Learning from the past
Have droughts in Europe become more severe?
Facts from Case Studies

Why do we need trend studies?
Climate change projections for 21st century in Europe indicate that drought is likely to become more frequent and more severe due to the increased likelihood of warmer Northern winters and hotter Mediterranean summers, together with decreases in precipitation and increases in evaporation demand. There is an urgent need to anticipate to this uncertain future to improve drought preparedness through measures that reduce vulnerability to drought and the risks they pose for Europe. Most of measures are substantial and should be based on robust climate change projections. This requires testing of the projections. One approach is to investigate if projections for the intermediate future (e.g. 2021-2050) are consistent with recent trends in historic data. Preferably, this is done with time series of observed hydrometeorological variables that cover large areas, because drought has a transnational nature. Additionally, trends have proven to be very dependent on the employed method and the period covered, which urges to use a consistent method and data from of the same period. There are ample large-scale studies on trends in historic observed precipitation (e.g. Klein Tank and Können, 2003) and a few on streamflow (e.g. Stahl et al., 2010). If sufficient time series are missing (e.g. short records or insufficient spatial coverage) time series of simulated historic data are used as an alternative (e.g. Stahl et al., 2012).

The exploration of measures that reduce vulnerability to drought in DROUGHT-R&SPI Case Study areas (Jucar, the Netherlands, Po, Portugal, Switzerland, Syros) also demands trends in historic hydrometeorological data to be determined. The first part of the study addressed trends derived from observed time series. The outcome is explained in the 2nd flyer of the Case Studies. The reported trends from observed data in the Case Study areas are difficult to intercompare because different periods and variables (precipitation, streamflow) were used. Moreover not everywhere the same trend identification method was applied. Hence, in the second part of the study, trends in the DROUGHT-R&SPI Case Study areas were calculated and intercompared through using reanalysis data (precipitation time series) and multi-model simulated data (runoff). We used the outcome from the EU WATer and global Change (WATCH) project (Harding et al., 2011).

Figure 1: Trends in monthly precipitation (1963-2001) derived from the WATCH Forcing Data. Left: March, and right: August. Blue: wetter, and red: dryer.

Trends in temperature, precipitation, river flow and drought
Trends in weather data and river flow were determined using the methodology proposed by Stahl et al. (2010; 2012), i.e. calculation of trend magnitude through the slope of the Kendall-Theil robust line for: (i) annual and monthly temperature and precipitation, and (ii) annual and monthly flow, as well as for summer low flow magnitude and timing. The same methodology was also applied to investigate trends in number of droughts per year, the average drought duration per year and the average deficit volume per year. Droughts were identified with the variable threshold approach, the 80% percentile of the cumulative frequency curve as threshold and the 15-day moving average of the mean multi-model daily runoff. The trend for each time series was expressed as the percent change over the period of record of years relative to the mean for the period (Alderlieste and Van Lanen, 2012).
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The annual temperature shows in increasing trend in all the Case Study areas, up to about 1%, which is approximately 2.8°C. In general, the trends in mean annual precipitation show an increased precipitation in the northern and central part of Europe and a decreased precipitation in the Mediterranean. Portugal has a few exceptions. The trends in mean March precipitation (Figure 1) show strong decreasing trends (i.e. dryer conditions) for southern Case Study areas, whereas The Netherlands and the majority of the Rhine basin show an increasing trend. In August most areas have weak or negative trends (less precipitation). The south of Portugal is an exception. There strong positive trends were found (more precipitation).

More trends:
- The annual mean 7-day minimum flow decreased in all Case Study areas (-9 to -44%);
- The annual mean 7-day minimum flow occurred earlier in all Case Study areas;
- Less than 10% of the regions in the Case Study areas shows a decrease in drought intensity (deficit volume / duration).

Partners responsible for the trend study in the Case Study areas:
- Wageningen University
- University of Freiburg
- National Technical University of Athens
- Instituto Superior de Agronomia, Lisbon
- Polytechnical University of Valencia
- Universita Commerciale ‘Luigi Bocconi’, Milan
- Oslo University

Figure 2 Trends in mean monthly flow (upper row) and drought (lower row) for the period 1963-2001 derived from multi-model mean runoff. Upper left: March flow, upper right: August flow, lower left: average drought duration per year, and lower right: average deficit volume per year. Blue: wetter, and red: dryer.

Trends in river flow in March follow the frequently-reported dipole (e.g. Stahl et al., 2010; 2012), i.e. North Europe that became wetter and South Europe observed dryer conditions (Figure 2). However, in August many regions in North Europe also show dryer conditions. The dryer conditions in the Mediterranean led to weak to stronger positive trends in average drought duration per year, i.e. longer droughts. Portugal also showed a trend to shorter droughts. The generally wetter winter conditions and dryer summer conditions in North Europe resulted in many regions in minor changes or in slightly longer droughts. This trend pattern can also be found in the severity (deficit volume per year). The Southern Alps in Switzerland clearly show up through trends towards shorter droughts and less severe droughts.

References