Spatial Data Architecture for Meteorological Operational Management in Romania

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Outline

- Context:
  - EC-INSPIRE directive and Romanian transposition
- Romanian National Integrated Meteorological System (SIMIN)
- Spatial Data Architecture for Meteorological Operational Management in Romania
  - MeteoRomania interoperable framework and spatial data infrastructure architecture: the online system – GEOMET
  - Application for Transboundary Flood Management: the FLOODSAT online system
- Challenges and conclusions
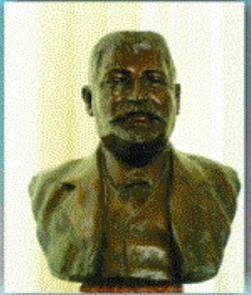
ROMANIAN
METEOROLOGICAL
SERVICE

Established in 1884

127 Years of History

http://www.meteoromania.ro

➢ **MeteoRomania** is the organization responsible for obtaining and spreading meteorological information in Romania.

➢ Romania is an **ECMWF co-operating state** and intends to become a full member in the near future.

➢ Romania is a **EUMETSAT full member** (December 2010).

➢ MeteoRomania is member of **ECOMET**.

INSPIRE: Directive 2007/2/EC as regards interoperability of spatial data sets and services

GOAL: to achieve interoperability, harmonization across spatial data themes and benefit from the endeavors of users' and producers' communities:

➢ international standards are integrated into the concepts and definitions of the elements of spatial data themes listed in the Directive 2007/2/EC Annex III:

- ▪ "13. **Atmospheric conditions**" (measurements, models…);

- ▪ "14. **Meteorological geographical features**" (temperature, precipitation, wind speed and direction…).

➢ requirements for data types, identification of spatial objects, metadata for interoperability, generic network model, other concepts and rules have to be applied to all spatial data themes.

➢ the classifications/definitions of spatial objects, their key attributes and association roles, data types, value domains and specific rules that apply to individual spatial data theme, have to be used.

Romanian INSPIRE transposition

➤ The Romanian Spatial Data Infrastructure (**SDI**) approach is truly national. Over the last years special efforts were made to develop and update key datasets which will become part of the Romanian SDI.

➤ Plans are made to develop components of the Romanian SDI, mainly through SDI related projects.

➤ SDI building blocks have reached a significant level of operation.

➤ As determined in **Ordinance nr. 4/2010 transposing the EC-INSPIRE directive**, the Council for National Infrastructure for Spatial Information (INIS Council) is the coordinating body established to implement INSPIRE and is composed from a number of National authorities and organizations.

GMES - INSPIRE

➢ Global Monitoring for Environment and Security (GMES) is a Joint EC ESA programme to establish a European capacity for the provision and use of operational information for monitoring and management of the environment.

➢ GMES in general and GMES in-situ component in particular can benefit from INSPIRE.

➢ Inspire is limited to EU27, however in most cases global coverage is required by GMES services;

➢ GMES services will be able to get access to many of the required data using Inspire services (Search, View and Download).

➢ Significant component will be forecast services from European National Met Services.

Romanian National Integrated Meteorological System (SIMIN)

Complex observation system, with networks for:

- 159 weather stations
- vertical sounder data
- Lightning detection
- actinometrical obs.
- upper-air soundings
- Radar data
- Satellite data

Regional Meteorological Centers

SIMIN:
Surface Observational Network

> Meteo Romania is operating **159** meteorological stations, **130** of them being automatic weather stations, and a network of 70 raingauges.

> **55** meteorological stations have agrometeorological program.
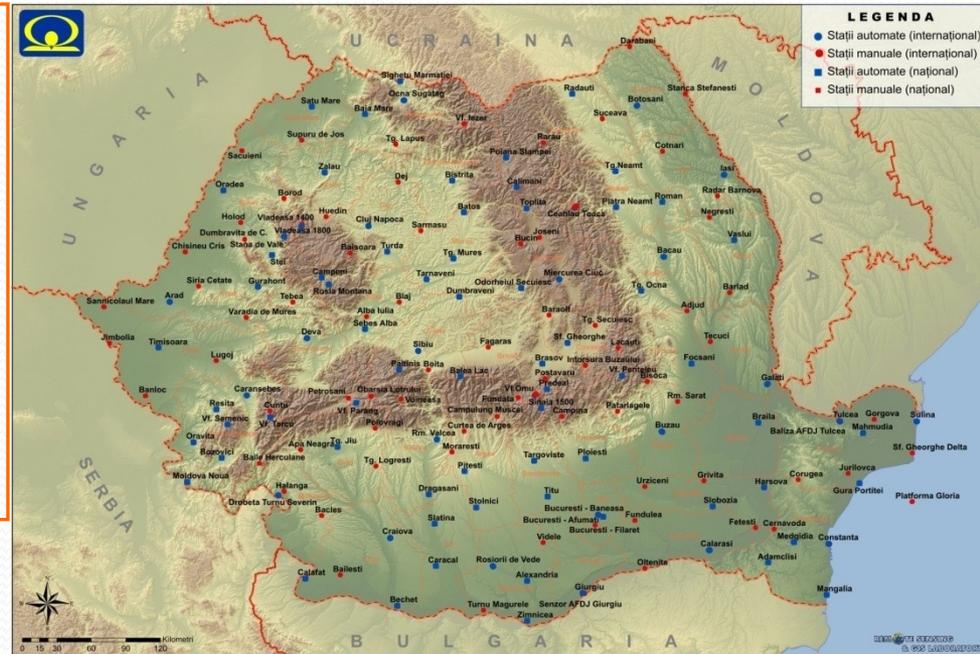
An internal project of modernising the maintenance system of the automatic network of weather stations has been finalised.

Now for all automatic weather stations in Romania the information regarding the status of each individual sensors is displayed online.

SIMIN: RADAR Network

Meteo Romania is operating a network of **8 Doppler radars:**

5 S-band: WSR-98D,

3 C-band: 2 EEC

1 Gematronik.
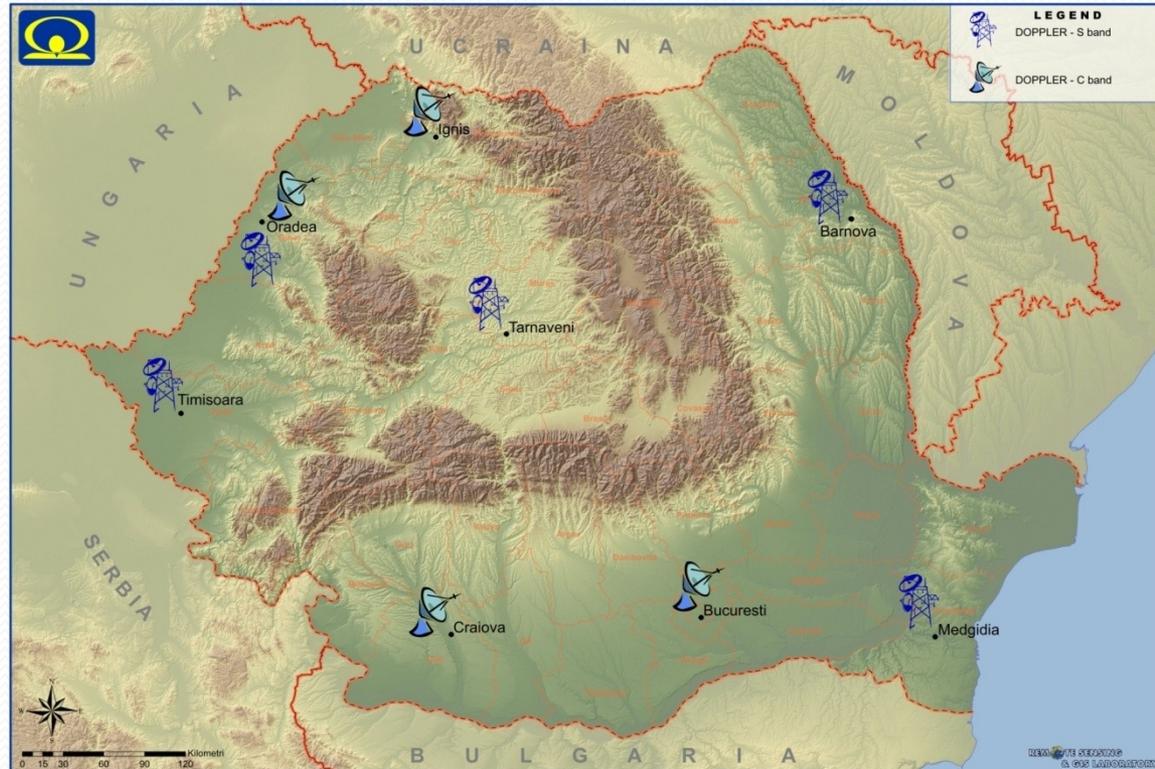
SIMIN:
Lightning Detection Network (SAFIR)

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SIMIN: Satellite receiving station

Satellite numerical data
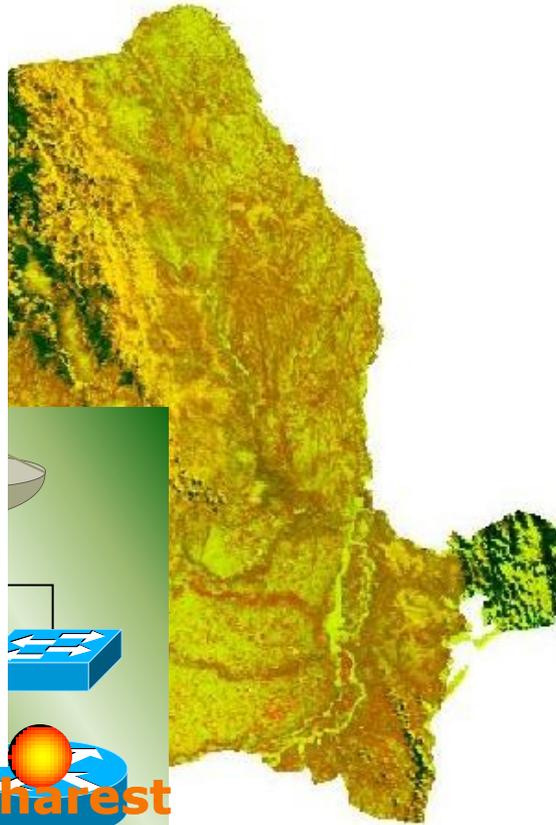
MSG data reception and processing station

