On the use of different data sources for drought analysis in cold climates

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Introduction:
In snow and glacier-dominated regions, causing factors of hydrological drought are diverse (Fig. 1). In this study, we use historical sources of information to find impacts of drought events in cold climates and data analysis to link these with possible causing factors.

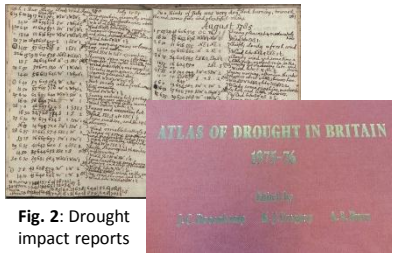
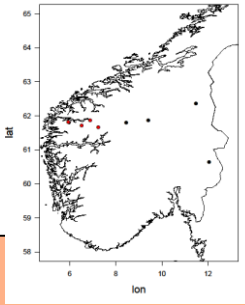


Fig. 2: Drought impact reports

Fig. 3: Catchments in Norway



Methodology:
Drought events related to snow and temperature anomalies were selected from the European Drought Impact report Inventory (EDII; Stahl et al. 2012) and historical archives (Fig. 2). Descriptions were translated into hydrological drought types (HDTs). Hydrometeorological data from eight catchments in Norway (Fig. 3) were transformed into anomalies (P = precipitation, T = air temperature, Q = discharge).

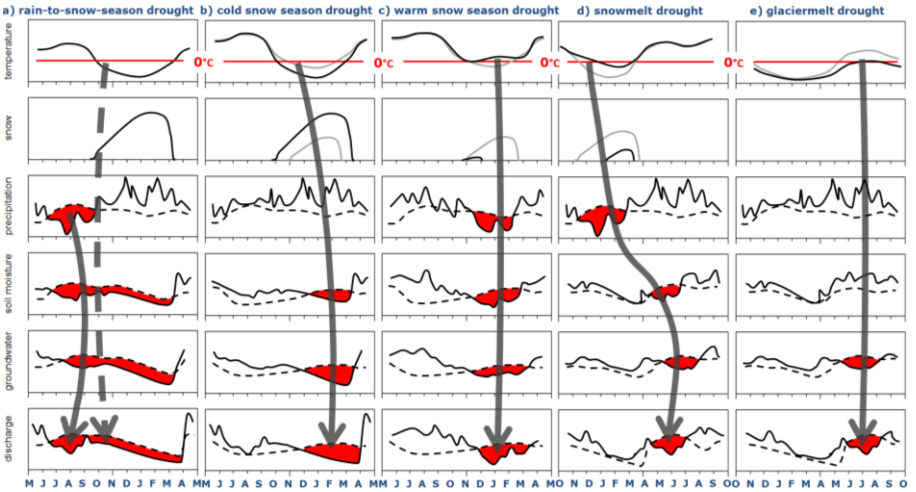


Fig. 1: Synthetic time series representing the propagation of a meteorological anomaly (P and/or T) through the terrestrial hydrological cycle per hydrological drought type (HDT): black lines = time series of hydrometeorological variable, grey lines = long-term averages T and snow, dashed lines = threshold levels, red surfaces = drought events. Propagation of drought is indicated by arrows, dashed arrows represent a lack of recovery of the hydrological drought (meteorological drought ceased).

