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FORECAST CHANGE IN DRY AND HUMID PERIODS IN SOUTH AMERICA, USING THE CORDEX RCM-SMHI WITH BIAS CORRECTION

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INTRODUCTION

Extreme precipitation events will be more common in the future due to climate change. In this work, precipitation deviations were computed using the *Standardized Precipitation Index* (SPI), which is broadly recognized because its simplicity. The SPI associates the precipitation data with standardized deviations, so long series are required to fit the distribution, then transformed into a standard normal variable. The SPI positive values point out precipitation surpluses, while negative values show precipitation deficits.

STUDY AREA AND DATASET

The study area spans 56°S – 13°N and 82°W - 34°W (see Figure 1), which corresponds to the whole South America territory. Inside the study area, the precipitation grids from the University of Delaware's Air Temperature and Precipitation database (UD-ATP), and from the Regional Climate Model developed by Swedish Meteorological and Hydrological Institute (RCM-SMHI), were employed.

The UD-ATP information consists of monthly grids of total precipitation (and average temperature values, not used) from 1901 to 2010 (version V3.01), with 0.5° spatial resolution (approximately 50 km close to the equator) and grid-points centered at 0.25°. These archives encompass all emerged surfaces on Earth (read: dry land areas), relying on 720 x 360 x 1332 pixlation. The interpolation process, as it pertains to the construction of monthly fields, is explained by Matsuura and Willmott [1], [2].

Inside the Coordinated Regional Downscaling Experiment (CORDEX), the SMHI developed a number of RCM in several CORDEX domains, which use dynamical downscaling [3]. The precipitation depth of South America RCM-SMHI was used. The chosen product, with 0.5° spatial resolution of RCM-SMHI grids, fits with both the spatial and temporal resolution of UD-ATP grids.

