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MAPPING THE SPATIAL-TEMPORAL VEGETATION RESPONSE TO DROUGHTS IN NORTHERN ITALY

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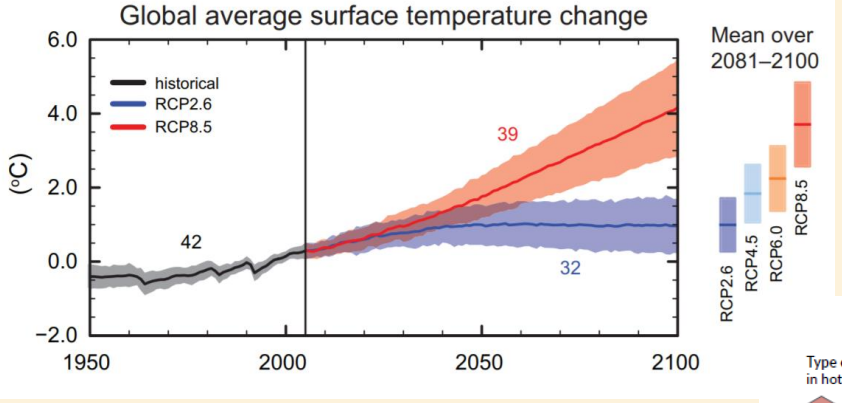
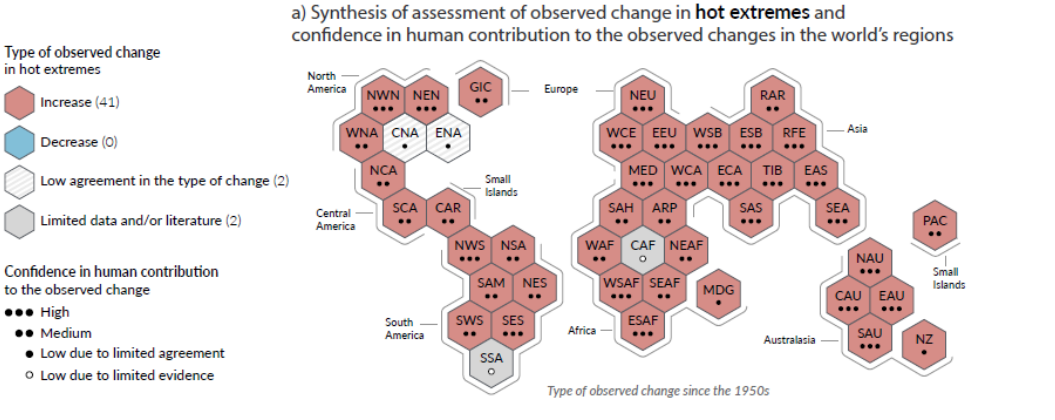
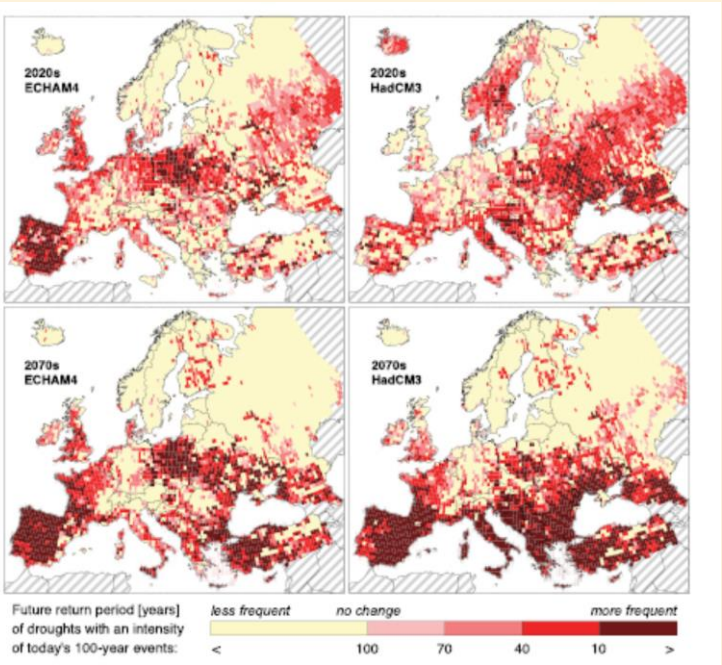


The increase of global mean surface temperature by the end of the 21st century (2081–2100) relative to 1986–2005 is likely to be:

- 1.1°C to 2.6°C under RCP4.5
- 2.6°C to 4.8°C under RCP8.5

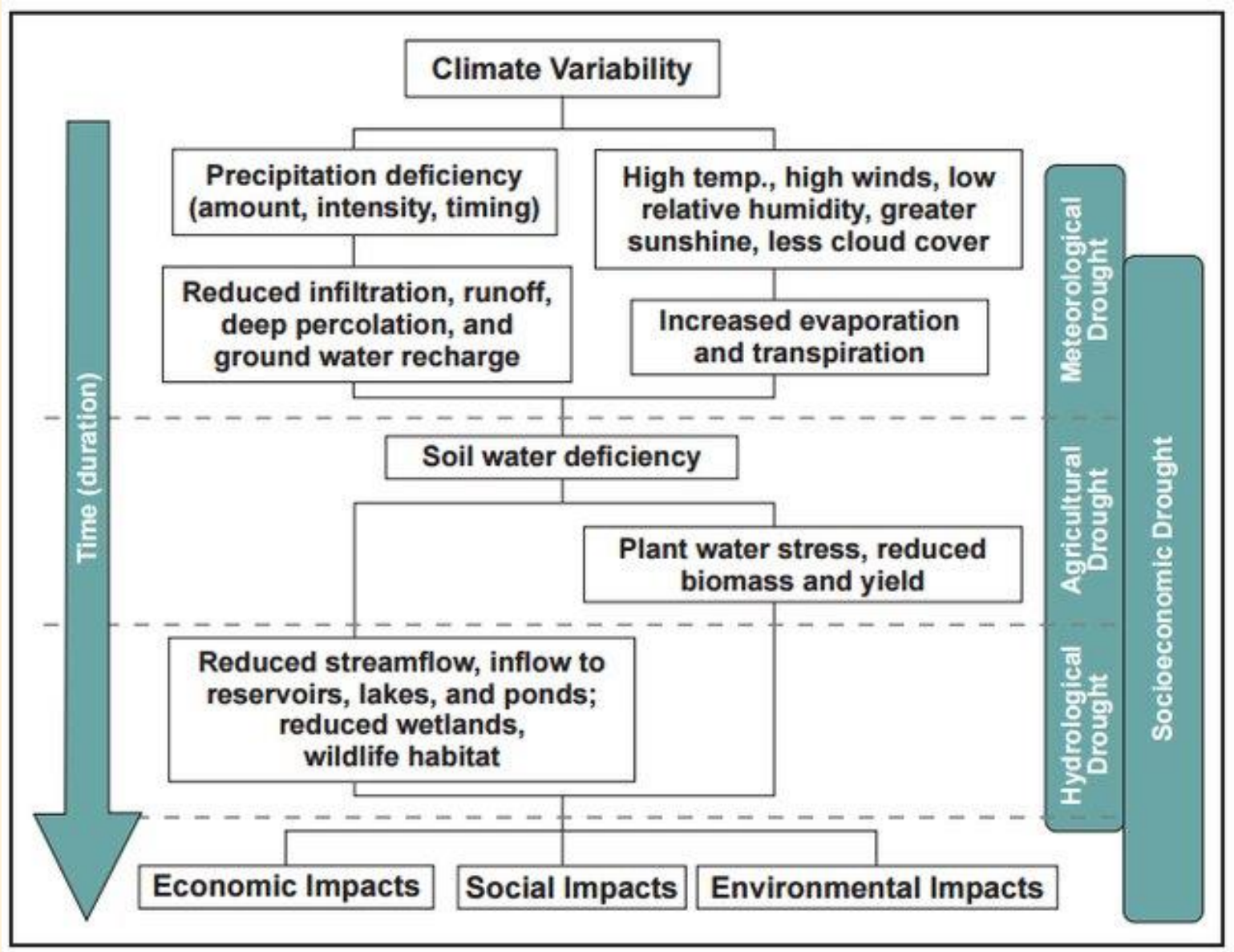




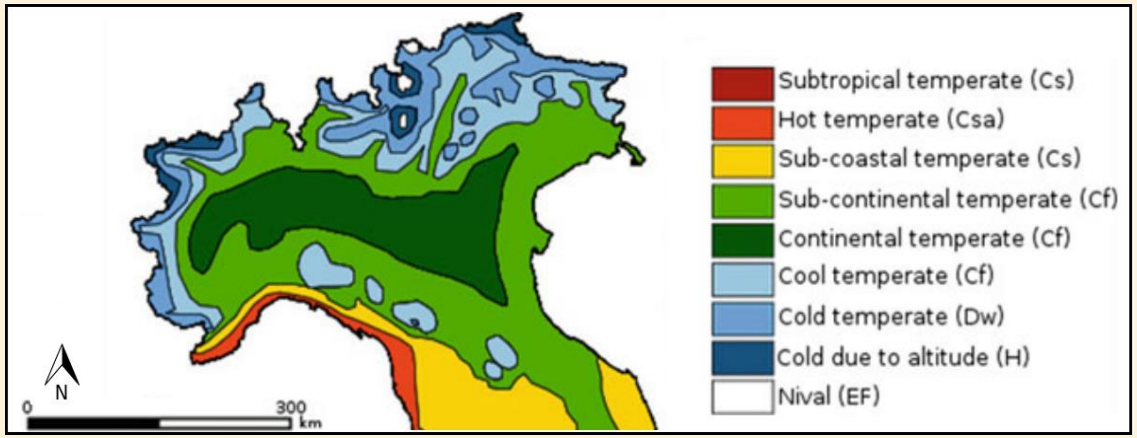
Pachauri et al., 2014

Extreme precipitation events will become more intense and more frequent

Increase in the global severity, in particular in the Mediterranean area, of droughts at the end of the 21st century (IPCC 2022).


