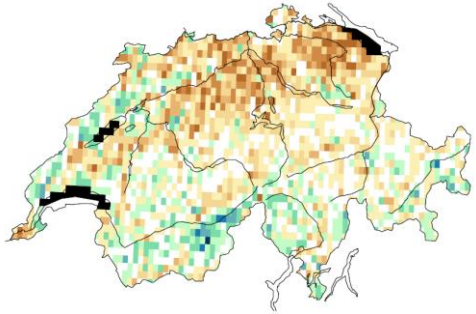
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Home Affairs FDHA
Federal Office of Meteorology and Climatology MeteoSwiss

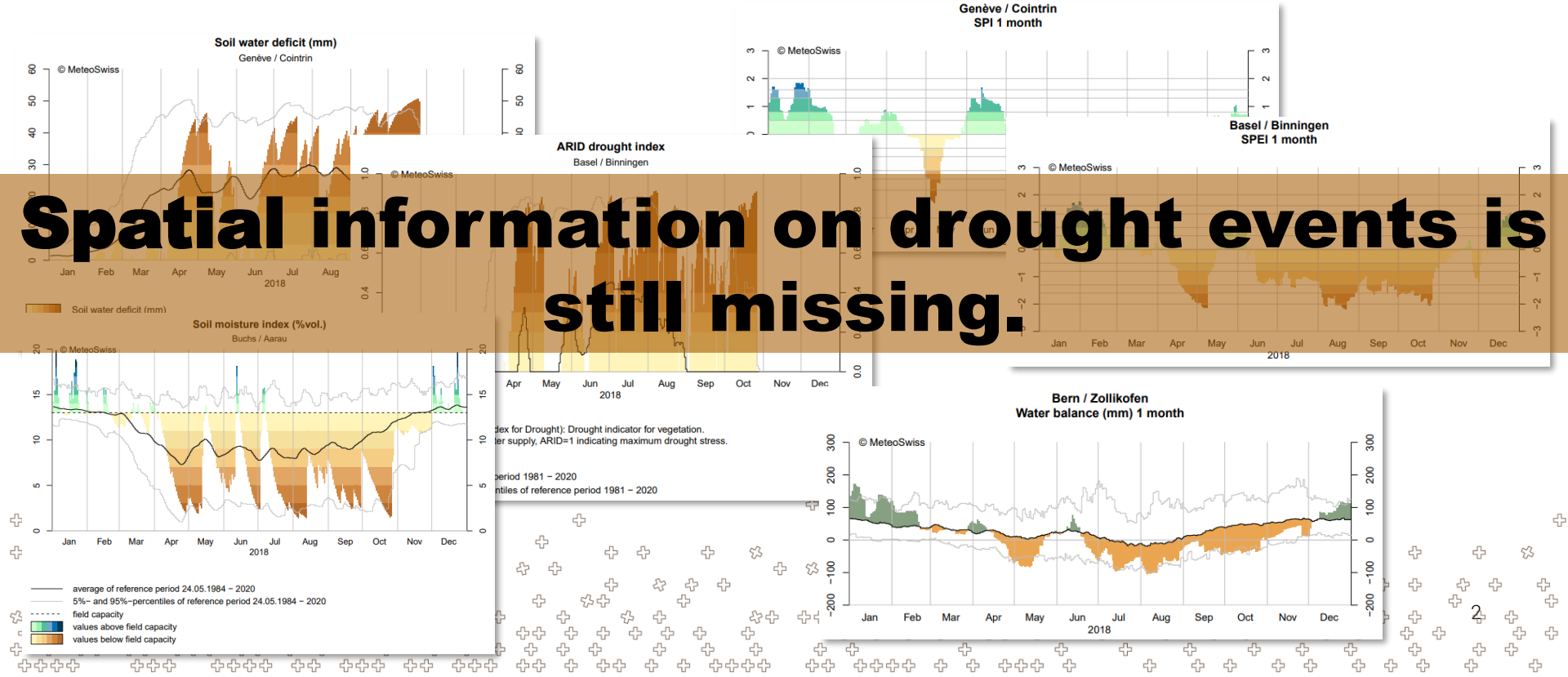


Climatological drought monitoring in Switzerland using SAF satellite products

Annkatrin Burgstall, Anke Duguay-Tetzlaff

ETH Zurich, TU Wien, RMIB

Current drought monitoring @MeteoSwiss



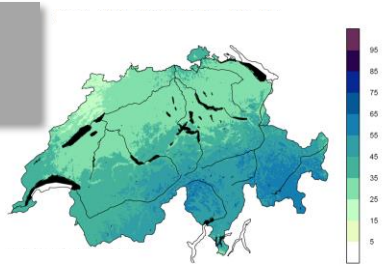
Spatial information on drought events is still missing.

Data

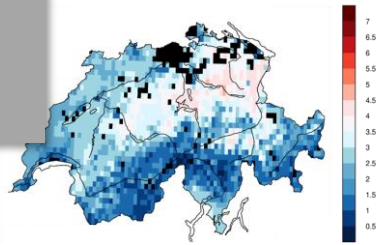
Satellite-based drought parameters

- ☑ *Long time series*
- ☑ *Developed specifically for central Europe*
- ☑ *Available open-source and operationally*

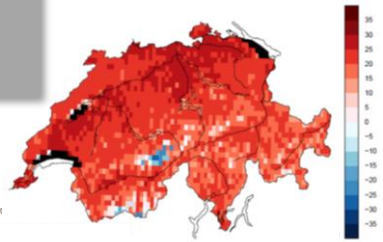
H SAF ASCAT surface **soil moisture** product



