

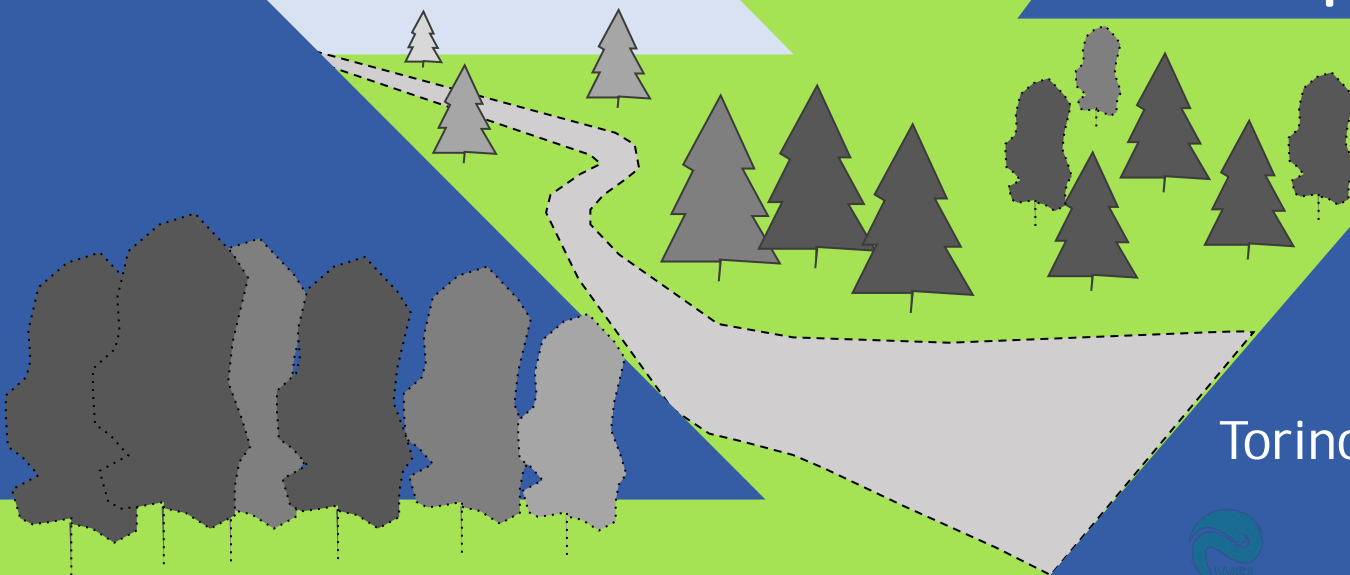
The Alpine Drought Observatory Project ADO WP T1/T2: Monitoraggio meteorologico e idrologico della siccità raccolta e armonizzazione dei dati

G. Bertoldi

in rappresentanza dei teams ADO WP1/WP2

Torino, Secondo workshop Italiano del progetto ADO

1° dicembre 2021



The Alpine Drought Observatory



The project consortium



Duration



Funding

eurac
research

ISKRIVA



Start: October 2019
End: October 2022

Interreg Alpine Space



REPUBLIKA SLOVENIJA
MINISTRSTVO ZA OKOLJE IN PROSTOR
AGENCIJA REPUBLIKE SLOVENIJE ZA OKOLJE

INRAE



The Alpine Drought Observatory



Drought Monitoring

- Drought index analysis
- Data collection

Study of drought impacts

ADO case studies

ADO Platform

Project outputs

- Alpine-wide mapping of meteorological, hydrological and agricultural drought
- Knowledge about the impact of drought
- Methods for assessing drought risk and economic impacts
- ADO web-site
- Recommendations and guidelines for improved drought management

ADO T1 T2 Objective



- to collect a near-real time **alpine-wide harmonized meteo-hydrological dataset**.
- to **review and establish indices** for early detection of drought over the Alpine area, considering the specific requirements related to the mountain terrain;
- to enable a **harmonised view** on the state of soil, vegetation and hydrological conditions across the region.

Output

- Alpine wide mapping of **meteorological, agricultural and hydrological drought**

Collection and harmonization of data



Shivani Anand / EyeEm / Getty Images



Collection and harmonization of data



From reanalysis:

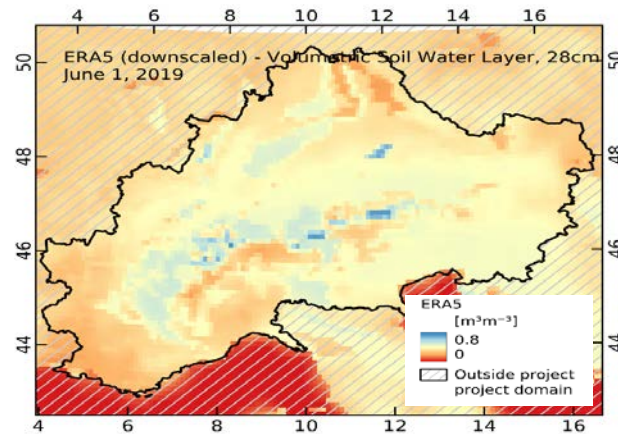
- Total precipitation
- Wind speed
- Relative Humidity
- Temperature
- Solar/Thermal Radiation

Derived variables:

- Potential Evapotranspiration (Penman-Monteith)
- Snow-Water-Equivalent (Snowgrid)

From satellite:

- MODIS optical and thermal imagery
- (soil moisture)



In-situ:

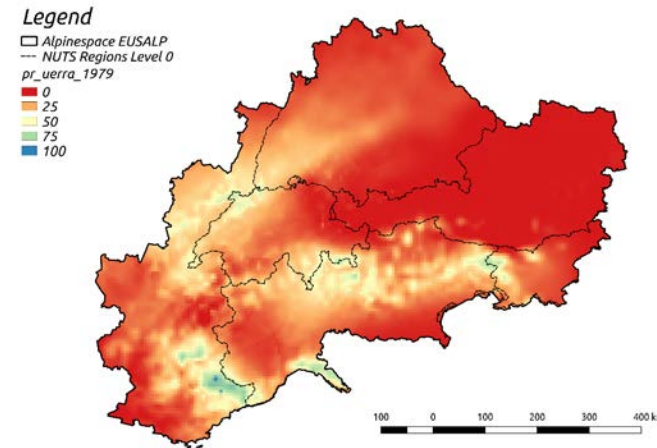
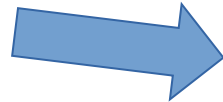
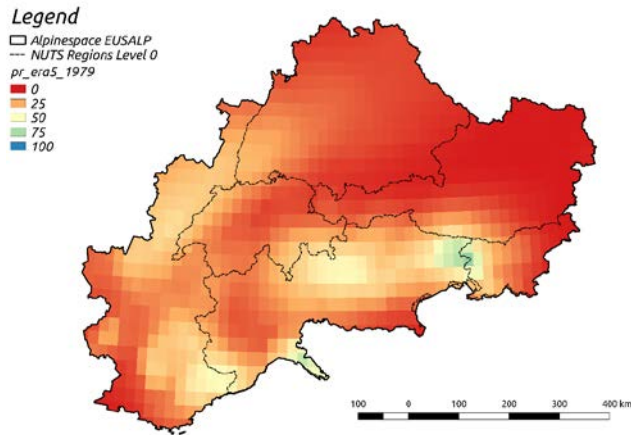
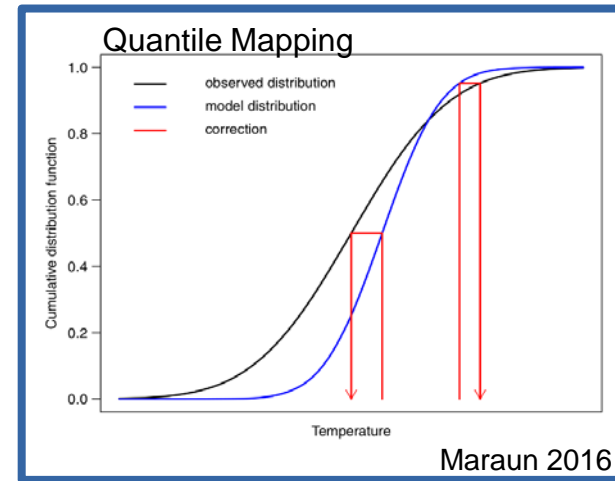
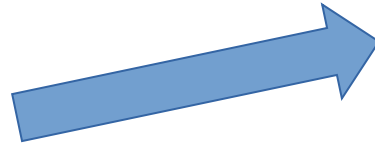
- Alpine wide river gaging data



