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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In the first year of the project weobtained very important results, even though in the first place only 50% of the requested computational resources were allocated.

Following the reviewer comments, we focused our attention on the performance of numerous sensitivity tests at a spatial resolution of 0.22°. No simulation has ever been performed for this region using COSMO-CLM and these experiments were necessary prior to the realization of future climate projections. Starting from a default model configuration used for the CORDEX Central America domain (Lange et al. 2015), our attention thus focused on testing the effects of parameters and physical options mainly inherent to the representation of convection, topography and ocean-atmosphere interaction.

By the end of October 2020, we performed a total of 25 simulations. 20 for testing the different model configurations and 4 for evaluating the model internal variability. In 1 additional simulation we analyzed the effects of a more extended domain on the simulation of main circulation patterns characteristic of the region. We let the model run on both the compute and the compute2 partitions of MISTRAL. The model required approximately 2000 node hours for the completion of 25-year long simulations on the compute2 partition, and 30% more resources in the other case, with approximately 2600 node hours required for the accomplishment of a complete simulation.

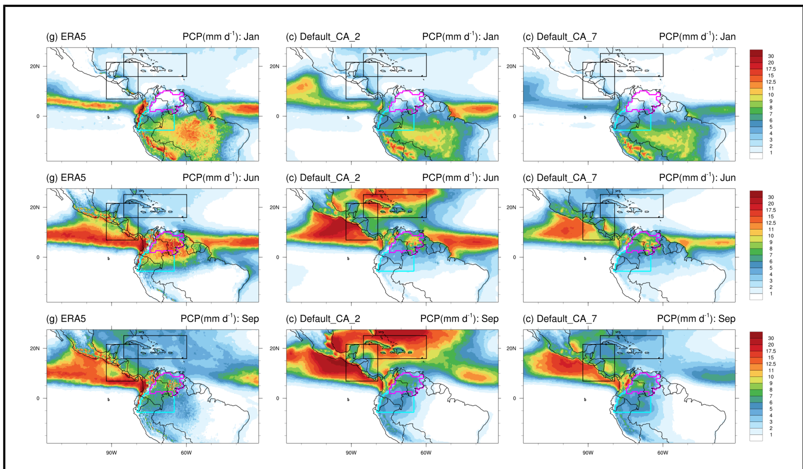

Figure 1: Maps of monthly mean precipitation calculated over the period 1996-2015 for, respectively from left to right, ERA5 reanalysis data, the reference model configuration of Lange et al. (2015), and a test with the parameter regulating heat exchange between ocean and lower atmosphere set to 20 (in the reference simulation the same parameter has a value of 10). From Top to bottom, the climatological monthly means for January, Jun and September are shown.

One remarkable issue related to the representation of precipitation was evident from the default simulation (Default_CA_2), with unrealistically enhanced precipitation over the Caribbean region (Fig. 1). With the help of different tests, we managed to solve this problem by increasing the value of the parameter rat_sea (the ratio of laminar scaling factors for heat over sea and land; this simulation is here denominated as default_CA_7). A higher value of this parameter increases the resistance of the laminar layer for heat transfer, with a subsequent decrease in heat fluxes between the ocean surface and the lower atmosphere. One important consideration about the evinced precipitation bias is that this could only be detected by analyzing model results over the entire domain of study. This is important for evaluation studies based on a mere comparison of model results against observations on the base of pre-defined metrics, since most of gridded data-sets are available only over land.