NOAA HRPT data reception and processing station

Bucharest

SIMIN: National Meteorological Telecommunications System

The main characteristics of the network:

➤ at the central headquarters, structured cabling, UTP-cable based, connection among buildings through optical fibre (CISCO network equipment);

➤ 7 Regional Meteo Centres connected through VPN to the central headquarters;

➤ Regional Meteorological Data Communication Network (RMDCN);

➤ dual INTERNET connection.
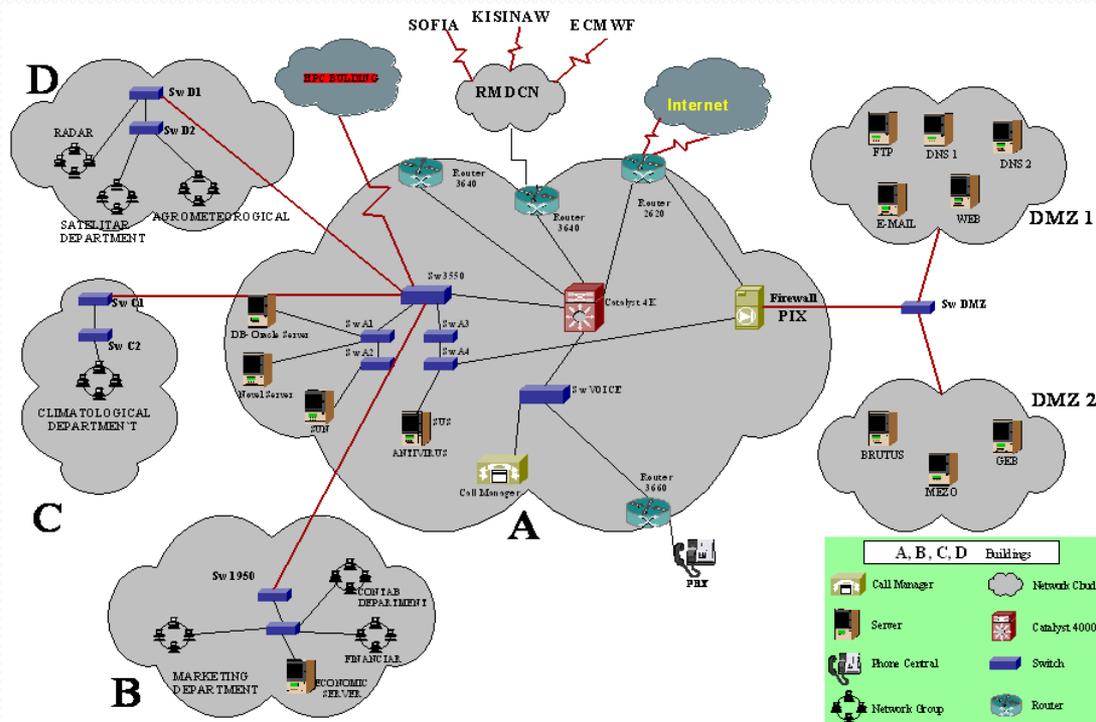
The telecommunications system has two components:

➤ Through SIMIN WAN, the national telecommunications system interconnects four radar sites, six Regional Forecasting Centres (RFCs) and the Operational Centre (COF)

➤ As a National Centre within WMO, the National Meteorological Administration is connected to the GTS (Global Telecommunications System) network, through RMDCN (Regional Meteorological Data Communication Network). Presently there are connected in this network with the Regional Centre in Sofia, with the World Centre in Moscow and with the ECMWF.

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SIMIN: Numerical Forecasting models

Meteo Romania is member of the ALADIN Consortium: since the feasibility stage of the ALADIN project (1991) for the development of the ALADIN model, especially designed for meso-scale phenomena simulation.

ALADIN model: operational since 1997;

currently: frozen version, mainly as a back-up solution.

- input for hydrological models within the DESWAT project;

- specialized forecast for different customers.

- Meteo Romania is member of the RC-LACE Consortium, from November 2006.
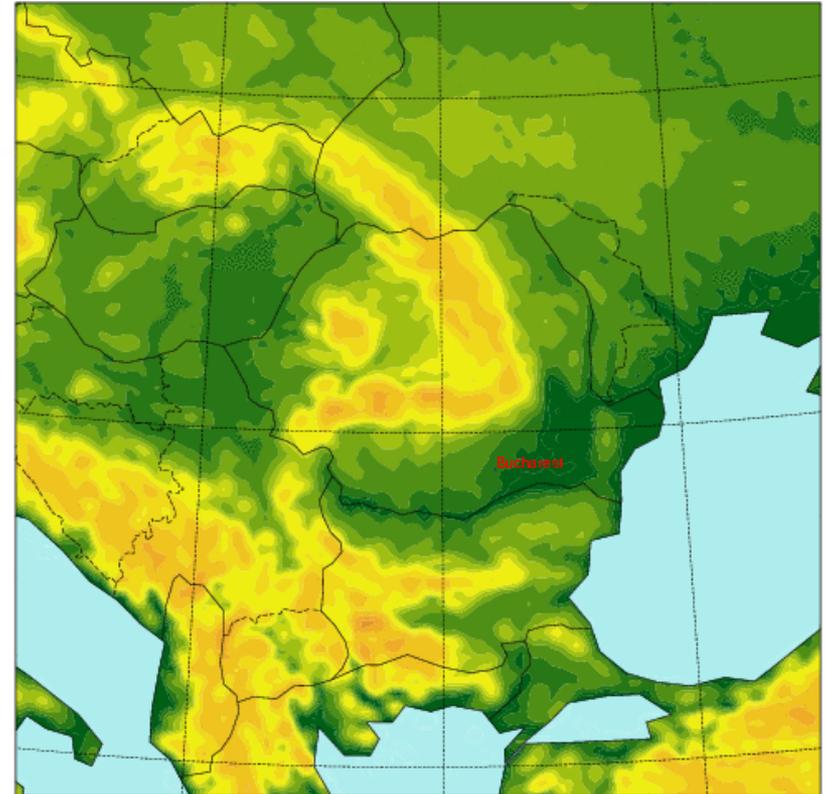
Δ=10 km, 144 x 144 points, 41 levels, integrated 4 times/day

Under the **ALA**   **s** contributed to
the research a   **LARO** model.

➢ **ALARO-Ro**

  •operationa

  •Δ=6.5 km   times/day
   (up to 78/

  • is used a   **odels**

  •**specializ**

➢ **ALARO-S**

  •operation

  •Δ=11.5 k   times/day

  •atmosphe   d circulation
  models)

➢ **ALARO-B**

  •experimental; input for **air quality model at urban scale**

  •Δ=2 km, 120 x 120 points, 49 levels.

Bucharest

MeteoRomania is member of the **COSMO Consortium**, since 2007)

➢ **COSMO-RO7**

- operational since 2008
- current version (from Ja...
- Δ=7 km, 201 x 177 poi...   ...day
  (up to 78 h)
- specialized forecasts for...
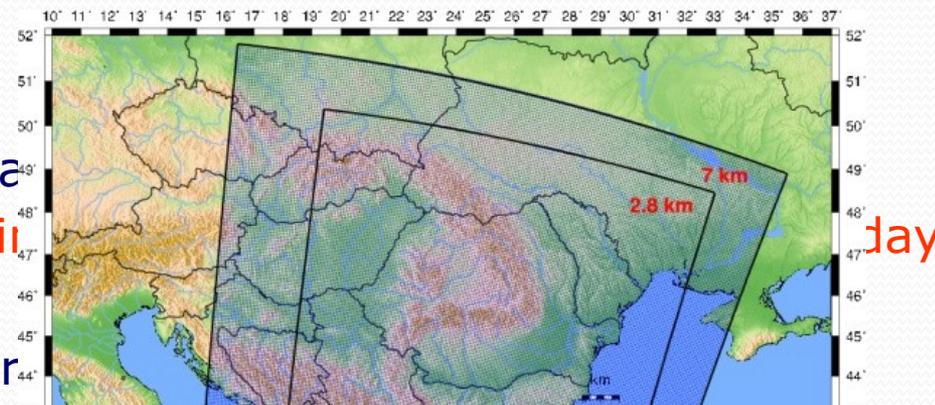
➢ **COSMO-RO2**

- operational since 2009
- Current version (January
- Δ=2.8 km, 361 x 291 points, 5...

➢ **HRM**

- Newest version operational fro...
- Δ=14 km, 217 x 229 points, ...
- coupled with the **pollution dis**...

