Advanced biogeophysical indexes for land surface state analyses and drought related applications

Julia Stoyanova, Christo Georgiev
contribution: Plamen Neytchev

National Institute of Meteorology and Hydrology (NIMH), Bulgaria
Bulgarian Academy of Sciences

Overview

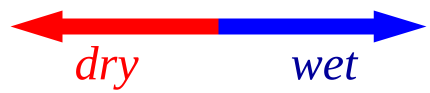
1. Land surface state analyses: Modeling and satellite observations
    a) Terrestrial drought: A complex biogeophysical process
    b) Satellite observations in support to drought identification
    c) Advanced biogeophysical indexes
2. Drought related operational applications
    a) Agricultural drought warning system
    b) Drought and fire risk
    c) Regional aspect: Ecosystem distribution
    d) Regional PFTs & Fire activity
3. SALGEE 2015 Workshop

EUMETSAT support through SALSEE Project 2014-2015

Land surface state analyses

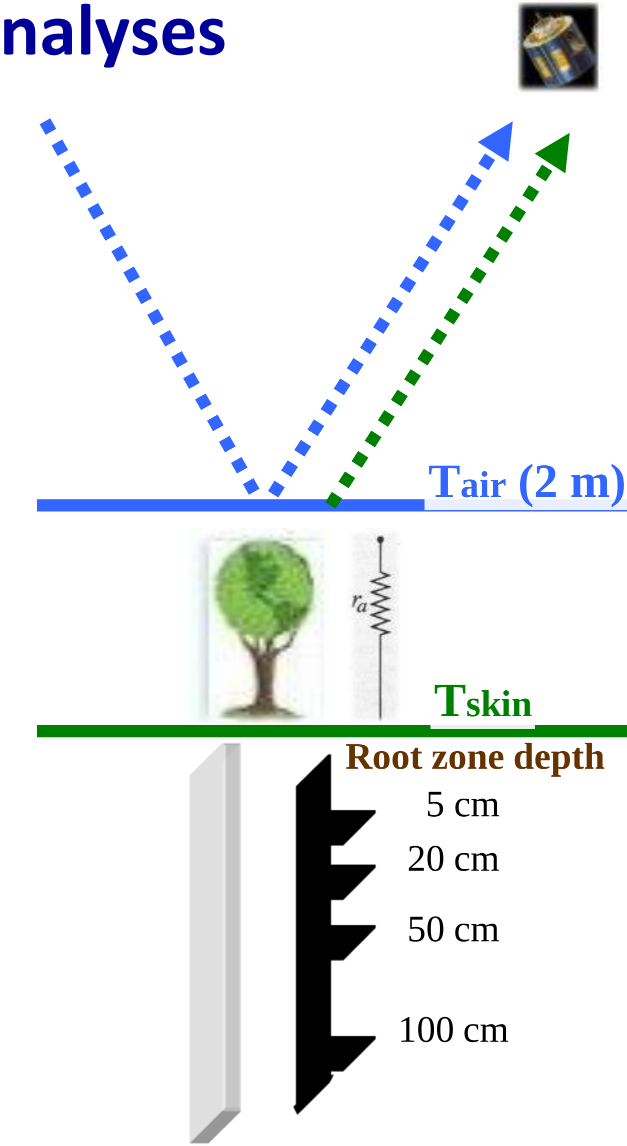
Basic mechanisms & principles:

- Biogeophysical cycle
- Biogeochemical cycle
- Biogeophysical & Biogeochemical cycles coupling
- Land surface state anomalies and extremes



- **Land–atmosphere interactions:**
  - → particularly important in transitional zones between dry and wet climates;
  - → For present climate: also the **Mediterranean region** is included *(Seneviratne et al., 2006);*
  - → These **"hot spots"** of land–atmosphere coupling is expected to be modified with shifts in climate regimes.

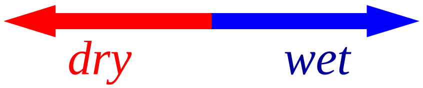
- **One of the problems that is of increasing interest** is the assessment of the role of land–atmosphere interactions and Land Surface Processes /LSPs/ related to climate dynamics/extremes on a **regional scale**.



Land surface state analyses:

→ Modeling and

→ Satellite observations



The concept that **drought begets drought** was proposed by *Namias (1960)*, who suggested that dry conditions in spring favour the formation of anticyclonic pressure conditions, thus perpetuating the dry conditions for a season, or even longer. Two decades later, numerical modelling studies by *Mintz (1982)* and *Shukla and Mintz (1982)* confirmed that there are important effects of soil moisture on local precipitation and on atmospheric circulations.

↓

m e t h o d o lo g y

- Drought is a more complex event-driven climate extreme *(Easterling et al., 2000)*.
- Accordingly, in our work we have examined drought as a ‘**dry’ biogeophysical cycle anomaly**, which assessment calls for:
  - → integrated and interdisciplinary approach,
  - → accounting for specific regional/local reveals
  - → possibilities for drought extent and impacts to be monitored routinely by numerous indicators.

Terrestrial drought: a complex biogeophysical process

methodological approach:

a) Modeling
b) Satellite observations in support to drought identification
c) Development of advanced biogeophysical indexes

Target region: Eastern Mediterranean, Bulgaria.

Terrestrial drought, a 'dry' biogeophysical cycle anomaly state with specific local/regional (national) reveals.

The above methodological approaches are applied separately or combined in advanced biogeophysical indexes, based on following main considerations:

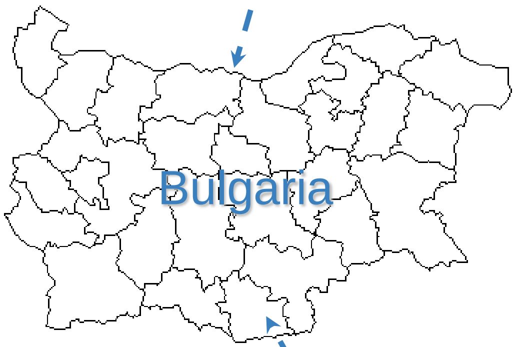
- Soil Moisture Availability /SMA/ as a result of biogeophysical cycling is accepted as a standpoint for land surface state estimates;
- Soil moisture deficit is assessed in terms of SMA to the (vegetated) land surface;
- LSA SAF biogeophysical products based on MSG SEVIRI data are used in their capacity to reflect space-time variability in land surface state/anomalies in target region.

- **The main limitation of SMA use as a key parameter** is the lack of relevant ground observations land surface parameters such as soil moisture or evapotranspiration. Approaches that allow obtaining indirect estimates of these variables are very promising.

a) Modeling

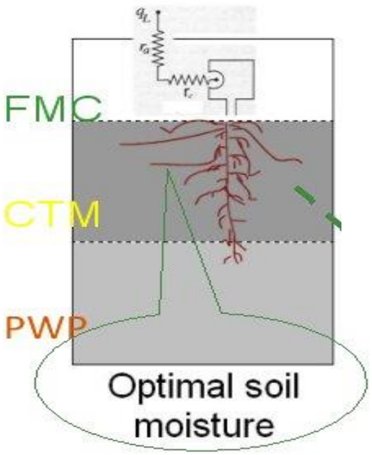
- Site scale

- 3-hour synoptic observations
- 10-daily agro meteorological observations



For each administrative unit of Bulgaria

SVAT model & Energy-Water balances variability

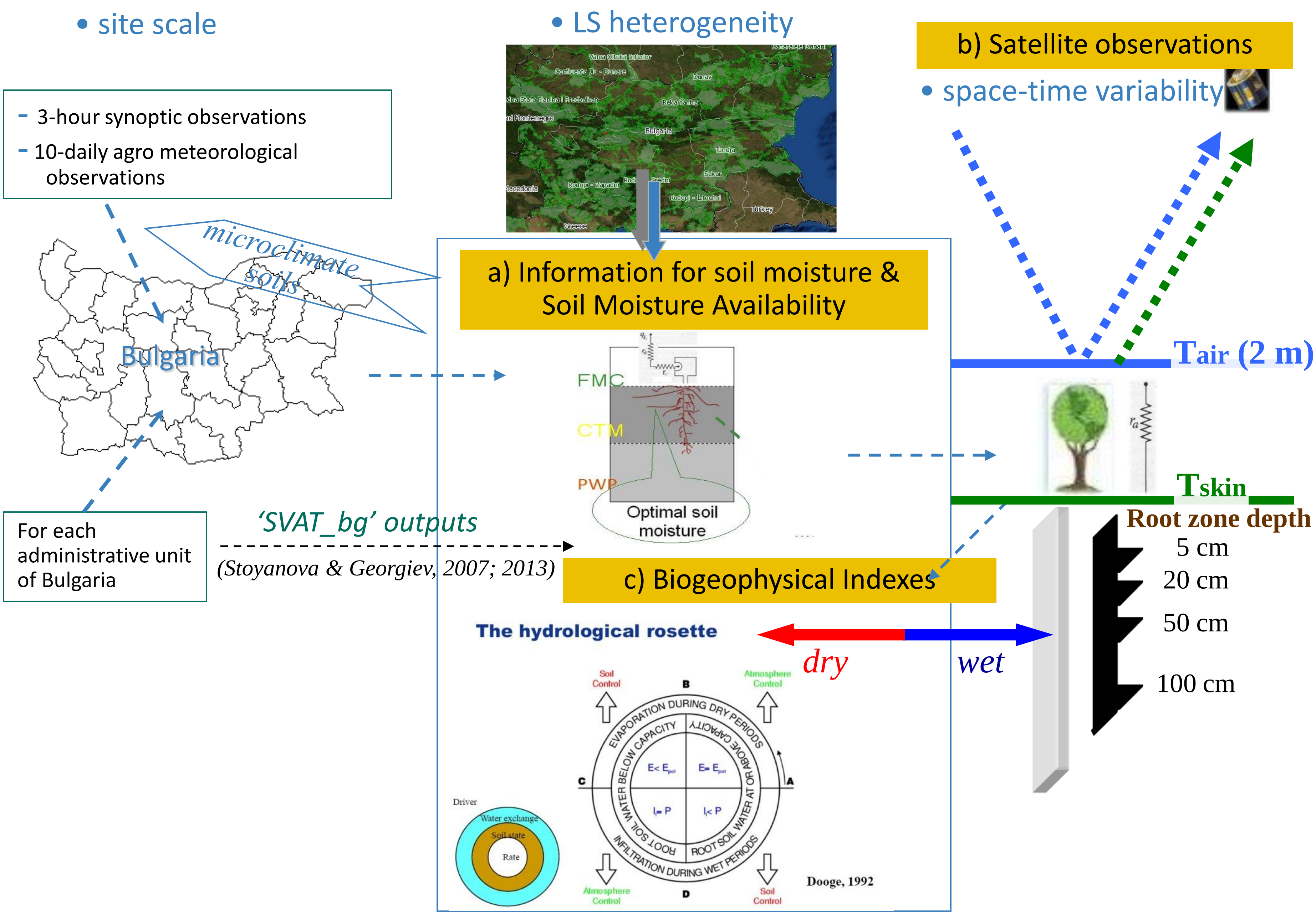


'SVAT_bg' outputs

(Stoyanova & Georgiev, 2007; 2013)

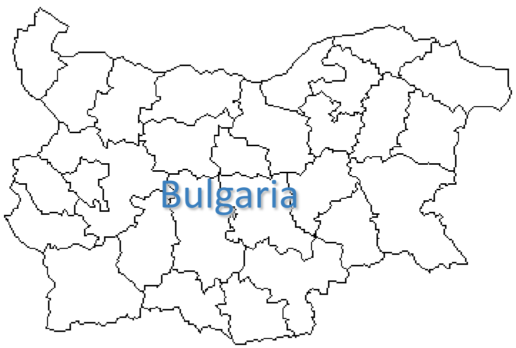
- **Biogeophysical output parameters**
- Soil moisture at 5, 20, 50, 100 cm /up to 2 m/
- Evapotranspiration
- Thermodynamic temperature, T_{td}

