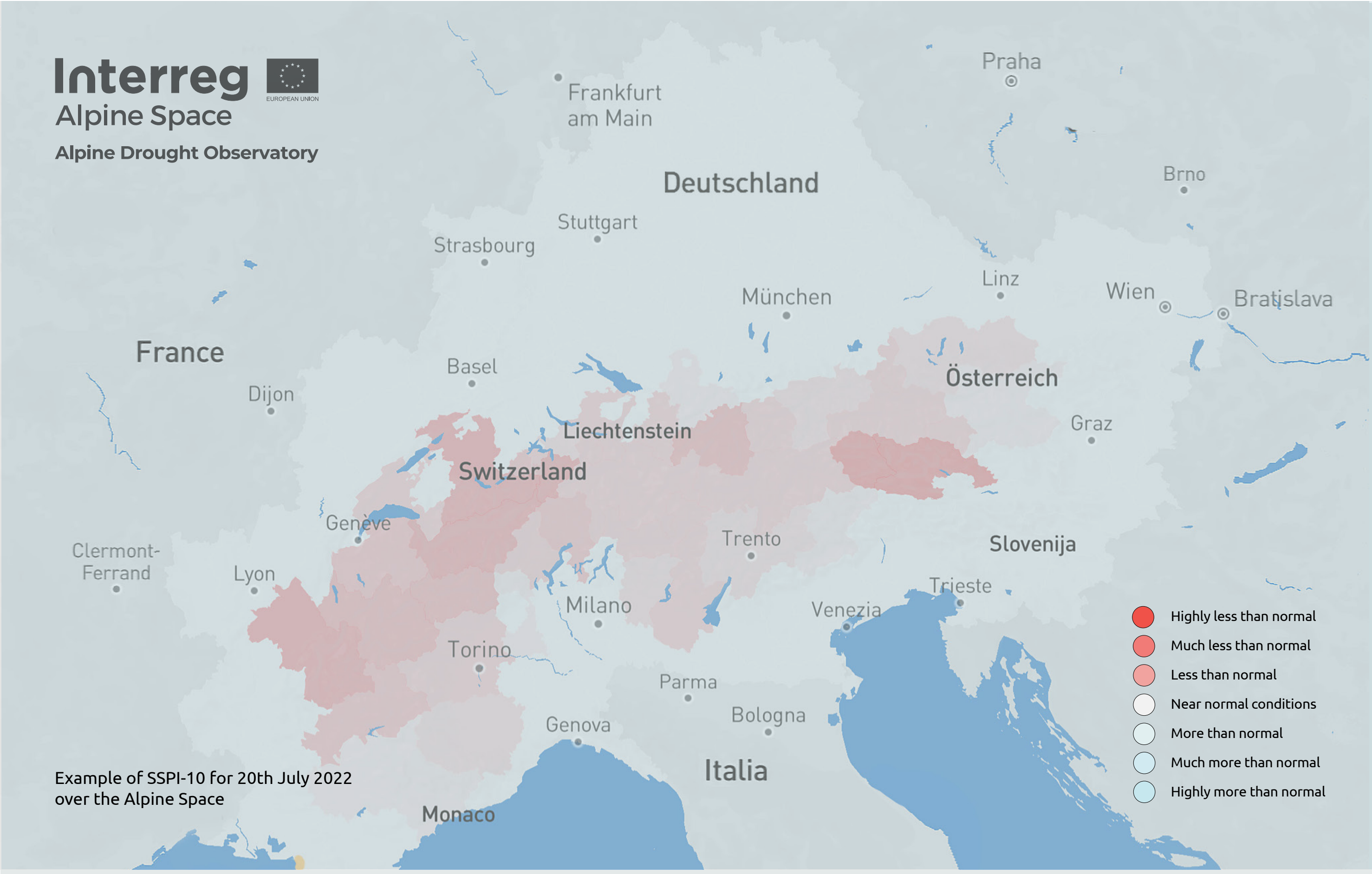
Interreg
Alpine Space
Alpine Drought Observatory



Example of SSPI-10 for 20th July 2022 over the Alpine Space

SSPI

Standardised SnowPack Index

When precipitation falls in the form of snow, water may be stored as snowpack. This decreases runoff and ground water recharge during the winter months and contributes to the increased runoff during the spring and early summer. The Standardized SnowPack Index provides information of the relative volume of the snowpack in the catchment on a ten-daily and monthly basis compared to the period of reference (JRC EDO, 2022). The name of the index is modified to include the averaging period in days. SSPI-10, for example, refers to averaging period of 10 days (JRC EDO, 2020).

