NATIONAL METEOROLOGICAL ADMINISTRATION

METEO ROMANIA

MONITORING SOIL DROUGHT IN ROMANIA AND THE IMPACT ON AGRICULTURE

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NATIONAL METEOROLOGICAL ADMINISTRATION

INTER-REGIONAL WORKSHOP ON INDICES AND YEARLY WARNING SYSYTEMS FOR DROUGHT

LINCOLN, NEBRASKA, USA, 8-11 December 2009

World Meteorological Organization

USDA United States Department of Agriculture

National Drought Mitigation Center

UNCCD United Nations Convention to Combat Desertification

U.S. National Oceanic and Atmospheric Administration

OUTLINE

- INTRODUCTION
- DATA AND METHOD
- RESULTS
  - GEOGRAFICAL AND AGROCLIMATIC CONDITION IN ROMANIA
  - DROUGHT INDICES and ILLUSTRATIVES EXAMPLES
  - DISSEMINATION PROCESS
- CONCLUSIONS
- FUTURE STEPS

The Concept of Drought:

► The **drought** represents a state of a biologic system in which the water requirement/need is below the optimal values, the supplying functions significantly vary, function of the growth and development stage. This phenomenon can be considered as being strictly meteorological, hydrological, agricultural, economic, etc., and the analysis methods allow the assessment of the severity level, function of the characteristics of intensity, duration, frequency, time and space extent, as well as the consequences upon the environment.

►**MITIGATING THE EFFECTS OF DROUGHT** means activities related to the prediction of drought and intended to reduce the vulnerability of society and natural systems to drought as it relates to combating desertification.

► **DROUGHT** can be expressed in terms of:

- **INTENSITY** – extreme, severe, moderate
- **DURATION** or **PERSISTENCE** – months, years
- **SPATIAL EXTENT** – local, sub-regional and regional level
- **FREQUENCY** – number of months and years for a given period

⇒ Disciplinary Definitions of Drought

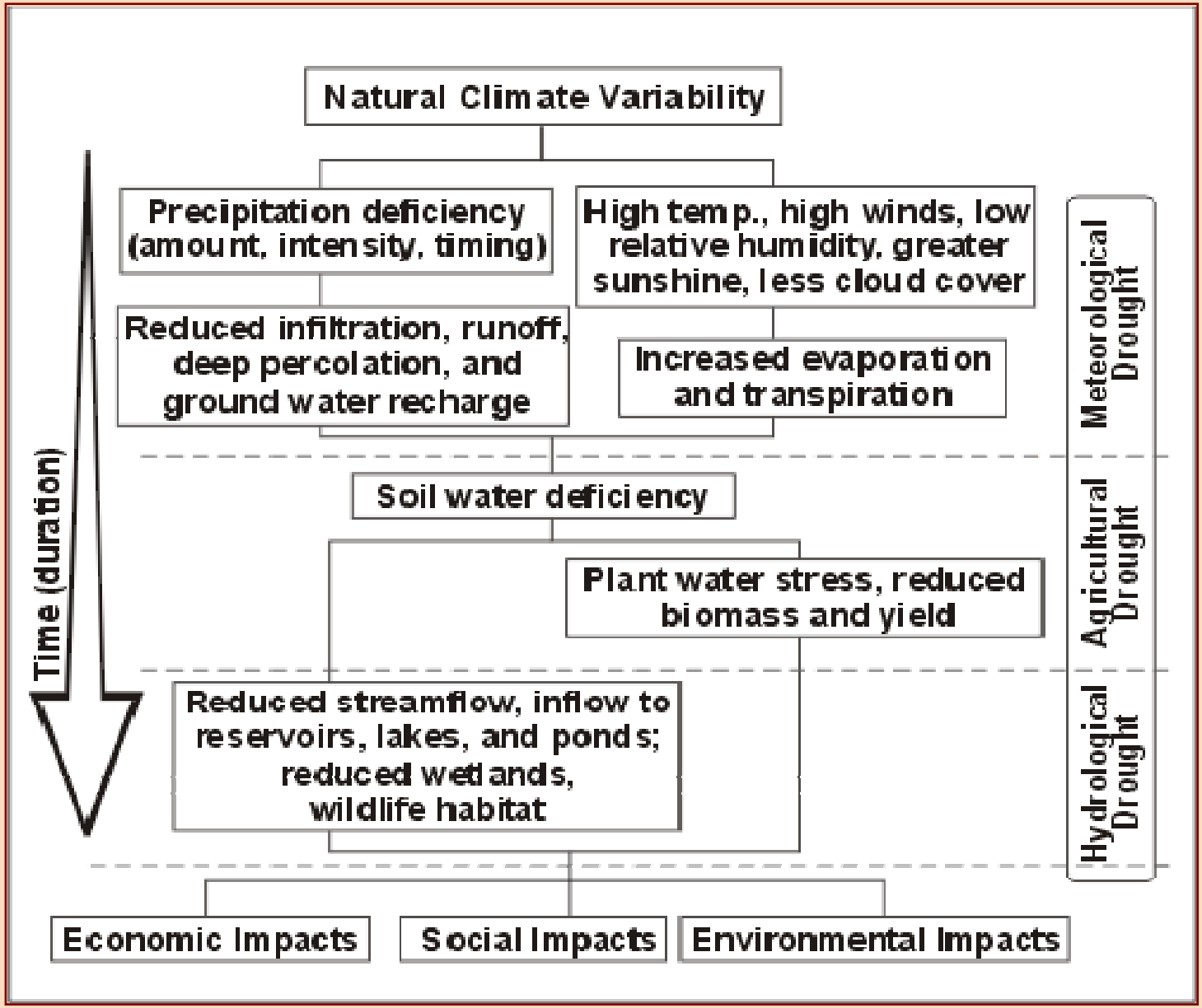
► **Meteorological** is defined usually on the basis of the degree of dryness (in comparison to some "normal" or average amount) and the duration of the dry period.
Another definition may relate actual precipitation departures to average amounts on monthly, seasonal, or annual time scales.

► **Agricultural** refers to a situation when the amount of moisture in the soil no longer meets the needs of a particular crop.
A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity.

► **Hydrological** is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., streamflow, reservoir and lake levels, ground water).
The frequency and severity of hydrological drought is often defined on a watershed or river basin scale.

► **Socio-economic** definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. Socio-economic drought occurs when the demand for an economic good exceeds supply as a result of a weather-related shortfall in water supply.

⇒ The conceptual scheme of DROUGHT IMPACT



Source: National Drought Mitigation Center, University of Nebraska, USA

DATA AND METHOD

► The paper presents aspects of climate variability impact on agriculture in Romania, emphasizing the effects of extreme drought and heat waves periods (characterized by intensity and duration) on vegetative development of agricultural crops.

► Analysis of drought frequency and intensity during the 20-th century shows the crucial importance of agrometeorological monitoring for early-warning systems and for efficient mitigation measures. The drought phenomena and heat waves that affected agricultural areas in Romania during the recent years, respectively 2001, 2002, 2003, 2007 and 2009, are analyzed in a more comprehensive manner, stressing the importance of multiple factors effects on soil moisture and crop development.

► The complex interaction among soil, plants and atmosphere is described using climatic data (temperature, heat units, precipitation), crop water requirements (depending on vegetation stage), and soil moisture data (measured and modeled). In addition, the spatial extent of the drought phenomenon, as well as the dynamics throughout the growing season, are presented in form of thematic maps using Geographical Information Systems (GIS) techniques. Such detailed and integrated analysis provides crucial information for delineation of areas most vulnerable to drought and is a useful tool for risk assessment and early-warning.

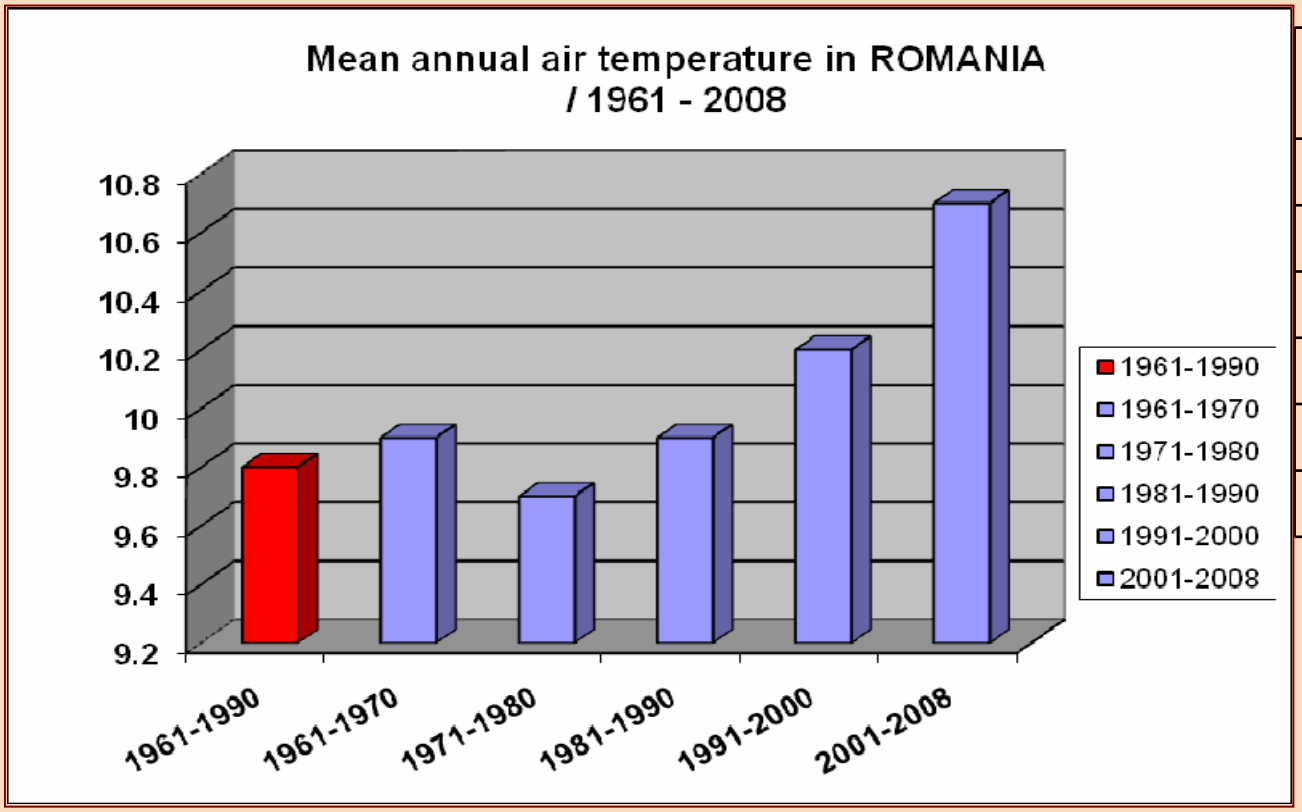
⇒ Geographical and agroclimatic conditions

Romania is situated in the South-Eastern part of Europe, inside and outside of the Carpathians Arch, on the Danube (1075 km) lower course and has exit to the Black Sea. The center of the country is placed at the crossing of the parallel 46°N with the meridian 25°E (at 17 km north of town Fagaras), and the Romanian territory is unfolding on 4°37'59" latitude (525 km) and 9°25'40" longitude (743 km).

Main features of **Romania's relief** units are: proportionality (31% mountains, 36% hills and plateaus, 33% plains and meadows), concentric display and in amphitheatre of the relief major levels.

Romania's climate is temperate-continental, with oceanic influences from the West, Mediterranean ones from South-West and continental-excessive ones from the North-East. Multiannual average temperature is latitudinally different, 8°C in the North and 11°C in the South, and altitudinally, with values of -2,5°C in the mountain areas (Omu peak-Bucegi massif) and 11,6°C in the plain (Zimnicea town-Teleorman county). Yearly precipitations decrease in intensity from west to east, from 600 mm to 500 mm in the Romanian Plain and under 400 mm in Dobrogea, and in the mountainous areas they reach 1000-1400 mm.

Decadal evolution of the mean annual air temperature recorded in Romania, over 1961- 2008 period



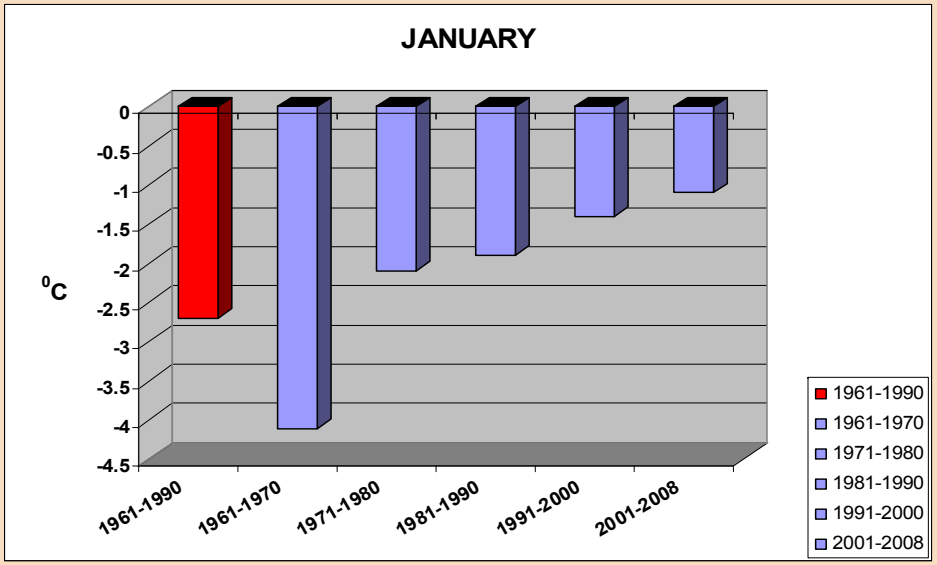
	Mean annual air temperature (°C)
1961-1990	**9.8**
1961-1970	9.9 / +0.1
1971-1980	9.7 / -0.1
1981-1990	9.9 / +0.1
1991-2000	10.2 / +0.4
2001-2008	**10.7 / +0.9**

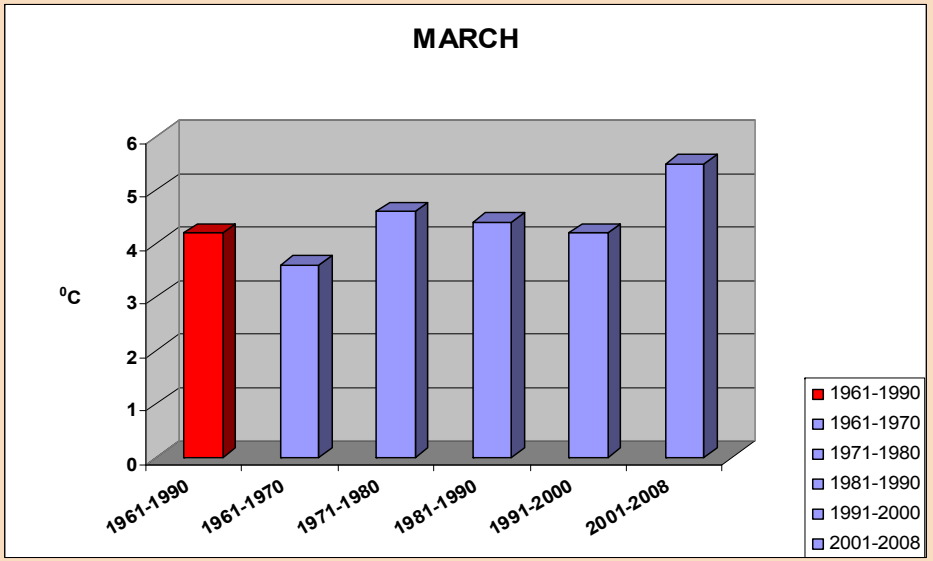
⇒ **2007 / 11.5°C**

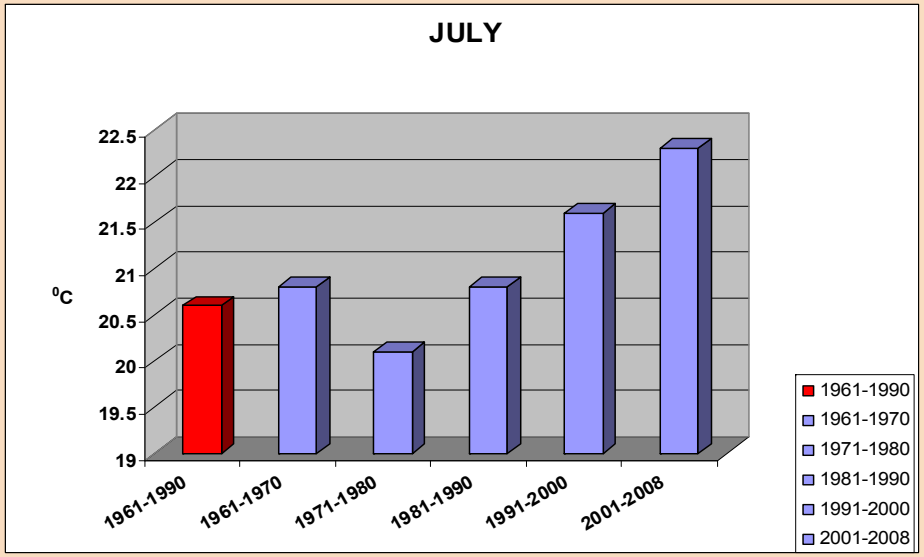
⇒ **1985 / 8.4 °C**

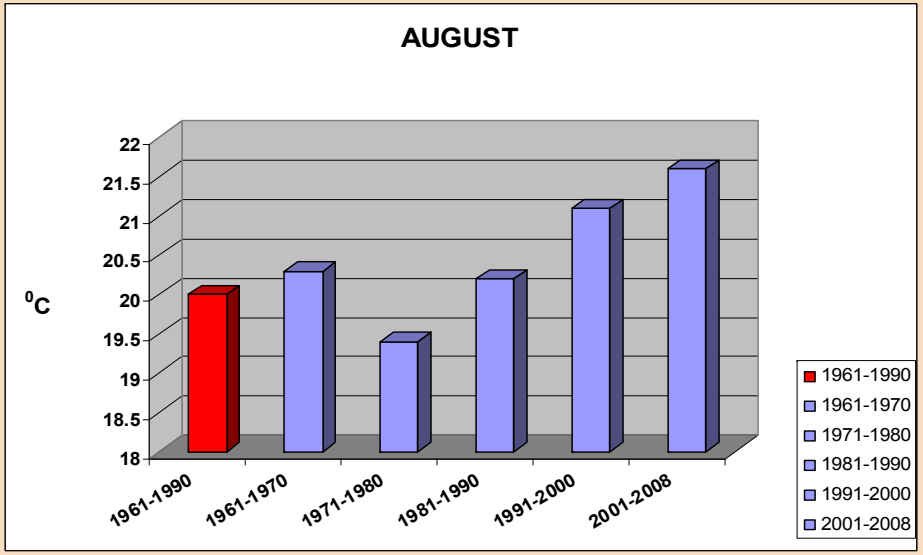
	Monthly mean air temperature (°C)											
	I	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
1961-1990	-2.7	-0.5	4.2	10.3	15.6	18.9	20.6	20.0	16.1	10.3	4.5	0.0
2001-2008	-1.1	0.4	5.5	10.6	16.8	20.1	22.3	21.6	15.9	11.0	5.2	-0.3
Deviation	**+1.6**	+0.9	**+1.3**	+0.3	**+1.2**	**+1.2**	**+1.7**	**+1.6**	-0.2	+0.7	+0.7	-0.3

