The challenges of empirical impact prediction with monitored drought indices

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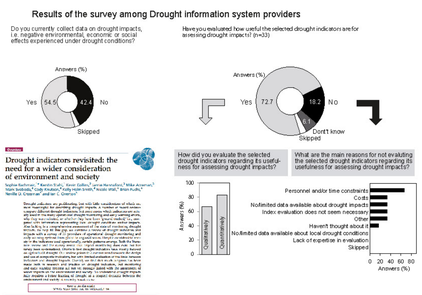
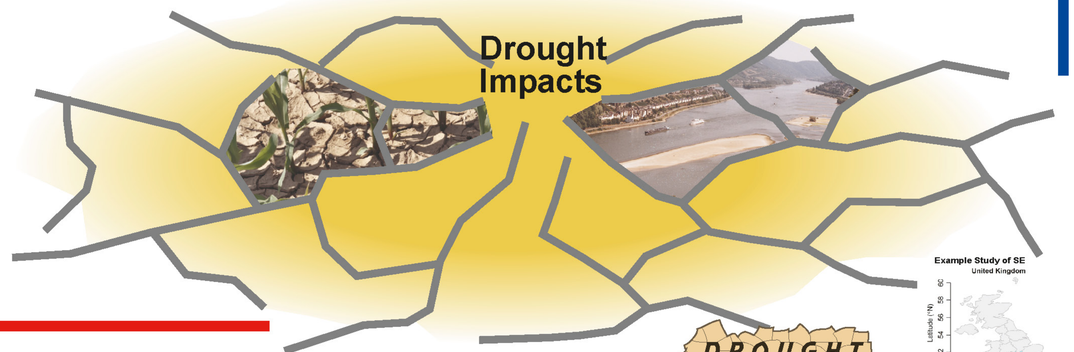
Motivation

Drought monitoring and early warning still relies primarily on drought indicators selected or combined from hydro-meteorological variables, such as precipitation, modeled soil moisture, observed or modeled streamflow, and in some cases remotely sensed vegetation health.

To guide the selection and give drought indices more meaning for drought management decisions, a number of studies have investigated empirically the linkage between these indices and records of drought impact occurrence. This can be done in a number of ways:





Co-Visualisation of Indicators & Impacts

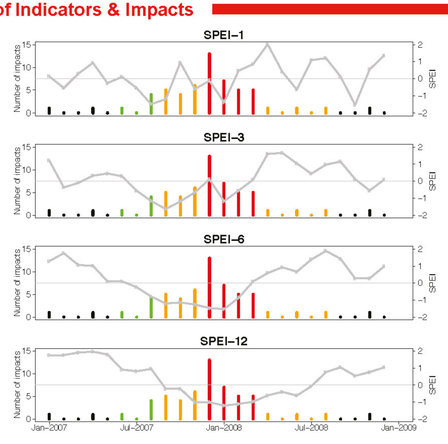
Example from North Carolina

SPEI-1 fluctuates strongly during the drought of 2007

SPEI-3 is negative during onset, neutral during peak of impacts and positive during recovery

SPEI-6 is negative at the peak of impact counts, but positive during onset and recovery.

SPEI-12 is low at the peak of impacts and



Lessons learned

Different drought indicators, e.g. SPEI at different time scales, link best to different phases of the drought (onset, peak, recovery)

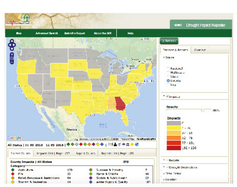
Impact counts reflect reported responses to drought, including water use restrictions.

These can mitigate or exacerbate water shortage impacts.

Data

US Drought Impact Reporter (DIR)

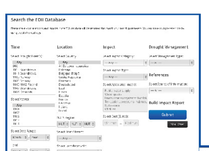
droughtreporter.unl.edu



The DIR collects near real-time News Media reports and observations of impacts.

European Drought Impact report Inventory (EDII)

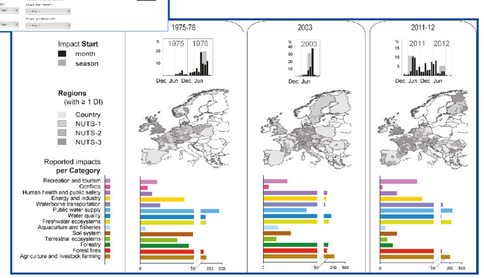
www.geo.uio.no/edc/droughtdb



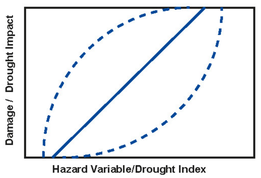
The EDII is a research database, collecting impact reports from a range of sources. It uses a more detailed sub-type categorisation to consider international differences in drought impacts.

Visualisation of reported impacts:

- provides narratives of past droughts,
- anecdotal evidence of drought impacts, and
- may be used as historical analogues to construct scenarios for planning purposes.

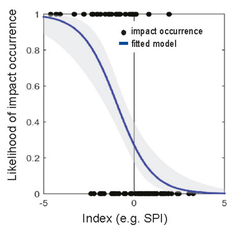


Statistical Modelling of Impacts as a Function of Drought Indices



Methods

The damage function approach employed in risk assessments of other natural hazards can be adapted to empirically relate impacts to drought indices.

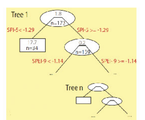


Case Study for SE England, comparing different models

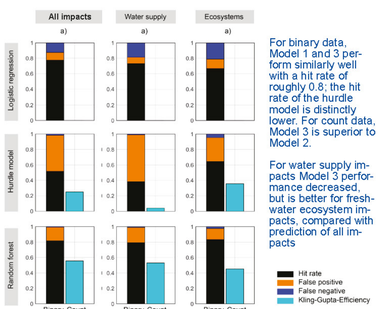
Model 1 relates impact ocurrence to drought indices by **logistic regression.**

Model 2 relates impact ocurrence and counts to drought indices by zero-altered negative binomial regression; this parametric model for count data is also known as a **"hurdle" model.**

Model 3 relates number of impacts to drought indices by ensemble regression-trees, i.e. a **random forest model.**



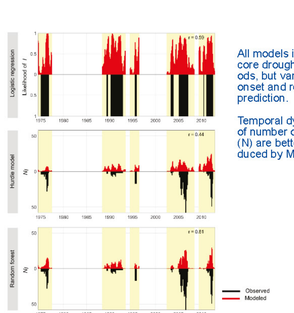
Model performance: metrics based on cross-validation



For binary data, Model 1 and 3 perform similarly well with a hit rate of roughly 0.8; the hit rate of the hurdle model is distinctly lower. For count data, Model 3 is superior to Model 2.

For water supply impacts Model 3 performance decreased, but is better for freshwater ecosystem impacts, compared with prediction of all impacts

Prediction: Observed and modeled time series



All models identify core drought periods, but vary in onset and recovery prediction.

Temporal dynamics of number of impacts (N) are better reproduced by Model 3

Towards impact-prediction

Coded impact reports, such as the EDII and the US DIR can be used to fit empirical impact models. The challenges include:

- a rapid decrease of data when subsetting for specific impact sectors or smaller spatial areas,
- the choice of the link model,
- a variety of potential dynamic changes to the underlying conditions between and even during drought events.

→ More systematic impact monitoring, reporting and archiving is needed!

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