

USE OF SATELLITE LAND SURFACE PRODUCTS FOR ASSESSMENT OF VEGETATION FIRE CONDITIONS OVER BULGARIA

Julia Stoyanova

National Institute of Meteorology and Hydrology, Bulgaria



4th LSA SAF User Workshop, 15 - 17 November 2010, Toulouse



OUTLOOK

The aim of the paper:

To present the activities of Land Surface Analyses at NIMH of Bulgaria for diagnosis conditions of drought & vegetation fires over the region of South Eastern Europe.

- **Introduction**
- **Operational Applications at NIMH Bulgaria**
- **Research Activities**
- **User Service Activities**
 - ✓ **For National Authorities**
 - ✓ **SALGEE Project**
- **Conclusion**



INTRODUCTION

Fire as an important process in modulating the Earth system, provides an opportunity to evaluate the links among weather, climate, vegetation as well the potential to feed back to the global climate system.

Vegetation Fire & Land-cover Dynamics

Due to its complexity, the fire problem needs an interdisciplinary international research activities for understanding:

- ✓ Weather, Climate (drought, heat) and fire danger.
- ✓ Land-use/land-cover dynamics impacts (*fire impacts on ecosystems, biogeochemical cycles*).
- ✓ Fire impact on the Essential Climate Variables (ECV).



INTRODUCTION

Land Surface Analyses at NIMH Bulgaria

Weather and climate extremes may provoke
Conditions favourable for Drought and Fire Risk.

**Operational activities at NIMH of Bulgaria are
focused on** evaluating the **Vegetation Water Status** as a
factor creating drought and pre-fire conditions



OPERATIONAL APPLICATIONS in Land Surface Analyses at NIMH Bulgaria

Drought Monitoring, Integrated Approach

- **daily SVAT model run,**
- **soil moisture gravimetric measurements at 10 days basis.**

Satellite Data Processing for Monitoring of Fire and Pre-fire signals of Vegetation Water Stress by using:

- **SEVIRI FIR product for thermal anomalies detection,**
- **MSG LST product as a measure of vegetation water stress.**

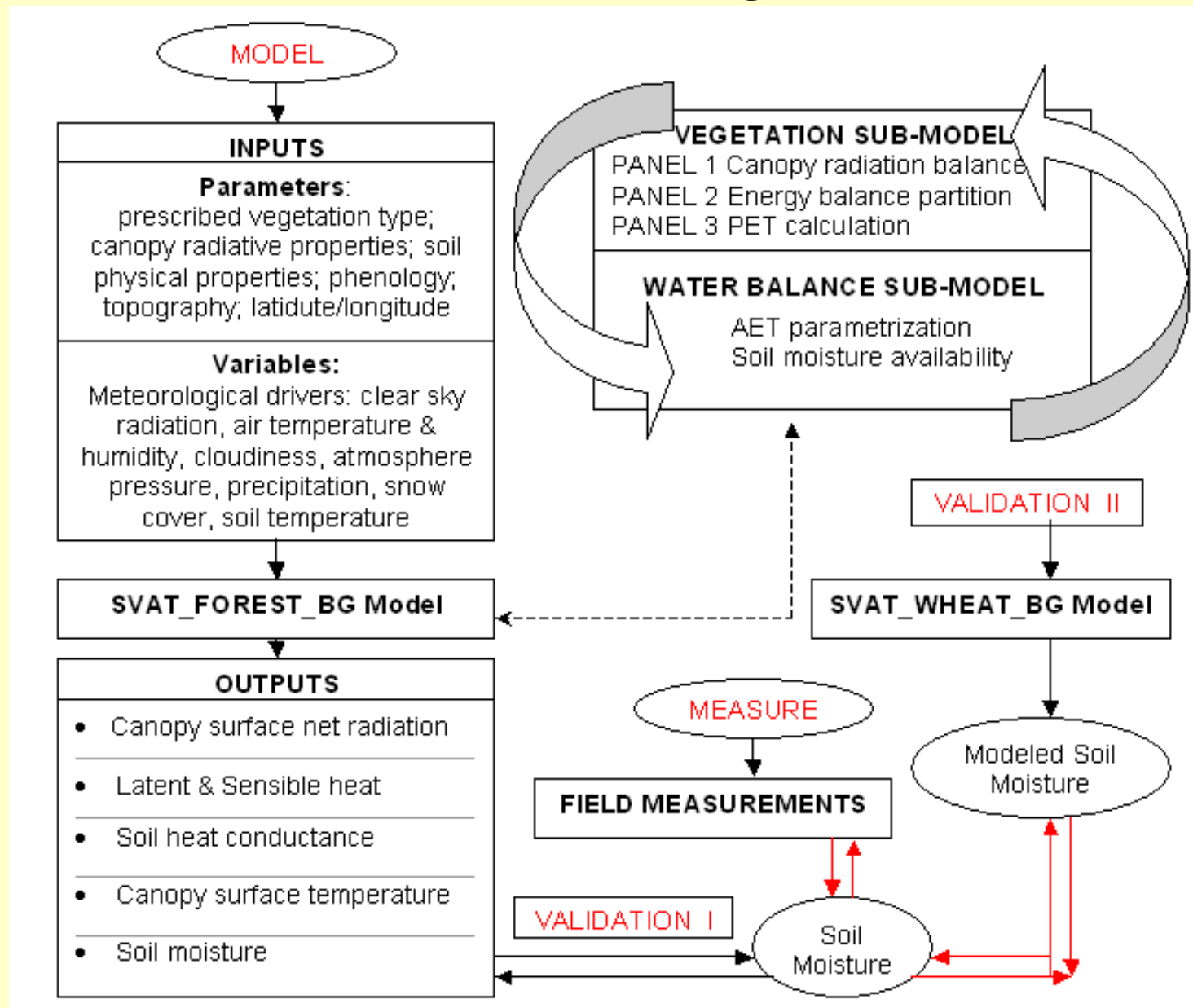
Information System for Early Detection and Monitoring of Vegetation Fires

- **modelling by a SVAT derived climatological index as a measure of water supply conditions and**
- **multispectral satellite information over Bulgaria.**



Soil-Vegetation-Atmosphere-Transfere Model ('SVAT_bg')

Chart Flow Diagram

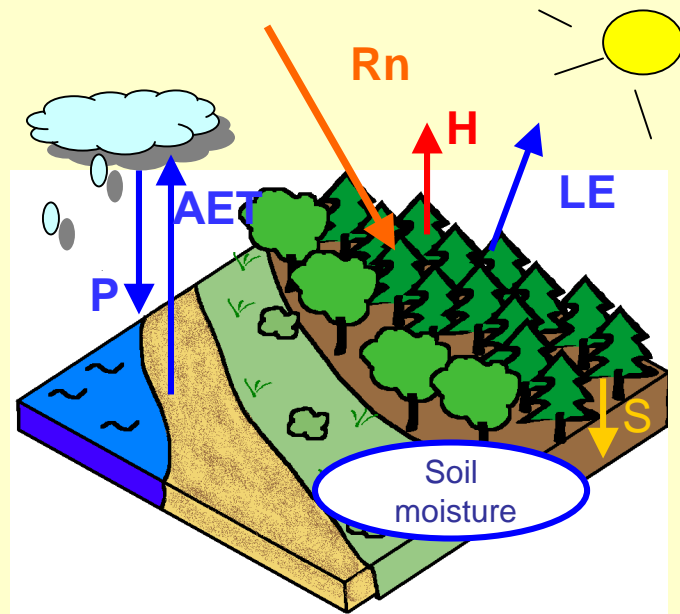


OPERATIONAL APPLICATIONS

Drought Monitoring

Soil-Vegetation-Atmosphere-Transfere Model ('SVAT_bg')

(Stoyanova, J.S. & Georgiev, C.G., 2007; 2008)



Biogeophysical cycling

- 1D (vertical) site-scale meteorological SVAT model at NIMH of Bulgaria, 'SVAT_bg':

INPUT

- Site specific soil and vegetation physical properties,
- Site and *spp.* specific vegetation physiology,
- Meteorological driving parameters,
- Geophysical driving parameters.

- Operational since Feb 2010.

OUTPUT: Data for land surface analyses:

- ✓ soil moisture conditions along root zone depth,
- ✓ plant canopy temperature.



