Proiect *„Calea Verde spre Dezvoltare Durabilă"*

Operator de Program:

Promotor:

Parteneri de proiect din partea Statelor Donatoare:

Parteneri de proiect:

Analysis and graphical representation of temperature and water risk indicators in Central Region 7, Romania

Daniel Alexandru, Radu Maria Alexandra

National Meteorological Administration Romania - PPP5

01 – 04 June 2015 / Workshop III Sibiu

Project “ Green Path to Sustainable Development ”

Program RO 07 – Adapting to Climatic Change 2009-2014

“ Green Path to Sustainable Development“
Current status of data collection and proccesing - work in progress

ICELAND LIECHTENSTEIN NORWAY eea grants

Activity 2.1.1. Development of meteorological studies: Data collection and mapping, experimental study numerical projection, determination of potential energy resources, Cross Sectorial Study and Regional Planning guideline regarding agricultural technologies.

Sub-activity 2.1.1.1. Data collection and mapping - a study on the progress of the current climate resources (1961-2010) to develop regional policies for managing extreme weather events:

- Organization and data processing of **air temperature** (minimum value, maximum and average) for **12 weather stations** (*Targu Mures, Sibiu, Fagaras, Sebes, Tg. Secuiesc, Blaj, Dumbraveni, Odorheiul Secuiesc, Alba-Iulia, Baraolt, Brasov and Fundata*) in Region 7 Centre, in the period 1961-2014, for evaluation of **risk indicators**:
  - winter severity by cold and frost units,
  - spring index,
  - heat intensity,
  - time of the first frost of fall and last spring frost.
- Were developed 3 GIS maps in Region 7 Centre zoning thermal resources (Spring index) for periods 1961-1990, 1981-2010 and 1961-2014;
- Collecting and processing of **monthly precipitation** and ranges of specific interest (seasonal / season crop year term average on every series) for **12 weather stations** (*Targu Mures, Sibiu, Fagaras, Sebes, Tg. Secuiesc, Blaj, Dumbraveni, Odorheiul Secuiesc, Alba-Iulia, Baraolt, Brasov and Fundata*) in Region 7 Centre, in the period 1961-2014, for evaluation of rainfall indicators:
  - Rainfall amount during the *sowing period* (September 1st – May 31);
  - Rainfall amount during the *dormant period* (November 1st – March 31);
  - Rainfall amount during the *summer period* (June 1st – August 31);
  - Rainfall amount during the *agricultural year* (September 1st – August 31).
- Were represented 12 maps in GIS environment for Region 7 Centre on zoning precipitation (periods 1961-1990, 1971-2000 and 1961-2014).

SPRING INDEX
February 1st – April 10th ($\Sigma T_{med} \geq 0°C$)

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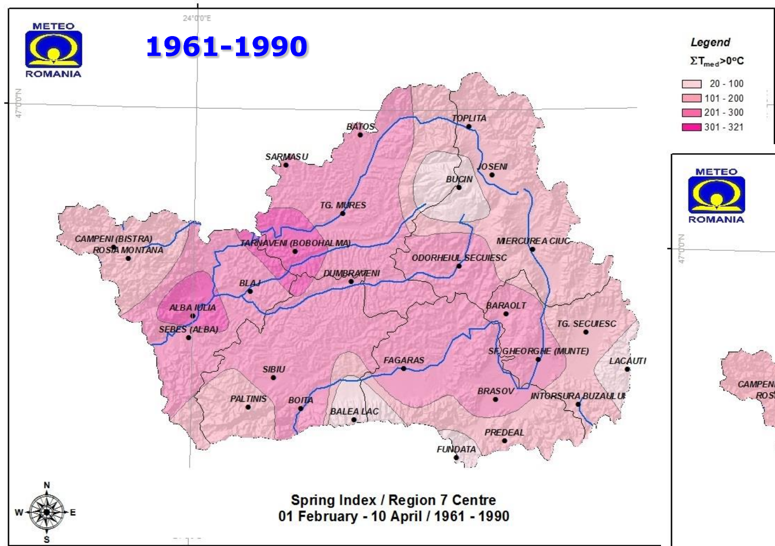

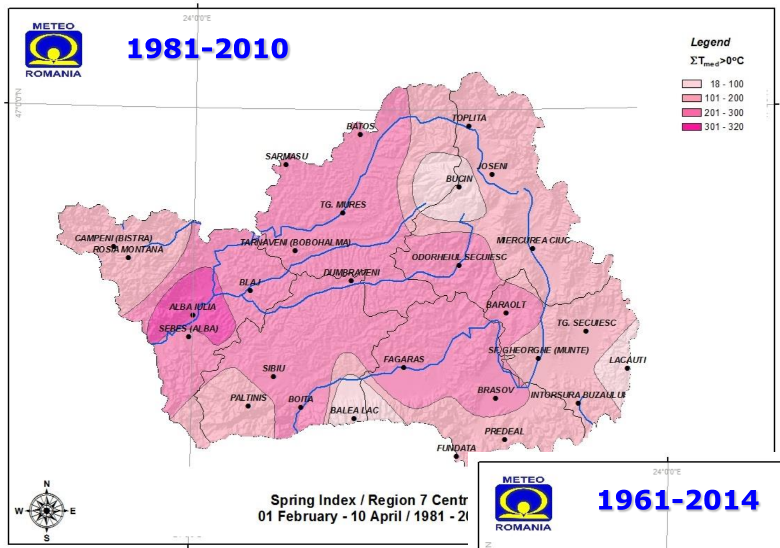

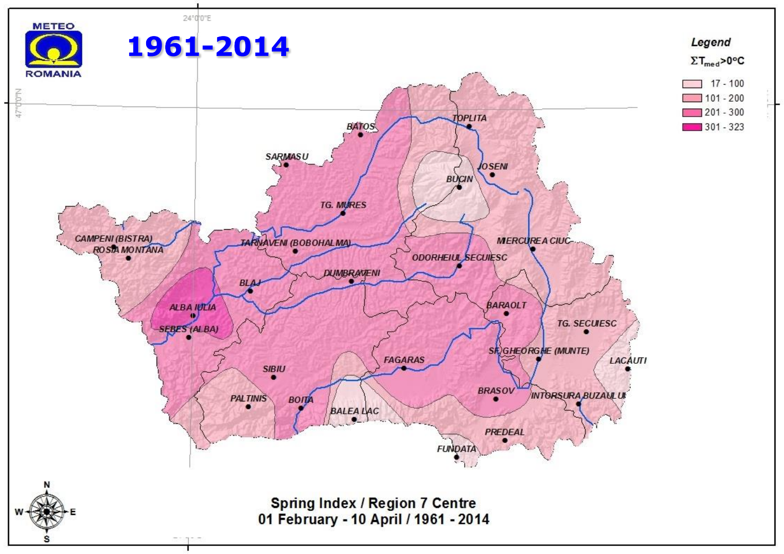

Spring Index regime classes

- late spring
- moderate spring
- normal spring

Rainfall
September 1st – October 31 (mm)
Sowing period for winter wheat

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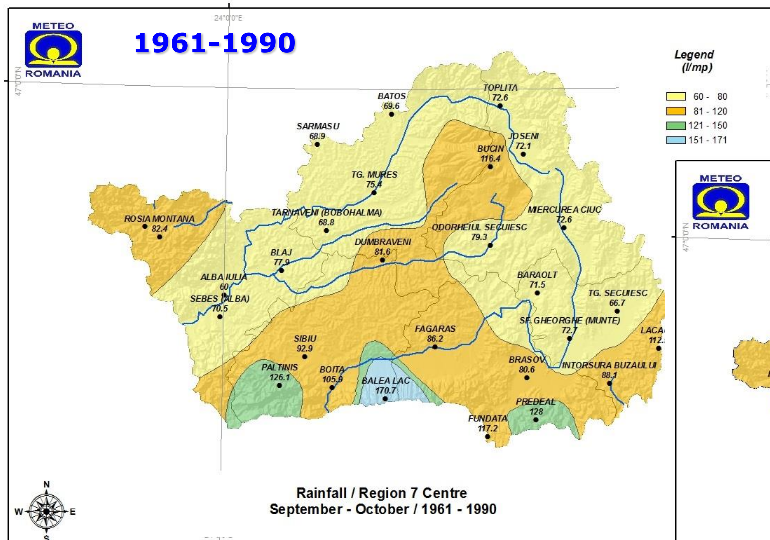
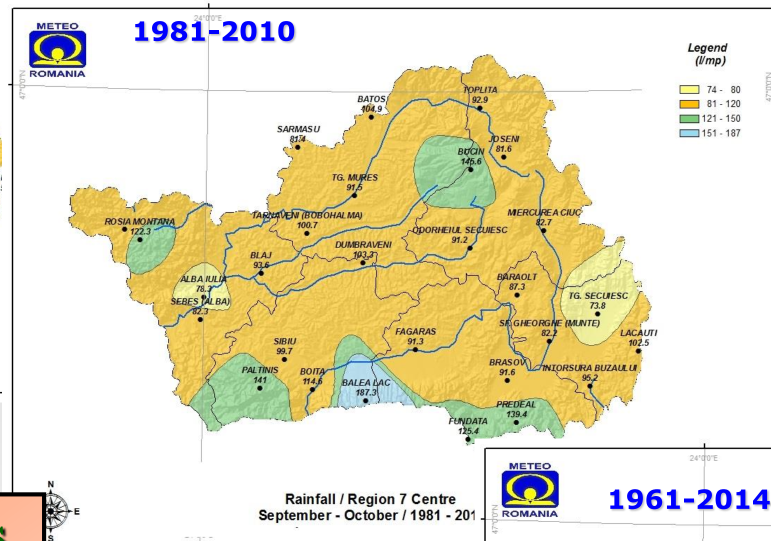
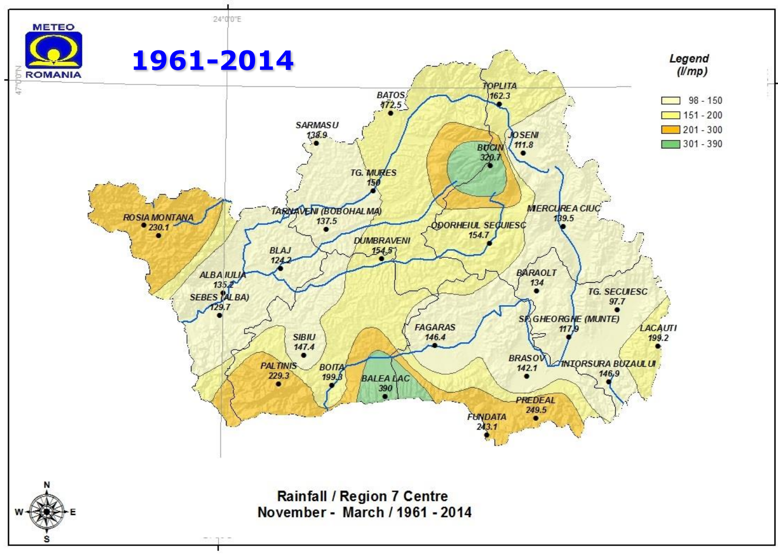