Key points of local/ regional land surface state modeling

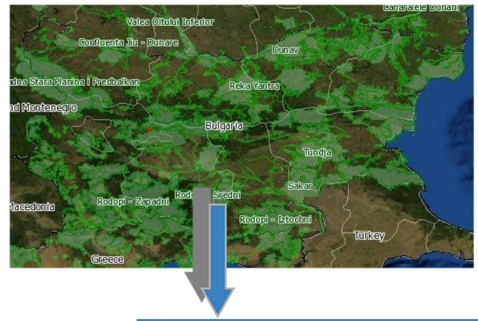


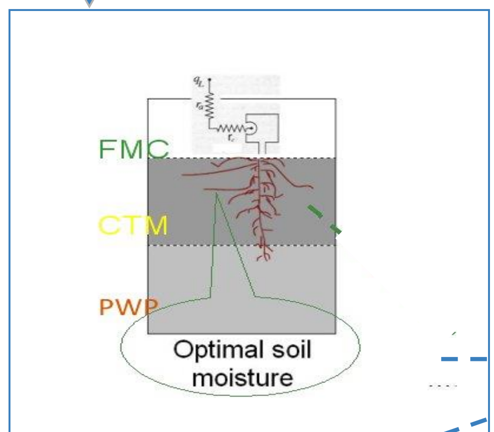
b) Satellite observations in support to drought identification

- Site scale
microclimate/soils

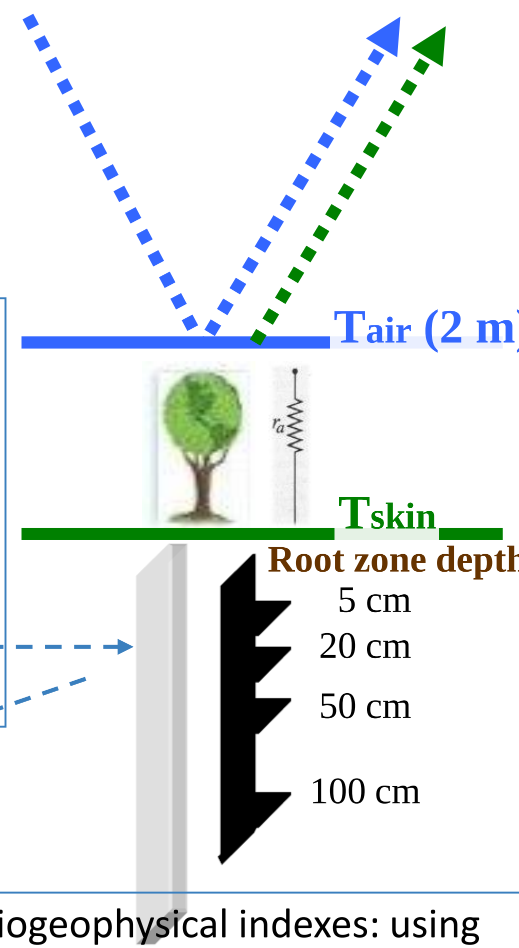


LS heterogeinity





b) Satellite observations

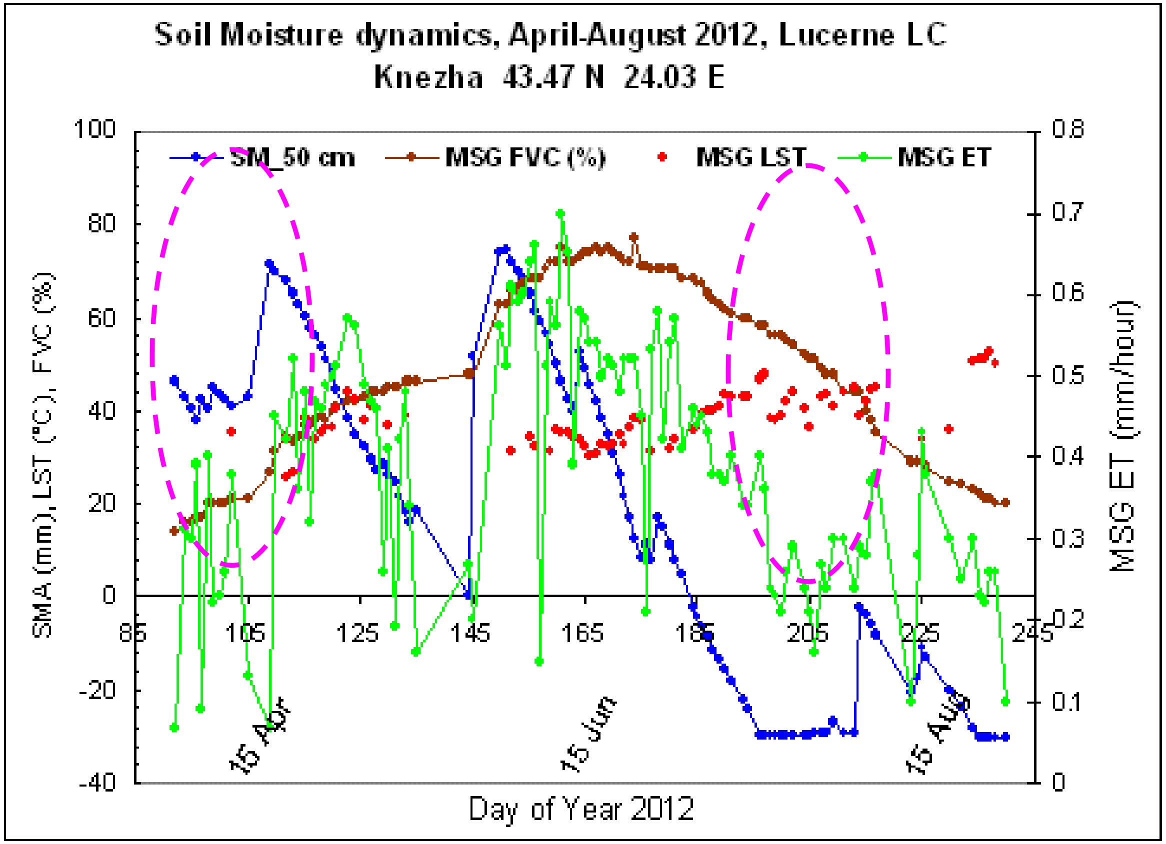


Methodological/ Technological problems for solving:

1) To evaluate the capacity of LSA SAF products based on MSG SEVIRI time/space resolution to reflect variety of terrestrial drought reveals.
2) To select the appropriate LSA SAF products for application in the context of regional assessments for operational purposes.

3) To develop complex biogeophysical indexes: using satellite data, model outputs, ground observations.
4) To apply these indexes from site-scale to landscape-scale.

LSA SAF products capacity to reflect terrestrial land surface state



Trends of numerical SMAI daily values (blued line, SVAT-bg model derived, mm) during the growing season of 2012 at synoptic station Knezha (43.47 N 24.03 E) along with functional and structural characteristics as seen by LSA SAF products: 1200 UTC ET (green line, daily FVC (brown line) and 1200 UTC LST (dot-marked red), for grass LC.

The efficiency of LSA SAF products ET, LST, FVC as geophysical indexes for monitoring initiation of vegetation water stress and propagation of drought is confirmed for the region of south-eastern part of Europe (Bulgaria), i.e.:

- At the beginning of growing season (April): high SMA, high LSA SAF ET and low LST; FVC starts to increase, reaching its maximum in June in line with the ET maximum.
- During mid-growing season: FVC can decrease up to its initial values from April; Due to high LST in August (up to 45 °C), the ET can increase sharply along with SMA increasing (due to precipitation inputs).
- Values of LST 28 °C in the beginning of April and 45 °C in the end of August result in the same evapotranspiration, at the same FVC, and quite different SMA conditions.

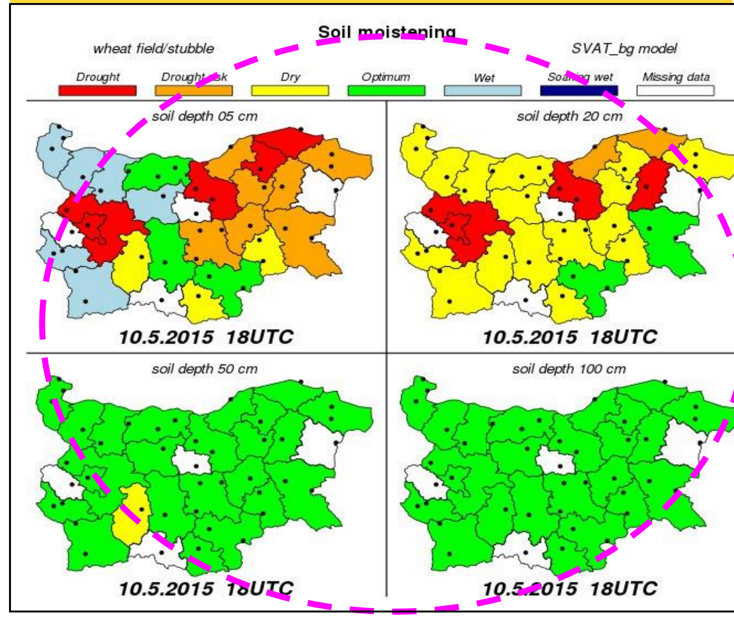
(Stoyanova & Georgiev, 2013; Stoyanova, 2014)

c) Biogeophysical indexes

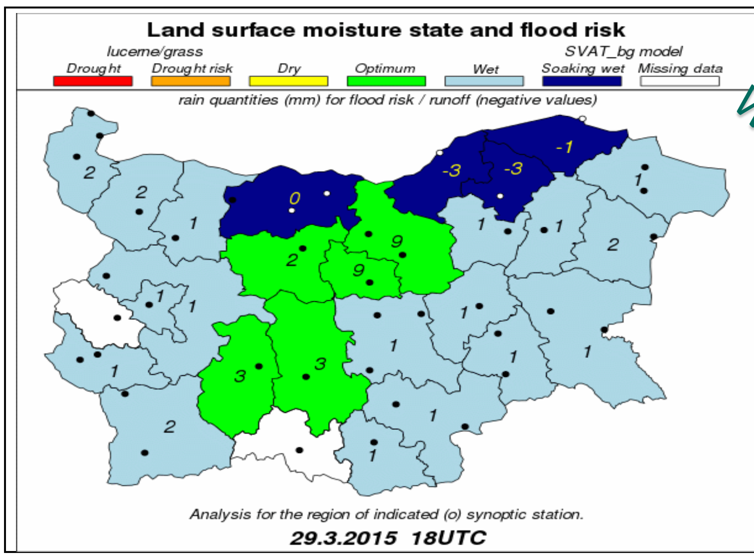
- **Meteorological operational products developed:**

→ Daily run or twice per day
→ Site-scale quantitative assessments *(microclimate/soils)*
→ Operational access
→ Specific land cover type (grass; wheat field).