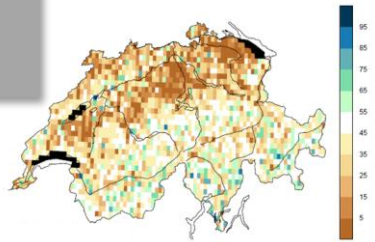
LSA SAF Meteosat **evapotranspiration** products



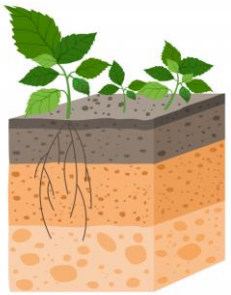
CM SAF **land surface temperature**



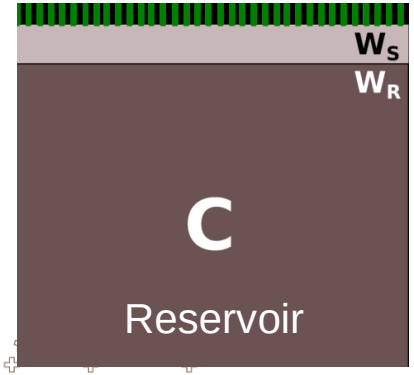
NOAA AVHRR **vegetation products**



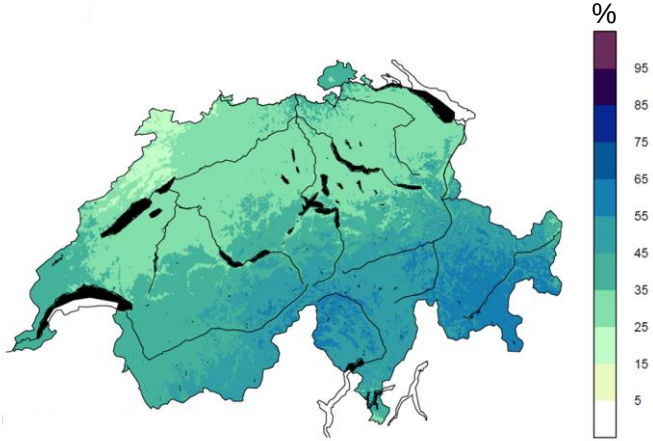
ASCAT Soil Water Index (SWI)



Radar measurements



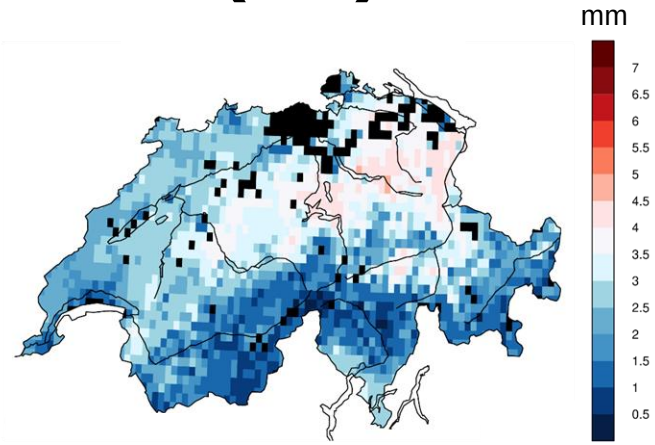
$$SWI(t_n) = \frac{\sum_i^n SSM(t_i) e^{-\frac{t_n - t_i}{T}}}{\sum_i^n e^{-\frac{t_n - t_i}{T}}} \quad for\, t_i \le t_n$$



25 km → 500 m

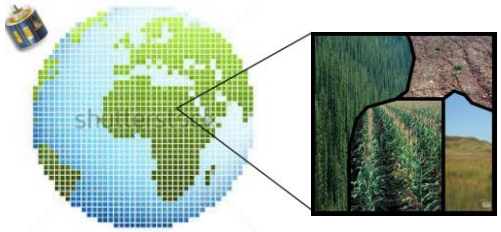
$t_{n,i}$ = *observation times*
T = *scaling factor*

Meteosat evapotranspiration (ET)



Model simulation based on satellite data:

- Radiation (S)
- Albedo (α)
- Land surface temperature (T_{SKT})
- Longwave radiation (SDL)
- Soil moisture …

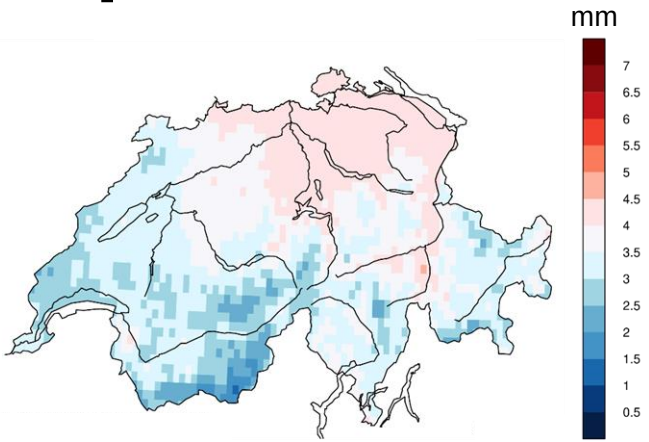


Energy balance model:

$$(1-\alpha)\ S + \varepsilon\ (SDL - \sigma T^4_{SKT}) + H + LE - G = 0$$

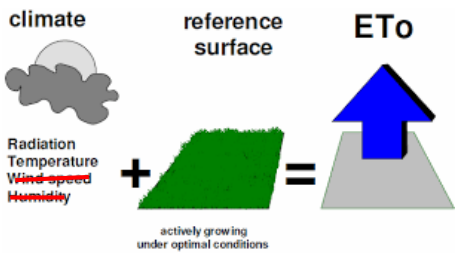
evapotranspiration (ET)

