Evaluating the Impact of Drought Events on Grassland and Forest Ecosystems in Northern Italian Mountains

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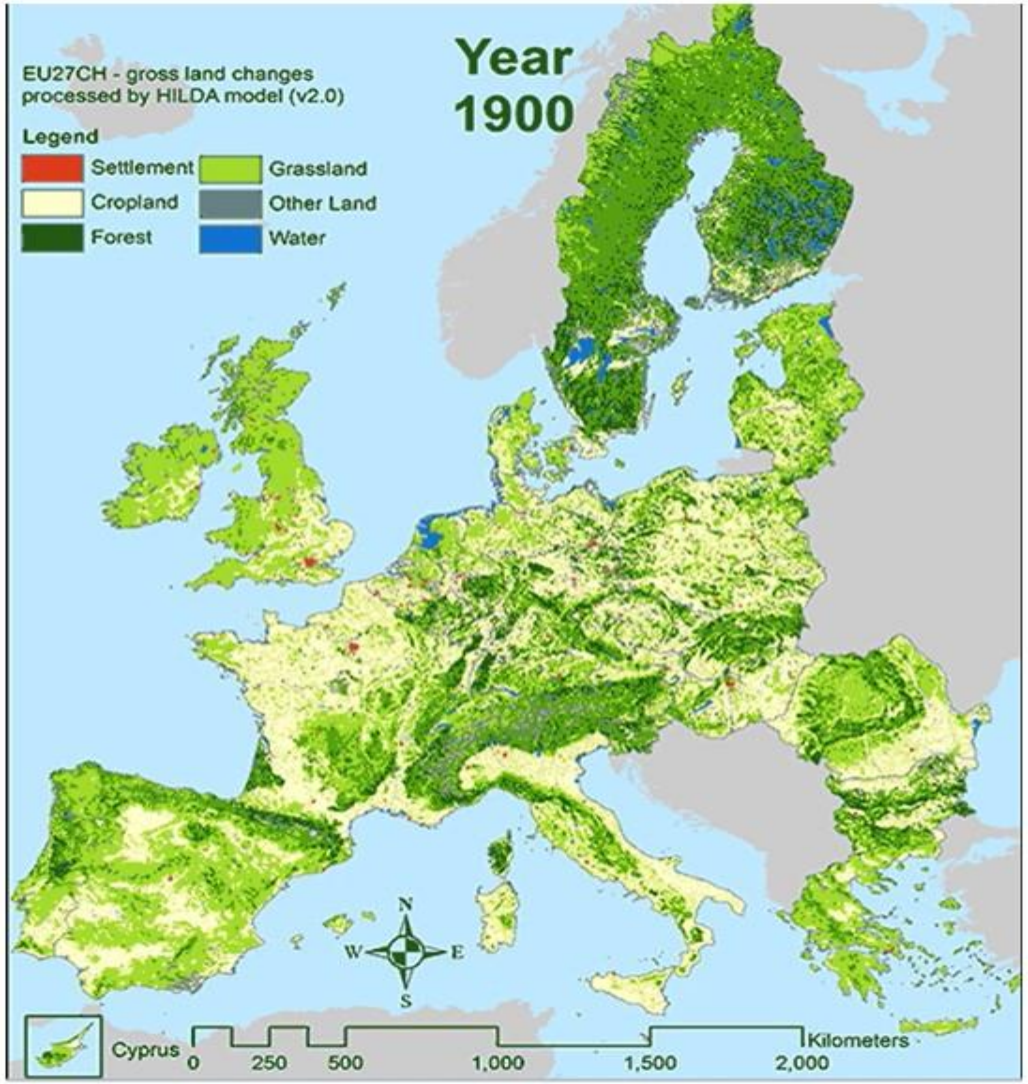
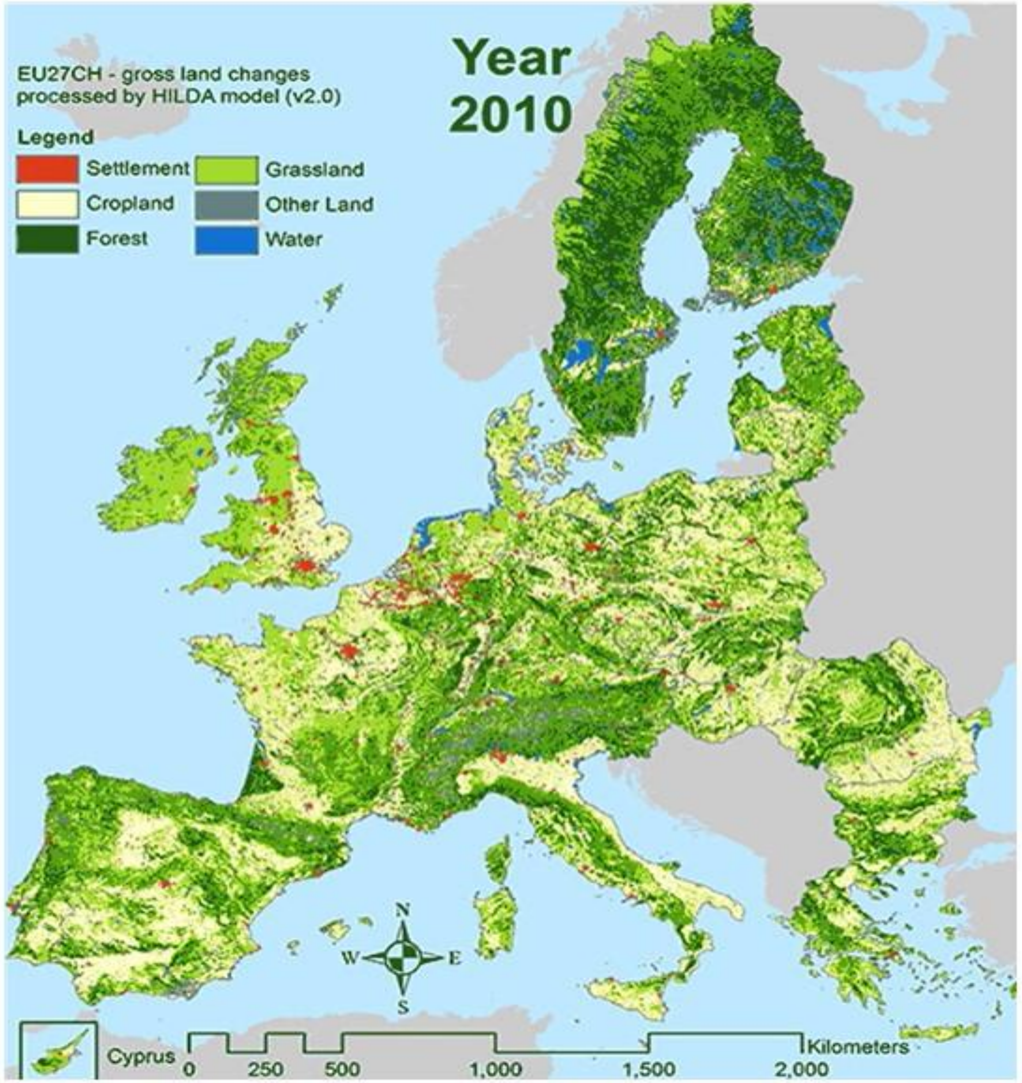
1. Introduction