Drought Monitoring

Soil-Vegetation-Atmosphere-Transfere Model ('SVAT_bg')

➤ Energetic balance

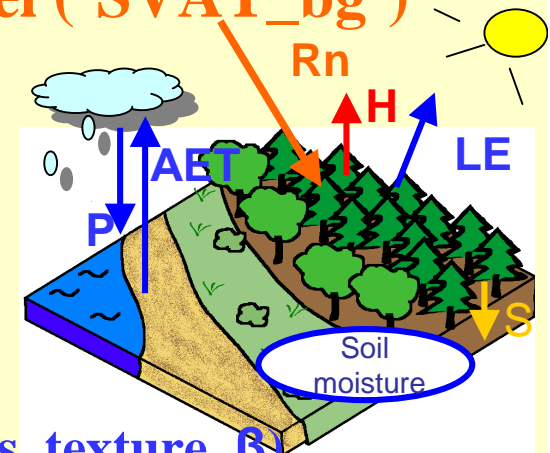
$$(1 - \alpha)S\downarrow + L_w\downarrow = L_u\uparrow + H + LE_o + G + P_h + H_t$$

➤ Coupling

$$AET = f(PET, LST, \text{soil type \& physical properties, texture, } \beta)$$

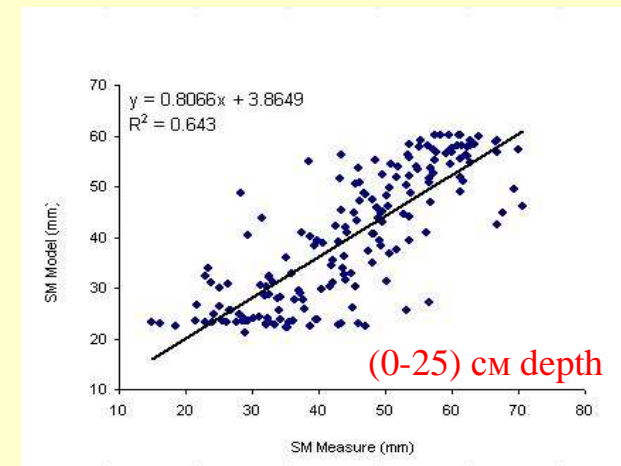
$$\beta = f(W, FMC, PWP, \text{soil texture}), 0 < \beta < 1 - \text{soil moisture availability}$$

$$PET = \rho D(q_s - q)$$



➤ Validation

A good agreement of the model-derived soil moisture with field gravimetric measurements of soil moisture has been obtained.

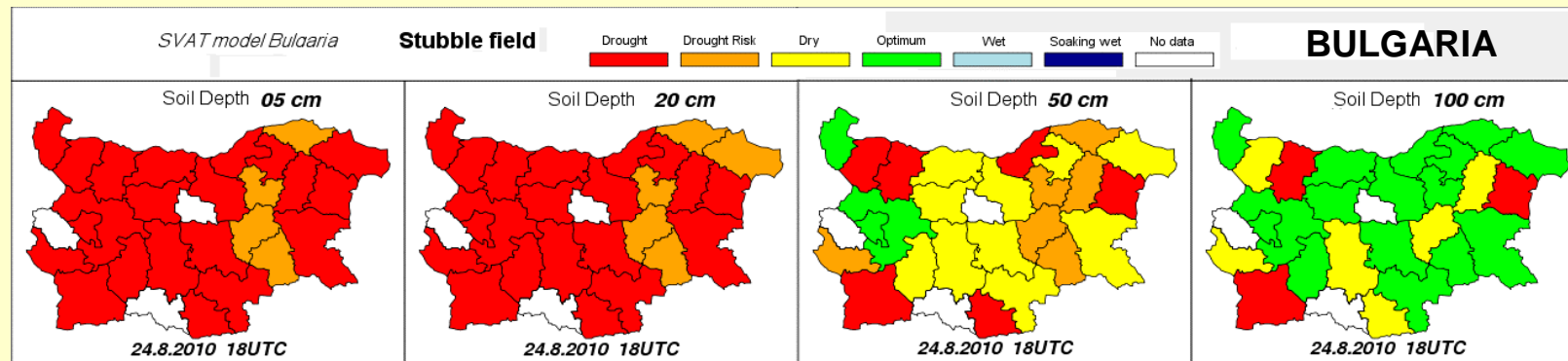


OPERATIONAL APPLICATIONS

Drought Monitoring

‘SVAT_bg’ Soil Moisture Availability Index

For using in fire risk assessment



Climatic Index as a measure of vegetation moisture status

Index of Soil Moisture Availability (ISMA)

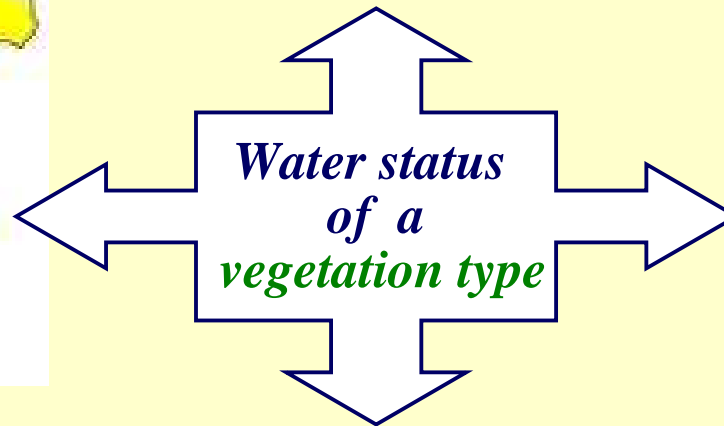
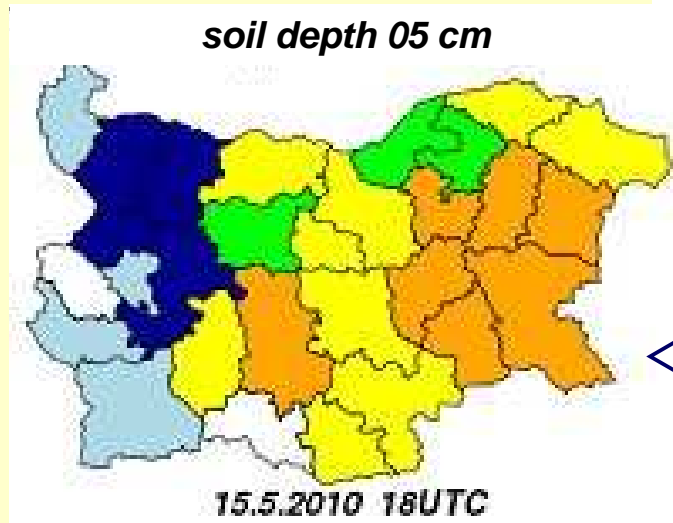
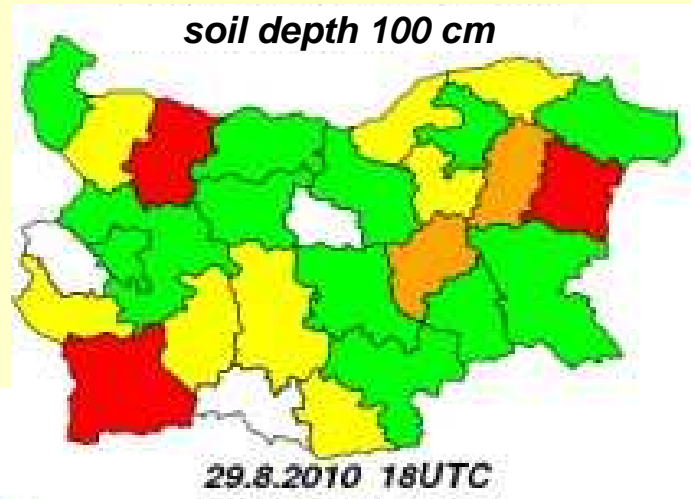
- Defined through a 6-level threshold scheme, based on ‘SVAT_bg’ derived soil moisture.
- Assessment of soil moisture availability at 4 depths in the root zone: 5, 20, 50, 100 cm.
- Visualized by colour-coded maps for the main administrative units of Bulgaria.



Drought Monitoring

Index of Soil Moisture Availability (ISMA)

Calculated for the 26 administrative regions of Bulgaria.



Colour scale

No available moisture
for > 5 days

No available moisture

The availability of
moisture is restricted

Optimum of soil
moisture availability

Soil moisture at field
moisture capacity

Over moistening >
Field moisture capacity

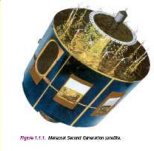
No data

ISMA

- ✓ Reflects regional climate/soil/vegetation types specificity.
- ✓ Operatively calculated for cropped field and lucerne.
- ✓ A diagnostic tool for land surface conditions favourable for extreme weather: drought and fire environment; over moistening.