Decadal evolution of the mean annual air temperature recorded in Romania, over 1961- 2008 period

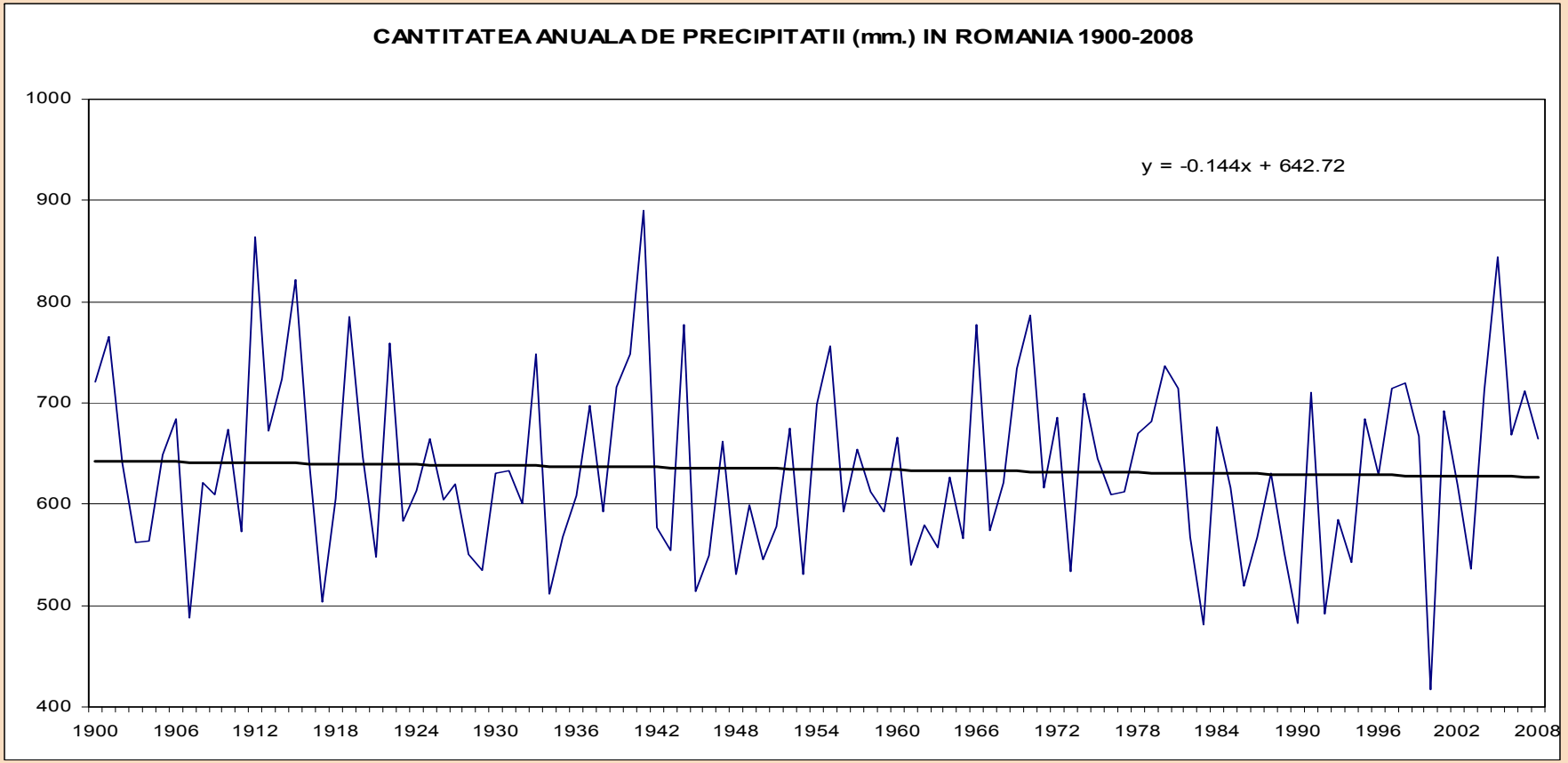








Annual rainfall amounts trend in Romania, over 1901-2008 period



The dry month over 2001-2008 period, Comparison with the baseline (1961-1990)

Moldova / June / -23.0%
Dobrogea / June / -17.1%
Muntenia / May / -17.6%
Oltenia / February / -33.1%
Banat-Crisana / May / -15.2%
Transilvania-Maramures / June / -16.1%

The rainy month over 2001-2008 , comparison with the baseline (1961-1990)

Moldova / July / +39.0%
Dobrogea / September / +72.2%
Muntenia / September / +78.1%
Oltenia / September / +86.3%
Banat-Crisana / September / +57.8%
Transilvania / September / +59.3%

⇒ *Drought monitoring map in Romania*

► **In the south and south-eastern area of Romania,** the complex agricultural drought is a climatic hazard phenomenon inducing the worst consequences ever occurred in agriculture.

►The drought phenomenon, although without a strict **cyclical character,** generally shows a repeatability at 15-25 years intervals. Within such cycles their are extremely dry years, but also short term interruptions of about 1-3 years with rainfalls above the normal amounts. These interruptions do not modify the general features of the droughty period from the point of view of the severe climate characteristics, as well as of the water resources in the soil and in the groundwater and in the surface and hydro-graphic network.

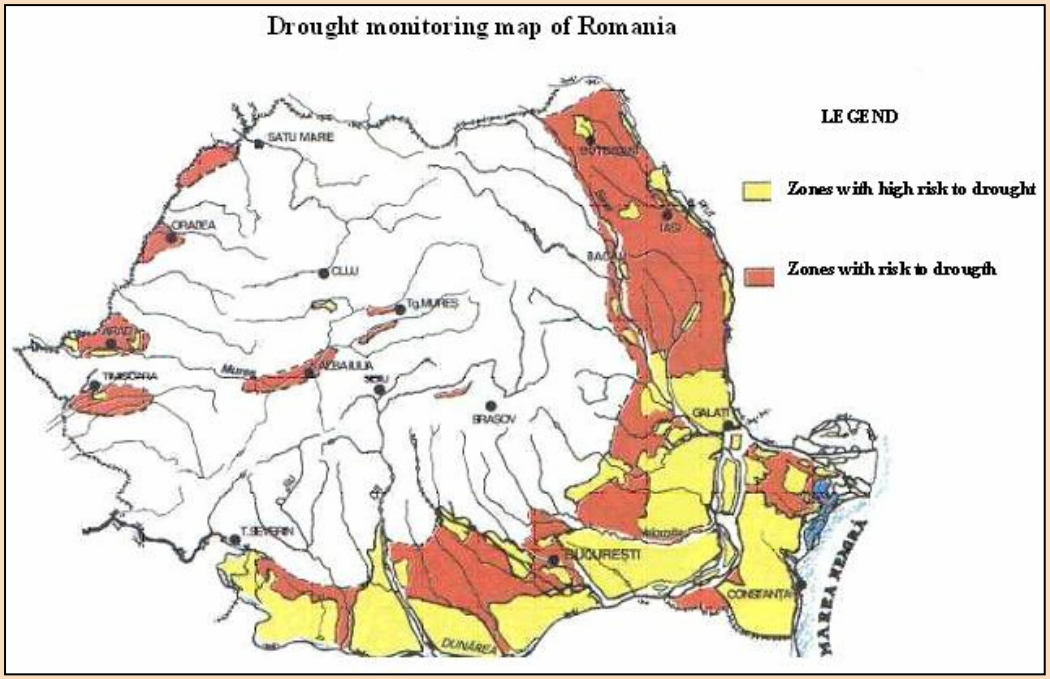
►**Average yields of various crops in droughty cycles are only 35-60% of the yields** which could be obtained under complete provision of crop water requirements by **irrigation.**

► **Extremely droughty agricultural years in the XXth century:**

Decade 1901-1910: **1907-1908**
Decade 1911-1920: **1917-1918**
Decade 1921-1930: **1923-1924, 1927-1928**
Decade 1931-1940: **1934-1935**
Decade 1941-1950: **1945-1946, 1947-1948, 1949-1950**
Decade 1951-1960: **1952-1953**
Decade 1981-1990: **1982-1983, 1985-1986, 1987-1988, 1989-1990**
Decade 1991-2000: **1992-1993, 1999-2000**

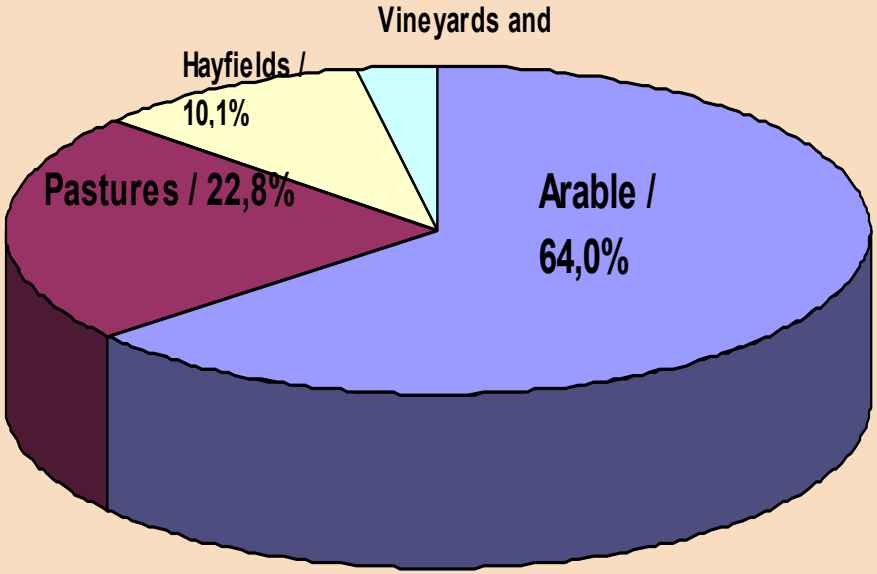
► **Extremely droughty agricultural years in the XXIth century:**

Decade 2001-2010: **2001, 2002, 2003, 2007, 2009**



⇒ *Agricultural land use and areas affected by drought*

In Romania, from a total surface of 237.500 km2, 62% are agricultural lands – approximately 14.7 million ha – categorized according to usage in arable land, pastures, vineyards and orchards. Frequent and prolonged drought affect 7.1 million ha, which represent 48% from the total agricultural land.

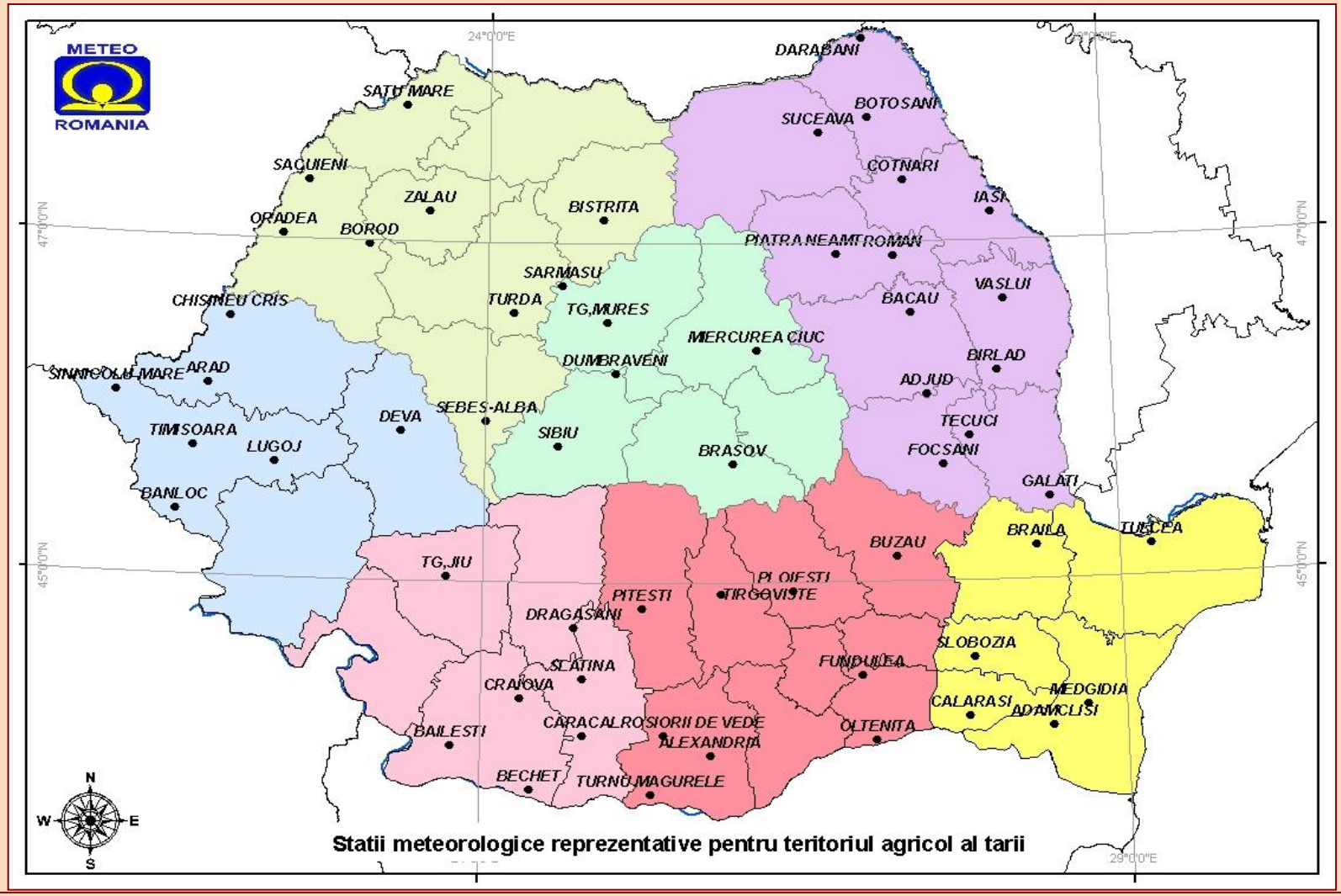


	Agricultural area (thou ha)	Structure (%)
Total	**14717,4**	**100,0**
Arable land	9414,3	64,0
Pastures	3355,0	22,8
Hayfields	1490,4	10,1
Vineyards and orchads	457,7	3,1
Agricultural area irigated	**569,1**	**3,9**
of which: arable	558,8	5,9
Affected by drought	**7100,0**	**48,0**

Source: Romanian Statistical Yearbook, 2006

⇒ National Meteorological Observation Network of ROMANIA

- *7 Regional Meteorological Centres*
- *162 weather meteorological stations*
- 55 weather stations integrating a special program of agrometeorological measurements



AGROMETEOROLOGICAL MEASUREMENTS NETWORK

⇒ DROUGHT INDICES IN ROMANIA

1. Agrometeorological indices / operationally activity

- ***soil moisture***
- ***rainfall regime***
- ***heat waves***

2. Drought related-indices derived from remote sensing data / operationally activity

- ***NDVI / Normalized difference vegetation index***

3. Climatological indices / research activity

- ***Aridity Index / UNEP***
- ***SPI / Standardized Precipitation Index***
- ***De Martonne's aridity index***

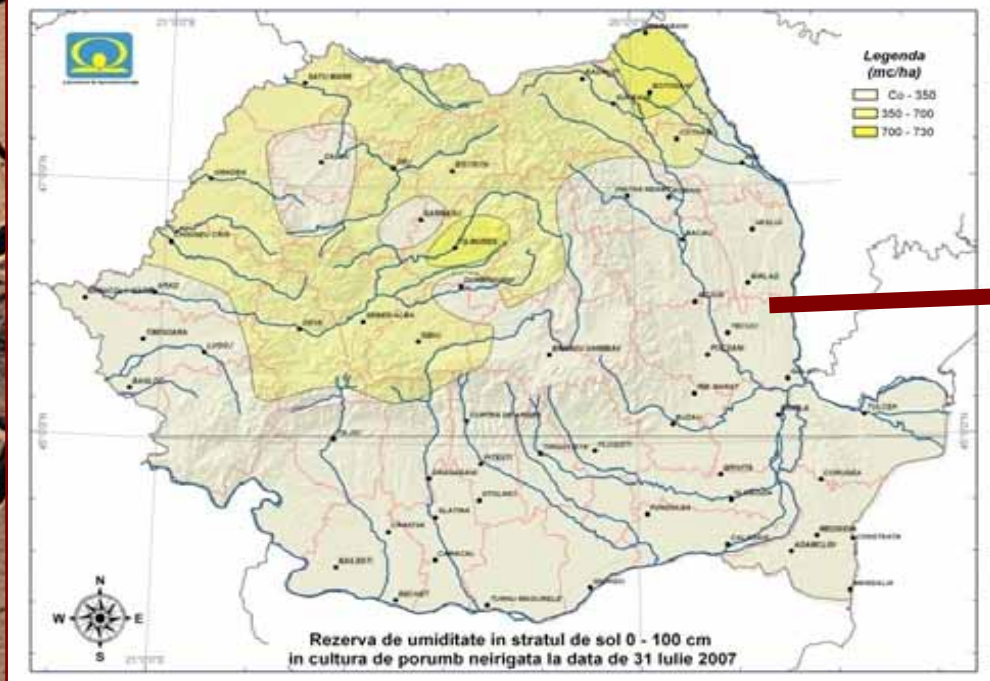
- **PDSI / Palmer Drought Severity Index**

⇒ AGROMETEOROLOGICAL INDICES OF DROUGHT

Classification of the soil moisture levels

% of AWC	Humidity classes
0 – 20 %	Extreme pedological drought / ED
20 – 35%	Severe pedological drought / SD
35 – 50%	Moderate pedological drought / MD
50 – 70%	Satisfactory supply / SS
70 – 100%	Optimal supply / OS
>100%	Above normal moisture values / EX

