Methodologies for the spatial and temporal analysis of European droughts

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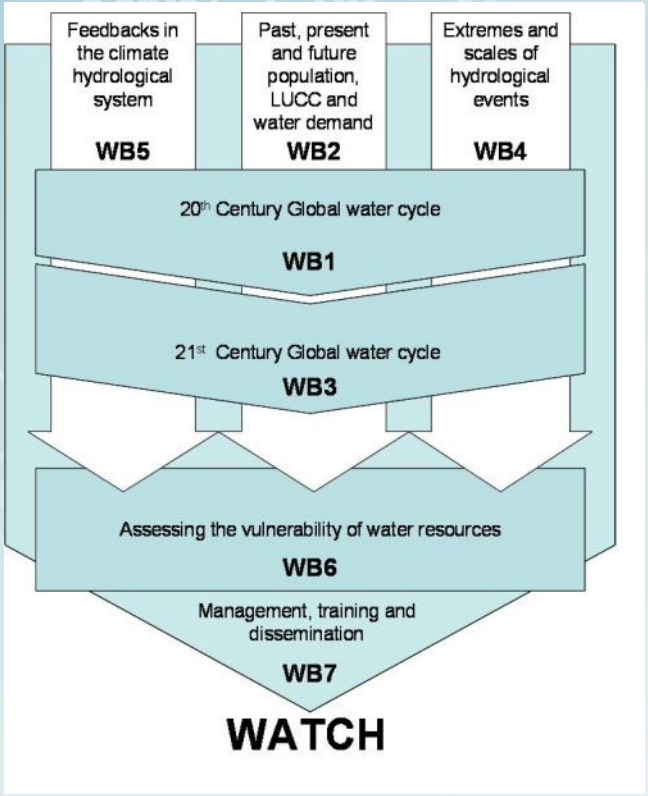
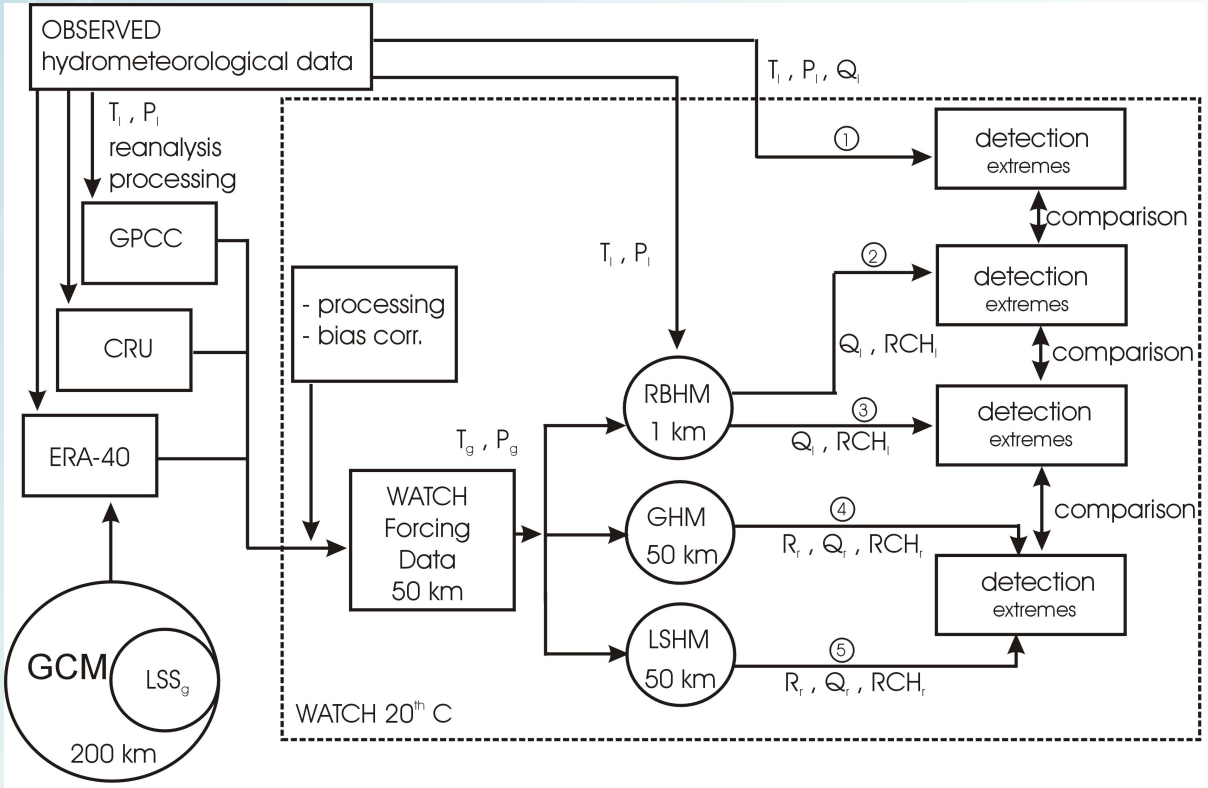
EU-WATCH background





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EU-WATCH background

NAME	Energy Balance	Evapo-transpiration	Runoff-scheme	Snow scheme
H08	YES	Bulk formula	Saturation excess/Beta function	Energy balance
HTESSEL	YES	Penman-Montieth	Variable infiltration capacity/Darcy	Energy balance
JULES	YES	Penman-Montieth	Infiltration excess/Darcy	Energy balance
LPJ	NO	Priestley-Tailor	Saturation excess	Degree day
MPI-HM	NO	Thornwaite	Saturation excess	Degree day
WaterGAP	NO	Priestley-Tailor	Beta function	Degree day
GWAVA	NO	Penman-Montieth	Saturation excess/Beta function	Degree day
ENSEMBLE			**Mean of all models**	

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Aim

- To explore to what extent large-scale models (GHM and LSHMs) capture characteristics of historic drought (e.g. frequency, duration, scale, severity)
- To examine and analyse the spatial distribution of European drought over time using different clustering algorithms
- To provide an insight into return periods of extreme events using severity-area-frequency (SAF) curves

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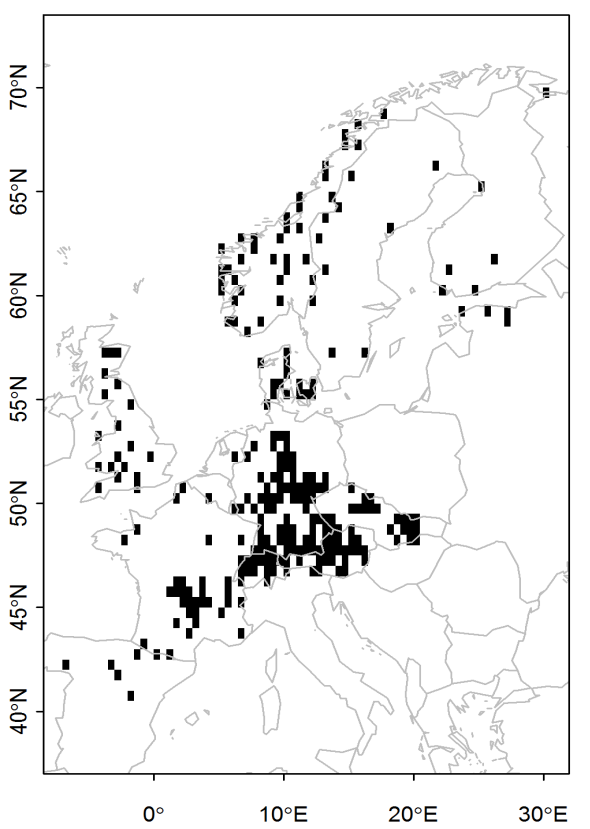
WB4: Hydrological Extremes – DROUGHT

