Early warning services and climate analyses in support to wildfire management in SEE

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SALGEE

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Early warning services and climate analyses in support to wildfire management in SEE

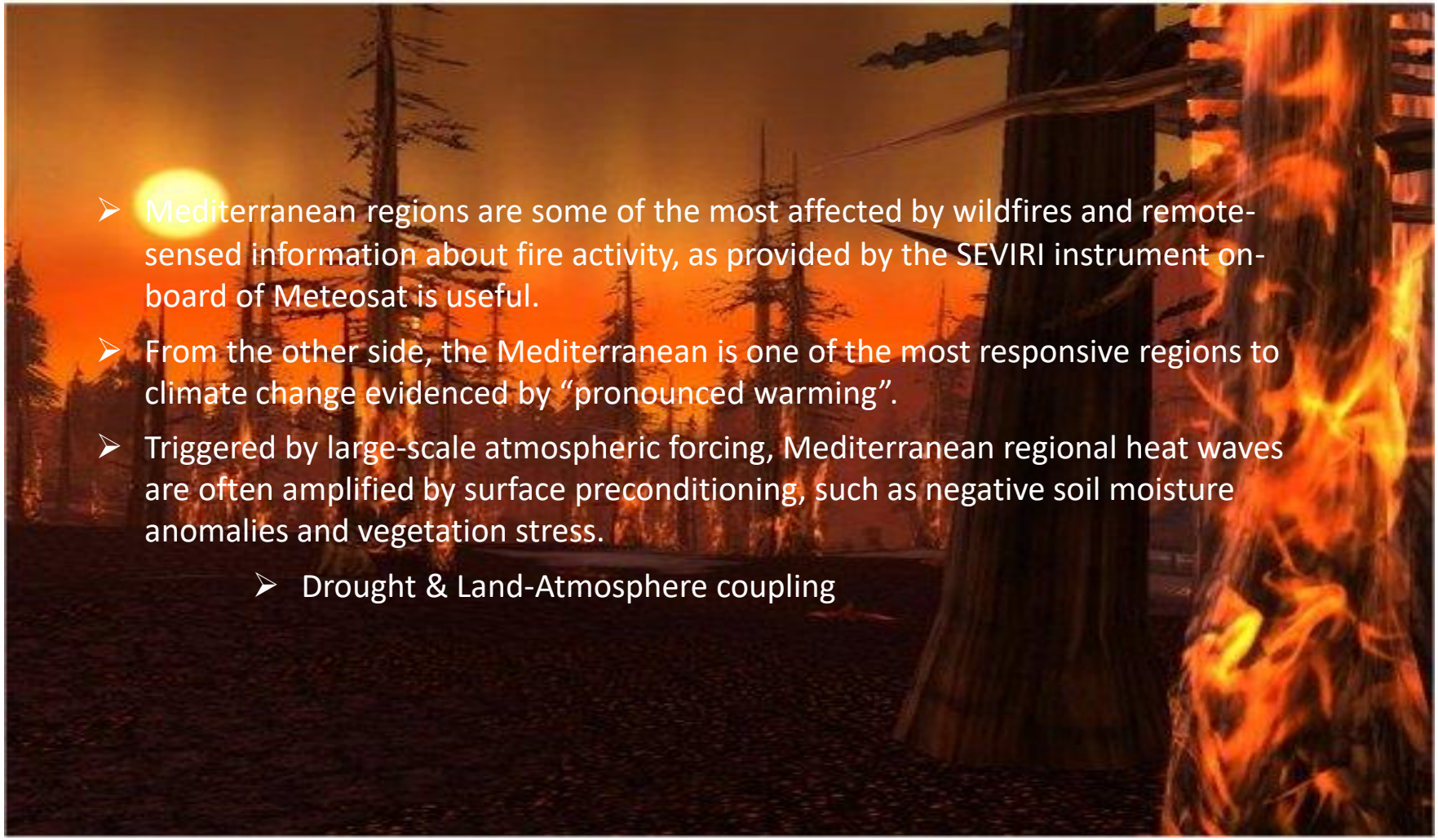
Outline

1. Importance of fire problem for Mediterranean

2. Early warning services in support to wildfire management

3. Climate impact analyses based on satellite data

1. Importance of fire problem for Mediterranean



- Mediterranean regions are some of the most affected by wildfires and remote-sensed information about fire activity, as provided by the SEVIRI instrument on-board of Meteosat is useful.
- From the other side, the Mediterranean is one of the most responsive regions to climate change evidenced by “pronounced warming”.
- Triggered by large-scale atmospheric forcing, Mediterranean regional heat waves are often amplified by surface preconditioning, such as negative soil moisture anomalies and vegetation stress.
    - Drought & Land-Atmosphere coupling

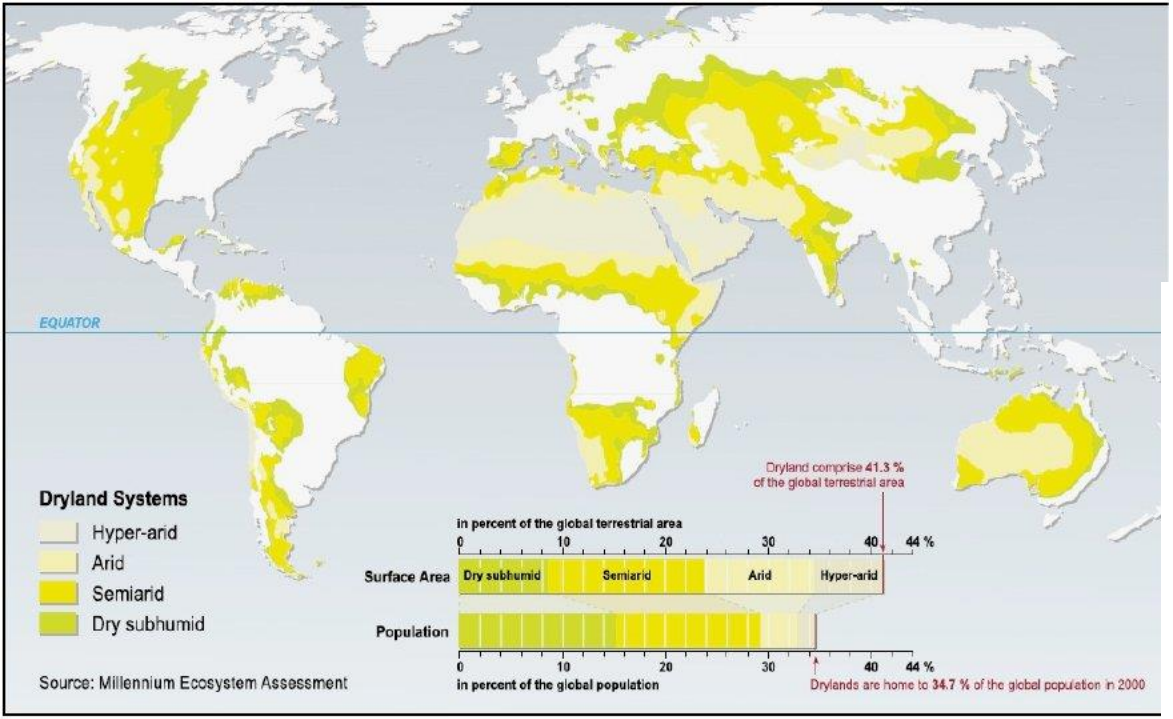


Fig. 2.2. *Global distribution and classification of arid land.*

Key issues in wildfire management

- Detection of biomass burning
- Using indexes for early warnings based on satellite information and/or modeling
- Information about climate of fire activity to facilitate prevention activities.

land-atmosphere coupling

→ Strong particularly in transitional zones between dry and wet climates.