- Prominent land-use change trends in Europe in recent decades include:
  - ✓ Abandonment of traditional pastoral activities
  - ✓ Conversion of grasslands to forests through rewilding

- In the context of the ongoing climate change, investigating how these different ecosystems respond to climate variability has become a growing research priority

Greening trends in Europe





- In Italy, this land use trend concerns primary mountains already experiencing accelerated climate change pressure with increase of extreme events like droughts

- Thus, this study aims to examine how grassland and forest ecosystems along the climatic gradient in Italy respond to the impacts of drought events

- The first evaluation concerned the Eastern Italian Alps and areas surrounding Passo Brocon (Trentino, Italy)

Current study area:
Passo Brocon

2. Materials and Methods

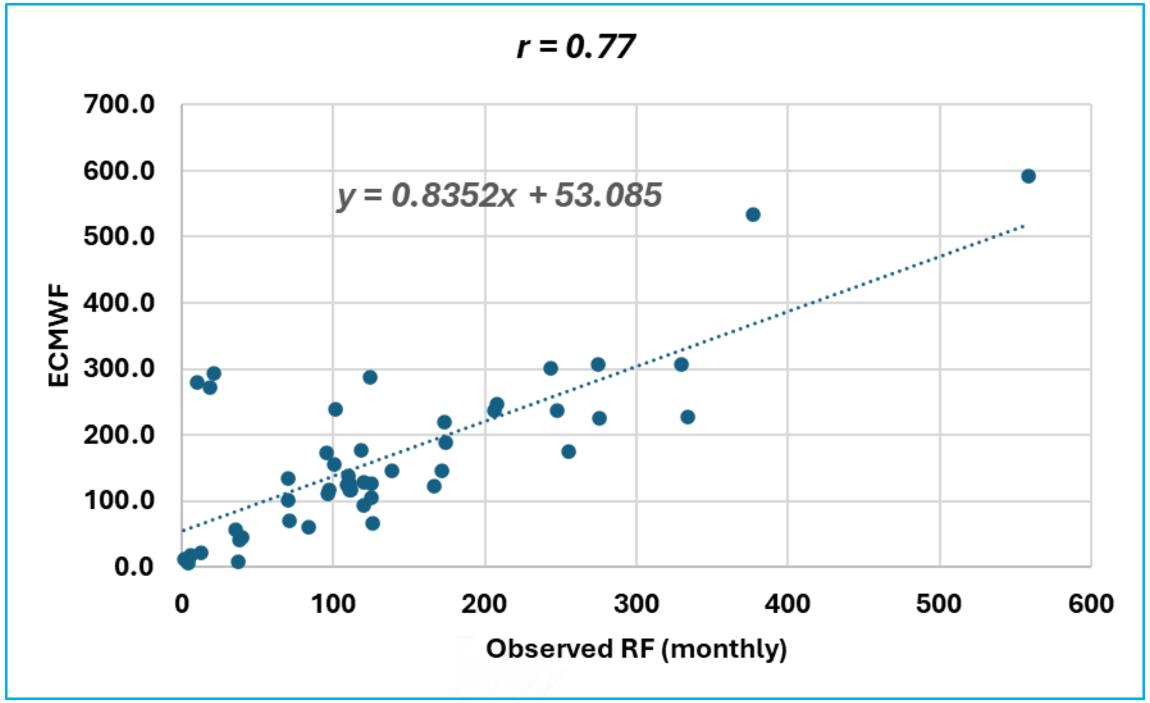
Input Data Sets

Data type	Variables (monthly)	Resolution	Time Range
Climate data (ECMW-Reanalysis ERA5)	**Precipitation**	2.2 km	1981 to 2023
	Minimum T°		
	Maximum T°		
Satellite image data	**MODIS16-day NDVI**	250 m	2001 to 2023

