Educational activities for initiating young people in space sciences and technologies

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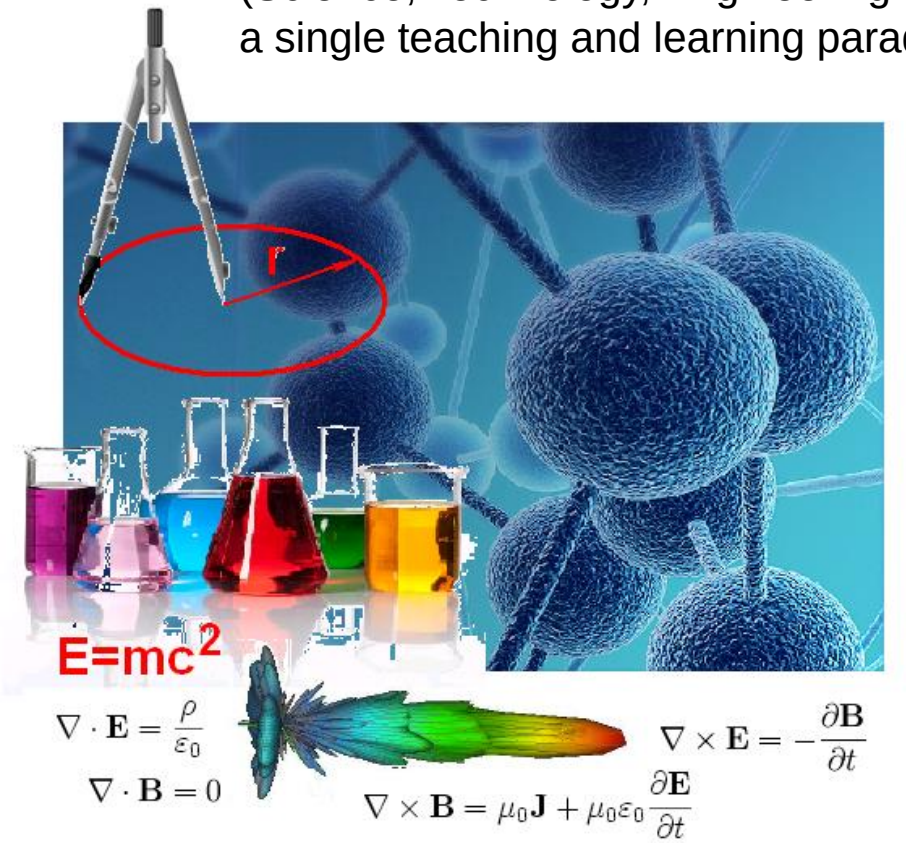
The STEM concept in education

- STEM education represents an interdisciplinary approach to learning in such way that rigorous academic concepts are coupled with real-world lessons.
- STEM concept removes the barriers between four areas of education (Science, Technology, Engineering and Mathematics) by integrating them into a single teaching and learning paradigm.



- **Science**
- **Technology**
- **Engineering**
- **Mathematics**

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STEM center endowment for space activities and technology initiation (exemplification)

In the field of Space Sciences:

- Telescope (astronomy)
- Radio telescope (radio astronomy)
- VLF (Very Low Frequency) reception equipment for analysis of EM waves (visualization of the spectrum, perturbation sources, etc.)

In the field of Space Technology:

- GPS receiver (time and geographical coordinates determination)
- Equipment for direct reception of images broadcasted by Earth observing LEO (Low Earth Orbit) satellites.
- Reception equipment for TV services broadcasted by GEO satellites.

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STEM center endowment for space activities and technology initiation: (exemplification)

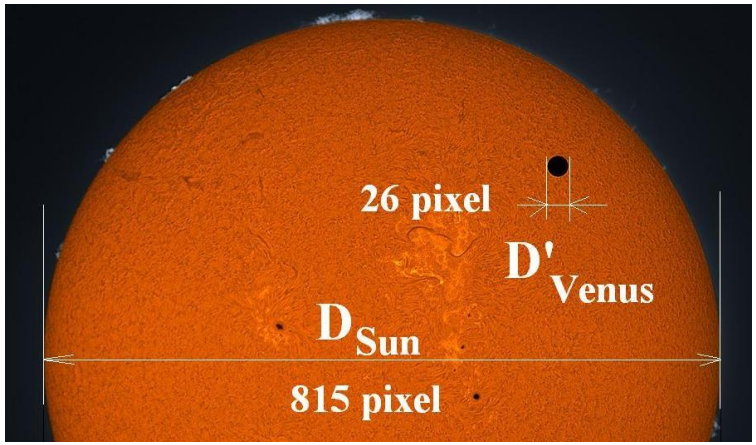
In the field of Space engineering:

- Equipment for monitoring the civil air traffic (radio navigation)
- Audio-video equipment for broadband radio link communication (using high directional Rx antenna)
- Photovoltaic panels
- Parabolic reflectors

In the field of Mathematics:

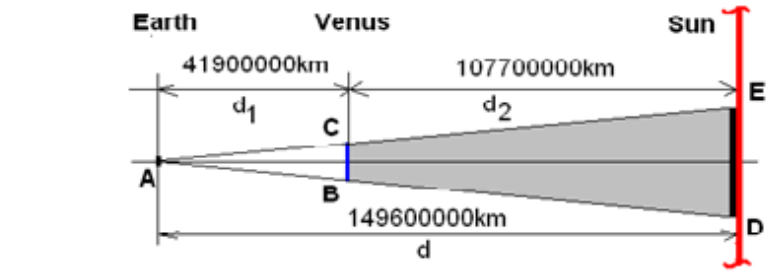
- All the above-mentioned equipment
- Laptop / PC (for processing, analyzing and storing experimental data)

Ratio determination of the Sun and planet Venus diameters, during Venus transit (June, 2012)



Apparent ratio: 815/26=31.35

Computed ratio: 111.9; The true ratio:115



$BC=D_V$: Venus diameter
$DE=D'_V$: Venus apparent diameter
D_S: Sun apparent diameter

$$\frac{D_S}{D'_V}=\frac{815\ \text{pixel}}{26\ \text{pixel}}=31.35$$

$$\frac{d_1}{d}=\frac{BC}{DE}=\frac{D_V}{D'_V} \Rightarrow D'_V=\frac{D_V\cdot d}{d_1}$$

$$\Rightarrow \frac{D_S}{D_V}=31.35\cdot\frac{d}{d_1}$$

$$\frac{D_S}{D_V}=111.9$$

The true ratio $\frac{D_S}{D_V}=115$

The relative Error < 2.7%

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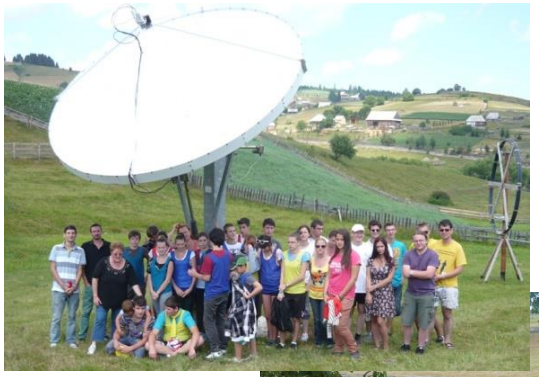
Brief statistics…

1) **The Next Generation Summer School – Marisel, Cluj county (**2010, 2011, 2012, 2015, 2016, 2017, 2018 - attended more than 170 students)
2) **ESERO training course on space activities and technologies** dedicated to physics and mathematics high school teachers (2014, 2015, 2016, 2017, 2018 – attended more than 120 teachers)
3) **ESERO training course in astrobiology and space technology** dedicated to biology, chemistry and physics high school teachers (2015, 2017,2018 - attended more than 70 teachers)
4) **Other occasional teaching activities** (2010-2018) attended more 250 young people



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“The Next Generation” Summer School – Marisel, Cluj

- **Initiation in space sciences**: astronomy, radio-astronomy, astrophysics and celestial mechanics.
- **Initiation in space technologies**: radio communication, DTH television, GNSS applications, spectral analysis techniques.
- **Initiation in space activities:** navigation, satellite image acquisition, meteorology at global level, etc.