NORUL DE POLUANT si CAMPUL DE VANT / CERNAVODA
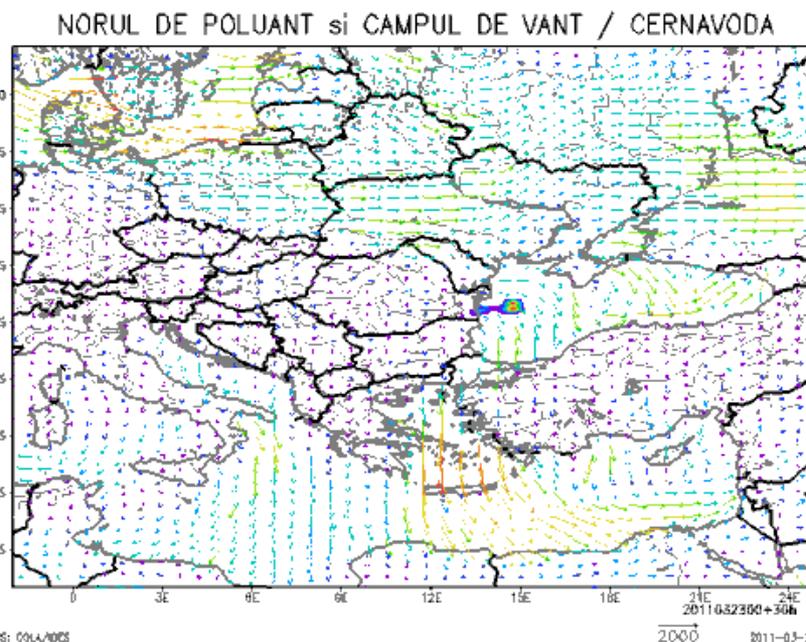
Use of the ECMWF products

➢**Deterministic model**

➢**Ensemble Prediction System**

for short and medium range forecast (days 1 to 7)

➢High Resolution Deterministic Model (16 km), carried out within the National Meteorological Administration of Romania;

➢Ensemble Model System, in graphic format or processed products from the ECMWF web site (epsograms, extreme weather indices, clusters, etc.).


Extreme Forecast Index
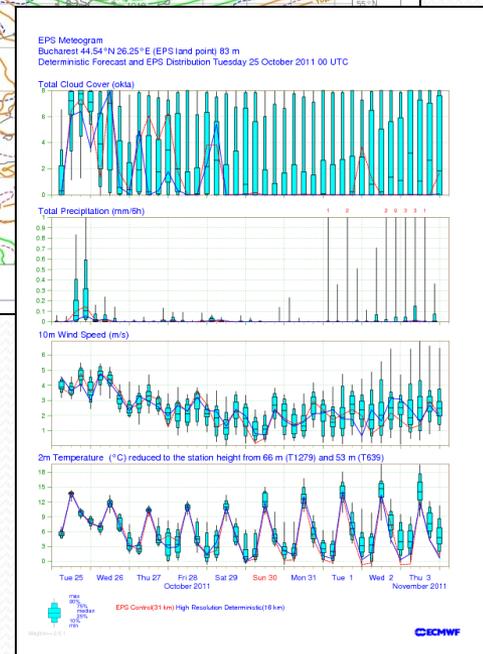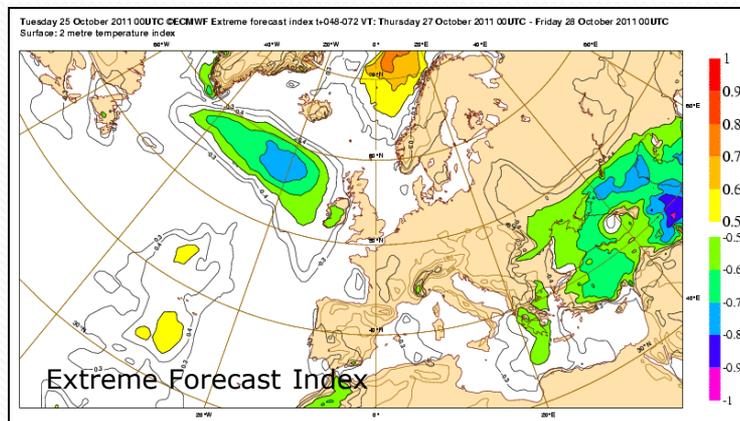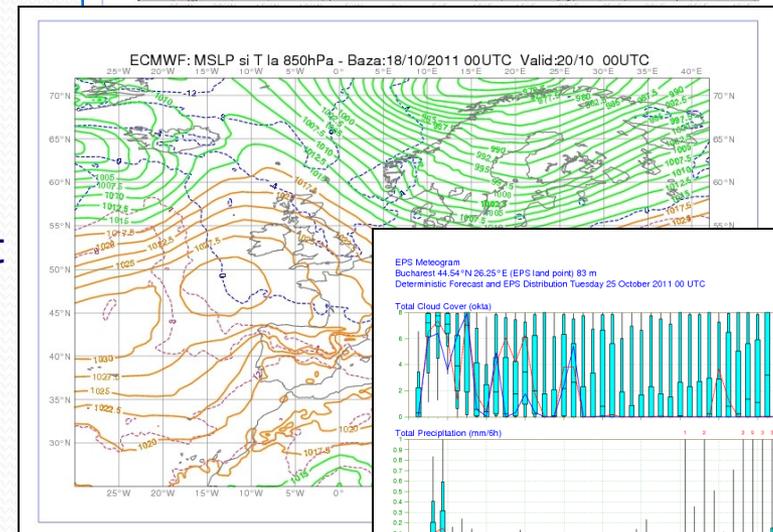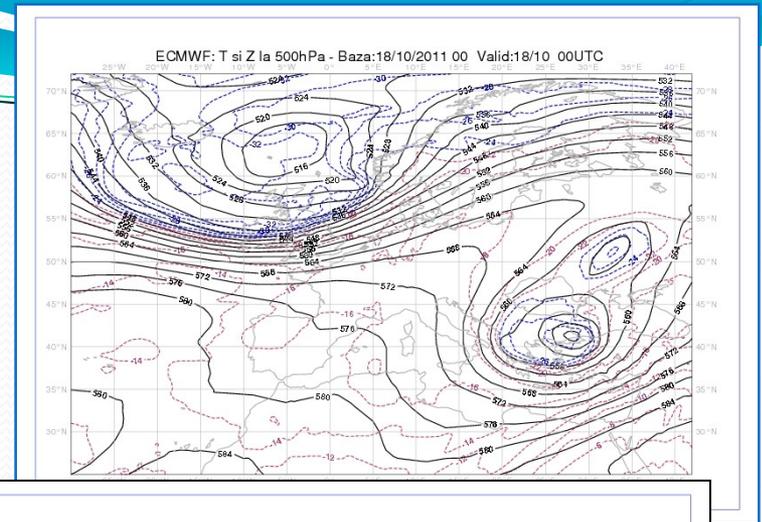
Use of the ECMWF products

The ECMWF products are used to achieve the statistic adaptation of the MOS extreme temperatures, 6-hour temperatures, wind speed, cloudiness and precipitation forecast at **159** weather stations.

2m Tmax, April 2012
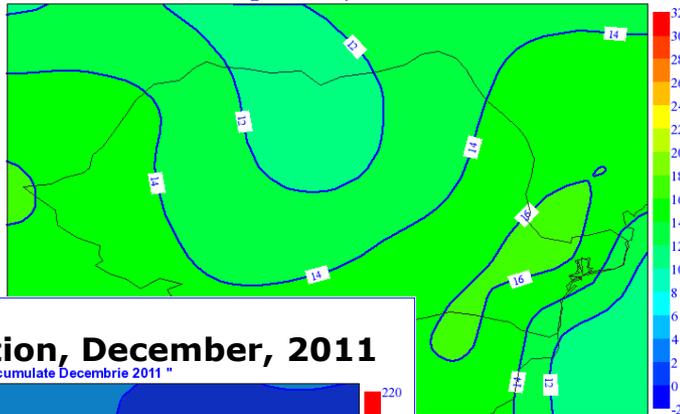
Total precipitation, December, 2011
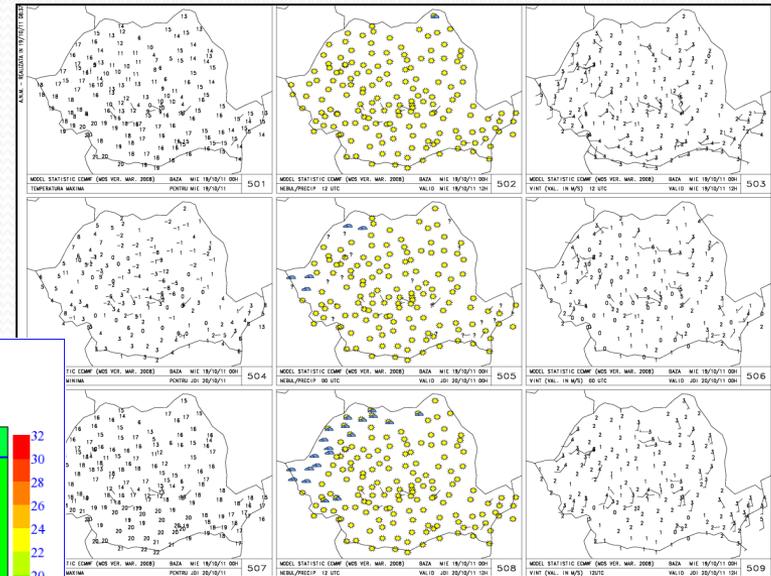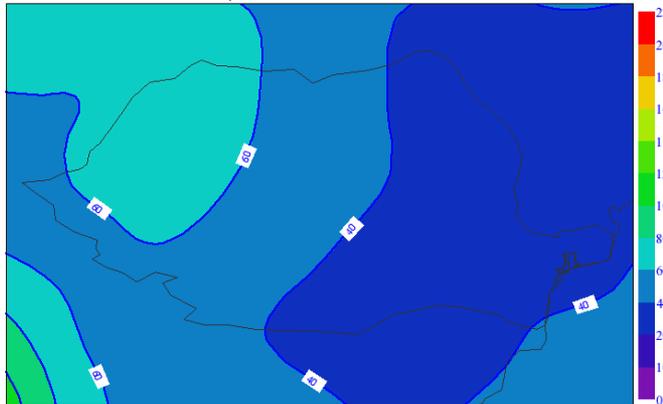
Products from the Seasonal Forecasting System (monthly means of ensemble means) are processed and interpreted over an area of interest for Romania.