Downscaling steps applied to the Copernicus ERA5 climate reanalysis ¹:

- Quantile Mapping (QM)
- Scaled Distribution Mapping (SDM) 11 km to 5 km

K. Haslinger, G. Seyerl (ZAMG)



Outputs: Precipitation, Temperature, Potential ET, Snow

¹ <https://climate.copernicus.eu/climate-reanalysis>

Snow cover reanalysis

K. Haslinger, G. Seyerl (ZAMG)

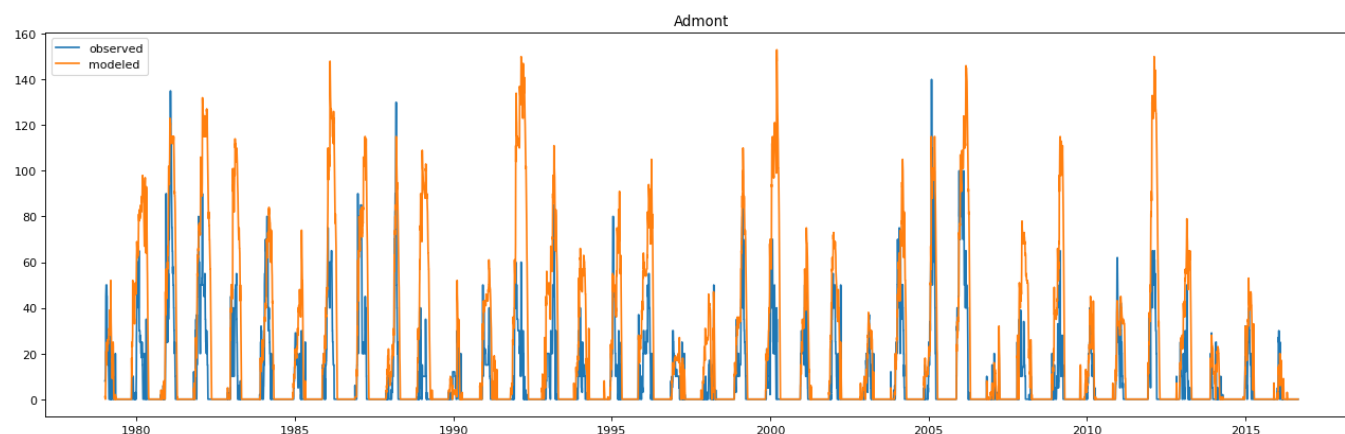
Based on the **SNOWGRID-CL** model ¹

Validation in progress

- License agreements with data providers completed
- Station data provided by EURAC from project **CliRsnow** ²

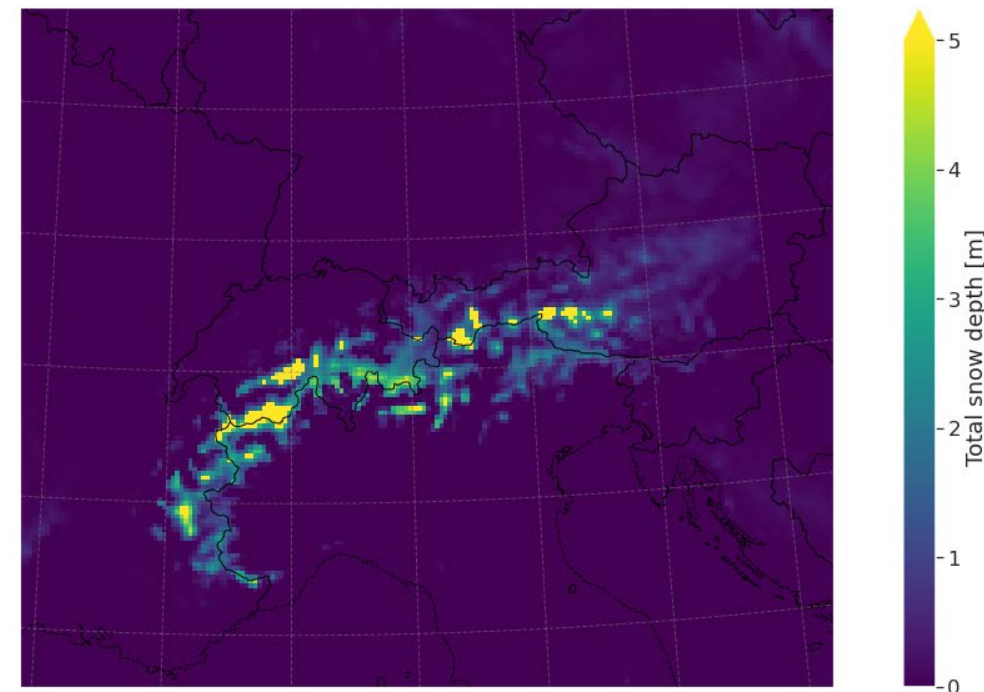
Fine-tuning parametrization

- Accumulation
- Ablation



Total snow depth [m]
2001-01-31

Mean: 0.44, Std: 5.79
Min: 0.00, Max: 258.44



¹ Olefs et al., SNOWGRID – A new operational snow cover model in Austria, 2013

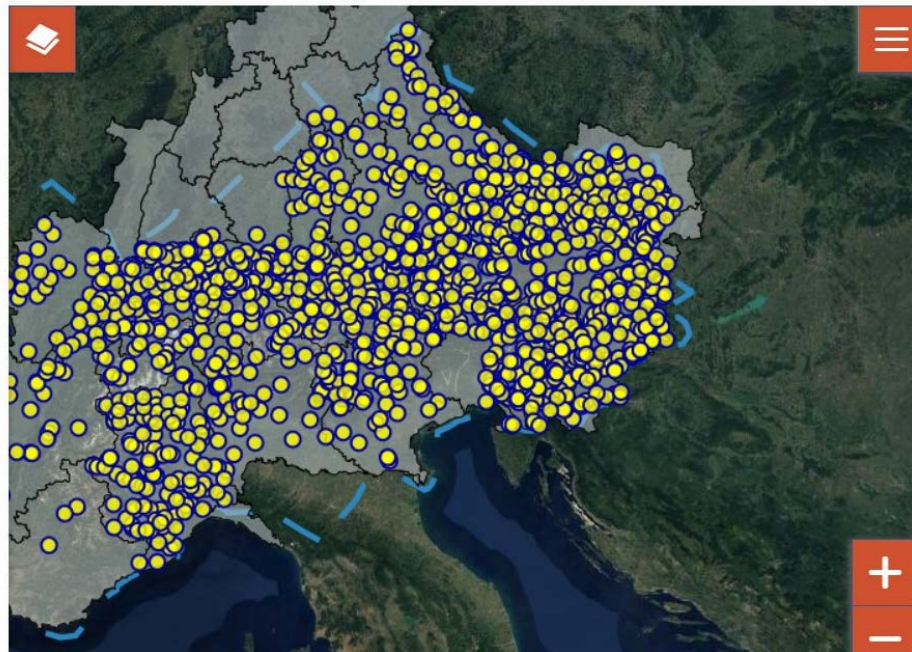
² Matiu, M. et al. Observed snow depth trends in the European Alps: 1971 to 2019. Cryosphere 15, 1343–1382 (2021).