1) Index of Soil Moisture Availability

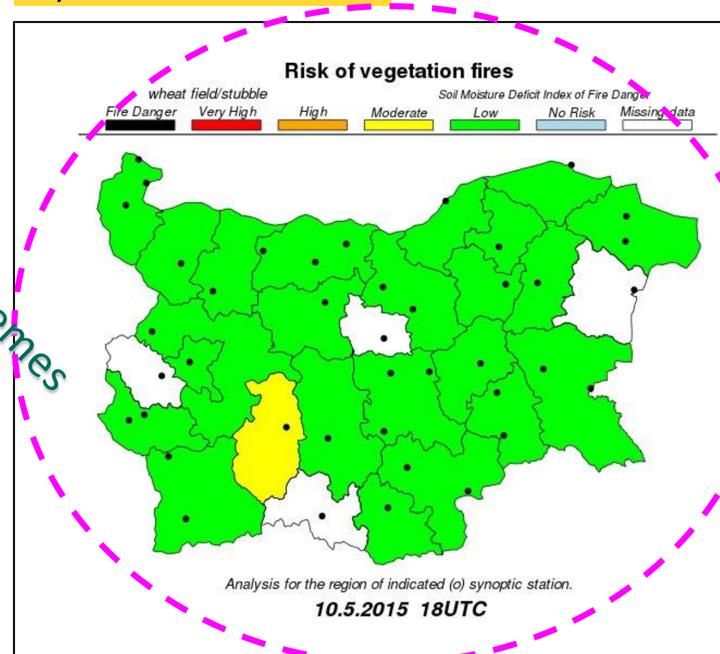


3a) Index of Soil moisture capacity & flood risk */grass LC/*



Water availability and extremes

2) Index of fire risk



3b) Index of soil moisture capacity & effective rainfall */wheat field LC/*

Can be applied in support to irrigation practice.

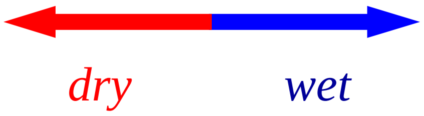
Water availability and extremes:
Better understanding, assessment, variability

Site-scale biogeophysical indexes

Blended biogeophysical indexes:
- Satellite data
- ECMWF data

- Satellite based parameter (Ts–T2m) is applied in the context of the functional relations in the thermodynamic continuum soil-vegetation-atmosphere.
- ET, FVC, LST, FRP

- Used index of water stress: (Tskin – T2m).
- (MSG LST – T2m) is applied as an effective index of land surface ‘dry’ anomalies.
- ECMWF model (0,125x0.125) for T2m.



Drought related operational applications

European level & NIMH Bulgaria level

- Soil Moisture Anomalies
- Indicators characterizing vegetation water stress

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- Satellite observations & products

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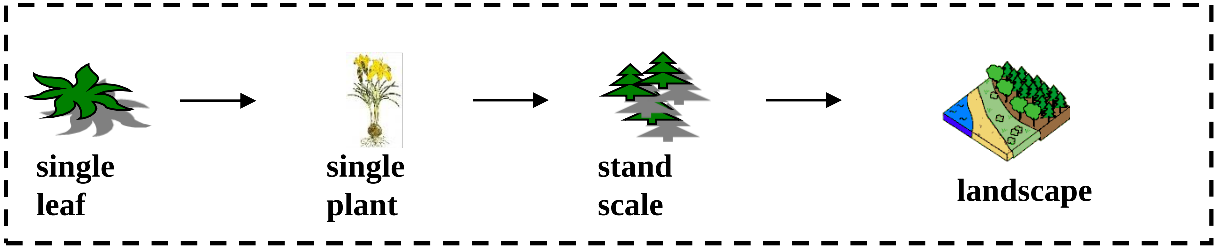
Joint International Activities
Drought Information System
Europe, Africa, Latin America:
- numerical modeling
- satellite data

(Horison et al., 2012)

Complex Drought Warning System /DWS/ developed at NIMH Bulgaria

Original scientific concepts on the bases of:

Long term experience in interdisciplinary research on land surface processes at different scales:



controlled microclimate / biogeophysical cycle

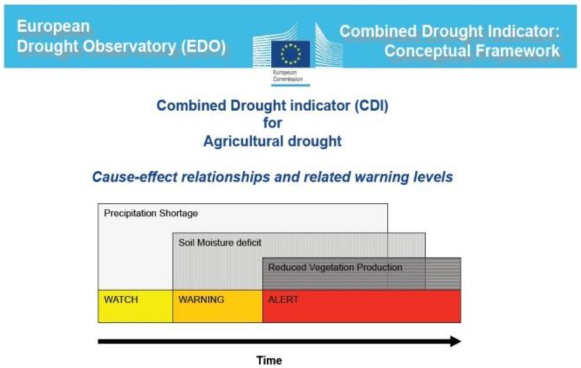
thermodynamic description of soil-vegetation-atmosphere interface/biophysical processes at natural environment

- Analyses applied are consistent with international experience
- Can reflect local / regional (national) specific environment
- Can be applied for a variety of drought related applications.

a) Agricultural drought
b) Drought and fire risk
c) Ecosystem distribution
d) Regional PFTs & Fire activity.

a) Agricultural Drought Warning System

- JRC Approach for agricultural drought assessment on European level



- **Scale:** Continental (Europe)
- **Parameters:** SPI, SM-, fAPAR anomalies
- **Capabilities:** Correlative cause-effect relations:
  - SM→ directly to water stress
  - fAPAR → plants biochemical productivity
- **Shortcomings** *(Sepulcre-Canto et al., 2012), e.g.*
  - Drought intensity not yet evaluated.
  - CDI categories are universal thresholds over Europe, not as local/national.

(Sepulcre-Canto et al., 2012)

- NIMH Bulgaria approach for agricultural drought assessment on regional level

Development of a Drought Warning System /DWS/

three level classification scheme of warnings: "watch", "warn", "alert" is composed:

Watch | **Warn** | **Alert**

- **Scale:** Local/regional (national)
- **Physical indicators: standardized** SMA, (Ts –T2m), LE, H; Entropy production, $\Phi = \Delta S/\Delta t$
- **Capabilities:** Developed concept is based on functional cause-consequence relations: **A)** energy-water cycles; **B)** biogeophysical- biogeochemical cycles:
  - SMA→ water stress → (Ts-T2m)
  - Φ → climatic bioenergetic resources → plants biochemical productivity
- **Reflects:**
  - Local microclimate/soil physics
  - Drought severity *via* SMA (SVAT derived)
  - Plants water stress *via* (Ts-T2m)
  - Individual thresholds at different environment
  - Intended for operational purposes, and
  - All this would allow near real time identification of specific drought reveals (severity, duration, yield effects) over target region/sub region.
- **Stage:** Development.

(Stoyanova 1985; Stoyanova et al., 2012; 2013; 2014)

NIMH Bulgaria approach for agricultural drought assessment on regional (national) level

Drought Warning System /DWS/

Interdisciplinary approach for analyses & forecast of land surface state in a three-level classification scheme of drought effects.

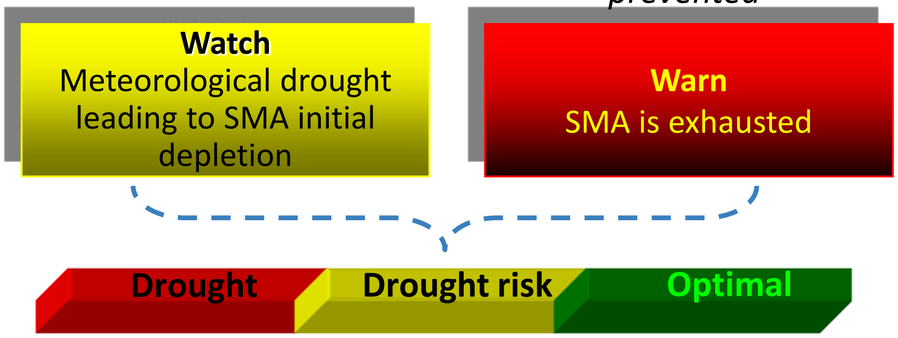
DWS Concept I:

Biogeophysical aspects of drought

'SVAT_bg' → Assessment of Soil Moisture Availability

SMA – limited/ Evapotranspitarion - restricted

SMA – exhausted/ Evapotranspitarion - prevented



In the frame of "Watch"/ "Warn" warnings, drought risk is defined by a 3-levels of color-coded Soil Moisture Availability scale.

DWS Concept II: A thermodynamic view of ecosystem functioning as open thermodynamic systems *(Wiener, 1948; Shannon, 1948).*

$$\Phi = T\frac{\Delta_i S}{\Delta t} = \frac{H\Delta T}{T\Delta t} + LE\frac{\Delta q}{\Delta t}$$

(Florov, 1983; 1988; 2002)
(Stoyanova, 1985;1996)

DWS Concept III: Coupling between biogeophysical & biogeochemical cycling *(Stoyanova, 1985;1996; 2013a,b).*

Alert
Risk of yield reduction

Accumulated SMA deficit in critical periods leads to increase of vegetation water stress, destroys energy-/water-exchange leading to decreased capacity of agroecosystems to utilize solar energy in biochemical energy and enhanced energy looses (quantified via the entropy production) that all reduce the crop yield at a specific site.

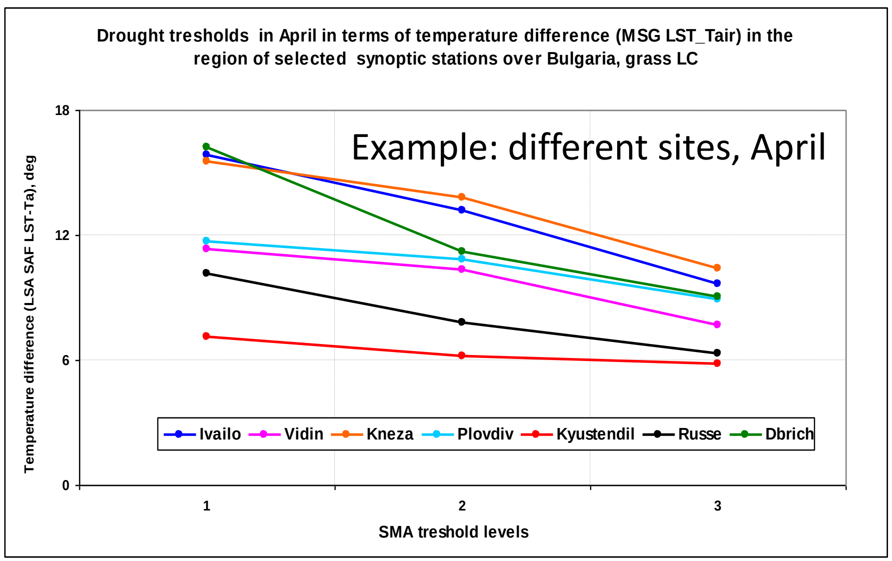
S - entropy production; E – evapotranspiration rate; H – leaf-air heat exchange rate; T – mean leaf-air absolute temperature; Δ T- leaf-air temperature difference; Δq is the difference between specific air humidity at the transpiring leaf level and the surrounding air, L – latent heat of vaporization of water.

Joint use of model output, satellite data and blended parameters in the DWS

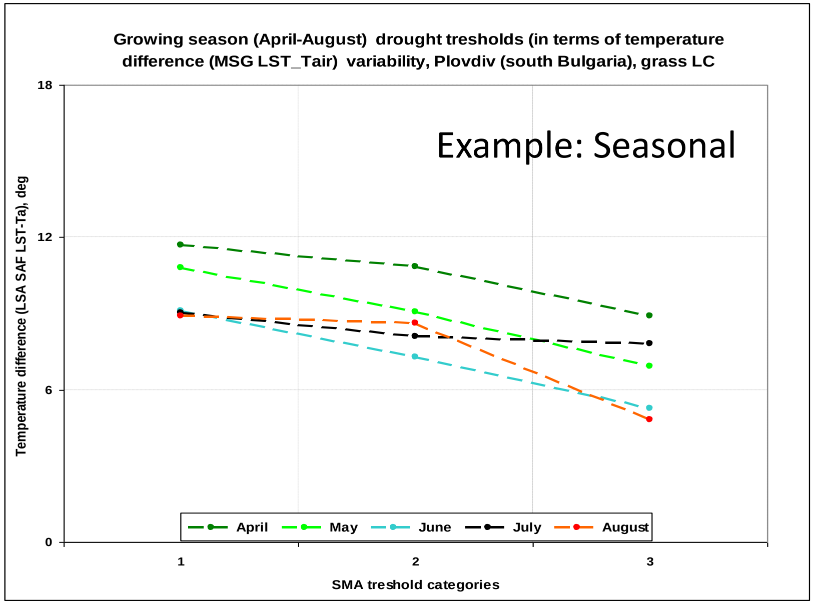
1) Scaling SMA *vs.* temperature difference (LSA SAF LST-T2m): (MSG LST–T2m) Index as a proxy of climatic SMA.

