

Fire risk assessment over Bulgaria

South Eastern part of Europe

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Contributor: *Mariana Popova*

Drought raises the fire hazard

Local scale assessment of soil moisture deficit and fire danger

The evaluation of **drought** and **fire risk** is performed by using LSA SAF products and information for Soil Moisture Deficit derived by SVAT operational model run at NIMH of Bulgaria, '**SVAT_bg**'

(Stoyanova, J.S. & Georgiev, C.G., 2007; 2013)

Soil–Vegetation–Atmosphere–Transfer (SVAT) Model

The SVAT models are run by using data from meteorological observations, site specific soil and vegetation physical properties and local scale geophysical parameters and thus can be used as a reference regarding the information content of satellite products for land surface analysis at local scale.

Bulgarian SVAT *numerical output*

Energy & Water cycle coupling

3-hour
synoptic
observations



For each
administrative
unit of Bulgaria

- **Daily run**
- **Site-scale quantitative assessments**
- **Operational access**
- **Specific land cover type.**

▪ **Biogeophysical parameters**

- Soil moisture at 5, 20, 50, 100 cm /up to 2 m/
- Evapotranspiration
- Land surface temperature

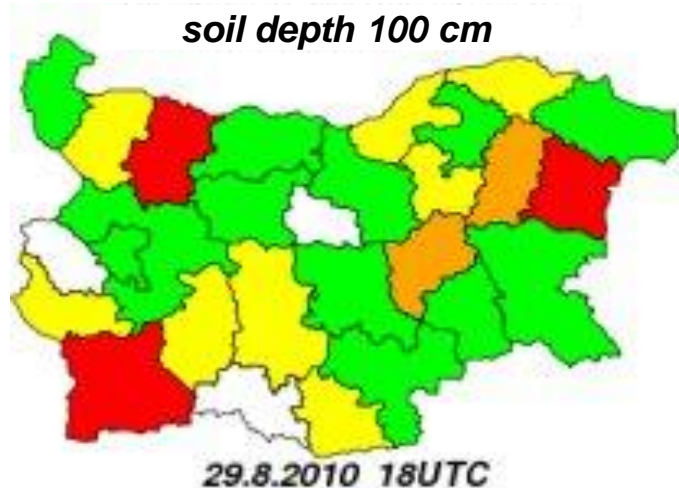
Land surface moistening conditions

Status–Dynamics & Hazards

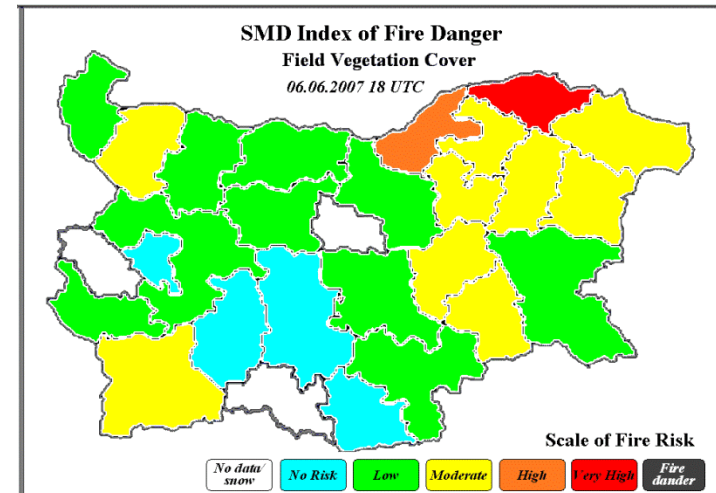
- **Meteorological operational products are developed**
 - Index of soil moisture availability
 - Index of fire risk of “vegetation fuel dryness”

OPERATIONAL APPLICATIONS based on the SMA concept

Drought Monitoring



Fire Risk Assessment



DRY

SMAI

Fire
Risk

A diagnostic tool for land surface conditions favorable for:

- ✓ Extreme weather: drought and fire environment; over moistening
- ✓ Crops water supply during vegetation /Agricultural drought/.

- The SMA concept in SVAT_bg model is used in this study for assessing the information content of LSA SAF products.

Drought assessment in Eastern Mediterranean

- **Satellite and SVAT model products**

LSA SAF LST product for retrieval of surface skin temperature in conjunction with the MSG products of **FVC** and **ET**.

Surface moistening, characterised by 'SVAT_bg' model Soil Moisture /SM/ and developed on this bases **Soil Moisture Availability /SMA/ Index**.

- **Blended parameters & time series**

From satellite and ground observations: MSG LST and air temperature at 2 m height (T_{air}) measured at synoptic stations network and the corresponding (MSG LST – T_{air}) difference.

The experimental framework

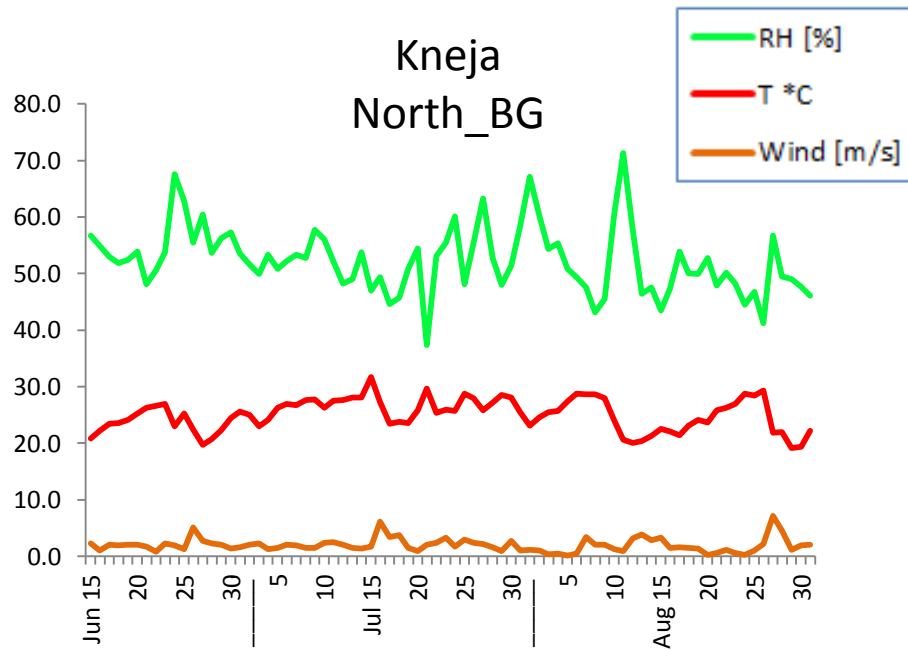
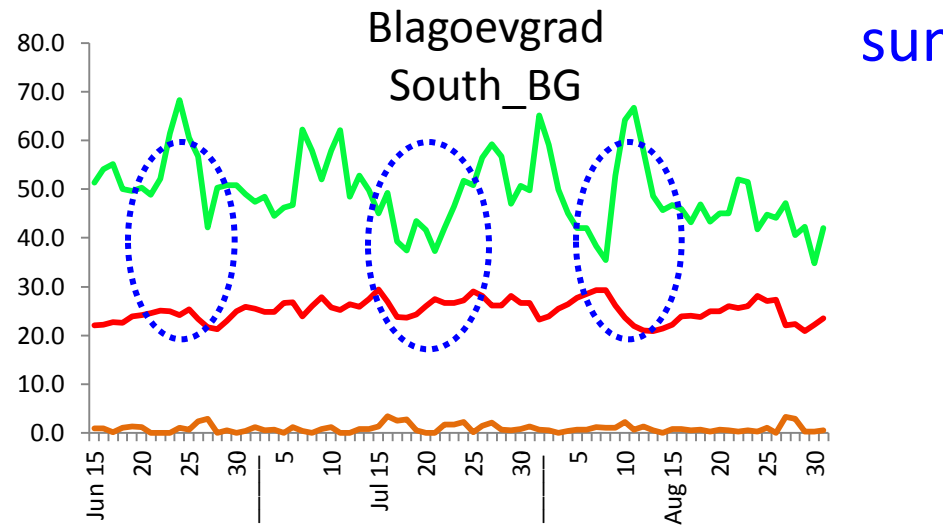
The approach is evaluated around “dry” and hot periods of 2012, without significant rain; vegetation water stress and increased risk of vegetation fires, including two periods:

1. Warm, dry atmosphere and optimal Land Cover /LC/ moistening:
15-25 June 2012
2. Warm, dry atmosphere and dry LC moistening periods:
8-10 July, 1-10 August of 2012

Weather conditions in 2012 summer season, Bulgaria, the Eastern Mediterranean

Data from SYNOPTIC
Stations

- There are many daily high temperature records:
 - late June: 3 days
 - July: 17 days
 - August: 11 days
- During the periods of daily temperature records, low levels of air humidity have been observed.



