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Droughts in Europe under current and future climate – initial results of the EU-funded WATCH project

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Observations from the 20th century suggest that drought in Europe has occurred more frequently in the latter part of the century, partly enhanced by higher temperatures. However, the scientific understanding of the driving forces behind large-scale droughts is incomplete and further complicated by insufficient knowledge about long-term natural variability. Moreover, knowledge on the role of the physical catchment structure (i.e. presence of stores) in drought development is still limited. Climate change projections for Europe further indicate that drought is likely to become more frequent and more severe due to warmer northern winters and a warmer and dryer Mediterranean region.

The WATCH project aims to advance our knowledge on the impact of global change on water resources. The project brings together the hydrological and climate communities to analyse, quantify and predict the components of the current (20th century) and future (21st century) global water cycle, with one work block dealing especially with changes in extremes (droughts and floods). In this presentation focus is on hydrological drought, which is assessed at three scales, the global, the regional (Europe) and the river basin using both observed and simulated time series. In a major interdisciplinary effort the simulation results of eight land surface (LSM) and global hydrological models (GHM) are compared with respect to their ability to reproduce the hydrological regime, extremes and observed trends in streamflow. All models are run using the WATCH Forcing Data (WFD) on a half-degree resolution. It is demonstrated that using the WFD as input for hydrological model simulations at the river basin scale for a range of European test basins and models, produce similar drought characteristics as those derived using more detailed local meteorological data. At the global scale, an initial set of streamflow data from rather undisturbed and medium sized river basins, shows that the broad characteristics of major droughts (i.e. timing, duration) are identified by both classes of models (LSM and GHM). However, a comparison for the period 1963-2001 demonstrates that the models still deviate when more detailed drought characteristics are investigated (e.g. average drought duration).

In Europe observations stem from a newly assembled dataset of near-natural daily streamflow records, consisting of around 400 stations (1962-2004). A drought catalogue has been compiled for 24 regions in Europe, using a consistent format which capture key drought characteristics (severity, duration and spatial coherence). Evidence from the observed dataset further reveals that low flows have decreased in most regions with a summer minimum and that a marked shift towards dryer conditions is observed in April. In general, the large regional scale patterns of change agree with the hydrological responses as projected by climate models. Regional patterns of trends in annual runoff are also well reproduced by the large-scale models, however, seasonal trends and trends in extremes are less well represented and differ substantially among the models. A benchmark framework has been introduced to allow comparison across different river basins, large-scale models and indices at the European scale. Initial results suggest that it is not possible to discriminate between the two classes of models, however, their performance differ significantly between individual models and hydrological regime. Overall, high flows are better captured than low flows, indicating that models perform better in under wet conditions, although less so in a snow dominated regimes. The models are also evaluated in the ability to capture the spatial characteristics of large-scale droughts, e.g. spatial extent, dynamics and variability across space.

Simulations with a synthetic hydrological model, which uses WATCH downscaled and bias-corrected future forcing data, indicate that globally the average number of droughts in discharge will increase for the period 2050-2100, although in some cases a considerable bias occurs between droughts derived from the models forced with climate model output and the WFD (control period: 1958-2000). The mean future drought durations remain almost unchanged in most Köppen-Geiger climates, however, a substantially increase is found in a few C-climates and a decrease in half of the D-climates. The presentation will add to these initial results on future drought, including projections for Europe.