EUMETSAT LSA SAF

A climatological assessment of drought impact on vegetation health index

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Contributions

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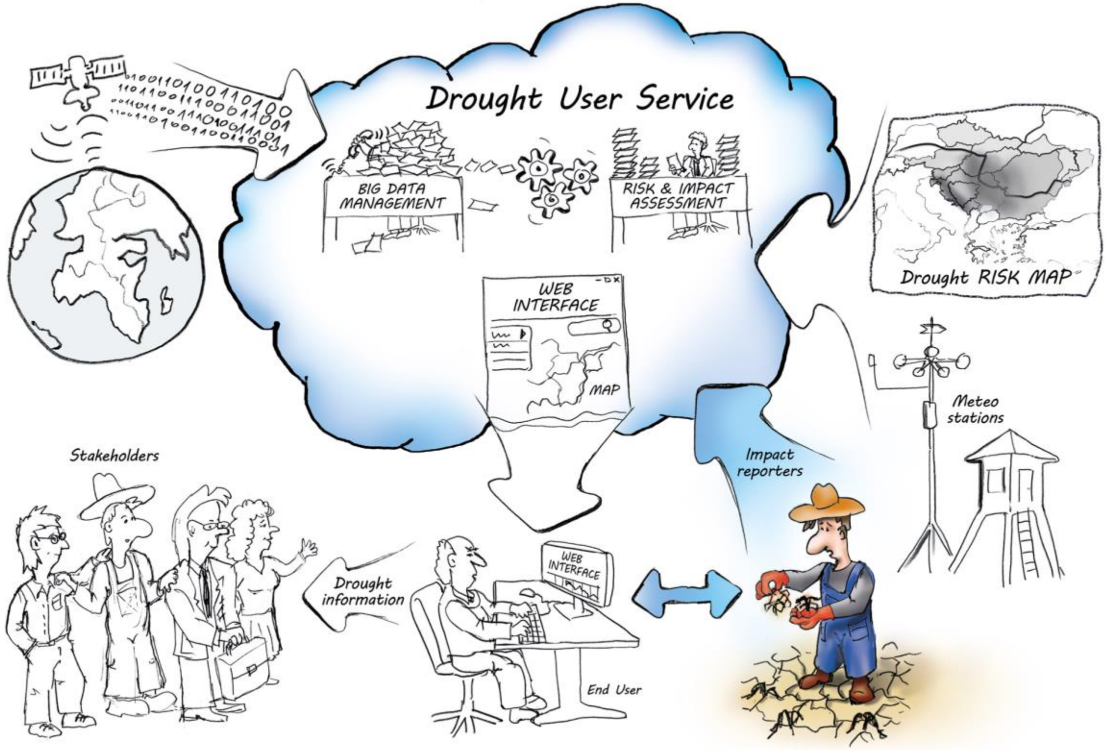
IPMA

Drought assessment and monitoring

- **rainfall data recorded in meteorological/ hydrological networks**
  represent local dynamics
  insufficient data coverage
- **remote sensing data**
  global coverage;
  independent estimation from space
  Limited (?) duration (~40 years)



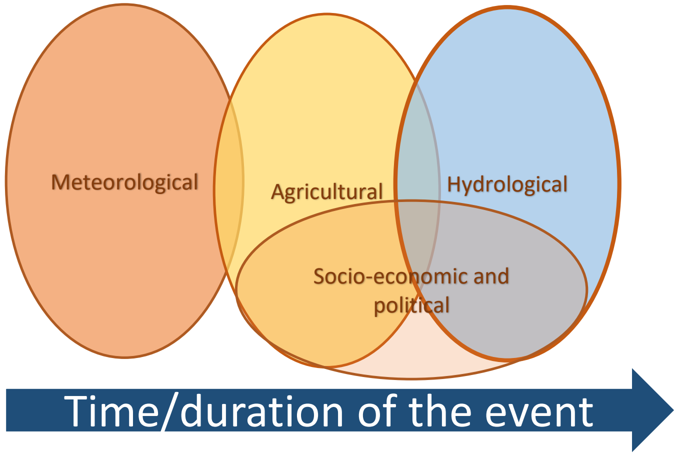
http://www.interreg-danube.eu/news-and-events/programme-news-and-events/2182

Drought Indices

Several indices have been developed to assess intensity, frequency, duration and surface extent of droughts

Different systems (hydrological, agricultural, economic systems to drought) respond to dry condition with different temporal scales

- to discriminate between different types of droughts.



- Flexible indicators are needed to quantify drought impacts

Table 1. Major drought indices discussed in this paper.

Index	Year introduced	Variables analyzed; application
Munger's Index	1916	Length of period without 24-h precipitation of 1.27 mm; daily measure of comparative forest fire risk
Kincer's Index	1919	30 or more consecutive days with less than 6.35 mm of precipitation in 24 h; seasonal distribution maps
Marcovitch's Index	1930	Temperature and precipitation; climatic requirements of the bean beetle
Blumenstock's Index	1942	Length of drought in days, where drought terminated by occurrence of 2.54 mm of precipitation in 48 h; short-term drought
Antecedent Precipitation Index	1954	Precipitation; a reverse drought index used for flood forecasting
Moisture Adequacy Index	1957	Precipitation and soil moisture; agricultural drought
Palmer's Index (PDSI and PHDI)	1965	Precipitation and temperature analyzed in a water balance model; comparison of meteorological and hydrological drought across space and time
Crop Moisture Index	1968	Precipitation and temperature analyzed in a water balance model; agricultural drought
Keetch–Byram Drought Index	1968	Precipitation and soil moisture analyzed in a water budget model; used by fire control managers
Surface Water Supply Index	1981	Snowpack, reservoir storage, streamflow, and precipitation; computed primarily for western river basins; statistical properties not well analyzed or understood
Standardized Precipitation Index	1993	Precipitation; allows measurement of droughts and wet spells in terms of precipitation deficit, percent of "normal," probability of nonexceedance, and SPI at multiple simultaneous timescales with potentially different behavior at all of them
Vegetation Condition Index	1995	Satellite AVHRR radiance (visible and near-IR); measures "health" of vegetation
Drought Monitor	1999	Integrates several drought indices and ancillary indicators into a weekly operational drought-monitoring map product; multipurpose

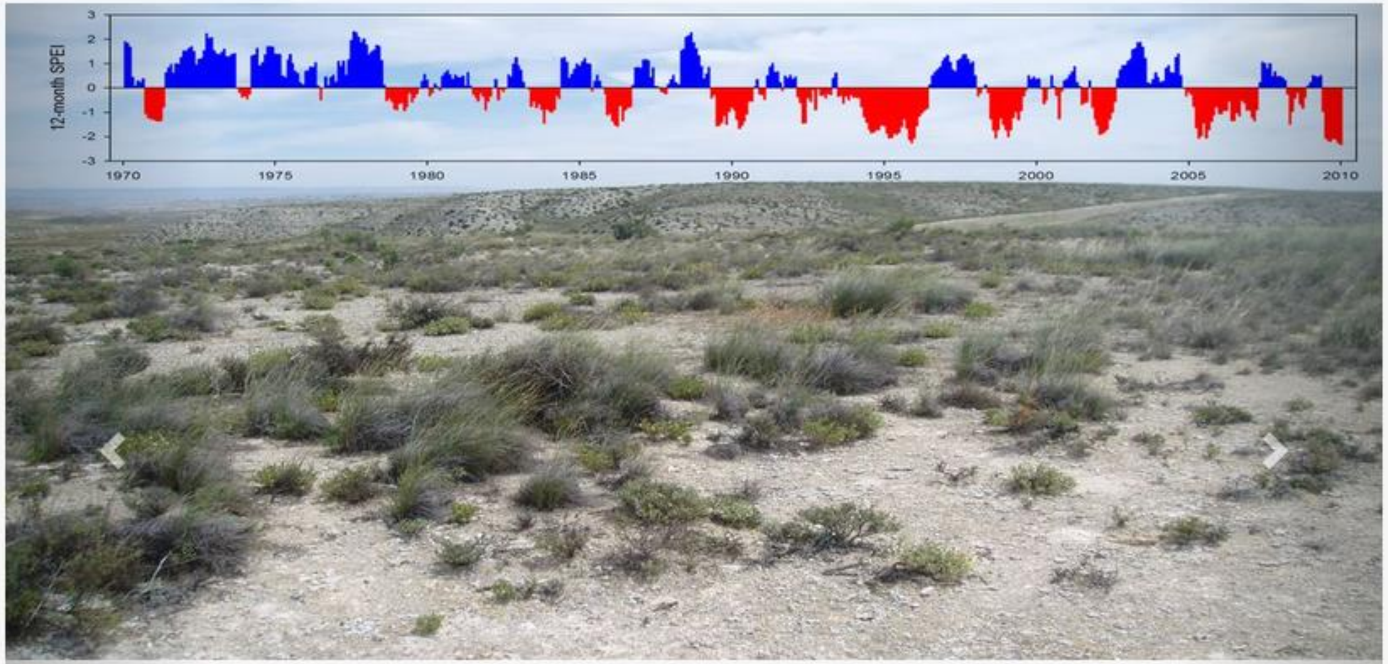
Heim (2002). Bulletin of the American Meteorological Society

Agricultural Drought Index	Rainfall	Temp.	Estimated soil moisture	Vegetation index	Stream flow	Potential evapo-transpiration	Crop coefficient	Soil type
Palmer Drought Severity Index	X	X						
Deciles	X							
Prescott Ratio Index								
Hutchinson Index	X							
Plant Growth Index								
Soil Moisture Anomaly	X	X	X?					
Enhanced Vegetation Index								
TCI								
NDVI								
Aridity Anomaly Index	X		X			X		
Two reservoir water balance model	X					X		
Soil Water Index	X			X		X		X
scPDSI	X	X						
Drought Severity Index	X							
Warm-spell duration Index		X						
Cold-spell duration Index		X						
Simple Daily Intensity Index	X							
Relative Soil Moisture	X	X	X			X		
Relative Water Deficit	X	X	X			X		
Accumulated Water Deficiency	X	X	X			X		
Accumulated Drought Index	X	X				X		
Crop Moisture Index (CMI)	X					X		
Days without rainfall	X							
Soil Moisture						X		
SPEI	X	X						
CMI-Palmer based	X	X						
Crop Specific ET	X	X						
Drought Monitor	X	X	X	X	X	X		
Standardized Precipitation Index (SPI)	X							
Percent Normal	X							
Relative Soil Moisture	X	X	X					
Soil Moisture Anomaly	X	X						
Cumulative rainfall	X							

Sivakumar et al. (2010): Agricultural Drought Indices, WMO

Drought assessment and monitoring

SPEI



Steppe areas affected by degradation processes in the central Ebro basin (Spain) and the evolution of the 12-month SPEI in the area. See details in Vicente-Serrano et al. (2012) Dryness is accelerating degradation of vulnerable shrublands in semiarid Mediterranean environments. Ecological Monographs, 82, 407-428.

