SWIM and Horizon 2020 Support Mechanism

Working for a Sustainable Mediterranean, Caring for our Future

Drought Hazard Indexes

Presented by:

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25 September 2018, Murcia, Spain

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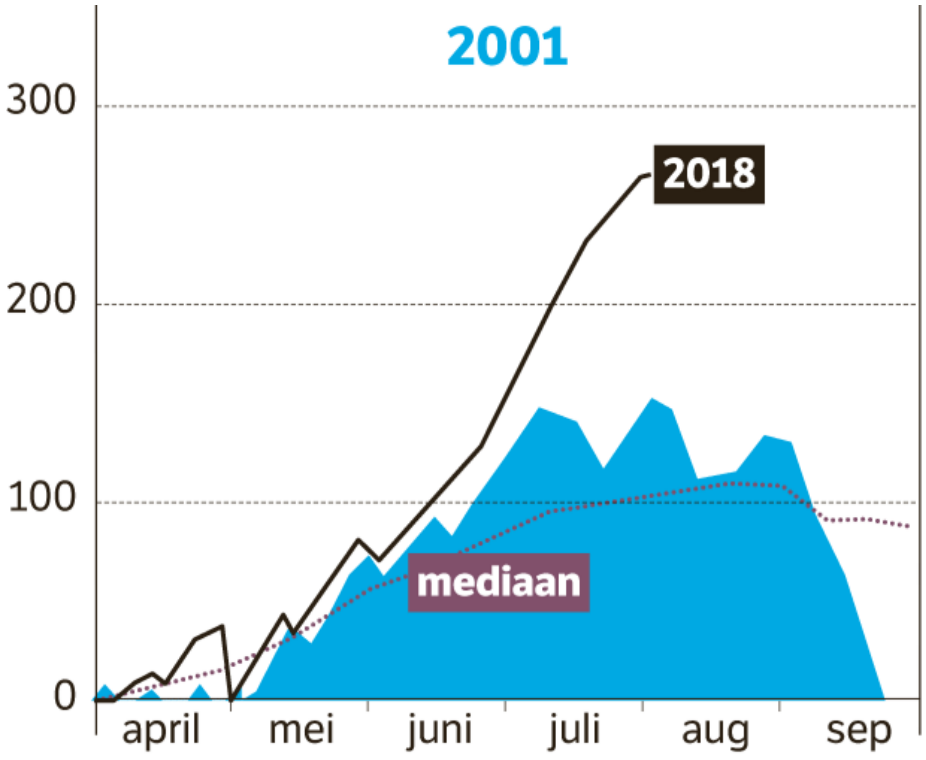
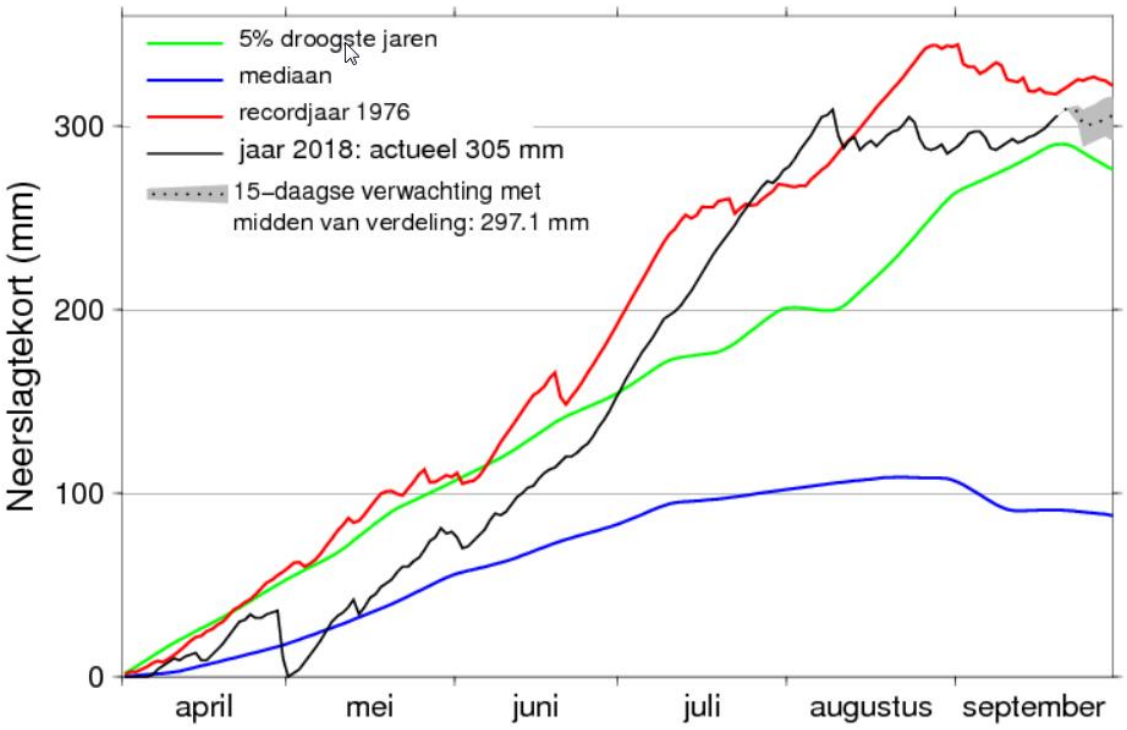
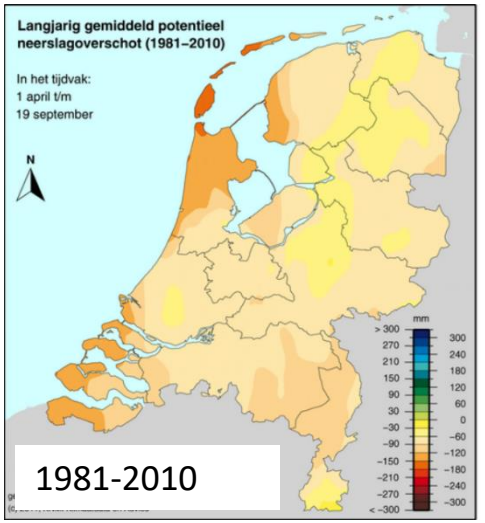
Potential evaporation minus rainfall in NL

