Proiect „*Calea Verde spre Dezvoltare Durabilă*"

Operator de Program:

MINISTERUL MEDIULUI,
APELOR ȘI PĂDURILOR

Promotor:

Parteneri de proiect din partea Statelor Donatoare:

KS

Parteneri de proiect:

METEO
ROMÂNIA

ULBS
Universitatea "Lucian Blaga" din Sibiu

ICELAND
LIECHTENSTEIN
NORWAY

eea
grants

Cum pot fi accesate și utilizate datele meteorologice în elaborarea strategiilor privind adaptarea la schimbările climatice / Using climate data for climate change adaptation

1.Alexandru DUMITRESCU – Department of Climatology

2.Oana Alexandra OPREA – Agrometeorological Laboratory

3.Argentina NERTAN - Remote Sensing & GIS Department

NATIONAL METEOROLOGICAL ADMINISTRATION

Sumar

- Introduction   ***Alexandru DUMITRESCU***
- Climate data
  - Meteorological observations
  - Gridded datests
- Climate model outputs
- Data related products
- Identification of vulnerable areas to the extreme events in Central Region 7, Romania   ***Oana Alexandra OPREA***
- Using remote sensing data for drought monitoring   ***Argentina NERTAN***

NATIONAL METEOROLOGICAL ADMINISTRATION

06 – 08 May 2015 / Workshop II Sibiu

Project " Green Path to Sustainable Development "

Program RO 07 – Adapting to Climatic Change 2009-2014

Introduction

- Climate change is considered one of the most important environmental issues of our time

- The economic activity is sensitive to climate change, and adapting to current and projected rates of climate change could be very challenging

- In order to better understand the past and the future climate scientists actively use longtime series of meteorological observations and theoretical models

Climate data

1. Meteorological observations
   a. Surface weather observations
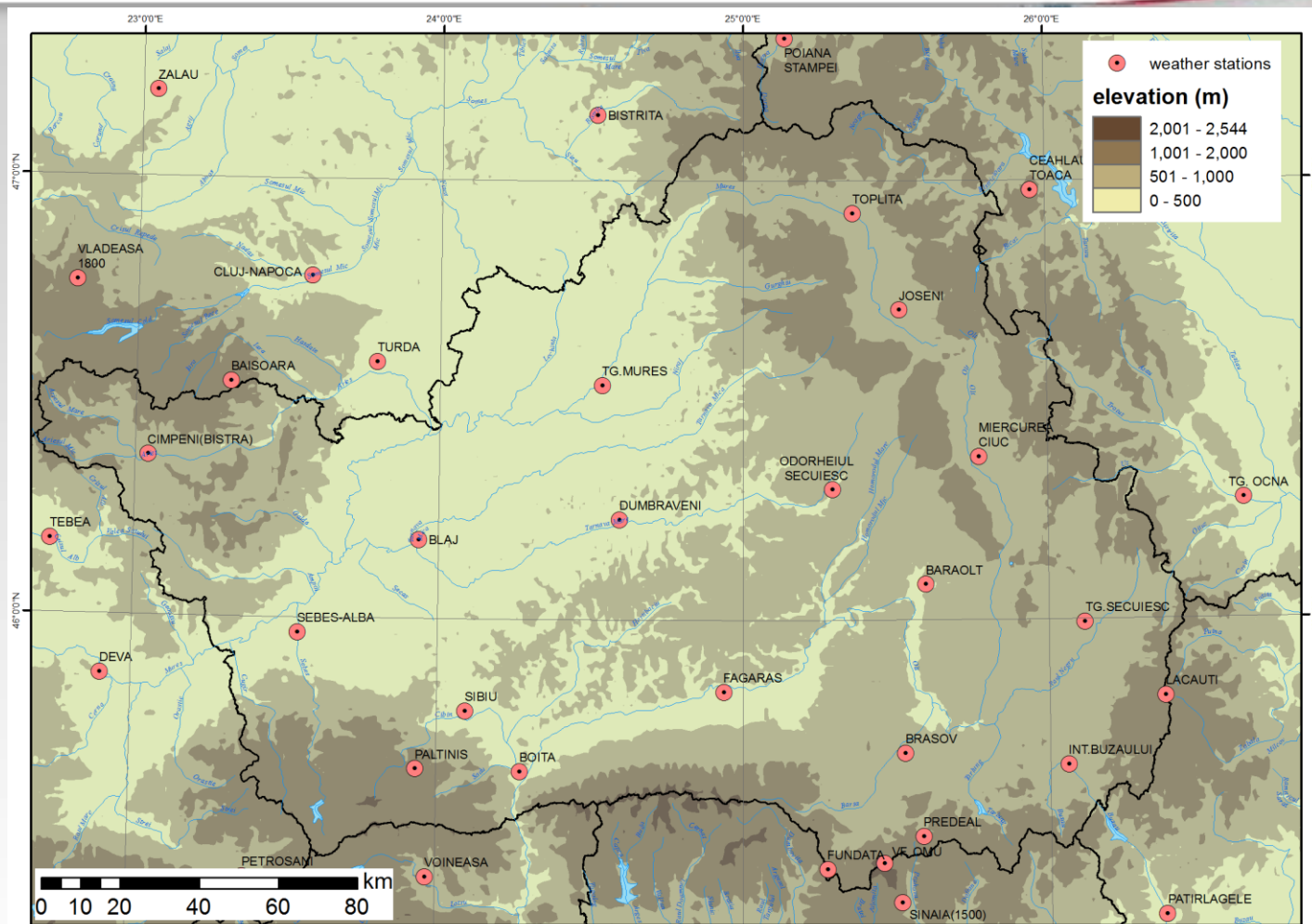   b. Satellite products

2. Gridded datasets

3. Climate model outputs
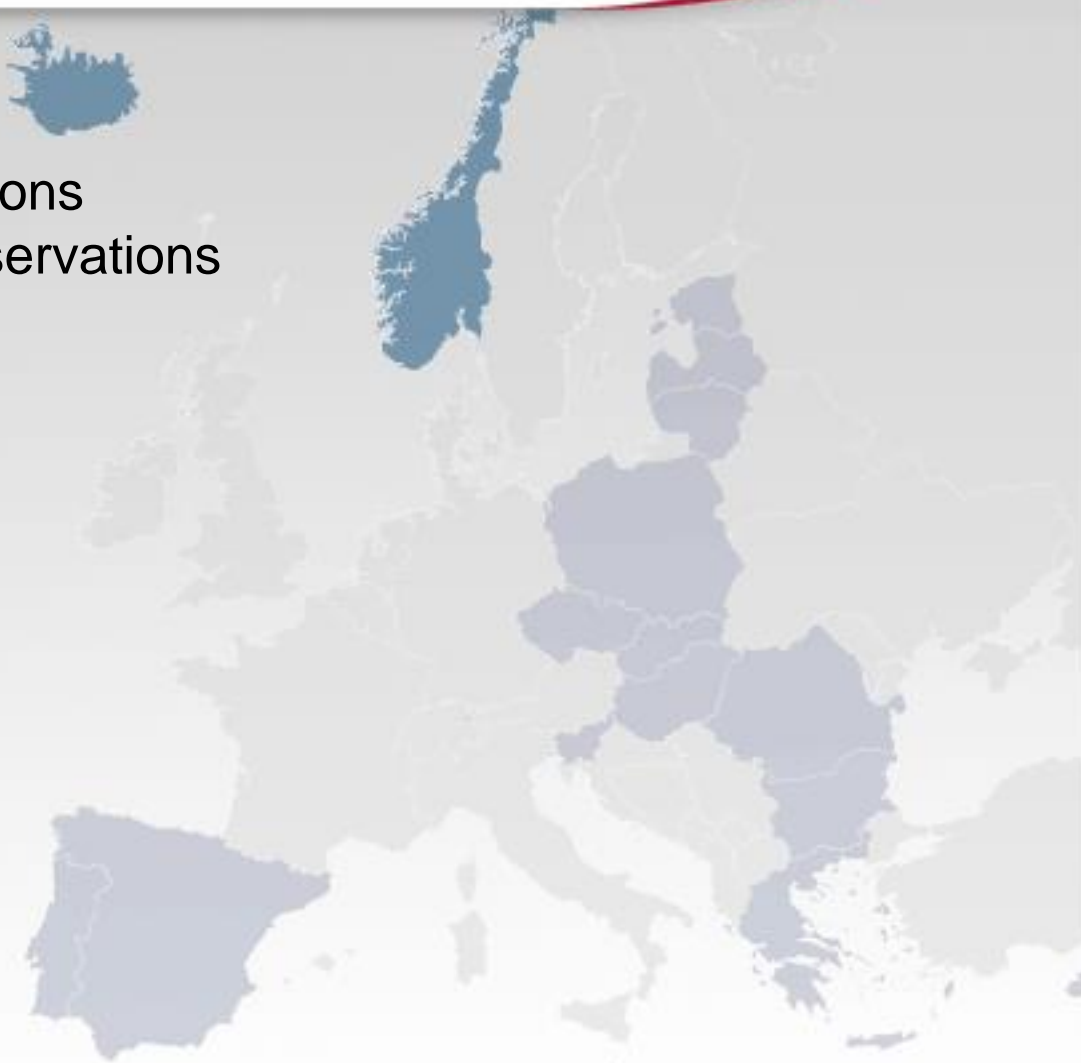
Climate data

Meteorological observations -Surface weather observations

- ☐They are the fundamental data used for climatological studies
- ☐ They can be taken manually, by a weather observer, by computer through the use of automated weather stations, or in a hybrid scheme;
- ☐Longtime series of surface observations (at least 30 years of data) are essential for evaluating the climate change signals
- ☐Essential climate variables for climate change assessment: air temperature, precipitation, sunshine duration, wind speed, climate indices (e.g. ETCCDI indices: http://www.climdex.org/indices.html)

Climate data

Meteorological observations -Surface weather observations

Meteorological stations with long records near/in the area of interest

Climate data

Meteorological observations -Satellite products

- Satellite meteorological data records are beginning to be long enough to evaluate multi-decadal changes (Meteosat climatic data records are available since the year 1984 - www.cmsaf.eu)

- ☐ The time series of measurements of sufficient length, consistency, and continuity to determine climate variability and change

- One advantage of using satellite data records along with the in situ measurements is that they provide information in locations where weather data are only sparsely available

Climate data

Meteorological observations -Satellite products
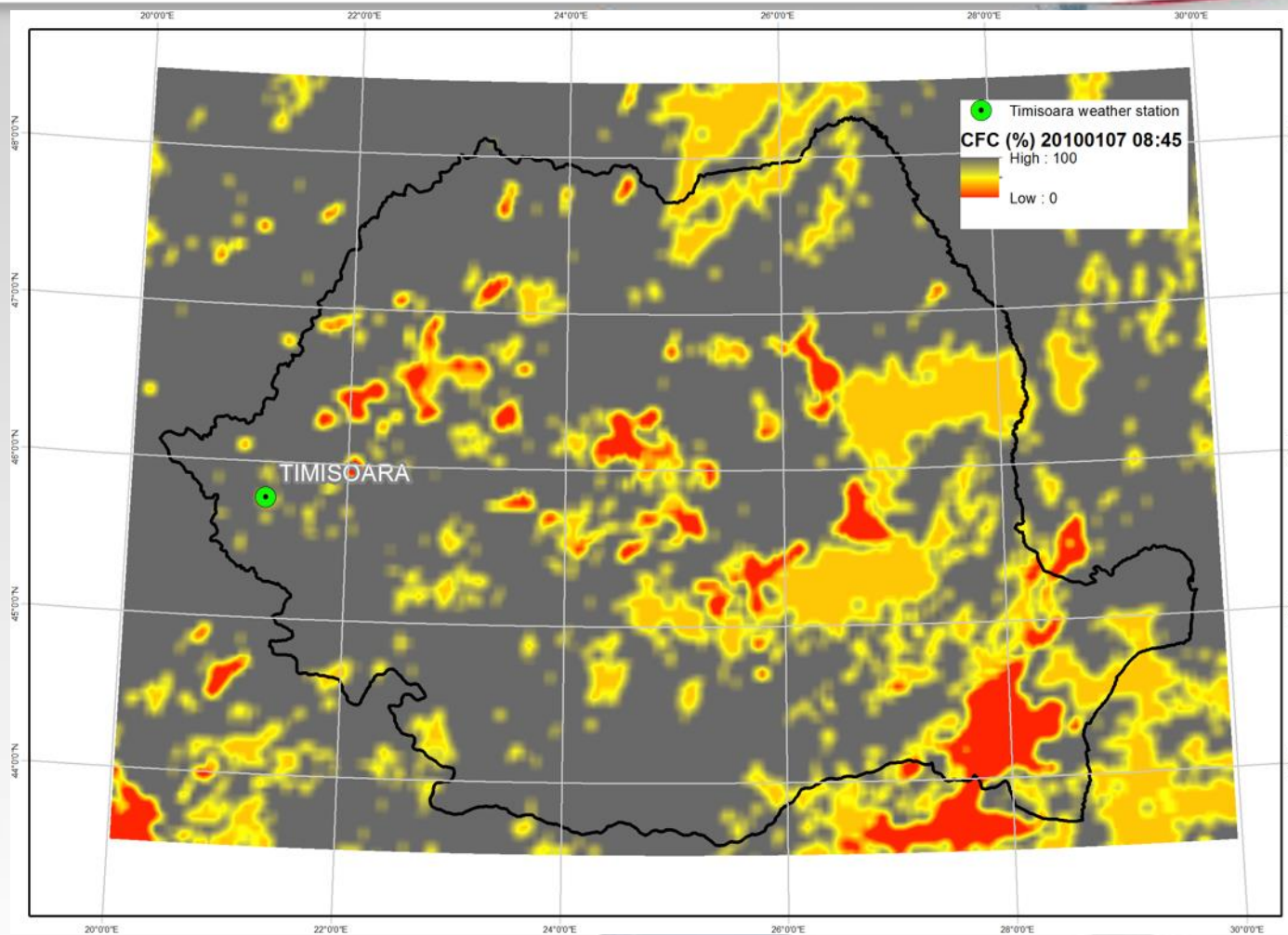
Instantaneous Meteosat Cloud Fractional Coverage CMSAF product

