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Comparison of rainfall based SPI drought indices with SMDI and ETDI indices derived from a soil water budget model

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Modelling soil water budget is a key issue for assessing drought awareness indices based on soil moisture estimation. The aim of the study is to compare drought indices based on rainfall time series to those based on soil water content time series and evapotranspiration time series. To this end, a vertically averaged water budget over the root zone is implemented to assist the estimation of evapotranspiration flux. A daily time step is adopted to run the water budget model for a lumped watershed of 250 km^2 under arid climate where recorded meteorological and hydrological data are available for a ten year period. The water balance including 7 parameters is computed including evapotranspiration, runoff and leakage. Soil properties related parameters are derived according to pedo transfer functions while two remaining parameters are considered as data driven and are subject to calibration. The model is calibrated using daily hydro meteorological data (solar radiation, air temperature, air humidity, mean areal rainfall) as well as daily runoff records and also average annual (or regional) evapotranspiration. The latter is estimated using an empirical sub-model. A set of acceptable solutions is identified according to the values of the Nash coefficients for annual and decadal runoffs as well as the relative bias for average annual evapotranspiration. Using these acceptable solutions several drought indices are computed: SPI (standard precipitation index), SMDI (soil moisture deficit index) and ETDI (evapotranspiration deficit index). While SPI indicators are based only on monthly precipitation time series, SMDI are based on weekly mean soil water content as computed by the hydrological model. On the other hand ETDI indices are based on weekly mean potential and actual evapotranspirations as estimated by the meteorological and hydrological models. For SPI evaluation various time scales are considered from one to twelve months (SPI1, SPI3, SPI6, SPI9 and SPI12). For all parameters sets it is found a high correlation coefficient between SMDI and ETDI measures from 0.7 to 0.8. Conversely the correlation with SPI indices of either SMDI or ETDI is weak. By means of a moving average of 3 months SMDI values, an improvement of the correlation coefficients was achieved. Similar results hold for the ETDI indicators.
Further comparison of drought classifications based on the previous indices is undertaken. According to the usual classification regarding SPI values, 8 stages were considered from extremely wet to extremely dry for all the indices. A matrix of concordance was build taking a score equal to one when the decisions are concordant and to zero when the decisions were discordant. Thus summing the scores, it was possible to compute the percent of concordance in the decision between SMDI from one part and the other indices from the other part. Also this was achieved with ETDI. The conclusion can be drawn that depending on the parameter set there is 60% to 70% of agreement between SMDI and ETDI while there is only 20% to 45% of agreement between SMDI and SPIs when using three month averaged SMDI and ETDI. If we consider brut SMDI and ETDI values the percents decrease with respectively a value of 50% to 70% and 20% to 35%. Consequently, despite the fact that SMDI and ETDI estimation is time consuming, these drought indices should be considered with care in agreement with SPI to make wise decisions about drought monitoring.