- Development of threshold scheme: A **three level Threshold scheme** /dataset: 2007 – April 2014; values within mean (+/-) 2sd are used/.

- Individual (LSA SAF LST-T2m) thresholds for each month and microclimate

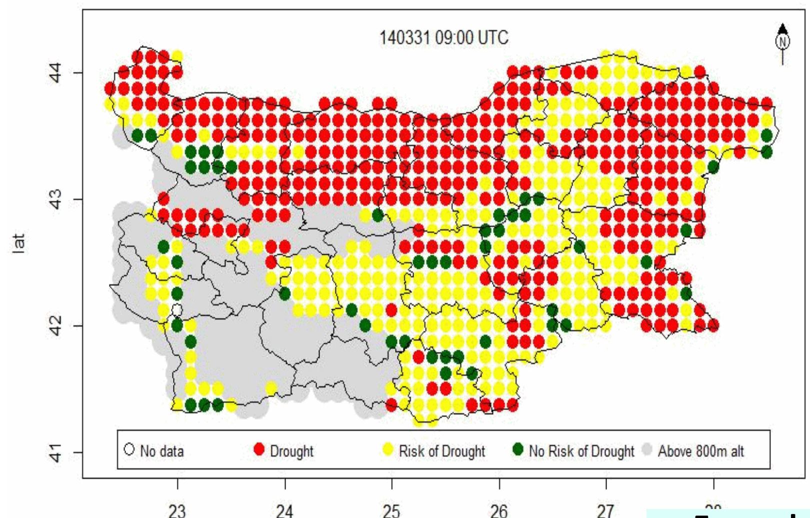


- Seasonal course of (LSA SAF LST-T2m) thresholds



2) Development of Drought Risk Maps over Bulgaria

(using MSG LST and NWP T2m dataset)

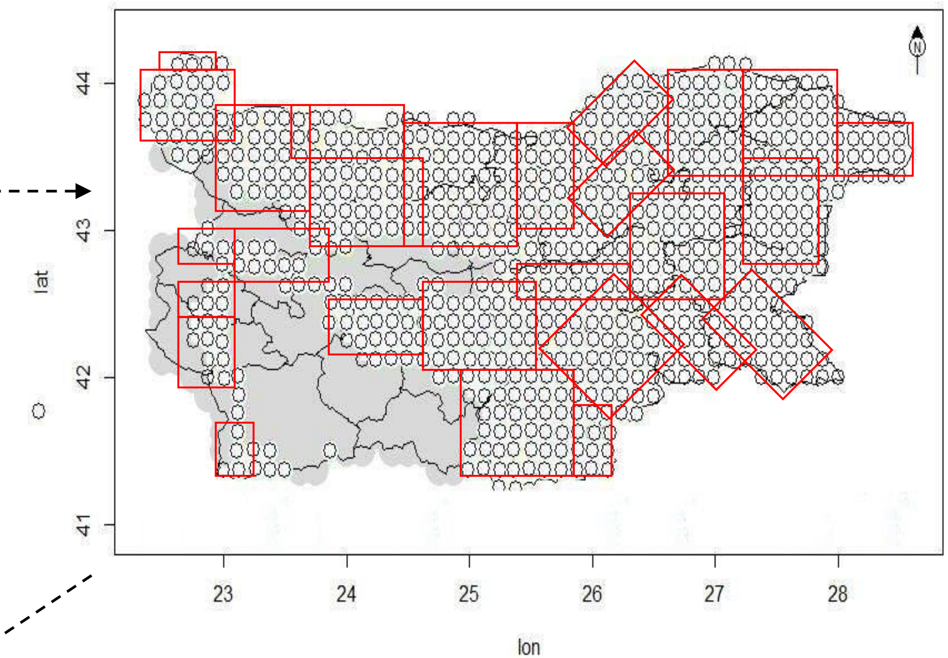


Drought risk over Bulgaria (up to 800 m alt.) as derived by (MSG LST-T2m) Index.

Example:
31 March 2014
0900 UTC

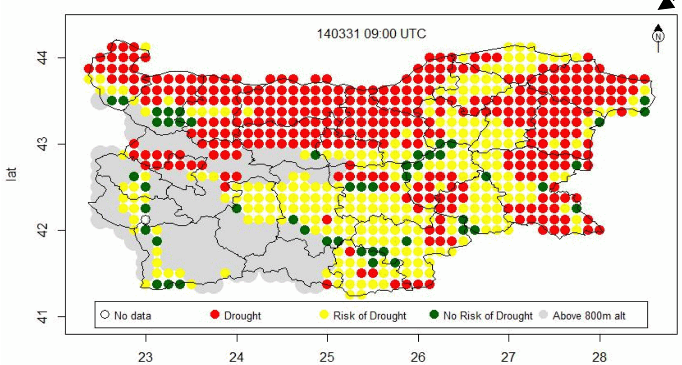
- Color-coded **Drought Risk Maps (DRM)** are generated on the bases of (MSG LSA SAF LST-T2m) Index.
- Index values are assigned to one of the categories (*Drought-Drought risk-Optimal*), which are distinguished using *site-specific* thresholds (*derived* at each synoptic station).
- DRMs are produced over Bulgaria with resolution of each ECMWF model (0.125°x0.125° grid),
    - for the regions up to 800 m altitude,
    - T2m air hourly values from ECMWF global model.
    - Recognition: T_s not equal to T_{td}

Threshold based approach for SMA assessment



ECMWF model grid points (up to 800 m altitude) over Bulgaria in which (Ts-T2m) are calculated based on specific thresholds derived for different microclimates/soils and regions within the red rectangles.

Map of SMA at wheat filed



Drought risk over Bulgaria (up to 800 m alt.) as derived by (MSG LST-T2m) Index.

Application # 1:
Diagnoses of agricultural drought risk

Alert
Risk of yield reduction

• Second Law of Thermodynamics & Ecosystem functioning *(Surface-Boundary approach in biothermodynamics, Florov, 1983; 1988; 2002).*

Thermodynamic model of yield production

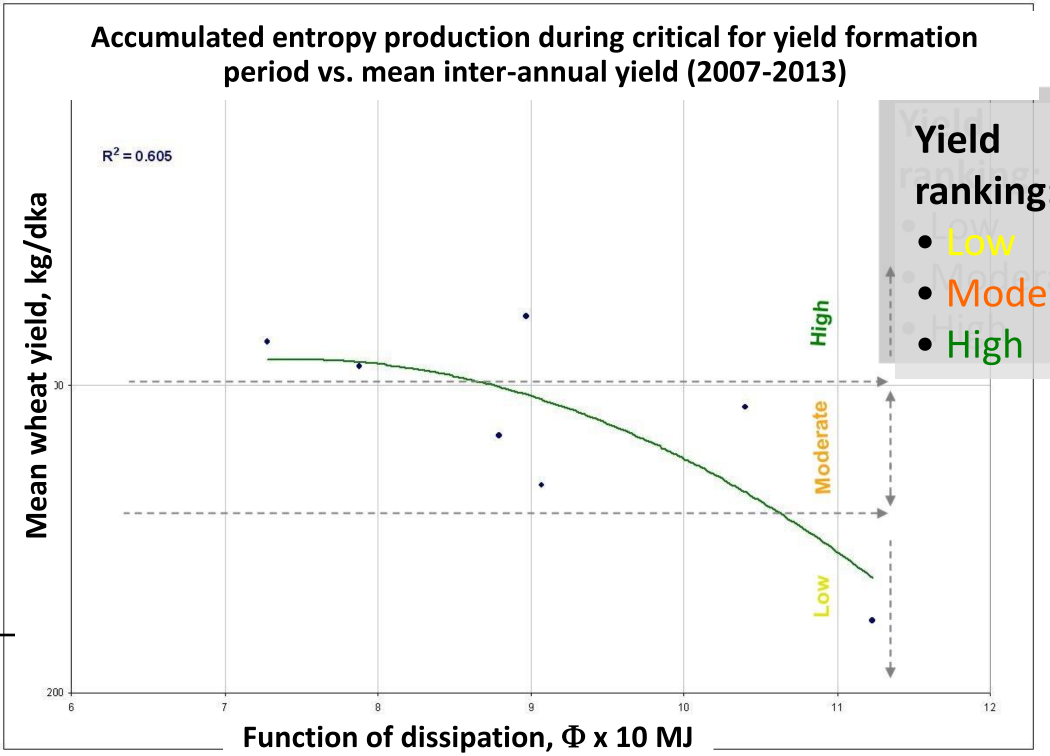
(Stoyanova, 1985;1996; 2014)

Climatic (bioenergetic) resources and entropy production quantification:

$$\Phi = T\frac{\Delta_i S}{\Delta t} = \frac{H\Delta T}{T\Delta t} + LE\frac{\Delta q}{\Delta t} \qquad (1)$$

• Analytical description of the relation between bioenergetic resources & yield production.

• Scaling climatic resources towards yield production: “High”, “Moderate”, “Low”.



Yield ranking:

- Low
- Moderate
- High

Climatic bioenergetic recourses versus mean country yield (winter wheat)* production in Bulgaria, **NIMH agro database yield estimates*.

- **Yield Forecast 2014 - Moderate**
- **Yield Assessed 2014 - Moderate**

/Ministry of Food and Agriculture/

Application # 2:
Thermodynamic model:
Climatic bioenergetic resources & Yield prediction

Alert
Risk of yield reduction

- Second Law of Thermodynamics & Ecosystem functioning *(Surface-Boundary approach in biothermodynamics, Florov, 1983; 1988; 2002).*

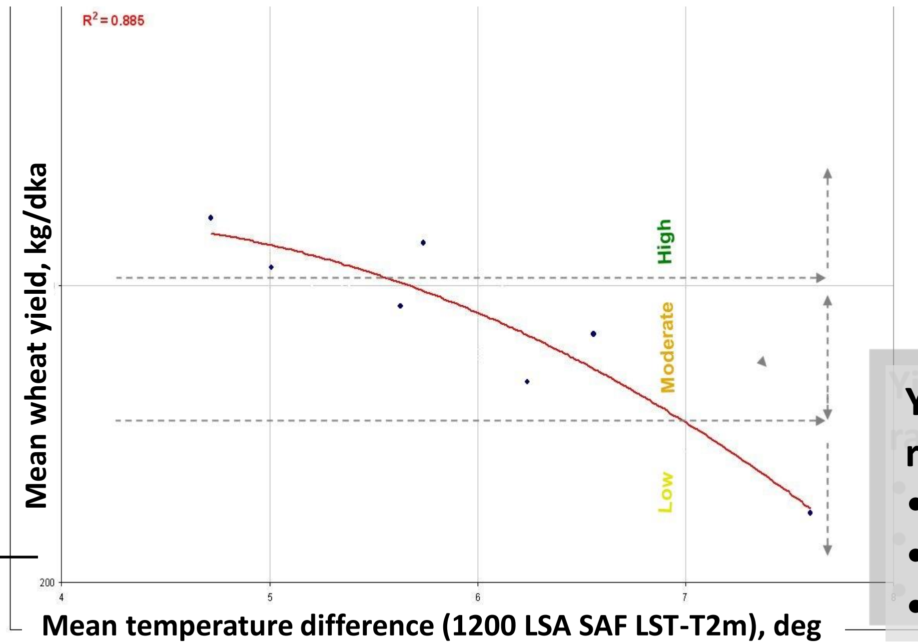
Climatic (bioenergetic) resources and entropy production quantification:

$$\Phi = T\frac{\Delta_i S}{\Delta t} = \frac{H\Delta T}{T\Delta t} + LE\frac{\Delta q}{\Delta t} \qquad (1)$$

- Analytical description of the relation between bioenergetic resources & yield production.
- Scaling climatic resources towards yield production: "High", "Moderate", "Low".

