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

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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

MODEL

INPUTS

Parameters:
- prescribed vegetation type; canopy radiative properties, soil physical properties; phenology; topography, latitude/longitude

Variables:
- Meteorological drivers: clear sky radiation, air temperature & humidity, cloudiness, atmosphere pressure, precipitation, snow cover, soil temperature

SVAT_FOREST_BG Model

OUTPUTS

- Canopy surface net radiation
- Latent & Sensible heat
- Soil heat conductance
- Canopy surface temperature
- Soil moisture

VEGETATION SUB-MODEL

PANEL 1 Canopy radiation balance
PANEL 2 Energy balance partition
PANEL 3 PET calculation

WATER BALANCE SUB-MODEL

AET parametrization
Soil moisture availability

VALIDATION II

SVAT_WHEAT_BG Model

MEASURE

FIELD MEASUREMENTS

Modeled Soil Moisture

VALIDATION I

Soil Moisture

Soil Moisture
OPERATIONAL APPLICATIONS

Drought Monitoring

Soil-Vegetation-Atmosphere-Transfere Model (‘SVAT_bg’)

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

- 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.

Biogeophysical cycling
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
  \[AET = f(PET, LST, soil \text{ type \& physical properties, texture, } \beta)\]
  \[\beta = f(W, FMC, PWP, soil \text{ texture}), \quad 0 < \beta < 1 \quad \text{– soil moisture availability}\]
  \[PET = \rho_D(q_s - q)\]

- 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

<table>
<thead>
<tr>
<th>Soil Depth</th>
<th>Stubble field</th>
</tr>
</thead>
<tbody>
<tr>
<td>05 cm</td>
<td>BULGARIA</td>
</tr>
<tr>
<td>20 cm</td>
<td></td>
</tr>
<tr>
<td>50 cm</td>
<td></td>
</tr>
<tr>
<td>100 cm</td>
<td></td>
</tr>
</tbody>
</table>

**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.

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4th LSA SAF User Workshop, 15 - 17 November 2010, Toulouse
Index of Soil Moisture Availability (ISMA)
Calcualted for the 26 administrative regions of Bulgaria.

Drought Monitoring

Water status of a vegetation type

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.

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
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.
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).

Depending on the fire conditions, the MPEF FIR product has failed to detect some large fires.
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.
SYNERGY system, a decision making tool for Forecasting and Early Warnings of fire development.

Case study over Bulgaria 05/08/09

SYNERGY System fire space distribution

Rain detected by MSG

Wind synoptic observations

Potential Fires detected by MSG
Analysis and forecasting of active fire development

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.

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

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

<table>
<thead>
<tr>
<th>31 July - 4 August 2009</th>
<th>Thermal Anomalies by MPEF FIR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corresponding to Actual fires reports</td>
<td>9</td>
</tr>
<tr>
<td>False alarms, confirmed</td>
<td>12</td>
</tr>
<tr>
<td>False alarms, not confirmed</td>
<td>142</td>
</tr>
<tr>
<td>Actual fires not detected by MSG</td>
<td>40</td>
</tr>
</tbody>
</table>
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).
MSG LST as a measure of plant canopy temperature

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

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

- 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.
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)
Pre-fire conditions
- Daily LST mean values (5x5 pixels averaged and centered at the forest fire locations) have been considered for 3 days before the ignition.
- Hourly LST values (6 hours before calculations) prior the ignition are considered.

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

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).
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)

BULGARIA

DATA EXCHANGE via WEB TECHNOLOGY

Executive Forest Agency

Ministry of Internal Affairs
Provisioning Services to National Authorities via Portal for data exchange

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

<table>
<thead>
<tr>
<th>Дата</th>
<th>Темп. средн.</th>
<th>Отн. влажн.</th>
<th>Валеж мм</th>
<th>Карнобат, 04-08 август 2009</th>
</tr>
</thead>
<tbody>
<tr>
<td>04.08</td>
<td>24.8</td>
<td>66.1</td>
<td>0.0</td>
<td>5</td>
</tr>
<tr>
<td>05.08</td>
<td>25.0</td>
<td>66.8</td>
<td>0.0</td>
<td>20</td>
</tr>
<tr>
<td>06.08</td>
<td>24.7</td>
<td>64.5</td>
<td>0.0</td>
<td>50</td>
</tr>
<tr>
<td>07.08</td>
<td>23.6</td>
<td>63.9</td>
<td>0.0</td>
<td>100</td>
</tr>
<tr>
<td>08.08</td>
<td>23.0</td>
<td>62.4</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>09.08</td>
<td>21.3</td>
<td>63.5</td>
<td>0.0</td>
<td></td>
</tr>
</tbody>
</table>
User Service Activities

Contribution to EUMETSAT and LSA SAF
User Services & Training

- **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.

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MSG Land Surface Applications: Drought & Fires
SOFIA 7-10 September 2009

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](http://oiswww.eumetsat.org/WEBOPS/msg_interpretation/index.html)).

Further details about the Workshop are given in the Information page and the Programme.
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 activates 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):
  - 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
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.
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