OPERATIONAL APPLICATIONS in Land Surface Analyses at NIMH Bulgaria

Satellite data processing for Drought & Fire monitoring



1. MSG Active Fire Monitoring (FIR)

- **MSG2 Full Earth disc scanning, every 15 min, subsatellite point location 0.0 longitude.**
- **MSG1 Rapid Scan, at 5-minute intervals, subsatellite point location longitude 9.5°E.**

2. MSG MPE Precipitation Estimates

3. MSG Land Surface Temperature (LST)



4. MODIS Thermal Anomalies Product (TAP) as a reference data, 4 overpasses daily

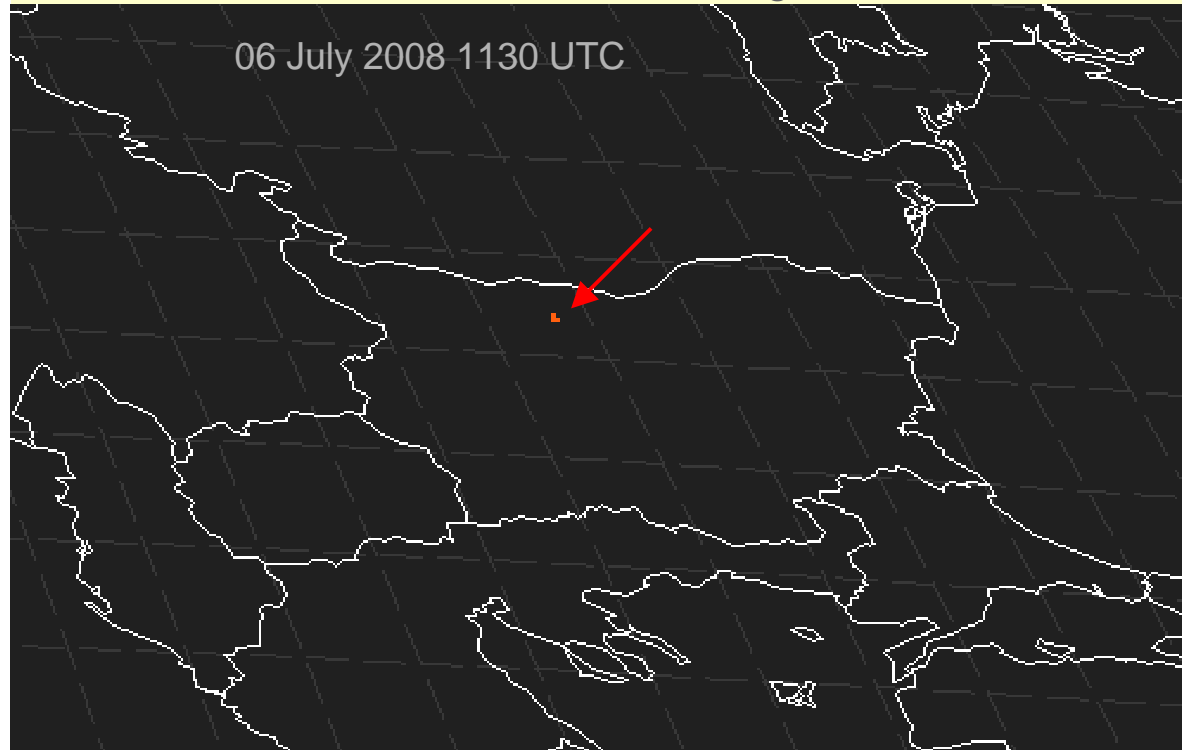
VISUALISATION

- **David Taylor software: Grib Viewer, HDF Viewer, Modis Fire Reader.**
- **SYNERGIE forecasting system.**

OPERATIONAL APPLICATIONS

MSG MPEF FIR Product sensitivity over Bulgaria

MPEF FIR Product view over Bulgaria



SEVIRI may detect a very small fire of **4 ha**, at the limit of the GOES-SEVIRI minimum detectable fire size (about 0.5 ha at the equator to less than 2 ha at 50° latitude, Prins and Schmetz (2000)).

MSG detection: 43.373,24.683,321,0,0,06.07.2008,1130,M,2 row: **3218** col: **1247**
National Fire Data Base: Radishevo, Pleven ,43.367 / 24.667 row: **3218** col: **1247**

Depending on the fire conditions, the MPEF FIR product has failed to detect some large fires.



OPERATIONAL APPLICATIONS in Land Surface Analyses at NIMH Bulgaria

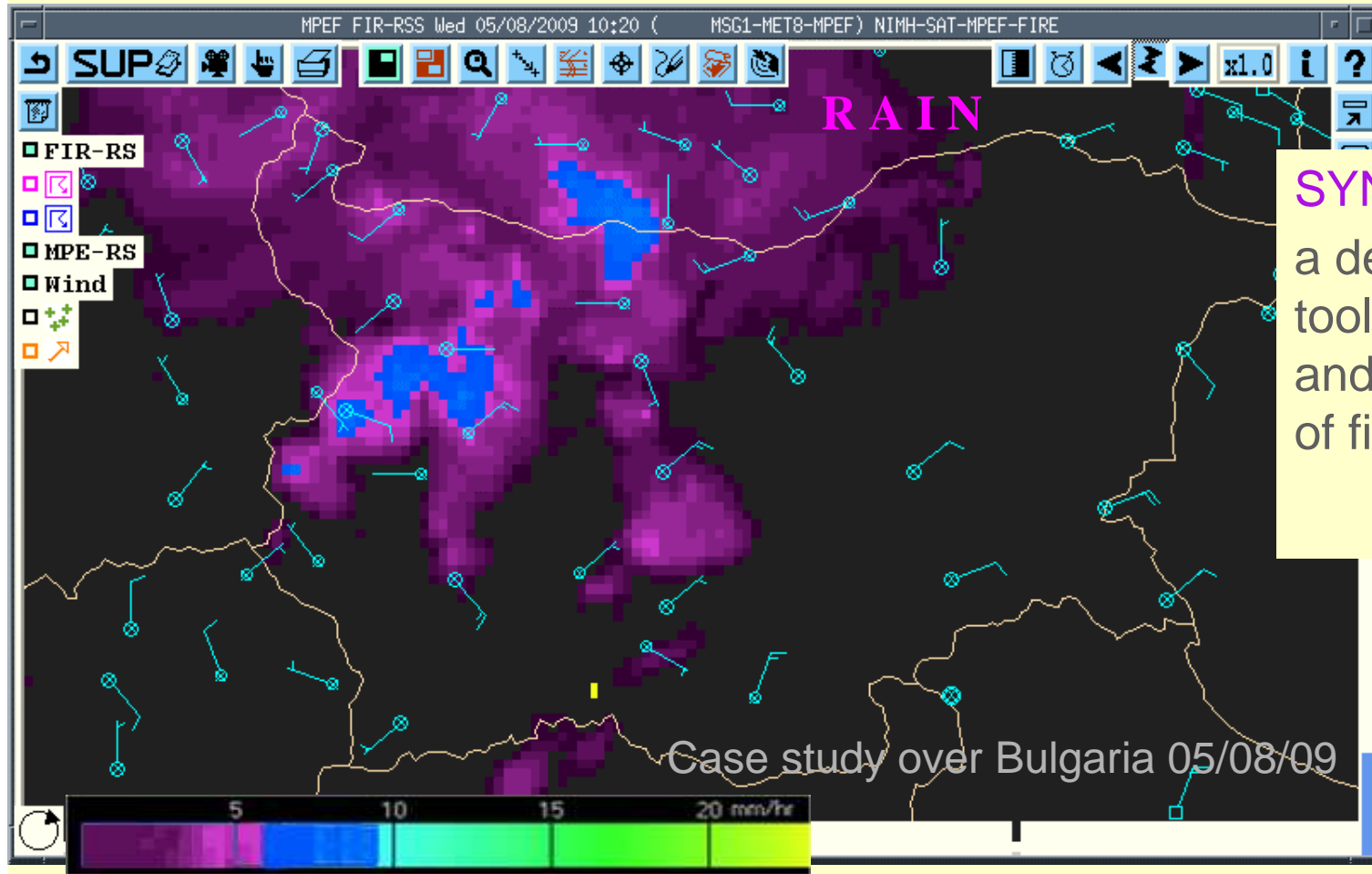
SYNERGY Forecasting System in support to Fire detection and monitoring fire evolution

- In 2008, NIMH introduced in operational work a **SYNERGY Forecasting system**.
- Meteo-France International and NIMH designed a special configuration for Bulgaria with options for satellite data processing in support to Land Surface Applications and Analyses.