2.1 Validation of Climate Data

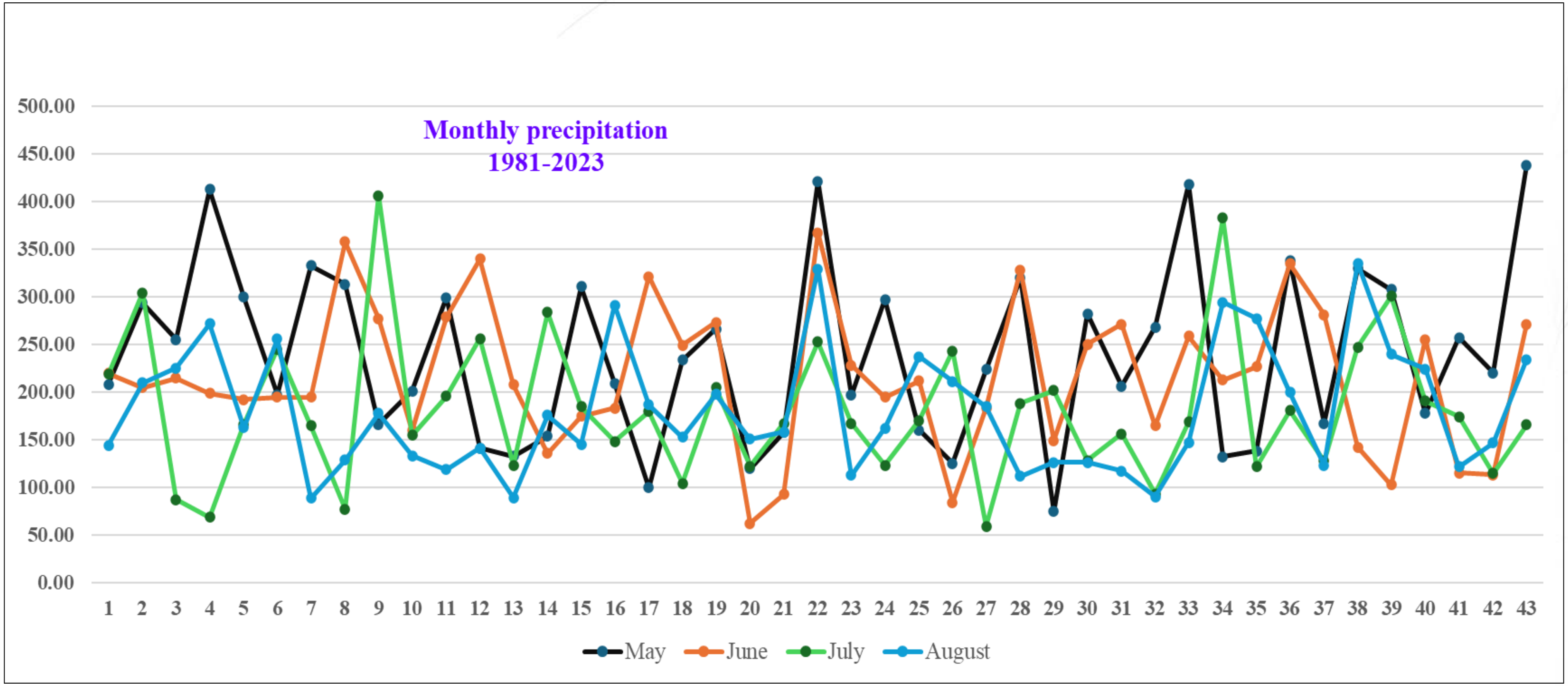
Correlation analysis

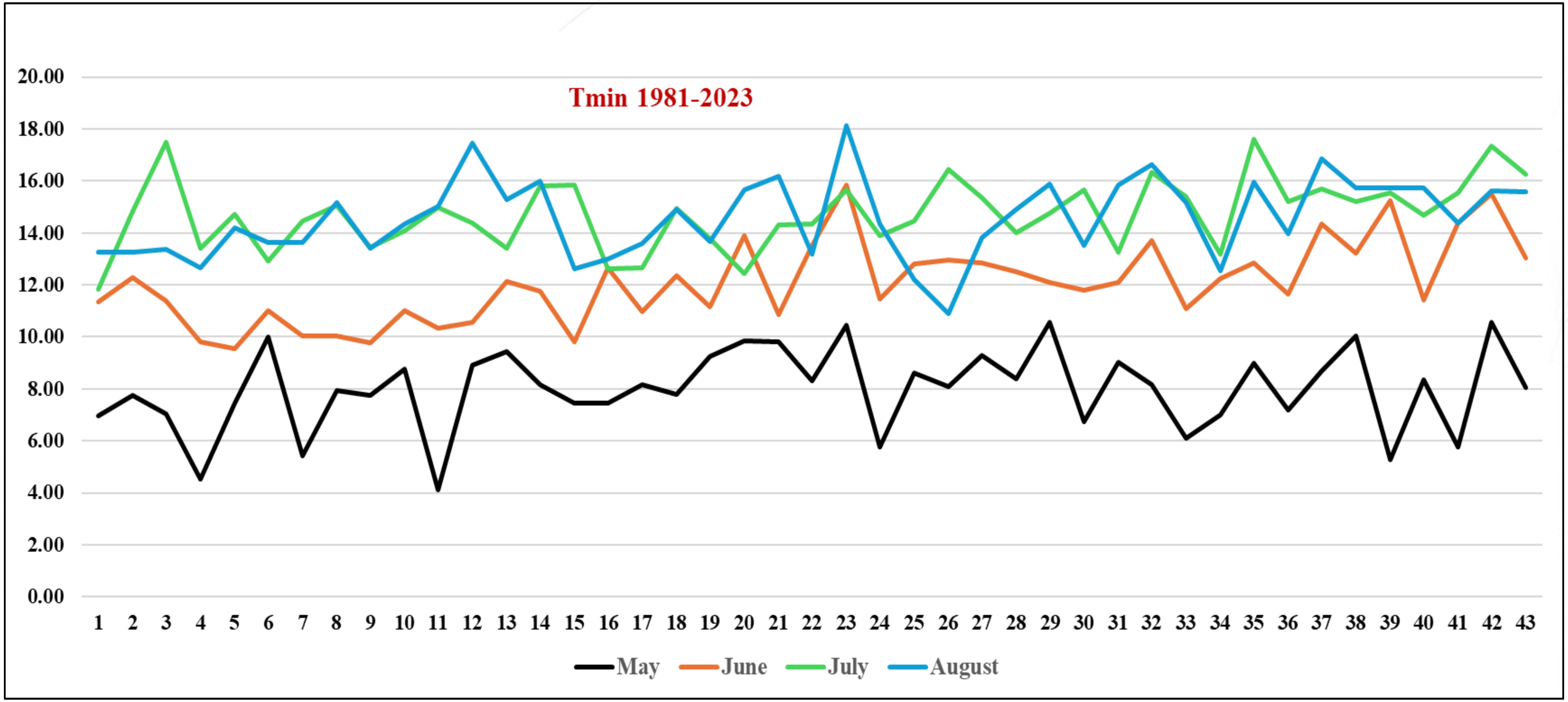
➢Accuracy of the ECMWF monthly precipitation was assessed against ground observations over 4 years (2019-2022)

