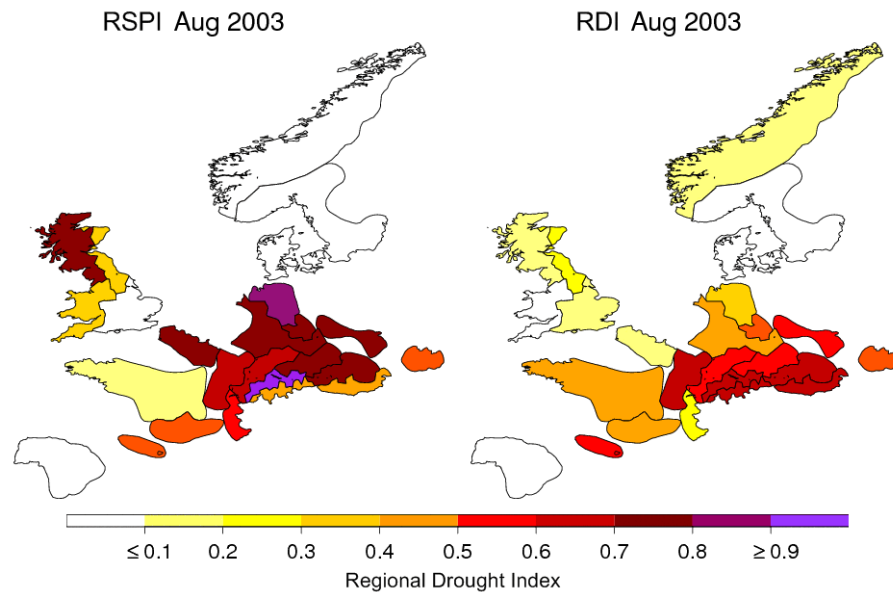




A Drought Catalogue for Europe

A tool for examining drought characteristics and drought impacts at regional to continental scales



Jamie Hannaford
Xerochore Final Conference
February 22 – 24th 2010, Brussels



Contributors & Funding

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Caroline Keef

Funded by:

Water and Global Change (WATCH)

Environment Agency England and Wales

Department of Environment, Food and Rural Affairs





Background

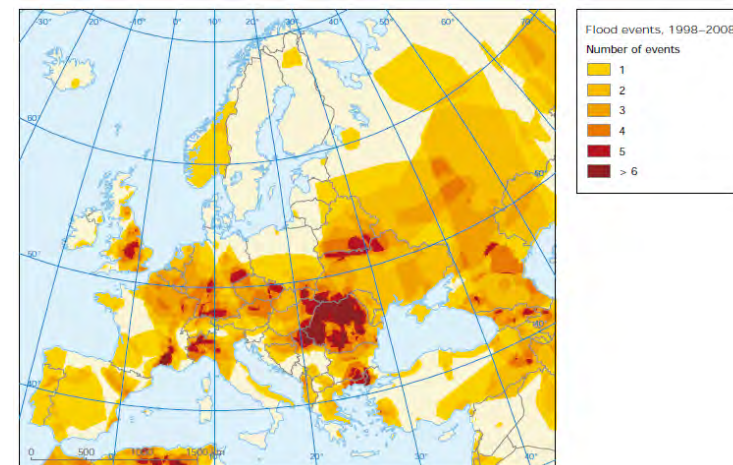
- Major historical droughts have been documented previously
- but not systematically (unlike floods)
- Droughts vary in their spatial extent, duration, intensity, seasonality
- Impacts can vary significantly from region to region...
- Therefore an objective classification of droughts is preferred.
- Why do we need a catalogue?
 - enable consistent comparison of drought characteristics between regions
 - examine temporal and spatial evolution of major European droughts
 - identify patterns of spatial coherence common to major droughts. Can they be explained?

Five-Year Drought Continues in Spain*

Antonio Mestre Barceló
National Institute of Meteorology, Ciudad Universitaria
Madrid, Spain



National/ regional drought assessments



Dartmouth Flood Observatory



- Hydrological Data

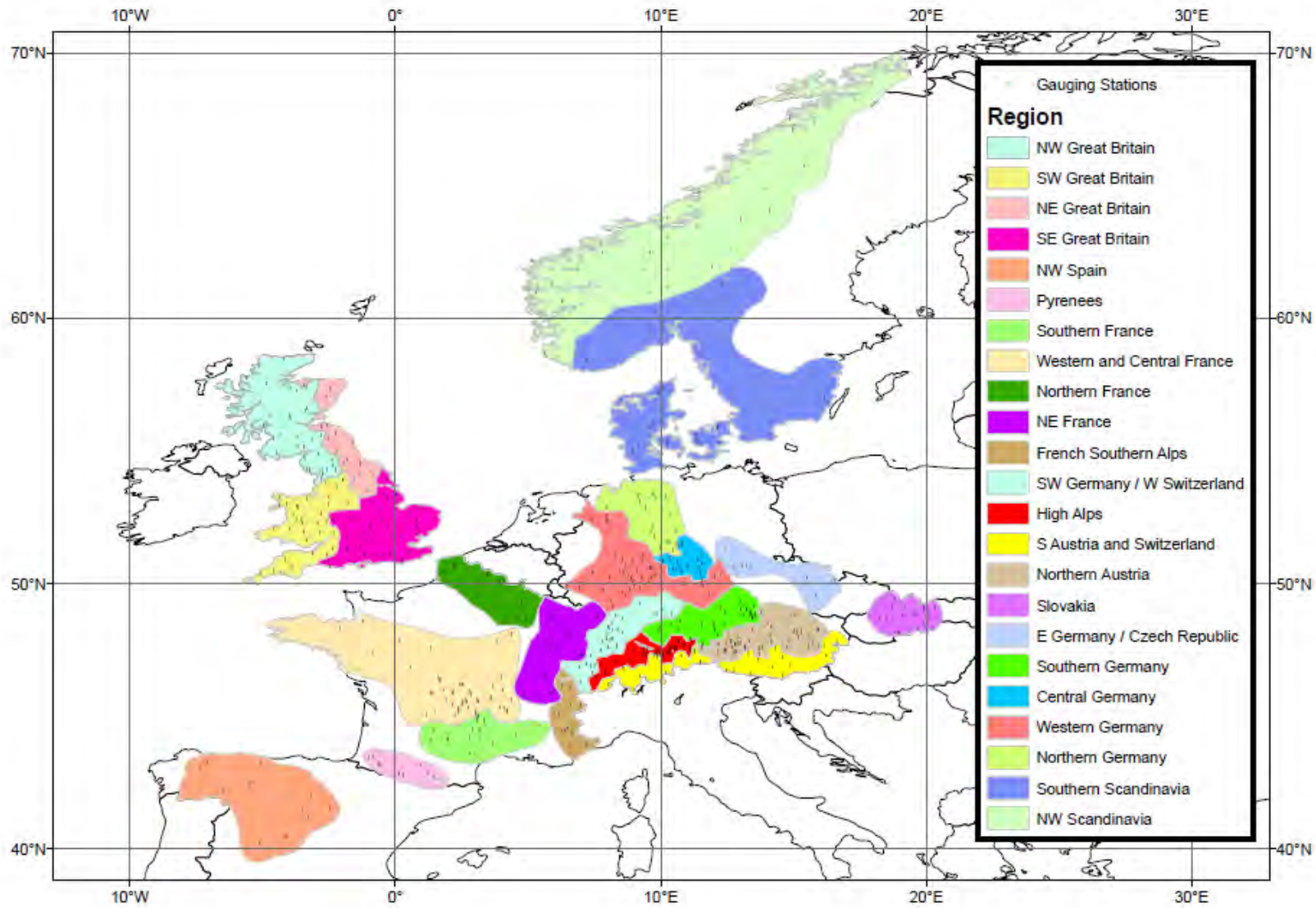
- Minimal artificial influence (generally small catchments)
- Data 1961 - 2005
- 579 catchments with daily river flow
- Most data from the [FRIEND European Water Archive](http://ne-friend.bafg.de) <http://ne-friend.bafg.de>
- France: [Banque Hydro](http://www.hydro.eaufrance.fr/) <http://www.hydro.eaufrance.fr/>
- UK: [National River Flow Archive](http://www.ceh.ac.uk/data/nrfa/) <http://www.ceh.ac.uk/data/nrfa/>

- Meteorological Data

- From [British Atmospheric Data Centre](http://badc.nerc.ac.uk/browse/badc/cru) , CRU TS 3 monthly precipitation time series, <http://badc.nerc.ac.uk/browse/badc/cru>
- 0.5 degree grid cells (~ 55km)
- Data 1901- 2006

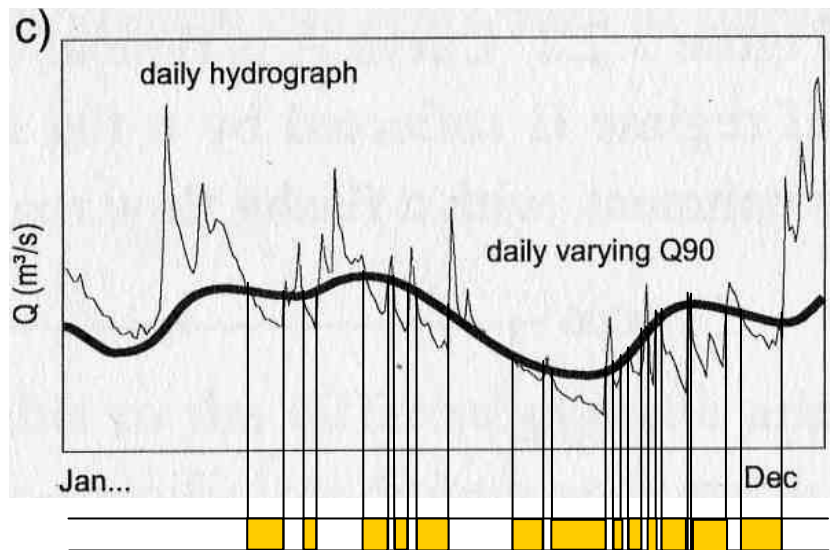


Homogeneous Drought Regions



Hydrological Drought Indicator

- For daily time series at each station, compare the measured river flow with a daily varying 90% percentile (Q90)



Flow time series transformed into binary series, or **Deficit Index**:
-1 for deficit, or flow under threshold: yellow periods

