Showcase on SDG 6.4.2
Levels of water stress

Policy context

Drought (water stress) affected 2.2 billion people in various countries around the world from 1950 to 2014 (Guha-Sapir et al., 2015). This is even expected to increase in both frequency and severity at nearly all ecosystems around the world (Wolf et al., 2013; Zhou et al., 2013).

Water stress can harshly affect various societal sectors (e.g., forestry, agriculture, water resources management, energy generation, health). For example, the 2003 drought event, occurred in many countries within Europe, caused 7000 fatalities in Germany alone (European Commission 2012) and had agro-economical damages around 1.5 billion EUR (Zink et al., 2016). For the same event at the European level, the number of fatalities exceeded 70 000 (Robine et al., 2008), with agro-economical damages of about 15 billion EUR (COPA-COGECA 2003). Therefore, quantifying water stress levels in a simple, operational and straightforward way is of great importance, and urgently needed, not only for farmers, policy and decision makers but also for the scientific community. The emergency of taking serious actions towards water stress quantification is also emphasized by the Sustainable Development Goals (SDGs), in particular, the SDG indicator 6.4.2 ("levels of water stress").

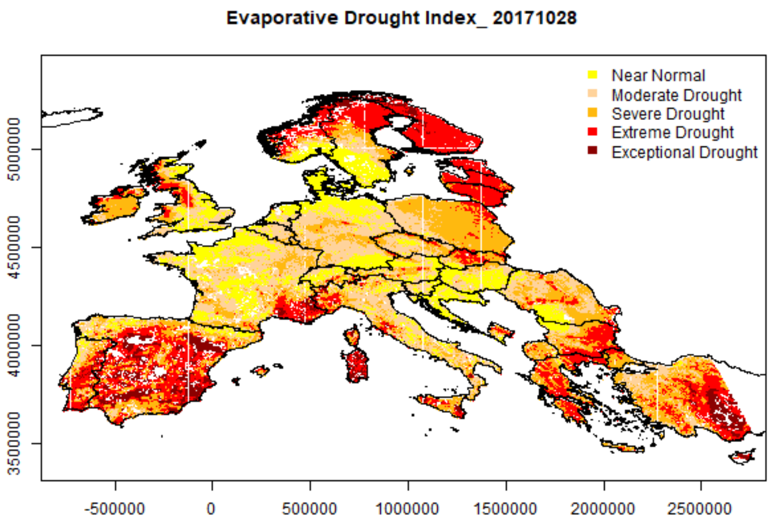
In this workflow, we used daily actual and reference satellite evapotranspiration (ET) products [from EUMETSAF LSA-SAF geostationary satellite products] to quantify water stress levels (Anderson et al., 2016; Bayat et al., 2018b, 2018a; Kim and Rhee, 2016; Narasimhan and Srinivasan, 2005) in European countries. We established all process chains in VLab on Amazon Web Services and successfully implemented our workflow to gather baseline data to document initial conditions and map water stress status. This provides a synoptic overview of water stress changes in European level at daily step with a spatial resolution of 4 kilometers. The workflow to receive the Evaporative Drought Index can easily be adapted to use any other ET products and also can be executed for any other location around the world.

There are two main outputs for this workflow:

1. Maps of water stress (drought) levels explaining spatio-temporal variations of water stress in EU level at daily step with a spatial resolution of 4 km (stress classes are adopted from PDSI index classes).
2. Text reports (tables) containing various water stress levels for each country based on the percentage of the total land area of that country.

Fig 1 shows the outputs of the proposed workflow for one day (i.e., 28 of October) in different years (i.e., 2017 and 2018).

(a)



(b)

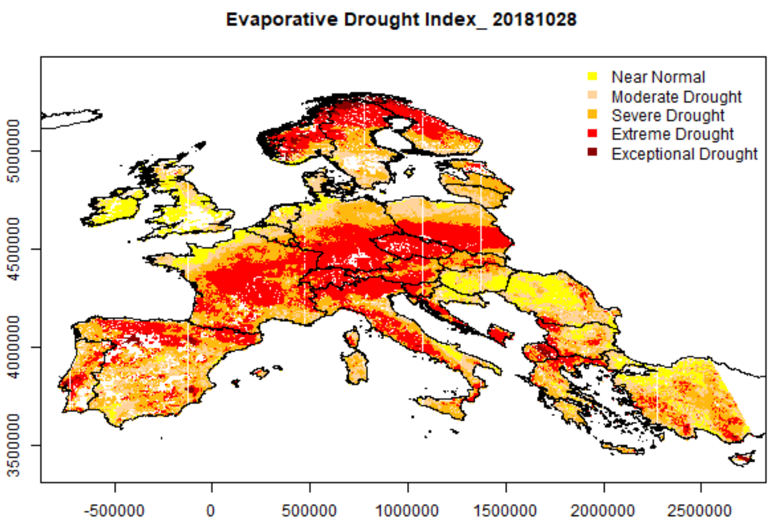


Figure 1. Water stress (drought) maps for day 28 of October in 2017 (a) and 2018 (b) generated by the proposed workflow.

Furthermore, Table 1 shows two text files, corresponding to two maps shown in Fig.1, to summarize the status of water stress in each country within Europe based on the percentage of its total land area.

Table 1. Water stress (drought) tables for day 28 of August in 2017 and 2018 generated by the proposed workflow. Germany is highlighted as an example for the sake of better comparsion.

