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AGROMETEOROLOGICAL INDICES, PRODUCTS AND REMOTE SENSING PRODUCTS USED IN ROMANIAN DROUGHT MONITORING SYSTEM

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National Meteorological Administration
ROMANIA

Training course on the use of satellite products for drought monitoring and agricultural meteorology applications

Budapest, Hungary
24 - 28 April 2017

CONTENT

1. National Meteorological Administration and Laboratory of Agrometeorogy, Romania

► National Meteorological Administration is the national authority in the meteorological field in Romania, with a continous service since 1884. NMA is subordinated to the Ministry of Environment and Forests (MEF), functioning on the basis of Law 216/2004.

► The National Meteorological Observation Network within the NMA is made up of 7 Regional Meteorological Centres / RMC.

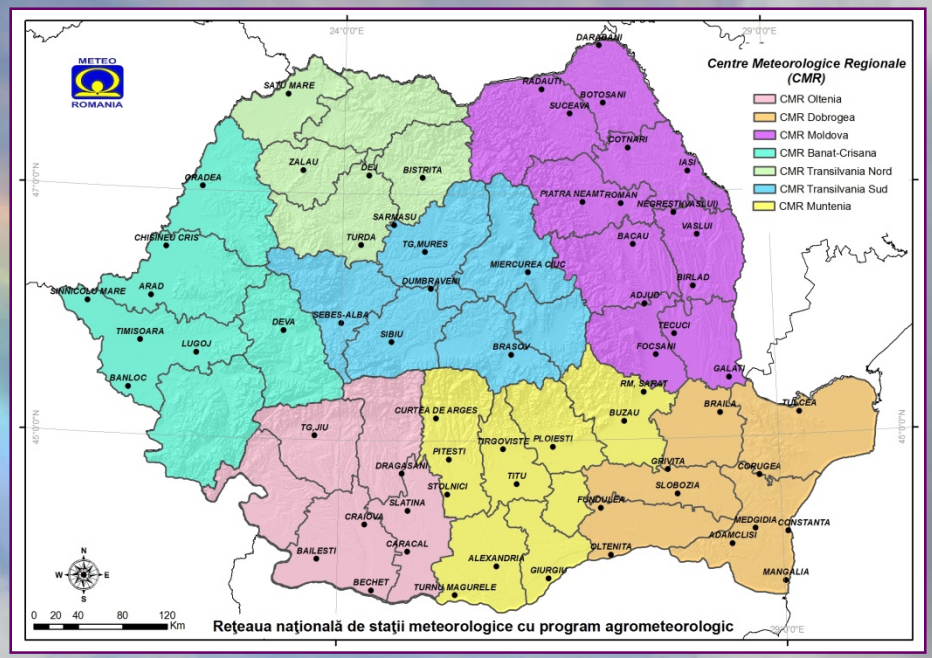
► Romania is a founding member of the International Meteorological Organization (IMO), and beginning with 1948 it has become a full member of the World Meteorological Organization (WMO).

http://www.meteoromania.ro/

National Meteorological Observation Network of Romania

- 7 Regional Meteorological Centres;
- 159 weather meteorological stations, 126 being automatic (MAWS);
- 66 weather stations integrating a special program of agrometeorological measurements – soil moisture and phenological data (winter wheat, maize, sunflower, rape, fruit trees and vineyards.

METEOROLOGICAL NETWORK



AGROMETEOROLOGICAL NETWORK

► Laboratory of Agrometeorology of NMA

develops specialized products such as:

1. Basic products:
-weekly, monthly and seasonal agrometeorological diagnoses/forecasts
-agrometeorological dedicated reports

2. Specialized products (i.e. maps):

► parameters and maps of thermal vulnerability and risks at sub-regional level (temperature, sunstroke, tropical nights, hot days, etc);
► parameters of water stress at regional and sub-regional level (rainfall, ETP, atmospheric relative humidity, soil water shortage, precipitation deficit, etc);
► aridity indices (standardized at full network level).

The weekly Agrometeorological Bulletin includes the specific information (air temperature, rainfall, ETP, soil moisture, crop water requirement) needed for assessment of drought occurrence. This data collected from the National Observation Network is analyzed and compared with the critical thresholds in order to evaluate the threat and make recommendations to decision-makers and farmers.

Also, the soil moisture maps, weekly agrometeorological informations and seasonal forecasts which are updated daily according with the flow operational activity are free on the NMA web-page (http://www.meteoromania.ro/) for informational and decisional purpose in terms of technological measures that can be applied in drought conditions.

► Laboratory of Agrometeorology of NMA

The meteorological data (from synoptic meteorological database / ORACLE) processing and interpretation are made using specific applications, such as AGRO-SYNOP, AGROSERV and AGRO-TEMPSOL. The agrometeorological data represent specialized information coming from the network's weather stations with agrometeorological programme, representative for areas of agricultural interest in Romania.

- This information is corroborated with in-situ measurements of soil moisture and field observations of crop development stage and apparition of water stress to plants. After the information is collected and transmitted to NMA Centre in Bucharest, soil water balance is computed the crops water requirements and water stress are analyzed in order to assess the available water resources for crops.

- During a crop year are developed an average of 166 specialized maps that show zoning agrometeorological parameters (air and soil temperature, precipitation, soil moisture reserve, vegetation indices, etc.) for the entire agricultural area of the country.

Soil Moisture in-situ measurements and GIS techniques

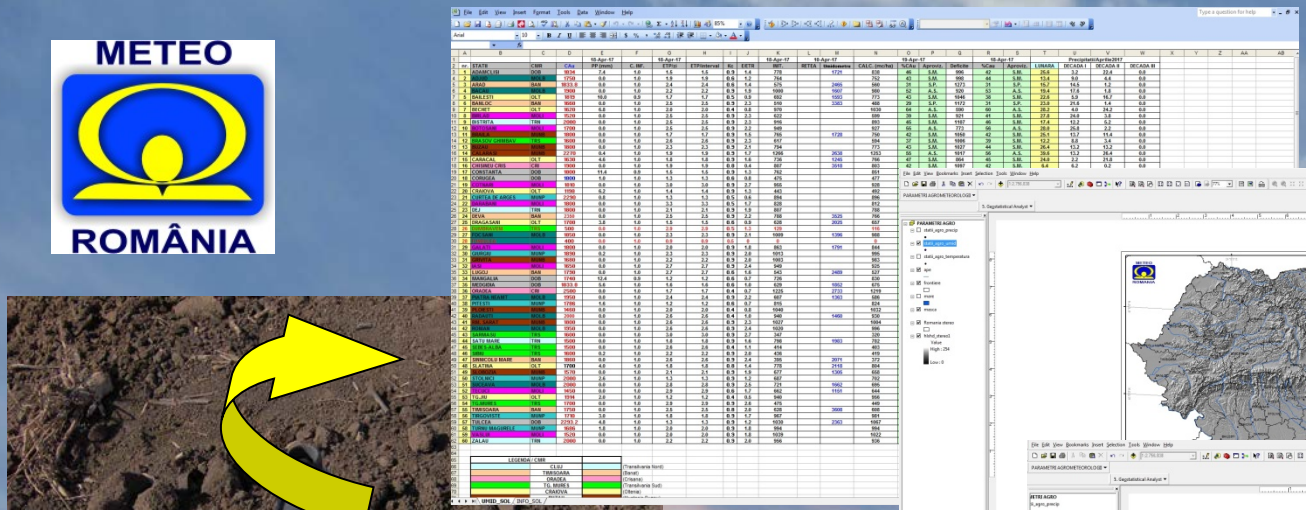
- During 2004 till present, the agrometeorological network was modernized, being endowed with specialized equipment such as 66 portable soil moisture measuring systems, in order to perform a current monitoring of the soil moisture reserves throughout the crops' active vegetation period (March-November).

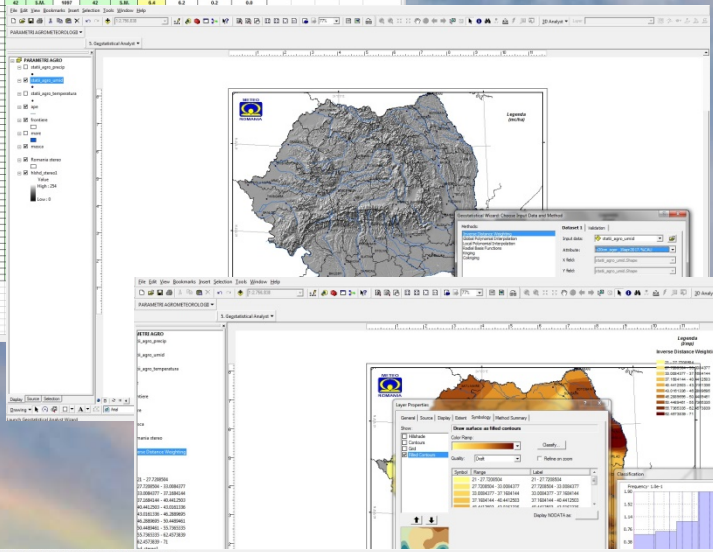
- The quantity of supplied water in soil is directly determined using the sensors in different observation points (agrometeorological platforms) representative for agriculture. The data collection is made every 10 days at the level of the Meteorological Services, by the agrometeorological specialists in the network, then transmitted via computer using the new "SYSTEM SOFTWARE AGROMETEO" to the Laboratory of Agrometeorology in order to carry out maps regarding the reserve (mc/ha) accessible to winter wheat and maize plants, at calendar dates of agricultural interest and at different soil depths (0-20 cm, 0-50 cm and 0-100 cm).

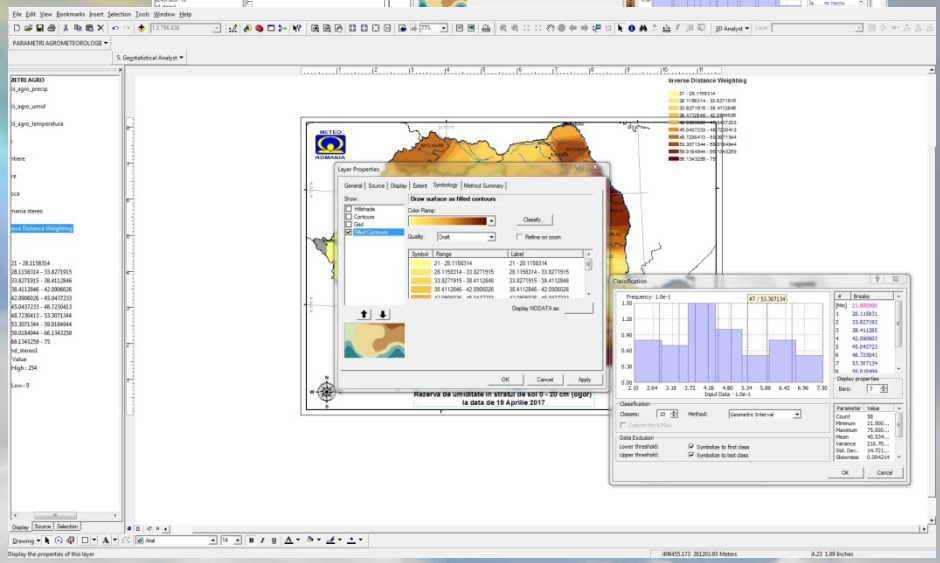
- The "Application for spatial representation (GIS) of agrometeorological parameters" included the air and soil temperature, precipitation and soil moisture modules.

METEO ROMÂNIA

MODULE Soil moisture







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2. Agrometeorological indices used in Romanian drought monitoring system

❖ Drought is a complex phenomenon, characterized by insufficient moisture in the atmosphere and soil in the root system and growth potential evapotranspiration. It can be studied from several points of view, namely meteorological, hydrological, agrometeorological, economic, environmental, etc. Drought affects primarily vegetal cover natural and anthropogenic, as some of the most aggressive risk phenomena impact on living conditions and the environment.

❖ Causes the complex, some pertaining to the climate change, especially as regards southern Europe, where the trend has already been noticed for diminished precipitation, which leads to diminished accumulated water resources.

❖ Experiments carried-out with climatic models have shown that this situation will worsen in future, especially in the southern and south-eastern Europe, where the precipitation deficit will keep enhancing, in step with the global warming.

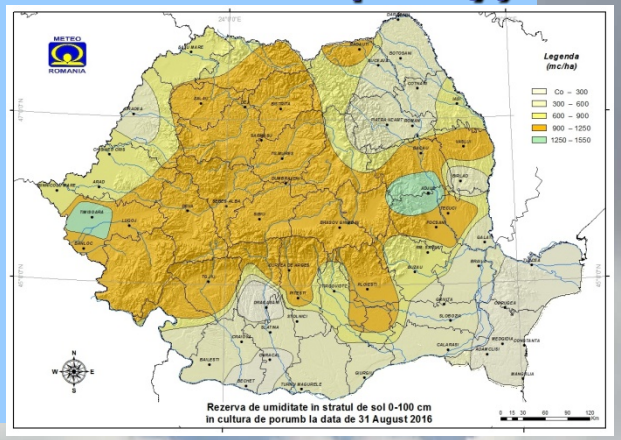
❖ Climate change predictions point to a warmer world within the next 50 years, yet the impact of rising temperatures on rainfall distribution patterns in much of the world remains far less certain

In agrometeorological operational activity using a number of parameters agrometeorological / agro-climatic risk / heat stress, atmospheric and hydrological that define, characterize and identify producing unique and / or complex agricultural drought.

An Agrometeorological indicator of water stress very important is the supply of the **soil moisture** available to the crops. Soil water supply express the degree of soil per plant about the water requirement of the crop in specific characteristic data and on different soil depths (0-20 cm, 0-50 cm and 0-100 cm) using a model of soil water balance.

► **Classes of the soil moisture / %AWC % (Avaible Water Capacity)**

Extreme pedological drought / 0-20%AWC;
Severe pedological drought / 20-35%AWC;
Moderate pedological drought / 35-50%AWC;
Satisfactory supply / 50-70%AWC;
Almost optimum supply / 70-85%AWC;
Optimal Supply / 85-100%AWC;
Excess supply / >100%AWC.



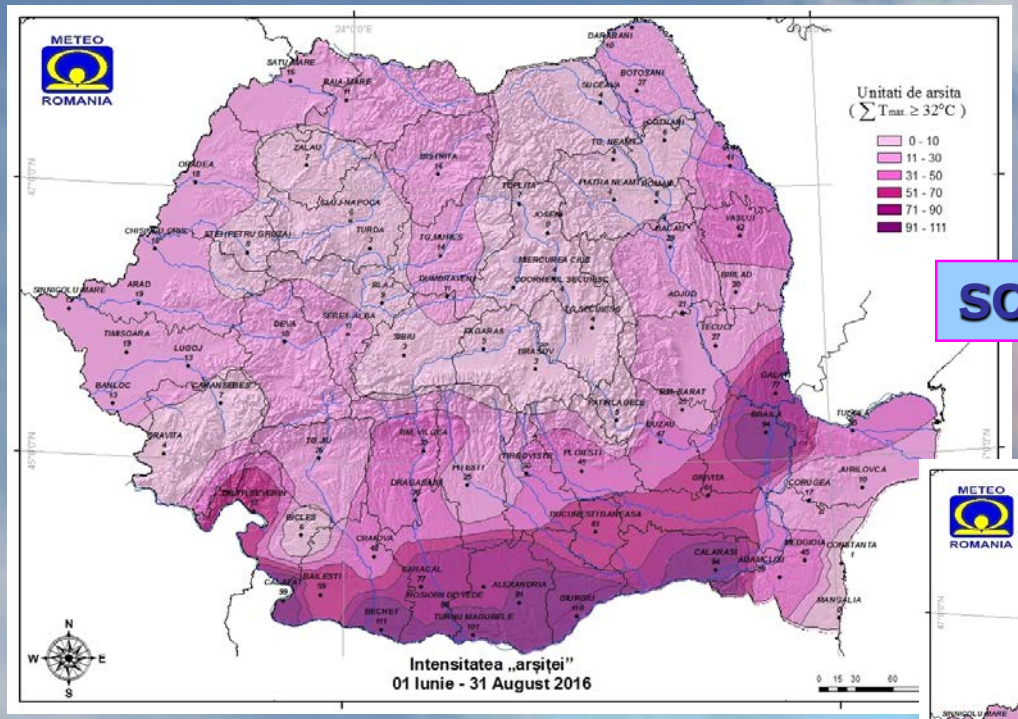
DROUGHT MONITORING SYSTEM IN ROMANIA

- Agrometeorological and climatic drought indices : heat stress, soil moisture, standardized precipitation evapotranspiration index, etc / **OPERATIONALLY ACTIVITY**

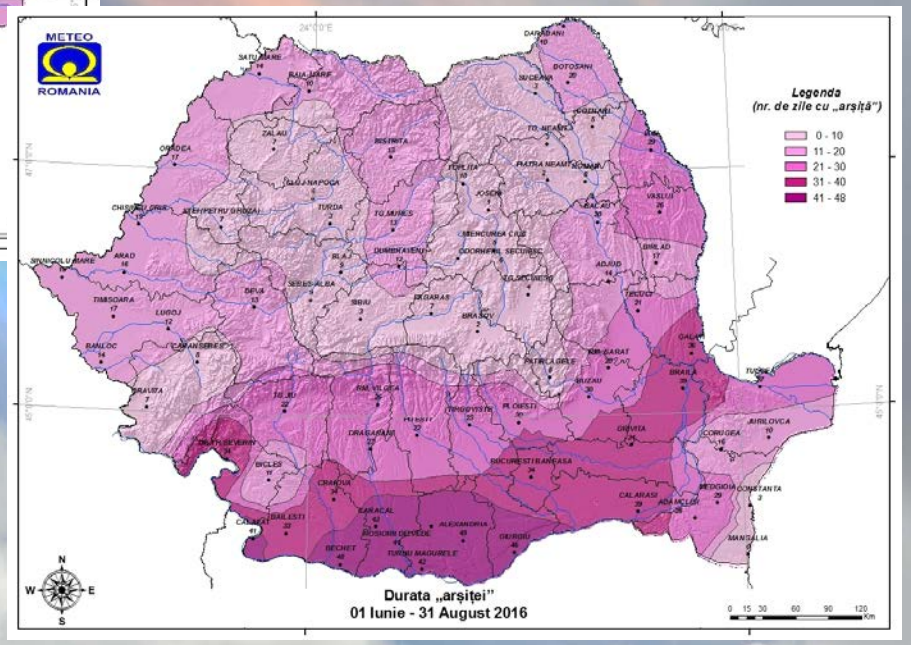
- Drought related-indices derived from remote sensing data / **OPERATIONALLY AND RESEARCH ACTIVITY**
  - LAI / Leaf Area Index
  - NDVI / Normalized Differences Vegetation Index
  - NDWI / Normalized Difference Water Index
  - NDDI / Normalized Difference Drought Index
  - fAPAR / Fraction of Absorbed Photosynthetically Active Radiation Index

- Drought indices / **RESEARCH ACTIVITY**
  - DVI / Drought Vulnerability Index
  - DROGHT-ADAPT – web platform

AGROMETEOROLOGICAL DROUGHT INDICATORS



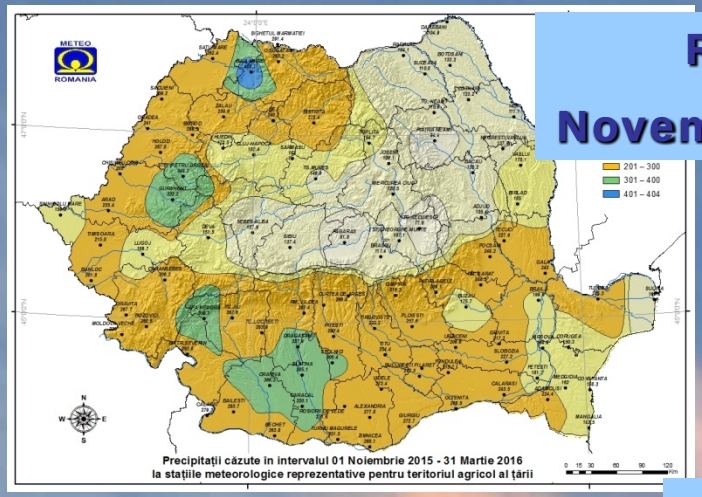
SCORCHING HEAT INTENSITY



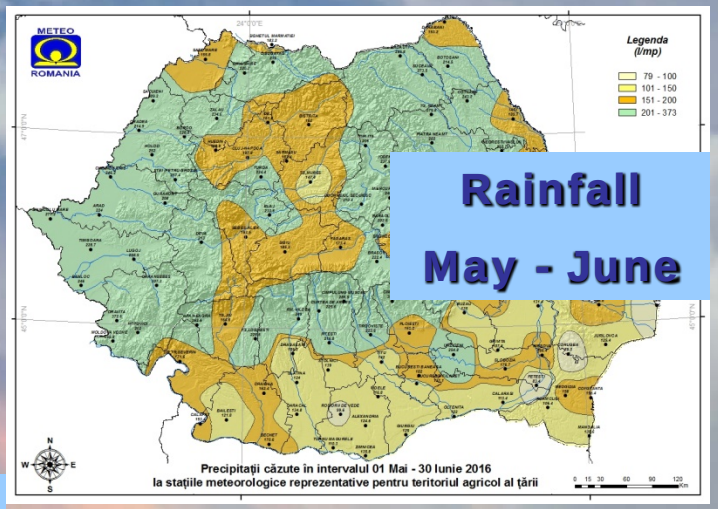
The intensity (sums of maximum temperatures =32°C) and duration (average number of days with maximum temperatures =32°C) of the heat phenomenon from June to August.

AGROMETEOROLOGICAL DROUGHT INDICATORS

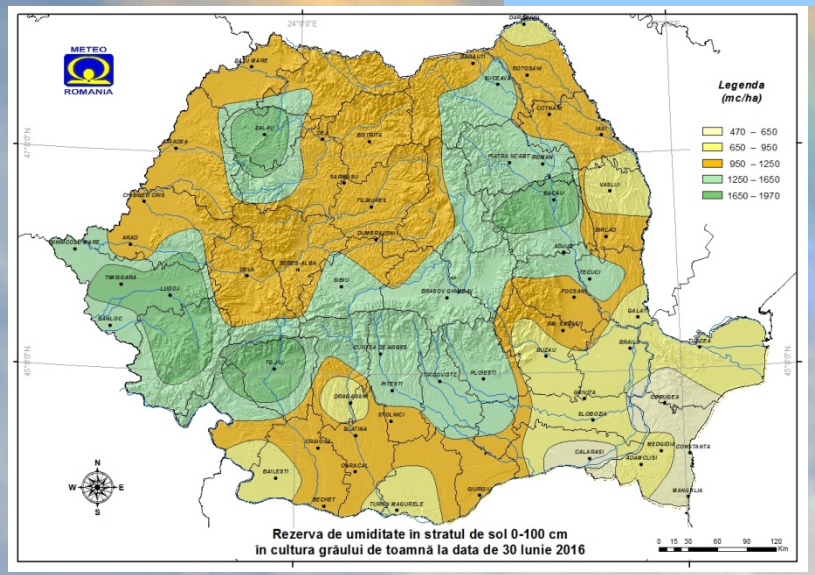
Rainfall
November - March



Rainfall
May - June



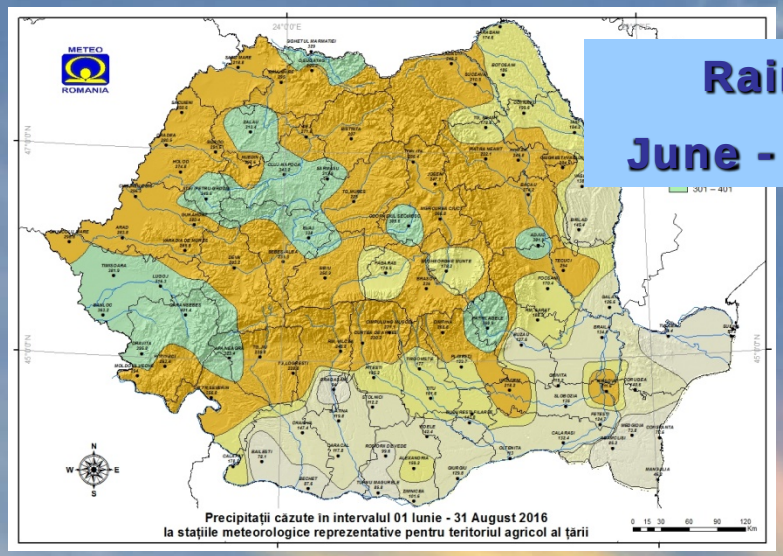
Winter wheat



SOIL MOISTURE RESERVE / JUNE 2016

- Strong pedological drought
- Moderate pedological drought
- Satisfactory supply
- Almost supply
- Optimal supply