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“The Next Generation” Summer School – Marisel, Cluj

- **Astronomy**: observations of celestial bodies in the visible spectrum, sunspots, solar clock, local meridian, etc
- **Radio communication:** audio and video radio link communication within the microwave frequency domain
- **Multimedia Technology**: recording audio/video signals using DVR (Digital Video Recording) equipment.
- **Spectral analysis**: analysis of sound waves and electromagnetic waves.
- **Radio astronomy**: scanning the sky within Ku-band educational purposes radio telescope and create a elementary map with different radio sources monitored.
- **Satellite technology**: GNSS applications, DTH television, remote-sensing satellites, photovoltaic panels

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Introductory course on space activities and technologies for mathematics and physics teachers (Marisel – 2014, 2015, 2016, 2017, 2018)

Purpose: training course aimed to inform teachers on how to use space-related fields as an attractive context for teaching students using STEM (Science, Technology, Engineering, Mathematics) concept

Lectures / presentations:

- ESERO Romania activities
- ESERO ESA activities
- CanSat competition in Romania

- Artificial satellites orbiting the Earth
- Fundamentals in space communications
- Initiation on space activities and technology

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Introductory course on space activities and technologies for mathematics and physics teachers (Marisel – 2014 2015, 2016, 2017)

Hands-on activities:

- Reception and spectral analysis of EM waves and interpretation of the spectrum.
- Obtaining the direction of the local meridian and the moment when the Sun crosses that meridian.
- Scanning the visible sky using a teaching-purpose radio telescope and developing an elementary map of the radio sources identified.

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Introductory course on space activities and technologies for mathematics and physics teachers (Marisel – 2014, 2015, 2016, 2017, 2018)

Hands-on activities:

- Audio-video radio link communication using high-directivity reception antenna
- Using GPS receivers to determine the exact time and geographical coordinates
- Real-time reception of images broadcasted by NOAA meteorological satellites
- Astronomical observations

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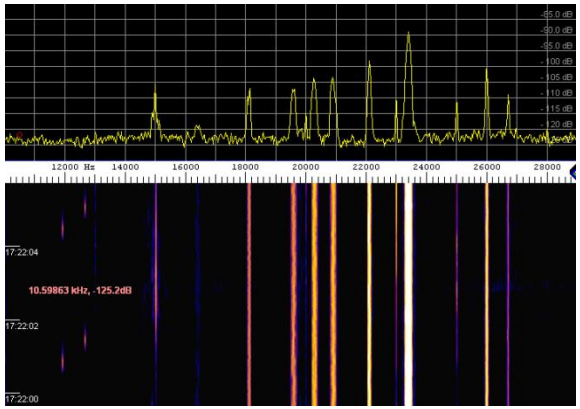
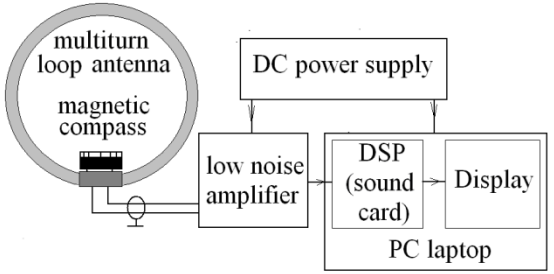
Monitoring and spectral analysis equipment for VLF electromagnetic waves (prototype equipment)



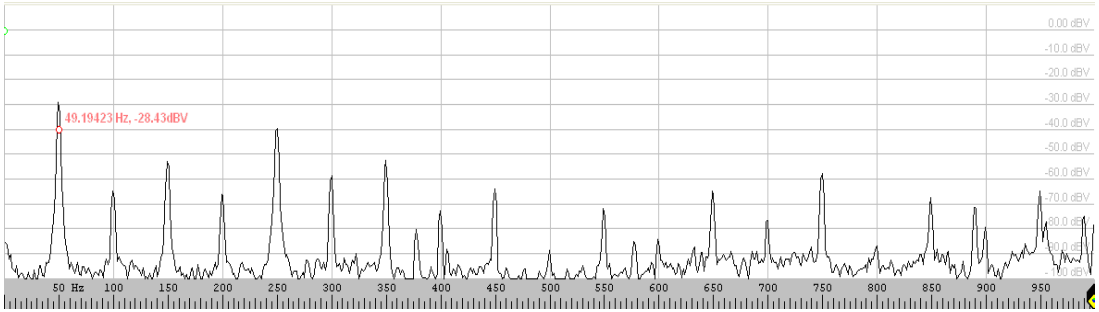
Characteristics:

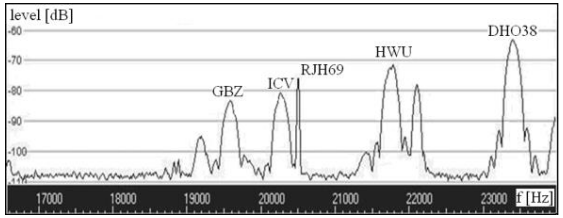
- Frequency domain: 30 Hz - 46 kHz (VLF)
- Reception and analysis of EM waves of natural / artificial origin:
  - Lightning, thunders
  - Low/high-voltage power grid lines
  - Electrical equipment: spark-ignition engines, trams, electric locomotives, etc.



STEM fields:

- Mathematics, Physics , Computer Science, Electronics, Telecommunications, Technology





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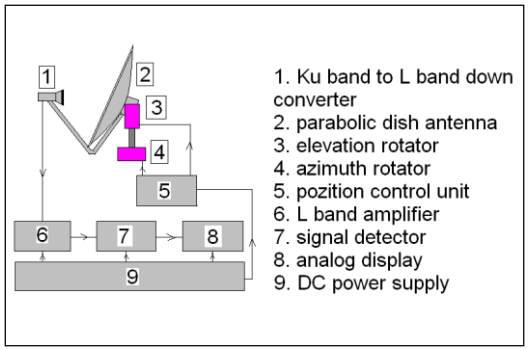
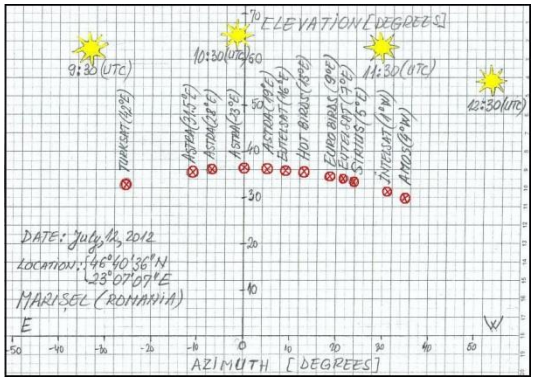
Dual axis teaching-purpose radio telescope
(prototype equipment)



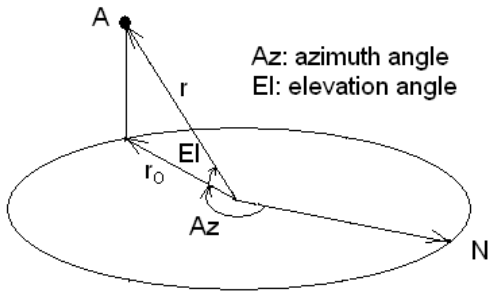
Characteristics:

- Mount type: Azimuth (AZ) – Elevation (EL)
- Parabolic reflector type: Offset
- Frequency domain: 10.7 GHz-12.75 GHz (Ku-Band)
- Control angles: AZ = -80°…+80° / EL= 0°…120°
- Analogue signal level indicator (actual)
- Digital signal level indicator (future development)
- Highly transportable



STEM fields:

- Mathematics (geometry, polar coordinates)
- Physics (wave reflection of parabolic surface, Sun's radio emissions, parallel and convergent beams, etc.)
- Astronomy (sun-meridian transit, detecting weak radio sources, GEO satellites, etc.)
- Technology (SatCom, DTH television, frequency conversion, amplification, detection, etc.)



