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The atmospheric water cycle over South America as seen in the new generation of global reanalyses

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In this study the main features of the hydrological cycle over the South American region are documented with three reanalysis datasets and two observation-derived precipitation products. Rather than attempting to "close the water balance" that requires additional terms, many model dependent, we focus on the individual terms of the water cycle. An additional analysis is also presented in this work to investigate the role of the transport of moisture over the La Plata Basin (LPB) and South Atlantic Convergence Zone (SACZ) in the precipitation regimes from 1979 to 2007.

Two recently developed global reanalyses are employed. They are: (a) the Modern Era Retrospective-Analysis for Research and Applications (MERRA) developed at the Goddard Space Flight Center (GSFC/NASA) with a particular interest on applications for hydroclimate studies; and (b) the Climate Forecast System Reanalysis (CFSR) developed at the National Centers for Environmental Prediction (NCEP) to provide the best estimate of the state of the coupled atmosphere-ocean-land surface-sea ice system . For reference, the NCEP/Department of Energy (NCEP/DOE) Reanalysis II (NCEP-2) is included in the analysis. Two sets of observed precipitation products were used for evaluation purposes in this study. The first data set is the Climate Prediction Center (CPC) unified global daily gauge analysis, which is prepared using ∼30,000 stations collected from the Global Telecommunications System (GTS) daily reports and additional reports provided by many hydrographic and agricultural agencies in countries around the world. This product will be used as the reference dataset for evaluation of the reanalyses, however, in an effort to assess the uncertainties in the observations themselves, another dataset is included. It is precipitation included in the forcing terms of the Global Land Data Assimilation System (GLDAS). For this dataset, data assimilation techniques are employed to merge satellite-based estimates and rain gauge observations.

In this analysis, the SACZ was divided into two regions by presenting different characteristics. Tropical SACZ (TSACZ) presents the maximum convective activity and small sub-seasonal variability, while Subtropical SSACZ (SSACZ) presents sub-seasonal variability in terms of transient systems in the region. The LPB region, while also presenting two different regimes of precipitation in the north through the South American Monsoon System (SAMS) and the south by the Mesoscale Convective Systems (MCSs) and frontal systems, has been treated in this study as a single region.

The moisture budget components for several regions of South America were assessed from multiple Reanalysis data products and observations. The uncertainties in the observations were first estimated by examining diverse observational datasets generated from raingauge measurements and/or satellite estimates.

The new generations of reanalyses show an improvement in the representation of the rainfall patterns and their magnitude. Specifically, while all reanalyses represent to different degrees the austral summer precipitation of reference (CPC), MERRA and CFSR most closely match the annual cycle of the observations. In most parts of South America, the CFSR exhibits the lowest biases, possibly due to the inclusion of GLDAS products in the assimilation process. In the central part of SA, some reanalyses present opposite biases, positive for the NCEP-2 and negative for MERRA. These differences contribute to the excess (NCEP-2) and deficit (MERRA) of precipitation in the region of SACZ.

Spatial averaging for bias and the skill at reproducing the annual precipitation spatial distribution with Taylor diagrams. These diagrams show that the observed GLDAS product tends to be tightly grouped and in the vicinity of the CPC reference point. The CFSR (new generation of reanalysis) provides the best correlation for the three regions analyzed, with correlations above 0.7 and a standard deviation slightly greater than that CPC dataset, with higher standard deviation over the TSACZ region and around the reference point in the region LPB. Furthermore, for the LPB region, MERRA reanalysis present small amplitude in the variability. The TSACZ region exhibits the

weakest correlations coefficients of the reanalysis and SD. In general, all reanalysis show SD greater than the CPC reference, and MERRA and NCEP-2 have correlations lower than 0.4.
The summer vertically integrated flux of moisture over the tropical region is strong and they are associated with moisture transport carried by the trade winds. Enhanced northerly flow evidence the moisture transport from Amazon region to LPB, associated to Low Level Jet (LLJ). The net flux in LPB is largest, resulting from a greater transport by easterly winds.