Testing remotely-sensed Snow Water Equivalent products

in the framework of the operational European Drought Observatory (EDO)

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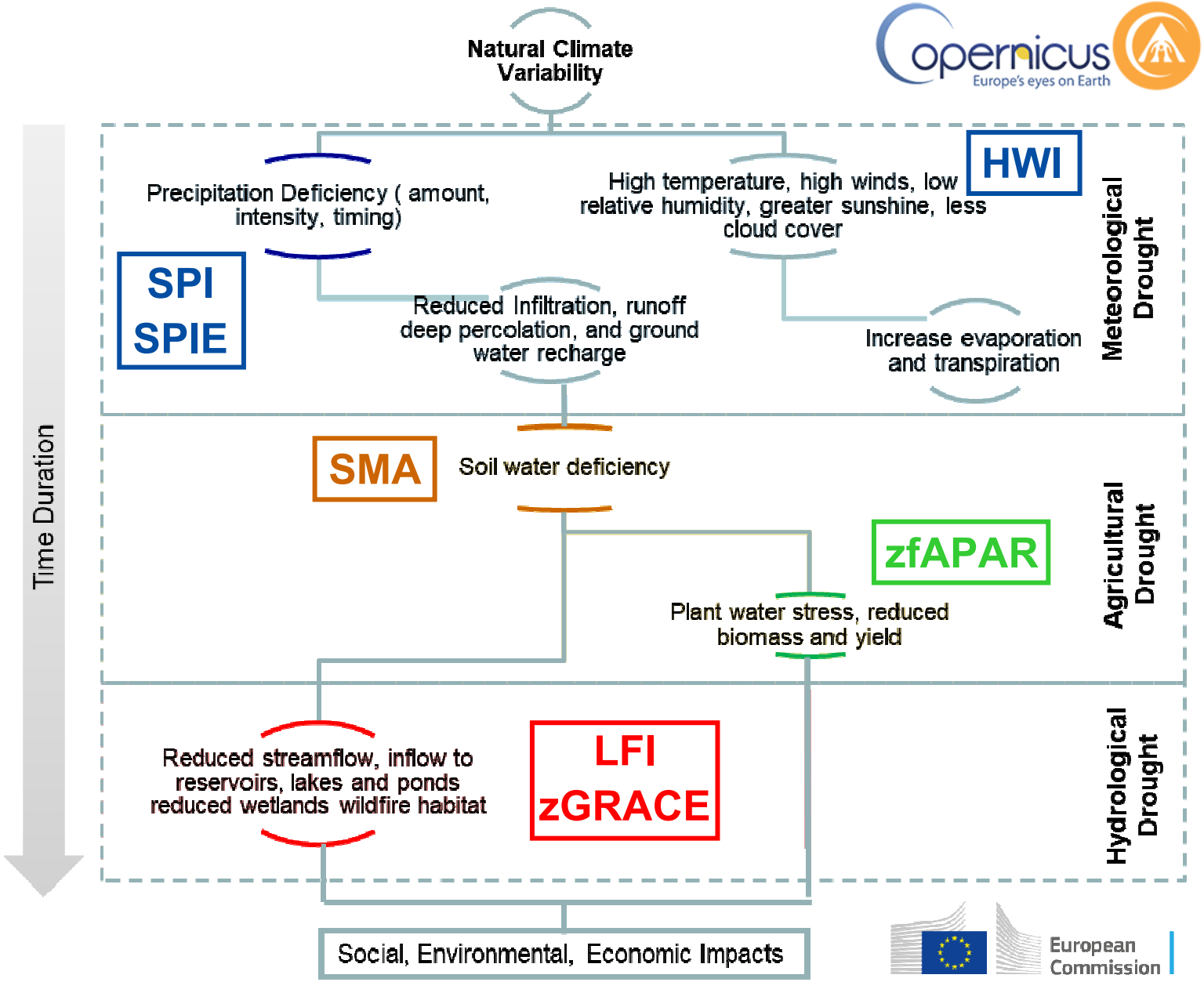
Joint Research Centre

What's in EDO

EDO (edo.jrc.ec.europa.eu) is an early warning, monitoring and forecasting system for droughts and their impacts.

