Multisensor Atmospheric data Mapping System: a Web-based Graphic Tool for multisensor observations of atmospheric data and NWP model forecasts.

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Abstract

The analysis of a specific atmospheric phenomena or severe event for civil protection purposes requires quick and simultaneous visualization of real time images and animations representing different meteorological fields. This led us to create a user-friendly web-based graphic tool for displaying data and products from different remote and ground-based sensors and NWP models. This Tool, named Multisensory Atmospheric data Mapping System (MAMS), allows the accurate display of different 2-D or 3-D data fields, ingested as images or as data files. Specific options simplify the archiving and overlapping and other GIS-like features, so that atmospheric data are co-located and shown along with satellite-based, physical, political, and hybrid maps. Hence, MAMS allows the overlapping of different fields to obtain multisensor monitoring of severe events in order to promptly analyze and react to their evolution.

MAMS is currently used within the CNR-ISAC (National Research Council - Institute of Atmospheric Sciences and Climate) in Rome for the analysis of heavy precipitation events that occurred in Italy. These studies involve data from Meteosat-10 SEVIRI (i.e., HRV, IR 10.8 μm, WV 6.2 μm), passive microwave precipitation retrievals from AMSU-A/MHS on board NOAA and MetOp-A satellites, high space/time resolution precipitation fields derived by MW/IR blending techniques, 3D lightning data acquired by LINET VLF/LF lightning detection network in Italy, and NWP model outputs. The use of multisensor observations, in conjunction with NWP model outputs, will demonstrates the utility of MAMS for short-term prediction of heavy precipitation events and for civil and environmental protection.

1. INTRODUCTION

The Satellite Meteorology (SatMet) group at CNR-ISAC in Rome has a long lasting experience in the development of complex algorithms for the estimation of precipitation from passive microwave (MW) sensors onboard polar satellites and in radiative transfer modeling through precipitating clouds, operating in different spectral ranges, devoted to the interpretation of remote sensing measurements from different platforms. It is one of the leading groups in Europe for the development of precipitation retrieval algorithms from passive microwave (PMW) radiometers. Two different algorithms have been developed: one is the Cloud Dynamics Radiation Database algorithm (CDRD) for conically scanning radiometers, such as the SSMIS on board the U.S. DMSP satellites (see Casella et al., 2013, Sanò et al., 2013a, Mugnai et al., 2013a, Smith et al., 2013, Panegrossi et al., 2013 for full description and applications), and one is the Passive microwave Neural-network Precipitation Retrieval algorithm (PNPR) for cross-track scanning radiometers, such as the AMSU-A/MHS on board U.S. NOAA and European MetOp satellites (see Mugnai et al., 2013, Sanò et al., 2013b, Panegrossi et al., 2013 for details). These two algorithms are currently used operationally within the EUMETSAT Hydrology Satellite Application Facility (H-SAF) (see Mugnai et al., 2013b) to provide surface precipitation rate (with indication of phase) over Europe and the Mediterranean Basin, and they are being extended to the MSG full-disk (Africa and Southern Atlantic). The group is also involved in the development of Nowcasting techniques of precipitation, in particular for severe and heavy precipitation events, using both LEO and GEO satellites observations. These techniques using combined MW/IR data are the Precipitation Evolving Technique (PET) described in Di Paola et al. (2012) and the Lightning-based PET described by Dietrich et al. (2011). The SatMet group manages the EUMETCAST receiving system at ISAC U.O.S. of Rome, of Meteosat, NOAA, MetOp, and (soon) NPP satellite data. Further activities are related to the study and monitoring of lightning activity. The SatMet group is responsible for the distribution in Italy of the lightning data from the ground lightning network LINET (Lightning
Detection NETwork, Betz et al., 2009). The network LINET is able to distinguish the two main types of lightning (cloud-to-ground and intra-cloud) and determine with good accuracy their location (geolocation and altitude).