15- 23 Jun

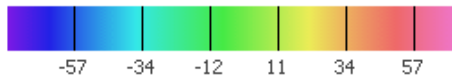
9-19 Jul

3-8 Aug 2012

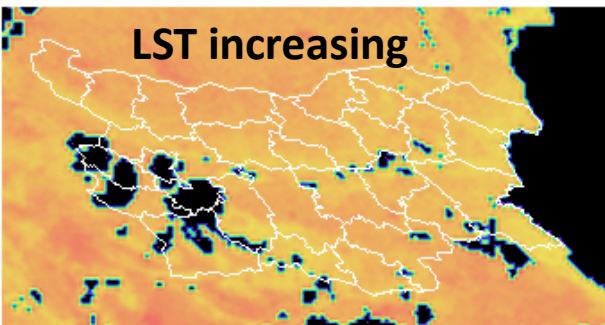
Contributed by Mariana Popova

LSA SAF products

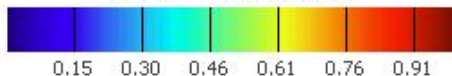
LST 2012-Jun-09 12:00 UTC



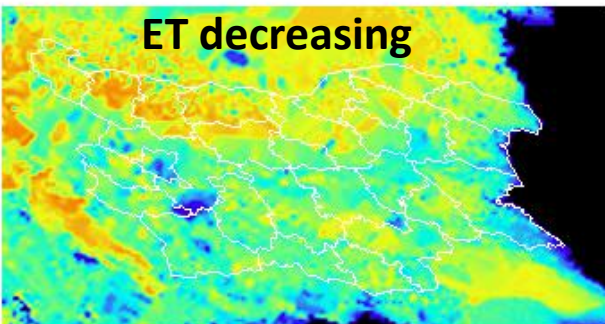
LST increasing



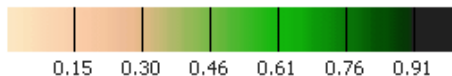
ET 2012-Jun-09 12:00 UTC



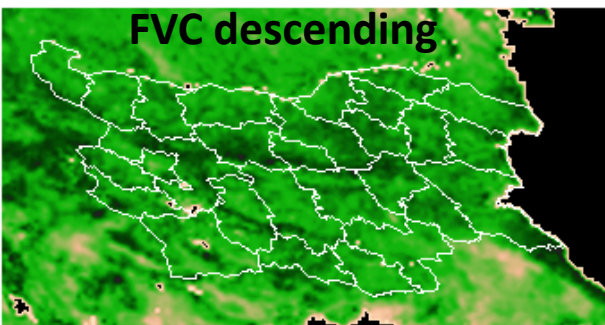
ET decreasing



FVC 2012-Jun-09 00:00 UTC



FVC descending



SVAT products

Soil Moisture Availability decreasing

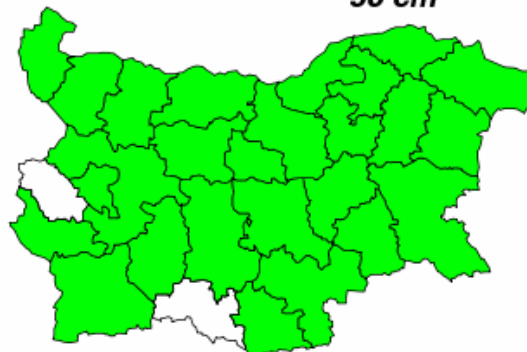
Lucerne/Grass

SVAT_bg model

Drought Drought Risk Dry Optimum Wet Soaking Wet No Data

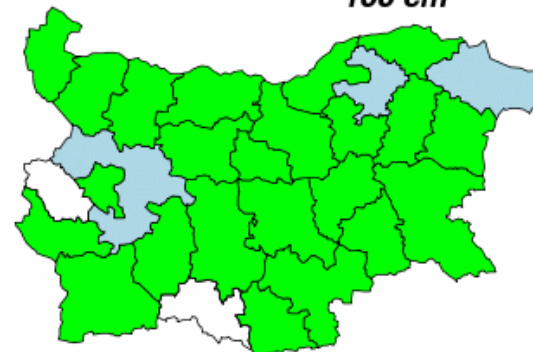


50 cm



9.6.2012 18UTC

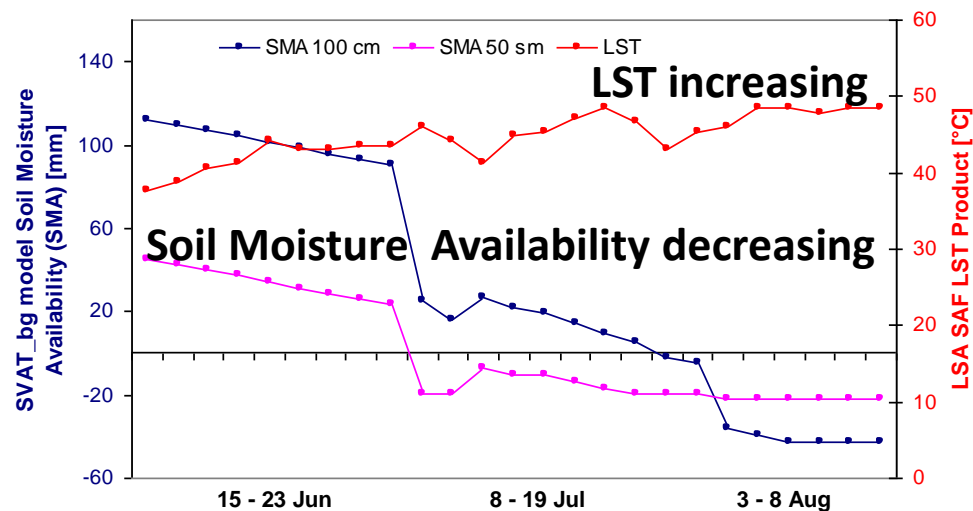
100 cm



9.6.2012 18UTC

SMA depletion is accompanied by increase of LST, decrease of ET, decrease of FVC.

Sandanski, 41.567 N 23.283 E, Cultivated and managed areas, 2012



SVAT SM

9 June

6 Aug

15 Aug

SOIL MOISTENING

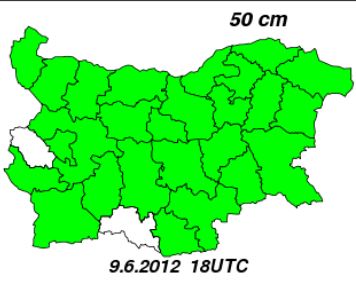
SOIL MOISTENING

SOIL MOISTENING

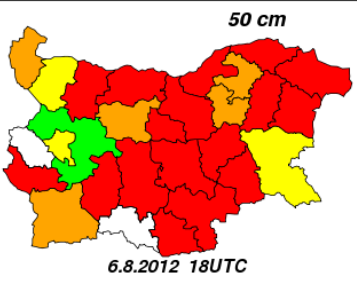
Lucerne/Grass SVAT_bg model
Drought Drought Risk Dry Optimum Wet Soaking Wet No Data

Lucerne/Grass SVAT_bg model
Drought Drought Risk Dry Optimum Wet Soaking Wet No Data

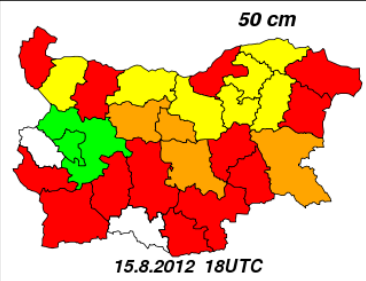
Lucerne/Grass SVAT_bg model
Drought Drought Risk Dry Optimum Wet Soaking Wet No Data



decreasing
→



increasing
→

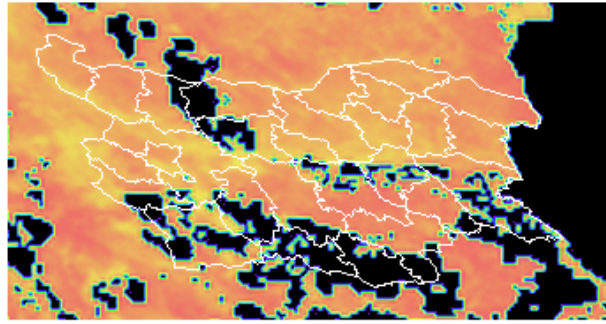
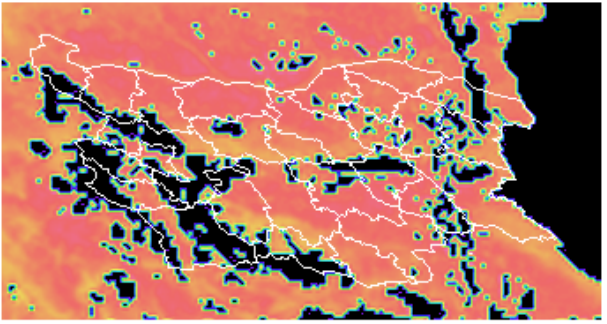
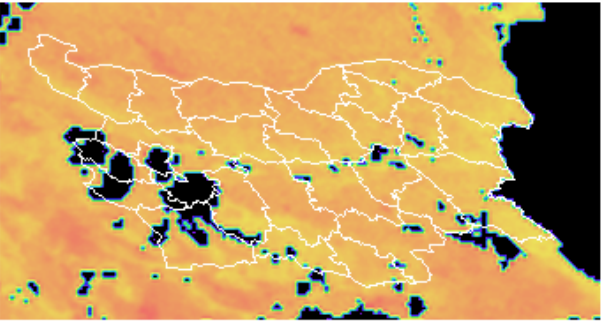
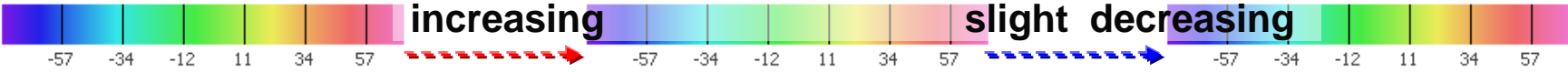