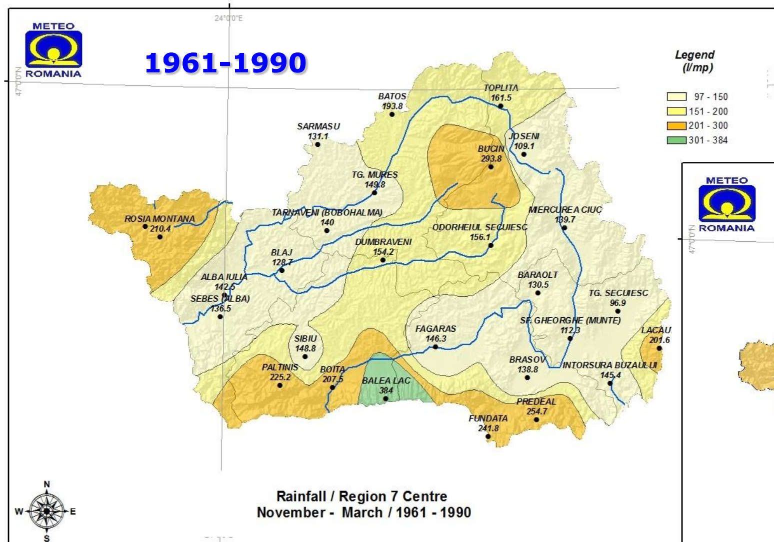


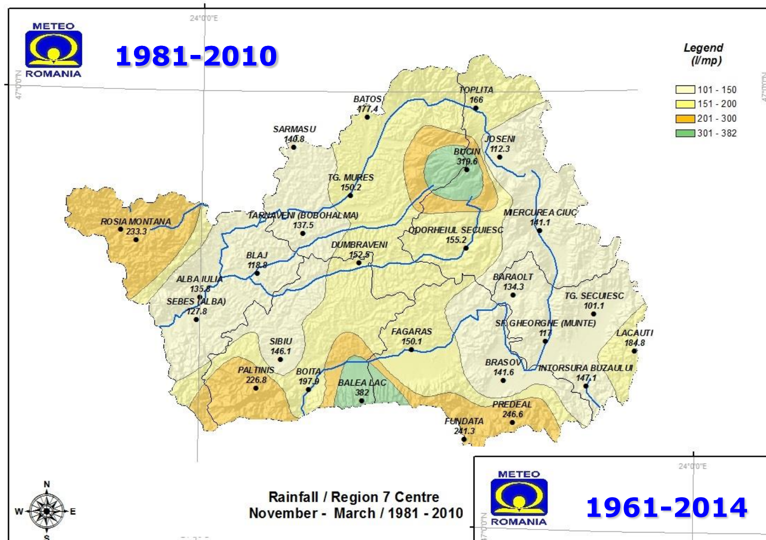


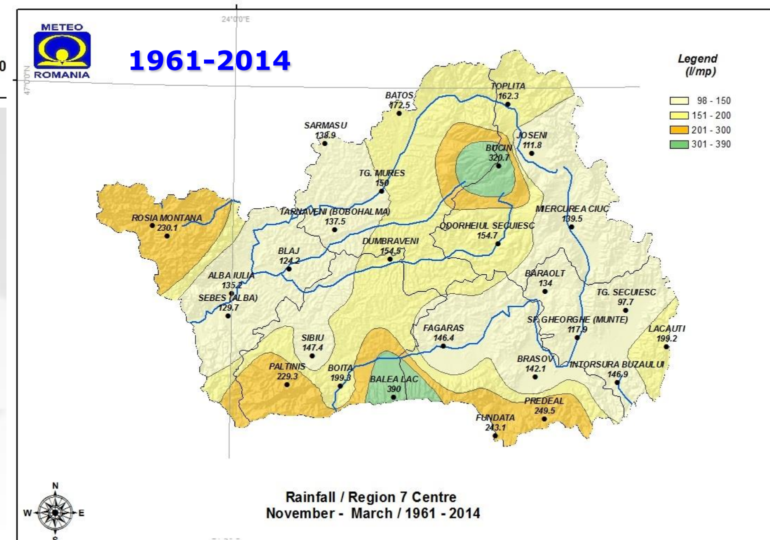
Rainfall regime classes

- dry
- moderate dry
- optimal
- rainy
- excessive rainy

Rainfall
November 1st – March 31 (mm)





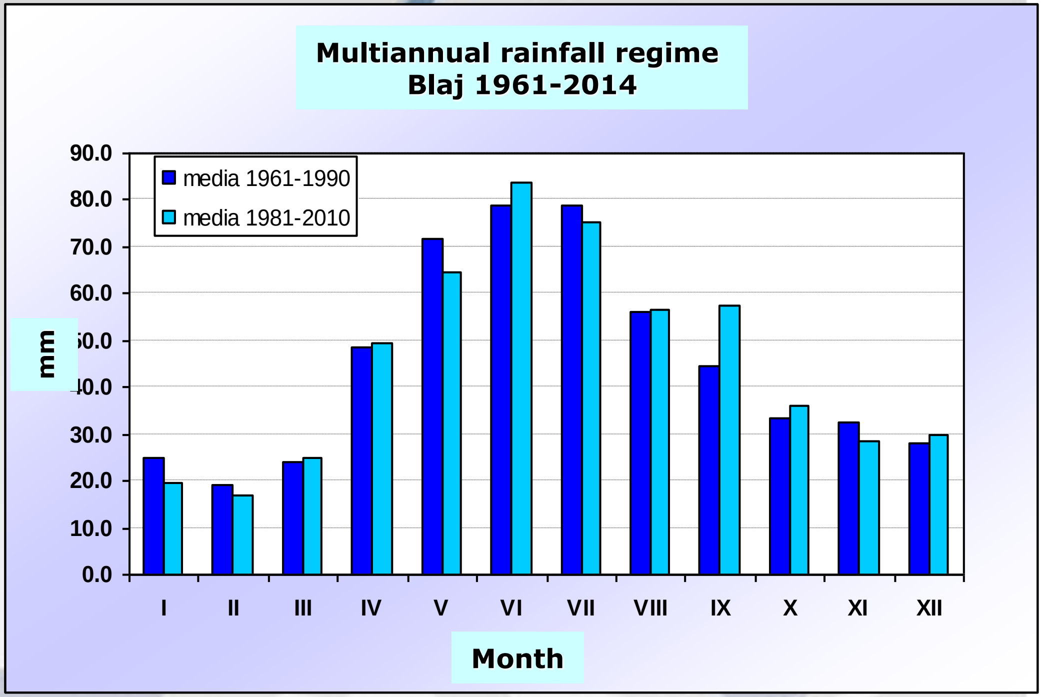


Rainfall regime classes

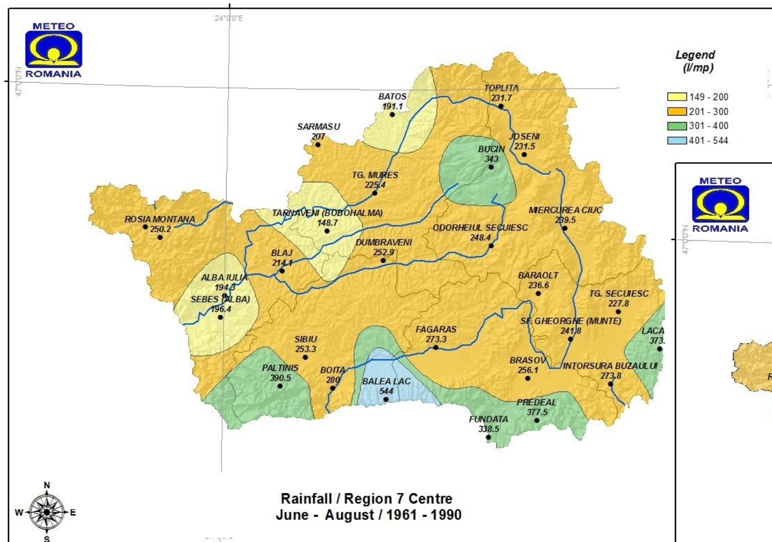
- dry
- moderate dry
- optimal
- rainy

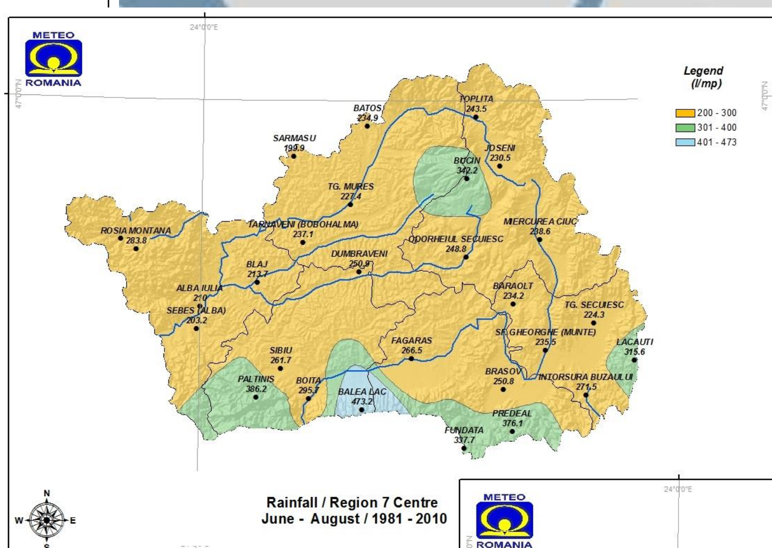
Zoning of the precipitation during the *dormant period* (November 1st – March 31)

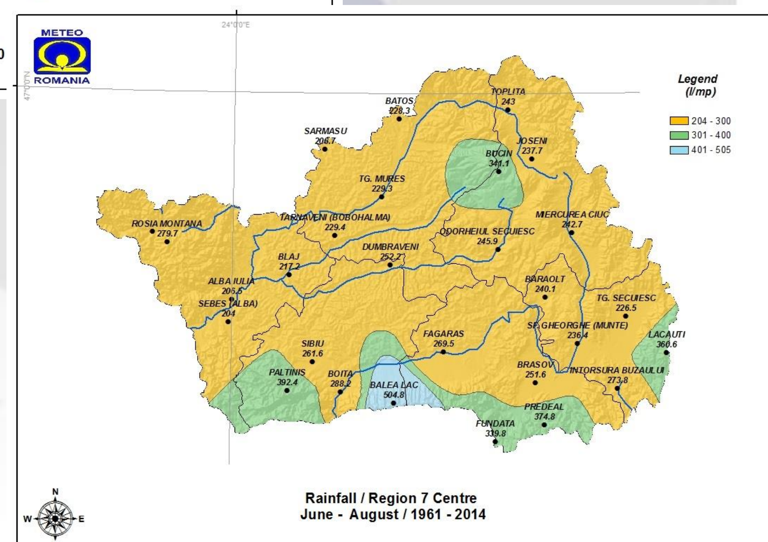
No	Station	November - March		Difference (%)
		1961-1990	1981-2010	
1	ALBA IULIA	142.5	135.8	-4.7%
2	BARAOLT	130.5	134.3	2.9%
3	BATOS	193.8	177.4	-8.5%
4	BALEA LAC	384.0	382.0	-0.5%
5	BLAJ	128.7	118.8	-7.7%
6	BOITA	207.5	197.9	-4.6%
7	BRASOV	138.8	141.6	2.0%
8	BUCIN	293.8	319.6	8.8%
9	CAMPENI (BISTRA)	240.7	256.4	6.5%
10	DUMBRAVENI	154.2	152.5	-1.1%
11	FAGARAS	146.3	150.1	2.6%
12	FUNDATA	241.8	241.3	-0.2%
13	INTORSURA BUZAULUI	145.4	147.1	1.2%
14	JOSENI	109.1	112.3	2.9%
15	LACAUTI	201.6	184.8	-8.3%
16	MIERCUREA CIUC	139.7	141.1	1.0%
17	ODORHEIUL SECUIESC	156.1	155.2	-0.6%
18	PALTINIS	225.2	226.8	0.7%
19	PREDEAL	254.7	246.6	-3.2%
20	ROSIA MONTANA	210.4	233.3	10.9%
21	SARMASU	131.1	140.8	7.4%
22	SEBES (ALBA)	136.5	127.8	-6.4%
23	SF. GHEORGHE (MUNTE)	112.3	117.0	4.2%
24	SIBIU	148.8	146.1	-1.8%
25	TARNAVENI (BOBOHALMA)	140.0	137.5	-1.8%
26	TG. MURES	149.8	150.2	0.3%
27	TG. SECUIESC	96.9	101.1	4.3%
28	TOPLITA	161.5	166.0	2.8%



