

Towards impact prediction: lessons from exploring links between drought indices and drought impacts

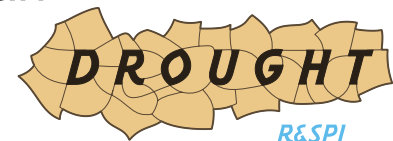
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**Sophie Bachmair, Irene Kohn,
Veit Blauhut, Erik Tjeldeman,
Lucy Barker, Jamie Hannaford,
Mark Svoboda, and others**



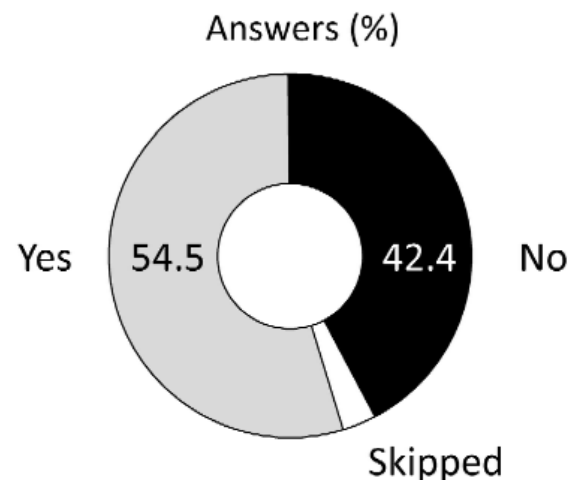
Jim Stagge, Lena Tallaksen,
Lucia de Stefano, Henny van
Lanen, and others



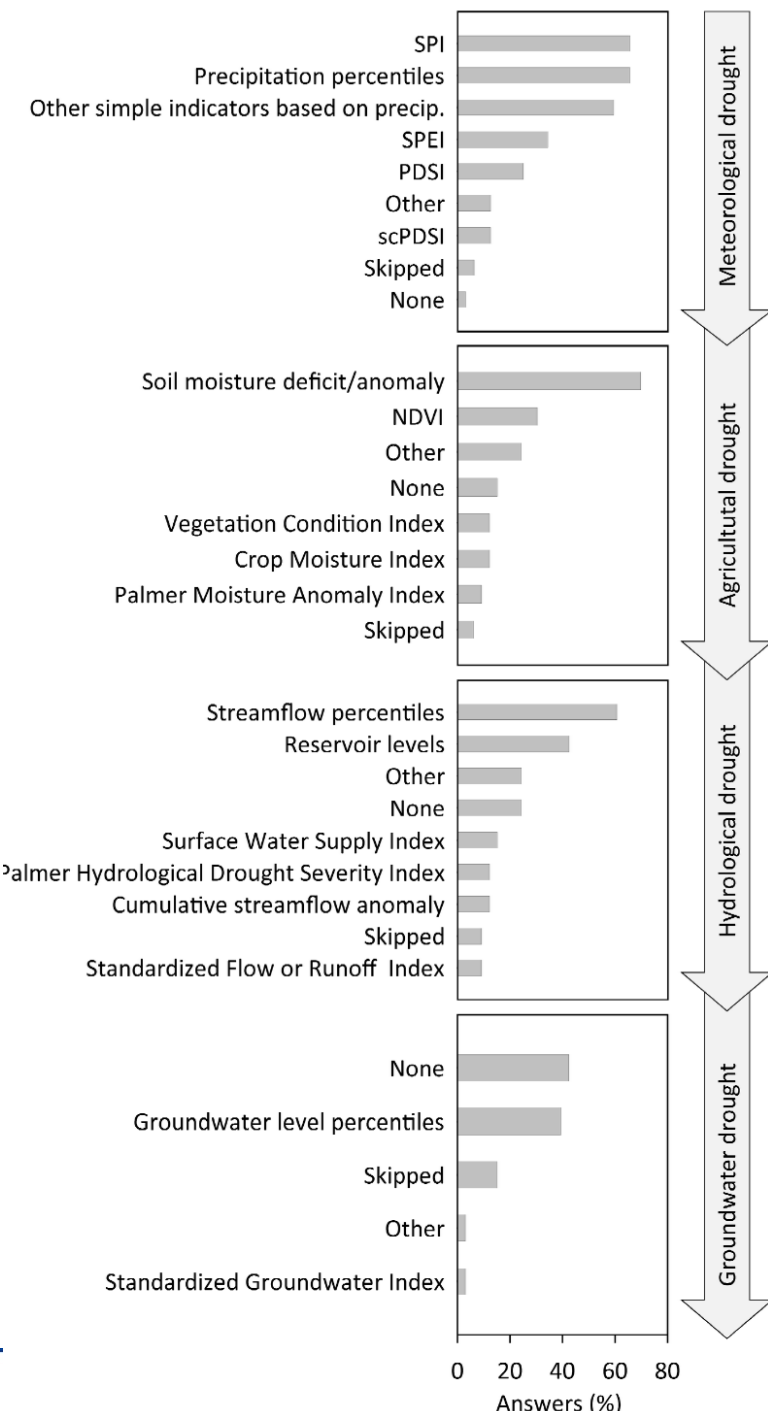


Which indicators does your system use?

Do you currently collect data on drought impacts, i.e. negative environmental, economic or social effects experienced under drought conditions?



But: few details, not systematically monitored and used

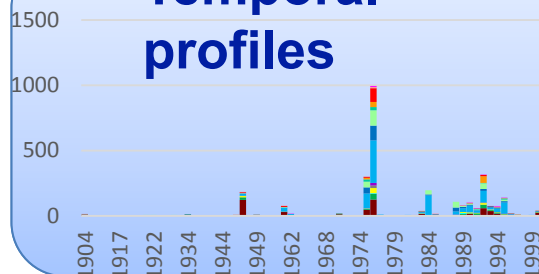


Impacts – lessons from a European perspective

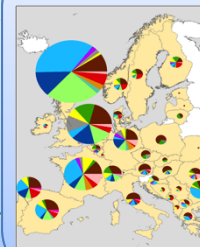
- Drought impact: **data** collection for Europe
- Drought impacts, **affected sectors** in time and space
- **Linking** impact occurrence to monitored drought indices: challenges

Data:
**The European Drought
impact report Inventory
(EDII)**
– a text-based archive –