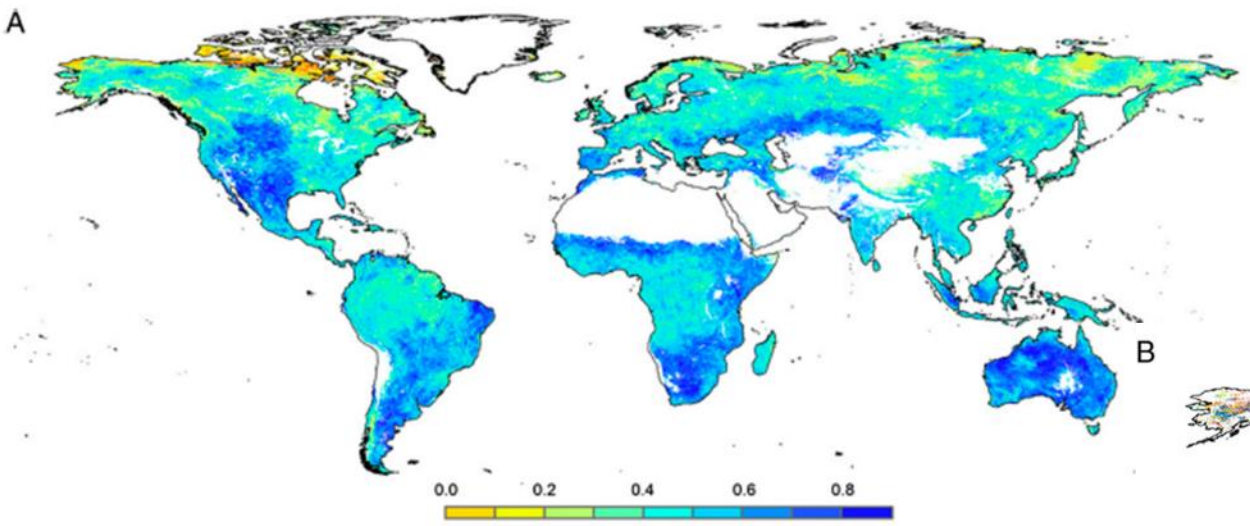
The Standardised Precipitation-Evapotranspiration Index

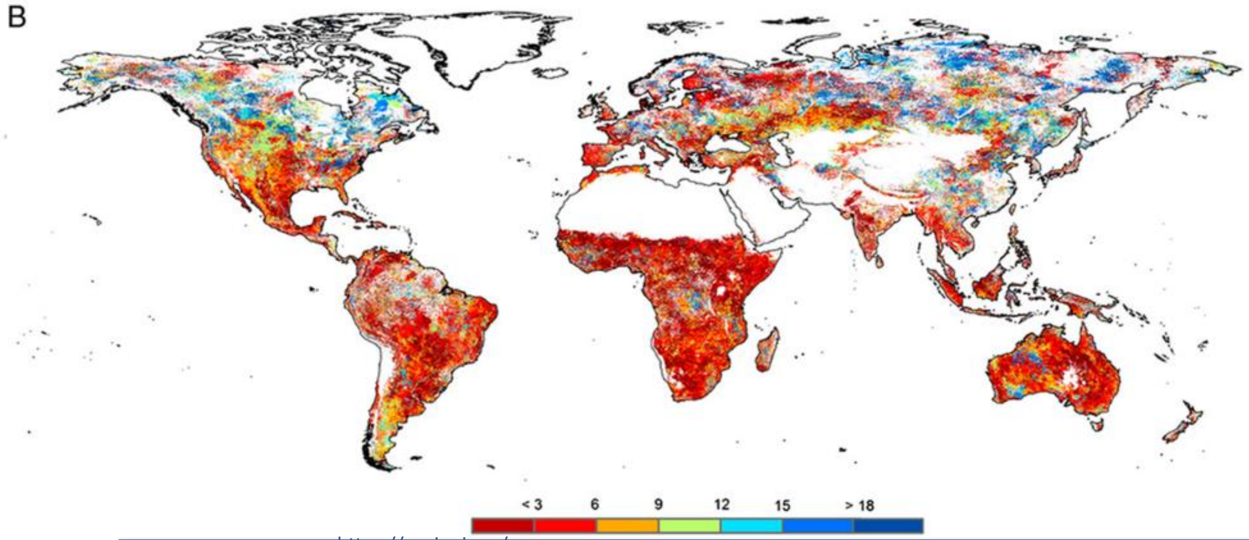
The SPEI is a multiscalar drought index based on climatic data. It can be used for determining the onset, duration and magnitude of drought conditions with respect to normal conditions in a variety of natural and managed systems such as crops, ecosystems, rivers, water resources, etc.

https://spei.csic.es/

NDVI and SPEI (global)

maximum correlations between SPEI and GIMMS-NDVI for the period 1981–2006





… and correspondent time-scales

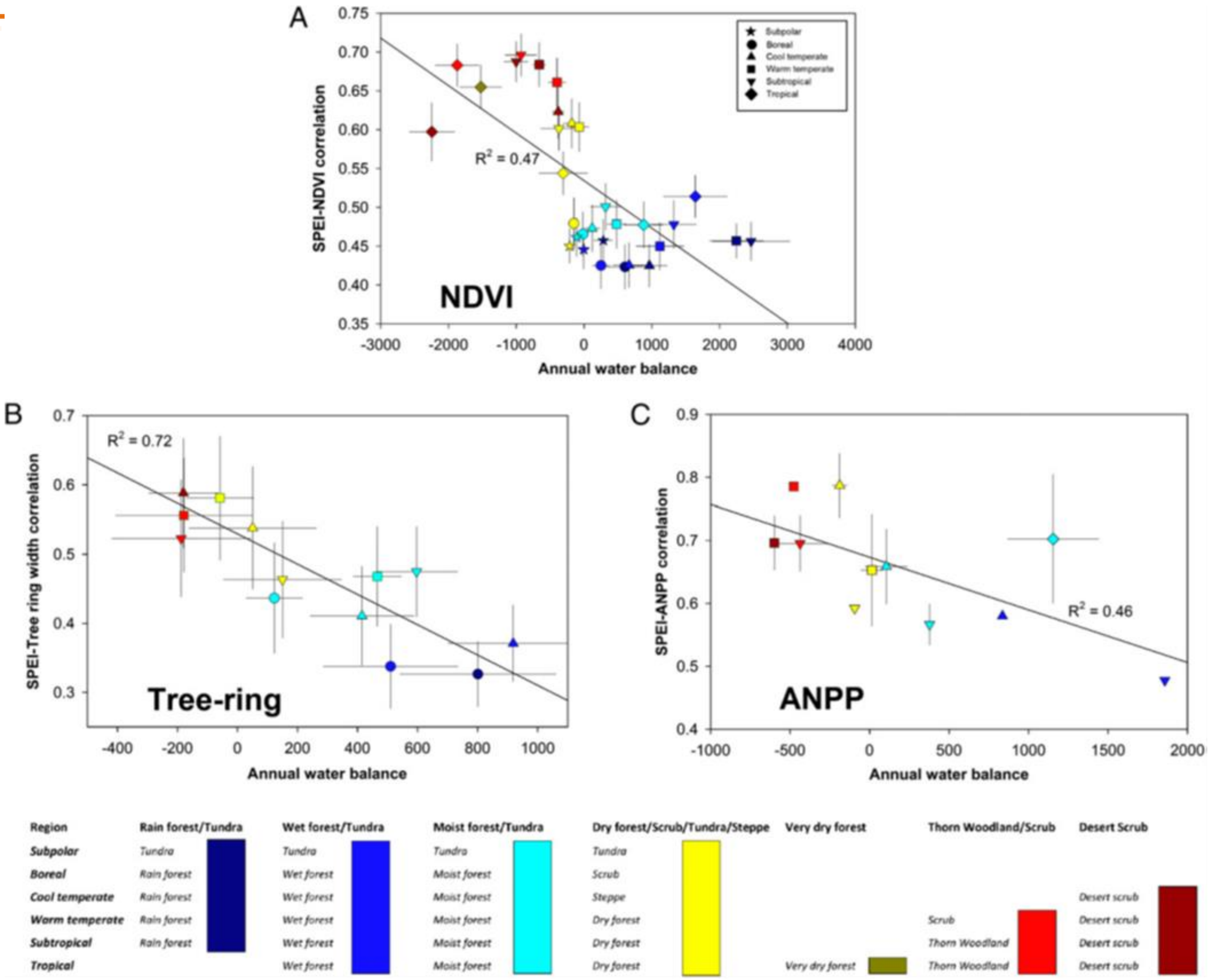
Vicente-Serrano et al (2013), PNAS

https://spei.csic.es/

Vegetation indices and Drought

NDVI and SPEI (global)