OPERATIONAL APPLICATIONS in LSA

SYNERGY System fire space distribution



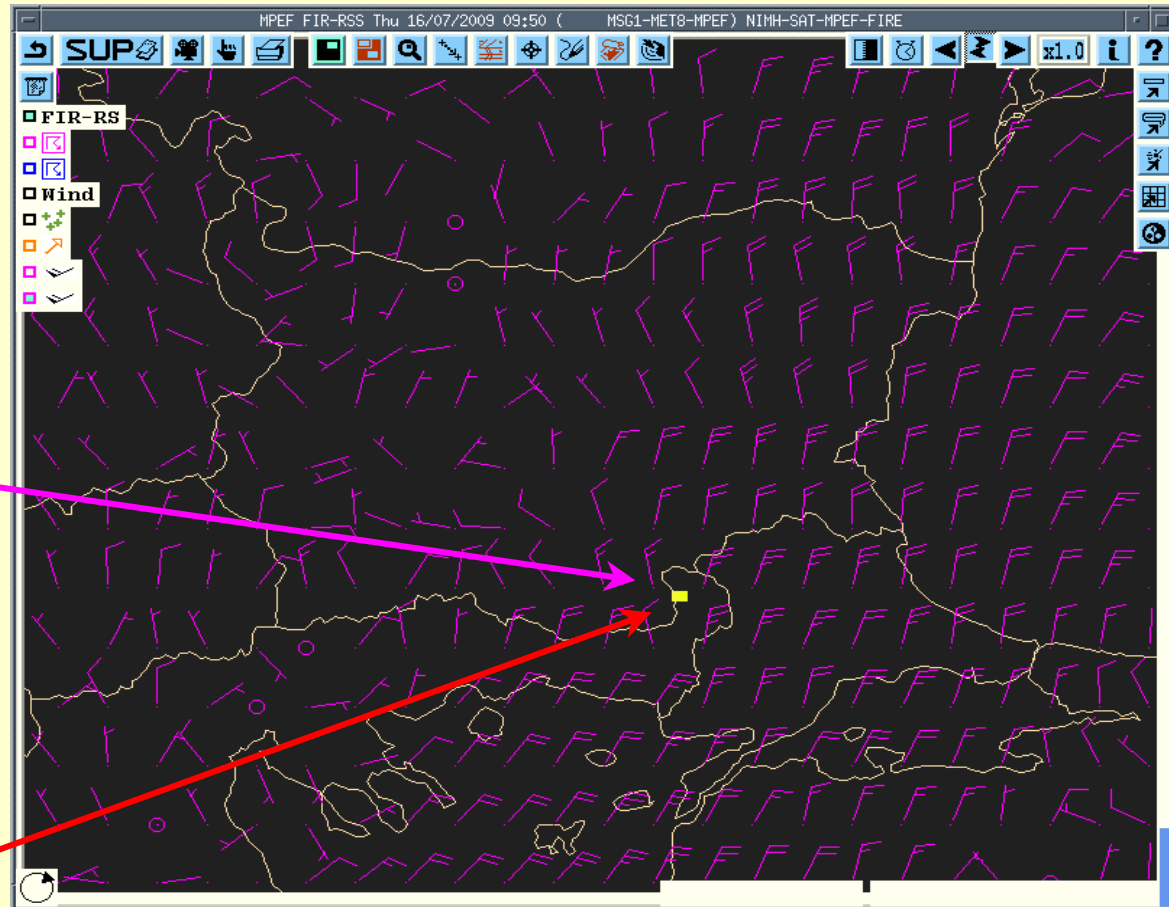
SYNERGY system
a decision making
tool for Forecasting
and Early Warnings
of fire development.

**Rain detected
by MSG**

**Wind synoptic
observations**

**Potential Fires
detected by MSG**

Analysis and forecasting of active fire development



ALADIN NWP model
18 h forecast wind

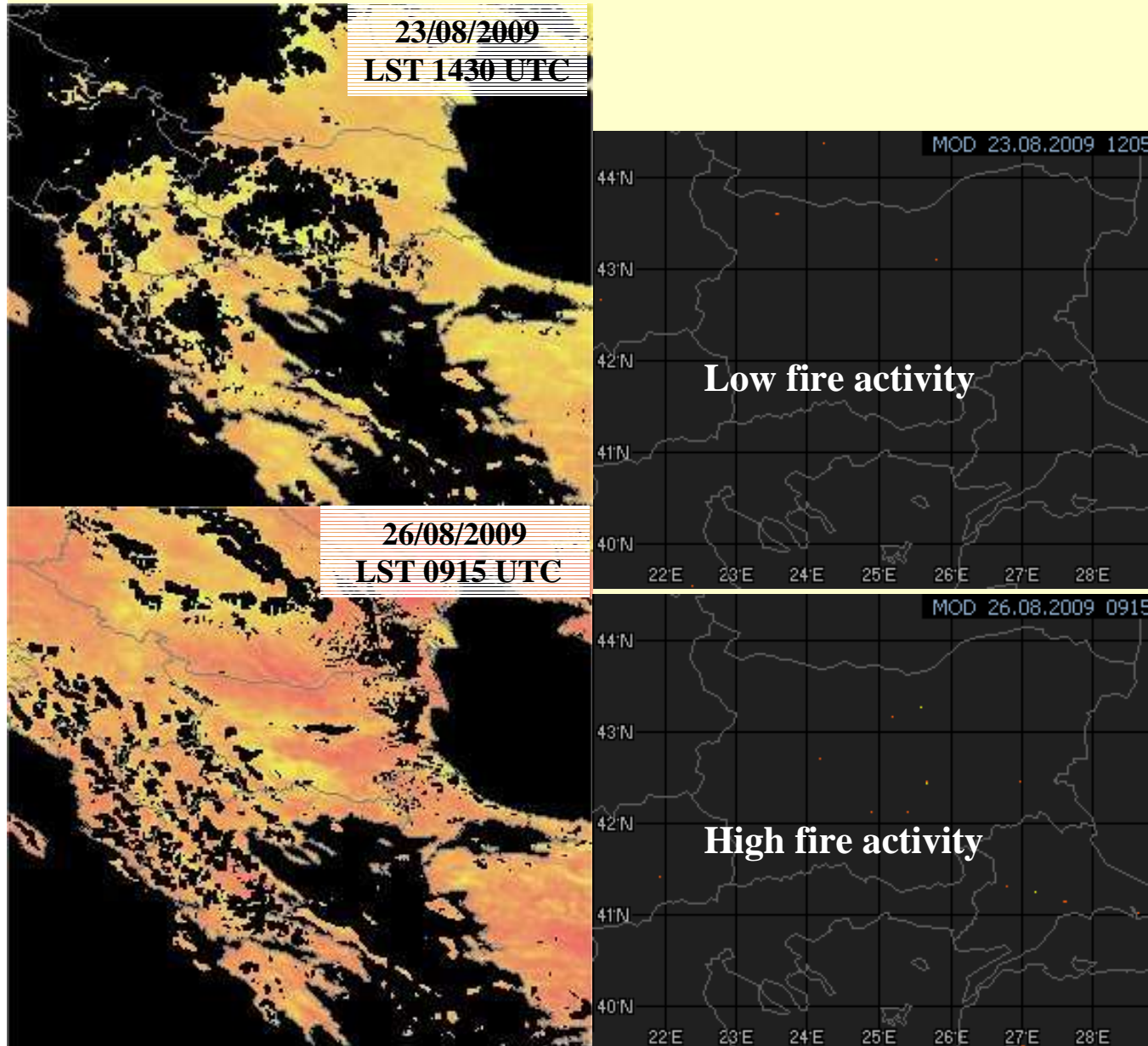
Potential Fires
detected by MSG

Interactive satellite data processing with a special configuration of SYNERGIE system for Bulgaria (2008) in support to Land Surface Applications. Fire detections can be also superimposed on the Numerical Wind Forecast near Earth surface to help forecasting fire development.



OPERATIONAL APPLICATIONS

Processing of MSG LST and MODIS TAP Products over Bulgaria



✓ Maps of LST and MODIS TAP illustrate thermal status of the land surface in fire-weather and non fire-weather conditions over Bulgaria are compared.

✓ Research on using LST product disseminated via EUMETCast as vegetation fire risk diagnostic tool are initiated.

RESEARCH ACTIVITIES

Research Activities are focused on Validation

1. MPEF FIR product
2. MSG LST product as a Drought Index



RESEARCH ACTIVITIES

MPEF FIR product Validation Activities

- Validation is a critical element to assess system performance, and also **to build confidence within the operational users communities.**
- Evaluation of the capabilities of SEVIRI FIR product:
Accuracy, Sensitivity, Early warning, False Alarms.
(Full Scan and Rapid Scan Missions)
- Results reported: **1st version 2008; 3rd version 2010** Annual EUMETSAT Satellite Conferences.