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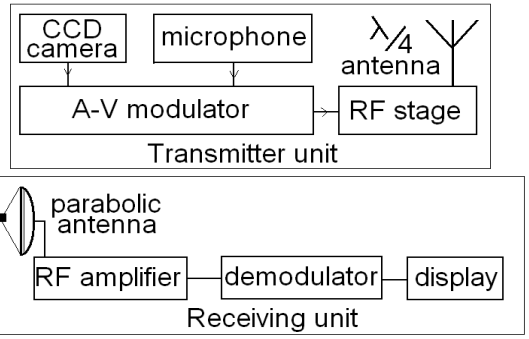
Audio-Video equipment for broadband radio link communication
(prototype equipment)

Characteristics:

- Frequency domain: ISM band (2.4 GHz)
- Broadcast antenna: omnidirectional
- A-V data sent using analogue (FM) modulation
- Power battery: 6F22 (9 V)
- Reception antenna: parabolic reflector (high directivity)
- A-V demodulated signal – compatible with TV monitor
- Stable radio link: ~ 500 m (line-of-sight)
- Highly transportable



STEM fields:

- Physics: EM waves, optics (reflection laws)
- Technology: Multimedia
- Engineering: Electronics, telecommunication

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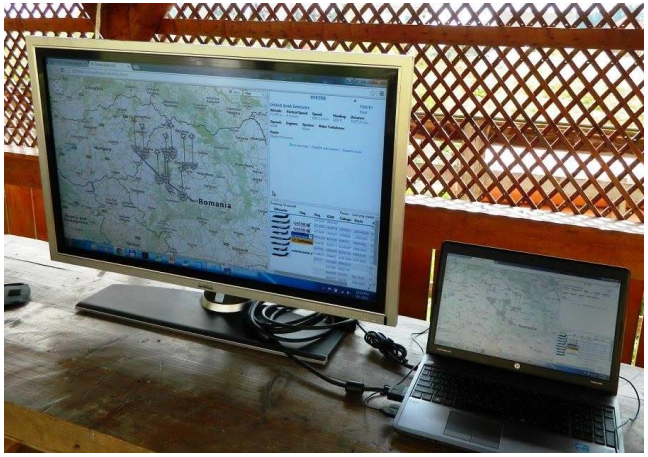
Civil air traffic monitoring equipment (prototype equipment)

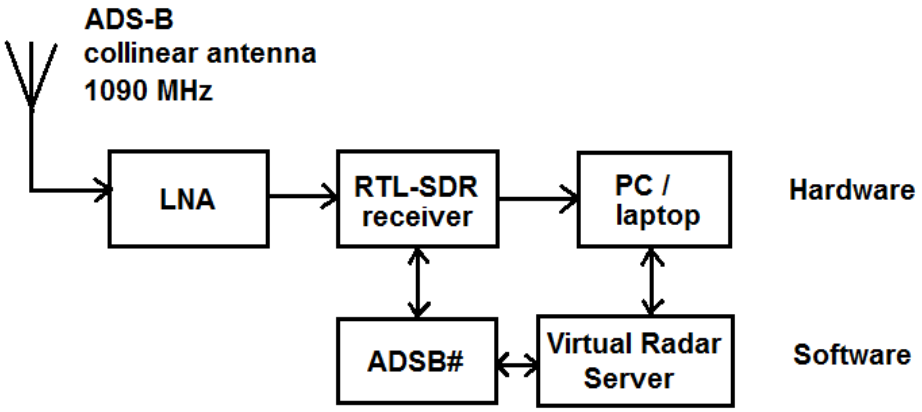
Characteristics:

- Reception frequency: 1090 MHz
- Provides direct reception of ADB-S (Automatic Dependent Surveillance – Broadcast) transmitters on-board aircrafts
- ADB-S provides data regarding: callsign, speed, heading and flight altitude
- Radio coverage: up to several hundred of km
- Highly transportable equipment

STEM fields:

- Technology, Navigation, Geography, Computer Science, Electronics, etc.





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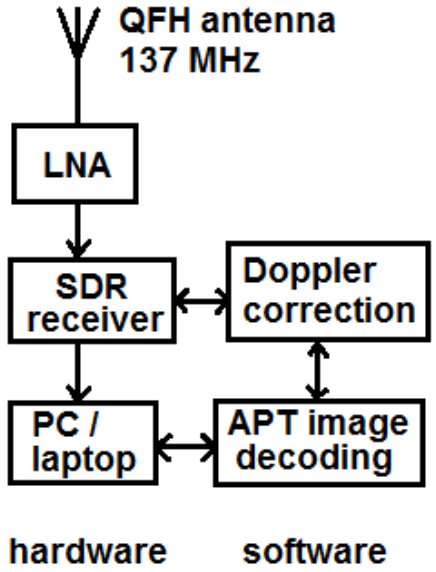
Weather satellite reception equipment (prototype equipment)