Rainfall (annual precipitation)
June 1st – August 31(mm)
Summer period



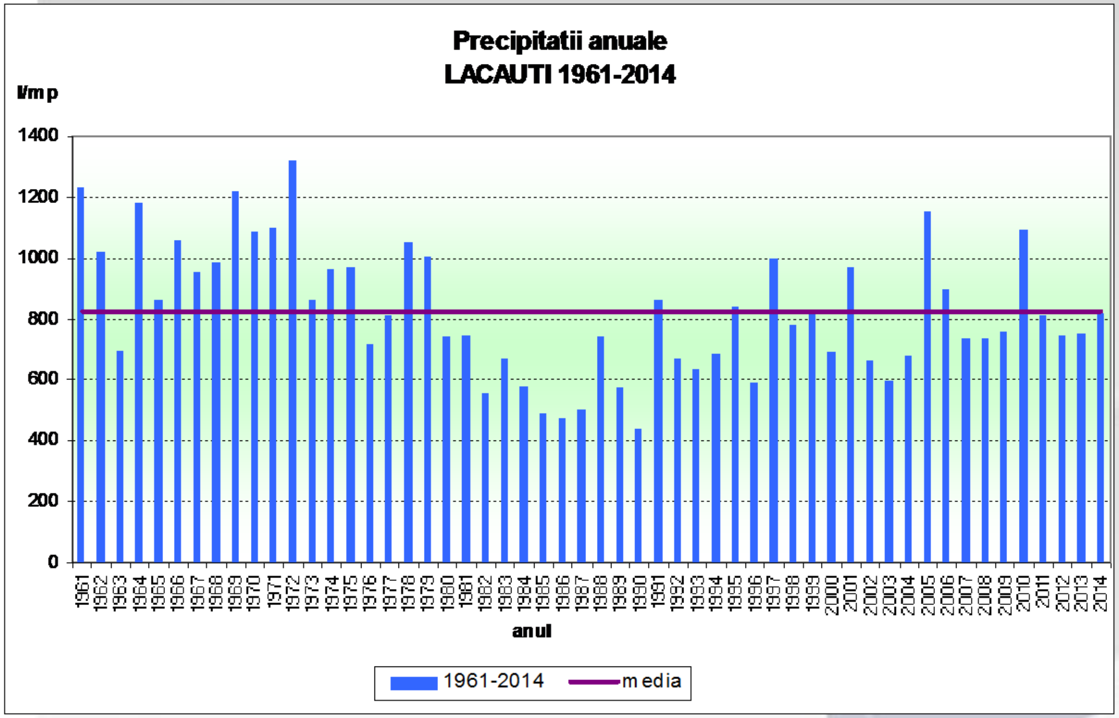




Rainfall regime classes

- moderate dry
- optimal
- rainy
- excessive rainy

Rainfall (annual precipitation)
June 1st – August 31(mm)
Summer period



No	Station	June-August 1961-1990	June-August 1981-2010	Difference (%)
1	ALBA IULIA	194.3	210.0	8.1%
2	BARAOLT	236.6	234.2	-1.0%
3	BATOS	191.1	234.9	22.9%
4	BILEA-LAC	544.0	473.2	-13.0%
5	BLAJ	214.1	213.7	-0.2%
6	BOITA	280.0	295.7	5.6%
7	BRASOV	256.1	250.8	-2.1%
8	BUCIN	343.0	342.2	-0.2%
9	CIMPENI(BISTRA)	265.4	264.1	-0.5%
10	DUMBRAVENI	252.9	250.9	-0.8%
11	FAGARAS	273.3	266.5	-2.5%
12	FUNDATA	338.5	337.7	-0.2%
13	INT.BUZAULUI	273.8	271.5	-0.8%
14	JOSENI	231.5	230.5	-0.4%
15	LACAUTI	373.6	315.6	-15.5%
16	MIERCUREA CIUC	239.5	238.6	-0.4%
17	ODORHEIUL SECUIESC	248.4	248.8	0.2%
18	PALTINIS	390.5	386.2	-1.1%
19	PREDEAL	377.5	376.1	-0.4%
20	ROSIA MONTANA	250.2	283.8	13.4%
21	SARMASU	207.0	199.9	-3.4%
22	SEBES-ALBA	196.4	203.2	3.5%
23	SF. GHEORGHE-COVASNA	241.8	235.5	-2.6%
24	SIBIU	253.3	261.7	3.3%
25	TARNAVENI(BOBOHALMA)	148.7	237.1	59.4%
26	TG.MURES	225.4	227.4	0.9%
27	TG.SECUIESC	227.8	224.3	-1.5%
28	TOPLITA	231.7	243.5	5.1%

Rainfall (annual precipitation)
September 1st – August 31(mm)
agricultural year

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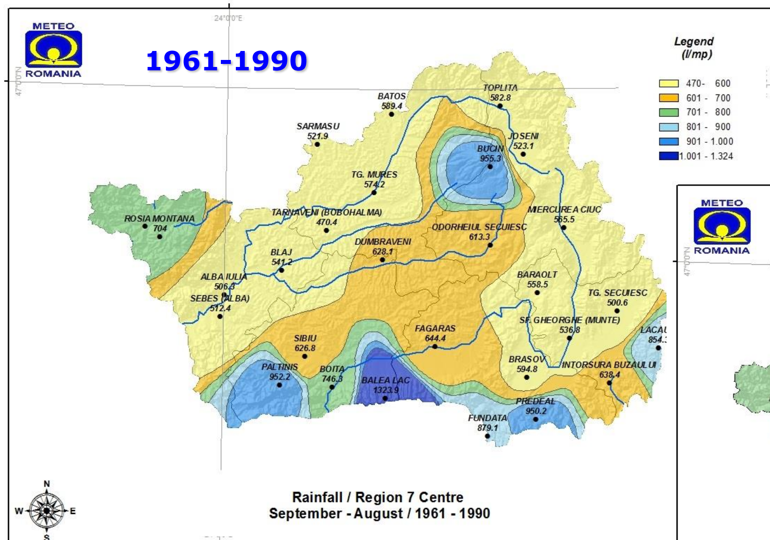
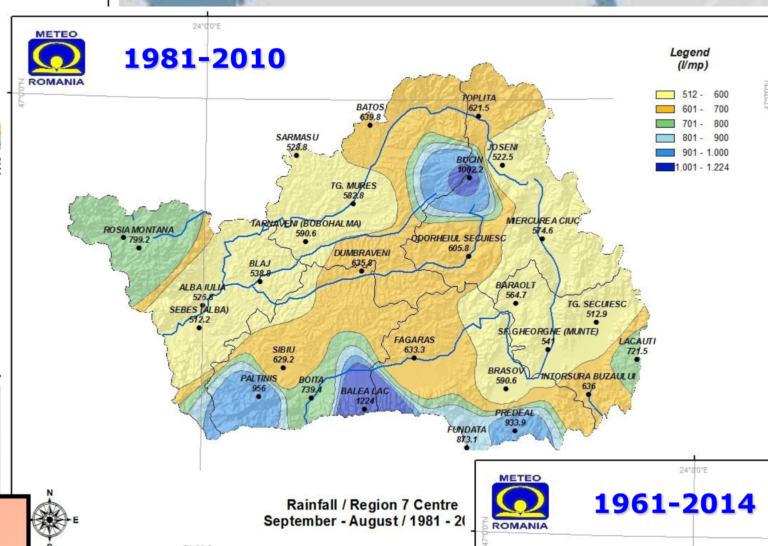
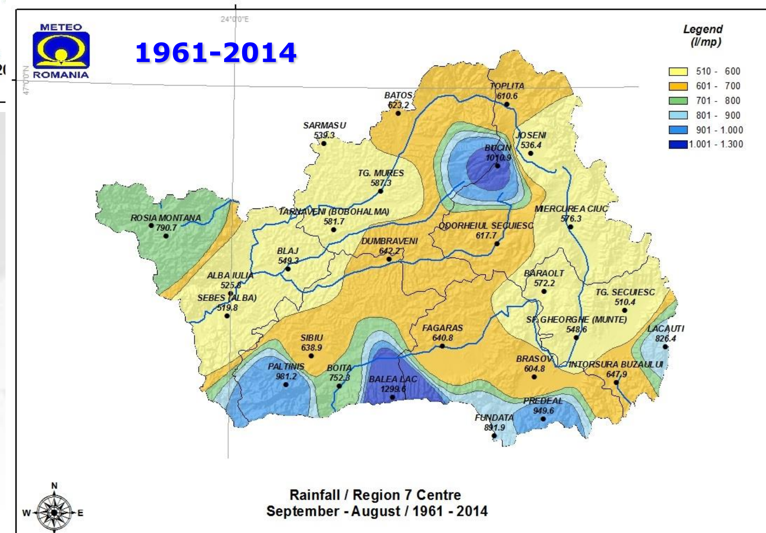