MSG LST

LST 2012-Jun-09 12:00 UTC

LST 2012-Aug-06 12:00 UTC

LST 2012-Aug-15 12:00 UTC

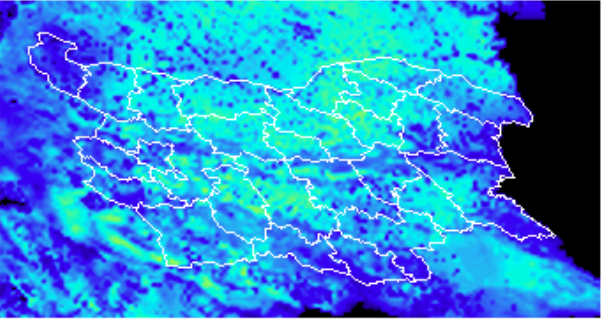
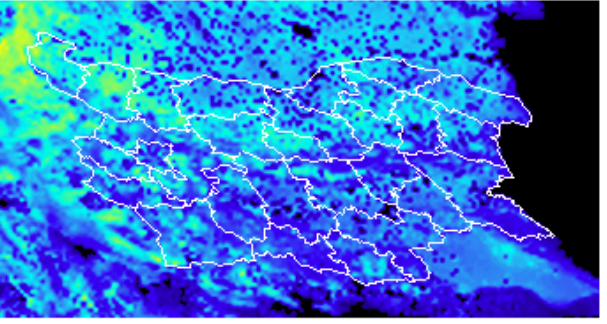
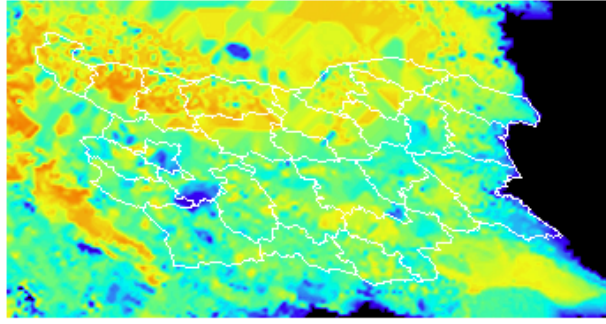
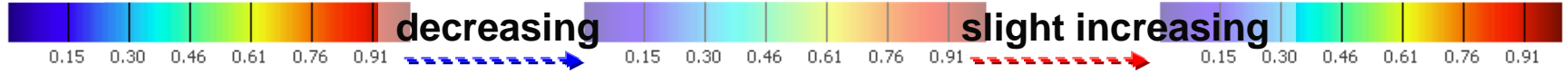


MSG ET

ET 2012-Jun-09 12:00 UTC

ET 2012-Aug-06 12:00 UTC

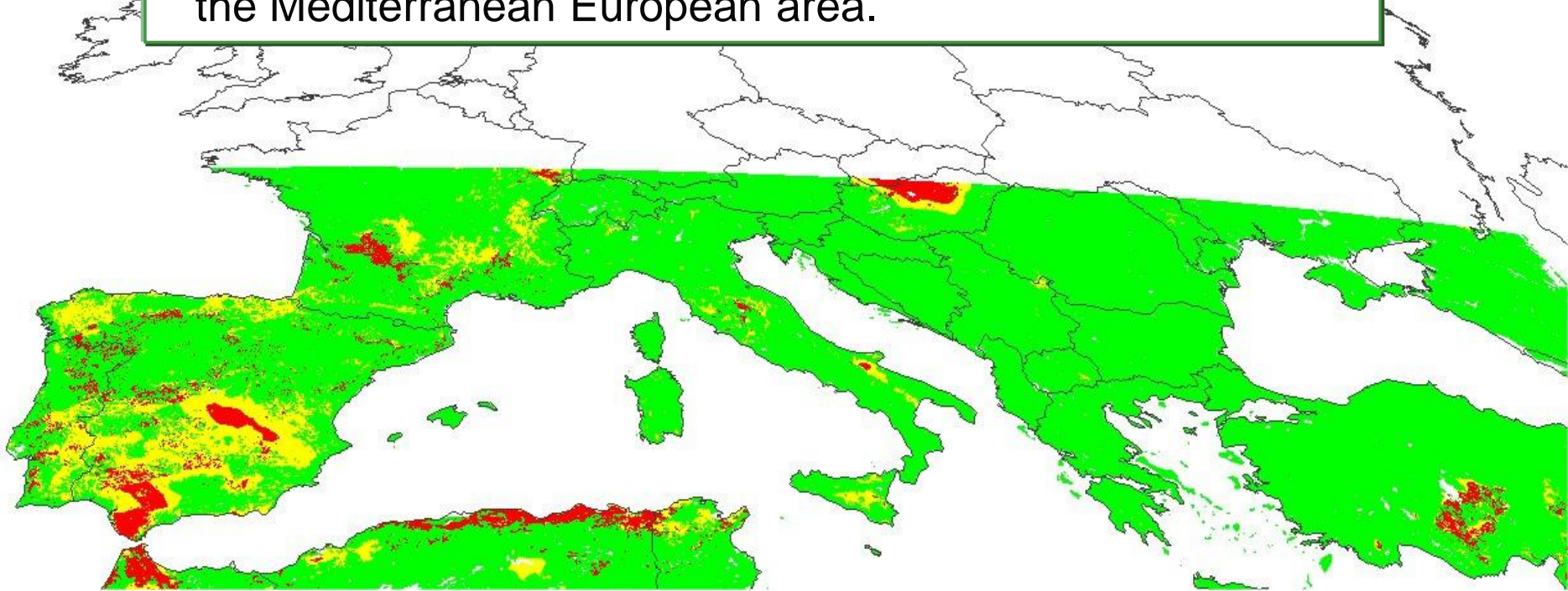
ET 2012-Aug-15 12:00 UTC



LSA SAF FRM product for meteorological fire risk evaluation over Mediterranean Europe

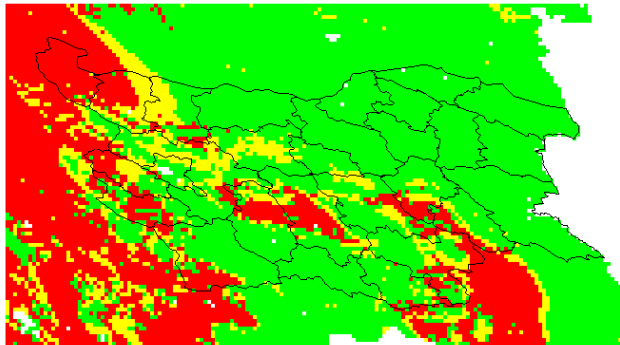
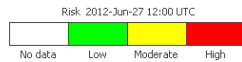
2012-May-31 12:00 UTC

- LSA SAF FRM product combines information from NWP operational forecasts from ECMWF.
- The product indicates prognostic levels of fire danger over the Mediterranean European area.



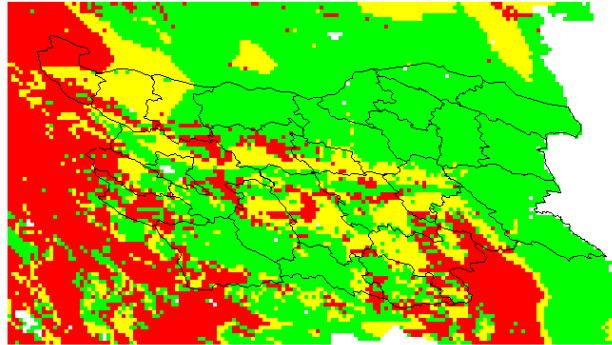
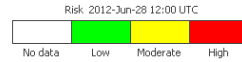
Fire risk maps over Eastern Mediterranean

24h forecast



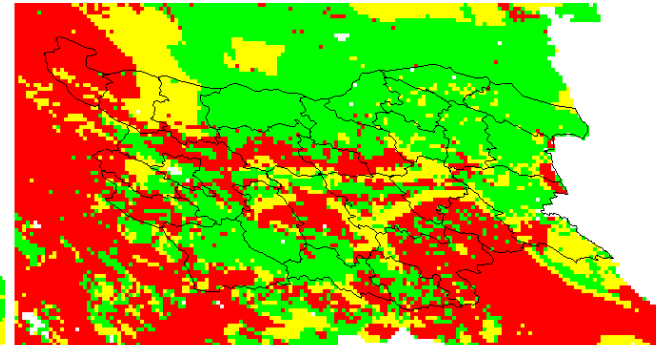
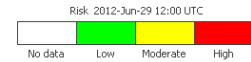
27 June 2012