Task 4.1.2 Spatial and temporal scales and severity of droughts

WATCH Multi-Model evaluation of Extremes

- Grid cells with observations: 263
- Grid cell ~ 2 500 km^2
- Catchment ~ 306 km^2
- Monthly sum of subsurface (Qsb) and surface (Qs) flow covering the period 1958-2001
- Models used: GWAVA and Htessel
- Droughts defined by 20th quantile, for each pixel with respect to their month



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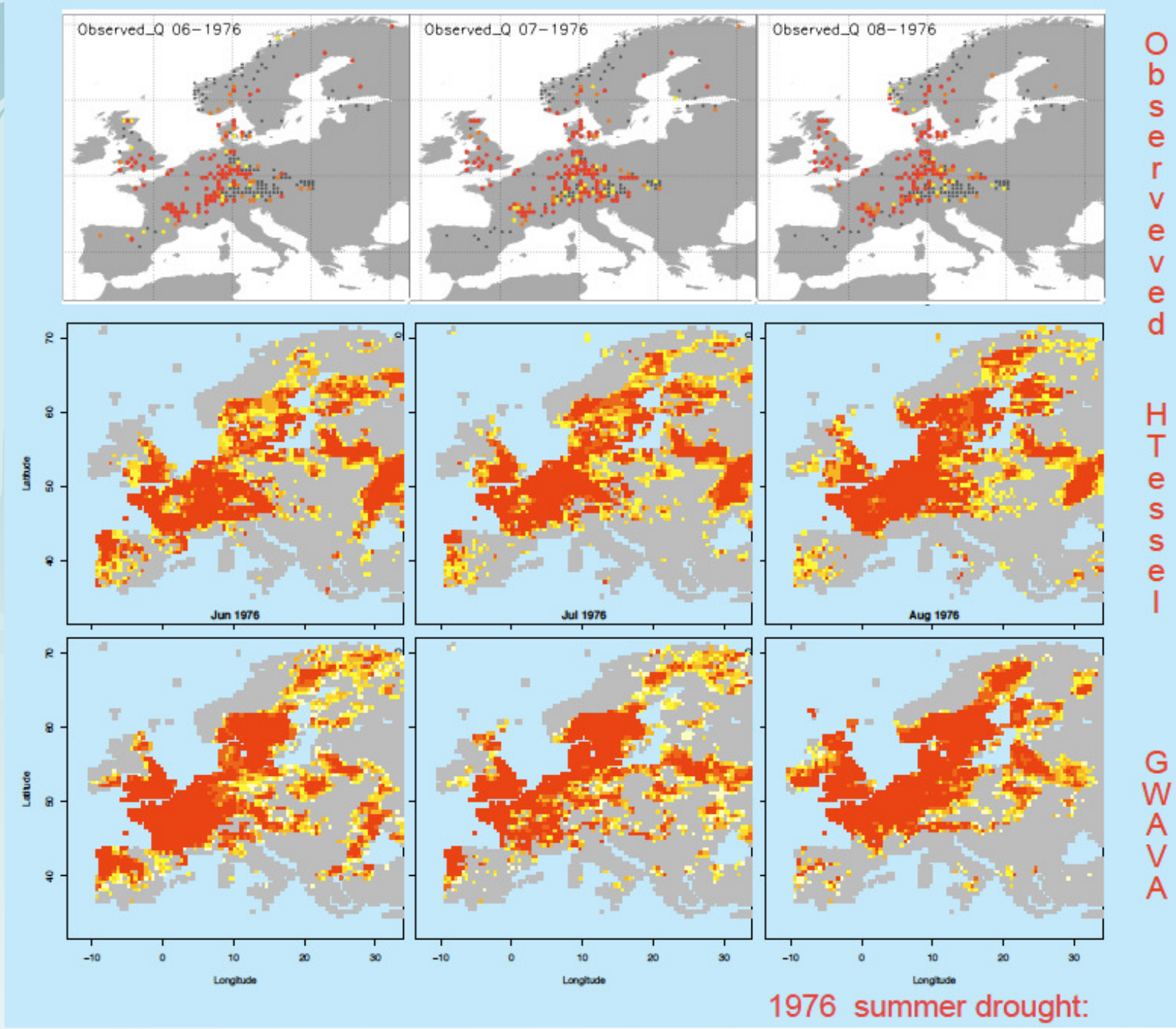
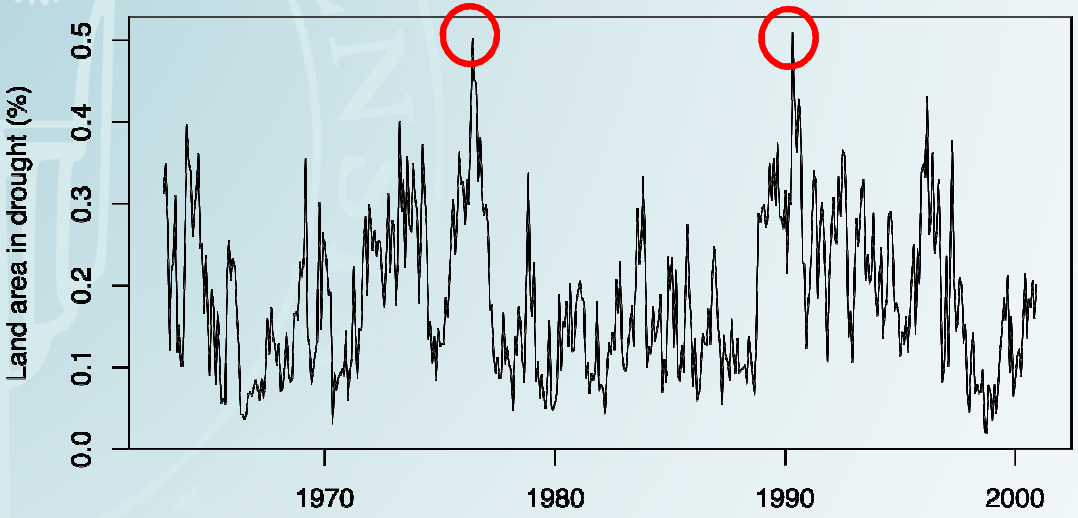
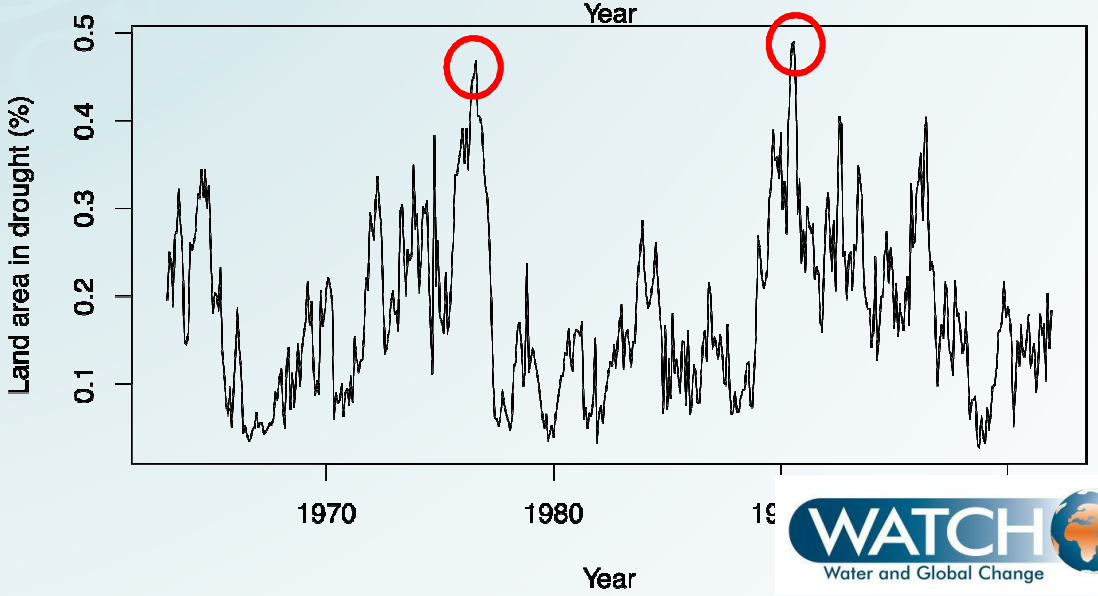