- **Active Fire Monitoring (FIR) validation**
 - **1st version: Jul/Aug 2007, MSG2 Full Scan**
 - **2nd version Jul/Aug 2008, MSG2 Full Scan, MSG1 RSS**
 - **3rd version: Aug/Sep 2009, MSG2 Full Scan, MSG1 RSS**

- **REFERENCE DATA**
 - **MODIS FTAB & FIRMS Alerts**
 - **National Fire Data Bases**
 - **The location of MODIS Aqua/Terra fire detections and ground observations are converted in MSG centered reference image coordinates (row and column)**



MPEF FIR Product 3rd Version: Validation Results

(Stoyanova & Georgiev, 2010)

SUMMARY Statistics

Test Period: August-September 2009, Bulgaria
Very low Fire Activity

- Accuracy: Displacement mainly to the **NW, N, W** directions towards the MODIS fire locations.
- Sensitivity: A small portion about 10 % of MODIS fire reports fit to corresponding MSG detections. In some cases the MSG product provides Early signals even for Small fires reported by National Fire Data Base. However some Large Crown fires are missed.

➤ False Alarms:

- **For 6-days period: 142 FIR-detectins not confirmed by MODIS data or National Fire Data Base.**
- **There are fire detections within the same pixel for at least three days at 12 specific locations.**
- **We consider these repetitions of detected hot spots at the same location can be wrong classification of the surface types .**

NW 30.7%	N 18.1%	NE 8.7%
W 17.3%	Fit 10.2%	E 6.3%
SW 6.3%	S 2.4%	

FIR detections displacement to centered MODIS-detection, August-September 2009.

The FIR algorithm has detected about 22.5 % of the records for actual fires registered in the National Fire Data Bases.

31 July - 4 August 2009	Thermal Anomalies by MPEF FIR
Corresponding to Actual fires reports	9
False alarms, confirmed	12
False alarms, not confirmed	142
Actual fires not detected by MSG	40

RESEARCH ACTIVITIES

Drought Monitoring: LST Product from MSG as a drought index

In 2010, studies on the LSA SAF LST product, as additional or complementary to the SVAT-model information were initiated at NIMH.

LST data processing

The following considerations are taken into account

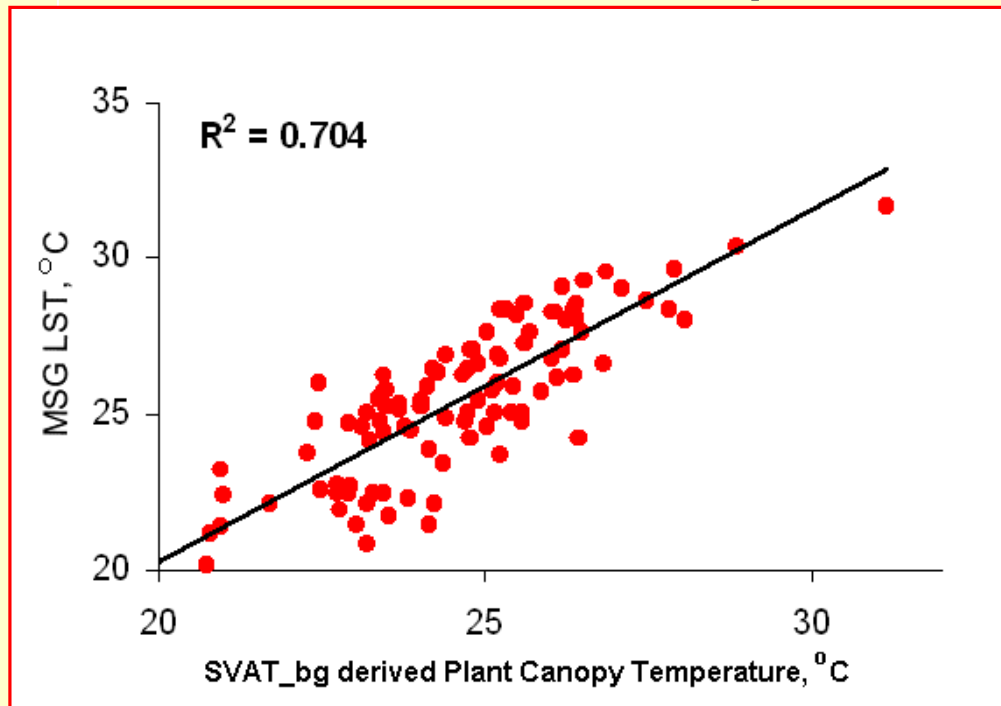
- Space (5 x 5 pixels) and time (hourly) averaged LST screened for clouds over Bulgaria.
- LST over two types of land cover are selected (forest, agricultural field).



RESEARCH ACTIVITIES

Validation of MSG LST Product

MSG LST as a measure of plant canopy temperature



- 5x5 pixels LSTs derived and centered at the locations of synoptic/agro stations from operational meteorological network of NIMH, Bulgaria.
- Daily SVAT model canopy skin temperature over Bulgaria.

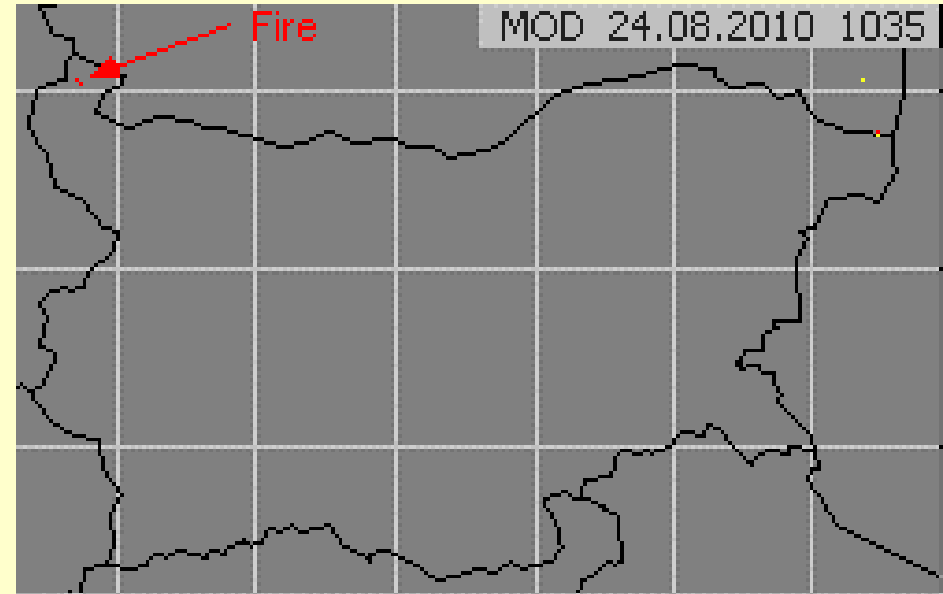
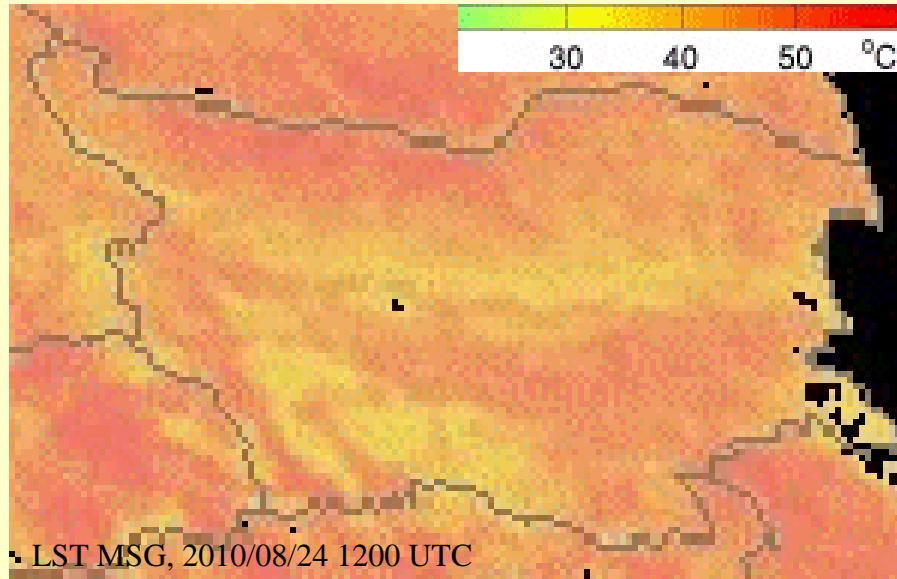
Scatter plot of MSG LST vs. SVAT_bg model-derived plant canopy temperature (°C) at (42.23 N 24.33 E), Lucerne land cover.