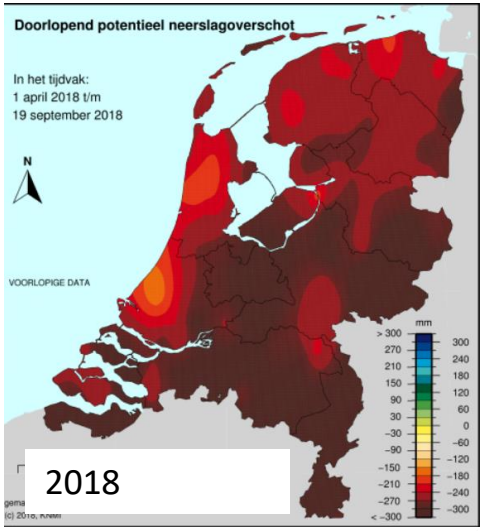


Published daily at website Royal Netherlands Meteorological Institute

Rainfall deficit in 2018. Average 2018





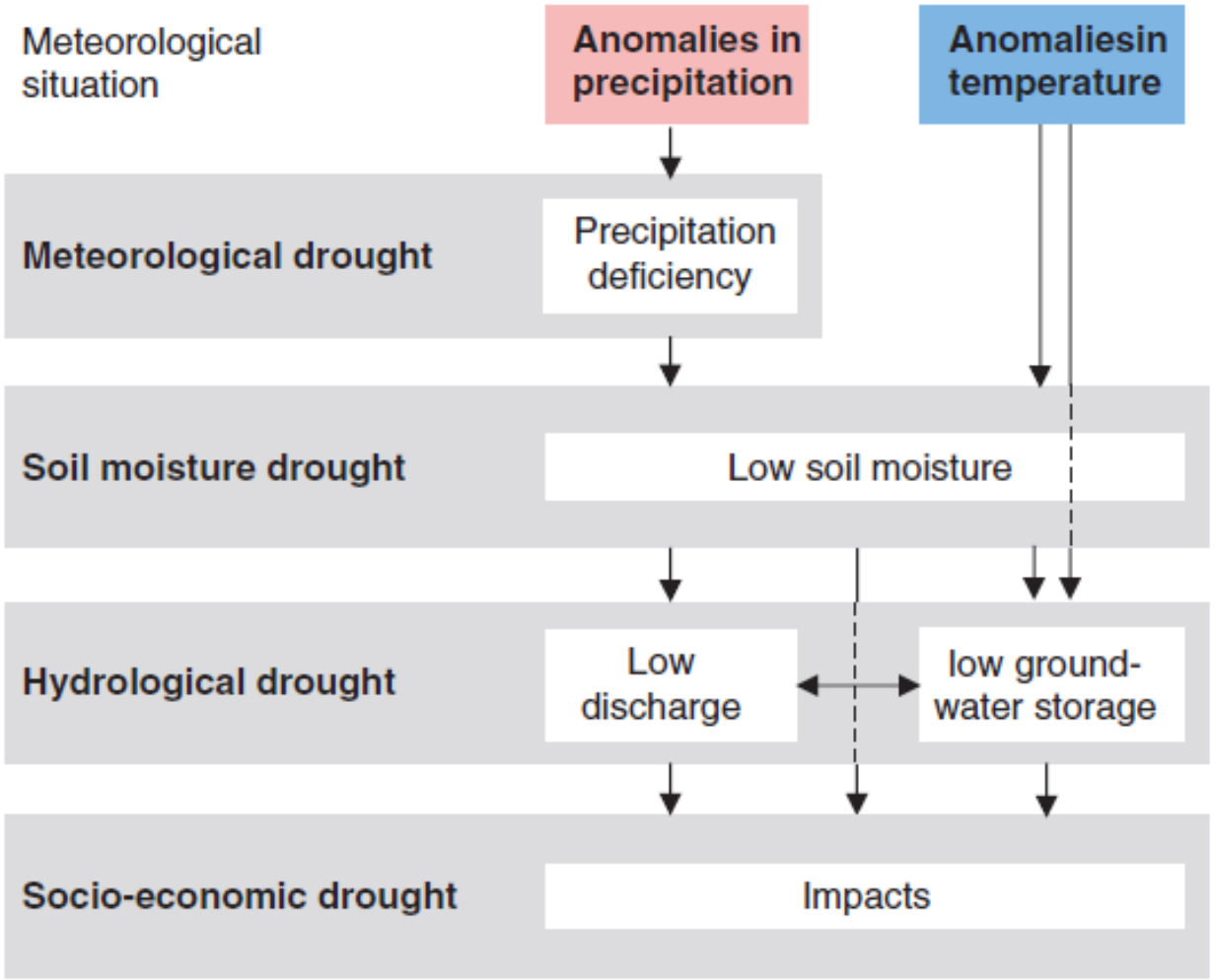


Concepts of drought

Types of drought

- **Meteorological droughts:** abnormally low precipitation over a region for a period of time.
- **Agricultural droughts:** moisture deficit in the soil to meet the growing needs of a particular crop at any stage of growth.
- **Hydrological droughts:** decrease in water flows and storages (artificial reservoirs), and groundwater, so they are not adequate to provide water resources to established water uses.
- **Socio-economic droughts**: water shortage affects people and economic activities.

Concepts of drought



Van Loon, WIREs Water 2015

Meteorological drought

Definition

- **Most simple:** deficit of water compared with normal conditions (Sheffield and Wood, 2011)
- **Widely accepted:** Sustained and regionally extensive occurrence of below average natural water availability (Tallaksen and van Lanen, 2004)
- **It is not:** low flow, aridity, water scarcity or desertification