FAO-reference evapotranspiration (ET_0)



Model simulation based on:

- Radiation (S, Meteosat)
- Air temperature (T_{2m}, ECMWF)



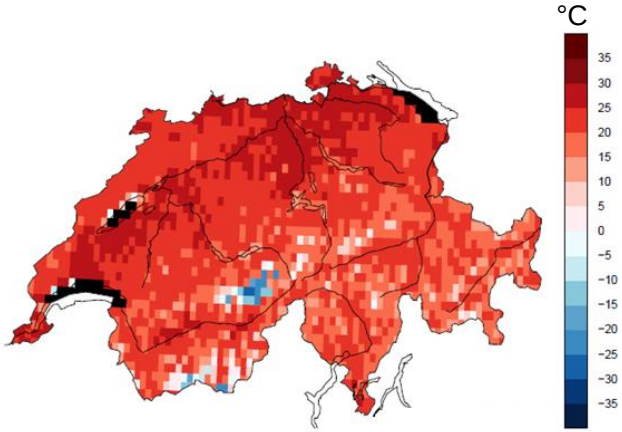
Thermodynamic model

$$ET_0 = \frac{1}{\lambda}\left(\frac{\Delta}{\Delta+\gamma}\left[(1-0.23)\,S - C_S\,\frac{S}{K_{ext}^{\downarrow}}\right] + \beta\right)$$

Meteoswiss LSA SAF KNMI

Land surface temperature (LST)

CM SAF Meteosat land surface temperature

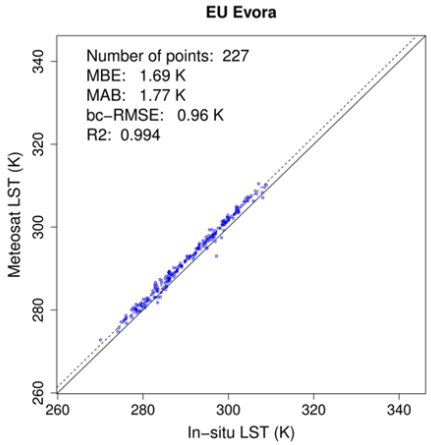


Radiative transfer modelling:

$$L_{ToA,x} = L_{SFC,x}\ \tau_{ATM,x} + L^{\uparrow}_{ATM,x} + L^{\downarrow}_{ATM,x}(1 - \varepsilon_{SFC})\ \tau_{ATM,x}$$

$$L_{SFC,x} = B\ (LST)$$

	Achieved Accuracy & Precision Physical LST model		
	Hourly	Daily	Monthly
Bias	0.8 K	0.7 K	0.8 K
Bc-RMS*	1.6 K	1.2 K	0.5 K



MeteoSwiss

EUMETSAT CM SAF

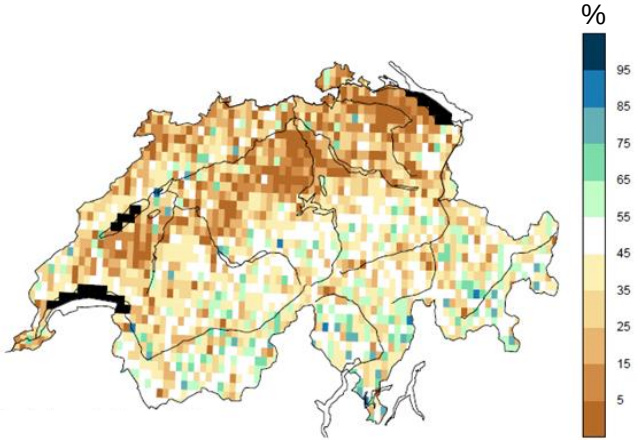
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Meteorologie und Klimatologie MeteoSchweiz

Vegetation Health Index (VHI)

NOAA satellite-based drought index:

- Land surface temperature
- Vegetation (NDVI)



Land surface temperature

$$\mathrm{TCI}_j = \frac{T_{\max} - Ts_j}{T_{\max} - T_{\min}} \times 100\,\%$$

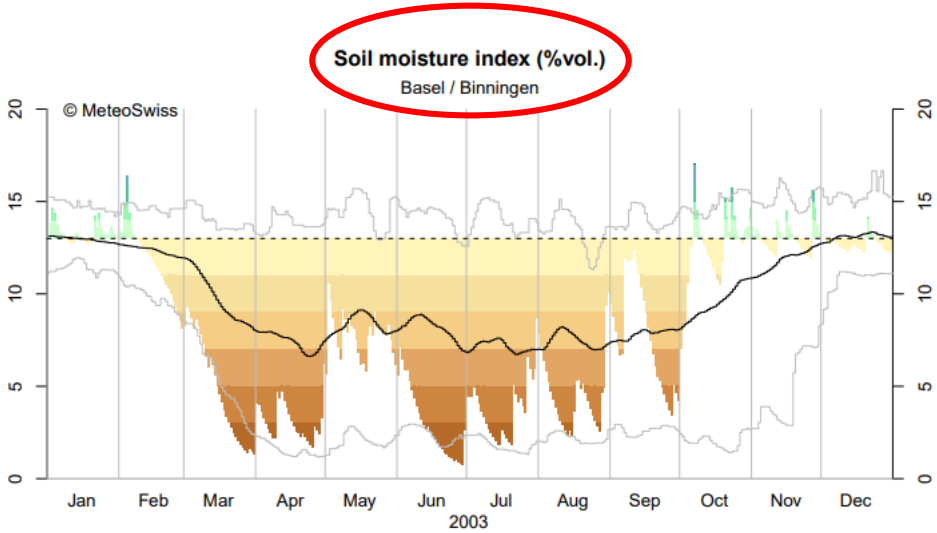
Vegetation

$$\mathrm{VCI}_j = \frac{\mathrm{NDVI}_j - \mathrm{NDVI}_{\min}}{\mathrm{NDVI}_{\max} - \mathrm{NDVI}_{\min}} \times 100\,\%$$

