AN ENHANCED DOWNSCALING METHODOLOGY FOR THE ELABORATION OF HIGH-RESOLUTION CLIMATE SCENARIOS FOR PERU TO 2050

Acuña Delia, Llacza Alan, Sulca Sheylla, De la Cruz Gustavo, Paredes Jonathan, Jácome Gerardo

Contact: dacuna@senamhi.gob.pe

Atmospheric Numerical Modeling Division - National Service of Meteorology and Hydrology of Peru

Introduction

Peru has a great variety of climates due mainly to the interaction of ocean-atmospheric systems and complex orography (e.g. Andean, Amazon, and Coastal regions), these factors contribute to the presence of wide biodiversity and natural resources. At the same time, they also make Peru vulnerable to the effects of climate change. Therefore, in order to better adapt to its impacts, it is necessary to generate information at an adequate spatial resolution that could enable decision-making. Numerical models are important tools for the assessment of climate change impacts and risks. However, these models have limitations when simulating atmospheric processes over complex orographic areas, making it necessary to use downscaling techniques that allow optimized outputs at high resolution. This study aims to describe a downscaling method for the generation of high-resolution climate scenarios for Peru using data from Global Circulation Models (GCM). The approach is based on the combination of dynamical downscaling methods and statistical techniques that will allow obtaining better precipitation and temperature patterns at a regional and local level.

Results

Based on the dynamical-statistical downscaled outputs generated from the ACCESS1-0, HadGEM2-ES, MPI-ESM-LR models, precipitation and temperature patterns are projected to change to 2050 over Peru as in:

Annual rainfall projections suggest reductions in most part of the Amazon region. On the Andes, increases up to 30% are projected on the eastern side. In contrast, important reductions may occur in the southern western Andes of ~45%. On the coastal region, the larger increases (>90%) of annual precipitation are expected on the southern part (Figure 2a).

As per the mean temperatures, the projections show generalized increases, mainly in the Amazon region on annual and seasonal time scales between 2.0 and 3.2 °C, with increases of up to 4.0 °C in winter. In the Andes, the greater increases are expected to occur in the southeastern highlands, from 1.8 to 4.0 °C. On the coastal region, temperatures are projected to increase between 1.6 and 2.8 °C, mainly on the northern coast.

It is important to note that the projected changes in mean temperature are more consistent than precipitation (Figure 2c).

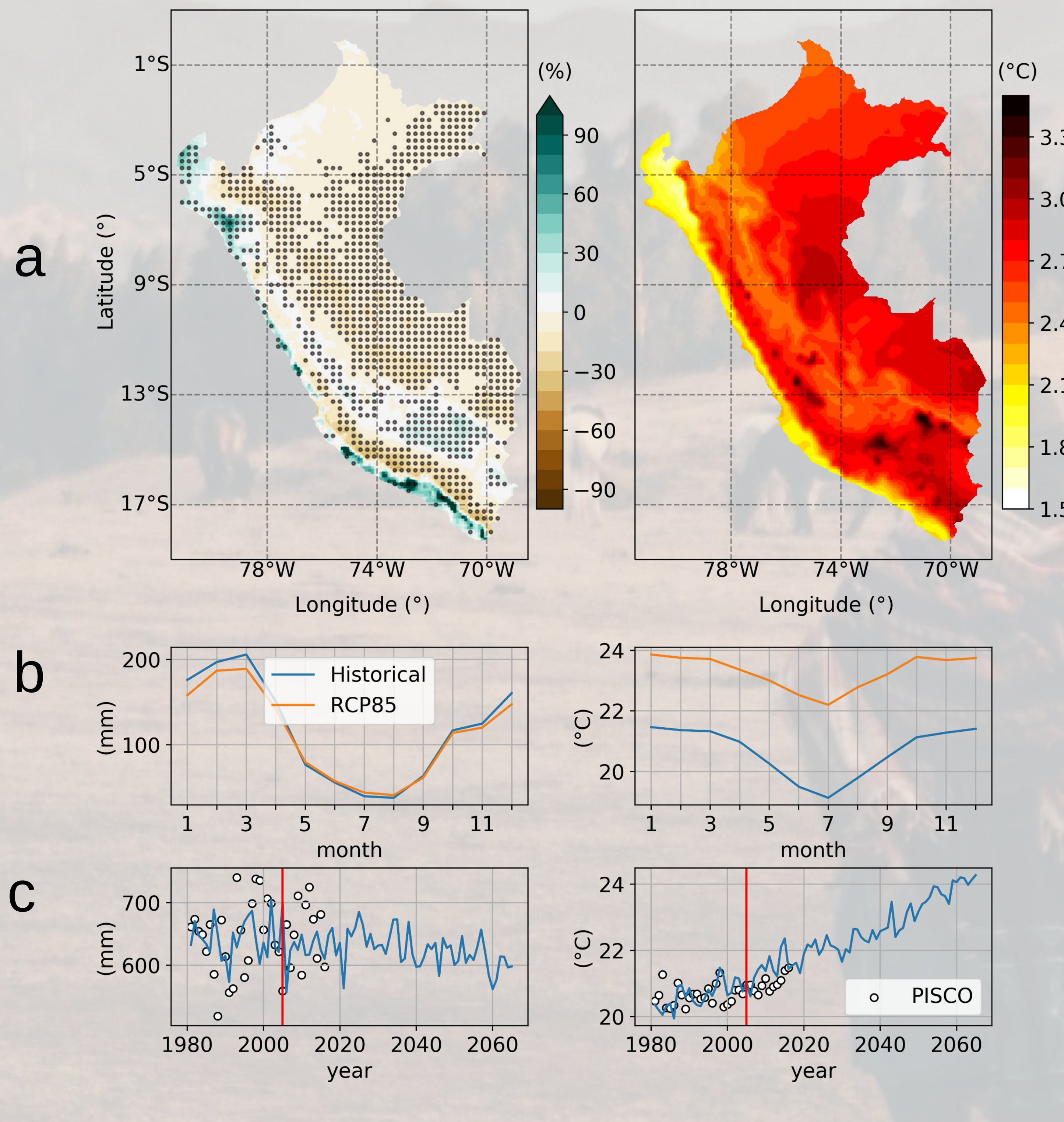

Figure 2. Annual total precipitation (left) and mean temperature (right) of a) Changes to 2050, b) Annual cycle, c) Time series.

