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Hydrological Reanalysis Across the 20th Century: A Case Study of the Amazon Basin

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The availability of adequate and accurate long term hydroclimatic records has been a challenge for water management around the world, especially in developing countries where such information is limited. In recent years, global reanalysis datasets have been developed to provide these records in hydrologic fields. However, many efforts have been limited to i) temporal coverage of ∼30 years and ii) simplified hydraulic scheme routing in rivers, which are not adequate for regional and long term scale studies. In this research we propose the development of a hydrological reanalysis across the 20th century (HRXX) in the Amazon Basin as a proof of the concept. The development of the HRXX spans from 1900 to 2010 through the use of: 1) a large-scale hydrologic-hydrodynamic model (MGB) forced by a long-term climatic reanalysis of rainfall (ERA-20CM) with bias removed; and 2) the Ensemble Kalman Filter (EnKF) data assimilation (DA) technique coupled with a localization method (LEnKF) to use several ground observations of daily discharge within a radius of influence. Several tests were assessed to find the best bias removal method, the optimal radius of influence for the localization method and the final HRXX dataset. A total of 114 hydrological ground observations of daily information were used for assimilation and validation purposes, and several statistics indexes were employed to assess their performance. Results indicate that the use of bias correction, LEnKF and both together, greatly improved the open-loop (OL) (free run) simulations, for instance improvements in bias from ∼18% to 14%, 17% and ∼10% respectively. Overestimations of the peaks in the OL simulation, mainly in the southern and northern regions of the Amazon Basin, were removed, and recession timing in the east-central region, as seen at the Óbidos gauge station, were corrected. An average performance of ∼0.6 and ∼0.7 of the Nash–Sutcliffe and Kling–Gupta indexes was reached, even when only a few of the longest ground observations were used, which can be representative of the oldest periods (since ∼1930). To assess extreme events, the Pearson correlation coefficient was used for maximum and minimum annual water level anomaly values, improving from 0.38 and 0.18 (OL) to 0.6 and 0.7 (HRXX), respectively, at the Manaus gauge station, which was not used for assimilation purposes. These results are remarkable considering that the analysis covers approximately 110 years. This new dataset is the first approach of long term data assimilation of in-situ data in the Amazon Basin, and considering the results of this case study and the global coverage of rainfall datasets, this methodology can be transferred to other regions in order to better estimate and create a hydrological reanalysis that adequately represents the hydrologic and hydraulic spatio-temporal fields in a certain region.