AGROMETEOROLOGICAL DROUGHT INDICATORS



Rainfall

June - August

Strong pedological drought

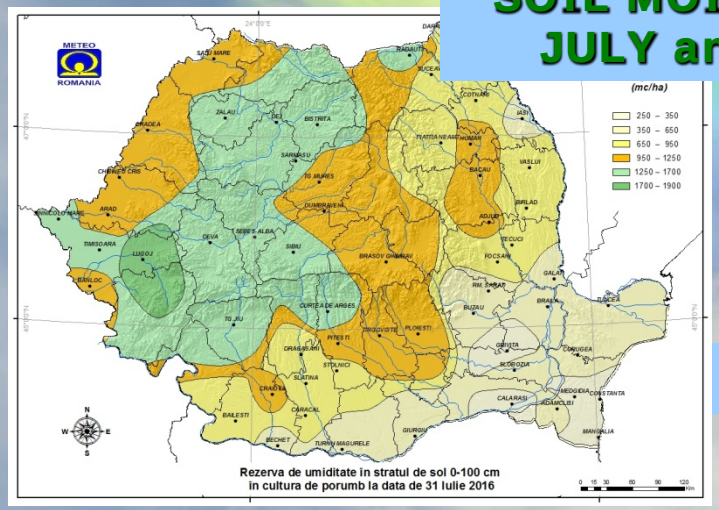
Moderate pedological drought

Satisfactory supply

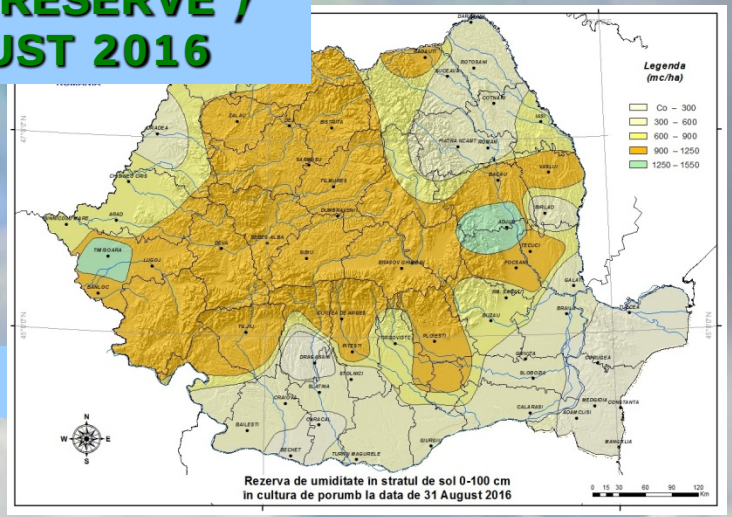
Almost supply

Optimal supply

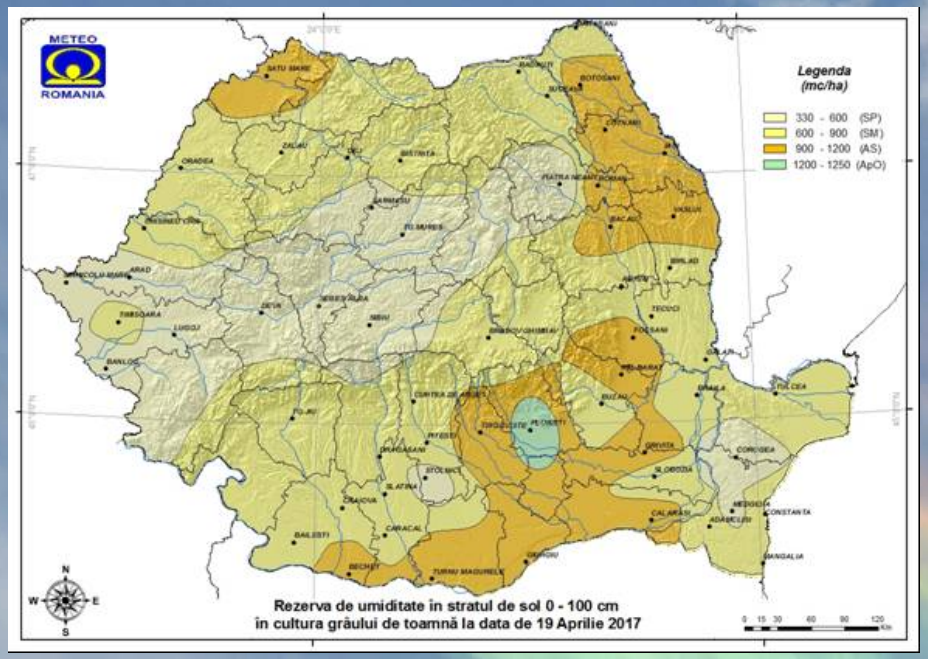
SOIL MOISTURE RESERVE / JULY and AUGUST 2016

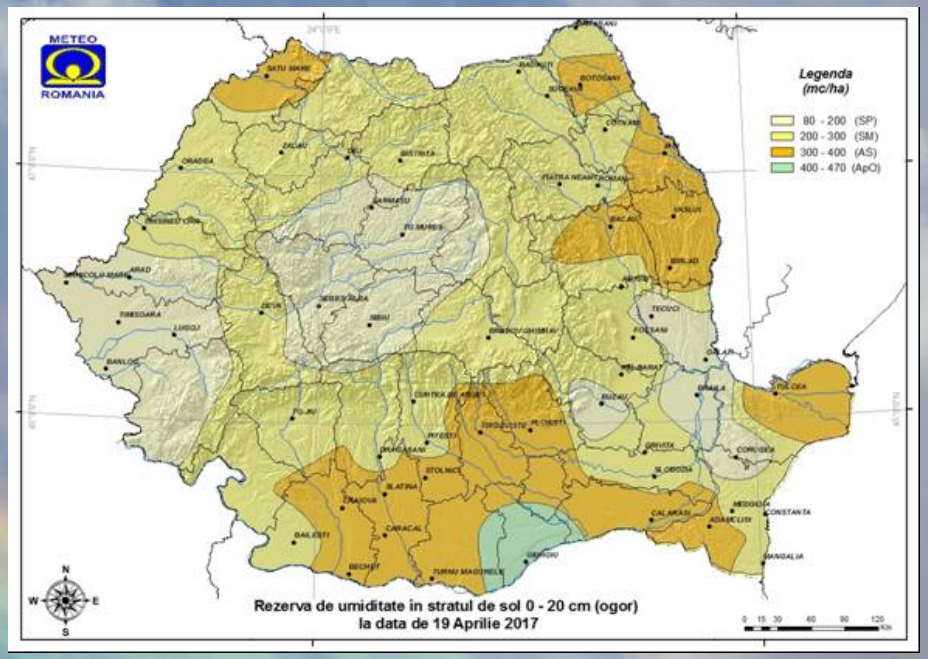


Maize



AGROMETEOROLOGICAL DROUGHT INDICATORS





SOIL MOISTURE RESERVE / WINTER WHEAT and MAIZE

April 2017

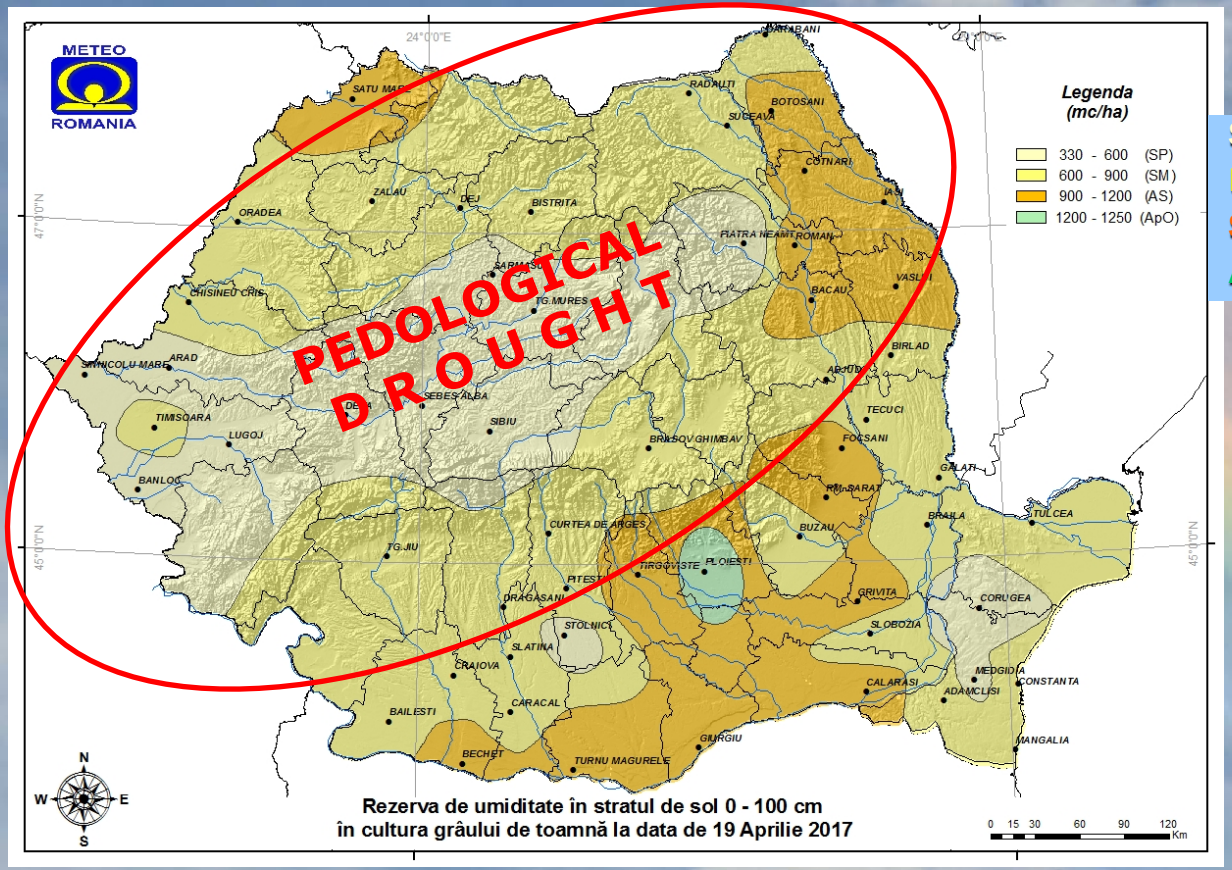
Strong pedological drought

Moderate pedological drought

Satisfactory supply

Almost supply

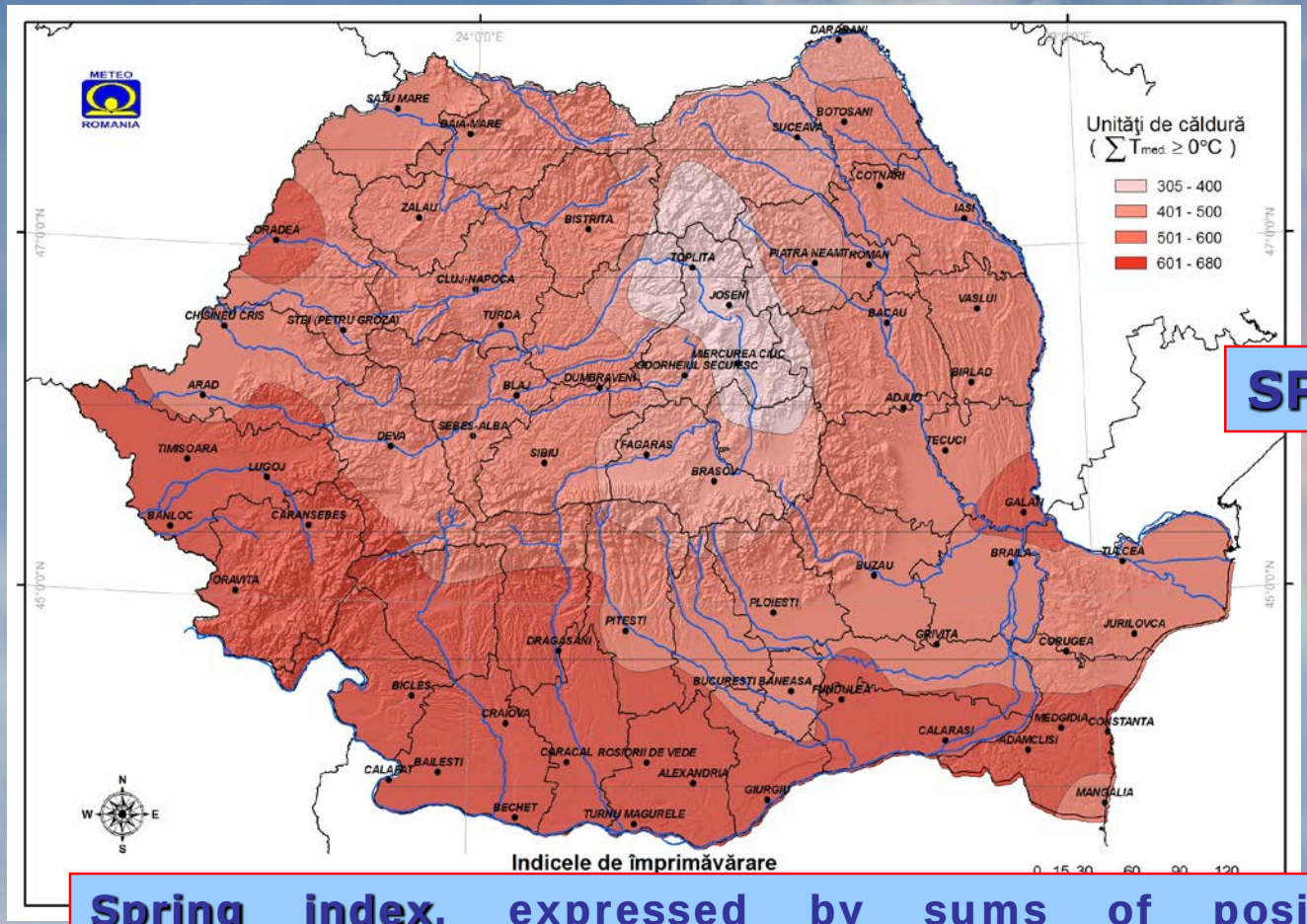
AGROMETEOROLOGICAL DROUGHT INDICATORS



Strong pedological drought
Moderate pedological drought
Satisfactory supply
Almost supply

Soil moisture in winter weat crop / 19 April 2017

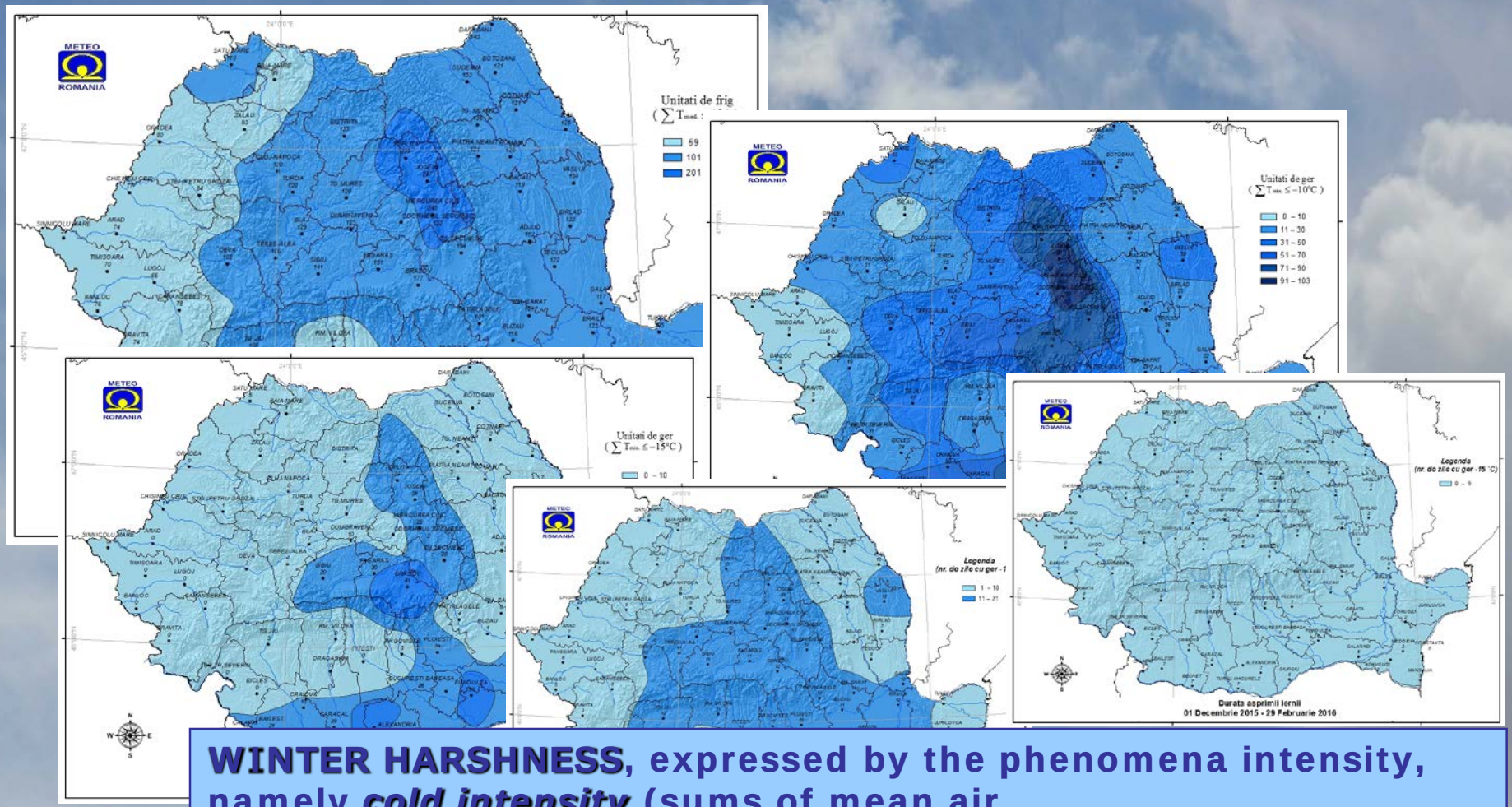
AGROMETEOROLOGICAL DROUGHT INDICATORS



SPRING INDEX

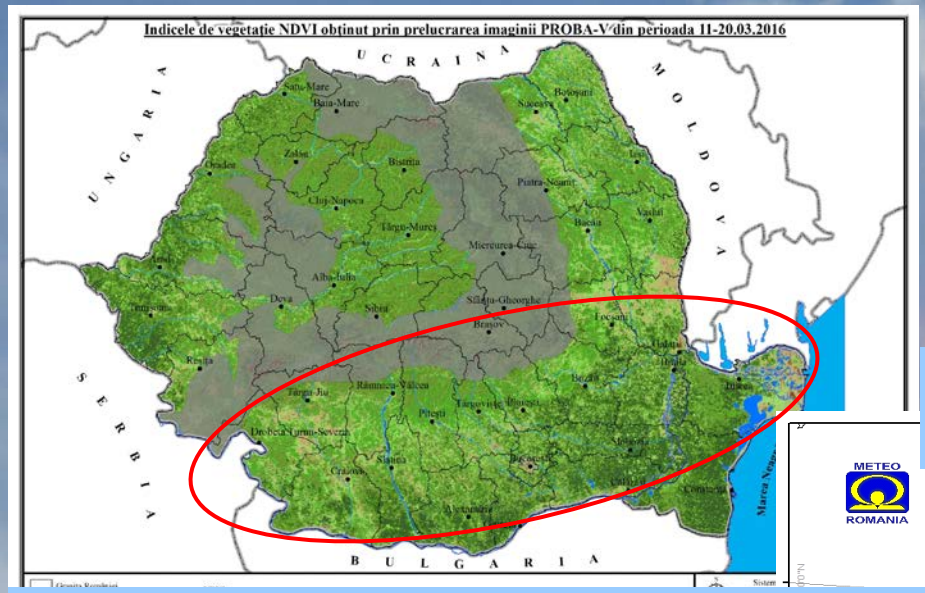
Spring index, expressed by sums of positive average temperatures and calculated for the 1st of February to the 10th April interval.

AGROMETEOROLOGICAL DROUGHT INDICATORS



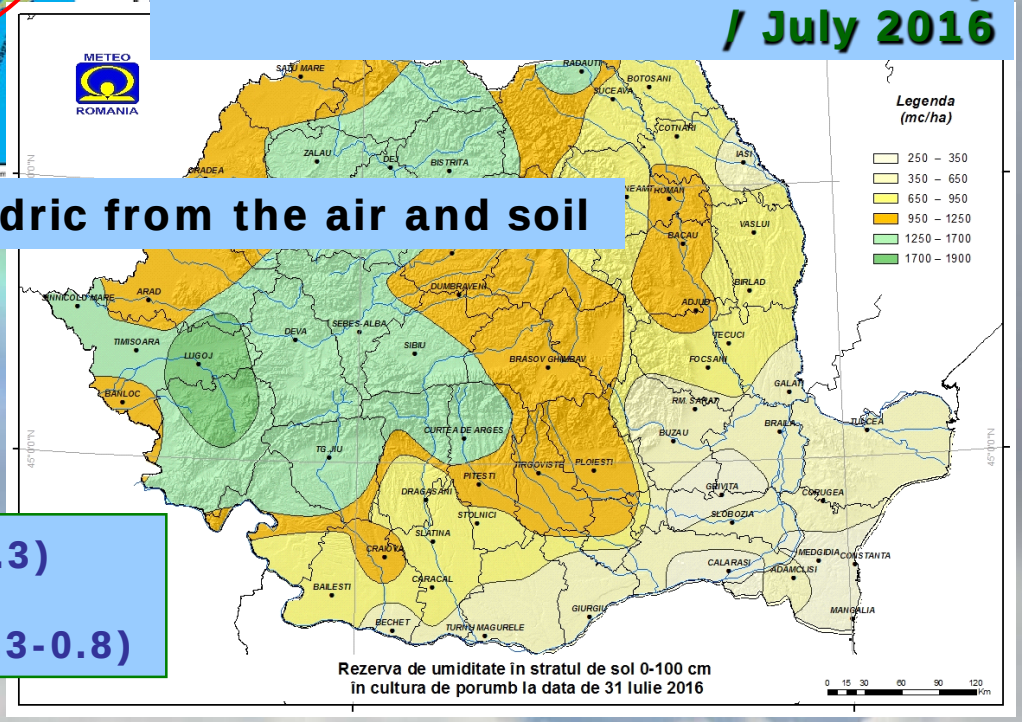
WINTER HARSHNESS, expressed by the phenomena intensity, namely ***cold intensity*** (sums of mean air temperatures below 0°C) recorded in the November to March period and ***frost intensity*** (sums of minimum air temperatures below -10…-15°C) in December-February interval.

NDVI vegetation index image obtained by processing PROBA-V



Extreme pedological drought
Strong pedological drought
Moderate pedological drought
Satisfactory supply
Almost supply

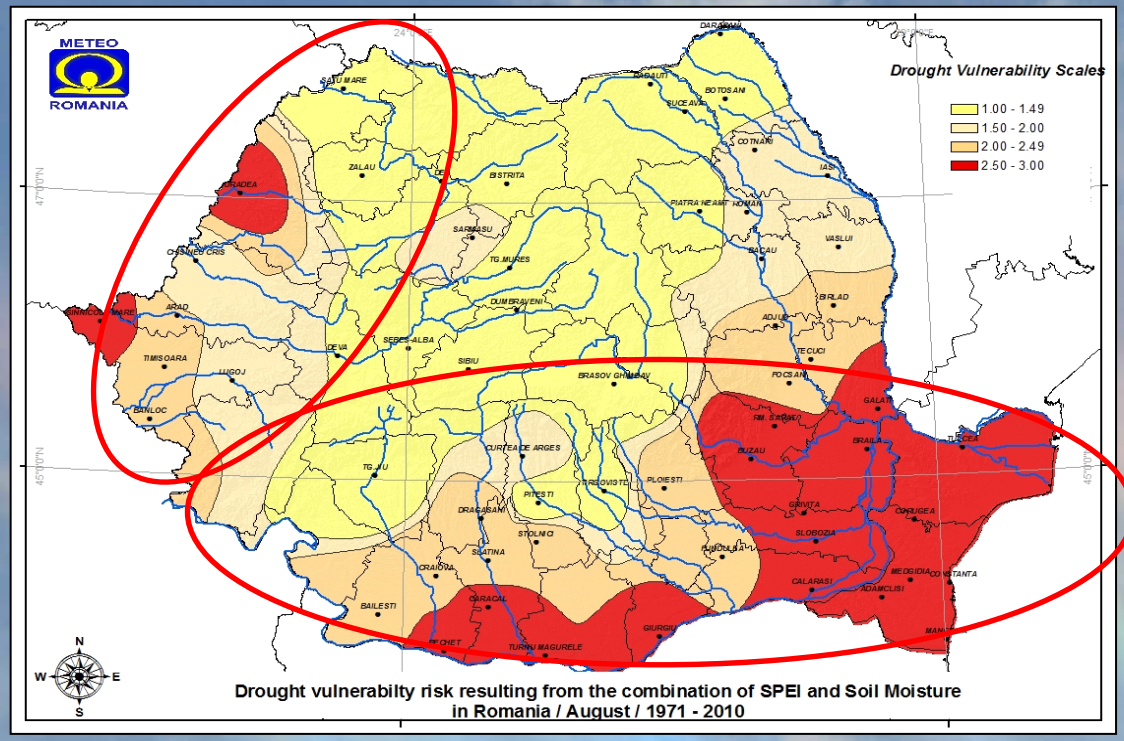
Soil moisture in maize crop / July 2016



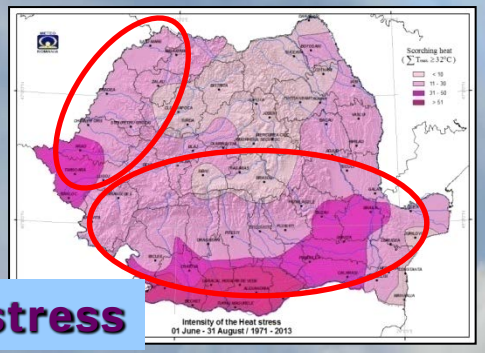
Maintaining heat stress and hydric from the air and soil

- Less dense vegetation (NDVI 0.2-0.3)
- Rare vegetation (NDVI 0.1-0.2)
- Rich and dense vegetation (NDVI 0.3-0.8)

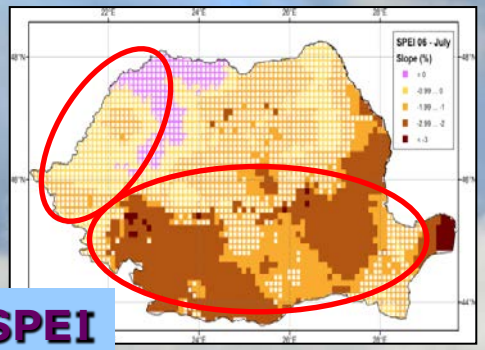
Drought Vulnerability Index for maize crop during the critical period for water plant needs (August)



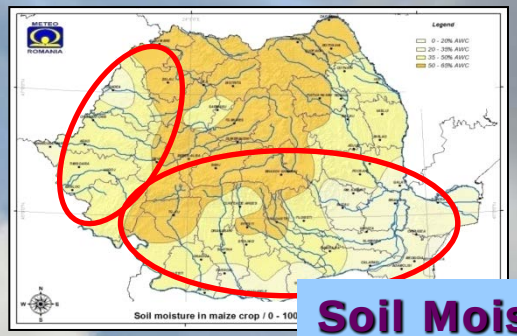
➢ The most critical areas is recorded in the south, south-east and west regions



Heat stress



SPEI



Soil Moisture

Drought vulnerability index (DVI) based on climatic variables

$$DVI = \frac{\sum W_i}{KN}$$, where:

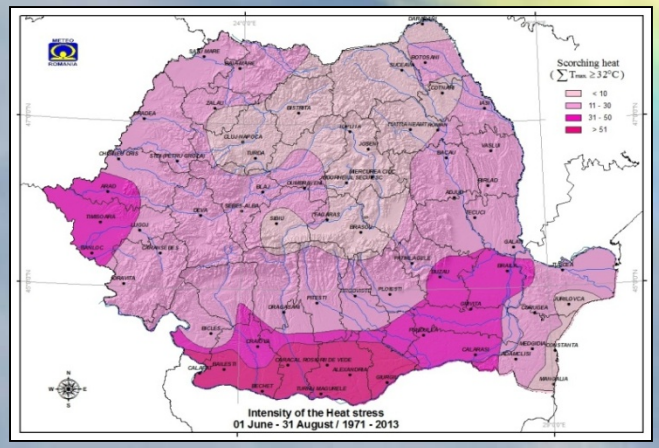
DVI = Drought Vulnerability Index
N = Number of indicators under consideration
W_I = Weights of drought vulnerability indicators, where *I = 1, 2….N*
k = Upper limit of vulnerability weights (e.g. scale = 0-*k*, where k is highest value of W_I