→ For present climate: also the **southern Europe/ Mediterranean region** have been identified as such regions *(Zhang et al., 2008)*.

→ These **"hot spots"** of land–atmosphere coupling is expected to be modified with shifts in climate regimes.

"hot spots" of land–atmosphere coupling

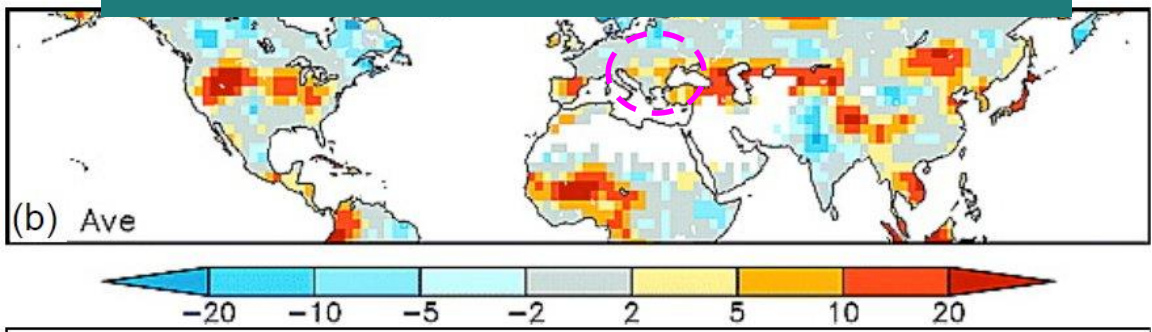


Fig. 2.6. *Quantifying land-atmosphere coupling through (a) correlations of monthly soil moisture anomalies leading CMAP precipitation anomalies by 1 month calculated using MJJ soil moisture and JJA precipitation and averaged across three land-surface models and (b) the percentage of variance of monthly precipitation anomalies due to soil moisture feedback calculated using JJA soil moisture and precipitation averaged across three land-surface models. Figures from Zhang et al., 2008.*

SALGEE, The **S**atellite **A**pplications in **L**and surface analyses **G**roup for **E**astern **E**urope has been established in 2009 for gathering experts in the field of satellite meteorology to complement the activities of EUMETSAT Land Surface SAF for progression of using satellite Land Surface Analyses techniques and training in Eastern Europe and other regions of interest where their application might be beneficial in conjunction with other source of information (CGMS-38, 2010), http://www.eumetsat.int/Home/Main/AboutEUMETSAT/InternationalRelations/CGMS/*CGMSPublications/index.htm*

EUMETSAT SALGEE Project /2009-2021/

in support to LSA SAF

EUMETSAT
Monitoring weather and climate from space
Surveiller le temps et le climat depuis l'espace

EUMETSAT LSA SAF
LAND SURFACE ANALYSIS

- *SALGEE/LSASAF & Fire problem*

✓ *Drought & Fire relations*
✓ *Fire products quality assessment*
✓ *FRP and climate relations*

The EUMETSAT Satellite Application Facility on Land Surface Analysis (Land-SAF) aims to be a leading centre for retrieval of information on land surfaces from remote sensing data, with emphasis on EUMETSAT satellites.

2. Early warning services in support to wildfire management

2.1. Thermal anomalies detection

2.2. Fire risk quantification

- Meteorological fire risk
- Live fuel dryness

Practical Applications: *Meteorological services on a regional level (Bulgaria)*

2.1. Thermal anomalies detection from EO satellites

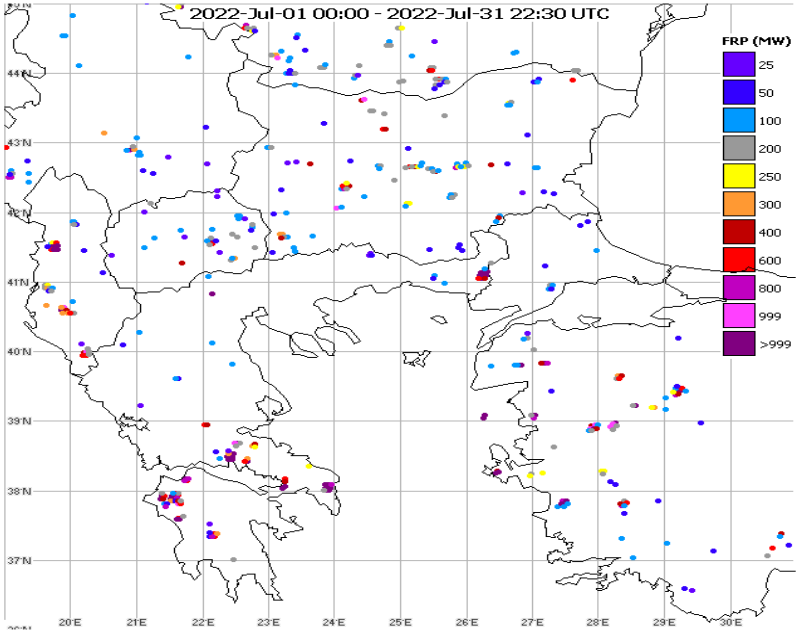
- Use of Earth Observation (EO) satellites for wildfire detection and assessing the atmospheric and terrestrial impacts
- Fire Radiative Power (FRP) approach.
- Cloudiness as a limitation
- Application of polar orbiting satellites: *Data from MIR channels of MODIS and VIIRS instruments are* ***considered as a reference***.

2.1. Thermal anomalies detection from EO satellites

- **Use of geostationary satellites for NRT fire detection and monitoring**

  - *EUMETSAT's Active Fire Monitoring Product (FIR)*
    - ✓ *Operationally produced from Meteosat data and disseminated every 15 min for the full-disk and every 5 min over Europe (Rapid Scan Service)*
    - ✓ Last improved version of EUMETSAT FIR algorithm, July 2019 with the aim to better detect wildfire in the coastal areas of Mediterranean See.

