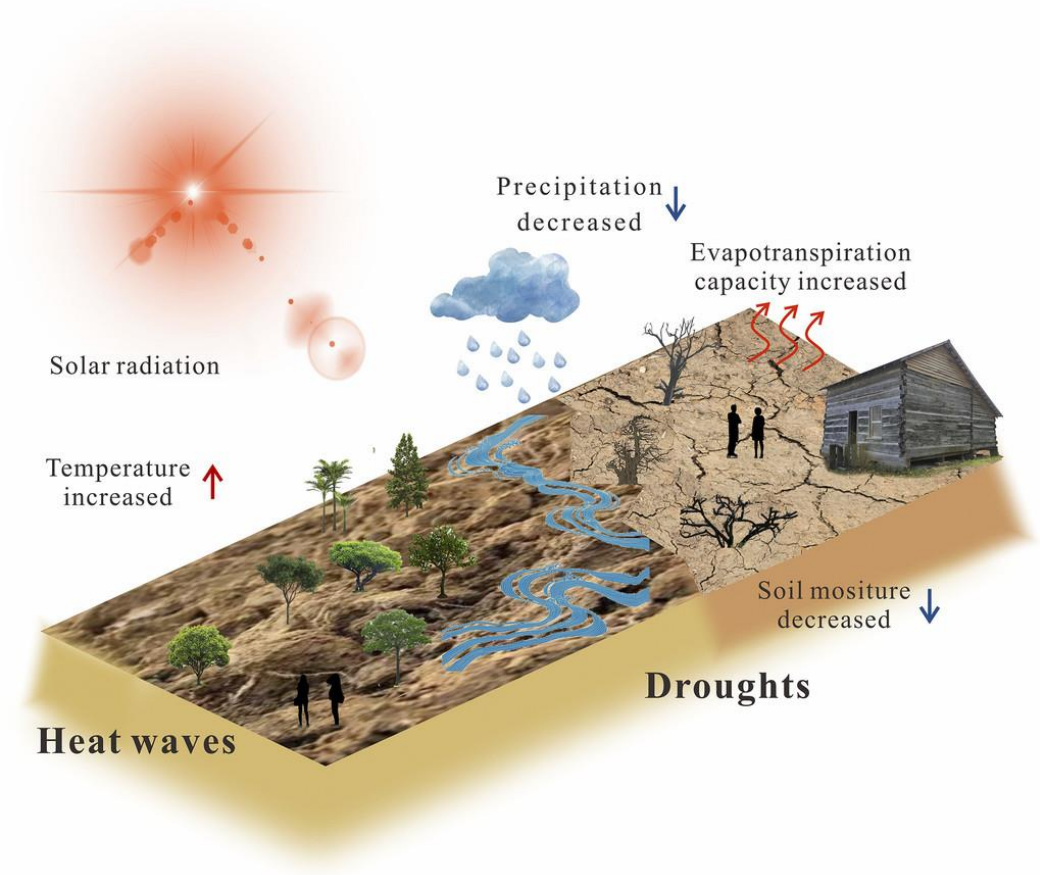
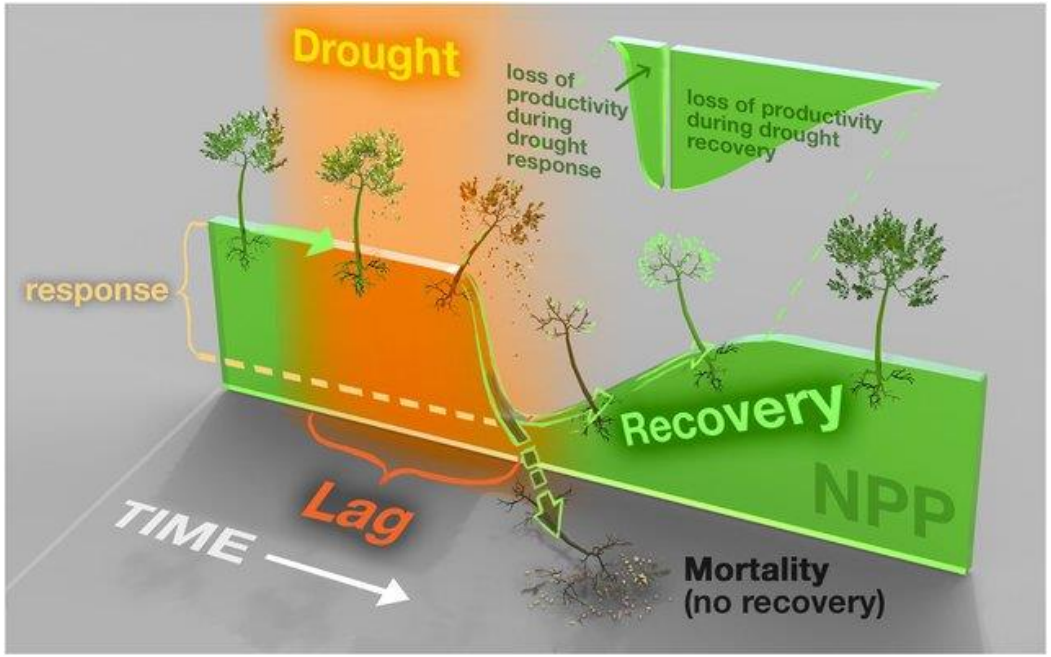
VEGETATION PRODUCTIVITY LOSSES LINKED TO MEDITERRANEAN HOT AND DRY EVENTS

Tiago Ermitão, Célia Gouveia, Ana Bastos, Ana Russo

HEATWAVE & DROUGHT IMPACTS ON VEGETATION



Wang et al. (2021) "Compound droughts and heatwaves over the Huai river basin of China: from a perspective of the magnitude index" *Journal of Hydrometeorology*



Kolus et al. (2019) "Land carbon models underestimate the severity and duration of drought's impact on plant productivity" *Natural Hazards and Earth Systems*

HEATWAVE & DROUGHT IMPACTS ON VEGETATION

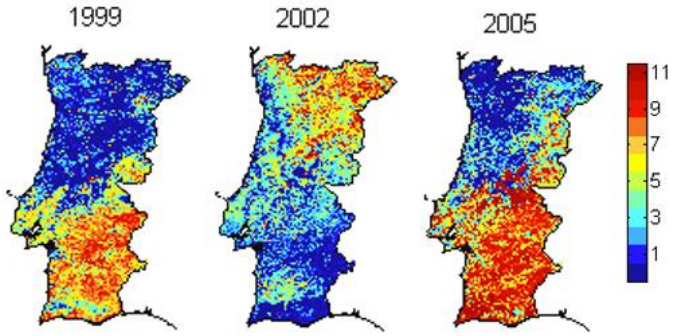


Fig. 12. Number of months between September and July that are characterised by NDVI anomaly values below −0.025, for 1999, 2002 and 2005.

