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The West African Monsoon: variability and teleconnection with ENSO during the years 1948-57

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The intensity of the West African Monsoon (WAM) has been shown to be influenced by different factors. Most important for the existence of the monsoon system is the land-sea thermal contrast between the North African landmass and the Gulf of Guinea. ENSO plays an important role for its interannual variability via an atmospheric teleconnection bridging the Pacific and Atlantic oceanic basins and favouring either descent/weak low-level monsoon flow or ascent/strong low-level monsoon flow over tropical West Africa.

Most published studies on the WAM variability are based on reanalysis datasets. However, while reproducing quite well the interannual variability, reanalysis products have been found to contain major biases in certain tropical regions before 1968. These lead to an unrealistic low frequency behaviour and might be explained by the lack of observations assimilated into the reanalyses, as is the case e.g. for tropical Africa where only the much sparser radiosonde data have been assimilated into the NCEP/NCAR Reanalysis (NNR).

Here we present an analysis of the interannual WAM variability and its teleconnection with ENSO for the years 1948-57 which is not based on a reanalysis, but on early pilot balloon observational wind data from the Comprehensive Historical Upper Air Network (CHUAN). We have examined wind data from all 36 stations located in the domain (10°S-30°N, 20°W-20°E) on 5 levels up to the mid troposphere (corresponding roughly to the 925, 850, 700, 600 and 500 hPa pressure levels). This analysis shows that 7 subregions can be defined which are characterised by similar vertical wind profiles as well as seasonality: the NW (Mauritania, northern Senegal), the SW (southern Senegal to coastal Guinea), central sub-Saharan West Africa (SSWA, from interior Guinea in the W to coastal Cameroon and southern Niger in the E), central and eastern Niger, western Chad, the western Central African Republic, and the southern coastal regions east of the Gulf of Guinea (SCR, Gabon and Congo).

During the period 1948-57 the number of upper-air observations assimilated into NNR over the Sahel-Guinean region is much smaller than after the 1957 IGY, especially before 1952/53. A comparison of the NNR with the observational data for the whole domain and time period reveals spatially coherent and seasonally as well as diurnally varying significant wind biases relative to the observations over large parts of West and central Africa. The biases reach absolute values up to several m/s. The vertical bias profiles display different, regionally characteristic shapes. The seasonal behaviour of bias fields on constant pressure levels can be summarised as follows: On the 850 hPa level, the highest absolute values are found from spring to autumn over SSWA and Niger (westerly, at the northernmost stations ENE bias), and from summer to autumn in the SCR (SE bias). This points to an overestimation of the westerly low-level monsoon flow and an underestimation of the easterly Harmattan winds by the NNR. At 700 hPa the biases are relatively small except for the SCR, where a strong easterly bias is found in all seasons, and for SSWA in summer and partly autumn. The northerly bias in SSWA exhibits a divergent structure and might be caused by a too shallow monsoon flow or an underestimation of the main altitude of the mid-tropospheric return flow in the reanalysis. The easterly bias in the SCR means a significant overestimation of the equatorial easterlies in this region. At 600 hPa this easterly bias is found again in the SCR. For SSWA, a northerly to easterly bias (divergent in the N, convergent in the S) can be distinguished with highest values in spring/summer, probably indicating a too strong monsoon return flow.