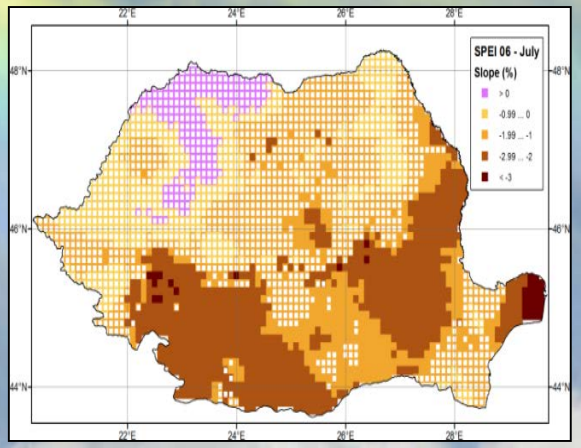
Drought vulnerability scales

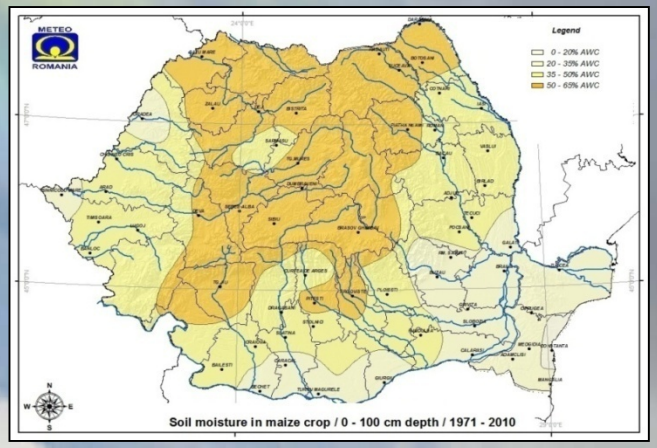
DVI	Vulnerability Scales	Color scale
0.00 – 0.49	No or less vulnerability	
0.50 – 0.99	Low vulnerability	
1.00 – 1.49	Medium vulnerability	
1.50 – 1.99	High vulnerability	
2.00 – 2.49	Very high vulnerability	
2.50 – 3.00	Extreme vulnerability	

Drought vulnerability component scale

Vulnerability level	Scales								
	Heat stress			SPEI			Soil Moisture		
No vulnerability	0	No stress	<10	0	No deficit	<-.0.99	0	No deficit	100%AWC
Low Vulnerability	1	Low stress	11-30	1	Low deficit	-1.99 to -1	1	Low deficit	65-100%AWC
High vulnerability	2	Moderat e stress	31 -50	2	Moderate dry	-2.99 to -2	2	Moderate deficit	35-65%AWC
Extreme vulnerability	3	Strong stress	>51	3	Very Dry	<-.3	3	Strong deficit	0-35%AWC

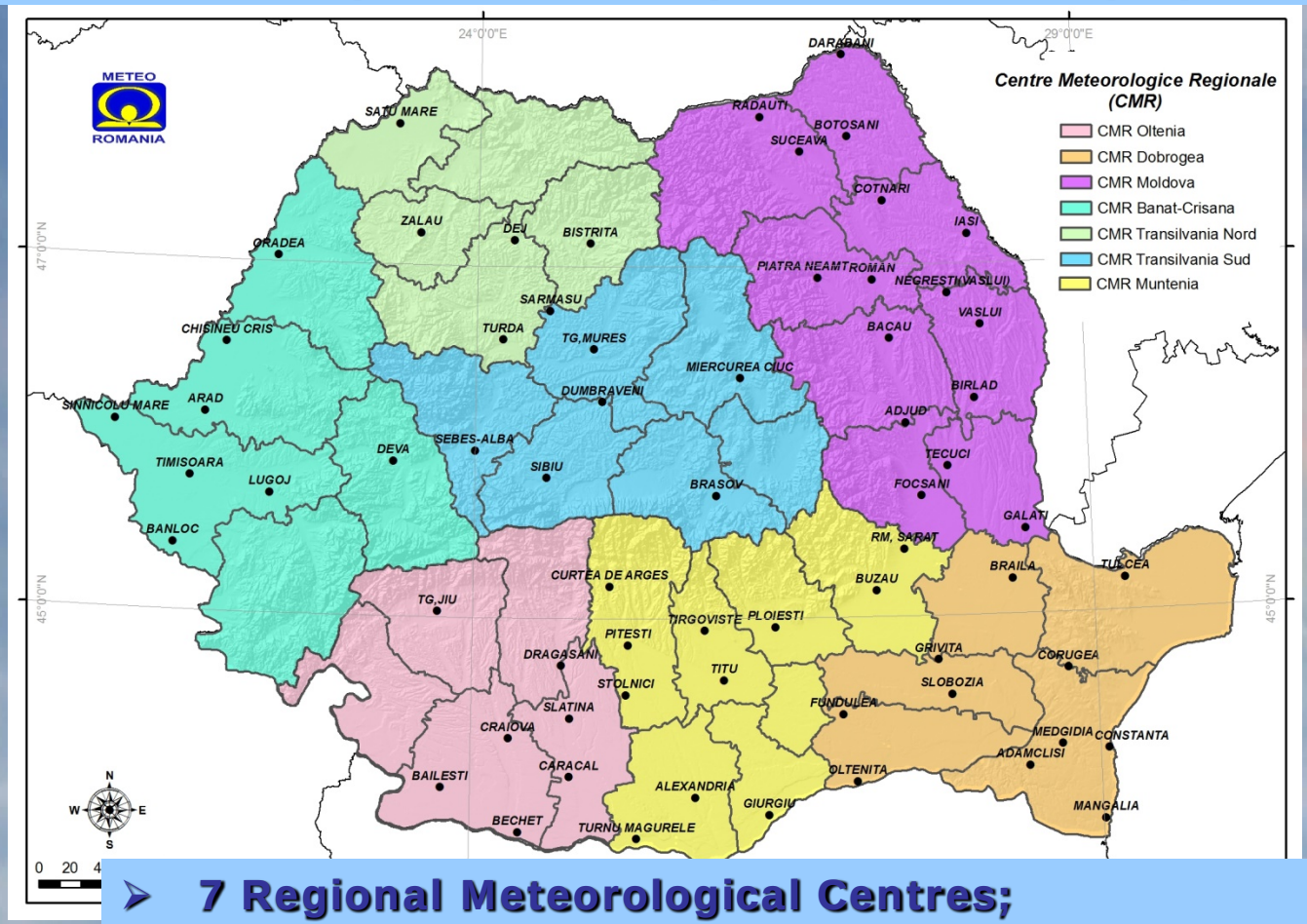






Heat stress **SPEI** **Soil Moisture**

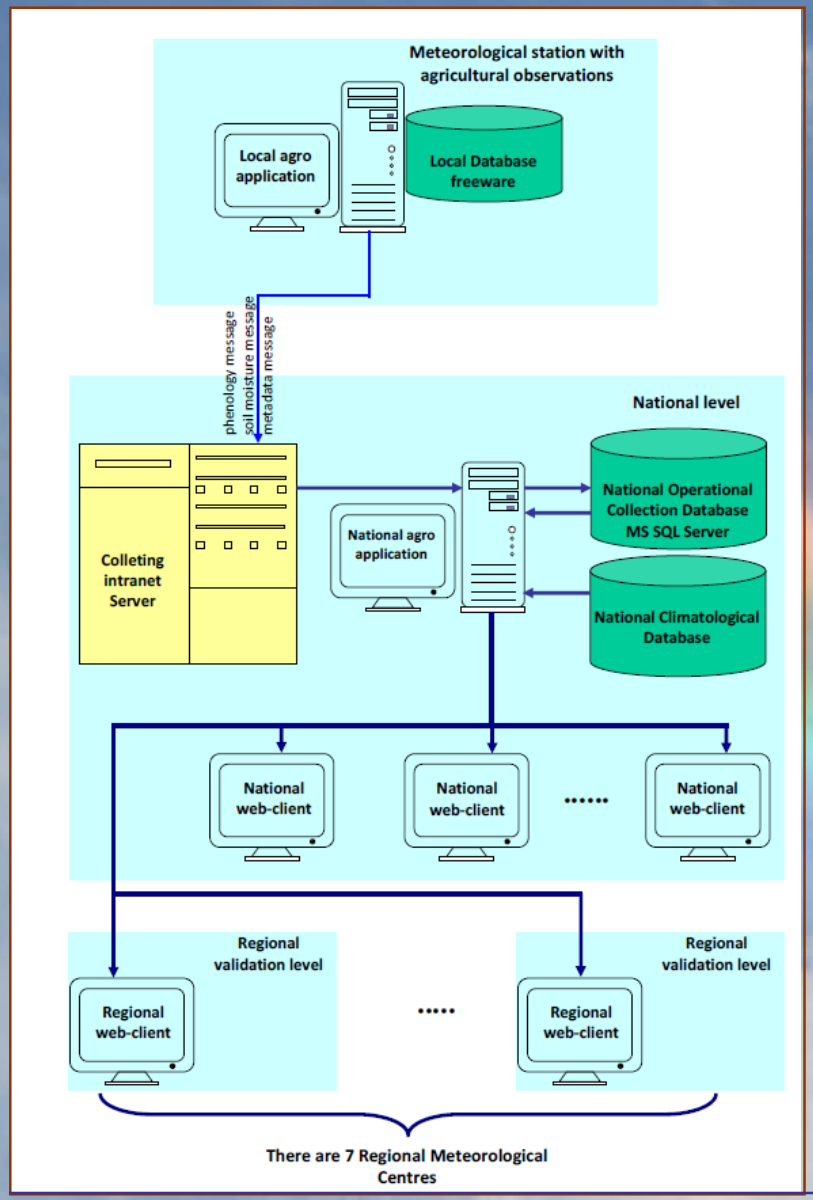
3. Romanian agrometeorological monitoring system



- 7 Regional Meteorological Centres;
- 66 weather stations integrating a special program of agrometeorological measurements (soil moisture and phenological data at winter wheat, maize, sunflower, rape, fruit trees and vineyards).

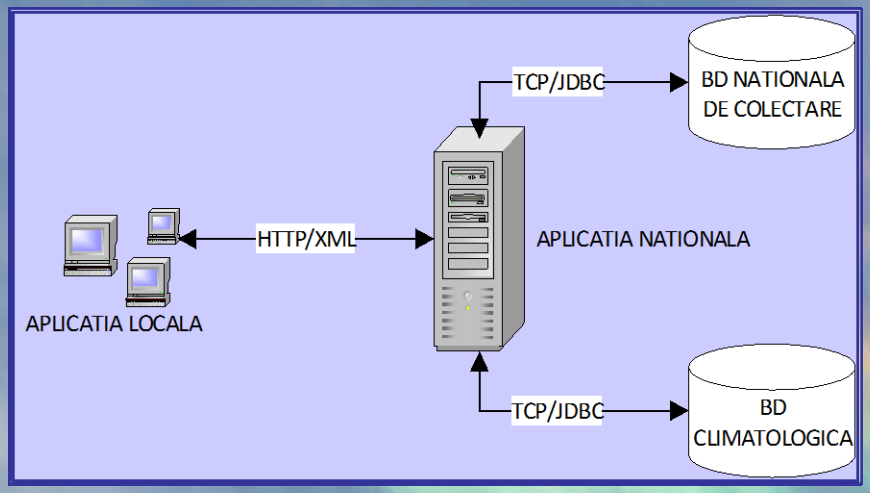
The conceptual scheme of "SYSTEM SOFTWARE AGROMETEO"

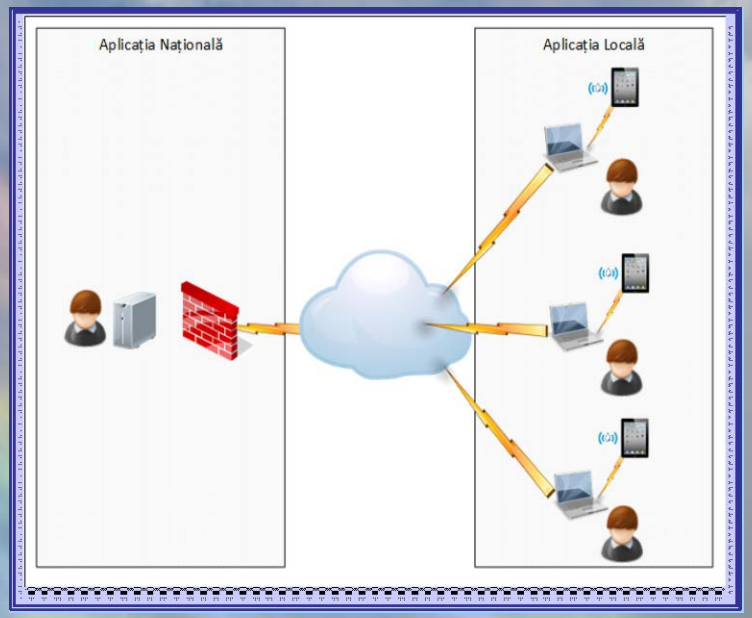
has next components:



- Local level / agrometeorological station – metadata
- National level – web application
- Validation of data at regional level by 7 responsible with agrometeorological activity using a friendly web interface

SYSTEM ARCHITECTURE
NATIONAL and LOCAL APPLICATION

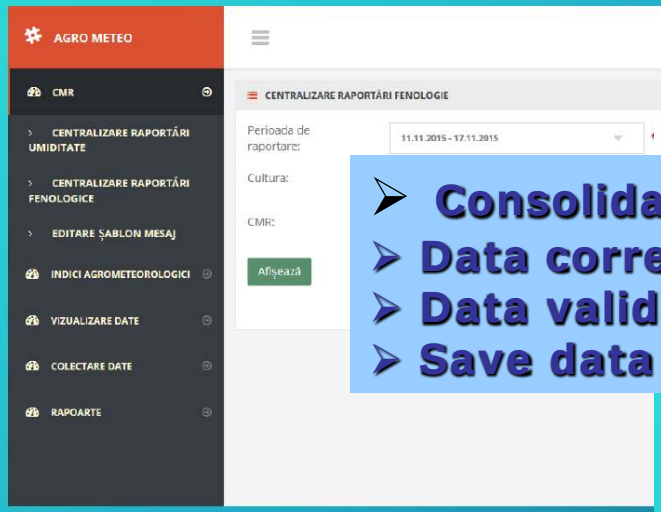




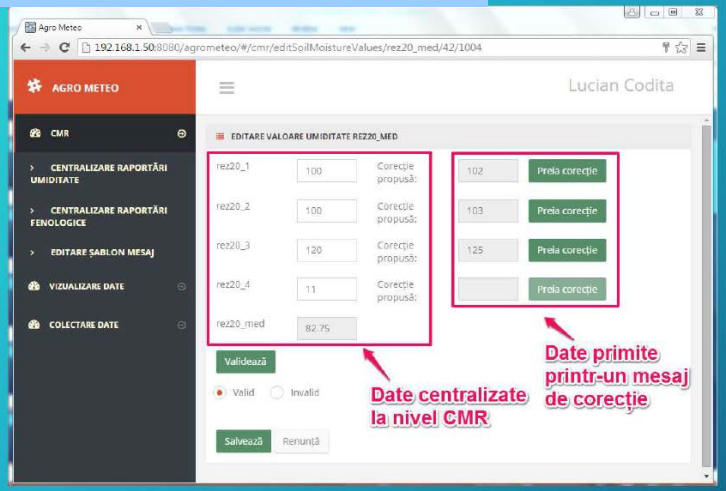
The developed system consists of two subsystems, namely LOCAL and NATIONAL application.

Aplicația Națională - Modul CMR - Centralizare Raportări Fenologie

- **National AGROMETEO Application is a web-application based on a module dedicated to agro-meteorological responsables from each Regional Meteorological Centre (are users of regional type)**



- **Consolidate phenological reports**
- **Data correction**
- **Data validation**
- **Save data**

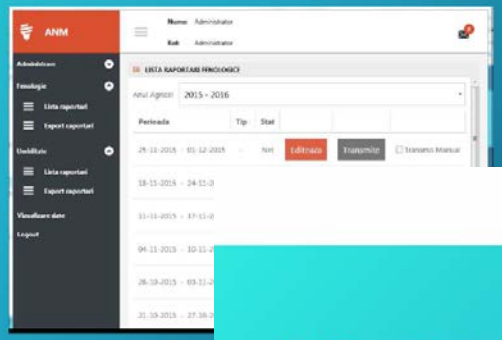


NATIONAL APPLICATION

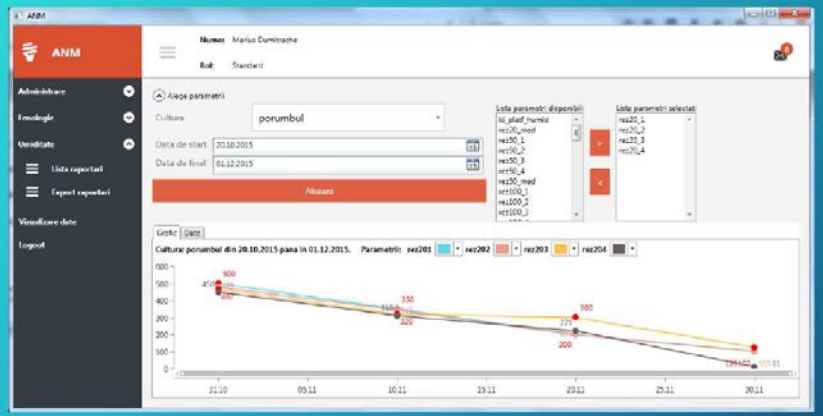
- Manage and configuration platform
- Phenological data management
- Moisture management data
- View data
- Manage user account

Aplicația Locală

- Administrare & configurare platforme agrometeorologice
- Gestionare date fenologice
- Gestionare date umiditate
- Vizualizare date
- Administrare conturi utilizatori



Aplicația Locală – Afișare Date în Mod Grafic



THE LOCAL APPLICATION

Secțiunea 1 - Date de identificare mesaj (Metadate mesaj)

NR.	DESCRIERE	UM	Format
1	Identificator stație cu program agrometeorologic		C5
2	tip mesaj	FN - mesaj fenologic MD - mesaj metadate US - mesaj umiditate sol	C2
3	tip date mesaj	P – principal C - corectie	C1
4	Data/Timp - An		C4
5	Data/Timp - Luna		
6	Data/Timp - decada (1, 2 sau 3)		
7	număr platforme pentru umiditatea solu		

Type of messages:

- **Phenology**
- **Metadata**
- **Soil moisture**

Soil moisture data

Secțiunea 2 - Date agrometeorologice decadice privind umiditatea solului

NR	DESCRIERE	UM	Format
8	identificator platformă pentru umiditatea solului		C10
9	rezerva de umiditate la 20 cm - prima măsurătoare	mc/ha	u4F1
10	rezerva de umiditate la 20 cm - a 2-a măsurătoare	mc/ha	u4F1
11	rezerva de umiditate la 20 cm - a 3-a măsurătoare	mc/ha	u4F1
12	rezerva de umiditate la 20 cm - a 4-a măsurătoare	mc/ha	u4F1
13	rezerva de umiditate la 20 cm - media celor 4 măsurători	mc/ha	u4F1
14	rezerva de umiditate la 50 cm - prima măsurătoare	mc/ha	u4F1
15	rezerva de umiditate la 50 cm - a 2-a măsurătoare	mc/ha	u4F1
16	rezerva de umiditate la 50 cm - a 3-a măsurătoare	mc/ha	u4F1
17	rezerva de umiditate la 50 cm - a 4-a măsurătoare	mc/ha	u4F1
18	rezerva de umiditate la 50 cm - media celor 4 măsurători	mc/ha	u4F1
19	rezerva de umiditate la 100 cm - prima măsurătoare	mc/ha	u4F1
20	rezerva de umiditate la 100 cm - a 2-a măsurătoare	mc/ha	u4F1
21	rezerva de umiditate la 100 cm - a 3-a măsurătoare	mc/ha	u4F1
22	rezerva de umiditate la 100 cm - a 4-a măsurătoare	mc/ha	u4F1
23	rezerva de umiditate la 100 cm - media celor 4 măsurători	mc/ha	u4F1
24	coeficientul de ofilire	%	u3F1

Agrometeorological web-software application / 80 INDICES

ANEXA 03 - Lista minimală indici care trebuie să fie calculați de Aplicația Națională

NR	NUME	UM	FRECV.	date intrare	formula/algoritm de calcul
1	Evapotranspiratia potentiala (ETP)	mc/ha	zilnic	Temperatura maxima a aerului Temperatura minima a aerului Umiditatea relativa a aerului Viteza vantului Durata de stralucire a Soarelui altitudinea statiei	
2	Evapotranspiratia reala (ETR)		zilnic	Coeficientul de cultura-Kc (functie de faza de vegetatie a culturii) Evapotranspiratia potentiala (ETP)	ETR=ETP*Kc
3				Precipitatii zilnice/interval (pp)	Umidcalc=[(UmidCalcInit+(pp*C Inf.)*10]-
15	Suma din temperatura maxima a aerului >32°C, 01 iunie-31 august (unitati arsita)	°C	zilnic	temperatura maxima a aerului (Tmax)	$\sum_{01\,iunie,\ T\,max>32}^{31\,august} T\,max$
16	Numarul de zile cu temperatura maxima a aerului >32 (01 iunie-31 august)		zilnic	temperatura maxima a aerului	
17	Numar de zile consecutive (minim 5 zile) cu temperatura maxima a aerului ≥32 (01 decembrie-28 februarie)		zilnic	temperatura maxima a aerului	
18	Suma din temperatura minima a aerului <-10 (01 decembrie-28 februarie)	°C	zilnic	temperatura minima a aerului (Tmin)	$\sum_{01\,.\,decembrie,\ T\,min\,<-10}^{28\,.\,februarie} T\,min$
19	Numar de zile cu				
20	Numar de zile cc decembrie-28 fel				
31	Suma decadica pozitiva (SDP)	°C	zilnic	temperatura maxima aer (Tmax) temperatura minima aer (Tmin)	$\sum_{prima\_zi\_decada,\ (T\max+T\min)/2>0}^{ultima\_zi\_decada} (T\max+T\min)/2$ unde decada I cuprinde zilele 01 ... 10 unde decada II cuprinde zilele 11 ... 20 unde decada III cuprinde zilele 21 ... ultima zi a lunii
32	Suma lunara pozitiva (SLP)	°C	zilnic	temperatura maxima aer (Tmax) temperatura minima aer (Tmin)	$\sum_{prima\_zi\_luna}^{ultima\_zi\_luna} (T\max+T\min)/2$
79	SPEI		zilnic	precipitatii (PP) evapotranspiratia potentiala (ETP) C0, C1, C2, D1, D2, D3 alfa, beta, gamma	SPEI=W-(C0+C1*W+C2*W*W)/(1+d1*W+d2*W*W+D3*W*W*W) unde W=-2*ln(P), daca P≤0.5 W=-2*ln(1-P), daca P>0.5, iar SPEI se trece cu semn schimbat P=1/(1+power(alfa/(pp-etp-gamma),beta))
80	DVI		zilnic	SPEI unitati arsita umiditatea solului	dvi=(if(unitati_arsita<10,0,if(unitati_arsita<31,1,if(unitati_arsita<51,2,3))) + if(spei<-0.99,0,if(spei<=1,1,if(spei<=-2,2,3))) + if(umiditate_sol<35,3,if(umiditate_sol<65,2,if(umiditate_sol<100,1,0))))/(3*3)

AGROMETEOROLOGICAL INDICES

27

LOCAL APPLICATION

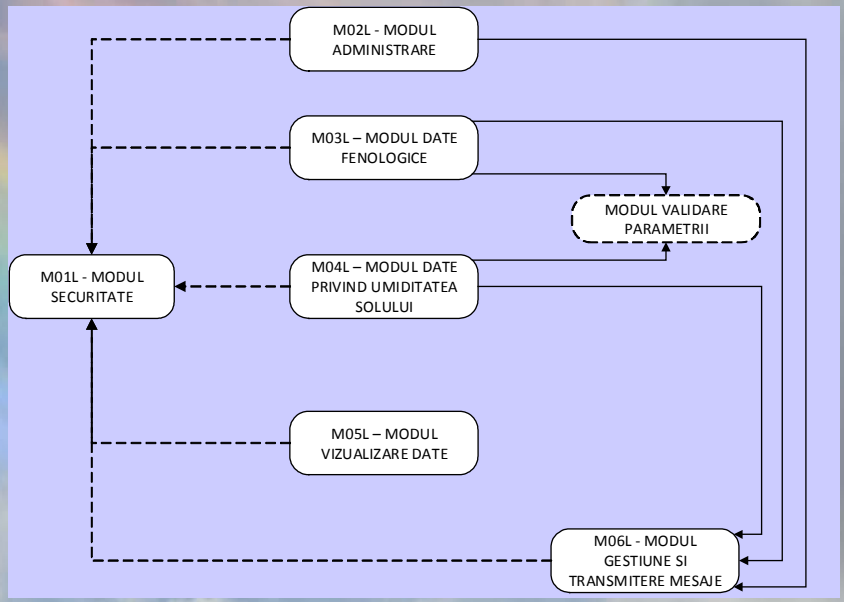
❖ It is installed on computers in the agrometeoroogical stations and comunicates with NATION APPLICATION using the HTTP protocol.

❖ Messages sent or received to/from the NATIONAL APPLICATION is in XML format.

❖ LOCAL APPLICATION is part of the computer system implemented to improve agrometeorological infrastructure and is installed directly on computers available in the agrometeorological stations.

LOCAL AAPPLICATION component diagram is composed of several functional modules coded as follows:

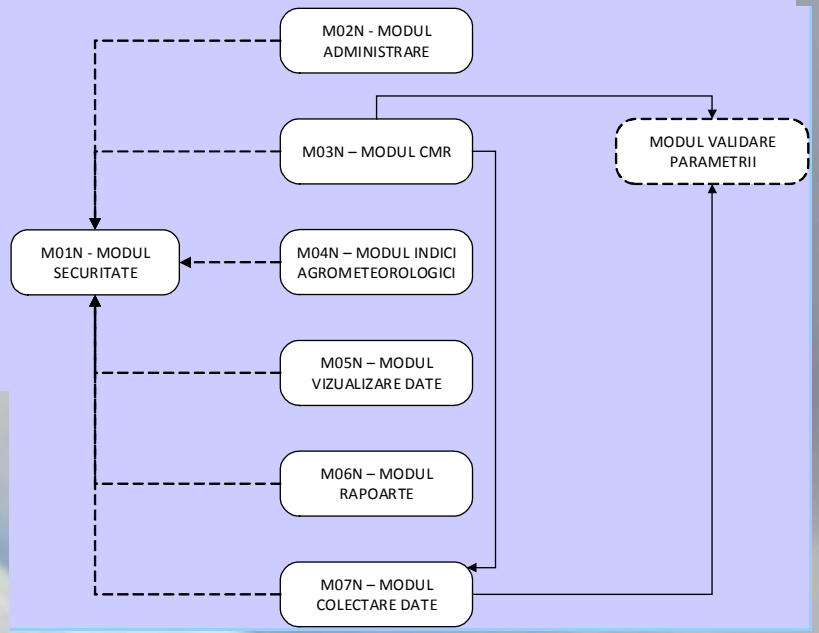
- ***M01L*** – Security module , to determine whether or not a user has access to certain functionality within that module;
- ***M02L*** – Management module;
- ***M03L*** – Phenological data module and ***M04L*** – Soil moisture data module, use a internal module, common validation parameter values based on validation rules defined for each parameter;
- ***M05L*** – View data module;
- ***M06L*** – Management and messaging to send messages with data/metadata that had been read to receive LOCAL APPLICATION settings transmitted.