Zoning of the soil moisture reserves (m3/ha) for the maize crop / 31 JULY 2007



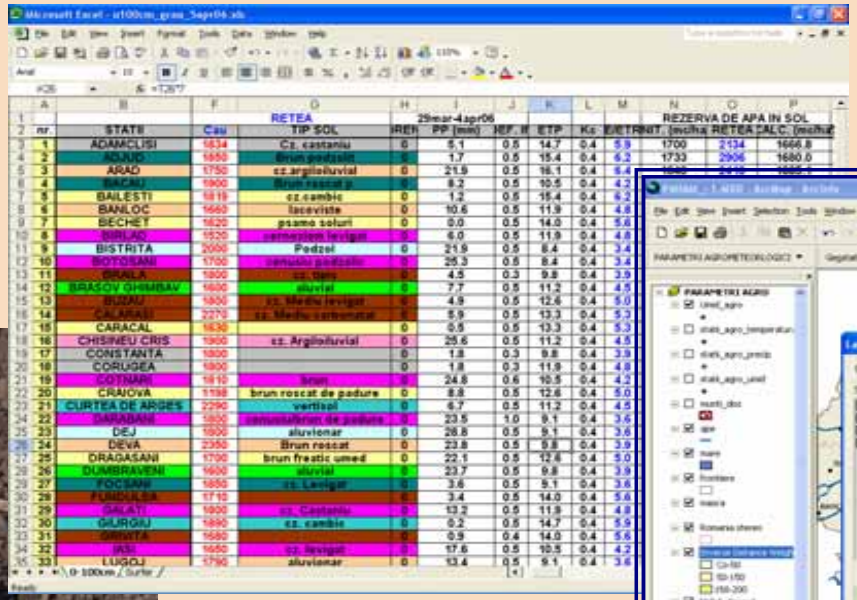
Legend

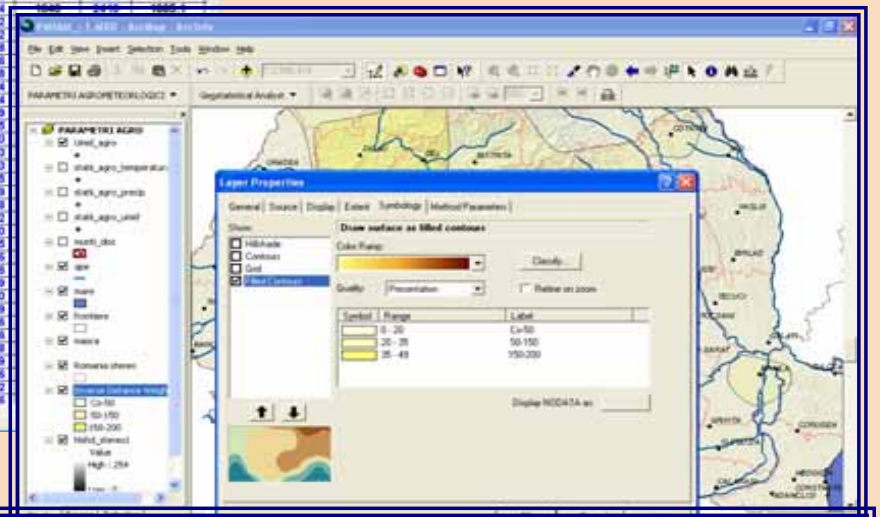
- Extreme pedological drought / 0-20 % AWC
- Severe pedological drought / 20-35 % AWC
- Moderate pedological drought / 35-50 % A

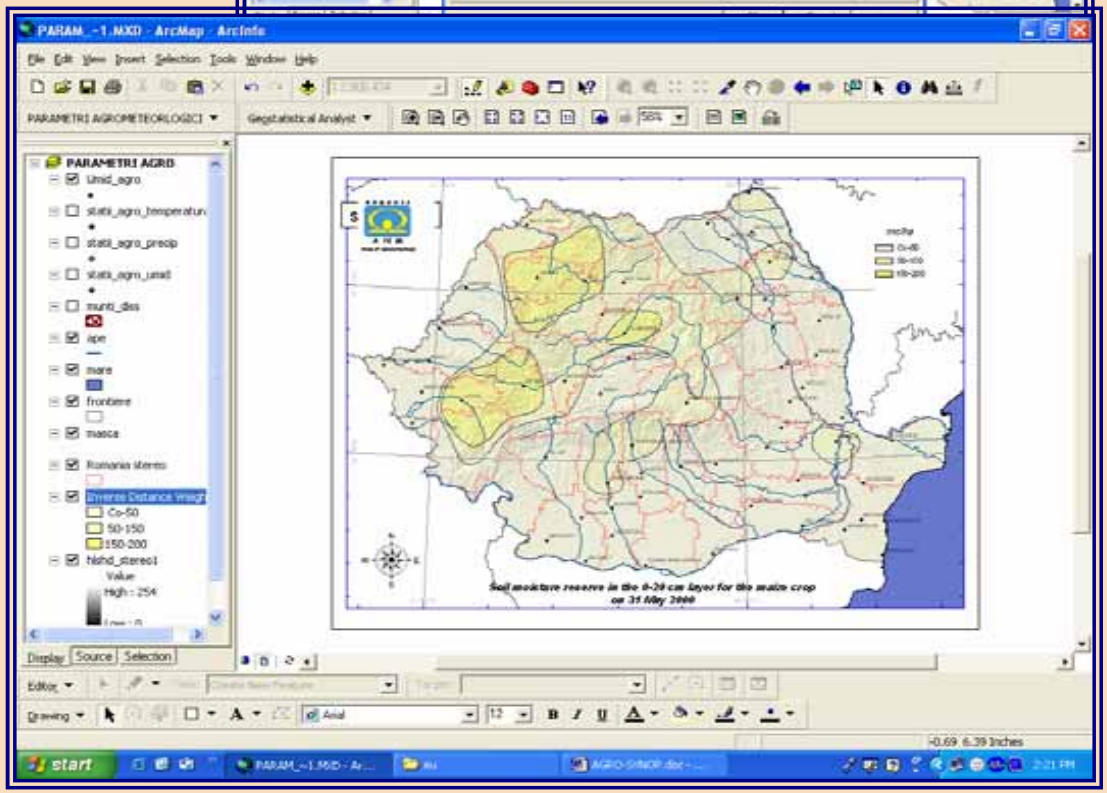
Information concerning the values of soil moisture content, % of AWC, soil moisture deficit and humidity class

Moisture data	
TECUCI	
Moisture reserve value (m^3/ha)	320
% AWC	18
Water deficit	1285
Significance	ED
OK	CANCEL

MODULE / Soil moisture

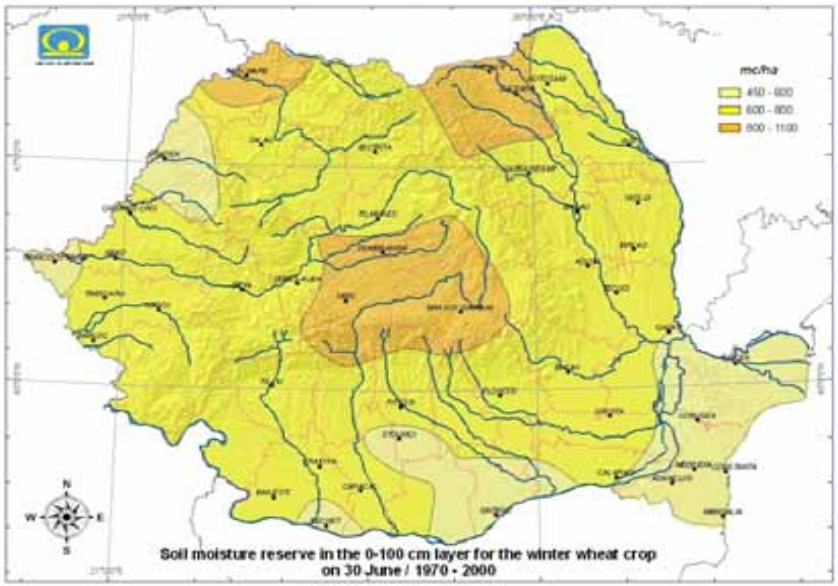




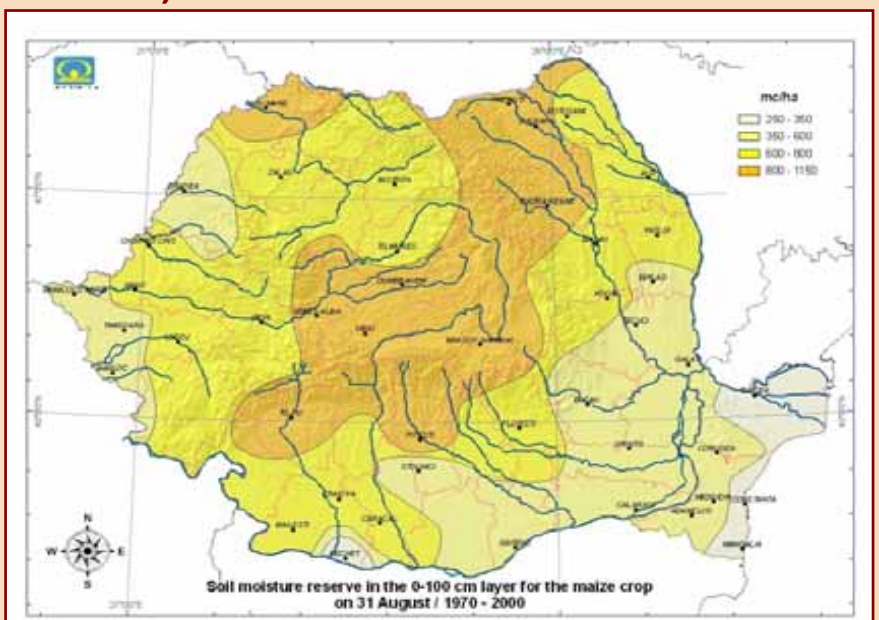


► *Soil moisture / multi-annual mean values*

a) Winter wheat



b) Maize

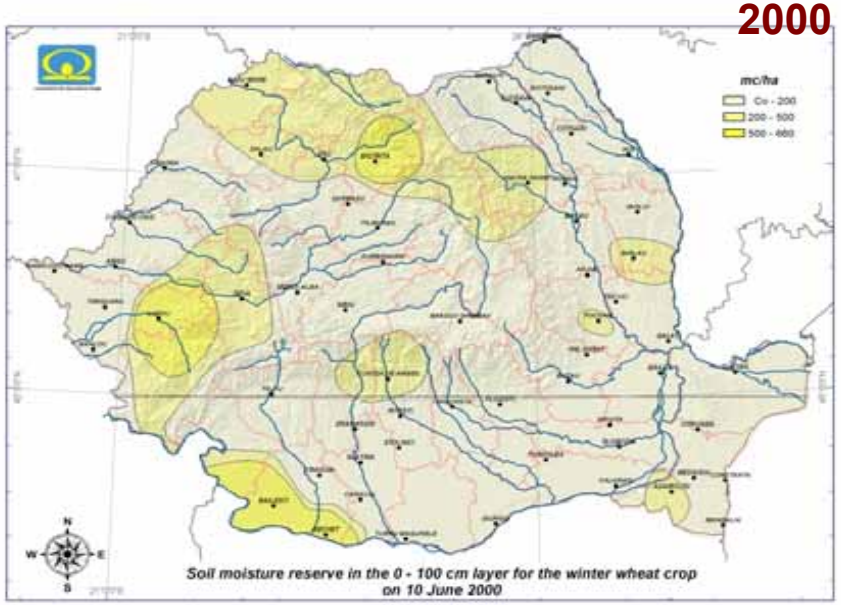


► Soil water balance is directly affected by the crop water requirement through evapotranspiration, which is dependent mainly on temperature and stage of vegetation. Crop water requirements depend on local weather conditions, soil and plants' characteristics and plant stage of growth.

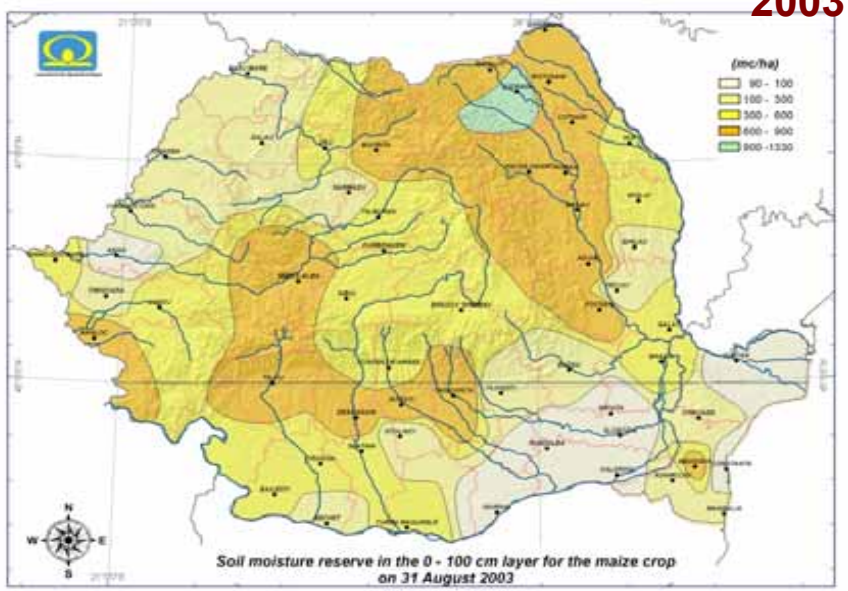
► The water balance of an agricultural field is an accounting of inputs (**precipitation**, **irrigation**, and capillary rise form **water table**), outputs (**evapo-transpiration**, **run-off**, **deep percolation**) and storage changes of water in the soil layer explored by roots. With a step of one day (or week or month), starting from water deficit rate at the end of previous period, water balance estimates the water deficit at the end of the current period. Since in many cases the major input of water is from precipitation and output is evapotranspiration, the following simplification is often used in water balances for irrigation.

► Zoning of the soil moisture reserves (m^3/ha) for the winter wheat crop / 30 June

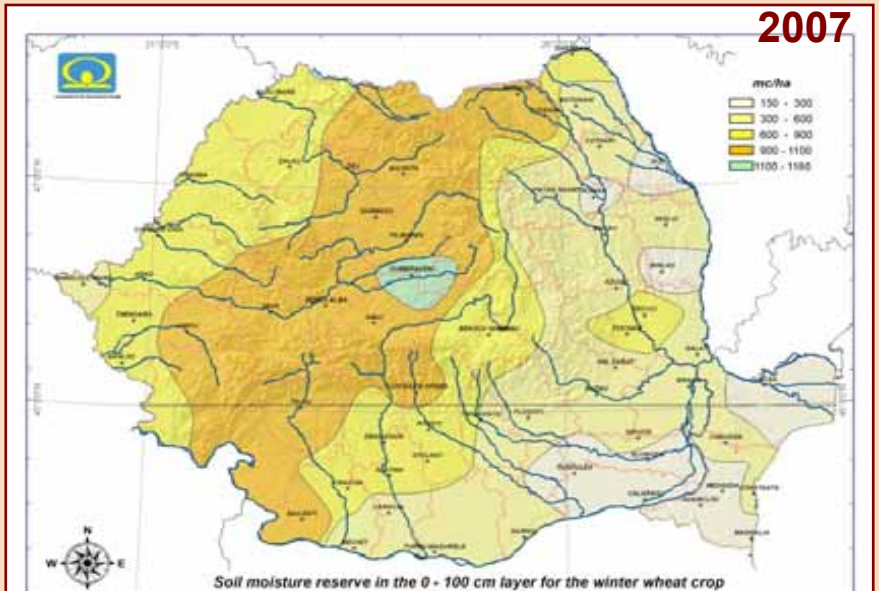
2000



2003



2007



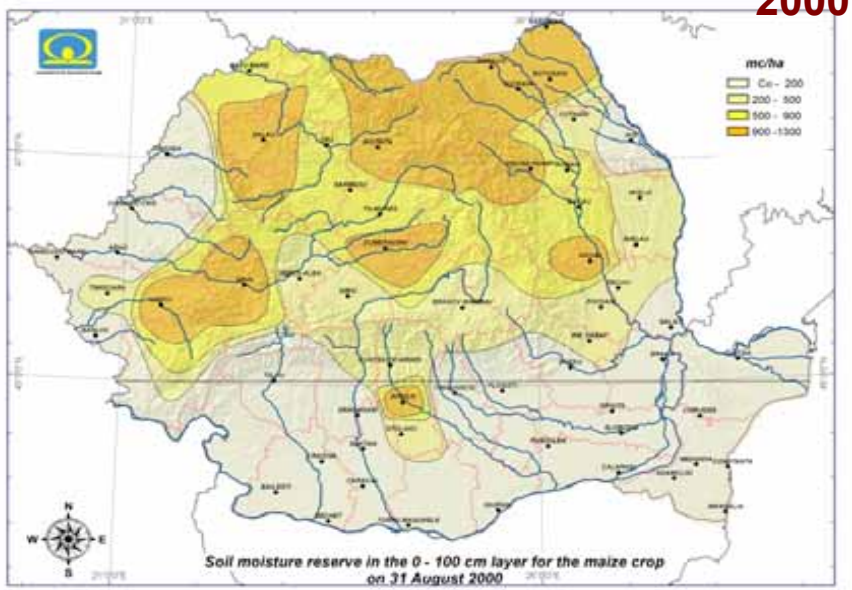
- 2000 / extremely droughty year, unfavourable for winter wheat crop in all most of the cultivated surface, especially in the South and South-East of the country, where the combined effect of thermal and water stress determined complete loss of the production;

- 2003 / extremely droughty year, with high water stress for plants; in most agricultural regions of the country the conditions were unfavorable for winter wheat;

- 2007 / extremely droughty year, with high thermal and water stress for plants; in most agricultural regions of the country, the conditions were unfavorable for winter wheat.