Climate data
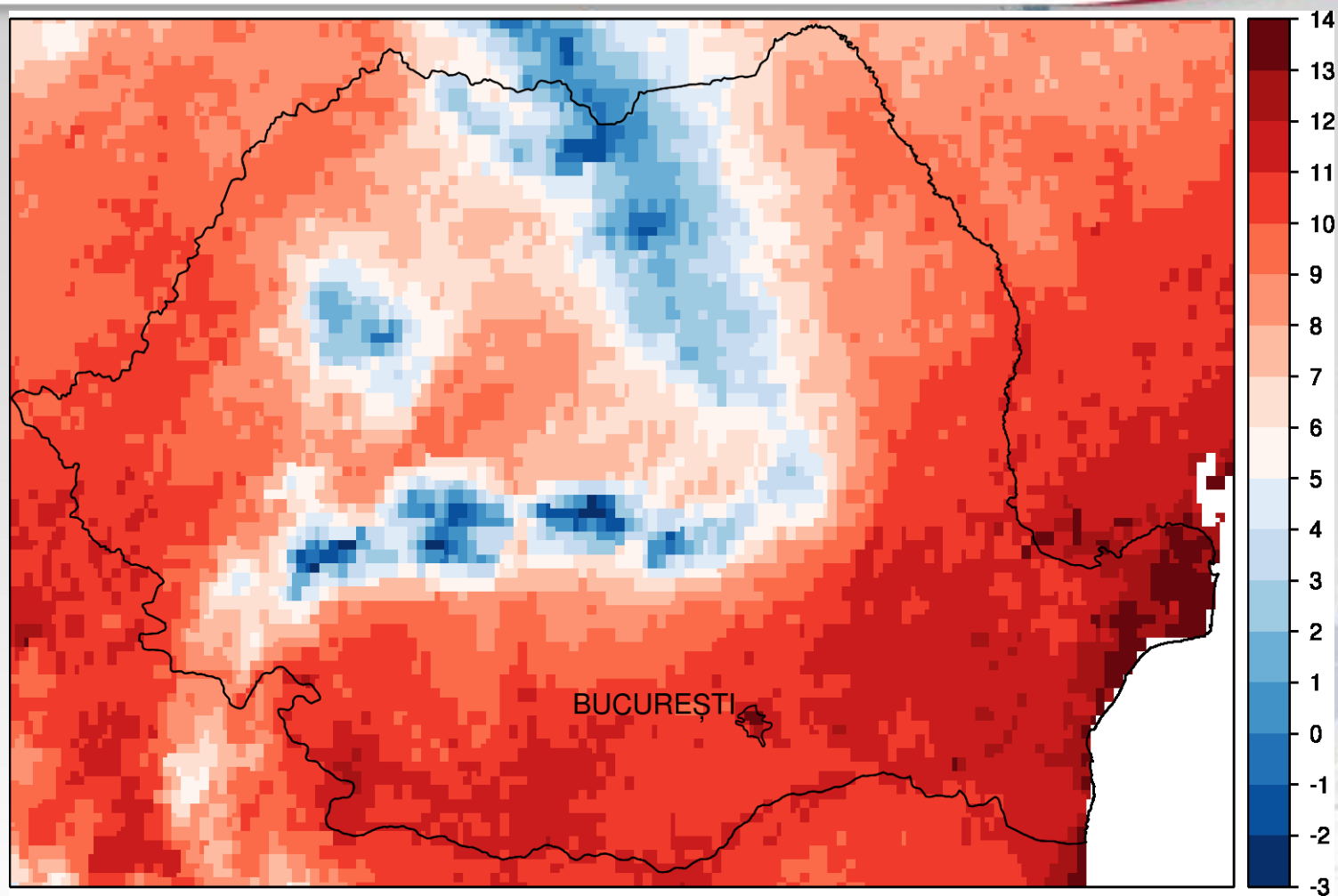
Meteorological observations -Satellite products
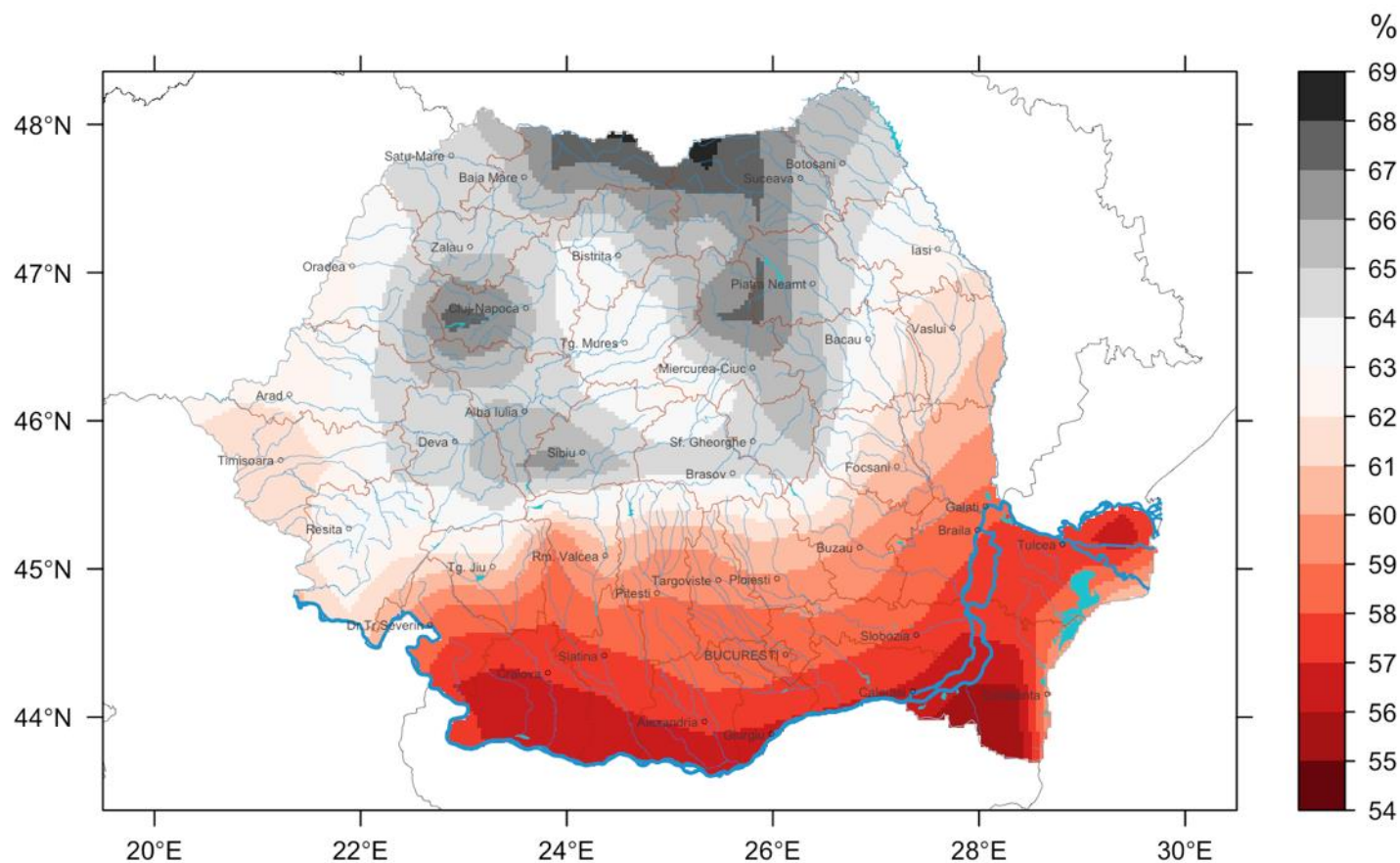
Multiannual mean of the Meteosat CMSAF Cloud Fractional Coverage product (May 2007 - August 2011)
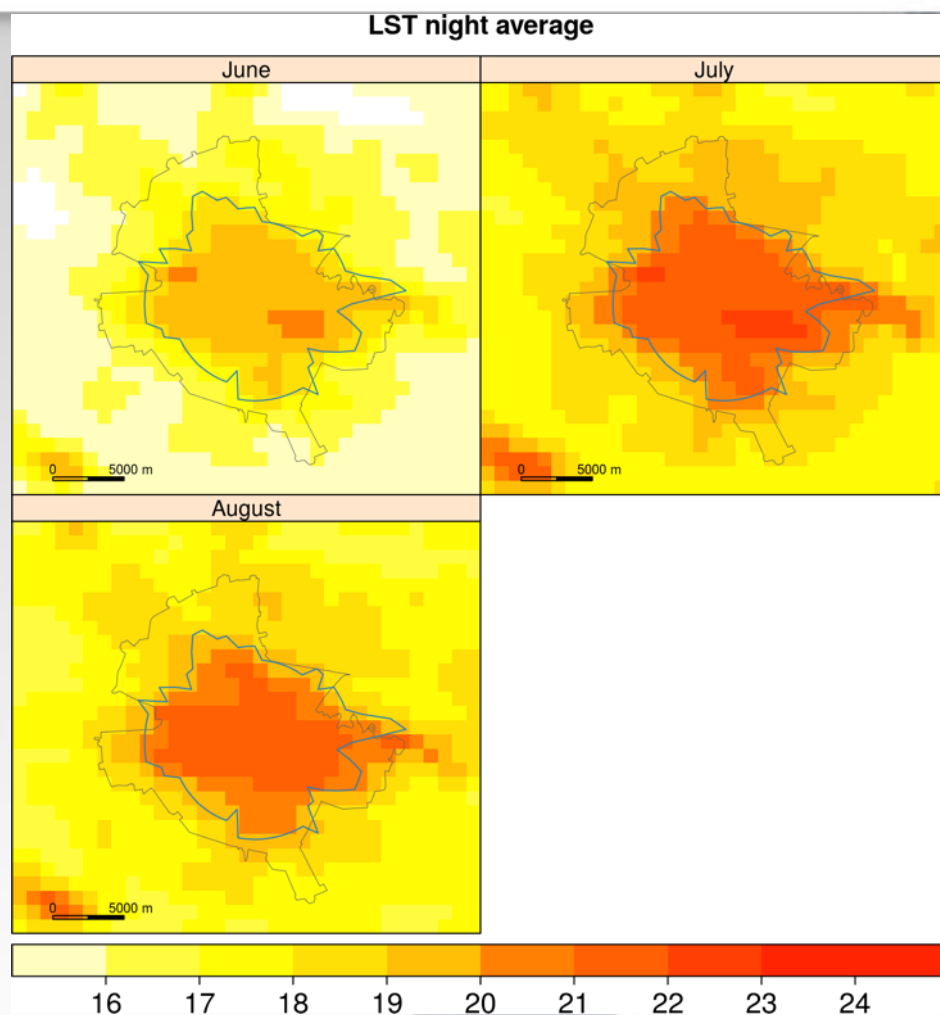
Climate data

Meteorological observations -Satellite products

Mean annual temperature (° C) Meteosat LST LANDSAF 2010

Climate data

Meteorological observations -Satellite products

Average LST (°C) values and Bucharest's UHI (as retrieved from MODIS (MOD11A1 and MYD11A1) images (2000–2013)

Climate data

Gridded datests

- One difficult tasks of a climatologist is to provide information about weather and climate for any place at any time at places where observations of the meteorological elements do not exist.

- ☐ Multiavriate geostatistics have have given opportunities to combine different geo-referenced variables and parameters in such a way that it should be possible to spatially estimate climatological variables at places without observations

- ☐ Gridded time-series dataset give the possibility of assessment of the potential impacts of climate change and variability at a local and regional scale

Average LST (°C) values and Bucharest's UHI (as retrieved from MODIS (MOD11A1 and MYD11A1) images (2000–2013)