0 for non deficit, or flow over threshold: white periods

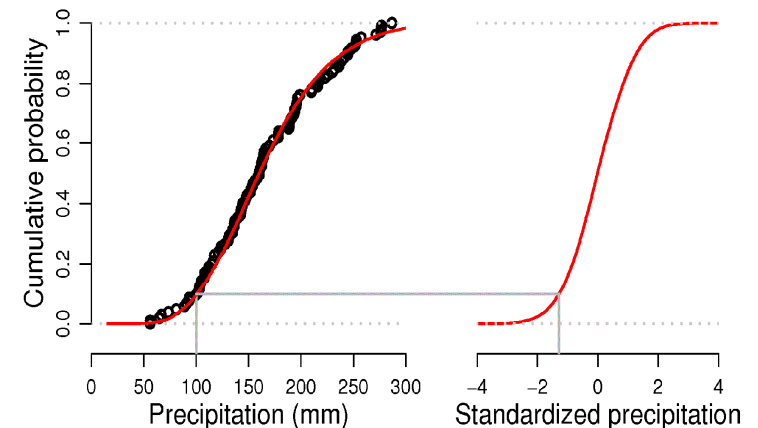
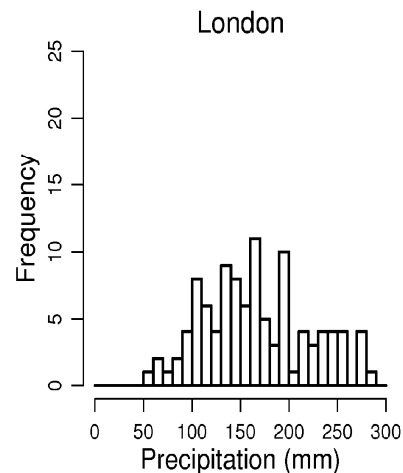
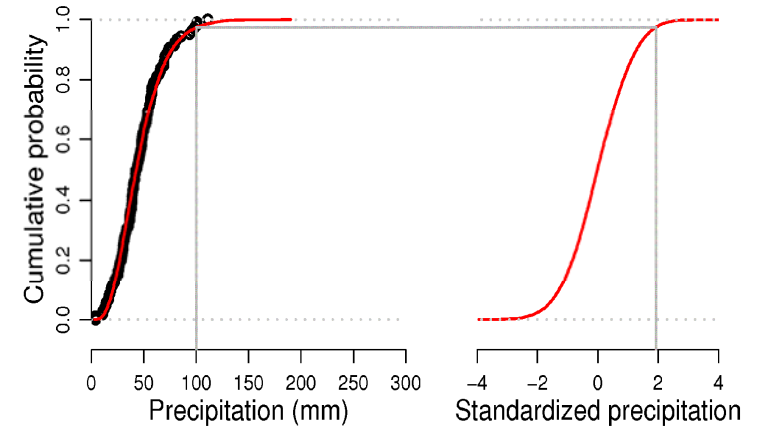
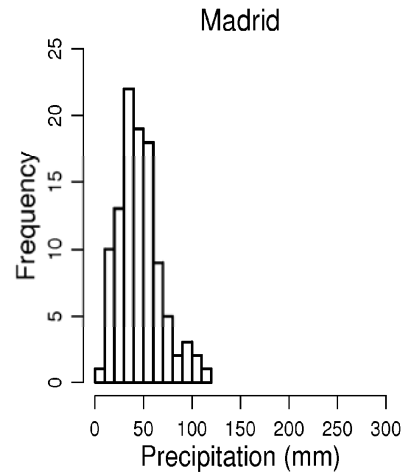
- For a region, the **Regional Deficiency Index (RDI)** is the proportion of stations which are below the threshold on any one day

Developed during ARIDE project (Stahl & Demuth, 1999)



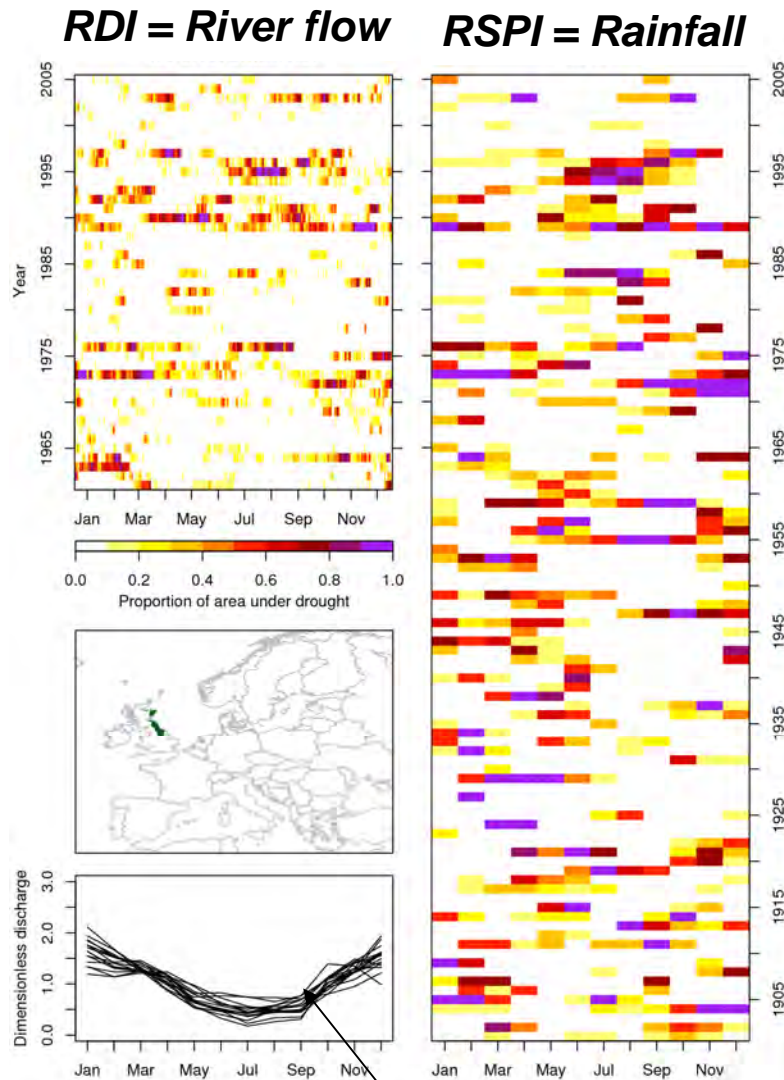
Meteorological Drought Indicator

- Standardised Precipitation Index (SPI) time series
- Specifically designed to enable comparison between regions with different rainfall regimes
- For each region, quantify proportion of grid cells under drought:
- **Regional Standardised Precipitation Index (RSPI)**

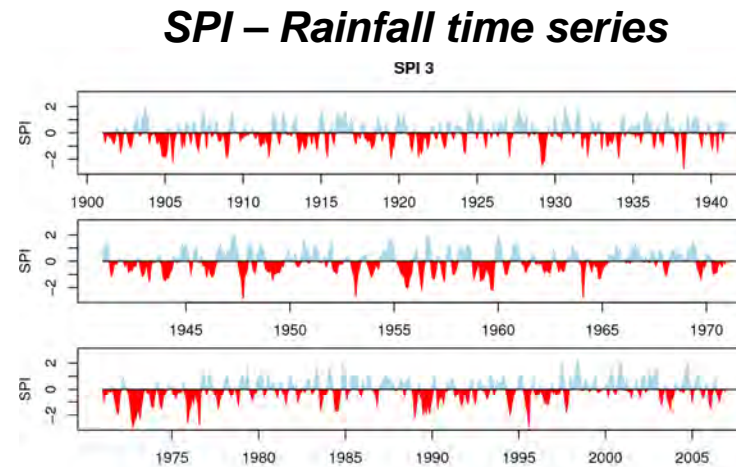




Example of Drought Catalogue pages: NE England

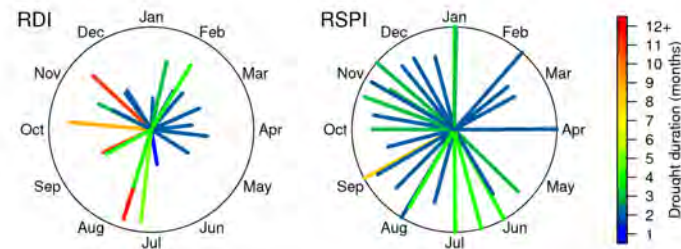


Flow Regime Plots



Notes

- Regime: Precipitation-dominated, high flows in winter, low flows in summer.
- The optimal meteorological proxy for streamflow drought is SPI 3 at a lag of 0 months with a rank correlation of 0.58.
- Some long coherent hydrological droughts but the majority are less coherent and of short duration.
- Multi-month hydrological droughts generally start from July to November.
- Spring/summer droughts dominated by short duration low coherency.

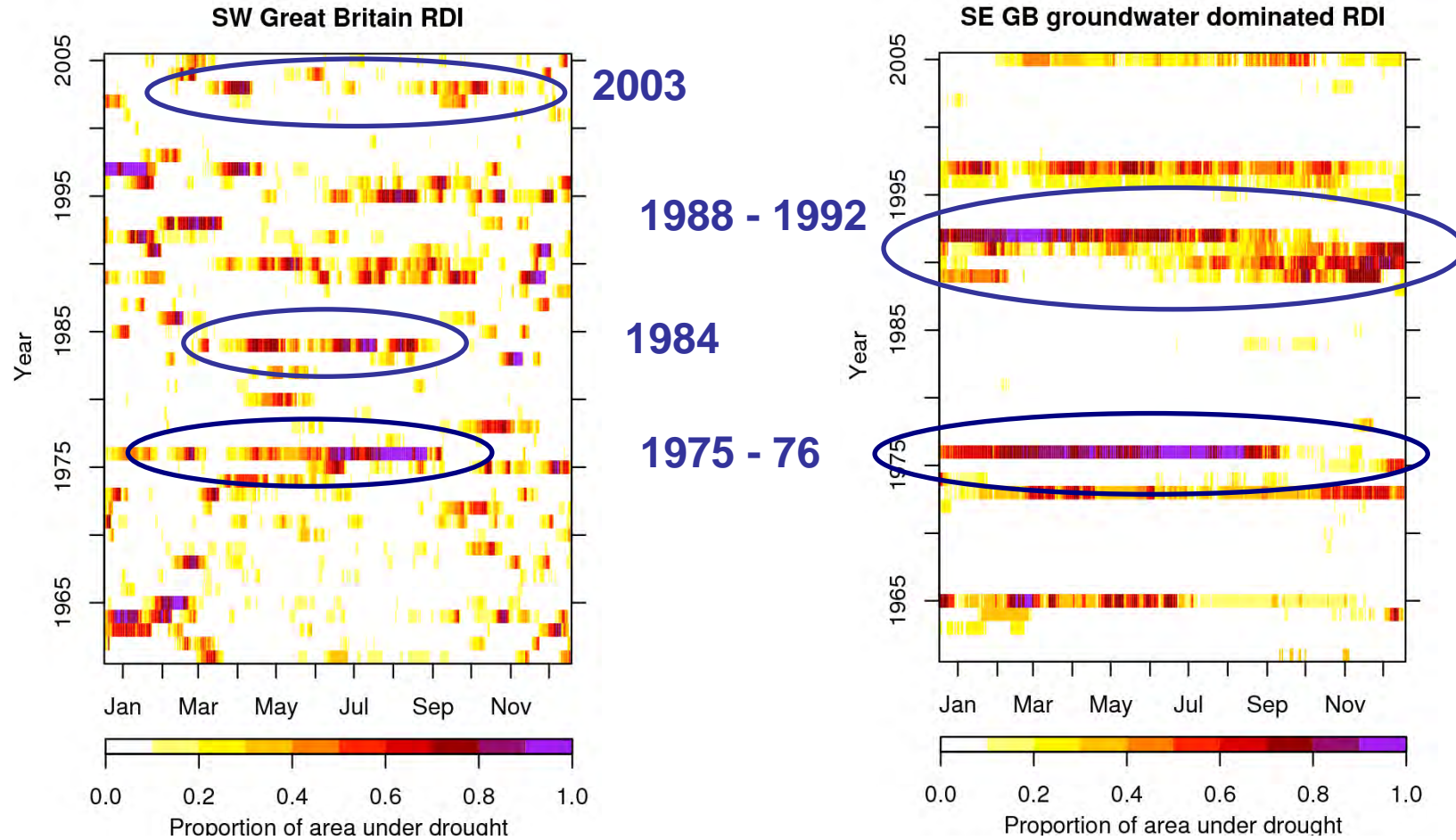


Circular plots of drought onset and duration 1961-2005. Radii are proportional to the cluster area under drought. The unit circle is 100%.