The mean 2m-temperature (minimum, maximum and mean) and precipitation fields are visualized at resolutions of 1.25^0 and 2.5^0.

SIMIN: The visualization system

neX_REAP*
(Next Generation Real-Time Environmental Application Program)
Main goal: to provide an easy, powerful way to analyze, forecast, and use weather data.

Major operational functions:

- Weather data receiving, collecting and organizing.
- Weather data analysis.
- Preparation of weather warnings and advisories.
- Development of professional meteorologist briefings, displays and printouts (weather products).
- Clear, graphical and helpful distribution of weather products for private pilots, maritime operators, commercial planners and others who need understandable, user-friendly weather information.
- Weather product archiving (saving files).

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*Prepared by: Harris Corporation, Government Communication Systems Division (GCSD)
 For: Lockheed Martin Overseas Corporation (LMOC)
 For the Romanian National Integrated Meteorological System (SIMIN)

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SIMIN: The visualization system (cont.)

Functional Description

➢ The neX_REAP system is comprised of Commercial Off-The-Shelf (COTS), Non-Developmental Item (NDI) hardware, and Harris developed software items. The system receives, processes and disseminates satellite imagery, radar, alpha-numeric, and high resolution, graphical weather products for display.

Software Architecture

➢ The **neX_REAP** software typically utilizes a server and workstation configuration to receive weather information from external sources that can then be processed, stored, displayed or printed.

➢ The **neX_REAP** application provides a windows NT compatible graphical user interface (GUI), to provide a user-friendly, multiple window environment for the display and animation of graphical weather products to multiple users.

Communications CSCI

➢ The Communications Computer Software Configuration Item (CSCI) is responsible for handling (ingesting, receiving, transmitting, etc.) all of the neX_REAP external communications. This CSCI notifies the Decode/DB CSCI when data arrives and transmits requests for new data from the Display CSCI.

Decode/DB CSCI

➢ The Decode/DB CSCI is responsible for decoding and storing data, as well as site control (retention), product generation, alarm/alerts and archival. Decoded and pre-generated products are made available for display at the Meteorologist's Workstation and Briefing Terminals. This CSCI also handles A/N requests from the Briefing Terminals.

Display CSCI

➢ The Display CSCI provides workstation system control, acquisition control, product manipulation and word processing for the meteorologists. This CSCI can also save products for transmission to the Briefing Terminals.

Briefing Terminal CSCI

➢ The Briefing Terminal CSCI utilizes the neX_REAP software to manage the viewing and manipulating of alphanumeric and graphical weather products. This CSCI also interfaces with the Decode/DB CSCI to provides the downloading of weather products.