Methodology

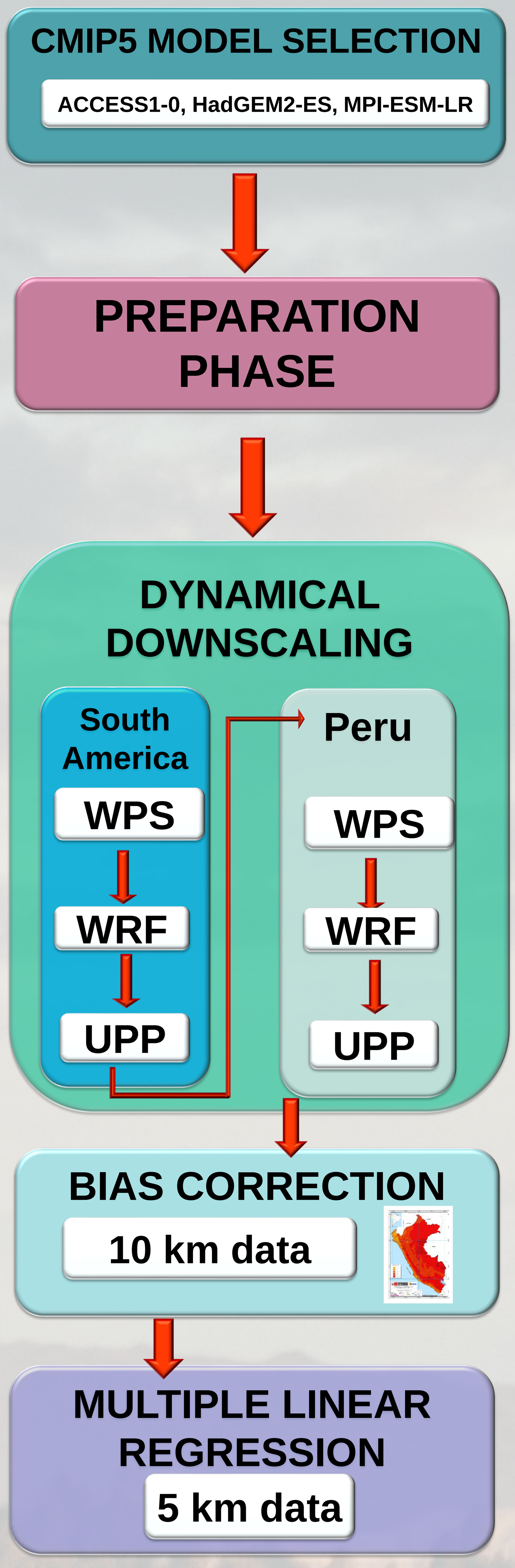

Figure 1. Downscaling method for the elaboration of high-resolution climate scenarios for Peru to 2050.

PHASE 1: CMIP5 model selection.

- Enhanced representation of South American atmospheric systems (Bolivian High, South Pacific Anticyclone, etc.).
- Verification of the RCP8.5 emission scenario.
- Hourly data collection.

PHASE 2: Global models preparation phase

- Interpolation of high-altitude atmospheric variables to vertical isobaric levels.
- Bias correction of atmospheric, soil, and oceanic variables of the global model based on ERA-Interim and OSTIA reanalysis.

PHASE 3: Dynamical downscaling

- Coupling of atmospheric, soil, and oceanic variables and geographic data in the WRF model preprocessing component (WPS).
- Preparation of initial and boundary conditions, the first part of the WRF model processing component (WRF).
- Numerical integration for downscaling at first over South America and then over Peru, as the second part of the WRF model processing component.
- Unified Post Processing System (UPPS).

PHASE 4: Bias correction.

- Extraction of the precipitation, maximum, and minimum temperature variables from the Peru domain.
- Bias correction by Linear Scaling (LS) technique using the PISCO database at 10 km.

PHASE 5: Multiple linear regression.

- Downscaling to 5 km based on multiple linear regression of 4 co-variables: temperature interpolated with Kriging at 5 km, latitude, longitude, and the difference between the heights of the WRF model and a DEM from the National Geographic Institute.

Since 2010, SENAMHI has been periodically updating climate scenarios for Peru, integrating a more robust methodology to provide better spatially detailed information on possible changes in precipitation and temperature patterns for the analysis of climate change impacts.

Conclusions

Considering the spatial heterogeneity of climates due to the complex topography of Peru and other factors, a methodology has been developed to elaborate on high-resolution climate scenarios for 2050. The methodological scheme consisted of data preparation from CMIP5 models, dynamical downscaling, bias correction to the downscaled output, and the application of geostatistical methods.

Through this methodology, it was possible to obtain more representative information on precipitation and temperature patterns at a resolution of 5 km. As a result, reliable climate information was obtained that will be useful for climate risk analysis and climate change impacts studies in Peru.

References

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