MSG LST gives reasonable approximations of canopy leaves temperature (resulted from the coupling of vegetated energy and water cycles) and confirms it usefulness as a measure of coupling between vegetated energy and water cycles .



RESEARCH ACTIVITIES

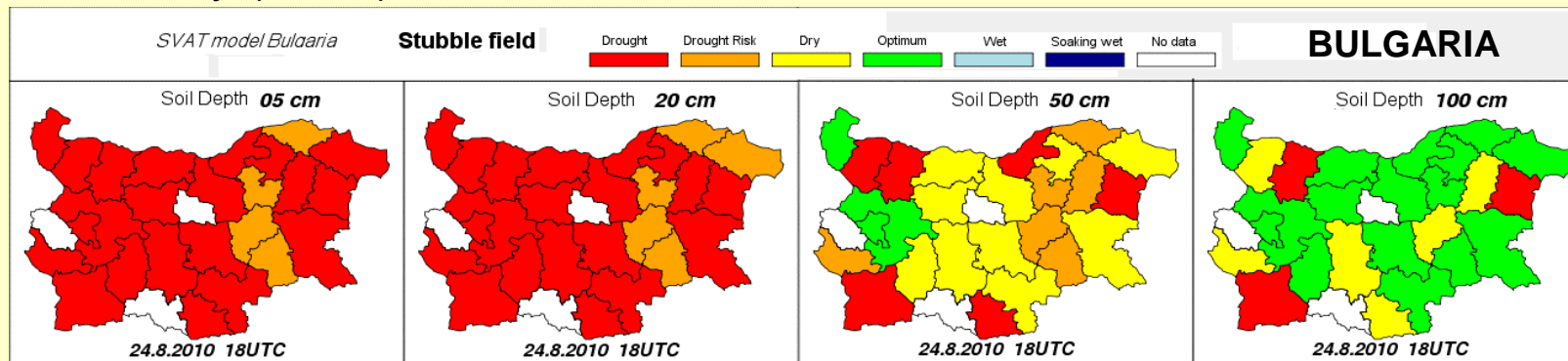
MSG LST as a measure of plant canopy temperature and water status



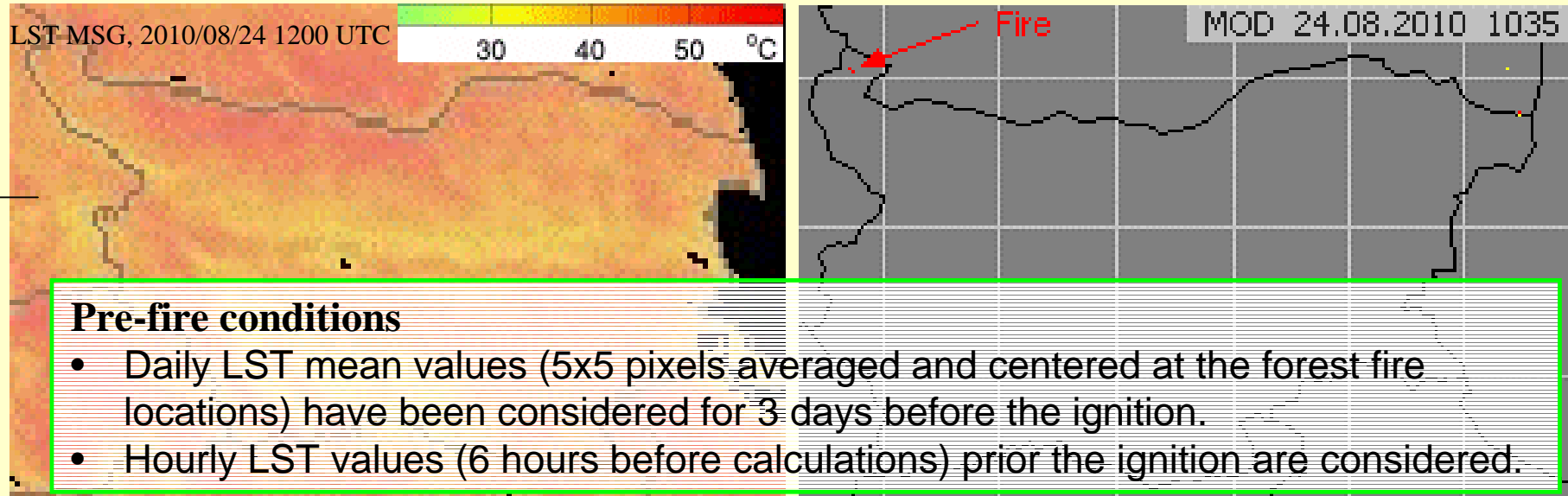
Pre-fire conditions

ISMA shows a cumulative drought, which favours the forest fire development on 24/08/2010 (detected by MODIS and confirmed by Executive Forest Agency, EFA).

SVAT_bg Index of Soil Moisture Availability (ISMA)



Drought Monitoring: LST Product from MSG as a drought index

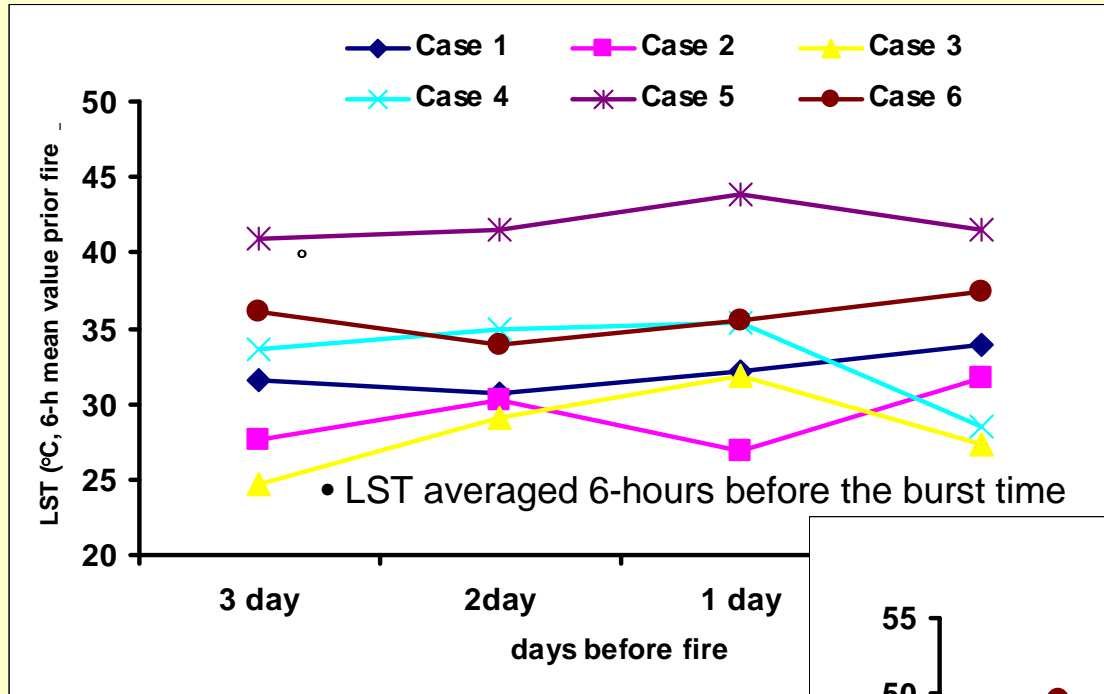


Case	Ignition date	Fire location (lat/lon)	Location MSG row/line	MSG detection	MODIS detection MSG row/line
1	24/08/2010	44.03/22.75	1523/3245	No detected	1524/3245
2	03/08/2009	43.77/22.47	1528/3239	1529/3239	No overpass
3	20/08/2009	41.97/26.15	1425/3195	No detected	Not detected
4	24/08/2009	42.03/25.83	1433/3197	1434/3198	1434/3196
5	23/07/2007	43.20/24.17	1257/3215	1256/3216	1255/3215
6	22/07/2007	42.00/26.08	1200/3184	11997/3183	No overpass

6 cases of forest fires reported by National Data Base are considered to study LST product as a pre-fire index. The evolution of LST, 3 days prior to fire event is considered.