48h forecast



28 June 2012

72h forecast



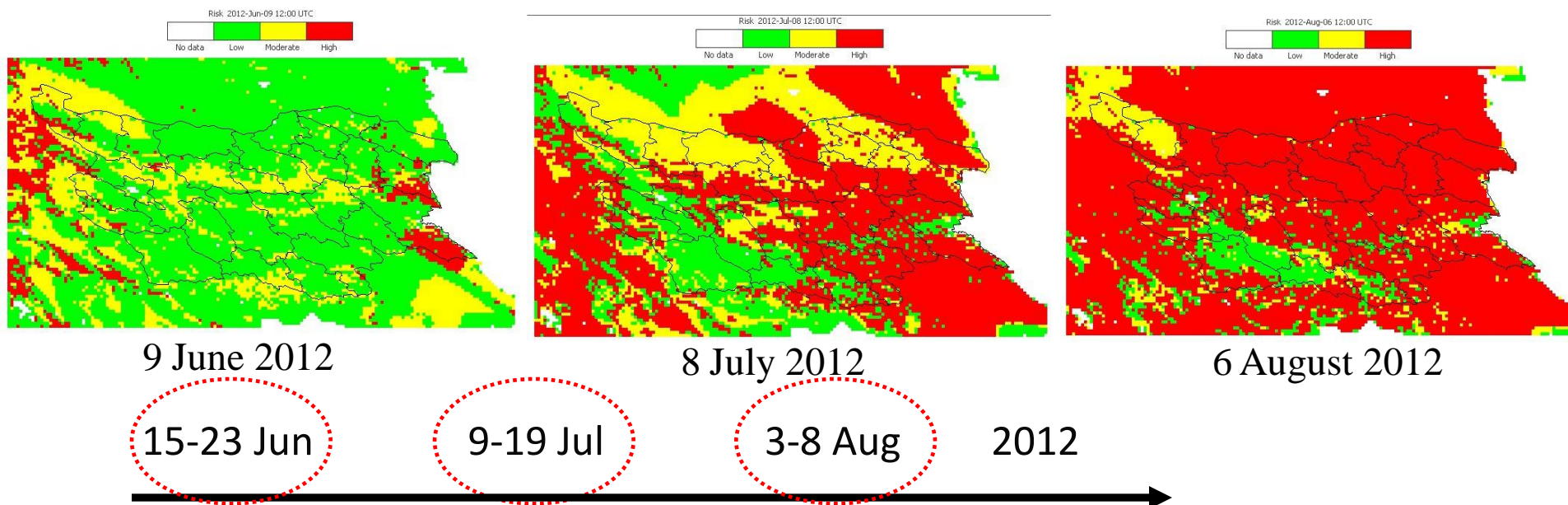
29 June 2012

- LSA SAF FRM product combines information from (NWP) models: in this case the operational forecasts from ECMWF.
- The product indicates prognostic levels of fire danger over the European area.
- The algorithm computes the set of components of the Canadian Forest Fire Weather Index System (*van Wagner, 1987*) for the following 24h, 48h and 72h.

Fire Risk over Bulgaria, South Eastern Europe

LSA SAF Fire Risk Map /FRM/

ECMWF forecasts of meteorological parameters (temperature at 2 m, relative humidity, wind velocity at 10m and cumulated precipitation in 24 h) to compute the set of six fire indices CFFWIS. Classes of fire danger are obtained by combining, at each MSG pixel, daily values of fire weather index (FWI) with vegetation status for the vegetation classes as derived from GLC2000.



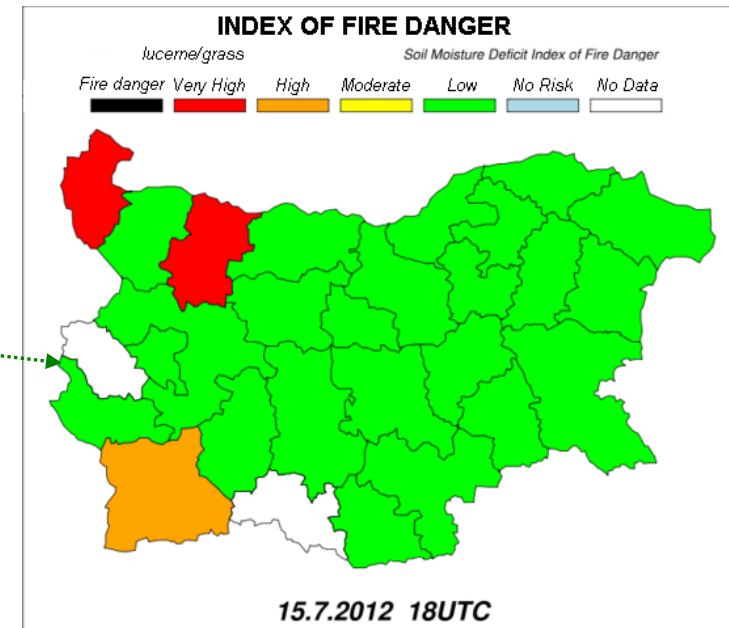
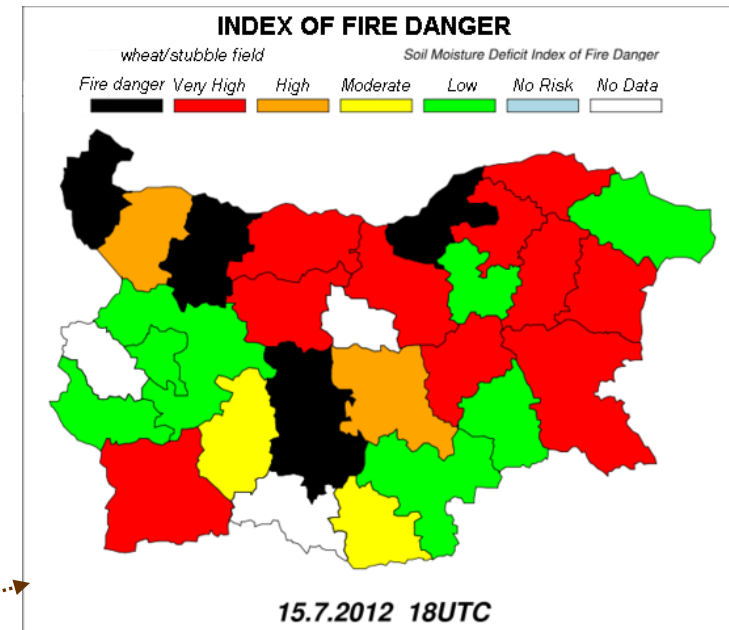
Periods of heat waves over Bulgaria
(Eastern Mediterranean) during the summer of 2012

SVAT-bg model-derived Fire Risk Index ('FRI_bg')

- Fire danger rating is approximated through the Vegetation/Soil dryness, characterized by the soil moisture deficit to reach the Field Moisture Capacity /FMC/.
- Scaling of soil moisture deficit to designate dry vegetated surface susceptibility to fire ignition and spread.
- Since forest fires often initiate at adjacent agricultural areas, the 'SVAT_bg' model 'FRI' is calculated operationally for

- **cropped field**
- and
- **lucerne**

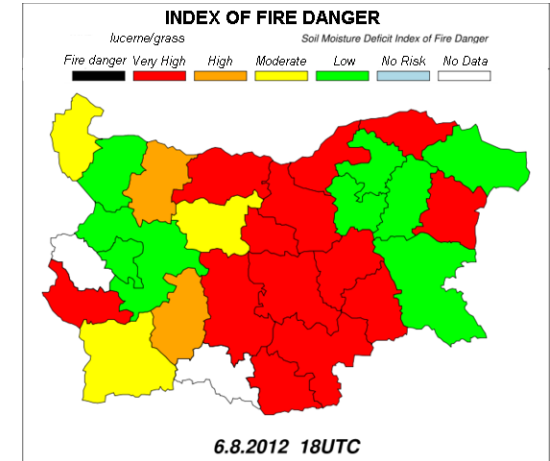
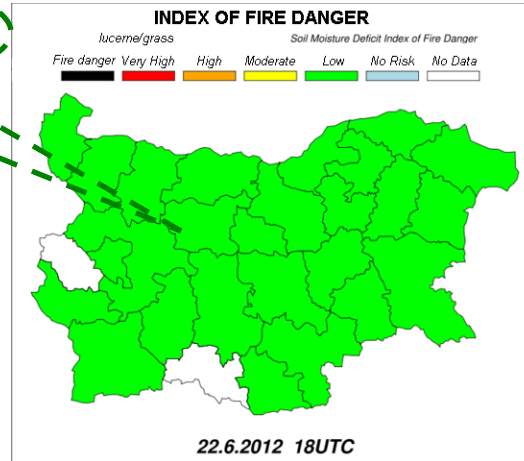
visualized by colour-coded maps for the main administrative units of Bulgaria