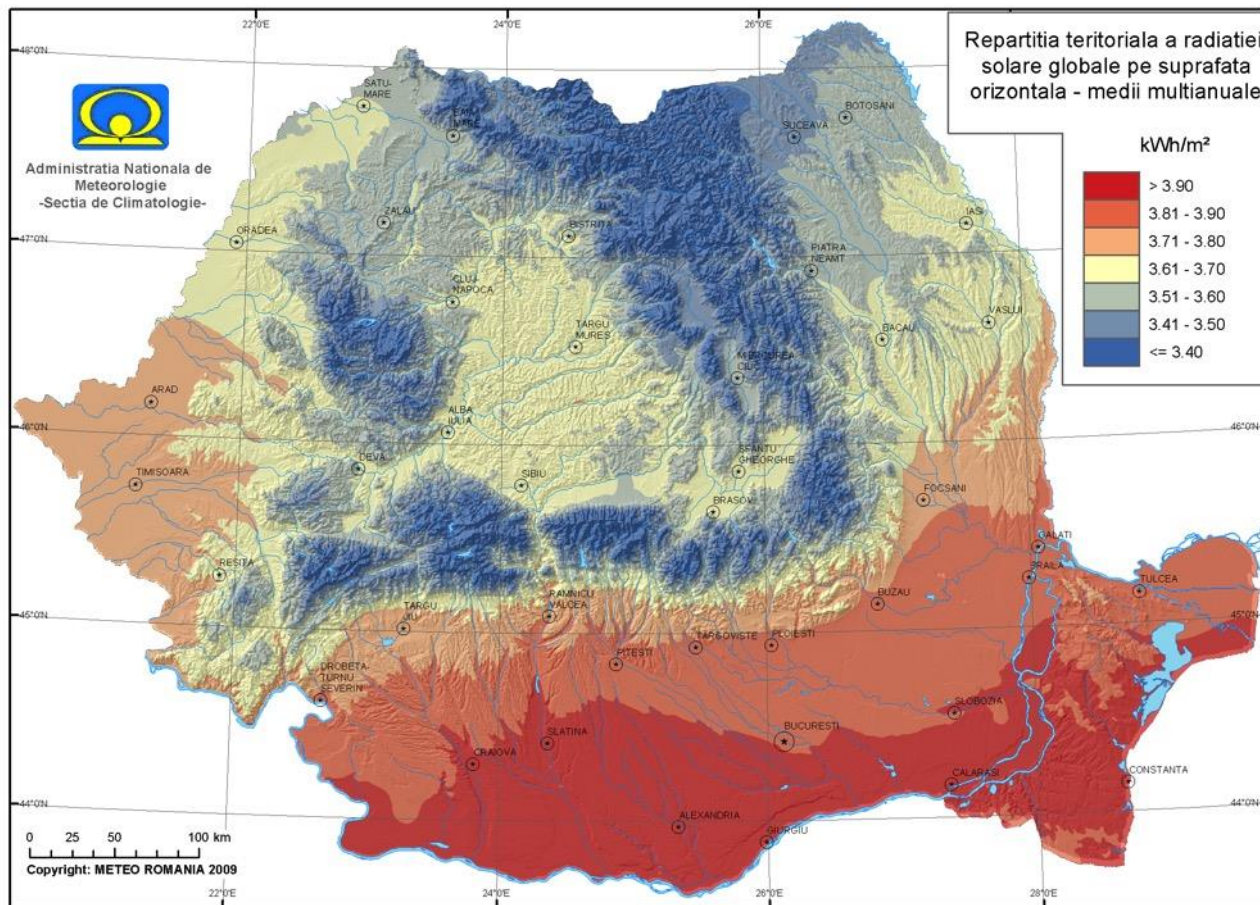# *Climate data*
Gridded datests
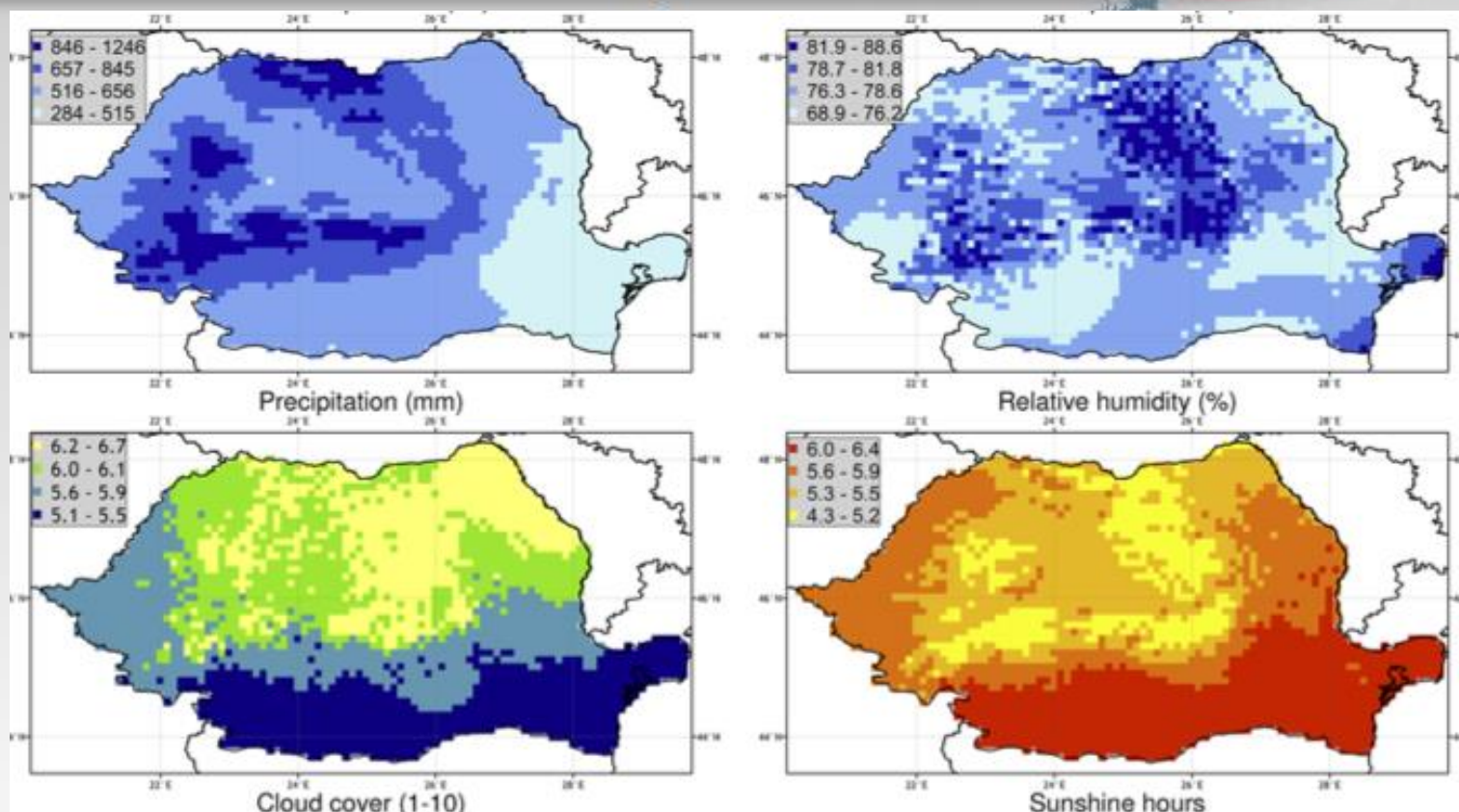
Multiannual means (1961–2013) for each parameter from: source *ROCADA: a gridded daily climatic dataset over Romania (1961–2013) for nine meteorological variables, Alexandru Dumitrescu, Marius-Victor Birsan, Natural Hazards 01/2015; DOI:10.1007/s11069-015-1757-z*
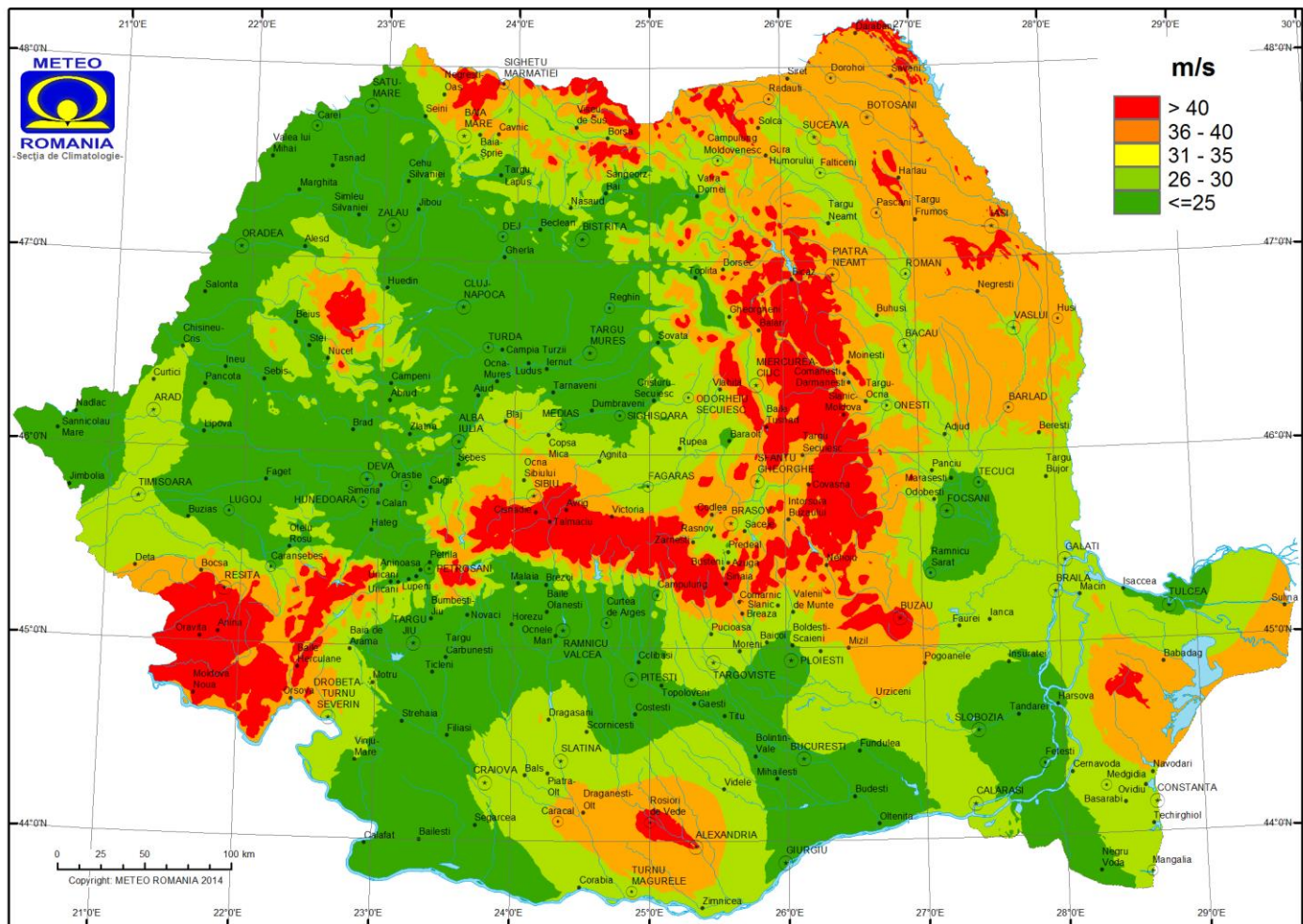
Global solar radiation - multiannual mean

Climate data

Gridded datests

Maximum wind speed : 50-year return-period

Climate data

Climate model outputs

- EURO-CORDEX is an international climate downscaling initiative that aims to provide high-resolution climate scenarios for Europe
- ☐ Region (center of boundaries): 27N :72N, 2W :45E
- ☐ Spatial resolution: EUR-11: 0.11 degree
- ☐ Periods: Control: 1951 – 2005 , Scenario: 2006 – 2100

Eurocordex domain (source:http://www.euro-cordex.net/About-EURO-CORDEX.1864.0.html)

Climate data
Climate model outputs
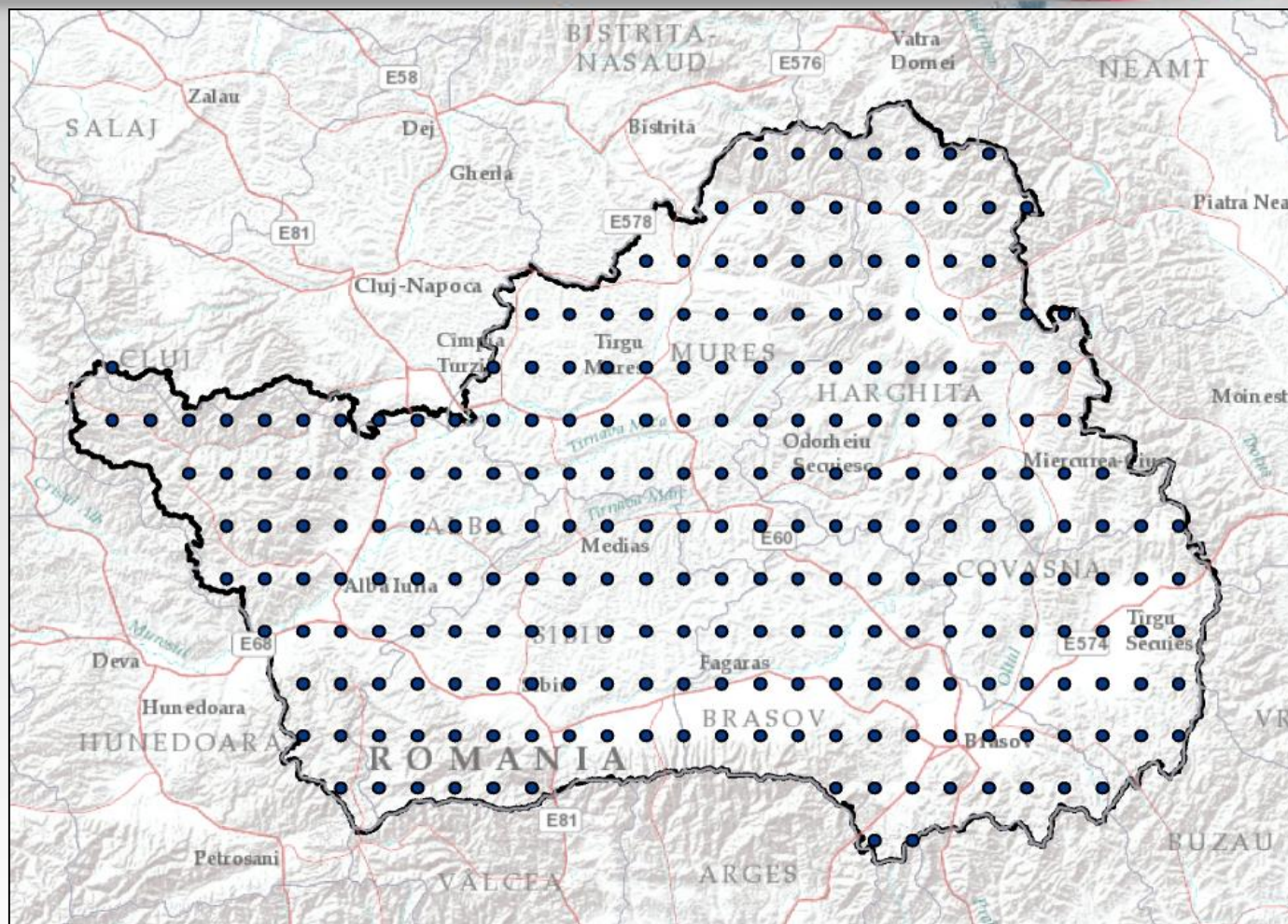
Eurocordex grid-size over the study area
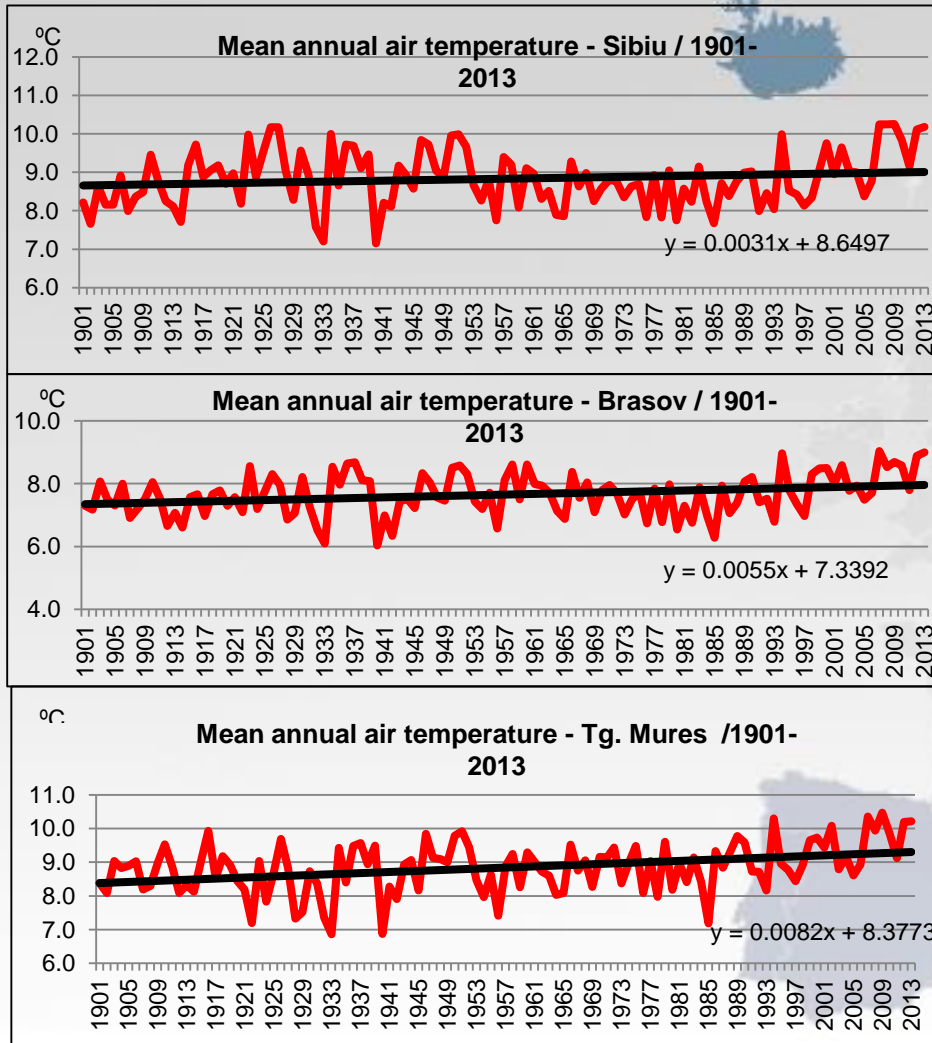
- The trend is the rate at which a climate variable changes over a time period