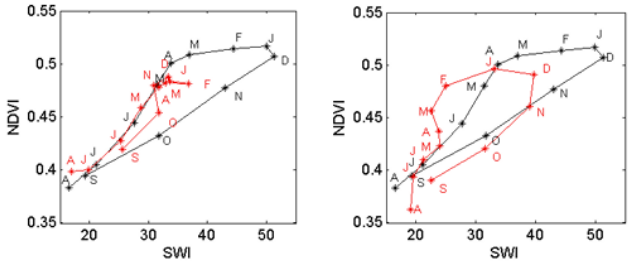
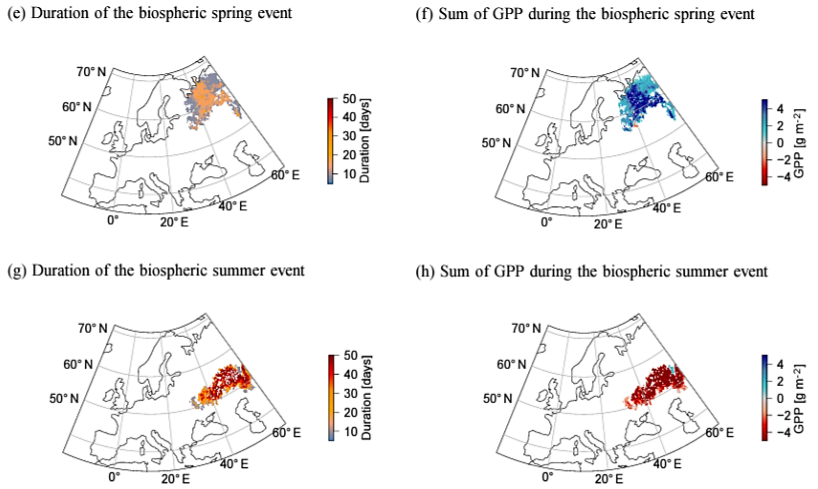
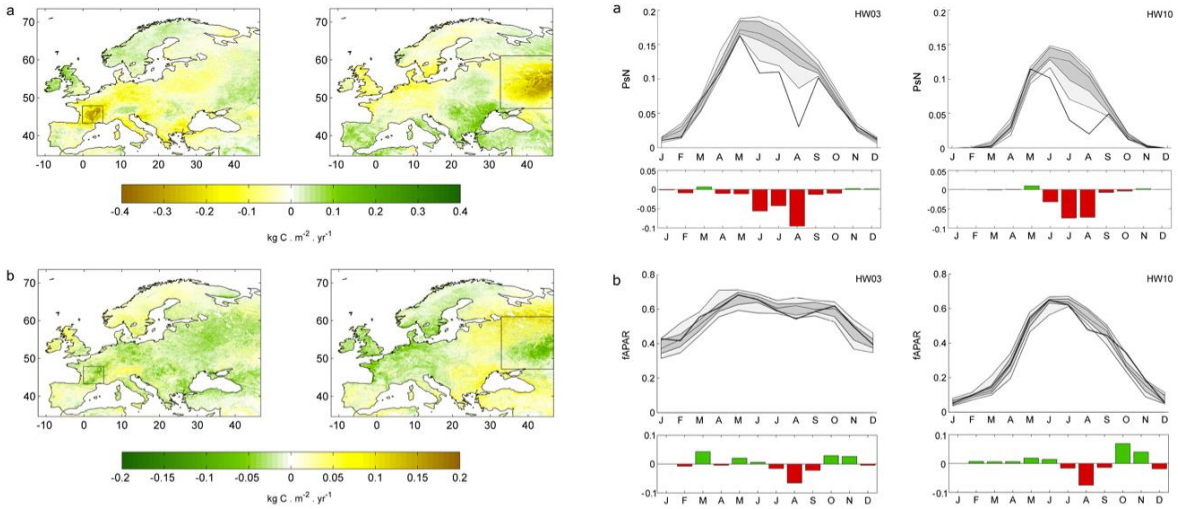


Fig. 9. Annual cycles (red curves) of SWI vs. NDVI for the drought episodes of 1998/1999 (left panel) and 2004/2005 (right panel).

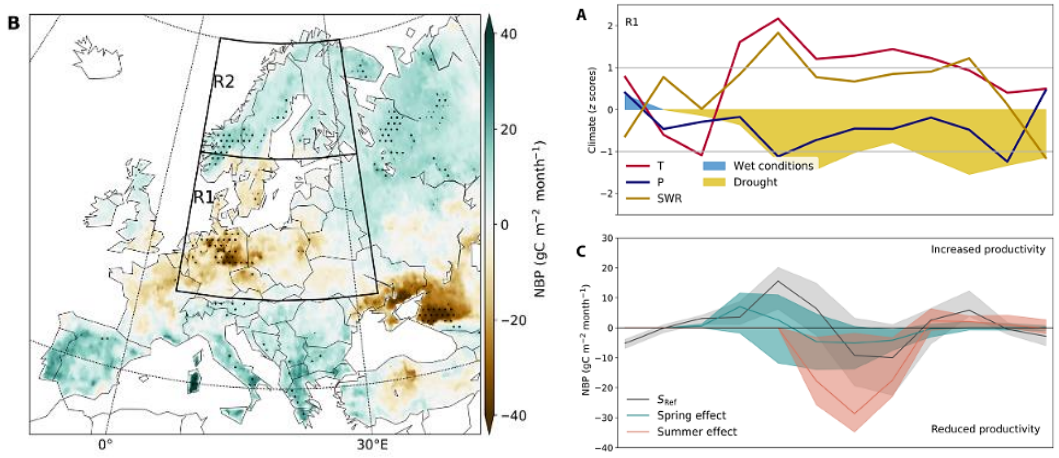
Gouveia et al. (2009) "Drought and vegetation stress monitoring in Portugal using satellite data" *Natural Hazards and Earth Systems*



Flach et al. (2018) "Contrasting biosphere responses to hydrometeorological extremes: revisiting the 2010 western Russian heatwave" *Biogeosciences*



Bastos et al. (2014) "Analysing the spatio-temporal impacts of the 2003 and 2010 extreme heatwaves on plant productivity in Europe" *Biogeosciences*



Bastos et al. (2020) "Direct and seasonal legacy effects of the 2018 heat wave and drought on European ecosystem productivity" *Science Advances*