D. Quintero, G. Bertoldi, B. Ventura, A. Vianello (EURAC)

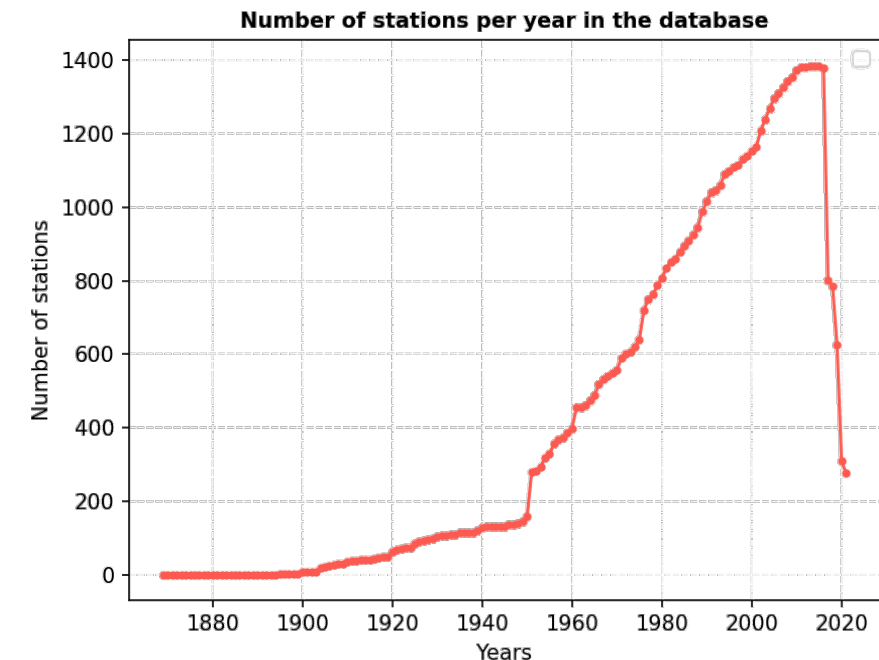
Alpine-wide dataset: discharge, water level, groundwater level, metadata

Problems: **different data providers**, real time data availability

https://edp-portal.eurac.edu/cdb_doc/ado/



Country	Runoff stations
Austria	567
Italy	242
Switzerland	235
Slovenia	185
Germany	129
France	65
TOTAL	1423



T1: Selection of drought indices



A. Susnik and collaborators (ARSO, Slovenia)

First selected indices

Name of the index	What the index focuses on
Precipitation	
Std. Precipitation I. (SPI)	Precipitation
Std. Precipitation-Evapotranspiration I. (SPEI)	Precipitation, evapotranspiration components (temp., wind, solar radiation, relative humidity)
Soil moisture (in general)	
Normalised Difference Vegetation I. (NDVI)	Greenness of vegetation cover
Vegetation Health I. (VHI)	Greenness of vegetation cover, air temperature
Std. Snowpack I.	Snow-water equivalent

Validation of indices with local data
(available over CS areas)

Final selection of indices

- Operationalization
- Selecting further indices (combined indices)






Regional Report on existing monitoring platforms

Commonly used drought indices

Collection of existing and proposed drought-related indicators and indices for potential integration into AQO platform

Indicator/Index	Source	Scale	Frequency	Availability	Relevance	Integration
Precipitation (mm)	ARSO	National	Daily	Yes	High	Yes
Temperature (°C)	ARSO	National	Daily	Yes	High	Yes
Relative Humidity (%)	ARSO	National	Daily	Yes	High	Yes
Wind Speed (m/s)	ARSO	National	Daily	Yes	High	Yes
Solar Radiation (MJ/m²)	ARSO	National	Daily	Yes	High	Yes
Soil Moisture (mm)	ARSO	National	Daily	Yes	High	Yes
Vegetation Index (NDVI)	ARSO	National	Daily	Yes	High	Yes
Snowpack (mm)	ARSO	National	Daily	Yes	High	Yes

Current list of selected indices

ATMOSPHERE		1. Precipitation Anomalies (%)		✓
		2. Standardised Precipitation Index (SPI)	✓	
TOP-SOIL		3. Standardised Precipitation-Evapotranspiration Index (SPEI)		✓
		4. Soil Moisture Anomalies		✓
VEGETATION HEALTH		5. Normalized Difference Vegetation Index (NDVI)	✓	
		6. Vegetation Health Index (VHI)	✓	
SURFACE WATER		7. Standardised Snowpack Index (SSPI)		...
GROUNDWATER		8. Hydrological Indices (SDI, SGI, ...)	...	
+ combined drought index - COMBINING 2 OR MORE TOPICS				
+ integration of impacts				

Precipitation Anomalies



- % of normal precipitation
- **downscaled ERA5 reanalysis** precipitation data
- 5 km spatial resolution
- 1979–present
- daily update, near real-time
- scale of 1, 2, 3, 6 and 12 months
- reference period 1981-2010

Downscaled ERA5 vs. UERRA

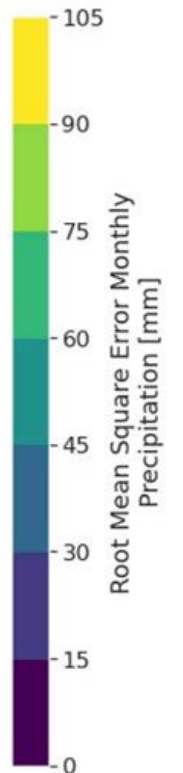
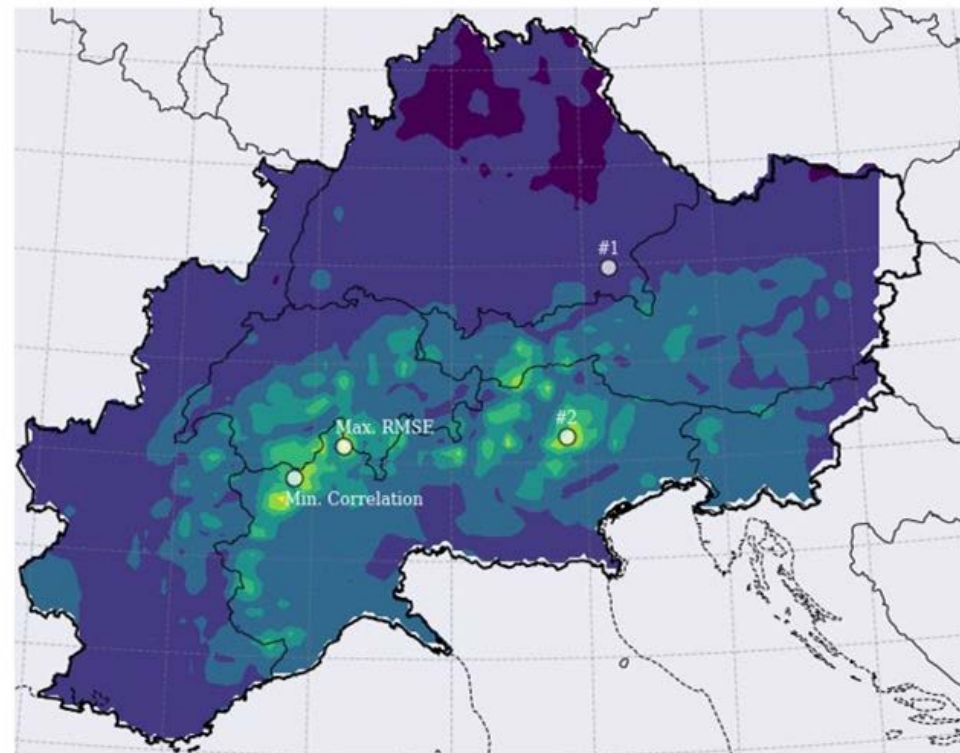
Root Mean Square Error Monthly Precipitation [mm]