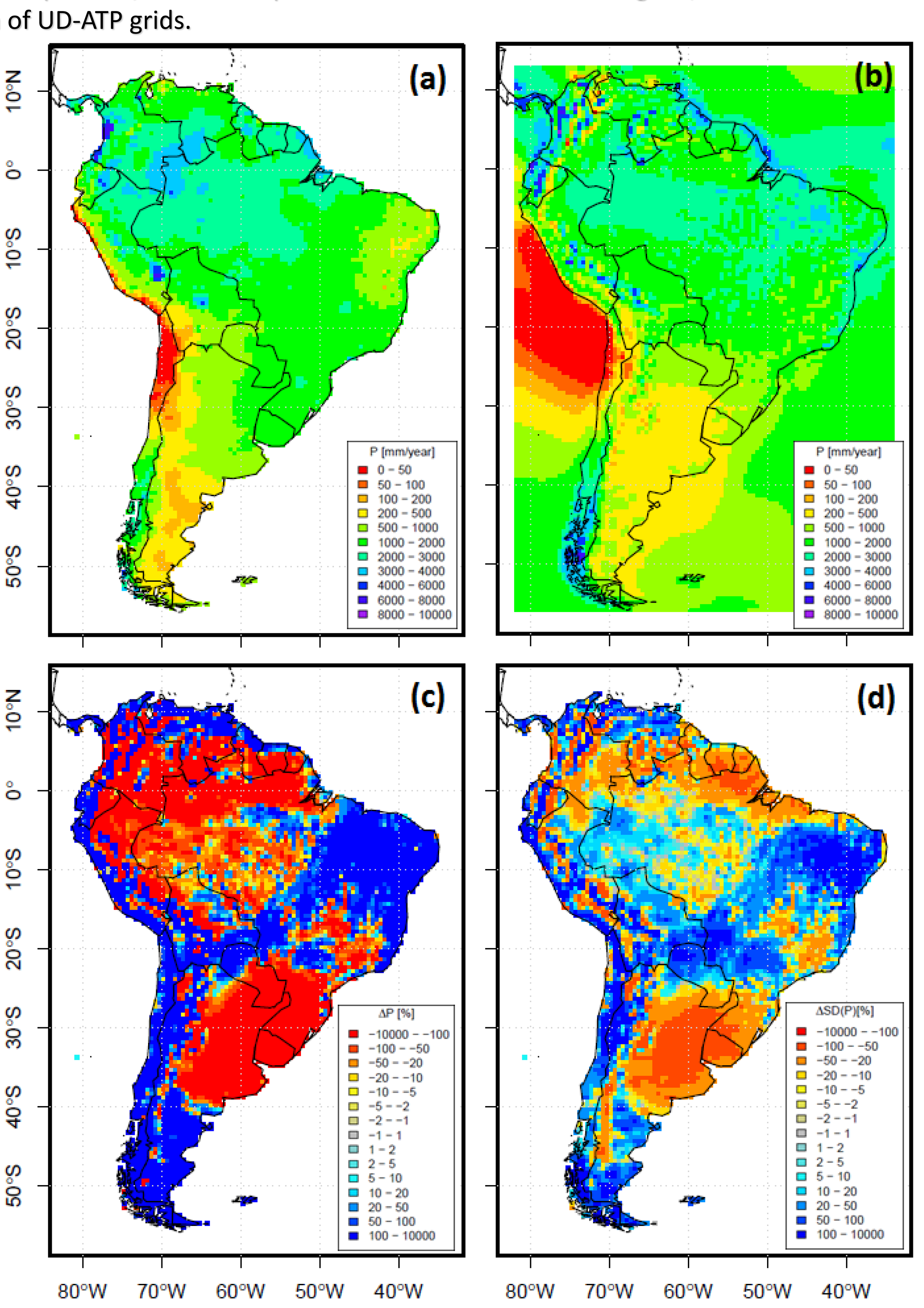

Figure 1. Mean annual precipitation over South America (computed in 1961-1990 period), from a) UD-ATP database and b) RCM-SMHI.
The bias of RCM-SMHI data is also presented in c) for mean values, and d) for standard deviation. In both, the warm colors shows areas where RCM-SMHI precipitation data under-estimates the UD-ATP c) observed mean precipitation, or d) the observed standard deviation. The maps c) and d) are expressed as percentage of standard deviation of UD-ATP monthly time series in each grid-point.

BIAS CORRECTION OF RCM-SMHI PRECIPITATION DATA

The bias correction of RCM-SMHI precipitation data was done, previous to the Standardized Precipitation Index (SPI) computation process, using as "observed" data the UD-ATP precipitation database. The bias correction was performed in each one of the 6183 grid-points inside the considered domain, using the 1961-1990 period.

The time series of precipitation from the used databases (UD-ATP and RCM-SMHI) were split in a monthly fashion. Then, a Gaussian Process Regression (GPR) was performed between the Cumulative Distribution Function (CDF) of both time series, using a linear kernel. Then, the RCM-SMHI time series were transformed (i. e. "bias corrected") using the computed transference functions.

The procedure was implemented using the `kernlab` R library [4]. The outputs of the previous procedure are showing in Figure 2 for a grid-point example (center at 74,25°W-4,75°N, close to Bogotá-Colombia), while the Figure 3 shows the bias correction map results for mean and standard deviation.

