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Identifying Spatial Patterns and Processes Affecting Mean Annual Runoff in the Alzette River Basin, Luxembourg

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Mean annual runoff can be impacted by changes to climate and anthropogenic activities within a catchment. Differences in mean annual runoff between catchments in a local region can also reflect variations in average catchment properties, particularly average soil water storage over the prevailing plant root depth.
We investigate the relative importance of precipitation, potential evapotranspiration and catchment properties using the Budyko framework on sub-catchments of the Alzette river basin in Luxembourg (as represented by the Choudhury model, which uses a single catchment parameter 'n' to encode catchment characteristics). We seek to establish if the 'Choudhury catchment parameter' can be used as a regionalisation index for mean annual runoff and therefore aid in identifying hydrologic response units.
For 51 Luxembourgish sub-catchments ranging in size from 0.45km2 to 4232km2 we used average annual precipitation, potential evapotranspiration and runoff over a 12 year period to 2012 to identify the 'n' parameter by curve fitting. We then break down 'n' into three component parts: annual mean storm depth, α, (mm); mean effective rooting depth, Ze, (mm) and relative soil water holding capacity, κ (dimensionless). The n parameter then becomes a function of κ Ze /α . Information on each of these three components can be obtained independently from GIS mapping of land use, soil texture and spatially distributed rainfall statistics.
Results showed the fitted n parameter is not affected by catchment size and did not increase with increased percentage of forest cover (potentially increased Ze). The soil water holding capacity exhibits a weak regional trend from north (0.1 to 0.2) to south (0.15 to 0.25) and α also declined from 18 mm in the north-east to 12 mm in the south-west, following a general slight orographic trend in the rainfall. The independent estimate of n suggests a regional trend, with the lowest values in the north-east and the highest values (less runoff per unit rainfall) in the south west of Luxembourg.
We conclude that climate, rather than land use controls the regional pattern of mean annual runoff from Luxembourgish catchments and that any reduction in rainfall could have a positive feedback on runoff if accompanied by a decrease in annual mean storm depth.