Final Report for Project **1133**

Project title: **Low-level circulation, Moisture Convergence and Precipitation Biases in Regional Climate Simulations for Central America with COSMO-CLM**

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The initial goal of the project was the calibration of COSMO-CLM for the Central America CORDEX domain (Fig. 1), with a particular focus on a proper representation of low-level jets and precipitation, variables of crucial importance for impact studies focusing on this region. Once determined whether a specific configuration of COSMO-CLM could have produced results close enough to observations, the second objective of the project was to conduct a series of high-resolution climate projections for the area, under the conditions that the latest CMIP6 simulations would have become available in the meantime. Unfortunately, due to some delays in the availability of CMIP6 simulations and in the development of proper strategies for adapting CMIP6 model outputs to the CLM grid by the CLM-community, it was not possible to accomplish the second of the two goals. However, over the two years we conducted more than 30 simulations that helped in substantially improving the reliability of COSMO-CLM for the region and to gain a better understanding of the main ingredients that need to be considered for the proper representation of specific atmospheric circulation features of the area in a regional climate model.

Starting from a reference simulation based on the proposed optimal model configuration for the CORDEX South America region of Lange et al. (2015), we tested different model configurations and demonstrated that turbulent heat exchanges between the ocean and the atmosphere play a major role in modulating the low-level atmospheric circulation in Central America (Fig. 2), with important consequences also for the reproduction of precipitation (Fig.3). Even if other factors, such as an extension of the original domain in each direction to better detect the shift of the ITCZ in the different seasons, are important at the tested resolution of ~22km, their effects are less relevant compared to changes in the parameter controlling the laminar scaling ratio of heat transfer between the ocean and the atmosphere (Fig. 4).

In a final simulation we also tested the effects of an increase in the spatial resolution of the model, going from a grid spacing of ~22 km to ~12 km. Also in this case we saw that no significant changes are obtained for the considered target variables (Fig. 5) that would justify the computational costs associated with this increase in resolution.

The results of the study were presented at several conferences, such as at the CLM Assembly 2021. Unfortunately, until today it has not been possible to publish the results in a peer-reviewed journal. We hope to finally submit a manuscript describing the results of the projects in the next months to the journal Climatic Change.