Observed_Q 06-1976
Observed_Q 07-1976
Observed_Q 08-1976
Jun 1976
Jul 1976
Aug 1976
Latitude
Longitude
Observed HTessel GWAVA
1976 summer drought:

Basic statistics

GWAVA



Htessel



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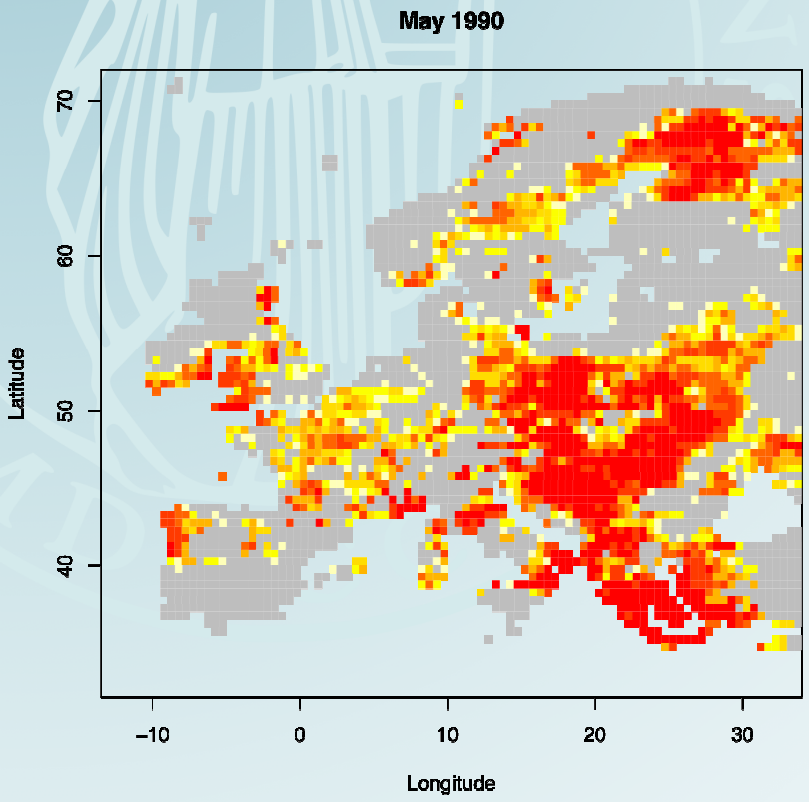
Spatial analysis

GWAVA



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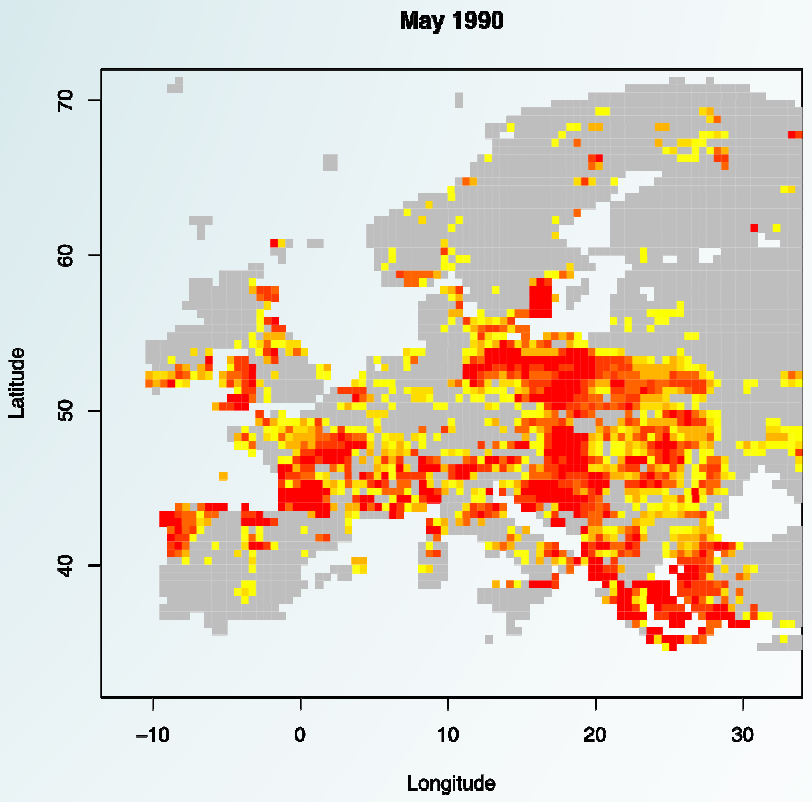

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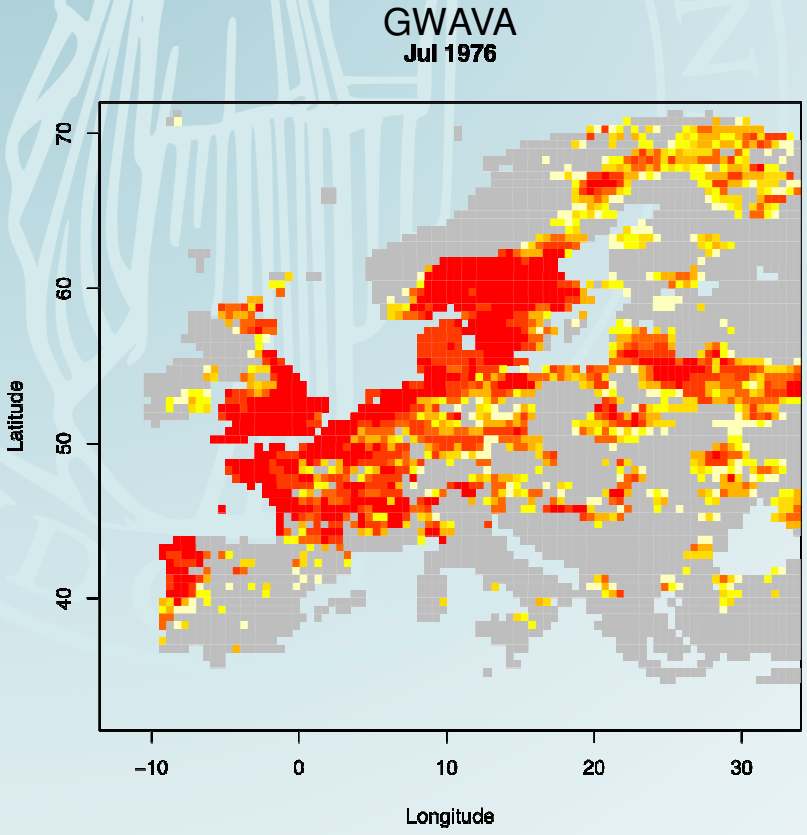
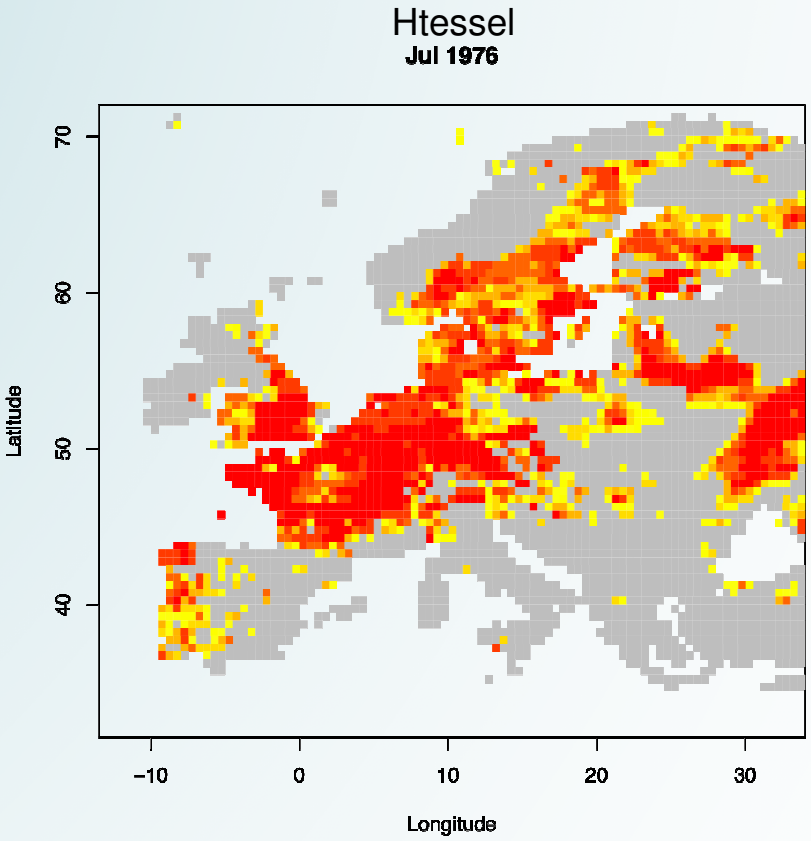
1976 drought