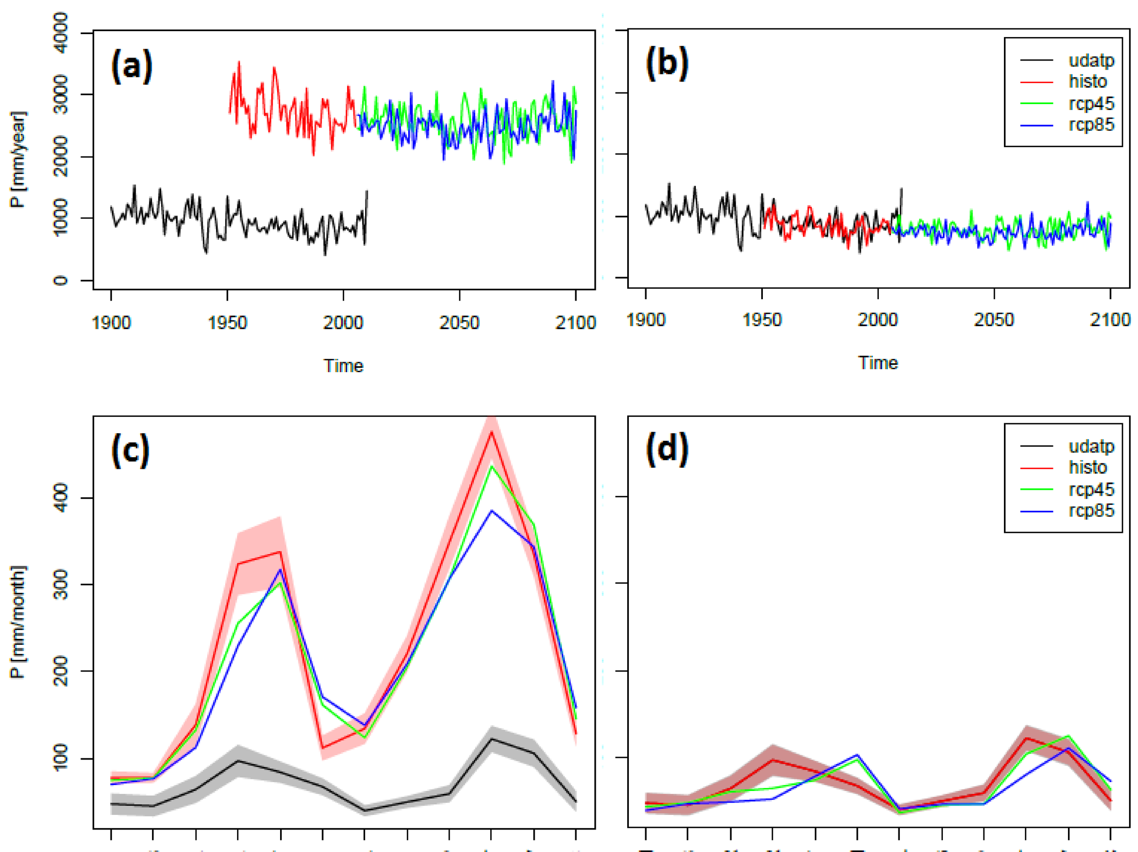

Figure 2. Result of the bias correction procedure. For all frames, the **black** color represents the UD-ATP data (observed precipitation). The RCM-SMHI data are represented by the **red** (historical), **green** (RCP45*) and **blue** (RCP85*) colors.
*RCP are the Representative Concentration Pathways adopted by the IPCC-AR5 in 2014.
a) Time series of annual precipitation depth for UD-ATP (1900-2010) and non corrected data of RCM-SMHI: historical (1951-2005), RCP45 and RCP85 (2006-2100). The frame b) is the same, but for RCM-SMHI data with bias correction. Annual cycles are presented for the RCM-SMHI data c) non corrected, and d) with bias correction. The monthly averages were computed in 1961-90 period for observed UD-ATP data and historical RCM-SMHI. Between 2071-2100 were computed the annual cycles for RCP45 and RCP85.