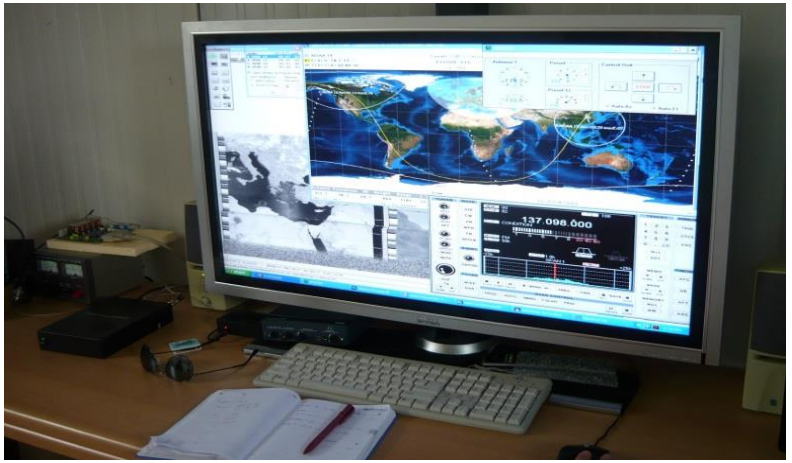
Characteristics:

- Direct reception from LEO (Low Earth Orbit) satellites
- Frequency domain: 137 – 138 MHz
- Real-time acquisition of weather images (different formats)
- Highly transportable equipment

STEM fields:

- Meteorology, Agriculture, Geography, Physics, Computer Science, Electronics, etc.