- *LSASAF FRP-Pixel product:* Major advances
  - ✓ *FRP-PIXEL: A LSA SAF operational product for ~18 years now;*
  - ✓ *FRP-PIXEL is the only product that provides an FRP value in addition to an active fire detection.*



Case study description: Kresna Gorge fire, SW Bulgaria

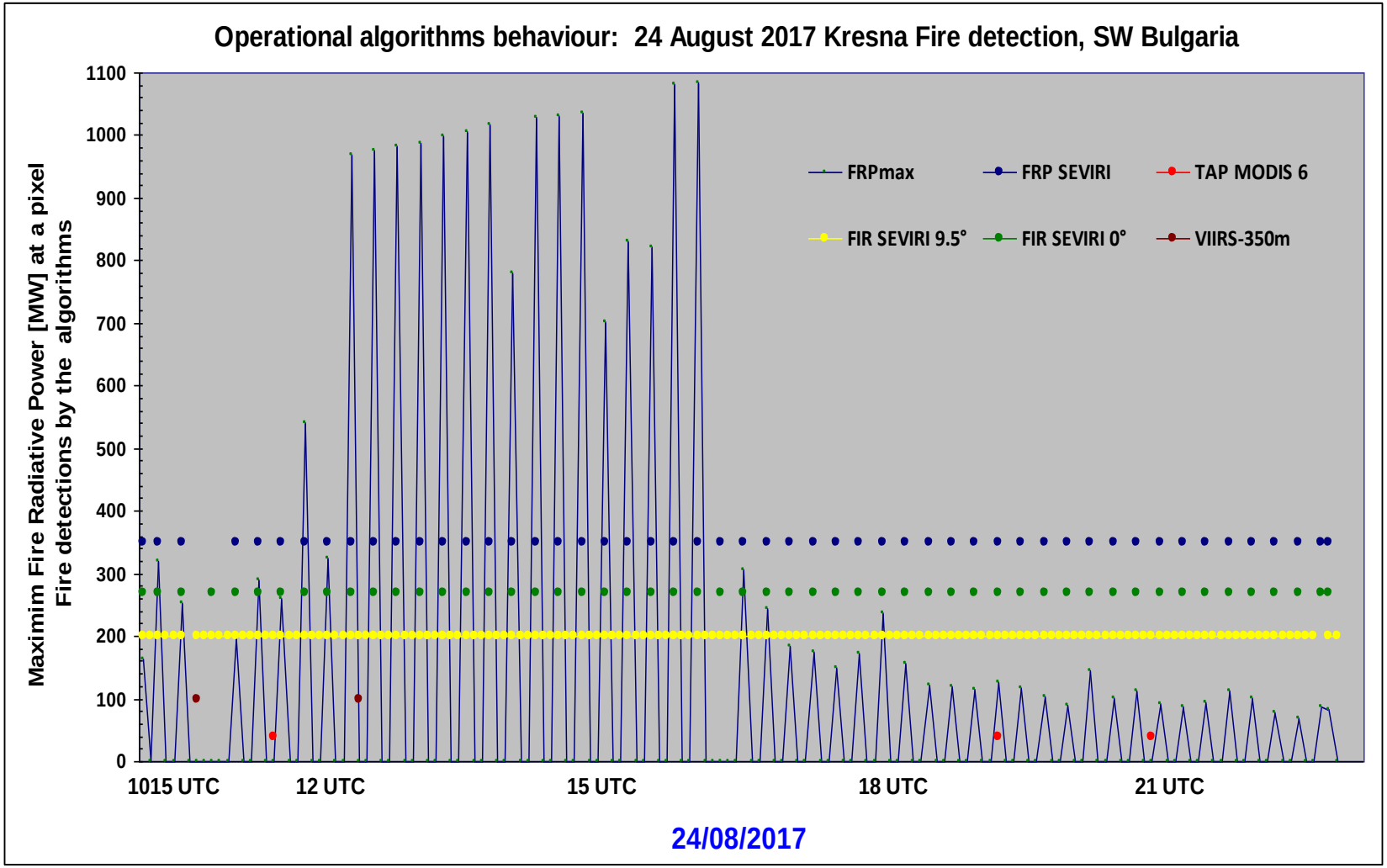
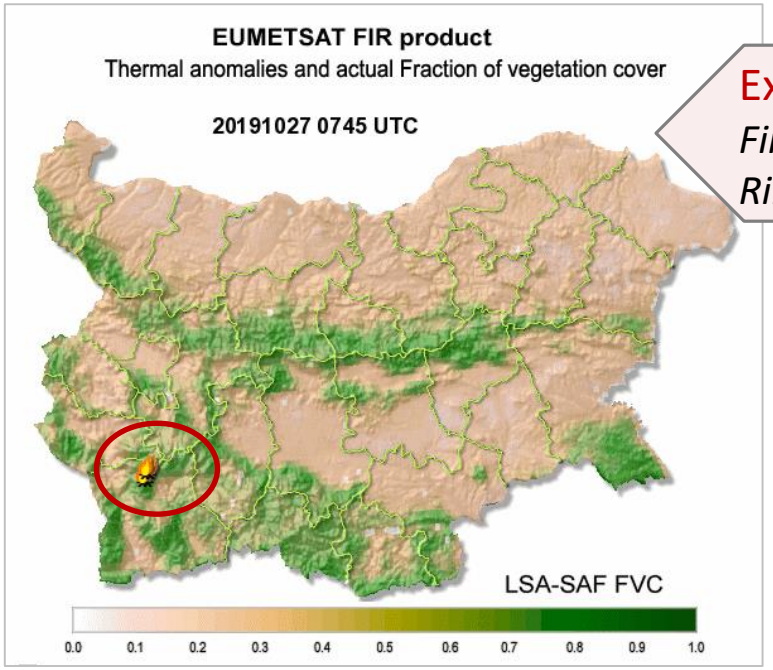


Figure: Satellite detection and monitoring of a major crown forest fire over Bulgaria on 24-28 August 2017 by available satellite algorithms

Operational applications of satellite information for Bulgaria

Day-time detections



Example of early warning
Fire in the national park
Rila mountain, 27 October 2019

First MSG detection – 07:45 UTC

- Duration of MSG detections

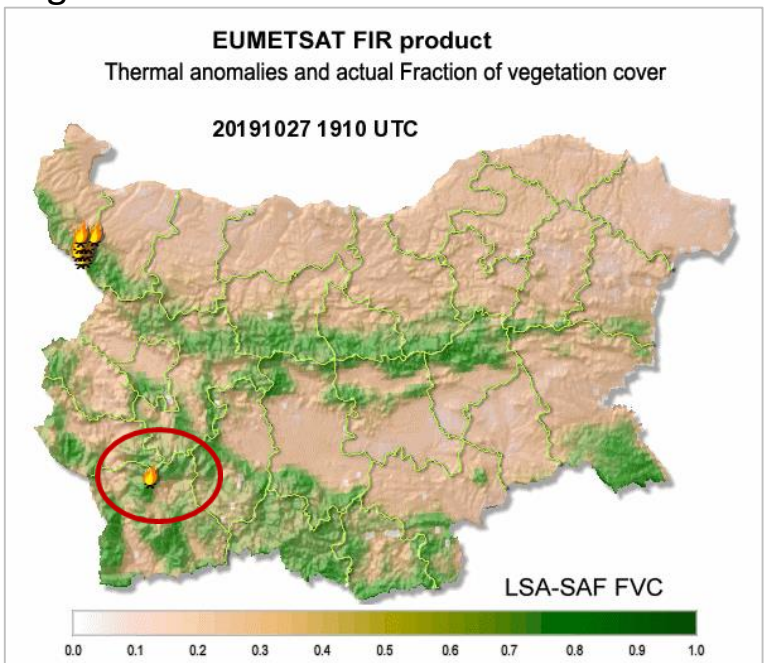
from 27.10/07:45UTC till 28.10/13:10 UTC

