INDICATOR FACT SHEET

SSPI: Standardized SnowPack Index

Indicator definition

The availability of water in rivers, lakes and ground is mainly related to precipitation. However, in the cold climate when precipitation falls in the form of snow, water is stored in the snowpack and this will decrease runoff and ground water recharge during the winter months and, on the other hand, contribute to the increased runoff during the spring and early summer. Changes in this pattern may cause serious shortfalls in the availability of water. The warming climate is predicted to decrease snowpack, cause snowmelt during winter and decrease the springtime snowmelt. Also the expected increased variation in the climate pattern will cause grater variations in the snowpack. Lack on snowmelt can increase possibilities for drought during the spring and early summer, which is an important growing period for plants and crops.

The SSPI is computed the same way as the SPI (Standardized Precipitation Index), except for being based on the daily snowpack water equivalent (=kg/m^2 of snow) time series. The SSPI 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.

The indicator can be used for awareness raising, evaluation of occurred droughts, forecasting future drought risks and management purposes.

Relevance of the indicator to Drought

Snowpack in river basins changes in response to air temperature and precipitation. Snowpack is a natural water reservoir which human cannot control. In the northern parts of Europe and in the mountains snowpack is an essential part of water cycle.

Snowpack indicator only applies in those regions where snowpack accumulation is regular annually. These regions in the EU are mainly the Nordic countries, the Alps, the Pyrenees and the Carpathian Mountains. Nevertheless, the impact of snowpack to the hydrology is not limited only to these regions. Several large Central Europe rivers' flow, e.g. the Rhein, partly depends on the melting snowpack of the Alps. The snowmelt increases streamflow and improves water balances in reservoirs and aquifers. This has great significance for all water uses during spring and summer when precipitation in often scarce and the need of water is high, particularly for agriculture.

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 indicates low risk of hydrological drought in early summer. On the contrast, negative values of SSPI during late winter and spring indicate high risk of hydrological drought in early summer. The SSPI indicator needs to be used hand in hand with SPI and SRI indicators: e.g. SSPI values might be negative during winter, but still the risk of drought during spring and early summer is not high if the SPI and SRI indicators are at the same time showing high positive values.

It is also possible that early snowpack prolongs hydrological drought; e.g. if winter comes early during ongoing drought, rainfall won't increase runoff, streamflow and groundwater recharge since the rain is stored into the snowpack. Thus positive values of SSPI during autumn and winter may indicate hydrological drought if the summer has been dry.

The relevance of the SSPI indicator to drought varies around Europe and it is not only related to the regularity of snowpack accumulation but also to the hydrological differences between river basins (e.g. size, number of lakes and reservoirs, etc.).

In addition the indicator is extremely relevant to flood risk management in forecasting the spring floods at least in Northern parts of Europe.

Policy relevance

Water Framework Directive WFD (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy)

- Environmental objectives: Exemption for temporary deterioration in the status (Art. 4 (6))
- Programme of measures: Additional measures are not practicable (Art. 11 (5))

Communication of the EC to the Council and European Parliament: “Addressing the challenge of water scarcity and droughts in the European Union” (published on July 2007)

- Improving drought risk management
- Developing drought risk management plans (Paragraph 2.3.1.)
- Developing an observatory and an early warning system on droughts (Paragraph 2.3.2.)
- Use of the EU Solidarity Fund (Paragraph 2.3.3.)
- Improve knowledge and data collection: Water scarcity and drought information system (Paragraph 2.7.1.)

Technical Information

1. Indicator

The SSPI is similar to the SPI, SRI and fAPAR indicators. The SSPI is computed the same way as the SPI, except for being based on the daily snowpack water equivalent (SWE) time series. The Standardized Snowpack Index (SSPI) gives snowpack values as standardised values between -3 to 3 calculated from snowpack values water equivalent in mm in water (=kg/m^2 of snow). The intensity of snowpack is classified into the following seven categories:

SSPI Values	**Category**	**Cumulative Probability**	**Probability of Event [%]**
SSPI ≥ 2.00	Highly more than normal	0.977 – 1.000	2.3%
1.50 < SSPI ≤ 2.00	Much more than normal	0.933 – 0.977	4.4%
1.00 < SSPI ≤ 1.50	More than normal	0.841 – 0.933	9.2%
-1.00 < SSPI ≤ 1.00	Near normal	0.159 – 0.841	68.2%
-1.50 < SSPI ≤ -1.00	Less than normal	0.067 – 0.159	9.2%
-2.00 < SSPI ≤ -1.50	Much less than normal	0.023 – 0.067	4.4%
SSPI < -2.00	Highly less than normal	0.000 – 0.023	2.3%

2. Spatial scale

Regional data; modelled for 25 km x 25 km grids in the catchment (soon 10 km X 10 km). The model uses remote sensing from the satellites.