HEATWAVE & DROUGHT IMPACTS ON VEGETATION

CLIMATE EXTREME EVENTS

- Droughts
- Heatwaves
- Large Fires

Impacts and Influence

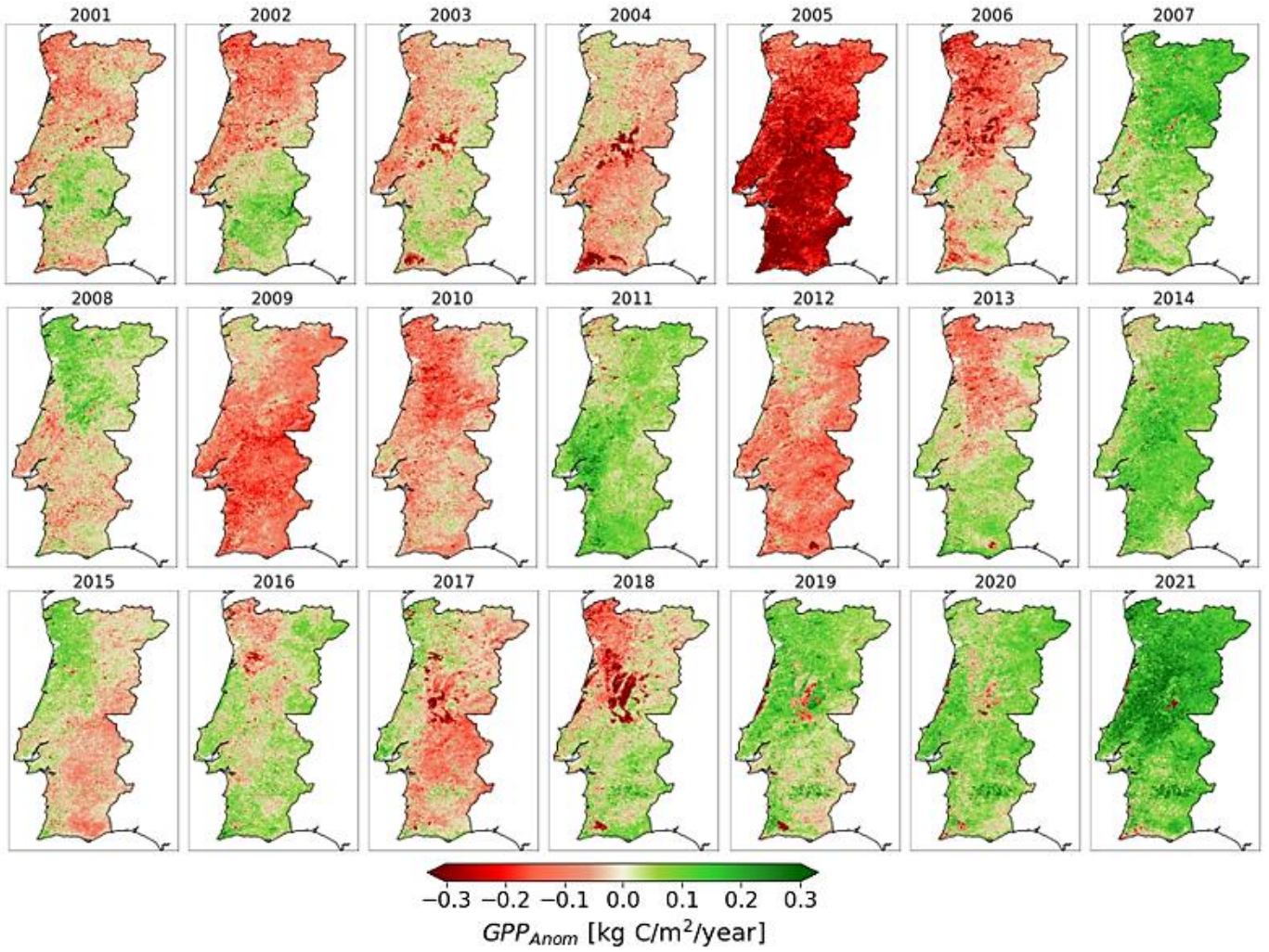
VEGETATION

Disturbances on vegetation activity

Carbon Uptake Reduction

Affect regular vegetation mechanisms

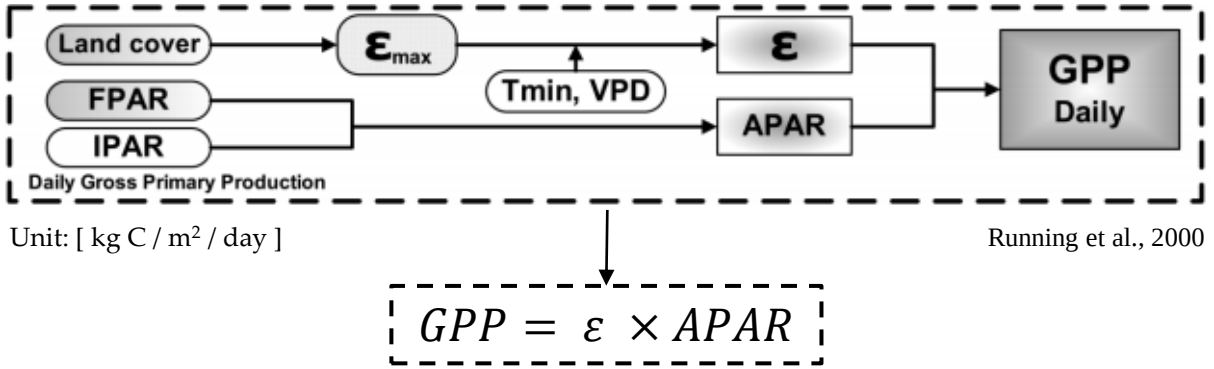
Disturb Carbon Cycle



MAIN CONCEPTS

GROSS PRIMARY PRODUCTION (GPP)

Total carbon fixation by the terrestrial ecosystems through vegetation production processes i.e., photosynthesis. (Running et al. 2000)



HOT AND DRY CONDITIONS → **GPP** ↓

High Temperature
Low Humidity → VPD ↑ → Stomata closure → ε, APAR ↓ → **Photosynthetic Activity** ↓

High Temperature
Low Humidity → Leaf Surface ↓ → ε, APAR ↓ → **Photosynthetic Activity** ↓

REMOTELY SENSED DATA

8-day Gross Primary Productivity (GPP)
(MODIS 2001-2019)

PRE-PROCESSING
- Cloud | Snow correction
- Aggregation of 8-day composites on monthly-basis

Land Surface Temperature (LST)
(MODIS 2001-2019)

PRE-PROCESSING
- Cloud | Snow correction
- Aggregation of 8-day composites on monthly-basis

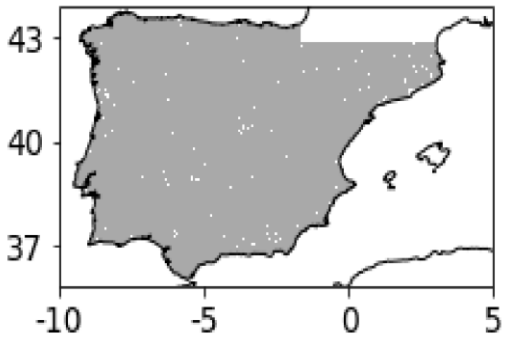
Soil Moisture (SM)
(ESACCI 2001-2019)

PRE-PROCESSING
- Missing pixels interpolation techniques
- Aggregation of daily data on monthly-basis

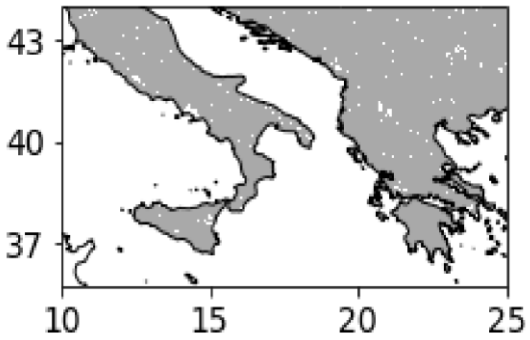
Land Cover
(MODIS 2001-2019)

AGGREGATION INTO 4 MAIN CLASSES
- High Tree Cover
- Low Tree Cover
- Cropland
- Others

