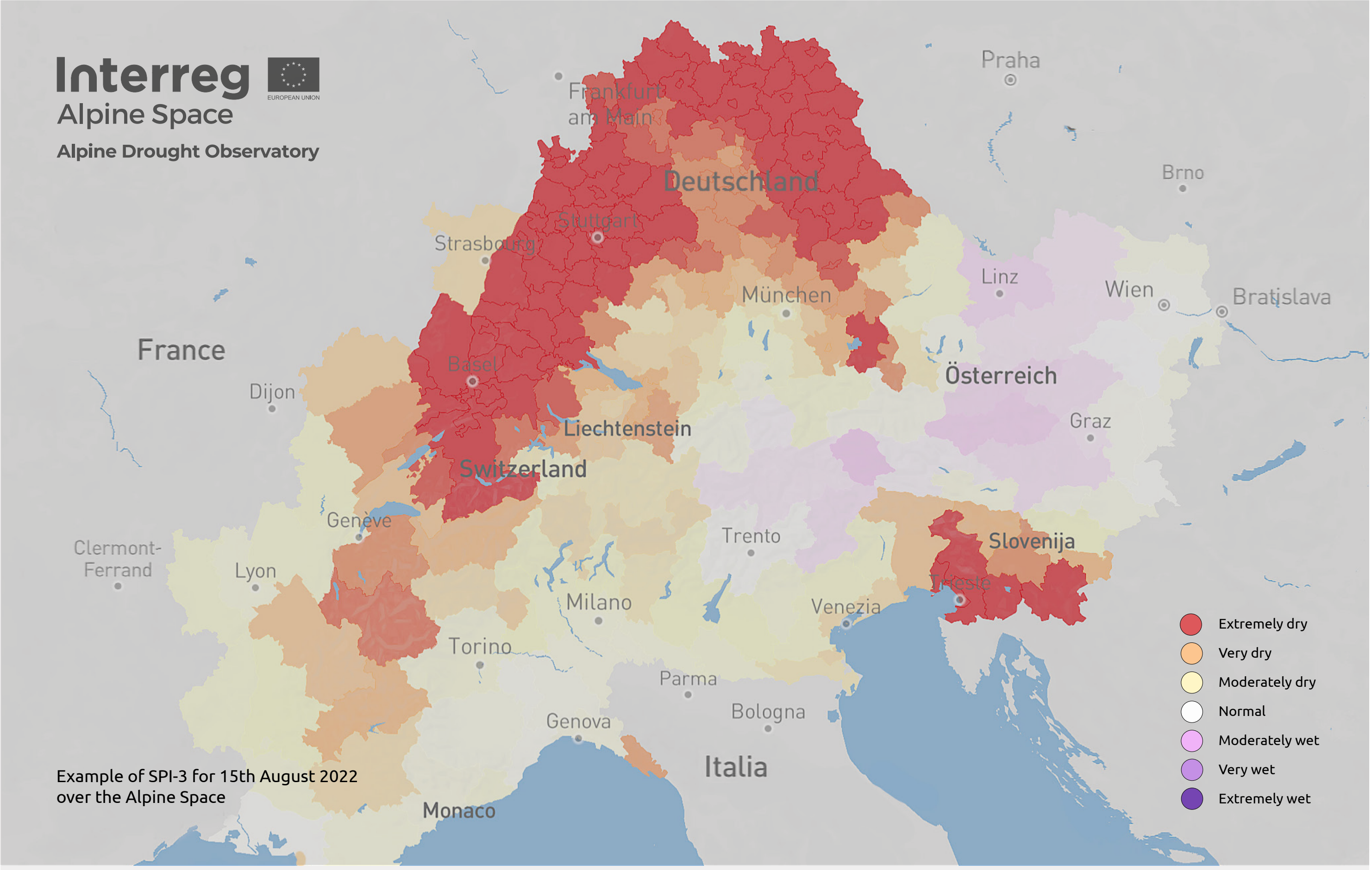
Interreg
Alpine Space
Alpine Drought Observatory