- ☐ Trend analysis can be performed on all types of climate data with time series of measurements of sufficient length
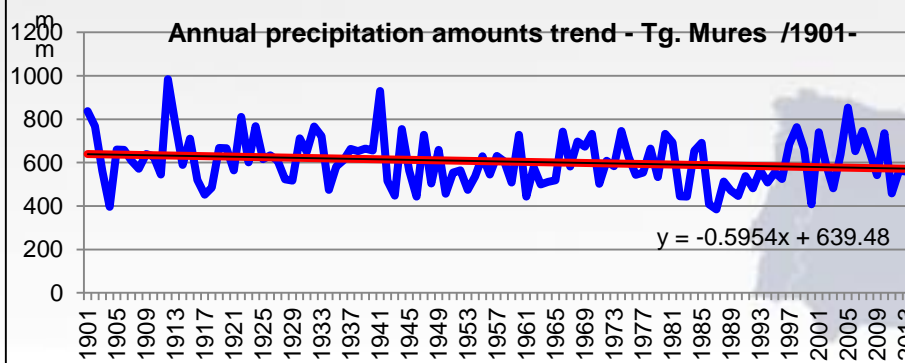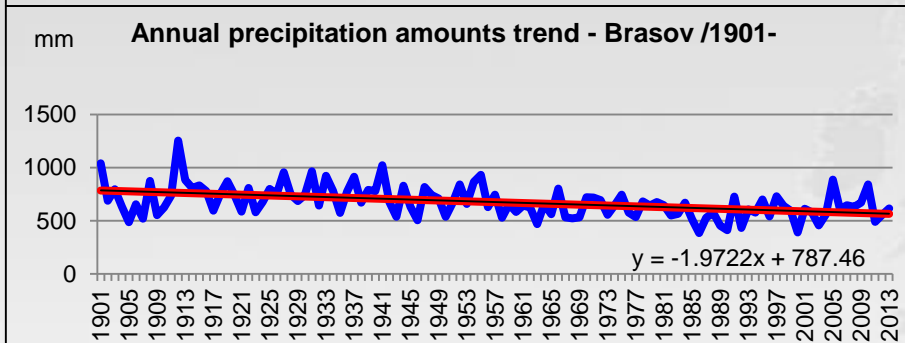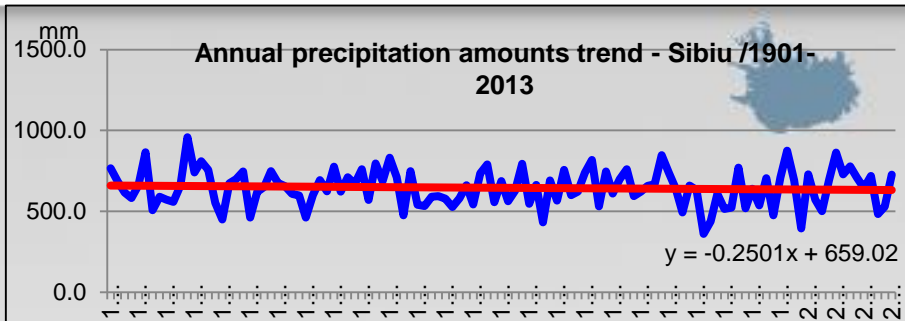
Data related products

Trend analysis

Mean annual air temperature - Sibiu / 1901-2013

$y = 0.0031x + 8.6497$

Mean annual air temperature - Brasov / 1901-2013

$y = 0.0055x + 7.3392$

Mean annual air temperature - Tg. Mures /1901-2013

$y = 0.0082x + 8.3773$

Observed shifts in the course of the mean annual air temperature

SIBIU	
1961-1990	8.5ºC
1991-2013	9.2ºC, +0.7ºC
BRASOV	
1961-1990	7.5ºC
1991-2013	8.1ºC, +0.6ºC
TG. MURES	
1961-1990	8.8ºC
1991-2013	9.4ºC, +0.6ºC

Data related products

Trend analysis

Annual precipitation amounts trend - Sibiu /1901-2013

$y = -0.2501x + 659.02$

Annual precipitation amounts trend - Brasov /1901-

$y = -1.9722x + 787.46$

Annual precipitation amounts trend - Tg. Mures /1901-

$y = -0.5954x + 639.48$

Observed shifts in the course of the annual precipitation amounts (mm)

SIBIU	
1901-1980	653.3 mm
1981-2013	624.1 mm
BRASOV	
1901-1980	711.2 mm
1981-2013	587.3 mm
TG. MURES	
1901-1980	617.2 mm
1981-2013	572.2 mm

Data related products

Trend analysis

Sunshine

Cloud cover

Relative humidity
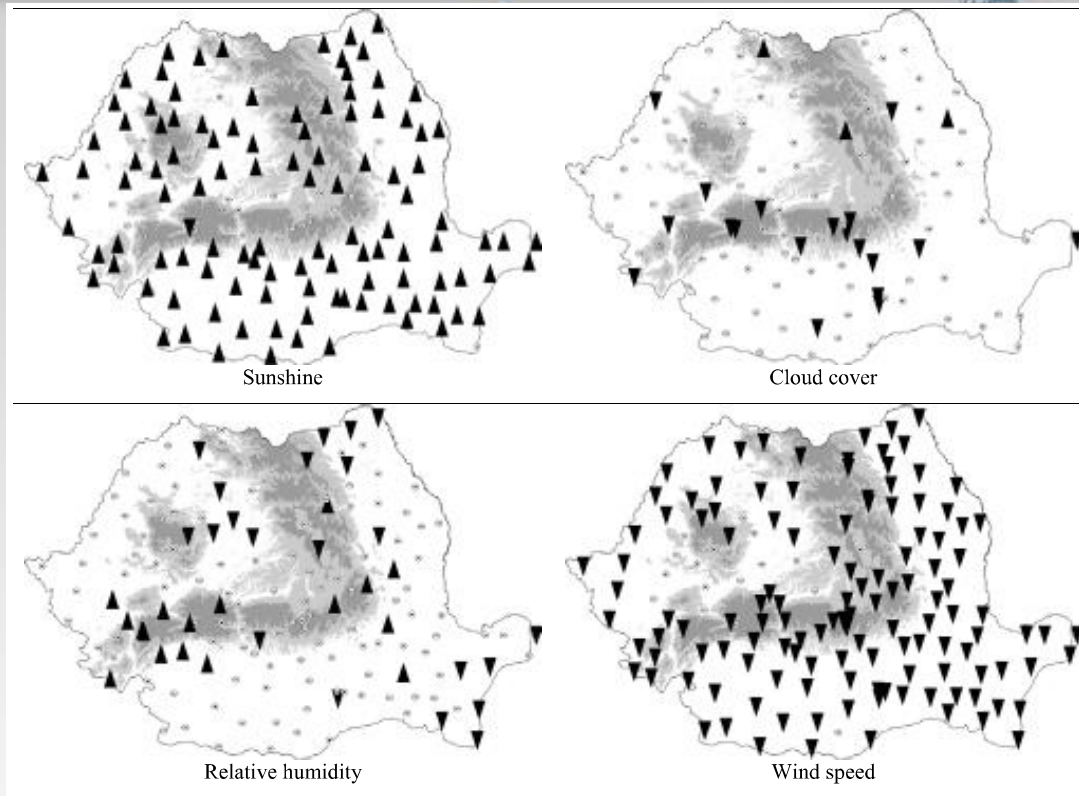
Wind speed

The Mann-Kendall nonparametric annual trends (1961-2013) in sunshine hours, nebulosity, relative humidity and wind speed in Romania. Increasing (decreasing) statistically significant trends are marked with upward (downward) triangles. Circles denote no significant trend. source:*An overview of annual climatic changes in Romania: trends in air temperature, precipitation, sunshine hours, cloud cover, relative humidity and wind speed during the 1961–2013 period, Lenuta MARIN, Marius-Victor BIRSAN, Roxana BOJARIU, Alexandru DUMITRESCU, Dana Magdalena MICU, Ancuta MANEA, Carpathian Journal of Earth and Environmental Sciences 10/2014; 9(4):253-258*

Data related products
Trend analysis
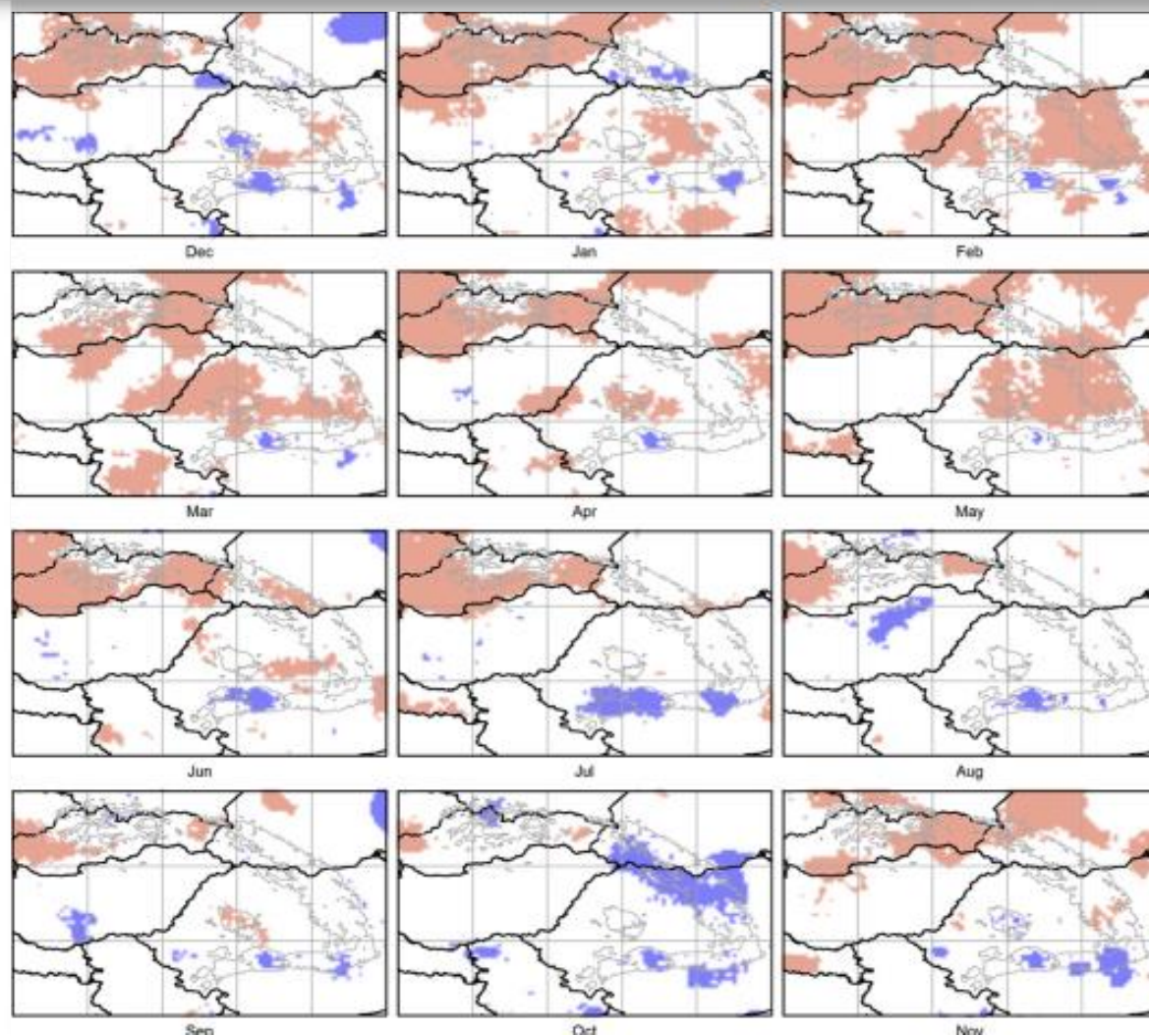
Sunshine duration Mann-Kendall nonparametric trends in the Carpathian Mountains Region (1961–2010) source:*Climate variability in the Carpathian Mountains Region over 1961-2010,Sorin Cheval, Marius-Victor Birsan, Alexandru Dumitrescu, Global and Planetary Change 07/2014; 118.*
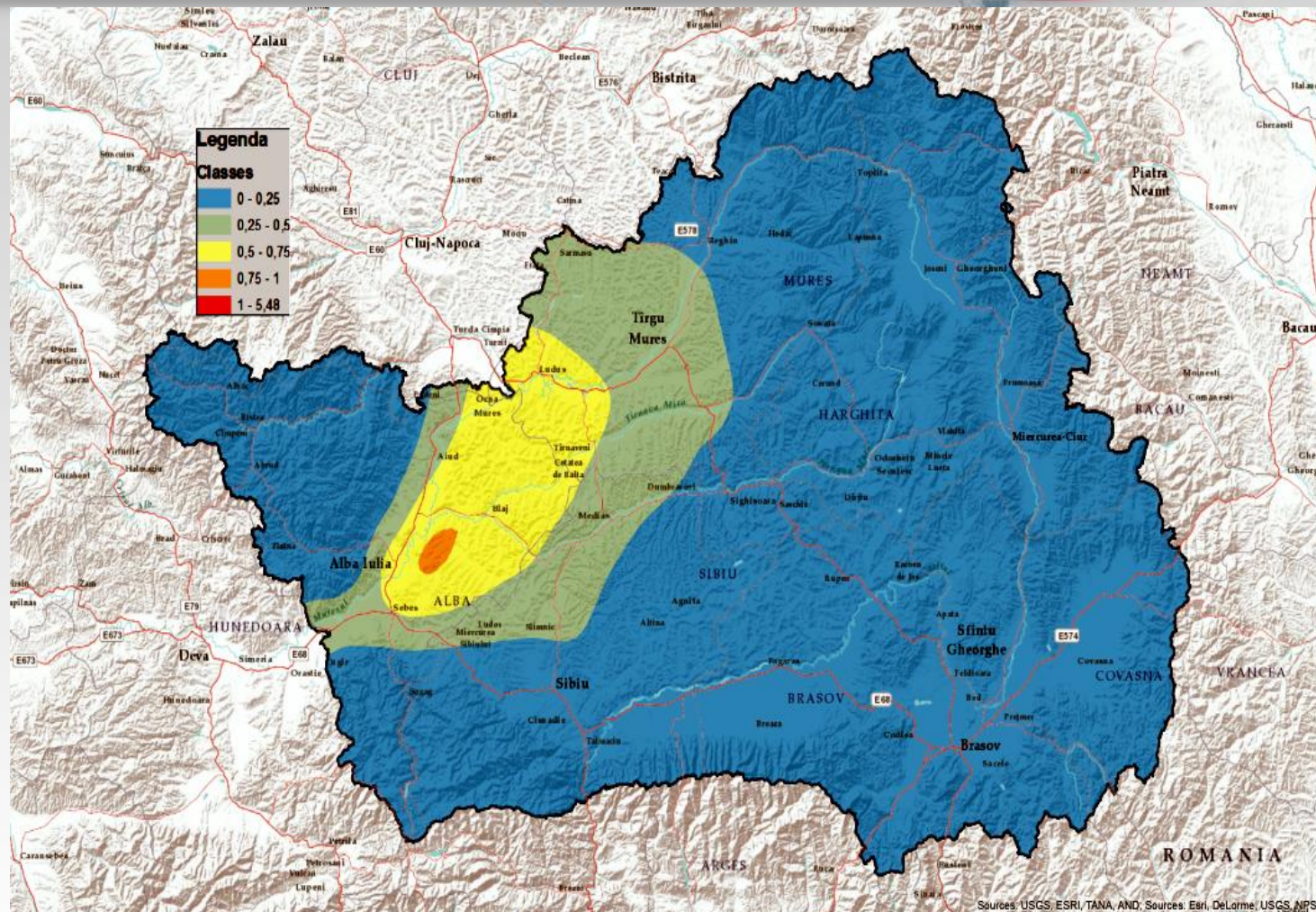
Data related products