Seasonality Plots



Comparing regional Drought Characteristics



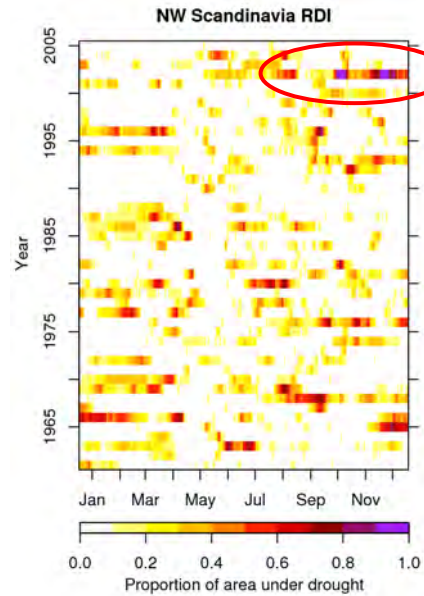
Catalogue can be used to compare the spatial extent and duration of droughts



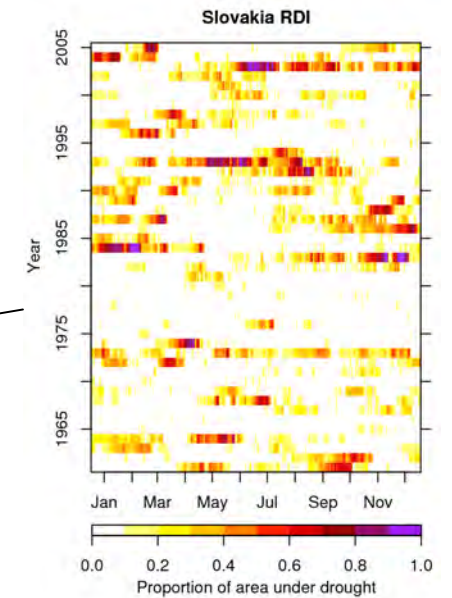
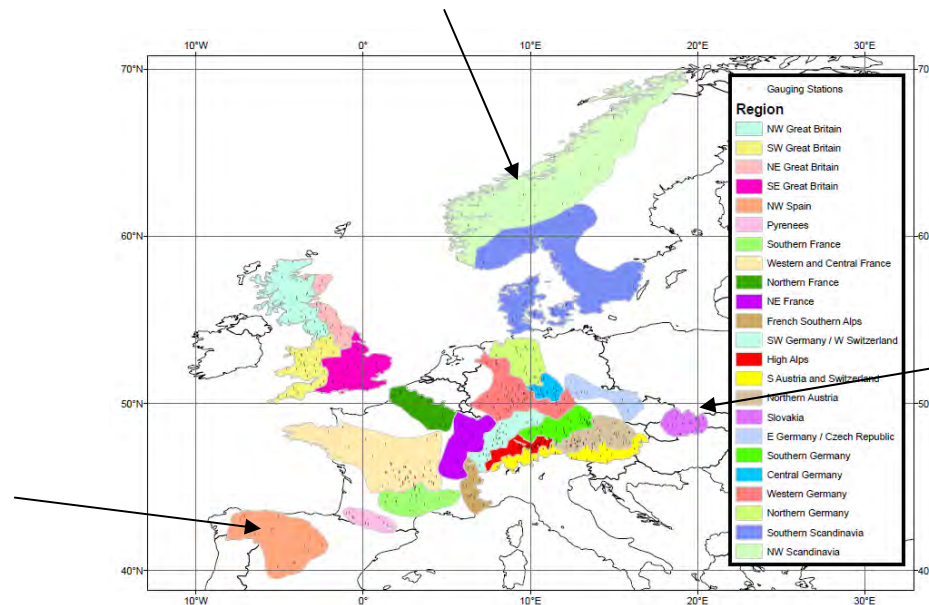
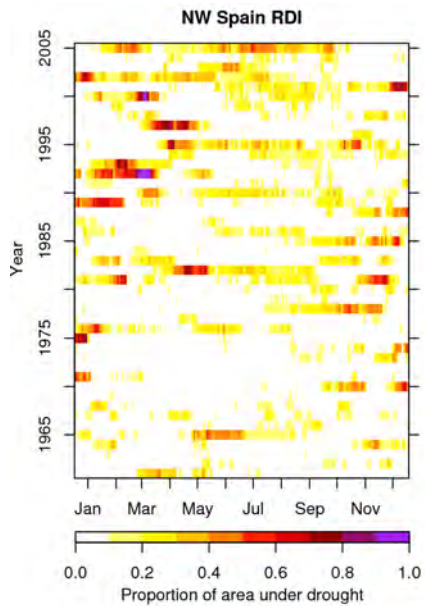
European Catalogues



Spain, 2005



Norway, 2002





Adding impacts to the catalogue



"reductions in reservoir inflows, but water resources situation never became critical"

"inter-basin water transfers required - 89 drought orders in 1989"

"hosepipe bans affected 12.5m consumers in summer 1989 and 18m in August 1990"

"ban on abstractions for spray irrigation - public awareness campaigns reduced demand"



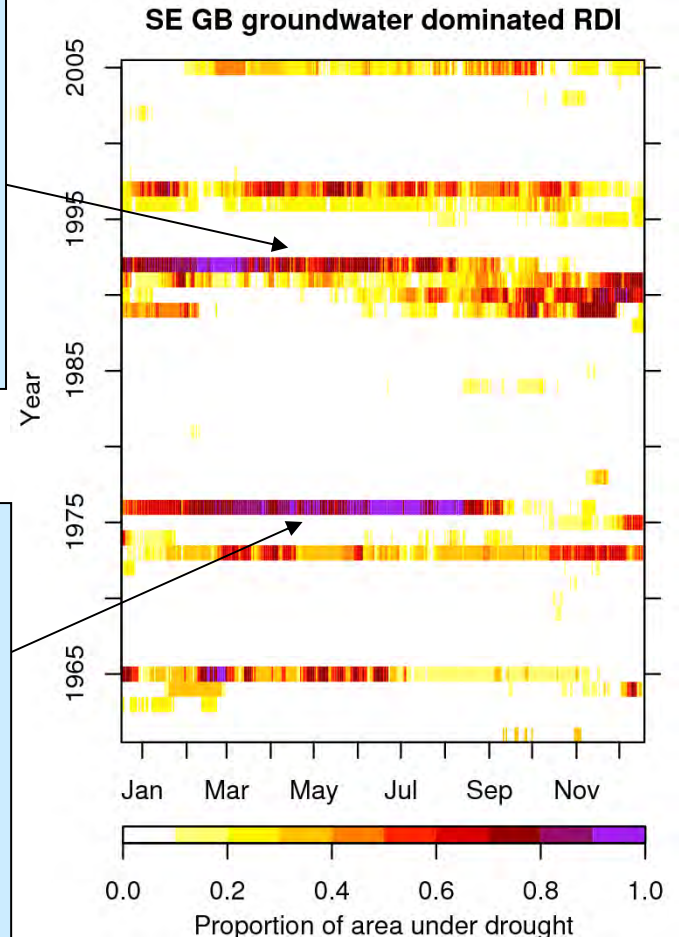
"most significant impact on water resources of all 20th century droughts"

"water quality problems, reduction in extent of the river network, loss of aquatic habitat"

"forest fires raged - 50,000 trees burned in one episode in Hurn Forest"

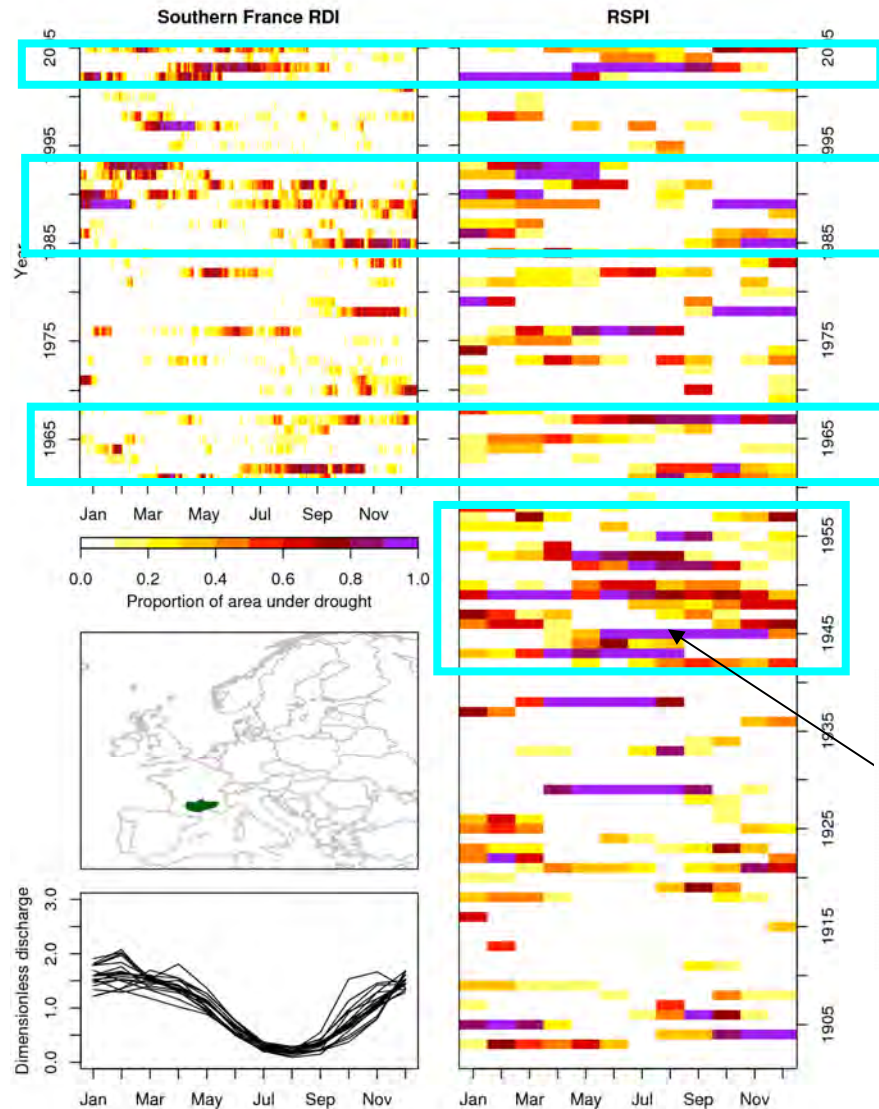
"136 drought orders - water shortages and rationing - standpipes introduced"

"water policy changed as result, incorporating water transfers and supply augmentation"





Meteorological Drought – a longer view



Pont du Gard in Aug 2003



(photo: H. Van Lanen)