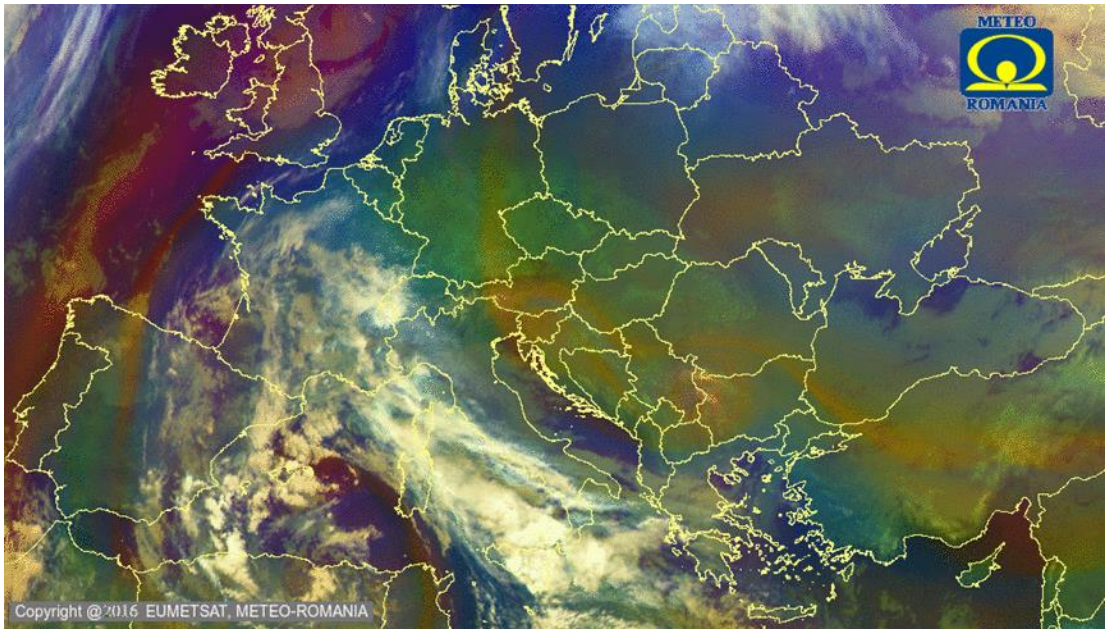


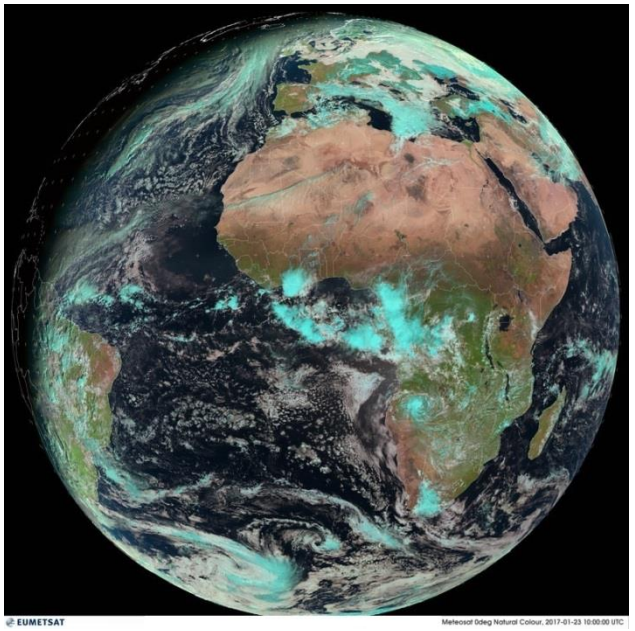


After completing the reception directly from the NOAA satellite we compared the images obtained with those provided by Meteosat satellites

Conclusions:

- Meteorological satellites provide useful information in agriculture, meteorology, climatology, hydrology and oceanography:
- Polar-orbiting satellites collect data for weather, climate, and environmental monitoring applications including precipitation, sea surface temperatures, atmospheric temperature and humidity, sea ice extent, forest fires, volcanic eruptions, and global vegetation analysis





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Teaching purposes equipment for estimating solar irradiance on Earth surface and solar energy conversion efficiency

Component parts:

- Steerable parabolic mirror
- Black container, positioned in the parabola focus, containing 200 ml of water
- Identical container containing 200 ml of water, heated by current supplied by the photovoltaic panels
- Digital thermometer
- Stopwatch
- Steerable photovoltaic panels
- Other materials: graph paper, sunglasses.

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Teaching purposes equipment for estimating solar irradiance on Earth surface and solar energy conversion efficiency

- The method for estimating solar irradiance on Earth surface use the formulas:

$$Q_1 = m \cdot c \cdot \Delta\theta_1 \,,$$

$$I = \frac{Q_1}{S_1 \cdot \Delta t} \text{ [W/sqm]}$$

where ***I*** is the solar irradiance and S_1 is the area of the parabolic reflector

- The electrical power generated by 1 sqm of the photovoltaic panel was estimated using the formulas

$$Q_2 = m \cdot c \cdot \Delta\theta_2$$

$$P_0 = \frac{Q_2}{S_2 \cdot \Delta t}$$

where S_2 is the area of the photovoltaic panel

- The conversion efficiency (η) was estimated using the formulas:

$$\eta = \frac{P_0}{I} = \frac{Q_2}{S_2 \cdot \Delta t} \cdot \frac{S_1 \cdot \Delta t}{Q_1} = \frac{\Delta\theta_2}{\Delta\theta_1} \cdot \frac{S_1}{S_2}$$

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Other educational activities, related to space solutions for precision farming, conducted at Marisel summer schools: initiation in satellite imagery

- Agricultural land monitoring regarding the state of vegetation

Satellite image of an agricultural area in 2005

The same agricultural area in 2014. The picture shows wind generators installed between 2010-2012

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Other educational activities, related to space solutions for precision farming, conducted at Marisel summer schools: initiation in satellite imagery

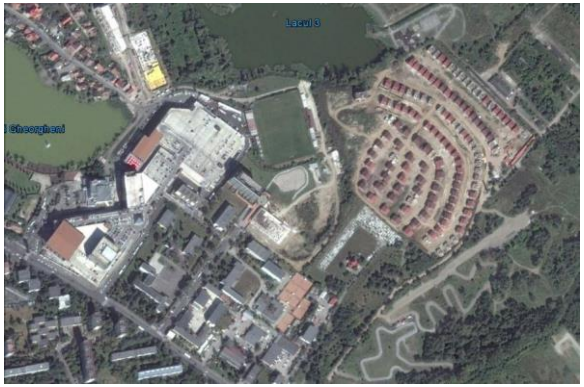
- Monitoring of the urban areas expansion