… and the average annual water balance across the world biomes



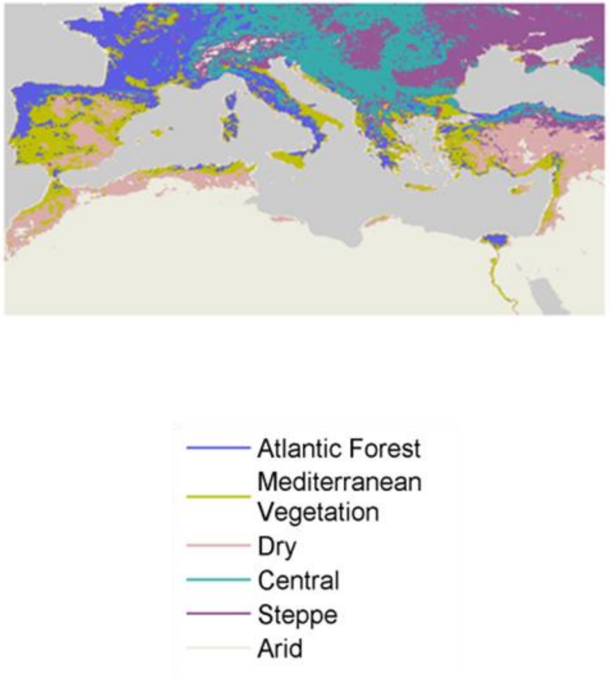
Vicente-Serrano et al (2013), PNAS

Vegetation indices and Drought

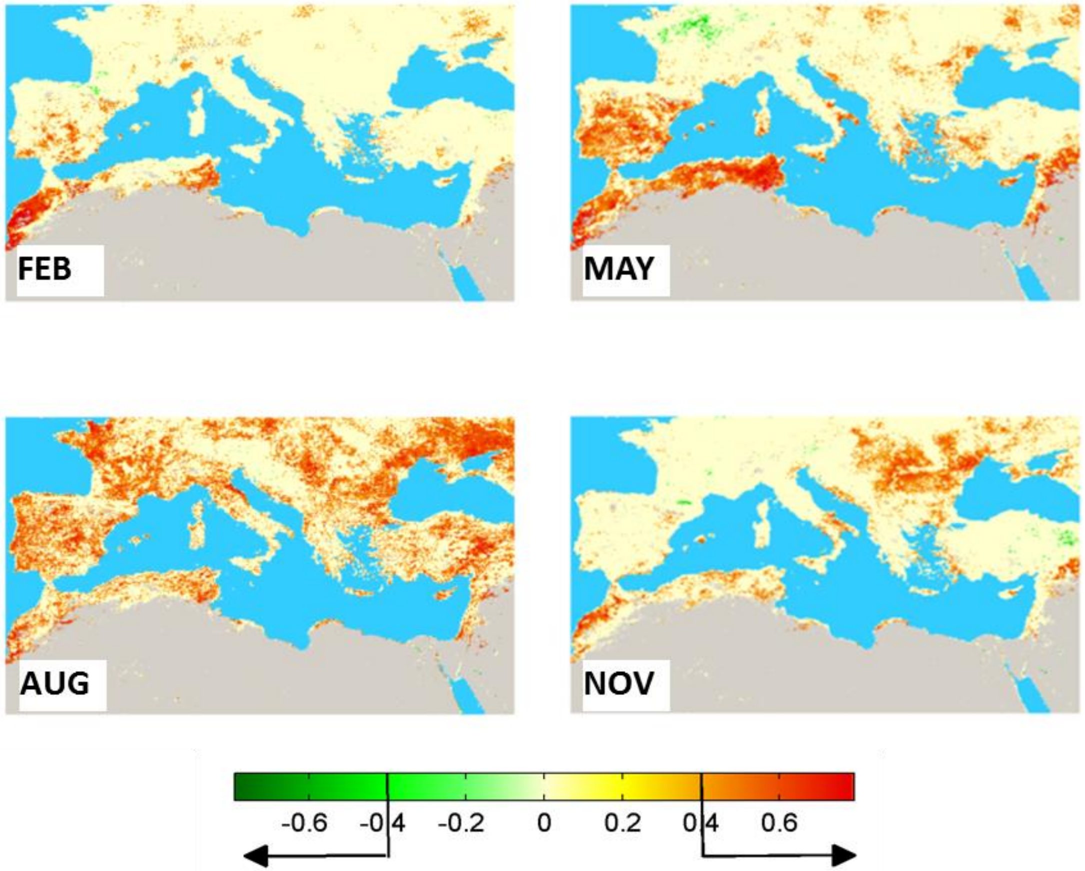
NDVI and SPEI

(Mediterranean Region)

1981–2006



Maximum grid point correlations NDVI/SPEI ($p<0.05$)



Gouveia et al (2017, Global and Planetary Change)

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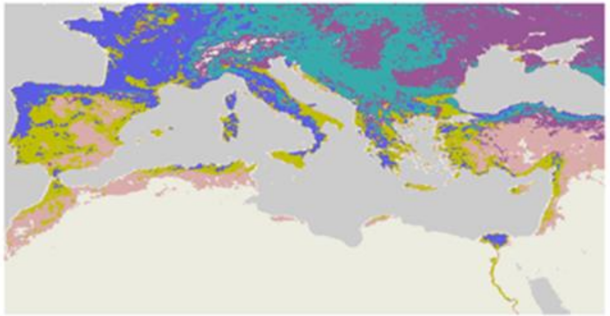
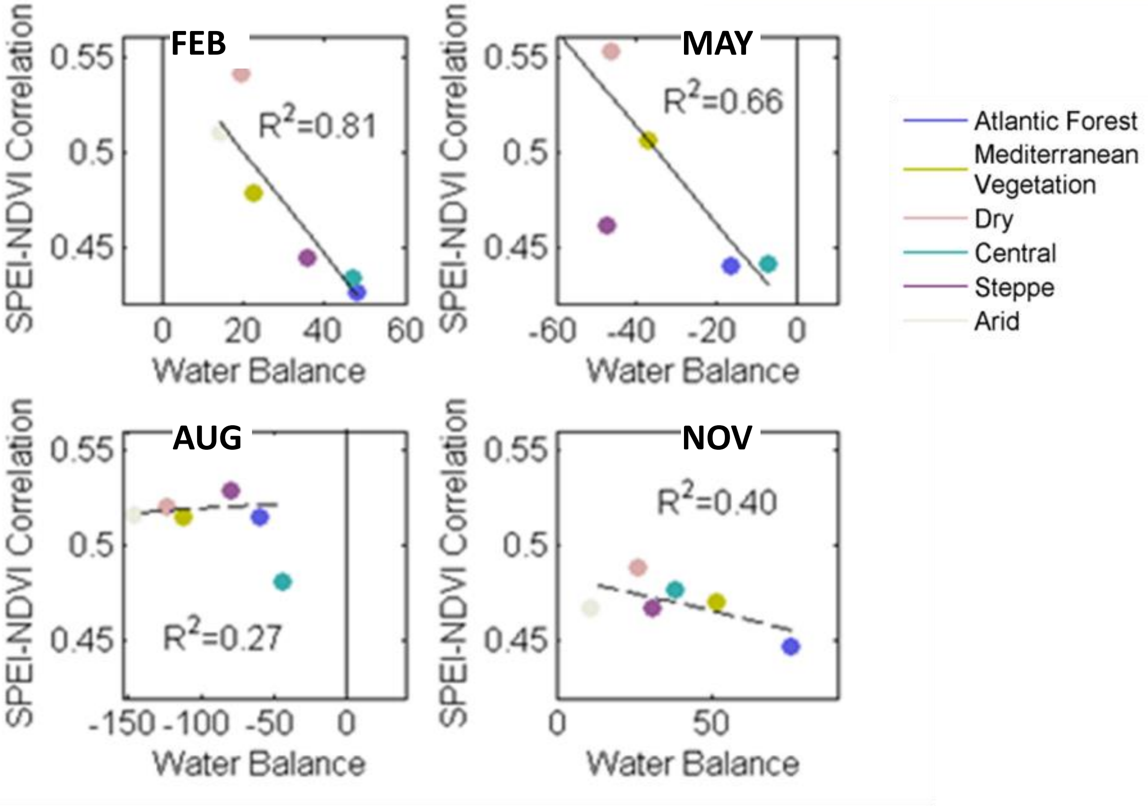
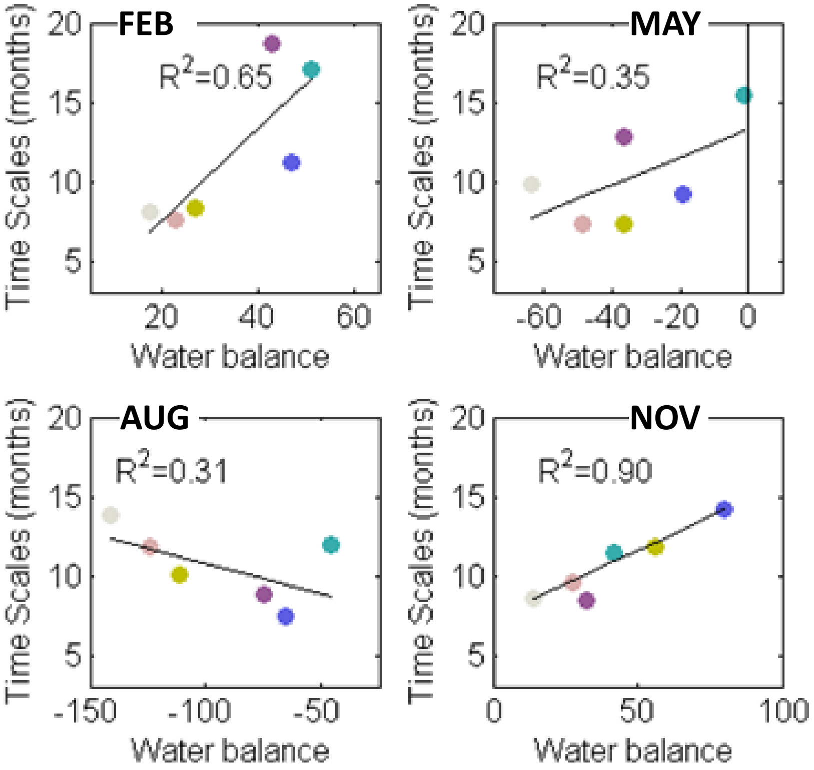
Vegetation indices and Drought

NDVI and SPEI

(Mediterranean Region)







Higher correlations in summer (other seasons) correspond to higher (lower) time scales.