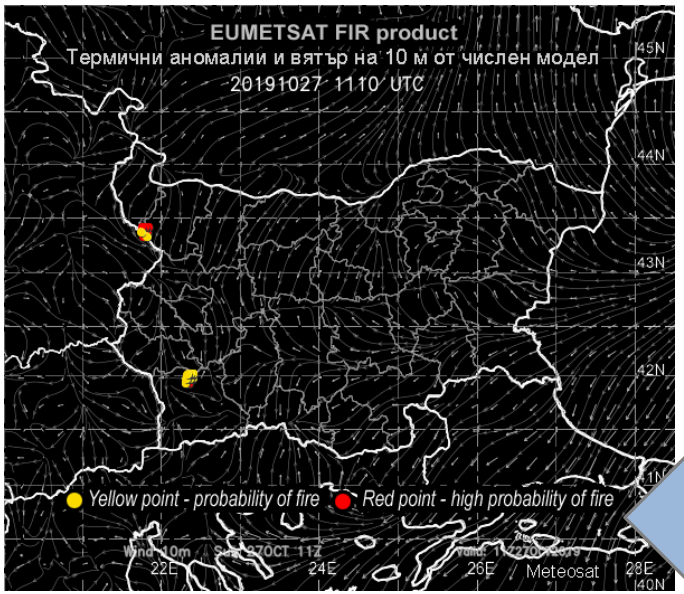
- Each 5 minutes detection
- Definite day/night detections

Signal from ground observation – 09:03 UTC.
Duration: 27-29.10 2019.

Land surface state and fire occurrence
FVC ~ 45.5 %

Night-time detections





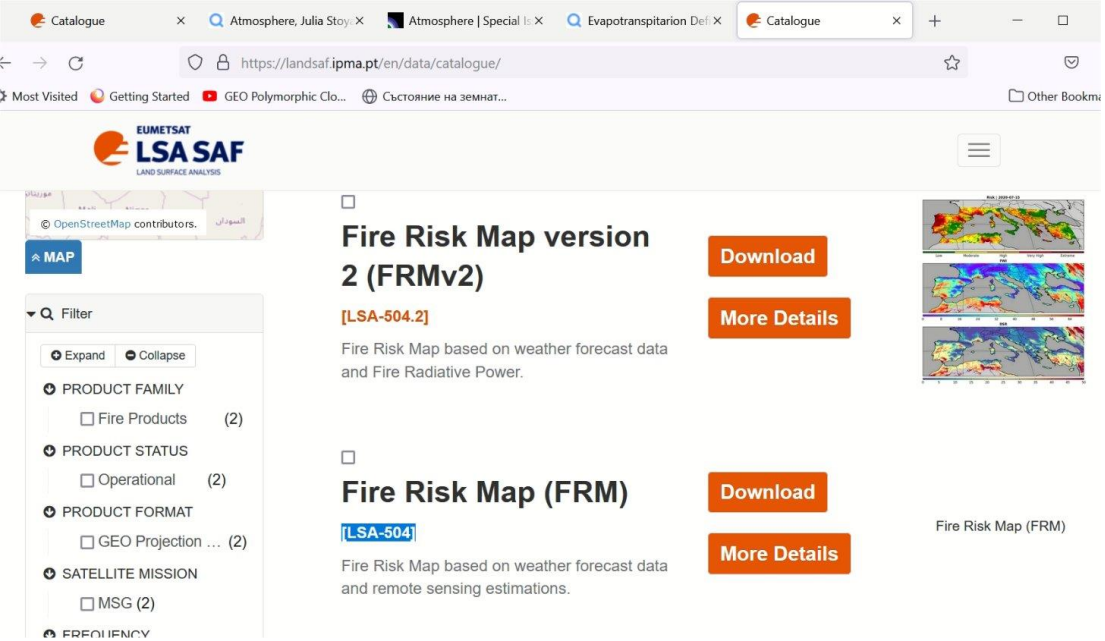
Thermal anomalies (fires) in wind field

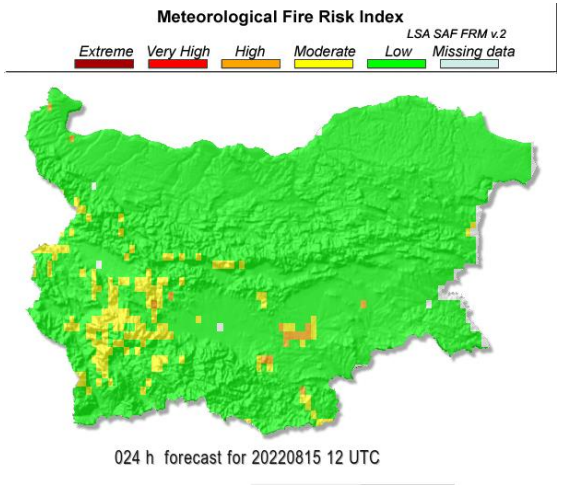
2.2. Fire risk quantification

- Meteorological fire risk
- Live fuel dryness

Fire Risk Indexes in use at NIMH Bulgaria	Index	Risk scale
LSA SAF product via EUMETCast	- Fire Risk Map (FRM) - Fire Risk Map (FRMv.2)	3 level risk scale (24,48,72-h frc) 5 level fire risk scale (24,48,72,96,120-h frc)
Regionally developed operational products for Bulgaria domain	- Soil Moisture Deficit Index of Fire Danger (SMDIFD) for live fuel dryness - Composite Fire Danger Index (meteorological fire risk LSASAF FRM/FRMv2 & SMDIFD, CoNew	5 level fire risk scale 3 level fire risk scale
Reference Data for Quality Monitoring (QM) of Fire Risk Indexes	- LSA SAF FRP-Pixel product detections and FRE (MW) - Number of fires & Total burned area ground observations *State Forest Agency, Ministry of Inner Affairs*	