Ensemble scenario analysis

Nr.	Centrul de modelare climatică regională/Regional modeling center	Model regional/ Regional model	Model global/Global model
1	CLMcom (Consorţiul CLMcom)	CCLM4-8-17	MPI-ESM-LR
3	IPSL-INERIS (Laboratorul de Stiinţa Climei şi Mediului, IPSL, CEA/CNRS/UVSQ – Institutul Naţional al Mediului Industrial şi la Riscurilor, Halatte, Franţa)	WRF331F	IPSL-CM5A-MR
4	KNMI (Institutul Regal Olandez de Meteorologie)	RACMO22E	ICHEC-EC-EARTH
6	SMHI (Institutul Hidrometeorologic Suedez)	RCA4	ICHEC-EC-EARTH
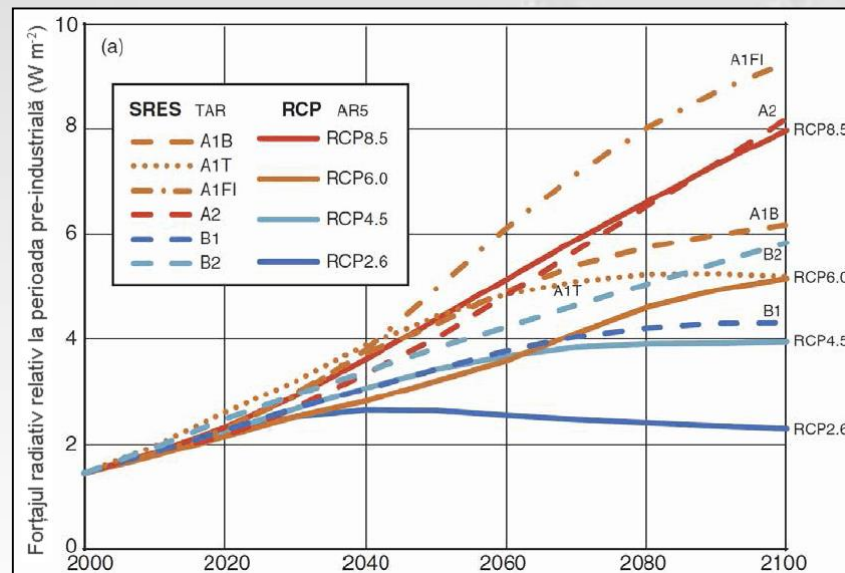
Source: WG 1 AR5 IPCC

Data related products
Ensemble scenario analysis

Mean difference of 4-models ensemble for number of days with T. max greater than 35 deg.C 2021-2050 vs. 1971-2000

Data related products

Ensemble scenario analysis
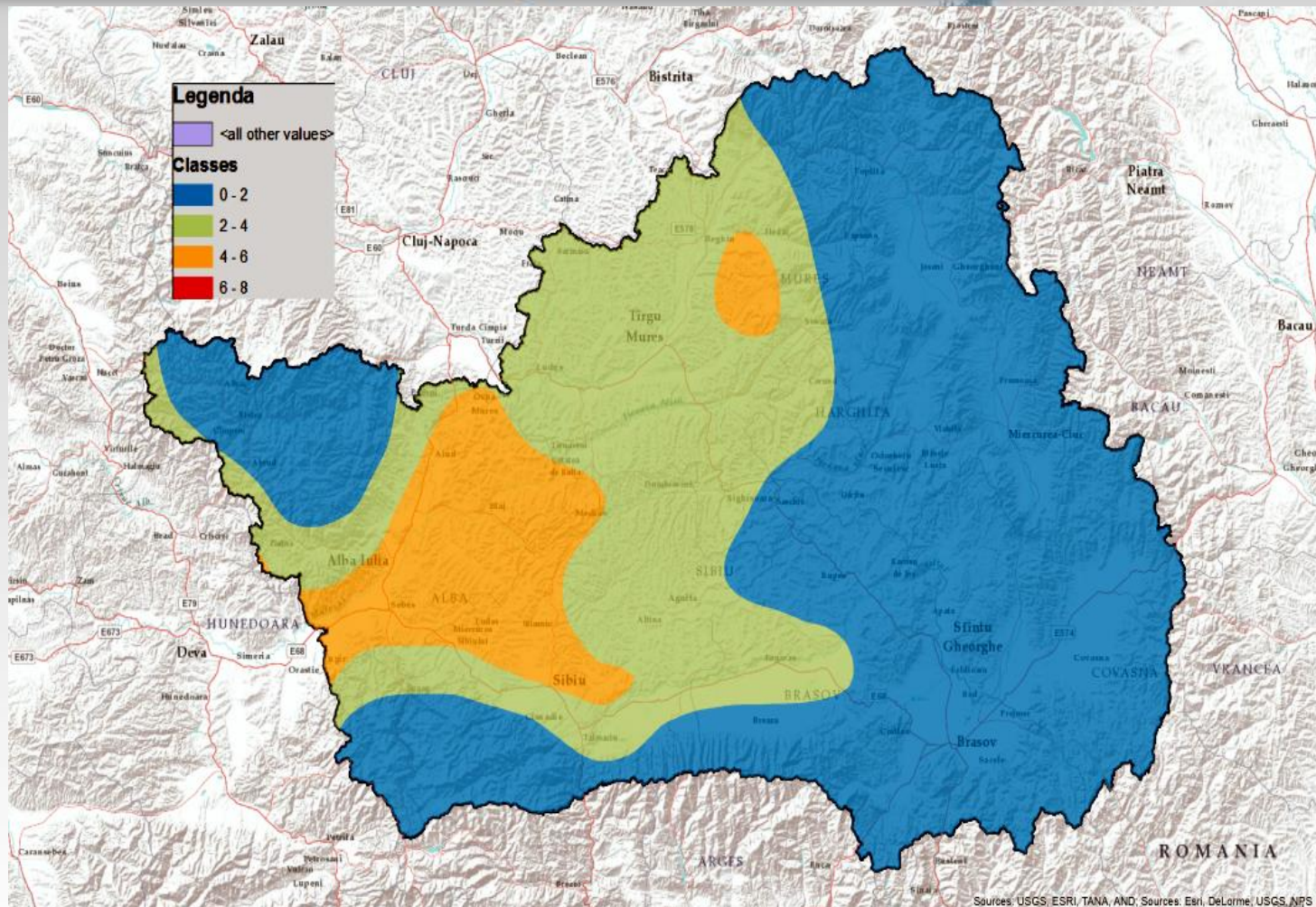
Mean difference of 4-models ensemble for number of days with T. min greater than 20 deg.C 2021-2050 vs. 1971-2000

Data related products

Ensemble scenario analysis
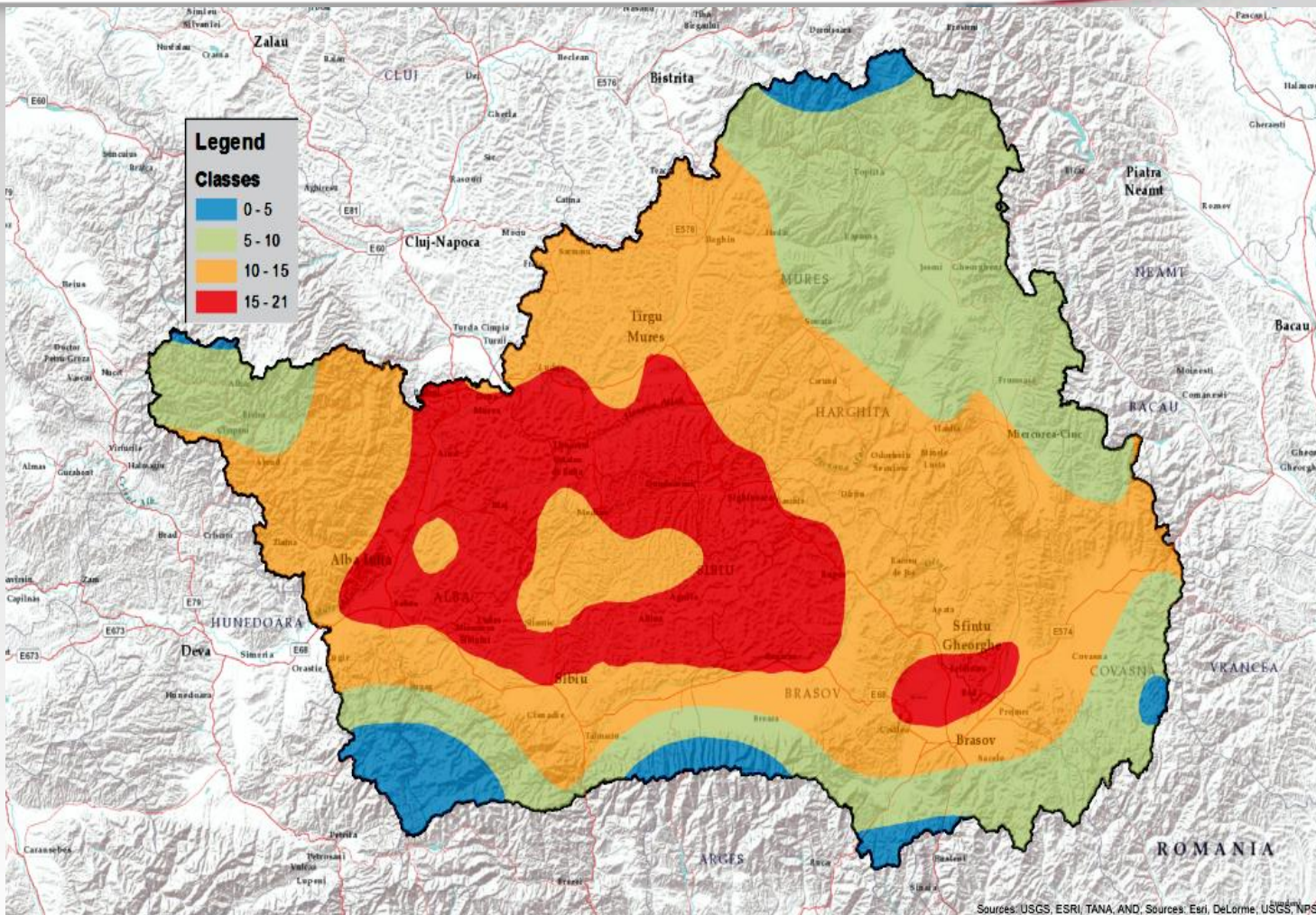
Mean difference of 4-models ensemble for number of summer days with T. mean greater than 20 deg.C 2021-2050 vs. 1971-2000

Identification of vulnerable areas to the extreme events in Central Region 7, Romania