(MSG LST-T2m) difference used as a first proxy of the entropy production, Φ (Eq. 1) *(Stoyanova, 1985;1996; 2014)*

Mean temperature difference (MSG LST-Tair) during critical for yield formation period vs. mean inter-annual yield(2007-2013)



Yield ranking:
- Low
- Moderate
- High

(MSG LST-T2m) difference vs. mean country yield (winter wheat*) production in Bulgaria, **NIMH agro database yield estimates.*

- **Yield Forecast 2014 - Moderate**
- **Yield Assessed 2014 - Moderate**

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User needs: LE, H

Application # 3:
MSG data in support to assessment of climatic resources

b) Drought and fire risk

Heat waves, land surface state (and human activities) → fire risk and probability to fire occurrence and spread.

↓

- Fire Risk Module as a part of the Drought Warning System, DWS

Stage 1: Development of a specific Fire Module of the Drought Alert System

- Use of LSA SAF Fire Risk Map **jointly** with a local fire risk map based on (LSA SAF LST –T2m) difference.
- Seasonal classification of synoptic scale fire weather systems.

Stage 2: Regional applications for the territory of Bulgaria.

Stage 1: Development of a specific Fire Module of the Drought Alert System

Source: Satellite data & NWP output

'LST FRI' — 'Land Surface Temperature Fire Risk Index'

the difference between the skin surface temperature characterised by the LSA SAF LST product and air temperature at 2 m height :

(LST FRI) = (MSG LSA SAF LST- T2m)

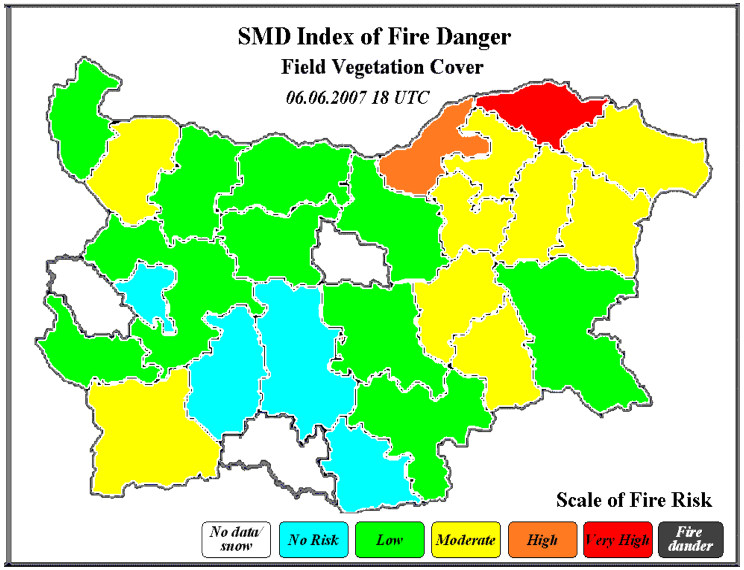
- Quantitative comparison: 'LST FRI' and SMDIFD
- Threshold scheme: site-scale (April-Sep; *7-years dataset, 2007- 2014; the region of each one of the synoptic stations at variety of specific microclimates).*
- **Three levels of fire risk estimates: High fire risk – Moderate fire risk – Low fire risk**
- Individual thresholds of 'LST FRI' for definition of fire risk for each month & microclimate are derived.

Thresholds definition:

Meteorological model output

Site-scale Soil Moisture Deficit Index for Fire Danger/ SMDIFD/:

- **SMDIFD** - assessment of critical soil-moisture deficit leading to fuel dryness and fire risk.
- Soil moisture deficit resulting from the misbalance between input (precipitations) and looses (PET/AET, energy balance derived).
- Developed for operational use - issued twice per day for the synoptic network of NIMH Bulgaria - through color-coded maps.

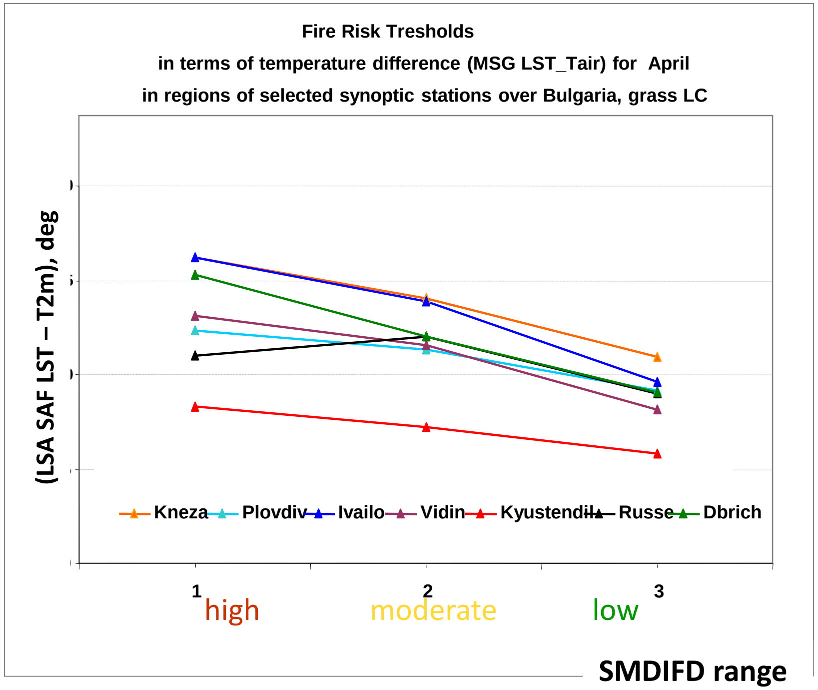


Classes of fire danger are selected according to the soil moisture deficiency.

Individual thresholds of ‘LST FRI’ for definition of fire risk for each month & microclimate are derived.

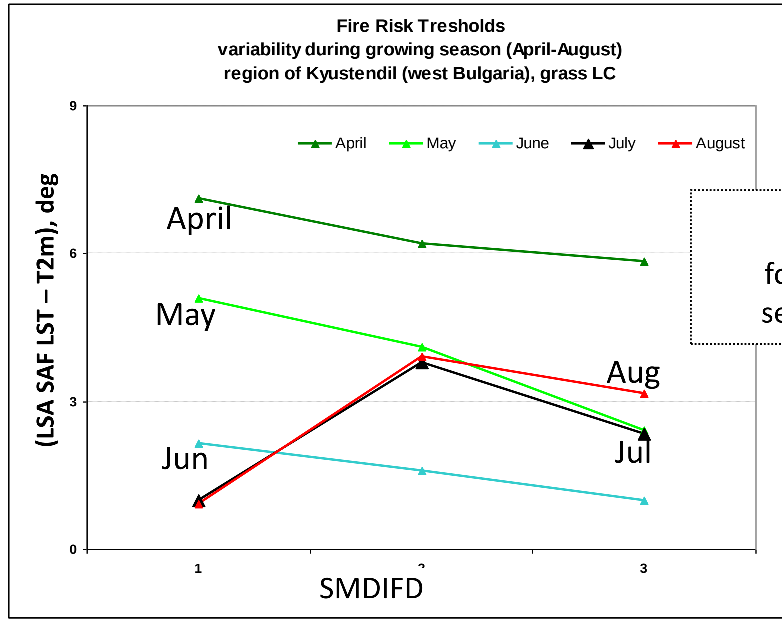
Fire risk threshold monthly definition

Example: selected regions (stations) over Bulgaria, April



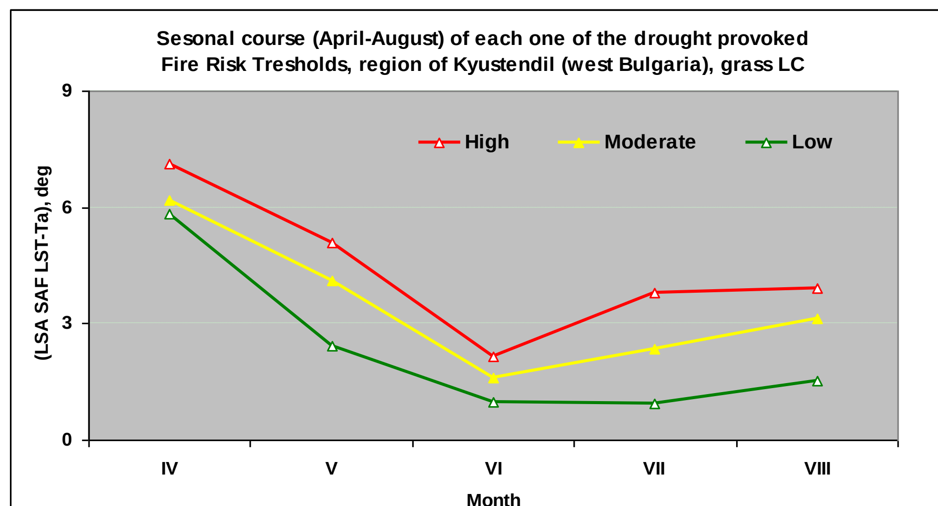
Decreased SMDIFD range (indicating ascending soil moisture deficit) is associated with an increased temperature difference values.

- **Statistical analyses show different monthly mean (MSG LST-T2m) threshold levels for fire risk (April-August period).**

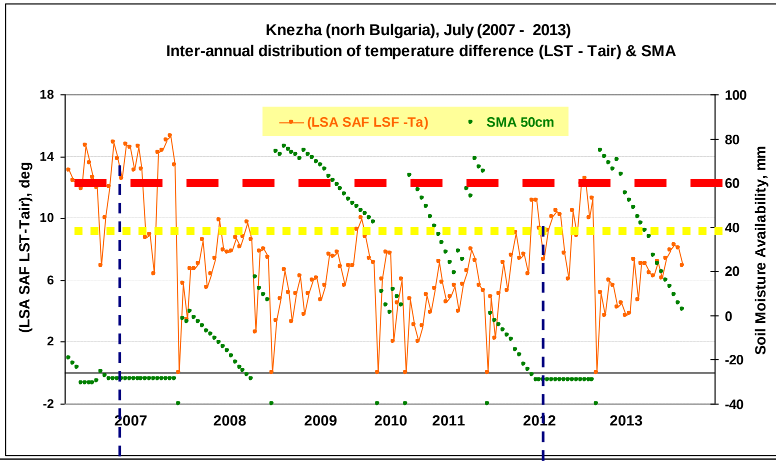


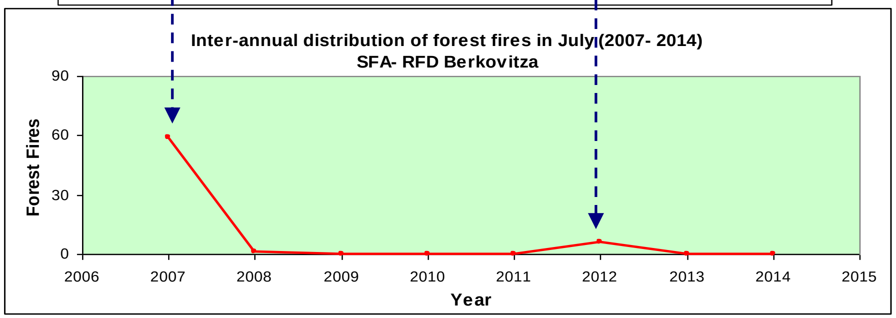
The thresholds follow a definite seasonal course.