Climate Variability
Precipitation deficiency (amount, intensity, timing)
High temp., high winds, low relative humidity, greater sunshine, less cloud cover
Reduced infiltration, runoff, deep percolation, and ground water recharge
Increased evaporation and transpiration
Soil water deficiency
Plant water stress, reduced biomass and yield
Reduced streamflow, inflow to reservoirs, lakes, and ponds; reduced wetlands, wildlife habitat
Economic Impacts
Social Impacts
Environmental Impacts
Time (duration)
Meteorological Drought
Agricultural Drought
Hydrological Drought
Socioeconomic Drought

Northern Italy Climate



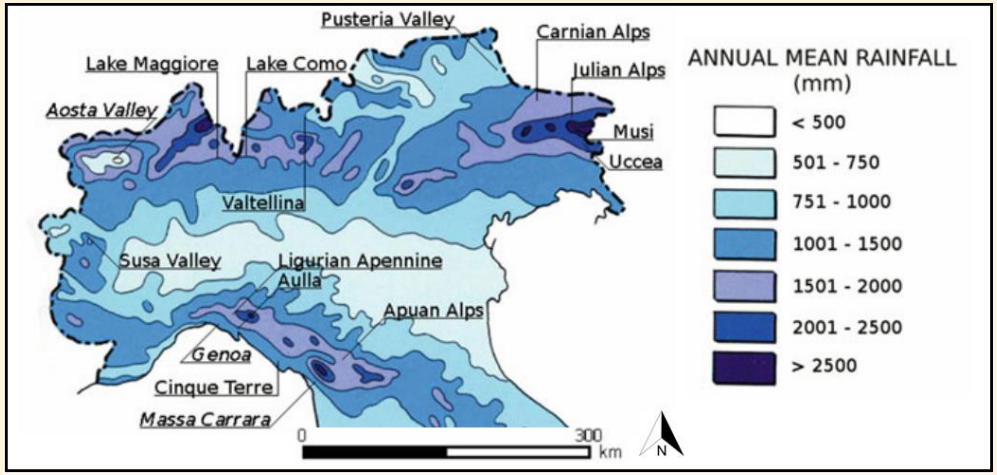
- Po Plain main climate Continaental Temperate (Cfa and Cfb)
- Alps Cool Temperate (Cf) and Cold Temperate(Dw)
- Ligurian coast Sub-coastal temperate (Cs) and Hot temperate (Csa)

Three rainiest sectors:

- Carnian and Julian Alps (2500-3000mm)
- Occidental Alps (1700-2000 mm)
- Ligurian Apennines (2300 mm)

Po Valley east-west decrease (500-1000 mm)

Susa Valley, Pusteria Valley (500 mm)

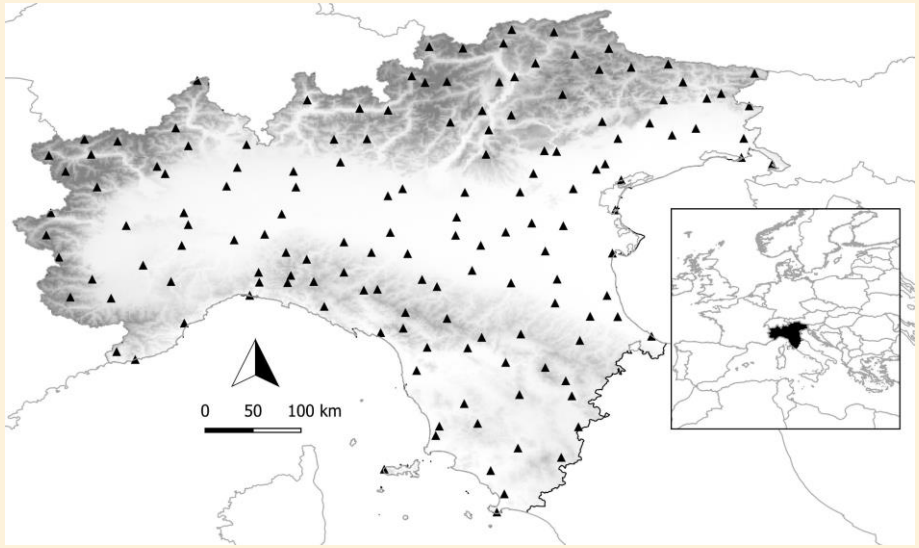


Main Goals

For the 2000-2020 period:

- Investigate on the spatial distributions of the main bi-weekly drought events in northern Italy.
- Identify Spring-Summer drought impacts on vegetation greenness and communities using MODIS images.

