DROUGHT INDICES

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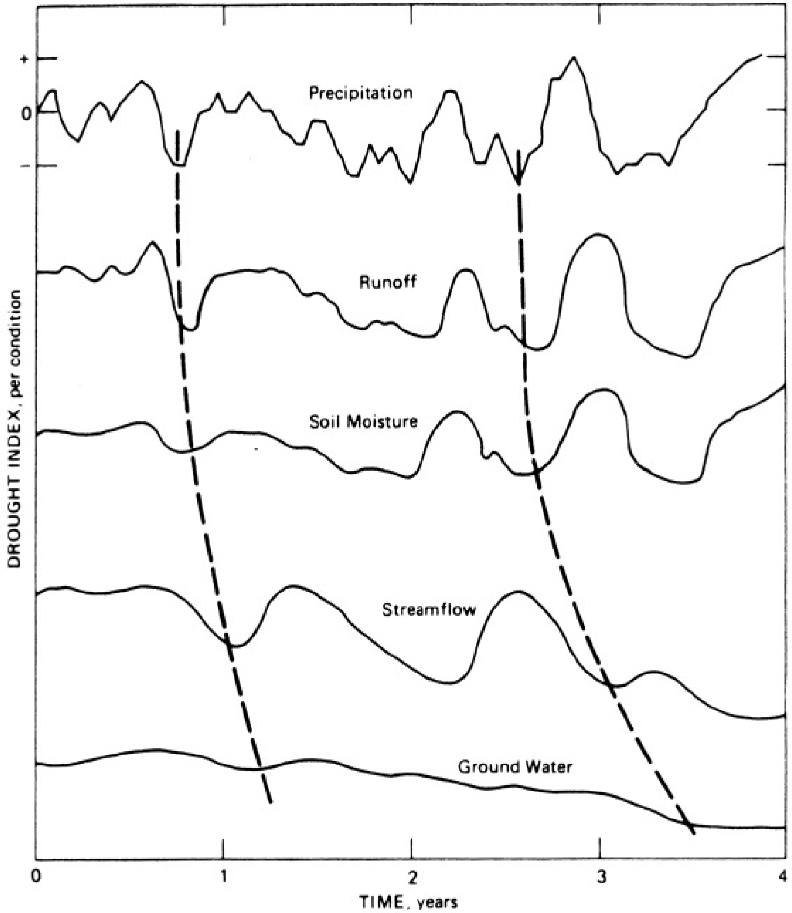
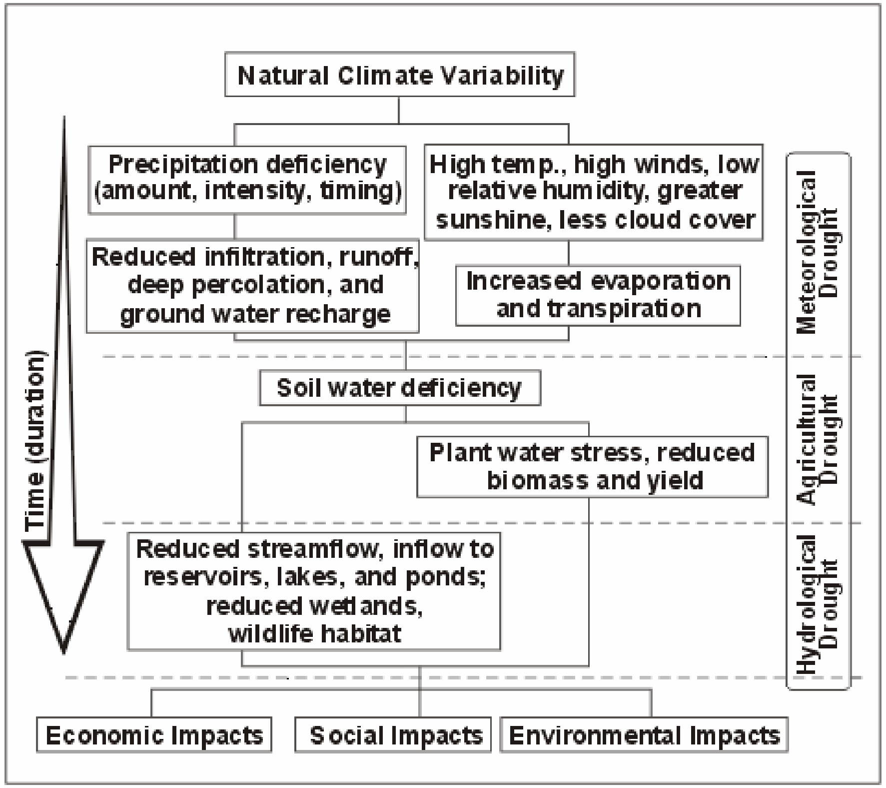


Proceeding of precipitation deficit throughout the hydrological cycle (Rasmusson, 1993)



Influence of precipitation deficiency and other factors on drought development (National Drought Mitigation Center)

- Meteorological, agricultural and hydrological drought are often represented in sense of drought indices (simple to use, they absorb great amount of data about precipitation, snow pack, ground water regime…)
- Importance of time scale when accessing different types of drought
  - Meteorological drought depends on precipitation deficit and duration of period with precipitation deficit
  - Agricultural drought refers to situations with insufficient soil moisture level to meet the plant needs for water during vegetation period
  - Hydrological drought occurs after longer period of precipitation deficit
- Choosing appropriate drought index:
  - available information
  - drought specific
  - can we reproduce drought events (impact on vegetation, agriculture, water levels, ...)
  - spatial scales (continental, national, regional, ...)

- Large number of drought indices
  - Meteorological drought (defined on the basis of degree of dryness)
    - Simply expressed in terms of a rainfall deficit in relation to some average amount and duration of drought period.
    - Definitions must be concidered as region specific (some definitions identify as number of days with precipitation less than some threshold value)
    - Longer term rainfall time series available
  - Standardised precipitation index (SPI), Palmer drought severity index (PDSI), Surface water supply index (SWSI), rainfall anomalies, Foley drought index, effective precipitation
  - Important information for general public: how long the drought has lasted, how long the drought will last (seasonal weather forecasting), how much rainfall is needed to return to normal conditions

- Agricultural drought:
    - Links various categories of meteorological and hydrological drought to agricultural impacts, focusing primarily on soil water deficits and differences between actual and potential evapotranspiration
    - Situations with insufficient soil moisture level to meet the plant needs during growing season
    - A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity
    - Common interpretation of agricultural drought as physiological drought (water deficiency in plant cells when the soil and air contain the water in insufficient quantities)
        - caused by an abrupt and marked increase in air temperature while soil temperature remains low
    - Temporal variability of water availability (precipitation distribution during growing season)

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- Assessment of agricultural drought requires calculation of water balance on weekly scale during growing season
- tools for calculating water balance
- tools for quantitative analysis of the growth and production of annual field crops
- Indices, used in agriculture: Agrohydropotential (AHP), Dry day Sequences, Generalized Hydrologic Model, Crop Moisture Index, Moisture Availability Index

- Hydrological drought:
  - Effects of periods of rain shortfall on surface and subsurface water supply
  - They lag behind meteorological and agrometeorological droughts
  - Groundwater drought is outlined by lower than average annual recharge for more than one year
    - Groundwater levels are good indicators in an acquifer area

- Considerations for drought indicators
  - Suitability for drought types of concern
    - include aspects of water demands, water supplies, drought vulnerabilities
    - make sense for the context
  - Data availability and consistency
    - Are the data readily available? Is the indicator straightforward to calculate? Are the data thrustworthy? Does the value of index vary, depending on the source of data or method of calculation?
    - Many drought plans use indicators based on data, that are already collected, subjected to quality control and consistently reported.
  - Clarity and validity
    - readily understood and scientifically sound
  - Temporal and spatial sensitivity
    - Indicator levels that imply drought conditions for one time period or one region could imply wet/normal conditions for another time period or another region.
  - Temporally and spatially specific
    - Indicators need to be associated with a specific time period of calculation and need to define spatial scale of analysis, such as climate division, hydrological basin etc.