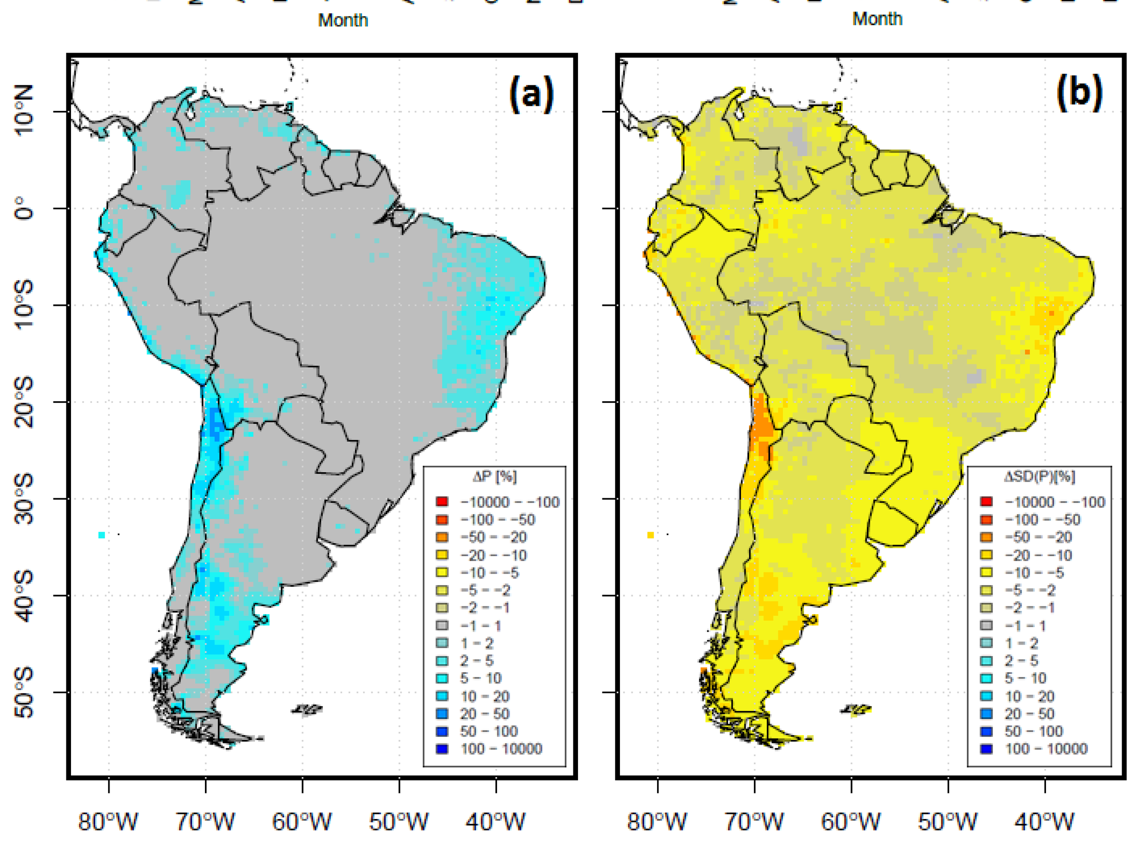

Figure 3. The bias of RCM-SMHI data, after bias correction, for a) for mean values (as Fig. 1c), and b) for standard deviation (as Fig. 1d).
Again, the warm colors shows areas where RCM-SMHI precipitation data under-estimates the UD-ATP a) observed mean precipitation, or b) the observed standard deviation. The maps are expressed as percentage of standard deviation of UD-ATP monthly time series in each grid-point.

IDENTIFYING PRECIPITATION ANOMALIES USING SPI

SPI classifies the precipitation anomalies according to specific periods, in order to identify drought length and intensity [5]. Corrected precipitation data of RCM-SMHI were used to calculate the SPI for the present study. SPI time series were created with several time scales (3, 6, 9 and 12 months) between 1951 and 2100, in order to quantify the dry and wet spells computed with the RCM. The period 1961-1990 was used as control period for SPI calculations. Because the data were undergone to a bias correction, then it should be able to represent the trends of precipitation amounts, and the length of dry and wet spells.

WET AND DRY SPELLS FROM SPI

Positive values of SPI point out surplus in the precipitation amount, while negative values indicates deficits. In this work, the wet spells were considered if SPI>1 in two or more consecutive months. In the same way, a dry spell was considered if SPI<-1 during two or more consecutive months.

In order to quantify the spells change predicted by RCM-SMHI, several features were computed from the spells in the control period 1961-1990, and between 2071-2100: the mean length, the maximum length, and the number of periods (months) in the wet or dry condition. The results for SPI12 are showed in Figure 4 for wet spells, and in Figure 5 for dry spells.