► Zoning of the soil moisture reserves (m^3/ha) for the maize crop / 31 August

2000



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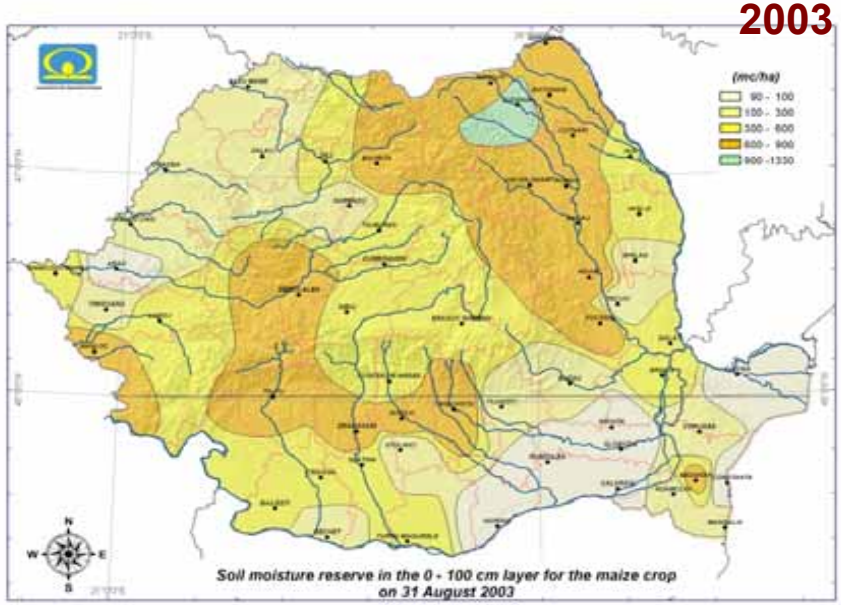
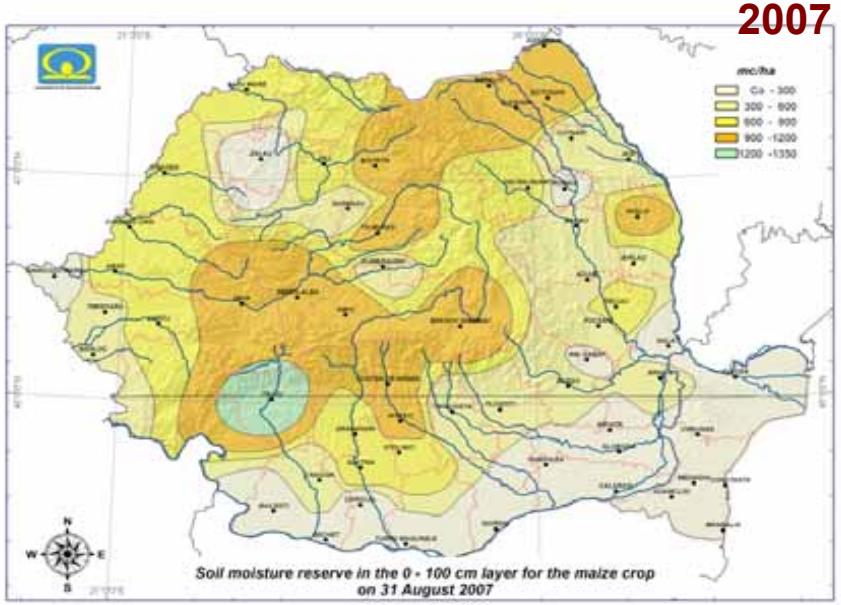


2007



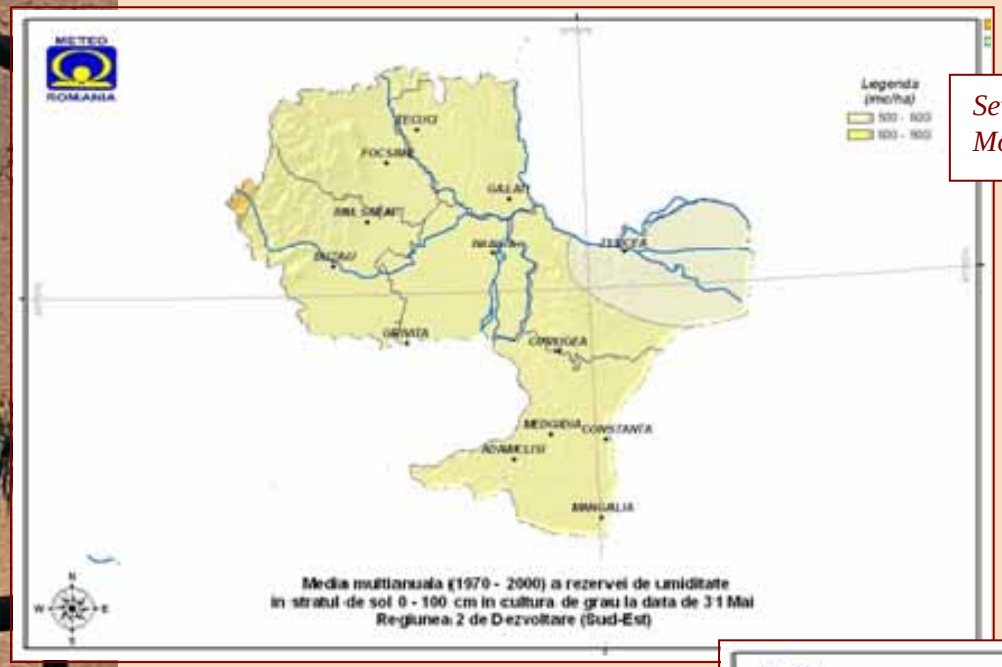
- 2000 / extremely droughty year, unfavourable for maize crop in all most of the cultivated surface, especially in the South and South-East of the country, where the combined effect of thermal and water stress determined complete loss of the production;

- 2003 / extremely droughty year, with high water stress for plants; in most agricultural regions of the country, the conditions were unfavorable for maize;

- 2007 / extremely droughty year, with high thermal and water stress for plants; in most agricultural regions of the country, the conditions were unfavorable for maize crop. A large surfaces cultivated with maize from south-eastern, south and east area was cut up.

ZONING OF THE SOIL MOISTURE FOR THE WINTER WHEAT CROP

/ South-East Development Region (RO 2)

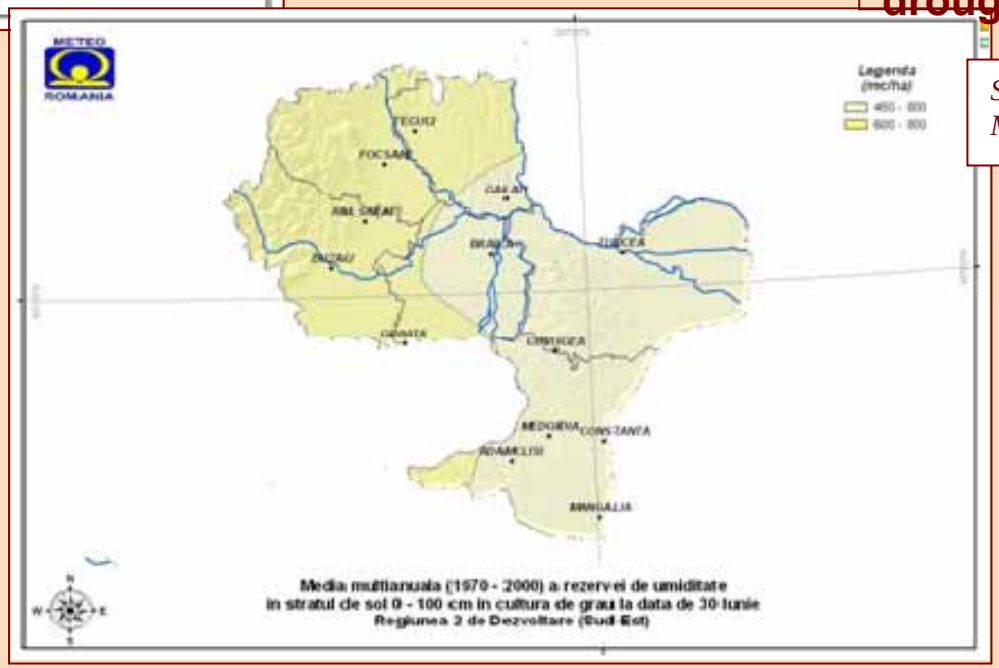


Severe pedological drought
Moderate pedological drought

WINTER WHEAT

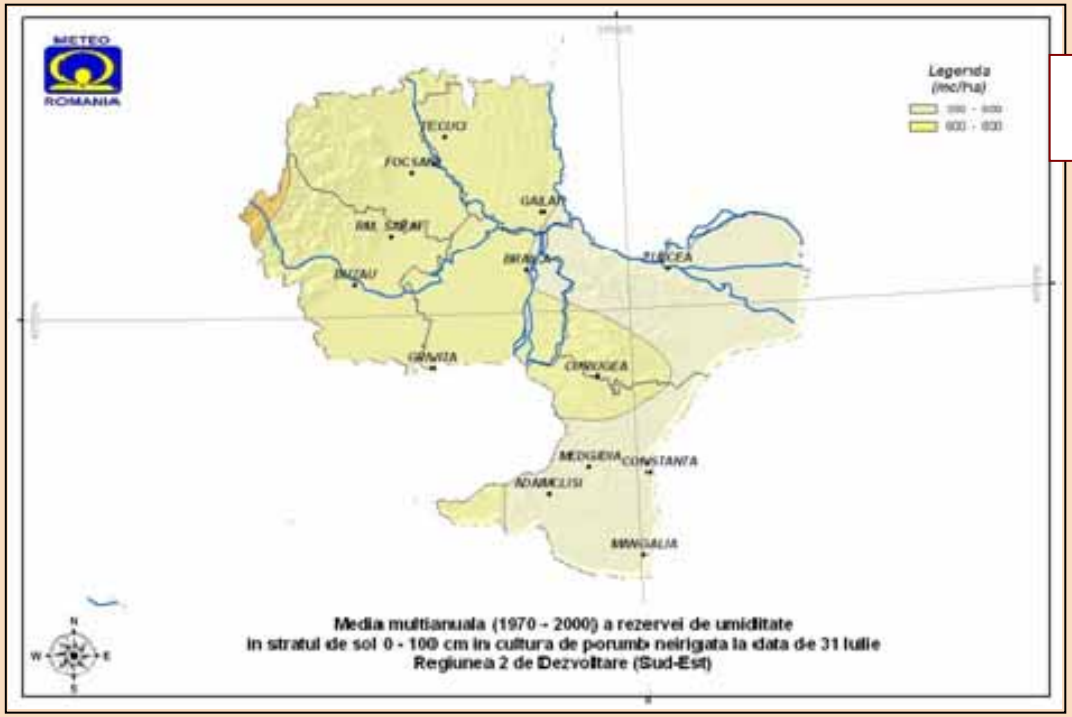
MAY - JUNE /
Severe and moderate pedological drought

MAy – 89.8% droughty years (6.5% /extreme pedological droughty years)
JUNE – 97.2% droughty years (6.5-27.0% /extreme pedological droughty years)

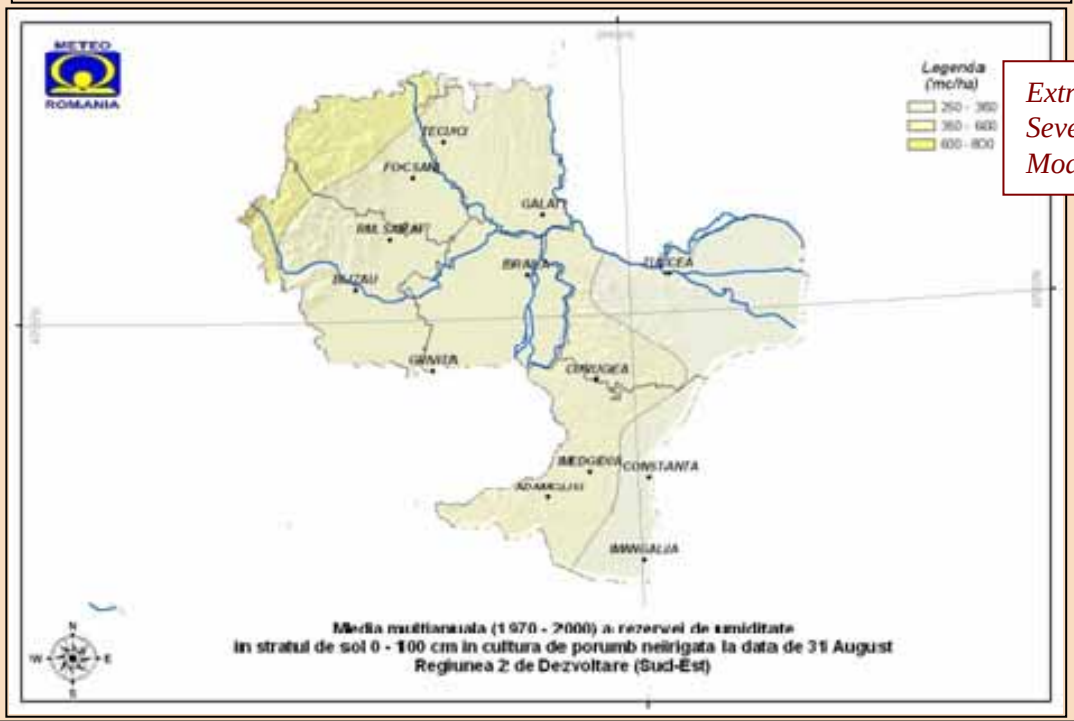


Severe pedological drought
Moderate pedological drought

ZONING OF THE SOIL MOISTURE FOR THE MAIZE CROP / South-East Development Region (RO 2)



Severe pedological drought
Moderate pedological drought



Extreme pedological drought
Severe pedological drought
Moderate pedological drought

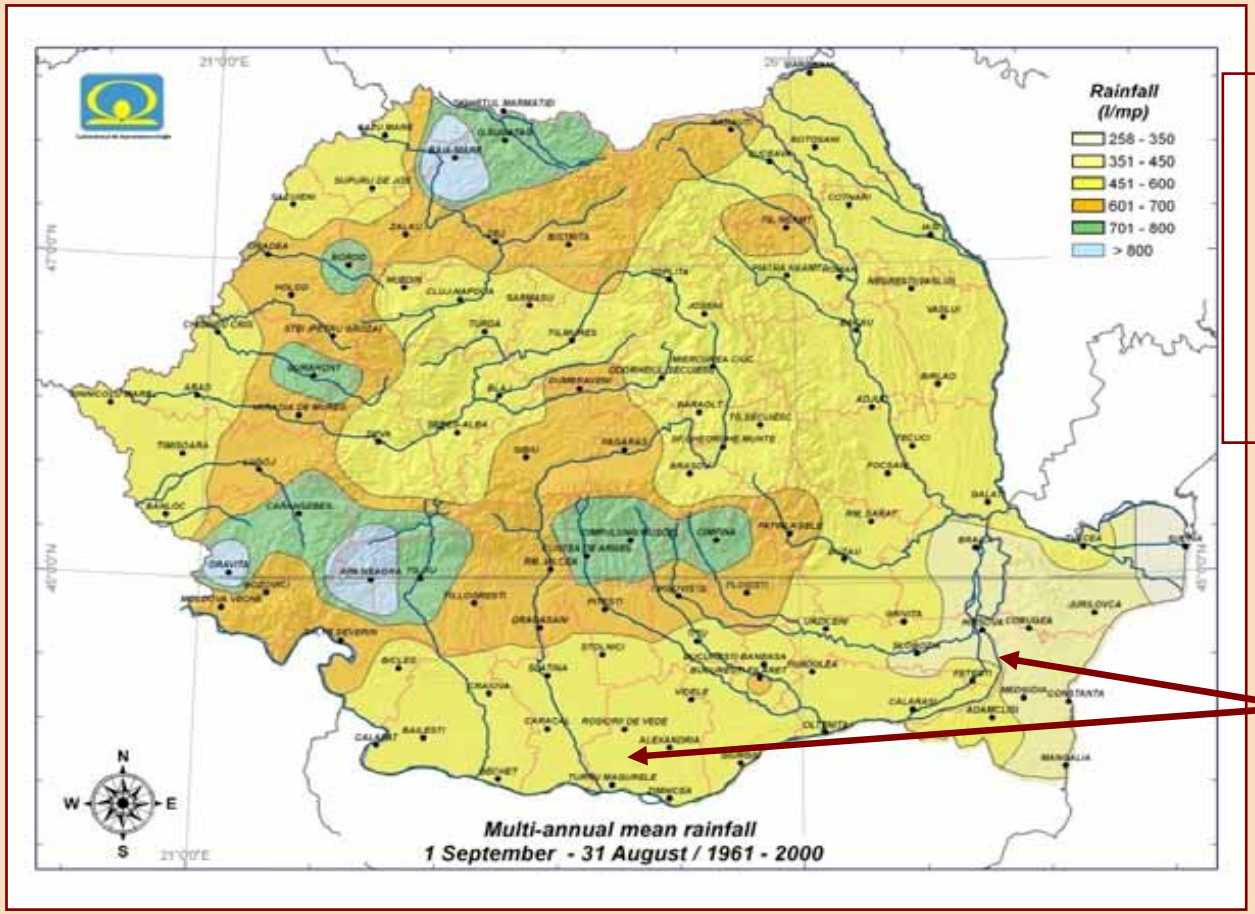
MAIZE

JULY - AUGUST / Extreme, severe and moderate pedological drought

JULY – 92.5% droughty years (6.5%...43.3% /extreme pedological droughty years)

AUGUST – 97.2% droughty years (36.7%...66.7% /extreme pedological droughty years)

⇒ RAINFALL REGIME



Rainfall regime classes
258 – 350 mm / excessively dry
351 – 450 mm / dry
451 – 600 mm / moderate dry
601 – 700 mm / optimal
701 – 800 mm / rainy
> 800 mm / excessive rainy

THE AGRICULTURAL REGIONS WITH HIGH RISK OF RAINFALL DEFICITARY REGIME

ROMANIA / 1961 - 2008

⇒ 5 ani / 10.4% - dry years (351.0 – 450.0 l/mp)

⇒ 21 ani / 43.8% - moderate dry years (451.0 – 600.0 l/mp)

TOTAl dry years - 26 years / 54.2%

⇒ 17 ani / 35.4% - optimal years (601.0 – 700.0 l/mp)

⇒ 5 ani / 10.4% - excessive rainy years (701.0 – 800.0 l/mp)

► Droughty extreme years in Romania

► ANI EXTREMI SECETOŞI ÎN SECOLUL XX

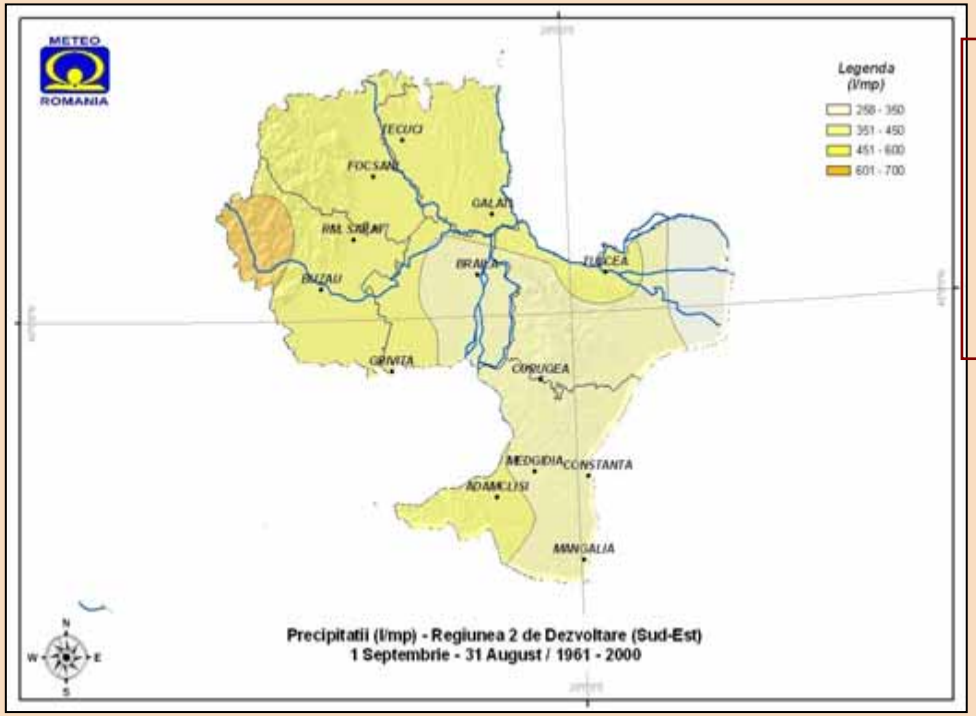
Deceniul 1901-1910: ***1907-1908***
Deceniul 1911-1920: ***1917-1918***
Deceniul 1921-1930: ***1923-1924, 1927-1928***
Deceniul 1931-1940: ***1934-1935***
Deceniul 1941-1950: 1945-1946, 1947-1948, 1949-1950
Deceniul 1951-1960: ***1952-1953***
Deceniul 1961-1970: ***1962-1963, 1964-1965***
Deceniul 1971-1980: ***1973-1974, 1975-1976***
Deceniul 1981-1990: 1982-1983, 1985-1986, 1987-1988
Deceniul 1991-2000: ***1992-1993, 1999-2000***