Datasets



Ground data: precipitation

150 daily precipitation series (2000-2020)

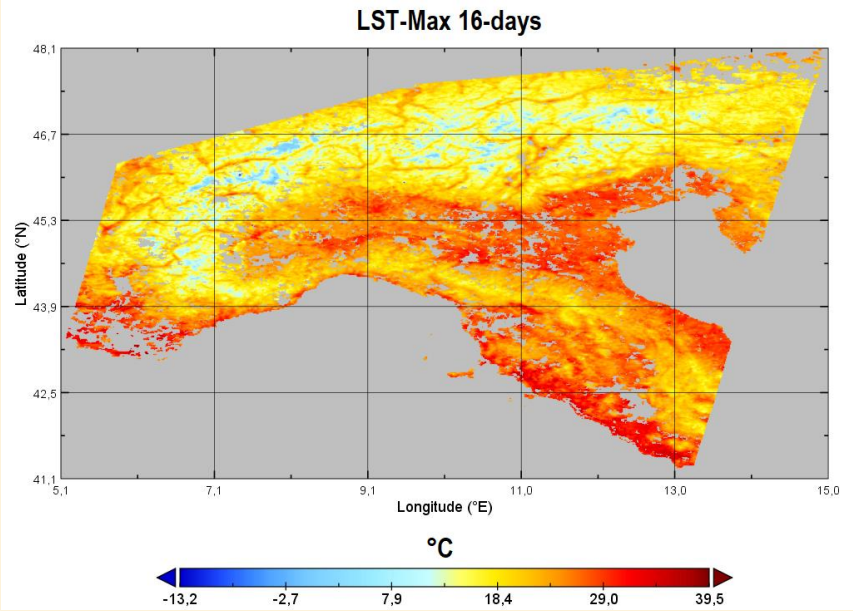
Daily precipitation series were:

- Quality controlled and aggregated at bi-weekly scale.
- Reconstructed (Baronetti et al., 2020).
- Homogenised (Vicente-Serrano et al., 2017).
- Spatialised at 1km of resolution by mean of the Universal Kriging with auxiliary variables.

Modis products at 1km of spatial resolution:

- 8-days Land Surface Temperature MOD11 (LST_Day and LST_Night)
- 16-days Normalized Difference Vegetation Index (NDVI) MOD13
- 16-days Enhanced vegetation index (EVI) MOD13
- CORINE Land Cover, MCD12

Pixels that included no data, low quality or were covered with clouds, were removed.



Method

- Application of SPEI (Vicente-Serrano et al. 2010) and SPI (McKee et al., 1993) drought indices at 12, 24 and 36 months.
- Severe (<-1.28)and extreme (<-1.65) drought episode that interest at least 25% for 3 consecutive weeks were detected (Baronetti et al., 2018).
- Trend analysis using the Mann-Kendal test with 5% p-value.
- Creation of maps of drought duration for severe and extreme events.
- Pearson's correlation test between vegetation indices (NDVI, EVI) and drought indices (SPEI and SPI) at 12, 24 and 36 months (Gouveia et al., 2016).
- Investigation on the vegetation types most sensitive to drought events at 12, 24 and 36 months, by mean of the CORINE Land Cover product.