Seasonal course of (MSG LST-T2m) thresholds of fire risk during (April-Aug)



Behavior of LST Fire Risk Index Example



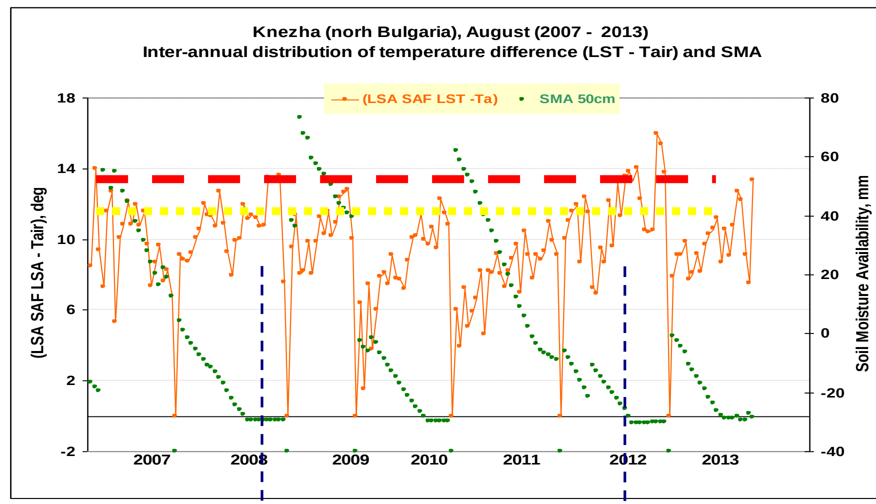


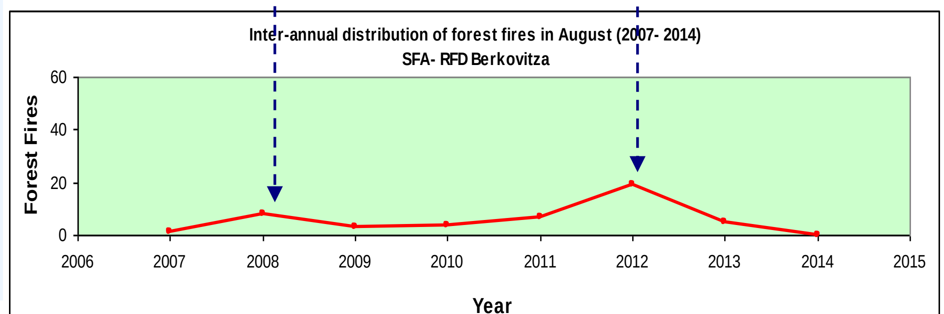
The region of Kneza is one of the ‘dry’ regions in Bulgaria with high temperature anomalies in summer/winter.

The course of July & August of SMD **(green dots)** are compared with

- The course of the (LSA SAF LST-T2m) temperature differences **(orange line)**, accounting for temperature thresholds of **‘High’ (red dashed)** and **‘Moderate’** (yellow dashed) fire risk.
- The inter annual distribution of forest fires in July & August **(red solid line)** on the corresponding second graphs.

- Maximum fire activity in July 2007 & 2012 match with the periods with increased above the (LST-T2m) thresholds of ‘High’ (2007) & “Moderate” (2012) fire risk, along with the corresponding high levels of SMD (Soil Moisture Deficit).
- For August the maximum fire activity is in 2012 when the “yellow” threshold of moderate fire risk is exceeded. In all other years the (LST-T2m) values show existing but not deep SMD of **“Low”** fire risk and the fire activity is much less than this for July 2017.
- There is a good match between the course of LST FRI and forest fires distribution in the corresponding Forest Estate.

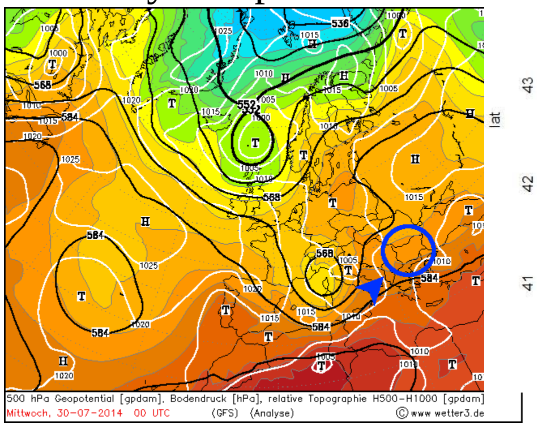




The Fire module:
Considering both ‘LST FRI’ and LSA SAF FRM to asses the risk of fire ignition as well as the risk of fire spread

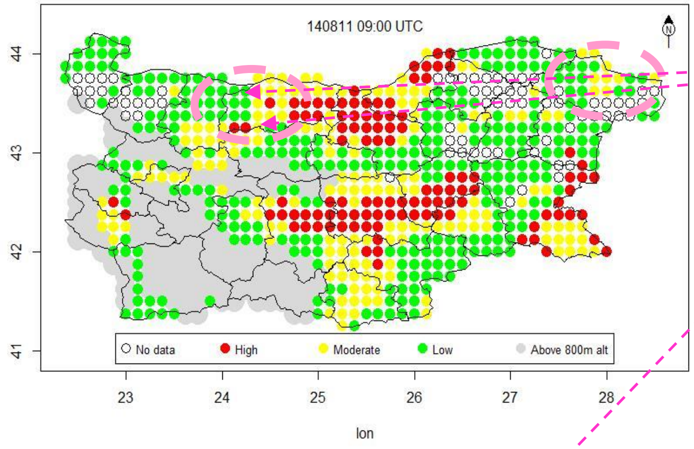
Case study: 30 July 2014

Synoptic analyses:
anticyclonic curvature, but relatively low pressure



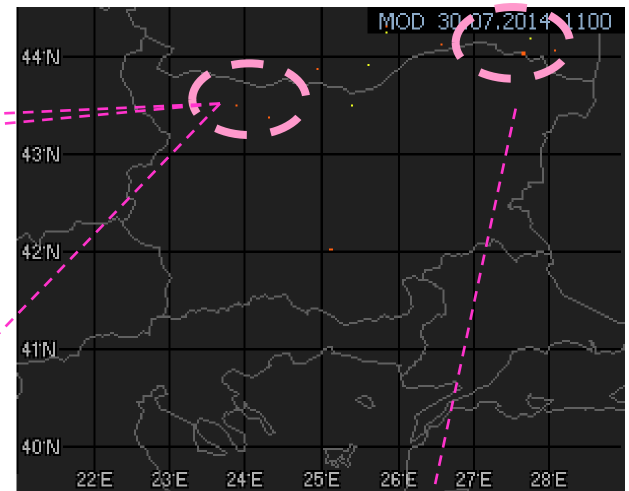
SPA – negative STA - positive

‘LST FRI’ map:



55 % confidence

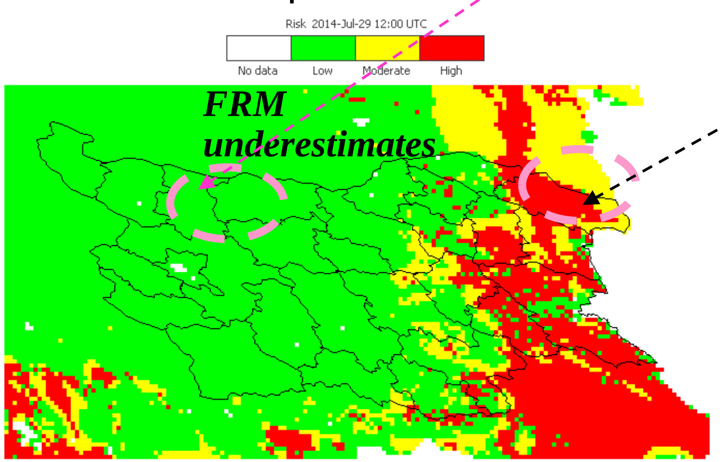
• **MODIS detect thermal anomaly**



82 % confidence

‘LST FRI’: Moderate risk of fire ignition
FRM: Low risk for fire spread

LSA SAF FRM product:



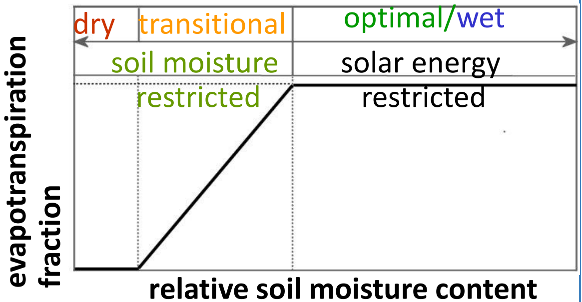
Moderate risk of fire ignition
High risk for fire spread

Application # 4:
MSG data in support to ‘fuel’ dryness diagnoses & risk of fire ignition

Classification of regional (bio)climates, PFTs concept:

1) Modeling of the coupling between climate and (potential) forest cover types. Regional Forest Functional Types, FFTs discrimination.

• Coupling between soil moisture and evapotranspiration *(Budyko (1956; 1974).*



• The biogeographycal zonation of global vegetation distribution made by *Budyko (1956; 1974).*

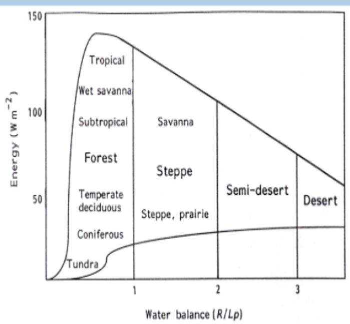


Figure 16.3 The ordination for biogeographical zones as defined by the energy balance (R, W m^{-2}) and the relative dryness index (R/LP, L = the latent heat of evaporation, P = annual precipitation) and the delineations of the major biogeographical zones (Budyko 1986)

2) Use of satellite information to discriminate FFTs properties.

Climatic concept for regional biome distribution

Land Cover (Forest Vegetation) Classification

Developed regional static bioclimatic equilibrium model

over Bulgaria

• The PFTs on a regional scale are defined.

• Bi-dimentional scheme: **the potential evapotranspiration of vegetation cover during the growing season – aridity index of Budyko.**

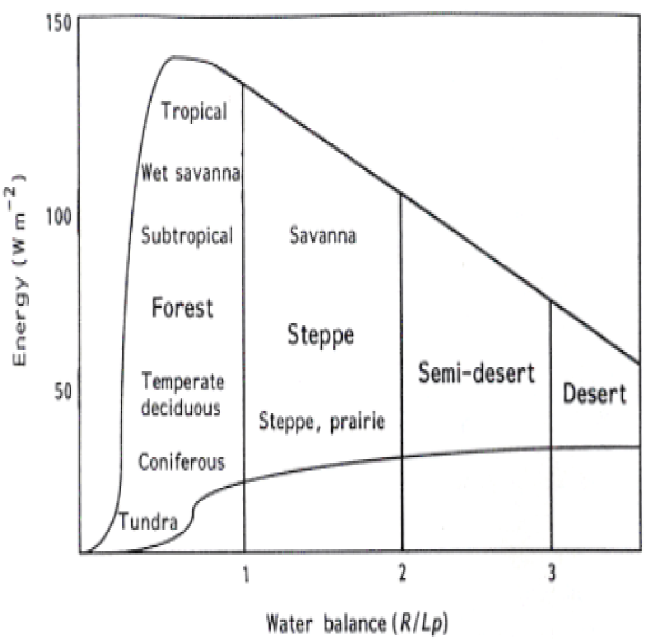
• They both are climatological approximations of vegetated land surface heat- and water- balances.