- internet-based system
- multiple indicators
- mapping
- analysis tools
- analytical reports



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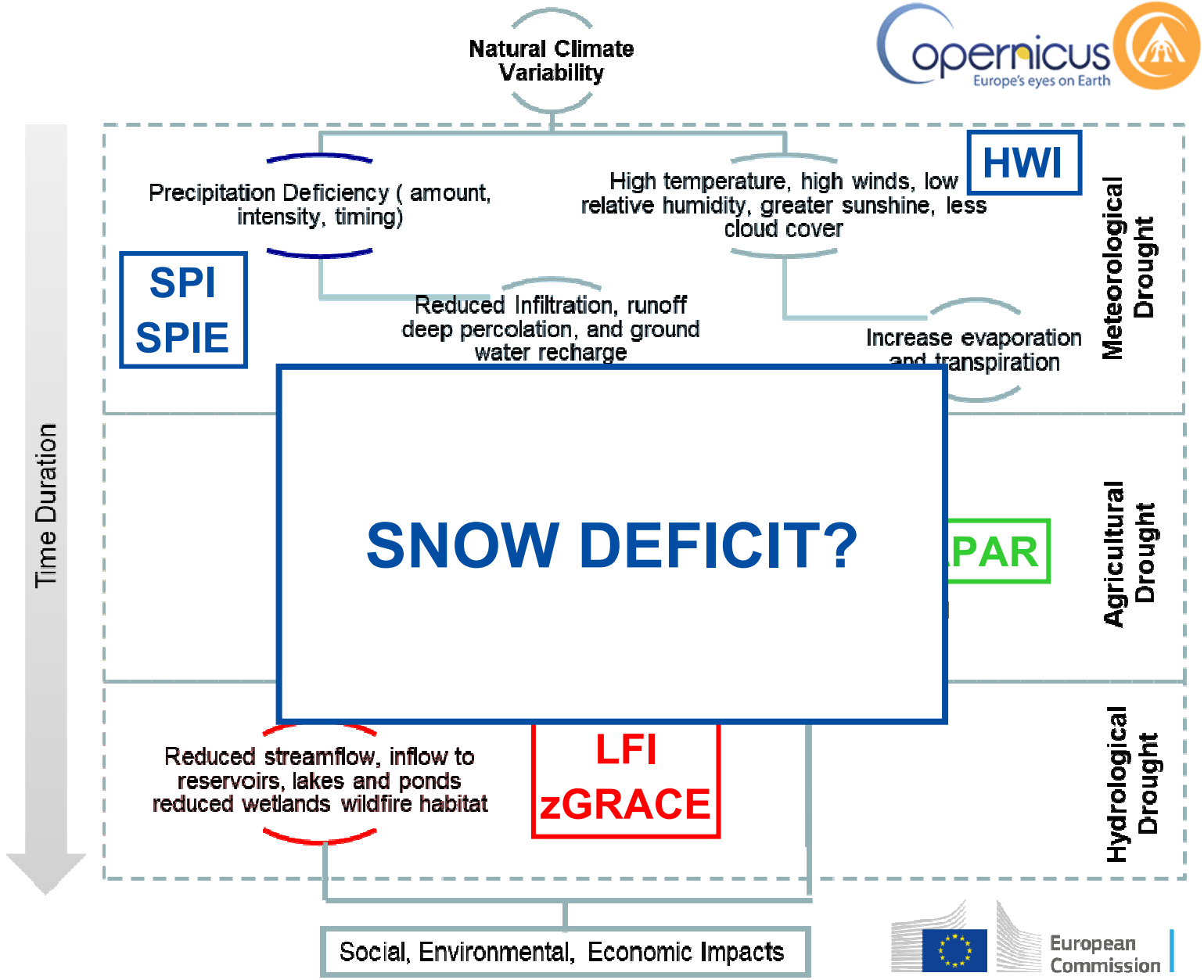


The role of snow in drought

Less than usual snow accumulation (due to either shift from snow to rain or early melting) may affect water availability over areas that rely on snow melting to fill reservoirs and increase streamflow.

Over **Europe** there is a well-defined **snow-season**, roughly **November-March**. This means that snow droughts may be an early sign of upcoming spring or summer droughts.