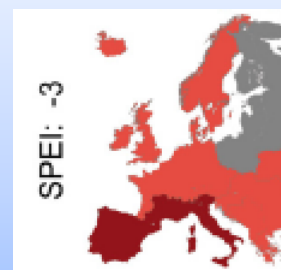
Temporal profiles



Spatial profiles



Correlation & Modelling



The EDII (European Drought Impact report Inventory @ www.geo.uio.no/edc/droughtdb/

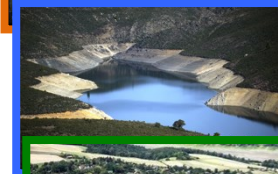
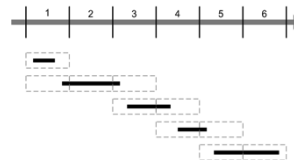
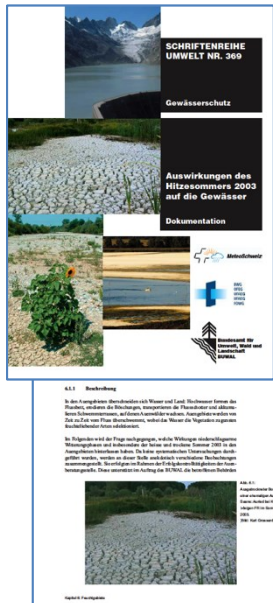
Source of information

Location

Impact Occurrence

Impact Categorization

The Archive



| ID | Location | | |
|------|-------------|-------------|------------------|
| | Country | NUTS 1 | NUTS 2 |
| bf_1 | Switzerland | Switzerland | Espace Mittellan |
| ik_1 | Switzerland | Switzerland | Nordwes |

| NUTS 3 | Location |
|-------------|---------------------------------------------------|
| bf | Bern |
| | nuclear power plant Mühleberg in Mühleberg |
| Aargau | nuclear power plant Beznau in Döttingen (Zurzach) |
| Bern/Luzern | several parts of |

| Impact details | | | |
|----------------|--------|------|-------------------------------------------------------------|
| YYYY | categ. | type | description |
| 2003 | 4 | 4.2; | Due to a lack of cooli were needed to redu |
| 2003 | 4 | 4.2; | Due to a lack of cooli were needed to redu and August 2003. |

- Collection is tedious
- + Textual evidence links cause (drought) and effect (impact)
- + - Coding guarantees consistency, but restrictive → **keep Text!**

Drought catalogue: impacts of historical events

Pan-European events

Impact **Start**

■ month
■ season

Regions

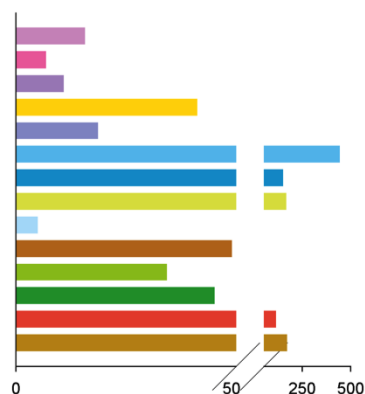
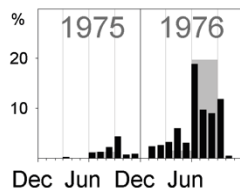
(with ≥ 1 DI)

■ Country
■ NUTS-1
■ NUTS-2
■ NUTS-3

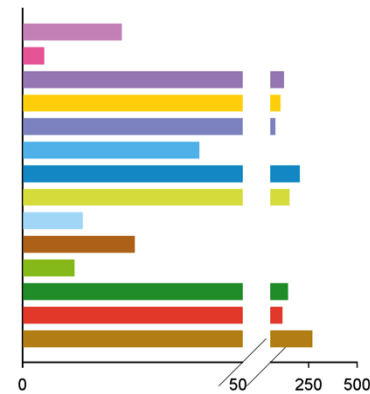
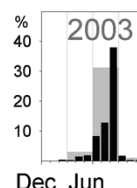
**Reported impacts
per Category**

Recreation and tourism
Conflicts
Human health and public safety
Energy and industry
Waterborne transportation
Public water supply
Water quality
Freshwater ecosystems
Aquaculture and fisheries
Soil system
Terrestrial ecosystems
Forestry
Forest fires
Agriculture and livestock farming

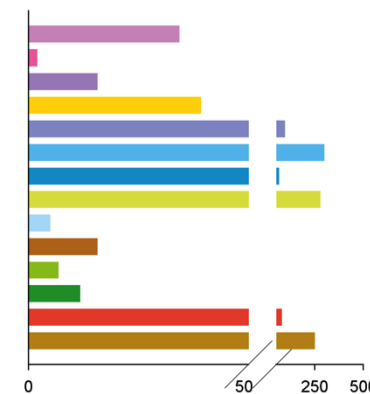
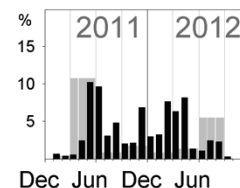
1975/76