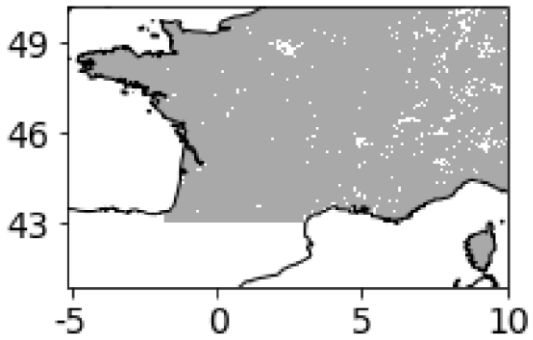
AFFECTED AREAS BY ECOLOGICAL EXTREME EVENTS



(a)



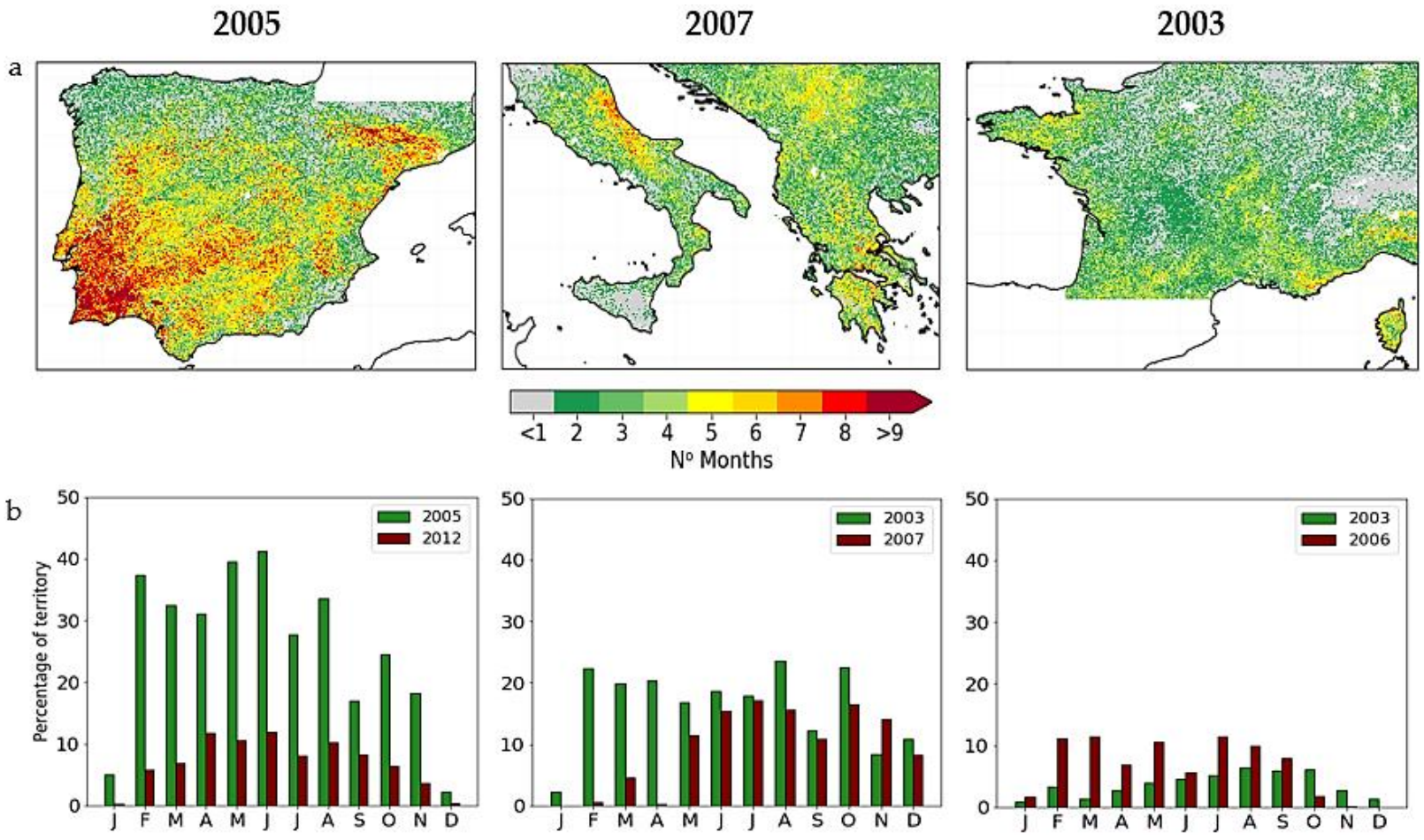
(b)



(c)

Areas	Study Cases	Affected Area [km^2]
Iberian Peninsula (IB)	2005	250,655
	2012	75,221
Eastern Mediterranean (EM)	2003	121,484
	2007	76,112
Western Europe (WE)	2003	45,626
	2006	76,766