Example of SPI-3 for 15th August 2022 over the Alpine Space

# SPI

# Standardised Precipitation Index

The Standardised Precipitation Index (SPI) is the most commonly used index worldwide for detecting and characterising meteorological droughts. A meteorological drought is defined as a period with abnormal precipitation deficit, in relation to normal conditions for a region, represented as a long-term average. The SPI shows the normalised anomalies (deviations from the long-term average) of the observed total precipitation for any given location and accumulation period of interest. The name of the index is usually modified to include the accumulation period. SPI-3, for example, refers to accumulation period of three months (JRC EDO, 2020).

| Input variable | Type of drought | Temporal resolution | Spatial resolution | Temporal coverage | Time scale (aggregation period) | Unit |
|---|---|---|---|---|---|---|
| Precipitation | Meteorological | Daily | 5 km | 1979–present | 1 month (SPI-1)<br>2 months (SPI-2)<br>3 months (SPI-3)<br>6 months (SPI-6)<br>12 months (SPI-12) | Unitless / SPI unit<br><br>(unit of standard deviation from the long-term mean) |

# Definition

The Standardised Precipitation Index (McKee et al., 1993) represents a standardised measure of a certain amount of precipitation over the selected time period in relation to the expected amount of precipitation for this period. It measures precipitation anomalies at a given location, based on a comparison of observed total precipitation amounts for an accumulation period of interest, with the long-term historic precipitation record for that period. For the reference period a probability distribution is fitted to the respective data, which is then transformed into a standard normal distribution such that the mean SPI value for that location and period is zero (JRC EDO, 2020). For any given region, the value of the SPI index around 0 represents the normal expected conditions regarding the amount of precipitation in the selected time scale (accumulation period) compared to the long-term average. Value 1 represents approximately one standard deviation of precipitation amount during wet conditions and –1 denotes about one standard deviation of precipitation amount during dry conditions. Drought is usually defined as a period when SPI values fall below –1. Because SPI values represent the number of standard deviations from the long-term mean, the index is applicable for all climate regimes and can be used to identify and monitor conditions associated with a variety of drought impacts. The World Meteorological Organization has recommended that the SPI be used by all national meteorological and hydrological services around the world to characterise meteorological droughts (WMO, 2012).