2003



2011/12



→ all impacts during 'big' droughts, more specific during regional droughts

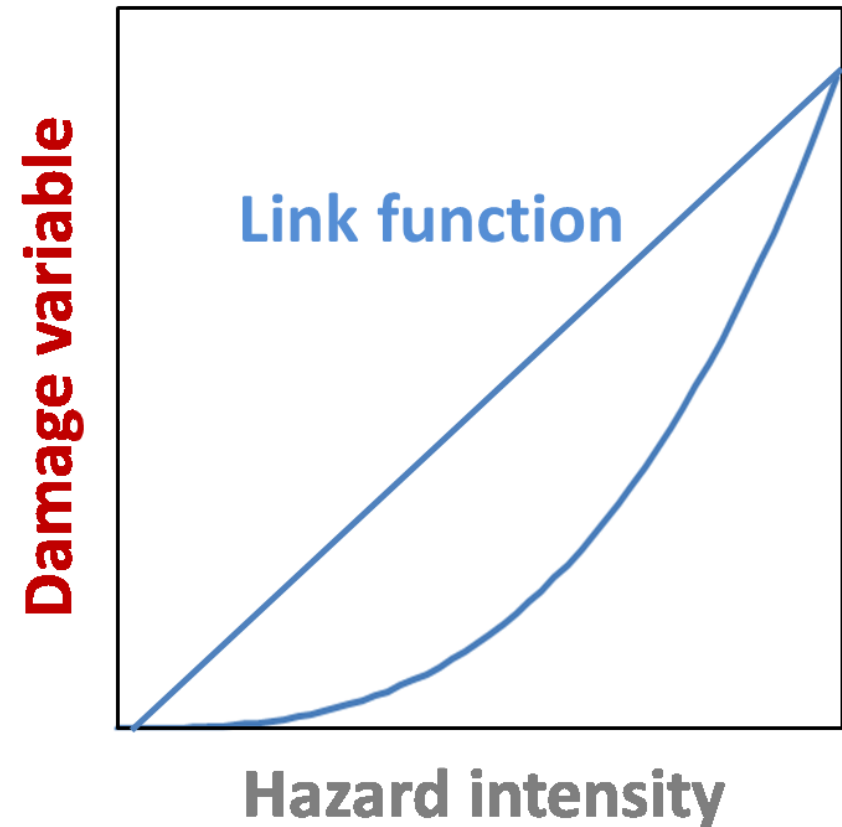


Impact functions (data driven empirical models)

- as a step towards damage or vulnerability functions for risk quantification
- to predict impact likelihood

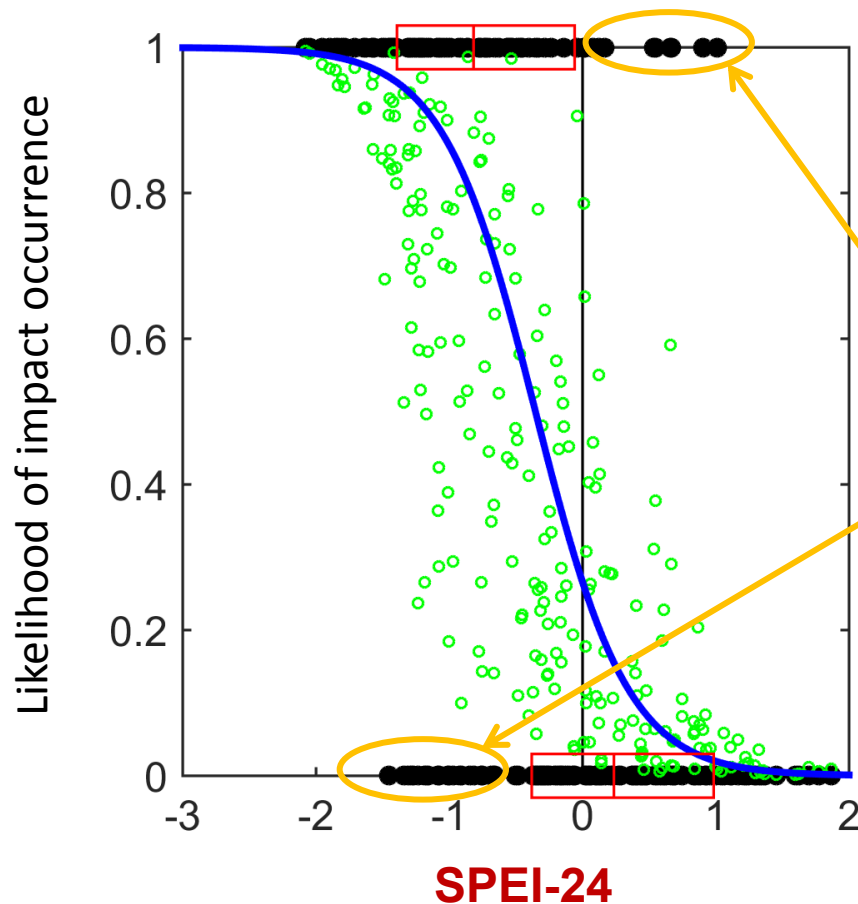
European experience:

- Drought impacts are diverse and different in different regions
- Drought impacts are often non-structural, hard to quantify or monetize
- Apart from crop yield statistics data on drought impacts is sparse



Drought impact function for S-E England

Logistic Regression



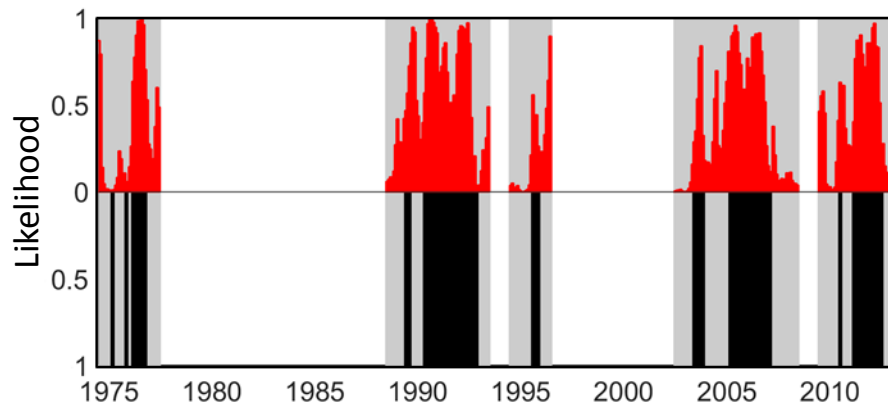
Multiple predictor model based on:
SPI-6 | **SPEI-24** | month

- Observed impacts
- Boxplot: 25-50-75 percentile
- Fitted data
- Model (SPI and SPEI constantly decreasing | constant month)

- Impacts persistent during wet conditions (e.g. water use restrictions due to low groundwater levels)
- No impacts during dry conditions (possible reasons: no reports on impacts or information missing in the database)

SEE: predictive performance of different models

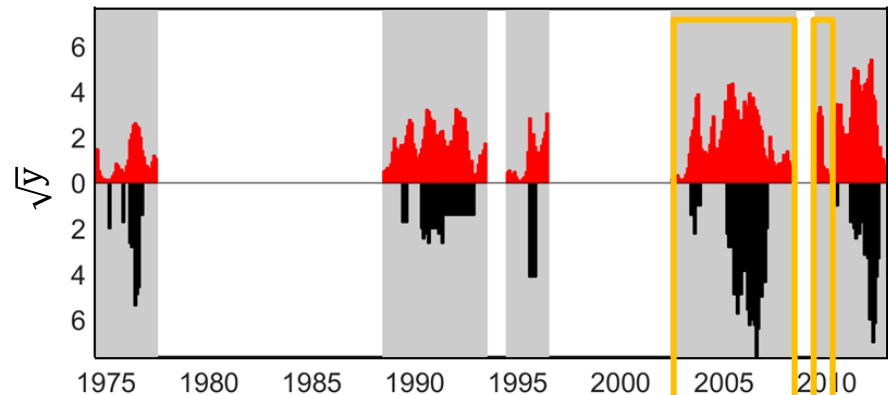
Logistic reg.



