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Hydrological impacts of forest decline and regrowth: a retrospective analysis of the past 60 years in Saxony, Germany

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It is generally believed that both, climate and land use land cover (LULC) changes impact evapotranspiration and runoff; yet there is some difficulty to separate the effects of these different impacts.

Here, we condense meteorological and hydrological data from the long and well established observation network over Saxony covering the period 1950-2009. The region can be considered as a typical Central European landscape with considerable anthropogenically related impacts. Certainly, one of the most severe impacts have been the air pollution driven tree dieback along the top mountain ranges peaking in the 1970s and 1980s.

To address the role of environmental factors on the long term annual average and the potential role of regional scale environmental pollution we conduct a hydro-climatic data analysis of 71 small to medium range river basins covering the greatest part of Saxony.

Plotting the 1950-2009 annual averages in a Budyko diagram reveals a significant linear relation of the evaporative fraction (ET/P) to the aridity index (E_0/P). It appears that topographically controlled gradients of precipitation, land use and basin water retention exist. While most basins are found to follow the Budyko curve, two groups of basins deviate. Agriculturally dominated basins at lower altitudes exceed the Budyko curve while a set of high altitude, forested basins fall well below. The latter group is characterized by significant temporal dynamics, which are consistent in space and time with tree damage data.

We visualize the decadal dynamics on the relative partitioning of water and energy at the catchment scale and show that the pollution driven tree damage affected head water catchments leading to a decline of ET (P-Q) of up to 200 mm/yr in the 1980s. The apparent regrowth since effective measures on industrial pollution have been established in the 1990s, shows a significant increase of ET. This increase is visible from space and we found good coherence with increasing trends in summer-time GIMMS derived NDVI allowing to disentangle apparent NDVI increases over Central Europe.