# Methodology

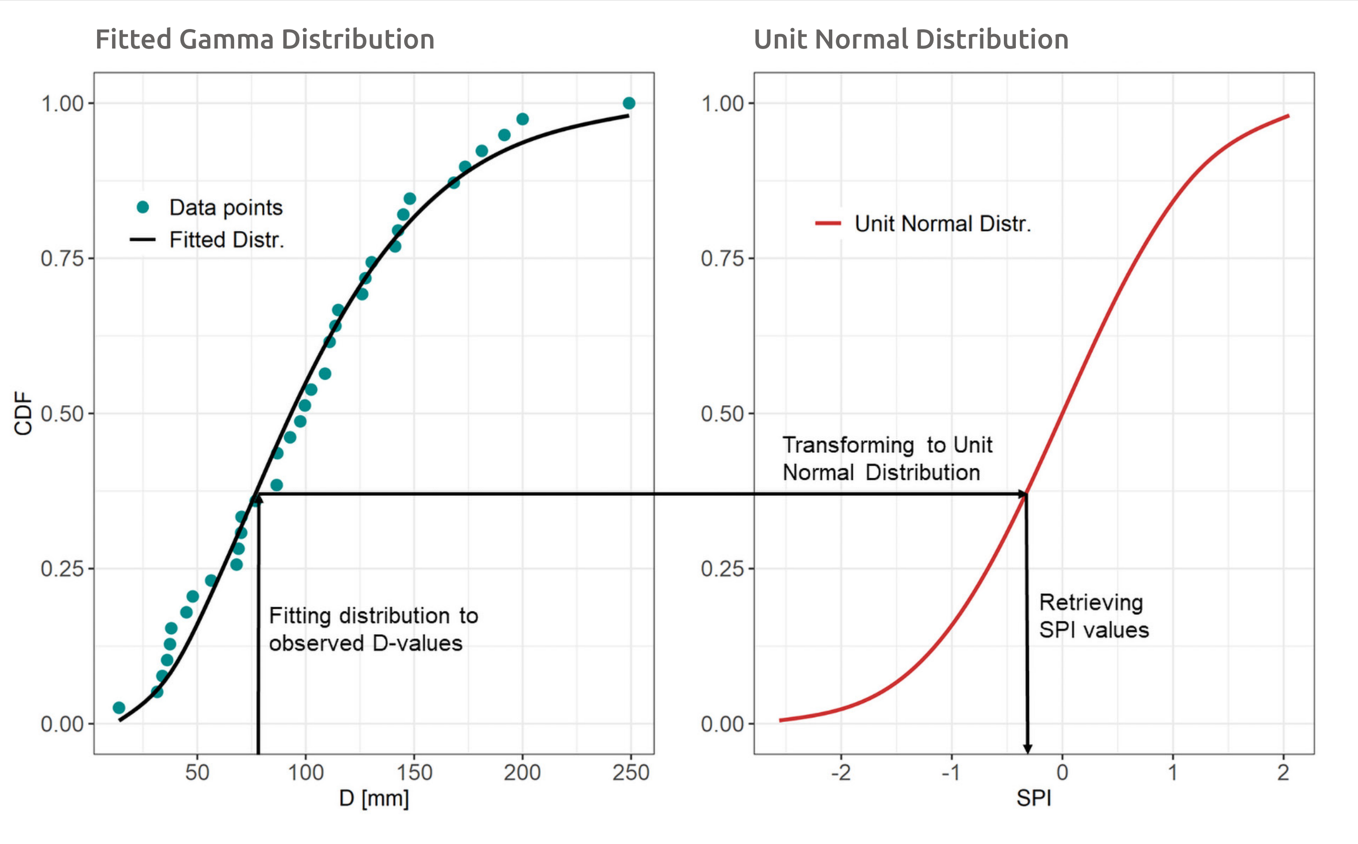
SPI

| Data source | Data provider | Index provider | Metadata |
|---|---|---|---|
| ERA5 reanalysis (Copernicus) | ZAMG | ARSO | Standardised Precipitation Index |

### CALCULATION

In the ADO platform, SPI is calculated daily on five different time scales (1, 2, 3, 6, 12 months) with limits set between –5 and 5 (Stagge et al., 2015), using 1981–2020 as the reference period for distribution fitting. The time scale (accumulation period) corresponds to the length of the rolling time window over which the total precipitation is calculated: 30 days for SPI-1, 60 days for SPI-2, 90 days for SPI-3, 180 days for SPI-6 and 365 days for SPI-12. This approach varies slightly from the more common approach, where SPI is calculated monthly according to the calendar month.

In order to compute the SPI for a time scale of interest, a two parameter continuous probability distribution known as the “gamma distribution” is fitted to the precipitation accumulation data in the reference period. The probability distribution is fitted using the centre of probability mass, as implemented in the SCI R package (Gudmundsson and Stagge, 2016) to account for potential regions with zero accumulated precipitation, particularly on shorter time scales. For any observed precipitation accumulation, the cumulative probability is derived, based on the parameters of the gamma distribution. The cumulative probability of the observed precipitation accumulation is then expressed as a quantile of the standard normal distribution with mean value 0 and variance value 1. This value is the SPI.




Schematic representation of the calculation steps for the SPI on a time scale of one month (30 days): fitting a distribution function (Gamma Distribution) to observed D values (left); probability preserving transformation into Unit Normal Distribution (right). This procedure is repeated for every day in the year.

## INPUT DATA

Precipitation data used as input data for the calculation of the SPI is downscaled directly from ERA5 reanalysis dataset at 0.25° resolution (Hersbach et al., 2018) to 5.5 km resolution using a quantile mapping approach. Quantile mapping is performed using the UERRA reanalysis dataset (Bazile et al., 2017) as reference data.

## REFERENCE PERIOD

It is important to define a reference period long enough to realistically capture climate variability in considered regions. ADO project consortium has recommended to use period 1981–2020 as reference where possible (depends on data availability). The reference period for calculating SPI is 1981–2020.