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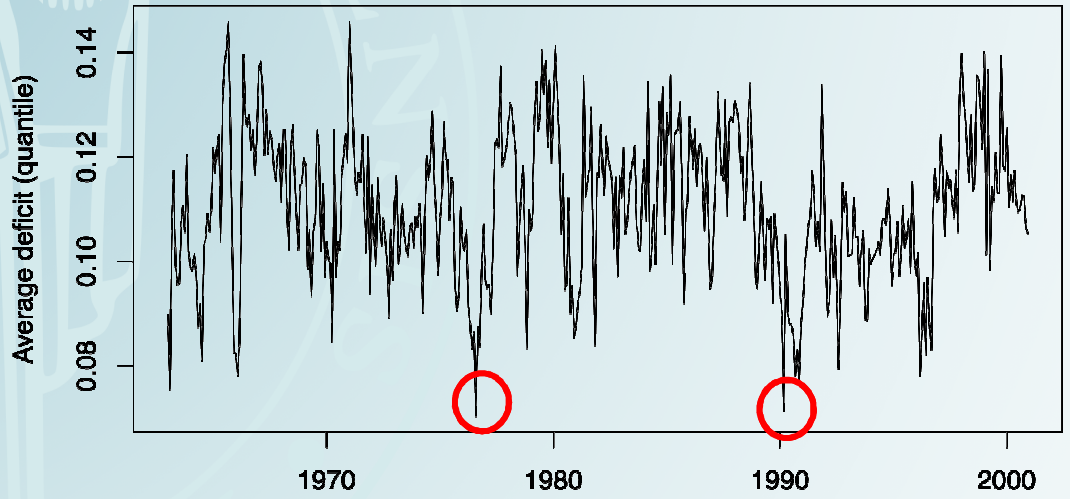
Drought severity

GWAVA



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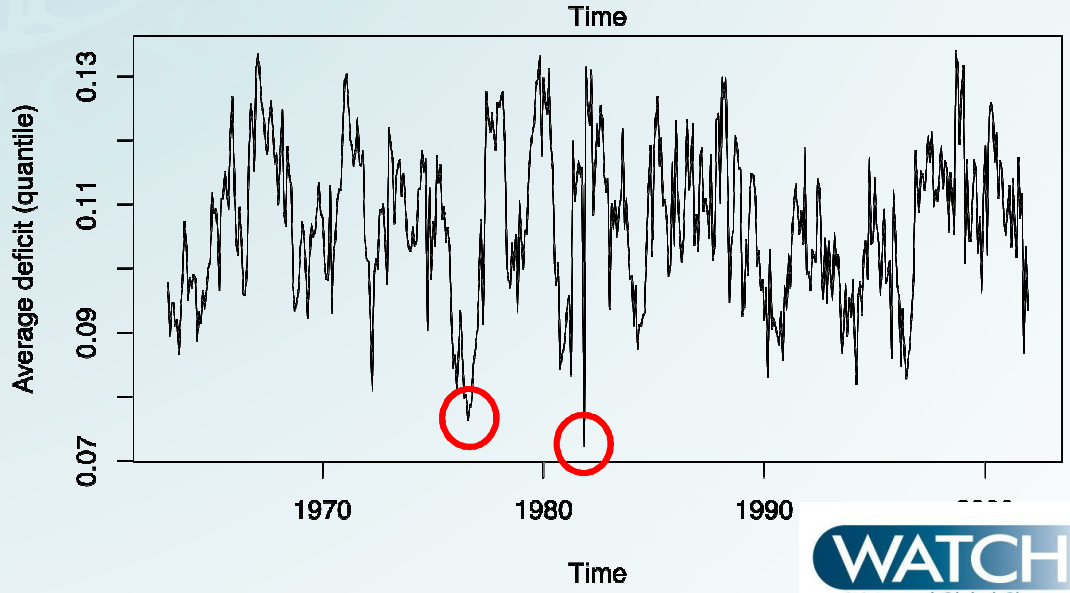

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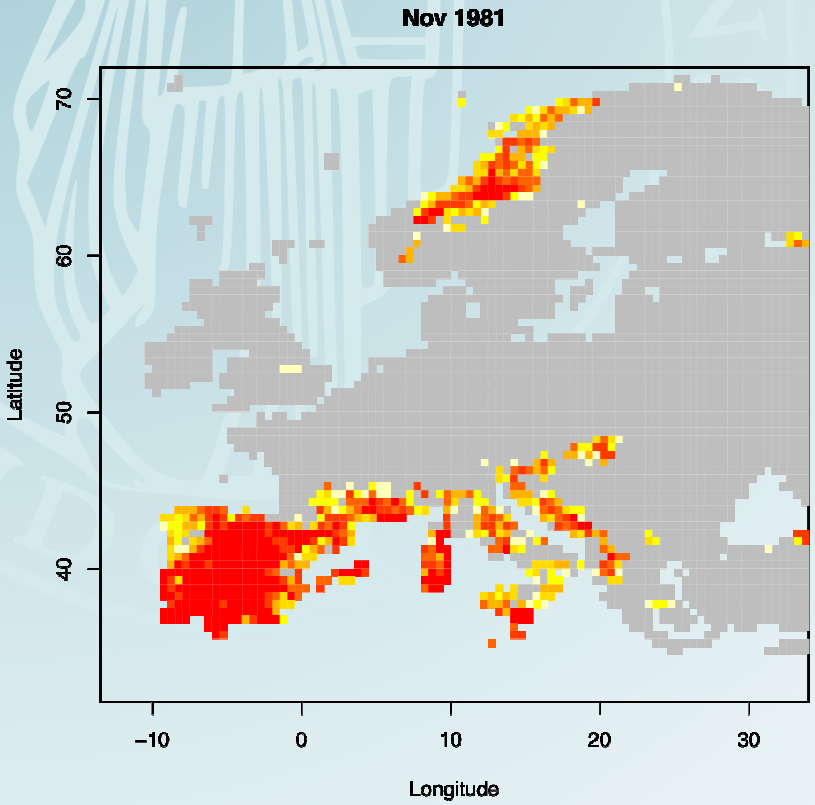
Corresponding drought figures