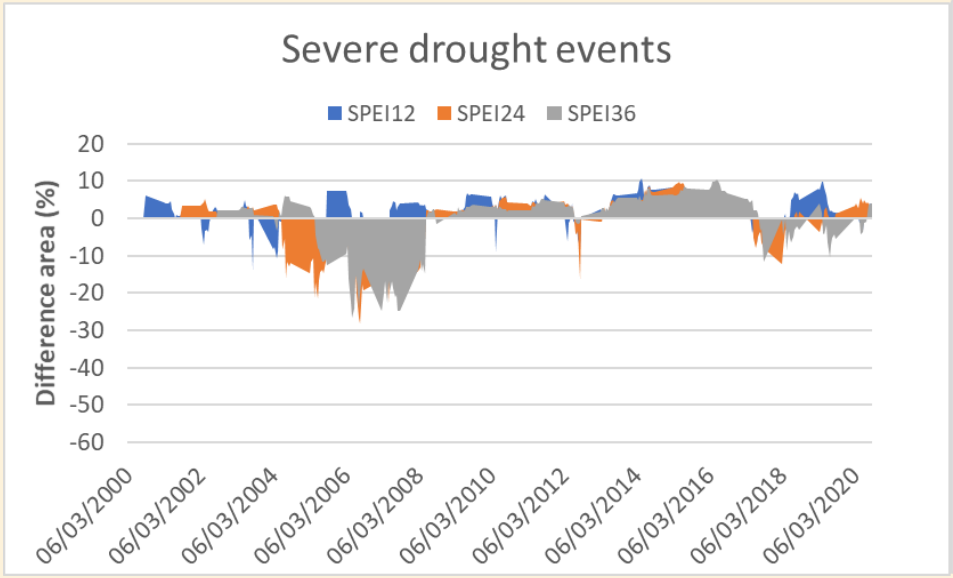
Main drought episodes

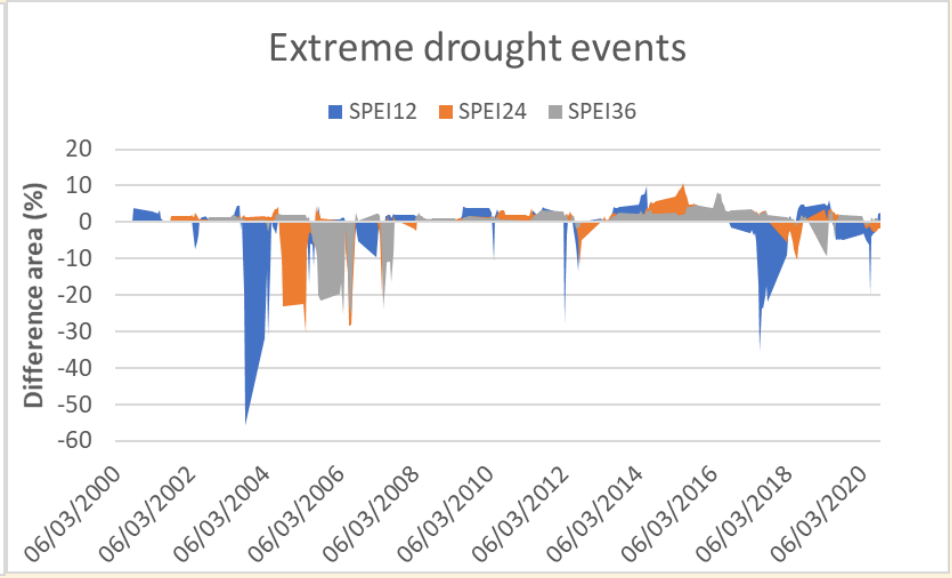
SPEI				SPI			
Start	End	Week	%Area	Start	End	Week	%Area
12/07/2003	29/08/2003	8	29	12/07/2003	29/08/2003	8	45
05/03/2004	06/04/2004	8	30	05/03/2004	12/04/2004	8	40
09/05/2005	18/08/2005	14	25	09/05/2005	28/08/2005	13	32
10/06/2006	26/06/2006	4	25	10/06/2006	26/06/2006	6	28
07/04/2007	23/04/2007	4	30	06/03/2007	09/05/2007	10	40
21/03/2012	06/04/2012	4	25	21/03/2012	06/04/2012	4	30
25/05/2014	10/06/2014	4	32	25/05/2014	10/06/2014	4	25
26/06/2017	29/08/2017	10	35	25/05/2017	29/08/2017	14	40
25/06/2020	28/08/2020	8	25	24/05/2020	11/07/2020	8	25

Concordance between SPEI and SPI indices

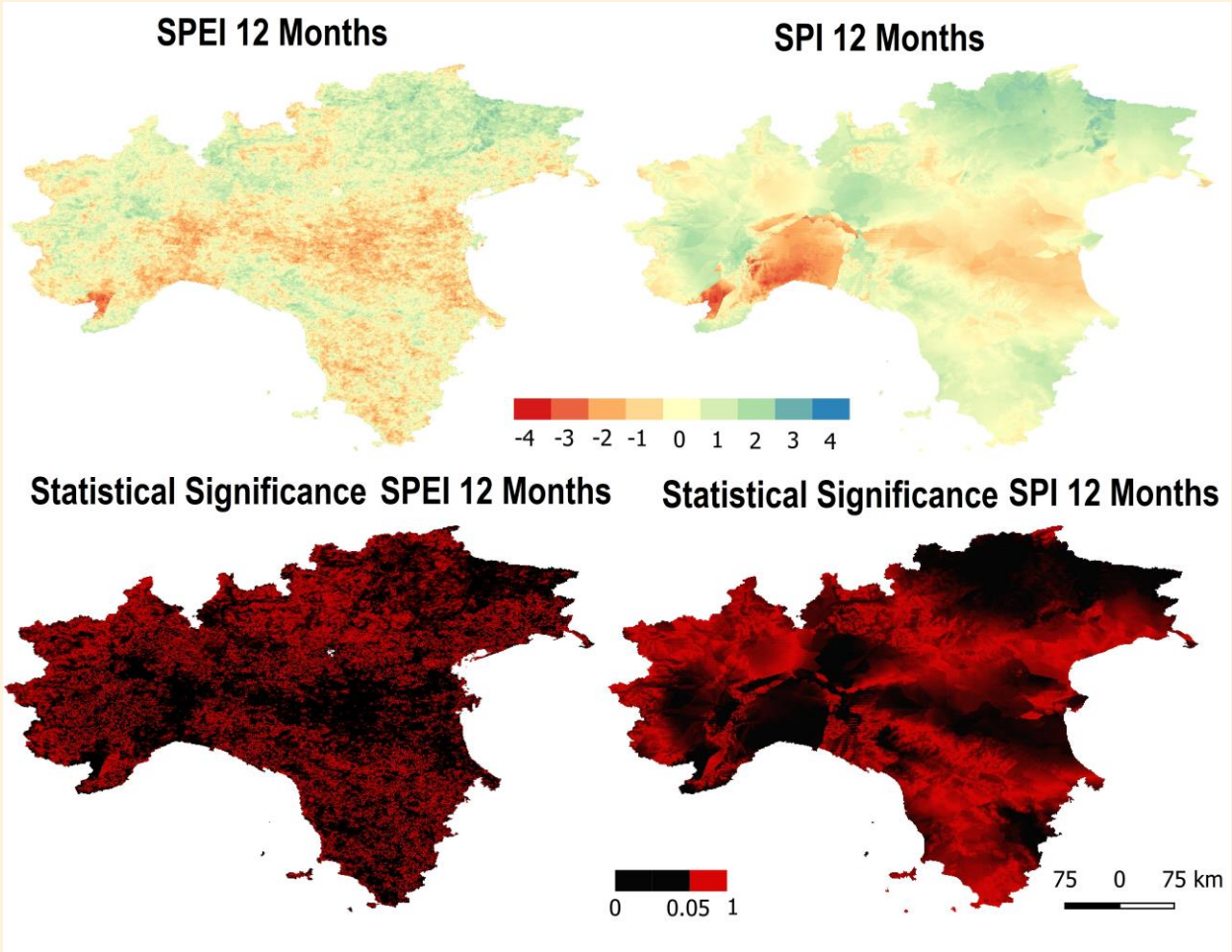
9 drought events

More extended SPI drought events.