Input variable	Type of drought	Temporal resolution	Spatial resolution	Temporal coverage	Time scale (aggregation period)	Unit
Snow water equivalent	Hydrological	Daily	5 km	1979–present	10 days (SSPI-10) 30 days (SSPI-30)	Unitless / SSPI unit (unit of standard deviation from the long-term mean)

Definition

The Standardised SnowPack Index (SSPI) represents a standardised measure of a certain value of snow water equivalent (SWE) averaged over the selected time period in relation to the expected value for this period. SSPI is computed the same way as the SPI (McKee et al., 1993), except that it is based on daily SWE time series, given in mm in water per square meter (i.e. kg/m2), instead of daily precipitation. For the reference period a probability distribution is fitted to the respective historic data record, which is then transformed into a standard normal distribution such that the mean SSPI value for that location and period is zero. The value of the SSPI index around 0 thus represents the normal expected conditions for the average SWE in the selected period based on the long-term average. The value of 1 represents approximately one standard deviation of the surplus, while the value of –1 is about one standard deviation of the deficit. The SSPI only applies in those regions where snowpack accumulation is regular annually, such as the Alpine region.

Snowpack interacts with droughts in several ways. In the case of meteorological drought, melting of the snowpack can postpone the occurrence of low river flows and thus hydrological drought. Positive SSPI values during late winter and spring indicate low risk of hydrological drought in early summer. In contrast, negative values of SSPI during late winter and spring indicate high risk of hydrological drought in early summer. The SSPI has to be interpreted together with other standardised indices based on precipitation, discharge and runoff (eg. SPI, SDI or SRI). SSPI values might be negative during winter, but the risk of drought during spring and early summer is not high if the SPI, SDI or SRI are showing high positive values at the same time (JRC EDO, 2022).

Methodology

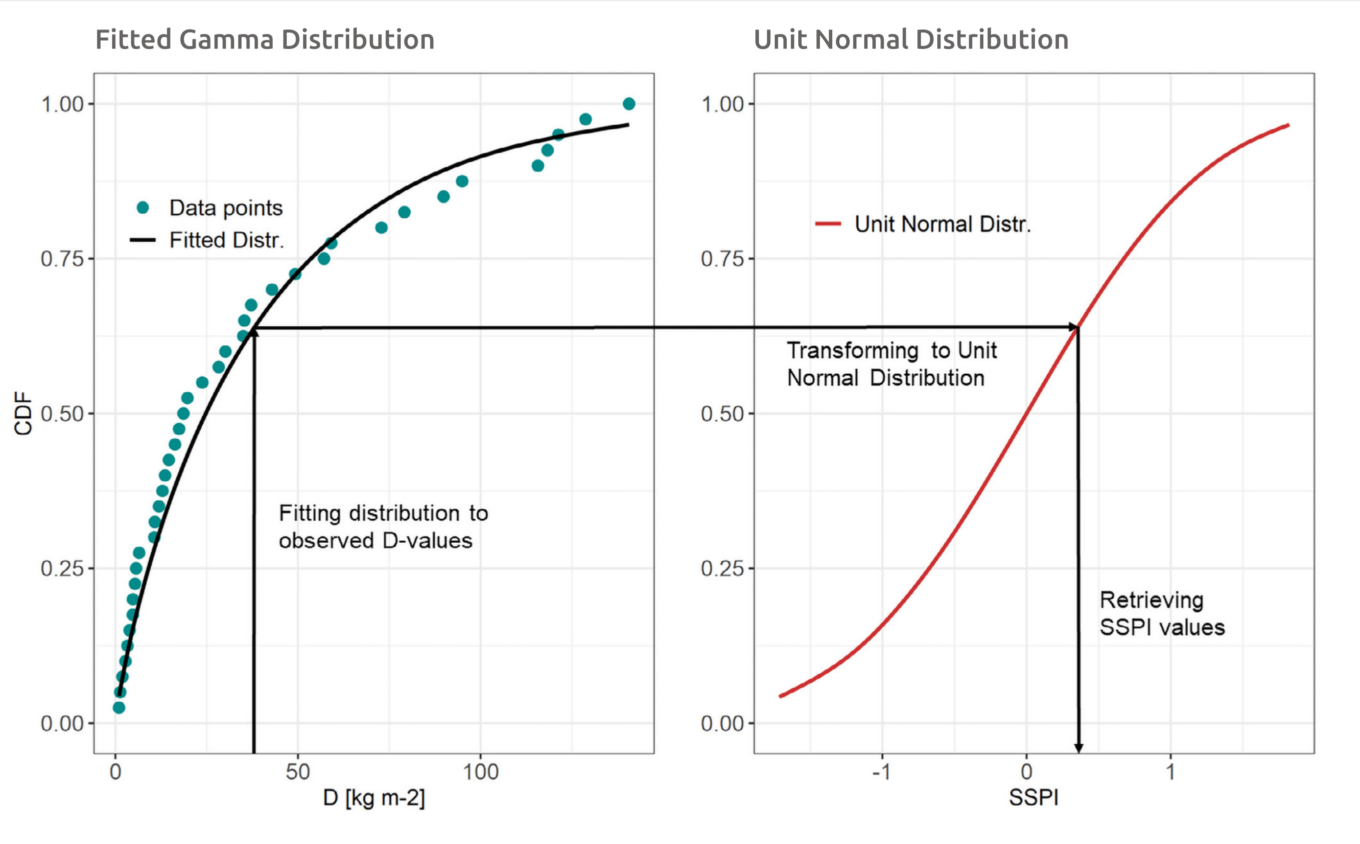
Data source	Data provider	Index provider	Metadata
ERA5 reanalysis (Copernicus) SNOWGRID-CL model (ZAMG)	ZAMG	ARSO	Standardised SnowPack Index