Source(s): Quantile Mapped ERA5, UERRA Mescan-Surfex

1979-2018

Mean: 29.35, Std: 11.66

Min: 12.45, Max: 92.86



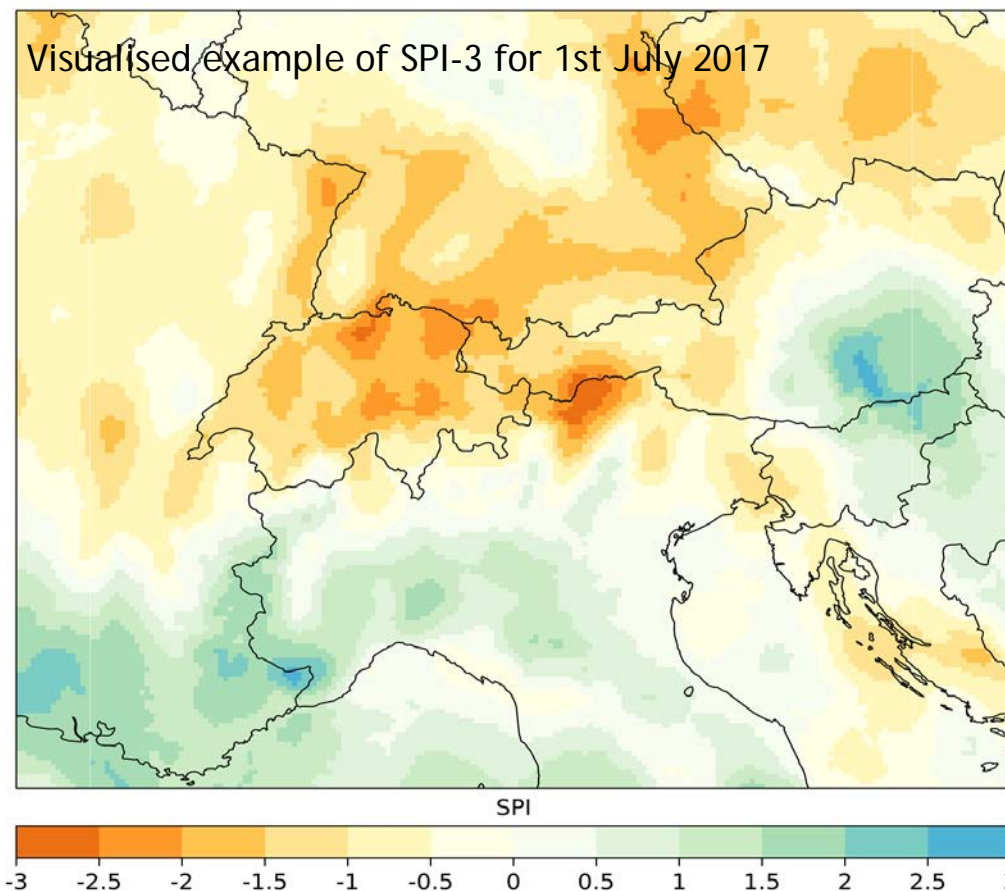
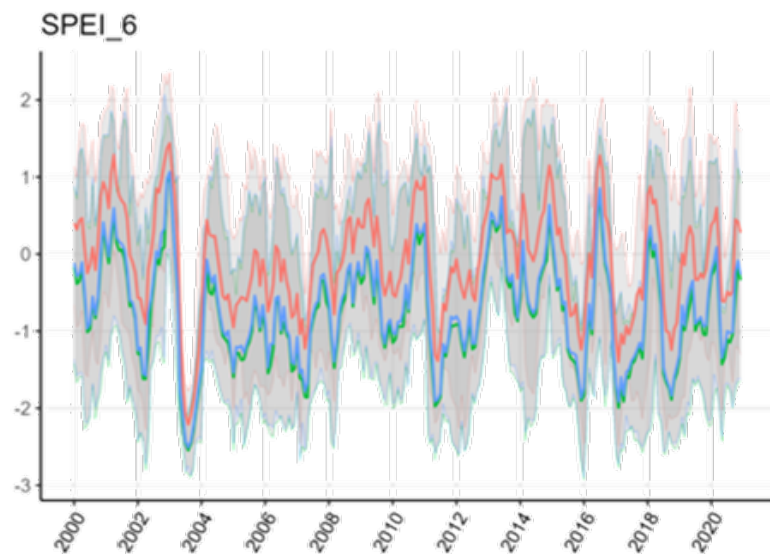


SPI and SPEI



- based on **downscaled ERA5 reanalysis**:
- 5 km spatial resolution
- 1979–present
- daily update, near-real time
- **time scale of 1, 2, 3, 6 and 12 months**
- comparable between different regions

Reference period: 1981-2020



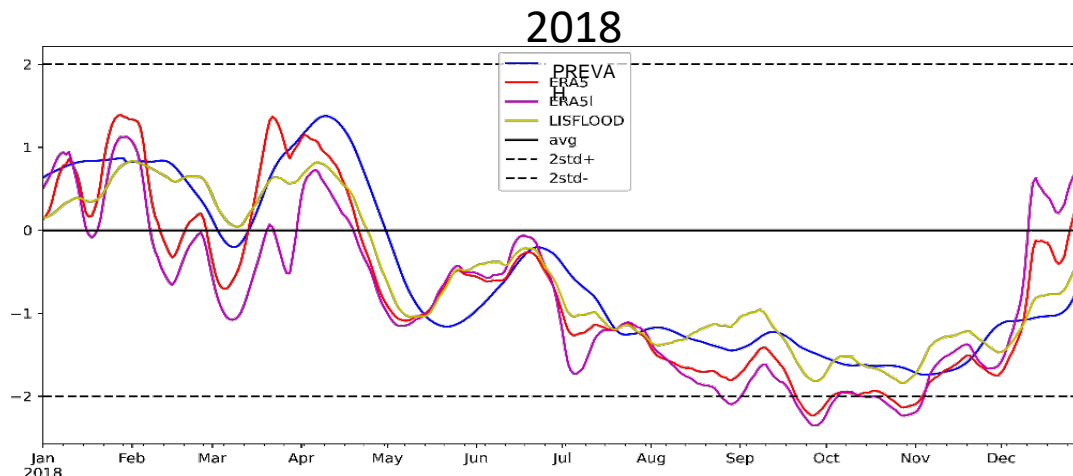
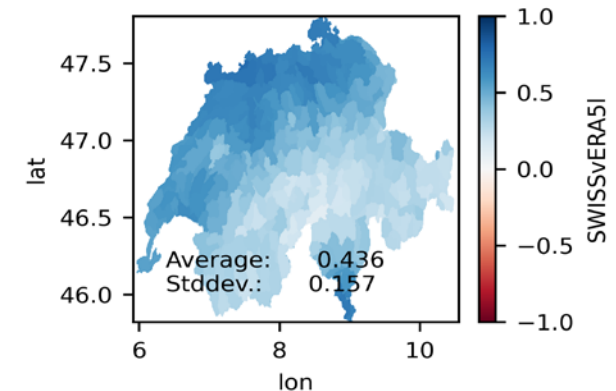
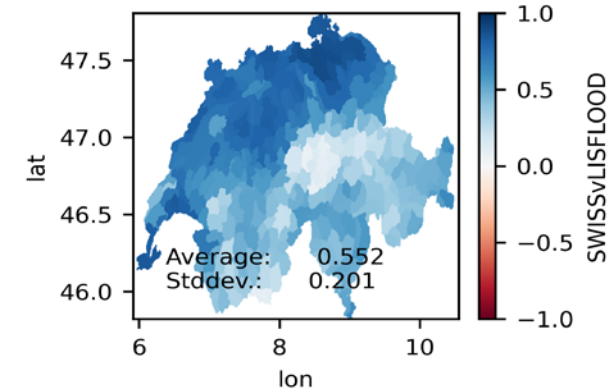
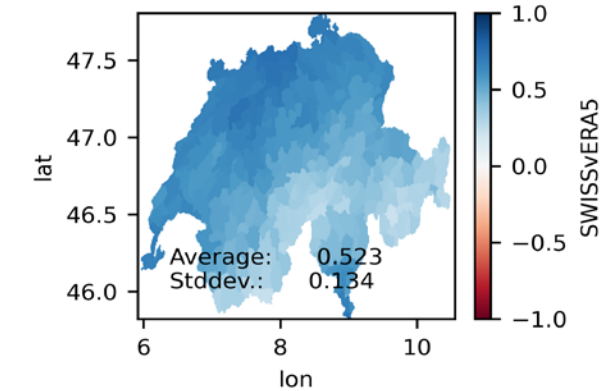
Soil Moisture Anomalies