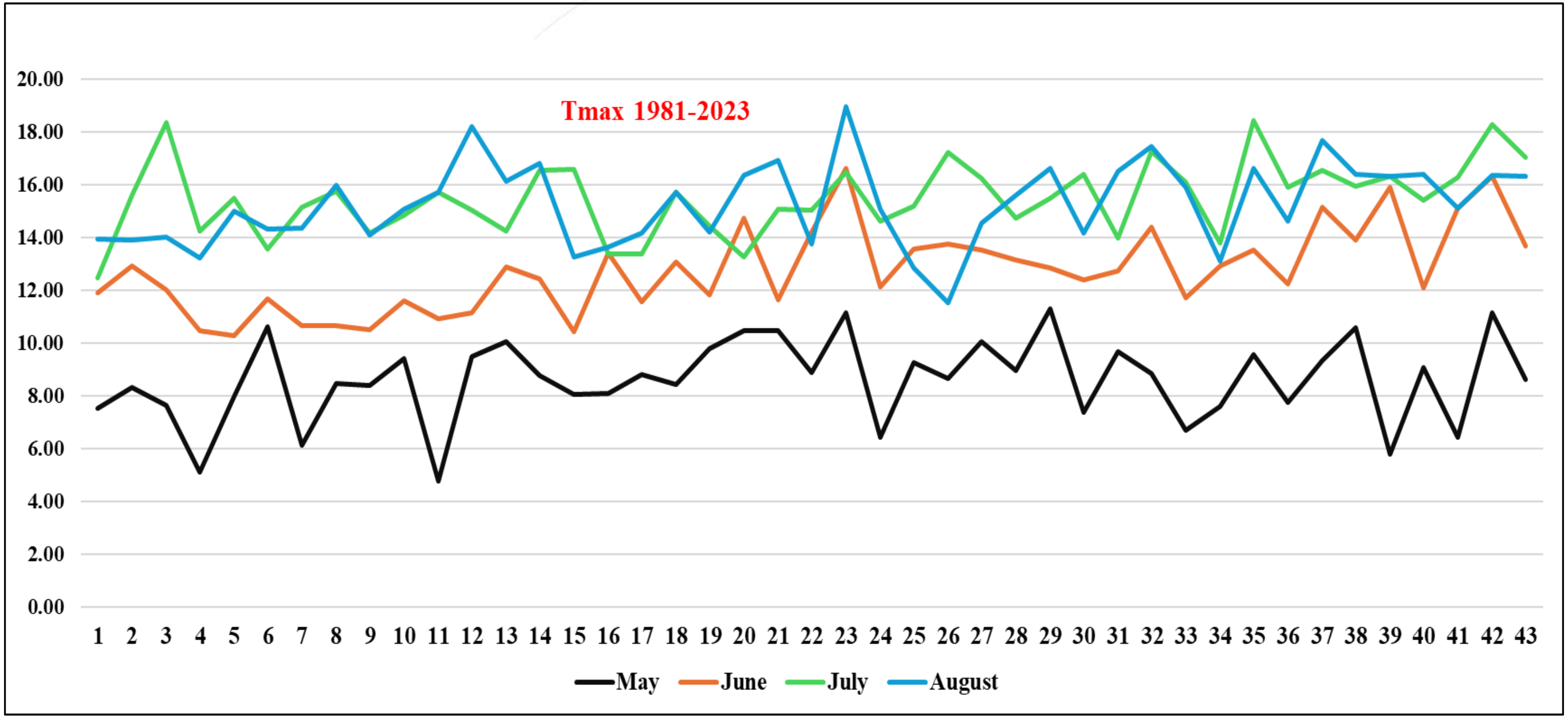


2.2 Trend analysis

- A trend analysis was performed
  - ✓ On three climate variables
    - ✓ Precipitation
    - ✓ Tmin
    - ✓ Tmax


Monthly precipitation
1981-2023
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
May
June
July
August


Tmin 1981-2023
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