$$\mathrm{VHI} = a\mathrm{VCI} + (1 - a)\,\mathrm{TCI}$$

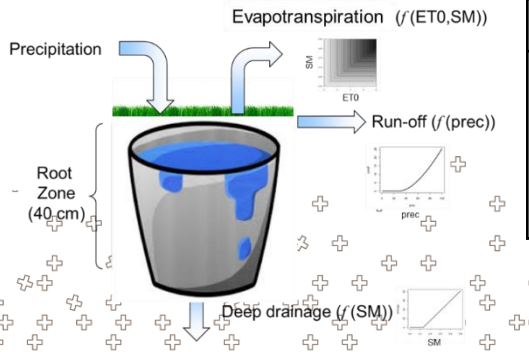
Met

Soil Moisture Index (SMI)



- **model-based soil moisture for a reference soil** (dense grass, 40 cm root zone), based on the meteorological parameters precipitation, temperature, radiation, relative humidity and wind
- «**bucket-model**» with daily balance of input and output:

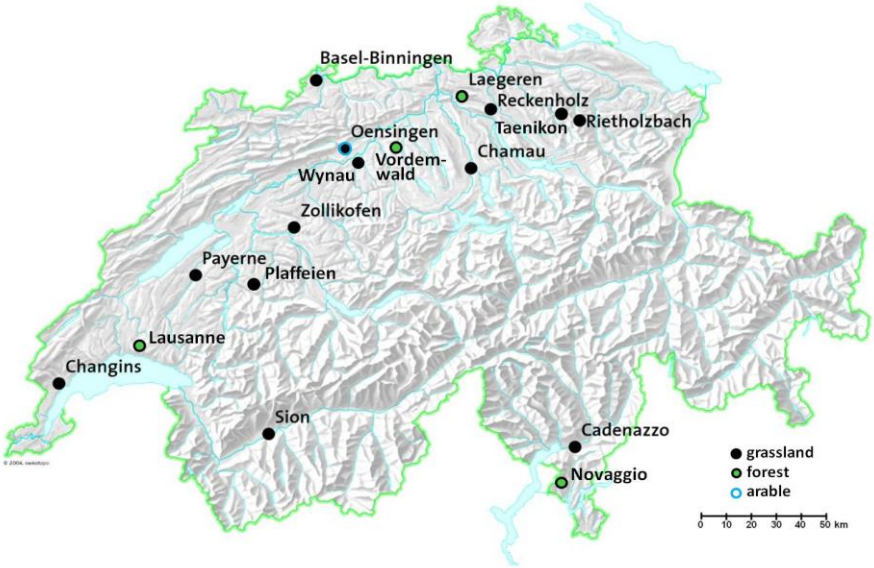
average of reference period 1981 – 2020
5%– and 95%–percentiles of reference period 1981 – 2020
field capacity
values above field capacity
values below field capacity



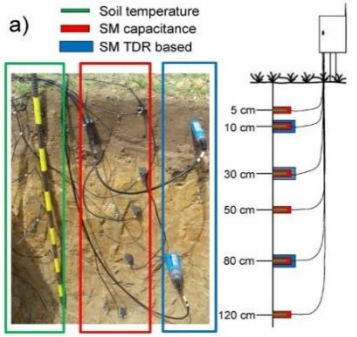
Input	Output
precipitation	- evapotranspiration=f (ET_0, soil moisture) - run-off=f (daily precipitation > threshold) - drainage=f (soil moisture > field capacity)

MeteoSwiss

Swiss Soil Moisture Experiment (SwissSMEX)



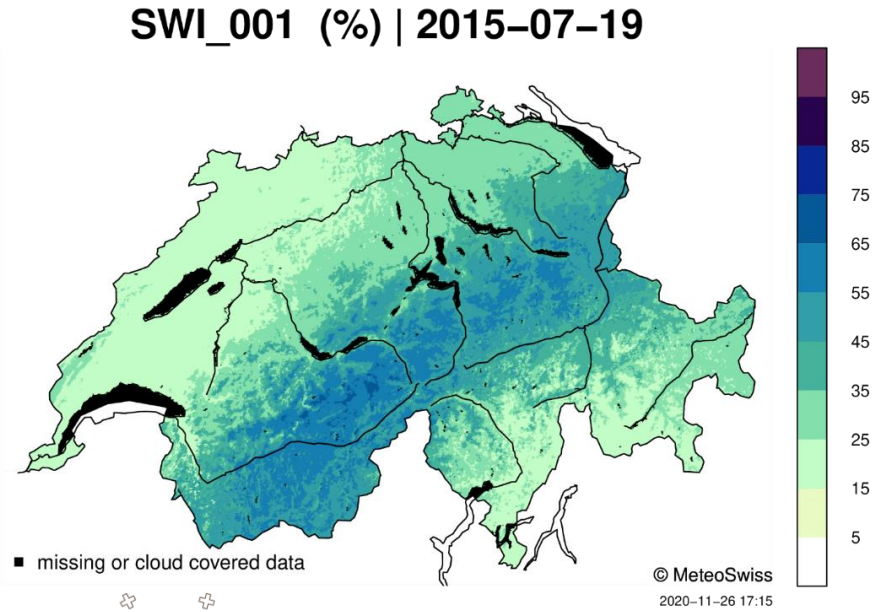
- Since 2008, the SwissSMEX project is monitoring **soil moisture** at 19 stations in Switzerland (14 grassland, 4 forest locations, 1 arable land)
- Since 2015, 7 sites have been equipped with **mini lysimeters** for **evapotranspiration measurements**

