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Simple catchments and where to find them: The storage discharge relationship as a proxy for catchment complexity

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Hydrology and especially hydrological models often treat catchments as if they were leaky buckets. But, do we find such catchments in the real world or is this just a convenient simplification? Moreover, if we find them, what attributes allow these catchments to show such a simple behavior? To study this, we look at time series of 27 years for 90 catchments in Hesse, Germany, which includes droughts and years of abundant precipitation. In addition, the state Hesse provides a wide range of catchment attributes like geology, soils and land use, while still having a relatively similar climate. Using discharge, evapotranspiration and precipitation, we calculate the cumulative storage change for all years separately and use it as a proxy for the storage. We group the 90 catchments by the complexity of their storage-discharge relationship, which we define as how good the relationship can be modelled by an exponential function. We find that climate and physical attributes of the catchments seem to have similar influence on the overall complexity of the storage-discharge relationship. However, we could also identify catchments that depict consistent behavior, mostly independent of climate. Those catchments either behave always complex or always simple in all the years considered. They differ in their permeability, conductivity, geology, soil and to a lesser extent their shape. We show that bucket like catchments exist in the real world and that they can be found by looking for oval catchments with good permeability in regions of igneous geology and clay silt soil texture.