The Snow Water Equivalent (**SWE**) is a good metric to capture both the so-called “dry” (lack of precipitation) and “warm” (high temperature) **snow droughts**.

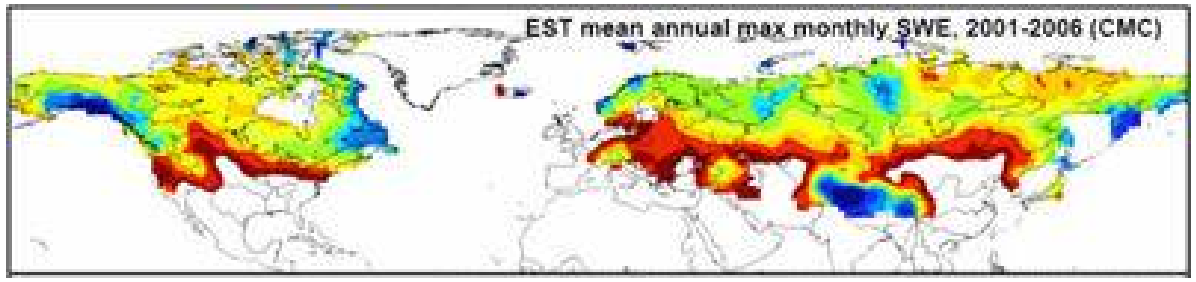
see:
Harpold et al. (2017). EOS Trans. Am. Geophys. Union. doi:10.1029/2017EO068775.

The “Gold Standard” in Snow Water Equivalent (SWE)

SWE represents the depth of water (in mm) that would be produced if the snow melted.

For the Northern Hemisphere, the Canadian Meteorological Centre (**CMC**) product can be considered a reference dataset. It combines in-situ observations with optimal interpolation and first-guess estimations from a snow accumulation and melt model.

- from 1998 to 2019 (22 years).
- monthly average.
- yearly updated.
- from October to June.



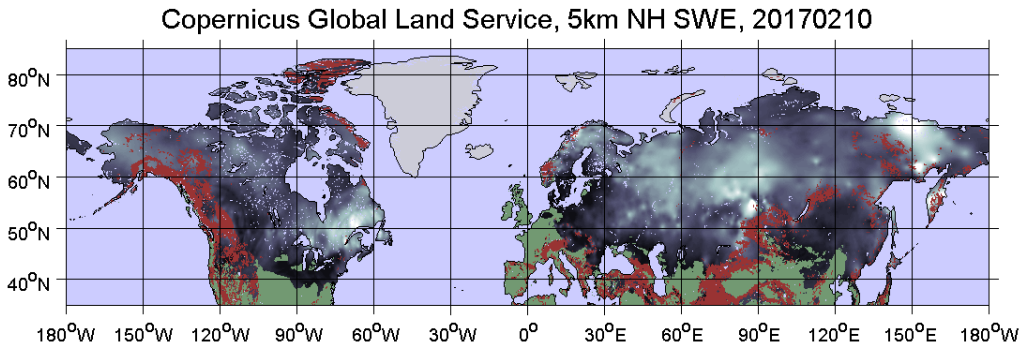
Sample analysis image courtesy of Ross Brown.

Brown, R.D. and B. Brasnett. 2010, updated annually. Canadian Meteorological Centre (CMC) Daily Snow Depth Analysis Data, Version 1. Boulder, Colorado USA. NASA National Snow and Ice Data Center Distributed Active Archive Center. doi:10.5067/W9FOYWH0EQZ3.

Potential candidates for operational snow drought monitoring

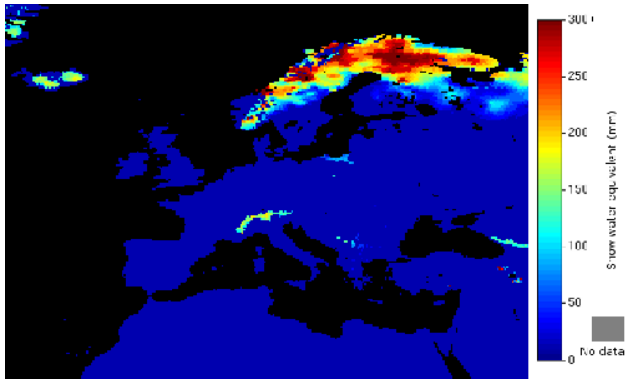
Copernicus GlobSnow

- near-real time
- since 2006
- Northern Hemisphere
- daily
- 5-km spatial resolution