Oana Alexandra OPREA

Agrometeorological Laboratory

06 – 08 May 2015 / Workshop II Sibiu

Project " Green Path to Sustainable Development "
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National Meteorological Observation Network

of Romania

METEOROLOGICAL NETWORK
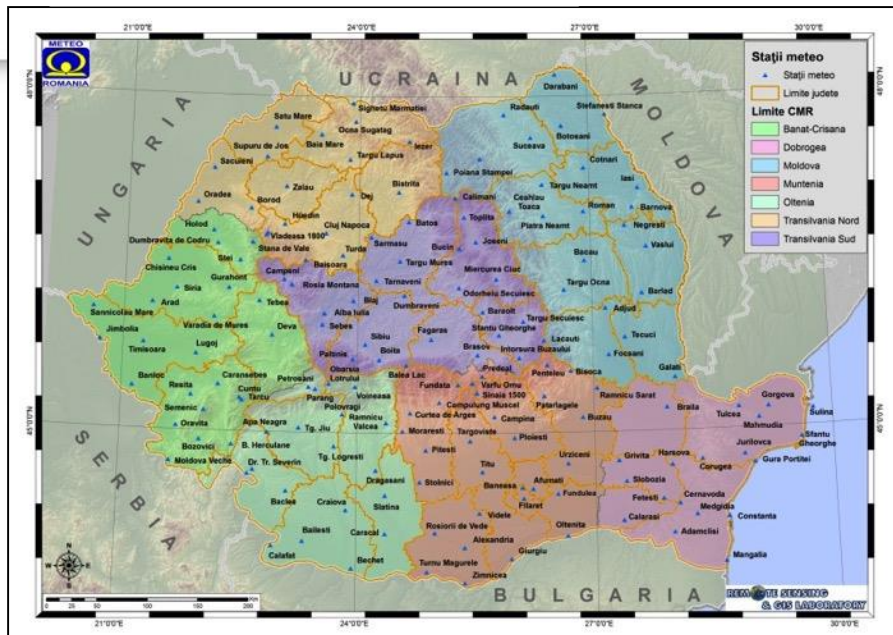
AGROMETEOROLOGICAL NETWORK

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

The Agrometeorological Laboratory of NMA
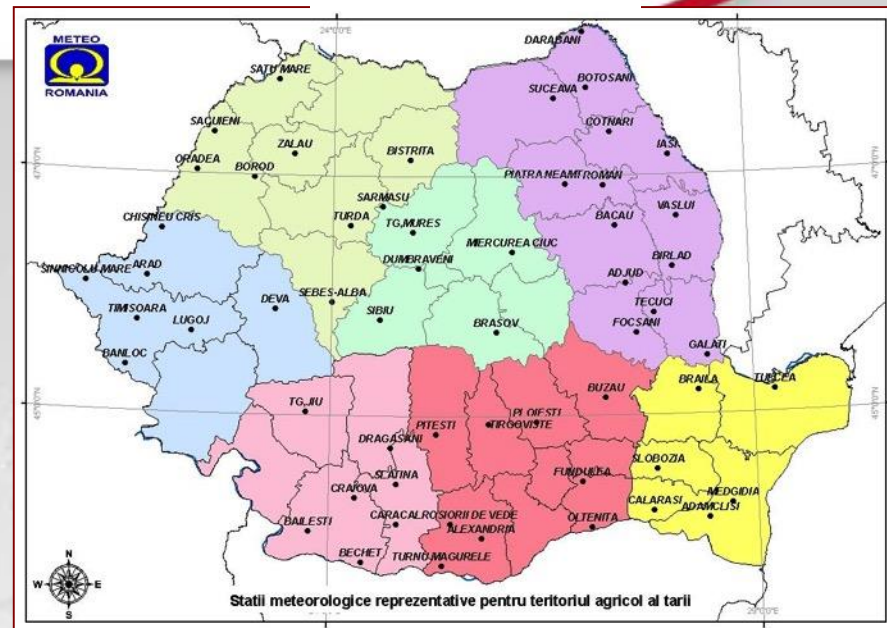
⮑ develops specialized products such as:

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 (**www.meteoromania.ro**) for informational and decisional purpose in terms of technological measures that can be applied in drought conditions.

The Agrometeorological Laboratory of NMA

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.

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 **55 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 to the Laboratory of Agrometeorology in order to carry out maps regarding the reserve (mc/ha) accessible to plants (winter wheat and maize), at calendar dates of agricultural interest and at different depths (0-20, 0-50 and 0-100 cm).

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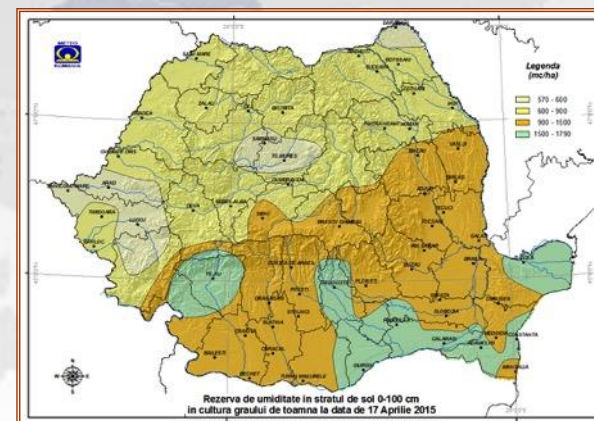
MODULE
Soil moisture

· 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.
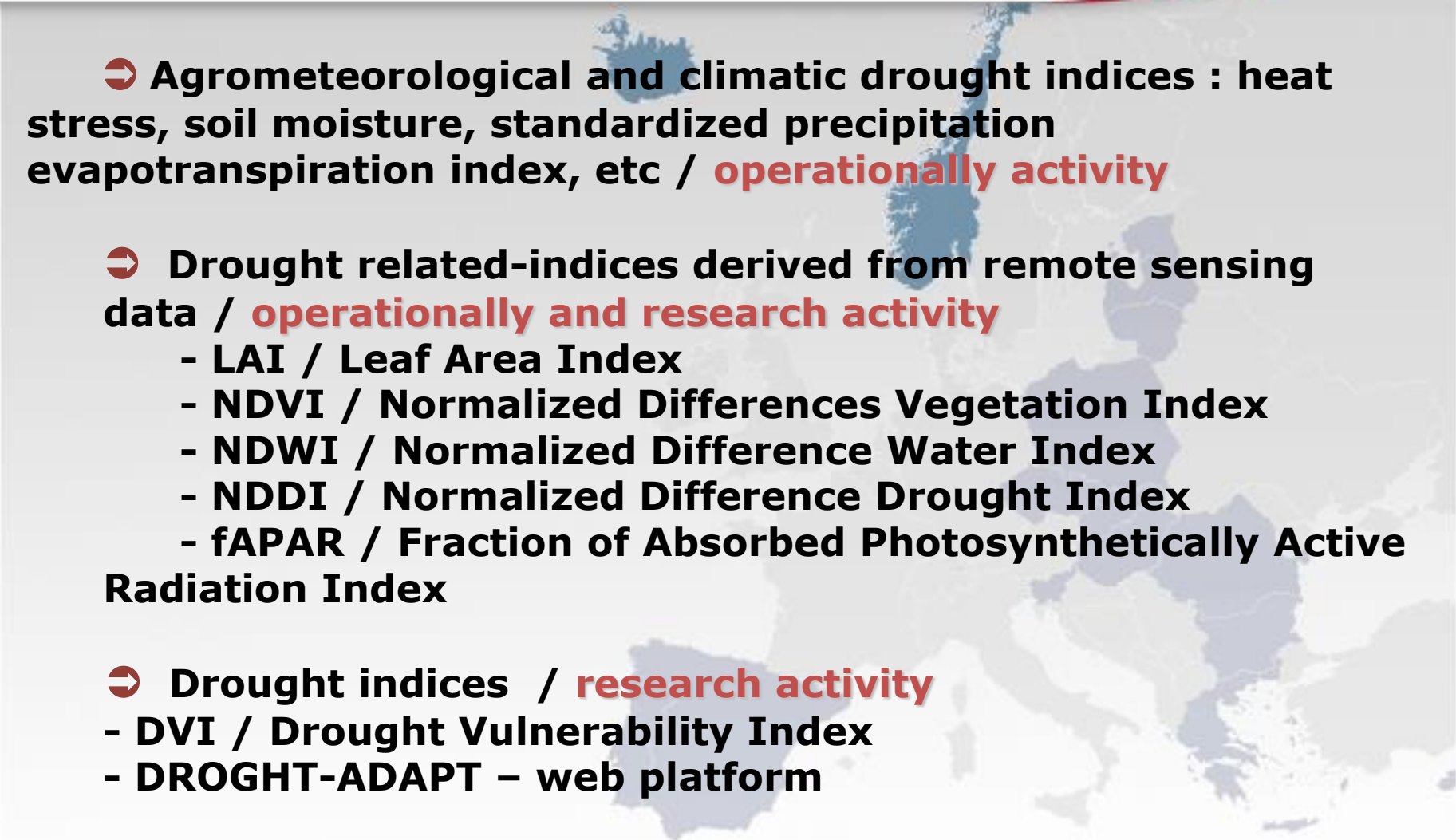
Classes of the soil moisture / %AWC (Avaible Water Capacity)

⇨ **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 .**

Rezerva de umiditate in stratul de sol 0-100 cm
in cultura graului de toamna la data de 17 Aprilie 2015

⮕ **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**

INTERNET – free access of meteorological forecasts and agrometeorological information

Agrometeorological forecasts

Soil moisture maps

Warnings at national level and now-casting forecasts at local level

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

STUDY AREA

Central Region 7

28 meteorological weather station

- 1961 – 1990
- 1981 – 2010
- 1961 - 2014

1. Alba Iulia
2. Bâlea Lac
3. Baraolt
4. Batoş
5. Blaj
6. Boiţa
7. Braşov
8. Bucin
9. Câmpeni
10. Dumbrăveni
11. Făgăraş
12. Fundata
13. Întorsura Buzăului
14. Joseni
15. Lăcăuţi
16. Miercurea Ciuc
17. Odorheiu Secuiesc
18. Păltiniş
19. Predeal
20. Roşia Montană
21. Sărmaşu
22. Sebeş
23. Sf. Ghe. Munte
24. Sibiu
25. Târnăveni
26. Târgu Mureş
27. Târgu Secuiesc
28. Topliţa

Agrometeorological parameters analyzed

Central Region 7

Thermal resources

❖ Winter frost units ($\sum$Tmin.$\leq$-10…-15°C /frost units), 01 December-28 February;
❖ Winter cold units ($\sum$Tmed.<0°C /cold units), 01 November-31 March;
❖ Spring index ($\sum$Tmed.>0°C /heat units), 01 February-10 April;
❖ Schorching heat intensity ($\sum$Tmax.$\geq$32°C/schorching heat units) and schorching heat days, 01 June-31 August;
❖ First frost in the fall (date of);
❖ Last frost in spring (date of).

Water resources
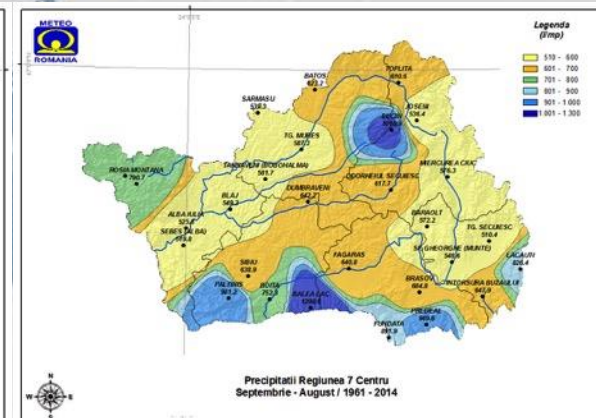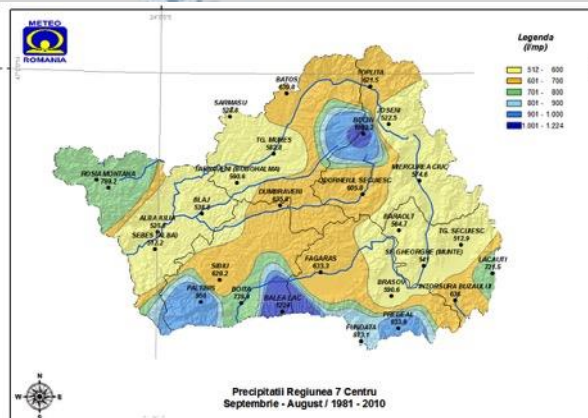
❖ Monthly Precipitation (l/mp), 01 September- 30 October;
❖ Monthly Precipitation (l/mp), 01 November-31 March (the period of accumulation of water in the soil for winter wheat crops);
❖ Monthly Precipitation (l/mp), 01 June-31 August (critical period for maize crops);
❖ Monthly Precipitation (l/mp), 01 September-31 August (agricultural year);
❖ Maximum Precipitation (l/mp) fallen within 24 hours / date of production;
❖ Seasonal Monthly Precipitation (l/mp) : Winter (September-February) and Summer (March-August);
❖ Standardized Precipitation Index - SPI.

Soil moisture

WINTER WHEAT **and** MAIZE

❖ Soil moisture reserve (mc/ha) on the 0-20 cm soil deph in winter wheat crop, 30 September;
❖ Soil moisture reserve (mc/ha) on 0-100 cm soil deph in winter wheat crop, 31 May;
❖ Soil moisture reserve (mc/ha) on 0-100 cm soil deph in winter wheat crop, 30 June;
❖ Soil moisture reserve (mc/ha) on 0-100 cm soil deph in maize crop, 31 July;
❖ Soil moisture reserve (mc/ha) on 0-100 cm soil deph in maize crop, 31 August.

Other indices

❖ Normalized Difference vegetation Index - NDVI;
❖ Photosynthetically Active Radiation daily fraction Absorbed by plant cover - fAPAR.

AGROMETEOROLOGICAL DROUGHT INDICATORS
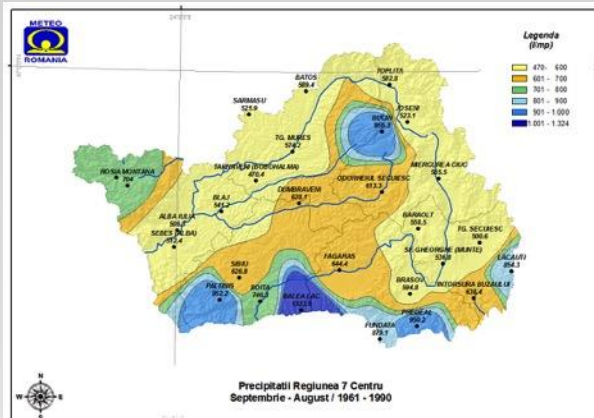

RAINFALL

❖ **Moderate drought**
❖ **Optimal**
❖ **Excesively rainy**

In term of meteorological definition, a drought period is defined by a significant deficit in the rainfall regime. The heat waves produce thermal stress to plants even if water is not limited especially during the summer period.