DROUGHT INDICES

- Drought progression and recession
  - Getting into a drought and getting out of drought.
- Linked with drought management and impact reduction goals
  - Triggers can be set so that certain percentile will invoke responses that will produce a desired percentage reduction in water use
  - Drought indicator performance should also be considered (the degree of responsiveness or persistence desired in an indicator)
- Explicit combination methods
  - drought plans rely on multiple indicators
  - quantitative methods (most severe of the indicators, at least one of the indicators, majority of indicators)
  - qualitative methods (convening a drought committe to determine when to implement responses)
- Quantitative and quantitative indicators
  - Indicators can be based on quantitative data or qualitative assessments, or both
  - The importance of qualitative expertise should not be overlooked

Standardized precipitation index

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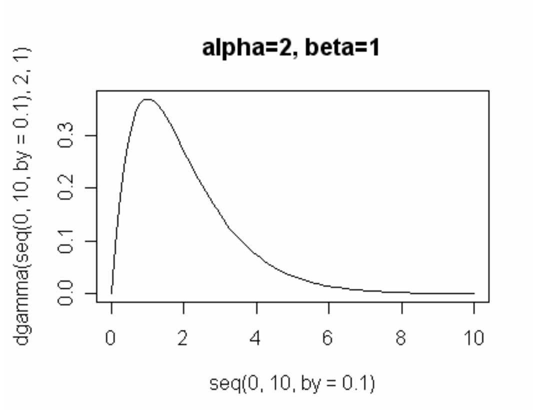
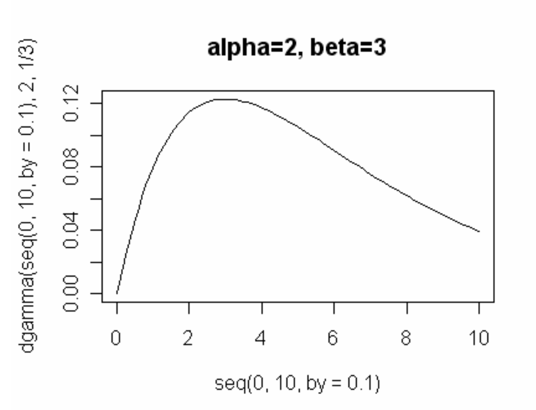
- The understanding that a deficit of precipitation has different impact on groundwater, reservoir storage, soil moisture, snowpack and streamflow led to development of SPI (Mckee, Doesken and Kleist, 1993)*
- Most common drought monitoring index
- Drought onset and duration
- Thom (1966) -> Gamma distribution fits precipitation sums well

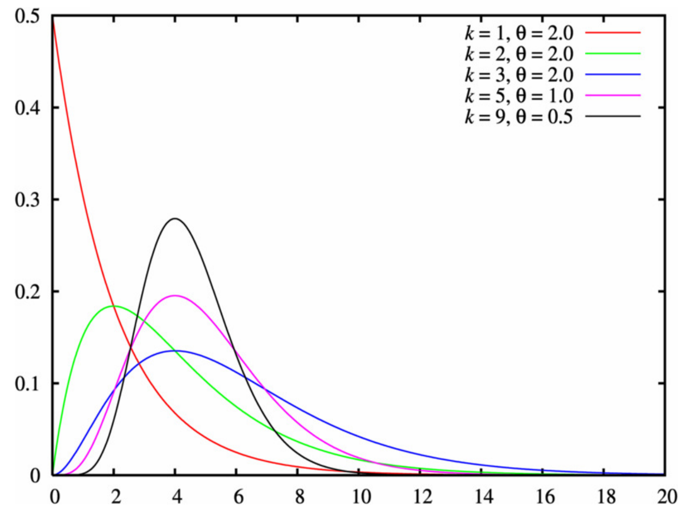
$$g(x) = \frac{1}{\beta^{\alpha}\Gamma(\alpha)} x^{\alpha-1} e^{-x/\beta} \quad \text{for } x>0$$

$\alpha > 0$	α is a shape parameter
$\beta > 0$	β is a scale parameter
$x > 0$	x is the precipitation amount
$\Gamma(\alpha) = \int_0^{\infty} y^{\alpha-1} e^{-y} dy$	$\Gamma(\alpha)$ is the gamma function

- Examples of Gamma distribution functions:







* McKee, T.B.; N.J. Doesken; and J. Kleist. 1993. The relationship of drought frequency and duration to time scales. Preprints, 8th Conference on Applied Climatology, pp. 179–184. January 17–22, Anaheim, California.

Standardized precipitation index

- SPI procedure:
  - Parameter estimation for Gamma distribution (based on least square method) – frequency distribution of precipitation sums for station
  - Parameters of Gamma distribution are determined for each station and time scale of interest (1 month, 2 months, ...)
  - Thom (1966) determined parameters based on maximum likelihood method:

$$\hat{\alpha} = \frac{1}{4A}\left(1 + \sqrt{1 + \frac{4A}{3}}\right)$$

$$A = \ln(\bar{x}) - \frac{\sum \ln(x)}{n}$$

$$\hat{\beta} = \frac{\bar{x}}{\hat{\alpha}}$$

- Estimated parameters are then used for calculating cumulative probability distribution for a specific precipitation event, which has been observed on a defined time scale (e. g. month):

$$G(x) = \int_0^x g(x)dx = \frac{1}{\hat{\beta}^{\hat{\alpha}}\Gamma(\hat{\alpha})}\int_0^x x^{\hat{\alpha}-1}e^{-x/\hat{\beta}}dx$$

- Gamma function is not defined at x=0 (but there is large number of no rainfall occurences as we move to shorter time scales); cumulative distribution is therefore modified to include these events:

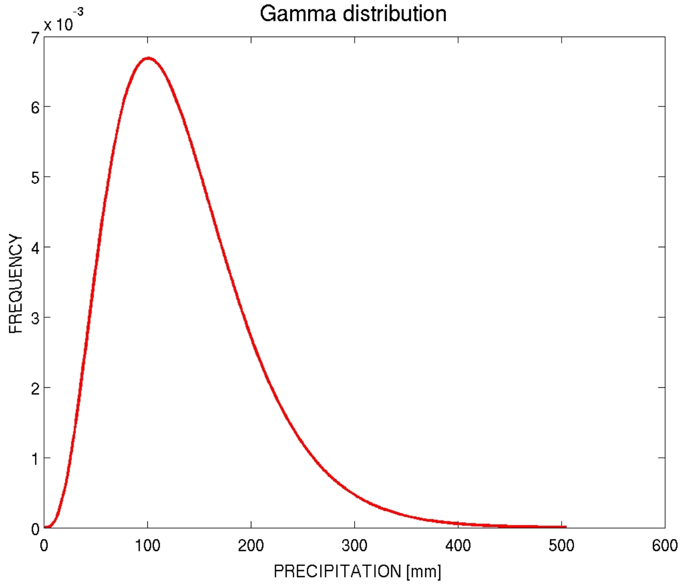
$$H(x) = q + (1-q)G(x)$$

where q is the probability of no rainfall on specified time scale

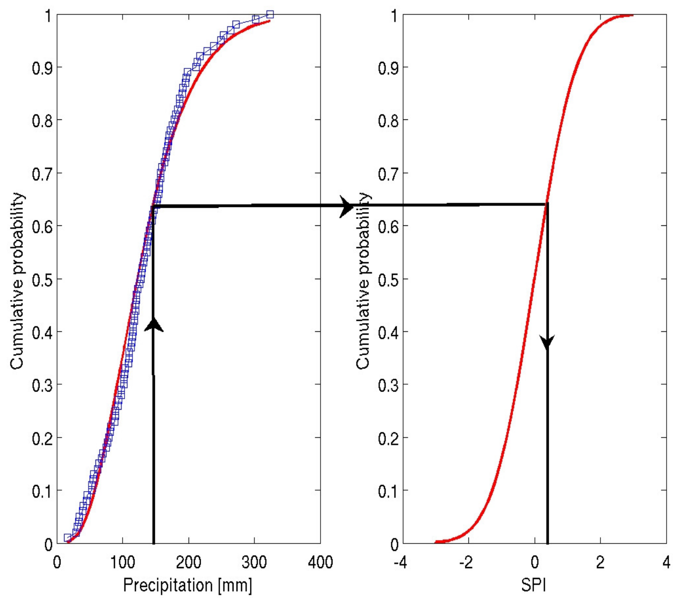
Standardized precipitation index

- Cumulative probability distribution H(x) is then transformed into standardized normal distribution Z with the average equal to 0 and standard deviation 1; SPI is number of standard deviations left (drought) or right (wet) from 0
- Panofsky in Birer (1958) – transformation from given probability distribution into different probability distribution:

  probability that the value of variable is less than some value in defined probability distribution must be identical to probability of the transformed variable being less than transformed value in second probability distribution



Gamma distribution for august precipitation (Ljubljana, 1850 -2005)



Transformation from cumulative probability distribution into standardized normal distribution

Standardized precipitation index

- Transformtion of cumulative probability distribution H(x) into standardized normal distribution (Abramowitz in Stegun, 1965)

SPI represents number of standard deviations from mean

$$Z = SPI = -\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad \text{for } 0 < H(x) \le 0.5$$

$$Z = SPI = +\left(t - \frac{c_0 + c_1 t + c_2 t^2}{1 + d_1 t + d_2 t^2 + d_3 t^3}\right) \quad \text{for } 0.5 < H(x) < 1.0$$

$$t = \sqrt{\ln\left(\frac{1}{(H(x))^2}\right)} \quad \text{for } 0 < H(x) \le 0.5$$

$$t = \sqrt{\ln\left(\frac{1}{(1.0 - H(x))^2}\right)} \quad \text{for } 0.5 < H(x) < 1.0$$

$c_0 = 2.515517$
$c_1 = 0.802853$
$c_2 = 0.010328$
$d_1 = 1.432788$
$d_2 = 0.189269$
$d_3 = 0.001308$

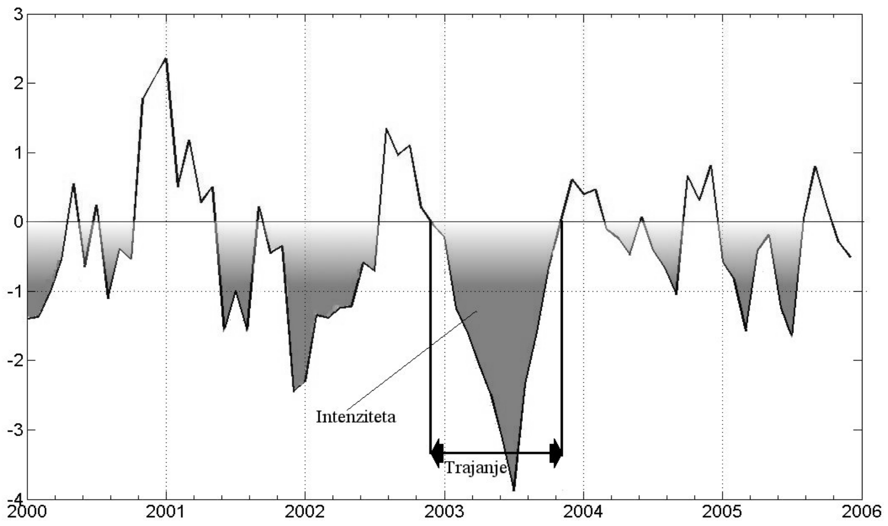
SPI	Classification	Probability (%)
2.00 >	Extremely wet	2.3
1.50 to 1.99	Very wet	4.4
1.00 to 1.49	Moderately wet	9.2
0 to 0.99	Mildly wet	34.1
0 to -0.99	Mild drought	34.1
-1 to -1.49	Moderate drought	9.2
-1.50 to -1.99	Severe drought	4.4
-2.00 <	Extreme drought	2.3

- SPI has fixed expected value and standard deviation, which is a precondition for comparing index values between different locations or regions.
- Frequencies of extreme drought events are comparable between different locations.

DROUGHT INDICES – SPI

- Different time scales reflect the impact of drought on the availability of the different water resources
- Mckee et al. (1993)* define a criteria for a drought event for any of the time scales
    - Drought event occurs any time the SPI is continuously negative and reaches an intensity of -1.00 or less
    - The event ends when the SPI becomes positive
    - The positive sum of the SPI for all the months within a drought event => drought magnitude

$$DM = -\left(\sum_{j=1}^{x} SPI_{ij}\right)$$



DROUGHT INDICES – SPI

- SPI advantages:
  - Simplicity (only rainfall data required for calculation)
  - Variable time scale (meteorological, agricultural, hydrological drought)
  - Standardization (frequency of extreme drought events at any location and time scale are consistent)
- SPI disadvantages:
  - Suitable theoretical probability distribution, which can model raw data
  - Extreme droughts (over longer period) occur with same frequency on all locations – SPI can't identify drought prone regions
  - Areas with small seasonal precipitation – misleadingly large positive or negative SPI values may result

DROUGHT INDICES – SPI (NDMC experience)

- SPI calibration period: how long period to use?
  - There is no “absolute best” recommended calibration period
  - Suggestion from NDMC (Nebraska): something like 50 years, ending around 2000; if you don’t have as much data history, then adjust accordingly
- What about stations with different lengths?
  - normally NDMC uses entire period of record for each station
  - if a person is trying to look at climate change and is comparing now to some future scenario period – then use the same length of record for comparison purposes (example will be shown later on this presentation)
  - when analyzing single station history, use all available (quality) data
- Issues that could be problematic: variability of precipitation and areal representativeness around a reporting station

DROUGHT MONITORING - PDSI

- Set of empirical relationships derived by Palmer (1965)*
- Palmer based his index on supply and demand concept of the water balance equation
- Objective: provide measurements of moisture conditions that were standardized, so that comparison using the index could be made between locations and months
- Calculation is based on precipitation and temperature data and Available Water Content (AWC) of the soil
    - All the basic terms of the water balance equation can be determined (ETP, soil recharge, runoff, moisture loss from surface layer)
    - Human impacts on water balance not included!
- Motivation: abnormally wet month in a middle of a long term drought should not have a major impact on the index, or a series of months with near-normal precipitation following a serious drought does not mean that the drought is over
- In near real time PDSI is no longer meteorological index, but becomes a hydrological index, reffered to as Palmer Hydrological Drought Index (PHDI).