F. Greifeneder and collaborators (EURAC, Italy)

- downscaled **ERA5 soil moisture** 4 soil layers at different depths
- 9 km spatial resolution
- 1979–present, daily update, near-real time
- approach based on correlation analysis between high-res modelled soil moisture in Switzerland and
 - ERA5 Re-analysis
 - ERA5-Land Re-analysis (latency of 2-3 months)
 - LISFLOOD output
- ERA5 shows good results + low latency + longest record

$$SMA = \frac{SM_t - \overline{SM}}{\delta_{SM}}$$



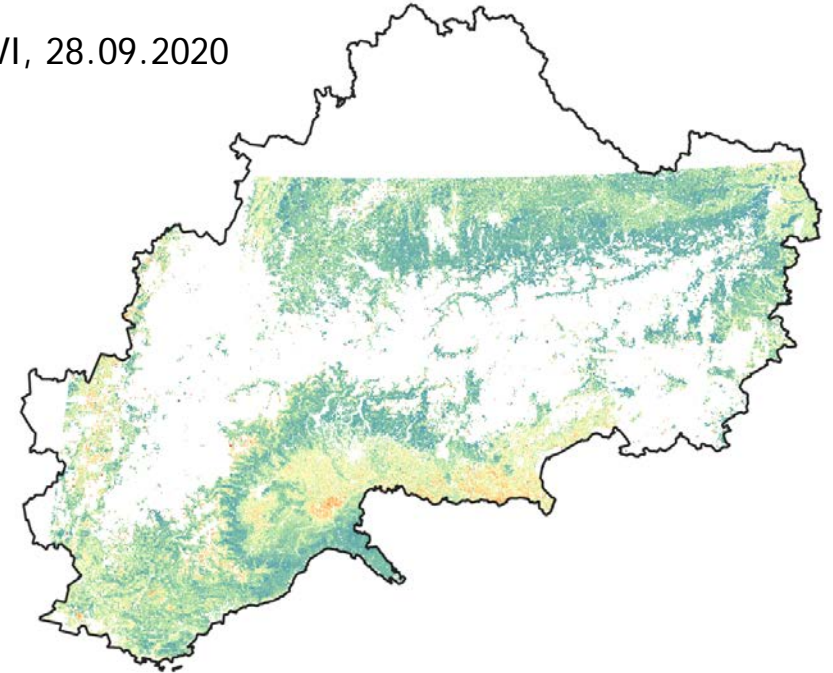
NDVI Anomalies

M. Castelli, P. Zellner and collaborators (EURAC, Italy)

- derived from daily **MODIS satellite observations** over vegetated surfaces in the Alps
- visible and near-infrared channels
- a measure of **vegetation greenness and vigour**
- 231 m spatial resolution
- 2000–present, **4-day composites**, near-real time
- **not necessarily** an indicator of drought (forest fires, mowing, diseases ...)



NDVI, 28.09.2020



NDVI



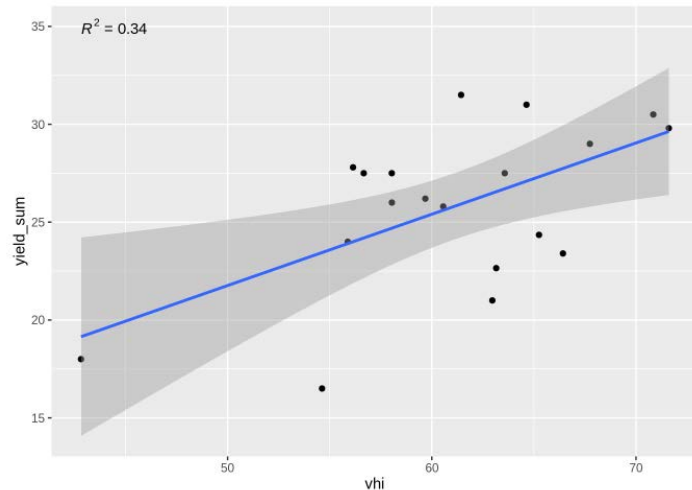
+ high resolution, good spatial coverage
- cloud contamination, short data record,
other signals

Vegetation Health Index (VHI)



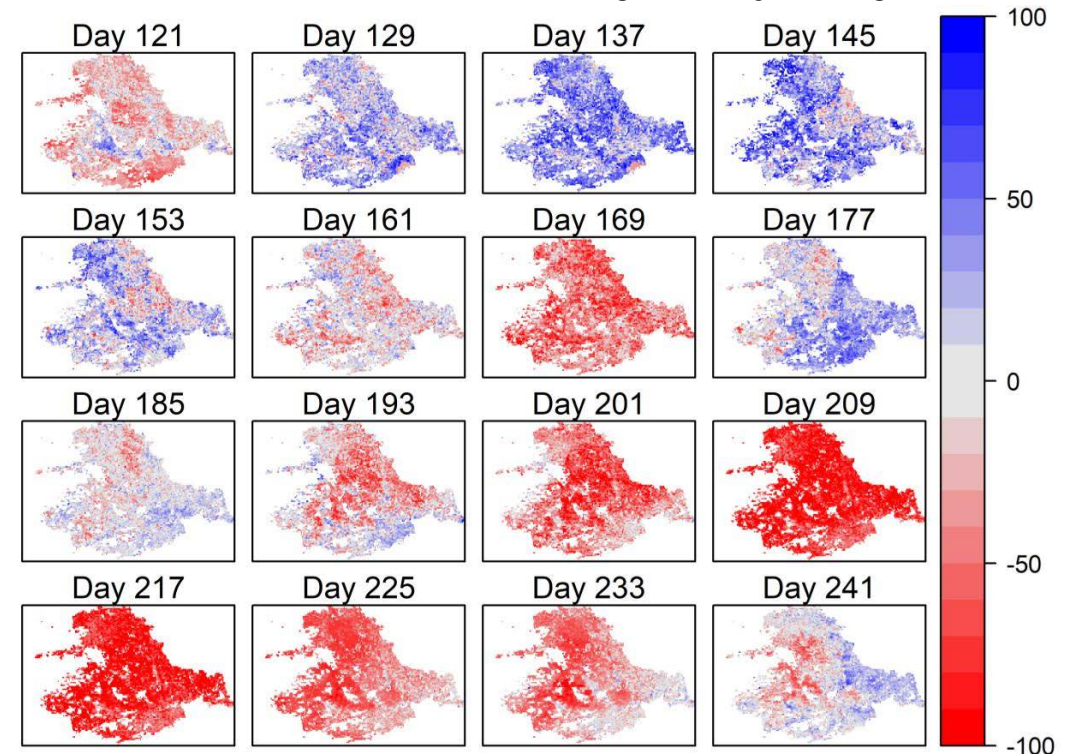
M. Castelli, F. Greifeneder and collaborators (EURAC, Italy)

- combination of **MODIS NDVI** and **LST** (Land Surface Temperature)
- 231 m spatial resolution
- 2000–present, 4-day composites, near-real time
- visible, near-infrared and **infrared** channels used
- combined estimation of **vegetation greenness and thermal conditions**



VHI validation vs Yield Uranjek, Slovenia

VHI anomalies for the Podravka region, May to August 2013



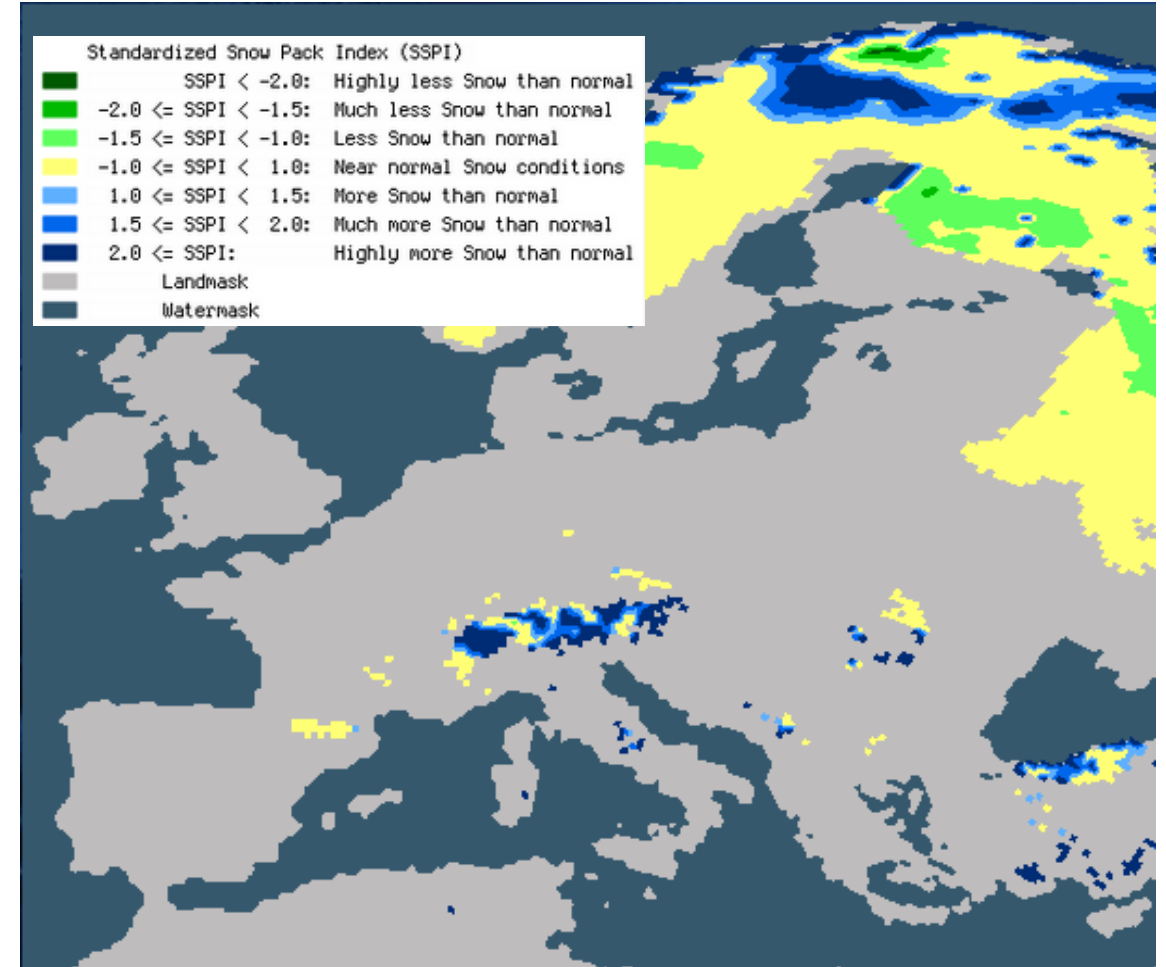
- + combined, high resolution, good spatial coverage
- cloud contamination, short data record