— Modeled
— Observed

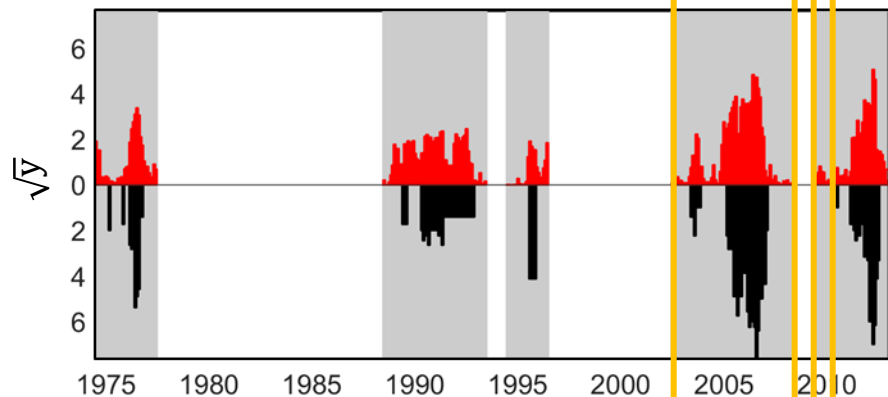
Selected
time for
analysis

Hurdle Model

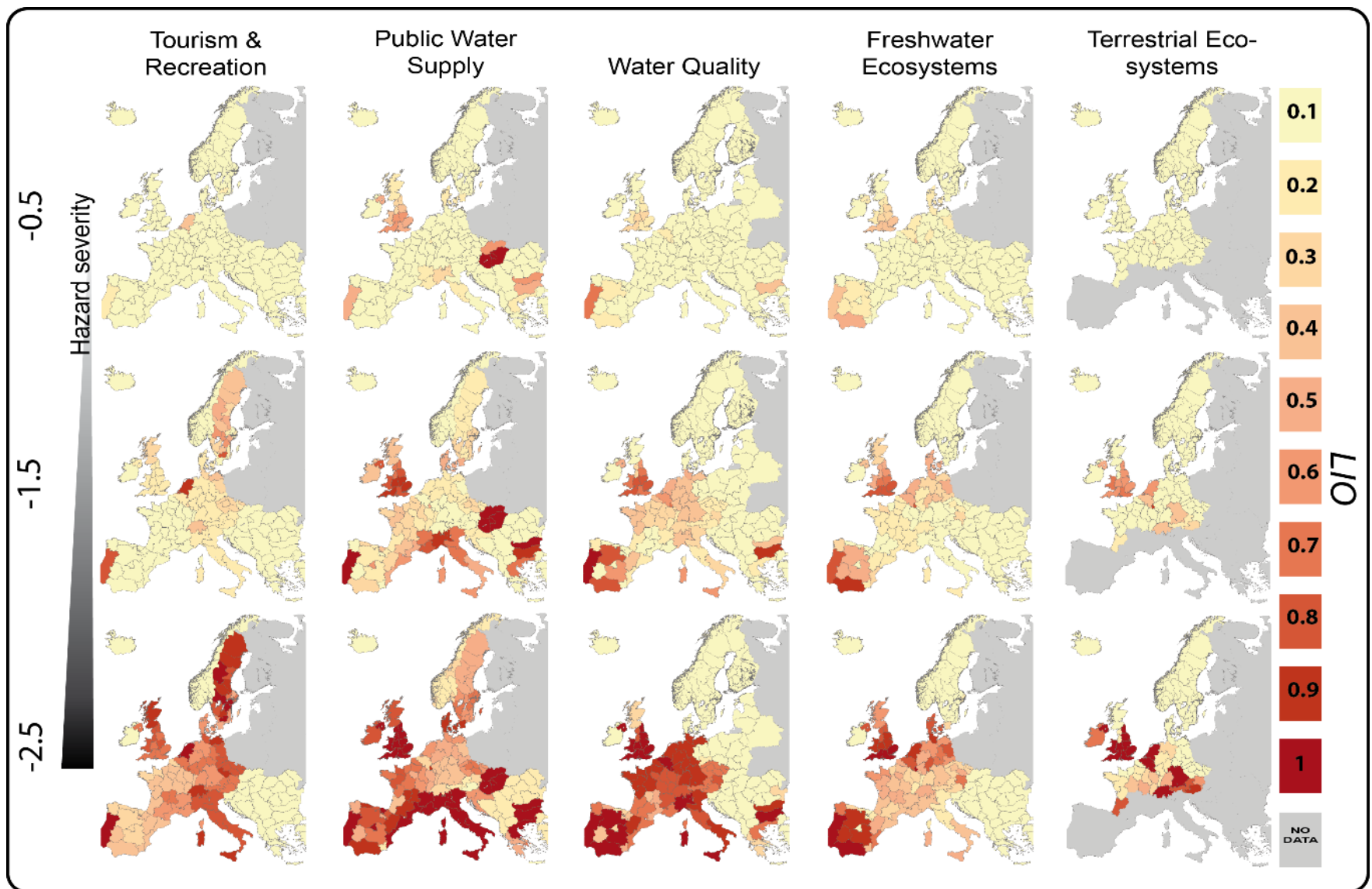


- The dynamics of impact occurrence are reasonably reproduced
- Peaks are underpredicted
- The Hurdle Model more often overpredicts small values than Random Forest