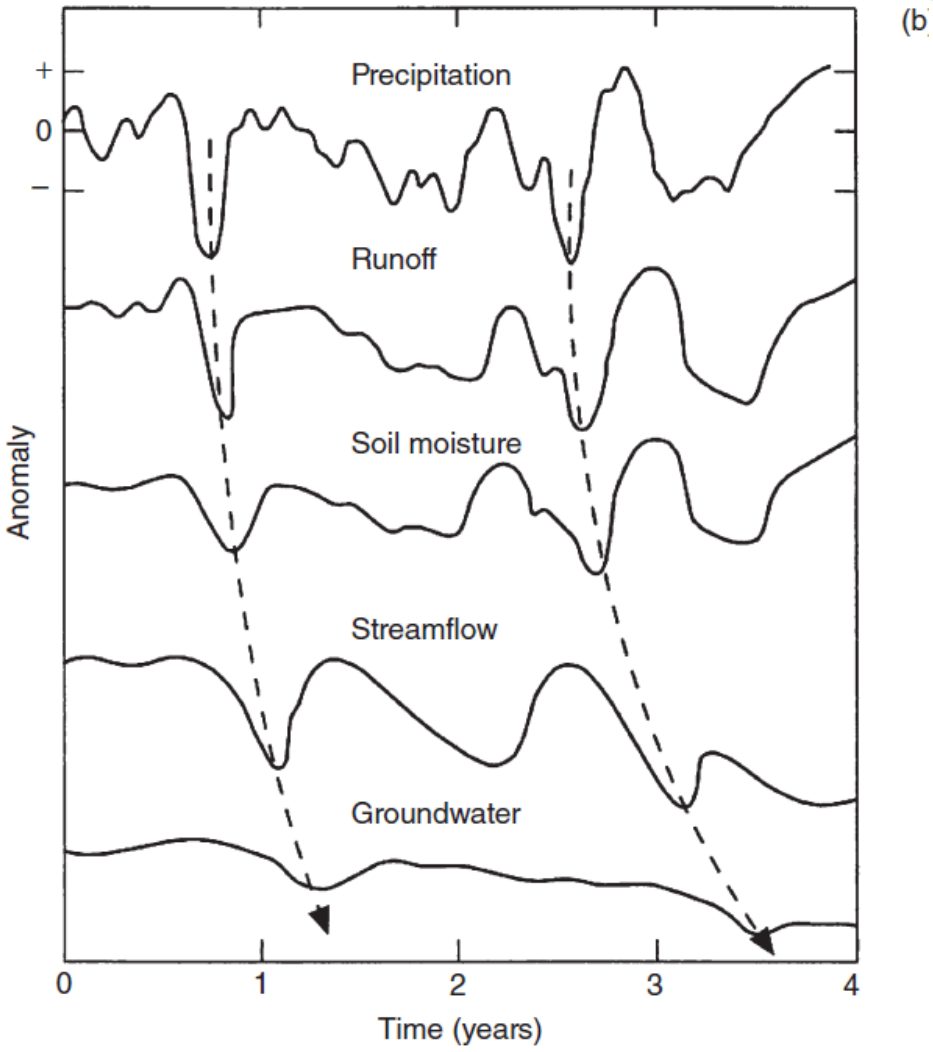
Characterization

- Severity ➔ drought index
- Time of onset and duration ➔ a slow onset and recovery
- Areal extent
- Frequency

Propagation in drought

Runoff and soil moisture variability respond to short-term precipitation anomalies

Streamflow and groundwater levels react to long-term anomalies.



Van Loon, WIREs Water 2015

Standardized Drought indexes

Approach

- Anomalies of a normal situation
- Relative approach for regional use

Examples

- Standardized **Precipitation** Index: SPI
- Standardized **Precipitation And Evapotranspiration** Index: SPEI
  - Precipitation, mean temperature and latitude of the site(s)
- Standardized **Snow Melt and Rain** Index: SMRI
- Palmer **Drought Severity** Index: PDSI
  - Bucket-type model for soil moisture calculations including calibration.
  - Fixed time scale 9 – 12 months
- Standardized **Soil Moisture** Anomalies: SMA
- Standardized **Streamflow** Index: SRI
- Standardized **Water-Level** Index (SWI) ➔ anomalies in groundwater levels
- There are many more ….

Standardized Precipitation Index: SPI

Approach

- Formulated by Tom Mckee et al. in 1993
- Only precipitation as input data
- Based on the long-term precipitation record (> 30 years)
- Calculation over a range of time scales
  - 1 – 2 months meteorological drought
  - 1 – 6 months agricultural drought
  - 6 – 24 months hydrological drought
- Takes no account of climate change due to temperature rise

Value	Category
Higher than 2	Extremely Wet
Between 1.5 and 2	Severely Wet
Between 1 and 1.5	Wet
Between 0.5 and 1	Moderately Wet
Between 0 and 0.5	Normal
Between -0.5 and -1	Moderately Dry
Between -1 and -1.5	Dry
Between -1.5 and -2	Severely Dry
Lower than -2	Extremely Dry

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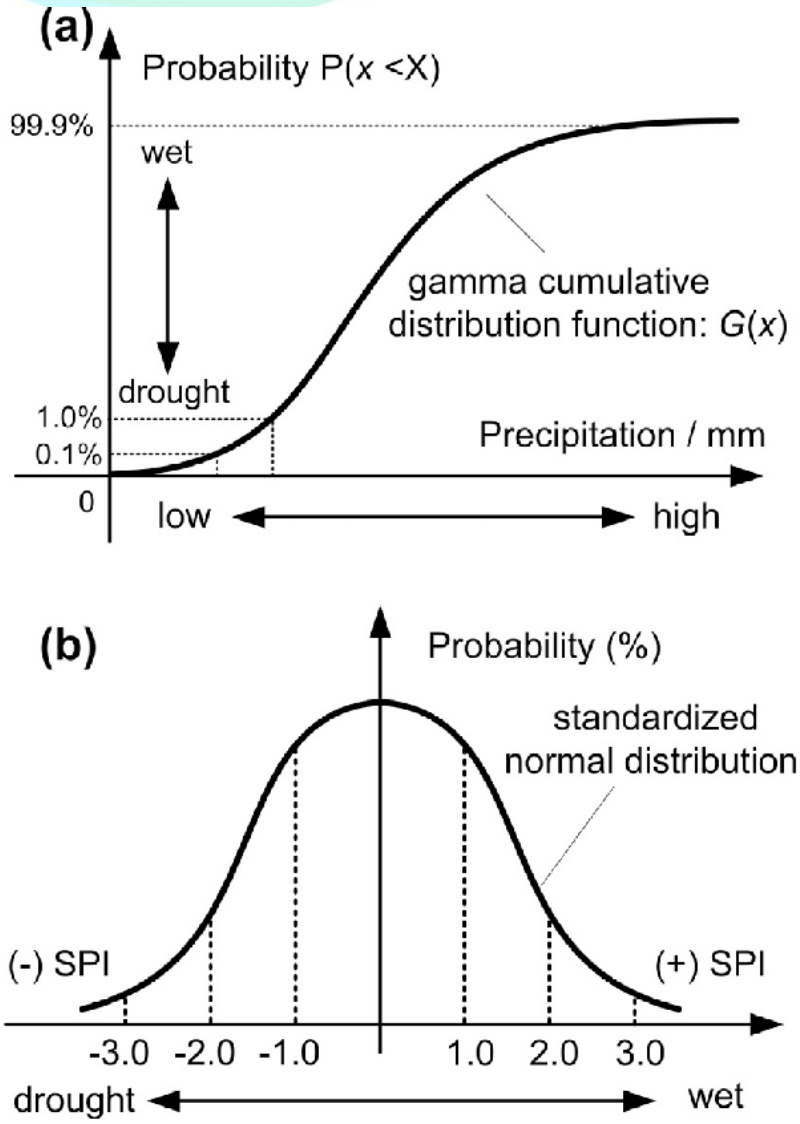
Standardized Precipitation Index: normal distribution