Spatial Drought Trends

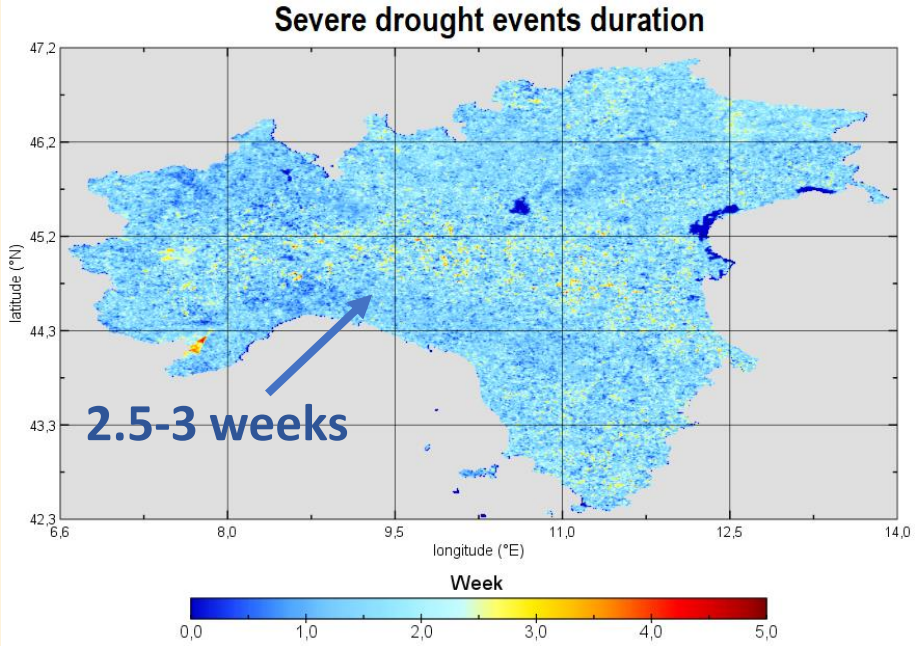


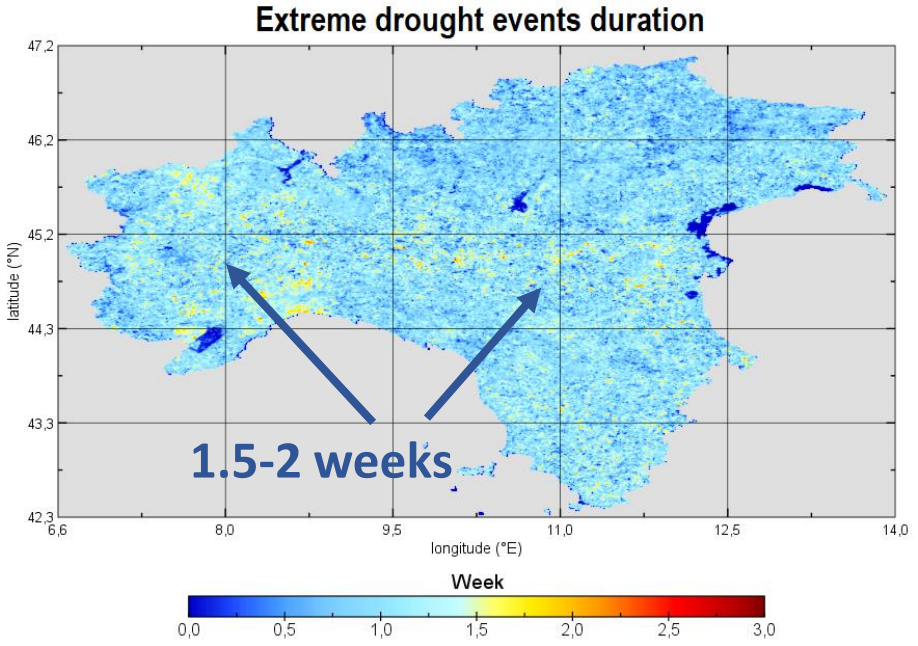
Negative and significant trends in the Po Valley.

Negative and non-significant trends for the Tuscany hills.

Positive and significative trends in the eastern Alps.