2003

2009

2012

2013



2014

2016

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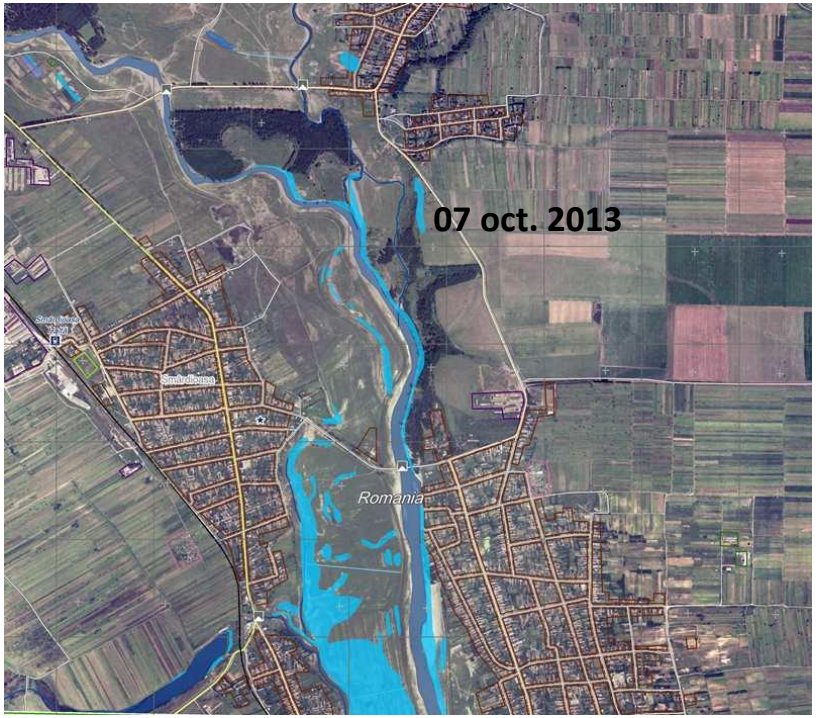
Other educational activities, related to space solutions for precision farming, conducted at Marisel summer schools: initiation in satellite imagery

- Monitoring of floodable agricultural areas

7 october 2013



20 april 2014

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Other educational activities, related to space solutions for precision farming, conducted at Marisel summer schools: initiation in satellite imagery

- Making maps using GPS receivers and graph paper
- Comparing these maps with satellite imagery

Point	Name	Latitude (North)	Longitude (East)
A	intersection of roads	46.668369	23.117029
B	road	46.666662	23.118028
C	intersection of roads	46.665121	23.118272
D	road	46.666927	23.119205
E	intersection of roads	46.668226	23.120814
F	road	46.666799	23.120585
G	road	46.666287	23.121001
H	church	46.668338	23.120604
I	house	46.668148	23.121202
J	hostel	46.667547	23.120428
K	hostel	46.667280	23.120117
L	the mayoral building	46.666417	23.120254
M	the police building	46.666123	23.120461
N	house	46.665525	23.119041

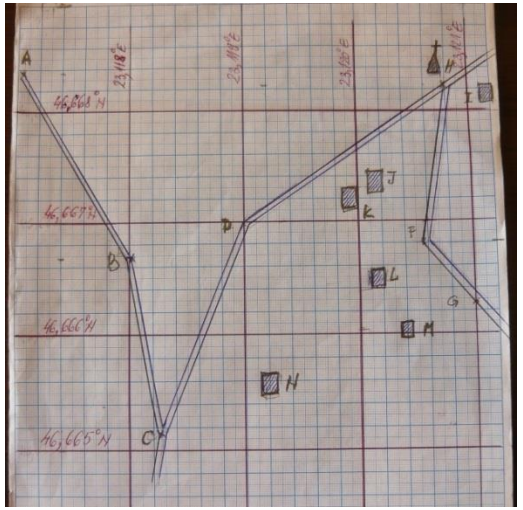

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Photo gallery









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Photo gallery

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Thank you for your attention !!

Teachers attending the “Introductory course on space activities and technology” (2015)