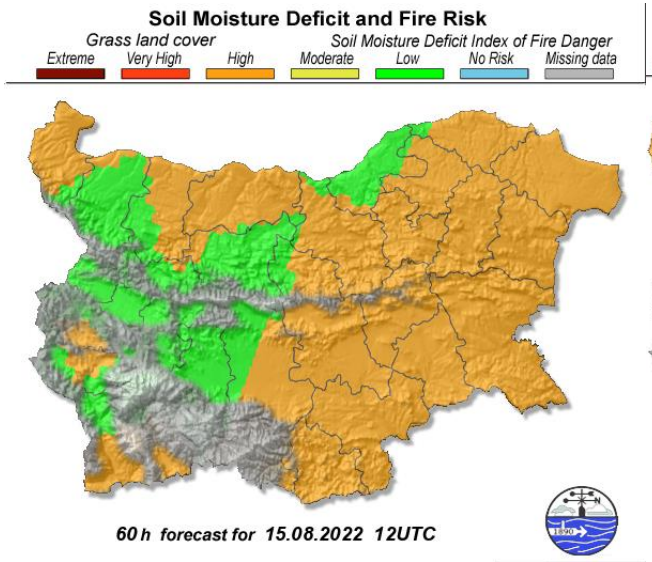
➢ Meteorological fire risk

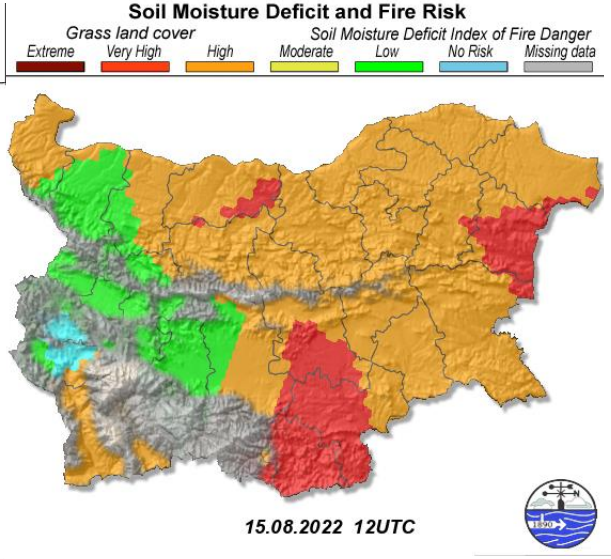




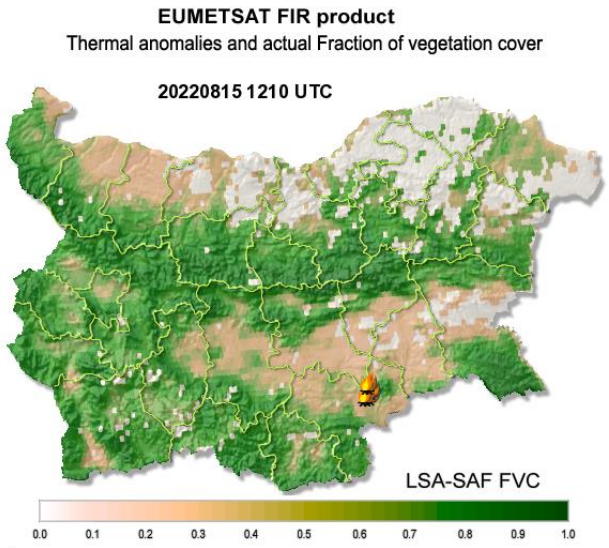
To account for drought impacts, i.e. of the life fuel dryness into fire danger for the purposes of its diagnoses and early warning?

1. SMDIFD based on SVAT SM forecast



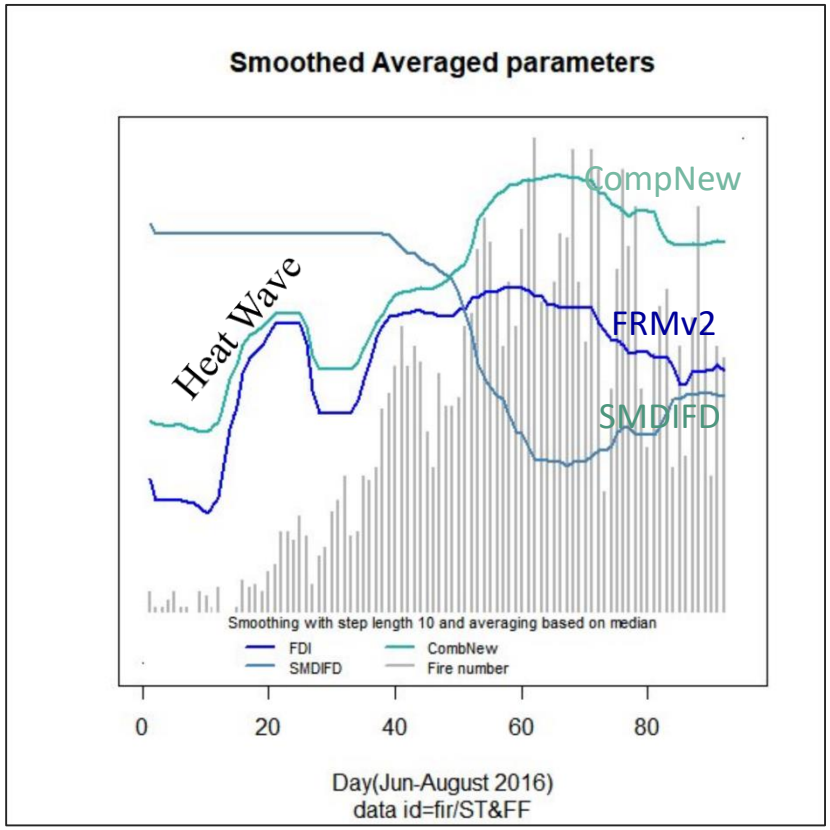


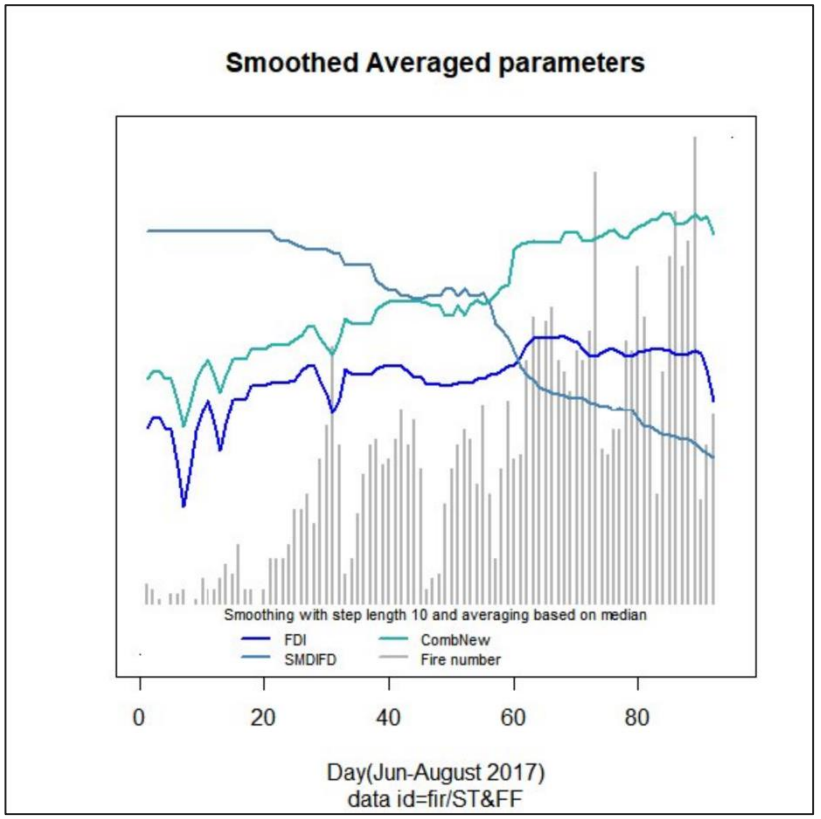
2. Map of fire detections over FVC



Qualitative analyses: FRIs variability along with seasonal fire activity

- ✓ Increased fire activity is related to enhanced fire risk according *CoNew and SMDIFD (*the higher fire activity the lower *SMDIFD)*. The course of Soil Moisture Deficit Index and Composite Index strictly follows the course of fire numbers (Examples: 2016, 2017).
- ✓ The course of Meteorological FRMv2 (FDI) alone is not so sensitive to fire activity.



