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Investigating changes in the land water balance based on the Budyko phase space

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Changes in the climatological land water balance affect a wide range of socio-economical issues. Thus, the identification of regions undergoing a substantial drying or wetting is of major interest in climate science. 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 changes in the land water balance and its components.

We use the Budyko phase space with the ratios ET$/P$ and E_p/P (with E_p being the potential evaporation) as proxies for the land water balance and climate conditions. Using many available global data sets for ET and P and different methods to determine E_p creates more than 700 possible combinations for ET$/P$ in conjunction with E_p/P within the period from 1950 to 2005 and more than 2000 combinations within a shorter period covering the satellite era since the 1980s. To assess the realism of the individual combinations, we compare them against the Budyko curve, which is a well established empirically-based relationship between ET$/P$ and E_p/P. We find that uncertainties are primarily induced by the ET data sets. In particular, reanalysis and CMIP5 data sets are characterized by low realism. To analyse decadal changes, only those combinations performing well within the Budyko framework are considered. Shifts towards drier or wetter conditions are identified in the Budyko phase space. When the majority of combinations reveals a consistent shift towards drier/wetter conditions, we interpret this as a significant change in the decadal land water balance.

This comprehensive approach is suitable to identify regional drying or wetting trends. Further, we are able to verify results of previous studies, using less data sets and only considering precipitation or temperature in their analysis. First results indicate consistent findings with previous studies regarding long-term changes in the water balance, but also some distinct features, e.g. in the Mediterranean region.