Standardised Snowpack Index (SSPI)



A. Susnik G. Gregovic and collaborators (ARSO, Slovenia)

- at high altitudes **water is stored in the snowpack**
- SSPI similar to SPI, but calculated using **snow-water equivalent**
- SWE modelled with SNOWGRID-CL model based on downscaled ERA5 data
- 5 km spatial resolution, 1979–present
- daily update, near real-time?
- **time scale of 10 and 30 days**



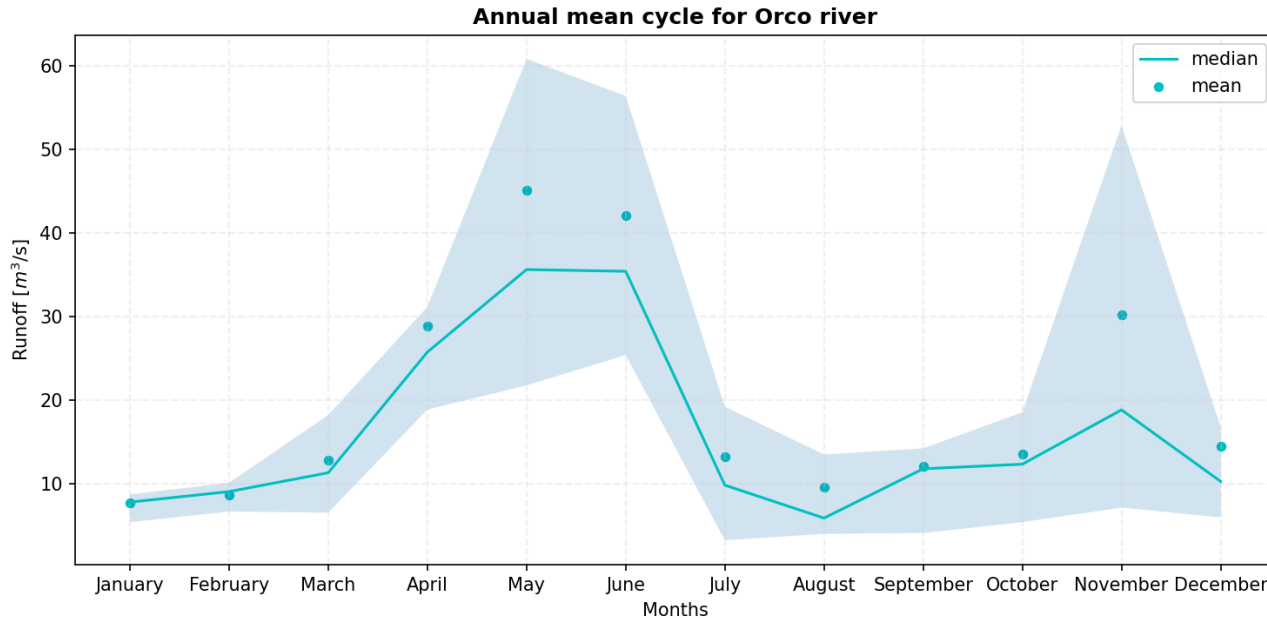
Source: CryoLand GeoPortal

Hydrological Indices

D. Quintero, G. Bertoldi, M. Mazzolini (EURAC)



Mean annual cycle of runoff



- Coherent Alpine-wide dataset of discharge, water level, groundwater level, metadata
- cross validation with multiple drought indicators and historical impacts needed



<https://maps.eurac.edu/maps/85/view>

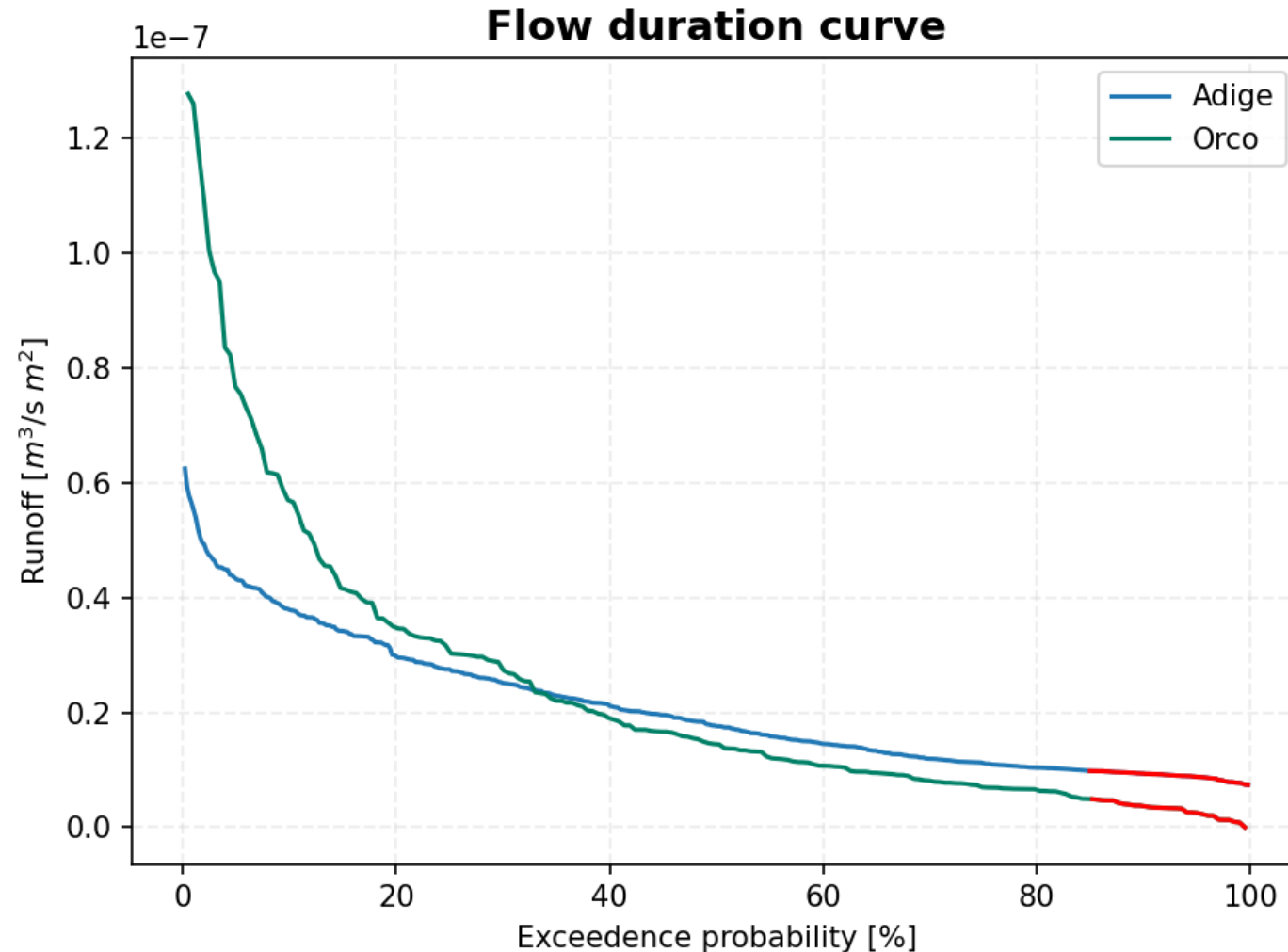
- + observed data, good spatial coverage
- **different data providers,**
- complex **real time data** availability
- + machine learning based approach examined for real time monitoring and forecast