H-SAF SN OBS 4 - H13

- near-real time
- since 2013
- Europe
- daily
- 25-km spatial resolution



Pros and Cons

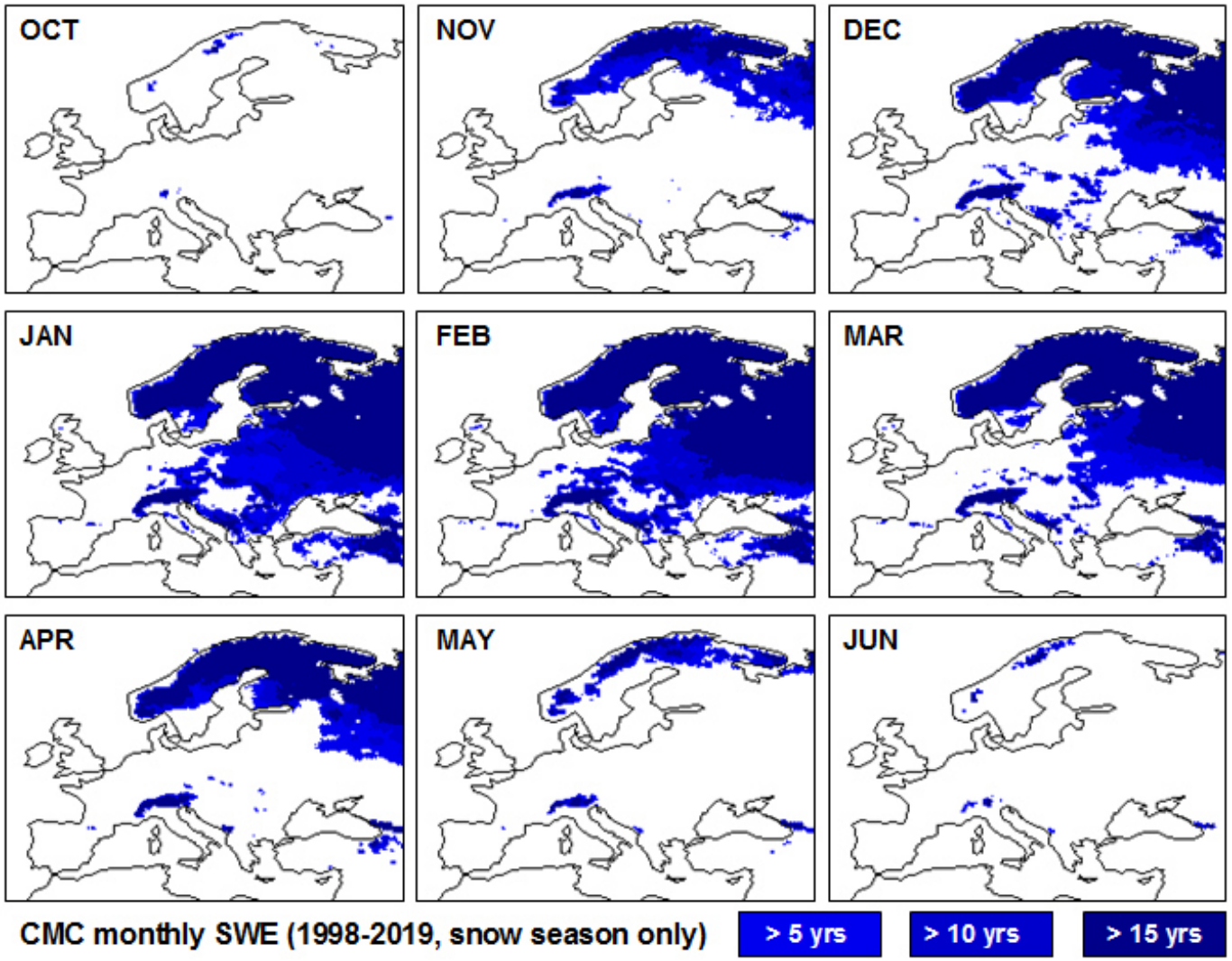
Copernicus GlobSnow

- Assimilation of ground observations by the Finnish Met. Institute.
- high spatial resolution.
- no coverage of mountain areas (defined as slope > 2° in the ETOPO5 relief dataset).

