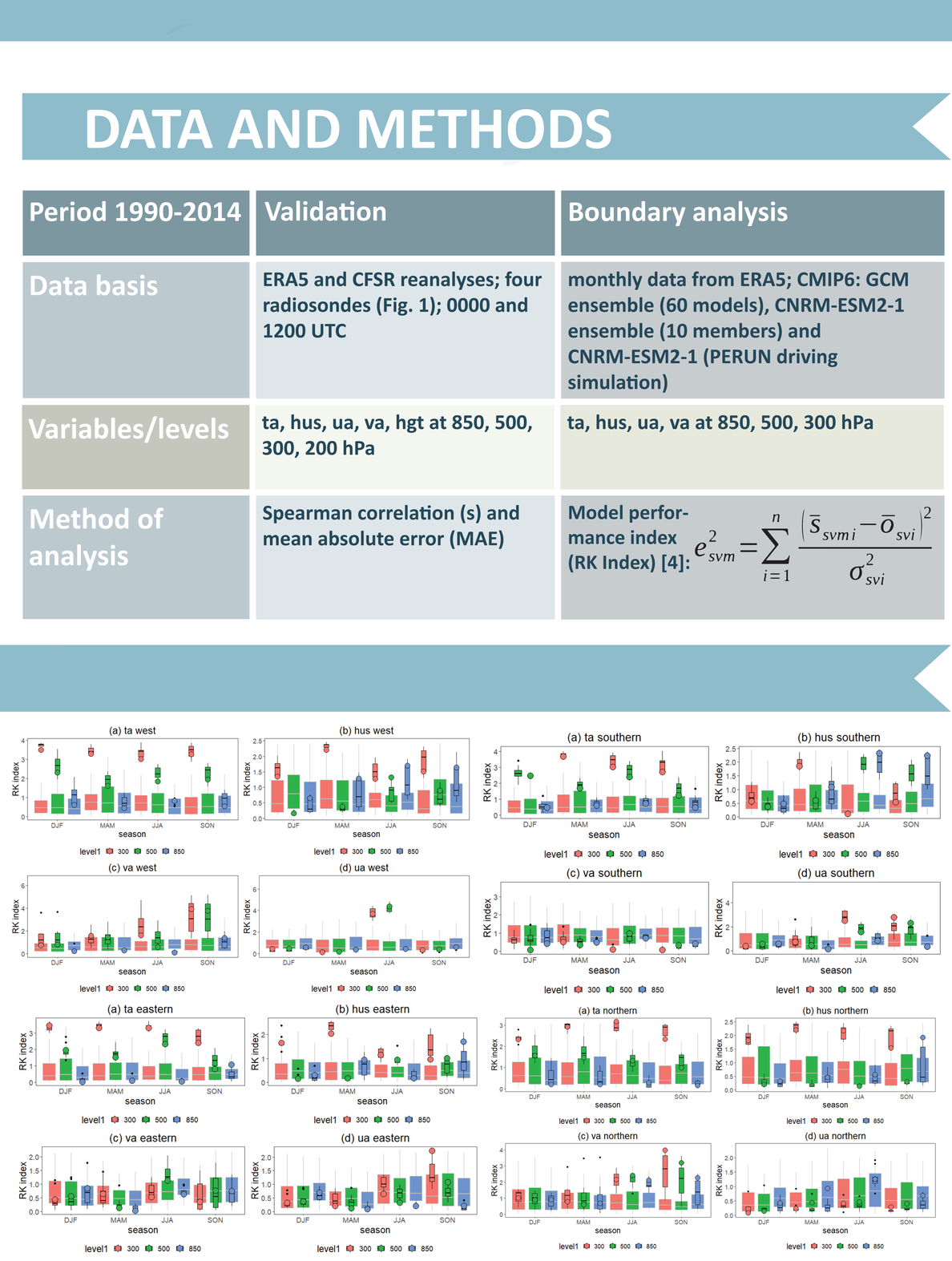


Fig 2. Seasonal RK Index for the four studied variables and boundaries; the GCM ensemble is represented by the large boxplots with grey lines, CNRM-ESM2-1 ensemble by the small boxplots and CNRM-ESM2-1 PERUN driving simulation by the filled circle.

General comments

CMIP6-GCM ensemble
- **ua** and **va** show higher spread during JJA in the eastern and northern boundaries for all levels
- **hus** has higher spread during DJF in the western and northern boundaries

CMIP6-CNRM ensemble
- **ua** and **va** have similar behavior of GCM ensemble but in some cases are even better for the western, northern and southern boundaries
- **ta** has higher RK Index but smaller spread compared to GCM ensemble, which means larger bias but smaller internal variability (especially at 300 hPa)
- **hus** presents higher RK Index than GCM ensemble, especially at 300 hPa

CMIP6-CNRM-ESM2-1 PERUN driving simulation
- follows the behavior of CNRM ensemble

CONCLUSIONS

- Correlation between reanalyses and radiosondes are very high in general; there are some differences in the correlation depending on the variable: for instance, **hus** is better correlated at **lower levels**, while **hgt, ua** and **va** are better correlated at **upper levels**; **NE** and **SE** locations show **lower** correlations
- **SE** and **NE** locations and **upper levels** present **higher errors** for most variables
- The CNRM ensemble, including the CNRM-ESM2-1 PERUN driving simulation, is rather exceptional, rarely behaving as a “mean” model. In most cases, CNRM RK Index is either smaller or much larger than GCM ensemble
- There is no clear pattern that would imply that the model errors are smaller or larger on some of the boundaries, levels or seasons, except for **northern** and **western** boundaries, where the CNRM ensemble has much **larger errors** of **ta** and **hus** at 300 hPa than the rest of GCMs, but **smaller errors** for **ua** and **va**, especially on the **southern** boundary
- *Next step is to evaluate how the errors propagate in the interior of the domain*
- *These results are part of a paper in preparation to be submitted to Climate Dynamics by this year*

References:
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[2] Termonia et al. (2018) https://doi.org/10.5194/gmd-11-257-2018
[3] Holtanová et al. (2023) https://doi.org/10.5194/egusphere-egu23-11741
[4] Reichler and Kim (2008) https://doi.org/10.1175/BAMS-89-3-303

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