May
June
July
August


Tmax 1981-2023
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43
May
June
July
August

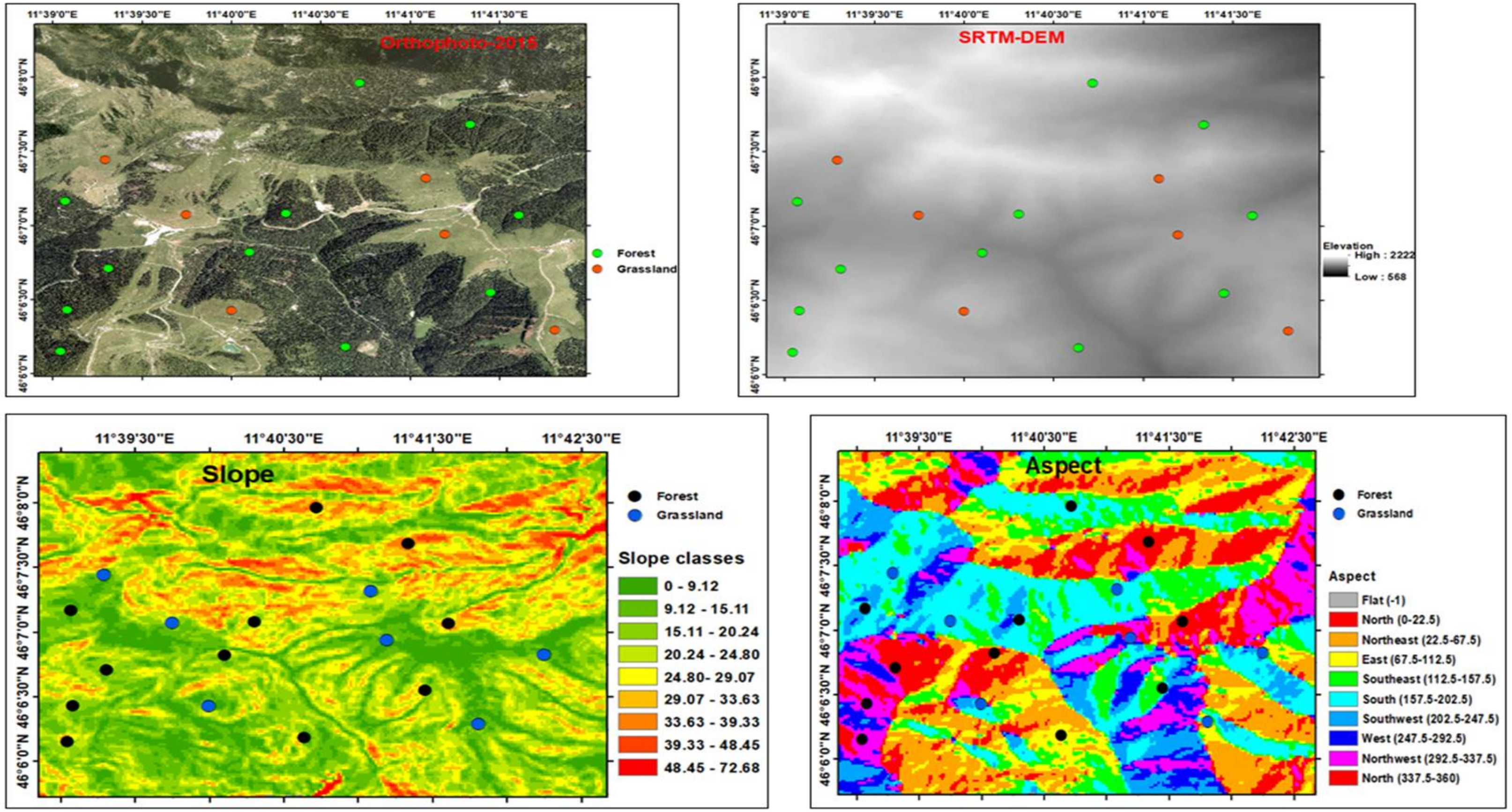
2.3 Methods of Meteorological Drought Assessment

- Standardized Precipitation Evapotranspiration Index (SPEI)
  - ✓ Engage more climate variables than SPI
    - ✓ Monthly Precipitation, Tmin, and Tmax