H-SAF SN OBS 4 - H13

- coverage of mountain areas, with a specific method developed by the Turkish Met. Service.
- same as GlobSnow on flat terrains.
- short time series.

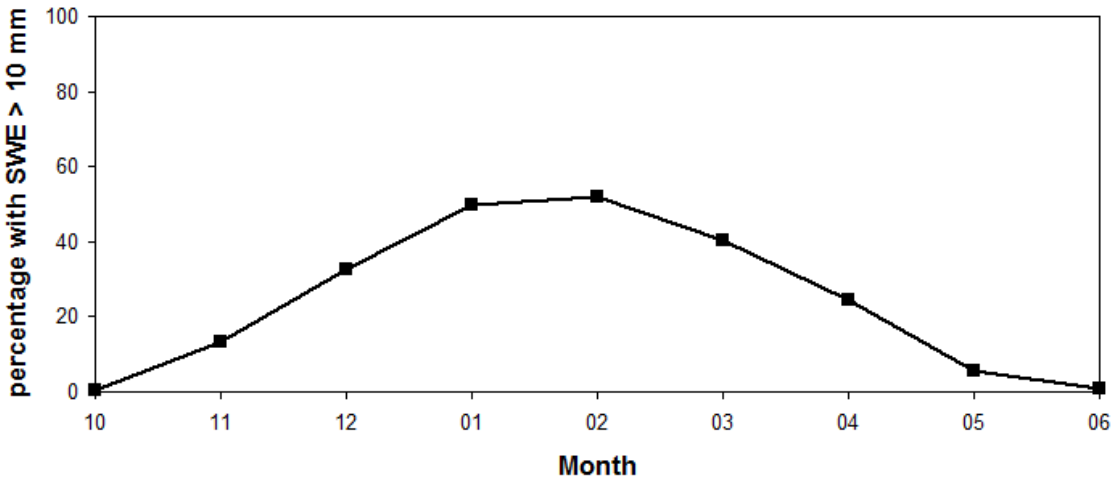
Preliminary comparison – coverage (1/2)



In **CMC** areas with consistent snow (SWE > 10 mm for at least 10 years) are from **November to May**.