► ANI EXTREMI SECETOŞI ÎN SECOLUL XXI

Deceniul 2001-2010: 2000-2001, 2001-2002, 2002-2003, 2006-2007, 2008-2009 / 5 years

The increase of frequency droughty years

Zoning of the annual precipitation and frequency (%) of dry years – Region 2 of Development (South-East)



Rainfall regime classes
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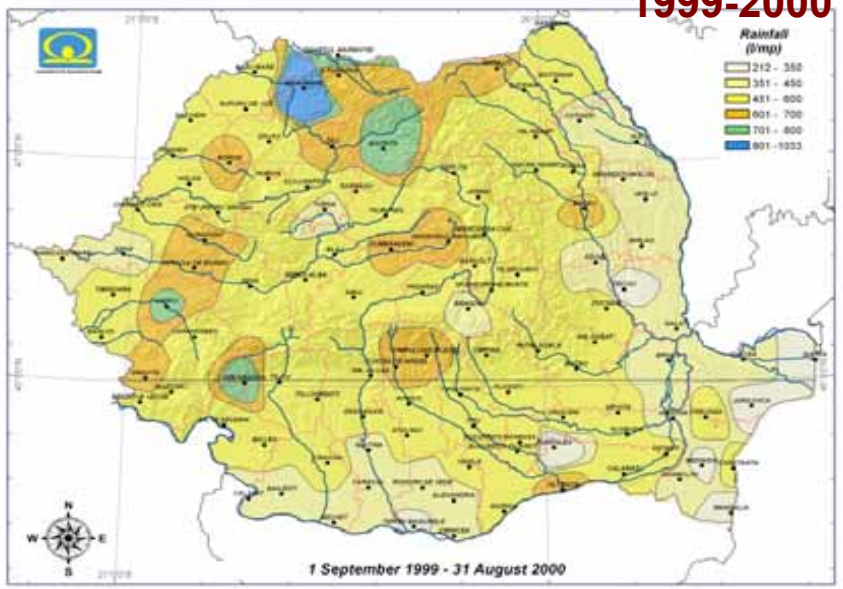
601 – 700 mm / optimal

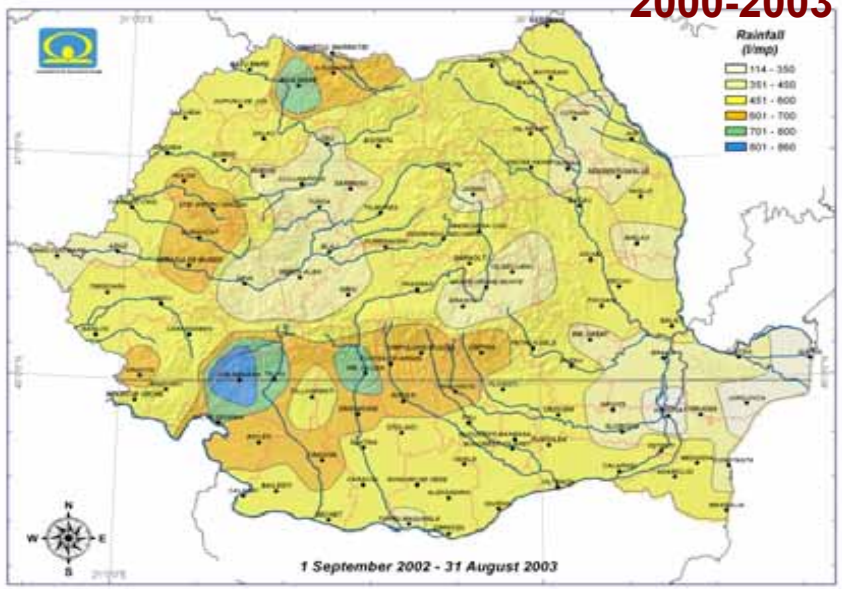
Region 2 of Development / 1961- 2008
⇒ 5 ani / 10.4% - excessivelly dry years (251.0 – 350.0 l/mp)
⇒ 21 ani / 43.8% - dry years (351.0 – 450.0 l/mp)
⇒ 19 ani / 39.6% - moderate dry years (451.0 – 600.0 l/mp)
TOTAL dry years - 45 years / 93.8%
⇒ 2 ani / 4.2% - optimal years (601.0 – 700.0 l/mp)
⇒ 1 an / 2.0% - rainy years (701.0 – 800.0 l/mp)

► Zoning of the annual precipitation / extreme droughty agricultural years

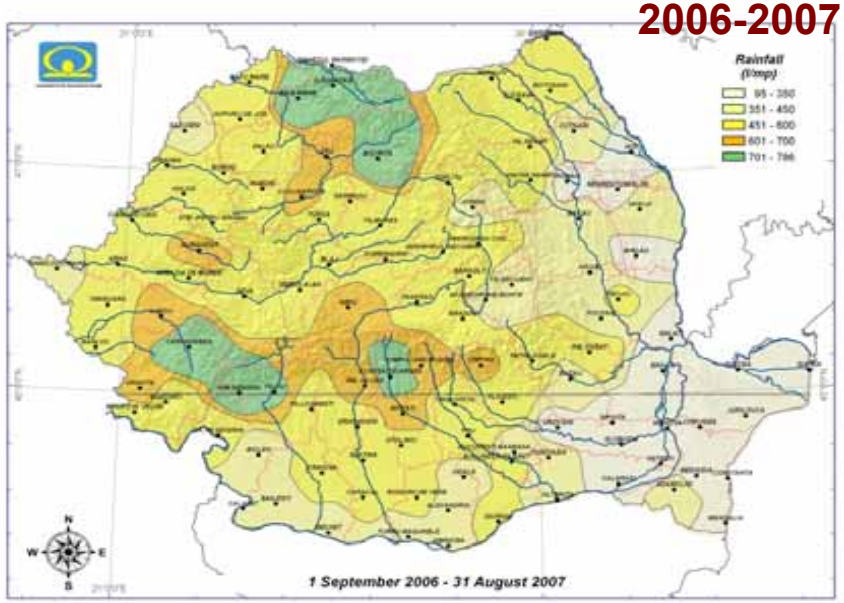
1999-2000



2000-2003



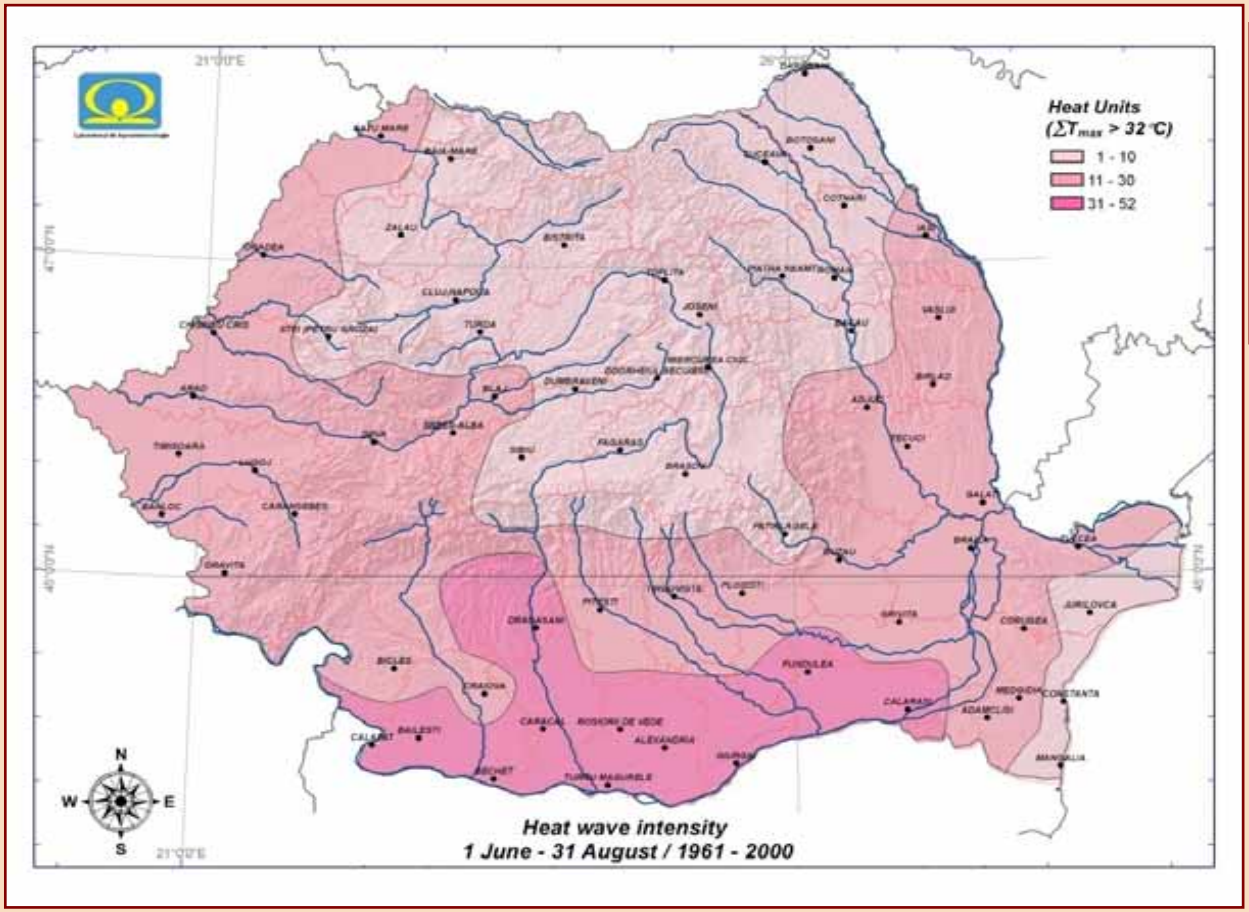
2006-2007



Rainfall deficitary regime /September - August
- risk threshold < 600 mm / in most agricultural areas

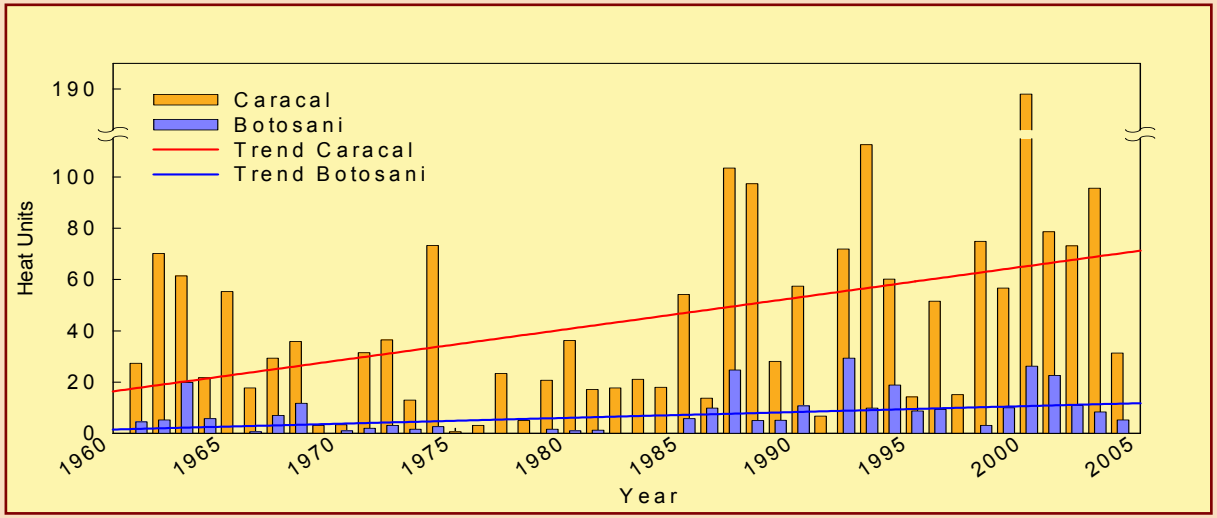
	Cumulative precipitation (mm)	Precipitation deficit (%)
2000	279,1 mm / Fundulea	- 49%
2003	260,0 mm / Harsova	-64%
2007	**257,5 mm / Corugea**	-62%

⇒ HEAT WAVE



► **Heat weave intensity:**

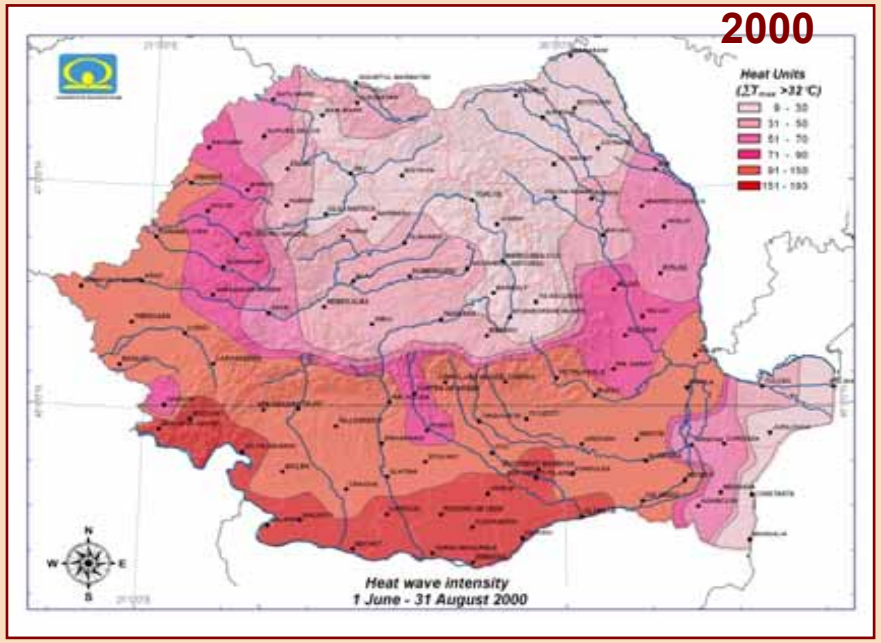
- ❑ **0 – 10 units/ low intensity**
- ❑ **11 – 30 units / moderate intensity**
- ❑ **31 – 50 units / high intensity**
- ❑ **51 – 70 units / extreme intensity**
- ❑ **>70 units / several intensity**

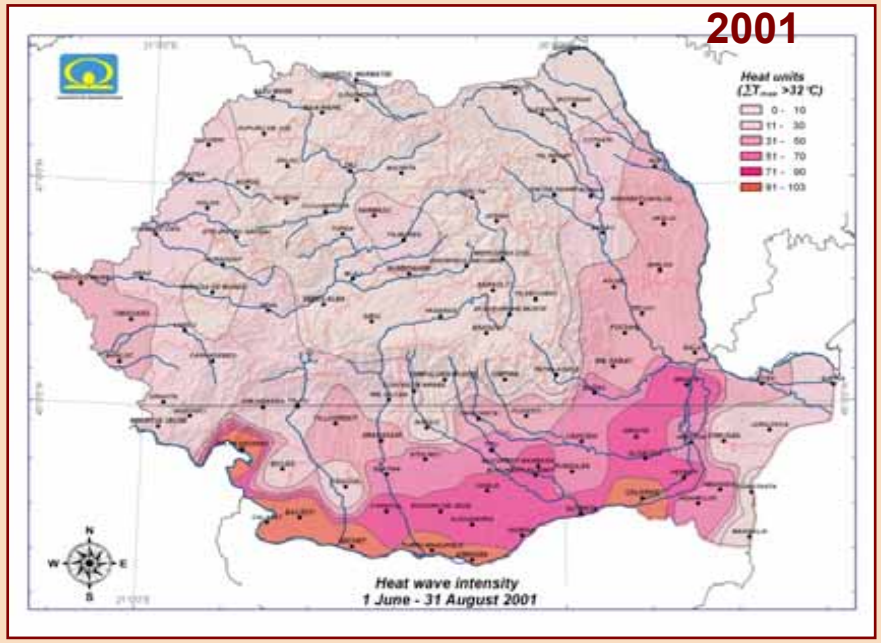


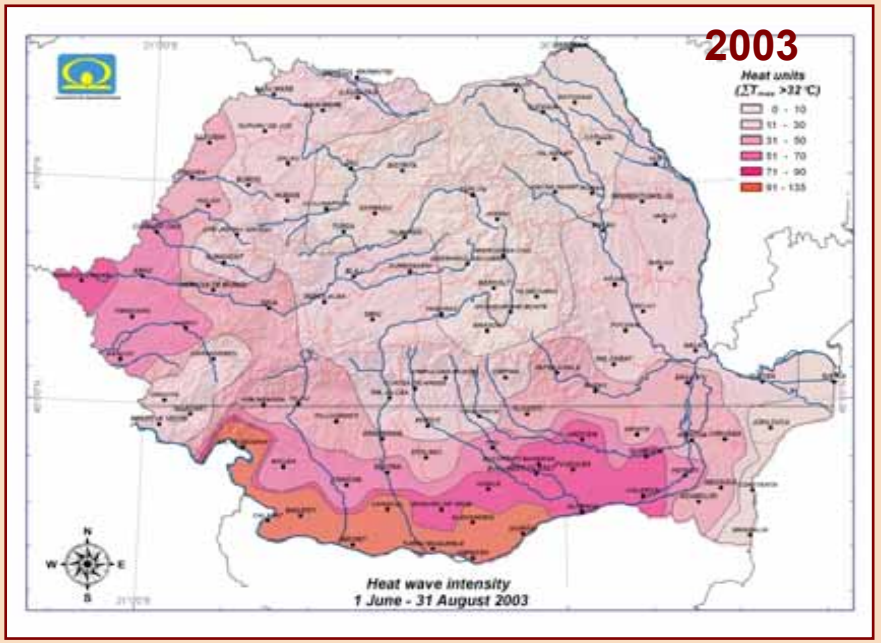
► High temperatures, especially the prolonged and intense heat waves may change dramatically the soil water balance by increasing the evapotranspiration thus reducing the soil available water and favouring the intensity of pedological drought. In addition, heat waves produce thermal stress to plants even if water is not limited.