MSG LST and forest fire risk evaluation

LST curves 3 days prior forest fire cases

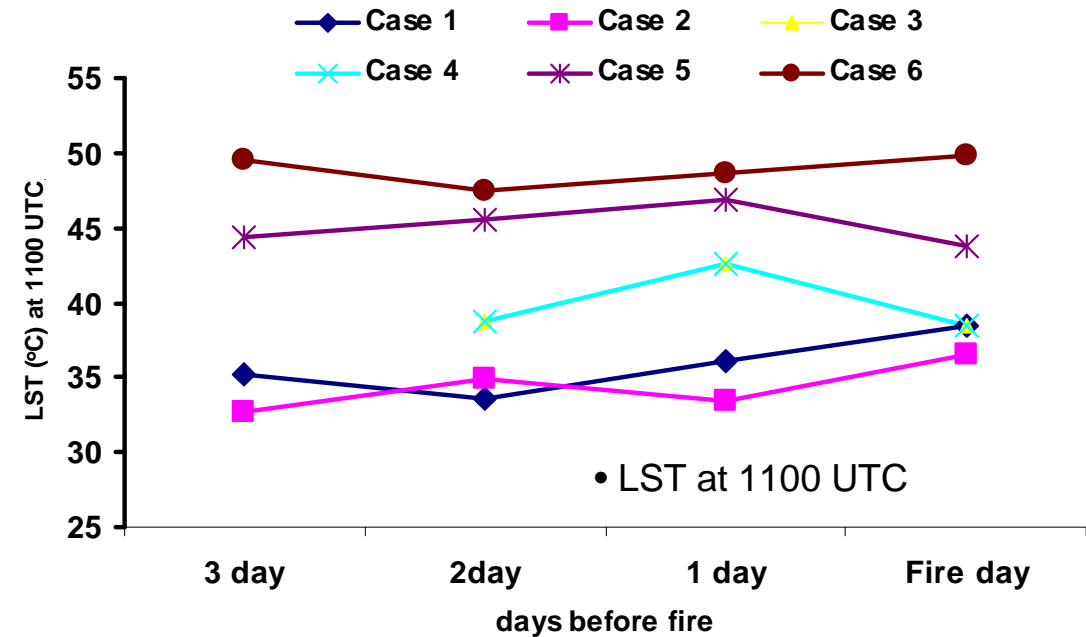


Pre-fire conditions

- ✓ Extremely high 6-hourly mean LST values have increased for 3 days before the ignition.

Pre-fire conditions

- ✓ Extremely high LST values at 2 p. m. that increase prior the ignition (6 hours before calculations).



RESEARCH ACTIVITIES

Drought Monitoring: LST Product from MSG as a drought index

- Additional work have to be involved to evaluate the LST as an index of risk of forest fires for future operational use.
- Fire risk assessment based on daily Soil Moisture Availability Index (derived as a SVAT model output) in conjunction with hourly MSG LST would provide more accurate maps of fire risk for the temporal and spatial allocation of fire prevention and fire management.



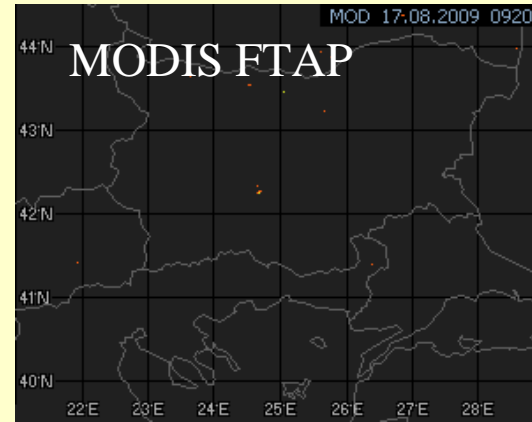
User Service Activities

1. **Providing Meteorological Services to National Authorities**
2. **Contribution to the EUMETSAT and LSA SAF User Services & Training in the region of South Eastern and Eastern Europe:**
 - **‘Drought & Fires’ Workshop**
 - **SALGEE Project**



User Service Activities

Information System for Providing Services to National Authorities

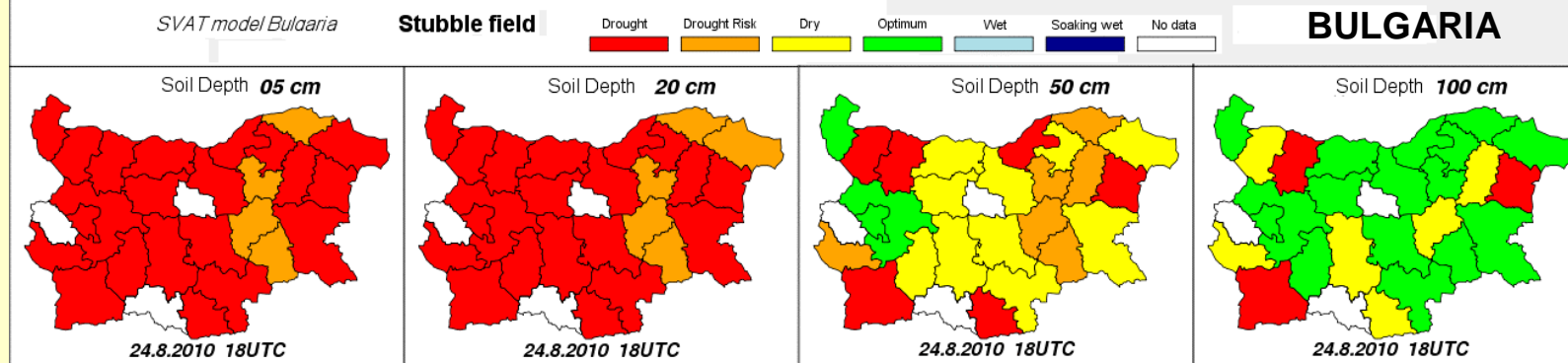


Fire Detection (by satellites)
in near-real time

Data from EUMETSAT, Satellite: MET08, Date: 2009/08/17 10:00Z

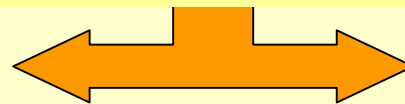
Row: 3194 Col: 1235 Lat: 42.328 Lon: 24.704 Possible fire
 Row: 3194 Col: 1236 Lat: 42.326 Lon: 24.660 *** Probable fire
 Row: 3194 Col: 1237 Lat: 42.323 Lon: 24.615 Possible fire
 Row: 3194 Col: 1238 Lat: 42.321 Lon: 24.570 Possible fire

Daily Fuel moisture conditions (assessed by SVAT_bg model)



Executive Forest
Agency

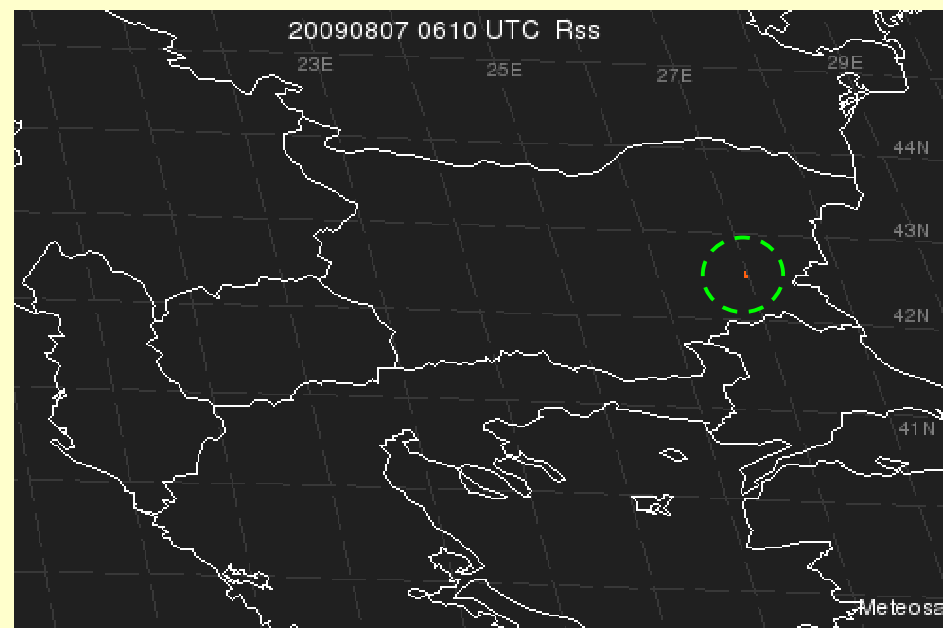
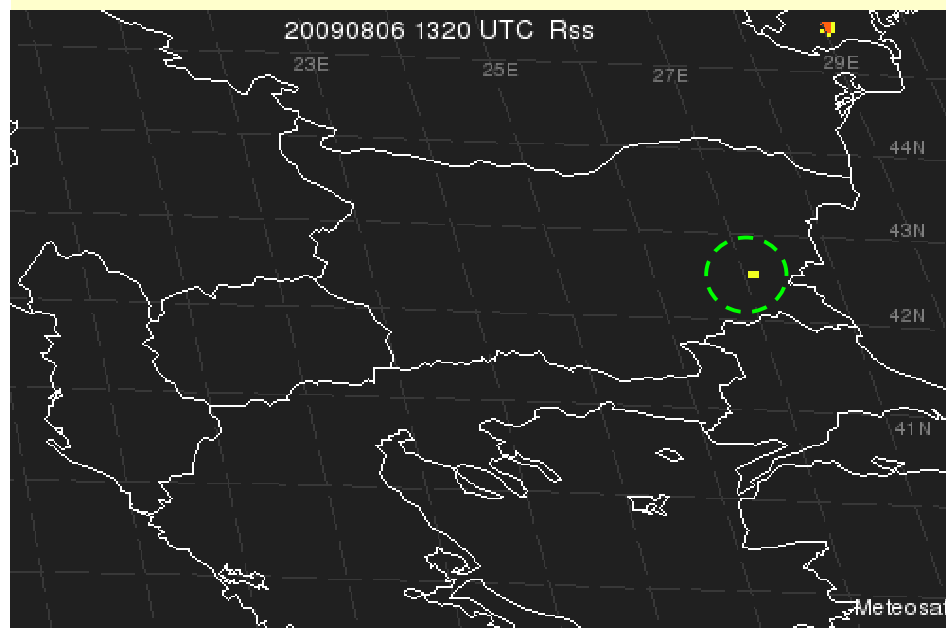
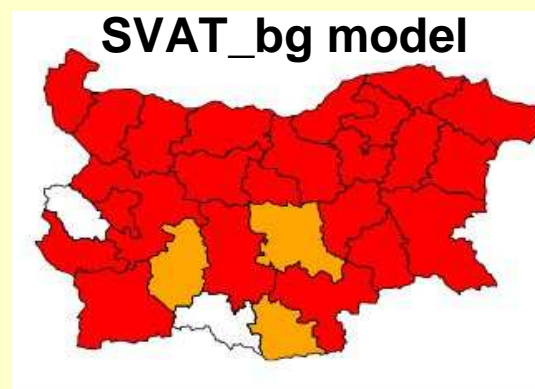
DATA EXCHANGE via
WEB TECHNOLOGY