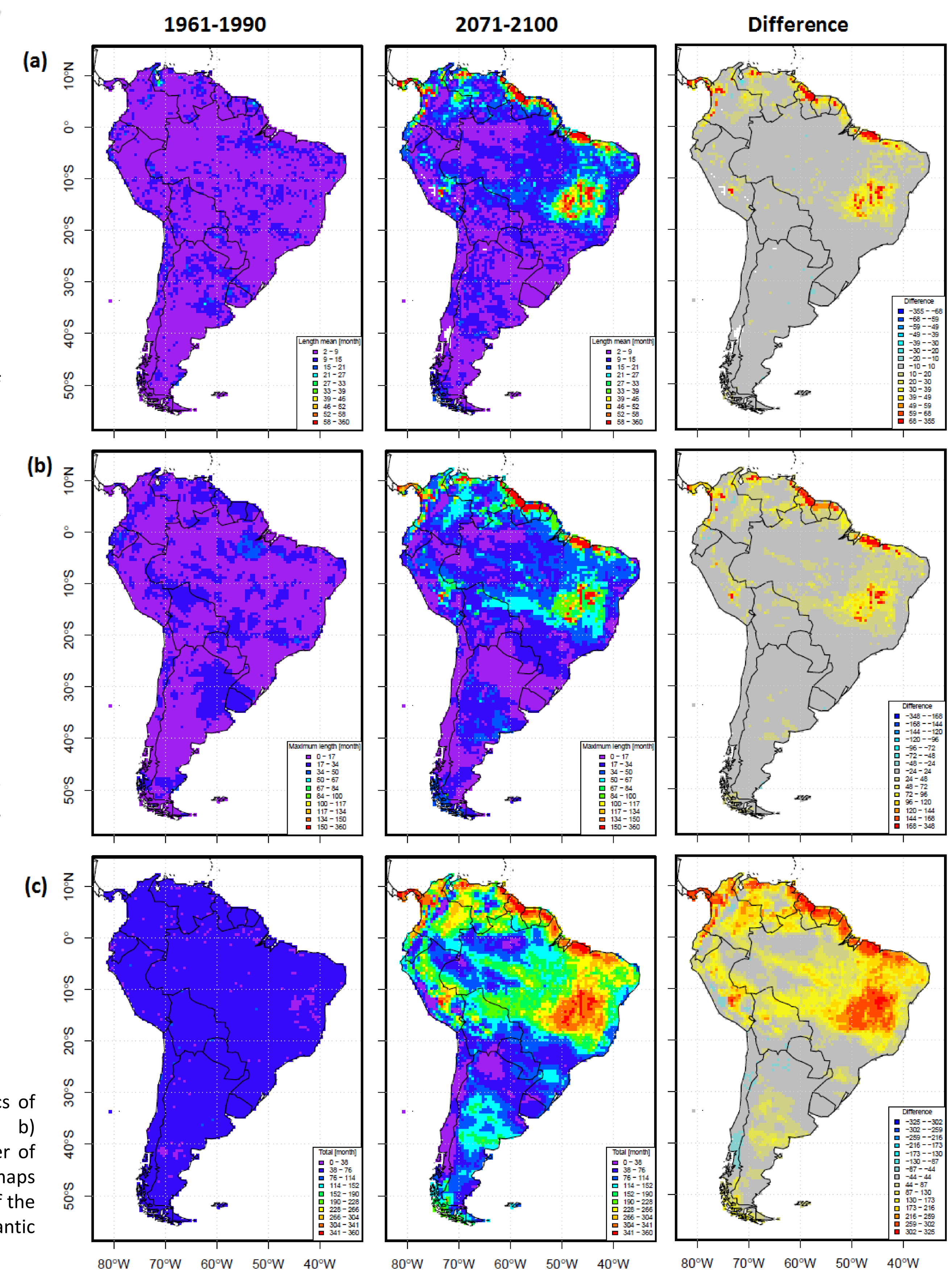

Figure 4. Assessed characteristics of wet spells. a) Mean length, b) maximum length and c) number of periods in wet condition. The maps show an increase of the length of the wet spells, particularly in the Atlantic Ocean shoreline.