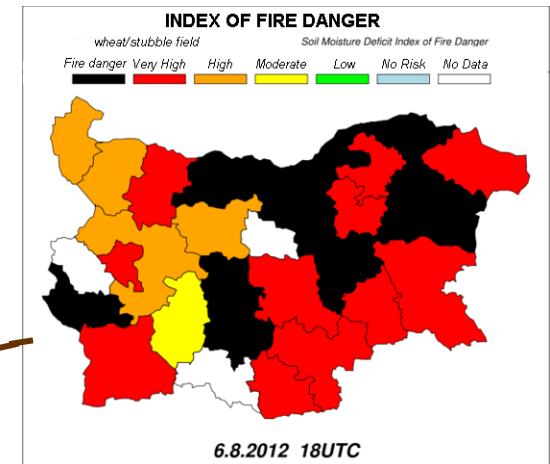
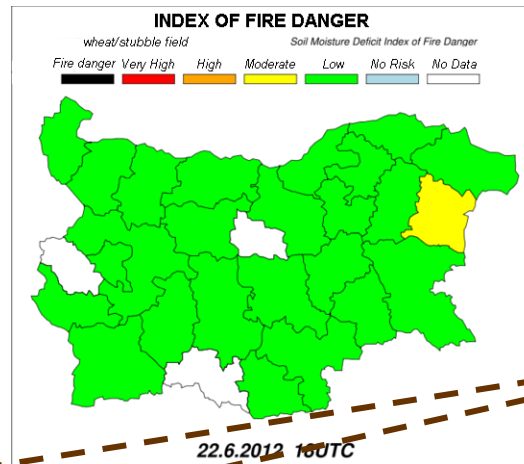
'FRI_bg' (SVAT based index)

*moist land cover
during vegetation*

Lucerne/grass
land cover



Wheat field
land cover



*a higher fire risk
is observed after
harvest*

15- 23 Jun

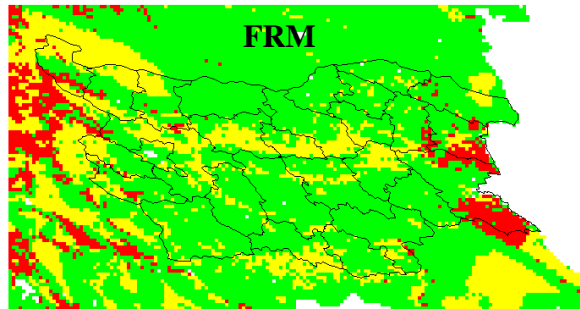
3-8 Aug 2012

'FRI_bg' (SVAT based index) behavior during selected periods of summer fire season 2012 in Bulgaria.

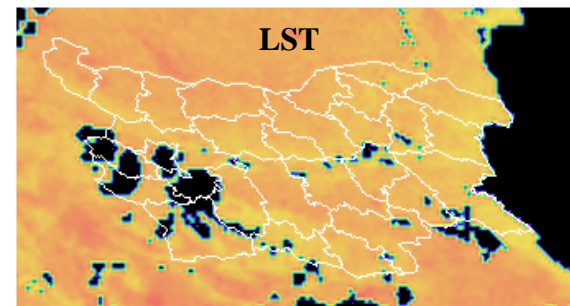
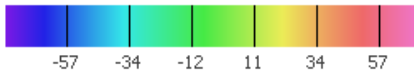
LSA SAF in support to diagnosing vegetation fire conditions

9 June 2012

Risk 2012-Jun-09 12:00 UTC
No data Low Moderate High

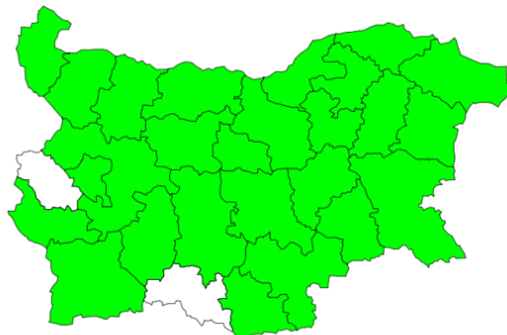


LST 2012-Jun-09 12:00 UTC



INDEX OF FIRE DANGER

Lucerne/grass Soil Moisture Deficit Index of Fire Danger
Fire danger Very High High Moderate Low No Risk No Data



9.6.2012 18UTC

9 June 2012

before active summer fire season

LSA SAF Fire Risk Map /FRM/

Environment of low fire danger confirmed by the three products:

- LSA SAF-FRM
- LSA SAF LST
- SVAT-FRI_bg

LSA SAF Land Surface Temperature /LST/

SVAT-bg model derived Fire Risk Index

LSA SAF in support to diagnosing vegetation fire conditions

Overestimated fire risk
by LSA SAF FRM

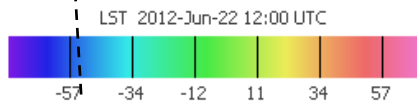
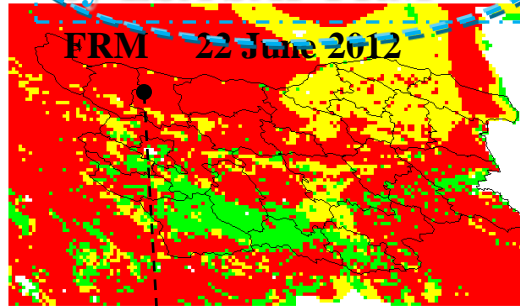
22 June 2012, Eastern Mediterranean region

- early summer, synoptic Knezha, 43.467 N 24.031 E
- $T_{air}=34.7^{\circ}\text{C}$, $RH=23\%$

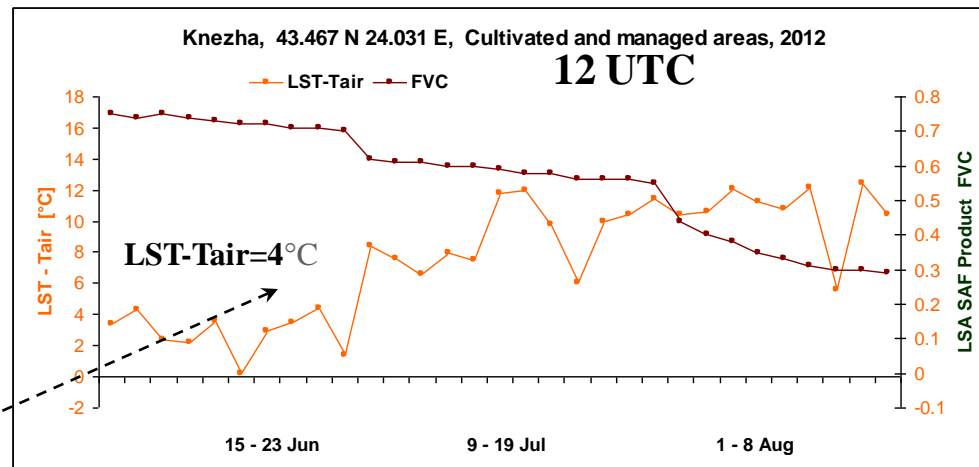
• FRM overestimates fire danger due to the weather extremes ($T_{air}=34.7^{\circ}\text{C}$, $RH=23\%$).

15 Jun – 8 Aug trends of:

- MSG FVC (brown line).
- MSG LST-Tair (orange)

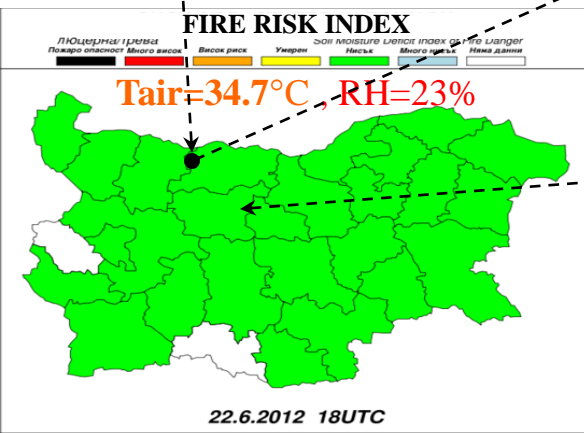


MSG LST: ranging
24.4 - 42.4 deg

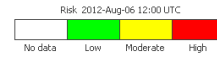
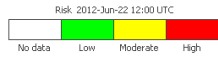


No forest fires reported by State Forest Agency /SFA/

- Fire danger is not confirmed by the SVAT model-derived Fire Risk Index ,which indicates **low risk** (green).
- MSG data do not provide signals for vegetation water stress: **$LST-T_{air}=4^{\circ}\text{C}$ and $FVC > 0.7$.**



LSA SAF in support to diagnosing vegetation fire conditions



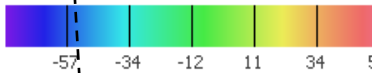
FRM 22 June 2012

FRM 15 July 2012

15 July 2012

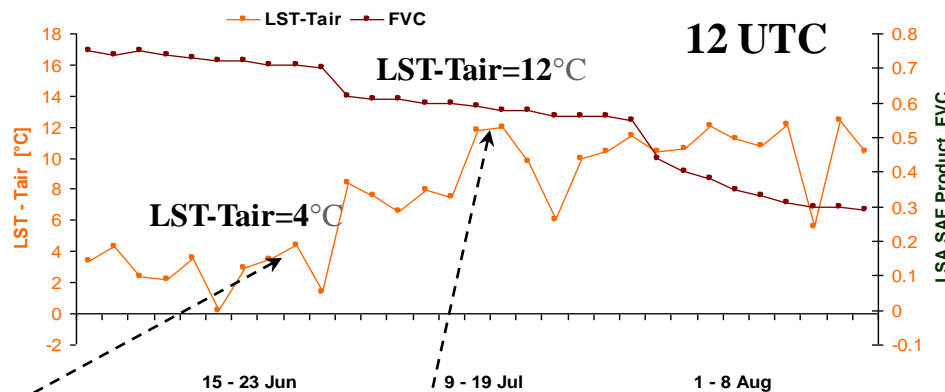
- The high fire risk in FRM is confirmed by the SVAT Fire Danger Index for single areas.