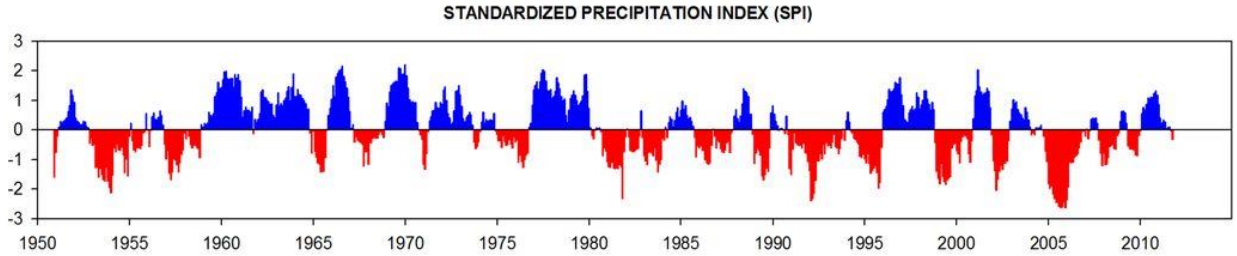
Approach

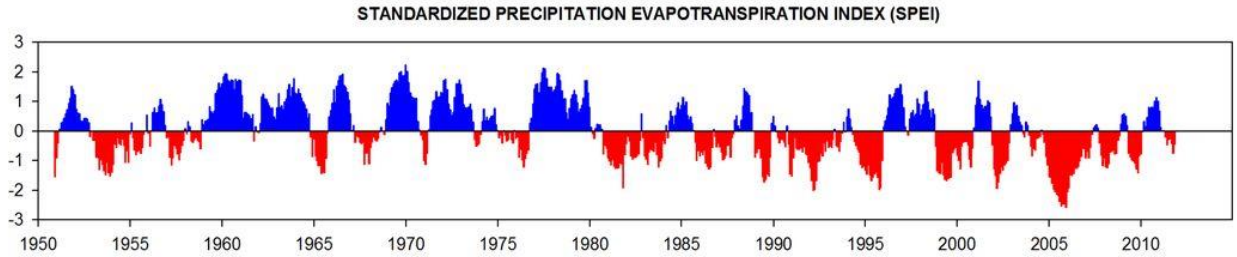
- Calculation by fitting long-term precipitation from a gamma transforming into normal distribution to calculate the mean SPI value as zero.
- Wetness is expressed by positive SPI values while dryness by negative values.

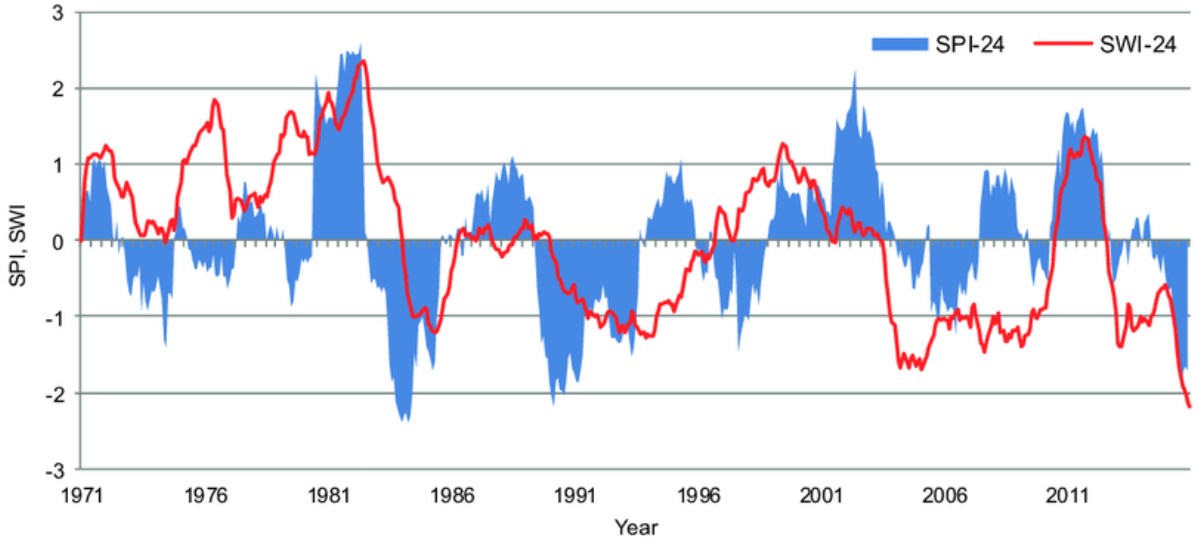
Y. Qin et al. / Journal of Hydrology 526 (2015)



