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On the hydrological cycle in the Zambezi River basin. A Lagrangian approach

Rogert Sorí Gómez (1), Raquel Nieto (1,2), Anita Drumond (1), and Luis Gimeno (1)

(1) Environmental Physics Laboratory (EPhysLab), Facultad de Ciencias, Universidade de Vigo, Ourense, Spain (rogert.sori@uvigo.es), (2) Department of Atmospheric Sciences, Institute of Astronomy, Geophysics and Atmospheric Sciences, University of São Paulo, São Paulo, Brazil

The Zambezi River basin (ZRB) is the fourth-largest of Africa and one of the most diverse and valuable natural resources of this continent. The hydrological resources at this basin are highly important to the economic development and poverty reduction in the region. In this study, we aim to investigate the hydrological cycle in the ZRB. The analysis was performed for the dry and rainy seasons in the period 1980 - 2016. The Lagrangian model FLEXPART v9.0 was utilized to identify and characterize the main climatological moisture sources of the ZRB. An important advantage of this model is that it permits to track backward (and forward) in time the air masses residing over the target region and to compute the freshwater budget (Evaporation minus Precipitation (E-P)) on air parcels in the vertical column along the trajectories; thereby identifying the origins of the air masses residing over the ZRB. The regions where positive (E-P) values prevail are considered sources of moisture for the basin. The results reveal that along the year the western tropical Indian Ocean; the basin itself; and surrounded continental areas are the main responsible providing humidity to the ZRB. Other regions like the eastern tropical Atlantic Ocean or central Equatorial Africa are less important. The Vertically Integrated Moisture Flux (VIMF) support these results. For every season, the air masses residing over the sources were tracked forward in time to quantify the moisture contribution to precipitation ((E-P) < 0) over the basin. The climatology of the precipitation, runoff and river discharge were also calculated, showing a lag in time respect the maximum and minimum moisture contribution to the basin from the sources. In addition, were identified dry and wet conditions in the ZRB through the Standardised Precipitation Evapotranspiration Index (SPEI). For seasons under severely and extremely dry and wet conditions was assessed the role of the sources; revealing the feedback impacts of atmospheric moisture input anomalies on subsequent hydrological steps. We believe that the methodology here proposed may be successfully applied in further research on the hydrological cycle in other river basins worldwide.