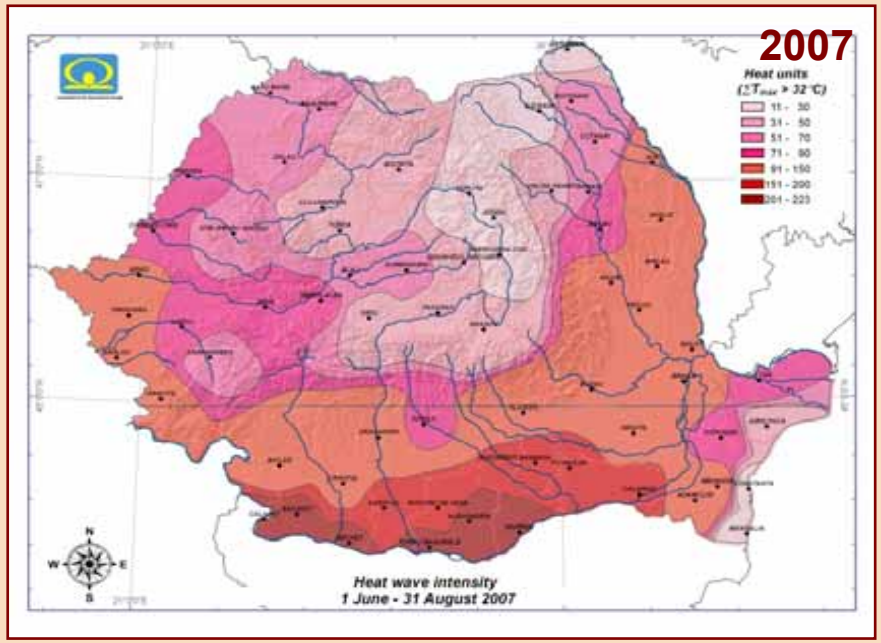
► Thermal stress due to heat spells was consistently increasing in the past 30 years, both in duration and intensity, inducing negative effects on crop development and production.

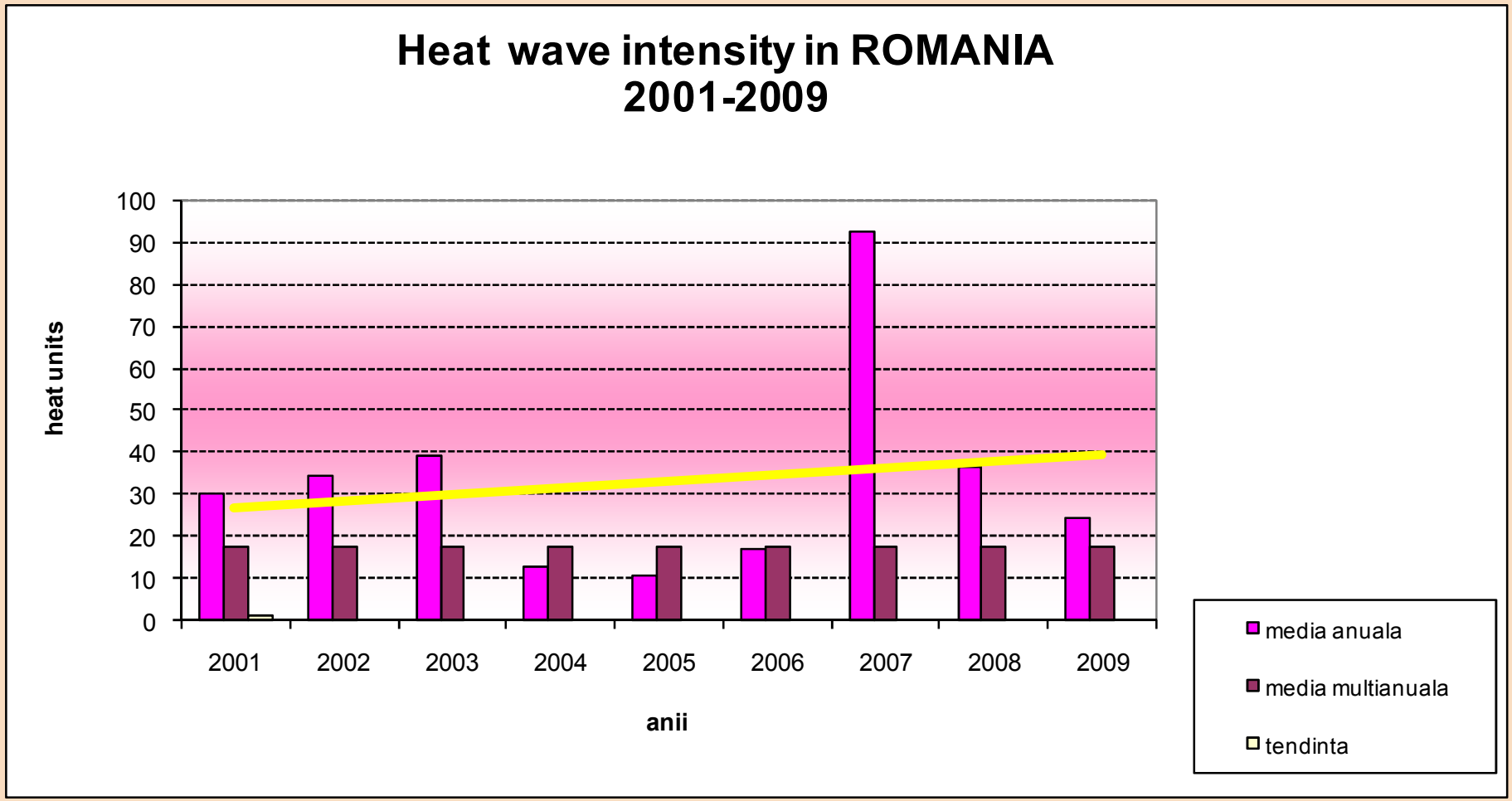
► Heat wave intensity during summer season











Year /Heat wave intensity (∑Tmax≥32°C)	2001	2002	2003	2004	2005	2006	2007	2008	2009
	30.4	34.6	39.0	12.8	10.8	16.9	92.5	36.5	24.5
1961-1990	17.4 heat units								

► Extreme values for “heat intensity” during 2001-2009 agricultural years

	“Heat intensity” / duration / agro-meteorological station
2001	**103,0 heat units / 46 days / Calarasi**
2002	91,5 heat units / 33 days / Calafat
2003	**135,1 heat units / 50 days / Calafat**
2004	68,1 heat units / 27 days / Calafat
2005	33,6 heat units / 13 days / Bechet
2006	65,2 heat units / 31 days / Turnu Magurele
2007	**222,5 heat units / 58 days / Giurgiu**
2008	**120.1 heat units / 47 days / Giurgiu**
2009	84.2 heat units / 38 days / Giurgiu

The maximum value for intensity and duration of the heat wave:
►2001 / 103,0 heat units in a total number of 46 days, at Calarasi
►2003 / 135,0 heat units in a total number of 50 days, at Calafat
►2007 / 222,5 heat units in a total number of 58 days, at Giurgiu
►2008 / 120.1 heat units in a total number of 47 days, at Giurgiu
► Generally, the South, South-East, and South-West regions of the country are affected by heat, but during the extreme years 2003 and 2007, both the intensity and the spatial extent of very intense heat were much larger than in other years, with more than half of the country affected by heat waves cumulating over 100…150 units.

⇒ Drought related-indices derived from remote sensing data

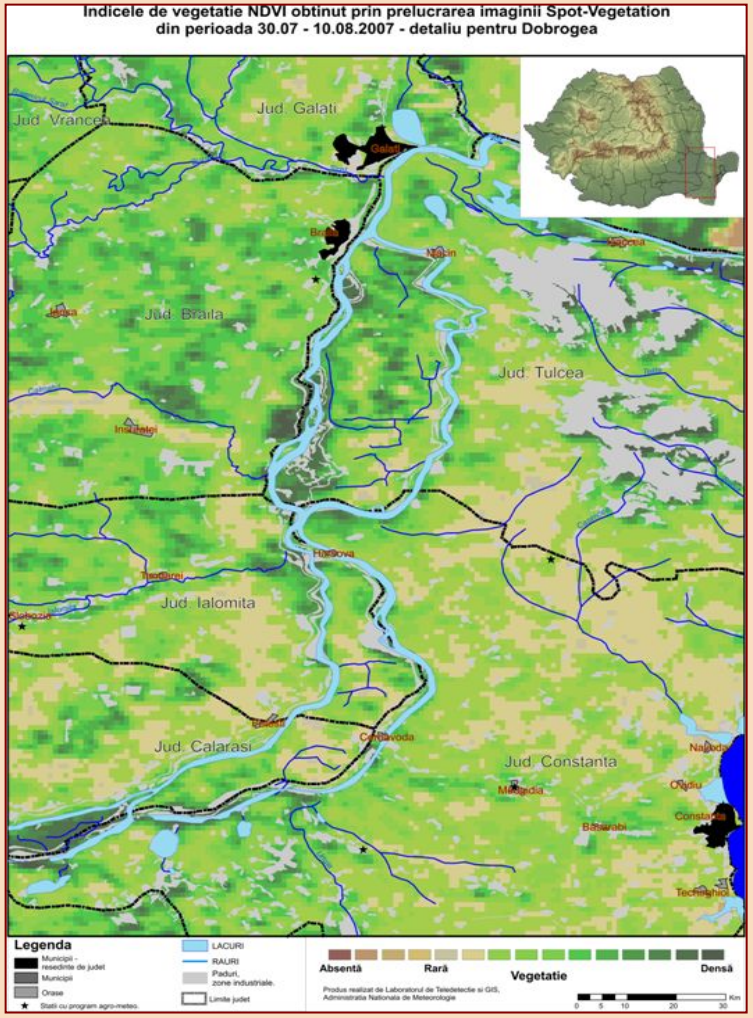
⇒ Applications of NDVI values derived from SPOT-VEGETATION imagery can be used to monitor the crop growth and development during active vegetation period.

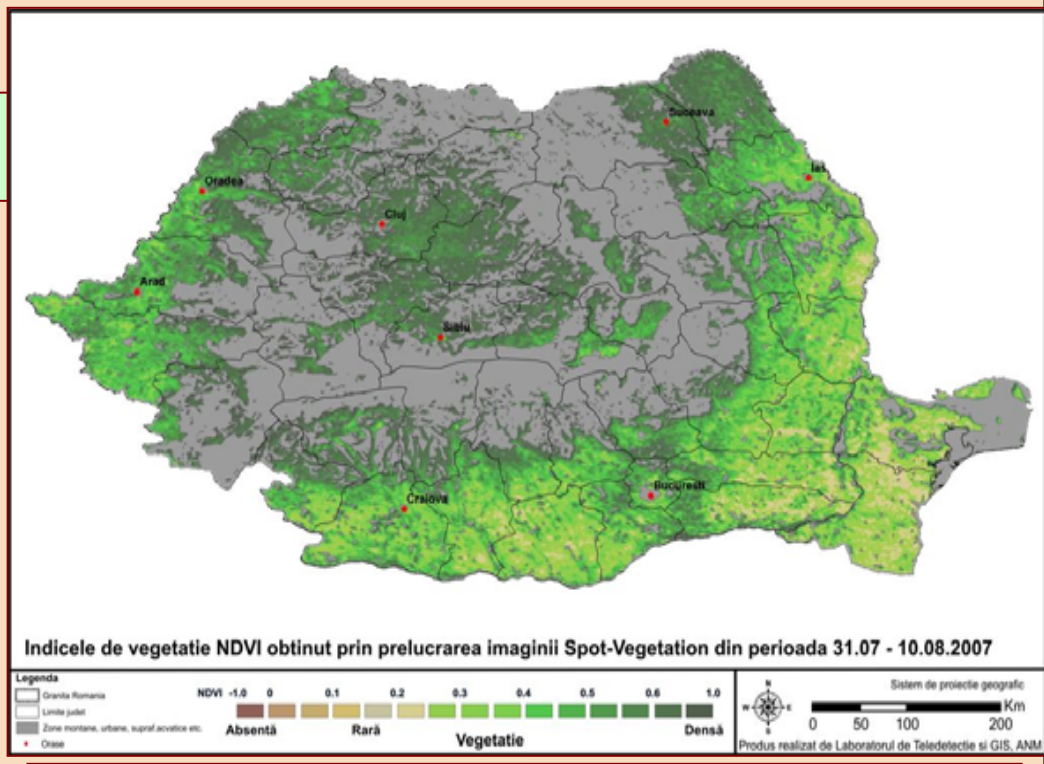
⇒ For a better operative surveillance of the agricultural areas and in order to work out new information products, starting with 2005 NMA benefits by data received from the SPOT/VEGETATION sensor, transmitted in real time (via FTP) from March to October. Begining from the last dekade of March 2005 these maps have been included and analysed in the Agrometeorological Bulletin each 10 days.

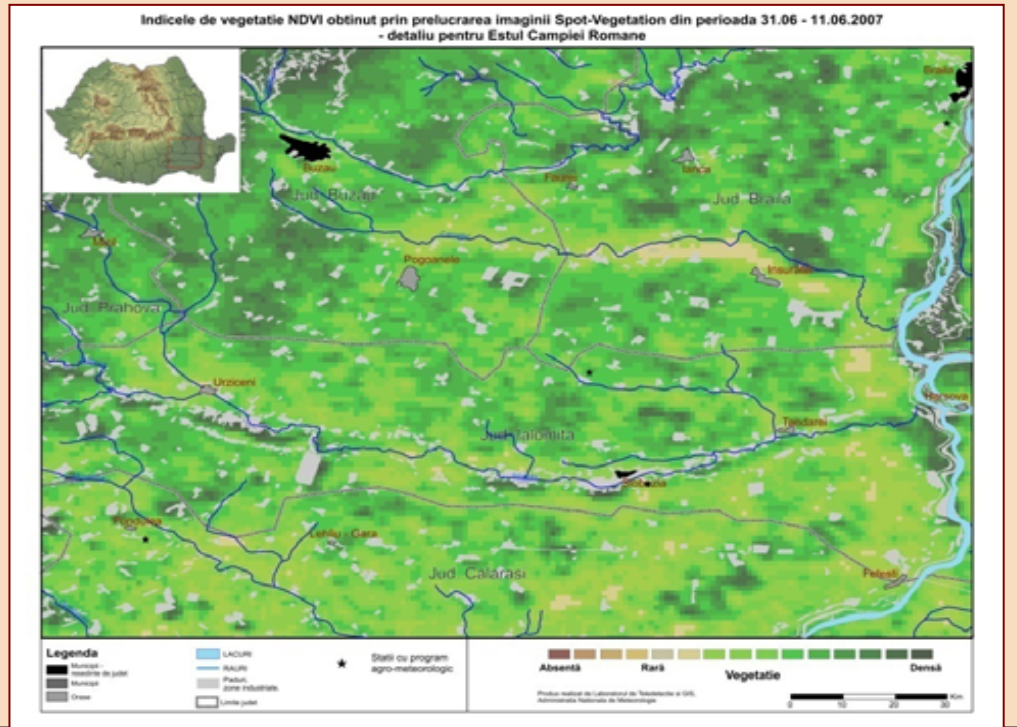
⇒ The capability of GIS technology is significant, enabling users to develop accurate and precise maps based on quantitative data to be analysed in combination with other sources of data.