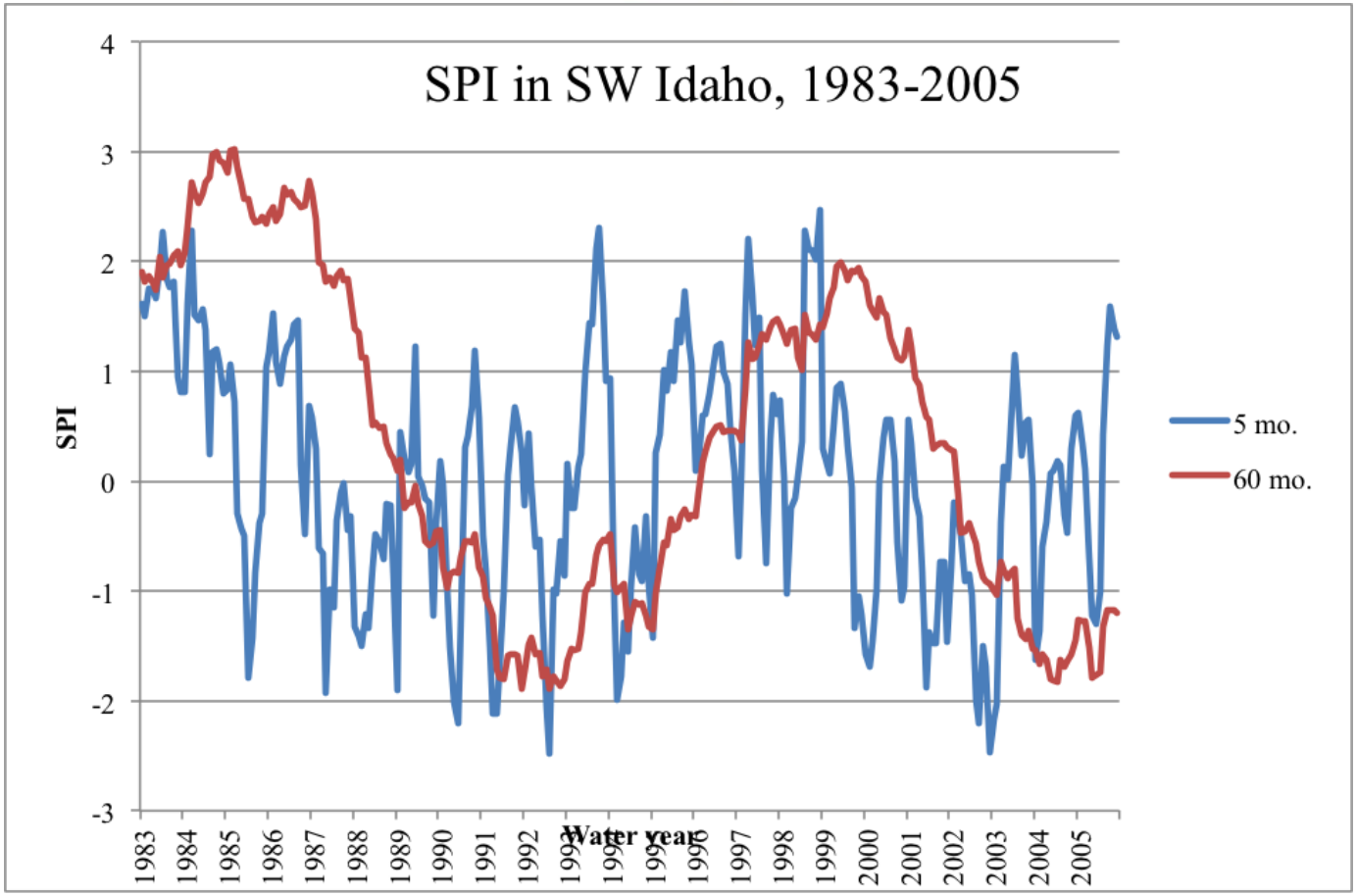
Standardized Precipitation Index: examples





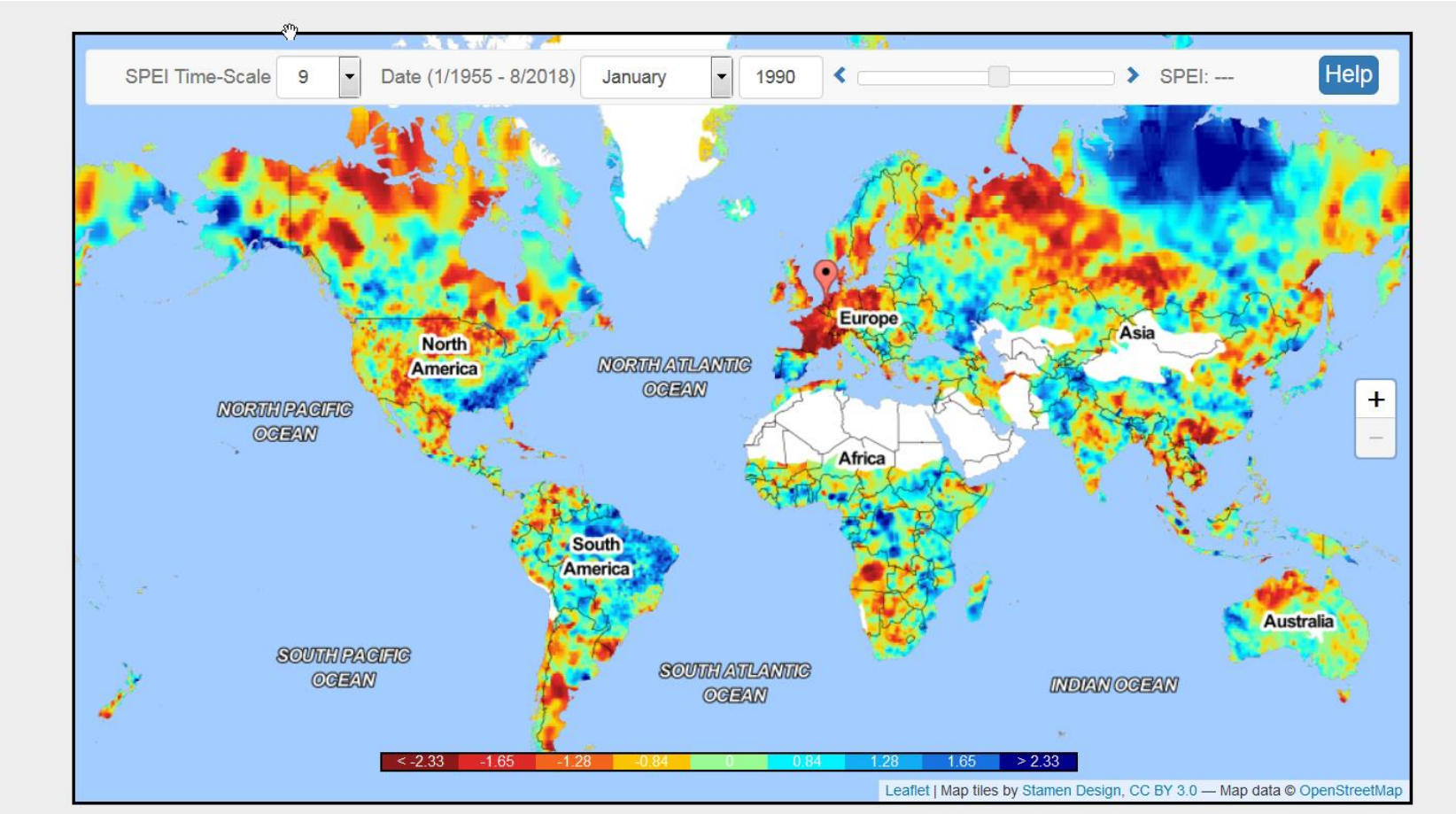


Standardized Precipitation Index: examples



SPI values for five month and sixty month timescales, in Idaho climate zone 5 (Southwestern Valleys). The sixty month SPI clearly tracks the long-term drought pattern. The SPI parameters for the data transformation were constructed using 111 years of observations. Contributed by J. Keyantash