• The main FFTs over a selected target region of S-SE Bulgaria are discriminated. These are three native **regional Forest-PFTs** with **different functional and structural properties.**

(Stoyanova, 2007)

Global Vegetation Distribution biogeographical zonality

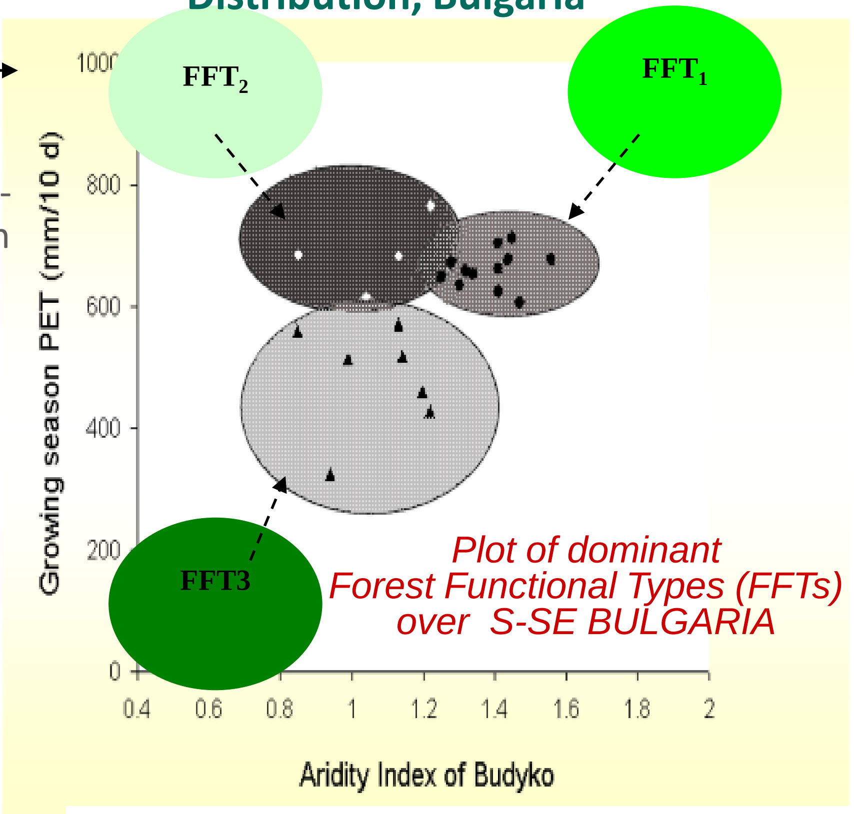
(Budyko, 1956; 1974)



Global vegetation distribution

Bi-dimensional framework of zonality in climate-vegetation pattern

Regional Classification of Vegetation Distribution, Bulgaria



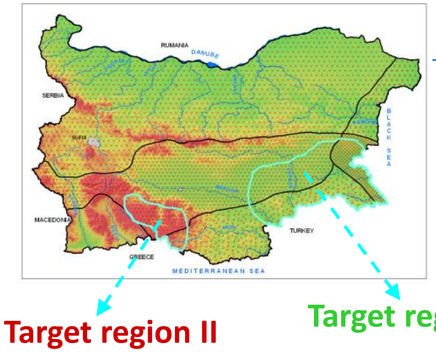
Plot of dominant Forest Functional Types (FFTs) over S-SE Bulgaria *(Stoyanova, 2007)*.

- Relation between the Energy, Rn and Water Budget:

$$\frac{E_o}{P} = \Phi\left(\frac{R_n}{LP}\right)$$

Budyko's Radiative Aridity Index, β.

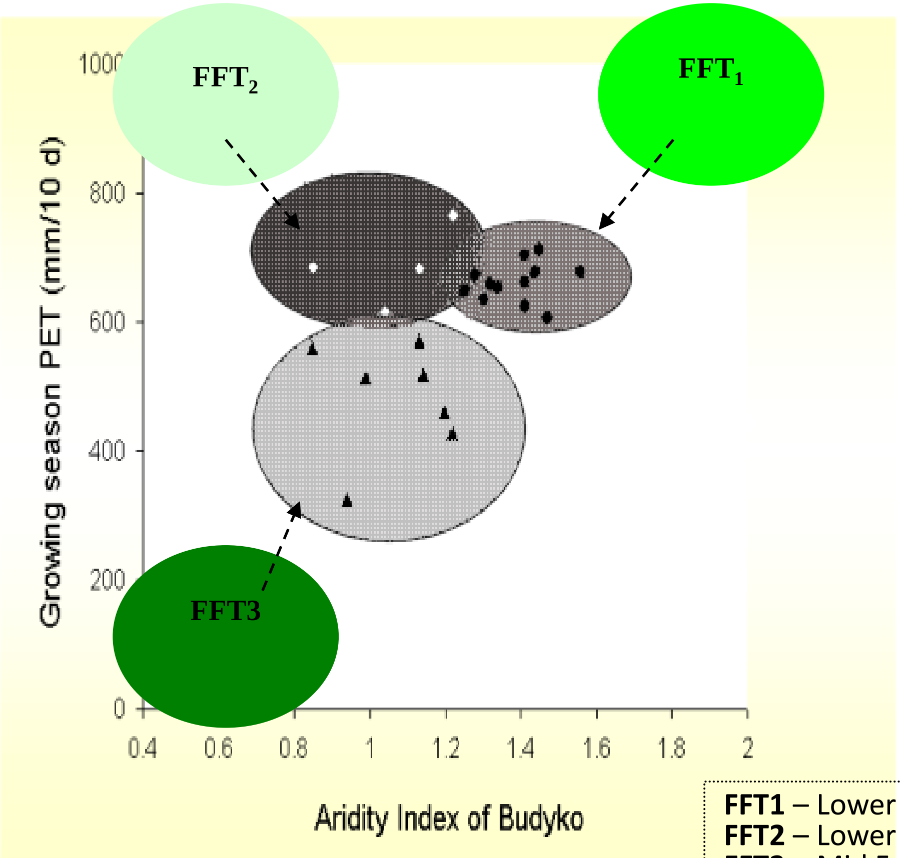
where: Rn canopy radiation balance, Eo – potential evapotranspiration, P – accumulated precipitation, L - latent heat of evapotranspiration.



Application: two selected target regions for the study.

REGIONAL SCALE BIOCLIMATIC MODELING

Biome Distribution Conceptual Model – Plant Functional Types



Plot of dominant Forest Functional Types (FFTs) over SE Bulgaria *(Stoyanova, 2007)*.

Coupling between soil moisture and evapotranspiration on a climatic scale:

1) Pattern of forest types as a function of regional climate is derived.

2) Regional PFTs identification as seen by LSA SAF products

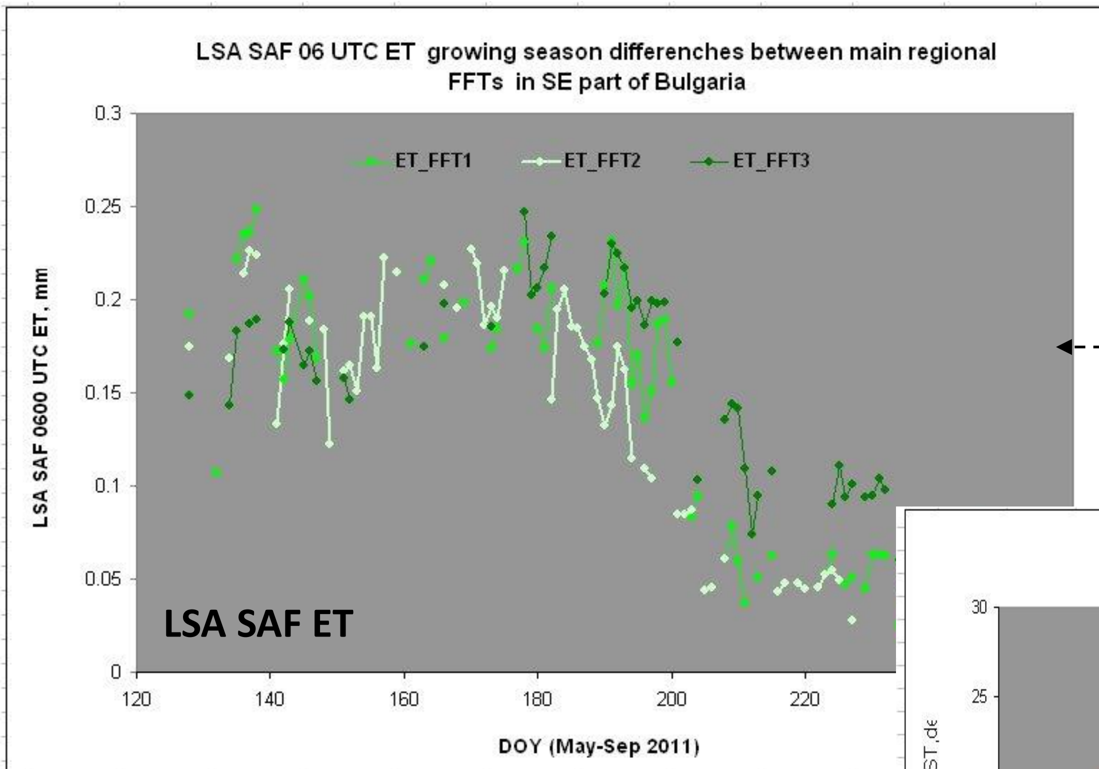
The discriminated regional FFTs are characterised by their functional and structural properties, as seen LSA SAF products based on MSG satellite information.

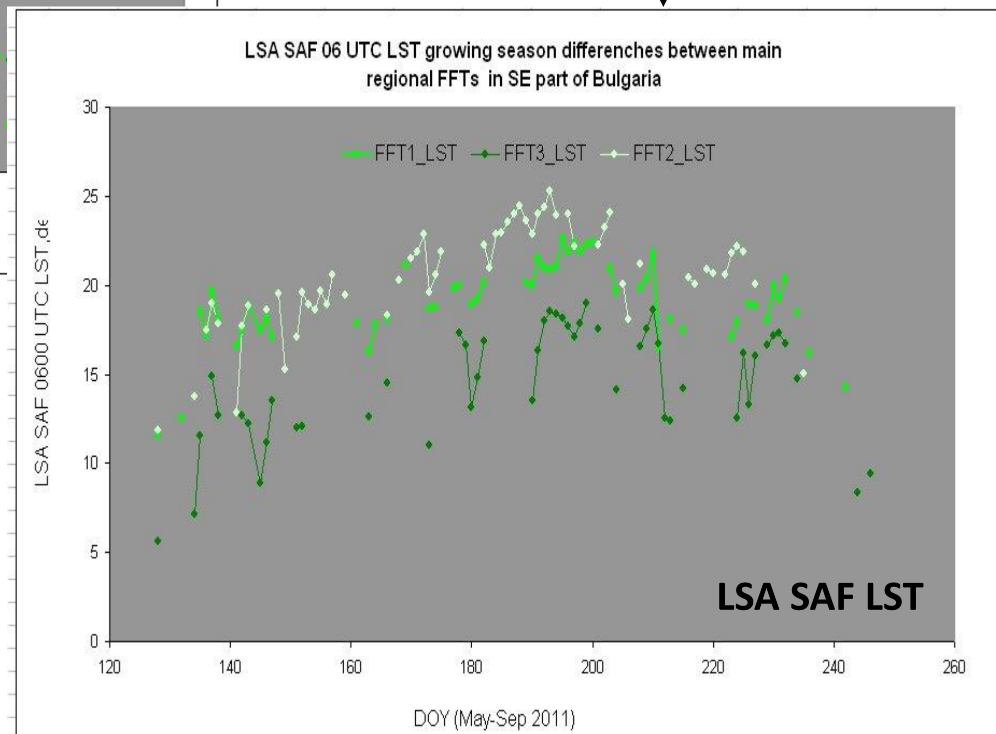
FFT1 – Lower Forest Belt *Xeromesophytes, broadleved*
FFT2 – Lower Forest Belt *Xerophytes, open deciduous, shrubs*
FFT3 – Mid Forest Belt *Native coniferous evergreen*

Bioclimatic schemes are based on knowledge of climatic regimes that prevails in a region and consideration that both vegetation physiognomy and species composition are functions of climate (following the observations).

c) Regional scale FFTs: Functional properties as seen by LSA SAF products

LSA SAF products provide a set of tools for discrimination of FFTs ecophysiological properties/ physico-geographycal location.