⇒Examples of the dekadal maps of NDVI for monitoring crop vegetation status

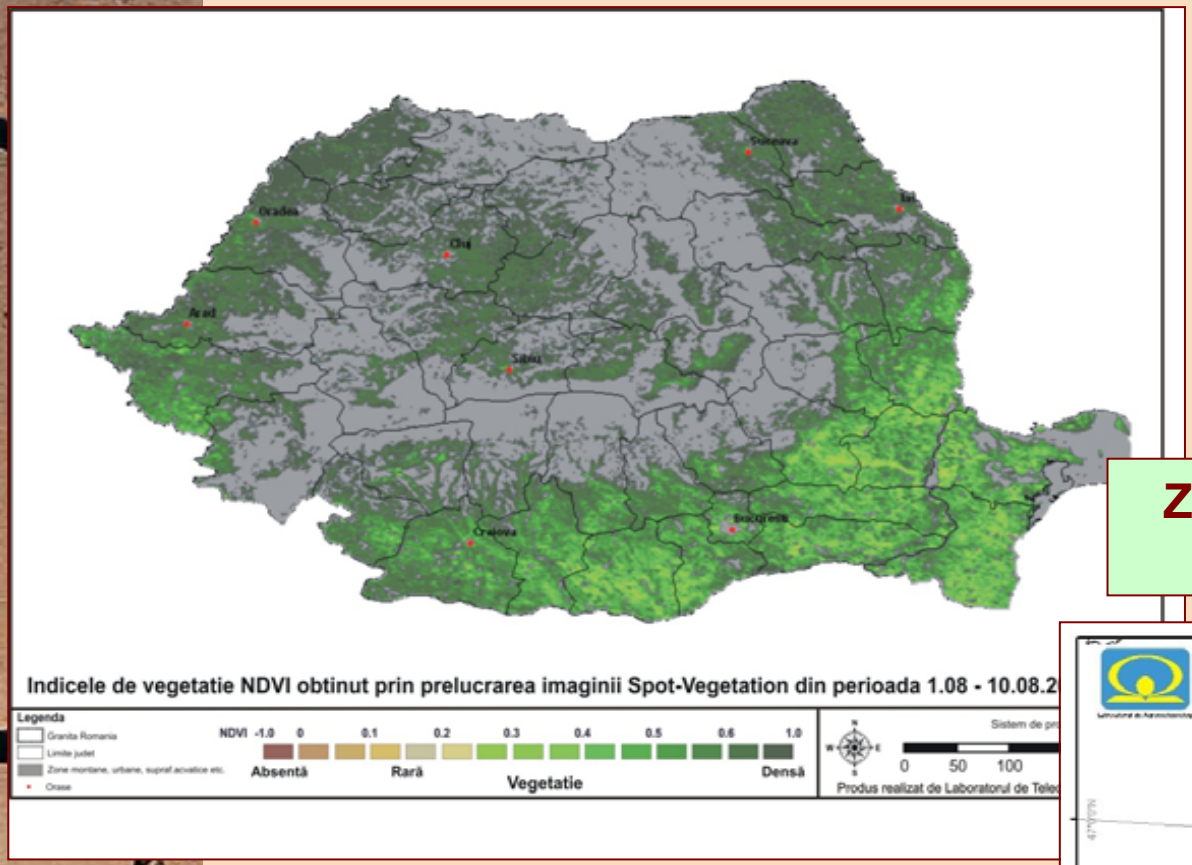
2007 / Extremely droughty year



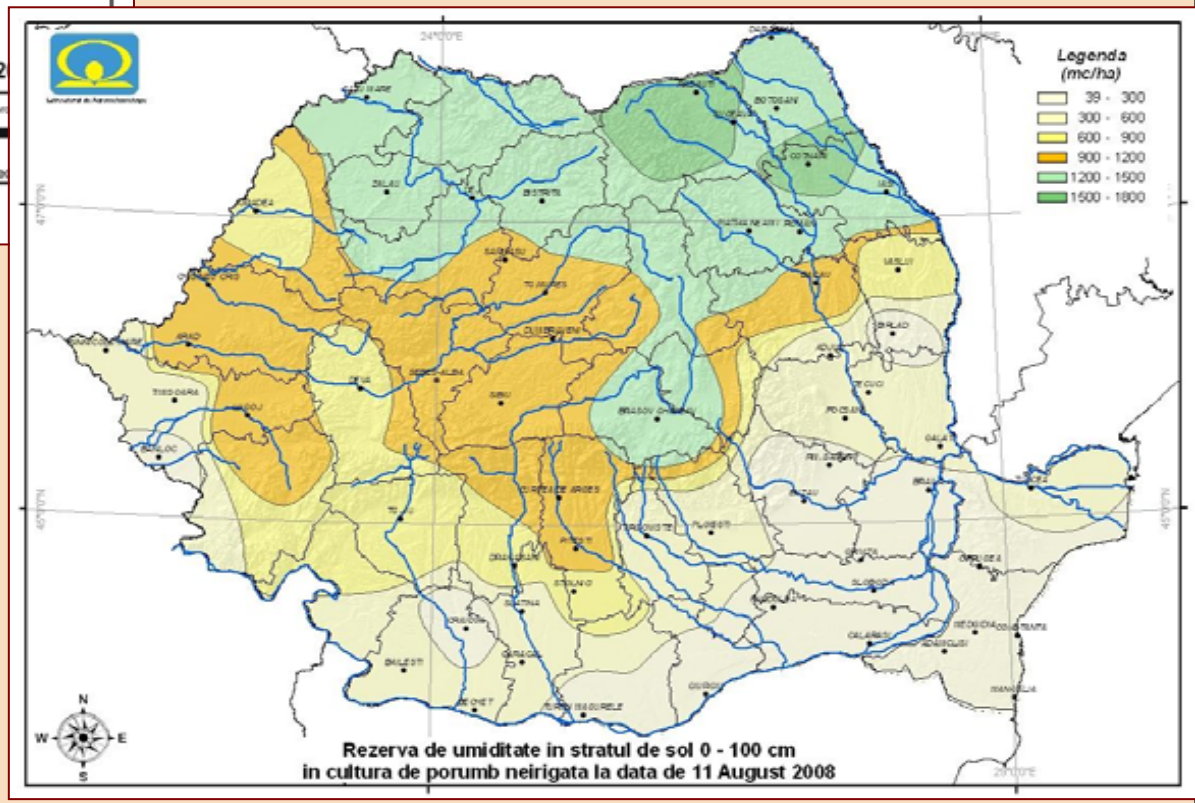




NDVI / Spot-Vegetation / 01-10 August 2008



Zoning of the soil moisture reserves (m3/ha) for the maize crop / 11 August 2008



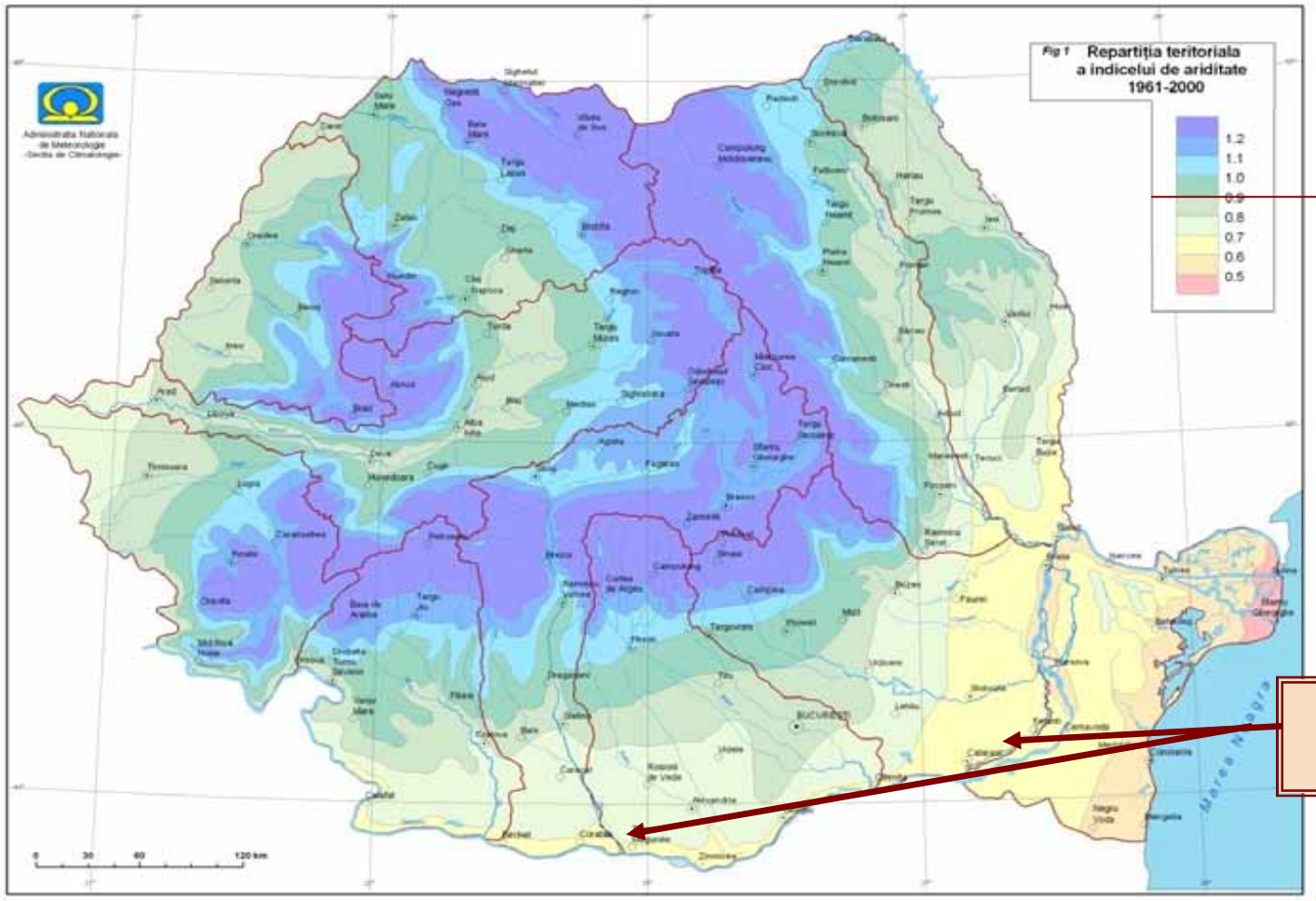
⇒ CLIMATOLOGICAL INDICES OF DROUGHT

$$I_A = \frac{P}{ETP}$$

I_A = *Aridity Index (UNEP, World Atlas of Desertification/1992)*

P = Annual rainfall (mm)

PET = Potential evapotranspiration (mm)



THRESHOLDS VALUES

REGIONS WITH HIGH RISK OF WATER DEFICIT

⇒ SPI / Standardized Precipitation Index

For the evaluation of the deficit/excess of precipitations, we have used the standardised precipitation index (SPI), proposed by Doessen & McKee (1991). This index measures how much the real rainfall (for the last 1 to 12 month) is far from the mean value (of the same period), in standard deviation units (SD).

$$SPI = \frac{P_i - P_m}{SD_i}$$

in which:

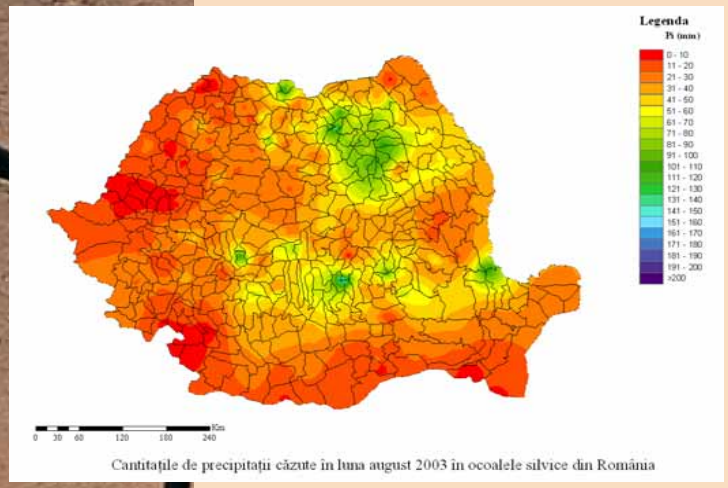
Pi = precipitations registered in the period i (1 to 12 months)

Pm = mean of the precipitations in the period i

SDi = standard deviation of the mean precipitations in the period I

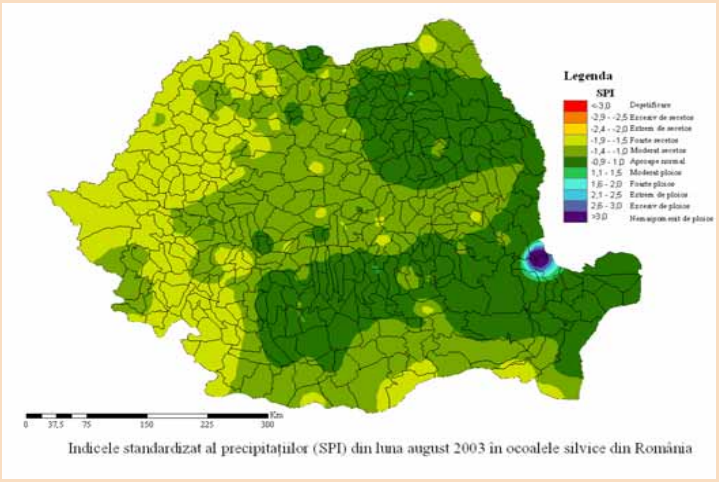
LEGEND

Regime	Excessive dry	Extreme dry	Very dry	Moderate dry	Near normal	Moderate wet	Very wet	Extreme wet	Excessive wet
Symbol	EXD	ED	VD	MD	NN	MW	VW	EW	EXW
SPI	< -2,5	-2…-2,5	-1,5...-2	-1…-1,5	-1…1	1…1,5	1,5…2	2…2,5.	> 2,5



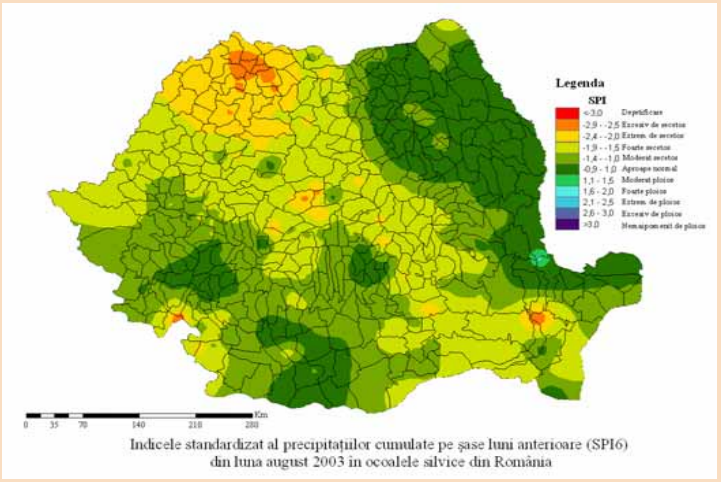
Cantitățile de precipitații căzute în luna august 2003 în ocoalele silvice din România

Pi



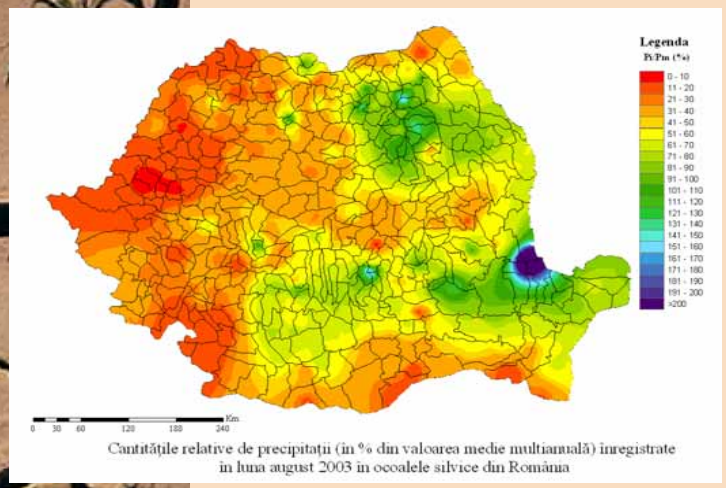
Indicele standardizat al precipitațiilor (SPI) din luna august 2003 în ocoalele silvice din România

SPI1



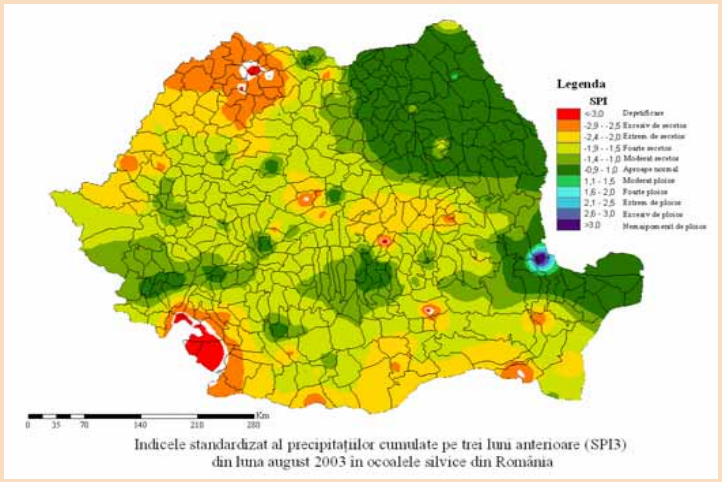
Indicele standardizat al precipitațiilor cumulate pe șase luni anterioare (SPI6) din luna august 2003 în ocoalele silvice din România

SPI6



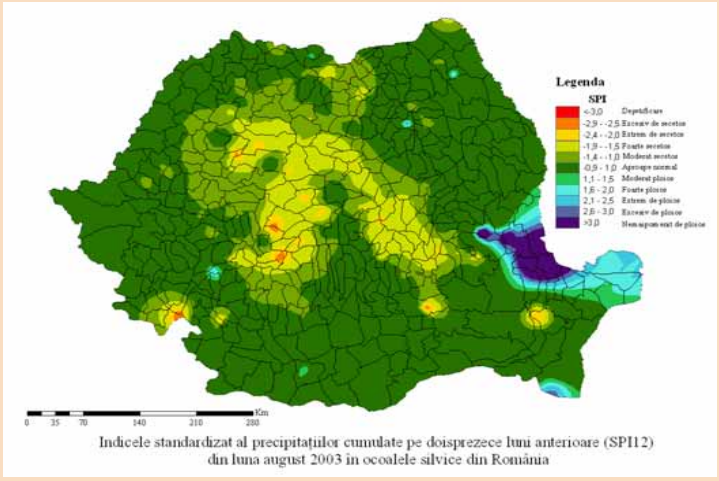
Cantitățile relative de precipitații (în % din valoarea medie multiannuală) înregistrate în luna august 2003 în ocoalele silvice din România

P%



Indicele standardizat al precipitațiilor cumulate pe trei luni anterioare (SPI3) din luna august 2003 în ocoalele silvice din România

SPI3



Indicele standardizat al precipitațiilor cumulate pe doisprezece luni anterioare (SPI12) din luna august 2003 în ocoalele silvice din România

SPI12

Examples of thematic maps for the characterization of the drought (rainfall regime) using Standardised Precipitation Index (SPI) in august 2003

⇒ *DISSEMINATION PROCESS*

⇒ **DECISION FACTORS** – standard agrometeorological bulletin:

- the product is disseminated to Presidency, Government, Ministry of Environment and Ministry of Agriculture, Forest and Rural Development for **informational** and **decisional purpose**.

⇒ **FARMERS** – specialized agrometeorological bulletin and forecasts:

- the information is disseminated through **mass-media**. Periodical broadcasts (i.e. "Village Life") are made at the public **radio** and **television** having nationwide and regional coverage, targeting especially rural audience.
- agrometeorological forecasts for **5 specialized publications** and **magazines** are disseminated weekly, bi-monthly and monthly in electronical format (www.magazinagricol.ro; www.gazetafermierului.ro; www. lumeasatului.ro; www.profitulagricol.ro; www.revista-ferma.ro) and paper format (i.e. "Village World").

⇒ Upon **REQUEST** - customized agrometeorological bulletin:

- the specialized information is delivered to end-users interested on particular **agricultural areas** (i.e. regional, local) and **crops** (winter wheat, maize, etc)