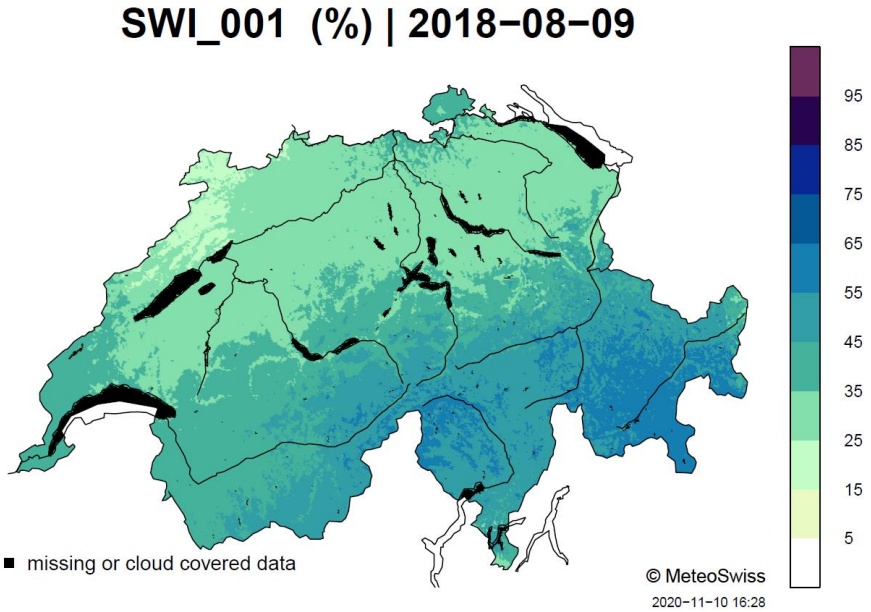


Source: https://iac.ethz.ch/group/land-climate-dynamics/research/swisssmex.html

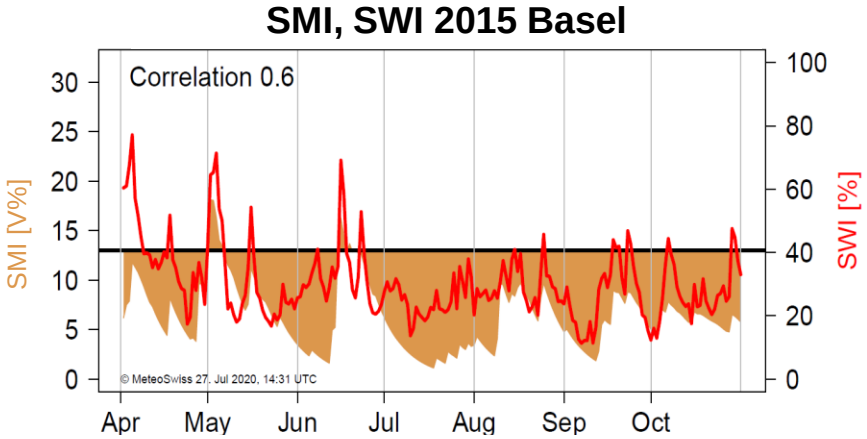
Results

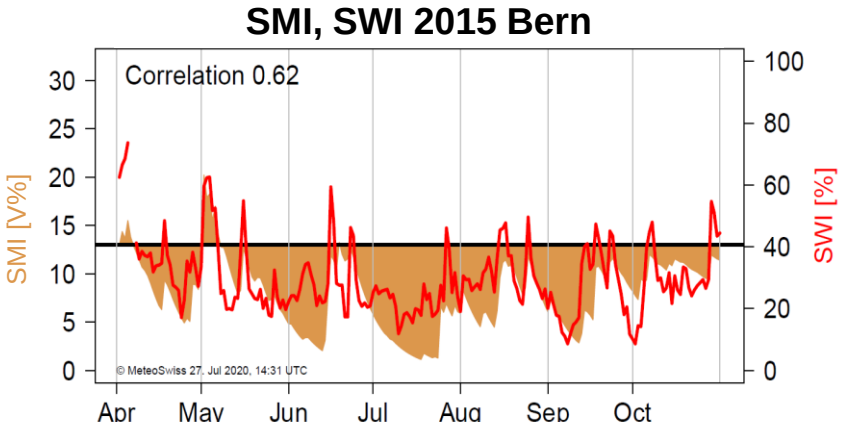
ASCAT Soil Water Index (SWI)