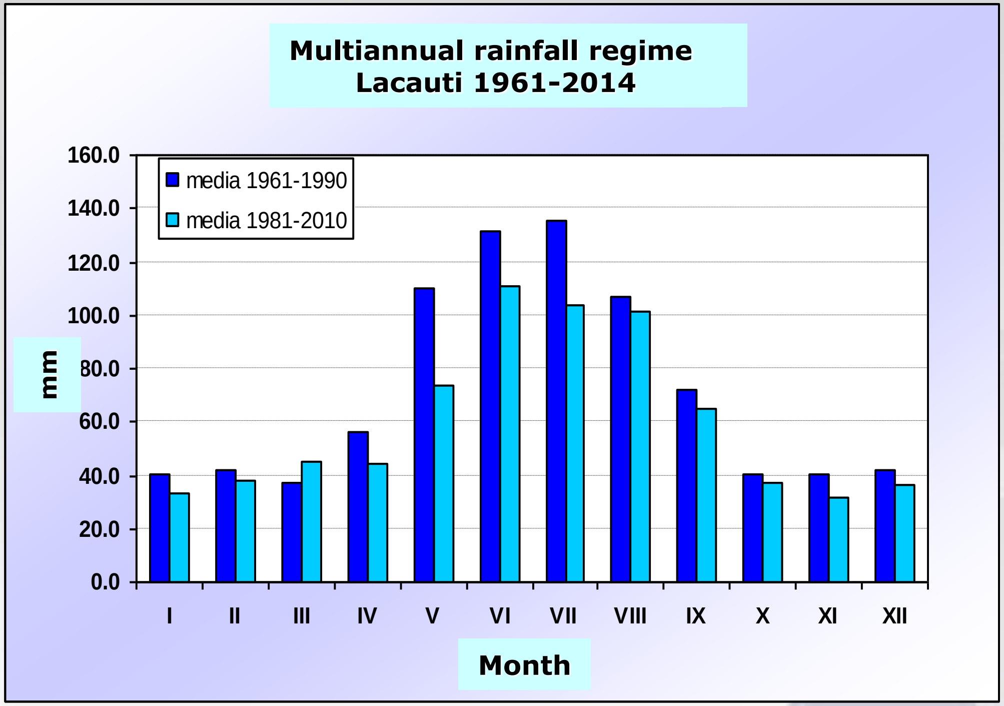


Rainfall regime classes

- moderate dry
- optimal
- rainy
- excessive rainy

Zoning of the precipitation during the *agricultural year* (September 1st - August 31)

- 15.5% rainfall

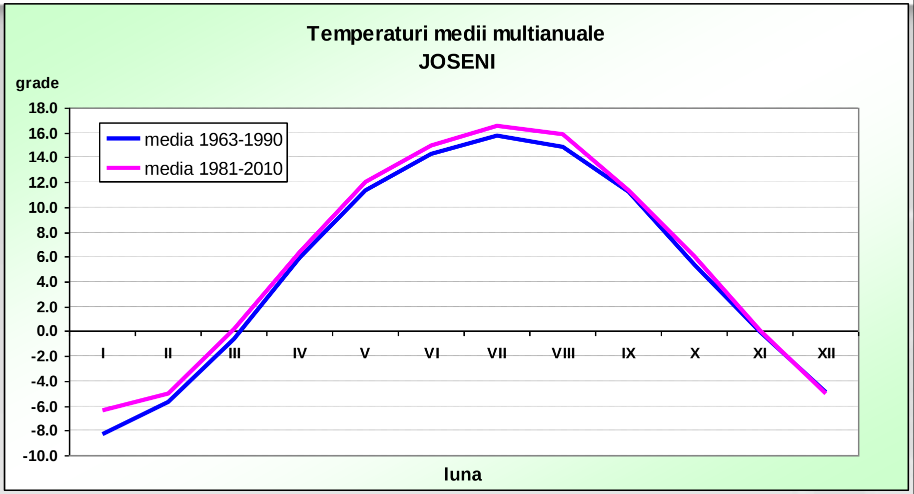


No	Station	September - August		Difference (%)
		1961-1990	1981-2010	
1	ALBA IULIA	506.3	526.8	4.0%
2	BARAOLT	558.5	564.7	1.1%
3	BATOS	589.4	639.8	8.6%
4	BALEA LAC	1323.9	1224.0	-7.5%
5	BLAJ	541.2	538.8	-0.4%
6	BOITA	746.3	739.4	-0.9%
7	BRASOV	594.8	590.6	-0.7%
8	BUCIN	955.3	1002.2	4.9%
9	CAMPENI (BISTRA)	739.7	769.4	4.0%
10	DUMBRAVENI	628.1	635.8	1.2%
11	FAGARAS	644.4	633.3	-1.7%
12	FUNDATA	879.1	873.1	-0.7%
13	INTORSURA BUZAULUI	638.4	636.0	-0.4%
14	JOSENI	523.1	522.5	-0.1%
15	LACAUTI	854.3	721.5	-15.5%
16	MIERCUREA CIUC	565.5	574.6	1.6%
17	ODORHEIUL SECUIESC	613.3	605.8	-1.2%
18	PALTINIS	952.2	956.0	0.4%
19	PREDEAL	950.2	933.9	-1.7%
20	ROSIA MONTANA	704.0	799.2	13.5%
21	SARMASU	521.9	528.8	1.3%
22	SEBES (ALBA)	512.4	512.2	0.0%
23	SF. GHEORGHE (MUNTE)	536.8	541.0	0.8%
24	SIBIU	626.8	629.2	0.4%
25	TARNAVENI (BOBOHALMA)	470.4	590.6	25.6%
26	TG. MURES	574.2	582.8	1.5%
27	TG. SECUIESC	500.6	512.9	2.5%
28	TOPLITA	582.8	621.5	6.6%

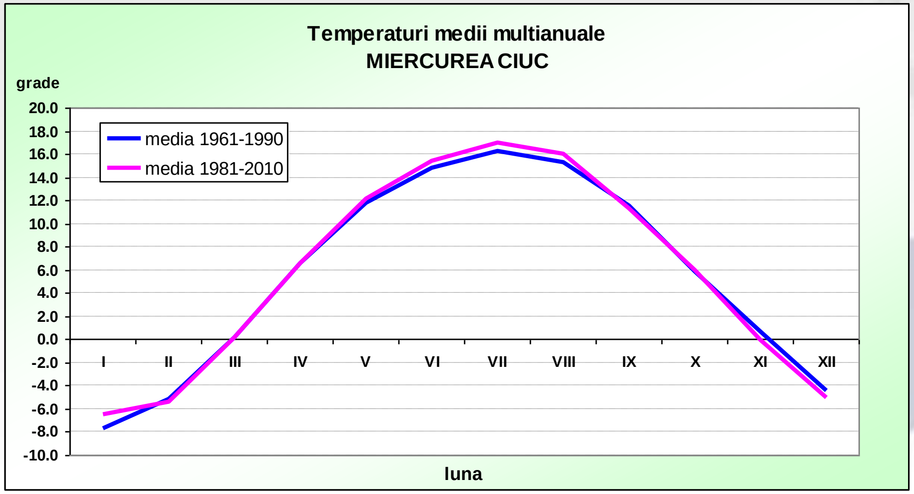
Maximum rainfall during 24 hours recorded in Region 7 Centre, 1961-2014

Month	Station	Date	Maximum rainfall 24 Hours (mm)1961-2014
I	**Lacauti**	17.01.1961	59.9
II	**Paltinis**	10.02.1984	54.4
III	**Tarnaveni**	28.03.1988	63.6
IV	**Paltinis**	30.04.1982	68.4
V	**Predeal**	15.05.1984	84.2
VI	**Balea Lac**	13.06.1988	**195.6**
VII	**Lacauti**	12.07.1969	**115.4**
VIII	**Paltinis**	25.08.1977	94.6
IX	**Predeal**	6.09.1989	92.1
X	**Intorsura Buzaului**	5.10.2008	91.8
XI	**Fundata**	18.11.1989	46.9
XII	**Predeal**	12.12.1990	47.8

Evolution of the mean annual air temperature recorded in Region 7 Centre, over 1961-1990 and 1981-2010 intervals

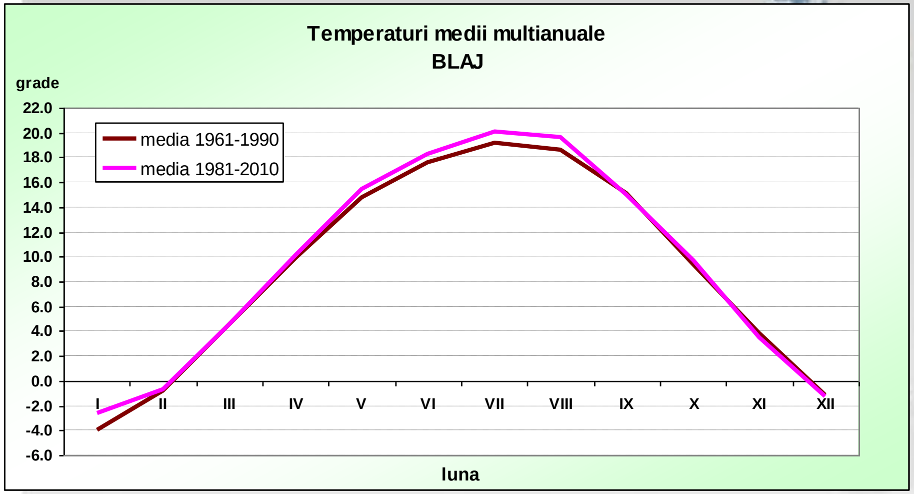


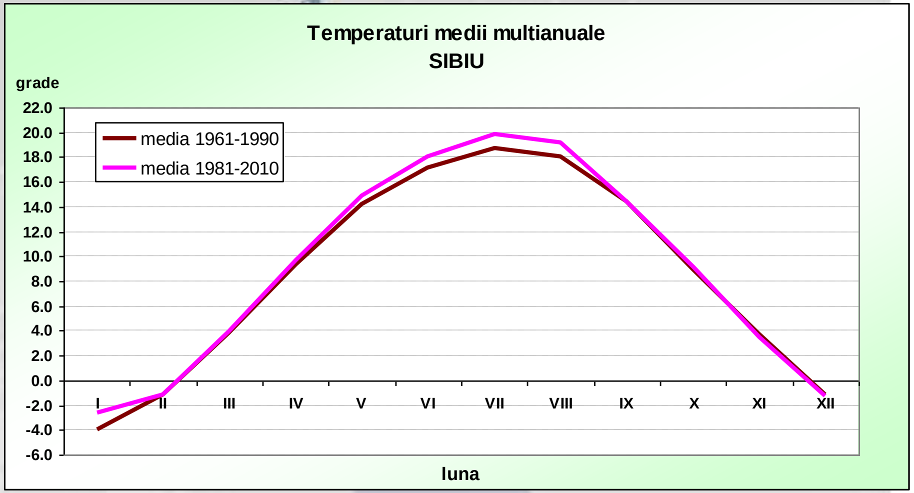
+ 0.6°C



Station	Tmed(°C) 1961-1990	Tmed(°C) 1981-2010	Increase/decrease (degree)
ALBA IULIA	9.4	9.9	+0.5
BARAOLT	7.4	7.8	+0.4
BATOS	8.5	8.9	+0.4
BILEA-LAC	0.2	0.5	+0.3
BLAJ	8.9	9.3	+0.4
BOITA	8.7	9.1	+0.4
BRASOV	7.5	7.8	+0.3
BUCIN	3.6	4.0	+0.4
CIMPENI(BISTRA)	7.1	7.5	+0.4
DUMBRAVENI	8.3	8.6	+0.3
FAGARAS	7.7	8.2	+0.5
FUNDATA	4.2	4.7	+0.5
INT.BUZAULUI	6.0	6.4	+0.4
JOSENI	5.0	5.6	**+0.6**
LACAUTI	1.2	1.5	+0.3
MIERCUREA CIUC	5.5	5.6	**+0.1**
ODORHEIUL SECUIESC	7.8	8.2	+0.4
PALTINIS	4.5	4.7	+0.2
PREDEAL	4.8	5.2	+0.4
ROSIA MONTANA	5.3	5.7	+0.4
SARMASU	8.6	9.1	+0.5
SEBES-ALBA	9.1	9.5	+0.4
SF. GHEORGHE-COVASNA	7.2	7.5	+0.3
SIBIU	8.5	8.9	+0.4
TARNAVENI(BOBOHALMA)	9.0	9.3	+0.3
TG.MURES	8.8	9.2	+0.4
TG.SECUIESC	6.8	7.2	+0.4
TOPLITA	5.3	5.8	+0.5