DROUGHT MONITORING - PDSI

Table 1: Drought classification by PDSI value

PDSI value	Classification
4.0 or more	extremely wet
3.0 to 3.99	very wet
2.0 to 2.99	moderately wet
1.0 to 1.99	slightly wet
0.5 to 0.99	incipient wet spell
0.49 to -0.49	near normal
-0.5 to -0.99	incipient dry spell
-1.0 to -1.99	mild drought
-2.0 to -2.99	moderate drought
-3.0 to -3.99	severe drought
-4.0 or less	extreme drought

- The values quantifying the intensity of drought and drought duration were arbitrarily selected based on Palmer's study of central Iowa and western Kansas

- PDSI is most effective measuring impacts, sensitive to soil moisture conditions
- Positive characteristics:
  - measurement of abnormality of recent weather for a region
  - opportunity to place current condition in historical perspective
  - spatial and temporal presentations of historical droughts
- negative characteristics:
  - applying index to climate division may be too general (AWC !)
  - water balance calculation assumptions
  - snowfall, snowcover and frozen ground are not included
  - Evapotranspiration techniqe used (Thorntwaite method)

• To overcome the problem of empirical coefficients, the self-calibrate PDSI was developed:

- Analyzes climate of each location and adjusts duration coefficients (empirical factors) accordingly
- Duration factors affect the sensitivity of the index to moisture deficits by determining how much weight is given to the current moisture anomaly and the previous index value
- Two sets of duration coefficients are calculated for every location (one for wet spells, other for dry spells)
- climate characteristic coefficient calibration: 2 % of PDSI values fall below -4.0 and 2 % rise above 4.0 => this gives index an uper and lower bounds
    - 2 % of extreme dry events and 2 % of extreme wet events
- Self calibrated PDSI performs much more consistently than the original PDSI (Wells et al., 2004)* and provides more realistic metric of relative periods of drought or excessive soil moisture

* Wells, N, Goddard, S., Hayes, M. J., A Self-Calibrating Palmer Drought Severity Index, J. Climate, 17, 2335–2351 (2004)

DROUGHT MONITORING – PHDI

- Palmer hydrological drought index
  - PHDI uses a modification of the PDSI to assess moisture anomalies that affect stream flow, ground water, water storage, being more sensitive to hydrological components
  - PHDI has more stringent criterion for the elimination of the drought or wet spell, which results in index rebounding gradually (more slowly than PDSI) toward the normal state
  - PDSI considers drought finished when a moisture conditions begin an uninterrupted rise that ultimately erases water deficit ; PHDI considers drought ended when the moisture deficit actually vanishes
- Palmer Crop Moisture Index
  - assess present conditions for crops
  - it can rapidly vacillate and is poor tool for monitoring long-term drought
  - The CMI begins and end each growing season near zero – not appropriate for monitoring long term droughts

- Examples of recent SPI related studies:
  - Drought in Slovenia

Cross-Correlation between SPI3 – SPI24 and PDSI for Ljubljana

	SPI1	SPI3	SPI6	SPI9	SPI12	SPI24	PDSI
SPI1	1	0.55	0.39	0.32	0.30	0.22	0.47
SPI3		1	0.71	0.58	0.53	0.40	0.67
SPI6			1	0.82	0.72	0.56	0.75
SPI9				1	0.88	0.66	0.76
SPI12					1	0.75	0.76
SPI24						1	0.70
PDSI							1

- PDSI has lower variability (higher “memory capacity”)
- PDSI has built in time step of 9 months
- The difference between PDSI and SPI9 can be described with accounting water balance calculation in PDSI
- Single precipitation events during drought are most visibly noticed at SPI on short time scales – not necessarily end drought on longer time scale

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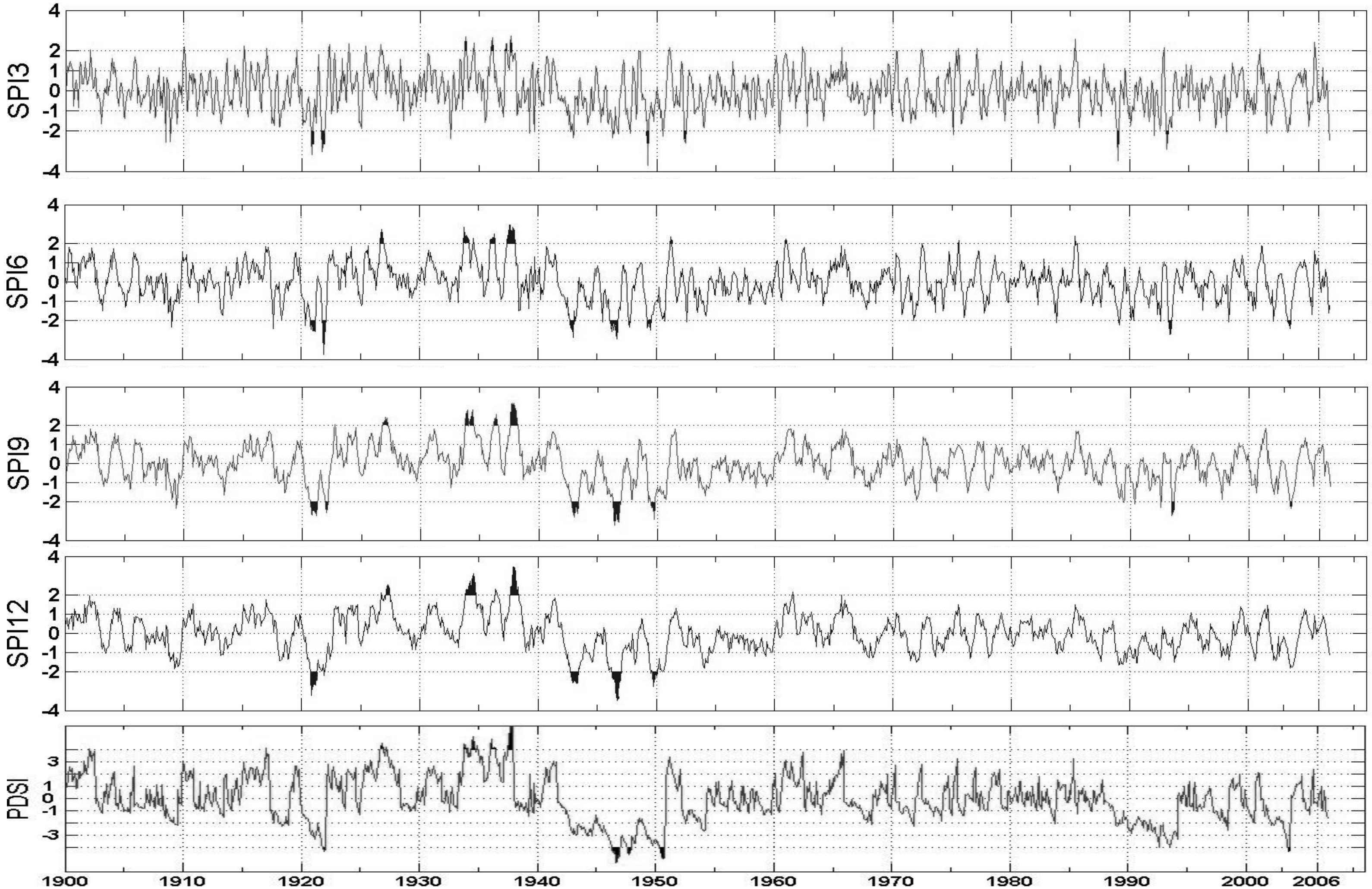
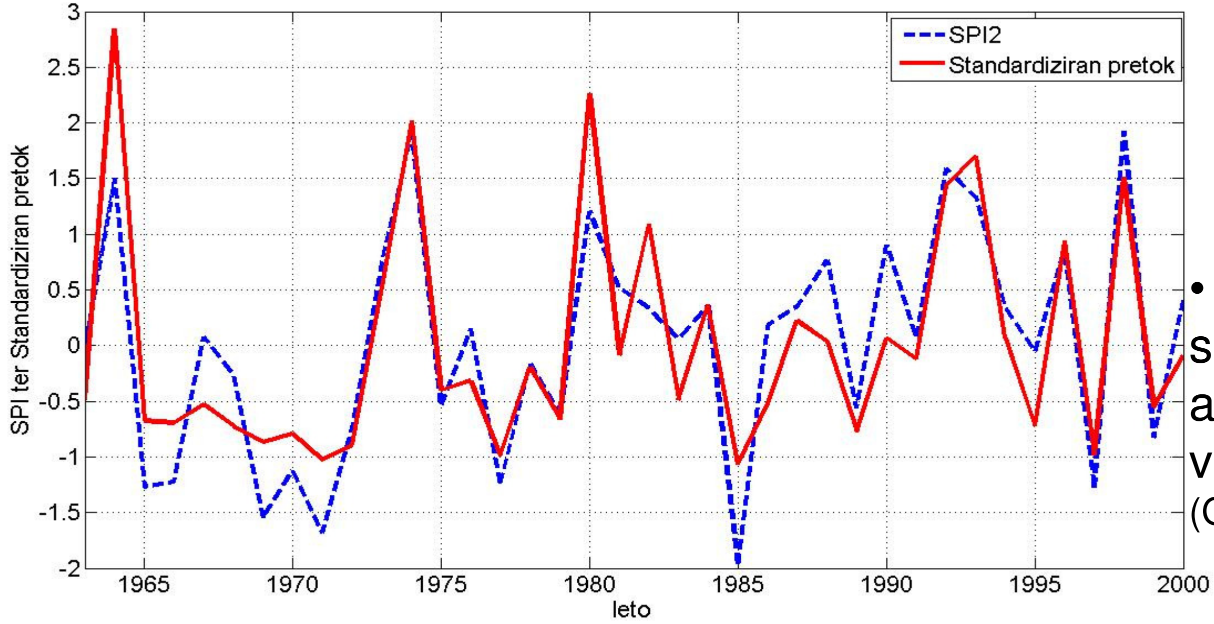
DROUGHT INDICES - SPI on several time scales and PDSI for Ljubljana