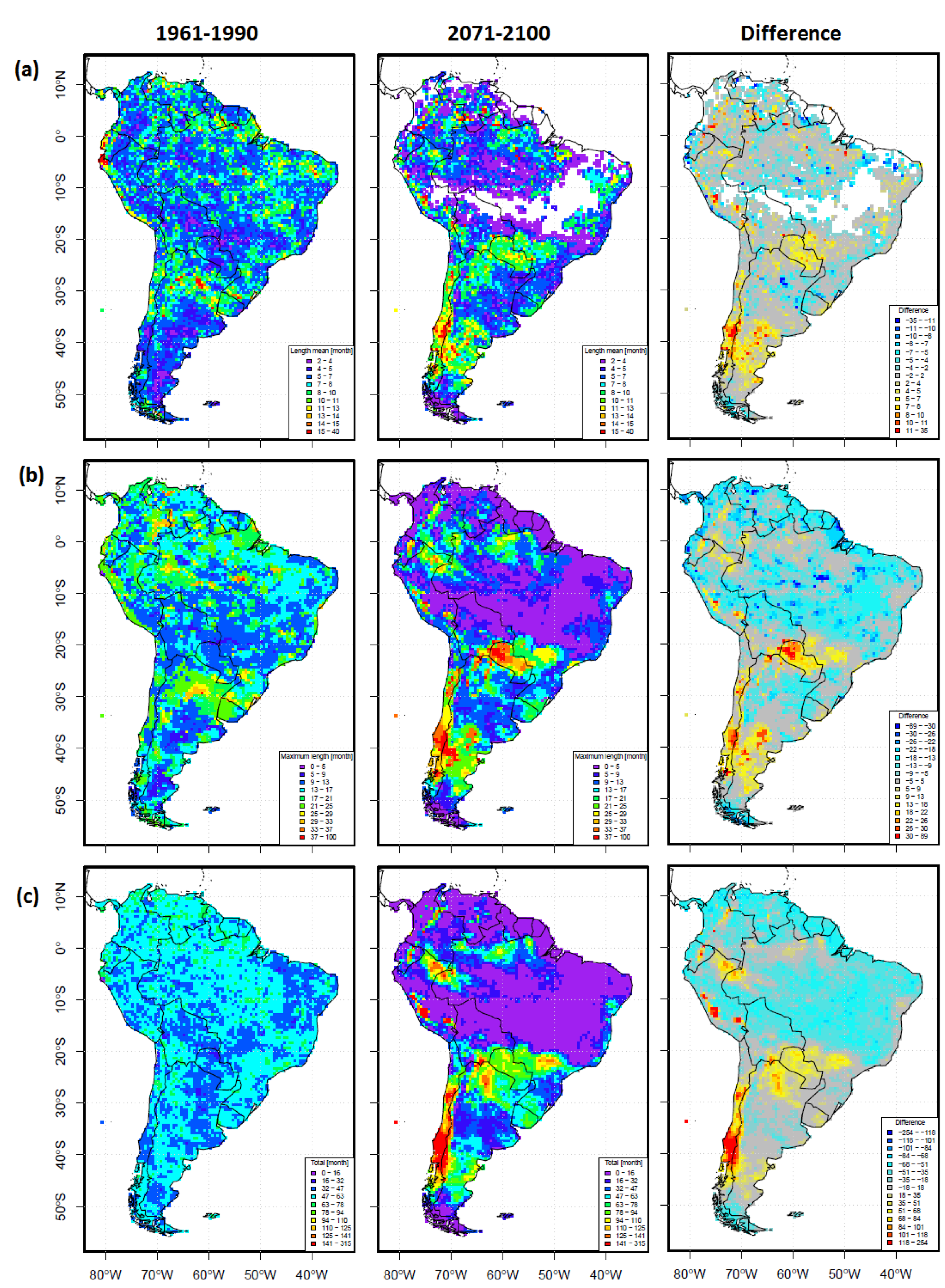

Figure 5. Assessed characteristics of dry spells. a) Mean length, b) maximum length and c) number of periods in wet condition. In a), the white areas represents locations with strong rises of precipitation amount, so the SPI trends is positive
The maps show an increase of the length of the dry spells in the southern part of the continent

DISCUSSION

The work shows the predicted changes in dry and wet spells in South America from RCM-SMHI. The computed values in the reference period 1961-1990, the forecast period 2071-2100, and the change between them are presented for SPI12, and several characteristics of the spells (mean length, maximum length and the number of periods in each condition).

According to forecast, a rise of the number of dry periods are expected in Chile, the Gran Chaco region, the Andean mountain range in Peru, Ecuador and Colombia, and the Amazonian forest between Peru and Colombia. On the other hand, a rise of the number of surplus periods are expected in northeast Brazil, and the Caribbean Sea coast of the continent. This analysis is concordant with the RCM-SMHI forecast of precipitation trends (not showed).

REFERENCES

[1] Matsuura, K., and Willmott, C., 2012. *Terrestrial air temperature: 1900-2010 gridded monthly time series, version V3.01, Global Air Temperature Archive*. National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL) Physical Science Division (PSD). Retrieved July 15, 2014, from http://climate.geog.udel.edu/~climate/html_pages/Global2011/README.GlobalTsT2011.html.
[2] Matsuura, K., and Willmott, C., 2012. *Terrestrial precipitation: 1900-2010 gridded monthly time series, version V3.01, Global Precipitation Archive*. National Oceanic and Atmospheric Administration (NOAA), Earth System Research Laboratory (ESRL) Physical Science Division (PSD). Retrieved July 15, 2014, from http://climate.geog.udel.edu/~climate/html_pages/Global2011/README.GlobalTsP2011.html.
[3] Jones C, F. Giorgi and G. Asrar, 2011. *The oordinated Regional Downscaling Experiment: CORDEX, An international downscaling link to CMIP5*. CLIVAR Exchanges, 56 (16), N°2, 34-40.
[4] Karatzoglou, A., Smola, A., Hornik, K., and Zeileis, A., 2004. *kernlab - An S4 Package for kernel methods in R*. Journal of Statistical Software, 11(9), 1-20. doi:http://dx.doi.org/10.18637/jss.v011.i09.
[5] McKee, T. B., N. J. Doesken, and J. Kleist., 1993. *The relationship of drought frequency and duration to time scale*. Eighth Conference on Applied Climatology, Anaheim, California: American Meteorological Society, 179–84.