RESULTS
LENGTH OF ECOLOGICAL EXTREME EVENTS



Ecological stressed vegetation

Monthly GPP_{ANOM} below -1σ during at least 5 months

IB2005

Persistent stress conditions especially in the southernmost regions of IB

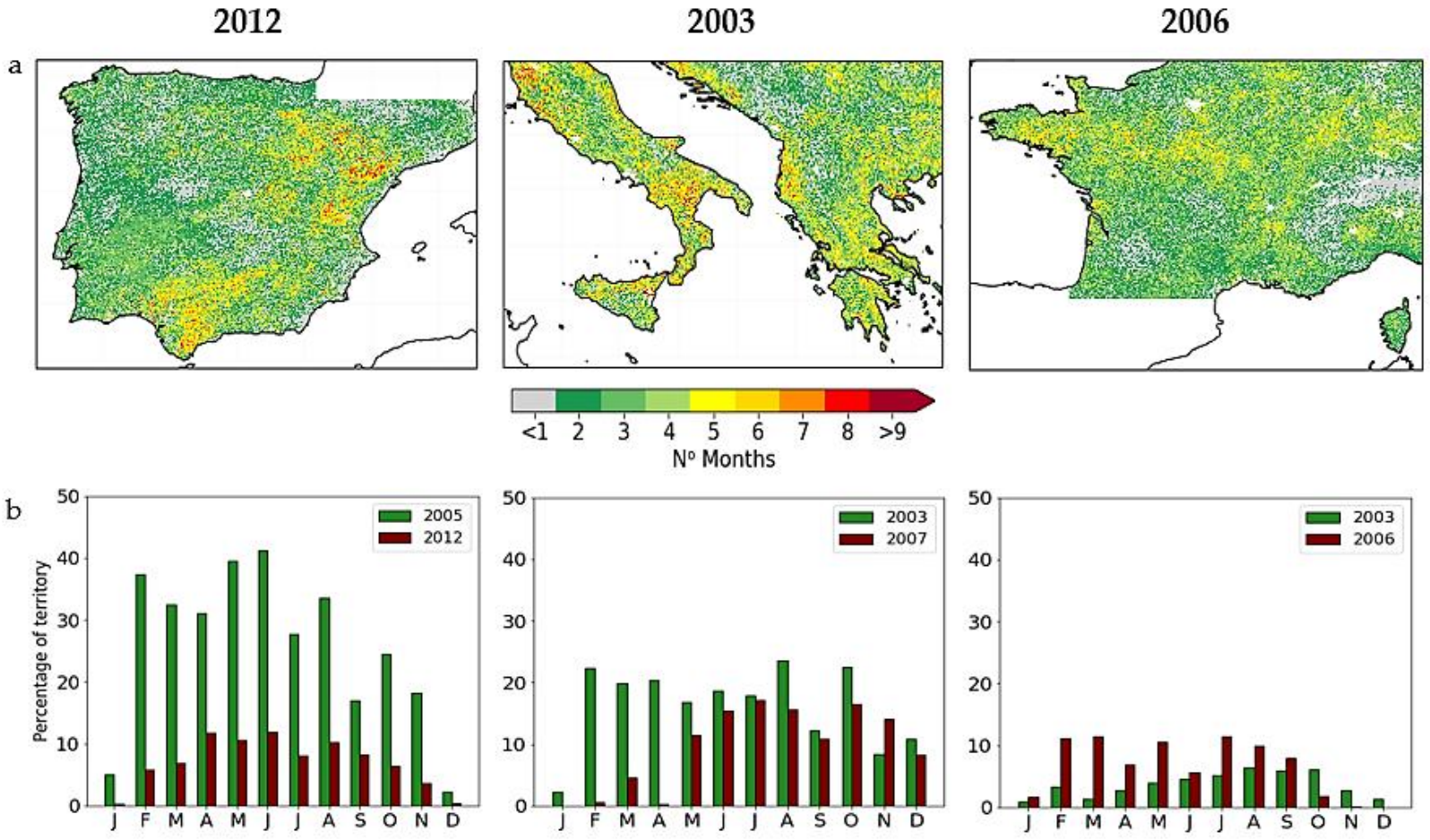
EM2007

Prolonged stress conditions in central Italy and southern Greece

WE2003

South of France and Corsica disturbed for several months by **stress conditions**

RESULTS
LENGTH OF ECOLOGICAL EXTREME EVENTS



Ecological stressed vegetation

Monthly GPP_{ANOM} below -1σ during at least 5 months

IB2012

Stress conditions especially in the southernmost and eastern regions of IB

EM2003

Italy, Balkans and southern Greece strongly disturbed

WE2006

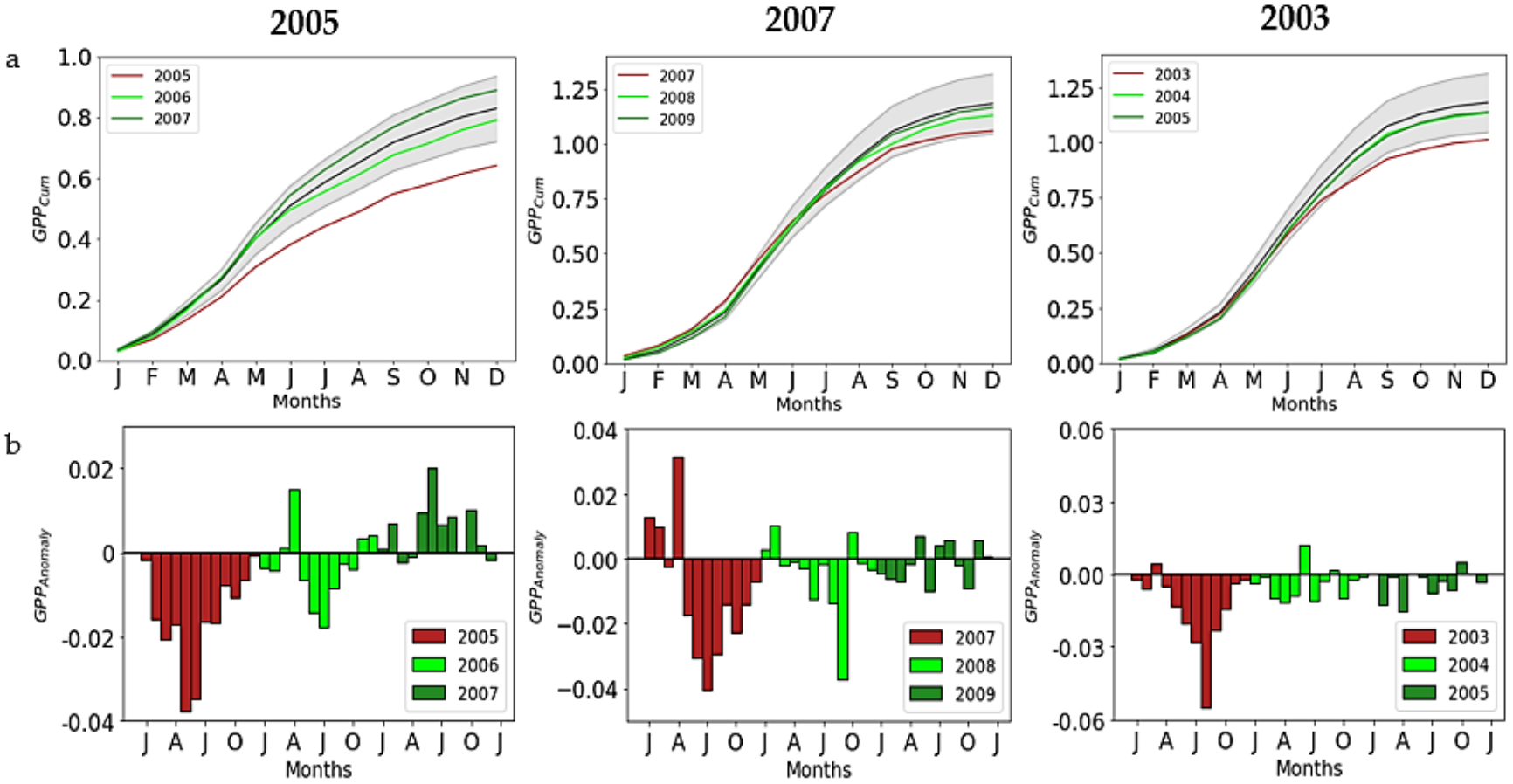
Central regions of France and central Europe affected for several months

RESULTS
PRODUCTIVITY DEFICITS

IB2005
Severe drought during many months, and amplification of GPP anomalies in summer

EM2007
Positive GPP anomalies in late winter and spring contrasting with strong negative anomalies due to **summer heatwaves**

WE2003
Amplification of GPP negative anomalies in late spring and especially in summer due to **heatwaves**.



