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Comprehensive evaluation of long-term hydrological data sets: Constraints of the Budyko framework

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An accurate estimate of the climatological land water balance is essential for a wide range of socio-economical issues. Despite the simplicity of the underlying water balance equation, its individual variables are of complex nature. Global estimates, either derived from observations or from models, of precipitation (P) and especially evapotranspiration (ET) are characterized by high uncertainties. This leads to inconsistent results in determining conditions related to the land water balance and its components.

In this study, we consider the Budyko framework as a constraint to evaluate long-term hydrological data sets within the period from 1984 to 2005. The Budyko framework is a well established empirically based relationsship between ET/P and E_p/P, with E_p being the potential evaporation. We use estimates of ET associated with the LandFlux-EVAL initiative (Mueller et. al., 2012), either derived from observations, CMIP5 models or land-surface models (LSMs) driven with observation-based forcing or atmospheric reanalyses. Data sets of P comprise all commonly used global observation-based estimates. E_p is determined by methods of differing complexity with recent global temperature and radiation data sets. Based on this comprehensive synthesis of data sets and methods to determine E_p, more than 2000 possible combinations for ET/P in conjunction with E_p/P are created. All combinations are validated against the Budyko curve and against physical limits within the Budyko phase space. For this purpose we develop an error measure based on the root mean square error which combines both constraints. We find that uncertainties are mainly induced by the ET data sets. In particular, reanalysis and CMIP5 data sets are characterized by low realism. The realism of LSMs is further not primarily controlled by the forcing, as different LSMs driven with the same forcing show significantly different error measures.

Our comprehensive approach is thus suitable to detect uncertainties associated with individual data sets. Furthermore, combinations performing well within the Budyko phase space are identified and could be used for future studies, like e.g. to investigate decadal changes of the land water balance.

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