LST 2012-Jun-22 12:00 UTC



MSG LST: ranging
29.2 – 53.8 deg

Knezha, 43.467 N 24.031 E, Cultivated and managed areas, 2012



6 forest fires
reported by SFA

FIRE RISK INDEX

Листопадний / листопадний
Ризик опадів / Ризик опадів

Tair=34.7°C, RH=23%

22.6.2012 18UTC

FIRE RISK INDEX

Листопадний / листопадний
Ризик опадів / Ризик опадів

Tair=38.0°C, RH=31%

15.7.2012 18UTC

- MSG data provide initial signals for vegetation water stress at the pixel of synoptic station Knezha:
- LST-Tair=12°C
- FVC ~ 0.5
- LST = 47.8°C

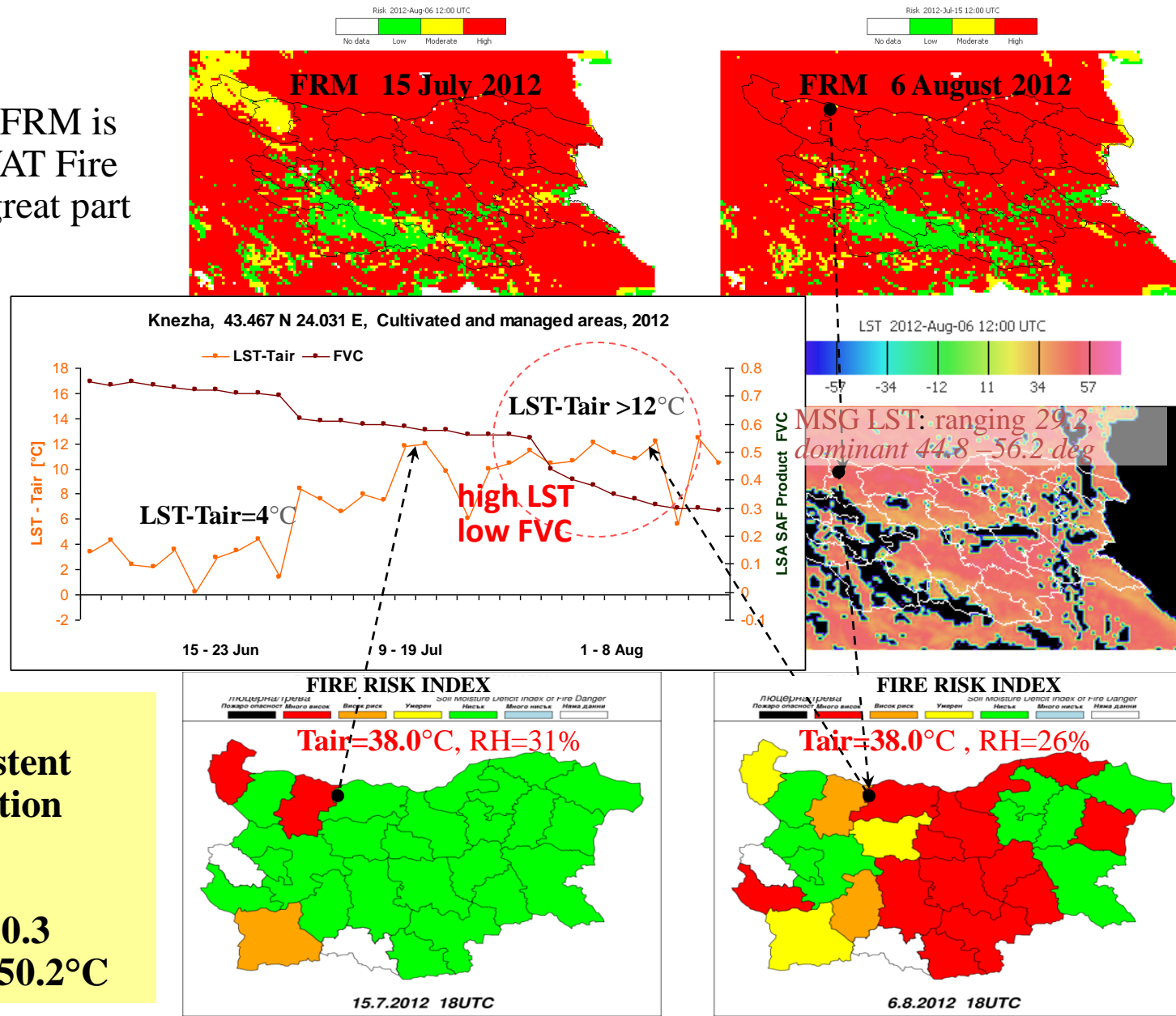
LSA SAF in support to diagnosing vegetation fire conditions

6 forest (SFA)

9 forest fires (SFA)

6 August 2012

The high fire risk in FRM is confirmed by the SVAT Fire Danger Index for a great part of Bulgaria.



- MSG data give widespread persistent signals for vegetation water stress:
- $LST - T_{air} > 12^{\circ}C$
- FVC decreasing ~ 0.3
- LST increases to $50.2^{\circ}C$

LSA SAF in support to diagnosing vegetation fire conditions

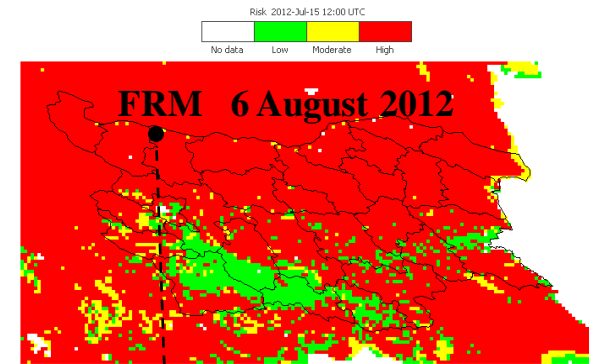
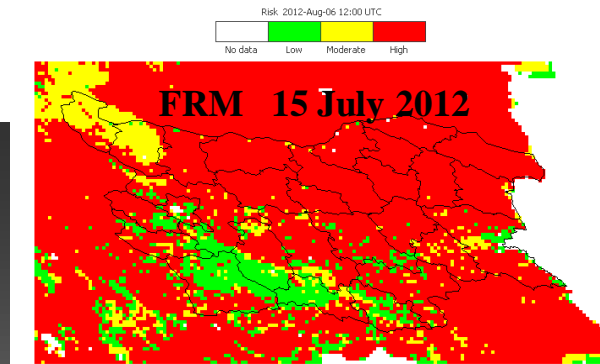
6 forest (SFA)

9 forest fires (SFA)

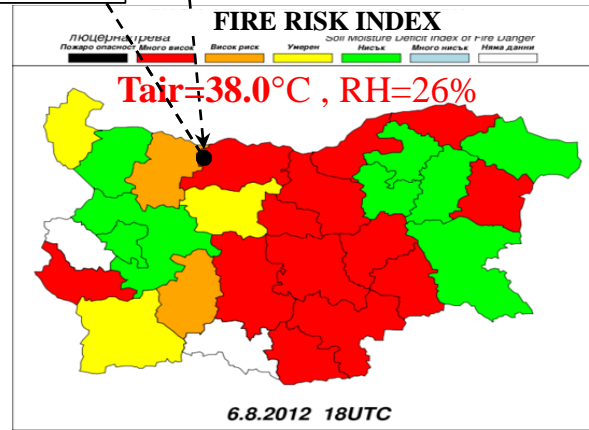
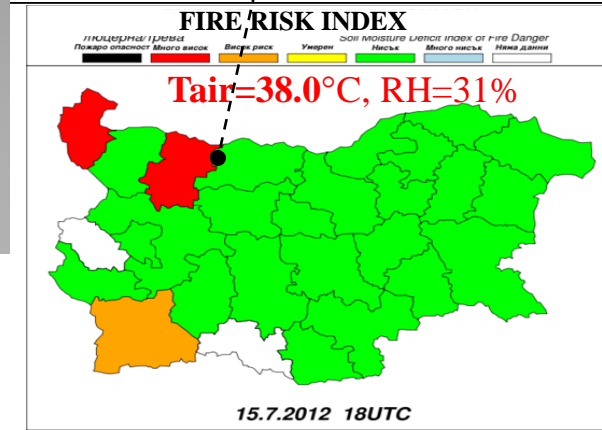
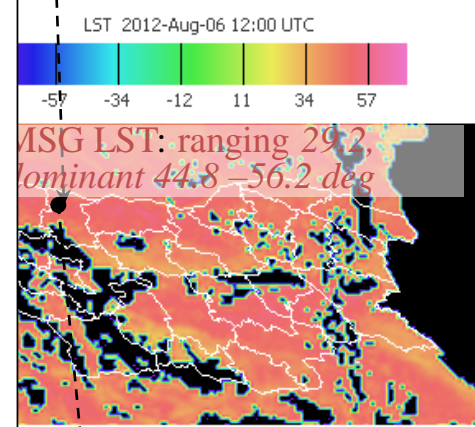
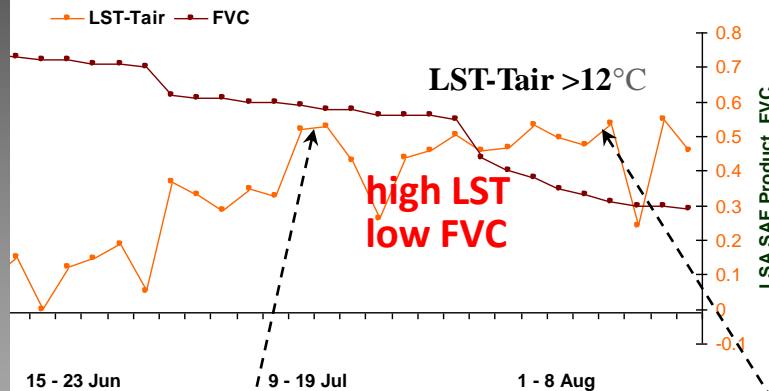
6 August 2012