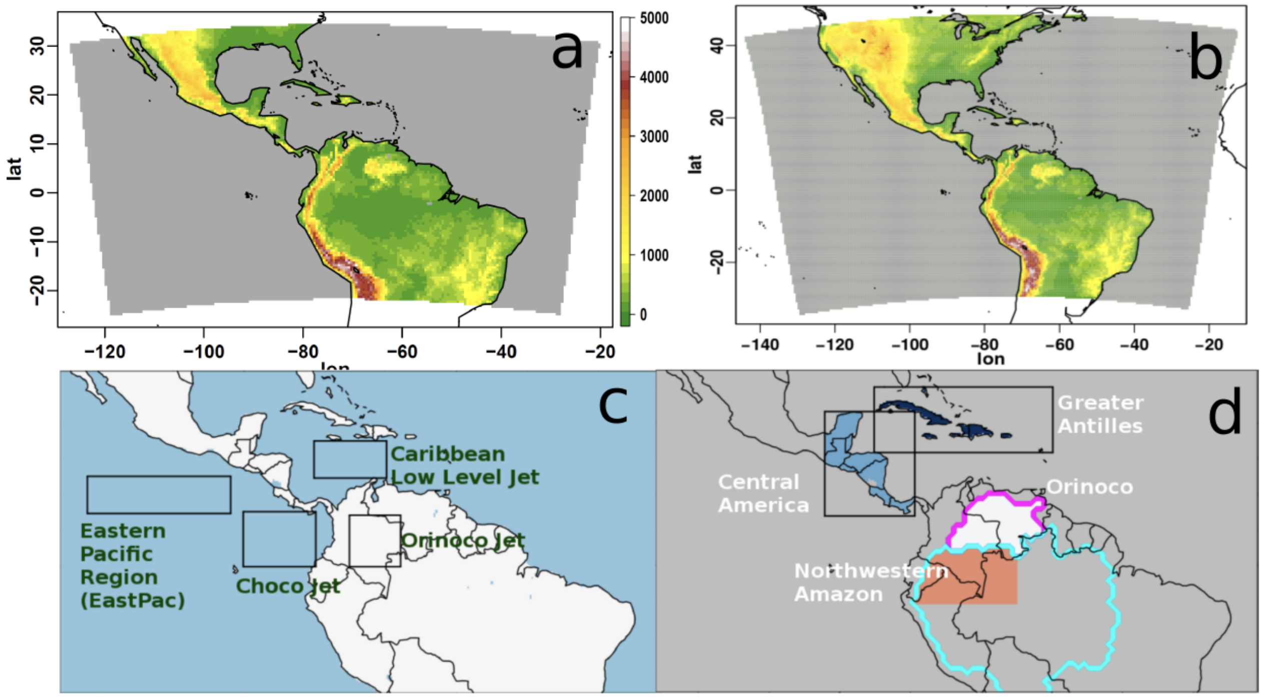

Figure 1: (a) *(a) Topography of the domain of study. In dark gray the area is highlighted over which the simulations are performed. (b) Extended Domain. (c) Definition of regions for wind indices. (d) Definition of regions (land-cells only) for assessment of precipitation and temperature*