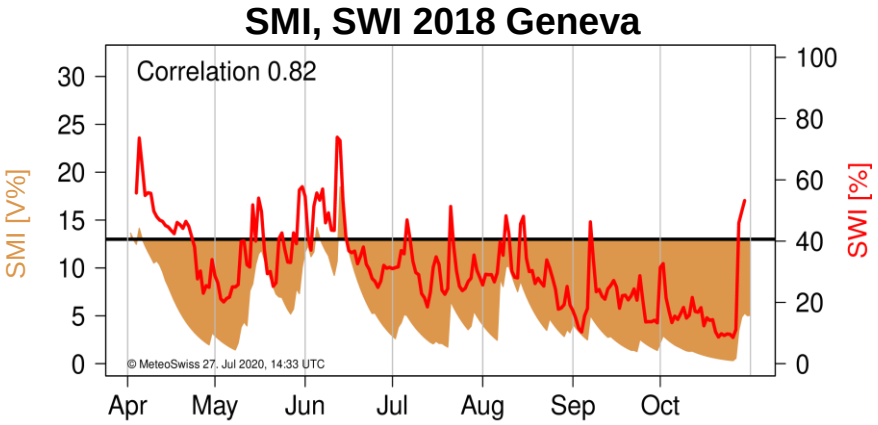


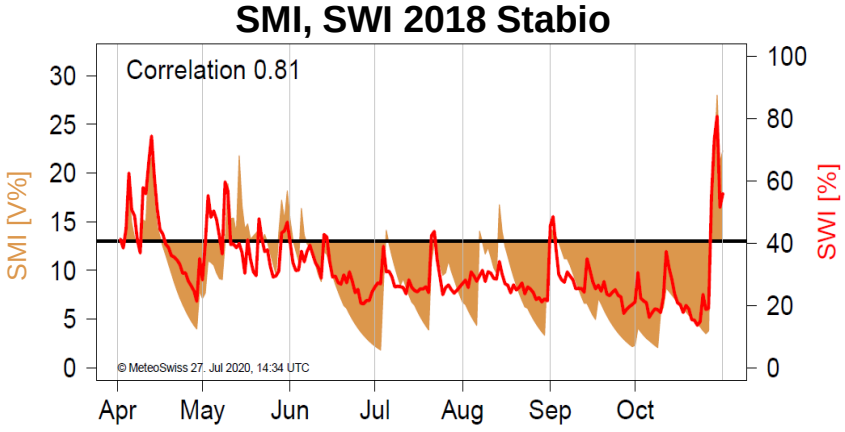


SMI in-situ + ASCAT SWI

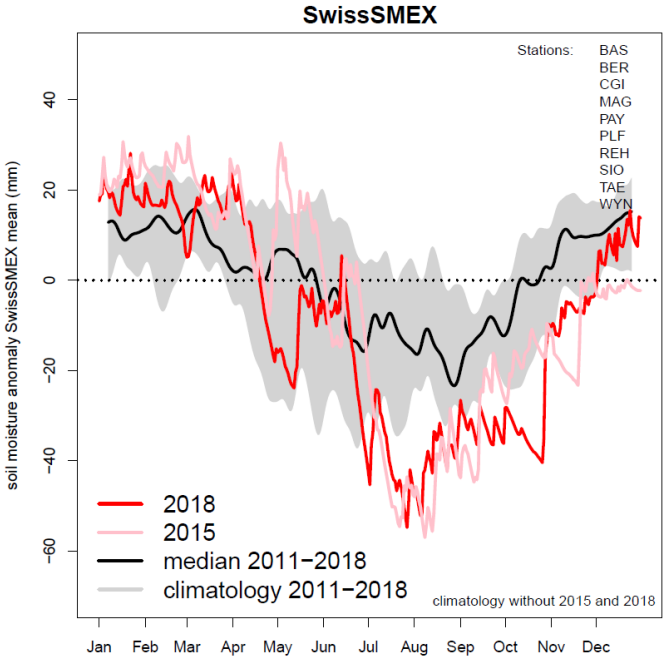


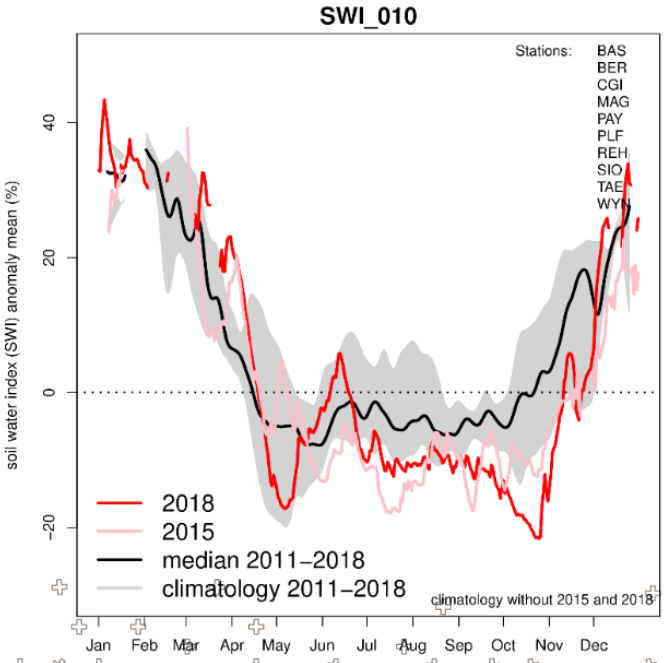






SwissSMEX in-situ + ASCAT SWI (T=10)