The (MSG LST_Tair) difference is a blended parameter that can be used for diagnosis of land surface drought as a pre-fire condition.

LSA SAF FRM product, being a **fire weather index** is not efficient as a single parameter for fire risk assessment and vegetation moisture status have to be considered for evaluation of drought as an ingredient of fire risk conditions.



ezha, 43.467 N 24.031 E, Cultivated and managed areas, 2012



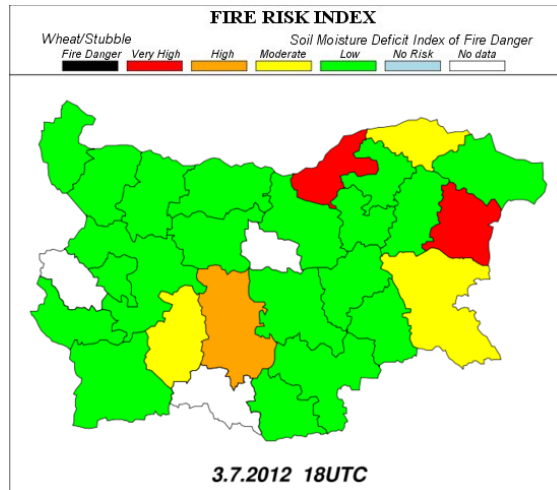
LSA SAF in support to diagnosing vegetation fire conditions

FRM forecasts valid for 3 July 2012

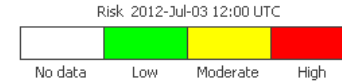
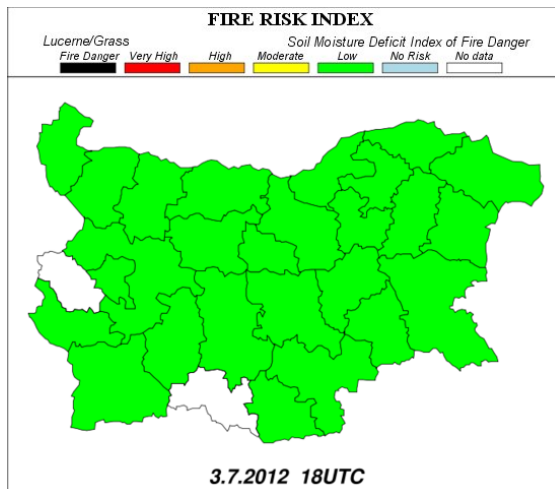
DISCREPANCY IN LSA SAF FRM FORECASTS

SVAT-bg Fire Risk Index

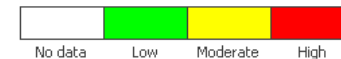
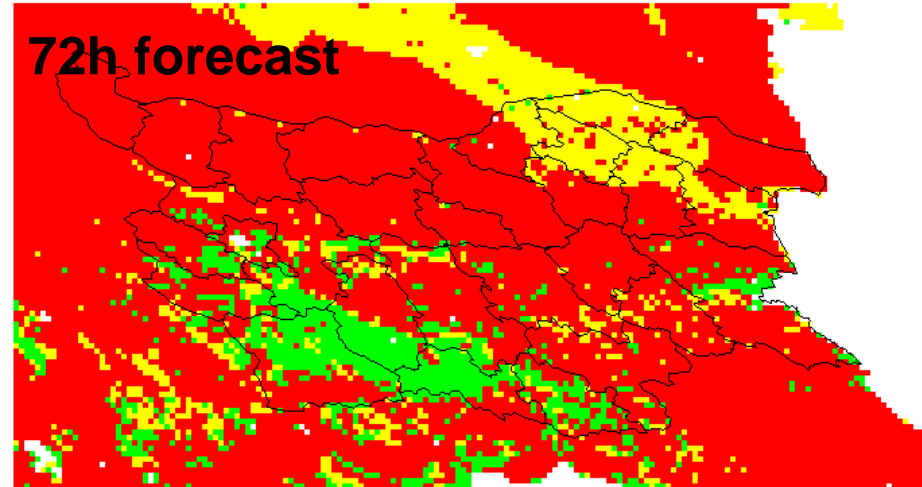
Stubble



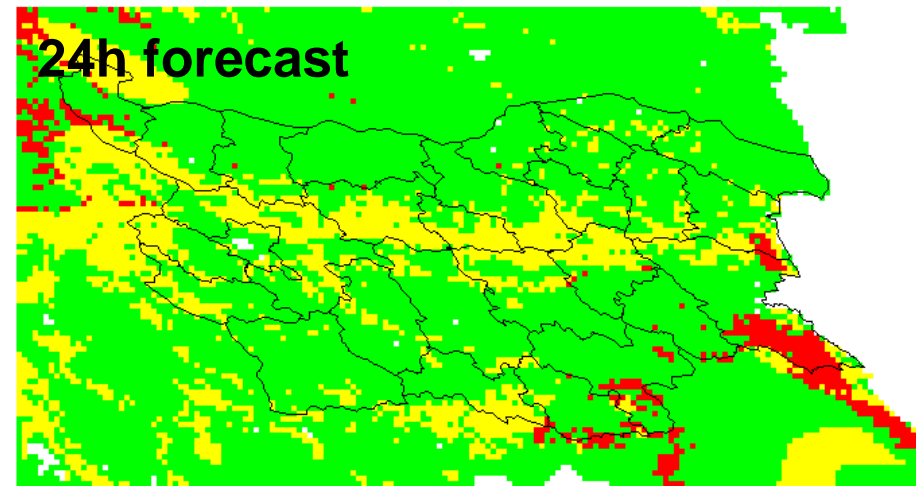
Grass



72h forecast



24h forecast



Comparison 72 h - 24 h forecast

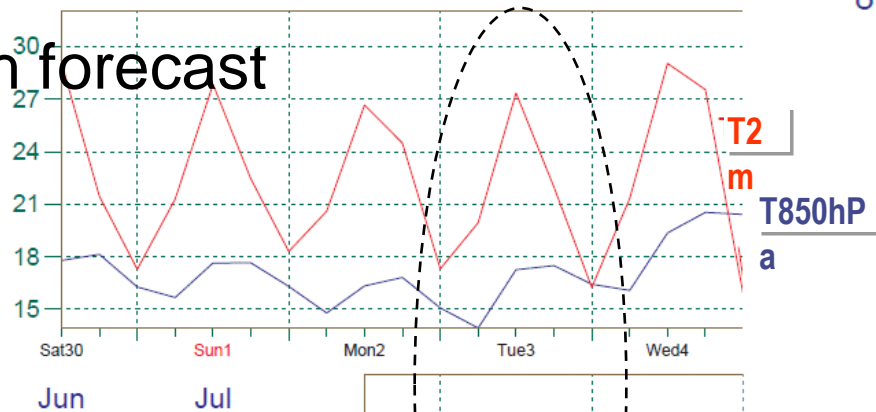
Sofia (Observ.) 42.66°N 23.44°E 631 m
ECMWF Forecast
Nearest land grid point (T1279)