Random Forest

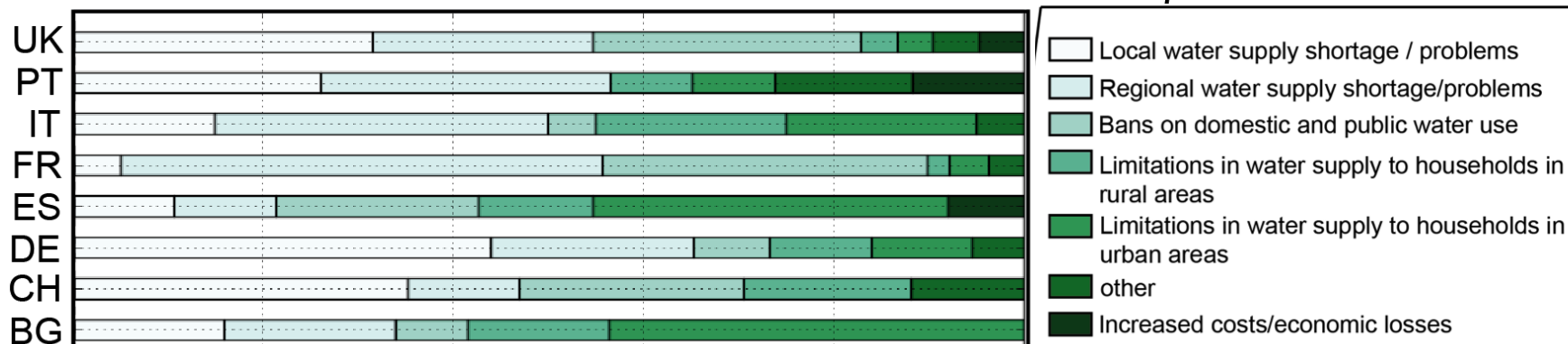


European perspective: LOI maps based on one model

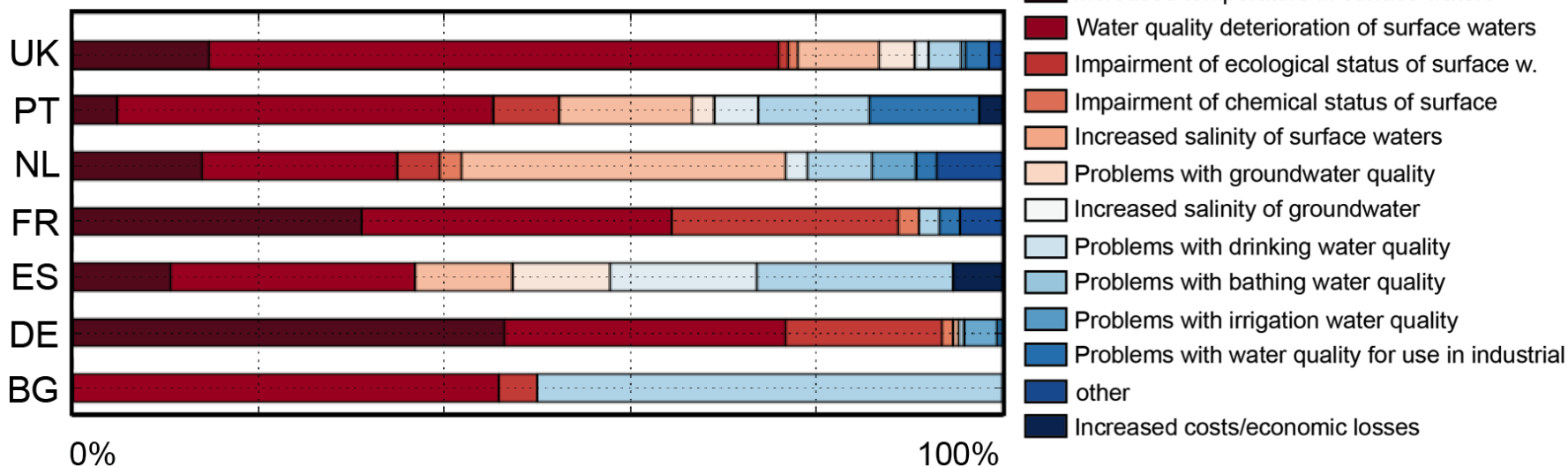


Zoom: details of impacts by sector and country

Public water supply



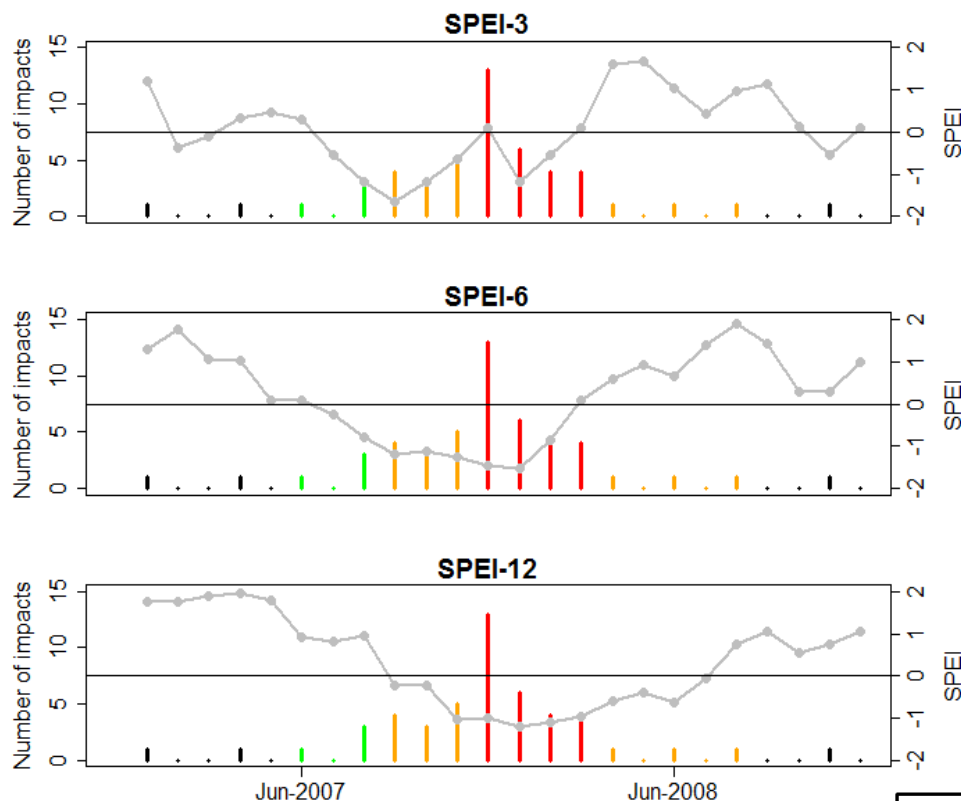
Water quality



→ Drought impact types (the detailed effects) differ in different regions



Historical analogues – reconstruction of drought beyond the indices



US experience:

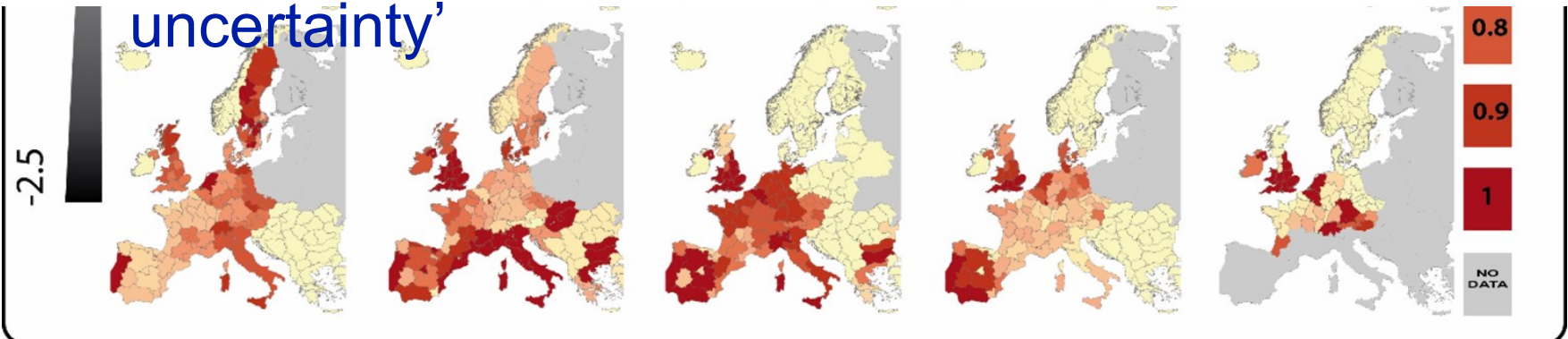
- Different indices indicate onset, peak, recovery of a drought
- Impacts are affected by management (e.g. water restrictions)
- Historical analogues are easy to communicate

Water usage restriction?

■ No ■ Voluntary ■ Mandatory (III) ■ Mandatory (IV)

Lessons and Limits of linking indices to impacts

- Data data data (more, more consistent, ...)
- Diversity and details of impacts
- Dynamics of link due to vulnerability changes
- Reserach needs:
 - search right scale for impact modelling
 - simpler approaches; robust models
 - communicate decision making under ‘impact uncertainty’



Acknowledgements & Further Information

- All EDII contributors
- WP3 of DROUGHT-R&SPI: Vanda Acácio, Carlo Bifulco, Lucia De Stefano, Susana Dias, Daniel Eilertz, Barbara Frielingsdorf, Lukas Gudmundsson, Eleni Kampragou, Lieke Melsen, Henny A.J. van Lanen, Anne F. van Loon, Antonio Massarutto, Dario Musolino, James Stagge, Lena Tallaksen, Julia Urquijo, and many more...






<http://europeandroughtcentre.com>

- DrIVER Project Team
www.drought.uni-freiburg.de



BUT: a variety of information sources

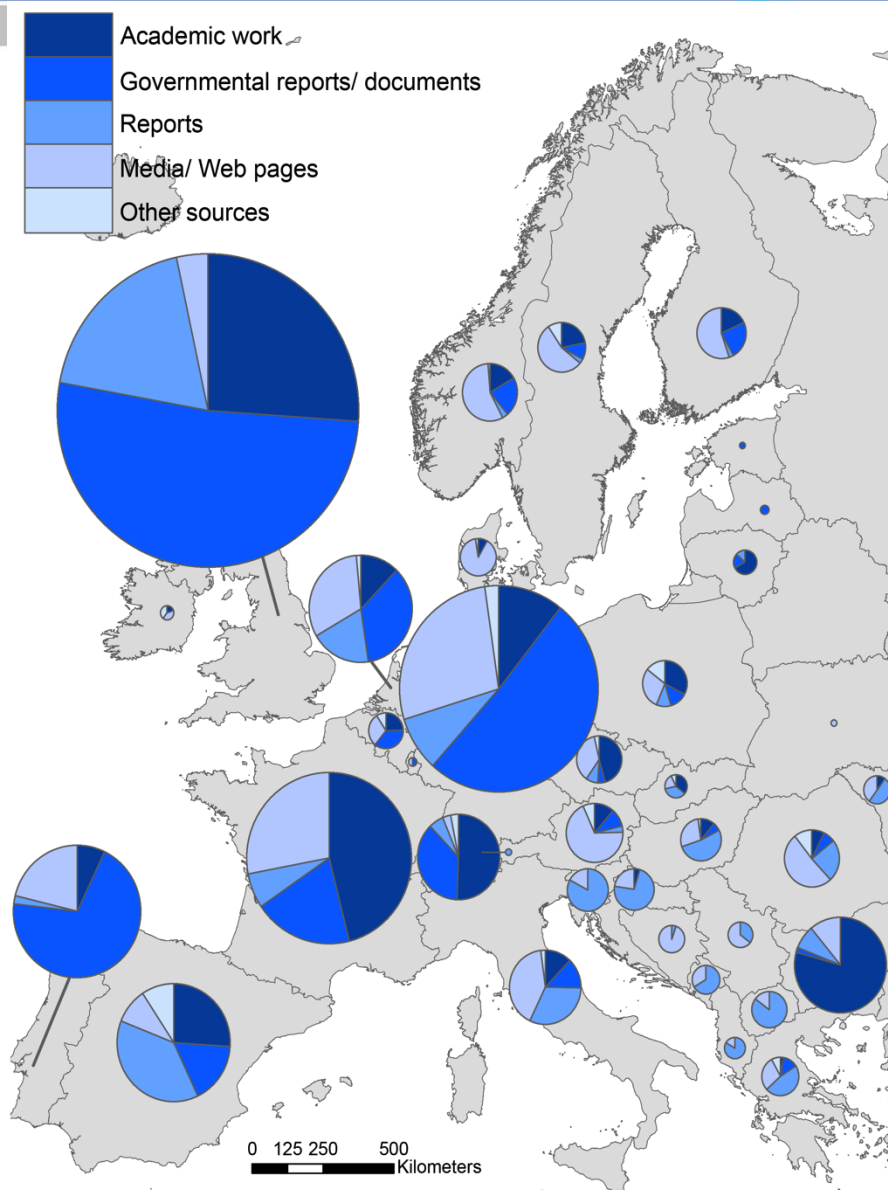
www.geo.uio.no/edc/droughtdb/

-  Academic work¹
-  Governmental reports/documents
-  Reports²
-  Media / Webpages
-  Other sources³