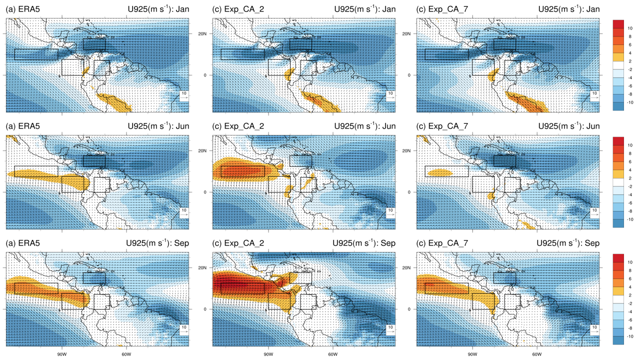

Figure 2: Maps of monthly mean of the horizontal component of wind (U) at 925 hPa, calculated over the period 1996-2015 for, respectively from left to right, ERA5 reanalysis data, the reference model configuration of Lange et al. (2015), and a test with the parameter regulating heat exchange between ocean and lower atmosphere set to 20 (in the reference simulation the same parameter has a value of 10). From Top to bottom, the climatological monthly means for January, Jun and September are shown.

The problem of the default simulation appeared to be related to the development of cyclonic circulation patterns during the summer and autumn seasons (Fig. 2). During June-August this patterns yield more northward flow over the Caribbean. During September-October the cyclonic circulation is stronger, even producing a reversal of the Caribbean Low-level Jet (CLLJ). A similar structure from May to October is found at 850hPa and 500hPa (not shown), along with a higher accumulation of precipitable water (not shown) and higher relative humidity at 500hPa (not shown) over the northern part of the domain, including the Gulf of Mexico, the Greater Antilles and the northern Atlantic. This overall modification of the flow is associated with more precipitation over these regions. These patterns are not realistic, according to comparisons with CHIRPS precipitation observations and ERA5 reanalysis data. Having a higher surface resistance the new configuration (default_CA_7) produces a much more realistic flow and moisture distribution (low- and mid-level flow, relative humidity and precipitable water), along with a better pattern of precipitation.

The newly determined model configuration with increased resistance of the laminar layer for heat transfer (default_CA_7), has been successively used in a second part of the project, for additional sensitivity tests, aimed at further improving model performance, with a main focus on near surface temperature.

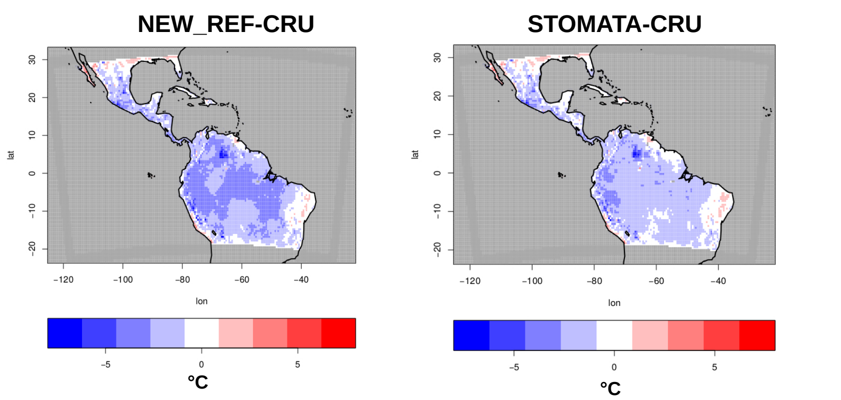

Figure 3: Bias of May monthly mean, calculated over the period 1996-2015, between the new reference simulation with increased surface resistance (DEFAULT_CA_7) and the CRU observational dataset on the left, and between the results of a simulation with minimum stomata resistance read from external data and the same CRU dataset, on the right.

In this second set of experiments we mainly focused on changes in the representation of land surface and soil properties available in the model. One experiment that led to further improved model results, in particular concerning the representation of temperatures over the Amazonian Basin, is the one that makes use of information on minimum stomata resistance of plants read from an external map (Fig. 3).

At the end of the sensitivity experiments conducted in the first year of the project we achieved our initial goals, managing to sensibly improve model performance with respect to a reference simulation, proposing a model configuration whose biases with respect to observational datasets are well within the range of other CORDEX simulations. The new setup can be reliably used for conducting climate projections for the region in the next year of the project.

A publication with the first results of the project is in preparation for the journal Climate Dynamics. We aim to submit it by the end of this year.