- Vegetation response was examined at various time-scales (1-, 3-, 4-, 6-, and 12-month)
- The focus of the drought assessment was on:
  - ✓ the growing period from May to August:
  - ✓ to align with the stage of maximum phenological development

2.4 Selection of Vegetation Response Assessment Sites

- **11 forest** and **7 grassland sites** were selected
- **Elevation**, **slope**, and **aspect** were considered
  - ✓ to understand the effect of topographic variations on vegetation responses to drought



Topographic Characteristics of Forest Sites

Forest	Elevation	Slope	Aspect
1	1500	10-25	East
2	1550	14-27	North
3	1550	21-32	North
4	1550	12-25	SE
5	1600	25-36	North
6	1600	6-20	SW
7	1715	14-23	North
8	1725	15-29	SW
9	1800	10-25	NW
10	1810	27-36	South
11	1850	15-32	NW

Topographic Characteristics of Grassland Sites

Grass	Elevation	Slope	Aspect
1	1641	14-24	South
2	1650	4-20	NW
3	1690	4-23	SW
4	1715	9-22	South
5	1724	5-19	SE
6	1750	13-25	South
7	1782	3-14	South

2.5 Characterizing Vegetation Response to Drought

Standardized NDVI anomaly

$$\Delta_{NDVI}(i,t) = \frac{NDVI(i,t) - mean_{u \in m}[NDVI(i,u)]}{sd_{u \in m}[NDVI(i,u)]}$$

- The monthly average NDVI in the time series is taken as the normal level (Ma *et al*, 2023)
- NDVI anomaly value **< -2 stdv** is considered as vegetation response to drought (disturbance)

3. Results

3.1 Trend Test Results

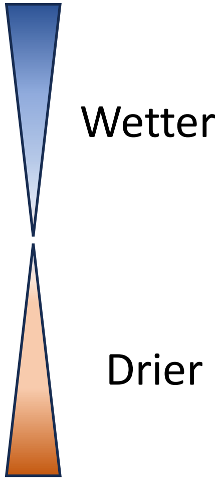
- The trend analysis result revealed
  - ✓ No significant trend in **precipitation** (MJJA)
  - ✓ Significant ($\alpha < 0.05$) increasing trends in **Tmin** and **Tmax** except for May
    - ✓ With rates of change > **0.04** ^{o}c/ year

Month	Variables	Trend type	Z-value	P-value	Sen's slope
June	Tmin	+ve	2.2815	0.02	0.0494 ^{o}c/year
	Tmax	+ve	2.2396	0.02	0.0487 ^{o}c/year
July	Tmin	+ve	2.6582	0.007	0.0497 ^{o}c/year
	Tmax	+ve	2.7001	0.006	0.0495 ^{o}c/year
August	Tmin	+ve	2.4908	0.01	0.0440 ^{o}c/year
	Tmax	+ve	2.4280	0.01	0.0438 ^{o}c/year

3.2. Drought Assessment Results

SPEI drought categories (Li et al., 2015)

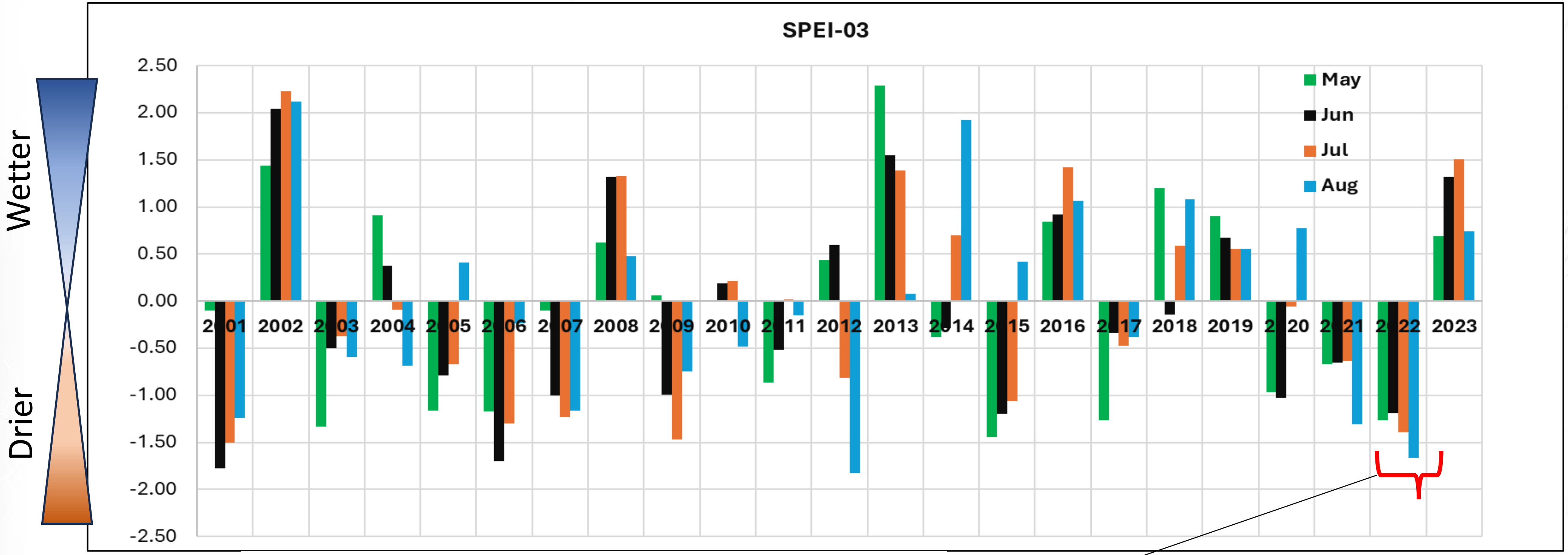
Drought category	SPEI values
Extremely wet	≥ 2.00
Very wet	1.50 to 1.99
Moderately wet	1.00 to 1.49
Near-normal	-0.99 to 0.99
Moderately dry	-1.49 to -1.00
Severely dry	-1.99 to -1.50
Extremely dry	≤ -2