- **LSA SAF ET**

→ higher in May, June – decreasing in July – lower in August /FFT1; FFT2/ compared with coniferous ET /FFT3/.
→ ET of FF1 ‘humid’ – higher than ET of ‘dry’ FF2 broadleaved.

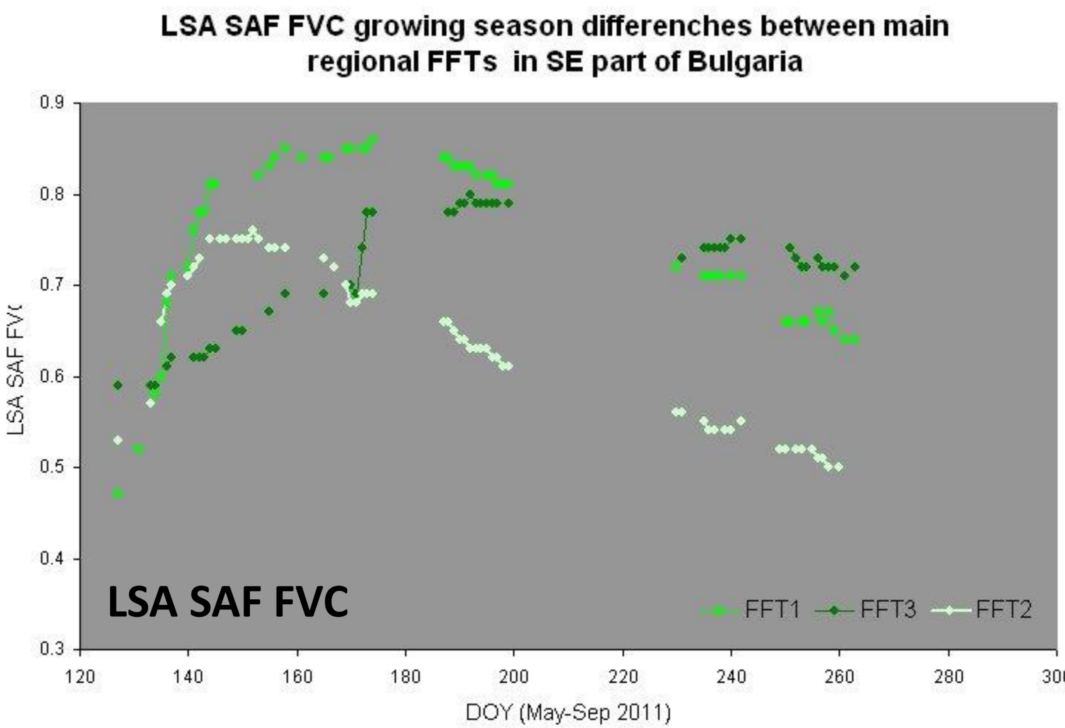
- **LSA SAF LST**

→ Broadleaved FFT1; FFT2 – higher LST compared to the Coniferous FFT3.
→ LST exhibits seasonal course.

FFT1 – Lower Forest Belt *Xeromesophytes, broadleved*
FFT2 – Lower Forest Belt *Xerophytes, open deciduous, shrubs*
FFT3 – Mid Forest Belt *Native coniferous evergreen*

Example: Dynamics (May-September 2011) of functional properties of regional FFTs (FFT1 at 41.96N 27.58E; FFT2 at 41.505N 25.78E; FFT3 at 41.7N 24.7E) as seen by MSG SEVIRI: (a) 06 UTC LSA SAF ET; (b) 06 UTC LSA SAF LST *(Stoyanova, 2012).*

c) Regional scale FFTs: Structural properties as seen by LSA SAF products



Example: **Dynamics (May-September 2011) of structural properties of regional FFTs** (FFT1 at 41.96N 27.58E; FFT2 at 41.505N 25.78E; FFT3 at 41.7N 24.7E) as seen by MSG SEVIRI: LSA SAF FVC.

FFT1 – Lower Forest Belt *Xeromesophytes, broadleved*
FFT2 – Lower Forest Belt *Xerophytes, open deciduous, shrubs*
FFT3 – Mid Forest Belt *Native coniferous evergreen*

- **LSA SAF FVC**

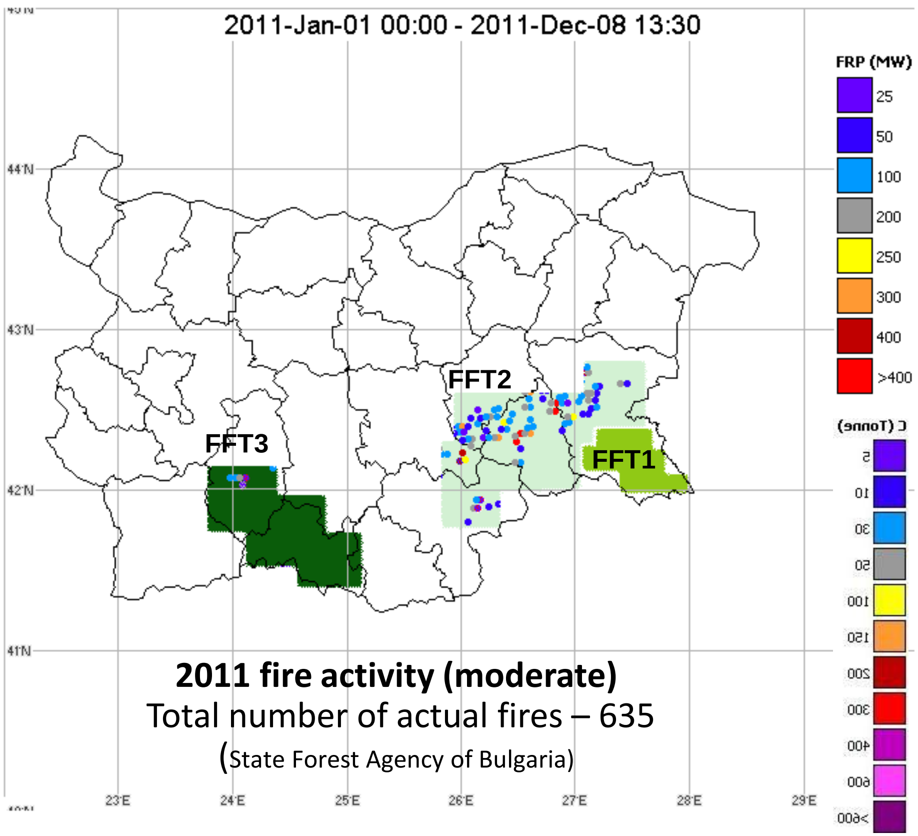
→ exhibit seasonal course for all FFTs,

→ consistent with the broadleaved/ coniferous ecophysiology and

→ reflects 'dry'/'wet' stands environment FFT2/FFT1.

Application # 5:
LSA SAF products in support to identify regional FFTs distribution

d) Regional Ecosystem Types and fire activity



- **BIOMASS BURNING PATTERN & REGIONAL PFTs**

Climate-forest-fire pattern:

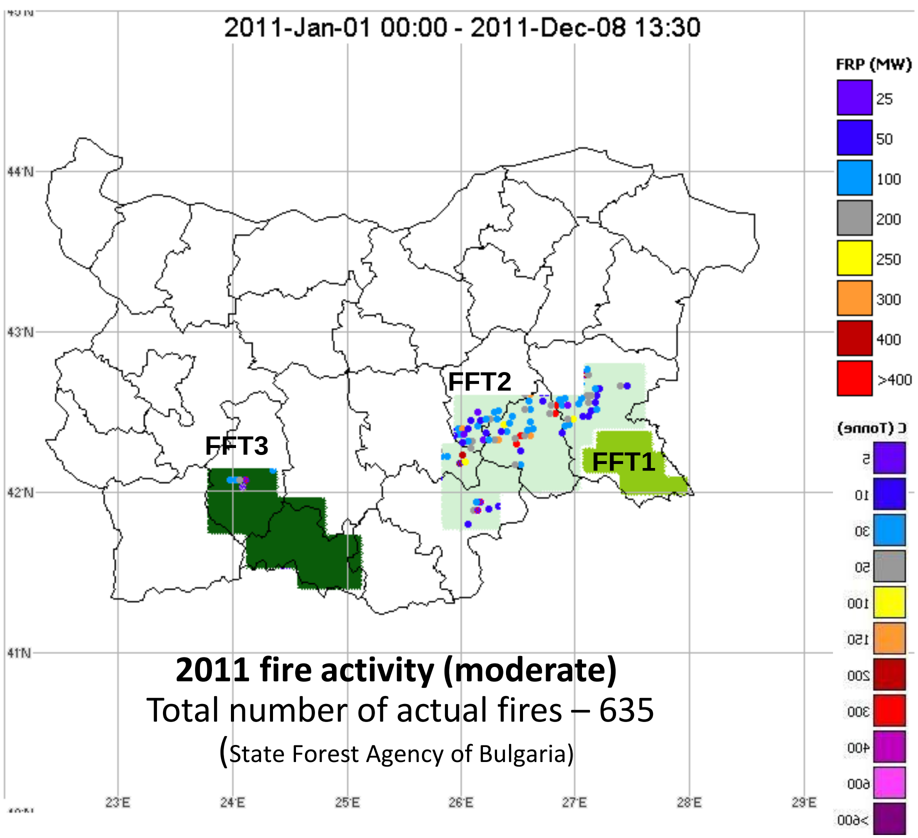
/MSG LSA SAF FRP, *Wooster et.al., 2005; Govarets et al., 2010*/:

- fire activity,
- radiative effects of biomass burning.

Drought stress and high temperature favor wild fire occurrence.

Fire activity varies among different bioclimates, */Stoyanova, 2012/.*

d) Regional Ecosystem Types and fire activity



- **BIOMASS BURNING PATTERN & REGIONAL PFTs** */Stoyanova, 2012/*

Accumulated effects and static fire risk during 2011 ('moderate' fire activity according to the Bulgarian SFA database, 635 forest fires).
Evaluation: on the basis of LSA SAF FRP product.

2011	Total FRE (MWatt)	Carbon Eq. (kg)	Forest fires, SFA
FFT 1	0	0	1
FFT 2	13697.3	2118572	18
FFT 3	2111.3	326555	5

(Stoyanova, 2012)

- MSG FRE estimates can reveal climatic influence on both: fire activity and feedbacks at a regional scale.
- A step in ranking natural forest cover regarding susceptibility to fire ignition and spread on a regional climatic scale can be made.

Application # 6:
Regional bioclimatic control on fire activity and biomass burning effects

4th SALGEE 2015 Workshop

"MSG Land Surface Applications: Drought and Environmental Response"