NATIONAL APPLICATION

The seven functional modules are encoded in the NATIONAL APPLICATION diagram components as follows:

- **M01N** – Security module to determine whether or not a user has access to certain functionality of the application;
- **M02N** – Management module;
- **M03N** – CMR module, used internal module, common validation parameter values based on validation rules defined for each parameter. This module is used in situations where CMR users make corrections on the data;
- **M04N** – Agrometeorological indices module;
- **M05N** – View data module;
- **M06N** – Reports module;
- **M07N** – Data collection module, validation applies when messages are received in the process of centralizing the reporting of phenology and transmitted by LOCAL APPLICATION.



NATIONAL APPLICATION

NATIONAL APPLICATION appear in the following concepts:

- ***Agrometeorological station*** – the source of agrometeorological data (through its platforms, but the NATIONAL APPLICATION data coming from the station, and not from each individual platform);
- ***Agrometeorological platform*** – represents the location where the measurements/observations are performed;
- ***Parameter*** – represents a agrometeorological characteristic that is measured/observed/calculated which describes one aspect of a phenomenon;
- ***Size*** – represents the effective value of a parameter resulting from a measurement/observation/calculation;
- ***Reporting*** – is a set of specified size for the agrometeorological platform and corresponding to a certain period of time;
- ***Agricultural year*** – is a period of 12 months when all activities reporting, validation, analysis and information processing takes place;
- ***Index*** – represents a size derived from a set of parameters and/or other indices, based on a formula or algorithm;
- ***Report*** – represents a synthesis situation generated based on a set of parameters and/or agrometeorological indicators.

NATIONAL APPLICATION

Within NATIONAL APPLICATION follow the next steps:

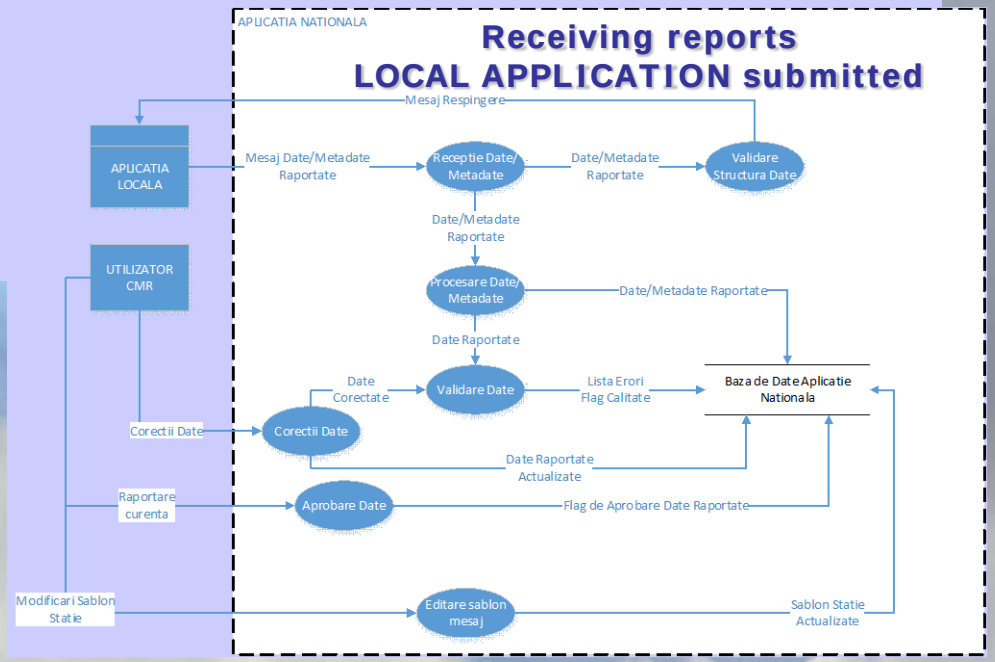
- Administration;
- Centralizing reports submitted by LOCAL APPLICATION;
- Agrometeorological indexes;
- View data;
- Reports;
- Data collection.

NATIONAL APPLICATION receives reports from each station through messages transmitted by LOCAL APPLICATION. In the context messages it is manageable and manually editing templates messages to RMC users.

Centralizing reports submitted by LOCAL APPLICATION functionality is provided by the RMC module and include the following activities:

- The reception of the data message;
- Validation data structure;
- Data processing;
- Data validation;
- Correction data;
- Endorsements;
- Edit template message.

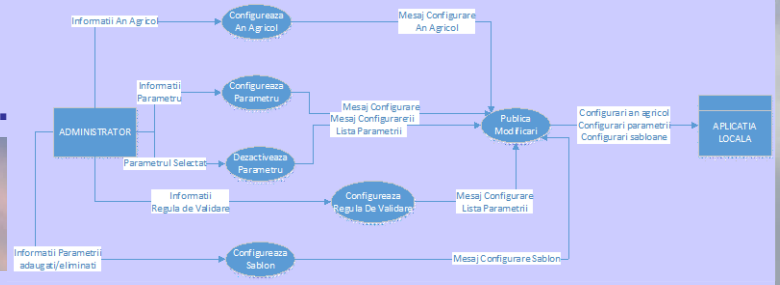
NATIONAL APPLICATION receives message data or correction validates the message structure and saves it in the database as it gets (and validation rules running correction parameters of the message).

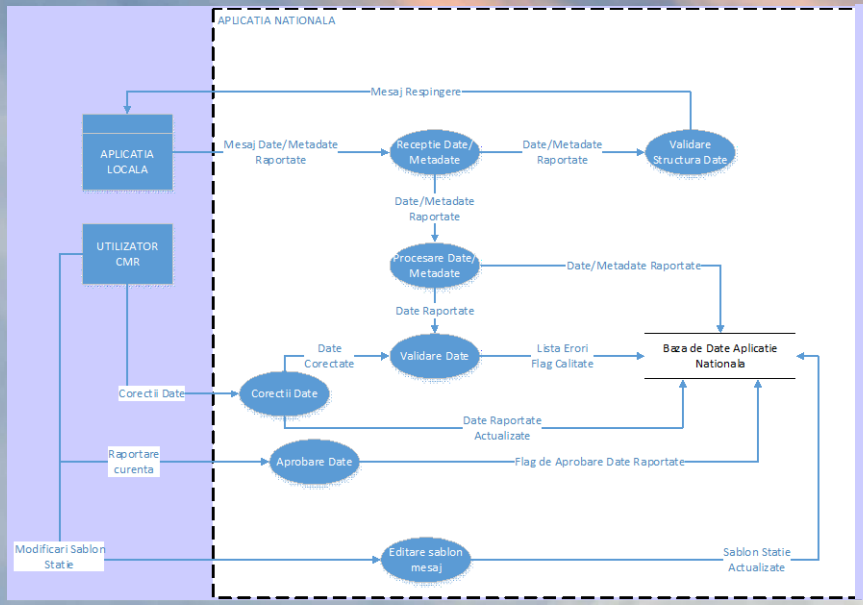


NATIONAL APPLICATION

Management configuration information of the whole system is achieved by the following activities:

- ❖ Setting agricultural years;
- ❖ Configuration parameters used for reports or metadata;
- ❖ Disabling a parameter;
- ❖ Setting a messaging templates;
- ❖ Publication of changes to LOCAL APPLICATIONS.





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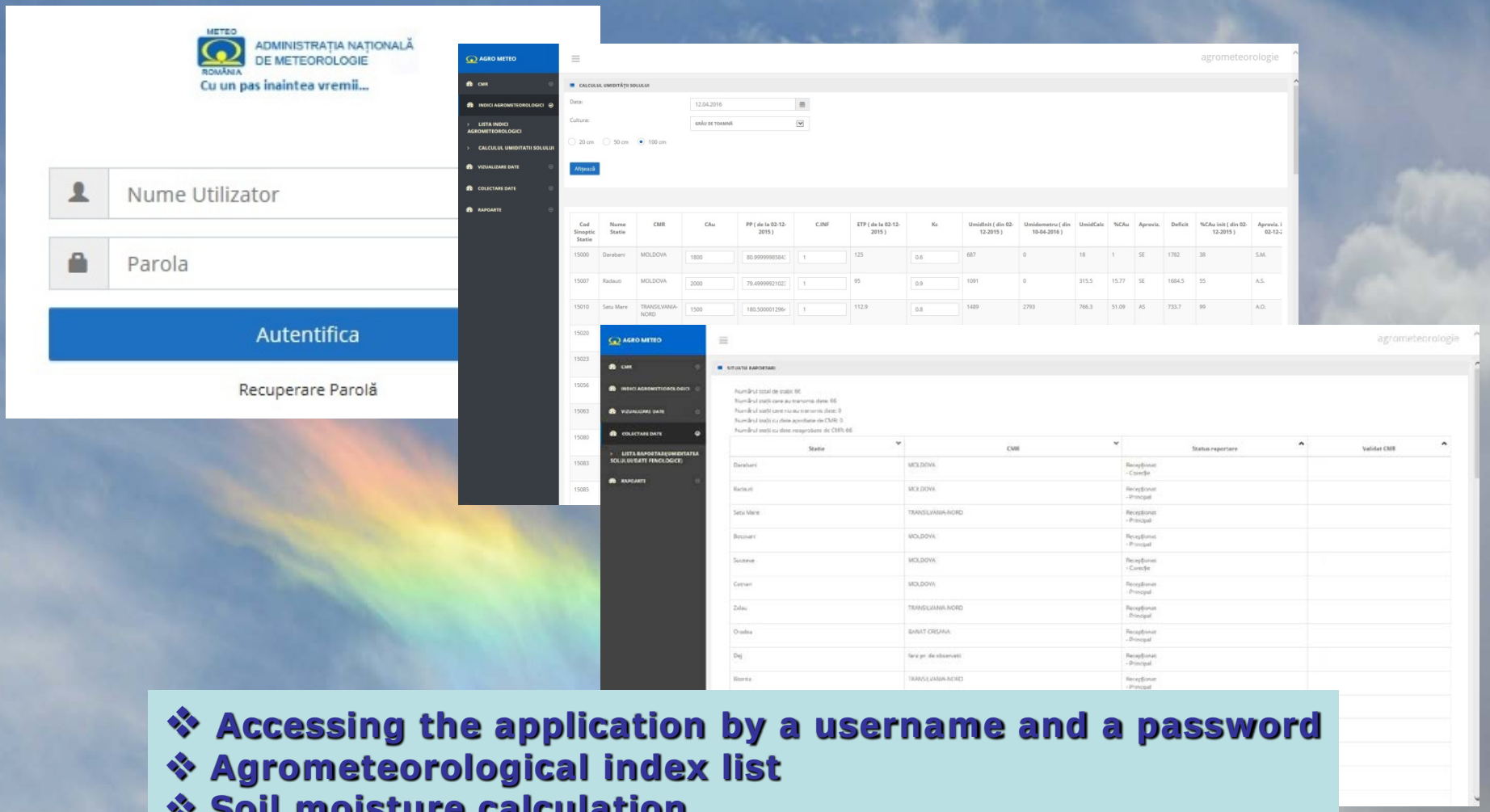
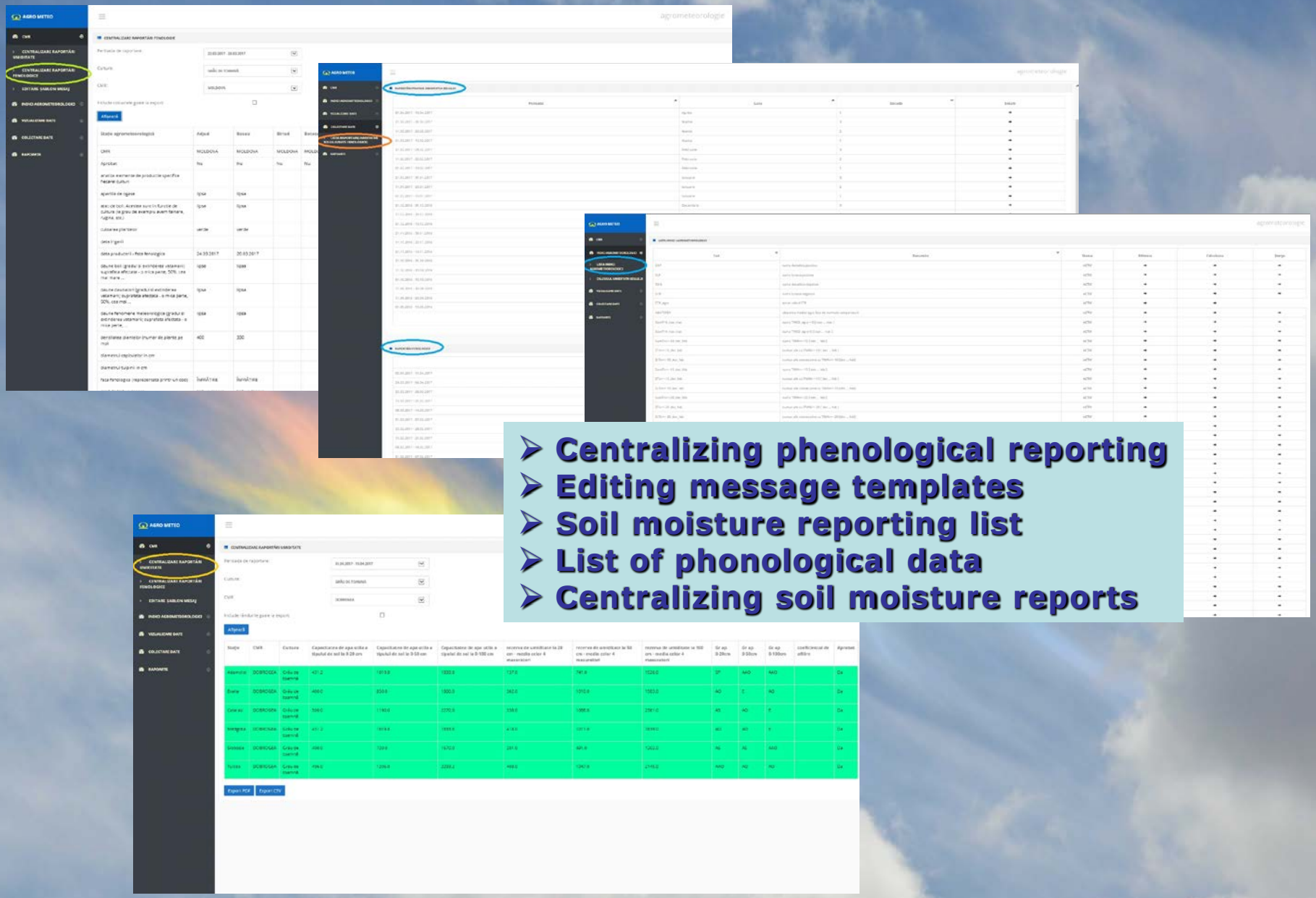
- The reception of the data message;
- Validation data structure;
- Data processing;
- Data validation;
- Correction data;
- Endorsements;
- Edit template message.



- Accessing the application by a username and a password
- Agrometeorological index list
- Soil moisture calculation
- View data
- Collection of data
- Reports



- Centralizing phenological reporting
- Editing message templates
- Soil moisture reporting list
- List of phonological data
- Centralizing soil moisture reports

4. AGROMETEOROLOGICAL PRODUCTS

4.1. AGROMETEOROLOGICAL BULETTIN

❖ AGROMETEOROLOGICAL DIAGNOSIS

- ***Meteorological features***

➲ ***The thermal air*** {
- ***Average daily temperature***
- ***Minimum temperatures***
- ***The maximum temperature***

➲ ***The thermal regime of the soil*** {
- ***Minimum temperature at the soil surface***
- ***The maximum temperature on the surface***

➲ ***Rainfall***

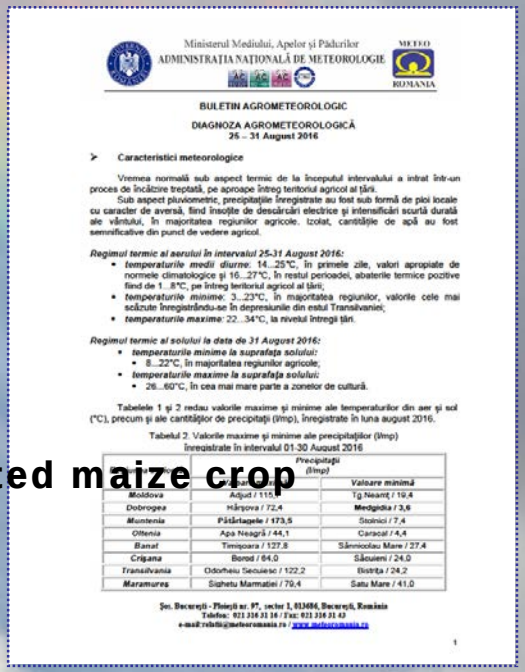
- ***Agrometeorological features***

➲ ***Soil moisture in various depths of the soil:***

{
0-20 cm soil layer (field)
0-20 cm soil layer in winter wheat and maize crop
0-50 cm soil layer in winter wheat and maize crop
0-100 cm soil layer in winter wheat and non-irrigated maize crop

➲ ***The state of growth of crops:***

- winter wheat, rape, barley, maize, sunflower, sugar beet, potato, fruit trees and vines.



Ministerul Mediului, Apelor şi Pădurilor
ADMINISTRAŢIA NAŢIONALĂ DE METEOROLOGIE
METEO ROMANIA

BULETIN AGROMETEOROLOGIC

DIAGNOZA AGROMETEOROLOGICĂ
25 – 31 August 2016

➢ Caracteristici meteorologice

Vremea normală sub aspect termic de la începutul intervalului a intrat într-un proces de încălzire treptată, pe aproape întreg teritoriul agricol al ţării.
Sub aspect pluviometric, precipitaţiile înregistrate au fost sub formă de ploi inoale cu caracter de aversă, fiind însoţite de descărcări electrice şi intensificări scurtă durată ale vântului, în majoritatea regiunilor agricole. Izolat, cantităţile de apă au fost semnificative din punct de vedere agricol.

Regimul termic al aerului în intervalul 25-31 August 2016:
- *temperaturile medii diurne*: 14...25°C, în primele zile, valori apropiate de normele climatologice şi 16...27°C, în restul perioadei, abaterile termice pozitive fiind de 1...8°C, pe întreg teritoriul agricol al ţării;
- *temperaturile minime*: 3...23°C, în majoritatea regiunilor, valorile cele mai scăzute înregistrându-se în depresiunile din estul Transilvaniei;
- *temperaturile maxime*: 22...34°C, la nivelul întregii ţări.

Regimul termic al solului la data de 31 August 2016:
- *temperaturile minime la suprafaţa solului:*
  - 8...22°C, în majoritatea regiunilor agricole,
- *temperaturile maxime la suprafaţa solului:*
  - 26...60°C, în cea mai mare parte a zonelor de cultură.

Tabelele 1 şi 2 redau valorile maxime şi minime ale temperaturilor din aer şi sol (°C), precum şi ale cantităţilor de precipitaţii (l/mp), înregistrate în luna august 2016.

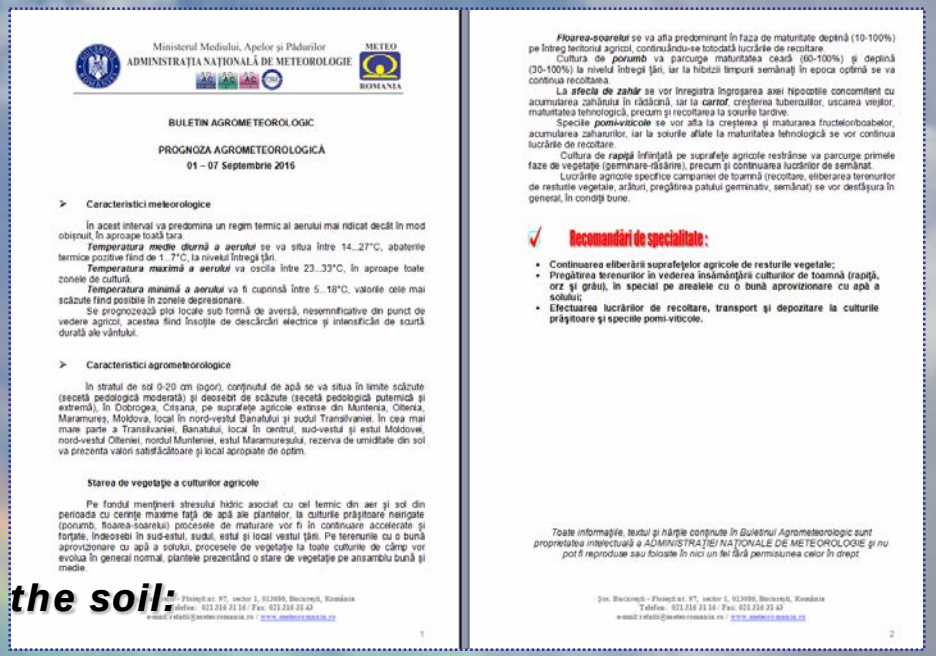
Tabelul 2. Valorile maxime şi minime ale precipitaţiilor (l/mp) înregistrate în intervalul 01-30 August 2016

	Precipitaţii (l/mp)	
	Valoare maximă	Valoare minimă
Moldova	Adjud / 115,8	Tg.Neamţ / 19,4
Dobrogea	Hârşova / 72,4	Medgidia / 3,6
Muntenia	Pătârlagele / 173,5	Stolnici / 7,4
Oltenia	Apa Neagră / 44,1	Caracal / 4,4
Banat	Timişoara / 127,8	Sânnicolau Mare / 27,4
Crişana	Borod / 64,0	Săcuieni / 24,0
Transilvania	Odorheiu Secuiesc / 122,2	Bistriţa / 24,2
Maramureş	Sighetu Marmaţiei / 79,4	Satu Mare / 41,0

Şos. Bucureşti - Ploieşti nr. 97, sector 1, 013686, Bucureşti, Romania
Telefon: 021 316 31 16 / Fax: 021 316 31 43
e-mail: relatii@meteoromania.ro / www.meteoromania.ro

4.1. AGROMETEOROLOGICAL BULETTIN

❖ AGROMETEOROLOGICAL FORECAST



Ministerul Mediului, Apelor şi Pădurilor
ADMINISTRAŢIA NAŢIONALĂ DE METEOROLOGIE
METEO ROMANIA

BULETIN AGROMETEOROLOGIC

PROGNOZA AGROMETEOROLOGICĂ
01 – 07 Septembrie 2016

➢ Caracteristici meteorologice

În acest interval va predomina un regim termic al aerului mai ridicat decât în mod obişnuit, în aproape toată ţara.
Temperatura medie diurnă a aerului se va situa între 14...27°C, abaterile termice pozitive fiind de 1...7°C, la nivelul întregii ţări.
Temperatura maximă a aerului va oscila între 23...33°C, în aproape toate zonele de cultură.
Temperatura minimă a aerului va fi cuprinsă între 5...18°C, valorile cele mai scăzute fiind posibile în zonele depresionare.
Se prognozează ploi locale sub formă de averse, nesemnificative din punct de vedere agricol, acestea fiind însoţite de descărcări electrice şi intensificări de scurtă durată ale vântului.

➢ Caracteristici agrometeorologice

În stratul de sol 0-20 cm (ogor), conţinutul de apă se va situa în limite scăzute (secetă pedologică moderată) şi deosebit de scăzute (secetă pedologică puternică şi extremă), în Dobrogea, Câmpia, pe suprafeţe agricole extinse din Muntenia, Oltenia, Maramureş, Moldova, local în nord-vestul Banatului şi sudul Transilvaniei. În cea mai mare parte a Transilvaniei, Banatului, local în centrul, sud-vestul şi estul Moldovei, nord-vestul Olteniei, nordul Munteniei, estul Maramureşului, rezerva de umiditate din sol va prezenta valori satisfăcătoare şi local apropiate de optim.

Starea de vegetaţie a culturilor agricole

Pe fondul menţinerii stresului hidric asociat cu cel termic din aer şi sol din perioada cu cerinţe maxime faţă de apă ale plantelor, la culturile prăşitoare neirigate (porumb, floarea-soarelui) procesele de maturare vor fi în continuare accelerate şi forţate, îndeosebi în sud-estul, sudul, estul şi local vestul ţării. Pe terenurile cu o bună aprovizionare cu apă a solului, procesele de vegetaţie la toate culturile de câmp vor evolua în general normal, plantele prezentând o stare de vegetaţie pe ansamblu bună şi medie.

Floarea-soarelui se va afla predominant în faza de maturitate deplină (10-100%) pe întreg teritoriul agricol, continuându-se totodată lucrările de recoltare.
Cultura de ***porumb*** va parcurge maturitatea cerută (60-100%) şi deplină (30-100%) la nivelul întregii ţări, iar la hibrizii timpurii semănaţi în epoca optimă se va continua recoltarea.
La ***sfecla de zahăr*** se vor înregistra îngroşarea axei hipocotile concomitent cu acumularea zahărului în rădăcină, iar la ***cartof***, creşterea tuberculilor, uscarea vrejilor, maturitatea tehnologică, precum şi recoltarea la sourile târzii.
Speciile ***pomi-viticole*** se vor afla la creşterea şi maturarea fructelor/boabelor, acumularea zaharurilor, iar la soiurile aflate la maturitatea tehnologică se vor continua lucrările de recoltare.
Cultura de ***rapiţă*** înfiinţată pe suprafeţe agricole restrânse va parcurge primele faze de vegetaţie (germinare-răsărire), precum şi continuarea lucrărilor de semănat.
Lucrările agricole specifice campaniei de toamnă (recoltare, eliberarea terenurilor de resturile vegetale, arături, pregătirea patului germinativ, semănat) se vor desfăşura în general, în condiţii bune.

Recomandări de specialitate:

- **Continuarea eliberării suprafeţelor agricole de resturile vegetale;**
- **Pregătirea terenurilor în vederea însămânţării culturilor de toamnă (rapiţă, orz şi grâu), în special pe arealele cu o bună aprovizionare cu apă a solului;**
- **Efectuarea lucrărilor de recoltare, transport şi depozitare la culturile prăşitoare şi specile pomi-viticole.**

Toate informaţiile, textul şi hărţile conţinute în Buletinul Agrometeorologic sunt proprietatea intelectuală a ADMINISTRAŢIEI NAŢIONALE DE METEOROLOGIE şi nu pot fi reproduse sau folosite în nici un fel fără permisiunea celor în drept.

- ***Meteorological features***

  - ***Average daily air temperature***
  - ***The maximum air temperature***
  - ***Minimum air temperature***
  - ***Rainfall***

- ***Agrometeorological features***

  - ***Soil moisture in various depths of the soil:***
    - **0-20 cm soil layer (field)**
    - **0-20 cm soil layer in winter wheat and maize crop**
    - **0-50 cm soil layer in winter wheat and maize crop**
    - **0-100 cm soil layer in winter wheat and non-irrigated maize crop**

  - ***The state of growth of crops:***
    - winter wheat, rape, barley, maize, sunflower, sugar beet, potato, fruit trees and vines.