GWAVA



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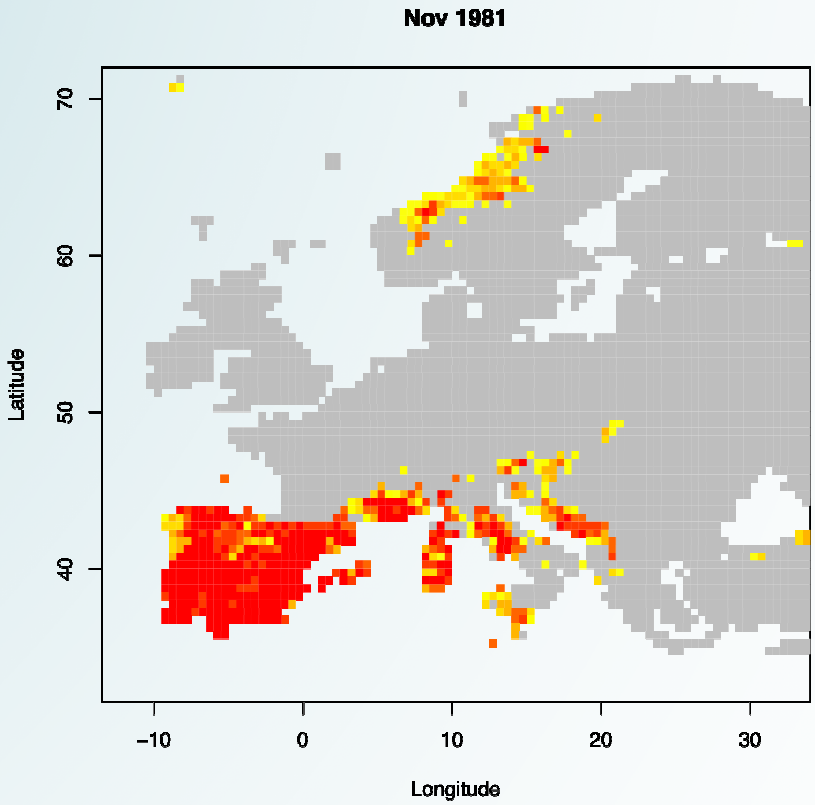

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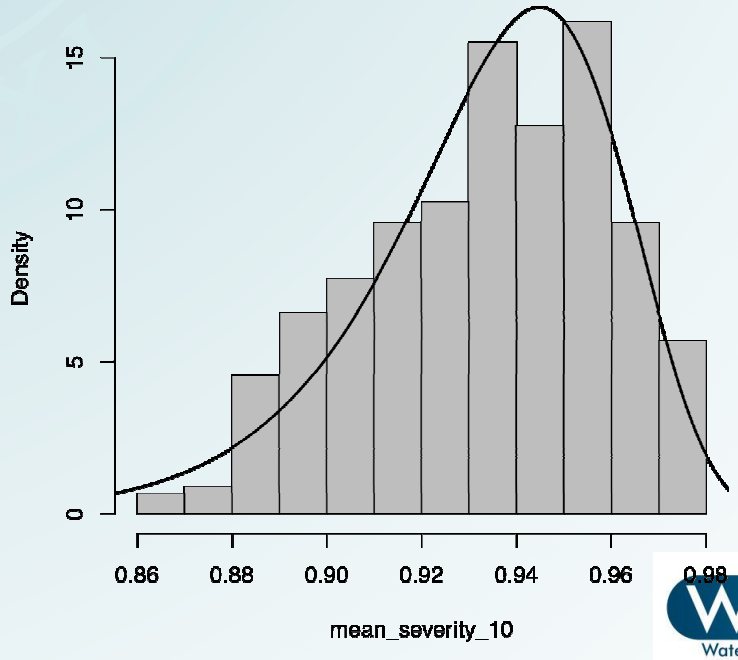
SAF curves – Method 1

- Does not take into account any spatial relationships
- Number of pixels (*n*) associated with each percentage of land area (*p*) affected by drought is calculated
- For month *t* ,severity of all drought land pixels are sorted in descending manner and most severe pixels associated with *n* are chosen
- Mean severity of these pixels are calculated
- For month *t*, if no. of drought affected pixels < *n*, then NA is recorded

Producing SAF curves

- Suitable distributions are fitted to mean severities associated to each *p*%
- ARI are calculated for return periods of 10,30, 50 and 100 years



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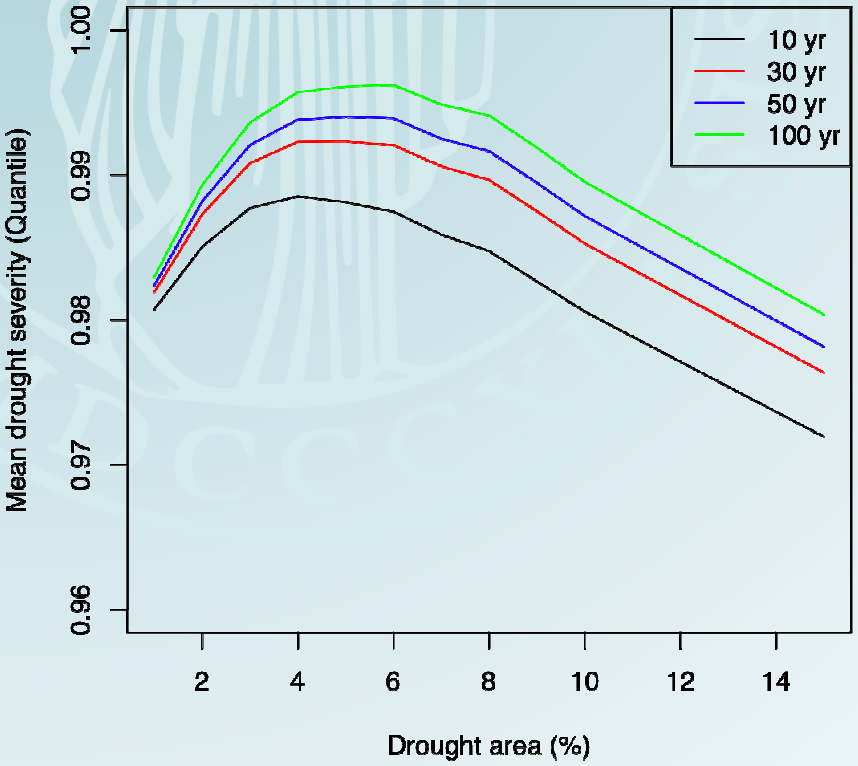
Results – Method 1

GWAVA



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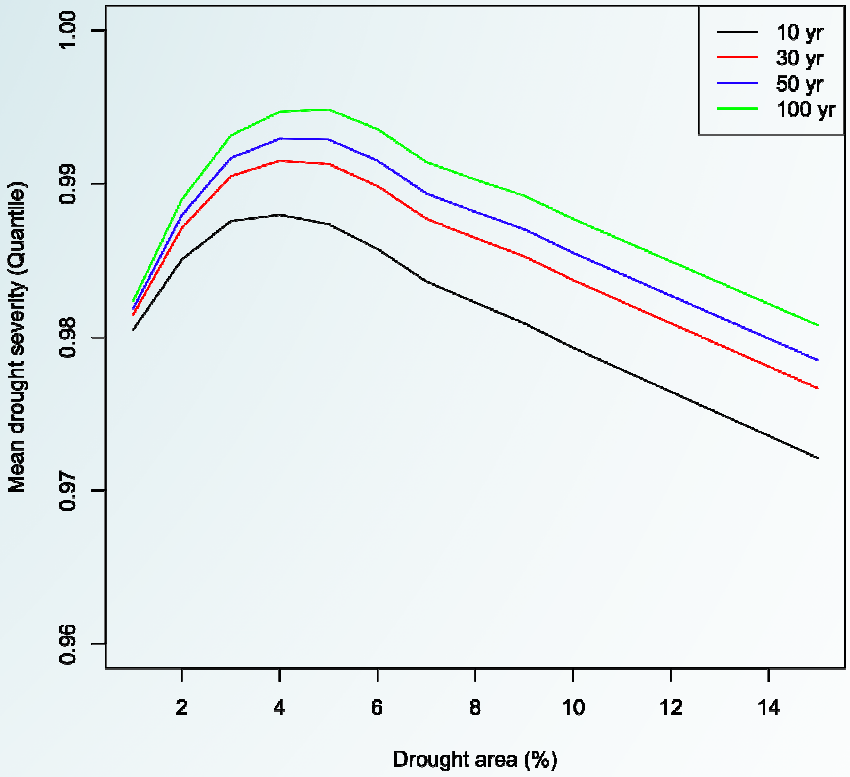