¹ including: Book, Scientific article, Thesis

² including: Report by NGO, River basin organization report, Report (private sector)

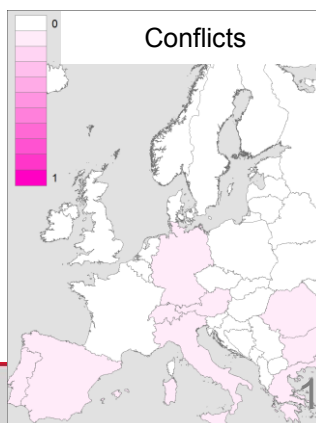
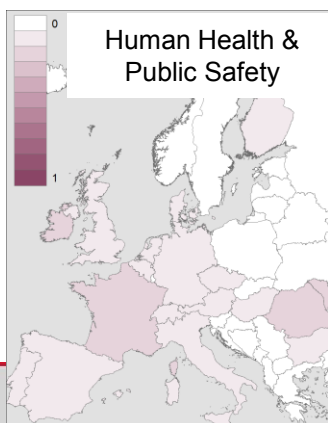
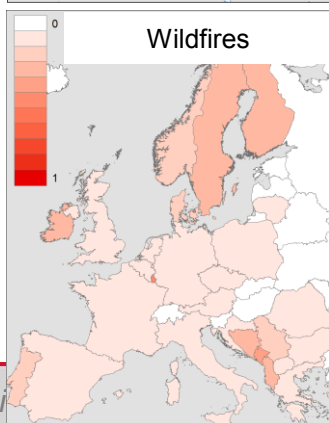
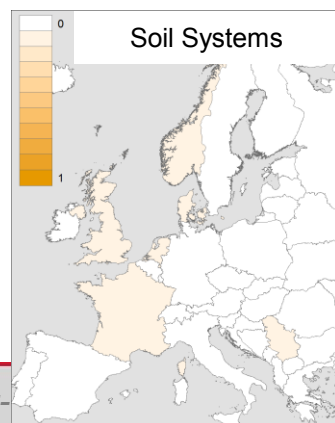
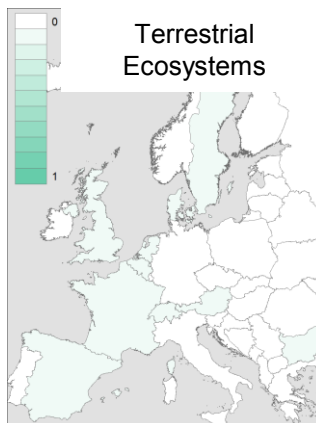
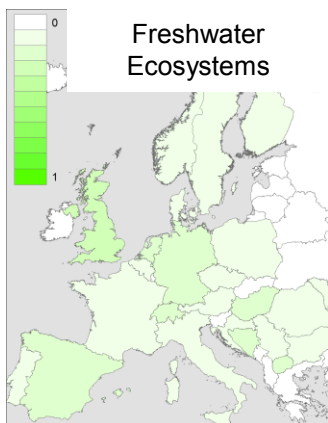
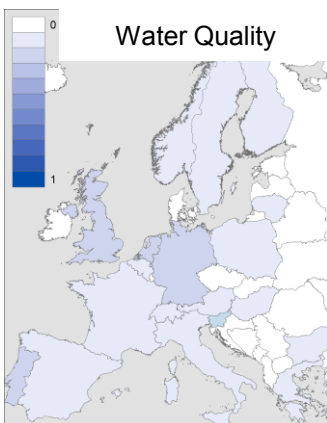
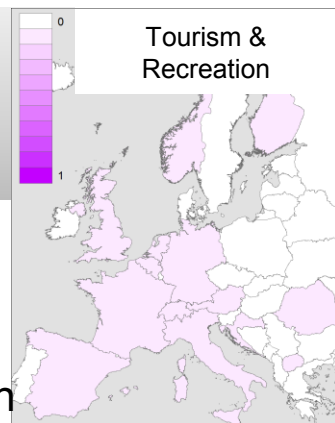
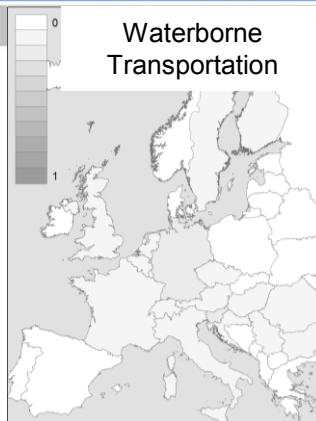
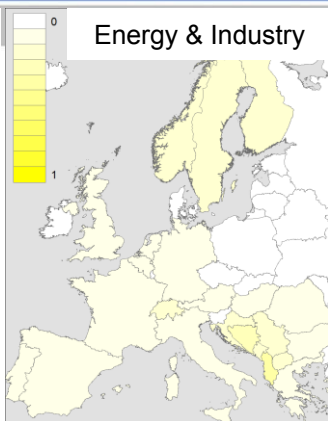
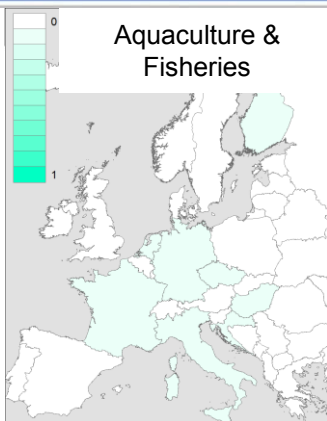
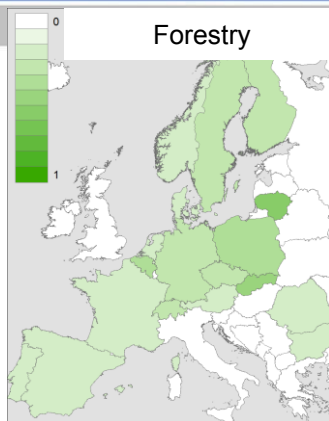
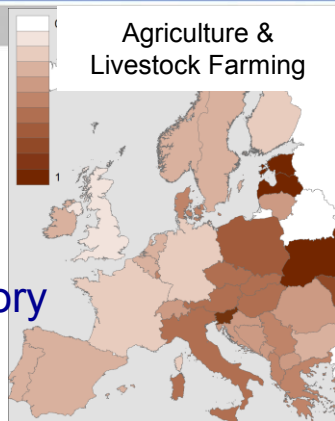
³ including: Database, Map, Press release, Pamphlet, Other