The SSPI can be calculated for any given area in Europe, e.g. river basin district, river basin or sub-basin.

3. Temporal scale
Daily values. Remote sensing gives real time observations once a day.

4. Methodology

a. Detailed methodology for the calculation of the indicator
Detailed guidelines on the methodologies to model snowpack water equivalent (SWE) values in the catchment can be obtained from the Finnish Meteorological Institute FMI (see par. 5.).

The SSPI is calculated using the same methodology as in the SPI to define the SSPI as the unit standard normal deviate associated with the percentile of snowpack accumulated over a specific duration. Computation of the SSPI involves fitting a probability density function (PDF, e.g. gamma PDF) to a given frequency distribution of daily snowpack. As in the same case of SPI, the PDF parameters are then used to find the cumulative probability of an observed snowpack. This probability is then transformed to the standardized normal distribution with mean zero and variance one, which results in the value of the SSPI.

The mathematical formula to calculate the SSPI is:

$SSPI_{y,d,k}$ is the average *k*-day (*k* = 10 or 30) Standardized Snow Pack Indicator for day *d* year *y*:

$$SSPI_{y,d,k} = \frac{SWE_{y,d,k} - SWE_{avg,d,k}}{SWE_{std,d,k}}$$

where $SWE_{y,d,k}$ is the *k*-day SWE for year y and day d, and $SWE_{avg,d,k}$ is the k-day average SWE for day d based on years 1979-2010:

$$SWE_{y,d,k} = \frac{1}{n} \sum_{i=d-(k-1)}^{n=k} SWE_{y,i}$$

$$SWE_{avg,d,k} = \frac{1}{n} \sum_{i=1979}^{n=32} SWE_{i,d,k}$$

and $SWE_{std,d,k}$ is the standard deviation of *k*-day SWE for day d from years 1979-2010

$$SWE_{std,d,k} = \sqrt{\frac{1}{n-1} \sum_{i=1979}^{n=32} \left(SWE_{i,d,k} - SWE_{avg,d,k}\right)^2}$$

The SWE data is provided and the SSPI is calculated by the FMI for whole EU.

b. Reference period for calculating the Statistics

The SWE data is available as daily values since 1979. Reference period 1979-2010 is used.

5. Data source and frequency of data collection

European Space Agency's (ESA) GlobSnow project led by the Finnish Meteorological Institute (FMI) has developed and provides snowpack water equivalent (SWE) values for the whole Northern Hemisphere. The SWE data is based on passive microwave radiometer data combined with ground-based synoptic snow observations. The SSPI is calculated based on SWE values by the FMI for the whole EU.

For more information, contact the FMI:
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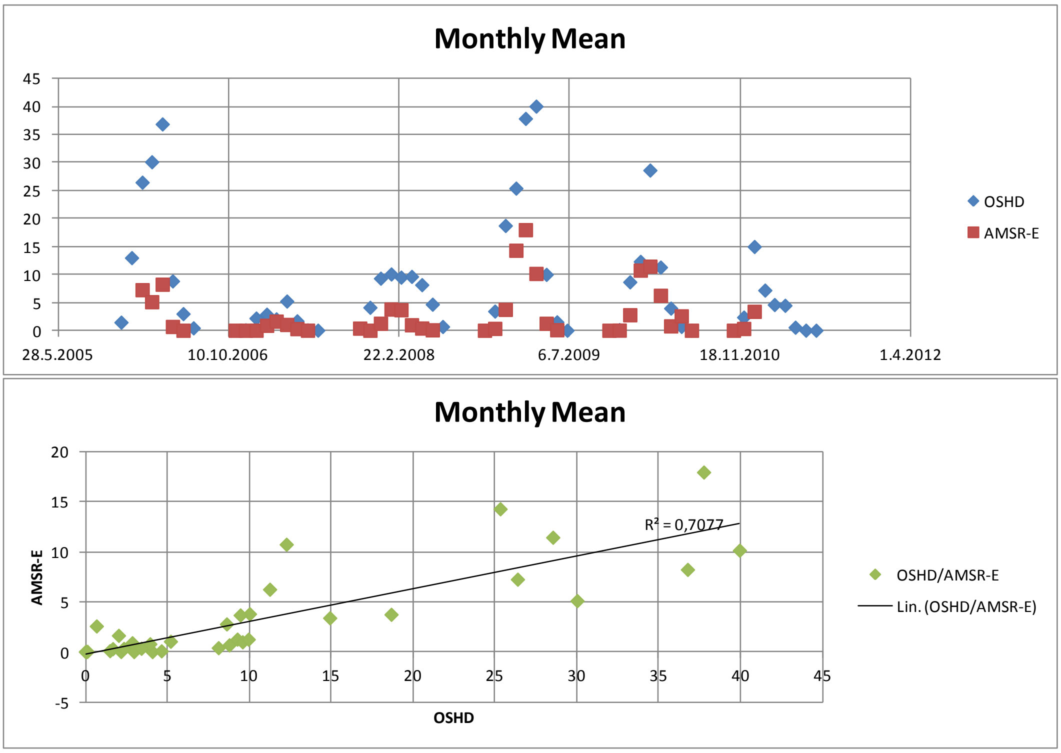
www.globsnow.info