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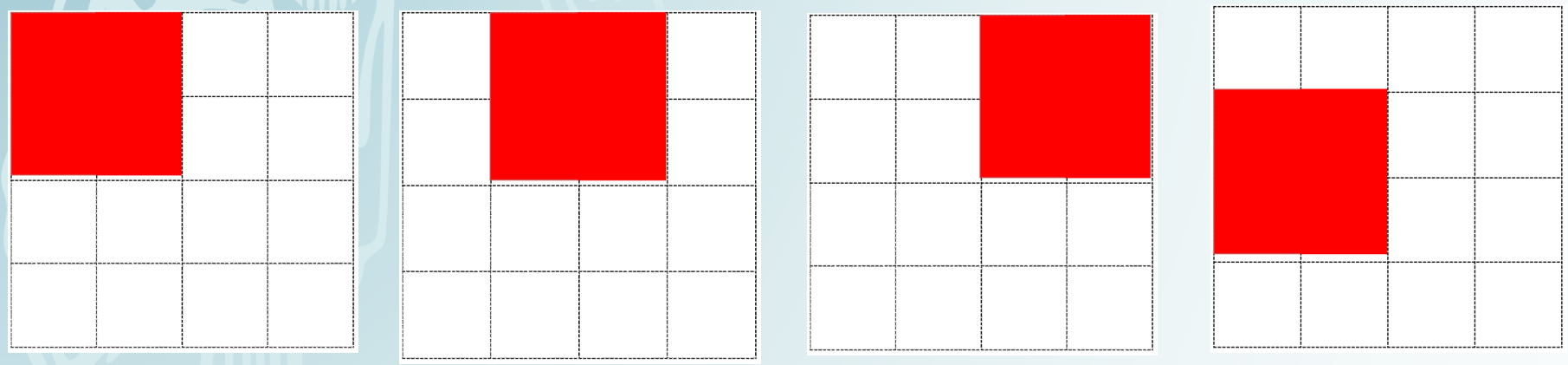
Method 2 – Spatial smoothing



- Spatially smoothing of monthly Qs+Qsb for n by n pixels
- Quantiles for each pixel are now calculated relative to the spatially averaged pixels
- Continue as Method 1

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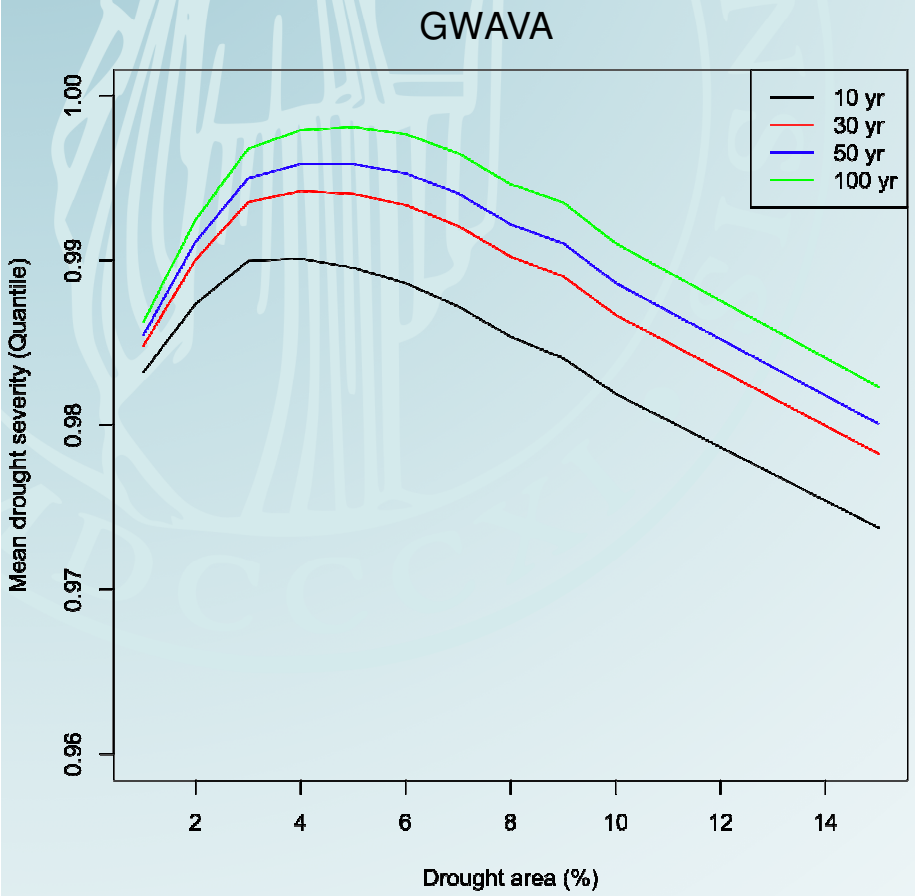
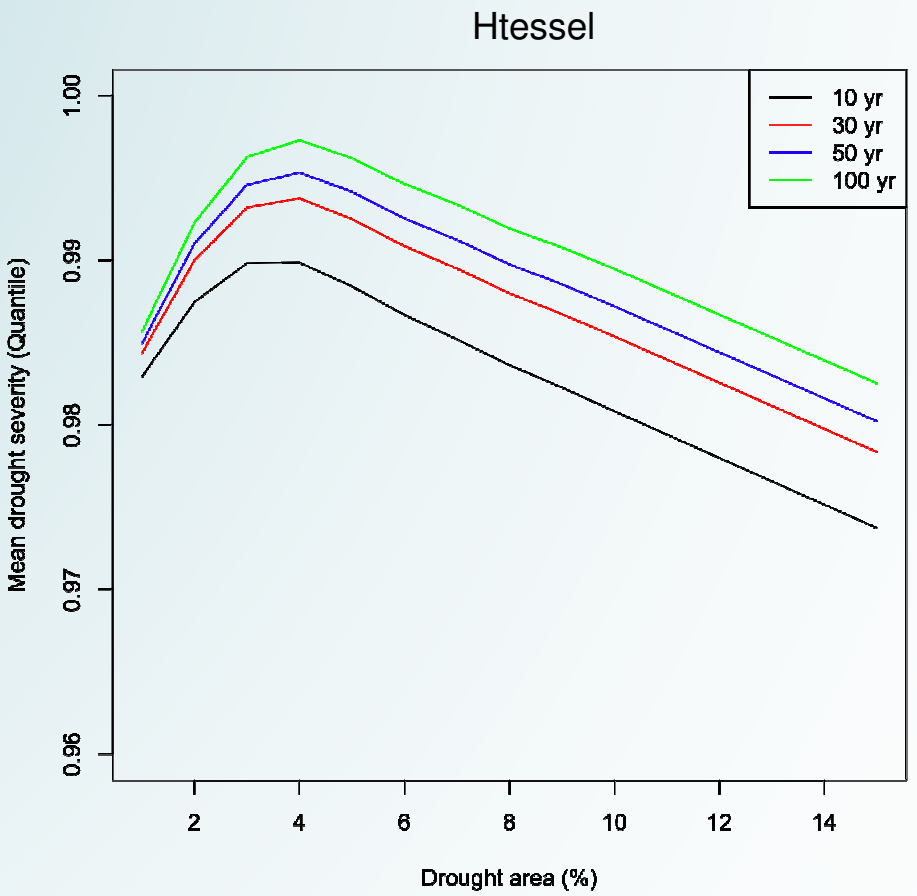
Results – Method 2 (2 by 2)