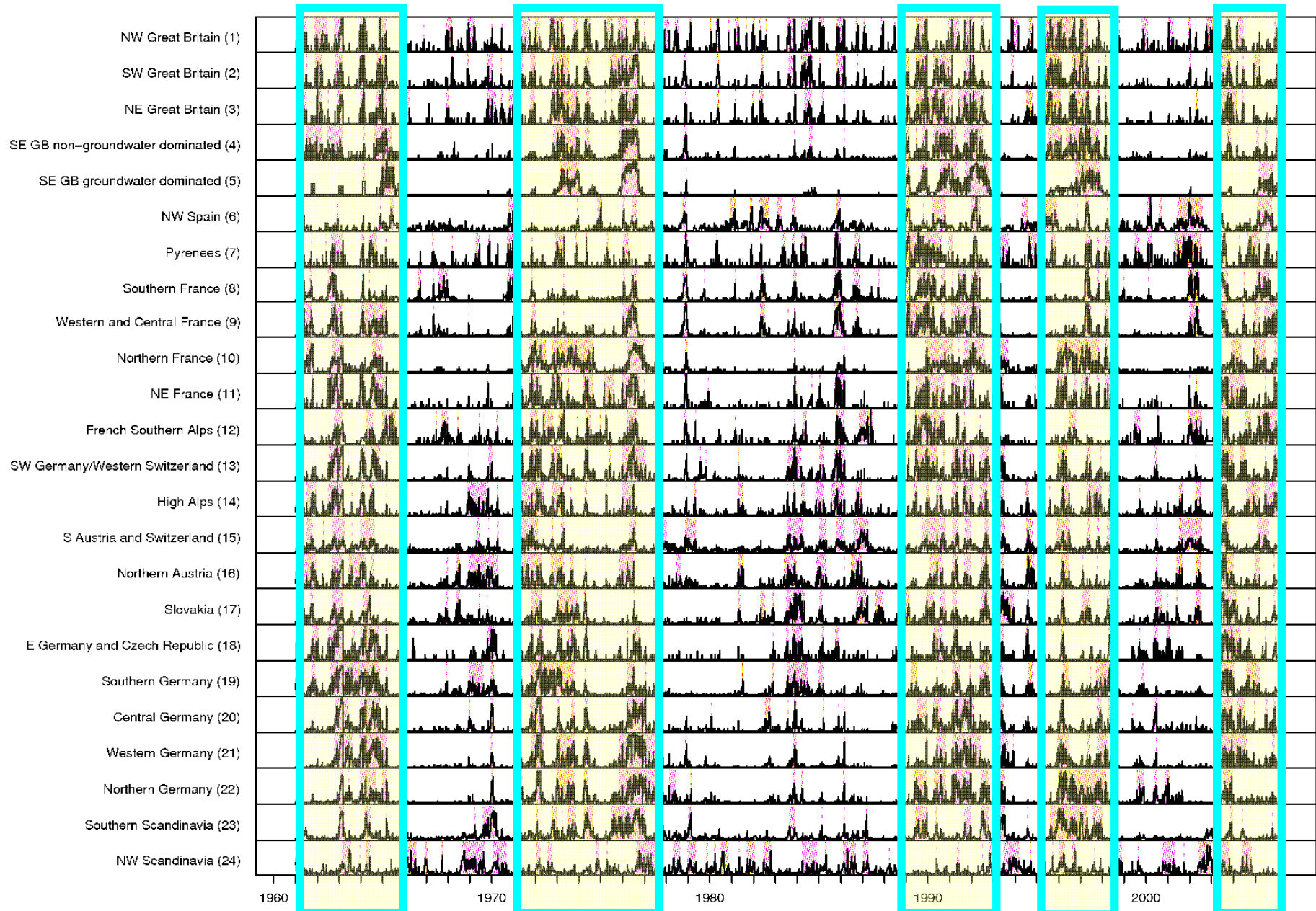
1941 – 1948 drought (Annales de Géographie)

La sécheresse des années 1941 à 1948.

STATIONS	JANVIER	FÉVRIER	MARS	AVRIL	MAI	JUIN	JUILLET	AOUT	SEPT.	OCTOBRE	NOV.	DÉC.	ANNÉE
I. — MASSIF CENTRAL													
Normales (en mm.)...	66	66	80	76	81	82	68	70	71	83	82	81	906
Écarts aux normales :													
1941.....	+ 41	+ 43	+ 9	- 11	+ 37	+ 11	- 7	+ 53	- 18	- 43	+ 25	- 53	+ 93
1942.....	+ 30	- 17	- 2	- 17	- 8	- 7	- 29	- 2	+ 6	- 5	- 59	- 26	- 136
1943.....	+ 47	- 17	- 62	- 47	- 6	- 48	+ 20	- 16	+ 32	+ 16	+ 6	- 15	- 90
1944.....	- 26	+ 2	- 61	- 14	- 50	- 37	+ 33	+ 38	+ 25	+ 63	+ 68	+ 56	+ 97
1945.....	+ 19	- 7	- 53	- 35	+ 12	- 54	- 29	+ 20	- 19	- 35	- 42	+ 32	- 191
1946.....	- 42	+ 7	- 41	- 25	+ 56	- 4	- 35	+ 6	- 27	- 35	- 14	+ 2	- 152
1947.....	- 5	+ 20	+ 10	- 40	- 2	- 10	- 17	+ 1	- 8	- 31	+ 3	- 11	- 91
1948.....	+ 70	- 47	- 63	+ 2	+ 26	- 10	- 21	+ 9	- 2	- 48	+ 46	- 32	- 162



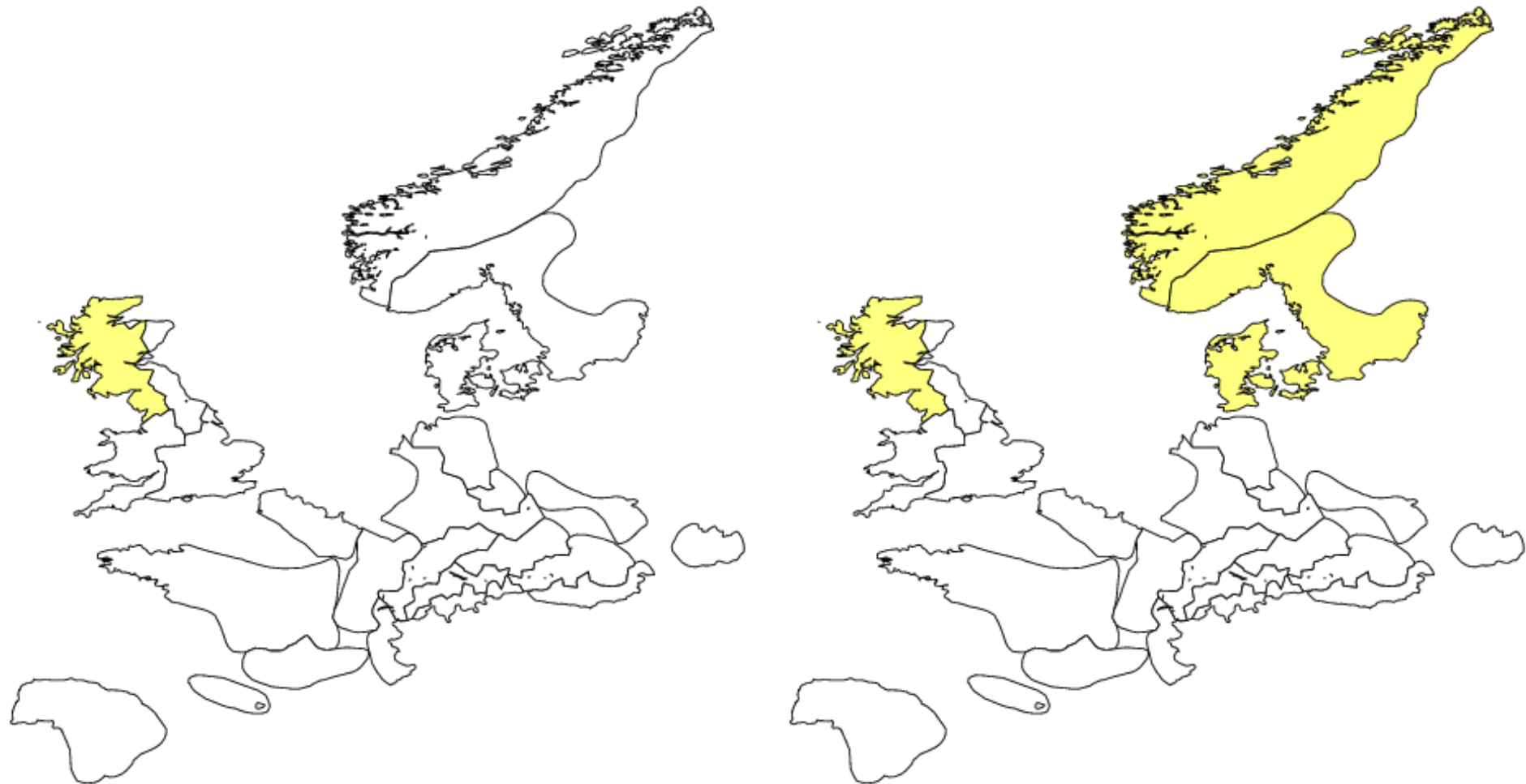
Coherence across Europe?