6. Quality Information

a. Strength & weaknesses at data level

Strength of the data is that it presents only natural variation since there is now human abstraction from the snowpack. It is also strength that the data is congruent throughout the Europe since the data is collected through same methodology.

The weakness of the data is that there are still some difficulties to estimate the snowpack in the mountains. Improvements regarding this issue are being made to the product (e.g. going from 25 km grids to 5 km grids). Testing of the data together with the Swiss snowpack data (done together with the WSL Institute for Snow and Avalanche Research SLF) shows that the GlobSnow data underestimates the actual snowpack in the mountains during high snowpack occurrence. Otherwise the data has consistent behaviour and it is suitable for detection of anomalies. The data is suitable for the calculation of the SSPI indicator since the indicator is calculated as anomalies from the time series (probabilities) and not as specific values of snowpack (cp. SPI).



Testing exercise of the GlobSnow data (AMSR-E) compared to the Swiss data (OSHD) of monthly mean snowpack values (mm of water) over Switzerland.

b. Performance of the indicator

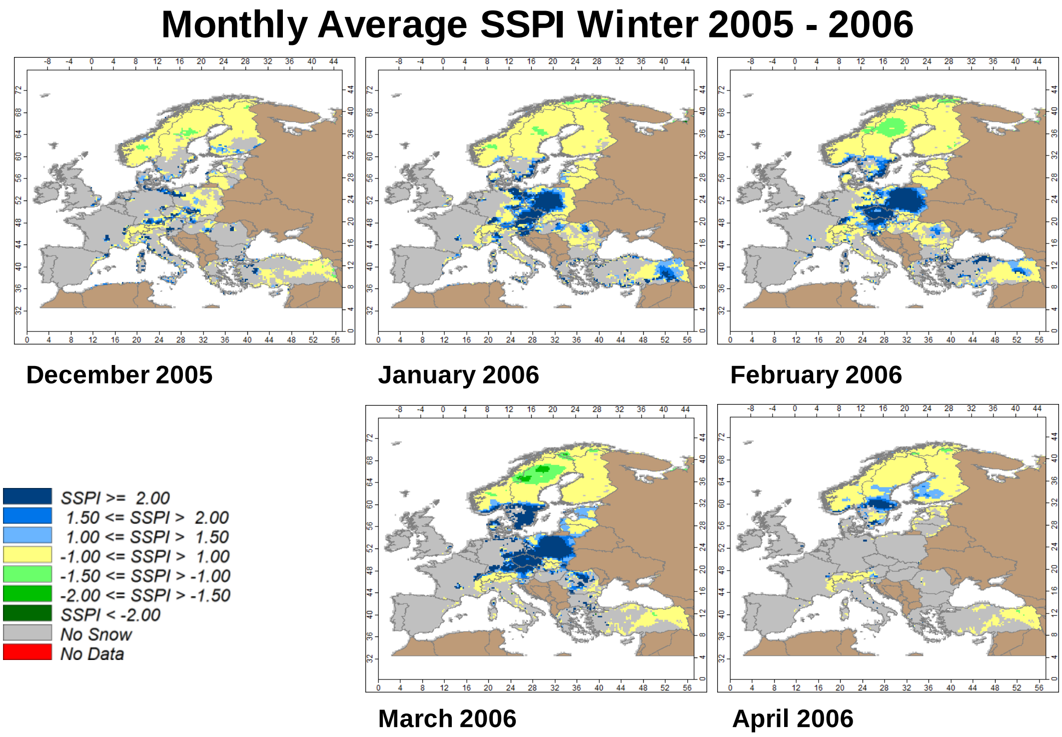
This indicator is already available and calculated automatically daily for the whole Europe by the FMI.