Drought severity index values for Ljubljana (Ceglar et al., 2007)

DROUGHT INDICES – SPI

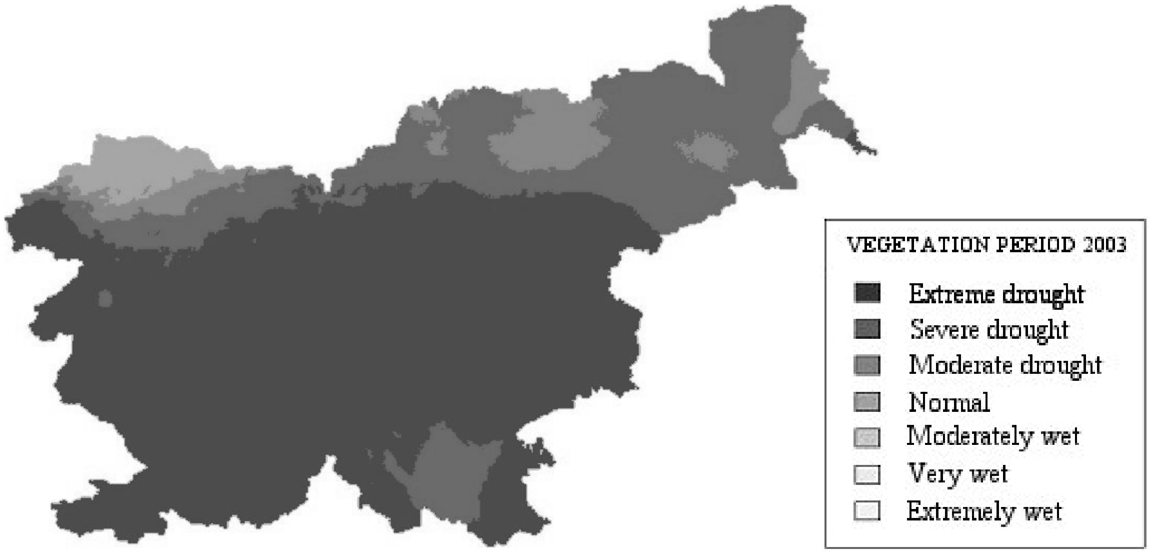
- Local and regional Implementation of PDSI
  - Research on accessible data sources for calculation of PDSI (precipitation, temperature, available water holding capacity)
  - Comparison of SPI and PDSI with river discharges, grounwater table depth and yield



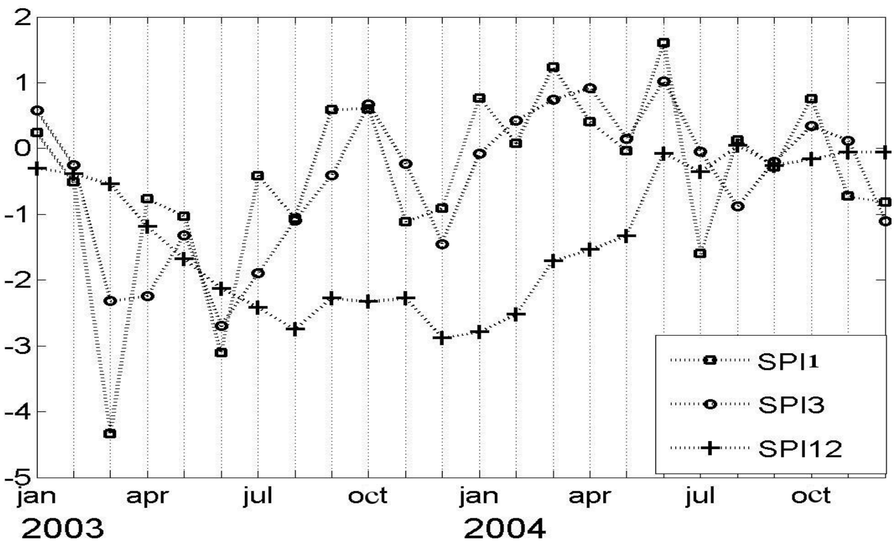
- SPI on two month time scale for october (blue line) and standardized discharge values for river Savinja (Gregorič, Ceglar, 2007)*

* Gregorič, G., Ceglar, A., 2007. Drought monitoring – regional aspects. In procedings. 18. Mišičev vodarski dan, Maribor, december 2007.

DROUGHT INDICES – SPI



- SPI on 6-months time scale in September 2003 (SPI6); calibration period 1961 – 2000 (Ceglar et al., 2007)



- SPI on different time scales for Murska Sobota – drought year 2003: **Such long-term conditions with precipitation deficiency have to a great extent influenced crop yields in the region and caused damage to cereals, maize, grassland and orchards**