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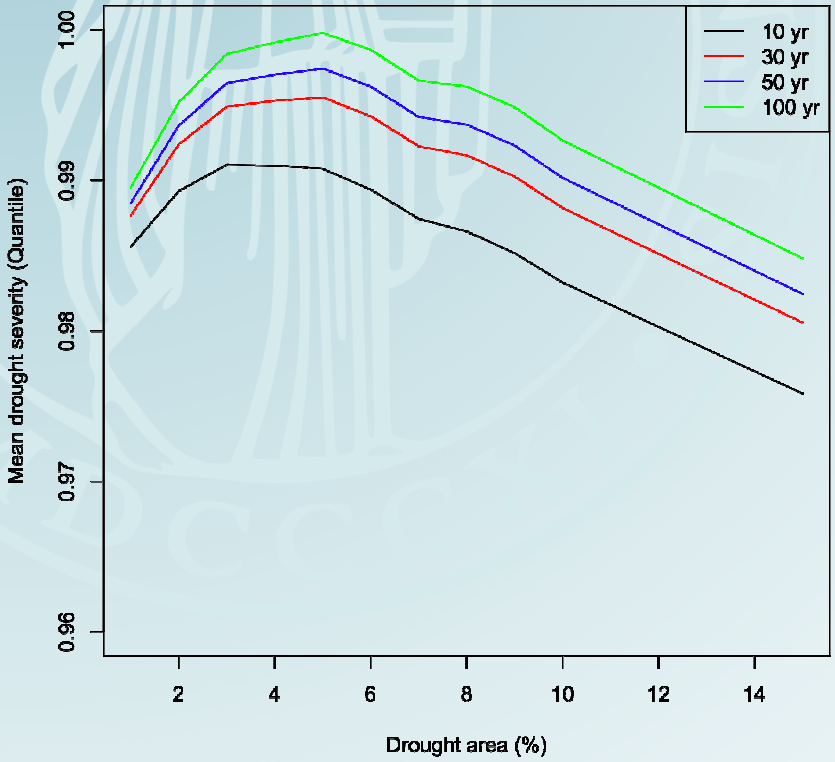
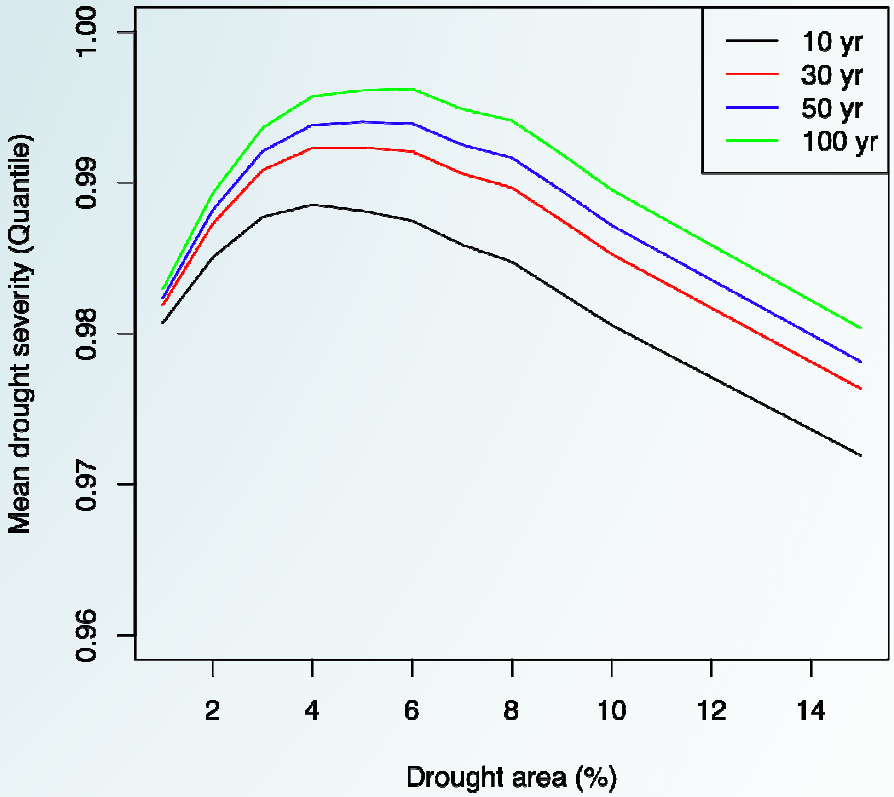
Results – Method 2 (3 by 3)



Method 1



GWAVA

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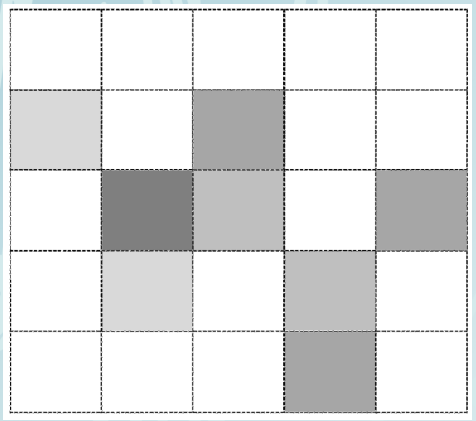
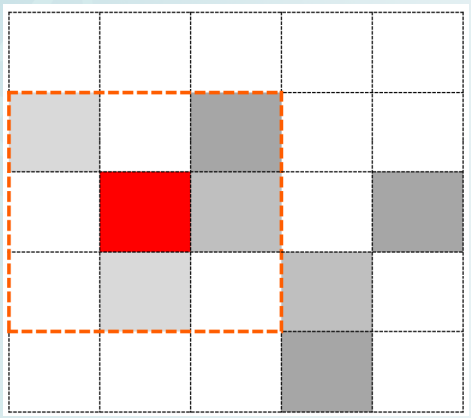
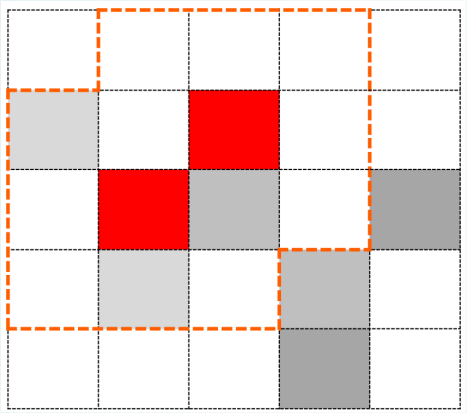
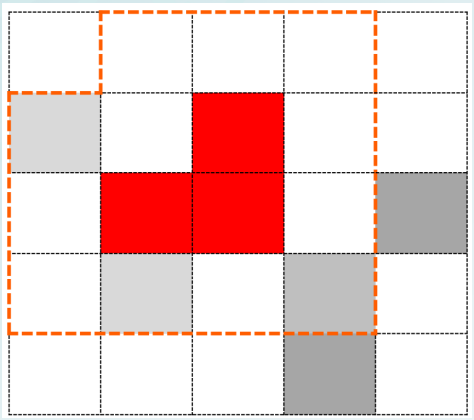
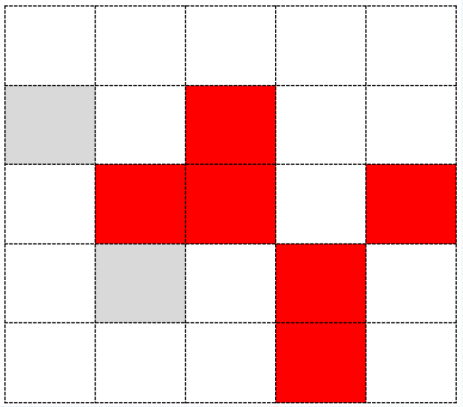
Method 3 – Drought clustering