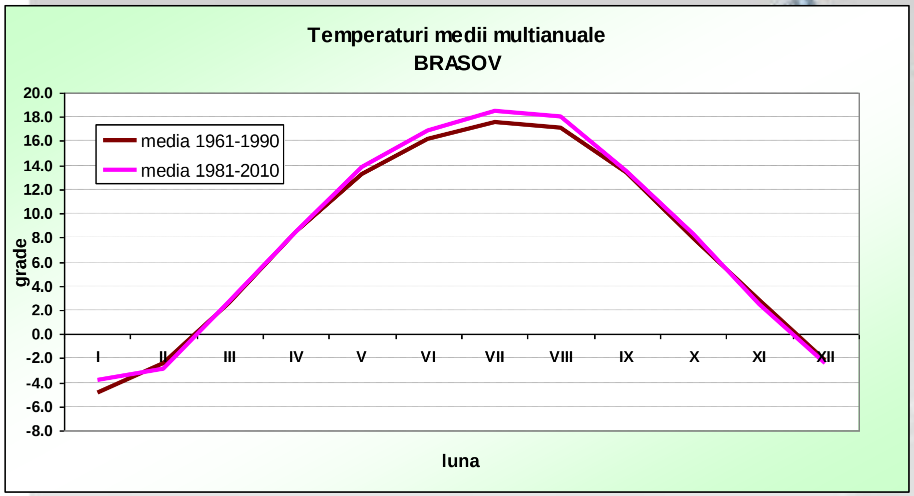
Evolution of the mean annual air temperature recorded in Region 7 Centre, over 1961-1990 and 1981-2010 intervals

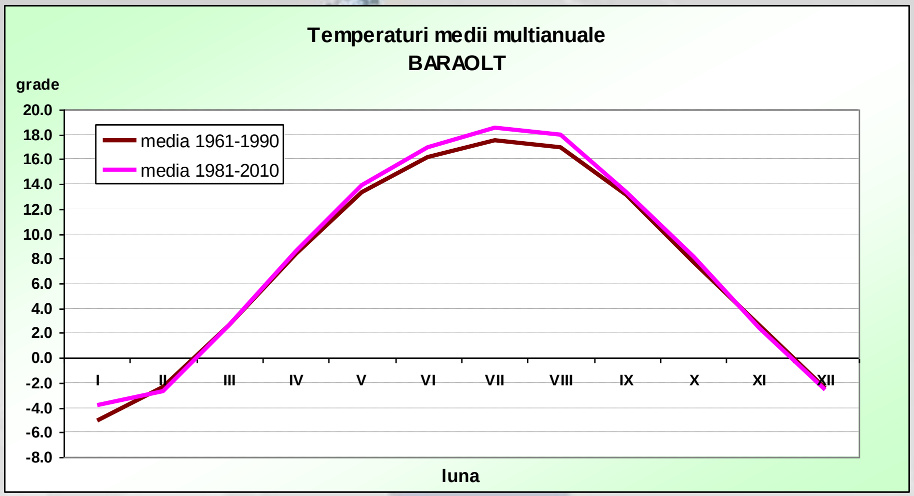


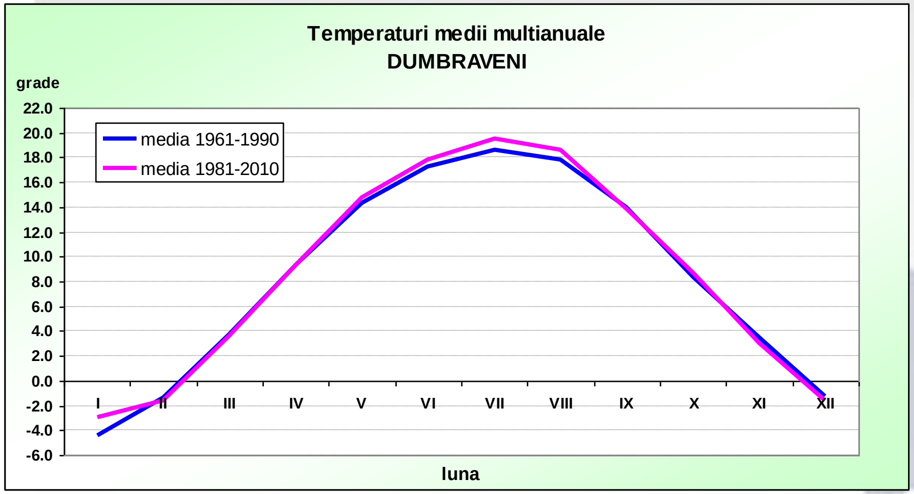


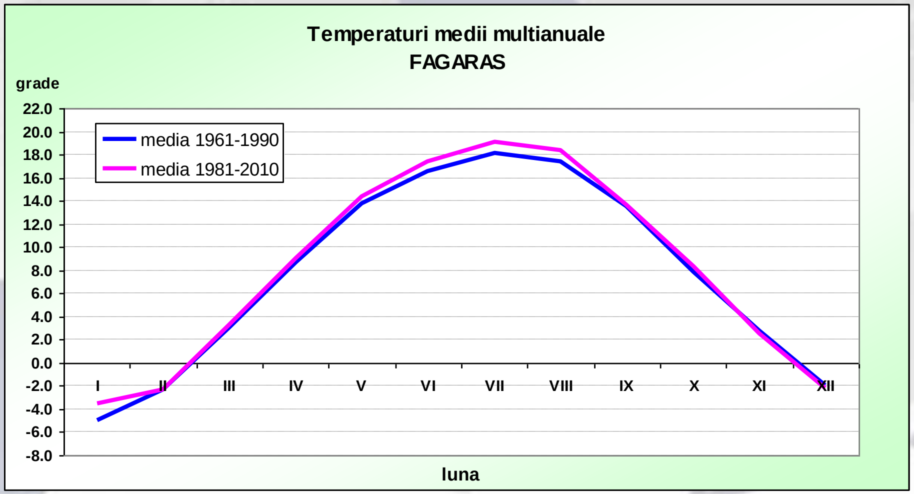
Interval	Monthly mean air temperature (°C) – Region 7 Centre											
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1961-1990	-5.0	-3.0	1.6	7.0	12.0	14.8	16.5	16.0	12.4	7.1	1.8	-2.5
1981-2010	-4.0	-3.0	1.5	7.2	12.6	15.6	17.4	17.0	12.4	7.5	1.9	-2.7
Deviation	**+1.0**	**0**	**+0.1**	**+0.2**	**+0.6**	**+0.8**	**+0.9**	**+1.0**	**0**	**+0.4**	**+0.1**	**-0.2**

Evolution of the mean annual air temperature recorded in Region 7 Centre, over 1961-1990 and 1981-2010 intervals





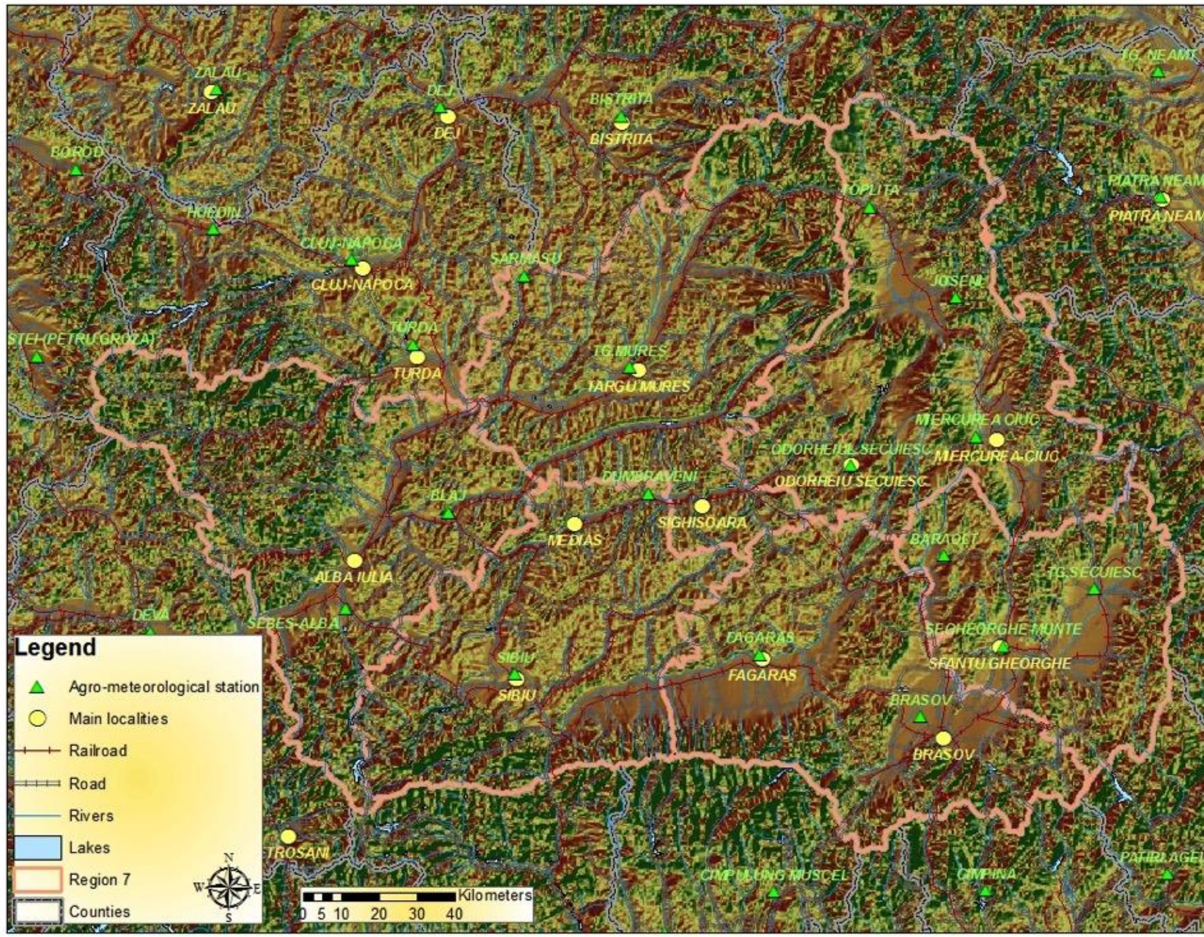




Using remote sensing data for drought monitoring

GIS database

•The GIS database contains info-layers in a relational structure, that are: sub-basins and basin limits; land topography (15m cell size DEM); hydrographic and canal networks; transport network (roads, railways); localities; administrative boundaries; agro – meteorological stations; land cover/land use, updated from satellite images