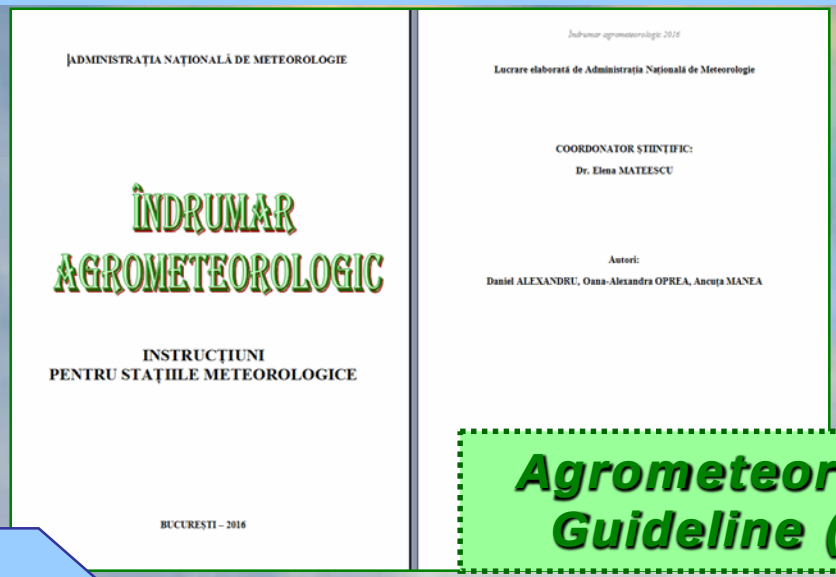
weekly

SPECIALIST ADVICE

4.2. AGROMETEOROLOGICAL GUIDELINE

PHENOLOGICAL OBSERVATIONS AND SPECIFIC MEASURES CARRIED OUT IN AGROMETEOROLOGICAL PLATFORMS IN ROMANIA

1) Agrometeorological platform;
2) European coding system BBCH phase of growth and development of agricultural plants;
3) Phenological observations;
4) The density of the plant;
5) Biometric measurements;
6) Weeding of crops;



Agrometeorological Guideline (2016)

7) Damage to crops produced by adverse weather phenomena, diseases and pests;

7) Estimation of the state of the crop growing season field and fruit trees in the winter;

7) Visual estimation of the state of vegetation in the warm season (summer);

7) Quantitative estimation of the state of vegetation;
8) Biological analysis of the yield.

☑ In a crop, phenological observations and specific measurements is performed over a long period of years and it is necessary to carry out these agrometeorological observations platforms to be relatively homogenous, where the natural particular conditions are relatively the same.

☑ Agrometeorological data and the specific phenological observations are used for the current agrometeorological service, and for agrometeorological data of The National Fund for the purpose of their use in scientific research works and specific projects.

1) Agrometeorological platform

Phenological observations are carried out in standard platforms and production fields. Standard observation platform has a surface area of 1 hectares (100×100 m) and is divided into four plots. Observation points are chosen in the four corners of the platform.

Agrometeorological platforms are located in surface as large (>10 ha in the plains and >3 ha in the hills). Platforms can be fixed in the lower surface, provided that the required uniformity of the soil and relief. In these conditions shall take into account the following requirements:

- to characterize the entire area under cultivation (may be arranged and liner);
- does not compromise the environmental conditions, that neighboring fields to be planted with close height and growing season;
- the distance from high vegetation nearby to be at least 20 times the height of the "obstacle plant".

In large fruit trees plantations, the platform must have surface 1 ha. For phenological observations will choose four trees numbered from I to IV, and for monitoring the growth rate of fruit will choose the other three will be noted from V to VII.

In private property, the phenological observations can made on smaller areas, in which case, four trees will be chosen for observations and other three for biometric measurements fruits.

2) European coding system BBCH phase of growth and development of agricultural plants

❖ **BBCH** scale is a uniform European coding system in terms of the phenological stages of growth of the plant similar for all mono- and dicotyledonous species. Decimal code system, which is divided in the growth and development stages of primary and secondary, it is based on the developed Zadoks et al (1974), in order to avoid major changes in the phenological classification widely used.

BBCH ⇒ **B**iologische **B**undesanstalt, Bundessortenamt and **CH**emical industry – ***Biologische Bundesanstalt, Federal Agency for the Environment and Chemical Industry***

The main stages of growth of the plant

Faza	Descriere etapă
0	Germinare / Încolțire / Dezvoltare mugure
1	Dezvoltare frunze (lăstar principal)
2	Formare de lăstari laterali / Înfrățire / Creștere lăstari
3	Alungire tulpină sau creștere rozetă/ Dezvoltare lăstari principali
4	Dezvoltare de părți recoltabile ale plantei sau de organe vegetative / Înspicare
5	Apariție inflorescență principală
6	Înflorire / Inflorescențe
7	Dezvoltare de fructe
8	Coacere sau maturitate a fructelor și a semințelor
9	Senescența, începând cu latența

Basic principles of BBCH scale

- The general scale are developed by the individual scales. Also, this scale can be used for those species for which a special scale is not currently avaible.
- Similar phenological phases for each species have identical code.
- A description is given for each code, and for some important stages drawings are included.
- For description of phenological development stages, clear and recognizable used external morphological characteristics.
- Unless otherwise indicated, only the main stem development is considered.
- Growth stages refer to representative individual plants under standard culture. Standard crop characteristics may also be taken into account.
- The relative values of the specific species and/or variety are used to indicate dimensions.
- Secondary growth stages (steps) from 0 to 8 correspond to those of ordinary number or percentage values. For example, step 3 could be: a third true leaf, the third internode or 30% of the final length or standard size of the species or 30% of the flowers are open.
- Post-harvest or production storage is encoded 99.
- Treatment of seeds before planting is coded 00.

Phonological codes used in Agrometeorology Network of National Meteorological Administration, depending on the growth and development of crops, according to European Standard BBCH

Agrometeorological Guideline

Winter wheat (*Triticum sp. L.*)

Nr.crt.	FAZA FENOLOGICĂ	COD FENOLOGIC
1.	Semănat	BBCH - 00
2.	Germinare	BBCH - 05
3.	Răsărire	BBCH - 10
4.	Aparitia frunzei a 3-a	BBCH - 13
5.	Înfrățire	BBCH - 21
6.	Încetarea vegetației	BBCH - 29
7.	Reluarea vegetației	BBCH *
8.	Alungirea paiului	BBCH - 30
9.	Înspicare	BBCH - 51
10.	Înflorire	BBCH - 61
11.	Maturitate lapte	BBCH - 75
12.	Maturitate ceară	BBCH - 87
13.	Maturitate deplină	BBCH - 89
14.	Recoltare	BBCH - 99

Maize (*Zea mays*)

Nr.crt.	FAZA FENOLOGICĂ	COD FENOLOGIC
1.	Semănat	BBCH - 00
2.	Germinare	BBCH - 05
3.	Răsărire	BBCH - 10
4.	Aparitia frunzei a 3-a	BBCH - 13
5.	Înfrunzire (3, 8, 10 frunze)	BBCH - 19
6.	Aparitia paniculului	BBCH - 30
7.	Înflorirea paniculului	BBCH - 51
8.	Mătăsire	BBCH - 65
9.	Maturitate lapte	BBCH - 75
10.	Maturitate ceară	BBCH - 83
11.	Maturitate deplină	BBCH - 89
12.	Recoltare	BBCH - 99

Fruit trees

Nr.crt.	FAZA FENOLOGICĂ	COD FENOLOGIC
1.	Repaus vegetativ	BBCH - 00
2.	Înmugurire	BBCH - 01
3.	Dezmugurire	BBCH - 07
4.	Cresterea lăstarilor / frunzelor	BBCH - 19
5.	Înflorire	BBCH - 60
6.	Legarea și cresterea rodului	BBCH - 69
7.	Maturarea fructelor	BBCH - 81
8.	Recoltare	BBCH - 89
9.	Maturarea lemnului, îngălbenirea și căderea frunzelor	BBCH - 92

Sunflower (*Helianthus annuus*)

Nr.crt.	FAZA FENOLOGICĂ	COD FENOLOGIC
1.	Semănat	BBCH - 00
2.	Germinare	BBCH - 05
3.	Răsărire	BBCH - 10
4.	Dezvoltarea primei perechi de frunze	BBCH - 12
5.	Înfrunzire	BBCH - 19
6.	Formarea calatidiului	BBCH - 51
7.	Înflorire	BBCH - 61
8.	Maturitate ceară	BBCH - 75
9.	Maturitate deplină	BBCH - 89
10.	Recoltare	BBCH - 99

- **Sugar beet (*Beta vulgaris*) ; Soybean (*Glycine max*)**
- **Potato (*Solanum tuberosum*) ; Vine (*Vitis vinifera*)**
- **Rape (*Brassica napus*)**

3) Phenological observations

❖ Perform a fixed number of typical plants that remain throughout the entire growing season;
❖ The number of typical plants (which are representative of the majority of the crop plants) differs depending on the crop. Thus, in each plot are selected ten plants, five stocks for vines, and four trees across each platform for fruit trees.

Phenological phases are noted as follows:

- the start phase, when 10 % of plants in the phase;
- mass phase, when 50 % of the plants are in phase;
- the end of phase, when 100 % of the plants had completed the phase.

4) The density of the plant

❖ The data of the plant density determinations are recorded in the register in electronic form (separately for each culture) and are used in the analysis of production.

These observations are transmitted briefings agrometeorological weekly or on demand through Local Application Software AGROMETEO

5) Biometric measurements

Wheat, barley, rice, soybean, potato

- plant height;
- production elements.

Maize

- plant height;
- stem diameter;
- foliar;
- production elements.

Sunflower

- plant height;
- stem diameter;
- flowering diameter.

Sugar beet

- root diameter;
- production elements.

Vines and fruit trees

- increase in length of the shoots;
- production elements.

Biometric determinations differ from one culture to another in their specific biological function.

6) Weeding of crop

Note	Quantitative estimation of weed	Observations
1	The absence of weeds	No one can see weeds in the crop.
2	Weeding very easy	It is rare weeds, but they are barely even nearby.
3	Easy weeding	Weeds are common. They can be easily distinguished in culture, close, to but a distance of 20 to 30 m can't be distinguished from the growning plants.
4	Average weed	Weeds are easily distinguishable even from a relatively great distance, but is not observed preventing the development of culture.
5	Strong weed	Strong weed that harms culture. Can notice the poor growth and development of the crops due to weeds.

❖ *Estimating the degree of crops weeding is done visually for each land parcel.*

❖ *The estimate is expressed in note from 1 to 5, in electronic registries.*

7) Damage to crops produced by adverse weather phenomena, diseases and pests

❖ ***Damage characteristic***, *consists in the description of the parts damaged, damaged organs, changes in product exterior look (wilting or darkness) of the plants, leaves, or fruits attacked by pests and diseases.*

❖ ***The damage*** *involve a visual assessment of the number of organ damage: isolated, many (more than half), most of all, all.*

❖ ***The surface of extending***, *by indicating the proportion of the affected part: a small part, less than half, most of the whole area (in hectares) occupied by the culture.*

❖ ***The peculiarities of the plant settlement*** *that have been damaged. Plant observation to be made in the second half of the day when the damaging weather phenomenon was observed, whether the habitual phenological observation made or not in that day.*

WINTER DAMAGE

- *Plant frostbite*
- *Asphyxiation*
- *The crust of ice*
- *The uprooting of the plants*
- *Drying crops*
- *The uprooting of the plants due the wind*

DAMAGE TO THE VEGETATION

- *Frosts*
- *Drought and dry wind (hot wind)*
- *Hail and heavy rains*
- *Asphyxiation*

- **Date of damaging weather phenomenon;**
- **Date of the plants examination;**
- **Name of the culture and variety;**
- **Date of sowing;**
- **The growing phase of the plants.**

8) Estimation of the state of the crop growing season field and fruit trees in the winter

➲ *It is during the winter and early spring with special importance for the implementation of appropriate measures to reduce damage caused by unfavorable factors.*

Winter observations are made from 15 to 15 days from termination of vegetation. Note if the ground is covered with snow, if there is soil crust , the appearance of the plants, etc.

The dormant period is to determine the viability of the crops, taking samples (monoliths) only when the ground is frozen. Samples are taken twice during the winter.

The percentage of destruction of the test plants (monolith):

$$P = \frac{b \times 100}{a}$$

where,

P = percentage of destruction
b = the number of plants which not increased in the sample
a = total number of plants

9) Visual estimation of the state of vegetation in the warm season (summer)

- Based on visual observations that are performed both by qualitative estimates and through notes (1 to 5).
- With the phenological in the day of collection of soil samples.
- A further determination must be made of rice, two weeks after the appearance of the third leaf mass.
- Measurement of trees and vines to be made at two weeks after flowering and fruit binding.

10) Quantitative estimation of the state of vegetation

➲ *Quantitative estimation of the state of vegetation is based on biometric measurements.*

11) Biological analysis to the yield

- The biological analysis to the yield involves performing a series of analyzes and special measurements on a variable number of slaughter plant, depending on the crop.

- Plants intended for analysis shall be harvested in the middle of the platform.

4.3. Characterization of the agricultural year (September – August)

- Description of the agricultural peculiarities of agrometeorological year (September to August) is to analyze specific agrometeorological parameters and their influence on field crops and fruit-wine.

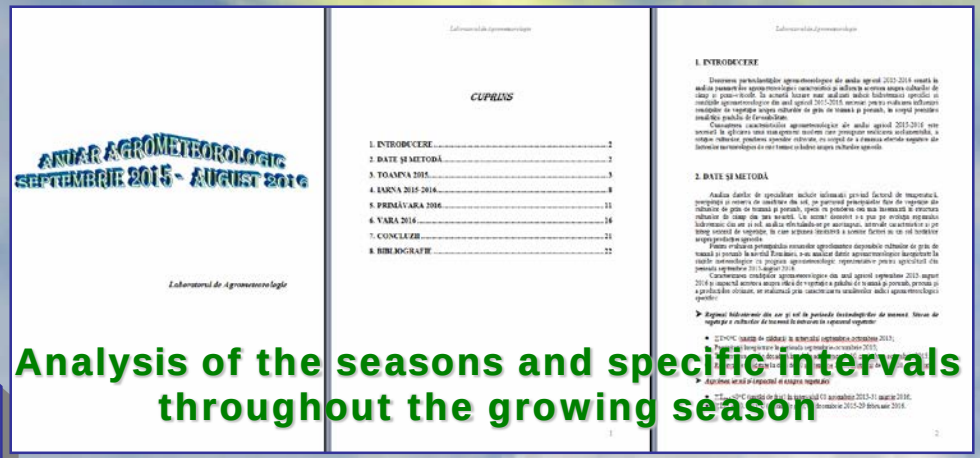
- Specific indices and specific thermal and hydro resources are analyzed, in direct correlation with the plants water demands, required to evaluate the influence of the growing conditions of the crop.

AUTUMN

WINTER

SPRING

SUMMER



Analysis of the seasons and specific intervals throughout the growing season

- Knowledge of agrometeorological characteristics of agricultural year is necessary for the application of modern management that involves making crop rotation, the share of cultivated species, in order to mitigate the negative effects of weather and water risk factors on crops.

Characterization of the agricultural year (September – August)

➢ **Characterization of the agricultural agrometeorological conditions since September to August and their impact on the state of growth of the winter wheat and maize crop, as well as the yields obtained, the characterization is carried out by specific *Agrometeorological indices*:**

➲ ***Hydrothermal regime of air and soil during the autumn sowing. Status vegetation of winter crops entering dormant:***

- ∑T>0°C (heat units) during the period from September to October;
- Precipitation amounts registered during September-October;
- Decadal average soil temperature at a depth of 10 cm in October;
- Soil moisture on 30 September in the 0-20 cm layer of soil (field).

➲ ***Winter harshness and its impact on vegetation:***

- Winter harshness, expressed by the phenomena intensity, namely ***cold intensity*** (sums of mean air temperatures below 0°C / $\sum T_{med.}$<0°C) recorded in the November to March period and ***frost intensity*** (sums of minimum air temperatures ≤-10...-15...-20°C / $\sum T_{min.}$≤-10...-15...-20°C) in December-February interval.

➲ ***Peculiarities of the transition period from winter to spring:***

- Spring index ($\sum T_{med.}$>0°C / heat units), expressed by sums of positive average temperatures and calculated for the 1st of February to the 10th April interval.
- Precipitation amounts registered during November-March;
- Soil moisture in the 0-100 cm soil layer in winter wheat crop at the end of May;
- Soil moisture in the 0-50 cm soil layer in maize crop at the end of April;
- Decadal average soil temperature at a depth of 10 cm in April.

➲ ***Agrometeorological characterization of the growing season crops. The dynamic analysis of rainfall and their effects on the state of vegetation and crop yield, with the evolution of the thermal impact on the production data of the phenological phases of winter wheat and maize:***

- Soil moisture in the 0-100 cm soil layer in winter wheat at the end of June;
- Rainfall in the period from June to August and during September to August;
- Soil moisture in the 0-100 cm soil layer in the non-irrigated maize crop at the end of July and August;
- The ***intensity*** (sums of maximum temperatures ≥32°C / $\sum T_{max.}$≥32°C/heat units) and ***duration*** (average number of days with maximum temperatures ≥32°C) of the heat phenomenon from June to August.

5. Remote sensing products used in Romanian drought monitoring system

- In the last decades, significant agricultural areas across Romania were affected by extreme climate events, with multiple negative implications in agriculture, water resources and ecosystems conservation.

- In this respect, it is particularly important to know the duration, intensity, frequency and spatio-temporal distribution of the risk factors for agriculture (drought, heat, excess / deficit of soil water, etc) in order to identify the agricultural areas with different degrees of vulnerability and elaboration of strategic decisions for long-term planning such as design, location and operation of irrigation systems in order to ensure the water needs for plants.

- To have complex agro meteorological information it is necessary to improve the operational capabilities of monitoring using advanced remote sensing techniques and Geographic Information Systems (GIS).

- Remote sensing techniques play an important role in crop identification, acreage and production estimation, disease and stress detection, soil and water resources characterization because they provide spatially explicit information and access to remote locations. These techniques allow examining the properties and processes of ecosystems and their inter-annual variability at multiple scales because remote sensing observations can be obtained over large areas of interest almost every day.

- Data sets provided by satellite systems can be used in global, regional or local studies, to obtain input data used to produce various models of energy balance, water balance, etc.

- From remote sensing data can be extracted biophysical, biological or structural vegetation parameters: leaf area index (LAI), biomass, photosynthetic active radiation daily fraction absorbed by vegetation cover (fAPAR), normalized difference vegetation index (NDVI), normalized difference water index (NDWI).

- **The Normalized Difference Vegetation Index (NDVI)** is a non-linear transformation of visible bands (Red) and near infrared (NIR), being defined as the difference between these two bands divided by their sum:

$$NDVI = \frac{NIR - VIS}{NIR + VIS}$$

- NDVI is a "measure" of development and vegetation density and is associated with biophysical parameters as: biomass, leaf area index (LAI), used widely in crop growth models, the percentage of vegetation cover of the land, photosynthetic activity of vegetation.
- NDVI values range from -1.0 to 1.0, with negative values indicating clouds and water, positive values near zero indicating bare soil, and higher positive values of NDVI ranging from sparse vegetation (0.1 - 0.5) to dense green vegetation (0.6 and above).

$$NDVI_{Pleiades} = \frac{B4 - B3}{B4 + B3}$$

$$NDVI_{Modis} = \frac{B2 - B1}{B2 + B1}$$

$$NDVI_{Landsat8} = \frac{B5 - B4}{B5 + B4}$$

- **The Normalized Difference Water Index (NDWI)** is a satellite-derived index from the Near-Infrared (NIR) and Short Wave Infrared (SWIR) reflectance channels:

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR}$$

Where: SWIR and NIR are spectral reflectance from short wave infrared band and near-infrared regions, respectively.

- **NDWI values range from -1.0 to 1.0. The common range for green vegetation is -0.1 to 0.4. This index increases with vegetation water content or from dry soil to free water.**
- **NDWI index is a good indicator of water content of leaves and is used for detecting and monitoring the humidity of the vegetation cover. During dry periods, the vegetation is affected by water stress, which influence plant development and can cause damage to crops. Because it is influenced by plants dehydration and wilting, NDWI may be a better indicator for drought monitoring than NDVI. By providing near real-time data related to plant water stress, the water management can be improve, particularly by irrigating agricultural areas affected by drought, according to water needs.**

$$NDWI_{Modis} = \frac{B2 - B7}{B2 + B7}$$

$$NDWI_{Landsat8} = \frac{B3 - B6}{B3 + B6}$$

- **The Normalized Difference Drought Index (NDDI)** is a relatively new superior drought indicator. It is calculated as the ratio of the difference between the normalized difference vegetation index and normalized difference water index and their sum:

$$NDDI = \frac{NDVI - NDWI}{NDVI + NDWI}$$

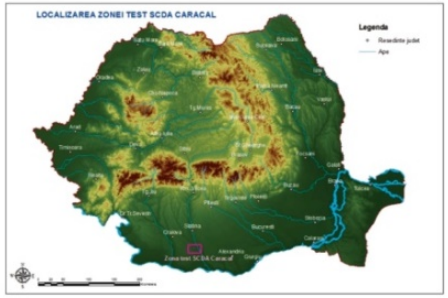
$$NDDI_{Landsat\ 8} = \frac{B_3 - B_6}{B_3 + B_6}$$

I- it combines information from visible, NIR, and SWIR channel. NDDI can offer an appropriate measure of the dryness of a particular area, because it combines information on both vegetation and water.

N- NDDI had a stronger response to summer drought conditions than a simple difference between NDVI and NDWI, and is therefore a more sensitive indicator of drought. This index can be an optimal complement to in-situ based indicators or for other indicators based on remote sensing data.

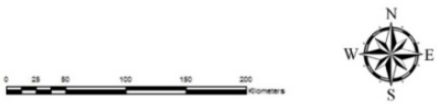
Applications developped in the Caracal area

P1 – sunflower
P2 – maize
P3 – winther wheat



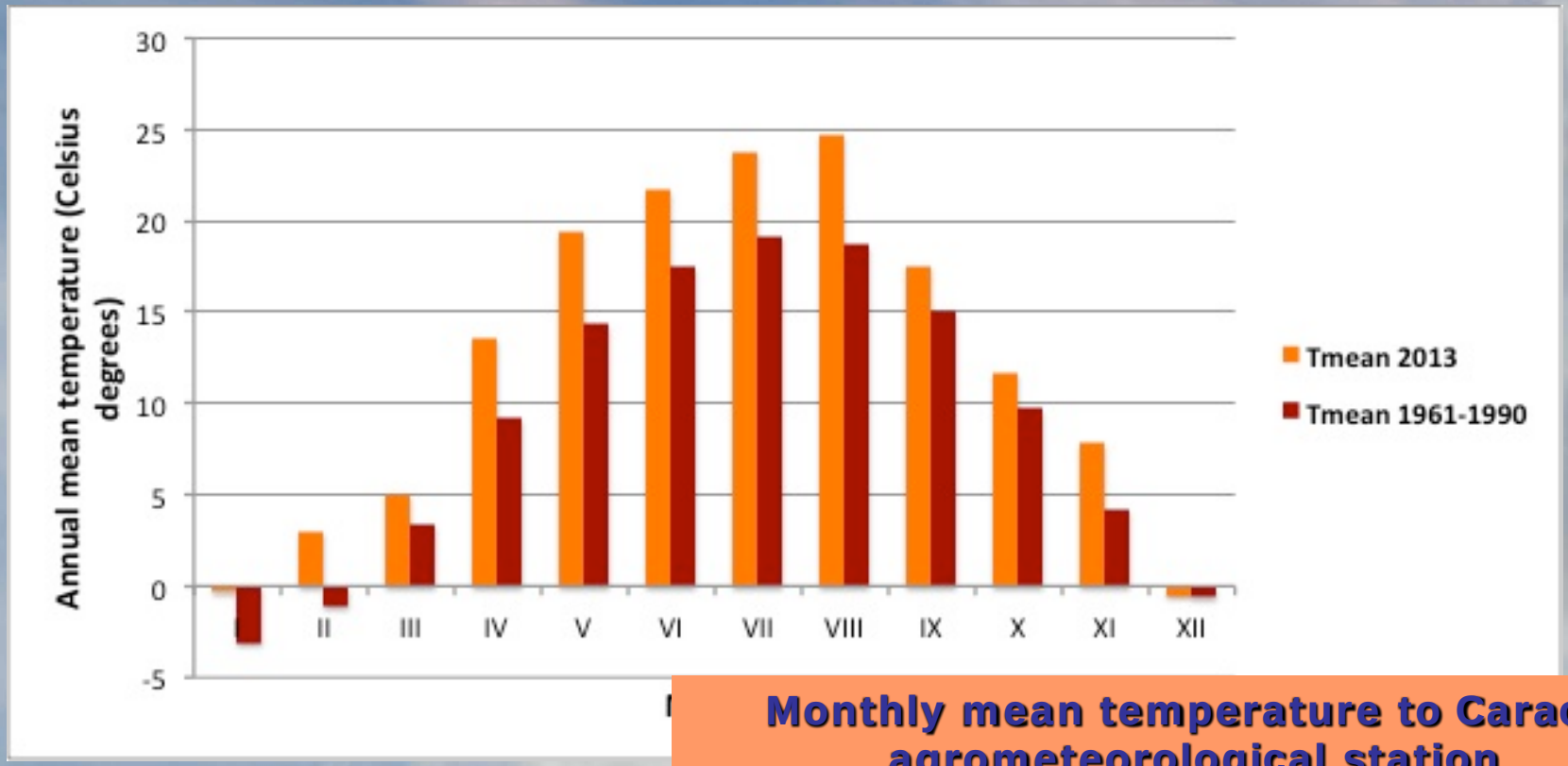
Zona test SCDA CARACAL - localizare

Imagine RGB - Pleiades - 10.05.2013



CLIMATIC INFORMATION

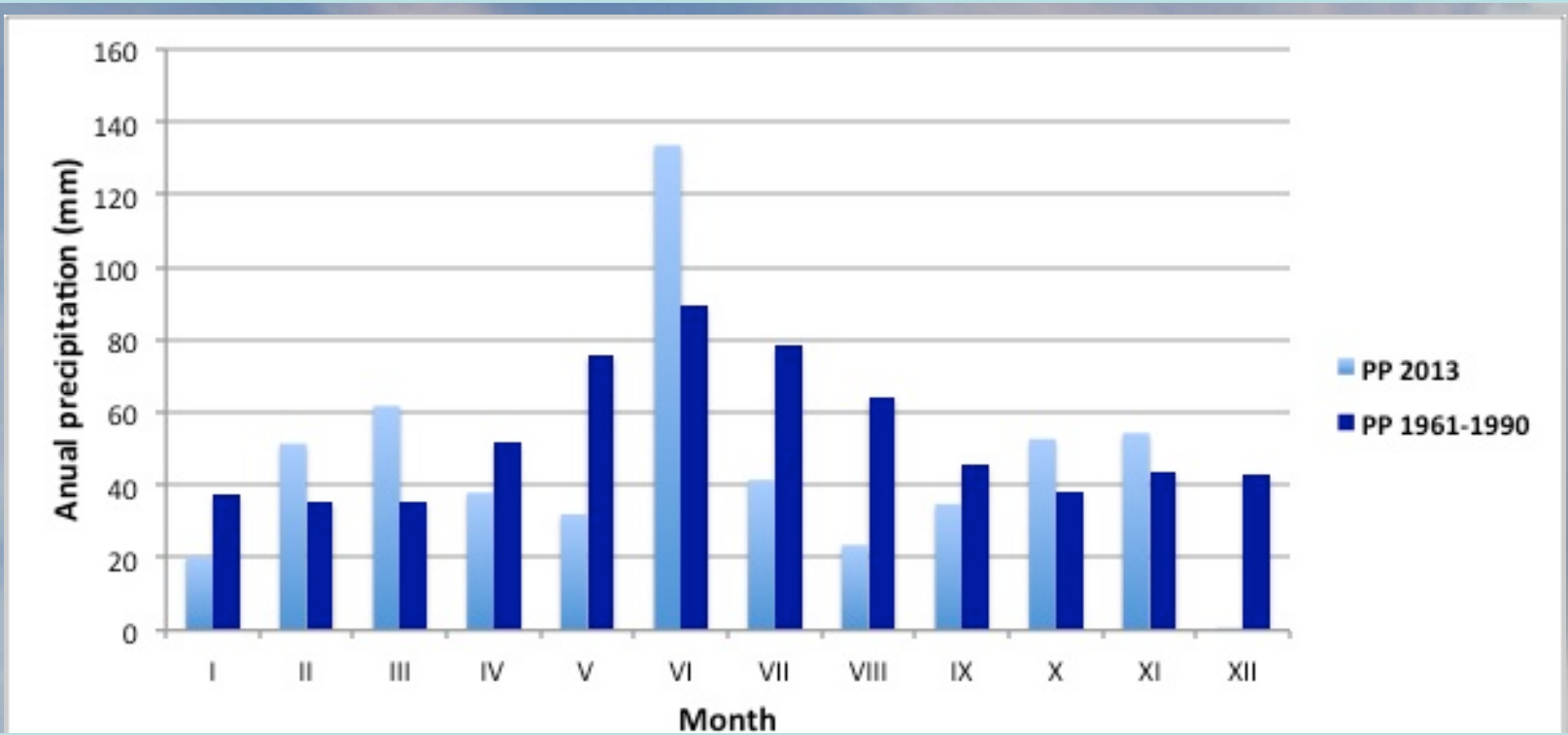
- The year 2013 was one of the warmest years, wit a deviation about 1.2°C comparing with the mean temperature for the reference period 1961-1990
- It can be observed that starting from April to August, mean monthly temperature was very high comparing to the reference period.