# Index values and thresholds

In the ADO platform, the SPI values range from –5 to 5. For any given location and accumulation period, they are classified into seven different categories (from dry to wet), as shown in the table. These also represent the commonly used thresholds for identifying drought through SPI.

| SPI value thresholds | Classification | Probability of event [%] |
|---|---|---|
| **SPI < –2.00** | extremely dry | 2.3 |
| **–1.99 < SPI < –1.5** | very dry | 4.4 |
| **–1.49 < SPI < –1** | moderately dry | 9.2 |
| **–0.99 SPI < 0.99** | normal | 68.2 |
| **1. < SPI < 1.49** | moderately wet | 9.2 |
| **1.5 < SPI < 1.99** | very wet | 4.4 |
| **SPI > 2.00** | extremely wet | 2.3 |

Source: WMO, 2012; JRC EDO, 2020.

# Key strengths and weaknesses

SPI

+ Index requires only climatological information without assumptions about the characteristics of the underlying system.

+ It is based on only one input parameter (precipitation accumulations), and thus easier to compute than other drought indices (WMO, 2016).

+ Due to standardisation, it can be computed and compared for any geographic location and for any number of time scales (WMO, 2016).

+ Due to normalisation, it is just as effective in analysing wet periods and cycles, as it is in analysing dry periods and cycles.

– Due to being based only on precipitation, it does not address the effects of evapotranspiration (driven by radiation, temperature, wind, humidity) on drought conditions and water stress.

– A long reference period data record is needed to sample the natural variability.

– Low values of SPI during the winter season could be overstated in the process of drought evaluation (winter in the Alps is a dry season with minimal evapotranspiration).

# Findings from the ADO project

## 1. PIEDMONT REGION – ORCO BASIN CASE STUDY

A comparison between SPI index calculated with ERA5 reanalysis (Copernicus) data and NWIOI local dataset* was performed over the Orco Basin (Piedmont Case Study). Main findings were:

- Very good agreement between the SPI calculated via ERA and SPI via NWIOI dataset at all time scales:
  - Pearson coefficient: SPI-1 = 0.81, SPI-3 = 0.86, SPI-6 = 0.88, SPI-12 = 0.9;
  - Contingency tables: around 10 % of the “events” (SPI monthly values) are not correctly described in terms of same class (see SPI index values and thresholds).
- All major dry spells observed over the Orco Basin in the last 20 years were correctly identified by the SPI (spring 2021, autumn 2017, winter 2016, summer 2006, 2003 and 2002).

Detailed information on the results is available from the project partner Arpa Piemonte (contact: christian.ronchi@arpa.piemonte.it).

* NWIOI dataset is a daily dataset of precipitation and temperatures on a regular grid (resolution=0.125°) derived by a high density network of meteorological stations over Piedmont region (Italy) via optimal interpolation technique (http://www.arpa.piemonte.it/rischinaturali/tematismi/clima/confronti-storici/dati/dati.html)

## 2. VALIDATION OF SPEI IN SLOVENIA

Validation of ADO SPI (-2, -3) against SPI calculated from ground observations at 15 representative meteorological stations in Slovenia has shown that the indices calculated for the Alpine domain are relevant on a national level and suitable to use operationally. The linear regression model indicates high correlation, with the values of r2 for both daily index values and monthly mean index values ranging from 0.62 to 0.79.

Validation of ADO SPI (-2, -3) against annual yield data for different crops and grassland types has shown that agreement between the two is greater for regions in the east of Slovenia, including Podravska, and for maize (grain or green) and different grassland types, with linear regression based coefficient r2 ranging from 0.15 to 0.51. The highest r2 value at 0.51 is found between SPI-3 and green maize yield in Posavska region. In contrast to SPEI, SPI shows relatively good agreement with yield data in Gorenjska, which could indicate that in mountainous regions the evapotranspiration component in drought indices is less relevant. Generally, 2-monthly indices show better agreement with annual yield data compared to 3-monthly indices, indicating that 2-monthly indices might be more suitable for monitoring agricultural drought in Slovenia.

Detailed information on the results is available from the project partner Slovenian Environment Agency (contact: ziva.vlahovic@gov.si).

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