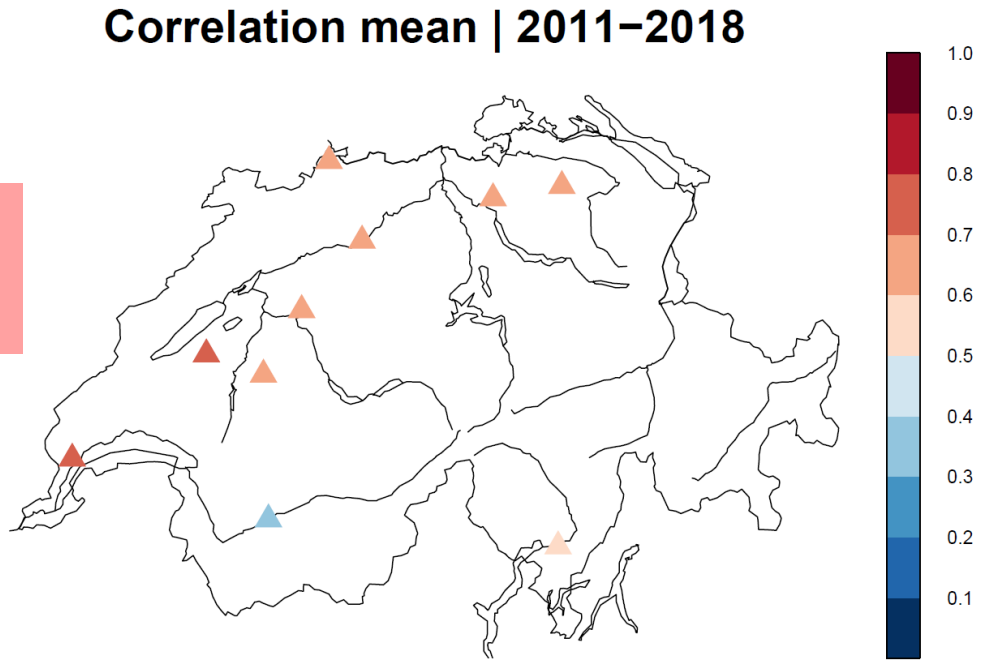




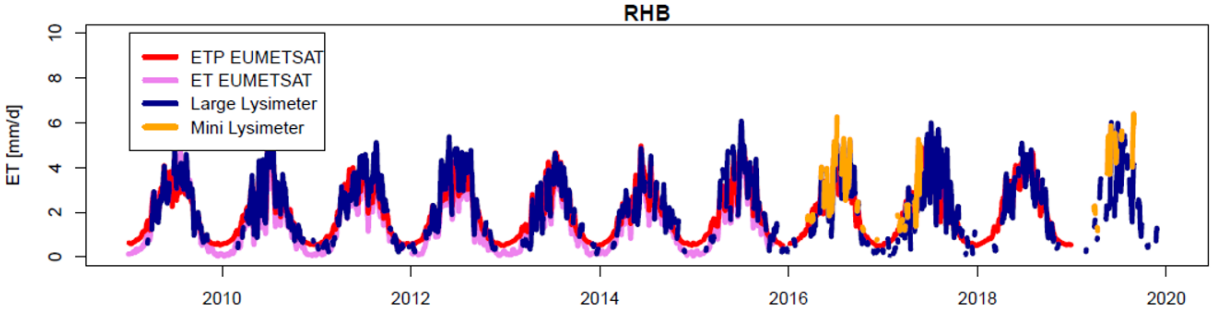
ETH zürich

SwissSMEX in-situ + ASCAT SWI (T=10)

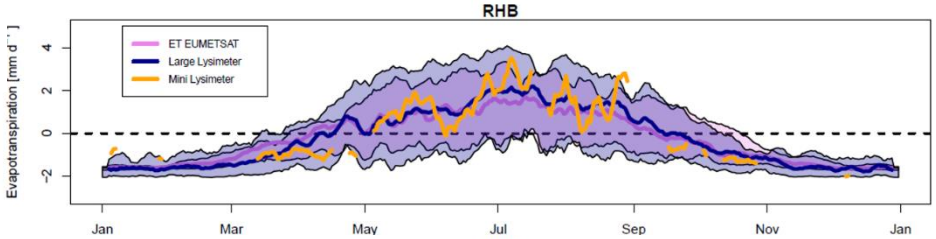
Generally high correlation (>.6)