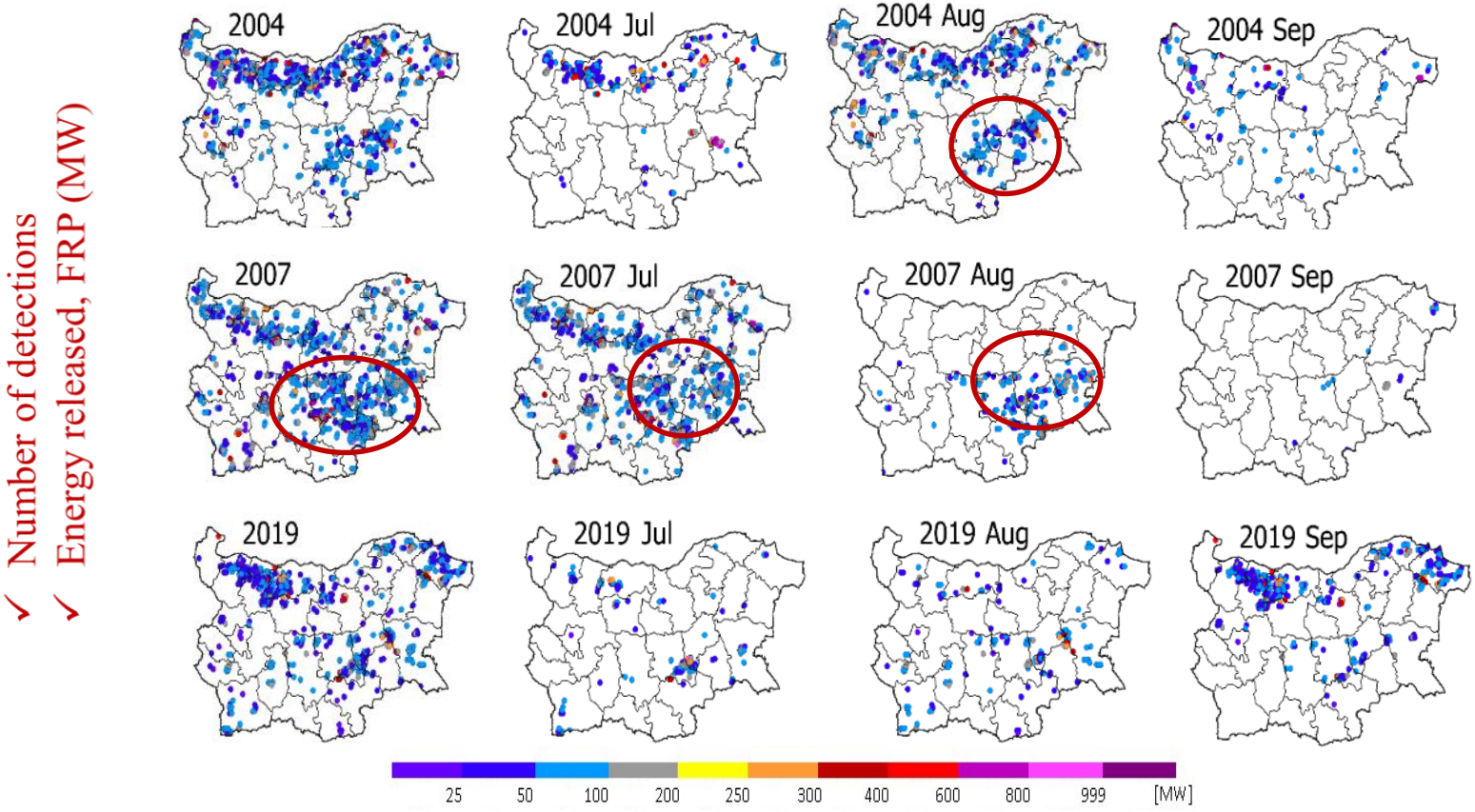


Smoothed averaged course of FRMv2, SMDIFD, CoNew FRIs along with fire activity (grey bars) June-August of: a) 2016 and b) 2017.

3. Climate impact analyses

3.1. Characterizing Fire Activity in Eastern Mediterranean Europe

- The spatial and temporal patterns of landscape fires in the Mediterranean characterised by remote sensing data from SEVERI sensor (LSASAF FRP product long term data records)



- ✓ Maps of spatial-temporal (monthly/annual) distribution of fire activity over Bulgaria.
- ✓ Color-coded severity of biomass burning according LSASAF FRP-Pixel (MW) is indicated.
- ✓ Examples for Jul, Aug, Sept and annual for 2004, 2007, and 2019 are presented.

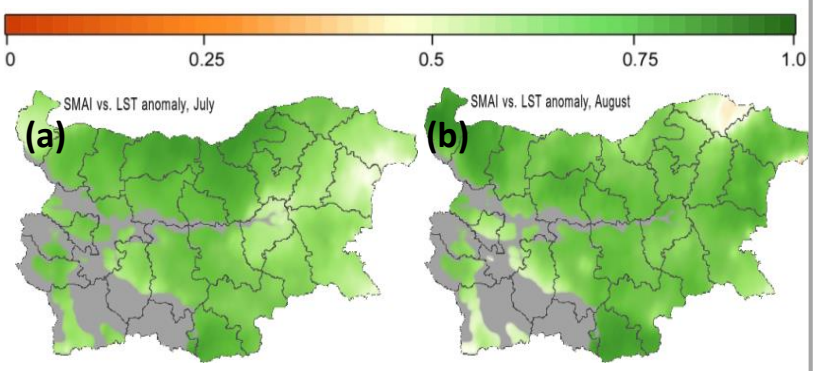
3.2. Fire Activity in relations to biophysical characteristics of land surface state

Summary of data used and their characteristics

Data	Temporal resolution	Spatial resolution
Fire Radiative Power-Pixel product *(hot spots detections & FRE (MW))* **time series (2004-2019)**	15 min	SEVIRI, about 5 km over Bulgaria
Land Surface Temperature (LST) and its anomalies **(June-September 2007-2018)**	15 min	SEVIRI, about 5 km over Bulgaria
Temperature difference between LST and air temperature at 2m (LST-T2m) **(June-September 2007-2018)**	0900 and 1200 UTC	NIMH synoptic station network
Soil Moisture Availability Index (SMAI)	Daily, 0600 UTC	NIMH synoptic station network (SVAT derived)