Higher correlations for Mediterranean, Arid and Steppe clusters for lower values of WB

Gouveia et al (2017, Global and Planetary Change)

IPMA

Application of LST CDRs for drought monitoring

VHI and SPEI

(Mediterranean Region)

1981–2009

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

α = 0.5

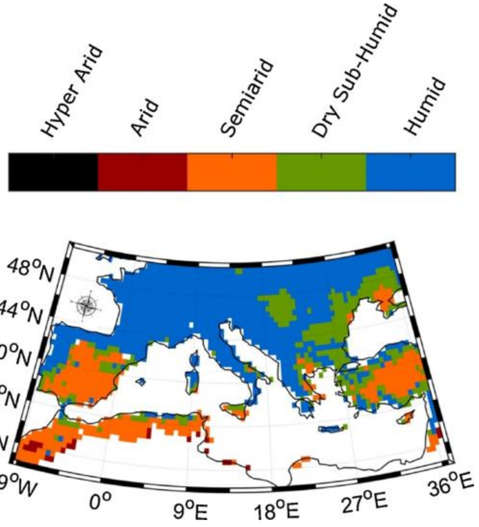
(Kogan, 1997, 2001)

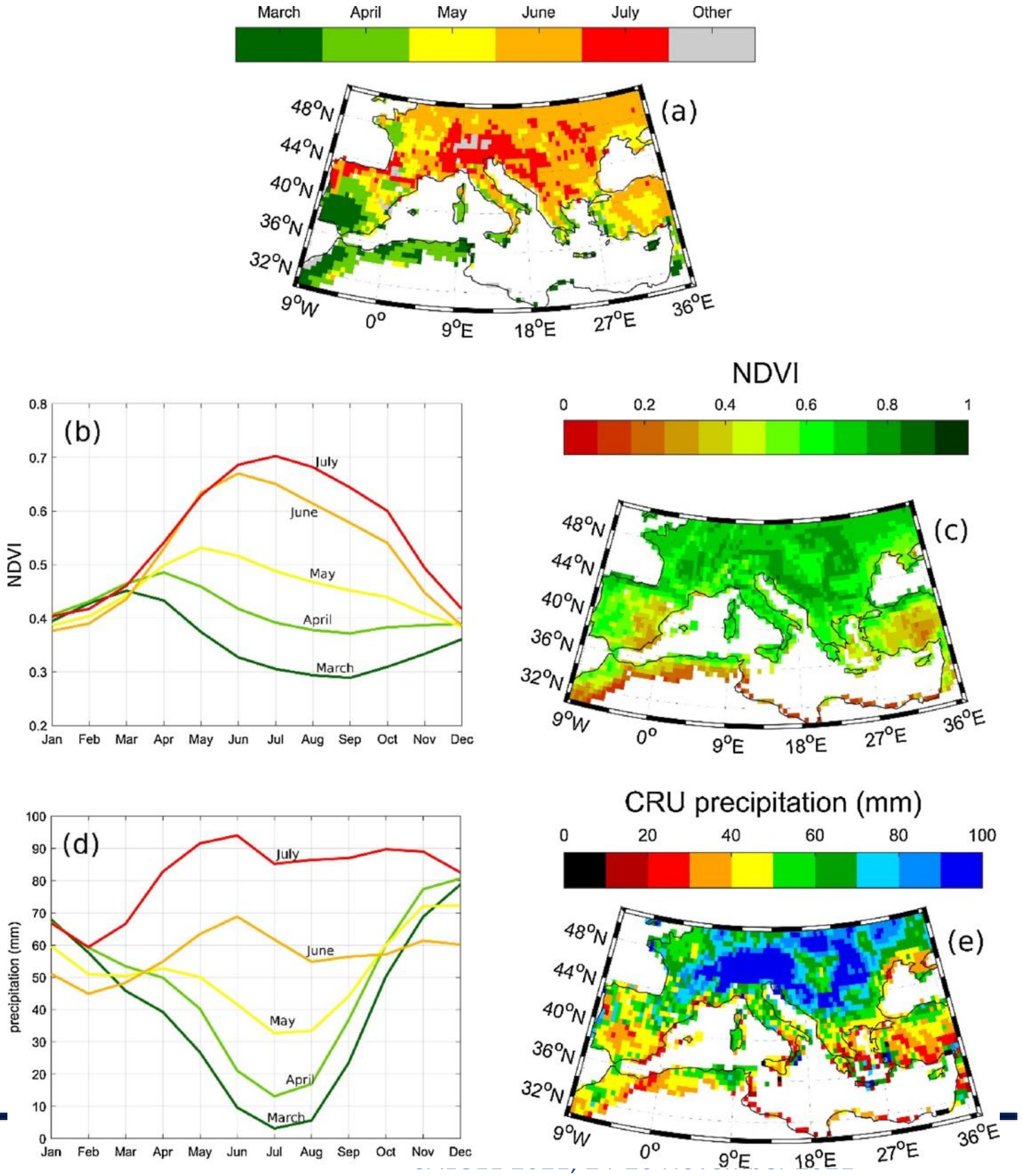
$$\mathrm{TCI} = \frac{\mathrm{LST_{max}} - \mathrm{LST}}{\mathrm{LST_{max}} - \mathrm{LST_{min}}},$$

(Princeton University, 0.5°, hourly)

$$\mathrm{VCI} = \frac{\mathrm{NDVI} - \mathrm{NDVI_{min}}}{\mathrm{NDVI_{max}} - \mathrm{NDVI_{min}}},$$

(GIMMS, 8 km, 15days)





Bento et al (2019a)

Application of LST CDRs for drought monitoring

VHI and SPEI

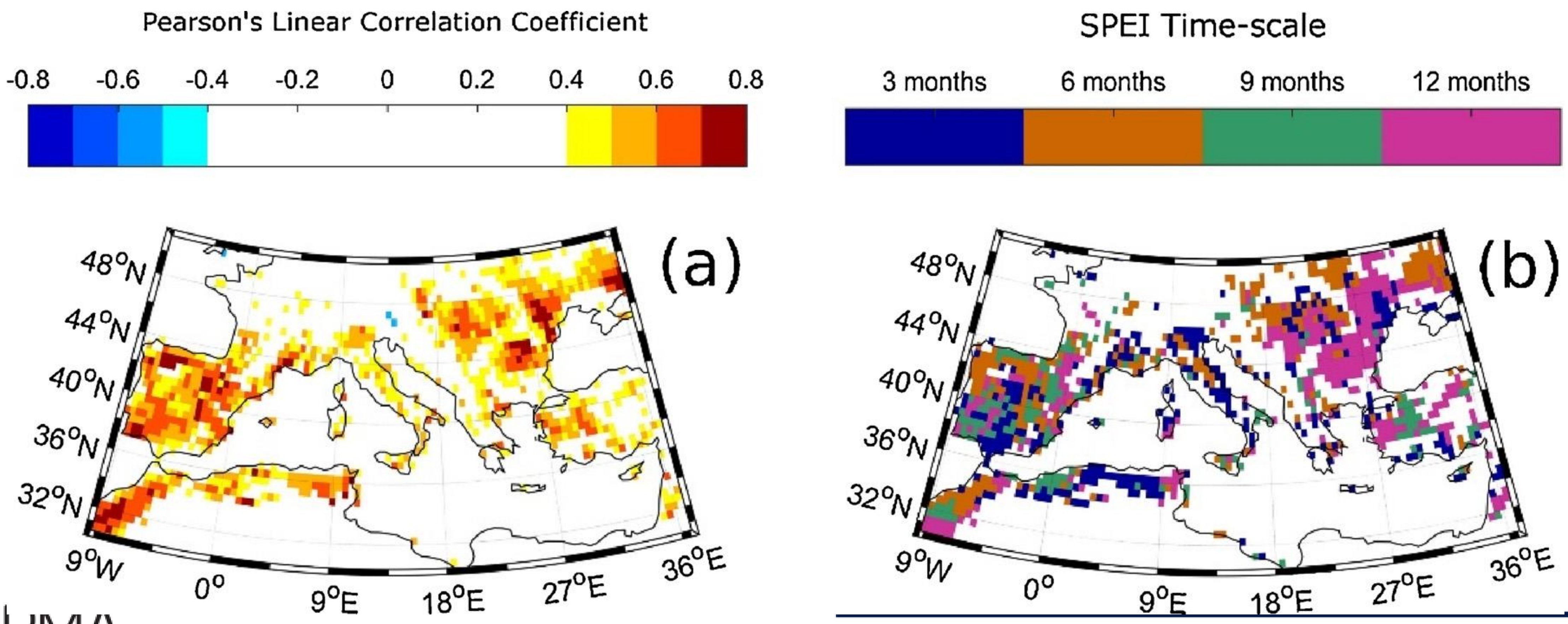
(Mediterranean Region)

1981–2009

Significant correlations in semiarid and dry sub-humid regions,

Vegetation health is more (less) determined by drought in semiarid (humid) regions

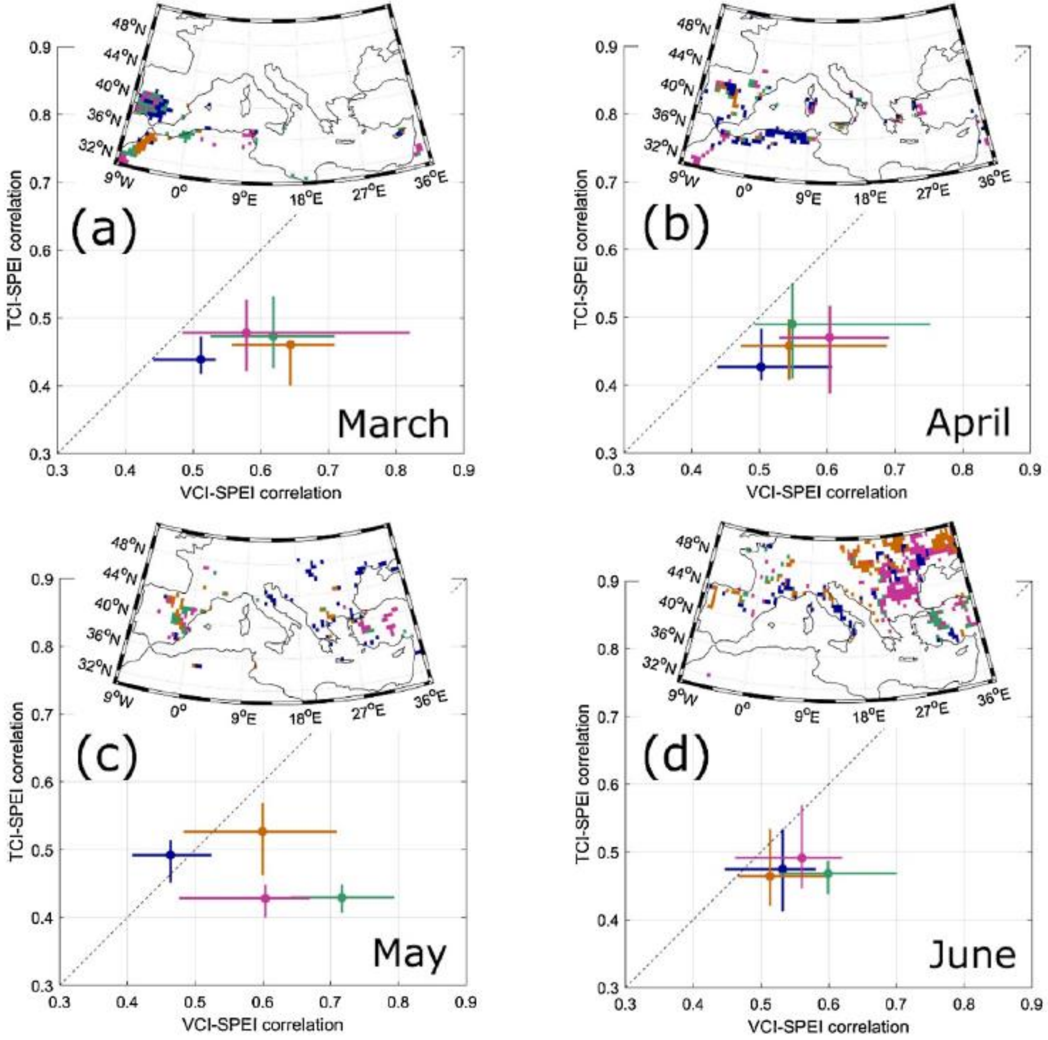
(exception: humid northern Iberia and some mountainous region)