RSPI Jan 2003

RDI Jan 2003

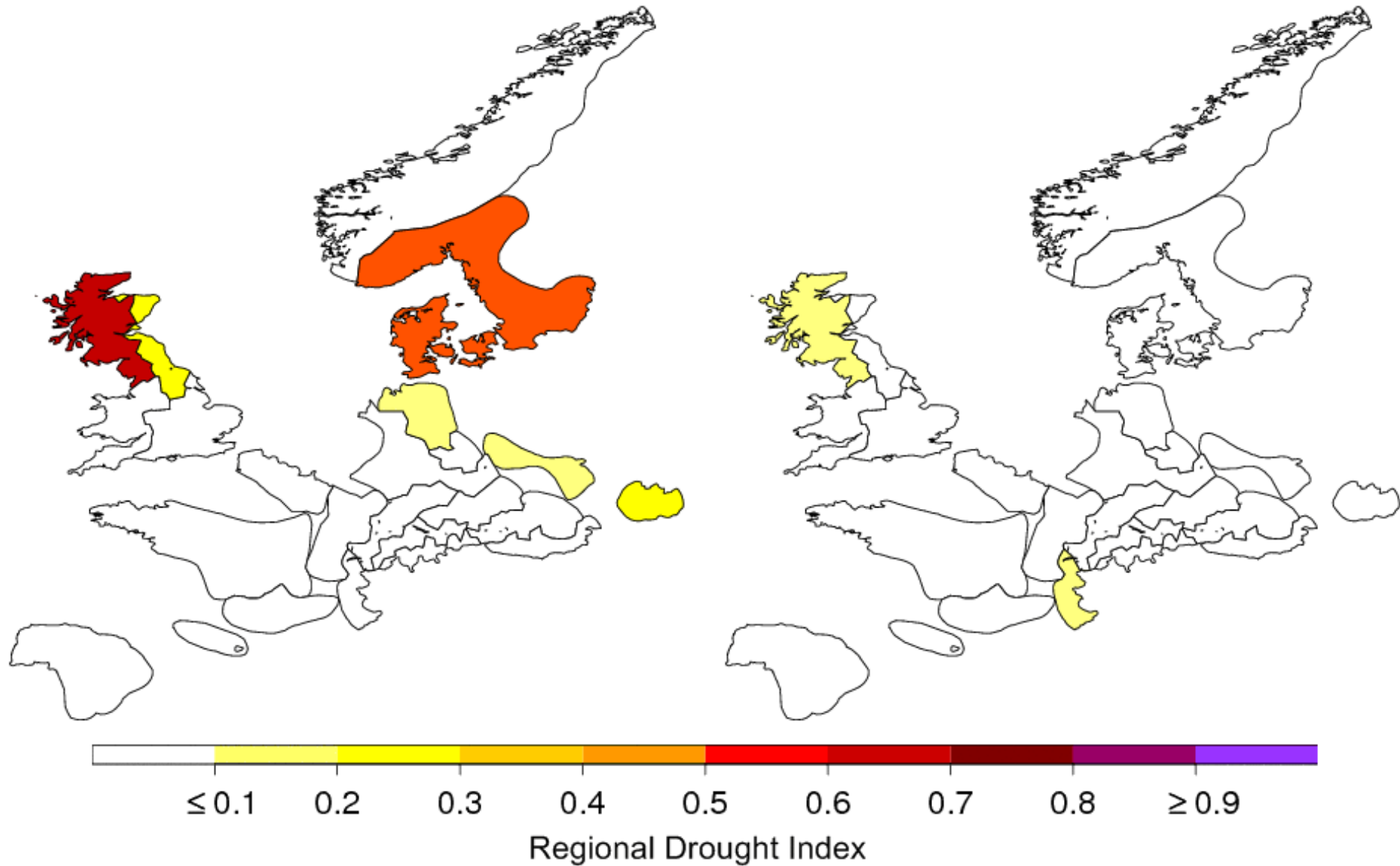


Regional Drought Index



RSPI Feb 2003

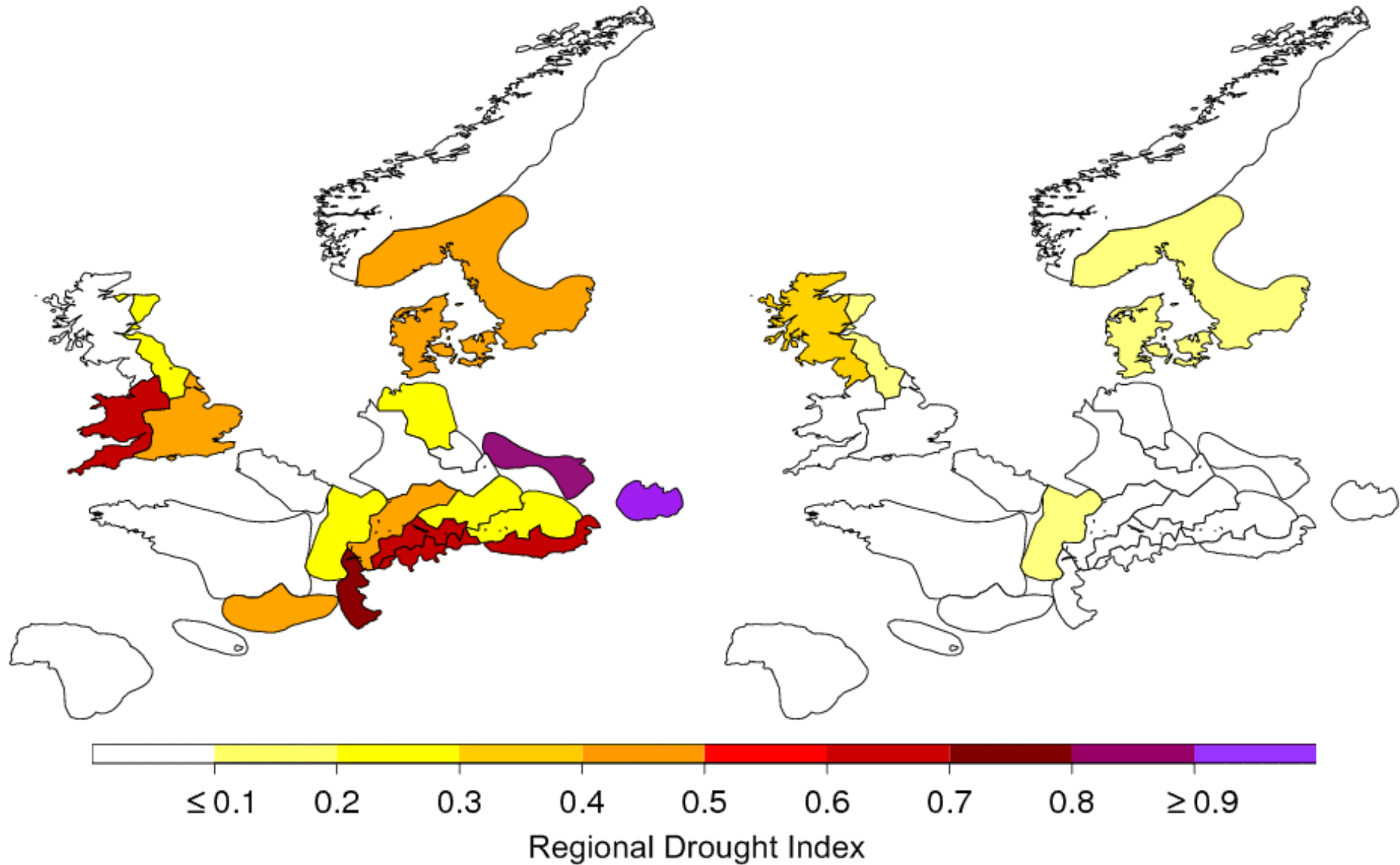
RDI Feb 2003





RSPI Mar 2003

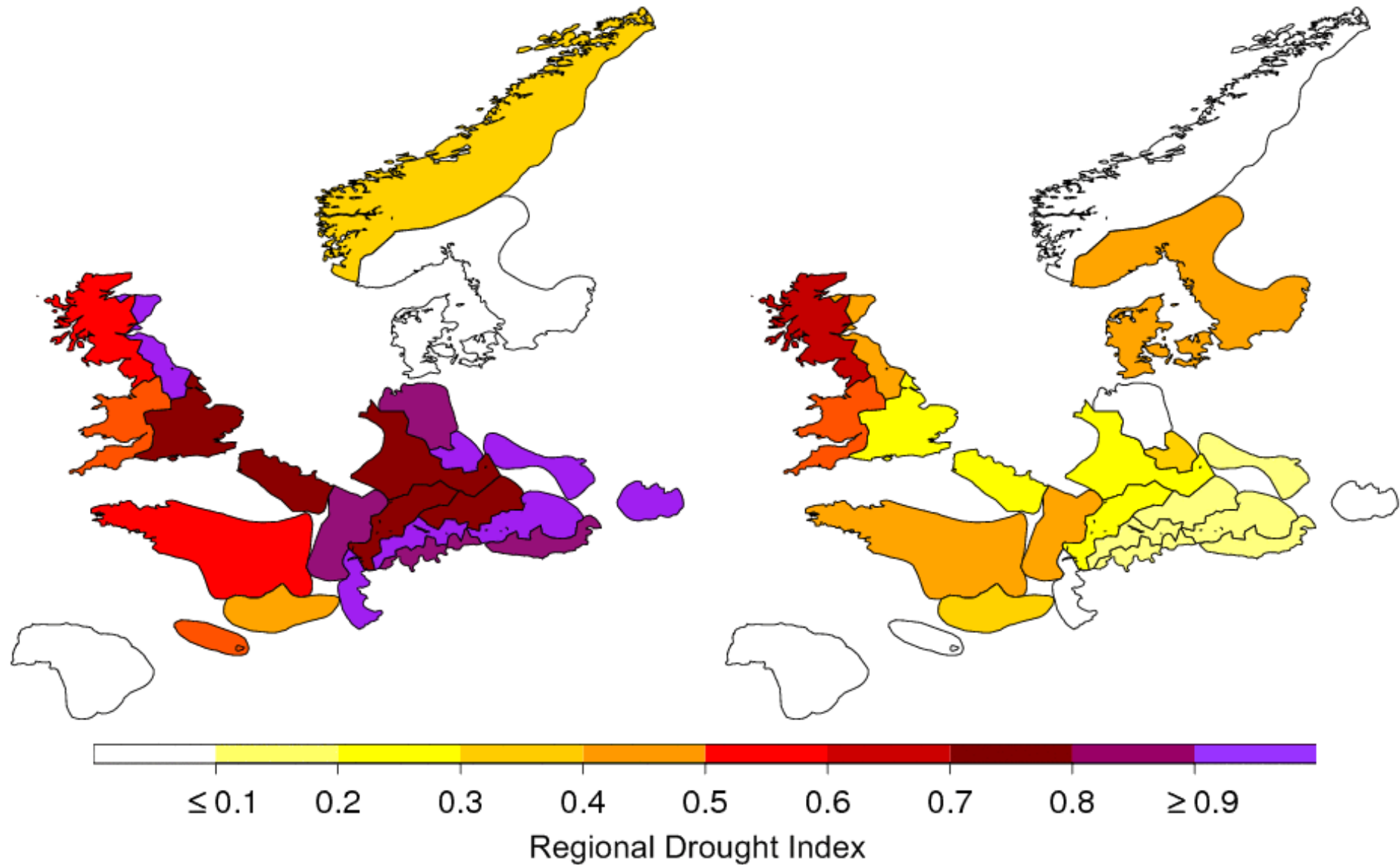
RDI Mar 2003





RSPI Apr 2003

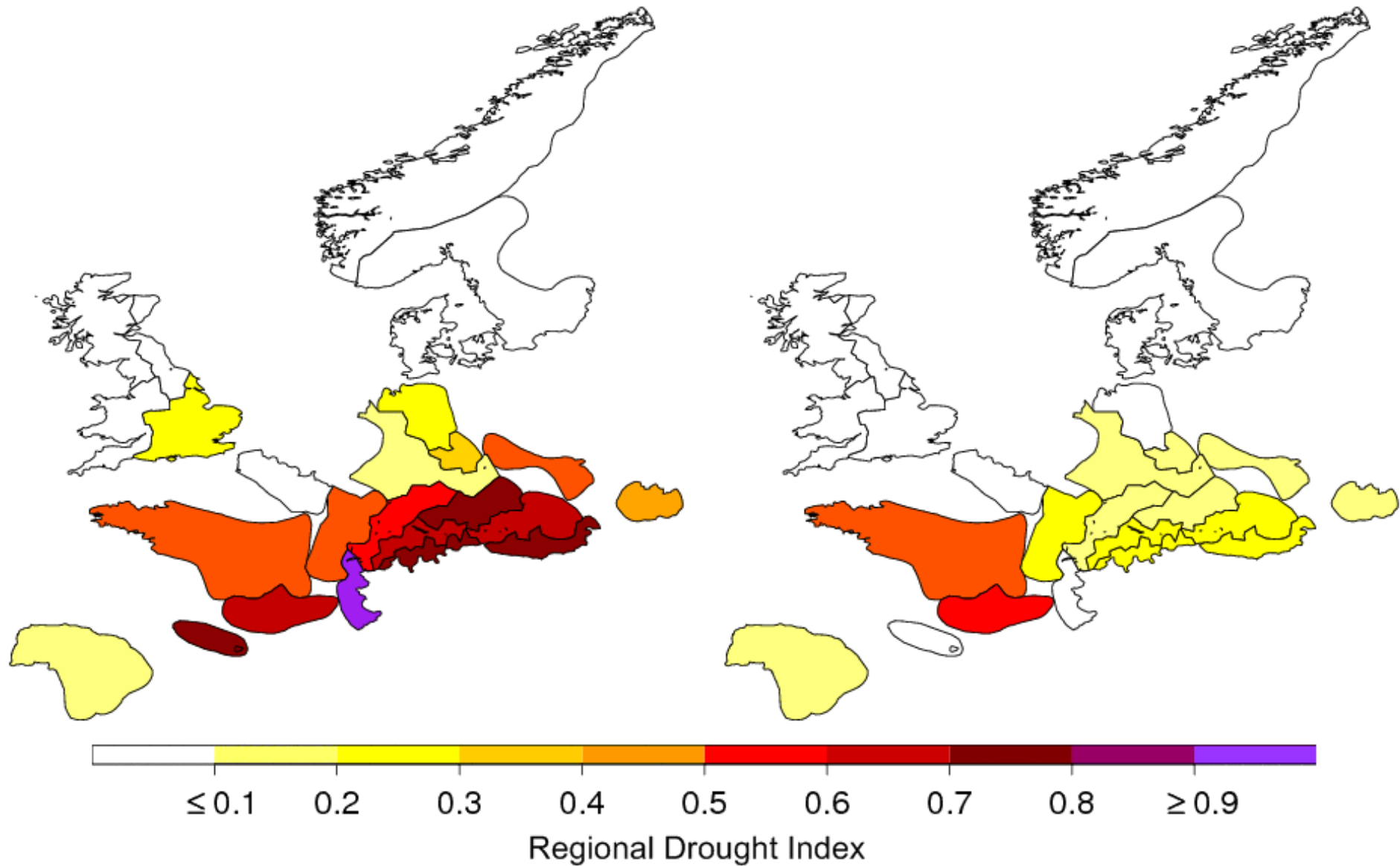
RDI Apr 2003





RSPI May 2003

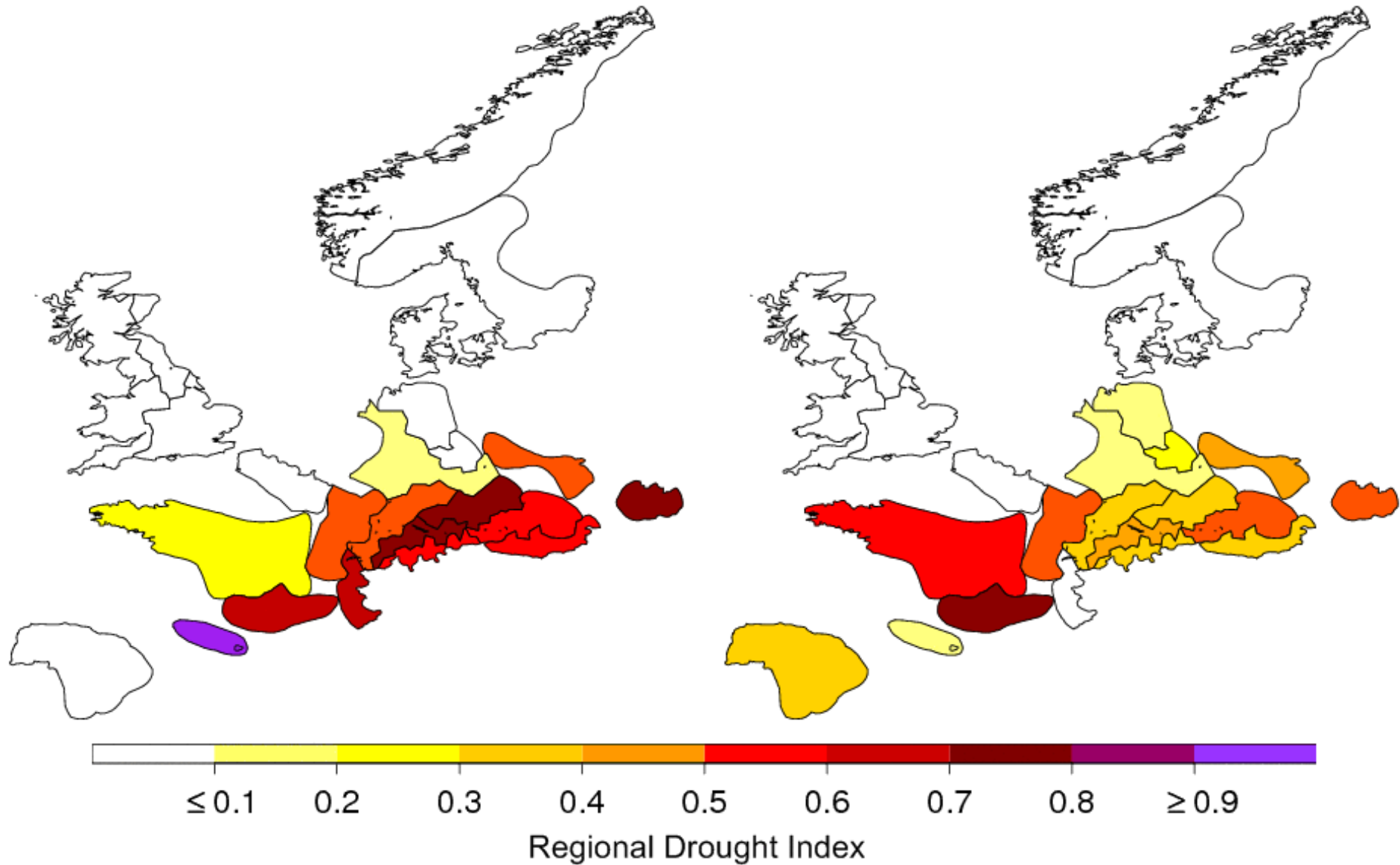
RDI May 2003





RSPI Jun 2003

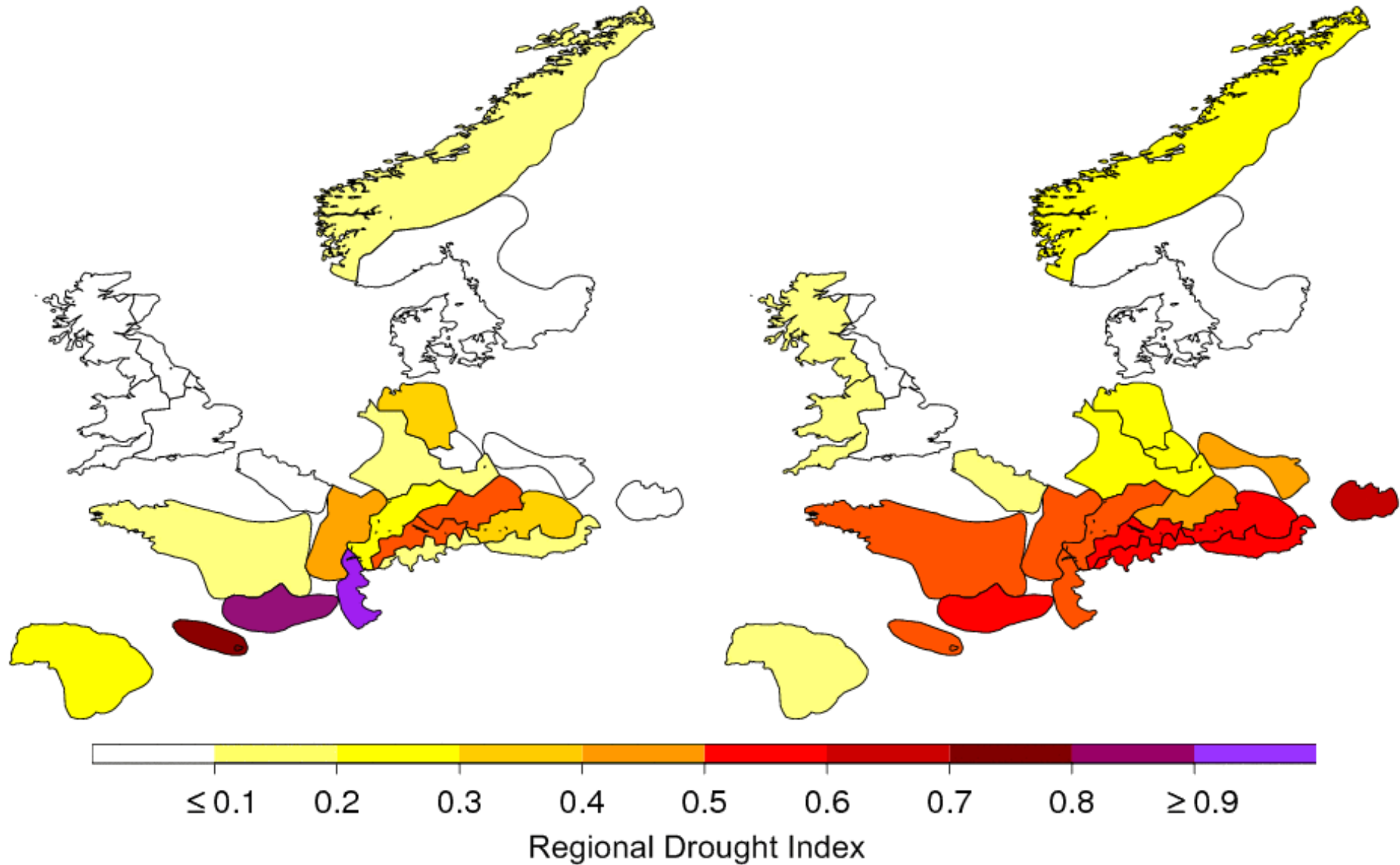
RDI Jun 2003





RSPI Jul 2003

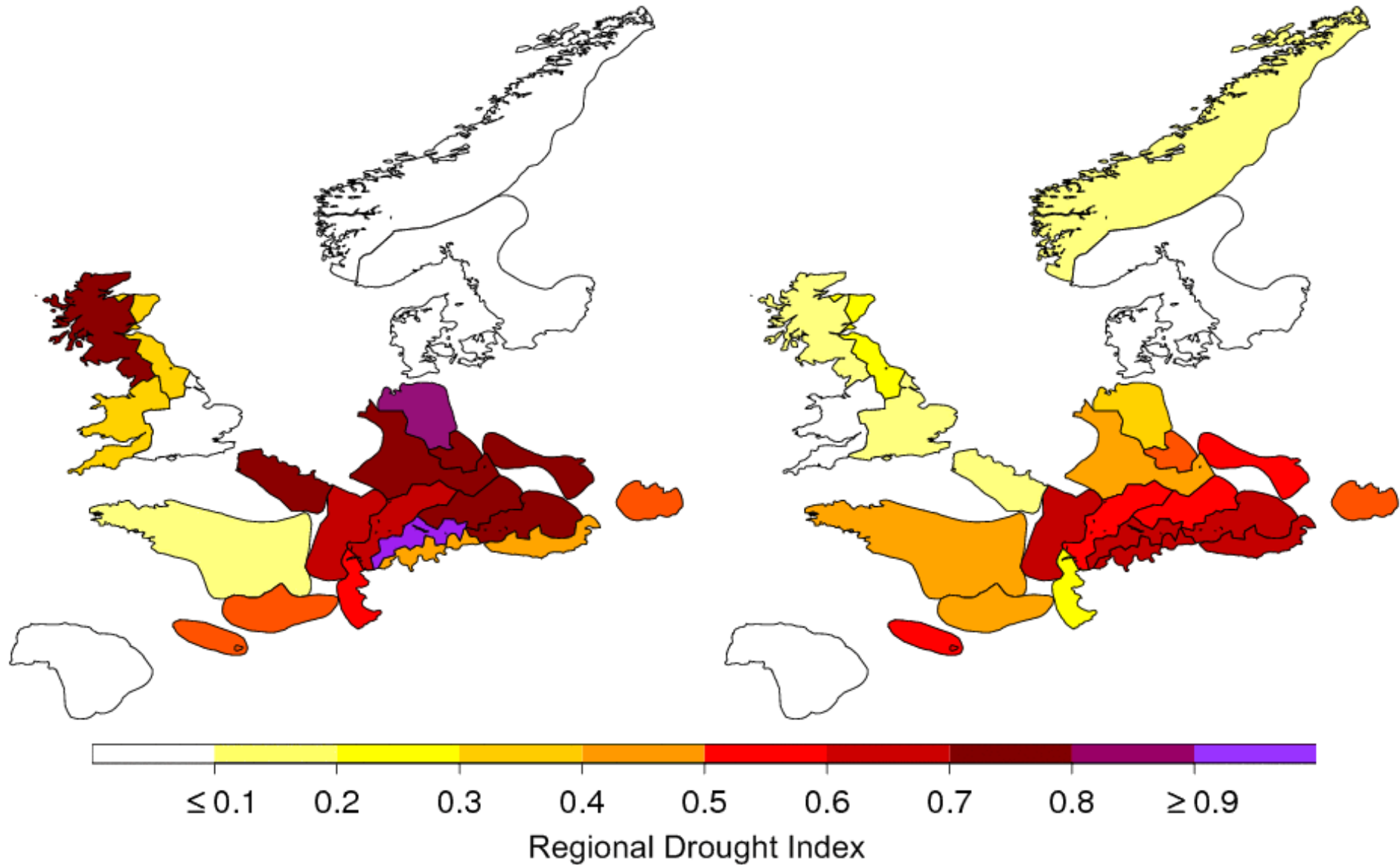
RDI Jul 2003





RSPI Aug 2003

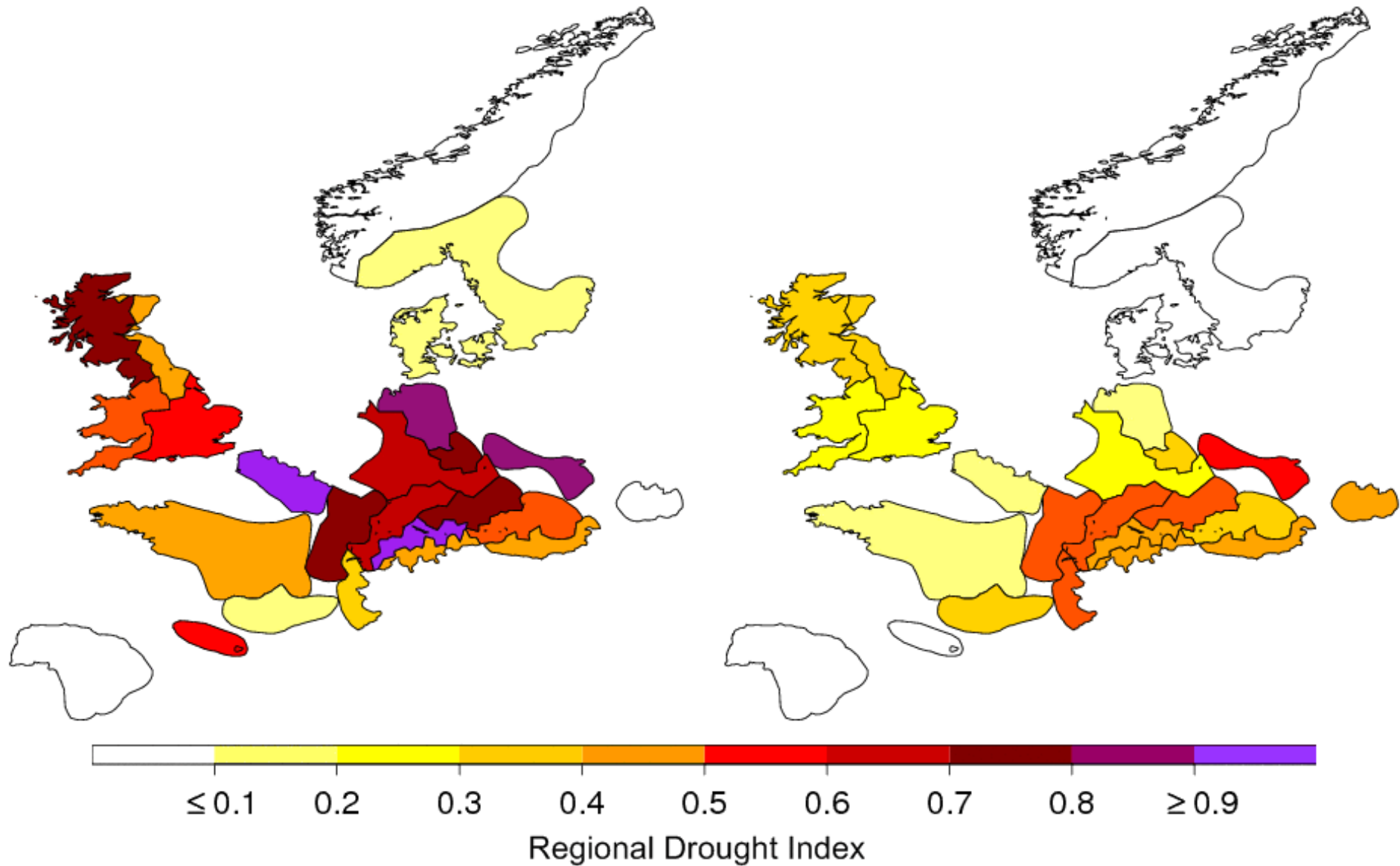
RDI Aug 2003





RSPI Sep 2003

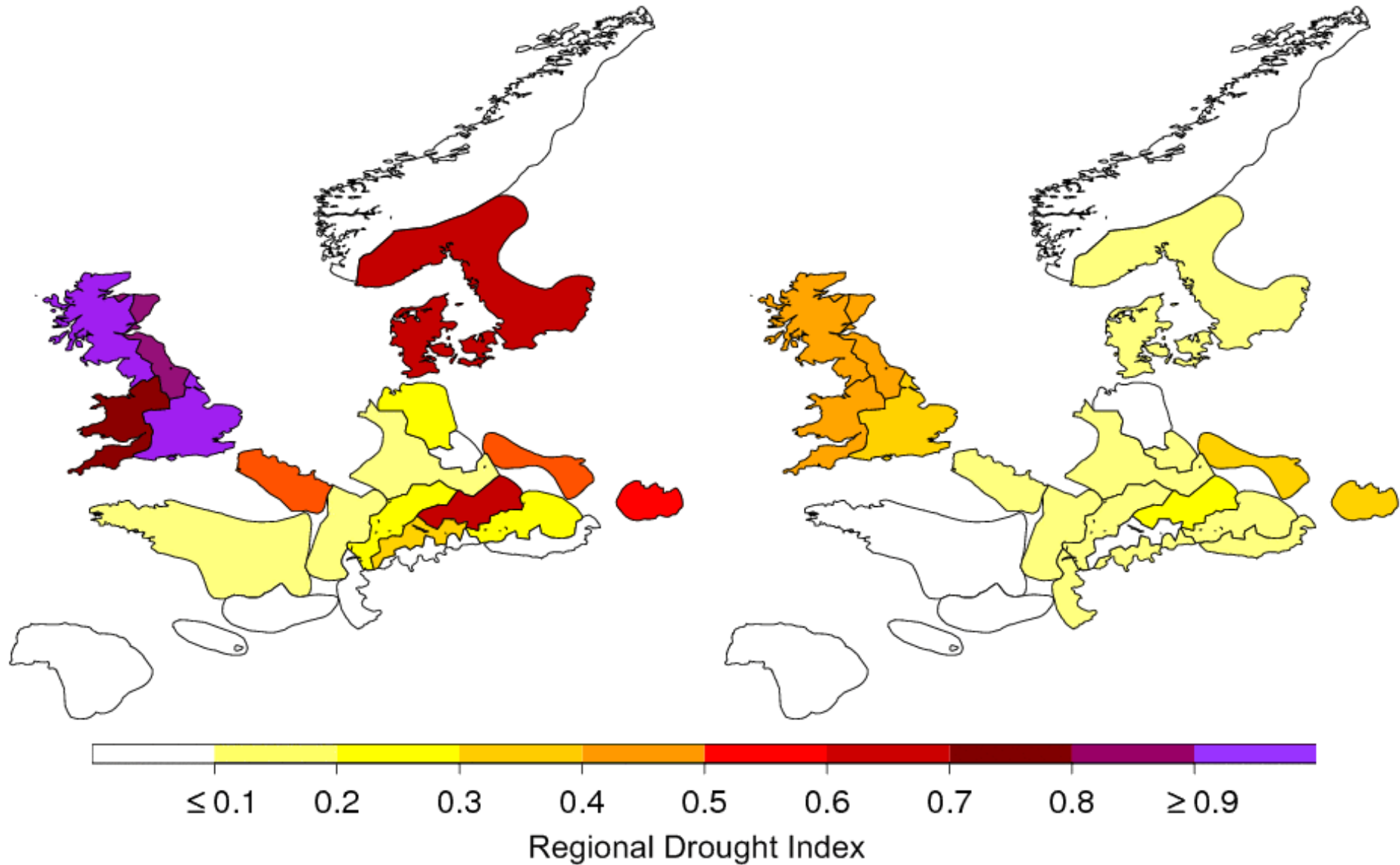
RDI Sep 2003