Unit: kg C/m^2/month

RESULTS

LAND SURFACE TEMPERATURE and SOIL MOISTURE

IB2005

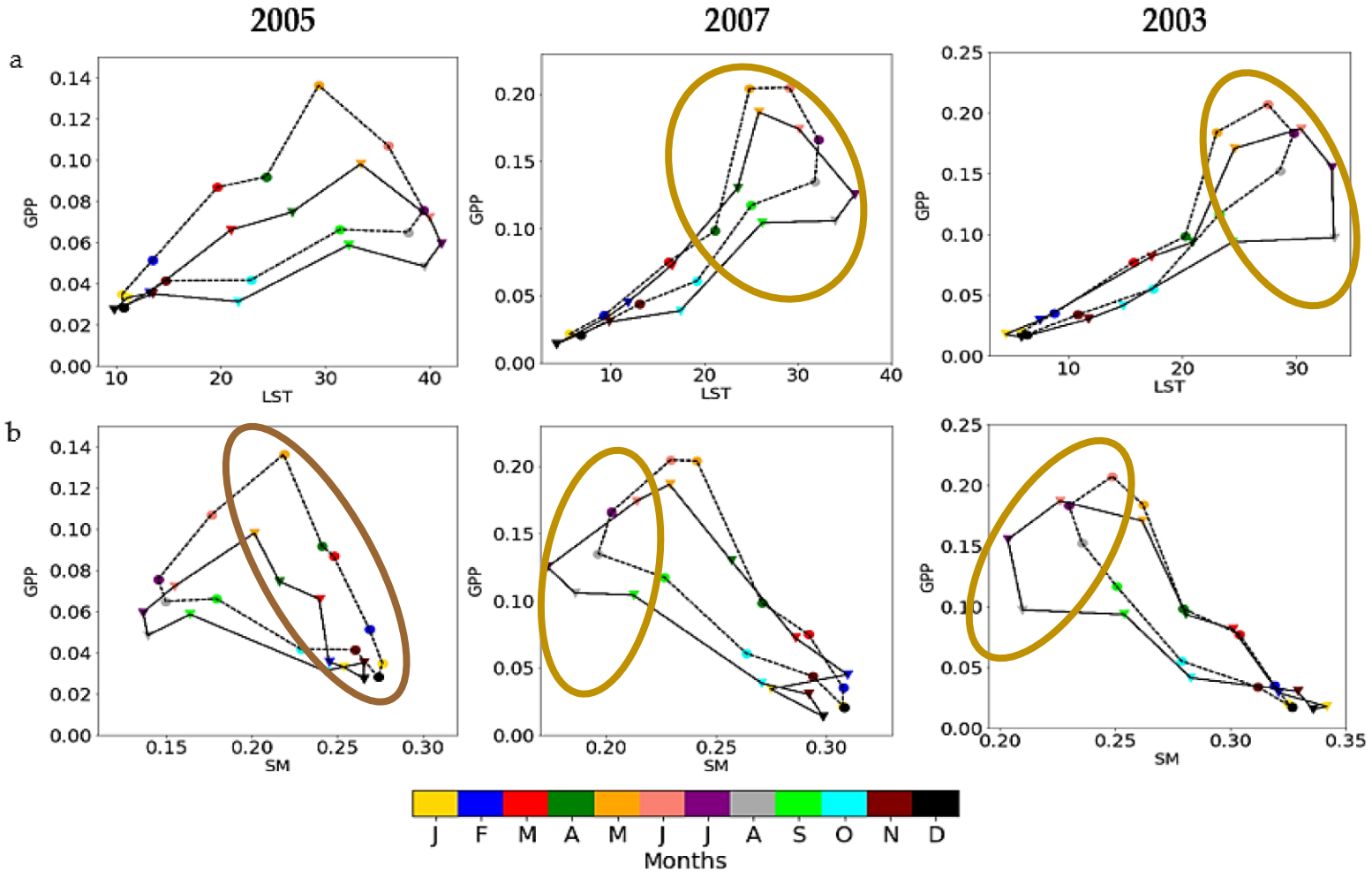
Severe drought during many months, and amplification of GPP anomalies in summer

EM2007

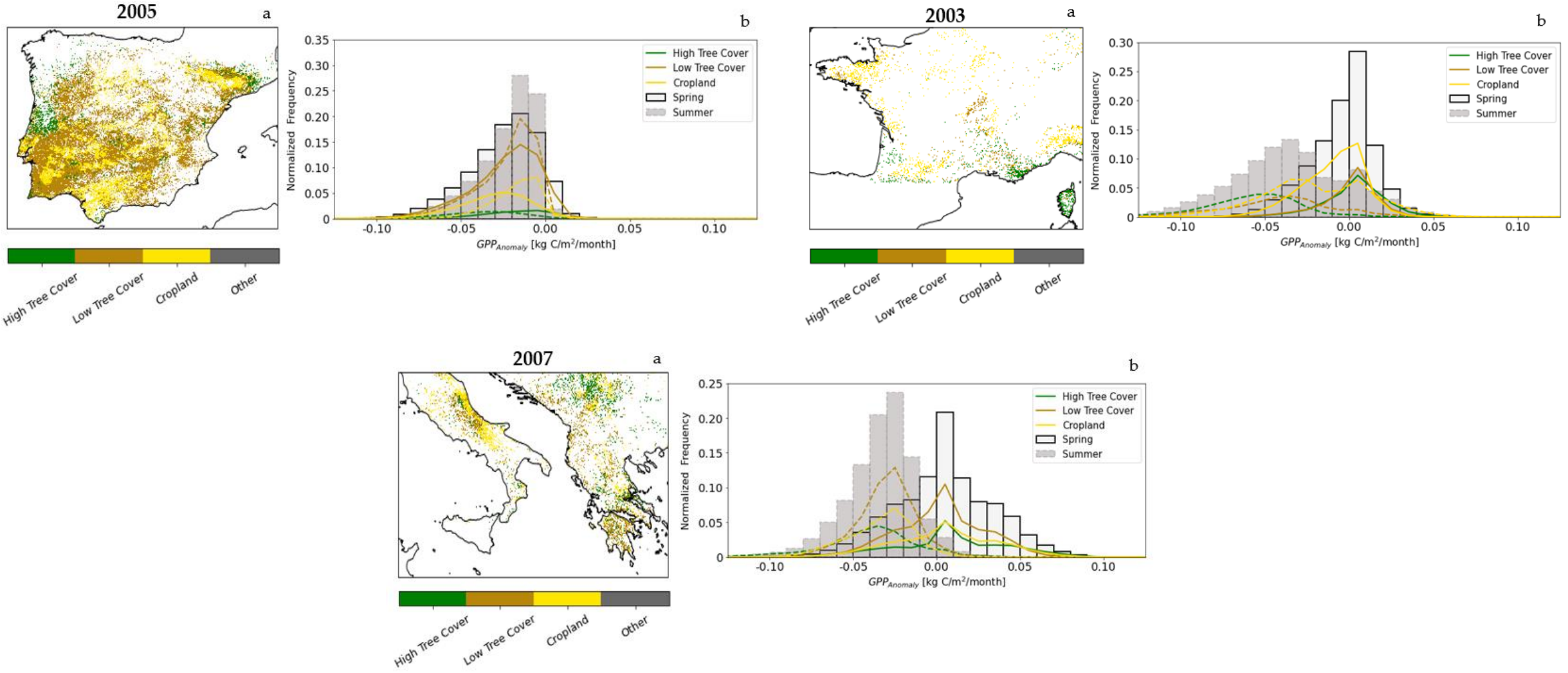
Positive GPP anomalies in late winter and spring contrasting with strong negative anomalies due to **summer heatwaves**

WE2003

Amplification of GPP negative anomalies in late spring and especially in summer due to **heatwaves**.