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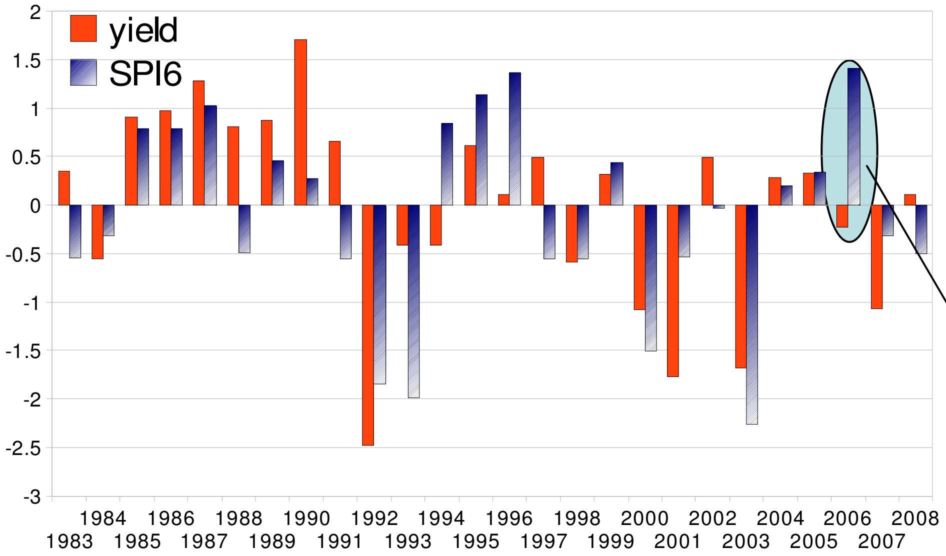
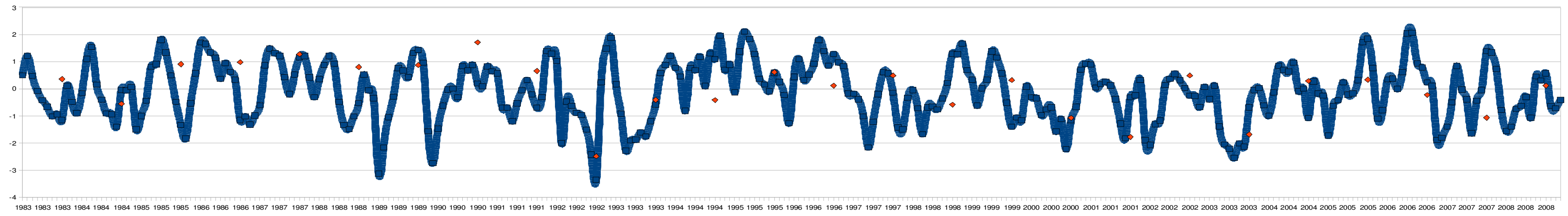
DROUGHT INDICES – SPI

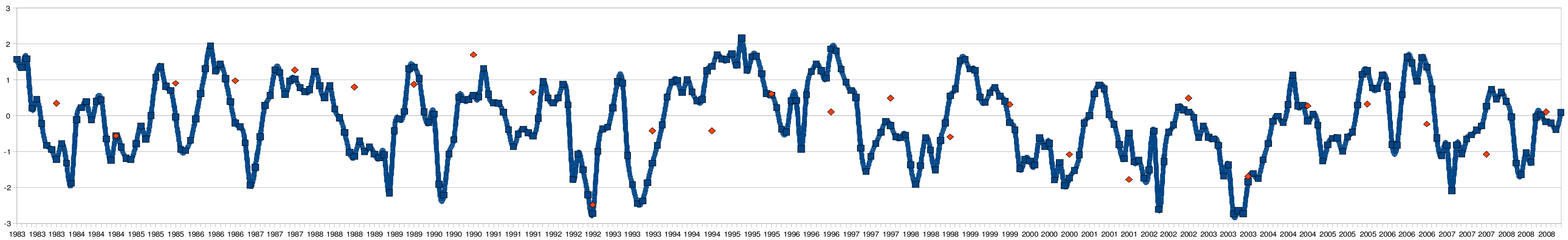


- SPI on 6 months time scale for vegetation period (black line) and standardized maize yield data (red line) for Murska Sobota

- Hot summer (1.8 ℃ warmer than average) with above normal precipitation (dry july, wet august)

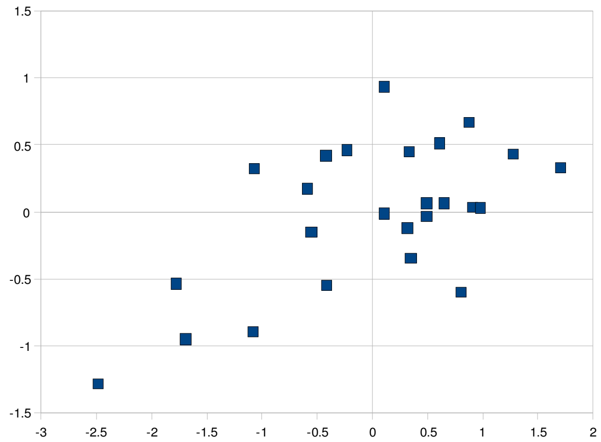


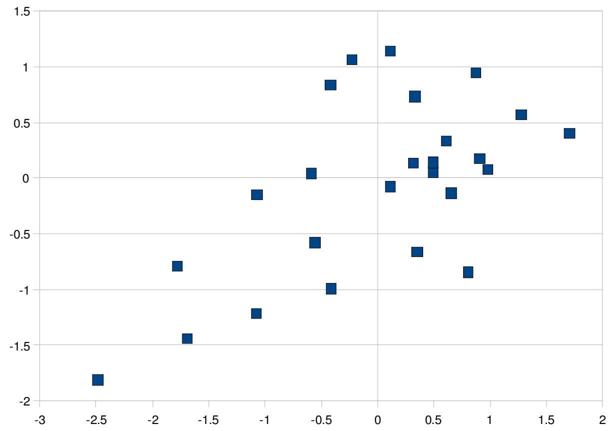
- Standardized yield and SPI on three month time scale



- Standardized yield and SPI on six months time scale

DROUGHT INDICES – SPI





- Scatterplot (average SPI on monthly time scale during growing season vs. Standardized yield)

- Scatterplot (average SPI on two months time scale during growing season vs. Standardized yield)

SPI (with flexible time scale) is capable of identifying all types of drought

- Example for Hungary:

.. streamflow drought: SPI2 – SPI5
.. groundwater drought: SPI5 – SPI24
.. agricultural drought: SPI2 – SPI3

	Correlation Coefficient (r)						
Well Location	SPI3	SPI5	SPI6	SPI12	SPI18	SPI24	PDSI
Southeast	*0.1200*	**0.1612**	**0.1688**	**0.1895**	**0.2404**	**0.2387**	**0.1470**
Southwest	**0.1356**	*0.1204*	*0.1225*	0.0574	**0.3079**	**0.3877**	**0.1411**
Central	**0.2938**	**0.3895**	**0.4297**	**0.5265**	**0.5083**	**0.5148**	**0.4596**
West	**0.4613**	**0.5249**	**0.5135**	**0.4972**	**0.4163**	**0.3471**	**0.4719**

- Relationship between the depth of groundwater table and SPI on several time scales *(Szalai, 2006)

* Szalai, S. 2006. Drought monitoring in the early warning system. Hungarian Meteorological Service.

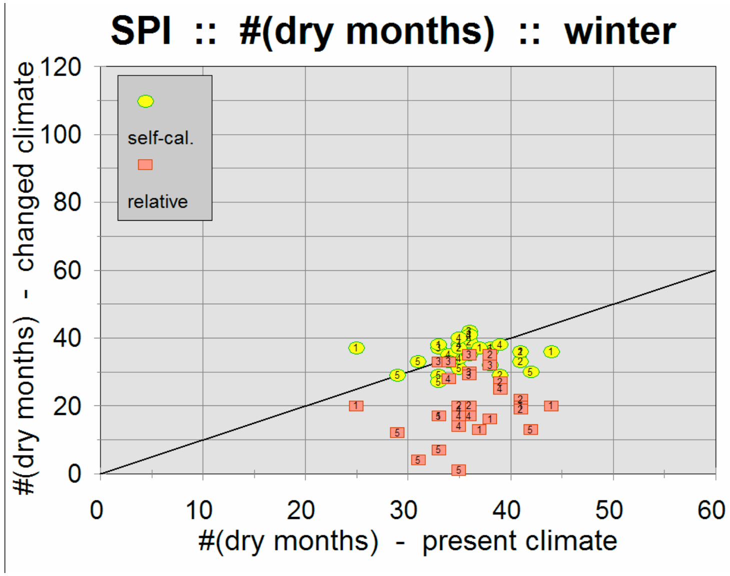
DROUGHT INDICES – SPI

- Drought forecasting:
    - seasonal precipitation forecasts
    - Linear deterministic and stochastic time series models (ARIMA, SARIMA, ...), nonlinear models (e. g. artificial neural network models)
        - Vasiliades and Loukas (2008)* compared different methods with observed SPI time series over Thessaly region – most of models could be operationaly in use
- Climate change:
    - Relative SPI /PDSI ; indices are calibrated using a "learning" series (reference station/period) which is generally different from the application series
    - base period for determination of gamma coefficients from control climate data (e. g. 1961 – 2000)

* Vasiliades, L., Loukas, A. 2008. Meteorological drought forecasting models. Geophysical Research Abstracts. Vol 10. 2008.