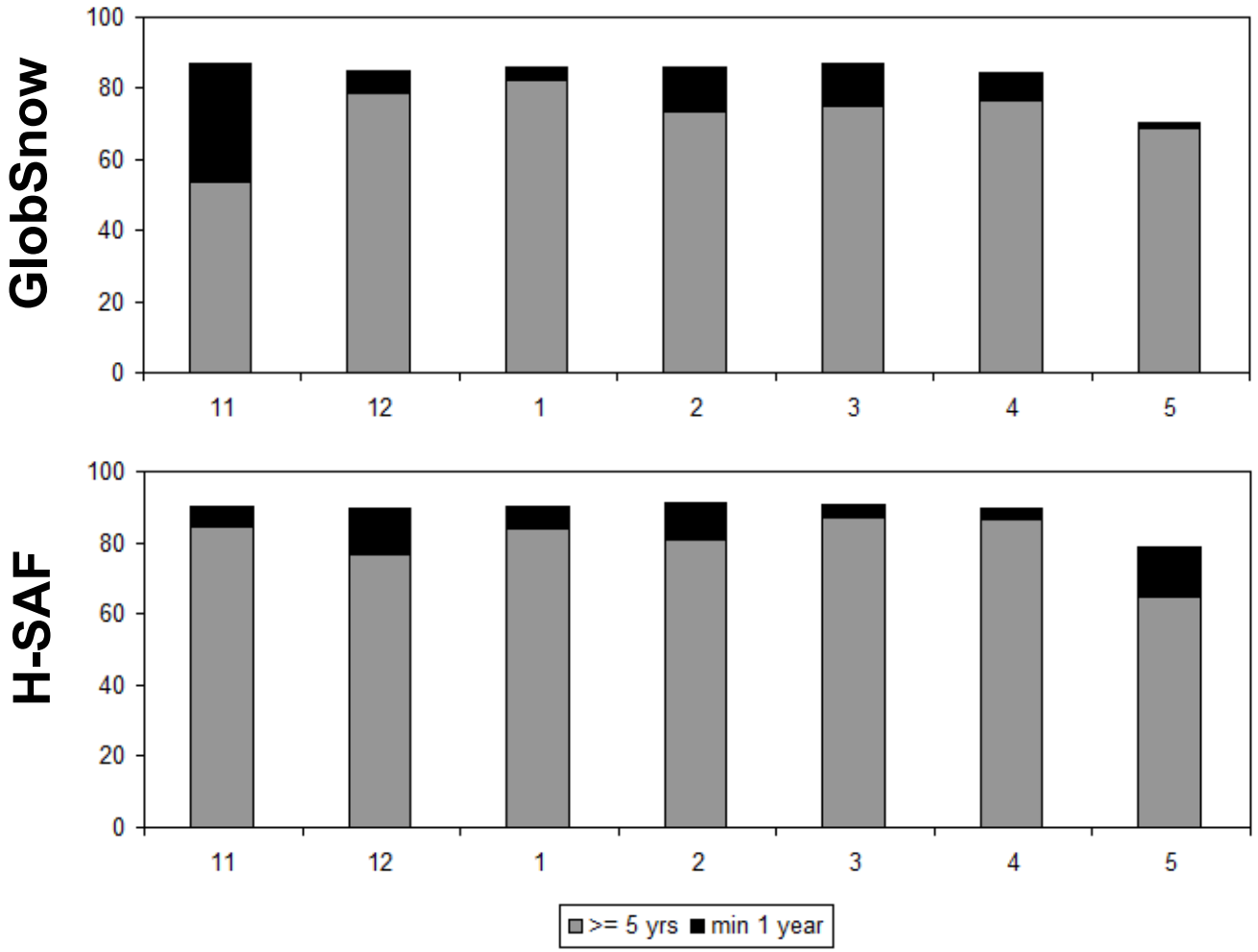
At its peak (**February**), about **50%** of the domain has consistent snow.

In early and late season (e.g., November and May) two main areas can be spotted (**Scandinavia and Alps**).



Preliminary comparison – coverage (2/2)

What snow areas of CMC are also detected by GlobSnow and H-SAF products?



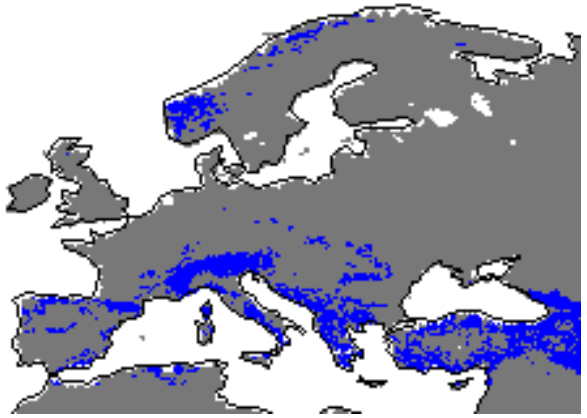
About **70%** and **80%** of CMC are detected by **GlobSnow** and **H-SAF**, respectively, with a **minimum of 5 years** in 2013-2019.

The percentages go up to 85% and 90% with a minimum of 1 year.

Major differences between GlobSnow and H-SAF in early and late season (e.g., November and May).

Discrepancies likely due to differences over **mountain** areas (not modeled by GlobSnow).