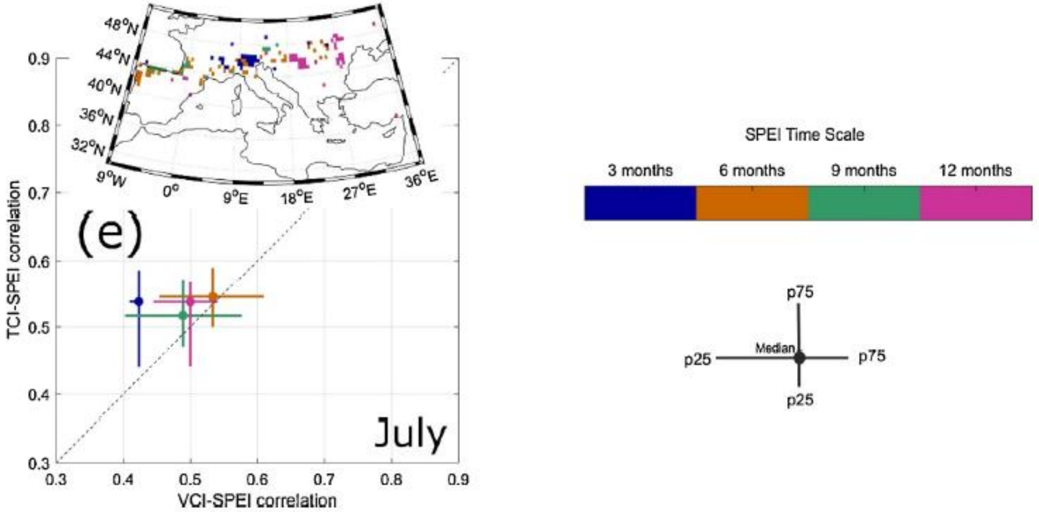
Application of LST CDRs for drought monitoring

VHI and SPEI

(Mediterranean Region)



How do VCI and TCI correlate with SPEI?

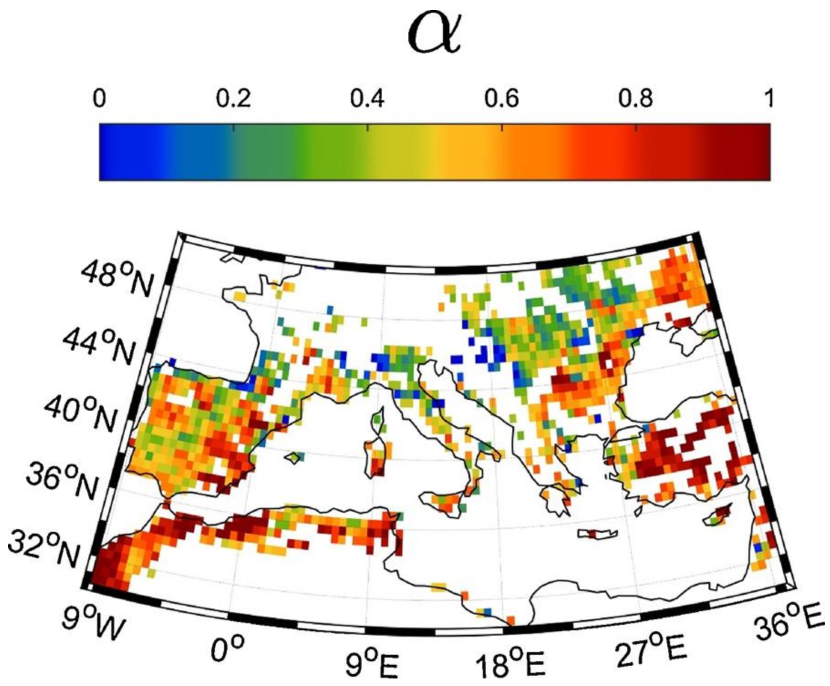


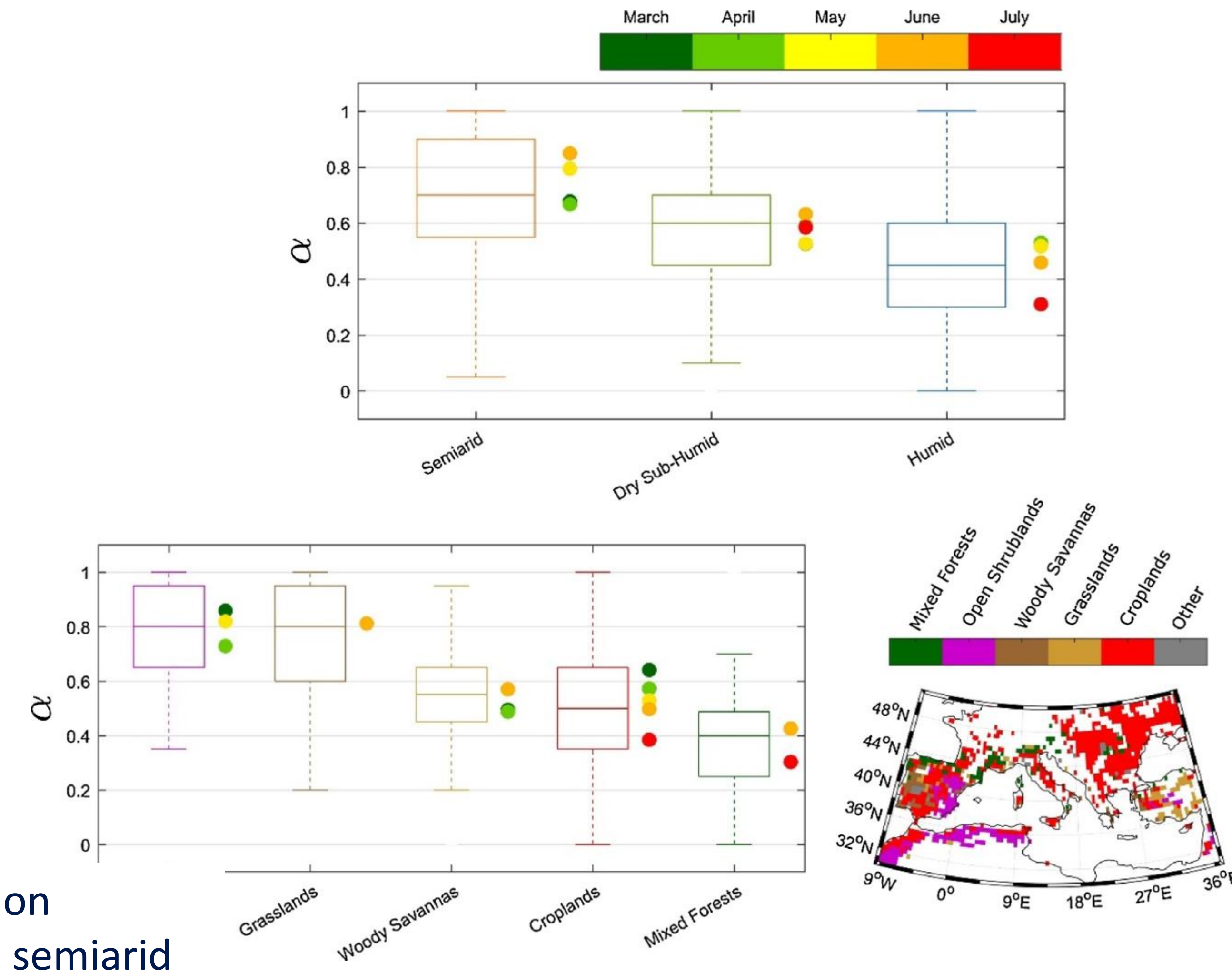
Relationship between the correlations of VCI-SPEI and TCI-SPEI for the significant pixels of the maximum NDVI months and its spatial distribution (For interpretation of the references to color in text, the reader is referred to the web version of this article).

Application of LST CDRs for drought monitoring

VHI and SPEI

(Mediterranean Region)





The relative contribution of VCI and TCI depends mostly on vegetation cover: VCI more relevant in water dependent semiarid regions and TCI in solar radiation dependent humid regions.
The corresponding weights to VHI are not necessarily equal.

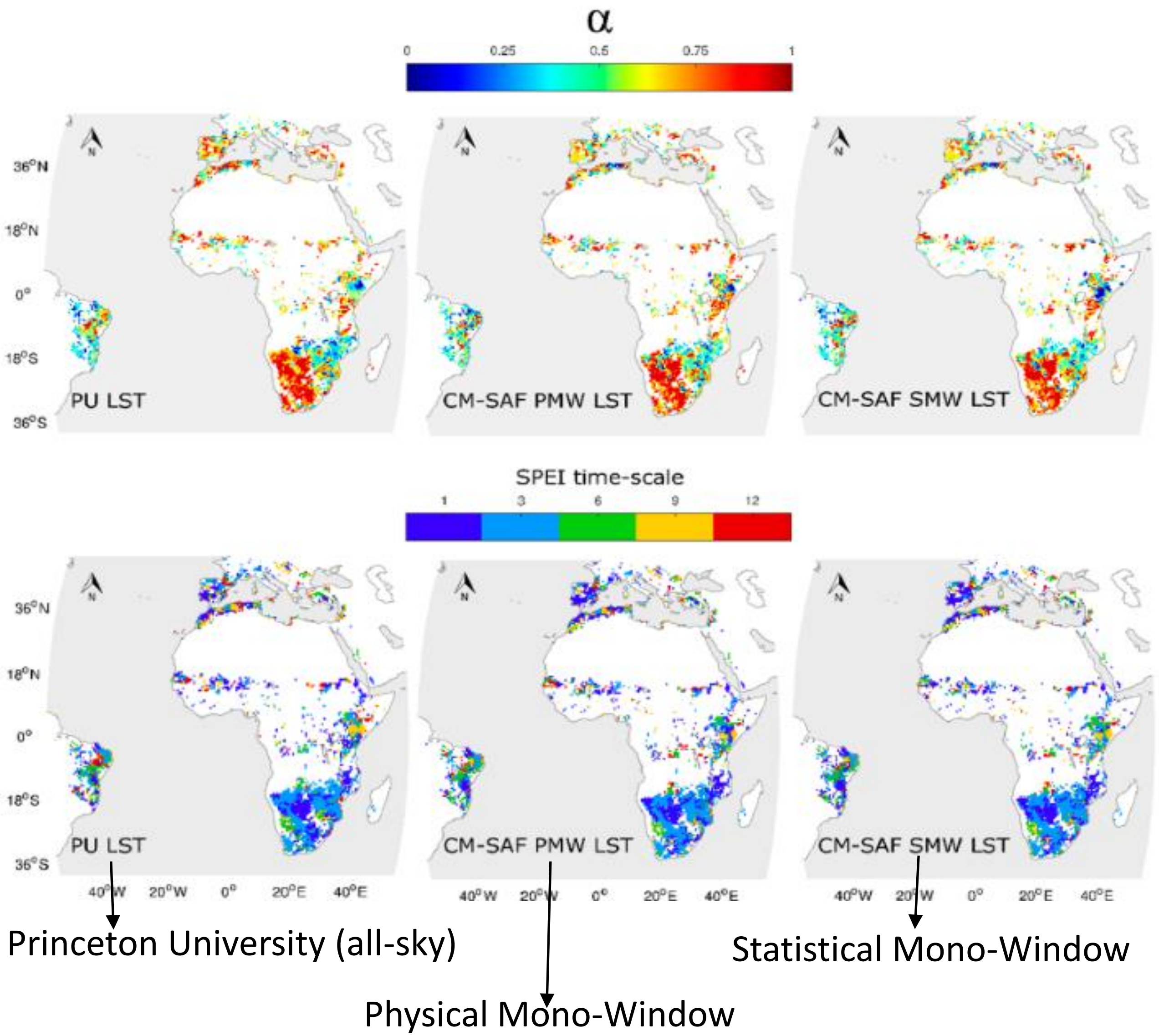
Distribution of α (top) for the different aridity classes and (bottom left) for the IGBP classes of landcover.