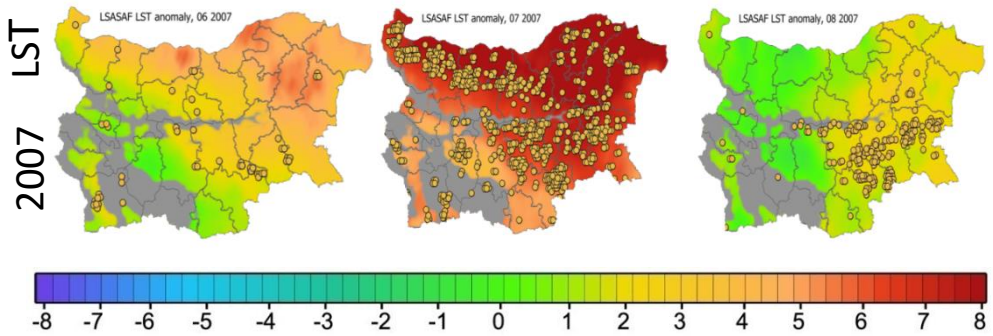
The relationship between spatial-temporal variability of LST and fire activity on a short-term climatic scale over Eastern Mediterranean (Bulgaria) accounting for physical properties such as land cover (*forest, shrubs, cultivated, All LC types*) and soil moisture that combined with LST provide a valuable metric of surface state is quantified.

➢ Spatial variability of biophysical drivers SMAI and LST anomalies as a factor of fire activity

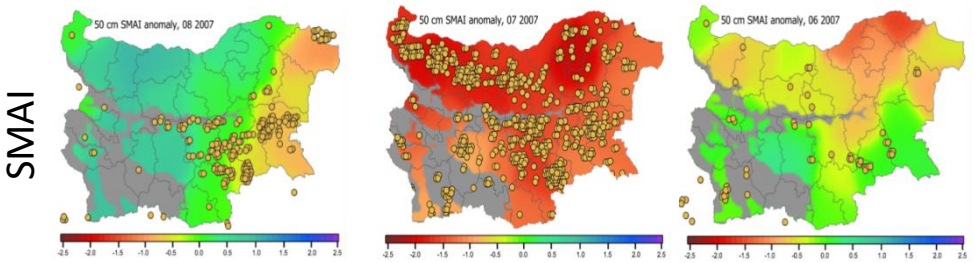


Spatial distribution over Bulgaria of correlation between the monthly mean anomalies of root zone SMAI and LSASAF LST (MSG retrieval) for: **(a)** July; **(b)** August. *Anomalies are calculated towards (2007-2018) period. Mountain regions above 800 m altitude are excluded with a mask.*

✓ LSASAF LST mean monthly anomalies and overlaid FRP fire detections



✓ SMA mean monthly anomalies with overlaid FRP fire detections

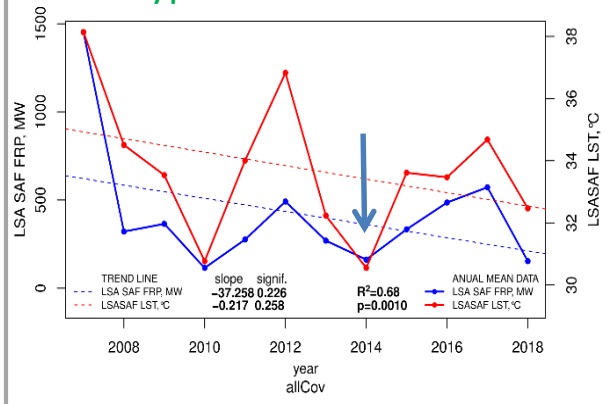


✓ Higher positive LST anomalies correspond to higher number of fire pixels, both being maxima in July 2007, extreme warm/dry climate anomaly.

✓ Higher negative SMA anomalies correspond to lower number of fire pixels, being minimum in 2014 */not presented/*.

➢ Trend lines: synchronized LST behavior with FRE (MW) from biomass burning

all LC types **FRP, MW & LST**

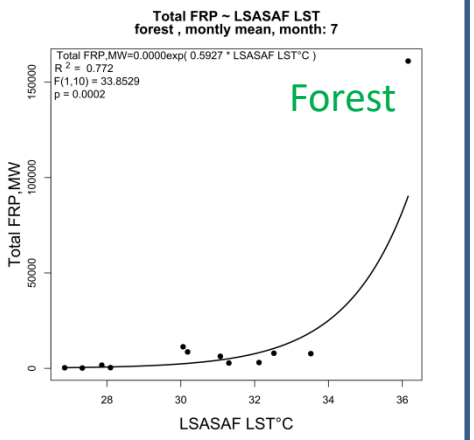


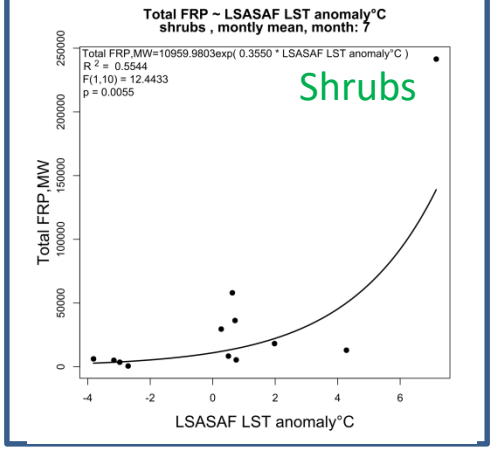
'all LC', R^2 = 0.68.
R^2 forest-shrubs-cultivated ~ 0.61 and 0.68

3.3. Quantitative relations between fire activity and biogeophysical indexes

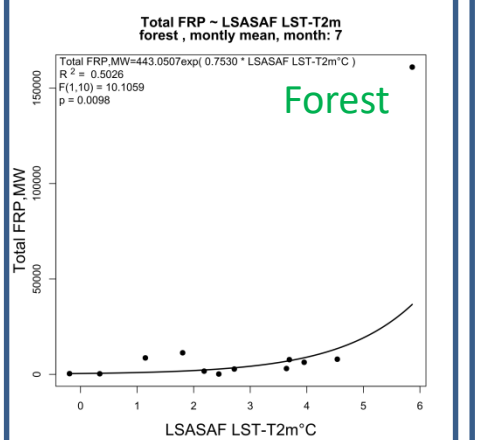
- ✓ Exponential regression models fit the link between LST montly means, LST positive anomalies, LST-T2 (as a first proxy of sensible heat exchange with atmosphere) and FRP fire characteristics (number of detections; released energy FRP, MW) at high correlations for: Forest; Shrubs; Cultivated
- ✓ Satellite IR retrievals of radiative temperature is a reliable source of information for vegetation dryness and fire activity.