SPEI Global Drought Monitor

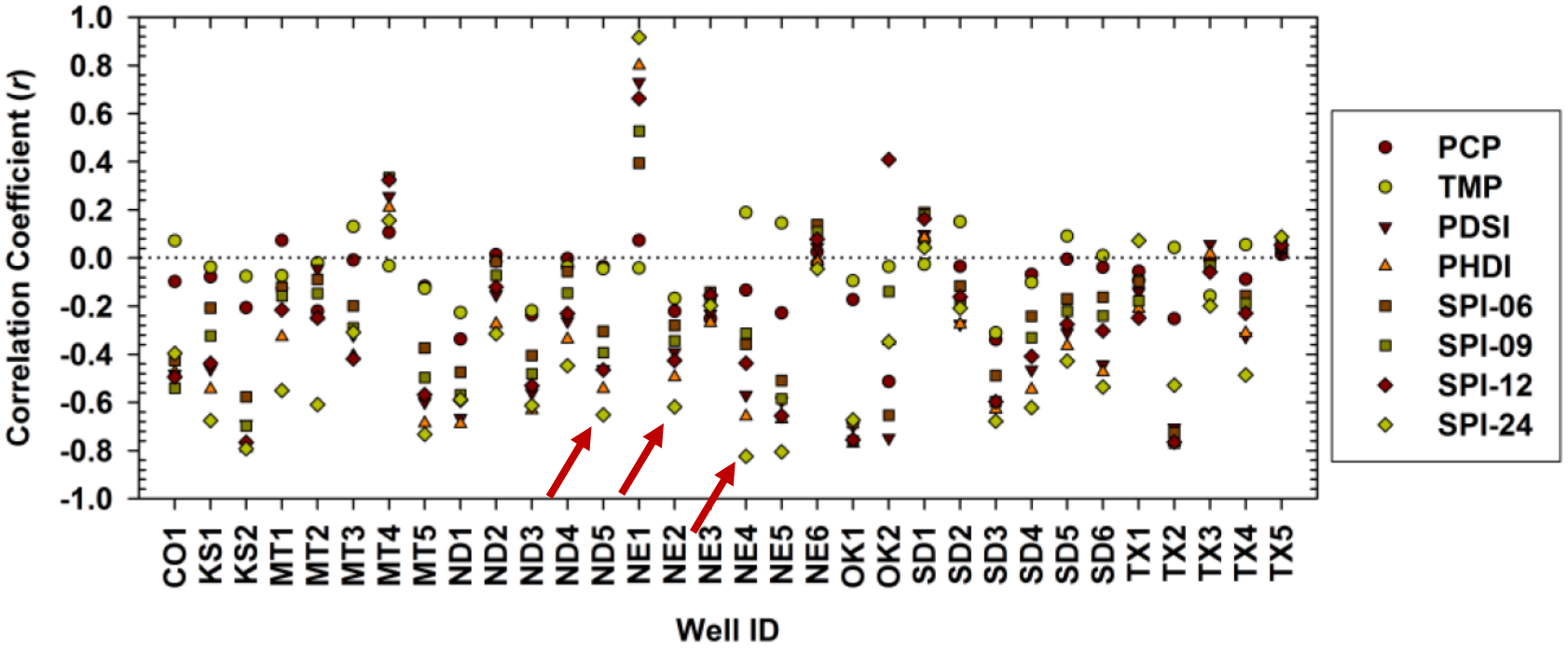


http://spei.csic.es/map/

Correlation between SPI and groundwater levels

Groundwater level data set in Texas, USA

- SPI-24 shows best correlation with groundwater level

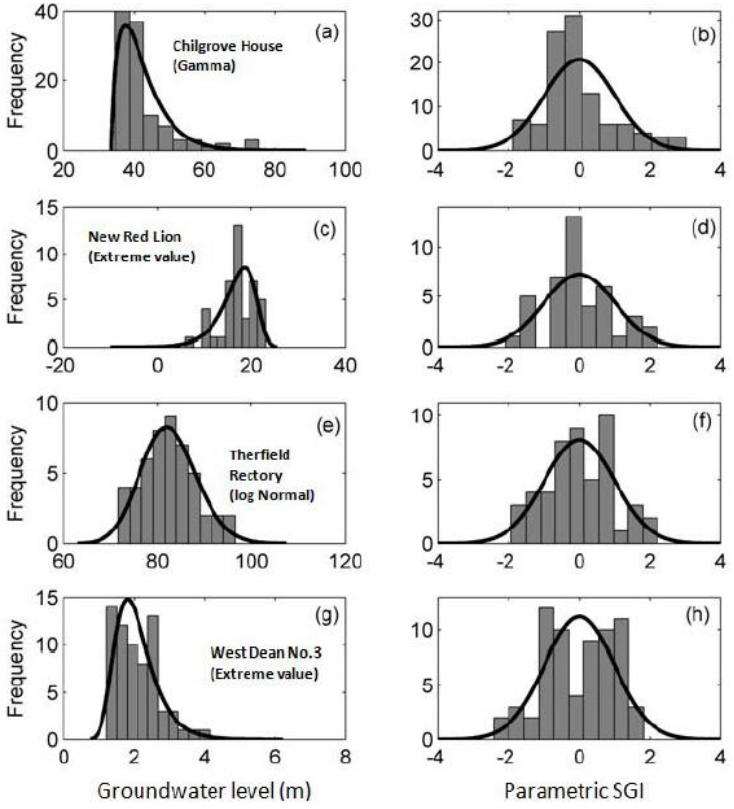


Leelaruban et. al, Water, 2017

Standardised Groundwaterlevel index (SGI)

Based on 14 sites in the UK

- Developed by Bloomfield and Marchant (2013)
- Indicator of groundwater drought
- Relative to mean hydrological baseline
- Based on SPI
- Main difference: non-parametric normal scores transformation
- SGI time series are a function of SGI autocorrelation
- Knowledge about hydro geological context is needed