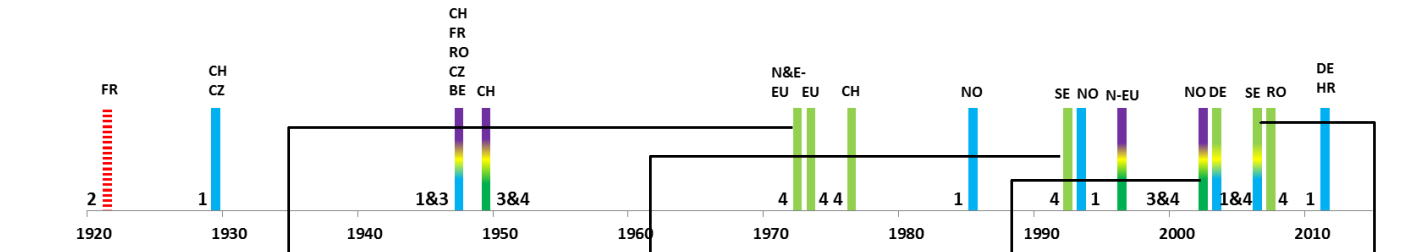


Fig. 4: Selected drought events that are connected to winter T anomalies obtained from the EDII (except for the 1920 event, which is obtained from historical archives). (1) (blue): cold snow season drought, (2) (red): warm snow season drought; (3) (purple): rain-to-snow-season drought, and (4) (green): snowmelt drought. Abbreviations represent countries in Europe (EU).

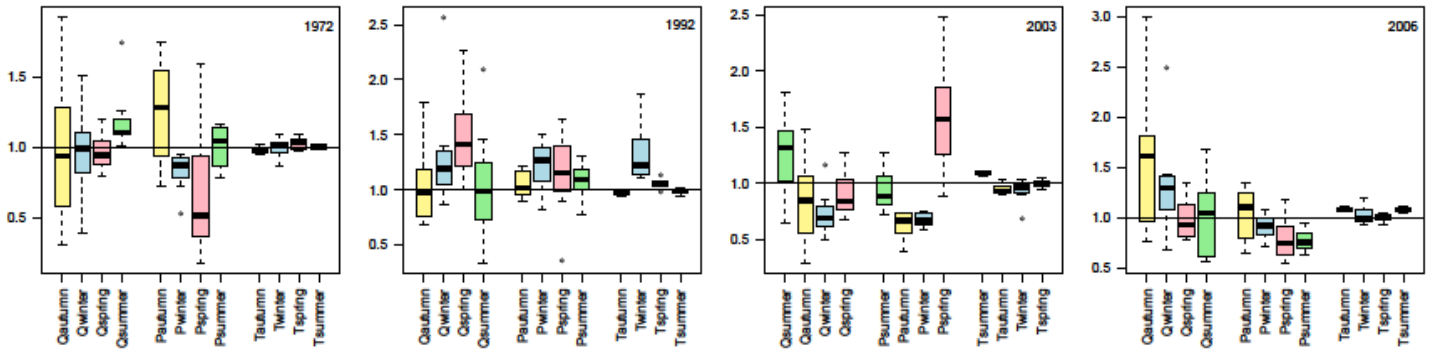


Fig. 5: Anomalies of hydrometeorological variables for selected drought events in Norway (below 1=below average, above 1=above average). Boxplots represent values for 8 catchments in Norway.

Results:
Selected temperature-related events are plotted in Fig. 2, showing the year and region of occurrence and HDT:
- Many snowmelt droughts and cold snow season droughts, and some rain-to-snow-season droughts occurred in Europe.
- Some events were local, others more regional.

From Fig. 3 four drought events were selected that impacted Norway or surrounding areas (Sweden, northern Europe):
- **1972**: only few catchments with below-average Qspring, although wide-spread below-average precipitation values
- **1992**: no dry spring in Norway, below-average Qsummer due to abnormally high Twinter leading to an early snowmelt peak and lower low flows in summer
- **2003**: precipitation was below average in summer and autumn 2002 and winter 2002–2003, leading to below-average Qautumn, Qwinter and Qspring
- **2006**: Qsping and Qsummer below-average for many catchments, related to below-average Pwinter, Pspring and Psummer, and possibly also to above-average temperatures

Conclusions:
We found that temperature-related hydrological droughts had socio-economic impacts in Europe and for some events we could find causing factors in anomalies in temperature and/or precipitation in preceding seasons. Although historical archives and drought impact databases suffer from limited temporal and spatial availability, reporting biases and language issues, we think that the qualitative analysis of drought impacts is a promising approach for analysing droughts in cold regions.

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- Stahl et al. (2012): A European Drought Impact Report Inventory (EDII): Design and Test for Selected Recent Droughts in Europe, DROUGHT-R&SPI Technical Report No. 3, 23, available at: www.eu-drought.org/technicalreports