The use of the indicator is straightforward, but the indicator is not comprehensive to assess or to forecast droughts by itself, since runoff from the snowpack is only part of the whole runoff of the catchment area. The SSPI needs to be used hand in hand with SPI and SRI.

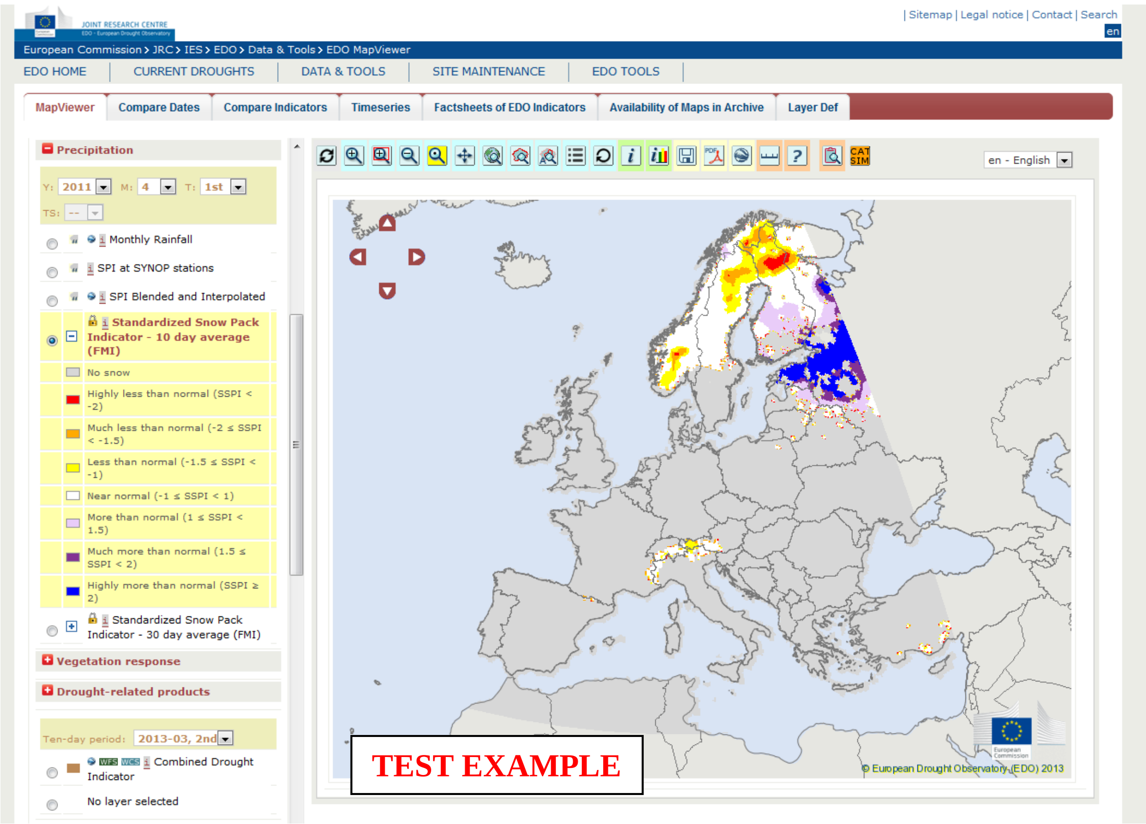
Products

SSPI can be presented in the form of maps and graphs, providing information both on the spatial distribution of the snowpack and the temporal evolution over longer time periods. Gridded data can easily be aggregated over administrative or natural entities such as hydrological watersheds, RBD's, etc. This allows for the qualitative and quantitative comparison of the intensity and duration of this pressure on water resources with recorded impacts such as yield reductions, low flows, or lowering of groundwater levels, for example.

Example of a monthly Standardized Snowpack Index SSPI for the EU as grid data, Winter 2005 – 2006:



The SSPI is under the process to be put into the European Drought Observatory (EDO) so that it can be viewed through same map server as the already existing EDO indicators SPI, fAPAR and Soil moisture. First example of the SSPI displayed in EDO (note that this is just a test display produced in order to develop the online data transfer between FMI and EDO):



References

Pulliainen, J, 2006. Mapping of snow water equivalent and snow depth in boreal and sub-arctic zones by assimilating space-borne microwave radiometer data and ground-based observations. Remote Sensing of Environment, vol. 101, pp. 257-269.

Takala, M., Pulliainen, J.,Metsämäki, S. and Koskinen, J., 2009. Detection of Snowmelt Using Spaceborne Microwave Radiometer Data in Eurasia from 1979 to 2007. IEEE Transactions on Geoscience and Remote Sensing, vol. 47, no. 9, pp. 2996-3007.

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