Drought Duration

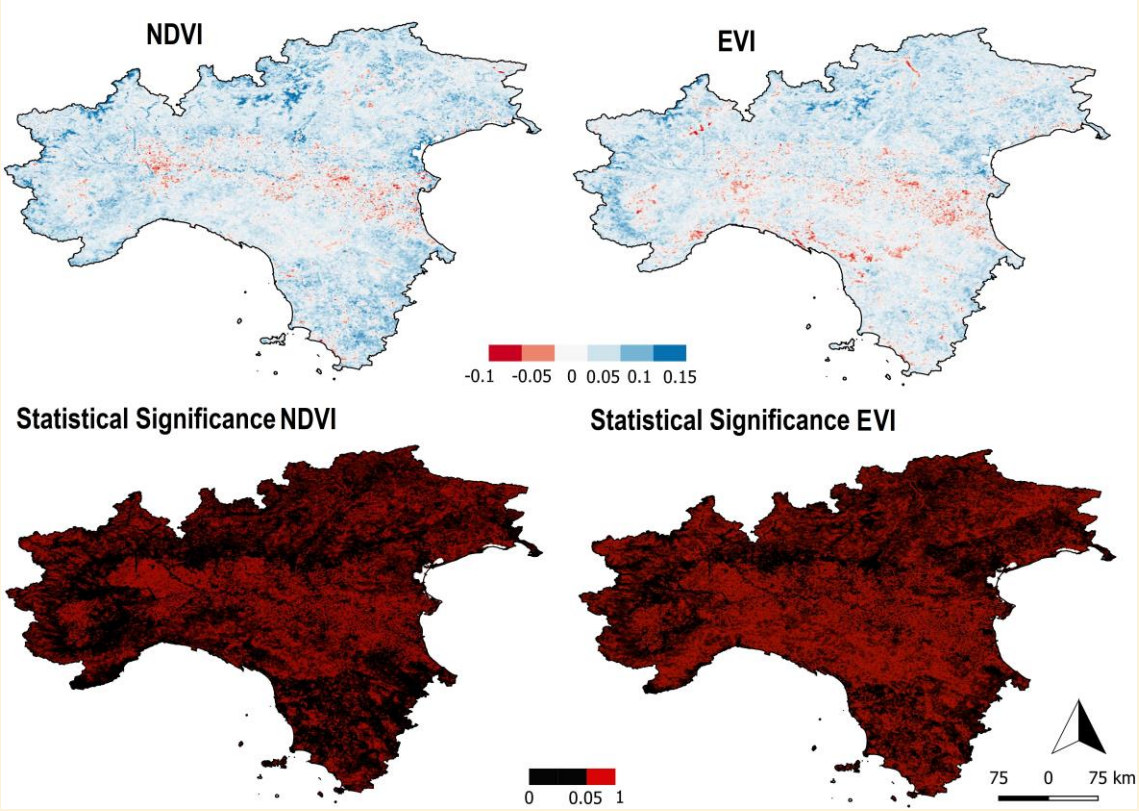




The Po Valley is interested by the longest severe (2.5-3 weeks) and extreme (1.5-2 weeks) events.

Long extreme episodes (1.5-2 weeks) were also recorded in the Occidental Alps.