Ministry of Internal
Affairs

Providing Services to National Authorities via Portal for data exchange

дата	Темп. средн	Отн. влажн	Валеж мм	Карнобат, 04- 08 август 2009			
				5	20	50	100
04.08	24.6	66.1	0.0				
05.08	25.0	66.8	0.0				
06.08	24.7	64.5	0.0				
07.08	23.6	63.9	0.0				
08.08	23.0	62.4	0.0				
09.08	21.3	63.5	0.0				



4 - 8 August 2009: SVAT_bg model & Satellites show vegetation drying (water stress) in the region of fire development.

User Service Activities

Contribution to EUMETSAT and LSA SAF User Services & Training

- NIMH Bulgaria initiated and hosted the First EUMETSAT training workshop on MSG land surface applications: 'Drought & Fires', Sofia, 7-12 September 2009.
- *Participants:* Primary satellite data users in SE Europe, product developers from EUMETSAT, LSA SAF Consortium, NOAA/NESDIS, NASA and University of Maryland, National Meteorological and Research Institutions of Brazil, Bulgaria and Portugal, experts from Civil Protection Authorities of Bulgaria.



MSG Land Surface Applications: Drought & Fires

SOFIA 7-10 September 2009



EUMETSAT

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

[Home](#) | [General information](#) | [Programme](#) | [Image](#) | [Venue and accomodation](#)

Advanced Training Workshop



NIMH of Bulgaria and EUMETSAT will be holding this Workshop, aimed to provide a forum for exchange of advanced knowledge and experience between meteorologists, developers of satellite products and primary end-users of Meteosat Second Generation data for Land Surface Analyses related to the natural hazards of Drought and Vegetation fires. Experts in meteorological products developers, experienced forecasters, experts in satellite data interpretation and land surface analyses will attend the workshop. (http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/index.html).

Further details about the Workshop are given in the **Information** page and the **Programme**.

National Institute of Meteorology and Hydrology, Bulgarian Academy of Science (NIMH-BAS)

E-mail us: **Julia Stoyanova**, **Christo Georgiev**

<http://info.meteo.bg/conferences/EUMETSAT07092009>

User Service Activities

SALGEE User Group

Satellite Applications in Land surface analyses Group for Eastern Europe

- Satellite Applications in Land surface analyses Group for Eastern Europe (**SALGEE**) was established as an outcome of the EUMETSAT Workshop in Sofia, September 2009.
 - ✓ Formally approved by EUMETSAT in December 2009 and supported by LSA SAF.
 - ✓ Aimed to facilitate exchange of knowledge on an integrated approach for using satellite data in conjunction with ground observations and model output and
 - ✓ To coordinate research and operational activities in using MSG and EPS data for quantification of land surface processes as well as to facilitate the validation and use of LSA SAF products.
 - ✓ SALGEE Terms and References (ToRs) were specified and agreed during a phone Conference with EUMETSAT & LSA SAF in Feb 2010.



User Service Activities

SALGEE Objectives

1. To promote EUMETSAT MSG and EPS data & products related to :
 - land,
 - land-atmosphere interaction,
 - biospheric applications.
2. To facilitate the use of LSA SAF products through development of appropriate tools for visualization in image format and digital processing in the countries of the target regions.
3. To validate satellite LSA SAF products for the target regions.
4. By exchange of knowledge, to contribute to increase benefits from the satellite products for the users of SEE and EE.



User Service Activities

SALGEE Activities

➤ **Main ACTIVITIES (among all 12 activities planned at ToRs):**

- Regular workshops (international biennial: 2009, 2011,...) for land surface applications.
- Establish mechanisms where scientists, and user community provide feedback to product developers at EUMETSAT and LSA SAF.
- Initiate and support cooperation between the NMSs and National Civil Protection Authorities and Forest Managements Authorities
- Planning and reporting on progress (during the EUMETSAT Annual Conference and/or LSA SAF Workshop).
- During the EUMETSAT Annual Conference in Córdoba, 20 - 24 September, 2010, “on-site” meeting was held for preparation of the

**2nd SALGEE users Workshop:
“MSG Land Surface Applications: Drought & Fires”
4 - 7 April 2011, Antalya, Turkey**



User Service Activities

SALGEE Activities

➤ **The 2nd SALGEE Workshop:**

- In addition to Bulgaria and Turkey, Ukraine to be included as an active player in the SALGEE activities.
- During the 39 CGMS meeting, India has expressed interest to participate in the 2nd SALGEE workshop.
- To extent possibilities for collaboration between South Eastern and Eastern European countries and the experienced in Fire problem Mediterranean countries: Italy, France, Portugal, Spain.
- Practical measures for improved coordination and opportunities for partners to join and facilitate extraction of data for vegetation characteristics to be specified.

**2nd SALGEE users Workshop:
“MSG Land Surface Applications: Drought & Fires”
4 - 7 April 2011, Antalya, Turkey**



User Service Activities

CONCLUSION

SALGEE Perspectives

- To make efforts new fire related products like FRP, FRM, etc. to be promoted among the user community and local national institutions.
- To initiate the FRP validation for regional applications.
- To use available algorithms for simulation of biomass production (NPP, GPP) and burning CO₂ emissions.
- To initiate LSA SAF activities for providing visualisation tools according to the needs of SALGEE user group countries.
- Using satellite LSA SAF products as inputs in SVATs.
- Using ground measurements available in the SALGEE countries for validation of satellite information.



Acknowledgements

We are grateful to the Ministry of Interior and Executive Forest Agency and Ministry of Interior of Bulgaria for providing information for the actual fires. LST SEVIRI archive data were kindly provided by LSA-SAF.

References

- Stoyanova, J. and Georgiev, C. (2007). Interactions between the atmosphere and mountain forest: local scale assessment of energy and water fluxes. Proceedings of the 29th International Conference on Alpine Meteorology (ICAM), 04-08 June 2007, Chambéry, France, 729-732.*
- Stoyanova J.S. and Georgiev C.G. (2008). A process-based agro-ecosystem SVAT model as diagnostic tool of land surface state. 10th Plinius Conference on Mediterranean Storms, Nicosia, Cyprus, 22-24 September 2008, EGU CD-R, PLINIUS10-A-00056 (Ed. Cyprus Meteorological Association, Univ of Cypros).*
- Stoyanova, J, Georgiev, C.G., Yordanova, D. and Mladenov, K. (2008). Active fire monitoring over Bulgaria: validation of SEVIRI FIR product. EUMETSAT Meteorological Satellite Conference, Darmstadt, Germany, 08-12 September 2008.*