Application of LST CDRs for drought monitoring

VHI and SPEI

(MSG Disk)

Parameter α estimated by iterative maximization of Vegetation Health Index (VHI) and Standardized Precipitation-Evapotranspiration Index (SPEI), and respective SPEI time-scale (bottom) for which VHI and SPEI have the largest correlation.



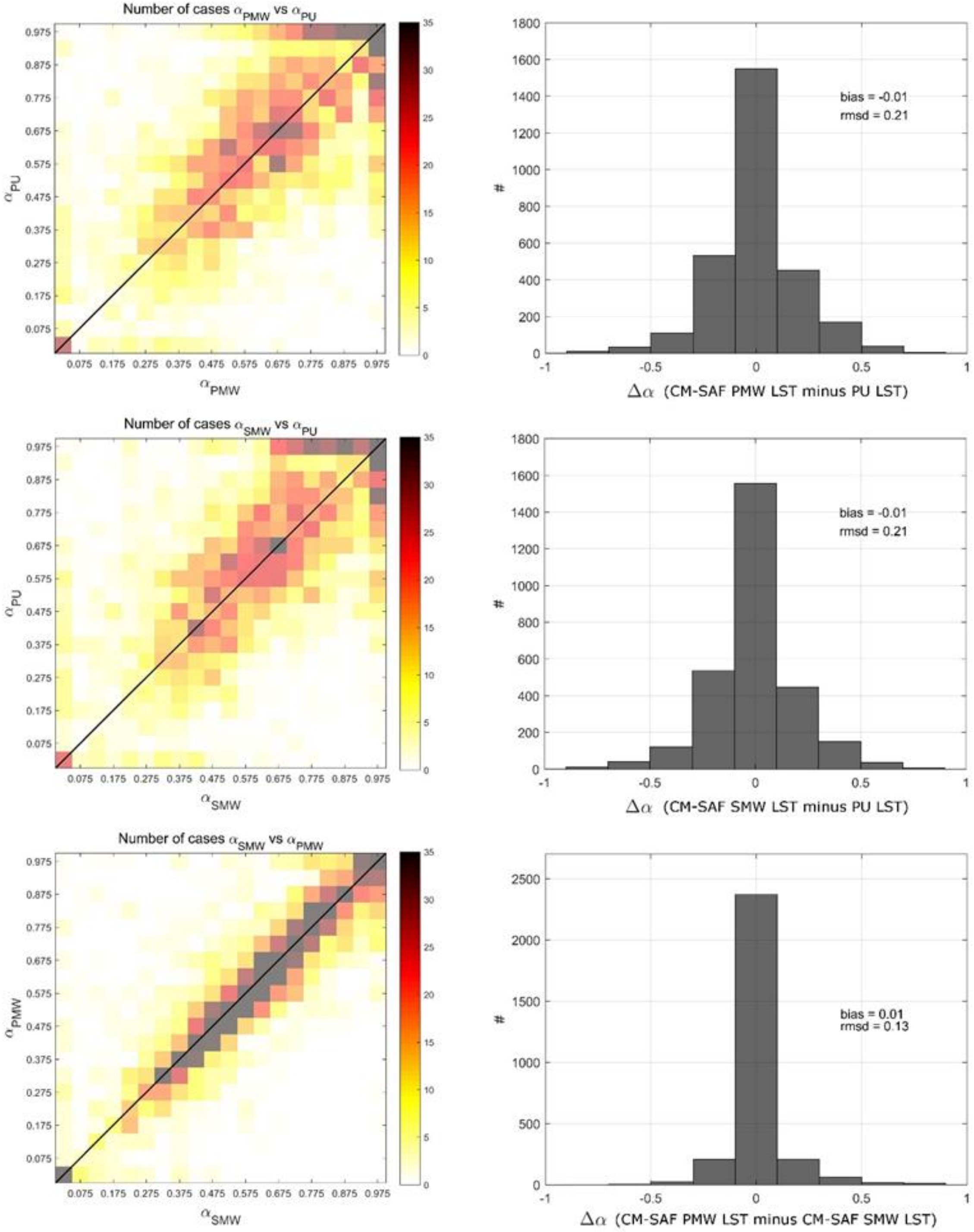
Bento et al (2019b)

Applicatio

VHI and SPEI

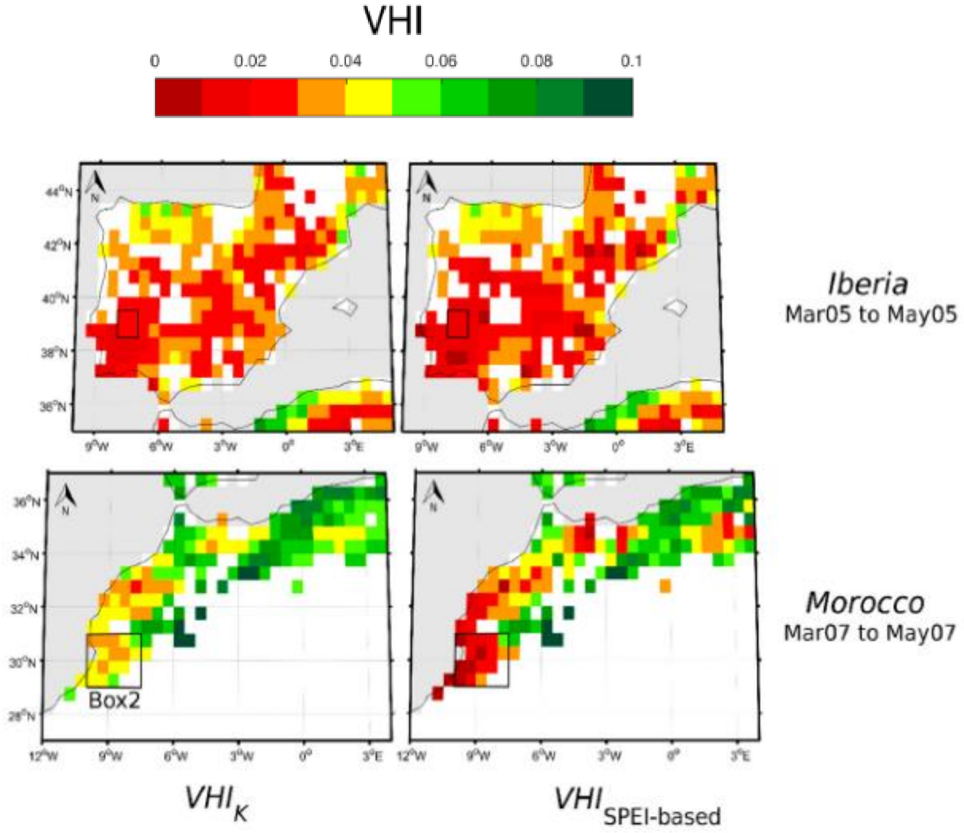
(MSG Disk)

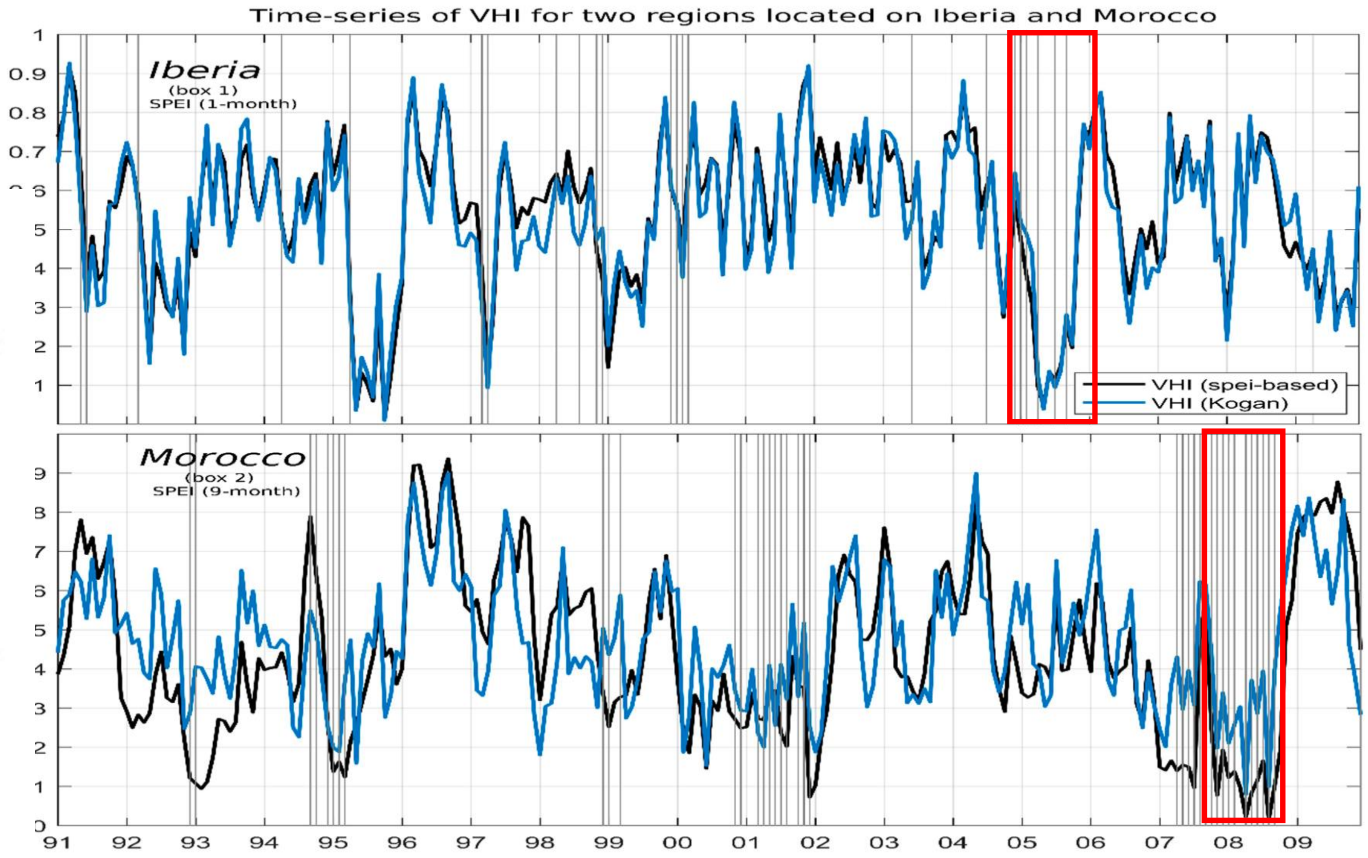
Scatter plots (left) and histograms of differences (right) resulting from the comparison of parameter α estimated with TCI.