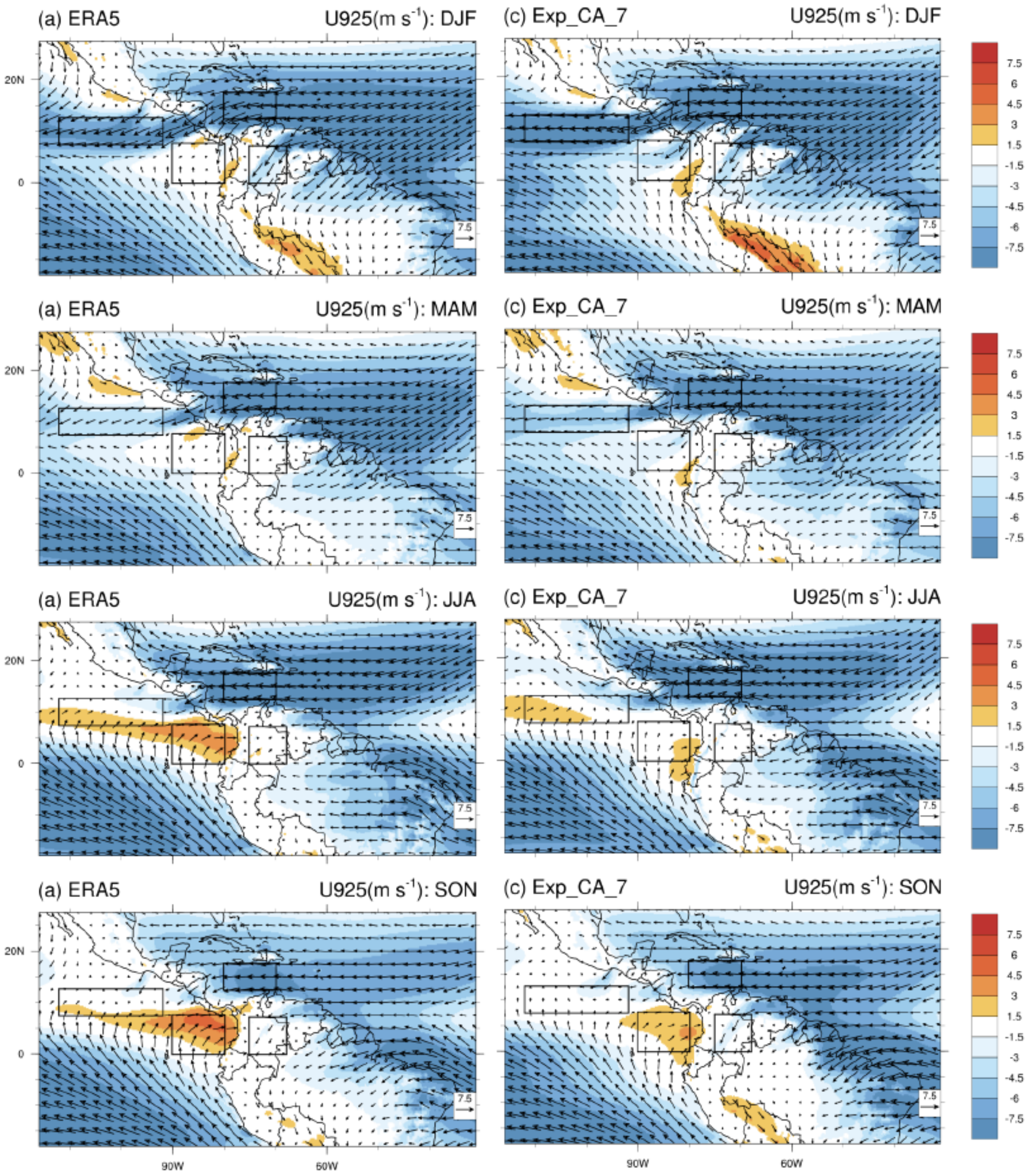

Figure 2: 20-year climatologies of seasonal means of mean sea level pressure (shading, in hPa) and wind at 925 hPa (arrows) as derived from the ERA5 reanalysis data (left) and the simulation with the parameter controlling the ratio of laminar scaling factors for heat over sea and land (rat_sea) set to 20 instead of the default value of 10.