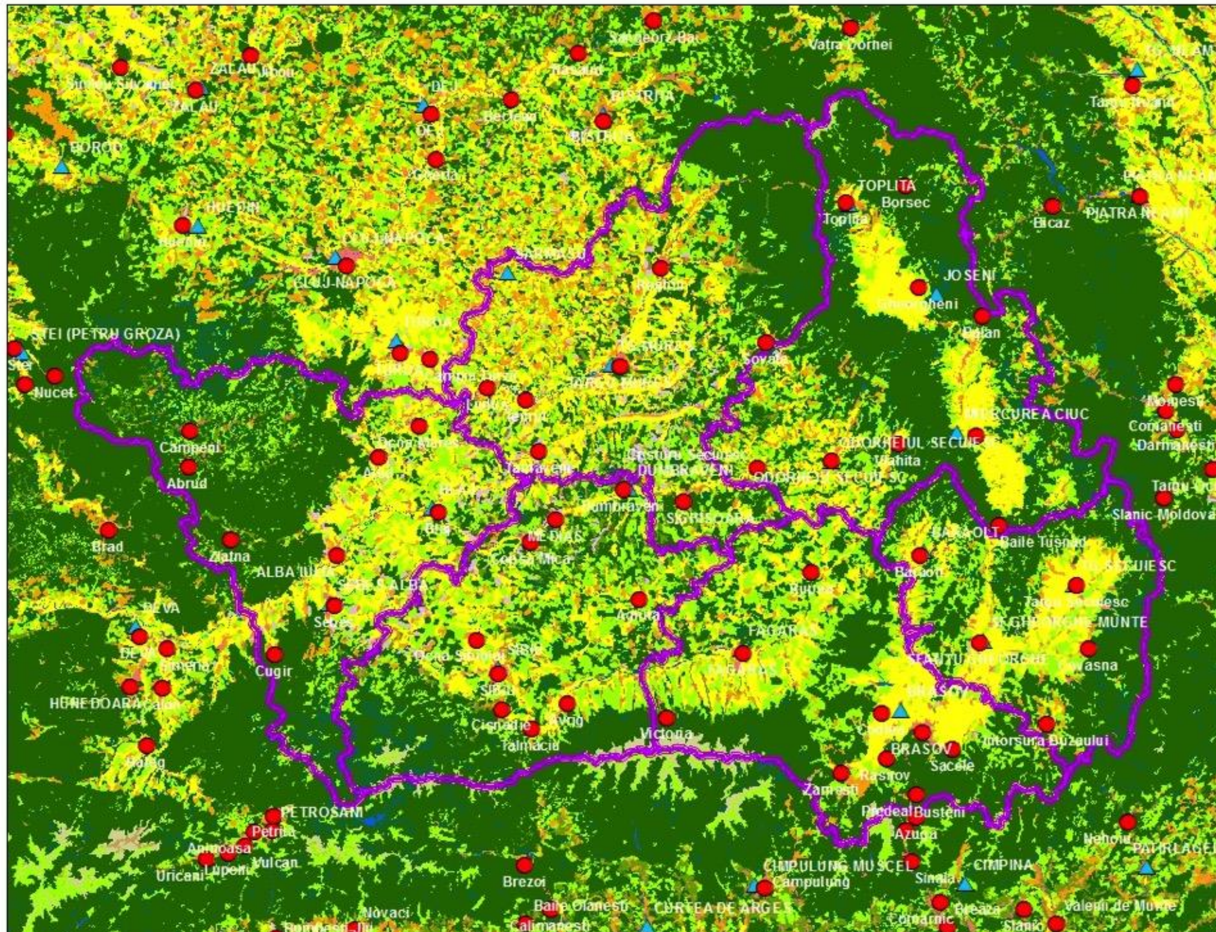


Using remote sensing data for drought monitoring

GIS database

- CLC 2012

- Urban/ artificial area
- Arable land
- Vineyards
- Orchards
- Pastures
- Complex cultivation
- Forest
- Sparley vegetated area
- Sand plane, dunes
- Bare soil
- Wetlands, inland marshes
- Hidrographic Network



Using remote sensing data for drought monitoring

Remote sensimg data

- In order to monitor the vegetation statement, the medium and high resolution satellite images have been used to obtain the dedicated vegetation indexes. These indexes are good indicators of drought and they are used also by the scientific community (European Drought Observatory).

- TERRA – AQUA/MODIS Surface Reflectance 8-Day L3 Global 500 m products (MOD09A1): provides bands 1–7 at 500 m resolution in an 8-day gridded level-3 product in the sinusoidal projection. Science Data Sets provided for this product include reflectance values for Bands 1–7, quality assessment, and the day of the year for the pixel along with solar, view, and zenith angles.

- TERRA MODIS 8 – day LAI/fAPAR product (1 km spatial resolution): is composited every 8 days at 1-kilometer resolution on a Sinusoidal grid. Science Data Sets provided in the MOD15A2 include LAI, FPAR, a quality rating, and standard deviation for each variable.

- Medium resolution satellite data: 2000 - present

Using remote sensing data for drought monitoring

Vegetation indices

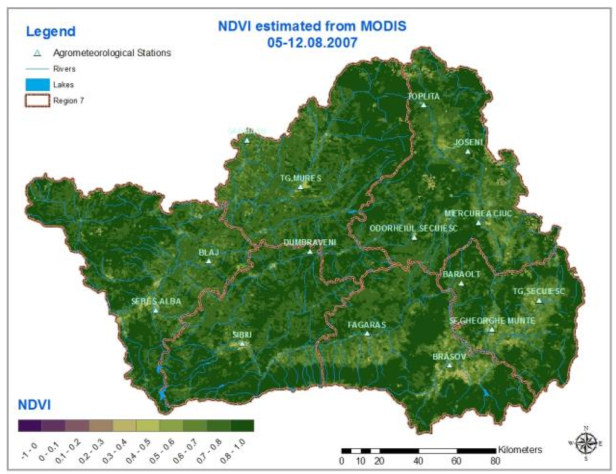
- The **Normalized Difference Vegetation Index (NDVI)** is a non-linear transformation of visible bands (Red) and near infrared (NIR), being defined as the difference between these two bands divided by their sum:

$$NDVI = (NIR-RED) / (NIR + RED).$$

- 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).
- Indirectly, NDVI is used to estimate the effects of rainfall over a period of time, to estimate the state of vegetation for different crops, and environmental quality as habitat for various animals, pests and diseases.

Using remote sensing data for drought monitoring

Vegetation indices (cont.)



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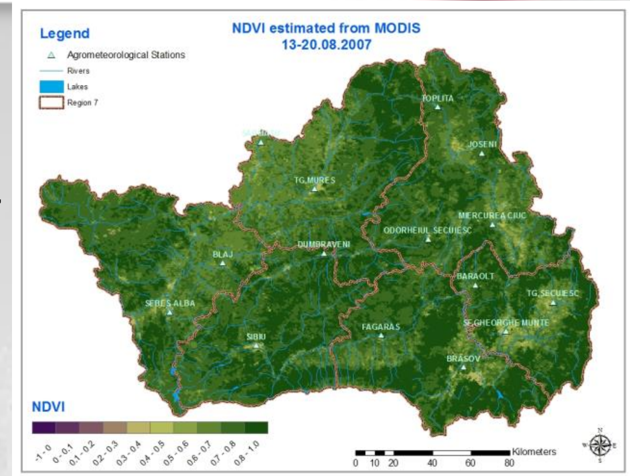
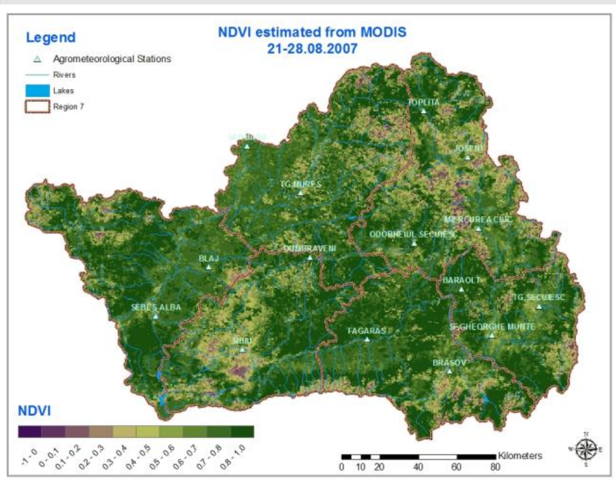
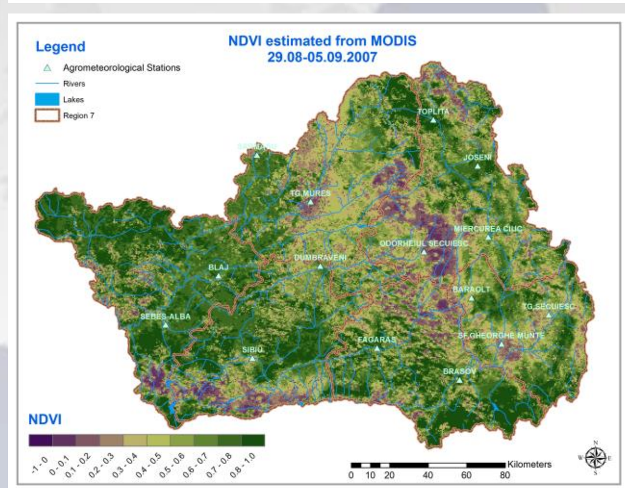


13-20.08.2007



21-28.08.2007



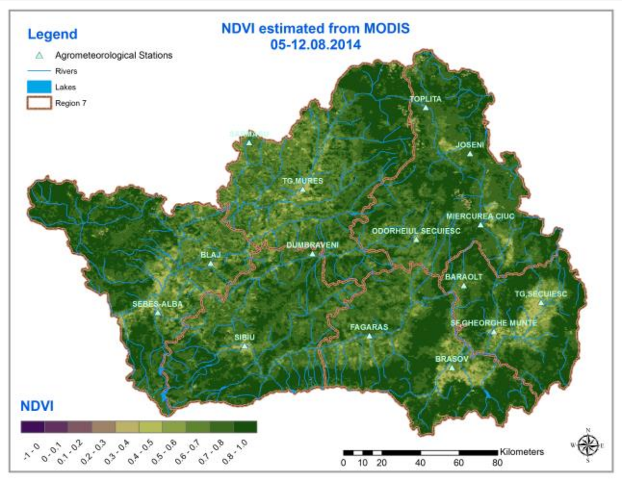
29.08-05.09.2007

NDVI is an indicator of presence, density and health of vegetation compared to a pixel ($1km^2$); the positive values are colored in shades of green to dark green and negative values are colored in shades from yellow to brown, indicating a lack of vegetation or bad health.