DECISION MAKING

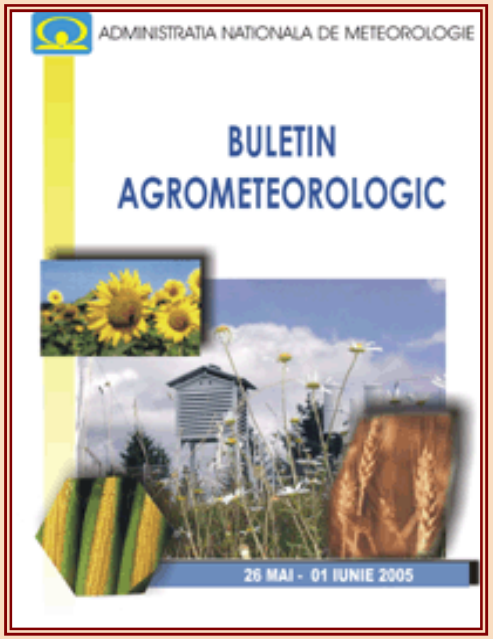
USERS

DISSEMINATION

Document Microsoft Word

Adobe Acrobat Document

AGROMETEOROLOGICAL BULLETIN
Diagnosis / Forecast

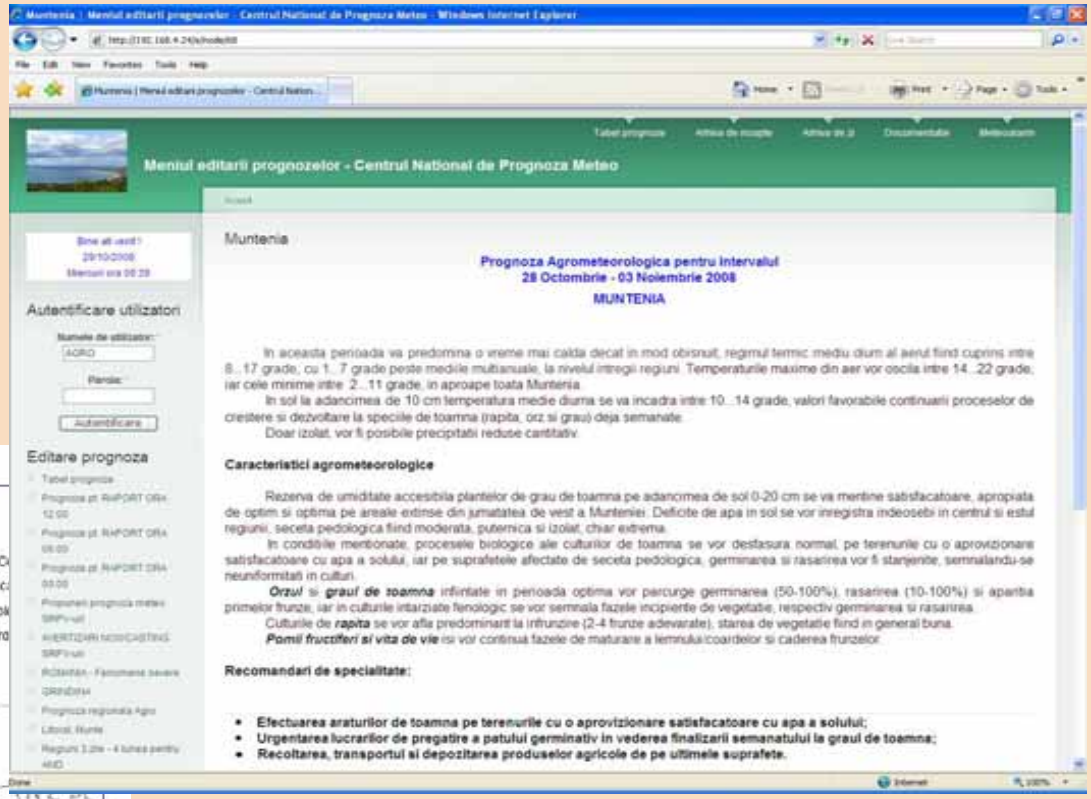


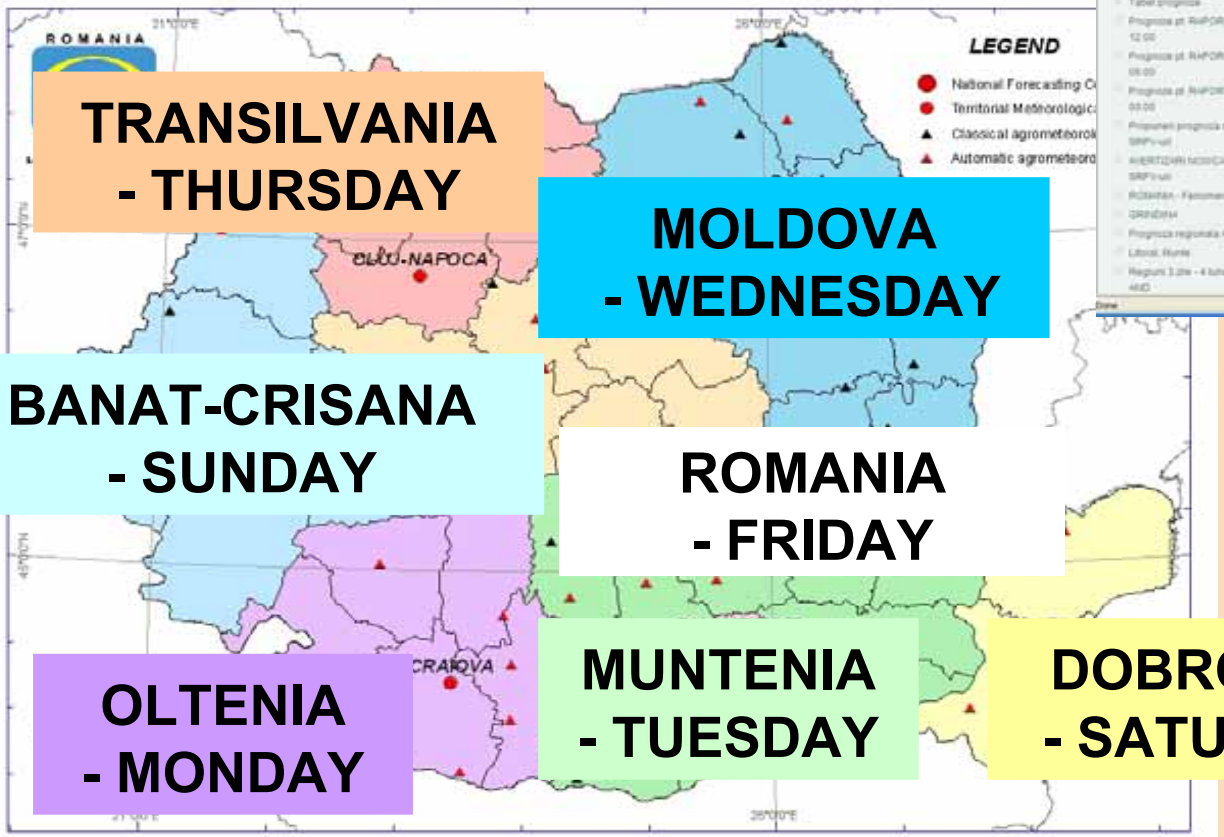
- Presidency
- Government
- Ministry of Environment
  - Water Department
  - Environment Department
- Ministry of Agriculture, Forest and Rural Development

TARGET USERS

- Private Agricultural Farm
- Mass-media
  - Radio/TV
    - ANTENA SATELOR
    - VIATA SATULUI
  - Specialized publications
    - FERMA
    - EURO-FERMA
    - AGRIPLUS
    - LUMEA SATULUI
- Universities and Agricultural and Forest Research Institute
- Insurance companies

⇒ WEEKLEY REGIONAL AGROMETEOROLOGICAL FORECASTS / RADIO BROADCAST “VILLAGE LIFE”





TRANSILVANIA - THURSDAY

MOLDOVA - WEDNESDAY

BANAT-CRISANA - SUNDAY

ROMANIA - FRIDAY

OLTENIA - MONDAY

MUNTENIA - TUESDAY

DOBROGEA - SATURDAY

⇒ Applications of agrometeorology including Internet technologies

webpage: http:// vremea.meteoromania.ro

Users / Farmers, Agricultural Associations, Insurance companies

- Name of user
- Password

AGRICULTURE

⇒ **Recommendations and options to improve the genotype varieties and yields**

- *Altered genetic coefficients, respectively for winter wheat the vernalization an photoperiod (P1V and P1D). For winter wheat the most suitable combinations can be the varieties with high or moderate vernalization and moderate or shorter photoperiod requirements*.

⇒ **Recommendations to improve effective use of water by crops**

- *Use of cultivars resistant to abiotic stresses (i.e. drought, high temperature) and resistance to specific diseases*
- *Using different soil classes*
- *Changing the seeding date and selection of cultivars with shorter germination and shorter growing season*
- *Application of irrigation and* choose the most suitable irrigation method considering type of crop, soil type, technology, costs and benefits
- *Changing the agricultural practices and crop rotation systems*
- *Perform periodical soil analysis and tests, in order to assess and correct the limiting factors which hinder the normal growth and development of plants (acidity, nutrient excess or deficit, etc.).*
- *Use of natural organic fertilizers, adapted to needs/demands*

Specific measures for adaptation to climate change and for mitigation of agricultural impacts on climate

Good practices for farmer benefits / *Code of Attitudes*

This measures summarizes risks for agriculture that are due to climate change.

1. Crop management and land use

1.1. Varietal selection

Good practices

- Use of cultivars resistant to abiotic stresses (i.e. water shortage, drought, high temperature;
- Selection of cultivars with shorter germination period and shorter growing season;
- Selection of varieties that are naturally resistant to specific diseases.

Farmer benefits

- Improved water management in agriculture
- Better use of the soil moisture conditions after sowing
- Increased yield production with less chemicals
- Reduced CO2 emissions and increased yield and biomass production

1.2. Cropping system

Good practices

- Use of adapted crop rotation as main crop system for the farm.
- Use of mixed cropping, catch cropping, cover cropping, as multiple crop in the same space or in the farm to increase biodiversity.

Farmer benefits

- Reduction of the effect of adverse weather, through planting and harvesting at different times.
- Improving soil structure and fertility and organic matter by alternating deep-rooted plants.
- Slower trends of spreading of pest and diseases during the growing season.
- Balance of the fertility demands of various crops to avoid excessive depletion of soil nutrients.

1.3. Practices favouring C sequestration

Good practices

- Planted fallows, cover crops and catch crops.
- Conservation tillage and mulch farming techniques, to reduce soil emissions of CO_2.
- Forestation and agro forestry.
- Science-based agriculture with judicious chemical inputs.

Farmer benefits

- Reduction of tillage costs.
- Reduced soil degradation, erosion, and salination.
- Better protection of land from desertification and degradation (erosion).
- Improved crop production, reduced soil and underground water pollution, more efficient use of natural resources.

2. Soil management and fertilization

2.1. Erosion control: water erosion

Good practices

- Maintain crop residue cover above 30 percent until crop canopy closure.
- Alternate summer crops with winter crops and perennial crops.
- Use cover crops during periods when the soil would have insufficient residue.
- Contour farming – crops are planted nearly on the contour (especially for moderate slopes, 2-6%).
- Contour strip-cropping – alternating strips with high-residue cover or perennial crops with strips with low residue cover. The strips should be laid out close to the contour.
- Construction of level terraces.

Farmer benefits

- Soil surface directly exposed to rain drops splash is reduced.Increase the time with vegetation cover.
- Reduces runoff and rain splash.
- Protection from water erosion on moderate slopes.
- Soil eroded from the bare or low-residue strips is deposited in strips with high residue or dense vegetation because runoff is decreased.
- Change of slope steepness.

3. Water management

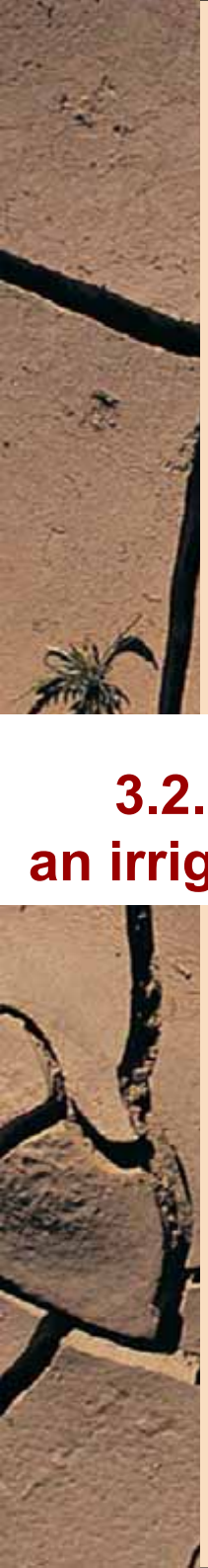
3.1. Irrigation best management practises

Good practices

- Rate irrigation highly within the management system.
- Know the soils property like capacity of soil to hold water, and where in the soil profile the roots of the crop are.
- Design and maintain irrigation systems correctly. Irrigation system setup, age, and maintenance are limiting factors in their ability to manage irrigation
- Monitor all aspects of each irrigation event before, during and after the irrigation. Deciding of when, monitoring of where water is going, both during the irrigation, by measuring system performance and uniformity of application, and after the irrigation, by assessing under- and over-irrigation.
- Use more than one objective monitoring tools to schedule irrigation. The most common and simplest included digging holes to check soil water, observation of the appearance of plants, and the checking of test-wells or drain flows after irrigation and subsequent adjustment in practice at the next irrigation.
- Retain control of irrigation scheduling. With modern technology, it is possible to set up irrigation systems to operate entirely automatically, based on the readings from a probe or a set of probes.
- Use software for water balance, running on personal computers or on web servers. Models for practical use must be simple, avoiding too many parameters, useful only for experimental purposes.

Farmer benefits

- Optimal use of irrigation water.



3.2. Choosing an irrigation method

Good practices

Choose the most suitable irrigation method according to the following natural conditions:

- **Soil type:** sandy soils have a low water storage capacity and a high infiltration rate. They therefore need frequent but small irrigation applications, in particular when the sandy soil is also shallow. Under these circumstances, sprinkler or drip irrigation are more suitable than surface irrigation. On loam or clay soils all three irrigation methods can be used, but surface irrigation is more commonly found. Clay soils with low infiltration rates are ideally suitable for surface irrigation. When a variety of different soil types is found within one irrigation scheme, sprinkler or drip irrigation are recommended as they will ensure a more even water distribution.
- **Slope:** Sprinkler or drip irrigation are preferred above surface irrigation on steeper or unevenly sloping lands as they require little or no land leveling. An exception is rice grown on terraces on sloping lands.
- **Climate:** Strong wind can disturb the spraying of water from sprinklers. Under very windy conditions, drip or surface irrigation methods are preferred. In areas of supplementary irrigation, sprinkler or drip irrigation may be more suitable than surface irrigation because of their flexibility and adaptability to varying irrigation demands in the farm.
- **Water availability:** Water application efficiency is generally higher with sprinkler and drip irrigation than surface irrigation and so these methods are preferred when water is in short supply. However, it must be remembered that efficiency is just as much a function of the irrigator as the method used.
- **Water quality:** Surface irrigation is preferred if the irrigation water contains much sediment. The sediments may clog the drip or sprinkler irrigation systems and increasing cost of maintenance. If the irrigation water contains dissolved salts, drip irrigation is particularly suitable, as less water is applied to the soil than with surface methods. Sprinkler systems are more efficient that surface irrigation methods in leaching out salts.

CONCLUSIONS

► Climate is the ensemble of meteorological processes and phenomena specific to a geographical region. The management and sustainable development decisions should aim to specialize the agricultural production by growing in each region the appropriate crops that have the largest benefit from the natural potential for agriculture, which is evaluated through analysis of pedo-climatic conditions.

► Agriculture is strongly influenced by the availability of water. Climate change will modify rainfall, evaporation, runoff, and soil moisture storage. Changes in total seasonal precipitation or in its pattern of variability are both important. The occurrence of moisture stress during flowering, pollination, and grain-filling is harmful to most crops and particularly so to maize, soybeans, and wheat. Increased evaporation from the soil and accelerated transpiration in the plants themselves will cause moisture stress; as a result there will be a need to develop crop varieties with greater drought tolerance. The demand for water for irrigation is projected to rise in a warmer climate.

► Accurate diagnose of agro-meteorological conditions is a crucial process needed for understanding the risks caused by extreme weather events and for decision making and sustainable development actions.

► Romanian agrometeorological observation network of NMA provides weekly in-situ monitoring and information is collected, analyzed and compiled in Operational Bulletin that is disseminated to decision factors and farmers for early-warning and advisories for agricultural practices (dry-farming system). During extremely droughty years this service enabled monitoring of drought dynamics and assessing the spatial extent and intensity of drought phenomenon.

►*Romania officially ratified the Convention to Combat Desertification (CCD) by Law Nr. 111/1998. In 2000, Romania elaborated the National Strategy and Action Programme concerning desertification, land degradation and drought prevention, and control" (NSAP). The Ministry of Agriculture, Forests and Rural Development (MAFRD) is responsible for drawing up the National Action Program to Combat Desertification as well as the National Report of UNCCD Implementation in Romania. There are also concerned the Ministry of Environment (ME), and research institutes subordinate to ME, focused on meteorology, hydrology, and environmental protection.*

► *The NMA scientists were actively involved in elaborating the NSAP and National Reports in the framework of UNCCD implementation (2000, 2002, 2008). The Romanian Government is assisted in taking decisions on drought, land degradation and desertification issues by the interdisciplinary National Committee to Combat Drought, Land Degradation and Desertification (Governmental Ordinance 474/2004) and NMA is member of the Technical Committee (Ministry Ordinance 503/2005), which is a consultative body.*

►*NMA is a key institution in the National Committee for Emergency and Disasters (NCED). According to Regulation for management of emergency situations generated by floods, in case of extreme weather events, accidental damages of hydro-technical constructions and accidental pollutions (Ministry of Administration and Interior, published in Official Monitor, Part I, No. 455/30.05.2005), NMA is responsible for carrying out the weather forecasts and warnings as well as operationally disseminate them to NCED and other decision points. In order to maintain the accuracy and rapid flow of information,*

► *NMA must ensure the well functioning of the national meteorological measurement network. NMA is the national authority in the meteorological field in charge with establishing critical thresholds for extreme weather events.*

► *NMA is one of the three institutions that operate the Technical Secretariat of the National Committee to Combat Drought, Land Degradation and Desertification, according the Rules of Procedure of the National Committee (approved by the Ministry of Agriculture, Forests and Rural Development by No. 27528/VL/04.10.2005) and is member of the Executive Bureau of the same Committee. National Committee to Combat Drought, Land Degradation and Desertification was established pursuant to Governmental Decision 474/2004 and its composition was formalized by Ministerial Order 503/2005.*

FUTURE STEPS

⇒ The agrometeorological activity undergoing within NMA, integrates complex issues concerning the evolution of the water supply of soils and vegetation state of the crops with respect to the meteorological parameters evolution, being a particularly important activity, whose final objective is to provide better decision support in agricultural management.

⇒ Better knowledge of climatic variability and change (including extreme events) together with the availability of agrometeorological information and forecasts are key components for improving agricultural decision making at the farm or policy level.

⇒ The continues application of GIS and Remote Sensing technologies to evaluate soil moisture and vegetation state of the crops will contribute to improving the agrometeorological information in order to provide better decision support in agricultural management.

⇒ The assessment and near-real time monitoring of the risk agrometeorological factors and their zoning over the country's agricultural territory, during vegetation season of crops will allow timely identification of the agricultural areas the most vulnerable and the dissemination of the information to the users for taking adequate measures (irrigation, fertilizing, agro-techniques to preserve the water in the soil, etc.).

THANK YOU!

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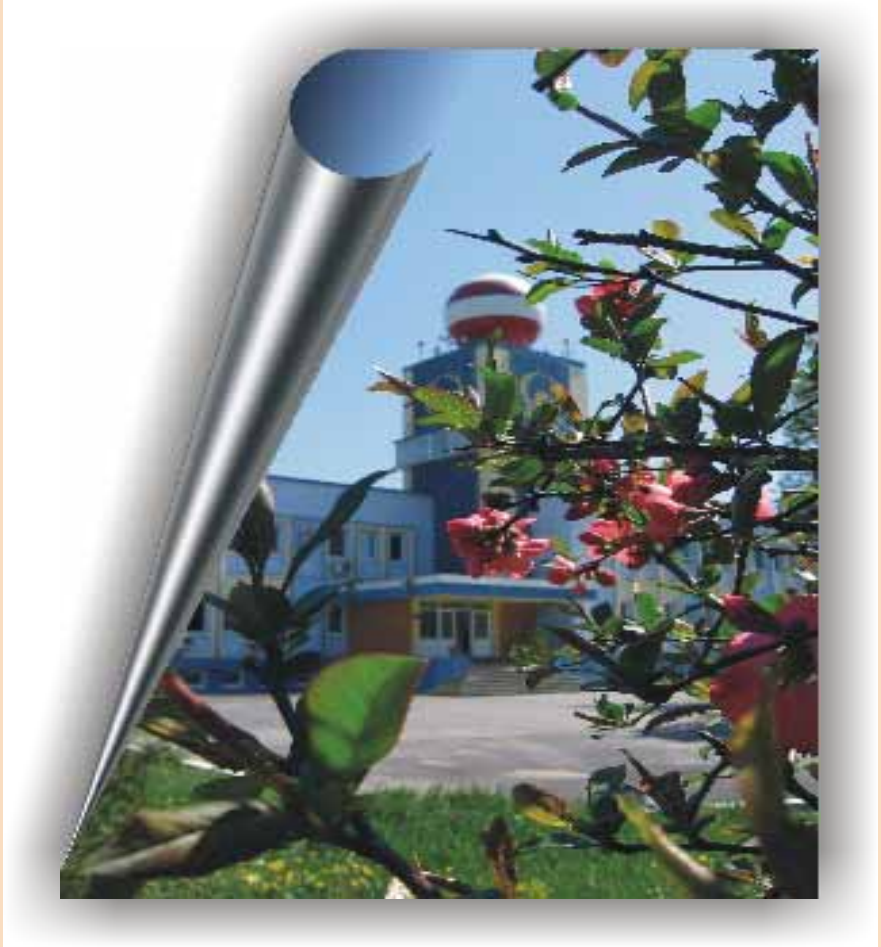

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