Data Ingest Process

➢ This information may be useful to a maintainer if a certain data type or types are missing or functioning properly. By understanding the software processes, decoders, and databases that handle each data type, maintainers can logically derive which processes may be suspect and restart them as necessary.

```
                    ┌──────────┐
                    │ Software │
                    └────┬─────┘
        ┌────────────┬───┴────┬────────────┐
   ┌────┴────┐  ┌────┴────┐ ┌─┴───────┐ ┌──┴────┐
   │  COMM   │  │ DECODE  │ │ DISPLAY │ │  BT   │
   │  CSCI   │  │  CSCI   │ │  CSCI   │ │ CSCI  │
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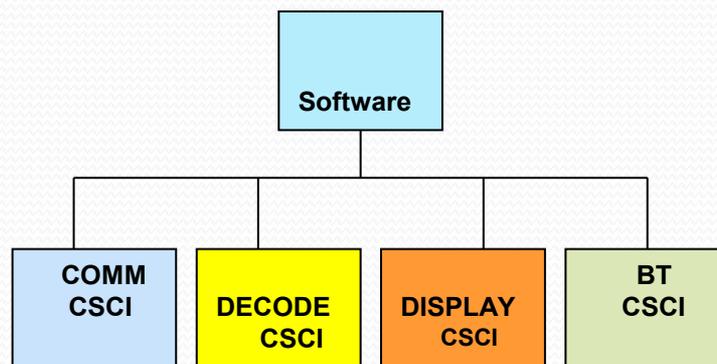
Data flows into the server and to the proper database

SIMIN: The visualization system (cont.)

- The neX_REAP system consists of a menu-driven graphical user interface which uses point-and-click interaction.
- This system provides a window environment with an interactive screen interface.
- The various menus on the menu bar enables the user to:
  - performing save, print and send options;
  - overlaying information;
  - requesting alphanumeric data;
  - viewing XY Diagrams;
  - initiating and controlling animation loops;
  - initiating and controlling product sequences;
  - requesting products from specific times, and controlling the image size or viewing areas.

SIMIN: The visualization system (cont.)
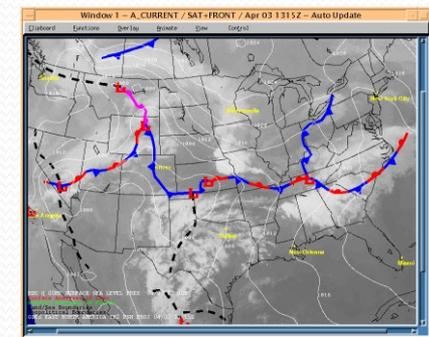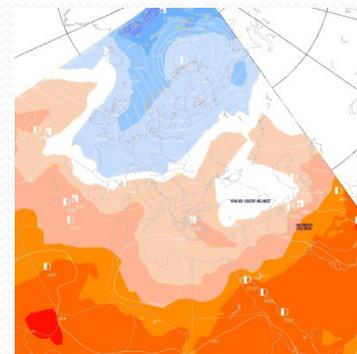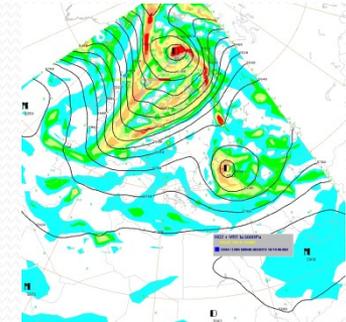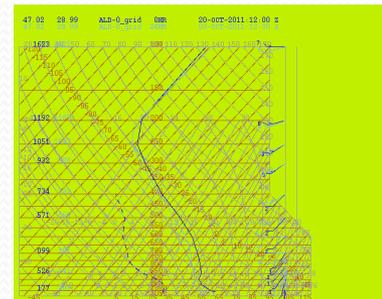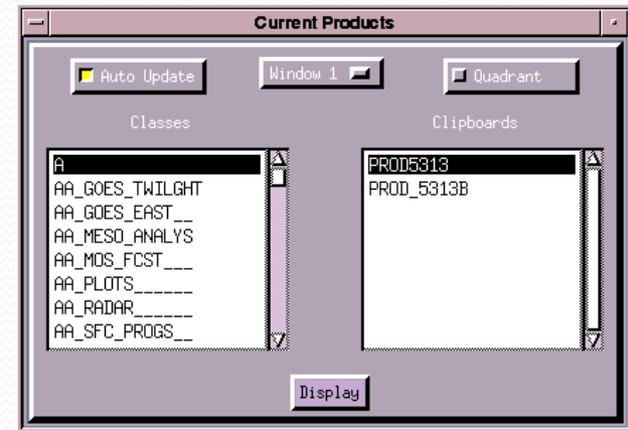
Product Control Window
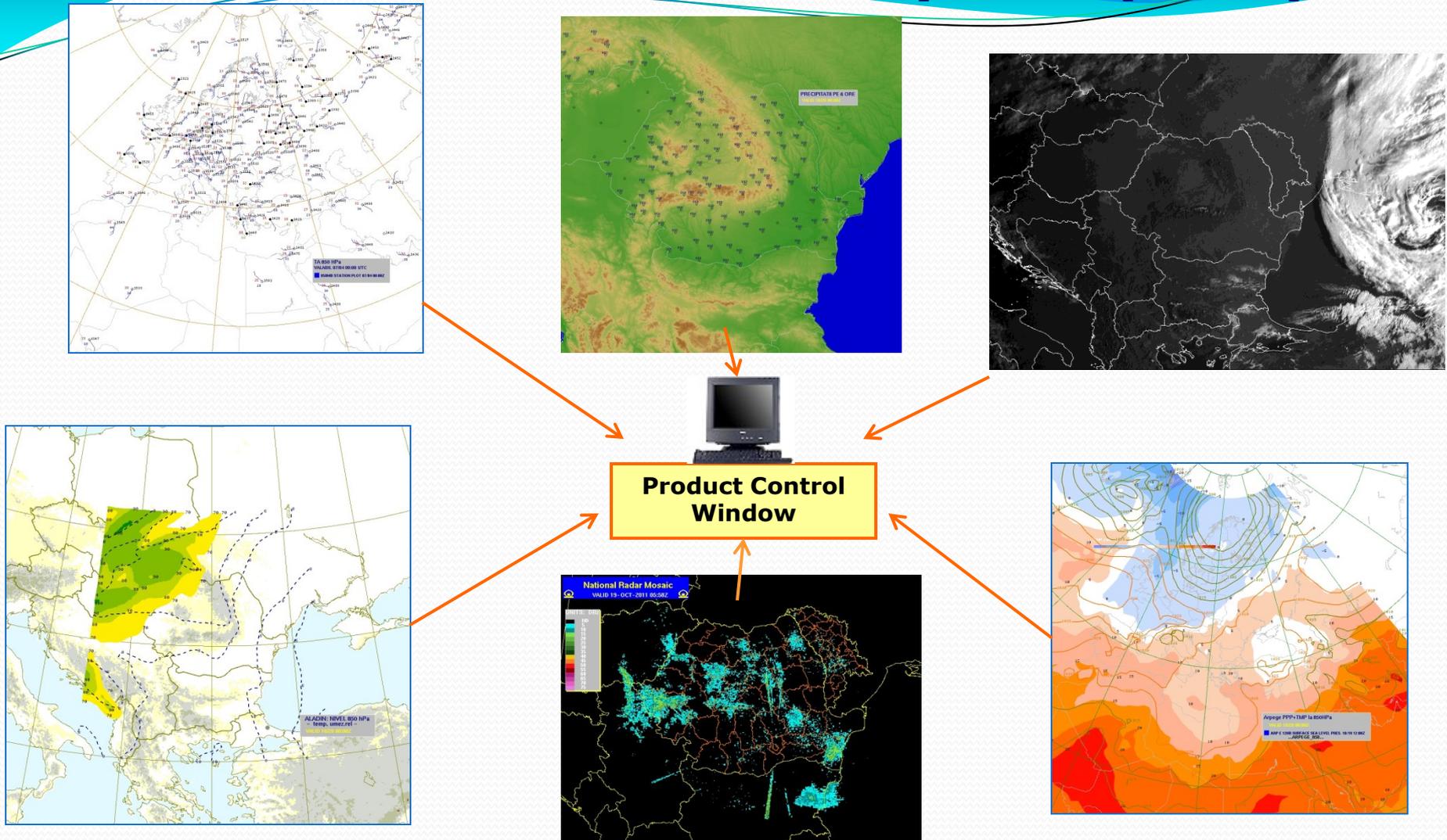
- ➤ The Current products options is the main tool used by users to display a product in a **PWC (Product Control Window)**.
- ➤ Typical products are satellite imagery, radar imagery, geographical maps, and other meteorological data.

SIMIN: The visualization system (cont.)

Constraints and limitations

- The system can not be implemented on a new computing platform, the actual platform being morally and physically surpassed;

- Some settings are hard coded in, which implies the impossibility to use facilities for changing a numerical model domain (e.g. the freezing level, vertical sections and upper-air polls prognostic);

- The new data in standard WMO formats BUFR, CREX, GRIB2, (for international operational exchange by the GTS) are not supported;

- There are also some limitations related to change of colors to zoom and unzoom, printing (resolution maps, and product quality printed format), etc.

Spatial Data Architecture for Meteorological Operational Management in Romania