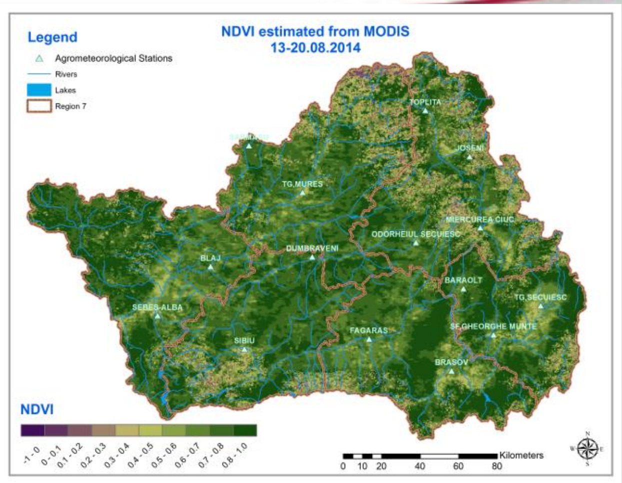
The NDVI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2007 (droughty year)

Using remote sensing data for drought monitoring

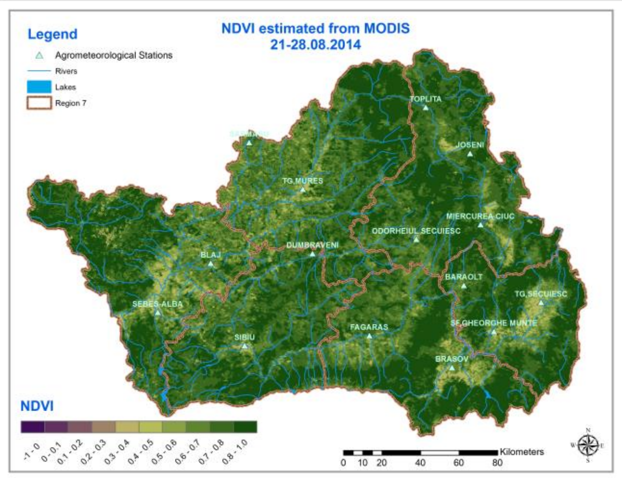
Vegetation indices (cont.)



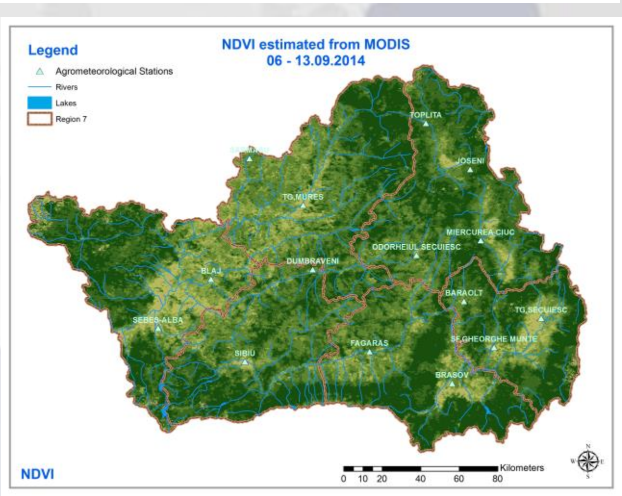
05-12.08.2014



13-20.08.2014



21-28.08.2014



29.08-05.09.2014

NDVI is an indicator of presence, density and health of vegetation compared to a pixel (1km^2); the positive values are colored in shades of green to dark green and negative values are colored in shades from yellow to brown, indicating a lack of vegetation or bad health.

The NDVI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2014

Using remote sensing data for drought monitoring

Vegetation indices (cont.)

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

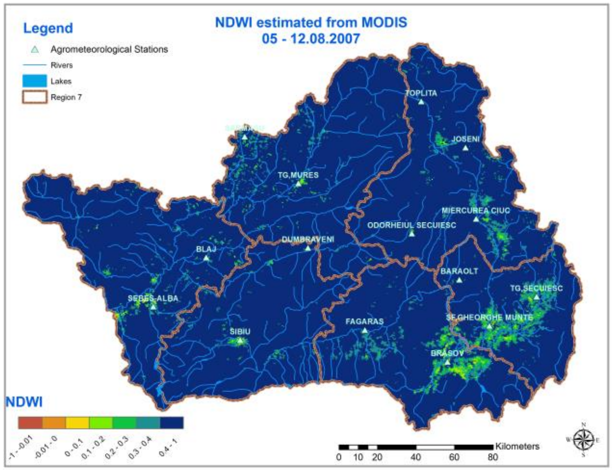
$$NDWI=(\rho NIR-\rho SWIR)/(\rho NI+-\rho SWIR)$$

- 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. It is well known that 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 to the users can be improved water management, particularly by irrigating agricultural areas affected by drought, according to water needs.

Using remote sensing data for drought monitoring

Vegetation indices (cont.)



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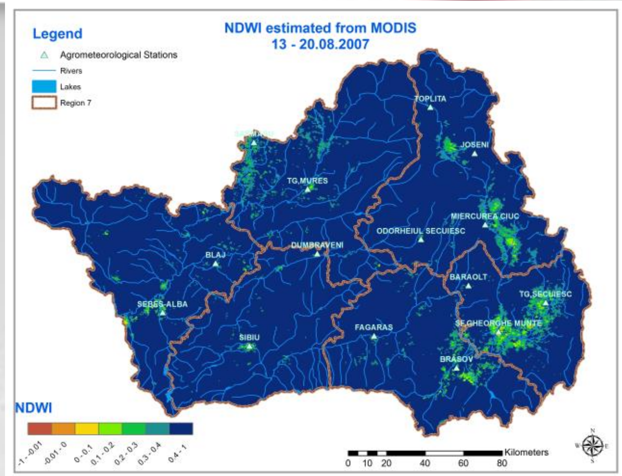
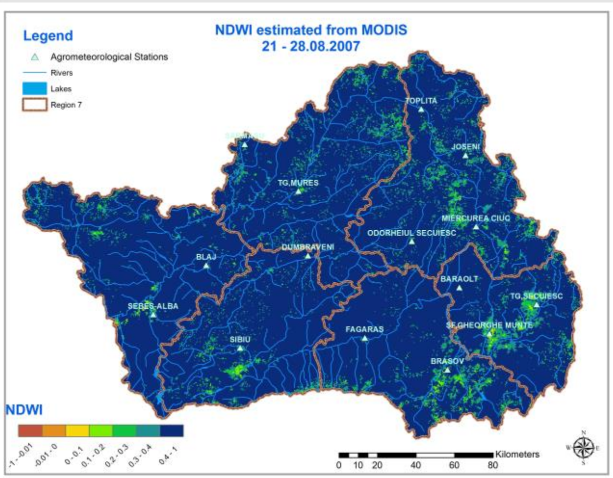
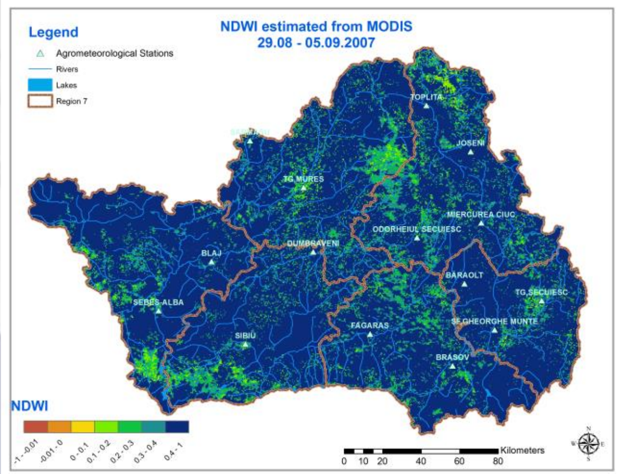


13-20.08.2007



21-28.08.2007



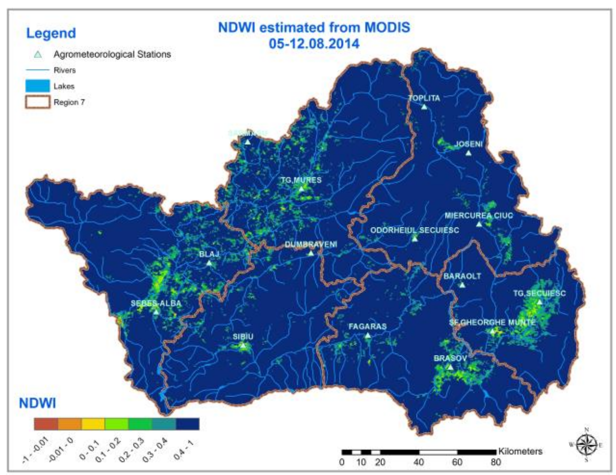
29.08-05.09.2007

NDWI index is a good indicator of water content of leaves; the positive values (NDWI > 0.3) are colored in shades of green to dark blue and negative values (NDWI < 0.2) are colored in shades from light green to brown, indicating vegetation affected by water stress.

The NDWI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2007 (droughty year)

Using remote sensing data for drought monitoring

Vegetation indices (cont.)



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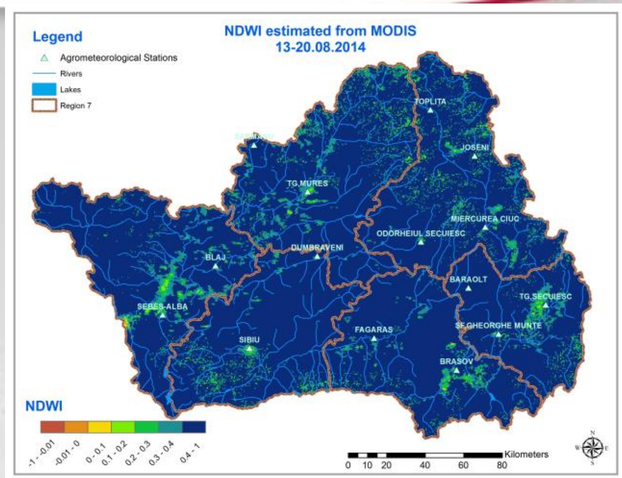

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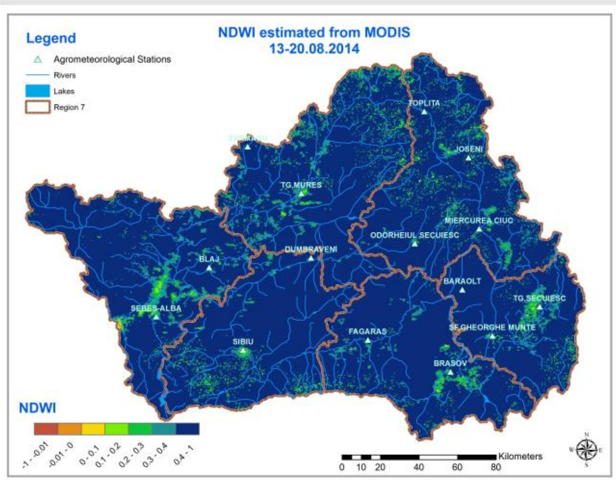
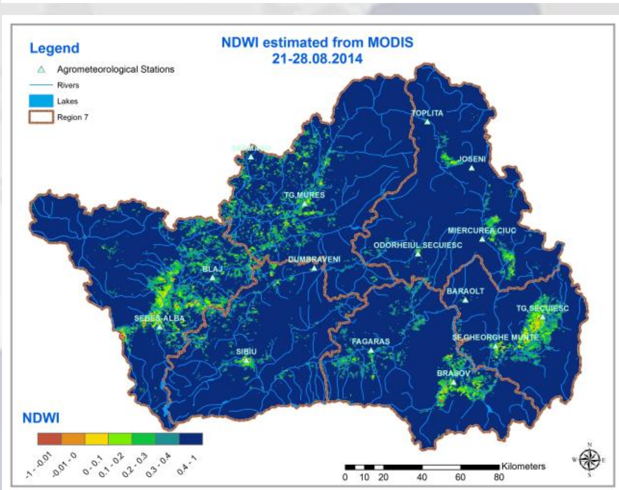


21-28.08.2014



29.08-05.09.2014

NDWI index is a good indicator of water content of leaves; the positive values (NDWI > 0.3) are colored in shades of green to dark blue and negative values (NDWI < 0.2) are colored in shades from light green to brown, indicating vegetation affected by water stress.