Application of LST CDRs for drought monitoring

VHI and SPEI **(MSG Disk)**



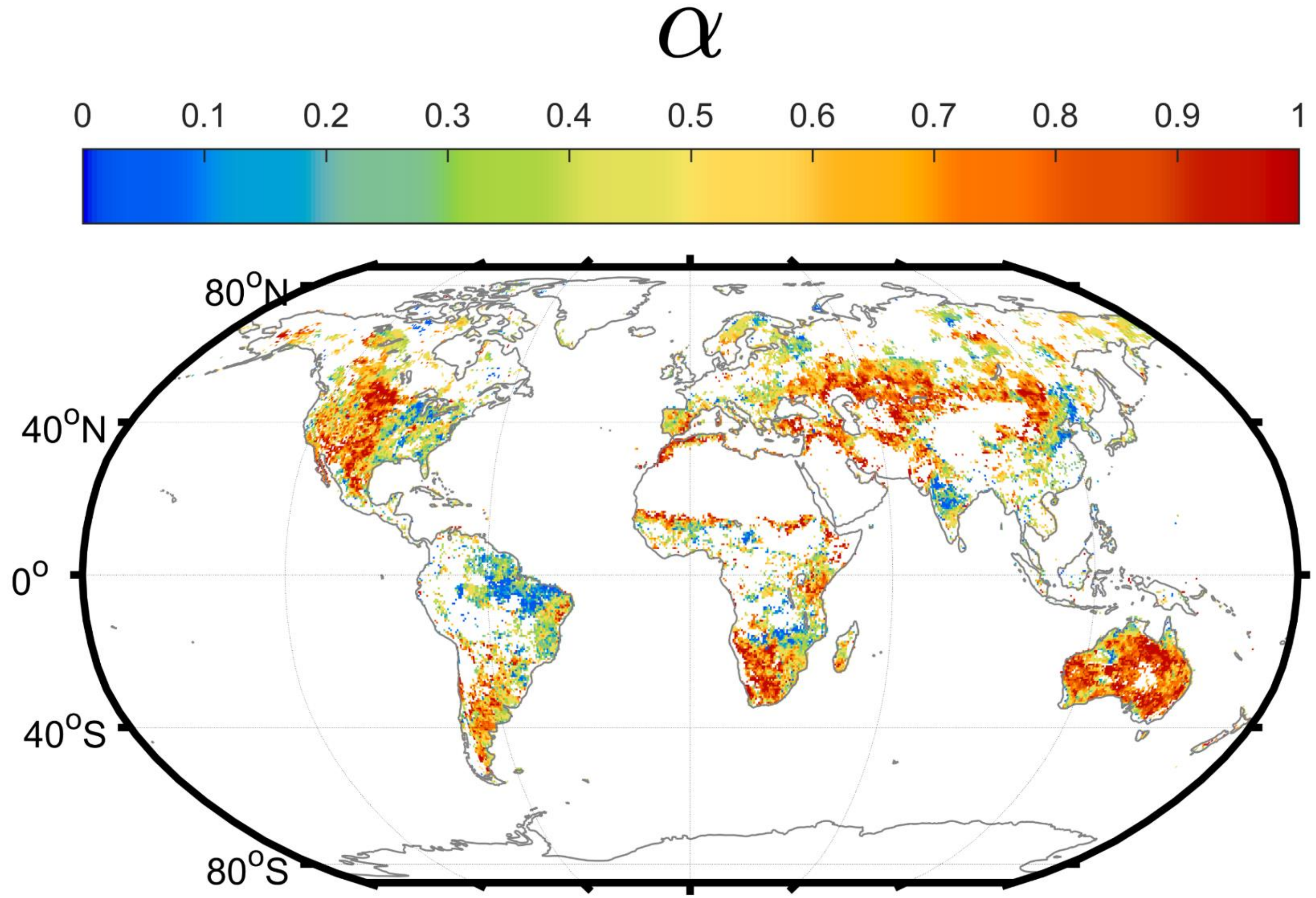


Larger differences occur in years characterised by known droughts in the region!

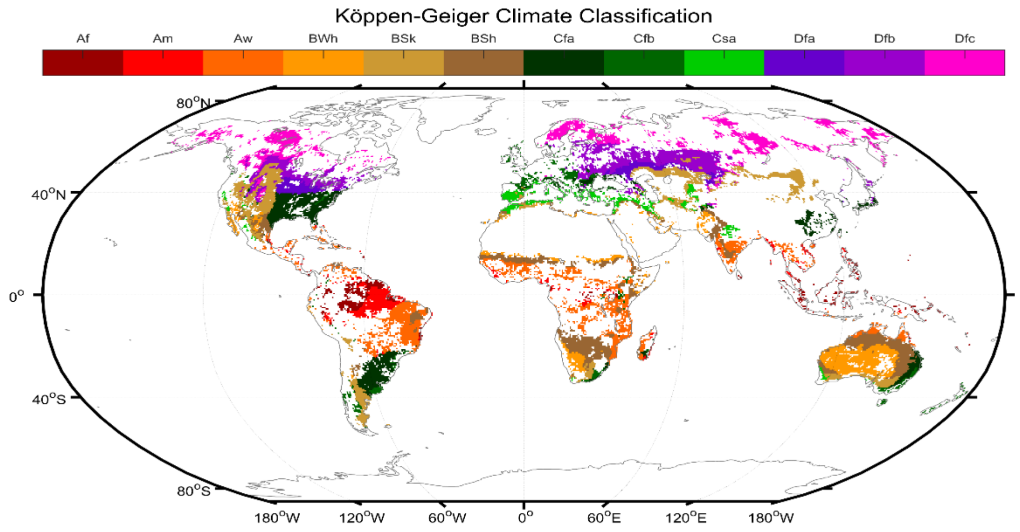
A comparison between the traditional VHI and the $VHI_{SPEI\text{-}based}$ by assessing the capability of capturing a drought event as identified by SPEI → $VHI_{SPEI\text{-}based}$ represents better the drought episodes.

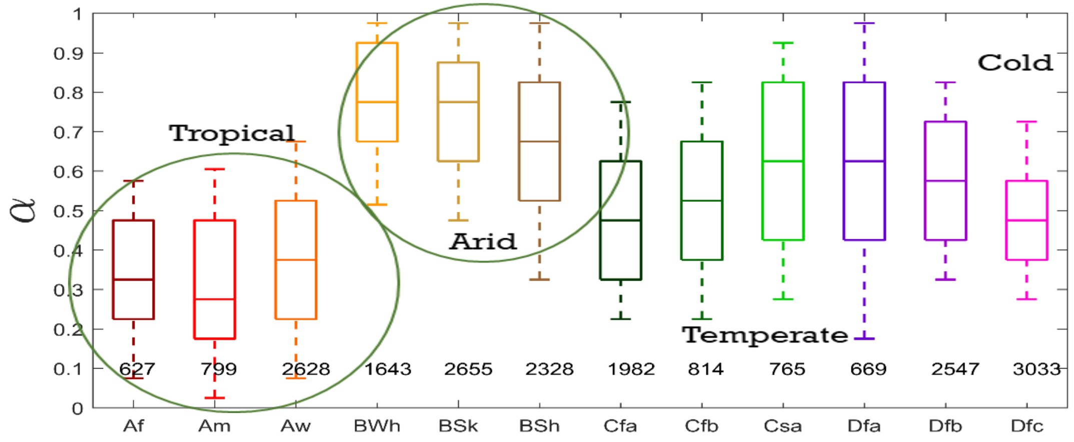
Application of LST CDRs for drought monitoring

VHI and SPEI (global)