Sofia (Observ.) 42.66°N 23.44°E 631 m
ECMWF Forecast
Nearest land grid point (T1279)

from Saturday
30 June 2012 12 UTC

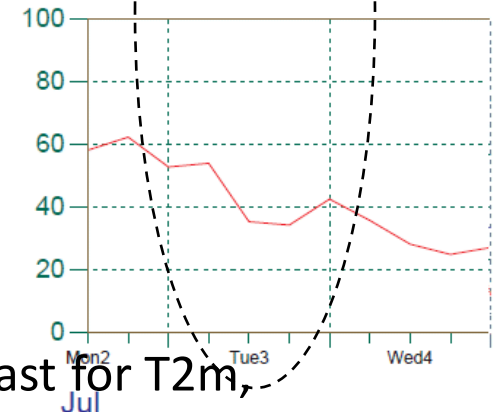
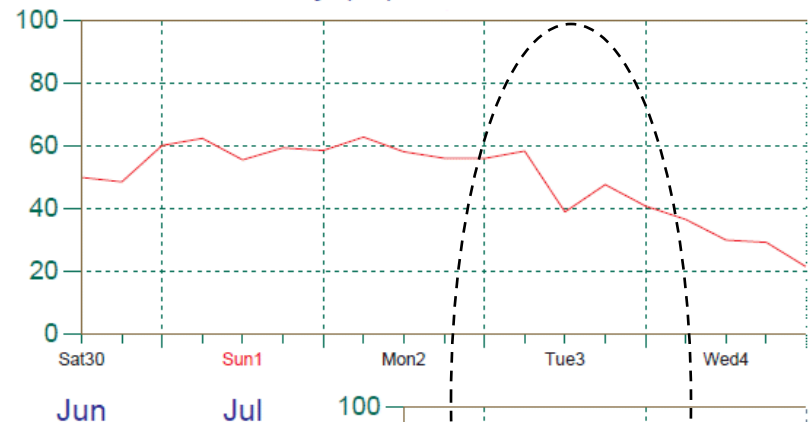
Temperature (°C)

72 h forecast



from Saturday
30 June 2012 12 UTC

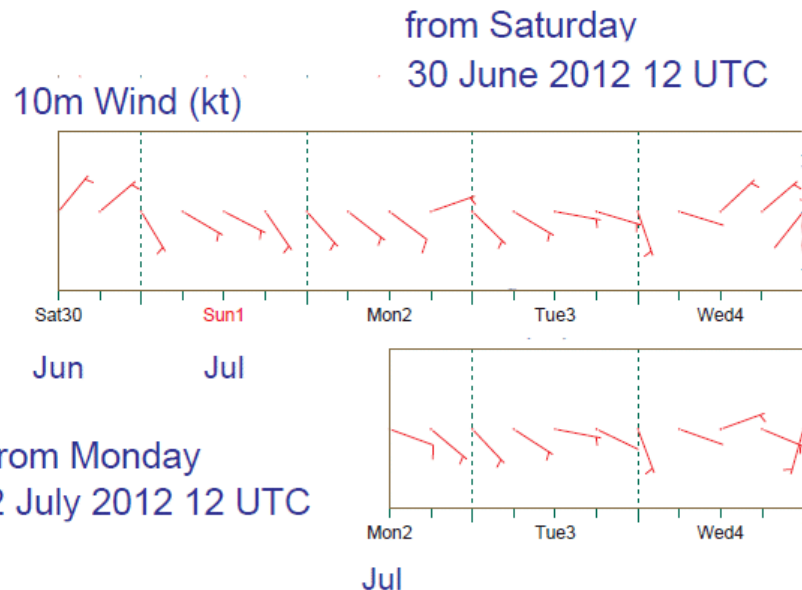
850 hPa Relative Humidity (%)



No significant differences in the 72 h and 24 h NWP forecast for T2m, T850hPa and Relative Humidity

Comparison 72 h - 24 h forecast

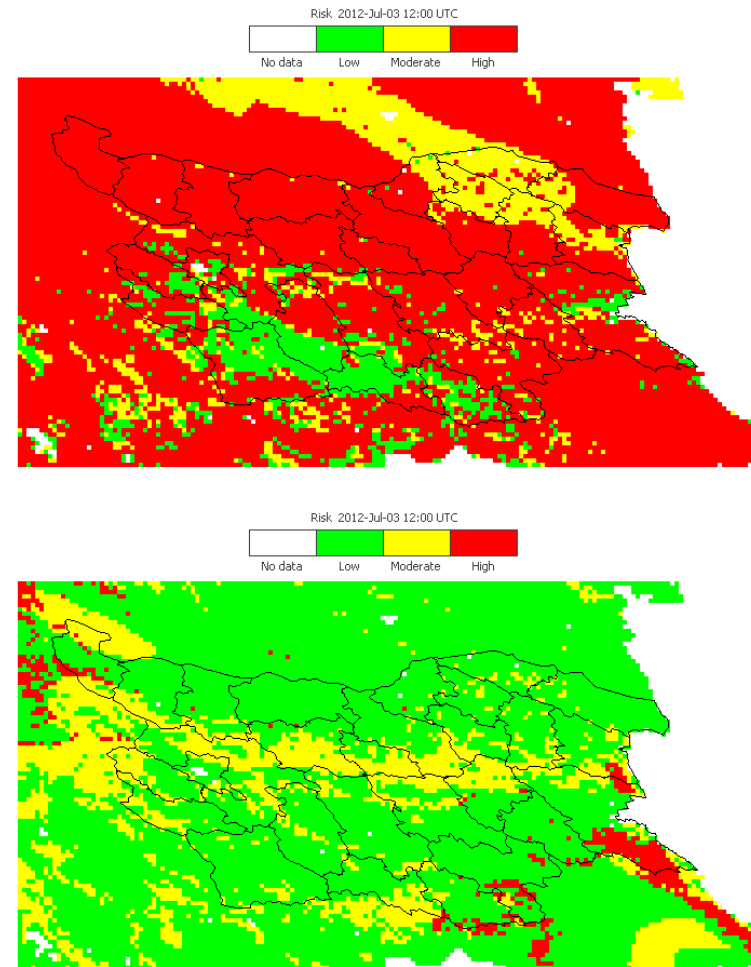
Sofia (Observ.) 42.66°N 23.44°E 631 m
ECMWF Forecast
Nearest land grid point (T1279)



Daily EUMETCast dissemination of LSA SAF FRM

No FRM dissemination at EUMETCast

- on 1 July 2012
- on 2 July 2012

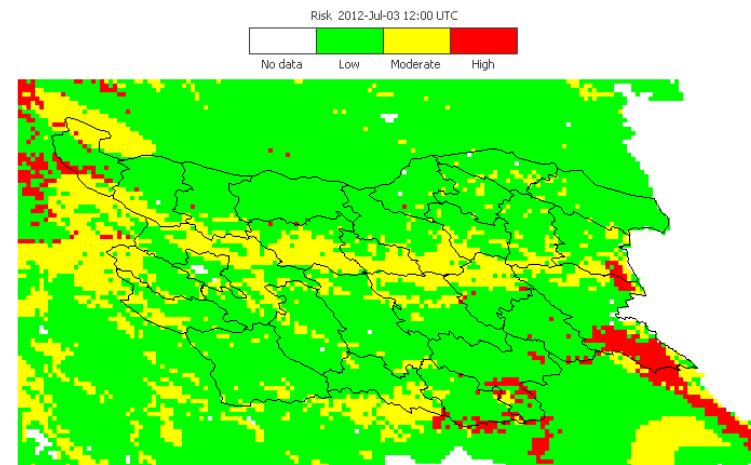
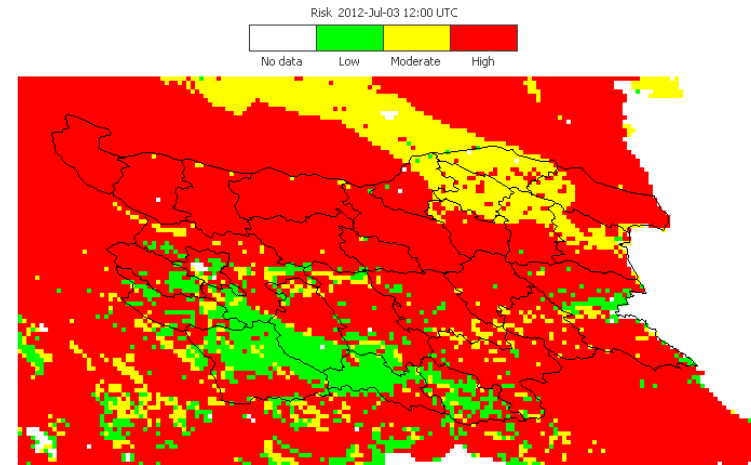


No significant differences in the 72 h and 24 h NWP forecast for T2m, T850hPa and Relative Humidity and wind.

Comparison 72 h - 24 h forecast

There is a significant difference in the 72 h and 24 h forecast of LSA SAF FRM valid for 3 July 2012

A signal for wrong performance of LSA SAF FRM Product



Daily EUMETCast dissemination of LSA SAF FRM

No FRM dissemination at EUMETCast

- on 1 July 2012
- on 2 July 2012

No significant differences in the 72 h and 24 h NWP forecast for T2m, T850hPa and Relative Humidity and wind

Summary

LSA SAF FRM product, being a meteorological fire weather index, is not efficient as a single parameter for fire risk assessment and vegetation moisture status have to be considered for evaluation of drought as an ingredient of fire risk conditions.

The results of this study show that for a better estimation of fire danger, meteorological FRM product can be used in parallel with satellite indicators of vegetation water stress (e.g. (LST_Tair), FVC or other vegetation indexes) as well as with model output products accounting for vegetation dryness.

Some improvements in FRM algorithm accounting for the functional influences of the above parameters might be also considered.

Acknowledgments

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