DROUGHT INDICES – SPI

- Relative indices allow:
  - between station comparison of drought conditions (learning series from reference station, input series any other station to be compared with the reference station)
  - assessing impact of the climate change on a specific location (learning series is present climate series, application series is future climate series from climate models)
  - Example for Prague (Dubrovsky et al., 2005)*:



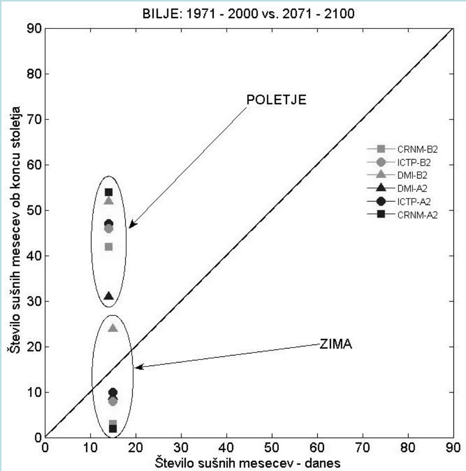
learn = GCM(1961-2000)

input = GCM(2060-2099)

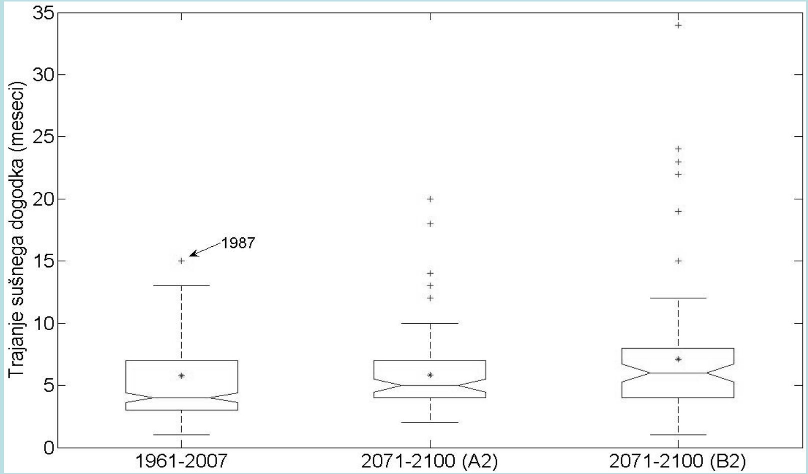
symbols: 5GCMs x 4grids

*Dubrovsky, M., Trnka, M., Svoboda, M., Hayes, M., Wilhite, D., Zalud, Z., Semeradova, D. 2005. Drought as the limiting factor in cereal productions. NATO Project.

DROUGHT INDICES – SPI

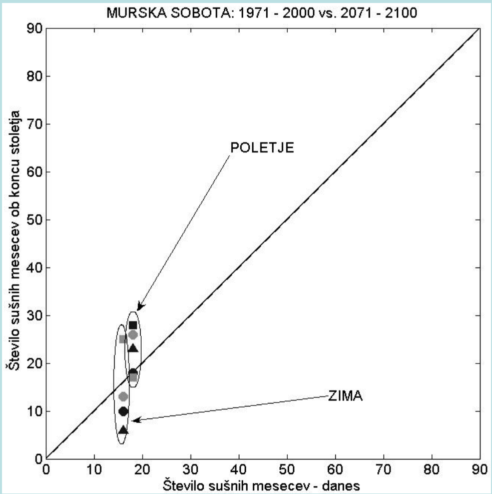


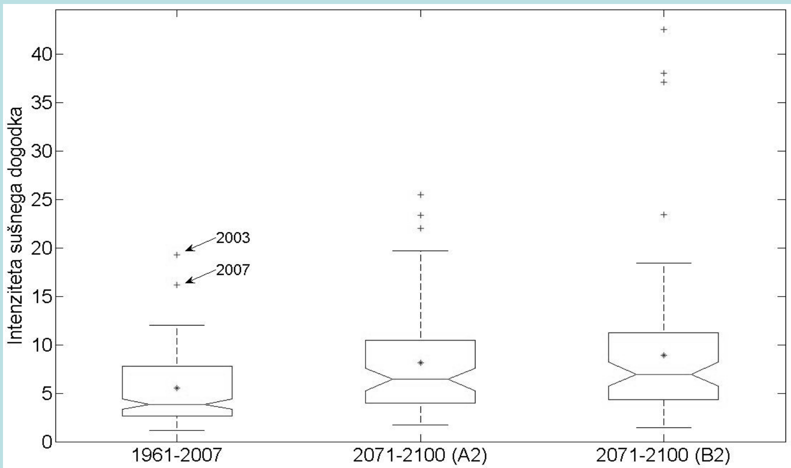
Number of drought events (based on SPI3) in Bilje



Duration of drought for control period (1971-2000) and period 2071-2100 (for two different SRES scenarios)

Number of drought events (based on SPI3) in Murska Sobota





Drought intensity for control period (1971-2000) and period 2071-2100 (for two different SRES scenarios)

Ceglar, A., Črepinšek, Z., Kajfež Bogataj, L. 2008. Climate change and related drought spells in SLovenia. Novi izzivi v poljedelstvu. 2008

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DROUGHT INDICES - programs

- **Upgrade of SPI product** (modification of original SPI source code, downloaded from NADSS)
    - if we calculate SPI on weekly time scale, we run into a problem of many zero precipitation events, which can cause problems on the extreme tail calculations
    - Instead we can calculate variety of SPI values every week (4-, 6-, 8-weeks, etc.)
    - modified version of program allows to choose time scale of calculation in days
    - original program was corrected to include specified beginning and end of calibration period into the calculation procedure
    - program is accessible as windows executable and as source code for unix – like systems
    - Main problem: quantity and reliability of the data, used to fit the distribution

- Example of use: running program SPI_daily.exe

- **Input section:**
  - file with daily precipitation data for calibration period
    - this is a “static” file (no need to change, unless we want to change (lengthen) calibration period).
    - file should contain daily precipitation data for the calibration period
    - file format:

    1. line: header line (e. g. station related information)
    2. line – EOF: year month day precipitation_mm

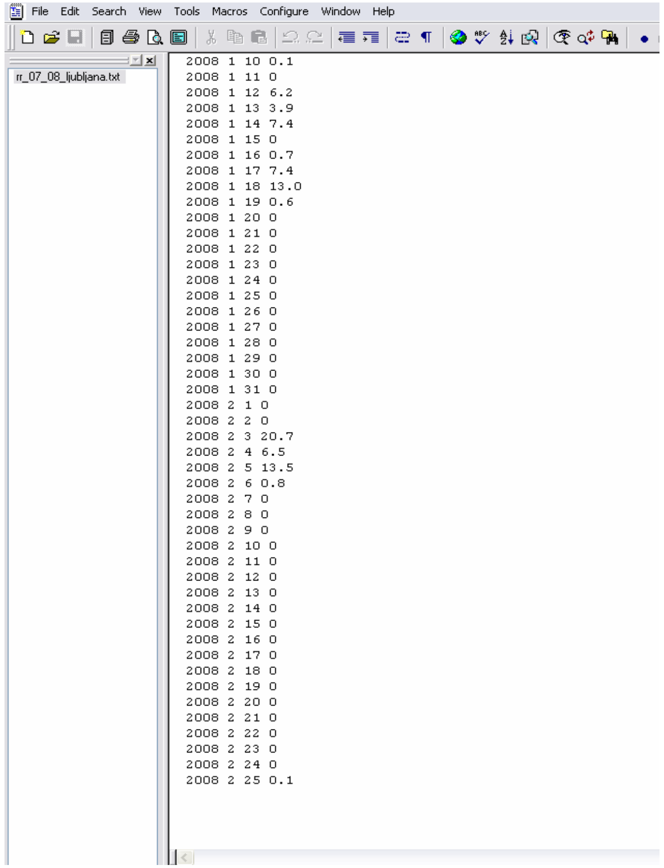
    !Separators between values should be spaces or tabulators!