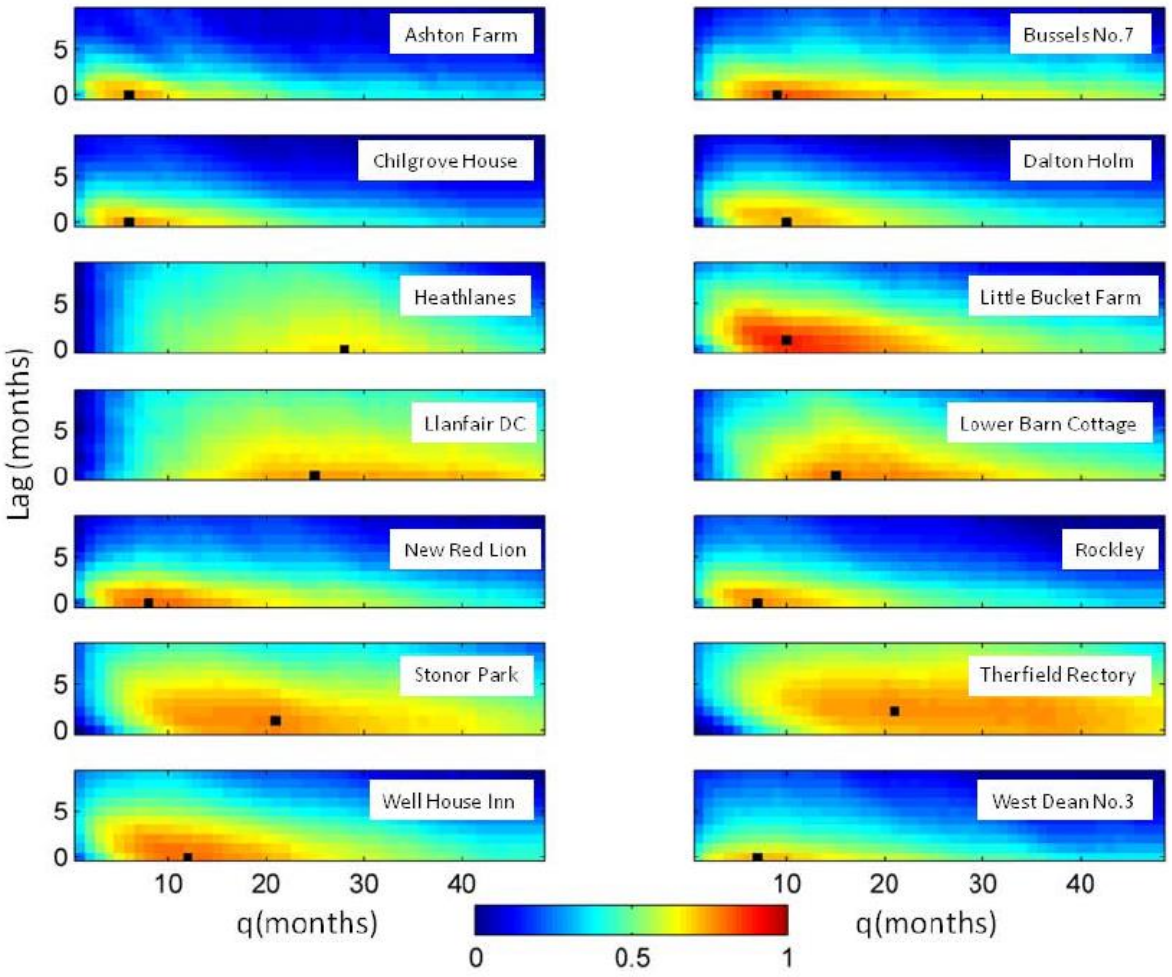


Bloomfield and Marchant, Hydrol. Earth Syst. Sci, 2013

Standardised Groundwaterlevel index (SGI)