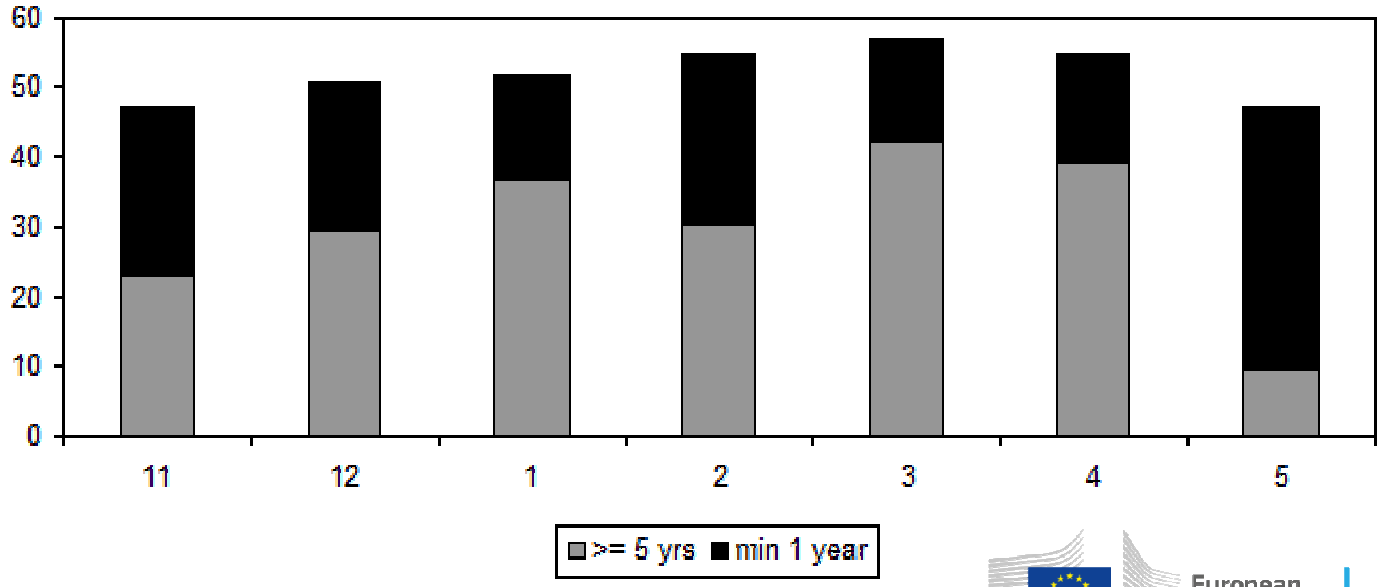
Preliminary comparison - mountains



Mountain mask used in GlobSnow.

Of the **mountain** areas with consistent snow according to CMC (SWE > 10 mm for at least 10 years), about **30%** is also **covered by** the **H-SAF** product (at least 5 years between 2013-2019) and about 50% of the area is covered by a minimum of 1 year.

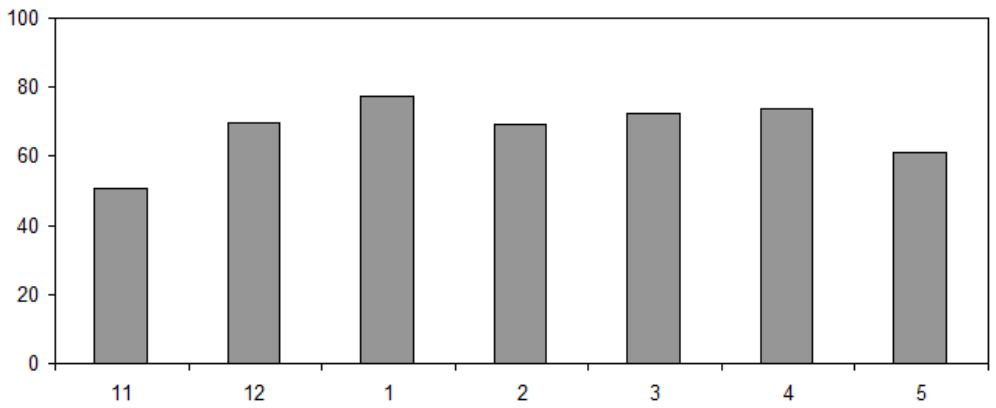
The results are worse than on flat areas, but an improvement over missing values in GlobSnow.



Preliminary comparison - overlap

The areas detected by GlobSnow (70%) and H-SAF (80%) largely overlap. On average, around 67% of the areas detected by CMC as consistently covered by snow is detected by both.

Only less the 5% (on average) of the areas detected by GlobSnow are missing in H-SAF, likely due to the difference in the raw data spatial resolution.



Percentage of the area in CMC with SWE > 10 mm for at least 10 years detected by both GlobSnow and H-SAF.