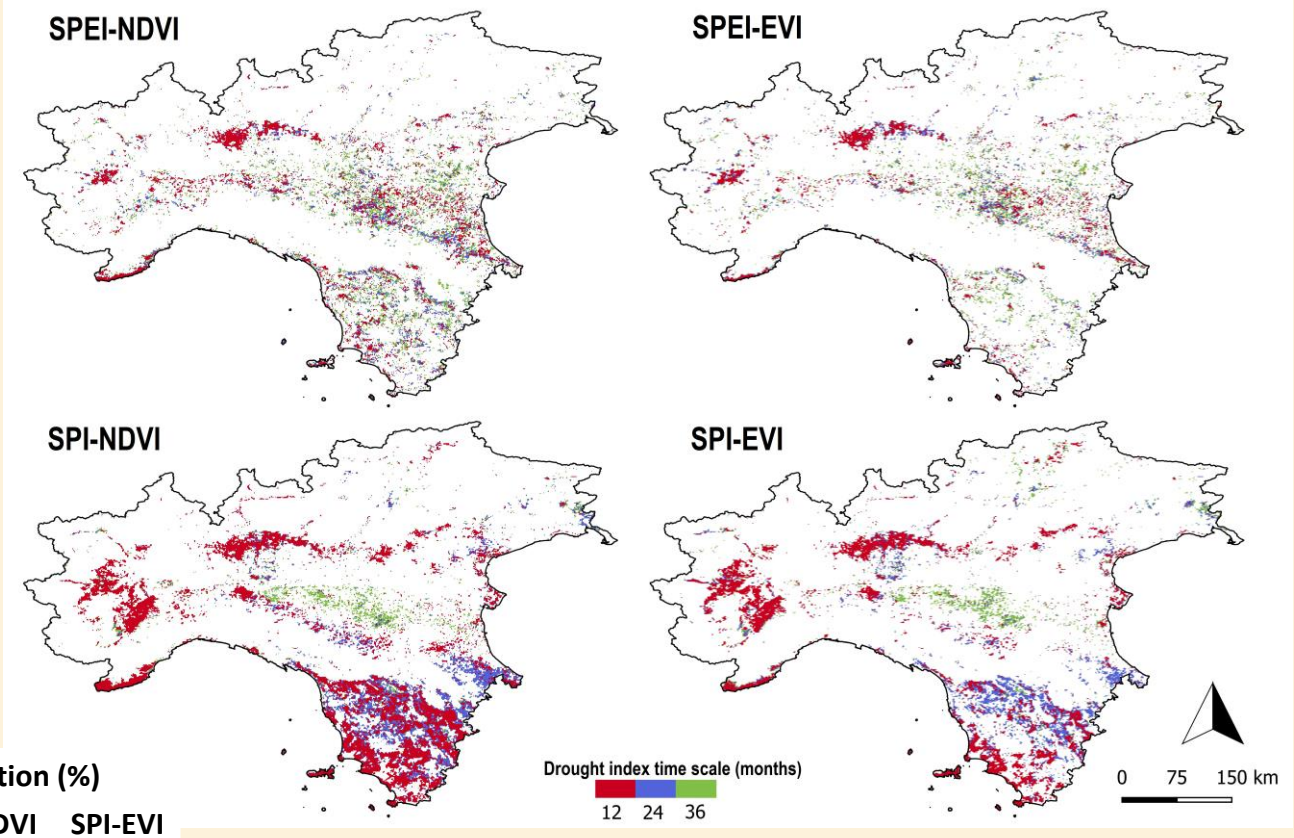
Spatial Vegetation Trends



Negative and non-significant trends for the plain (Po Valley) and Tuscany hills

Vegetation response to droughts

The strongest correlations were found in the Po Valley and the Tuscan hills



Timescale	Percentage of total vegetation (%)			
	SPEI-NDVI	SPEI-EVI	SPI-NDVI	SPI-EVI
12 Months	5	3	9	7
24 Months	7	4	13	9
36 Months	10	7	18	13

At long drought timescales, the percentage of involved vegetation area is double than at short timescales.

Vegetation response to droughts

	SPEI-NDVI (%)			SPEI-EVI (%)			SPI-NDVI (%)			SPI-EVI (%)		
	12	24	36	12	24	36	12	24	36	12	24	36
Dense Forests	1.37	1.90	2.52	0.62	1.05	1.71	4.82	5.78	5.49	2.50	3.04	3.32
Evergreen Needleleaf Forests	3.13	4.20	4.76	2.26	2.88	3.57	7.46	8.40	8.40	5.01	6.08	5.45
Evergreen Broadleaf Forests	3.47	4.92	5.97	2.42	4.11	3.95	8.47	11.13	10.00	5.81	7.50	8.97
Deciduous Needleleaf Forests	4.09	5.42	6.37	2.66	3.71	3.71	9.13	11.22	10.17	6.27	7.51	8.80
Deciduous Broadleaf Forests	3.18	4.77	5.57	2.09	3.18	3.58	9.05	11.73	9.84	5.96	7.06	9.06
Broadleaf/Needleleaf Forests	3.25	4.24	5.12	1.97	2.56	3.15	8.67	11.03	9.16	5.91	7.29	8.02
Broadleaf Evergreen/Deciduous Forests	3.02	5.17	6.92	1.27	2.63	3.80	8.38	11.11	10.53	5.07	7.41	8.95
Open Forests	3.01	6.22	10.15	1.24	2.55	4.30	20.08	28.59	22.02	10.00	17.99	20.97
Sparce Forests	4.07	6.35	7.42	1.80	2.33	3.87	10.34	10.16	11.02	11.42	12.44	11.05
Forest /Cropland Mosaics	7.01	14.10	22.01	4.29	8.10	13.05	26.57	32.05	39.02	17.02	26.84	33.30
Woody Wetlands	7.79	9.40	12.32	4.16	7.40	9.94	15.41	19.33	22.67	8.88	13.00	16.43
Herbaceous	5.45	6.20	7.71	1.64	2.75	3.24	7.86	8.73	9.35	5.17	6.96	7.94
Natural Herbaceous / Croplands Mosaics	5.26	8.60	15.62	3.23	5.64	10.58	14.85	18.48	26.82	10.03	15.66	19.68
Herbaceous Croplands	5.32	6.71	13.28	3.67	4.83	10.09	5.06	5.85	8.54	3.93	5.02	8.02

Forests and herbaceous mixed with croplands are the mostly sensitive vegetation types to droughts

To Conclude….

- Agreement between SPEI and SPI in the detection of nine drought episodes.
- In 2007 and in 2017 SPI used to detect events that are more spatially and temporally extended → main triggering factor is the lack of precipitation.
- Po Plain and the Tuscan hills are the most sensitive areas to droughts with the strongest vegetation response.
- Vegetation responses in the main drought events shows that the effects are not exclusively correlated with temperature trends in Northern Italy (Marked in the Alps).
- Drought impacts are strictly linked with vegetation communities and human activities.
- High sensitivity to droughts was observed for all vegetation types mixed with croplands → extension of monoculture (rice and maize) increased in the last sixty years.
- Minimal drought for the forest types → increase of dry periods during the wet season could increase the potential risk for forest fires.

THANK YOU!

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