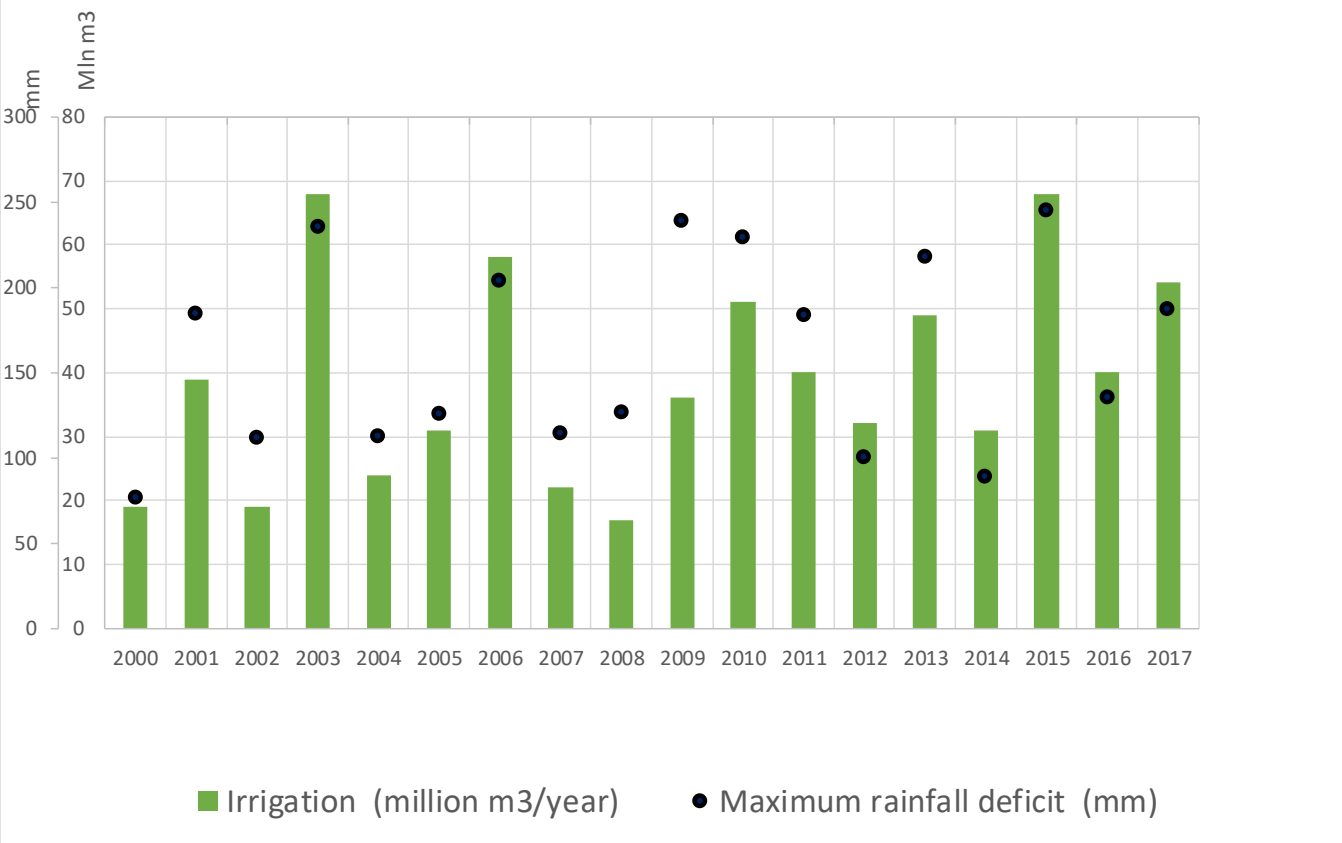
Ccross-correlation

- Good correlations between SGI and SPI
- Lag time is different
- All major droughts had large geographical footprints



Bloomfield and Marchant, Hydrol. Earth Syst. Sci, 2013

Relationship irrigation – rainfall deficit

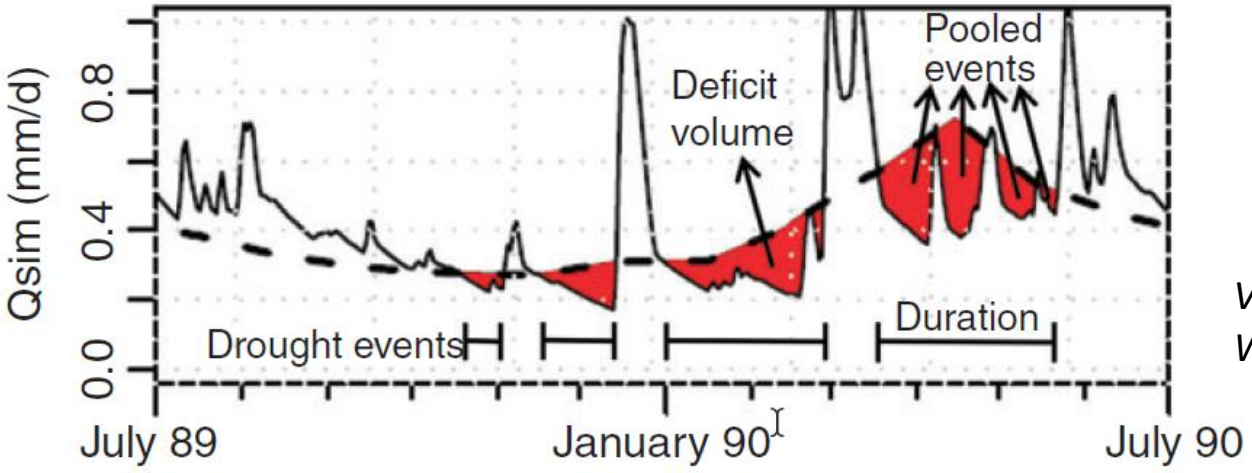


Type 2: Threshold Level Method

Approach

- Predefined threshold value
- Also called deficit method ➔ lacking volume of water
- Related to demand for irrigation, ecology, industry,..
- Seasonal or constant threshold value can be used
- Using groundwater levels or stream flow

Example stream flow



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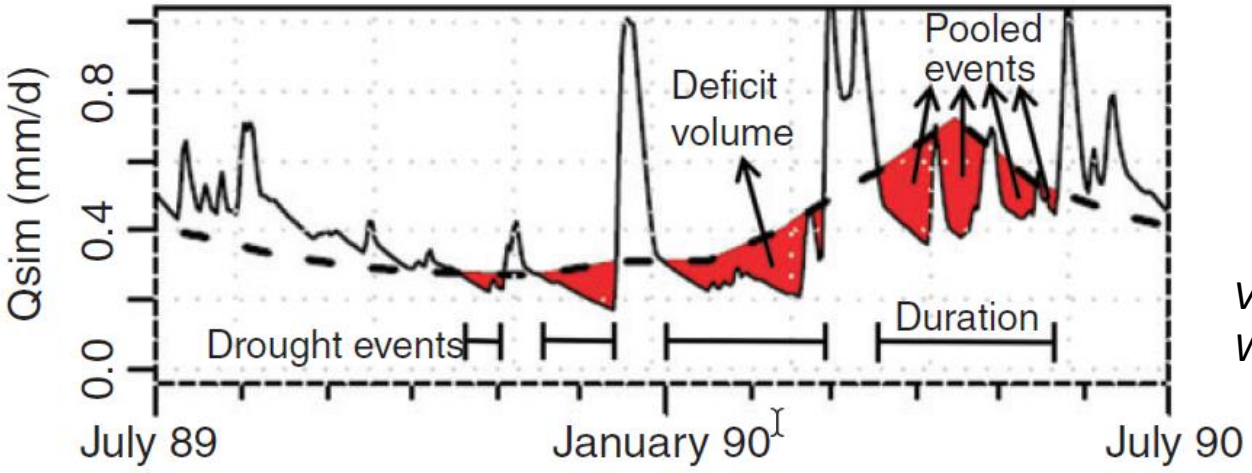


Van Loon, WIREs Water 2015

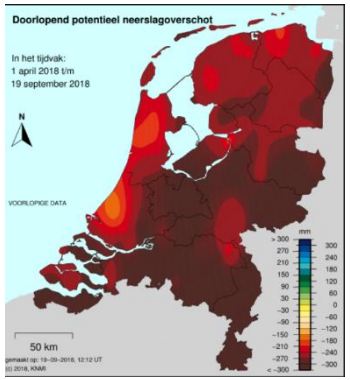
Drawback of SPI/SPEI and challenges

Drawback

- Not detailed enough for local water management
- Because not all processes are incorporated
  - Correct evapotranspiration, run-off, snow

Challenges and alternative sources of information

- Use of large scale river run-off data
- Better understanding of soil moisture drought propagation
  - From catchment to continental scale
- Anthropogenic effects like abstractions or reservoirs
- Use of large scale data sets
  - Satellite data like GRACE, Sentinel, Landsat



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Thank you for your attention.

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