Monthly mean temperature to Caracal agrometeorological station

CLIMATIC INFORMATION

- Even the year 2013 was warmest comparing with 1961-1990 period, excepting few month (April, May, July, August and September), precipitation were higher than precipitation from referencing period (the maximum value was in June, 133.6 mm).



Monthly precipitation at Caracal agrometeorological station

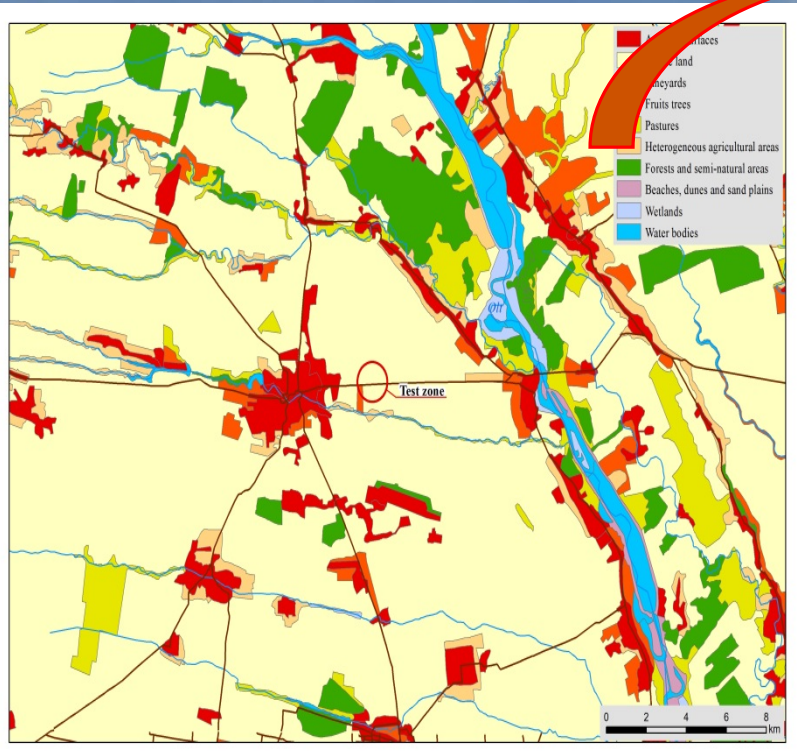
PLÉIADES satellite data

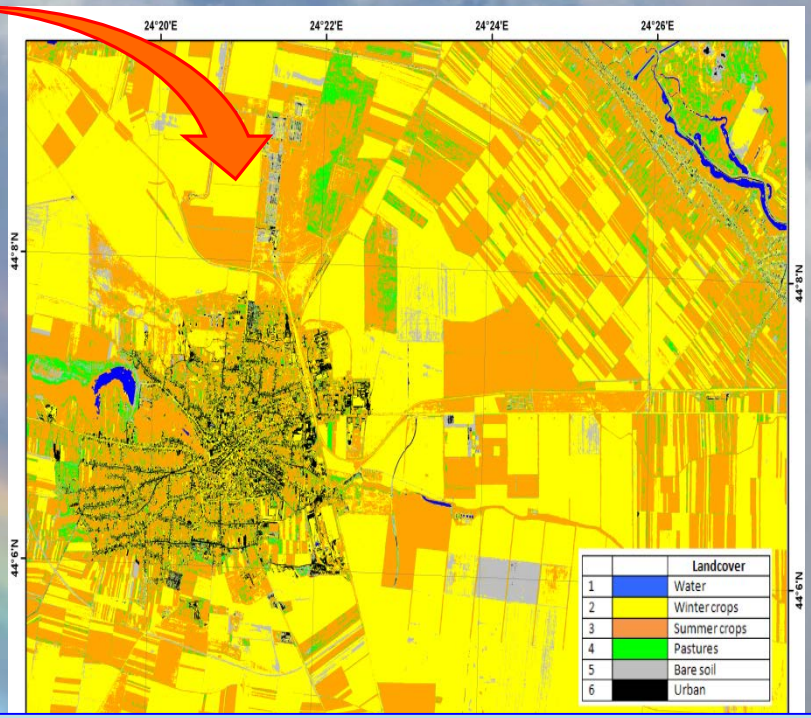
Resolution	Panchromatic: 50 cm
	Multispectral: 2 m
	Bundle: 50 cm PAN & 2 m MS
Footprint	20 km swath
	Single pass mosaics up to 100 km x 100 km

Spectral bands	Spectral interval (nm)
Panchromatic	480-830 nm
Blue	430-550 nm
Green	490-610 nm
Red	600-720 nm
Near Infrared	750-950 nm

May, July and August 2013

Land cover/use categories over the Caracal study area

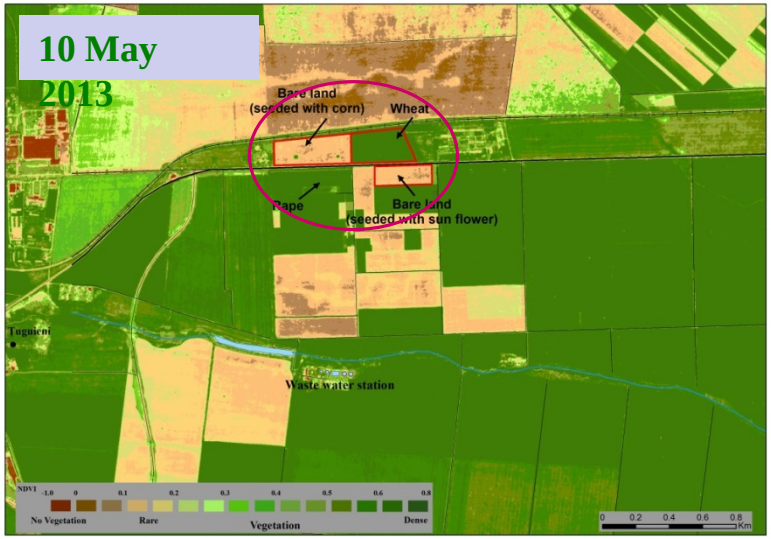




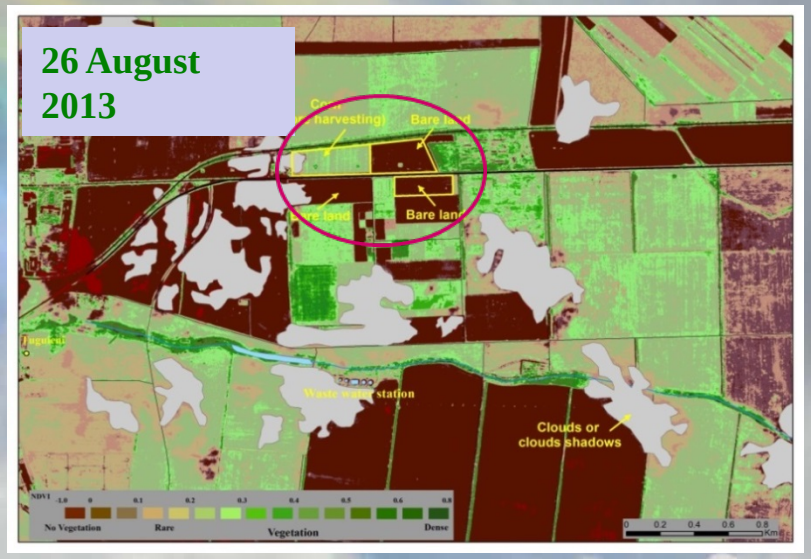
The land cover / use categories of the test area based on the CLC database: cities/villages, arable land, pastures, vineyards, forests and semi-natural areas, wetlands, water). .

Detailed land cover/use of the test area based on Pleiadés image of 10 May 2013.
The unsupervised image classification, followed by classes regrouping finally led to 6 main land cover / use classes: winter crops (wheat), summer crops (corn, sunflower), pastures, barren soil, urban and water.

NDVI over the Caracal study area issues from the Pleiades images

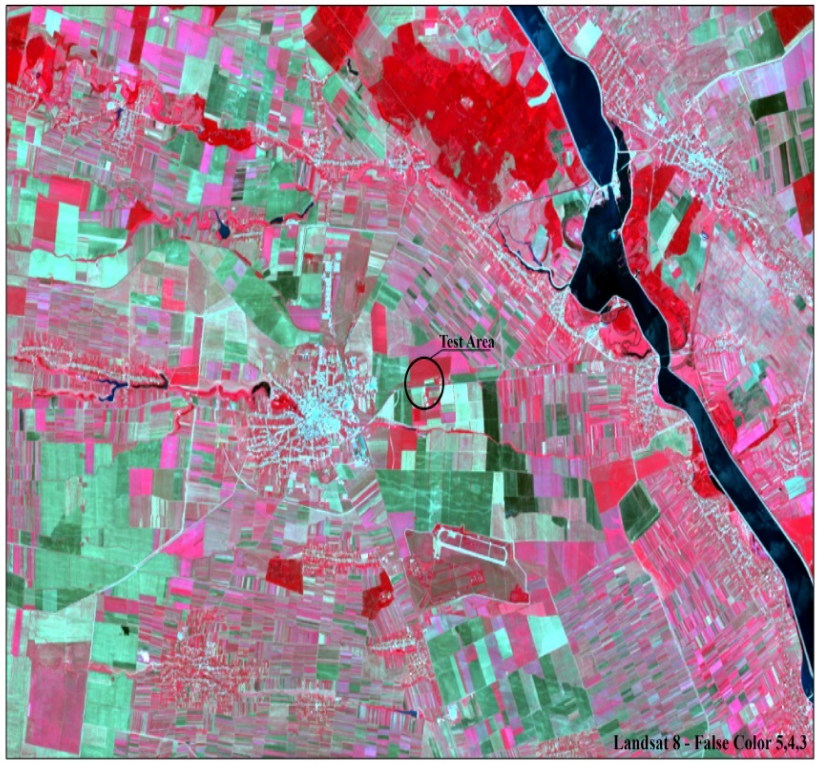


Satellite data	Crop	NDVI
10-May-2013	Wheat	0.609
	Corn	0.235
	Sun Flower	0.246
3-Jul-2013	Wheat	0.166
	Corn	0.687
	Sun Flower	0.704
26-Aug-2013	Wheat	0.124
	Corn	0.23
	Sun Flower	0.156



LANDSAT 8 satellite data

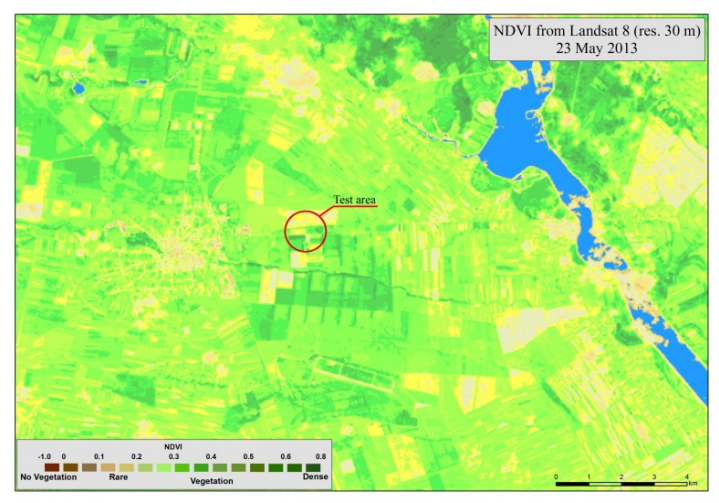
Band Number	Spectral domain (μm)	Spatial Resolution (m)
1	0.433–0.453	30 m
2	0.450–0.515 (blue)	30 m
3	0.525–0.600 (green)	30 m
4	0.630–0.680 (red)	30 m
5	0.845–0.885 (near IR)	30 m
6	1.560–1.660 (short wavelength IR)	30 m
7	2.100–2.300 (short wavelength IR)	30 m
8	0.500–0.680 (panchromatic)	15 m
9	1.360–1.390	30 m
10	10.6-11.2	100 m
11	11.5-12.5	100 m

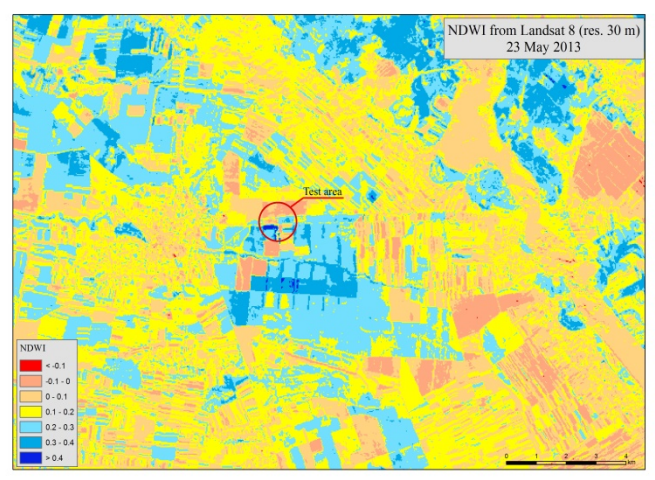


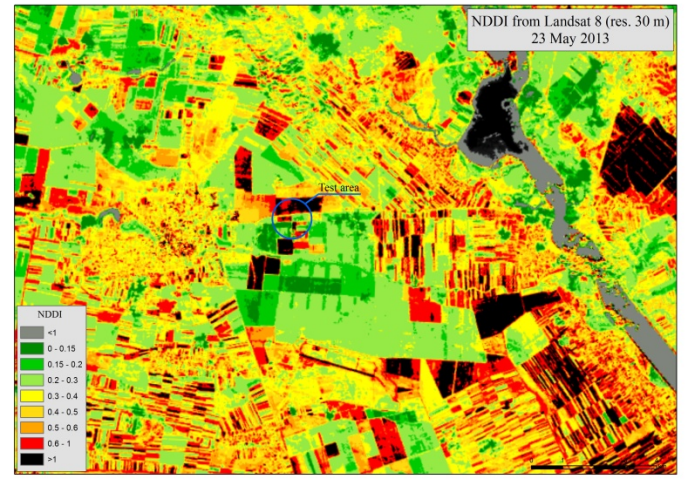
LANDSAT 8 color composite (5, 4, 3) on Caracal study area 26.07.2014

For this study LANDSAT 8 satellite data of the period May – September 2013 have been downloaded; finally five images cloud free have been used (10.07.2013, 23.05.2013, 12.09.2013, 26.07.2013, 27.08.2013).

NDVI, NDWI, NDDI over the Caracal study area estimated from Landsat 8 data – 23. 05.2013

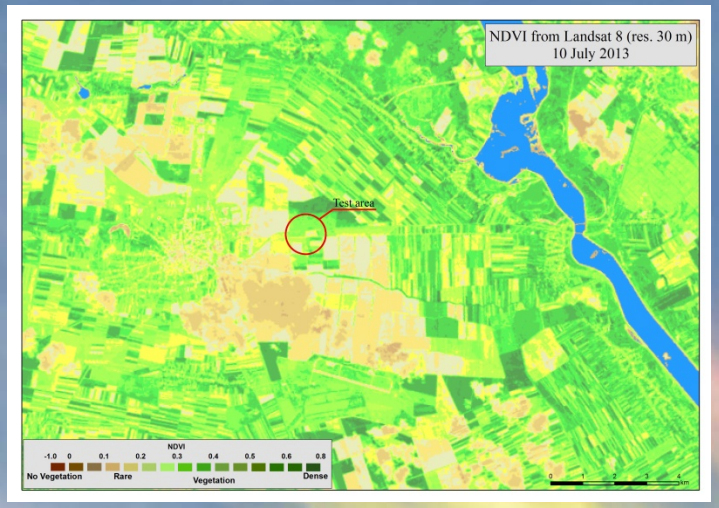


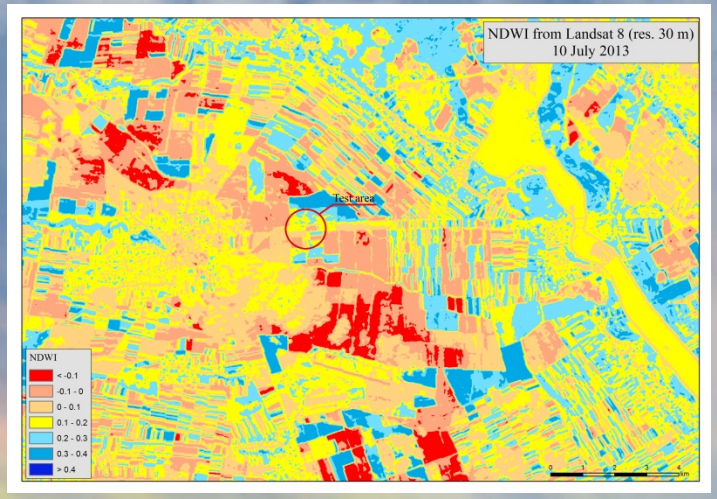


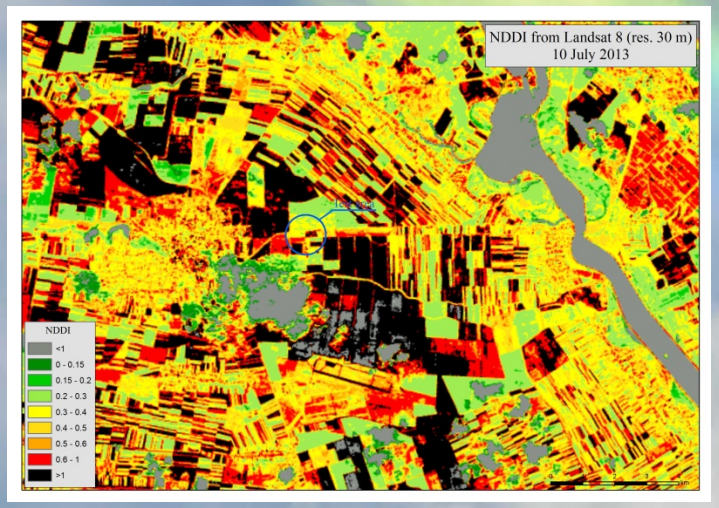


Data	Soil moisture (m^3/ha) (0-100 cm)	Type of drought	Phenological phase
23.05.2013	Wheat: 381	Strong pedological drought	maturity
	Maize: 302	Moderate pedological drought	leaf forming
10.07.2013	Maize: 1318	Supply near normal	flowering panicle, silk, grain filling
26.07.2013	Maize: 802	Moderate pedological drought	flowering panicle, silk, grain filling
27.08.2013	Maize: 374	Strong pedological drought	continues flowering panicle, matasirea, milk maturity, wax maturity continues flowering panicle, silk, milk maturity, wax maturity

NDVI, NDWI, NDDI over the Caracal study area estimated from Landsat 8 data







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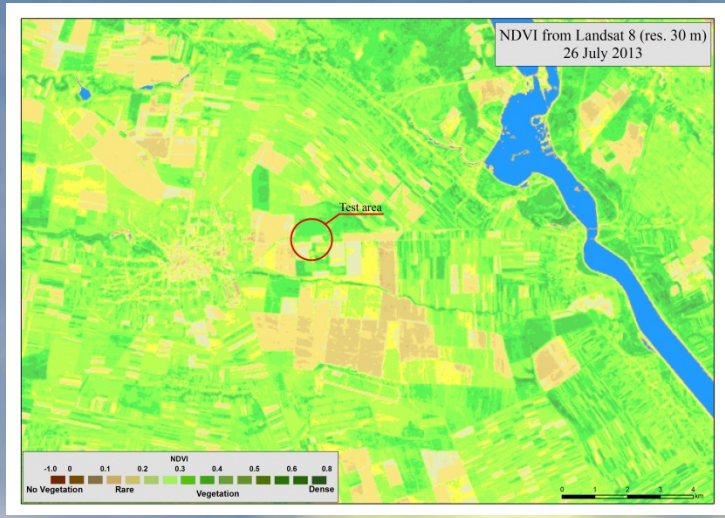
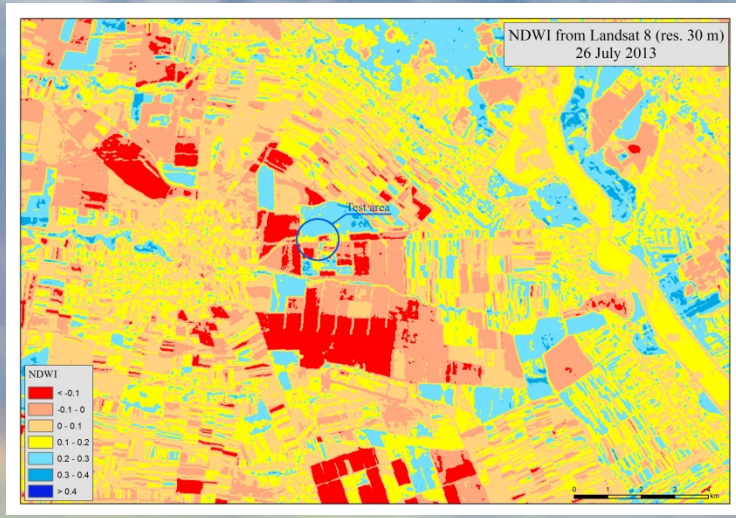
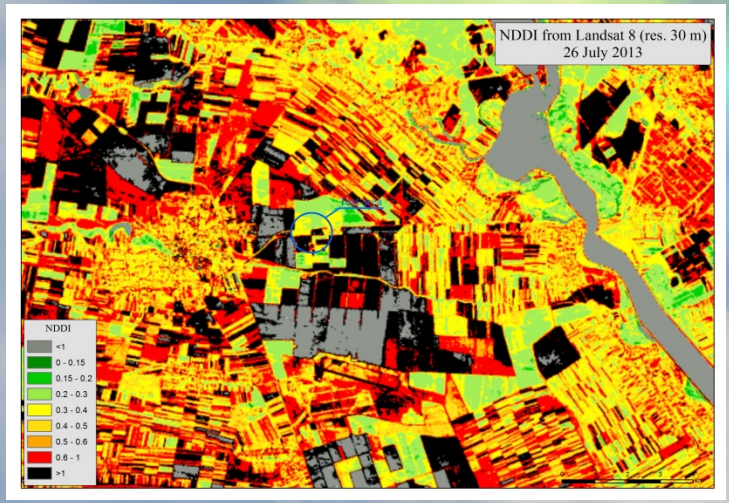
NDVI, NDWI, NDDI over the Caracal study area estimated from Landsat 8 data – 26.07.2013