Stratification of the contributions

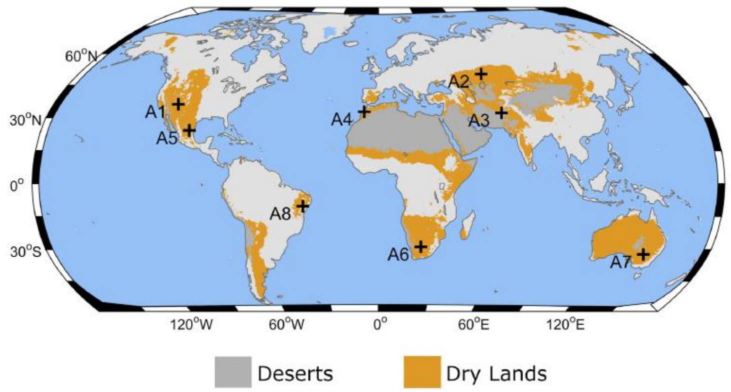


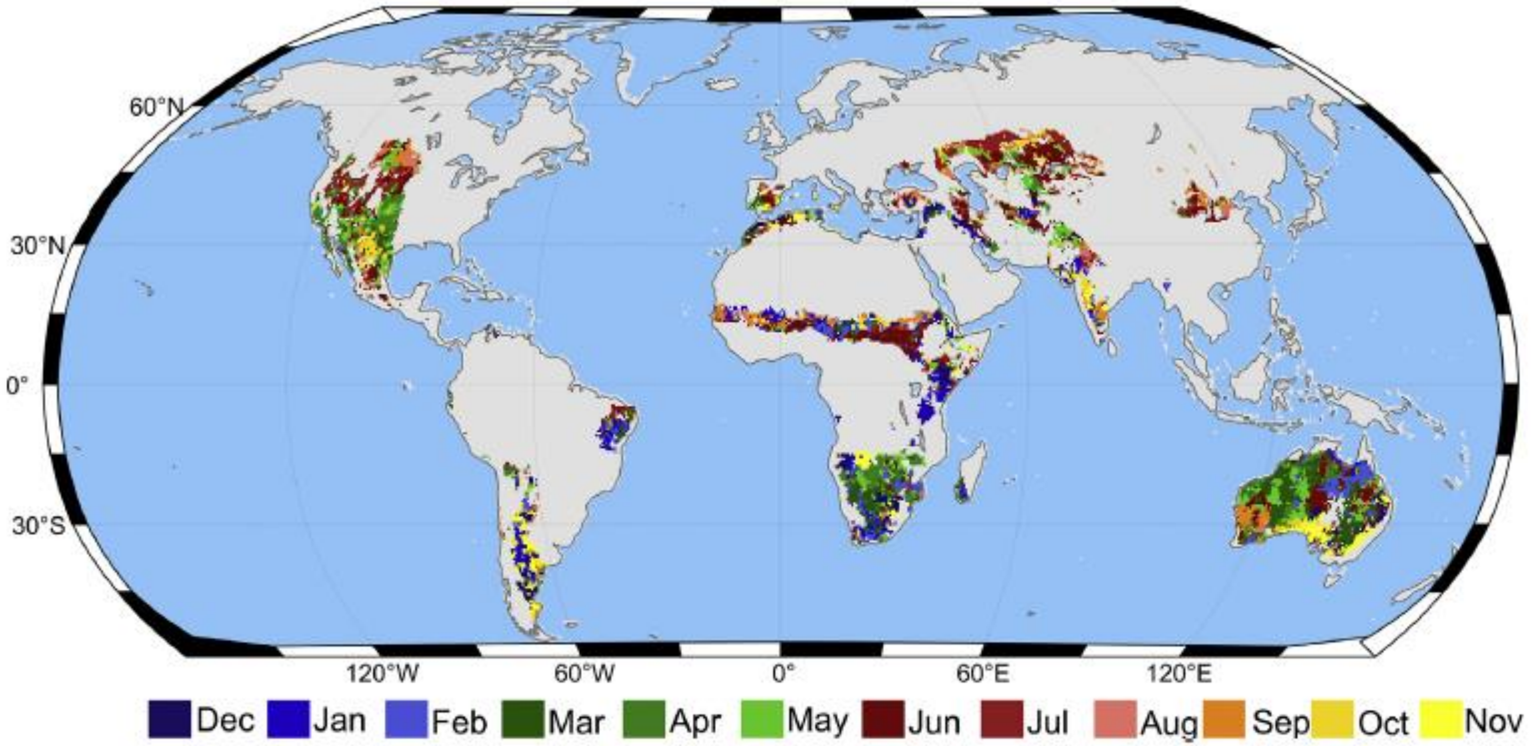


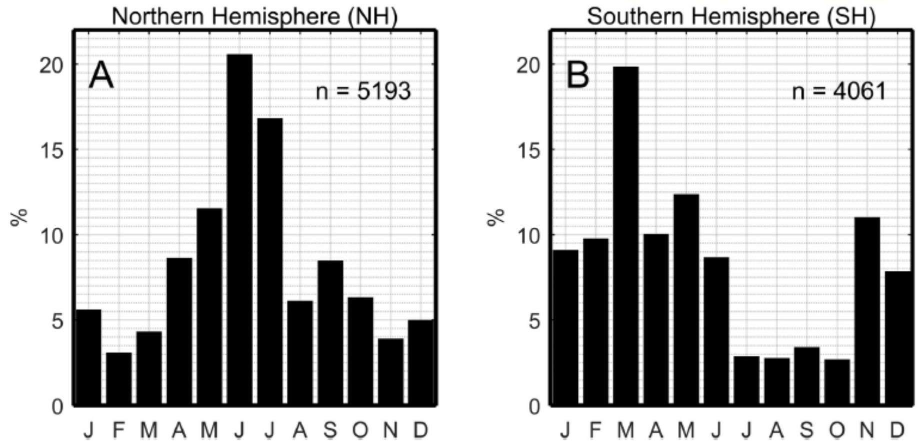
Bento et al (2020)

Application of LST CDRs for drought monitoring

VHI and SPEI (global)



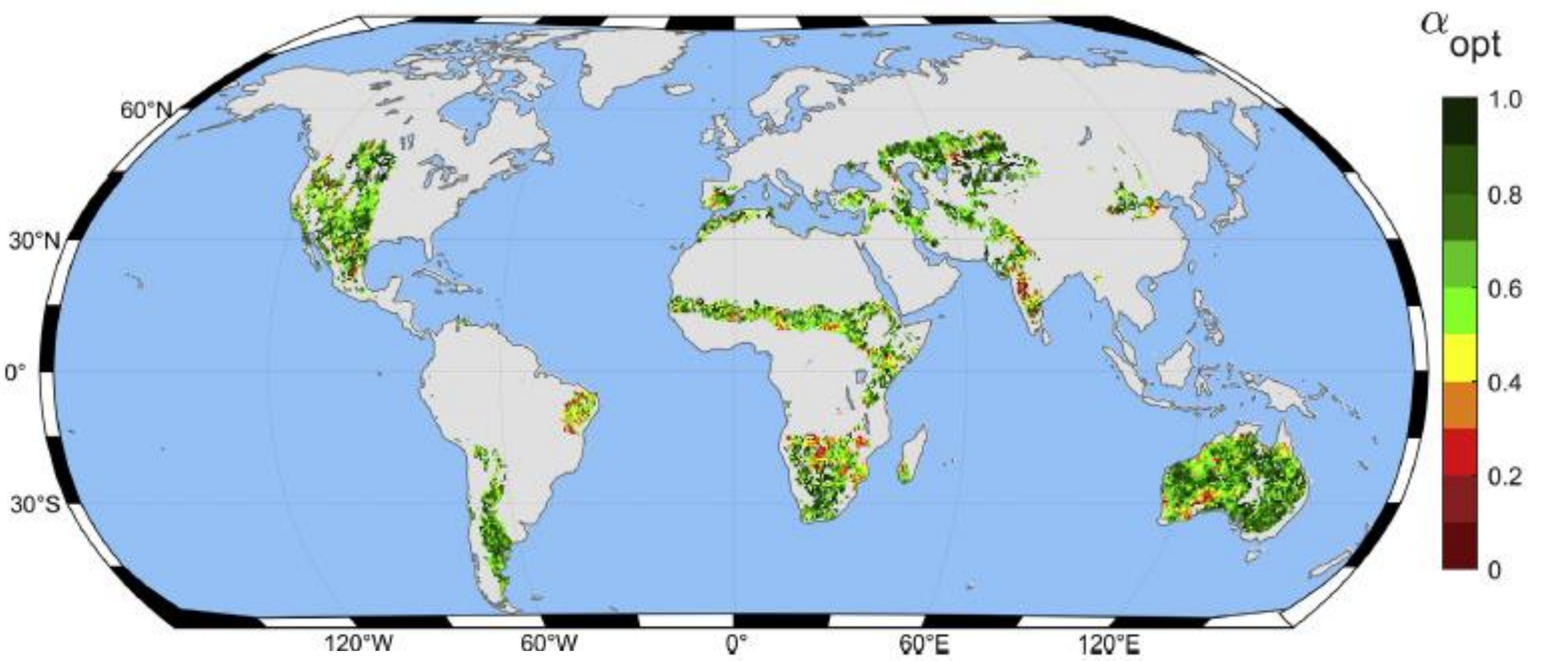


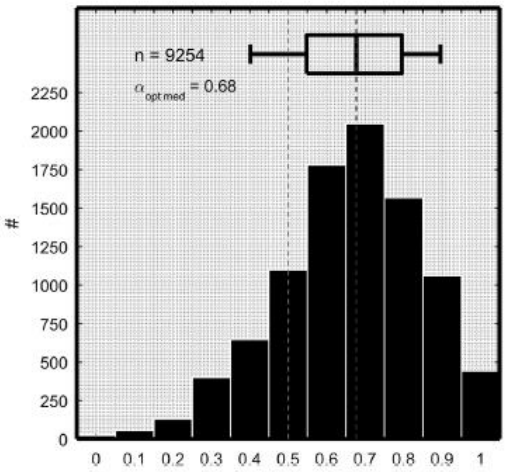


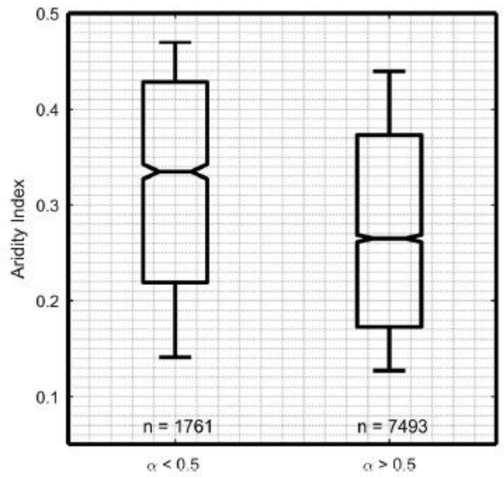
Monthly distribution of pixels with significant correlation between VHI0.5 and SPEI (at 6-month timescale) in the (A) Northern and (B) Southern hemispheres

Application of LST CDRs for drought monitoring

VHI and SPEI (global)







Histogram (black bars) and box and whiskers plot of the distribution of α_{opt} over dry lands (left panel); and distribution of aridity values for pixels where αopt ≤ 0.5 and αopt > 0.5 (right panel).

Application of LST CDRs for drought monitoring

>30 years of satellite remote sensing data

Possibility of gather LST CDRs

Applications using LST CDRs

Assessing vegetation health

VHI is traditionally estimated with equal weights to VCI and TCI

✔ With LST and NDVI CDRs and SPEI drought index new VCI/TCI weights are assessed

✔ These contributions are strongly related to the climate of the region

✔ Sensitivity of the methodology to different LST CDRs is evaluated

No bias
RMSD between 0.1 and 0.2

A new NRT satellite product to monitor drought events is possible: VHIαop !

Thank you!

Questions?