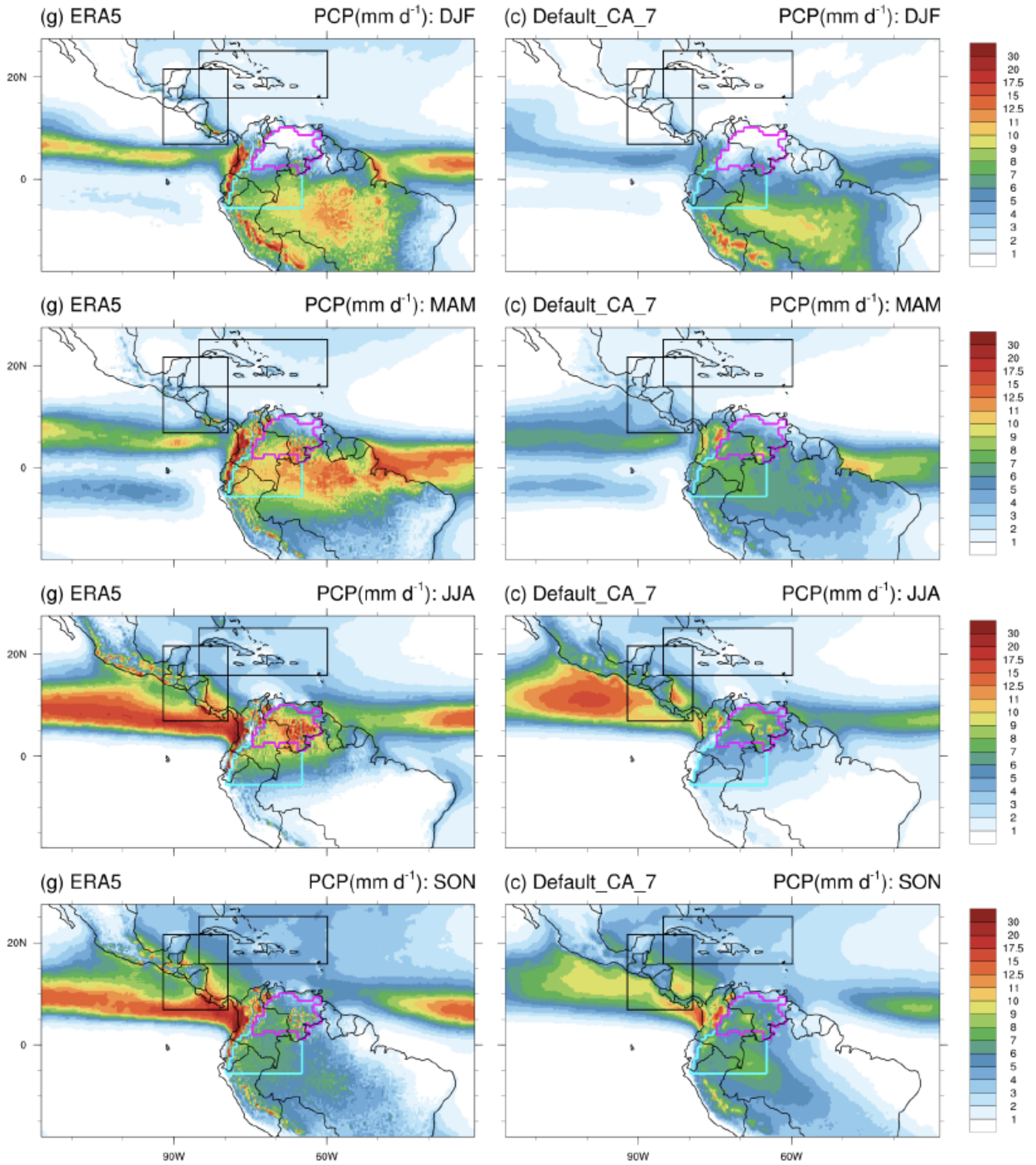

Figure 3: 20-year climatologies of seasonal means of precipitation (shading, in mm/day) as derived from the ERA5 reanalysis data (left) and the simulation with the parameter controlling the ratio of laminar scaling factors for heat over sea and land (rat_sea) set to 20 instead of the default value of 10.