Goal:

Initiating and developing of an **interoperable framework** for the management of the available **observation and forecasting meteorological geoinformation**, able to contribute to rounding off a national spatial data infrastructure (SDI) , in conformity with the provisions of the European Directive INSPRE.

Objectives:

➤ Designing an **online system "GEOMET"**, based on open source applications, allowing the management of meteorological data in a geospatial context;

➤ Implementing the data cataloguing component using the **GeoNetwork** Open source application;

➤ Application for heavy rain and related transboundary flood management.

The online system "GEOMET"

➢ Effectively achieve the system through developing a **webmapping client** based on the open source OpenLayers library.

➢ The application implements the most relevant international standards concerning the description of the geographic information:

- ISO 19139 (GI -- Metadata -- XML schema implementation);
- FDGC (Federal Geographic Data Committee);
- Dublin core (Dublin Core Metadata Initiative).

➢ The application's architecture is compatible with OGC (Open Geospatial Consortium) standards regarding the Geospatial Portal Reference Architecture and the CSW (Catalogue Service for Web).

➢ The implementation of the data cataloguing component will be based of the **GeoNetwork** Open source application:

- Geonetwork open source is a standard web application for the management of geospatial information.
- Geonetwork is the reference application for implementing the specification regarding the interrogation and retrieval of information coming from the web (CSW) catalogues.
- Geonetwork supplies a complex metadata editor as well as advanced search functions for the data indexed on the basis of metadata, using descriptive and spatial criteria.

The online system "GEOMET"

Functionality of GEOMET

- Searching geospatial data in local or distributed catalogues;

- Downloading and uploading geospatial datasets;

- It includes an interactive webmapping application which allows combining geospatial layers using the WMS (Web Mapping Service) standard. This application can also be used for introducing the spatial data search criteria.

- Online generation of maps and reports and their export in a PDF format;

- Programming CSW-compatible sampling sessions of metadata from the distributed servers;

- Synchronizing the metadata among the distributed catalogues;

- Managing the users and user groups;

- Defining policies for accessing data by user levels.

The online system "GEOMET"

Data search