    !Missing values should be denoted with -99.0
  - beginning and end of calibration period

- number of time scales for calculation of SPI and their duration (in days)
- file with daily precipitation data for observed period
- name of output file (for calculated SPI values) – if we don't provide the name, results will be written on screen

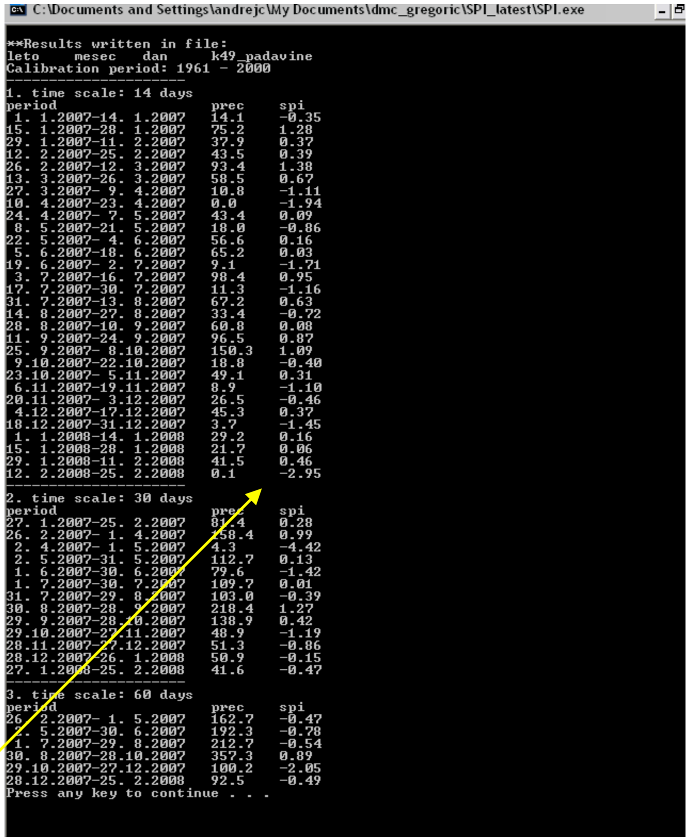
- Results for Ljubljana:

example of input file



```
2008 1 10 0.1
2008 1 11 0
2008 1 12 6.2
2008 1 13 3.9
2008 1 14 7.4
2008 1 15 0
2008 1 16 0.7
2008 1 17 7.4
2008 1 18 13.0
2008 1 19 0.6
2008 1 20 0
2008 1 21 0
2008 1 22 0
2008 1 23 0
2008 1 24 0
2008 1 25 0
2008 1 26 0
2008 1 27 0
2008 1 28 0
2008 1 29 0
2008 1 30 0
2008 1 31 0
2008 2 1 0
2008 2 2 0
2008 2 3 20.7
2008 2 4 6.5
2008 2 5 13.5
2008 2 6 0.8
2008 2 7 0
2008 2 8 0
2008 2 9 0
2008 2 10 0
2008 2 11 0
2008 2 12 0
2008 2 13 0
2008 2 14 0
2008 2 15 0
2008 2 16 0
2008 2 17 0
2008 2 18 0
2008 2 19 0
2008 2 20 0
2008 2 21 0
2008 2 22 0
2008 2 23 0
2008 2 24 0
2008 2 25 0.1
```

calculated SPI on different time scales



```
C:\Documents and Settings\andrejc\My Documents\dmc_gregoric\SPI_latest\SPI.exe

**Results written in file:
leto     mesec    dan      k49_padavine
Calibration period: 1961 - 2000
---------------------
1. time scale: 14 days
period                   prec     spi
 1. 1.2007-14. 1.2007    14.1     -0.35
15. 1.2007-28. 1.2007    75.2     1.28
29. 1.2007-11. 2.2007    37.9     0.37
12. 2.2007-25. 2.2007    43.5     0.39
26. 2.2007-12. 3.2007    93.4     1.38
13. 3.2007-26. 3.2007    58.5     0.67
27. 3.2007- 9. 4.2007    10.8     -1.11
10. 4.2007-23. 4.2007    0.0      -1.94
24. 4.2007- 7. 5.2007    43.4     0.09
 8. 5.2007-21. 5.2007    18.0     -0.86
22. 5.2007- 4. 6.2007    56.6     0.16
 5. 6.2007-18. 6.2007    65.2     0.03
19. 6.2007- 2. 7.2007    9.1      -1.71
 3. 7.2007-16. 7.2007    98.4     0.95
17. 7.2007-30. 7.2007    11.3     -1.16
31. 7.2007-13. 8.2007    67.2     0.63
14. 8.2007-27. 8.2007    33.4     -0.72
28. 8.2007-10. 9.2007    60.8     0.08
11. 9.2007-24. 9.2007    96.5     0.87
25. 9.2007- 8.10.2007    150.3    1.09
 9.10.2007-22.10.2007    18.8     -0.40
23.10.2007- 5.11.2007    49.1     0.31
 6.11.2007-19.11.2007    8.9      -1.10
20.11.2007- 3.12.2007    26.5     -0.46
 4.12.2007-17.12.2007    45.3     0.37
18.12.2007-31.12.2007    3.7      -1.45
 1. 1.2008-14. 1.2008    29.2     0.16
15. 1.2008-28. 1.2008    21.7     0.06
29. 1.2008-11. 2.2008    41.5     0.46
12. 2.2008-25. 2.2008    0.1      -2.95
---------------------
2. time scale: 30 days
period                   prec     spi
27. 1.2007-25. 2.2007    81.4     0.28
26. 2.2007- 1. 4.2007    158.4    0.99
 2. 4.2007- 1. 5.2007    4.3      -4.42
 2. 5.2007-31. 5.2007    112.7    0.13
 1. 6.2007-30. 6.2007    79.6     -1.42
 1. 7.2007-30. 7.2007    109.7    0.01
31. 7.2007-29. 8.2007    103.0    -0.39
30. 8.2007-28. 9.2007    218.4    1.27
29. 9.2007-28.10.2007    138.9    0.42
29.10.2007-27.11.2007    48.9     -1.19
28.11.2007-27.12.2007    51.3     -0.86
28.12.2007-26. 1.2008    50.9     -0.15
27. 1.2008-25. 2.2008    41.6     -0.47
---------------------
3. time scale: 60 days
period                   prec     spi
26. 2.2007- 1. 5.2007    162.7    -0.47
 2. 5.2007-30. 6.2007    192.3    -0.78
 1. 7.2007-29. 8.2007    212.7    -0.54
30. 8.2007-28.10.2007    357.3    0.89
29.10.2007-27.12.2007    100.2    -2.05
28.12.2007-25. 2.2008    92.5     -0.49
Press any key to continue . . .
```

Last two weeks before 25. of february (12. 2. – 25. 2.) were very dry (extreme drought, as shown by SPI value). On longer time scale though (one and two months) SPI shows mild drought. Drought is persisting from october on monthly time scale.