Hydrological Indices



Flow duration curve

D. Quintero, G. Bertoldi, M. Mazzolini (EURAC)



Basin area:

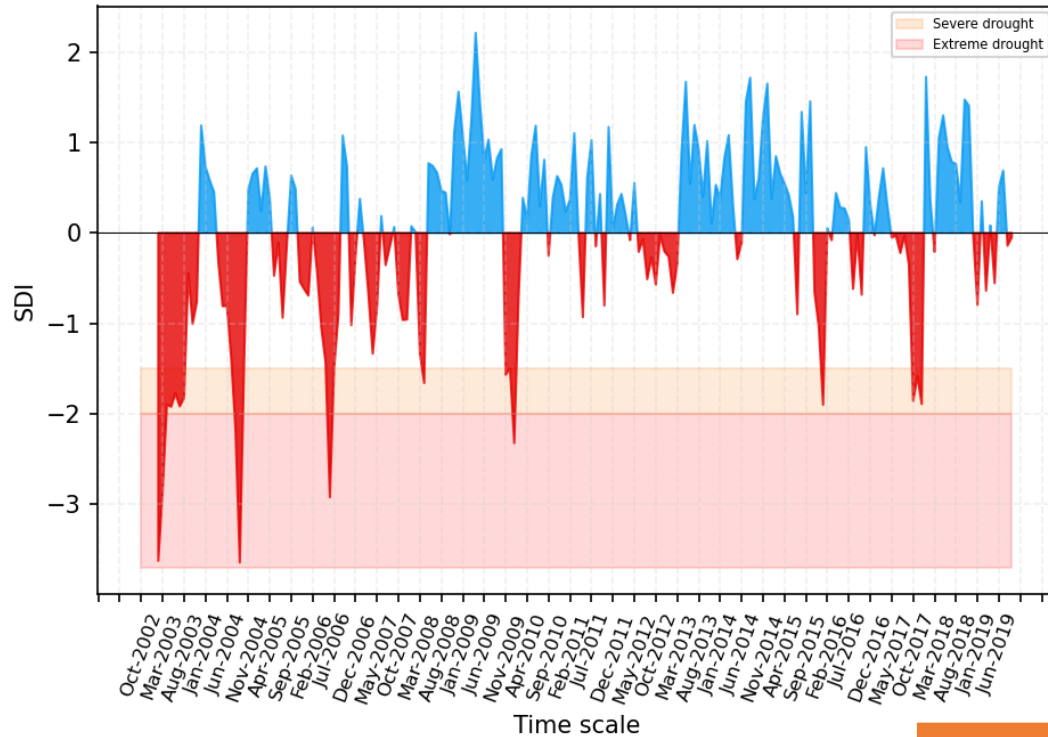
- Orco river 855 km^2
- Adige river 7000 km^2

Hydrological Indices

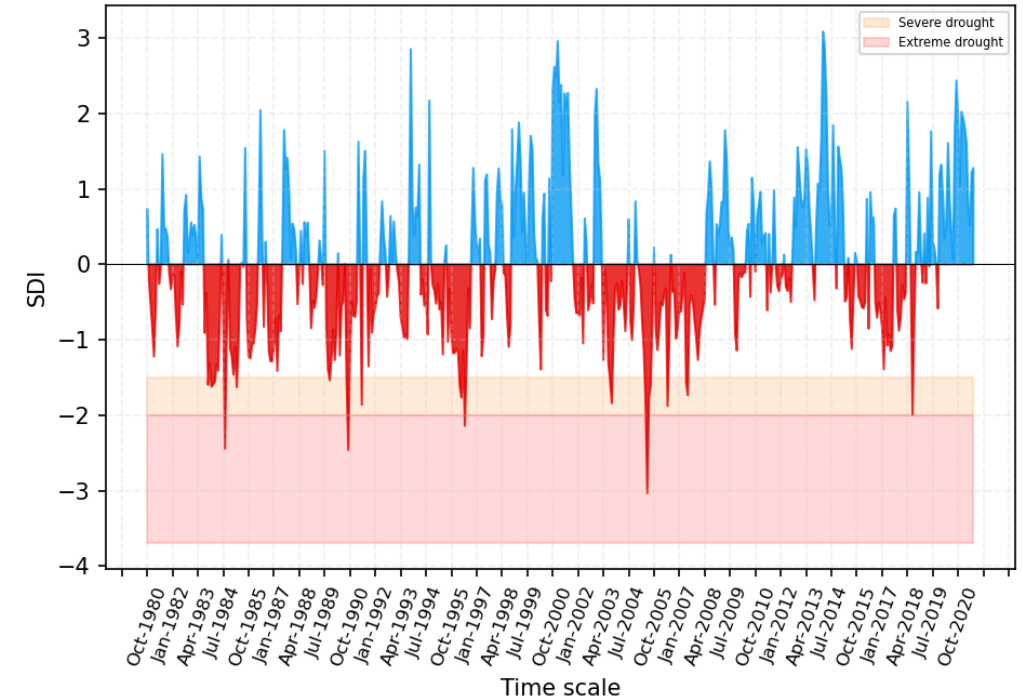


Streamflow Drought Index (SDI)

Streamflow Drought Index - Orco river



Streamflow Drought Index - Adige river



Steps

1. Length of time-series
2. Determine best distribution function
3. Compute cumulative streamflow

Description	Criterion
Non-drought	$0.0 \leq \text{SDI}$
Mild-drought	$-1.0 \leq \text{SDI} < 0$
Moderate-drought	$-1.5 \leq \text{SDI} < -1.0$
Severe-drought	$-2.0 \leq \text{SDI} < -1.5$
Extreme-drought	$\text{SDI} < -2.0$

$$SDI_{i,k} = \frac{v_{ik} - \bar{v}_k}{s_k}$$

v_{ik} = cumulative streamflow; i hydrological year; k period

\bar{v}_k = mean for k^{th} period of cumulative flow

s_k = standard deviation for k^{th} period

ADO T1 and T2: Conclusions & Next steps



DROUGHT MONITORING

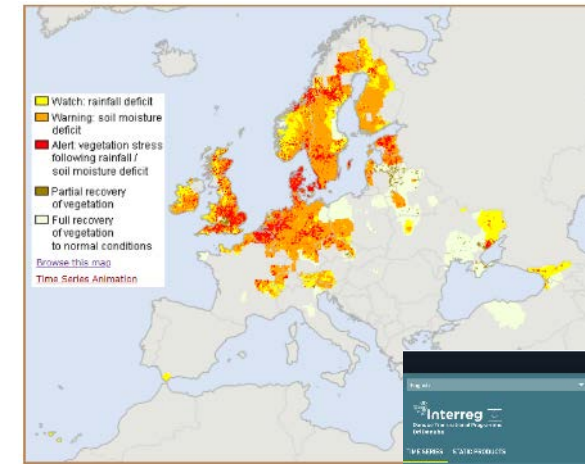
- Homogeneous, Alpine-wide **drought indicators** time series.
- Covered **different compartments** (meteo, hydro, veg.)
- Set up of **near-real time monitoring** tools.