The cataloguing application supplies two interfaces for searching the indexed data:

1. **Simple** (implicit): allows the search following key words and / or the geographic location.

2. **Advanced:** supplies multiple search criteria including spatial ones, key words, temporal criteria, etc.

Metadata introduction

The cataloguing application supplies two possibilities for introducing metadata:

1. Using the **online editor** (selecting one of the three templates: ISO, FDGC or DC).

2. **Importing XML metadata** created with an external editor.

Metadata sampling

➢ Is based on the **unique universal identifier (uuid) concept.**

➢ Each metadata set created with **Geonetwork, or with a CSW – compatible editor** has such an indicator associated.

➢ **Updating** the metadata, from a network sampling nodes network is performed such that only those metadata sets are downloaded that have undergone modifications between the moment now and the last updating.

➢ **Propagation** takes place from node to node and the metadata sampled until a certain moment by one node can also be transmitted to other nodes, without the need of those nodes to access the parent node.

Application for heavy rain and related transboundary flood management

FLOODSAT is a dedicated on-line system, based on meteorological information, satellite data and GIS technology, for geospatial information management.
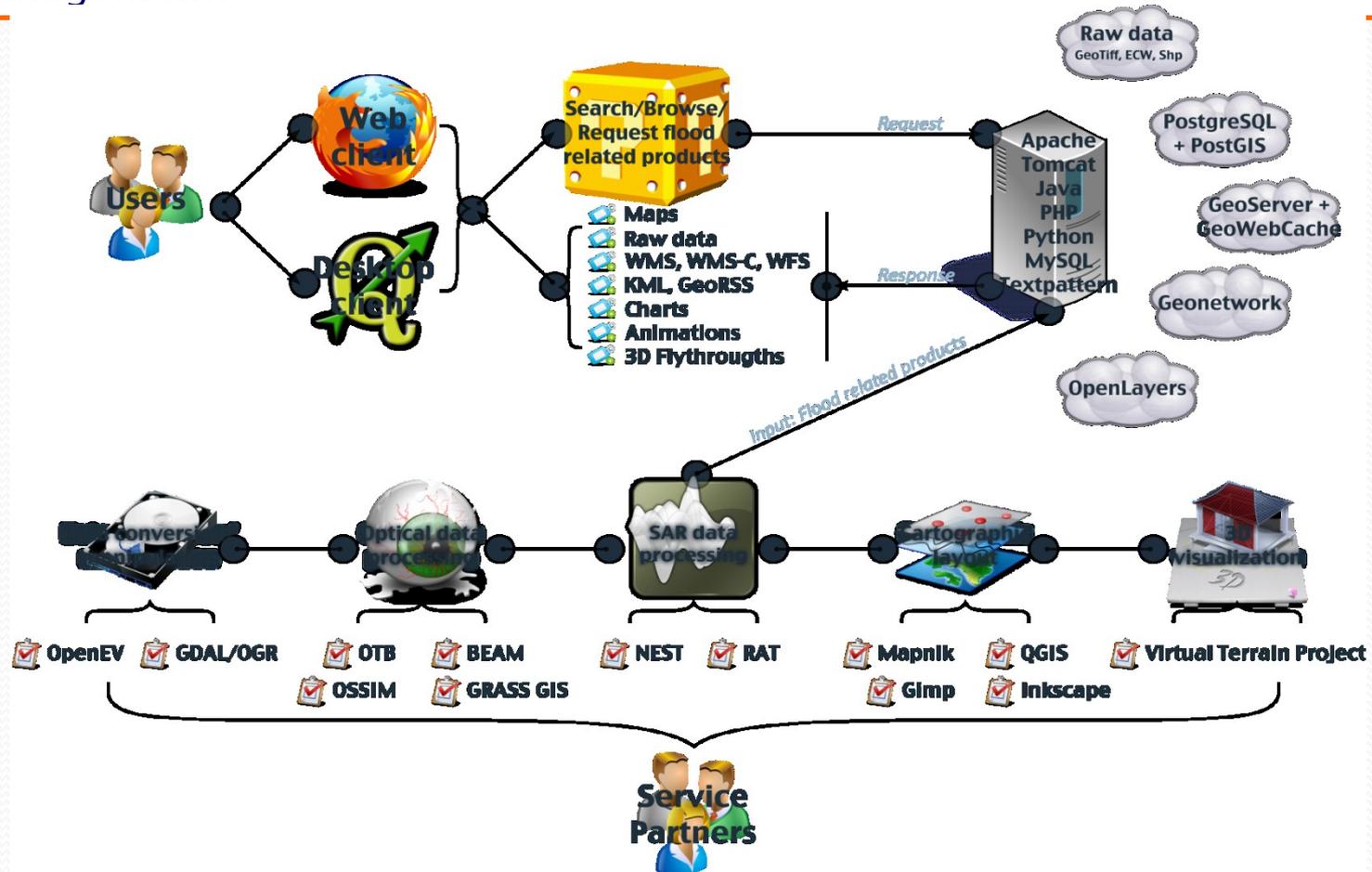
FLOODSAT online system: main functions

- Acquisition, storage, analysis and interpretation of data;
- Management and exchange of raster and vector graphic information, and also of related attribute data for the flood monitoring activities;
- Handling and preparation for a rapid data access;
- Updating the information (temporal modification);
- Data restoring, including the elaboration of thematic documents;
- Generation of value-added information (complex indices for flood prevention, risk maps);
- Distribution of the derived products to authorities, institutions, media, etc.

FLOODSAT: Flow chart
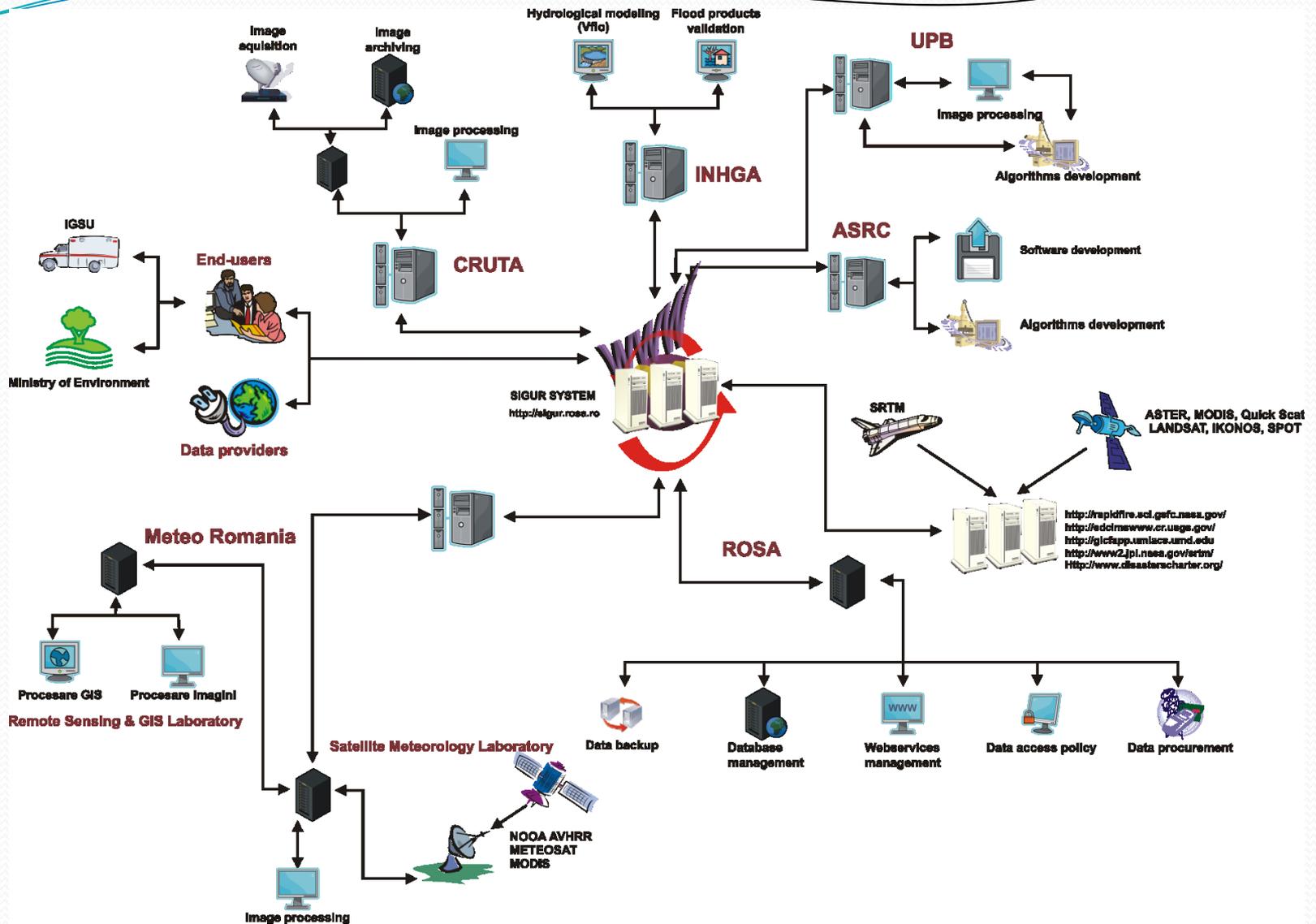
FLOODSAT: Satellite data processing chain
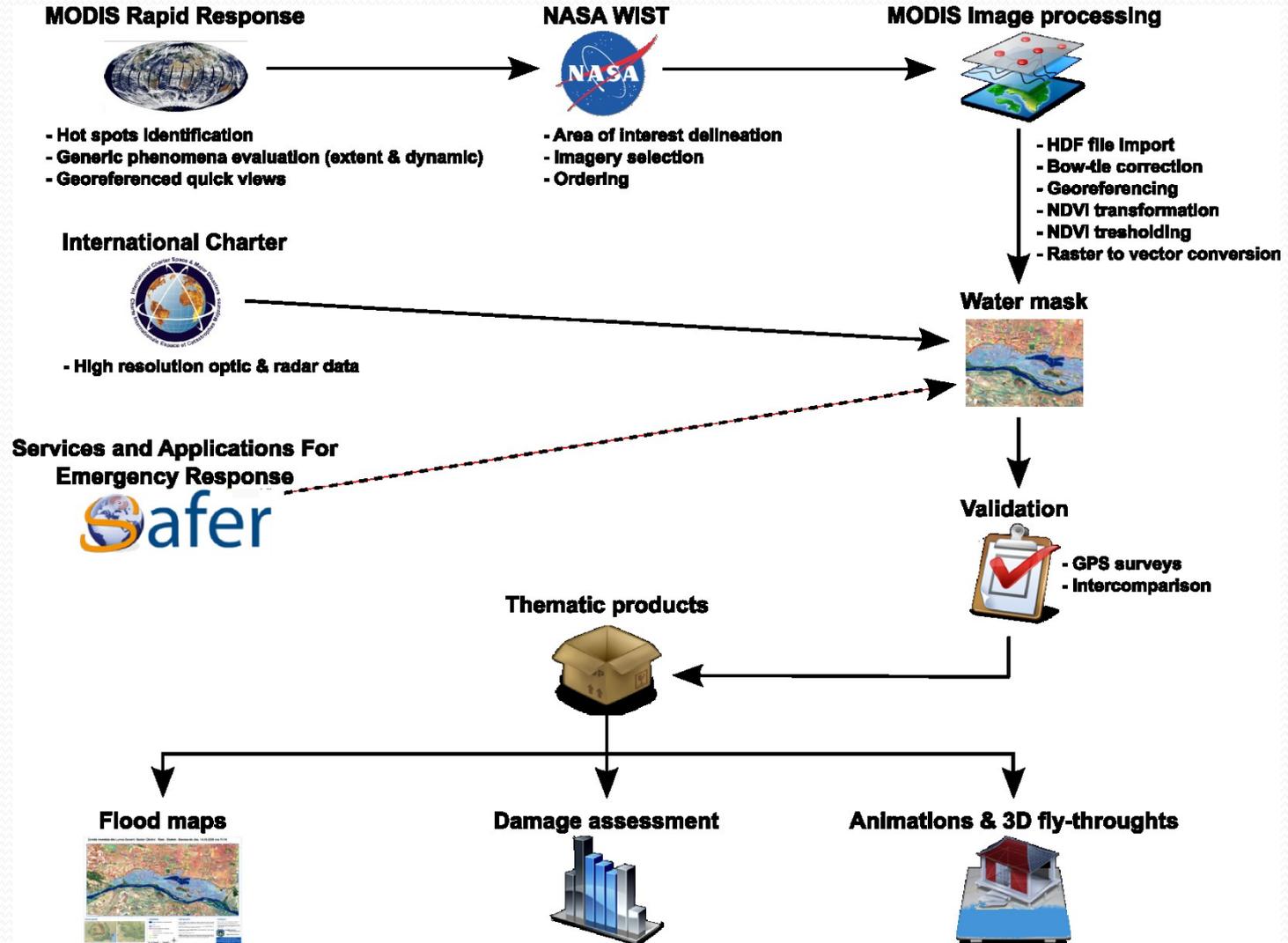
FLOODSAT online system
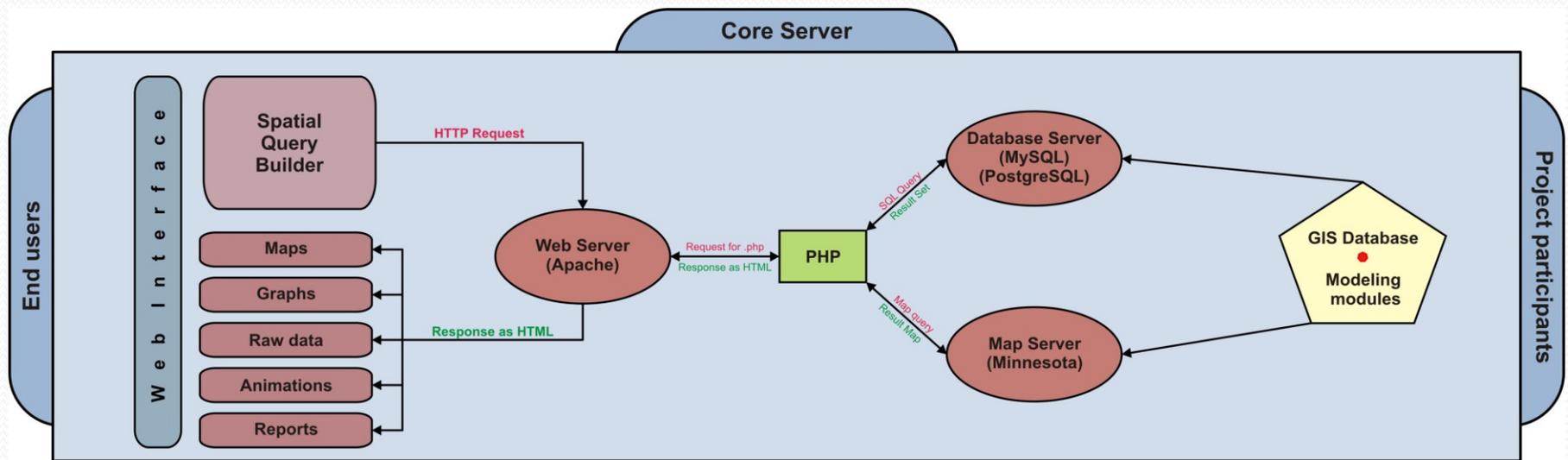
- ➢ Typical products are: numerical weather forecasting and warning, hydrological/hydraulical model outputs, satellite-derived products, radar-derived products, geographical maps, and other meteorological data.

- ➢ End-users can access the system using a simple Web browser (like Internet Explorer or Mozilla Firefox) to display, query, analyze and retrieve information.

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FLOODSAT: geospatial products