CALCULATION

In the ADO platform, SSPI is calculated daily on two different time scales (10 and 30 days) with limits set between –5 and 5 (Stagge et al., 2015), using 1981–2020 as the reference period for distribution fitting. In contrast to SPI and SPEI, where the sum over a selected time period is considered, SSPI is based on the average value of SWE over the selected time period. The time scale (averaging period) corresponds to the length of the rolling time window over which the mean SWE is calculated: 10 days for SSPI-10 and 30 days for SSPI-30. Periods of 10 and 30 days are used to consider both the fast and slow impact and response of downstream water supplies. However, as snowpack is often accumulated over longer time periods (e.g. over the complete winter season), the different time periods are more relevant for lower elevation areas with low and intermittent snowpack.

In order to compute the SSPI for a time scale of interest, a two parameter continuous probability distribution known as the “gamma distribution” is fitted to the SWE data in the reference period, averaged over the selected time scale. The probability distribution is fitted using the centre of probability mass, as implemented in the SCI R package (Gudmundsson, Stagge, 2016) to account for regions and seasons with predominantly zero average SWE over the selected time period.

For any observed 10 or 30 day average SWE value, the cumulative probability is derived, based on the parameters of the gamma distribution. The cumulative probability of the observed average SWE value is then expressed as a quantile of the standard normal distribution with mean value 0 and variance value 1. This value is the SSPI. SSPI cannot be derived for parts of the Prealpine region, particularly in the warm period of the year, due to a smaller non-zero SWE data sample.



Schematic representation of the calculation steps for the SSPI on a time scale of 1 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 of the year.

INPUT DATA

A modified version of the deterministic snow model SNOWGRID-CL (Olefs et al., 2020) was used to derive daily fields of SWE in the Alpine Space domain. In order to run the model, the meteorological datasets downscaled from ERA5 (total precipitation, temperature, wind speed, relative humidity and solar radiation) (Hersbach et al., 2018) had to be extended by several additional input datasets and static fields, including static albedo, radiation, digital elevation model and maximum temperature. Model performance was evaluated and pixels masked, wherever the model is not applicable (e.g. at glaciers).

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 the period 1981–2020 as reference where possible (depends on data availability). The reference period for calculating SSPI is 1981–2020.

Index values and thresholds

In the ADO platform, the SSPI values range from −5 to 5. For any given location and time scale, they are classified into seven different categories, as shown in the table. These also represent the commonly used thresholds for identifying drought through SSPI.

SSPI value thresholds	Classification	Probability of event [%]
SSPI < −2.00	significantly lower than normal	2.3
−1.99 < SSPI < −1.5	much lower than normal	4.4
−1.49 < SSPI < −1	lower than normal	9.2
−0.99 SSPI < 0.99	near normal	68.2
1. < SSPI < 1.49	higher than normal	9.2
1.5 < SSPI < 1.99	much higher than normal	4.4
SSPI > 2.00	significantly higher than normal	2.3

Source: JRC EDO, 2020.

Key strengths and weaknesses

+ Index gives an indication of future development of downstream discharge, runoff and ground water recharge through information on the relative amount of water stored in the snowpack.

- Index is not relevant for warm seasons and regions where snowpack is not regular annually, such as the Prealpine region.
- Input variable to SSPI (SWE) depends on several different meteorological variables, which increases its uncertainty. The variable has to be modelled, which is more computationally expensive.
- Model limitations also introduce uncertainties and influence the representativeness of SWE. In addition, SWE cannot be derived well for certain areas (eg. glaciers). A mask has to be applied in the post-processing to exclude certain grid cells from the calculation of the SSPI.

References

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