Space: relative importance of impacts

$$\frac{n_{c,s}}{n_s}$$

c= category
s=state
(country)



European perspective: best-predictors for impacts

- Combination of long and short accumulation times
- Seasonality matters for some

Table 3

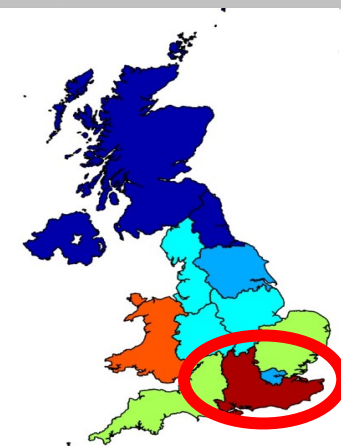
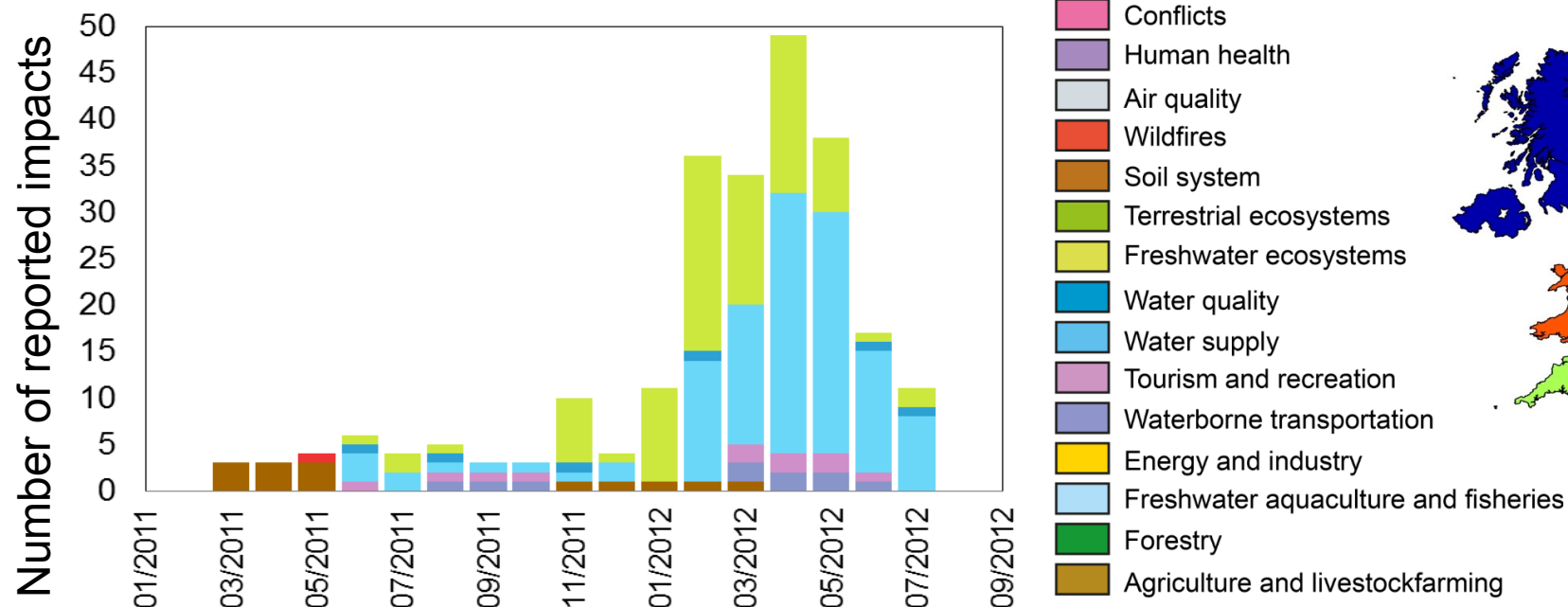
Summary of drought impact models for different impact types and countries. Estimated variable significance shown as ***<0.001; **0.0

| Category | Predictor | | BG | DE | NO | SI |
|-----------------------|-----------|--------|-----------------|-----------------|-----------------|-------------------|
| Agriculture | Month | | *** | *** | | *** |
| | Year | | *** | *** | | |
| | Indices | Short | | SPEI 3*** | | SPI 2/SPEI 2*** |
| | | Medium | SPEI 9** | | | |
| | | Long | | | | SPI 12/SPEI 12*** |
| Energy and industry | Month | | | | | |
| | Year | | | *** | * | * |
| | Indices | Short | | | | |
| | | Medium | | SPI 9/SPEI 9*** | SPEI 6** | |
| | | Long | | | | SPEI 12** |
| Water supply | Month | | | | | |
| | Year | | | * | | *** |
| | Indices | Short | SPEI 1* | SPEI 3*** | SPI 1* | SPEI 3** |
| | | Medium | SPI 6/SPEI 6*** | | SPI 6/SPEI 6*** | SPEI 9*** |
| | | Long | | SPEI 12** | | SPEI 24** |
| Freshwater ecosystems | Month | | | | | |
| | Year | | | ** | * | *** |
| | Indices | Short | | SPI 3/SPEI 3*** | | SPI 2/SPEI 2*** |
| | | Medium | | SPEI 9** | SPI 6/SPEI 6*** | |
| | | Long | | | | SPEI 24*** |



Fig. 1. Countries with drought impact models.

Zoom: impacts in SEE in 2011-12



Freshwater ecosystems

1-2/2012: Fish deaths and distress in River Meon and a lake in Hampshire. 30 mature sea trout and 6 salmon reported dead.

Water supply

4/2012: 7 water companies in the south and east of England imposed **temporary water use bans** on 20 million customers.

3/2012: In some regions in the east and south east of England several domestic **wells dried up**.