Maps of the flooded areas with satellite image as background

Animations

Flooded areas merged in a GIS environment
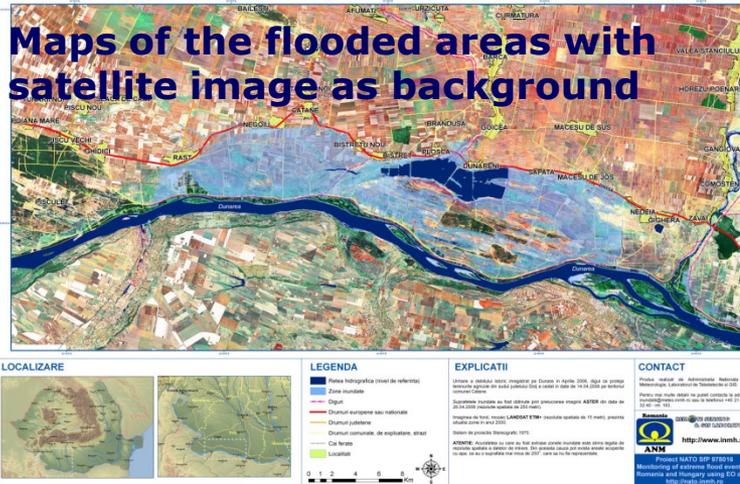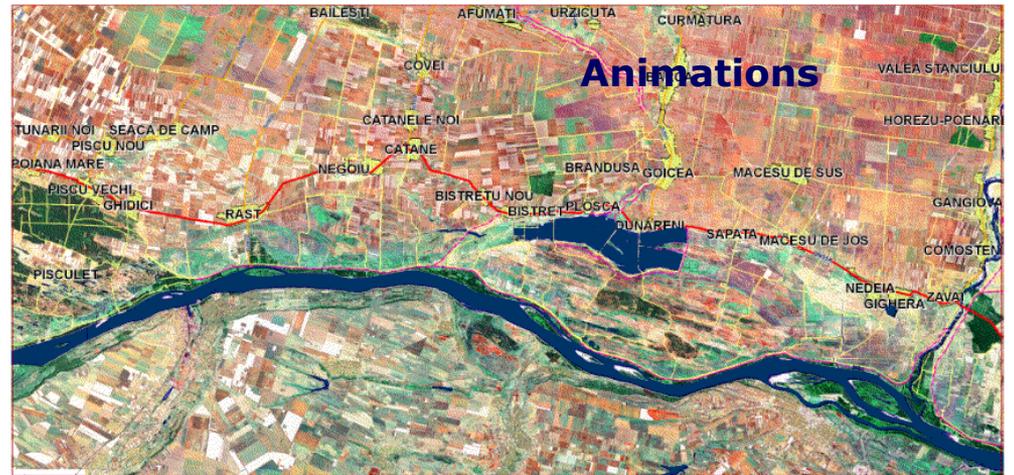
Romania flood hazard map Based on satellite data
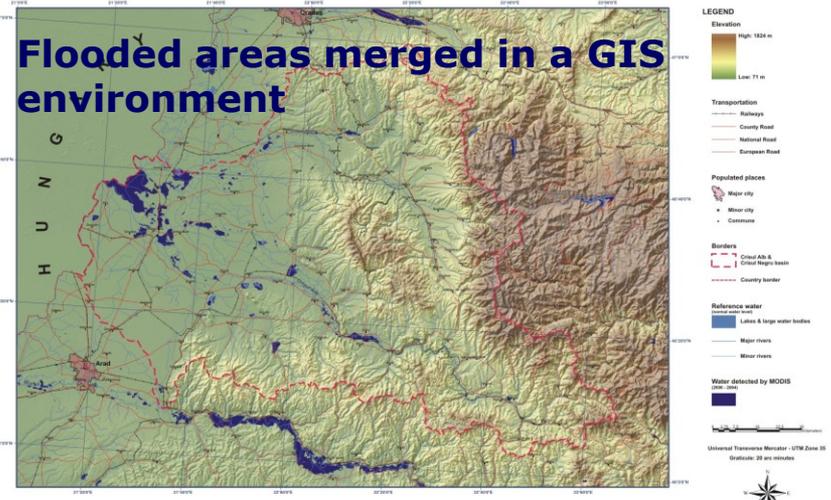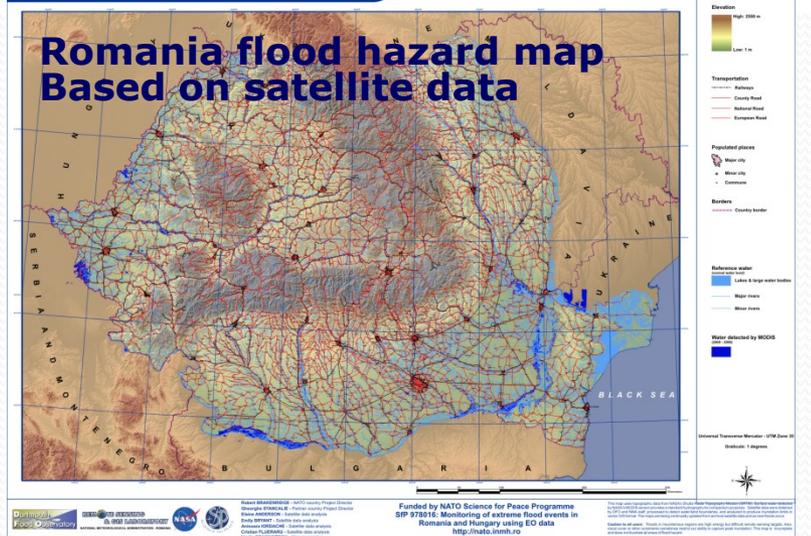
FLOODSAT: geospatial products

Satellite and radar loops
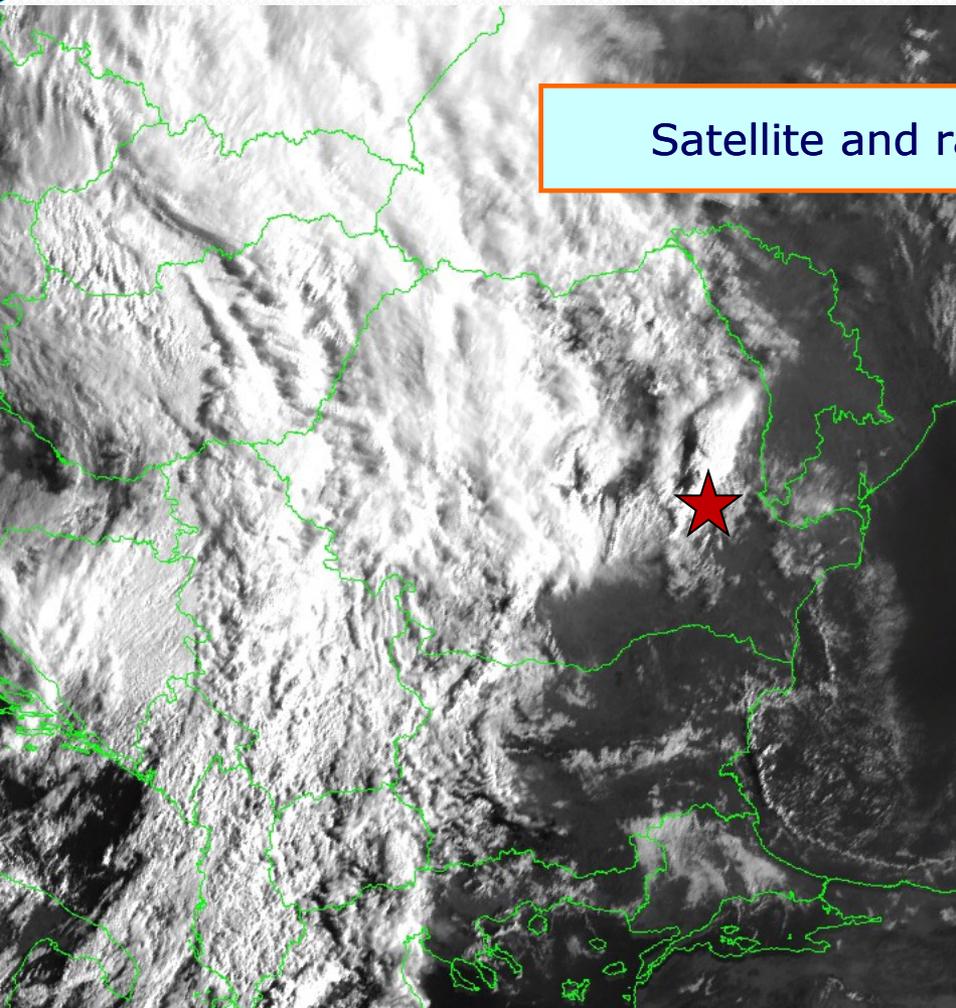
Barlad flash flood – 05.09.2007 – Tecucel basin

FLOODSAT: geospatial products

Discharge forecast
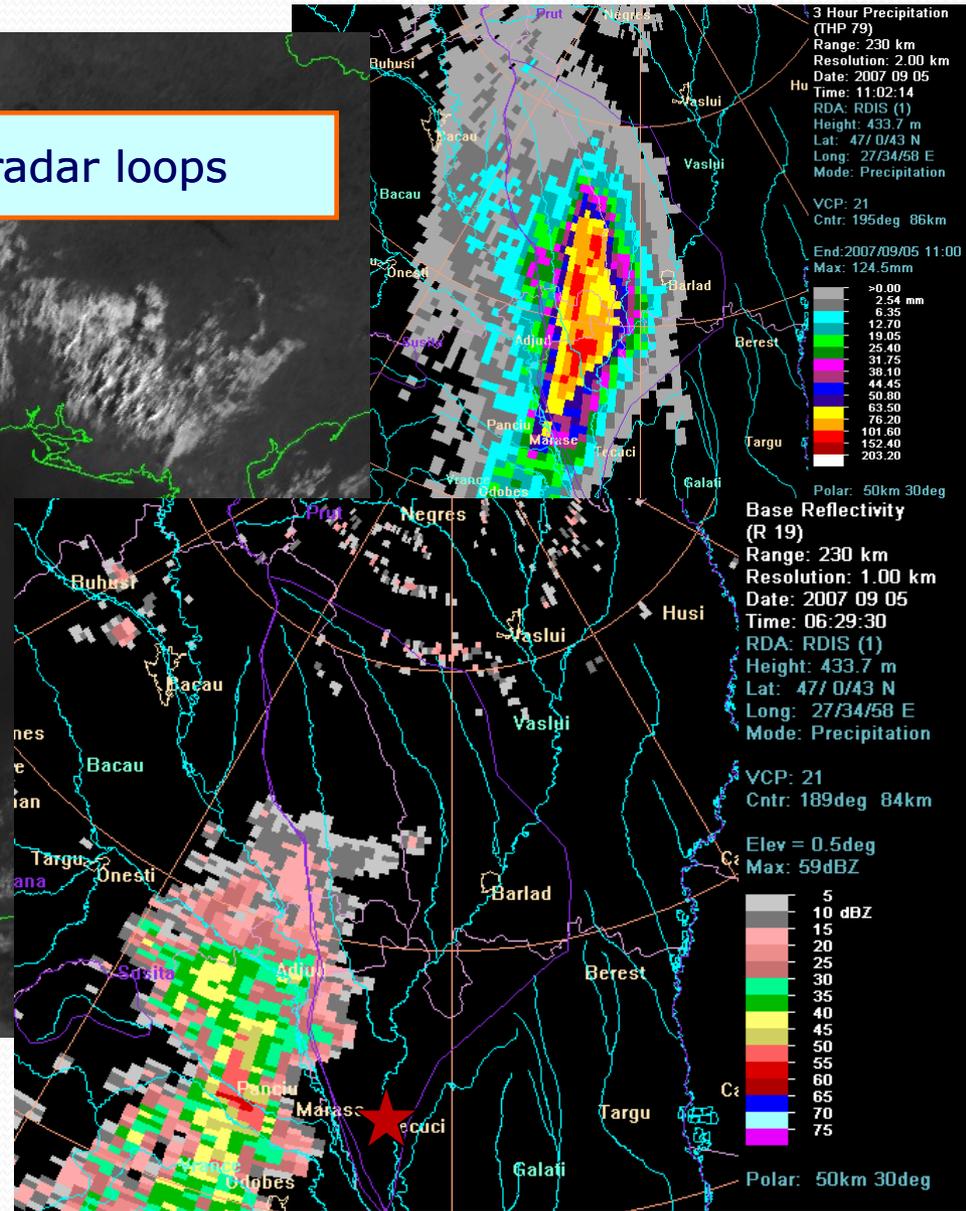
Hydraulic scenarios
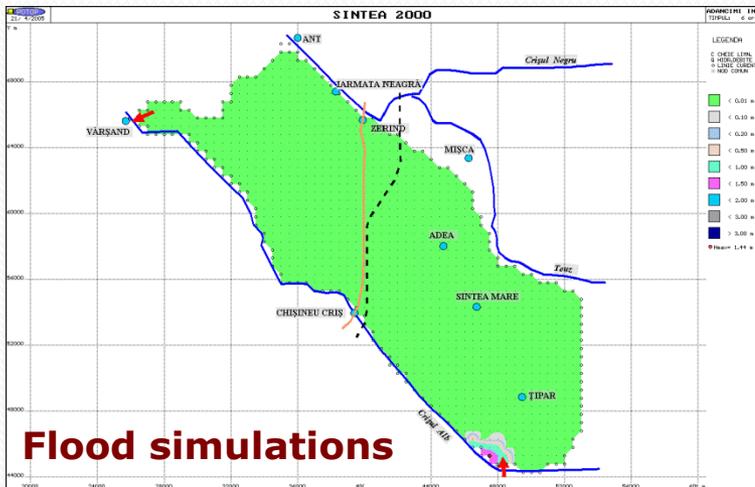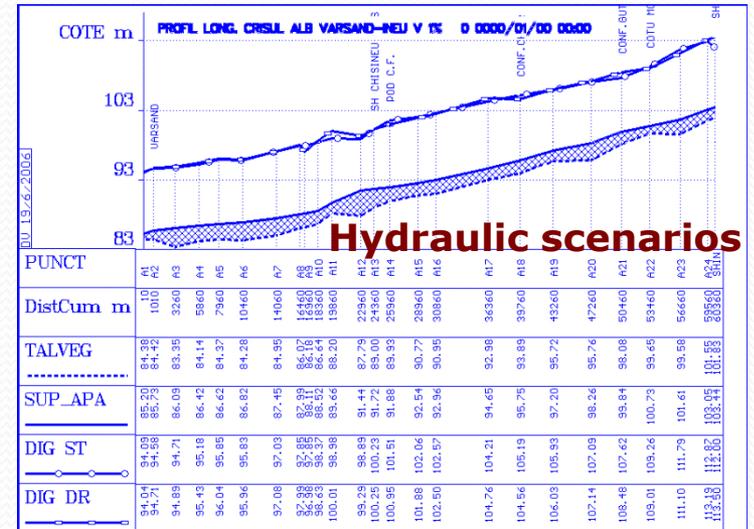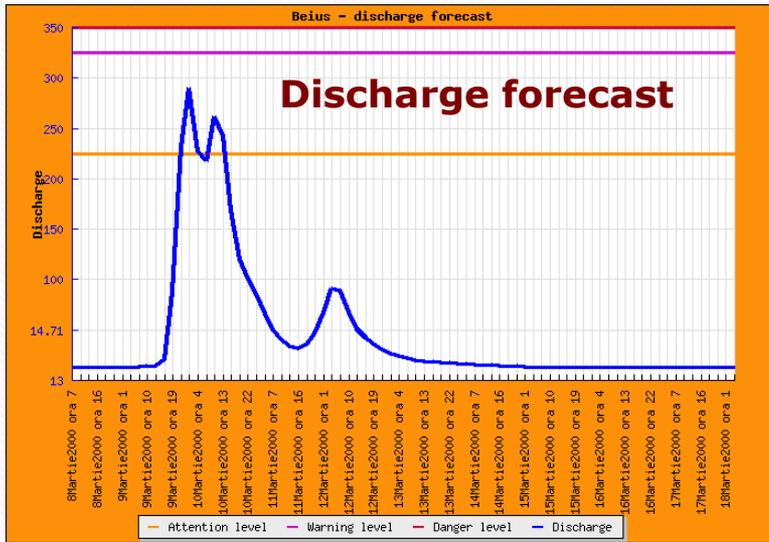
Flood simulations

Flooding Risk Map

35
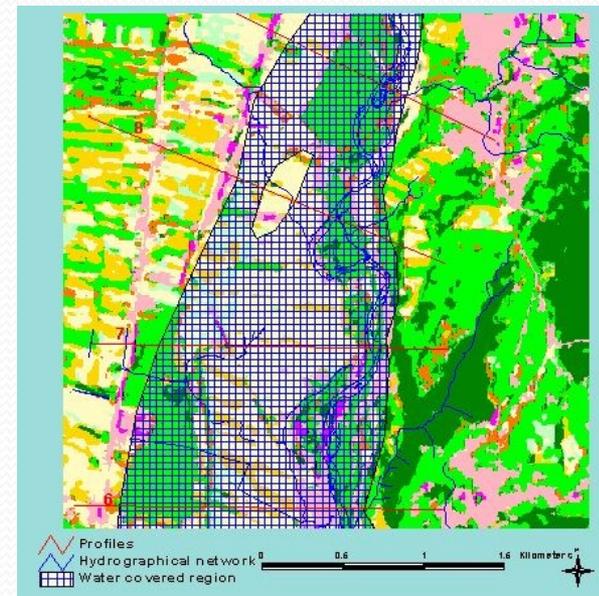
Challenges and conclusions

➢ In Romania already exists a reliable infrastructure for the operational management and dissemination of the meteorological data and products in the framework of the **National Integrated Meteorological System (SIMIN)**.

➢ In Romania a "modus operandi" with different end-users, for the extreme meteorological and hydrological phenomena generated disasters has been already established; a good example of cooperation work between the existing actors from different Romanian institutions was done during the recent big floods (2005, 2009, 2010).

➢ **A Web-based Information System for Trans-boundary Flood Management** (FLOODSAT), based on satellite data and GIS technology, was implemented in the Romania. The data registered into the system is published through standard compliant services and can be accessed by users via a web or desktop client.

Challenges and conclusions

- The Romanian Meteorological Administration started some actions in order to develop and implement an interoperable framework for the management of meteorological information. This effort will contribute to carrying out a national spatial data infrastructure (SDI) , in conformity with the provisions of the **European Directive INSPRE**.

- The main goal is to achieve interoperability, harmonization across spatial data themes and benefit from the endeavors of users' and producers' communities.

- In the near future a great concern is dealing with the implementation of the **online system – GEOMET** - based on open source applications, allowing the management of meteorological data in a geospatial context.

- This new system will improve the capabilities of operational evaluation, mapping and analysis of meteorological and hydrological hazardous phenomena and the environment changes detection.

Thank you for your kind attention !

http://www.meteoromania.ro