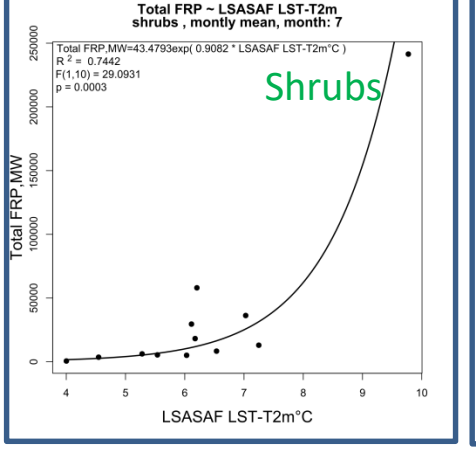
FRP vs. LST



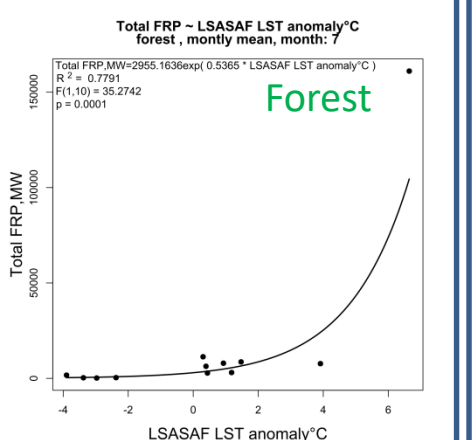


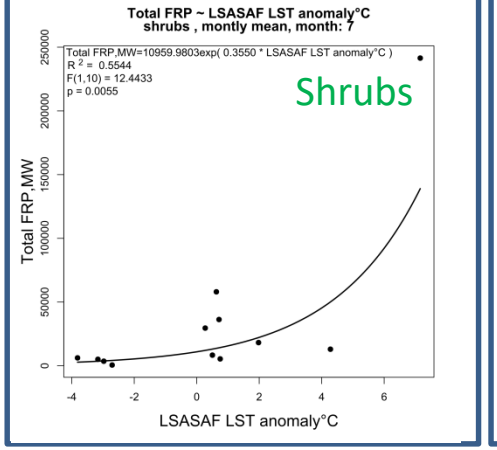
FRP vs. (LST-T2)



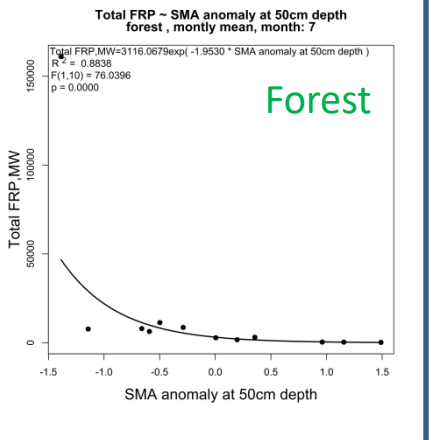


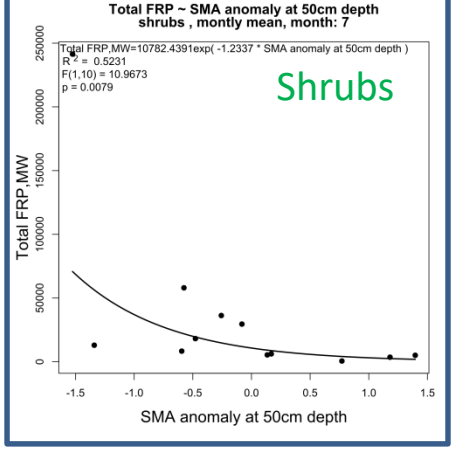
FRP vs. LST anomaly



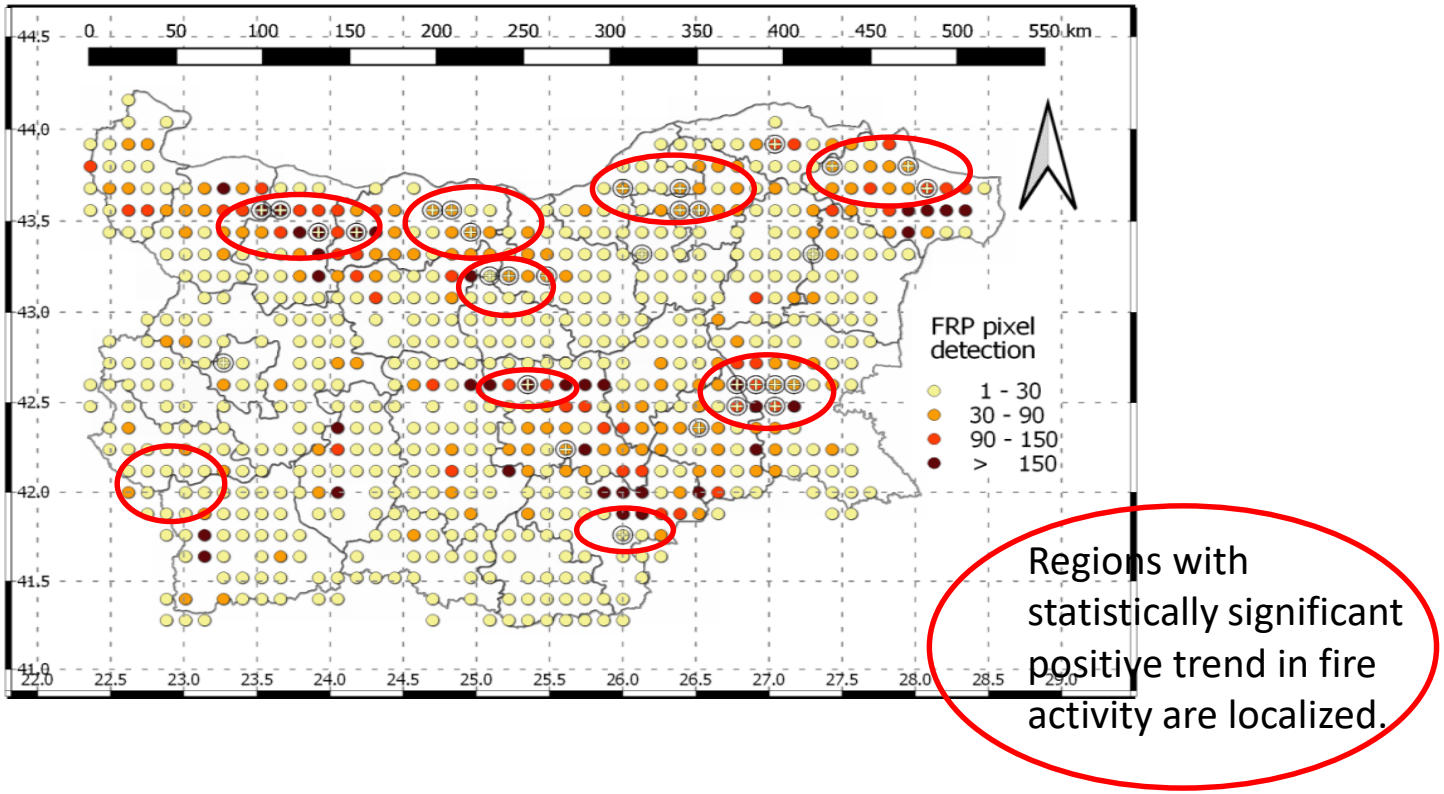


FRP vs. SMA





3.4 Hot spots of Fire Activity



- ✓ Map of 'hot spots' of fire activity over Bulgaria, SE Europe based on long-term satellite observations (June-September, 2004–2019) using LSASAF FRP-Pixel product.
- ✓ The "+" sign indicates locations where the trend has passed the Mann–Kendall significance test at the 5% level.

THANK YOU!