NEXT STEPS

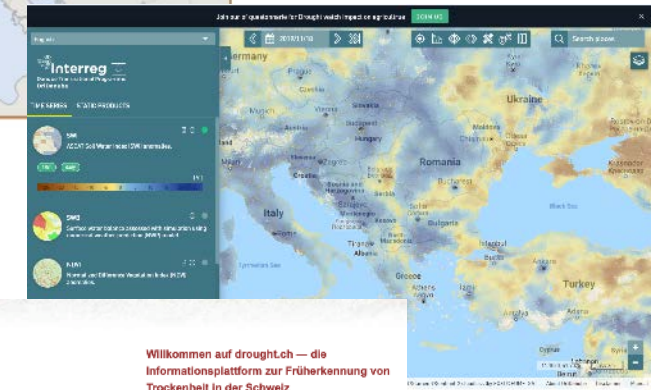
- **Cross validation** with multiple drought indicators.
- Comparison **with observed impacts (WP3)**
- Publication on **ADO platform (WP4)**
- Applications to **case studies (WP5)**

POLICY RECCOMENDATIONS

- Very **different drought monitoring platforms** among countries, regions, river districts
- Needs of cross-country **discharge data sharing** and homogenization.
- Building the datasets as much **open** as possible.



[Source](#)



[Source](#)

Allgemeine Lage



Willkommen auf drought.ch — die Informationsplattform zur Früherkennung von Trockenheit in der Schweiz

Die Plattform ist ein Forschungsprodukt des im 2013 abgeschlossenen Nationalen Forschungsprogramms 01 des SNE und wurde in Zusammenarbeit mit der [MeteoSchweiz](#) und dem [BAFU](#) entwickelt und wird seit dem Ende des NFP01 durch die WSL weitergeführt. drought.ch liefert Informationen zu aktueller und bevorstehender Trockenheit, resp. Wassermessungsdefizit - es handelt sich dabei nicht um offizielle Warnungen.

Bitte wählen Sie aus:

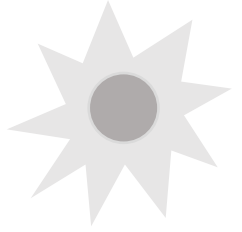
Aktuelle Situation Vorhersagen

(Browserempfehlung: Firefox oder Chrome)

PROTOTYPE (c) WSL, 2020-06-30

Für weitere Infos auf die Karte klicken

[Source](#)



Thank you for your kind attention

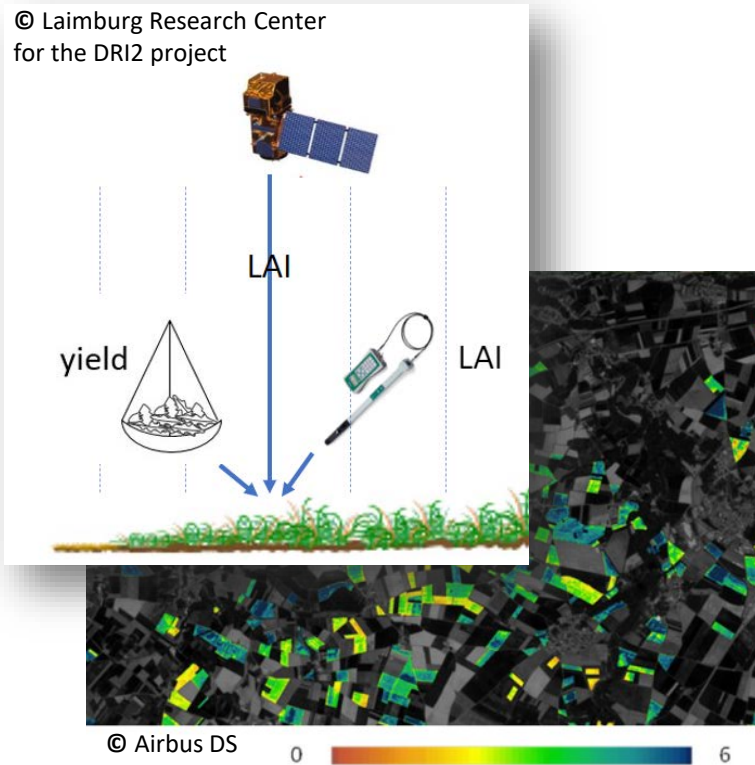
PI Project contact: Felix.Greifeneder@eurac.edu

Project website: <https://www.alpine-space.eu/projects/ado/en/homePI>

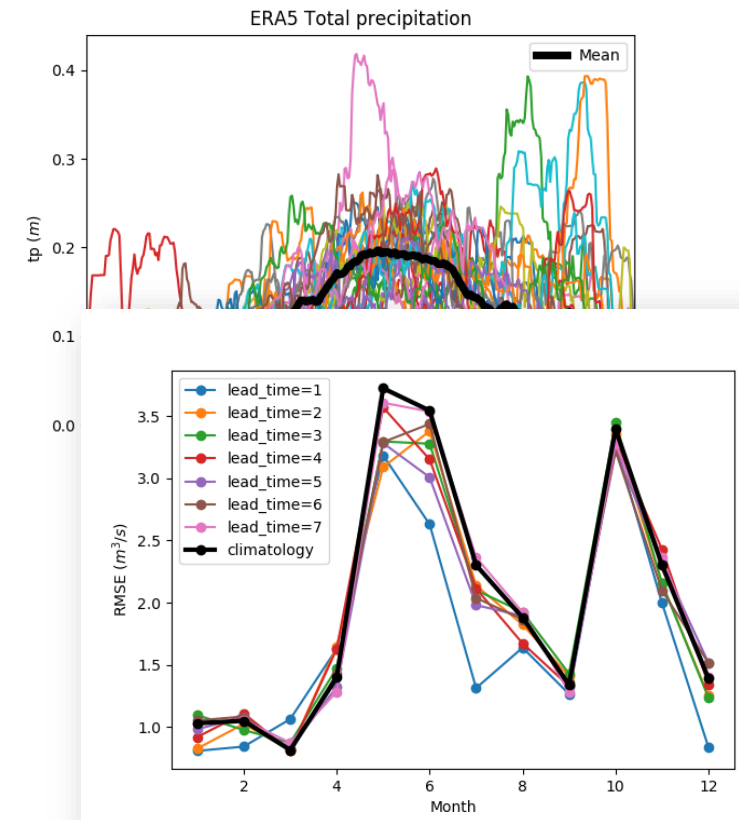
Outlook on activities in ADO T1 and T2

High resolution Leaf-Area-Index for the mapping of grassland yield losses

© Laimburg Research Center for the DRI2 project



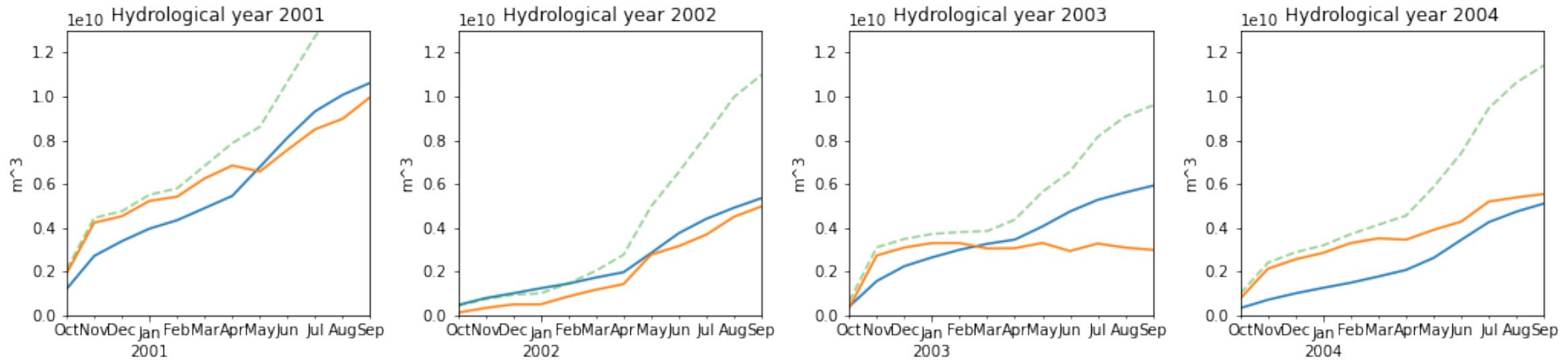
Machine-learning based approach for river discharge machine real time monitoring and forecast



Preliminary products validation - Hydro-Year BUDGET

M. Mazzolini (EURAC)

Example– Trento Ponte S.Lorenzo



Observed discharge

Precipitation – Potential ET

Total Precipitation

Impact 2003 hot summer