RSPI Oct 2003

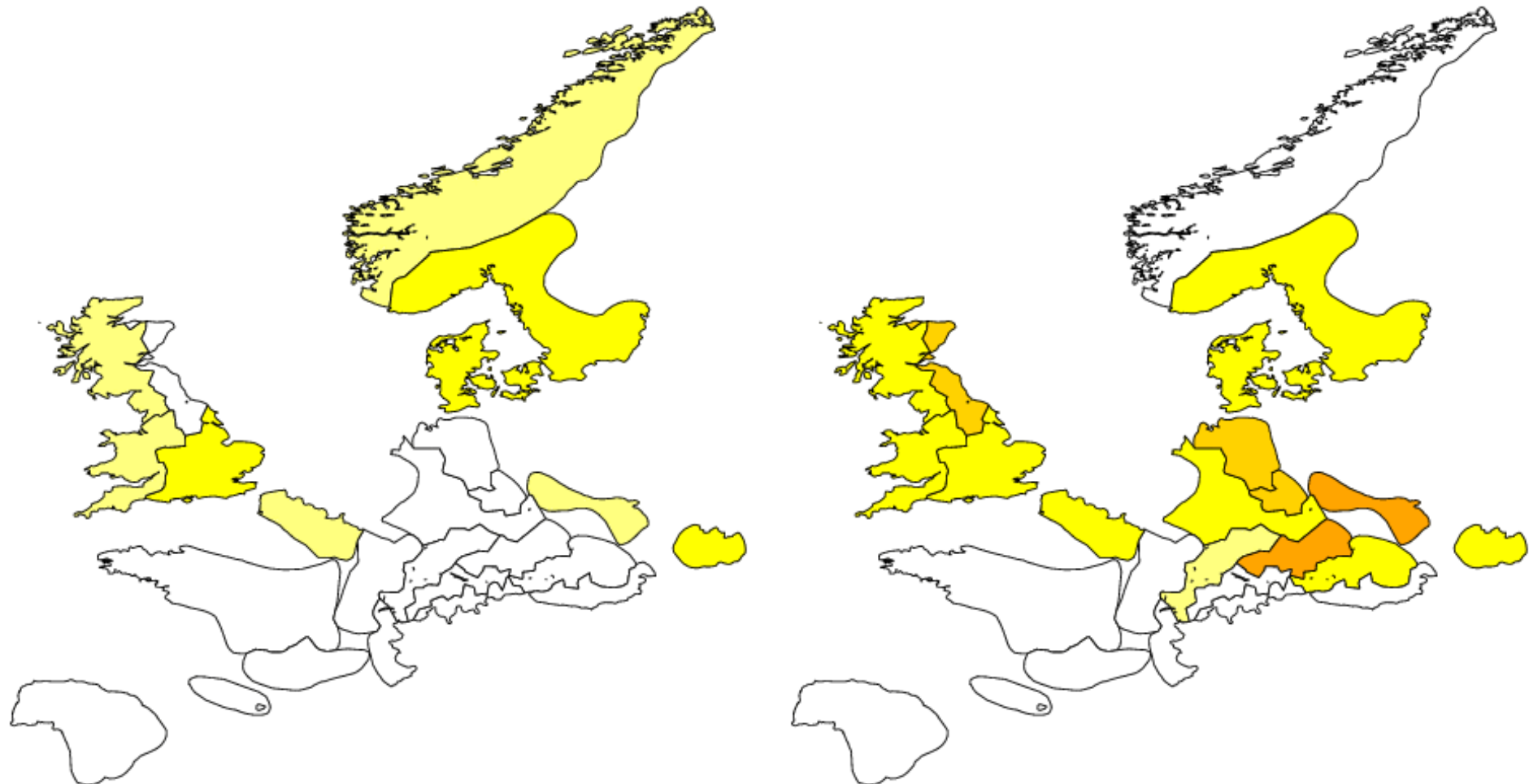
RDI Oct 2003





RSPI Nov 2003

RDI Nov 2003

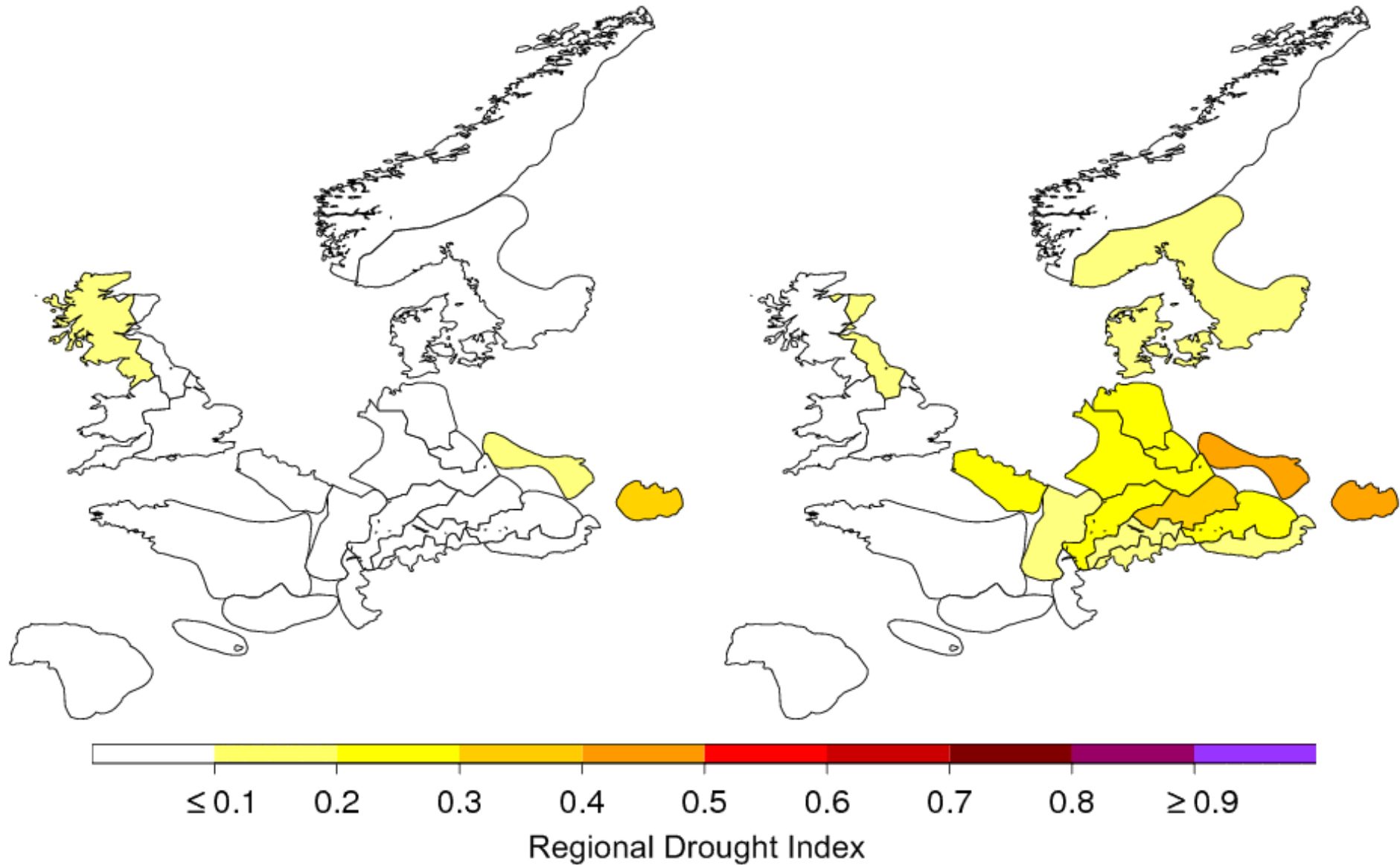


Regional Drought Index



RSPI Dec 2003

RDI Dec 2003

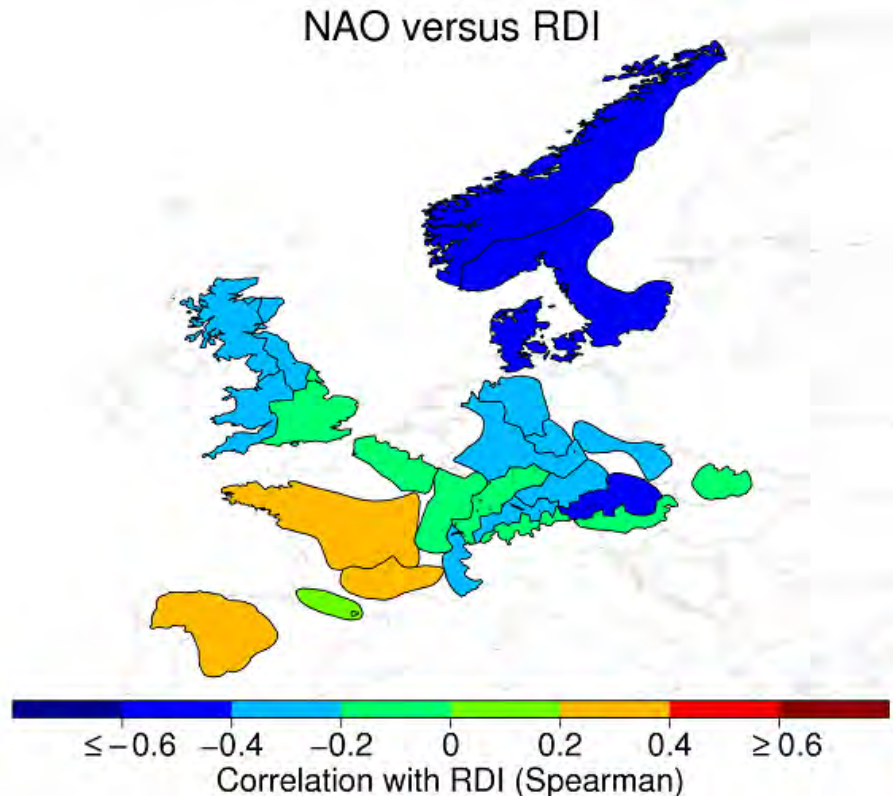




Other Applications: links with atmospheric circulation

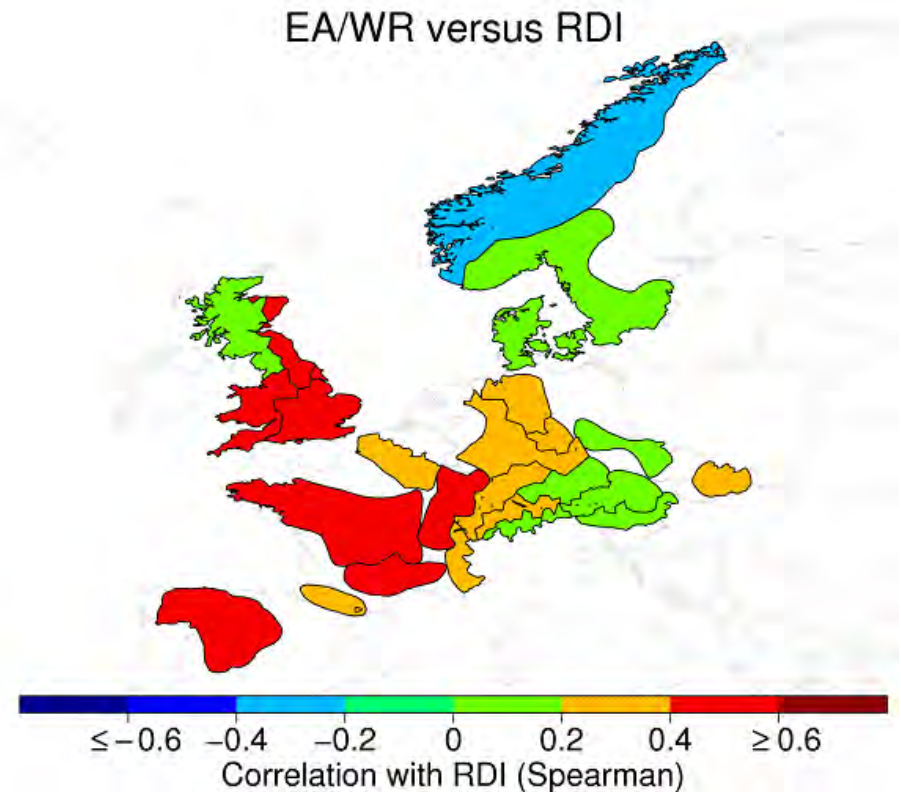
North Atlantic Oscillation

NAO versus RDI



East Atlantic/West Russia Circulation

EA/WR versus RDI



Can we provide a physical interpretation for spatial coherence? Can we forecast 'drought from drought'?

See paper in *Hydrological Processes*



Conclusions

- Drought catalogue provides a means of comparing drought characteristics across Europe using a consistent dataset and methodology
- Considers both hydrological (1961 – 2005) and meteorological (1901 – 2005) drought
- For 24 regions, characterises: occurrence, duration, spatial coherence, seasonality
- Information on drought impacts is now being added to the catalogue
- Evidence suggests there is some coherence in major European drought episodes
- Method provides a framework for visualising the spatio-temporal development of major droughts
- Catalogue provides a ‘benchmark’ against which to compare with future change
- Other applications (see *Hydrological Processes* paper)
 - Examine relationships between regional indicators and atmospheric circulation
 - Develop forecasting tools based on regional coherence
- Major limitation: lack of coverage in some areas of Europe



Finding out more

- Catalogue due for release on Environment Agency website (<http://www.environment-agency.gov.uk/>)
- Eventual release on European Drought Centre
- Papers:

Hannaford, J., Lloyd-Hughes, B., Keef, C., Parry, S., Prudhomme, C.

Examining the large-scale spatial coherence of European drought using regional indicators of rainfall and streamflow deficit. *Hydrological Processes*.

Hannaford, J., Lloyd-Hughes, B., Parry, S., Prudhomme, C.

Spatio-temporal evolution of large-scale historical droughts in Europe. *Journal of Hydrometeorology*, WATCH special collection.

