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Diagnosis of GLDAS LSM based aridity index and dryland identification for socioeconomic aspect of water resources management

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Water resources scarcity plays an important role in socioeconomic aspect of livelihood pattern in dryland areas. Hydrological perspective of aridity is required for social and economic coping Strategies. Identification of dryland areas is crucial to guide policy aimed at intervening in water stressed areas and addressing its perennial livelihood or food insecurity. Yet, prevailing aridity indices are beset with methodological limitations that restrict their use in delineating drylands and, might be insuffient for decision making frameworks. Palmer's Drought Severity index (PDSI) reports relative soil moisture deviations from long term means, which does not allow cross comparisons, while UNEP's aridity index, the ratio of annual evaporative demand to rainfall supply, ignores site specific soil and vegetation characteristics that are needed for appropriate water balance assessment. We propose to refine UNEP's aridity index by accounting for site specific soil and vegetation to partition precipitation into competing demands of evaporation and runoff. We create three aridity indices at a 1 x 1 degree spatial resolution based on 3 decades of soil moisture time series from three GLDAS Land Surface Models (LSM's): VIC, MOSAIC and NOAH. We compare each LSM model aridity map with the UNEP aridity map which was created based on LSM data forcing. Our approach is to extract the first Eigen function from Empirical Orthogonal Function (EOF) analysis that represents the dominant spatial template of soil moisture conditions of the three LSM's. Frequency of non-exceedence of this dominant soil moisture mode for a location by all other locations is used as our proposed aridity index. The EOF analysis reveals that the first Eigen function explains, respectively, 33%, 43% and 47% of the VIC, NOAH and MOSAIC models. The temporal coefficients associated with the first OF (Orthogonal Function) for all three LSMS clearly show seasonality with a discrete jump in trend around the year 1999 for NOAH and MOSAIC. The VIC aridity index displays a pattern most closely resembling that of UNEP though all LSM based indices isolate dominant dryland areas, correctly. The UNEP classification identifies some parts of south central Africa, southeast United States and eastern India as drier than all LSMs. NOAH and MOSAIC categorize parts of SouthWestern Africa drier than the other two classifications, while all LSMs classify parts of central India wetter than the UNEP classification. We find long term average NDVI values showing vegetation cover in areas that UNEP classifies drier than other three LSMs. Finally, based on unsupervised clustering of global land surface based on long term mean temperature and precipitation, soil texture and land slope, areas classified as dry by UNEP but wet by LSMs have relatively wet characteristics while areas classified as wet by UNEP but dry by LSMs have dry characteristics. We conclude that LSM based aridity index identifies dryland areas other than UNEP aridity index since the former also incorporates the role of vegetation and soil in partitioning of precipitation into evaporation, runoff and infiltration.