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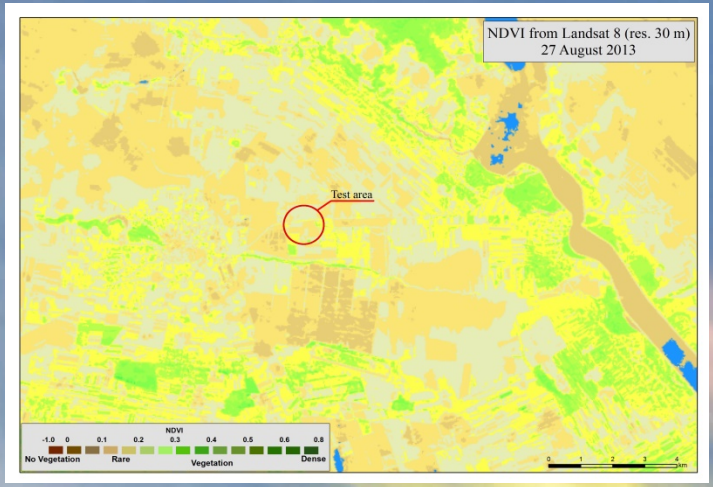
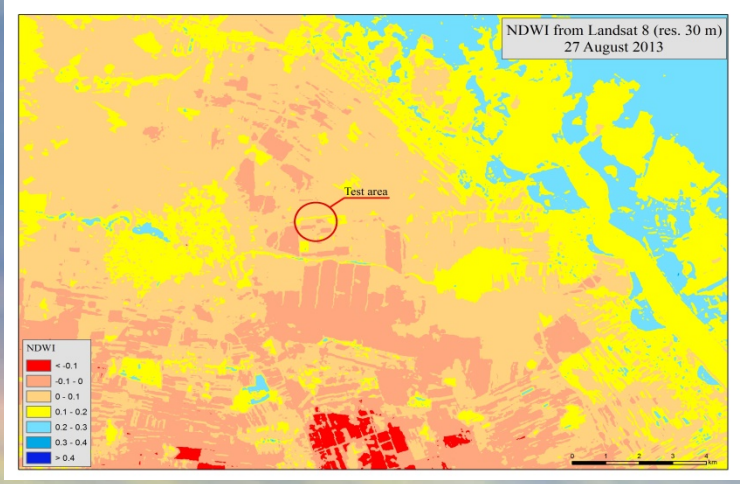
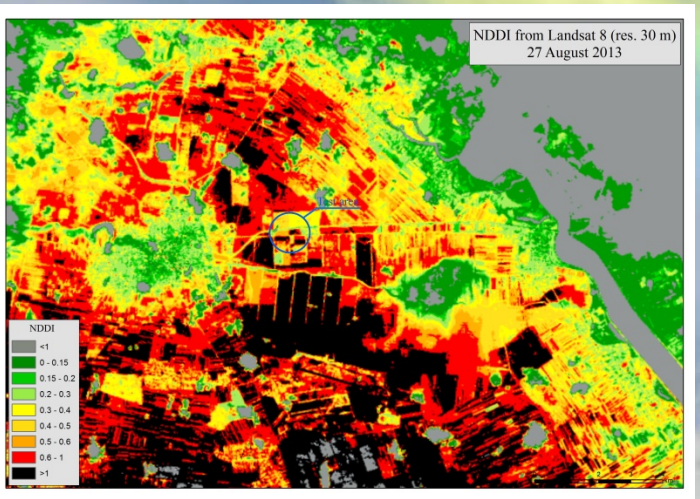
26.07.2013	Maize: 802	Moderate pedological drought	flowering panicle, silk, grain filling
27.08.2013	Maize: 374	Strong pedological drought	continues flowering panicle, matasirea, milk maturity, wax maturity continues flowering panicle, silk, milk maturity, wax maturity

NDVI, NDWI, NDDI over the Caracal study area estimated from Landsat 8 data – 27.08.2017

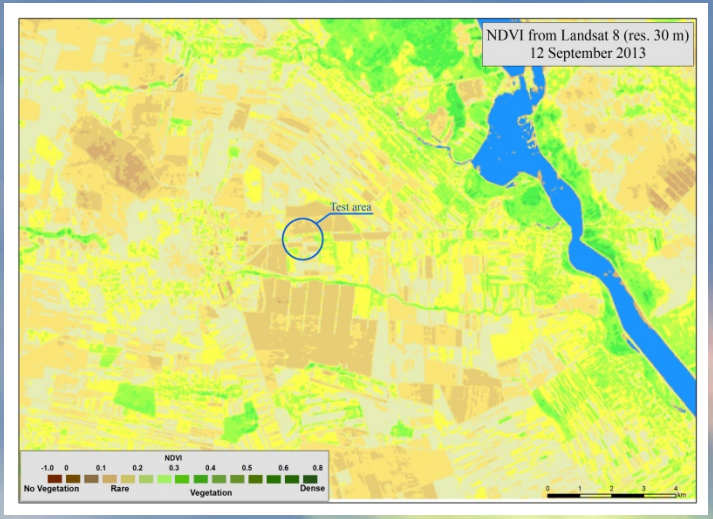


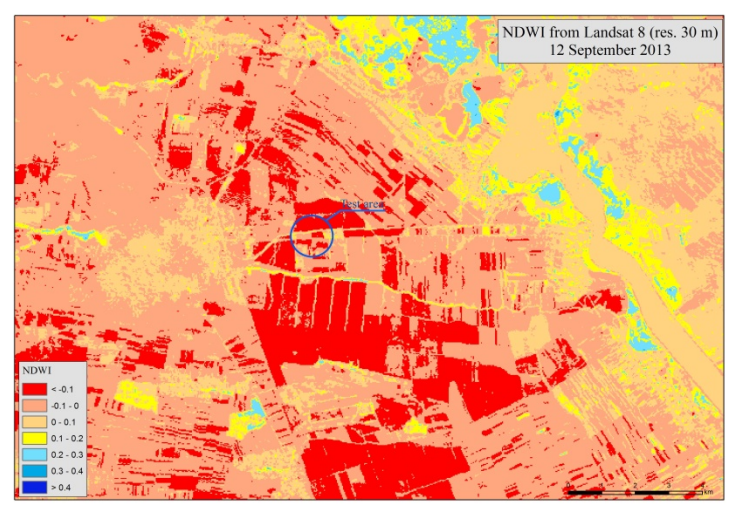


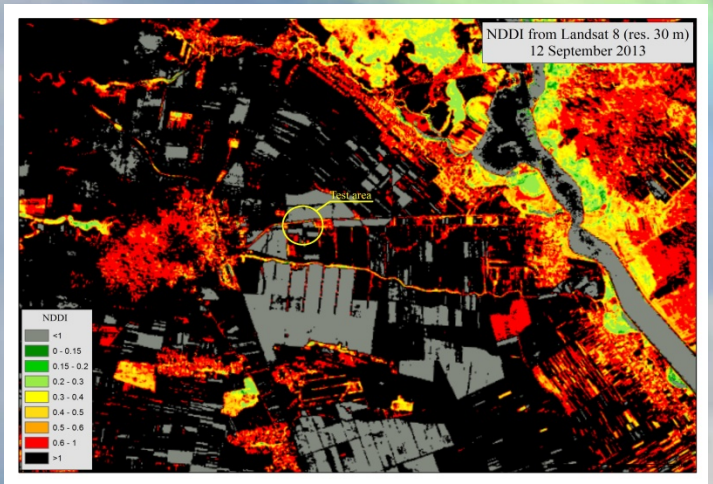


Data	Soil moisture (m^3/ha) (0-100 cm)	Type of drought	Phenological phase
23.05.2013	Wheat: 381	Strong pedological drought	maturity
	Maize: 302	Moderate pedological drought	leaf forming
10.07.2013	Maize: 1318	Supply near normal	flowering panicle, silk, grain filling
26.07.2013	Maize: 802	Moderate pedological drought	flowering panicle, silk, grain filling
27.08.2013	Maize: 374	Strong pedological drought	continues flowering panicle, matasirea, milk maturity, wax maturity continues flowering panicle, silk, milk maturity, wax maturity

NDVI, NDWI, NDDI over the Caracal study area estimated from Landsat 8 data – 12.09.2017







Data	Soil moisture (m^3/ha) (0-100 cm)	Type of drought	Phenological phase
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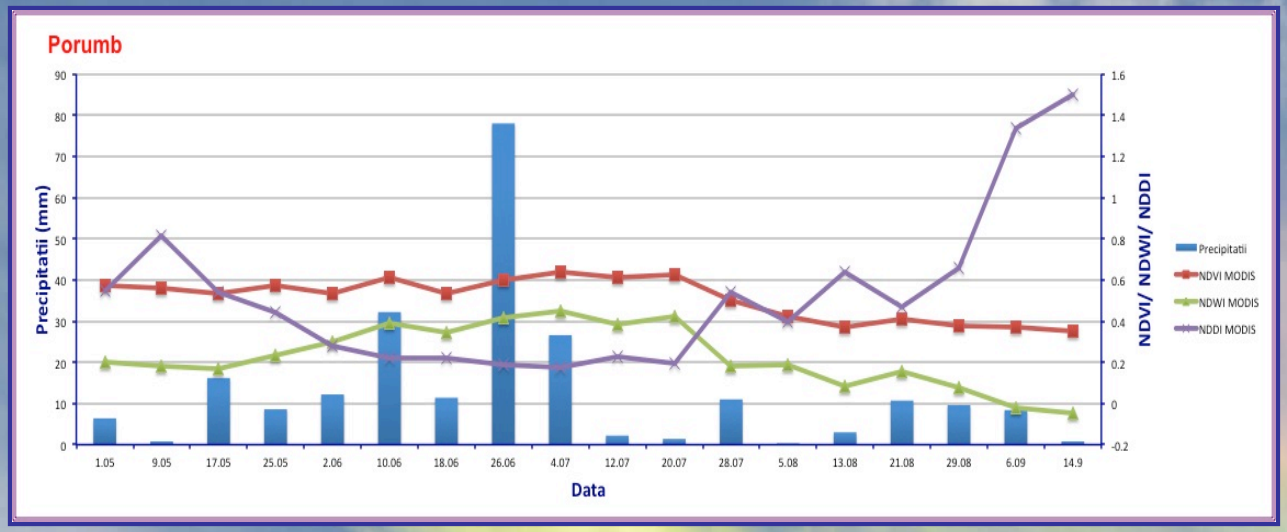
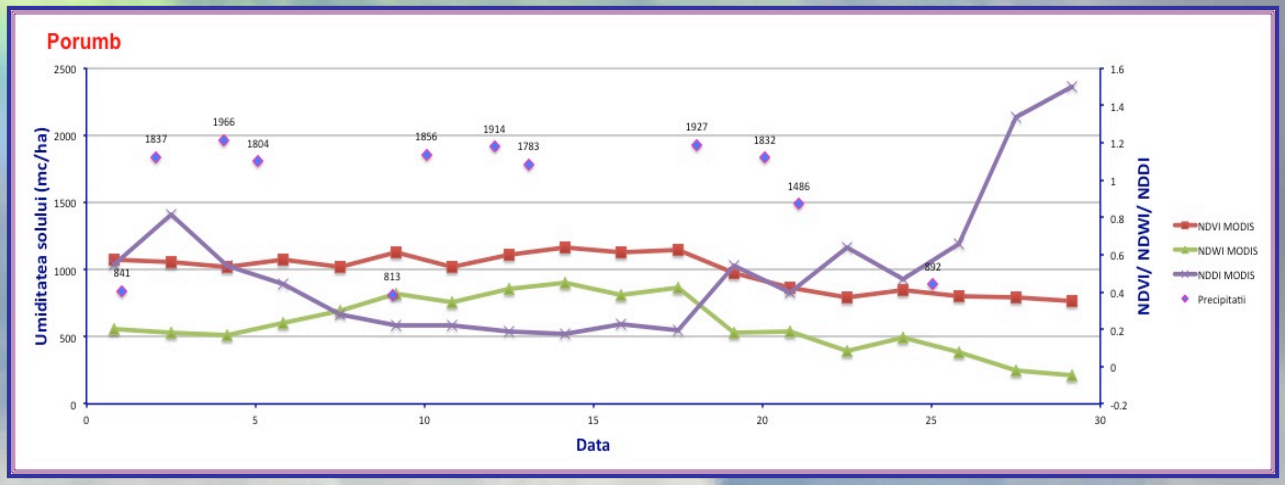
27.08.2013	Maize: 374	Strong pedological drought	continues flowering panicle, matasirea, milk maturity, wax maturity continues flowering panicle, silk, milk maturity, wax maturity

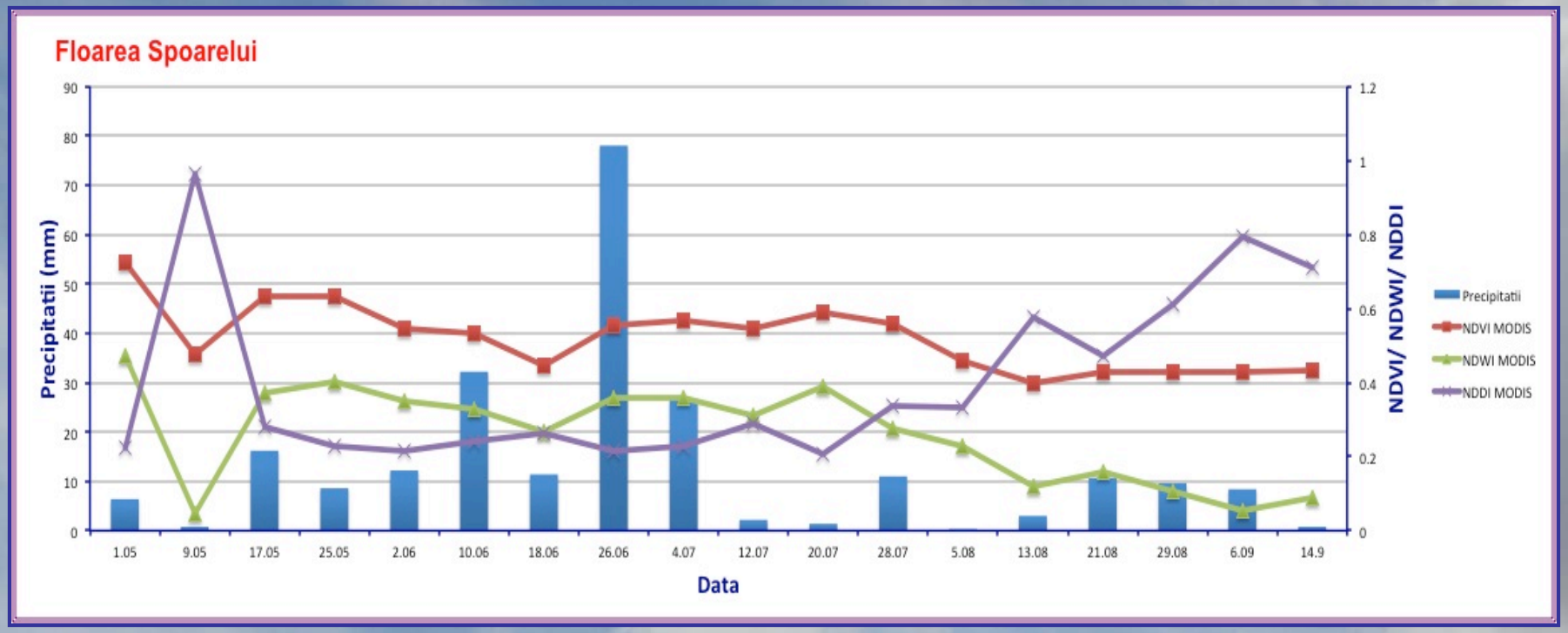
MODIS – NDVI, NDWI and NDDI (500 m resolution) evolution versus precipitation (recorded at Caracal weather station) for May – September 2013 - Maize



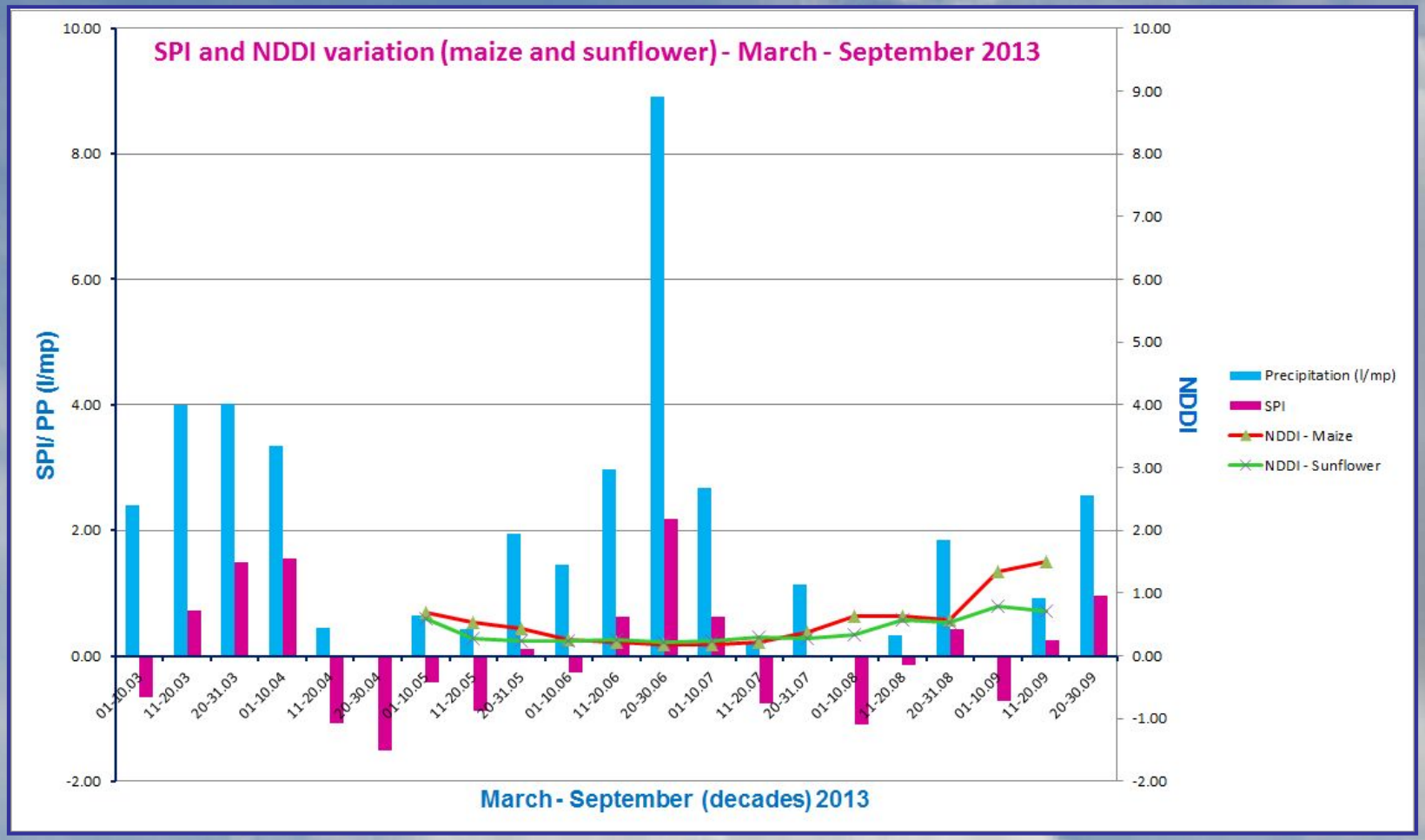
NDVI, NDWI, NDDI variation estimated from MODIS data, with soil moisture recorded at agrometeorological station Caracal (maize), May-Sptember 2013.



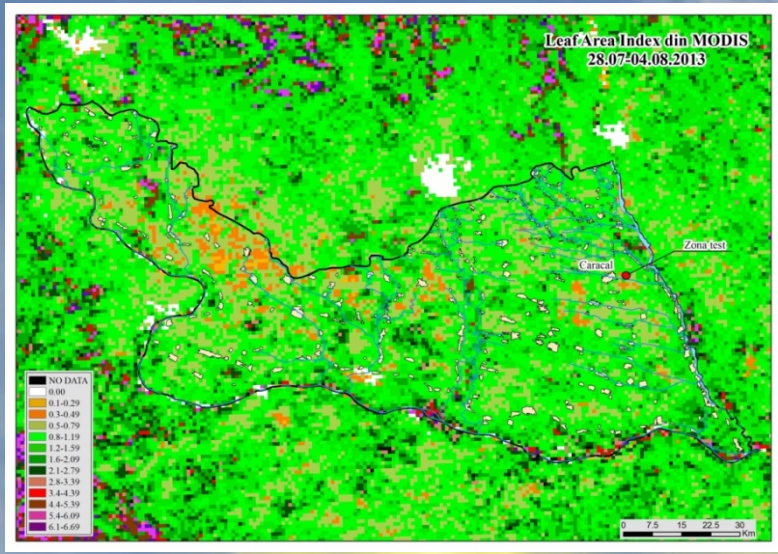
MODIS – NDVI, NDWI and NDDI (500 m resolution) evolution versus precipitation (recorded at Caracal weather station) for May – September 2013 – Sun flower

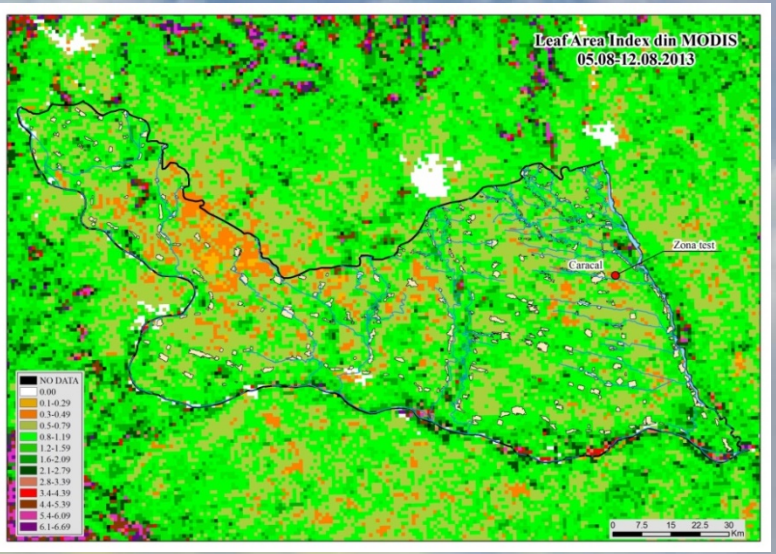


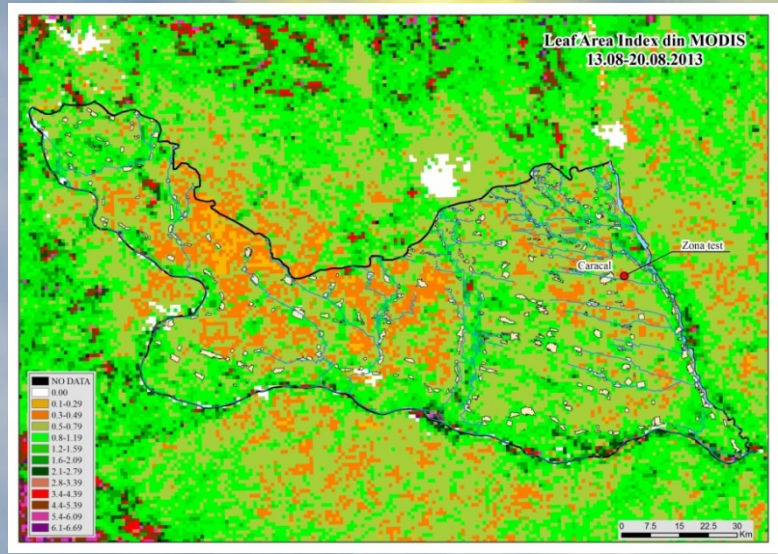
MODIS – NDVI, NDWI and NDDI (500 m resolution) evolution versus Standardized Precipitation Index (calculated for Caracal weather station) for May – September 2013 – Sun flower