The NDWI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2014

Using remote sensing data for drought monitoring

Vegetation indices (cont.)

- The Normalized Difference Drought Index (NDDI) 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:

$$NDDI = (NDVI - NDWI) / (NDVI + NDWI)$$

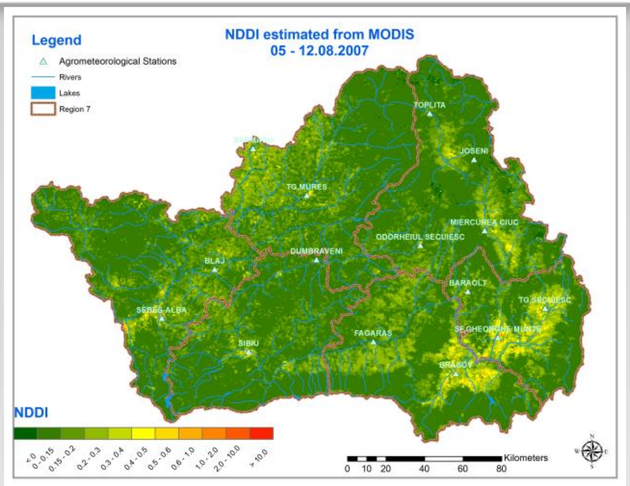
- It combines information from visible, NIR, and SWIR channel. NDDI can offer an appropriate measure of the dryness of a particular area, because it combines information on both vegetation and water.

- 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.

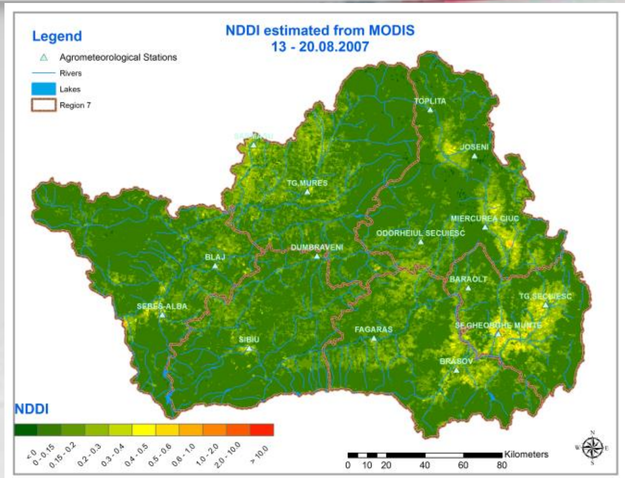
- This index can be an optimal complement to in-situ based indicators or for other indicators based on remote sensing data.

Using remote sensing data for drought monitoring

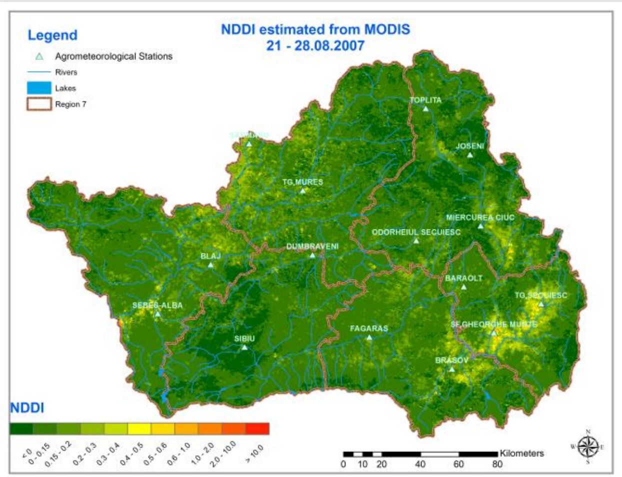
Vegetation indices (cont.)



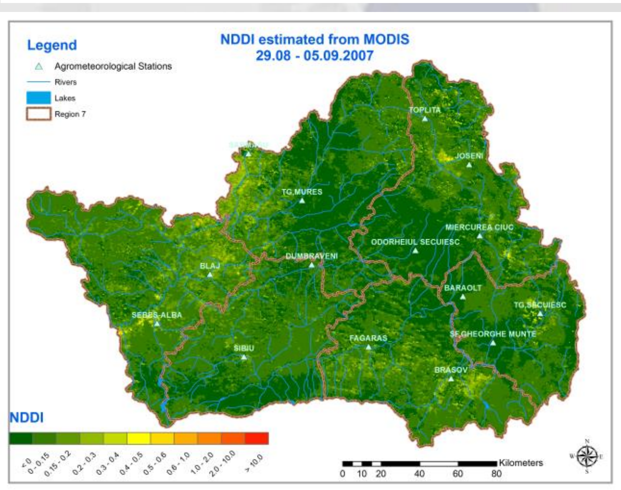
05-12.08.2007



13-20.08.2007



21-28.08.2007



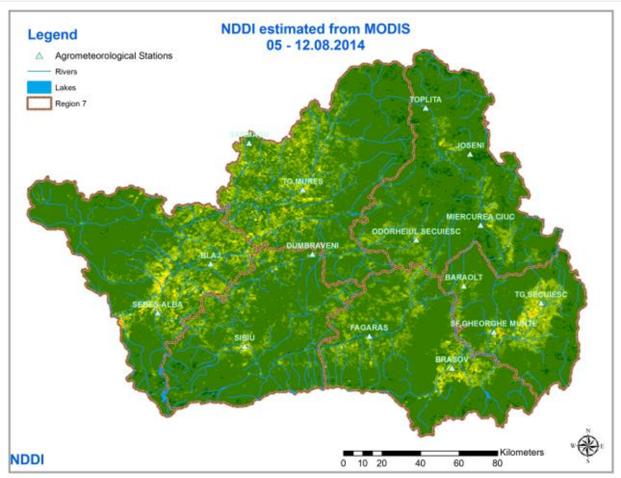
29.08-05.09.2007

NDDI had a stronger response to summer drought; NDDI > 0.4 values, colored in shades from yellow to red, are indicating vegetation affected drought.

The NDDI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2007 (droughty year)

Using remote sensing data for drought monitoring

Vegetation indices (cont.)



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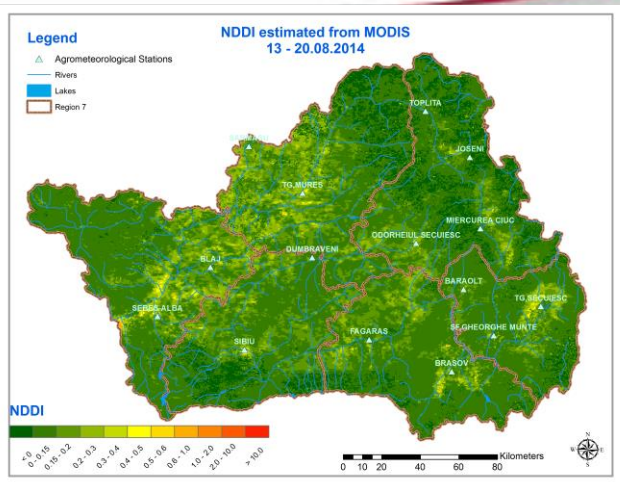

13-20.08.2014

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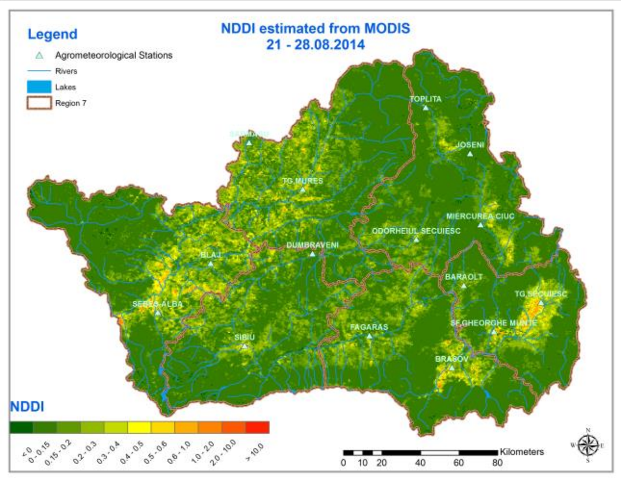
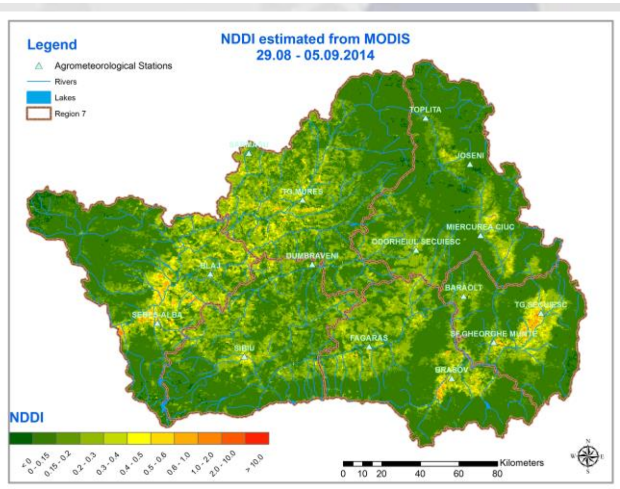


21-28.08.2014



29.08-05.09.2014

The NDDI spatial distribution obtained from MODIS data (MOD09A1): 05.08-05.09.2014

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.
- In Region 7 centre, the mean annual air temperature raise by 0.6°C in the last 30 years. The evolution of the mean multiannual air temperature over the 1961-2014 period show that the air temperature raise by 0.1...0.6°C in the 1981-2010 interval in comparison with 1961-1990 period;
- As regards precipitation, the 1981-2010 period has a decreasing trend in the annual precipitation amounts especially after 1980 year and a parallel enhance of the precipitation deficit;
- The vegetation indexes extracted from satellite images, correlated with meteorological and agrometeorological information, are good indicators of vegetation condition, in this case are relevant for monitoring the beginning, duration and intensity of drought.
- The advantage of multi-annual imagery availability allows the overlay and cross-checking of droughty, normal or rainy years.
- GIS technologies offer the possibility of crossed-analysis between various data sources such as vegetation indexes and CORINE land-cover classes.

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National Meteorological Administration - PPP5

Thank you very much for your attention!