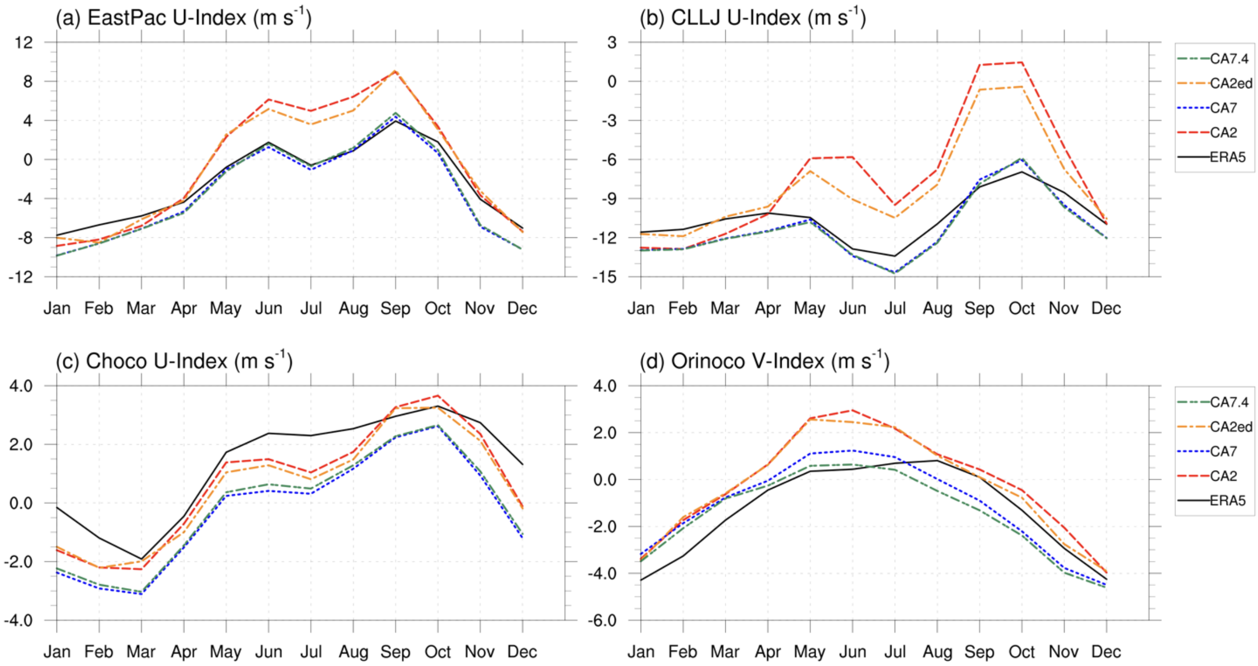

Figure 4: *Indices of low-level (925 hPa) winds calculated over the corresponding boxes of Fig. 1c. In black the monthly climatologies calculated over the period 1996-2015 as derived from ERA5 are shown. The results of the monthly climatolologies from the default simulation using the configuration of Lange et al. 2015 are presented in red, while the results using the same configuration but a more extended domain (as shown in Fig. 1b) are presented in orange. Finally, two simulations with the parameter controlling the ratio of laminar scaling factors for heat over sea and land set to 20 instead of the default value of 10, are presented in blue and dark green. The simulation 7.4 (dark green) uses a different representation of tree canopies based on observational data compared to experiment 7 (blue).*

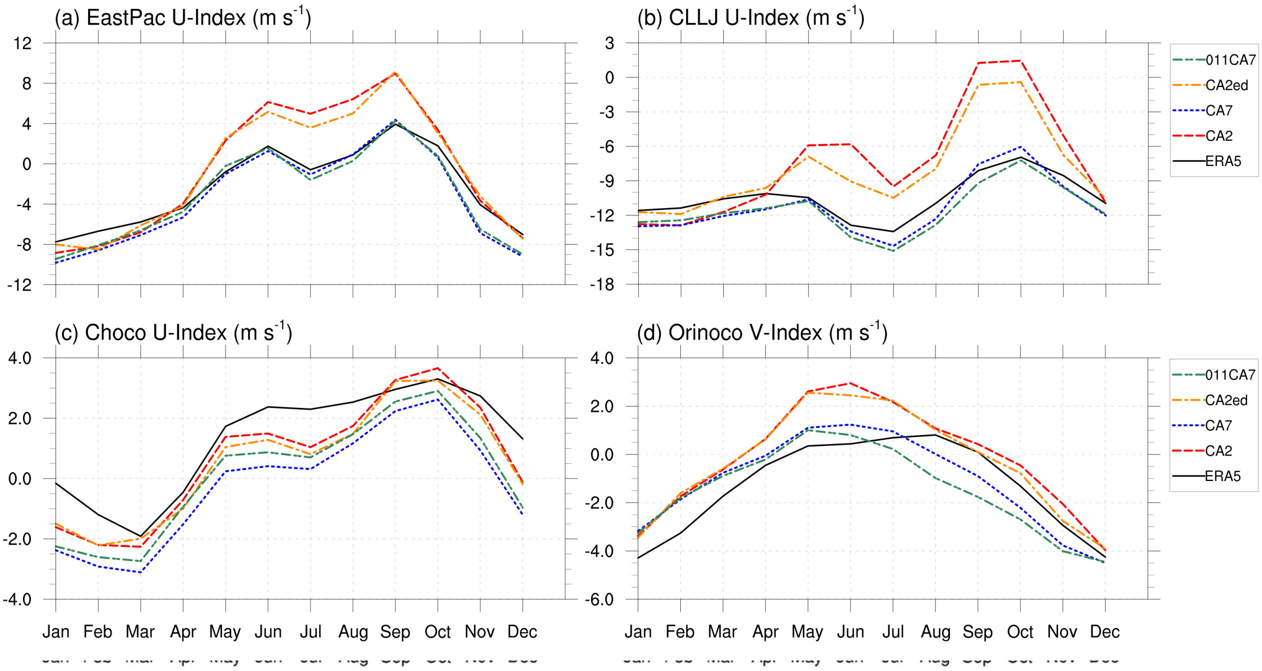

Figure 5: Same as in Fig. 4, but here the results of the simulation CA7 using a grid with an increased spatial resolution of ~12 km are presented in green (011CA7) instead of the simulation CA7.4.