- Finally, the drought assessment focused on **two more important time-scales**
  - ✓ SPEI-03 and SPEI-04
    - ✓ Relatively correlated with **grassland** and **forest** responses, respectively

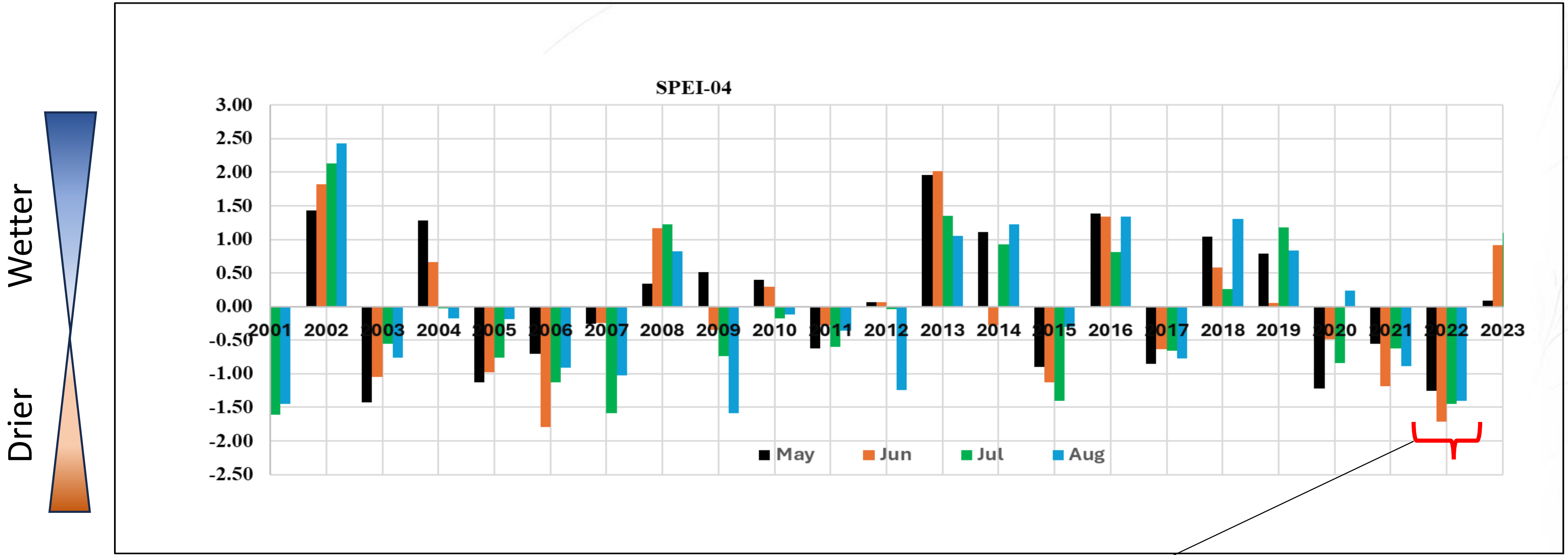
CNR IRET Conference   Rome, February 18th-19th, 2025

Characteristics of drought events (2001-2023)



Drought category	Number
Severe	4 (17.40%)
Moderate	19 (82.60%)
Extreme	0
Total	**23**

