Assessment of droughts at a continental scale under different climate change scenarios. Case study: La Plata Basin

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In this study, we characterized and diagnosed the droughts across La Plata Basin for the reference (1961 – 2005) and future (2007 – 2040, 2041 – 2070 and 2071 – 2099) scenarios. La Plata Basin is located in the Centre-South of South America and comprises 3,174,229 km2 and five countries. Despite the significant impact of droughts on agriculture, cattle, water supply, natural water courses and wetlands, droughts are still difficult to predict in the region, both in time and space. We used the Standardized Precipitation-Evapotranspiration Index (SPEI) to characterize droughts based on Potential Evapotranspiration (PET) and Precipitation (P) at a monthly scale. PET and P were obtained for all 10 x 10 km-size cells within the basin by using the regional climatic model Eta, under the boundary conditions of the HadGEM2-ES model and the CO2 emissions scenario RCP 4.5. Cell to cell information was integrated into a sub-basin level in order to show and analyze the results. For each sub-basin, climate scenario, and temporal scale of SPEI (1, 3, 6 and 12 months), we identified the beginning of each drought, calculated its duration, magnitude, maximum and mean intensities, and the duration between drought events. Additionally, for each SPEI temporal scale and sub-basin, we described the spatial coverage of droughts for the temporal series of all climate scenarios.

Spatially, we found a decrease of PET from North to South. Temporally, results showed a future increase of PET for the Paraguay river basin and upper Parana river basin but similar to present values for the remaining basin. Results showed that P will be similar in the future for the Paraguay river basin and upper Parana river basin, but will increase within the remaining basin. During the 2007 – 2040 scenario, we expect that the northern sub-basins suffer from several droughts while the southern ones have wetter climate with few short drought events. As we analyzed more distant future scenarios the wet climate spreads towards northern sub-basins and droughts became less intense. Similarly, the area covered by droughts for each sub-basin, in general, tended to decrease in the farther future. Finally, the results highlight a significant heterogeneity of droughts (occurrence and drought characteristics) in La Plata Basin.
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ABSTRACT

In this study, we characterized and diagnosed the droughts across La Plata Basin for the reference (1961–2005) and future (2007–2040, 2041–2070 and 2071–2099) scenarios. La Plata Basin is located in the Centre-South of South America and comprises 3,174,229 km² and five countries. Despite the significant impact of droughts on agriculture, cattle, water supply, natural water courses and wetlands, droughts are still difficult to predict in the region, both in time and space. We used the Standardized Precipitation-Evapotranspiration Index (SPEI) to characterize droughts based on Potential Evapotranspiration (PET) and Precipitation (P) monthly scale. PET and P were obtained for all 10 x 10 km sub-cells within the basin by using the regional climatic modelEta, under the boundary conditions of the HadGEM2-ES model and the CO2 emissions scenario RCP 4.5. Cell to cell information was integrated into a sub-basin level in order to show and analyze the results. For each sub-basin, climate scenario, and temporal scale of SPEI (1, 3, 6 and 12 months), we identified the beginning of each drought, calculated its duration, magnitude, maximum and mean intensities, and the duration between drought events. Additionally, for each SPEI temporal scale and sub-basin, we described the spatial coverage of droughts for the temporal series of all climate scenarios.

Spatially, we found a decrease of PET from north to south. Temporally, results showed a future increase of PET for the Paraná river basin and upper Paraná river basin but similar to present values for the remaining basin. Results showed that P will be similar in the future for the Paraguay river basin and upper Paraná river basin, but will increase within the remaining basin. During the 2007–2040 scenario, we expect that the northern sub-basins suffer from several droughts while the southern ones have wetter climate with few short drought events. As we analyzed more distant future scenarios the wet climate spreads towards northern sub-basins and droughts became less intense. Similarly, the area covered by droughts for each sub-basin, in general, tended to decrease in the farther future. Finally, the results highlight a significant heterogeneity of droughts (occurrence and drought characteristics) in La Plata Basin.

1. Introduction

Drought and water scarcity influences greatly the areas with temperate grasslands and all crops throughout the region, as well as the critical production of hydropower. The IPCC (2014) clearly shows that an increased frequency of extreme events is likely to have larger impacts than changes in mean precipitation. Also, droughts are still difficult to predict in the region, both in time and space. However, this information is needed in order to accurately define specific measures and plans for drought prevention and mitigation.

2. Objective


3. Study Case

- This study was carried out in seven macro-basins (Figure 1).

4. Methodology (I)

- We studied the control (1961 – 2005) and future (2007 – 2040, 2041 – 2070 y 2071 – 2099) scenarios. Climate change effect was assessed by calculating the Standardized Precipitation-Evapotranspiration Index (SPEI; 1, 3, 6 and 12 months) based on the control scenario.
- We analyzed the behavior of the ETP and P at a monthly time scale and sub-basin scale for the different climate change scenarios. ETP and PET were obtained for all 10 x 10 km-size cells within the basin by using the regional climatic model Eta (provided by the National Institute for Space Research, INPE – Brazil). The ETP values were obtained for each sub-basin sub-basin level and the total time series for each scenario.

4. Methodology (II)

- For each i) macro-basin, ii) climate scenario, and iii) temporal scale of SPEI, we made the analysis at two levels: 1) cell to cell and 2) sub-basin level.

4. Results and discussion

5. Temporal behavior of the drought

We expect that during 2007 – 2040 scenario, whereas the northern macro-basins will suffer from several droughts, the southern ones will have wetter climate with few short drought events. As we analyze more distant future scenarios the wet climate spreads towards northern macro-basins and droughts became less intense (Figure 3).

5. Spatial coverage of the drought

The area under drought condition for each macro-basin, in general, tends to decrease in the farther future. The situation gets better from South to North with time. Noteworthy that for many time periods which were not defined as droughts, the wetter climate with few short drought events. As we analyzed more distant future scenarios the wet climate spreads towards northern sub-basins and droughts became less intense. Similarly, the area covered by droughts for each sub-basin, in general, tended to decrease in the farther future. Finally, the results highlight a significant heterogeneity of droughts (occurrence and drought characteristics) in La Plata Basin.

6. Conclusions

- Our results highlight a significant heterogeneity of droughts (drought occurrence and drought characteristics) in La Plata Basin (Figure 5).
- La Plata Basin would require complementary detailed studies for the current situation and future scenarios. This will provide the objective technical foundation for the drafting and implementation of water resources management plans and specifically for drought management plans.

7. Acknowledgements

The authors thank the support of the “The Framework Program for the Sustainable Management of La Plata Basin’s Water Resources with respect to the effects of climate variability and change” and the EU research project “Bottom-Up Climate Adaptation Strategies Towards a Sustainable Europe” (BASE). Appreciation is also shown to the INPE (Brazil) team for providing P and ETP data.