Winter frost units (ΣTmin. ≤ - 10° C) / Frost units

01 December – 28 February / Central Region 7

⇨ In order to assess the conditions for wintering of winter crops analyze specific heat index for 1 December to 28 February period, ie negative amount of air daytime minimum temperatures (ΣTmin≤-10° C/frost units), which characterize the **intensity of frost units of winter season**
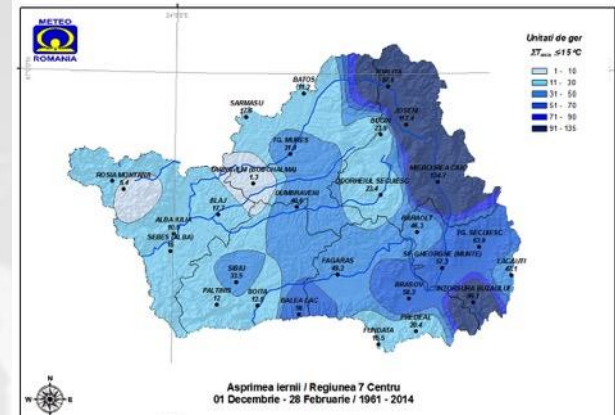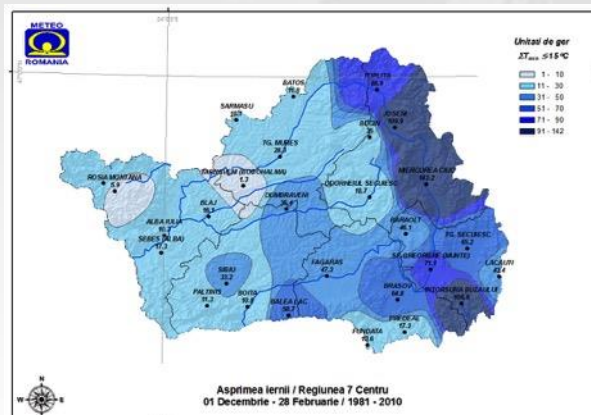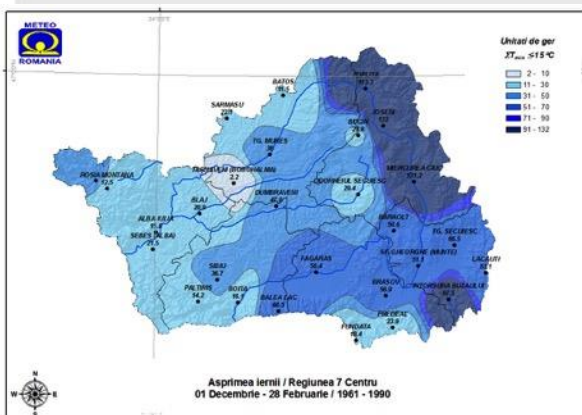
AGROMETEOROLOGICAL DROUGHT INDICATORS

Soil moisture / 30 April 2015
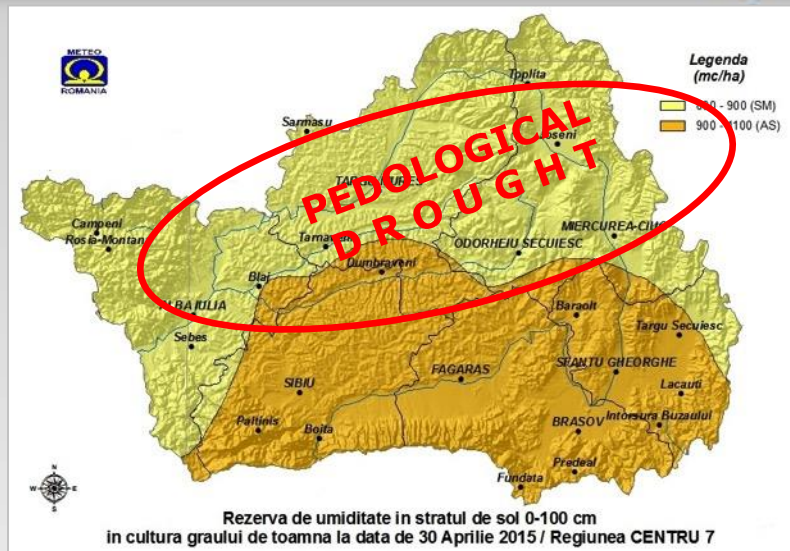
winter weat crop

SM - *Moderate pedological drought*
AS - *Satisfactory supply*
ApO - *Almost optimum supply*

maize crop

➤ **Pedological drought refers to a significant deficit in the soil moisture. For agriculture, drought is defined by parameters affecting crops growth and yield.**

➤ **All type of drought affect agricultural production loss varying function of their intensity and duration.**

Using remote sensing data for drought monitoring

Argentina NERTAN
Remote Sensing & GIS Department

06 – 08 May 2015 / Workshop II Sibiu
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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;; land cover/land use, updated from satellite images

Using remote sensing data for drought monitoring
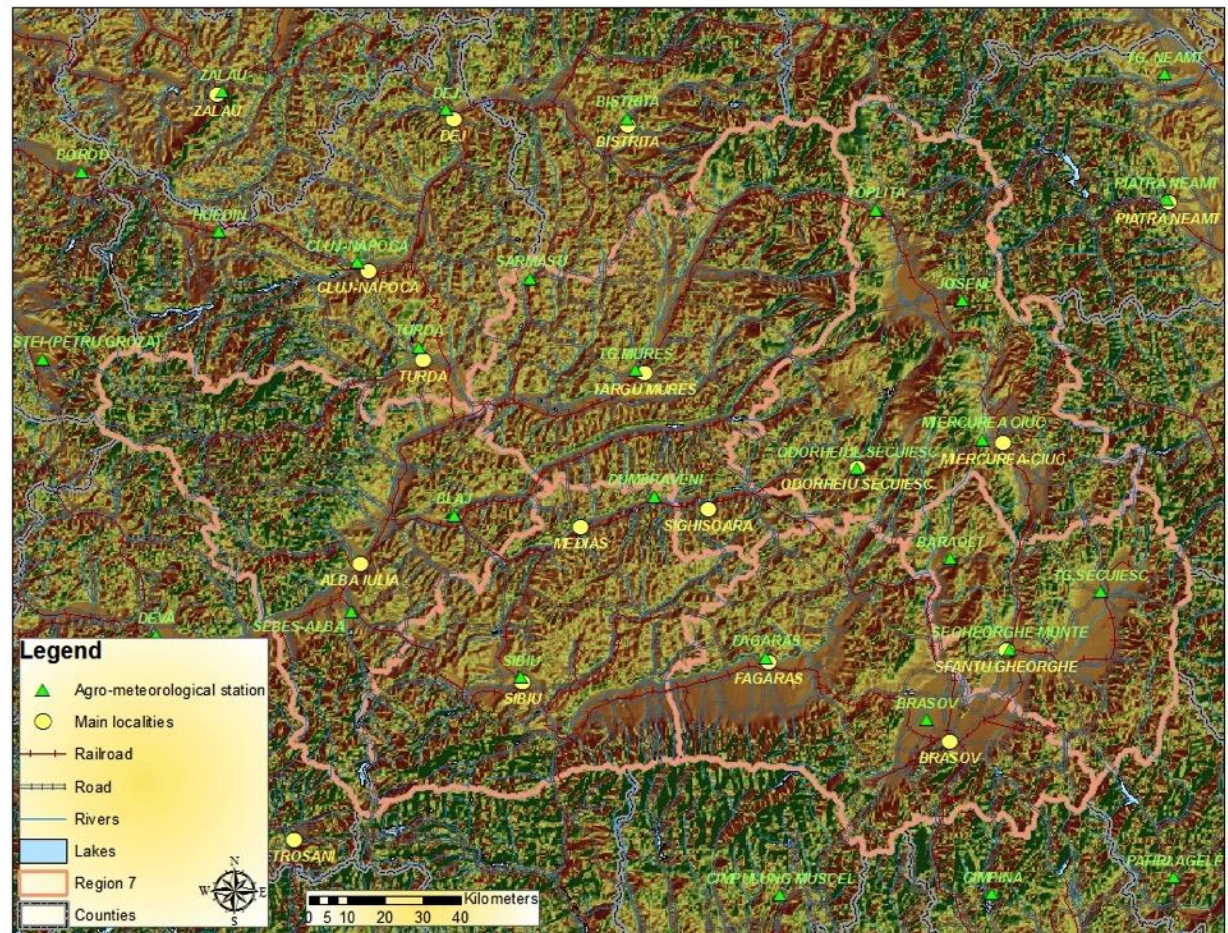
Using remote sensing data for drought monitoring

GIS database

•CLC 2012

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).
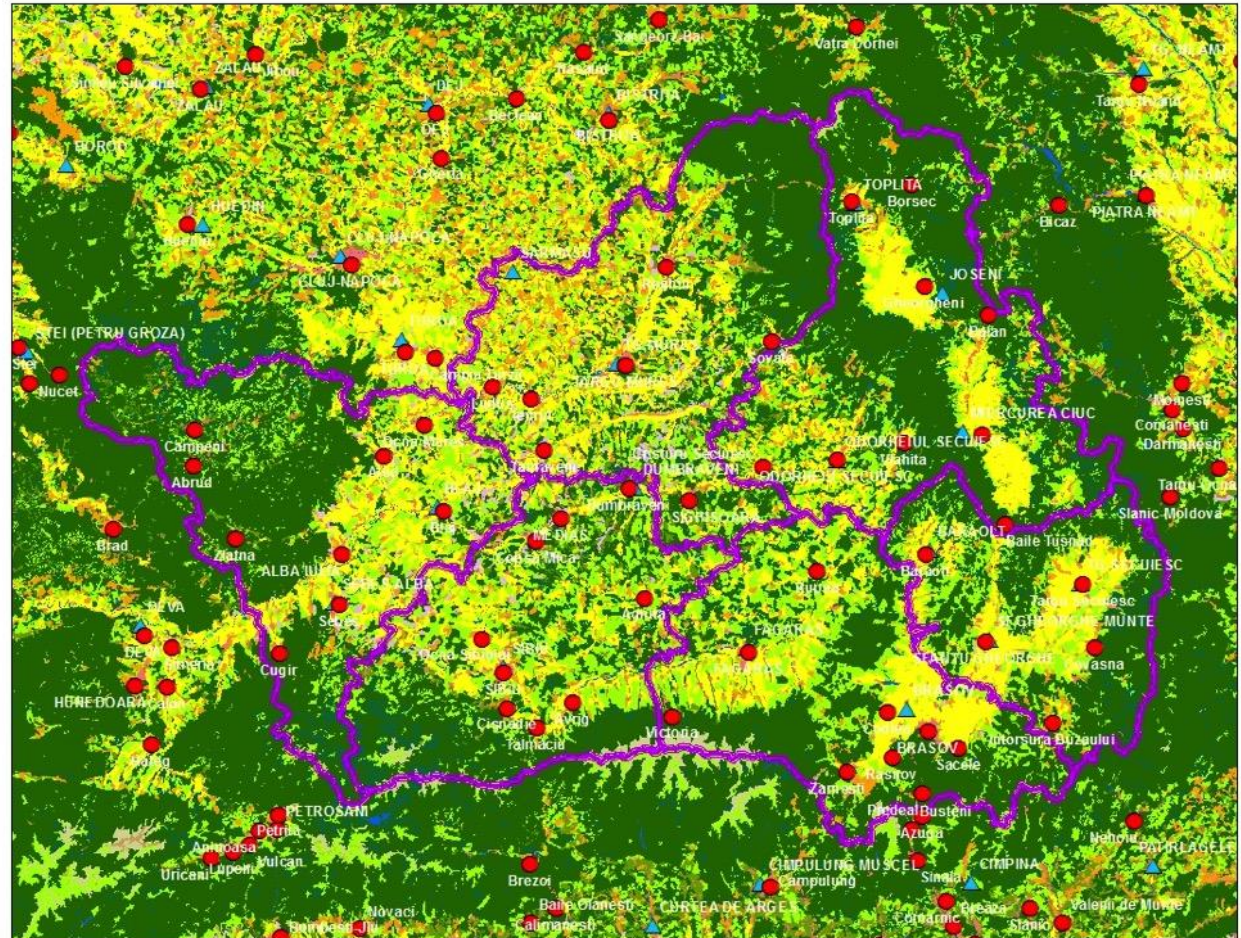- TERRA – AQUA/MODIS Surface Reflectance 8-Day L3 Global 500 m products (MOD09A1): provides bands 1–7 at 500 m resolution in an 8-day gridded level-3 product in the sinusoidal projection. Science Data Sets provided for this product include reflectance values for Bands 1–7, quality assessment, and the day of the year for the pixel along with solar, view, and zenith angles.
- The LANDSAT 7 ETM+ data: the main features are: a panchromatic band with 15 m spatial resolution (band 8); visible bands in the spectrum of blue, green, red, near-infrared (NIR), and mid-infrared (MIR) with 30 m spatial resolution (bands 1-5, 7); a thermal infrared channel with 60 m spatial resolution (band 6).
- SPOT 5 data: has two high resolution geometrical (HRG) instruments that were deduced from the HRVIR of SPOT 4. They offer a higher resolution of 2.5 to 5 meters in panchromatic mode and 10 meters in multispectral mode (20 metre on short wave infrared 1.58 – 1.75 µm). Onboard sensors can point across the satellite track, providing a revisit capability of 1-4 days depending on latitude. Spectral bands: Pan: 480-710 nm; Green: 500-590 nm; Red: 610-680 nm; Near Infrared: 780-890 nm; Short Wave Infrared: 1.58-1.75 µm

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.
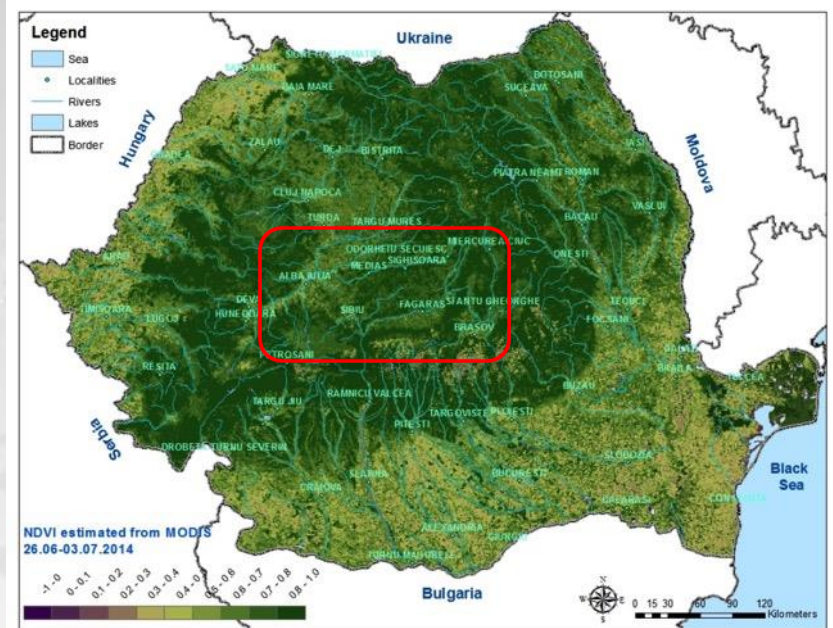
Using remote sensing data for drought monitoring

Vegetation indices (cont.)
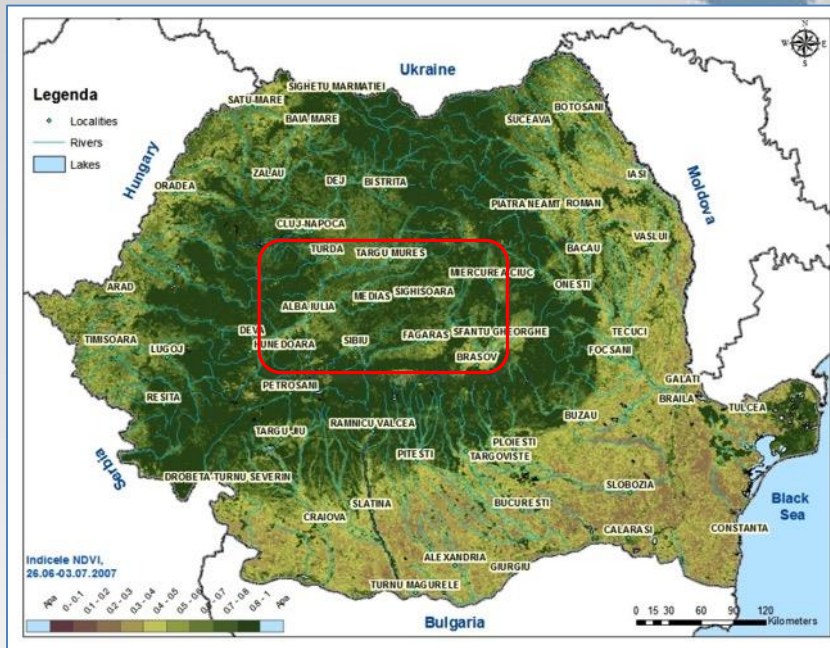
(a) NDVI: 26.06 – 03.07.2007

(b) NDVI: 26.06 – 03.07.2014

The NDVI spatial distribution obtained from MODIS data (MOD09A1)

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:

$$NDWI = (NIR - SWIR)/(NIR + SWIR)$$

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. 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.