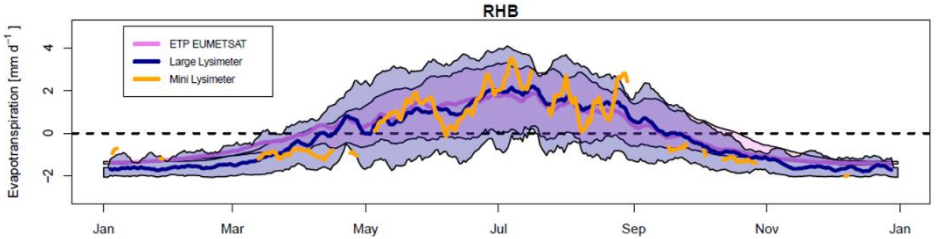
Lysimeter in-situ + EUMETSAT ET/ETP



ET

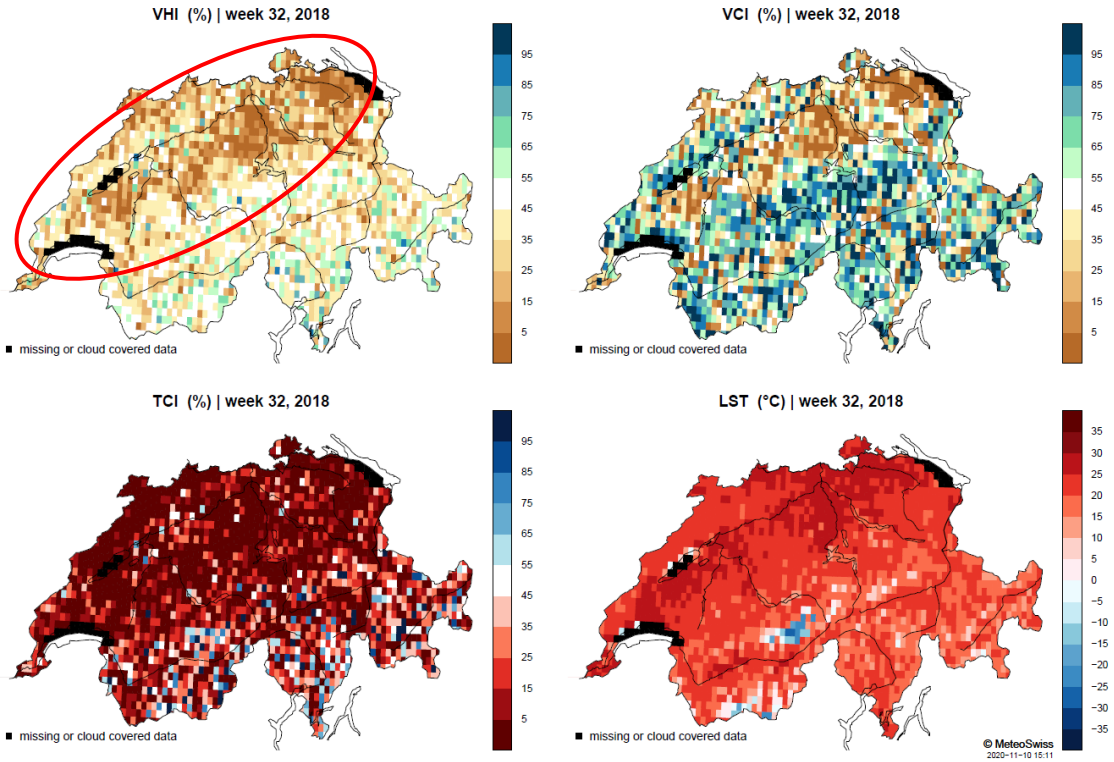


ETP



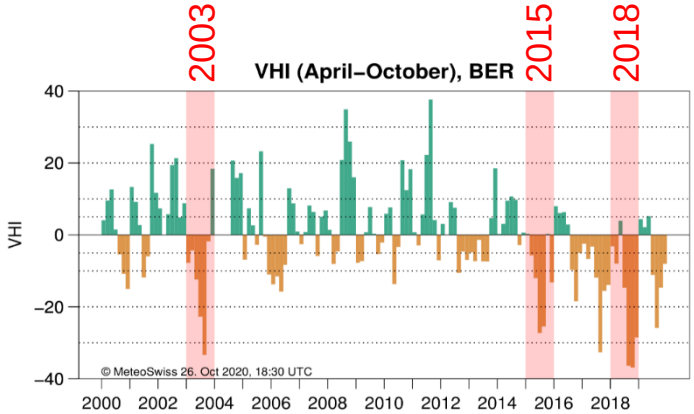
Analyses by Dominik Michel, ETH Zurich

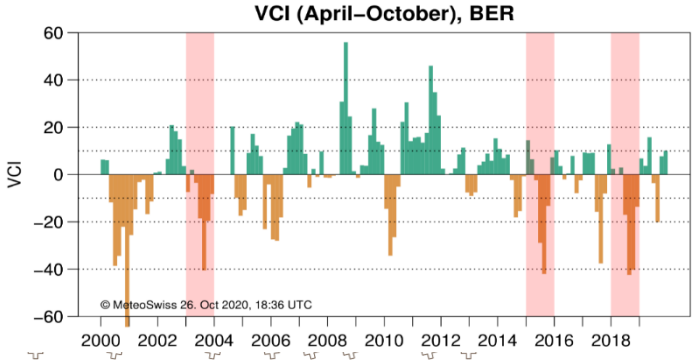
NOAA AVHRR vegetation products

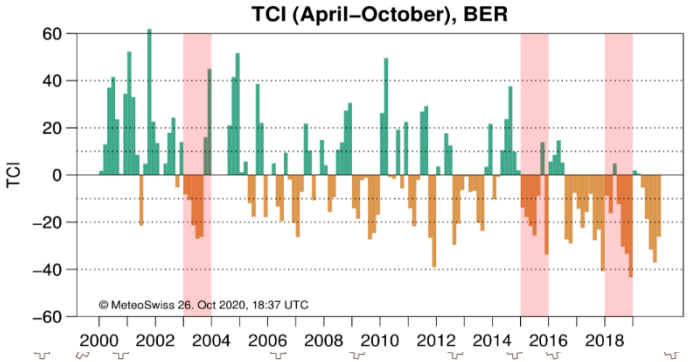


MeteoSwiss

NOAA AVHRR vegetation products | Bern

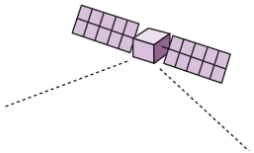






MeteoSwiss

Summary



- Satellite-based **soil moisture data** correlate high with modeled Soil Moisture Index (except in high altitudes) and with SwissSMEX measurements
- Satellite-based **evapotranspiration data** agree well with SwissSMEX measurements
- Drought events are well depicted in satellite-based **vegetation products**

SAF satellite products can well complement the station-based indicators for drought monitoring in Switzerland with spatial information.

MeteoSwiss
Operation Center 1
CH-8058 Zurich-Airport
T +41 58 460 91 11
www.meteoswiss.ch

Thank you.

Contact: annkatrin.burgstall@meteoswiss.ch

MeteoSvizzera
Via ai Monti 146
CH-6605 Locarno-Monti
T +41 58 460 92 22
www.meteosvizzera.ch

MétéoSuisse
7bis, av. de la Paix
CH-1211 Genève 2
T +41 58 460 98 88
www.meteosuisse.ch

MétéoSuisse
Chemin de l‘Aérologie
CH-1530 Payerne
T +41 58 460 94 44
www.meteosuisse.ch