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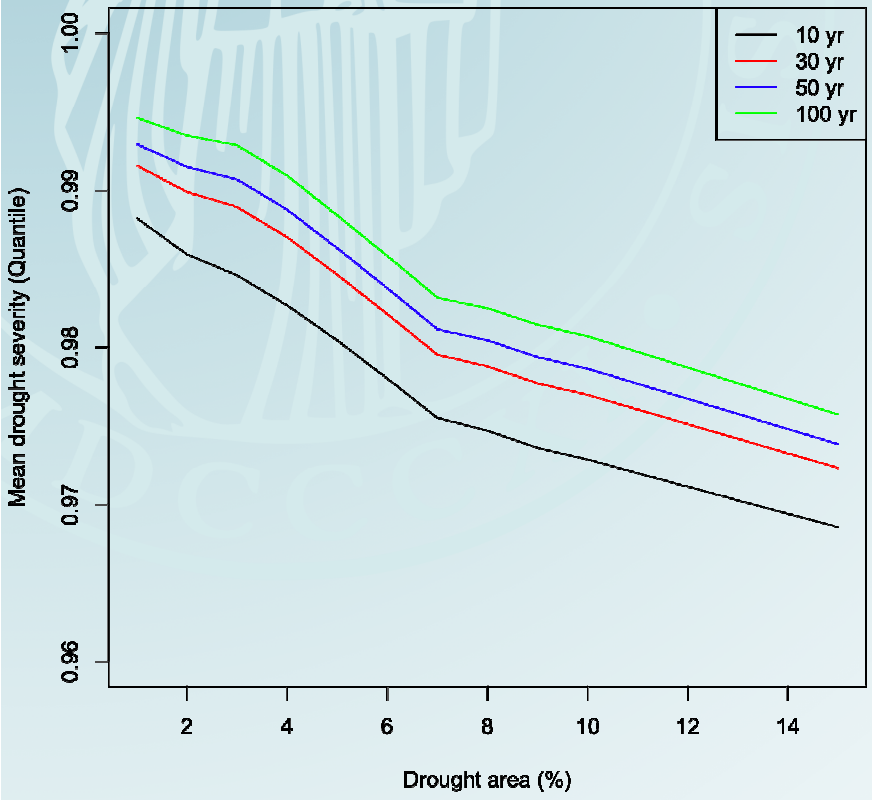
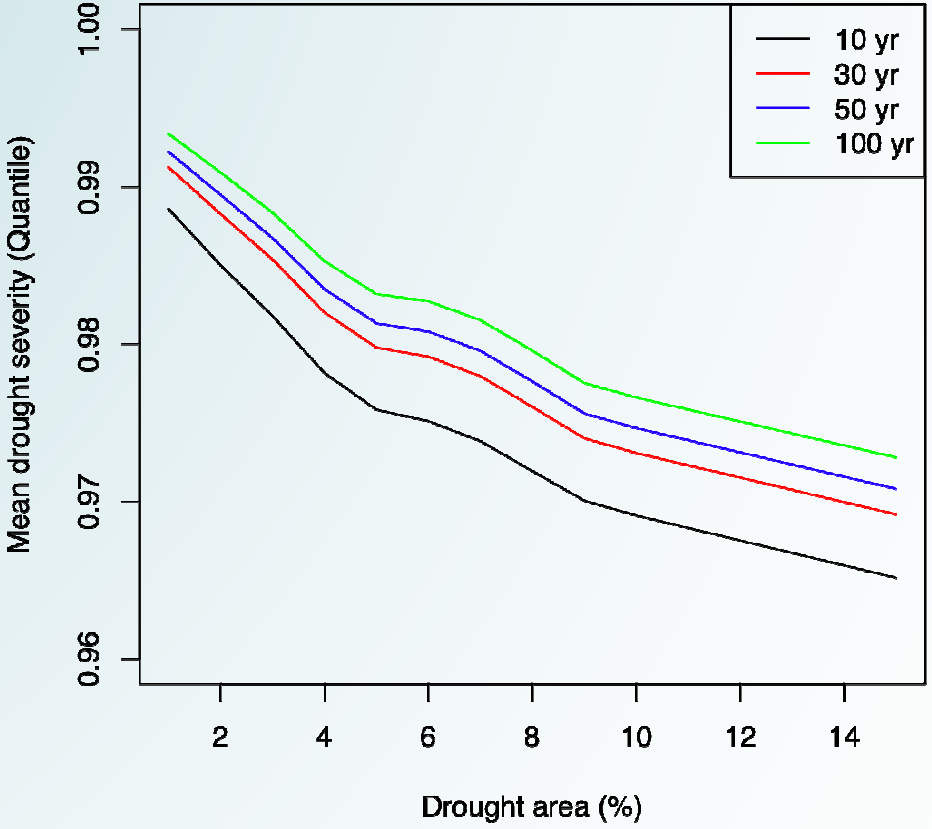
Results – Method 3

GWAVA



Htessel



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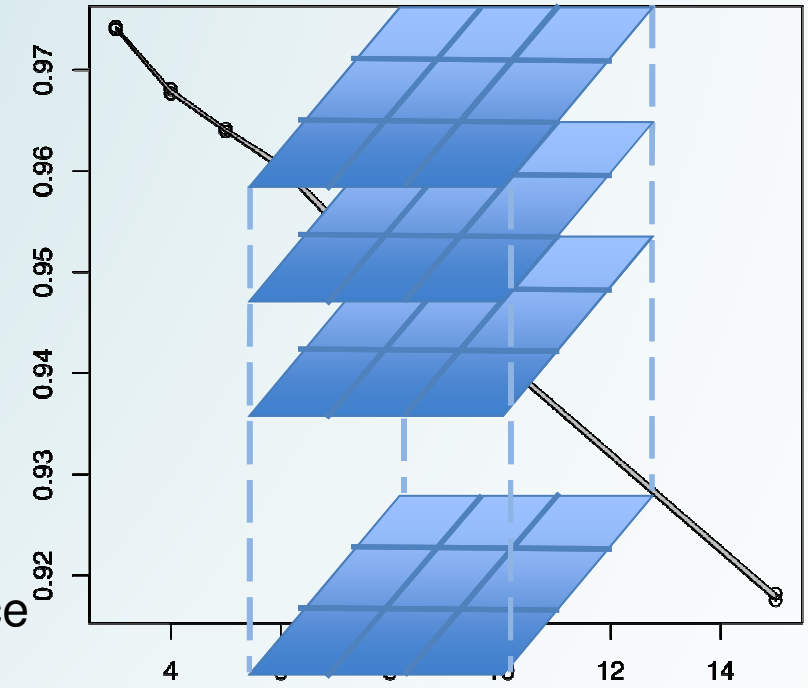
Spatial and temporal independence

- For each land grid cell, randomly select from the collection of months.
- Each grid cell is randomly sampled and are independent.
- Choose most severe n% grid cells and calculate mean severity.
- This is repeated for 100 runs, to produce simulation bounds.



Conclusions

- More severe drought for smaller drought area.
- Higher sensitivity to change in mean drought severity at larger areas for Method 1 and 2 but smaller areas for Method 3 (drought clustering)
- Increased spatial smoothing produces slight increase in severity
- Spatial and temporal dependence is significant.

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Ongoing work

- Comparisons across other models
- Modelling spatial-temporal dependence structure as multivariate distribution

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