(a)

EUcoun	NearNormal	ModerateDro	SevereDr	ExtremeDro	Exception
AT	35.78714	33.7915743	24.346	5.898004	0.17738
BE	18.765743	66.9395466	14.295	0	0
BG	9.3278008	13.0456432	30.523	47.10373	0
CY	0	0	7.9365	25.79365	66.2698
CZ	10.073214	49.9116385	33.274	6.740722	0
CH	38.819474	30.2886687	21.198	7.367514	2.32658
DE	31.740342	50.7481368	16.647	0.864766	0
DK	97.644141	1.36391816	0.62	0.061996	0.30998
ES	4.4838829	10.5710732	26.49	37.17186	21.2833
EL	0.6475486	5.22003436	41.721	50.58808	1.82371
EE	0	0	2.3791	97.62094	0
FR	29.391869	42.9206181	17.339	7.023012	3.32582
FI	0	0	0.0988	90.08043	9.8208
IS	0	0	0	0	0
IT	11.621974	41.4025738	25.835	14.15046	6.99019
HU	59.301848	32.2997947	8.0493	0.349076	0
IE	0.8275405	12.4793115	70.54	16.15359	0
HR	72.047635	26.4968574	1.1247	0.231558	0.09924
NO	26.169107	8.72303574	14.58	40.21414	10.3133
ME	23.409669	19.7201018	26.463	30.40712	0
MT	0	0	0	100	0
NL	50.623886	47.3559121	1.3072	0.534759	0.17825
MK	2.4911032	20.7117438	62.633	14.1637	0
LU	0	42.0289855	57.971	0	0
LI	22.222222	33.3333333	44.444	0	0
LT	0	0.25041736	11.686	88.06344	0
LV	0	0.27497709	9.3034	90.42163	0
PL	0.9127128	19.7971749	69.091	10.1992	0
SE	30.202691	15.0096103	19.605	33.14695	2.03565
RO	13.864481	35.5947955	41.112	9.428861	0
PT	5.3706638	14.2630745	27.258	42.56031	10.5476
TR	0.5117208	18.9629124	40.465	28.3932	11.6672
SK	14.971288	13.9868745	39.089	31.95242	0
SI	40.363636	56.9090909	2.7273	0	0
UK	32.851511	30.1107565	20.696	16.33189	0.00939

(b)

EUcou	NearNormal	ModerateDr	SevereDr	ExtremeDr	Exceptior
AT	0	2.5011579	31.566	65.6091	0.3242
BE	12.342569	43.513854	38.791	5.35264	0
BG	13.250763	33.423821	31.727	20.3936	1.2046
CY	1.8867925	19.245283	20.755	17.3585	40.755
CZ	0	0	6.1873	93.8127	0
CH	0	0	10.279	87.026	2.6953
DE	5.5109273	13.036031	29.273	52.0732	0.1063
DK	12.975671	65.814099	20.337	0.56145	0.3119
ES	3.282598	21.97517	46.104	26.2222	2.4164
EL	4.0065191	24.718186	49.423	20.4944	1.3581
EE	0	3.4207526	65.678	30.9008	0
FR	6.56833	10.057453	36.205	47.1015	0.0678
FI	0.7513148	13.38843	32.742	49.7821	3.3358
IS	0	0	0	0	0
IT	3.9495798	18.957983	37.35	39.5014	0.2409
HU	48.218673	32.268632	17.076	2.43653	0
IE	81.978022	17.509158	0.5128	0	0
HR	19.596639	29.142857	24.538	26.6218	0.1008
NO	8.7660053	9.4413958	16.716	43.7878	21.289
ME	0	0.1246883	17.83	82.0449	0
MT	0	22.222222	66.667	11.1111	0
NL	37.358715	51.873885	9.9941	0.59488	0.1785
MK	0	2.5	28.636	45.8333	23.03
LU	0	0	28.986	71.0145	0
LI	0	0	11.111	88.8889	0
LT	2.2537563	53.464107	44.282	0	0
LV	0.2311604	12.991216	83.079	3.69857	0
PL	2.7520916	22.30295	26.75	48.1946	0
SE	2.4111312	23.41561	33.756	35.2997	5.1177
RO	40.282145	36.398402	17.464	5.60891	0.2465
PT	2.6016932	21.845963	43.96	28.7632	2.8288
TR	21.589198	31.16767	36.38	10.3265	0.5363
SK	0.2464066	12.648871	58.357	28.7474	0
SI	0.630063	8.2808281	36.994	54.0954	0
UK	60.898935	31.358794	7.2616	0.48064	0

This workflow can provide valuable information for farmers, policy and decision makers who usually need simple numbers and instructions for making quick and efficient decisions.

Showcase description

Workflow 6.4:	**Water stress levels**
Spatial Extent	European Union (can also be easily adapted for any specific country or Global)
Dashboard link	To be included soon

Temporal Extent	Currently from 2016-2018 at daily step (but will be extended from 2005 to 2019 at daily step in the final version)
EVs used	Evapotranspiration (ET)
Inputs	EUMETSAF LSA-SAF geostationary satellite ET products
Outputs	Maps of water stress (drought) levels and text reports (tables) containing various water stress levels for each country based on the percentage of the total land area of that country.
Targeted Policy	SDG 6.4: substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
Targeted indicators	6.4.2: Levels of water stress
Main Process	This workflow simply uses ET as an essential variable from satellite observations to quantify water stress levels based on Evaporative Drought Index (EDI).
Level of development	80%
GitHub code	To be included soon
Outputs endpoint	To be included soon
Partner(s)	Forschungszentrum Juelich (FZJ)
Contact person	Bagher Bayat*, Carsten Montzka, Harry Vereecken (FZJ)

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