NB: The driest year was 2022

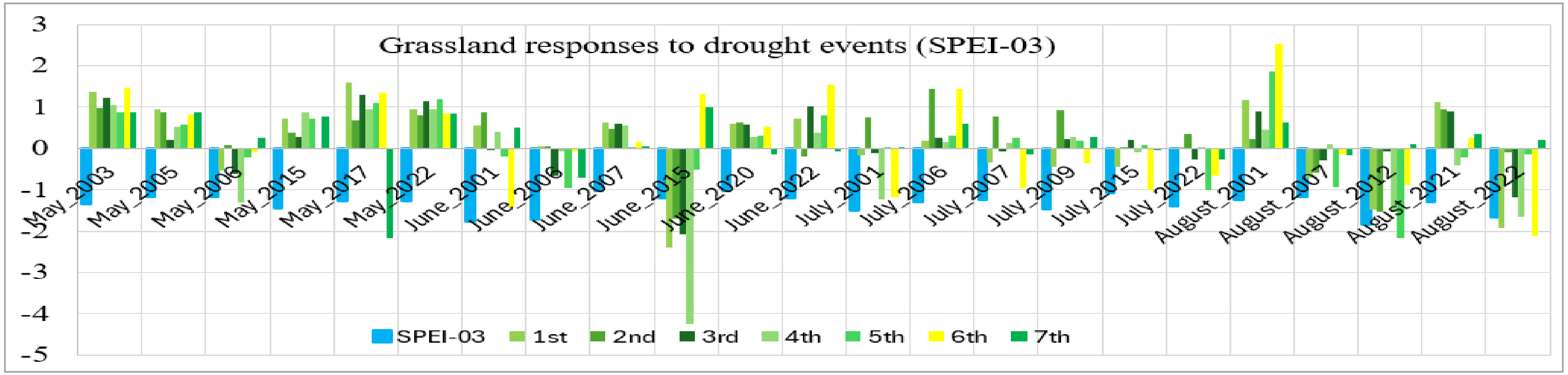


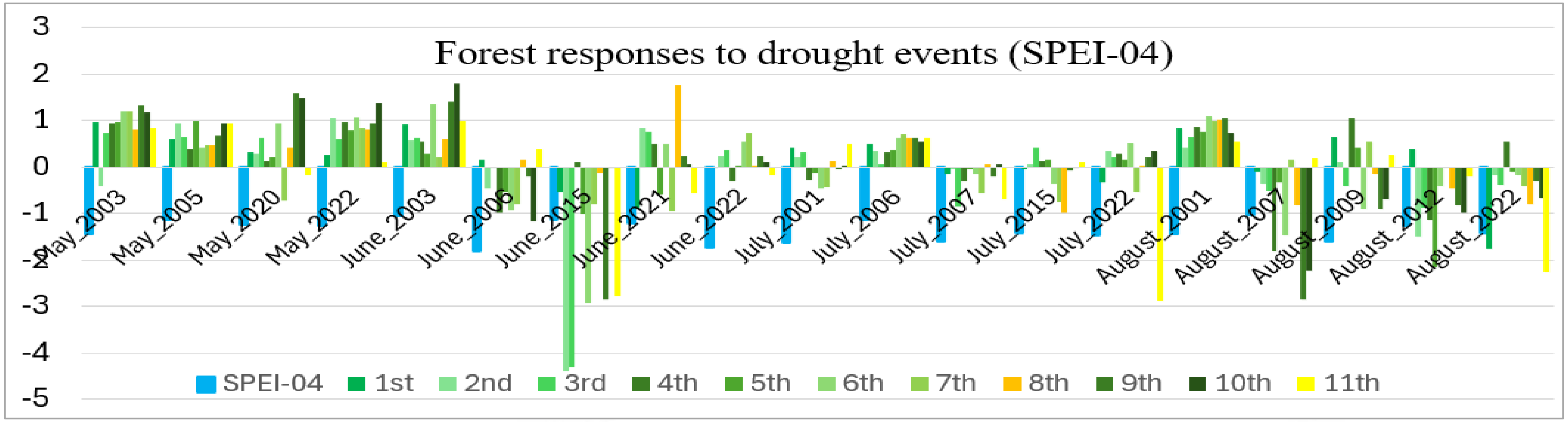
Drought category	Number
Severe	5 (26.32%)
Moderate	14 (73.68%)
Extreme	0
Total	**19**

NB: The driest year was 2022

3.3 Correlations of Met Drought Events and Ecosystem Responses

- Generally, they were found to be poorly correlated





Drought events vs Grassland responses (2001-2023)

Drought events	Stressed grass events	Response %
23	4	17.40

NB: Seasonal grazing might have distorted Grassland responses

Drought events vs Forest responses (2001-2023)

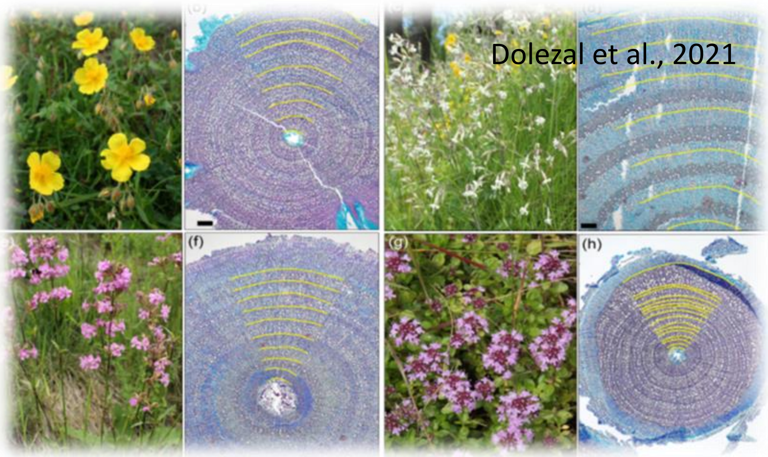
Drought events	Stressed forest events	Response %
19	5	26.3

- Both ecosystems have remained largely resistant to drought events
  - ✓ High elevation (low PET) and snow cover might have contributed to such resistance

4. Next Work

- Evaluating the response of forests and grasslands to drought events at other sites along the climatic gradient.

- Confront the NDVI time series with other proxies of ecosystem's sensitivity to drought: **dendrochronological** and **herb-chronological** study



5. Summary

- So far, the forest and grassland ecosystems have shown low sensitivity to warming temperatures and recurrent drought events
- However, if such climate anomaly trends persist in the future, they could have growing impacts on vegetation productivity and ecosystem functioning

Thank you!