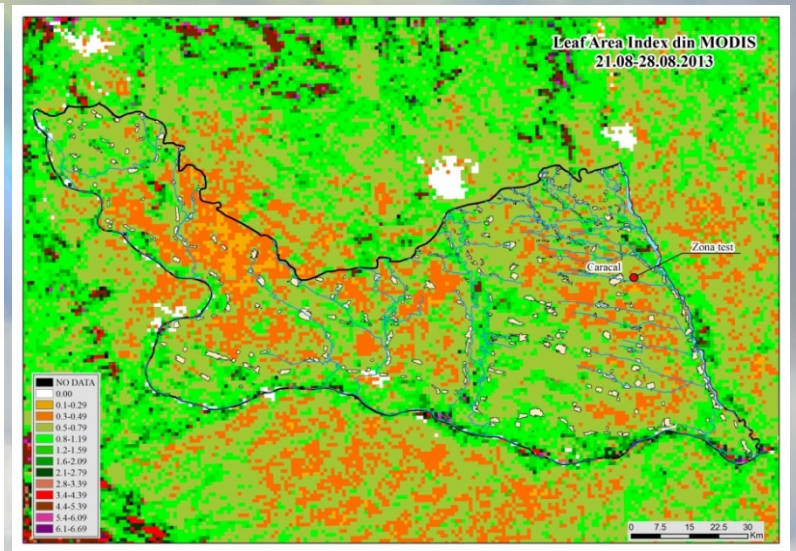


MODIS – LAI (1 km) evolution in the Oltenia Plain for 27 July to 28 August 2013

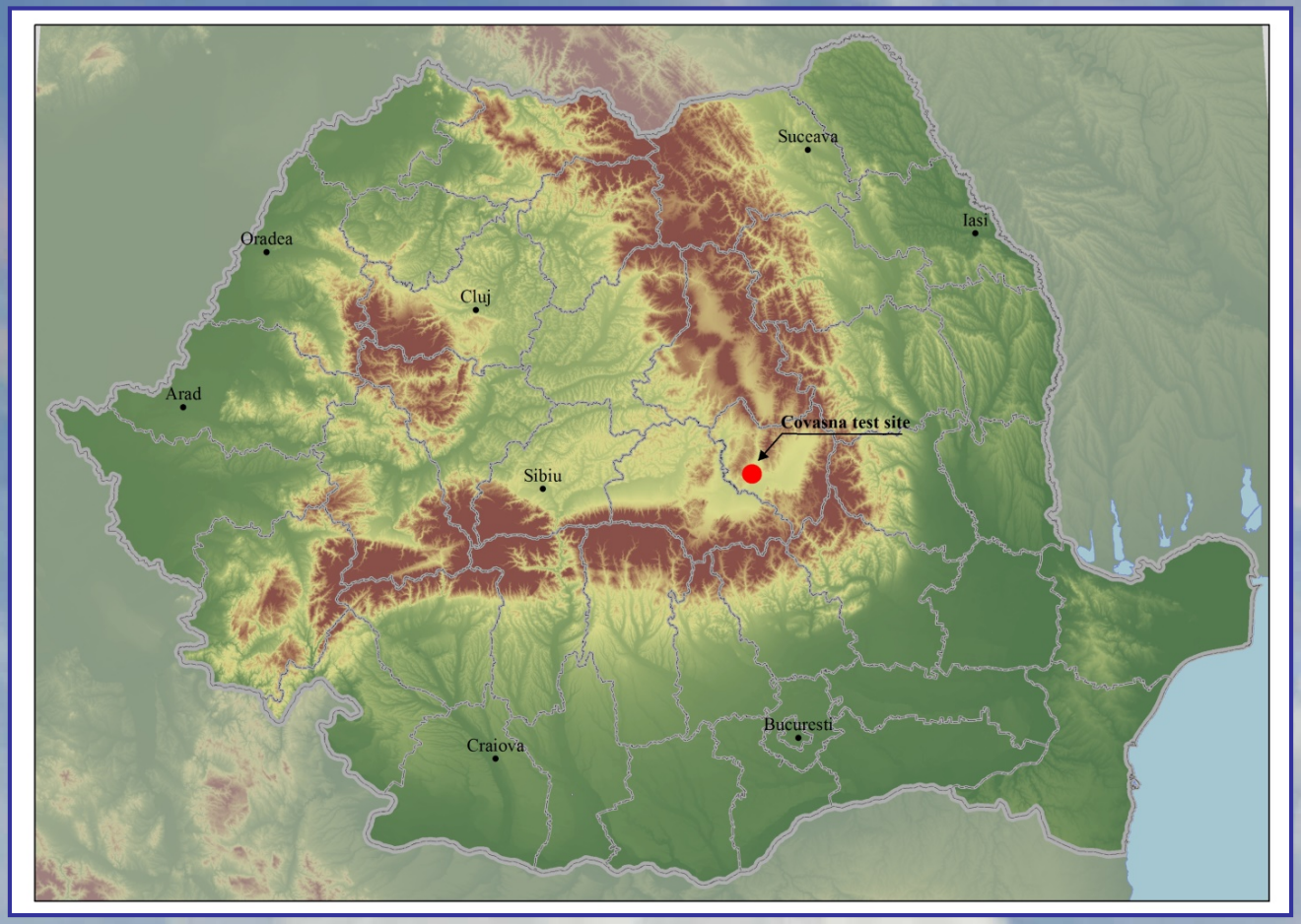




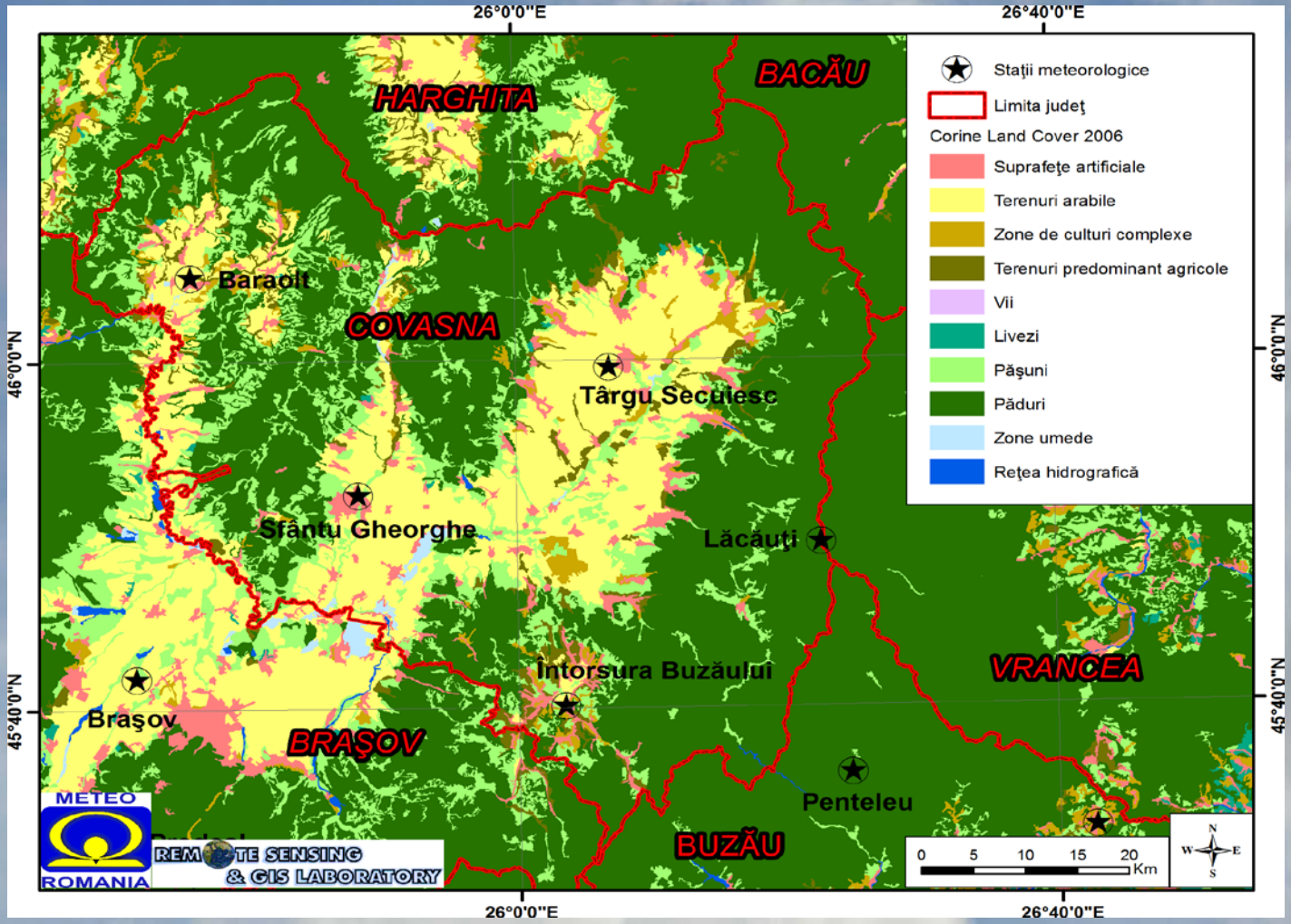




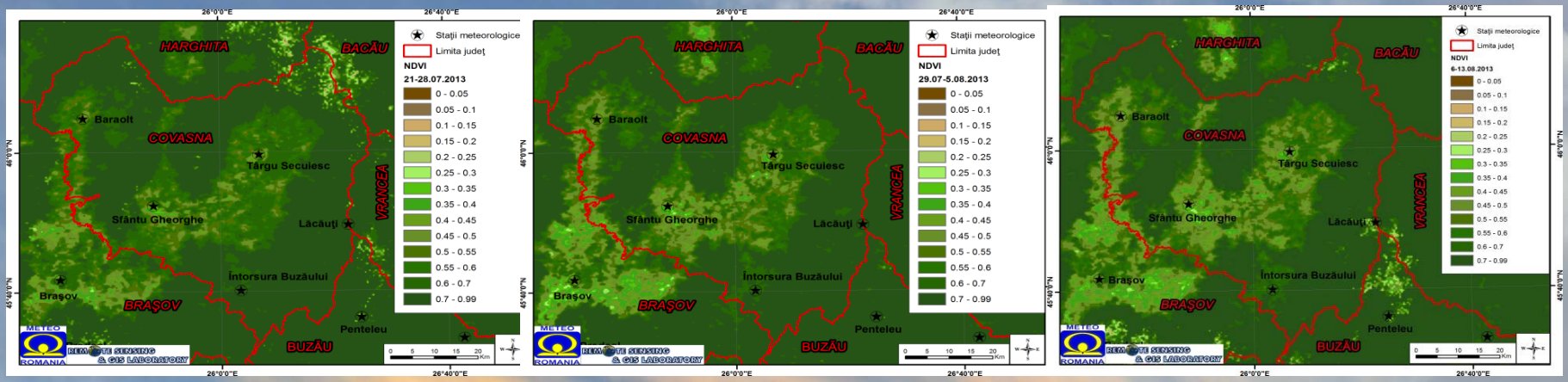
APPLICATIONS DEVELOPPED IN THE COVASNA AREA



Land cover/use categories over the Covasna study area



MODIS NDVI over Covasna county
21.07 - 13.08.2013

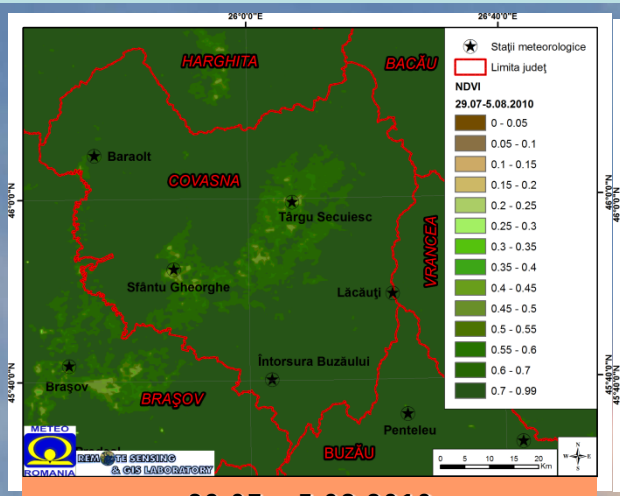


21.07 – 28.07.2013	29.07 – 5.08.2013	6.08 – 13.08.2013

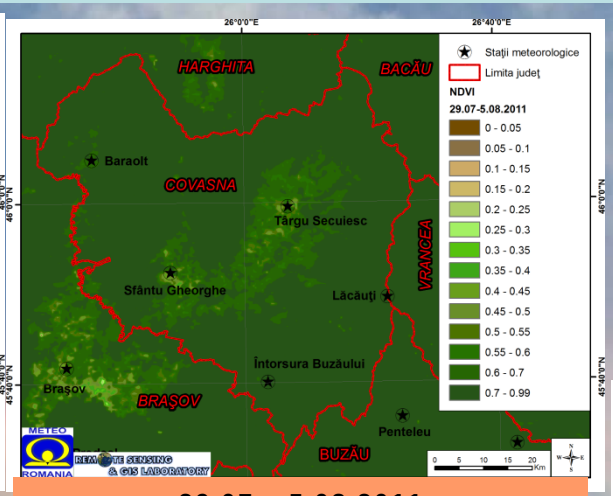
Date	Soil moisture (mc/ha)	% CAu (Soil water supply capacity)	Classes
10.07.2013	1216	76 %CAu	Close to the optimal supply
20.07.2013	883	55 %CAu	Satisfactory supply
31.07.2013	695	43 %CAu	Moderate pedological drought
10.08.2013	548	34 %CAu	Strong pedological drought
20.08.2013	667	42 %CAu	Moderate pedological drought

The soil moisture and soil water supply capacity values recorded at the agrometeorological station Sfantu Gheorghe.

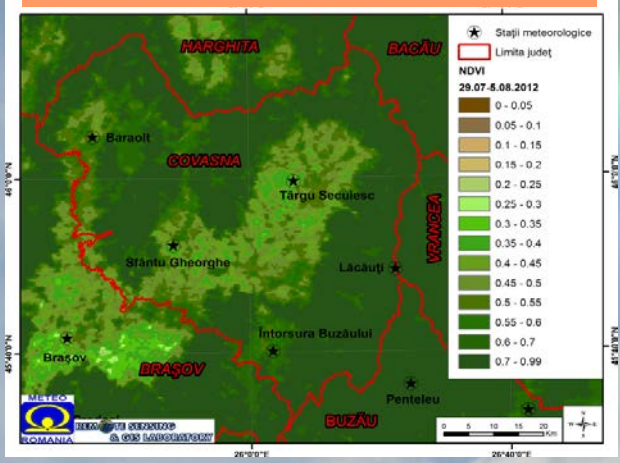
MODIS NDVI evolution over Covasna county 29.07 - 5.08.2010; 2011; 2012 and 2013



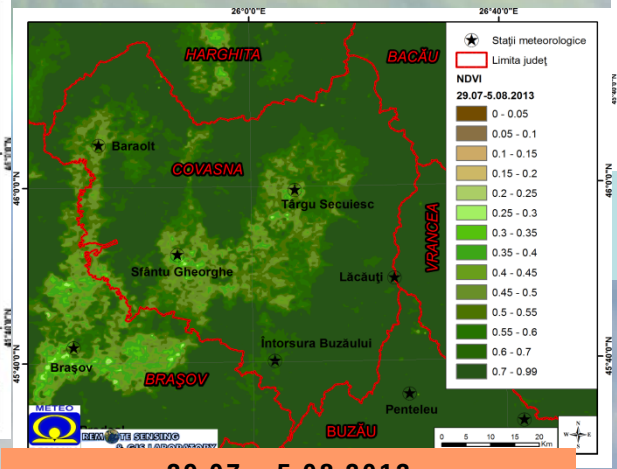
29.07 – 5.08.2010
Close to the optimal supply



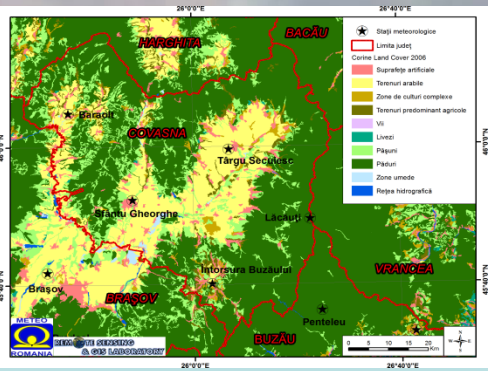
29.07 – 5.08.2011
Satisfactory supply



29.07 – 5.08.2012
Moderate pedological drought

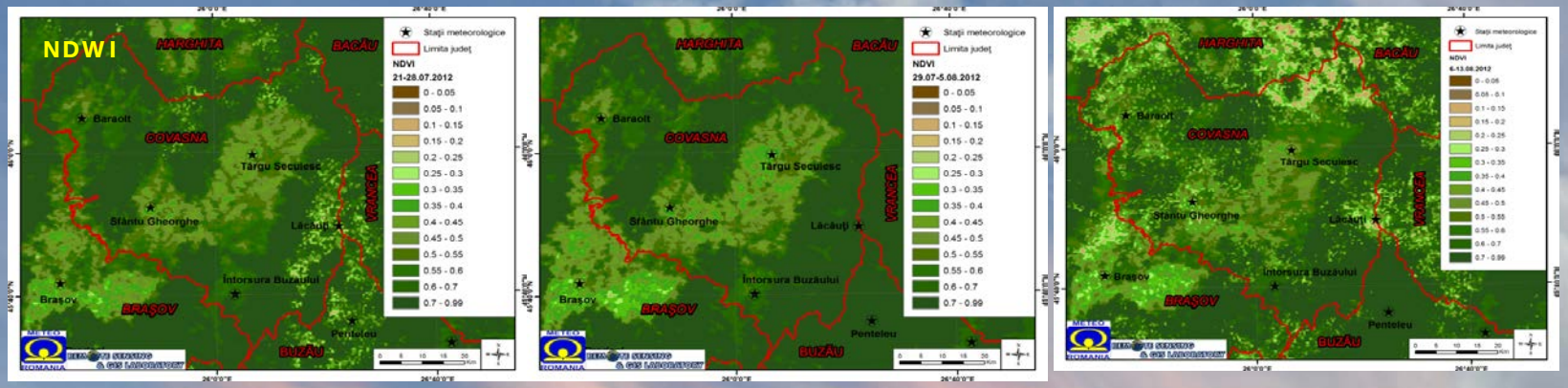


29.07 – 5.08.2013
Moderate pedological drought

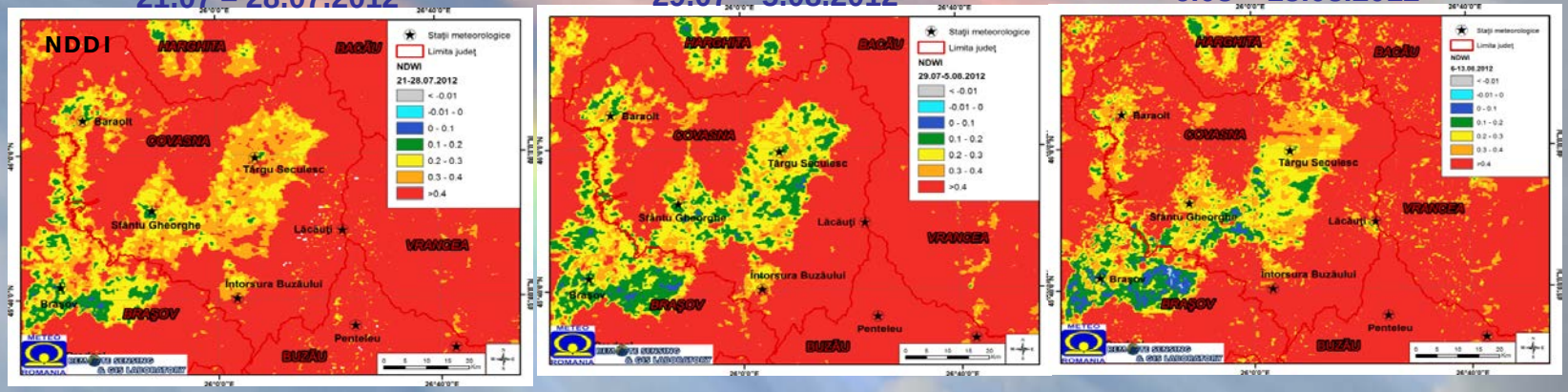


Land cover/land use map over Covasna Study Area

MODIS NDWI and NDDI over Covasna county on 21.07 -13.08.2012

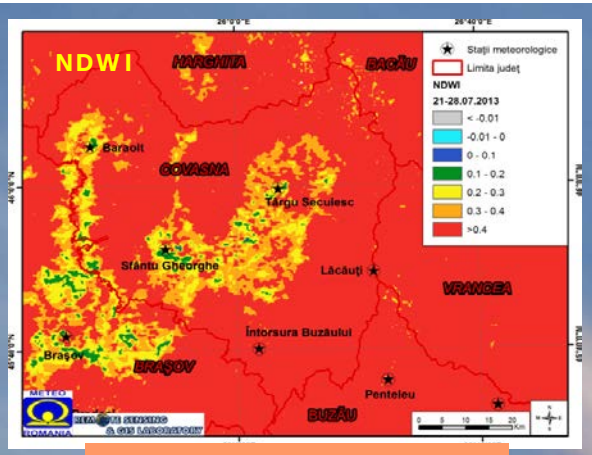


21.07 – 28.07.2012 | 29.07 – 5.08.2012 | 6.08 – 13.08.2012

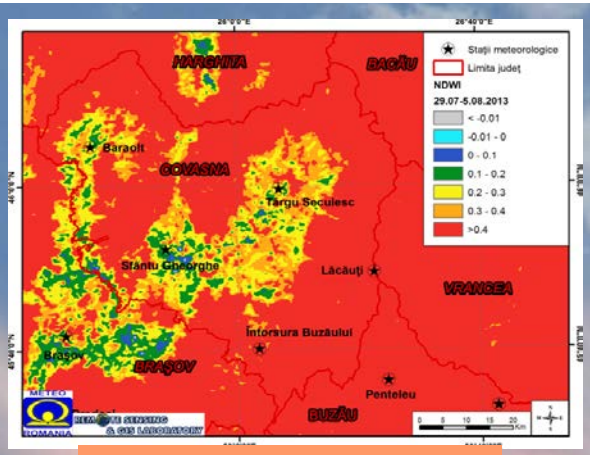


Date	Soil moisture (mc/ha)	% CAu (Soil water supply capacity)	Classes
10.07.2012	811 mc/ha	51 %CAu	Satisfactory supply
20.07.2012	804 mc/ha	51 %CAu	Satisfactory supply
31.07.2012	679 mc/ha	42 %CAu	Moderate pedological drought
10.08.2012	636 mc/ha	40 %CAu	Moderate pedological drought
20.08.2012	571 mc/ha	36 %CAu	Moderate pedological drought

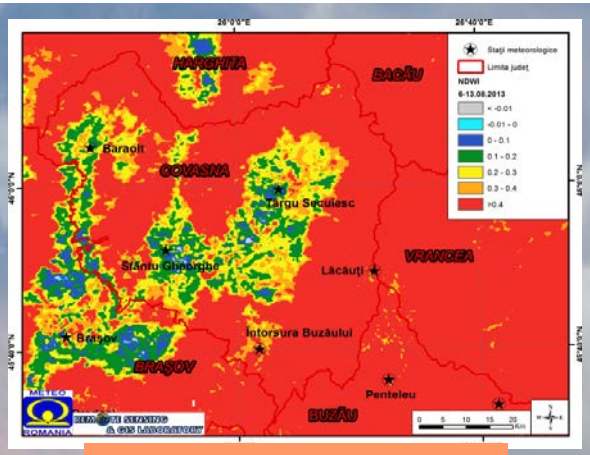
MODIS NDWI and NDDI over Covasna county on 21.07 -13.08.2013



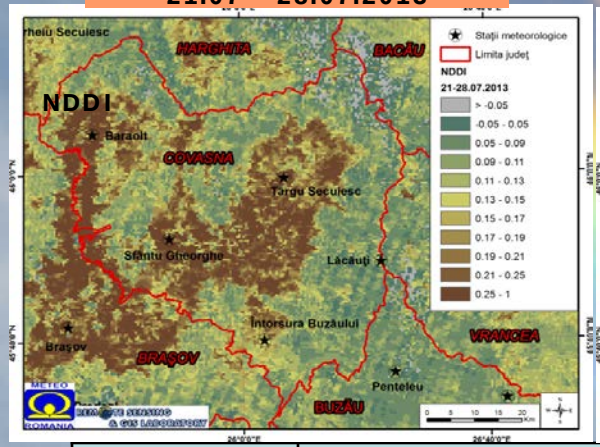
21.07 – 28.07.2013

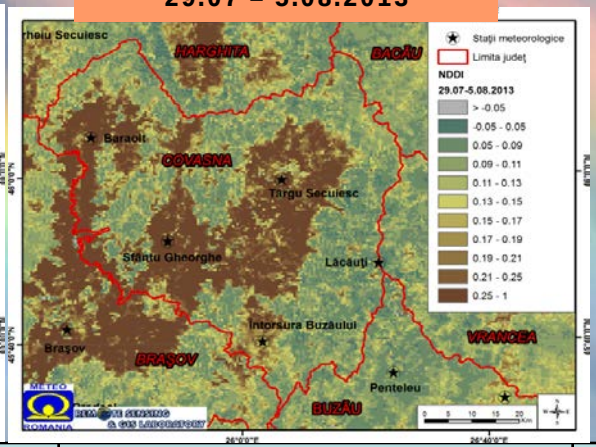


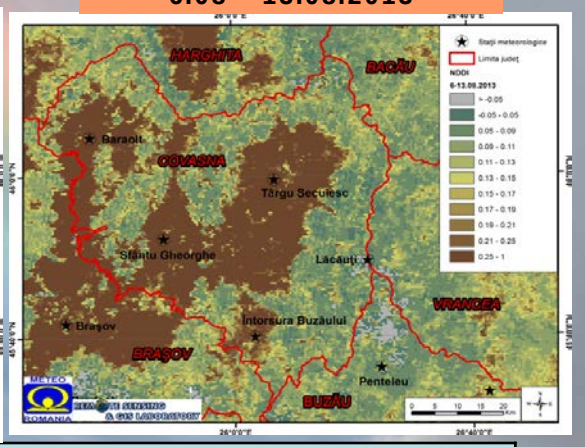
29.07 – 5.08.2013



6.08 – 13.08.2013







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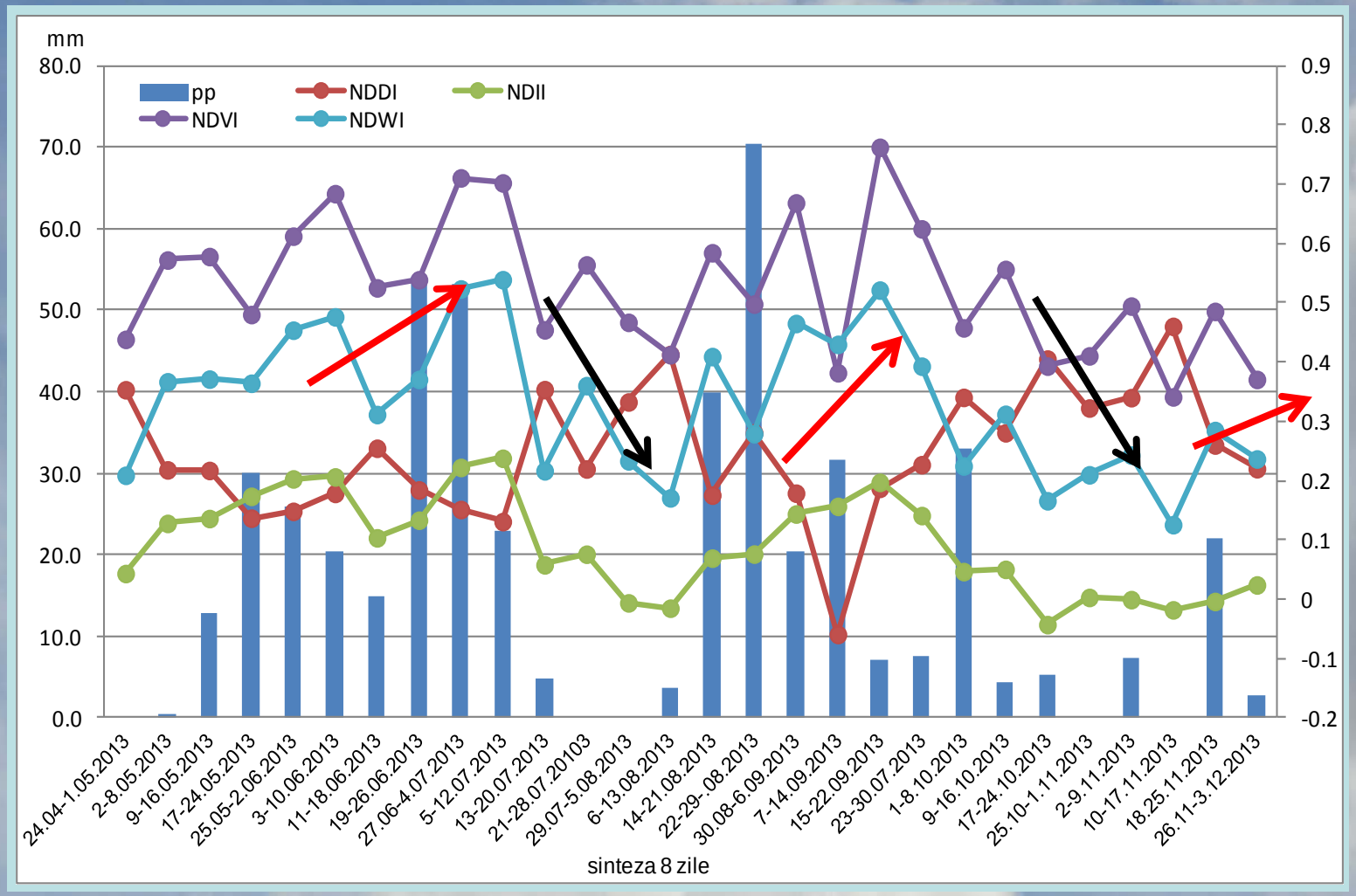
Analysis of vegetation state evolution with satellite-based indices in Sfantu Gheorghe area on 24 April – 3 Dec. 2013



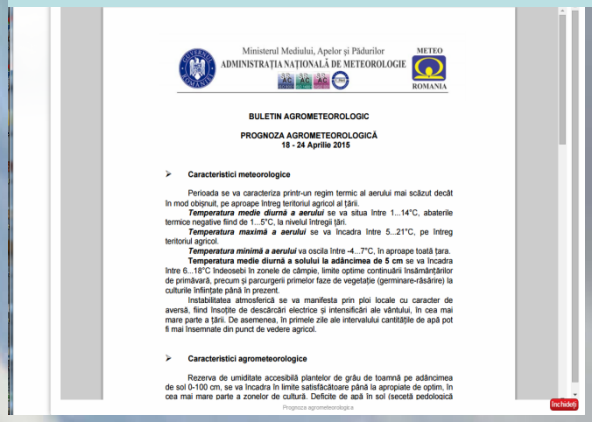
INTERNET – free access of meteorological forecasts and agrometeorological information

- Seasonal forecasts (1-3 months)
- Regional forecasts (2 weeks)
- Notes on the drought evolution

- Warnings at national level
- Now-casting forecasts at local level

- Soil moisture maps

- Agrometeorological forecasts



http://www.meteoromania.ro/

Reflections … … …

Today I learned … … …

Today I remembered … … …

Today I discovered … … …

Today I realized … … …

Today I was surprised … … …

Today I enjoyed … … …

Today disappointed me … … …

Today I … … …

Thank you for your attention!

Köszönjük a figyelmet!

Oana-Alexandra OPREA & Argentina NERTAN

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