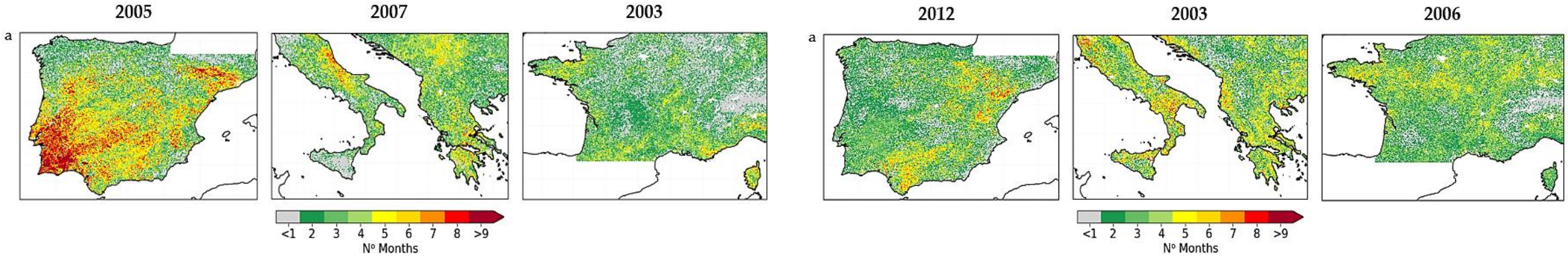


RESULTS
LAND COVER RESPONSE



RESULTS

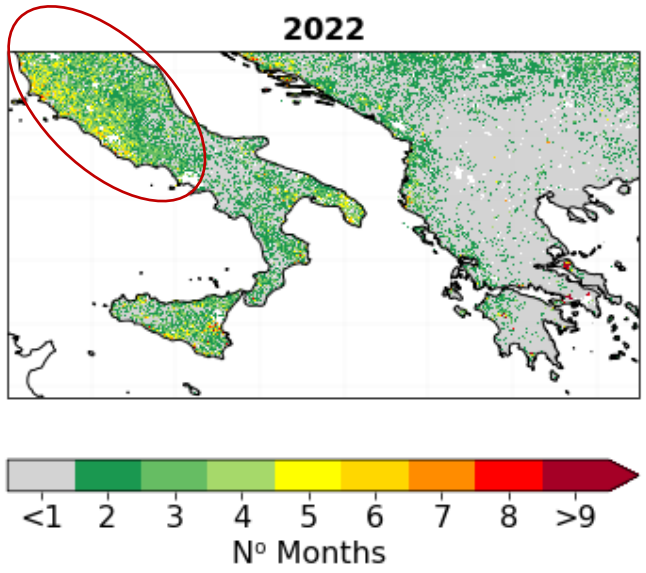
ANNUAL BALANCE OF GPP



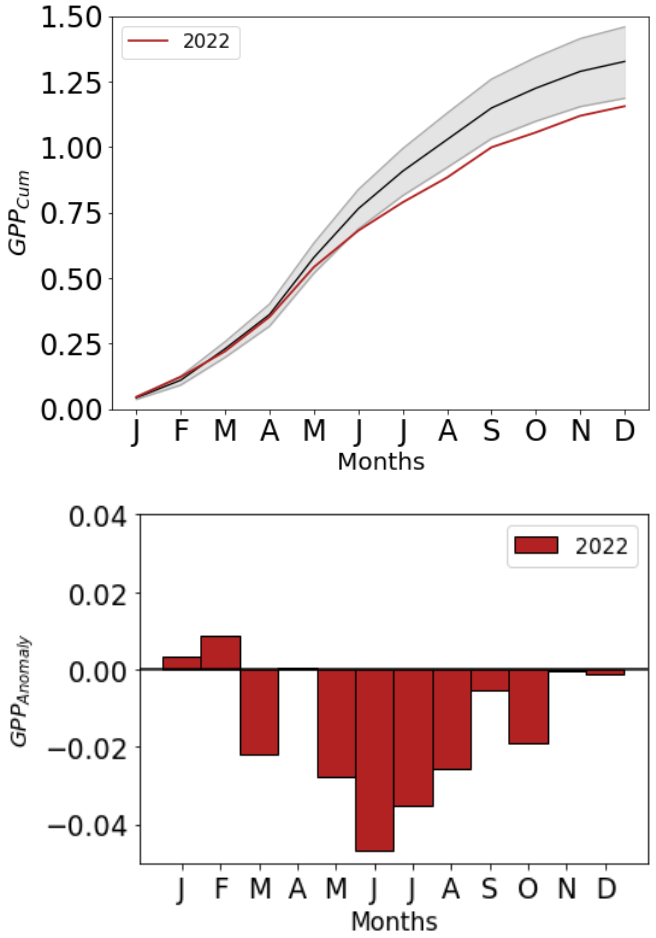
Annual GPP Balance	IB		EM		WE	
	2005	2012	2003	2007	2003	2006
Extreme Year Productivity Losses	−46.98	−10.19	−21.12	−9.31	−7.72	−13.58
1st Year of Recovery	−8.99	3.60	−1.12	−3.64	−2.11	3.72
2nd Year of Recovery	14.91	1.93	−2.49	−1.15	−2.00	−2.58
3-Year Productivity Balance	**−41.06**	**−4.66**	**−24.73**	**−14.10**	**−11.93**	**−12.44**

