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(Hydrological) drought: an overview of past, ongoing and upcoming international research

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In Europe, international drought research became priority not earlier than about 2-3 decades ago. Drought definitions were further advanced building upon achievements in North America. Hydrological drought (groundwater, streamflow) was introduced to distinguish from meteorological drought. Understanding of hydrological drought is essential for water resources management. Propagation studies investigated differences between meteorological and hydrological droughts. Differences were connected to climate and catchment characteristics. Groundwater response appears to have a significant influence on drought characteristics. Drought typologies, e.g. classical rainfall deficit drought, cold season drought, were developed to recognize drought-generating processes. Temperature control also appeared to play an important role on drought development. Continental databases were created, such as the European Drought Reference (EDR) database and the European Drought Catalogue to explore spatial and temporal patterns. Striking were the drying trends found in observed summer low flows in most of Europe, which were not in line with the frequently reported dipole derived from annual totals (wetter northern and dryer southern Europe). Single and multi-model studies were used to project droughts under a future climate. Multiple regions across the globe are likely to suffer from more extreme drought, although this is substantially affected by the selected benchmark.

In the first period, drought research focussed on (near-)natural hydrological conditions. However, stakeholders, policy-makers and water managers were only partly interested in natural drought. The influence of drought on people (impacts) and from people (intended and unintended interferences in the hydrological cycle that alleviate or aggravate drought) had to be considered. A more user-centred perspective had to be established. Climate-induced drought and human-modified drought were introduced to account for people alleviating/aggravating natural drought. Approaches were developed to distinguish between natural and human components. These are being applied to tens of catchments around the world to investigate if human activities have alleviated/aggravated drought. In many cases, humans have aggravated drought. Global model studies complement the catchment findings to obtain an indicative worldwide overview of human influences on drought. Clearly, models need improvement (e.g. processes, spatial resolution), whereas more catchment cases are required to progress model performance and eventually to arrive at consistent outcome.

Recently, numerous drought impacts were collated and stored in the European Drought Impact Inventory (EDII), which built upon the US Drought Impact Reporter. These impacts were connected to drought hazard indices, which allows impact prediction for different sectors using these indices. Currently, meteorological drought indices are used for the prediction, but likely predictive skills for some sectors (e.g. public water supply) would improve if hydrological drought indices will be used. However, this requires that more groundwater and streamflow become available.

Another research priority set by the user' community is further development of seasonal drought forecasting to improve pro-active risk management via Early Warning Systems (EWS). Drought science should realize that this is not an isolated activity, because future EWS have to address multi-hazards that should forecast cascading effects of successive hazards.