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.
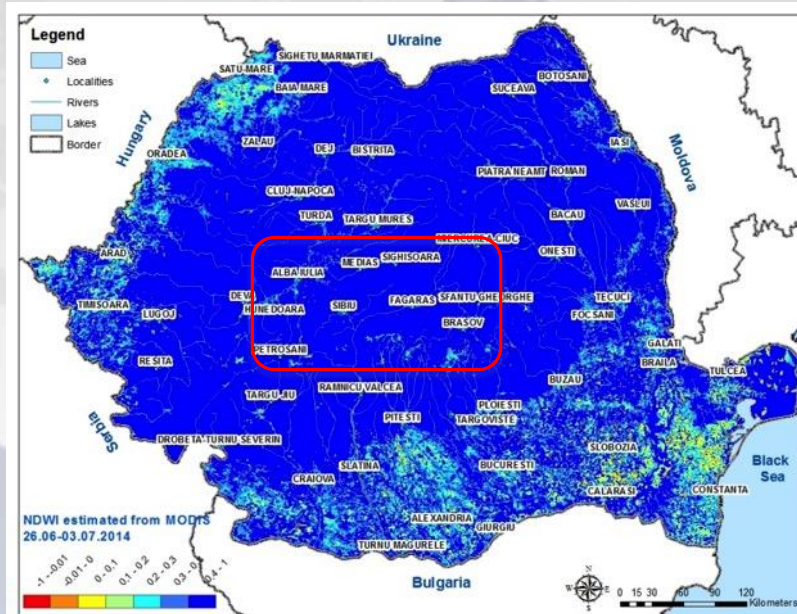
Using remote sensing data for drought monitoring

Vegetation indices (cont.)

NDWI: 26.06-3.07.2007

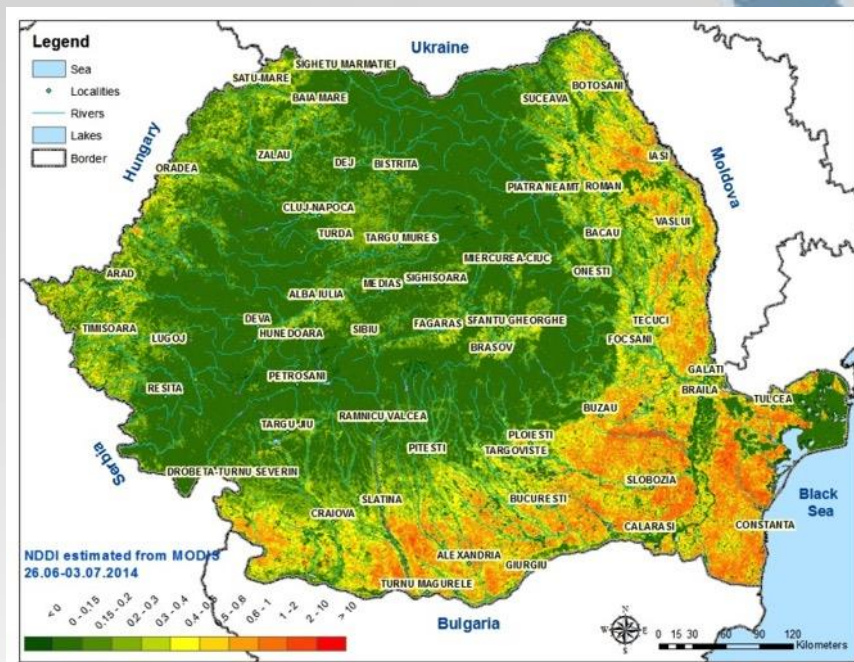The NDWI obtained from MODIS MOD09A1 products (8-days composite) for 2007 and 2014
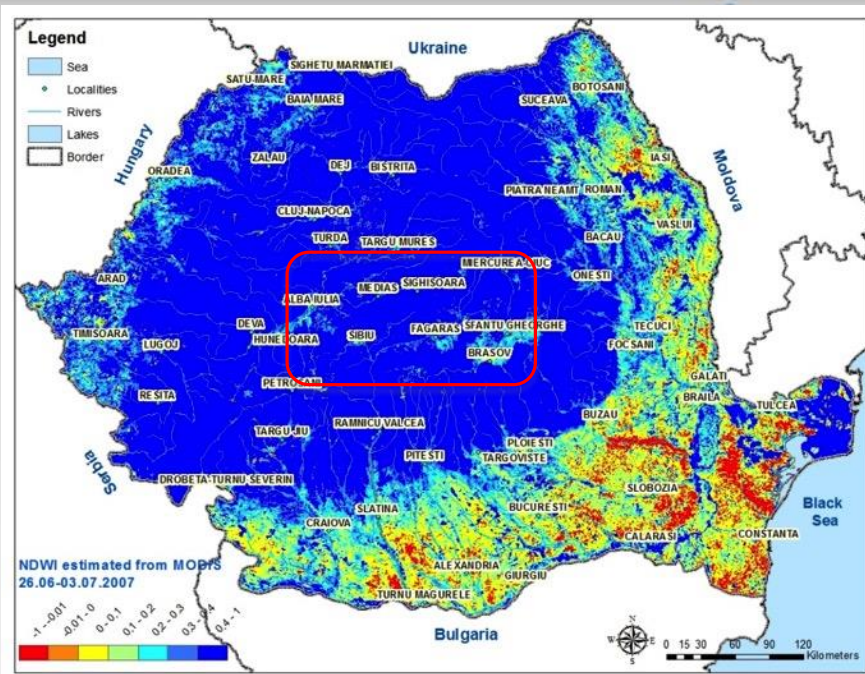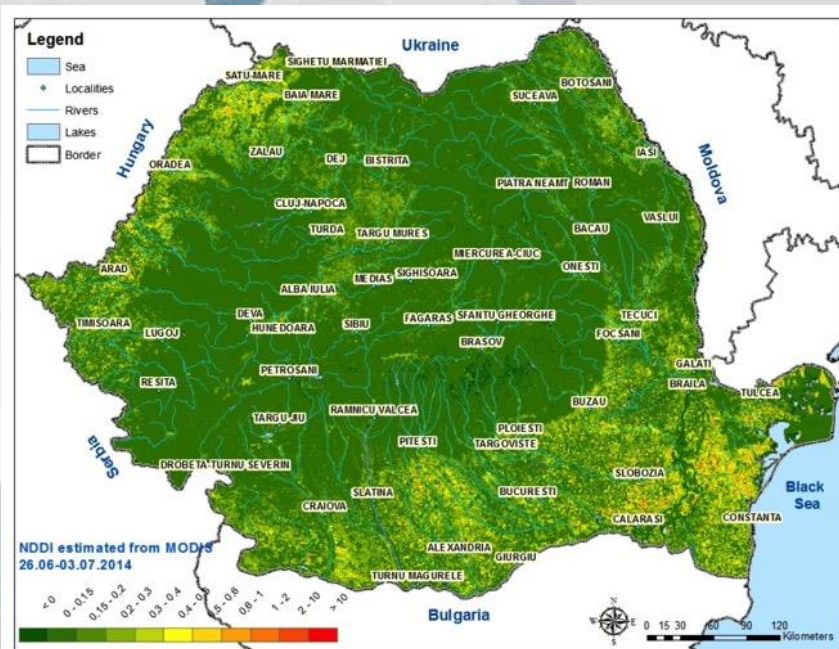

NDWI: 26.06-3.07.2014

Using remote sensing data for drought monitoring

Vegetation indices (cont.)

NDDI: 26.06-3.07.2007 droughty year

The NDDI obtained from MODIS - MOD09A1 products (8-days composite) 2007 and 2014 over Romania

NDDI: 26.06-3.07.2014

Biophysical parameters

- Leaf Area Index (LAI) is a key biophysical canopy descriptor, that is directly related to photosynthesis, evapotranspiration, and productivity of agro-ecosystems. Assessment of crop LAI and its spatial distribution are of importance for crop growth monitoring, vegetation stress, crop forecasting, yield predictions and management practices.

- Drought monitoring, corresponding to the state and dynamics of vegetation, in a given time interval may be accounting for LAI values derived from satellite data.

- LAI are generated globally from various sensors (AVHRR, MODIS, MISR, POLDER, SPOT-VGT, etc.) with data at different spatial resolutions (250 m to 1 – 3 Km) and temporal frequencies (4-day, 8-day and monthly).

- The algorithm for generating the MODIS LAI products uses surface reflectance (MOD09) and land cover (MOD12) products. The MODIS LAI algorithm is based on the analysis of multispectral and multidirectional surface reflectance signatures of vegetation elements.
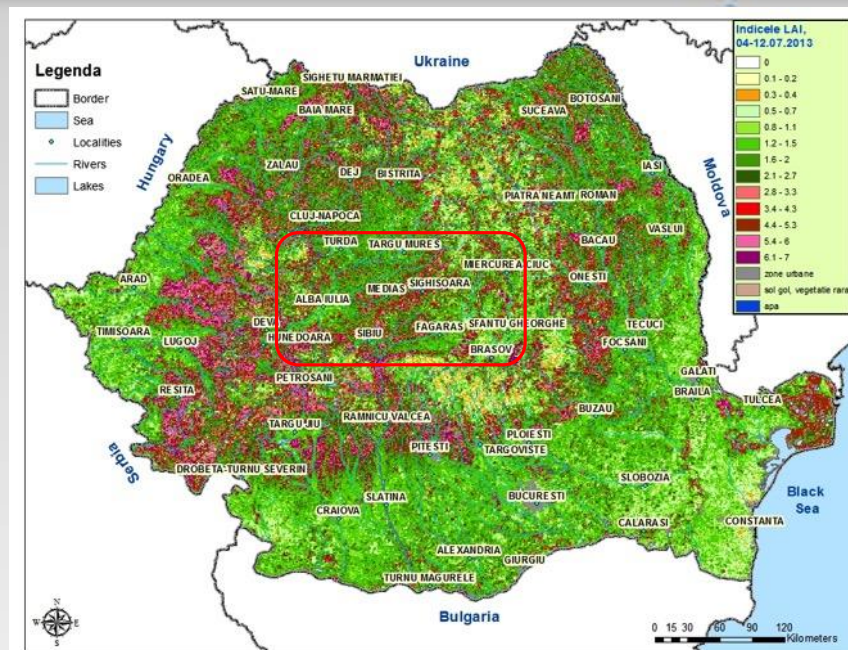
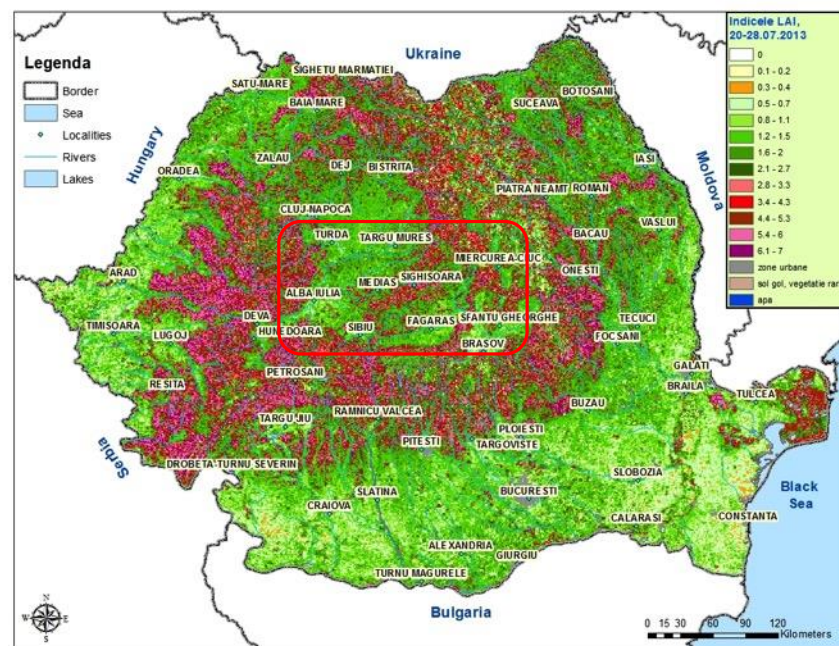# Using remote sensing data for drought monitoring

Biophysical parameters (cont.)

The LAI spatial distribution obtained from MODIS data

28.07.2013

12.07.2013

Using remote sensing data for drought monitoring

Conclusions

- 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.

- Remote sensing techniques can enhance and improve the drought analysis, especially considering the scarce availability of measured ground truth data.

- The advantage of multi-annual imagery availability allows the overlay and cross-checking of doughty, 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.

- Referring to the entire image without offering information on how vegetation indices reflects the behavior of various land-cover classes under drought stress.

Thank you for your attention !

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