Unit: Tg C/year

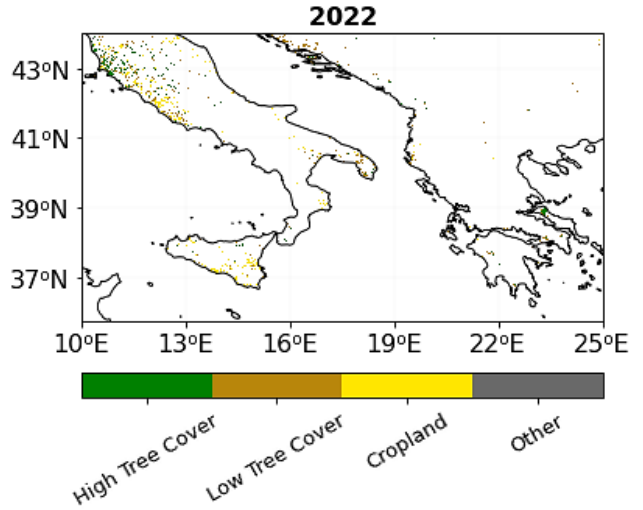
STUDY CASE of 2022 in EM

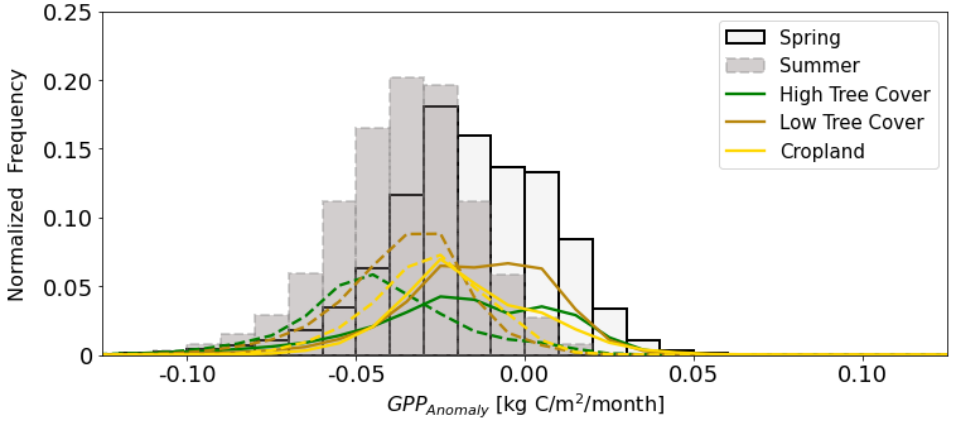


Productivity Balance:
-3.28 Tg C/year

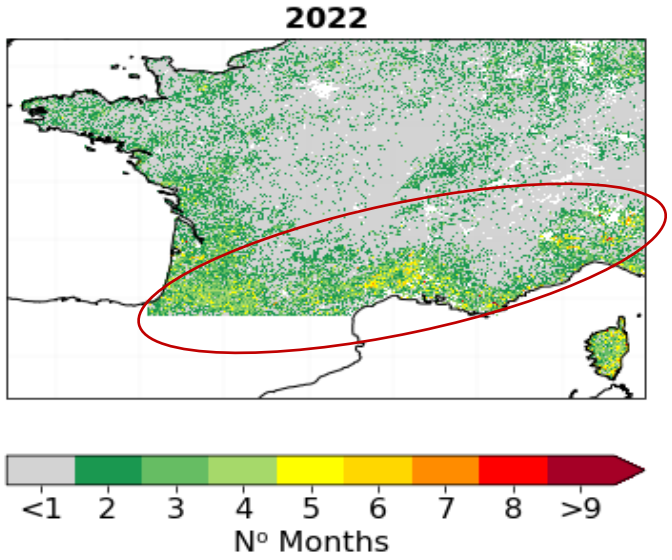


Unit: kg C/m²/month

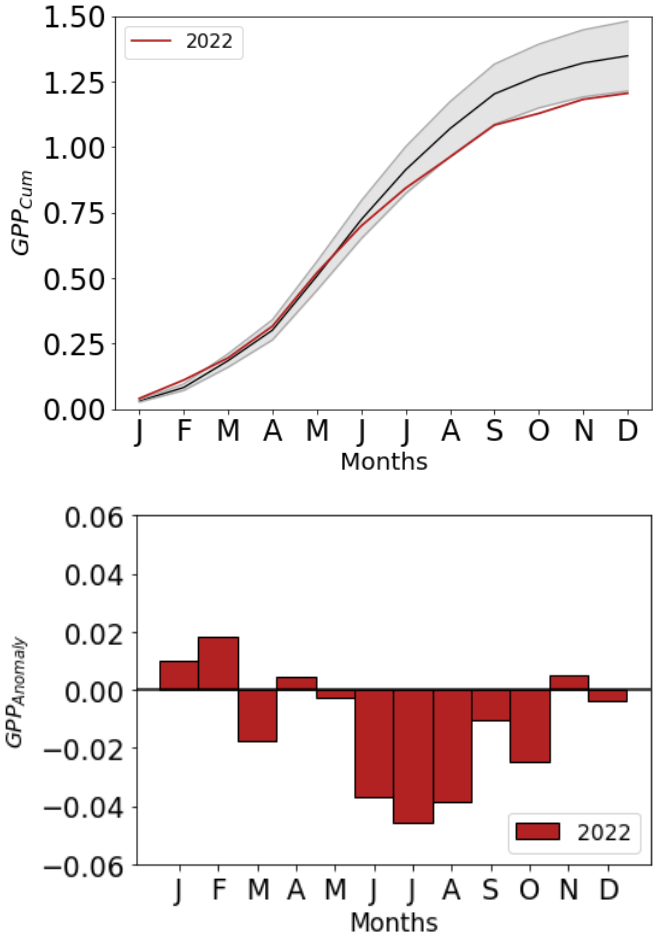




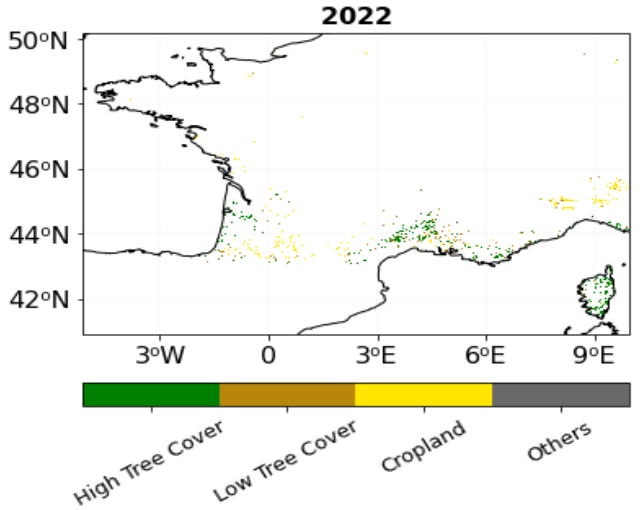
STUDY CASE of 2022 in WE

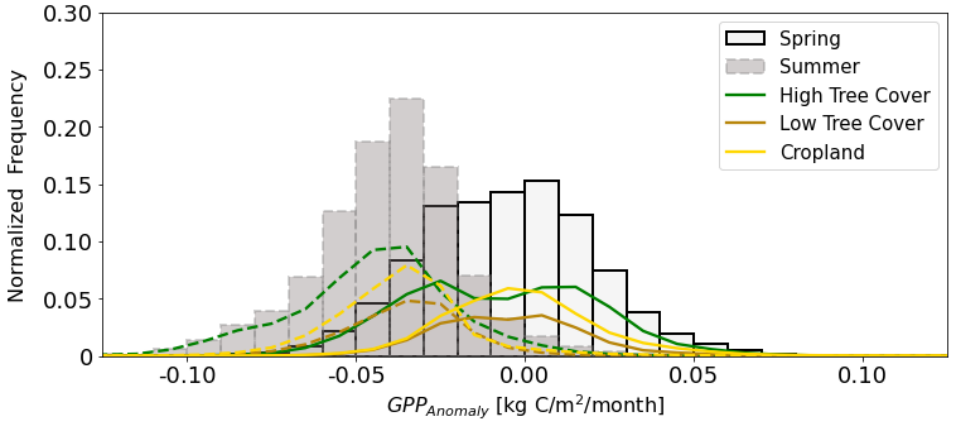


Productivity Balance:
-2.11 Tg C/year



Unit: kg C/m²/month





TAKE-HOME MESSAGES

REMOTELY SENSED DATA

- Remotely sensed products are highly suitable to monitor the activity on vegetation, land surface temperature and soil moisture.

- Remotely sensed data allows to accurately detect the impact of climate extreme events in ecosystems.

IMPACTS OF HOT AND DRY CONDITONS ON VEGETATION PRODUCTIVITY

- Soil moisture and temperature have a strong influence on vegetation productivity, playing an important role on controlling the disturbances on ecosystems.

- Warm springs contribute to early soil moisture depletion, leading to amplified hotter and drier conditions in summer months.

- In water-limited environments, like the Mediterranean basin, productivity of croplands and low tree cover areas is reduced more rapidly in response to dry conditions than high tree cover areas.

This work is available in Ermitão et al. (2021) "Vegetation Productivity Losses linked to Mediterranean Hot and Dry Events", *Remote Sensing*, 13(19), 4010