COMBINED DATASET: GlobSnow (flat areas) + H-SAF (mountain areas)

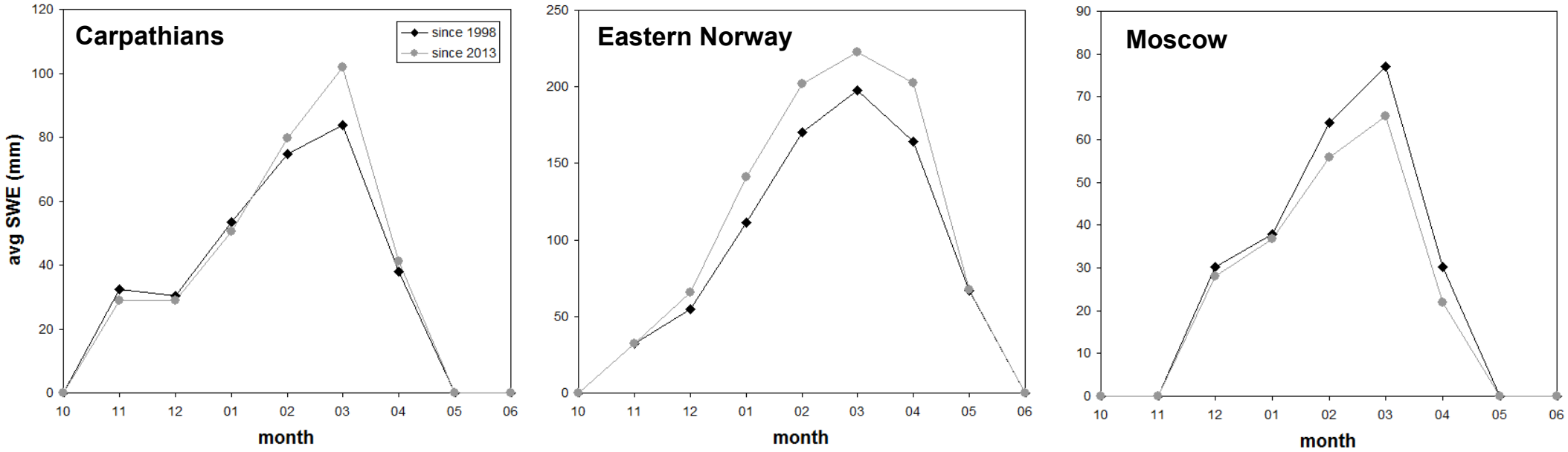
dataset	HSS	POD	POFD
GlobSnow	0.69±0.10	0.72±0.09	0.04±0.03
H-SAF	0.62±0.17	0.81±0.08	0.13±0.04
Combined	0.71±0.11	0.75±0.10	0.05±0.03

HSS: Heidke Skill Score, POD: Prob. of Detection, POFD: Prob. Of False Detection

Preliminary comparison - timeseries

Baseline statistics may differ significantly if a shorter reference period (2013-2019) is used instead of 1998-2019.

The Welch's t-test on the two monthly average datasets identified statistically significant differences ($p < 0.05$, two-sided) only for less that 1.5% of the cells with consistent snow.

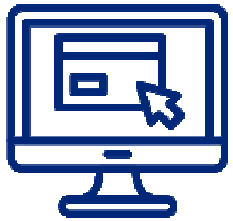


Some example of monthly climatology for the snow season using two different CMC baselines (1998-2019 vs. 2013-2019).

Some final thoughts

- the CMC dataset allows detecting the areas (North-Eastern Europe and Alps) and periods (from November to May) relevant for snow drought monitoring.
- both SnowGlob and H-SAF datasets detect most of the same areas, also thanks to the similarities of the two products over flat terrains.
- the consistent snow areas in mountain terrains not covered by GlobSnow are partially (about 30%) covered by H-SAF.
- a combined product exploiting the high resolution of GlobSnow in flat terrain and the coverage of mountain areas of H-SAF has a good potential for operational monitoring.
- the limited length of a combined time series (only 7 years) does not seem to significantly affect the baseline statistics.

Want to know more?



European Drought Observatory

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Copernicus Europe's eyes on Earth

European Commission