Within the agreement between CNR-ISAC and the Italian Department of Civil Protection, aimed at real-time monitoring and nowcasting of heavy precipitation systems in Italy, it has become evident the need of developing an advanced visualization system consisting of a unique platform for all images and data available. It was also part of the agreement to combine the observations available with NWP model outputs in order to analyze the forecasted fields, and compare them to the observations available in quasi-real time. The goal was to exploit all the information useful to monitor the development of severe precipitation events throughout the different phases of their development and evolution through the optimal use of observational data and numerical weather prediction (NWP) model outputs.

The Multisensor Atmospheric data Mapping System (MAMS) is a web-based tool developed at CNR-ISAC to archive and visualize different types of atmospheric data such as images and satellite products, radar products, lightning, and NWP model outputs. This tool allows:

- To have all available information on one platform;
- Archiving and managing data obtained from various sensors;
- To compare instrumental measurements with estimates obtained from Numerical Weather Prediction models and retrieval algorithms through graphic superposition;
- To have the possibility to compare data with different spatial and temporal resolution and combine the different sources of information;
- To geolocate different meteorological data on Google Maps® and Google Earth®.

In this paper we describe the MAMS, its visualization and archiving features, and its current application to the real-time observational data and NWP model outputs available at CNR-ISAC. It will be shown how this tool can be used for severe precipitation events monitoring and for civil protection purposes, as it allows to analyze the evolution of severe storms by quickly and simultaneously displaying quasi-real time images and animations representing different meteorological fields.

2. DATA

MAMS currently incorporates operationally data from Meteosat-10 HRV, IR 10.8 μm or WV 6.2 μm SEVIRI channels, passive microwave precipitation retrievals from AMSU-A/MHS on board NOAA and MetOp-A satellites, high space/time resolution precipitation fields derived by MW/IR blending techniques such as Rapid Update technique (Levizzani et al. 2000) and 3D lightning data acquired over Italy by the LINET VLF/LF lightning detection network. Soon it will also incorporate the PET Nowcasting technique and the passive microwave precipitation retrieval from the conically scanning radiometer SSMIS. The NWP model outputs from the MOLOCH model are provided by the CNR-ISAC Dynamic Meteorology research group (http://www.isac.cnr.it/dinamica/projects/forecasts). Figure 1 shows different images of the data available (both observations and forecast) and evidences the need of having a visualization system such as MAMS tool to be able to optimally combine in real-time all the information available.

3. ARCHITECTURE

The MAMS consists of three different modules:

- **The Data Processing Server**
  The server processes in real time all input data and creates the products to be displayed and stored in the database.

- **The MySql Database**
  The database contains all processed data in different formats, allowing the analysis of events over a wide range of time.
The Visualization Servers
These servers allow multiple users to utilize the MAMS. The number of users connected to each server is balanced automatically allowing maximum performance.

Figure 1: Example of data involved in MAMS tool.

Figure 2: MAMS block diagram and data-flow.
The system and the data-flow are displayed in a block diagram in Figure 2: all sensors and antenna acquire the data that are collected and sent to the data processing server. Here data are collected, processed and stored in different databases. Meanwhile, the same processed data are made available to computers dedicated to the graphic display. Registered users have full access to the data and to the display utilities (including Google Maps® and Google Earth®), using Internet fast connection from computers, tablets and smart-phones.

4. GRAPHIC USER INTERFACE

MAMS allows analyzing different types of data through an easy and user-friendly interface. Each user has his/her own credentials to manage and personalize his/her account. In the following the various sections within the tool will be described. In each section, a top bar contains useful information about the personal account, the current time and date, and displays the main menu to quickly browse between the different sections of the tool.

Figure 3: Example of dedicated user interface.

Figure 3 shows an example of the MAMS entry page. It is a dynamic page; each user will be able to independently customize the interface to suit his/her personal needs through the use and/or creation of widgets.

Different types of widgets may be set up, such as:

- **Command History:**
  The program highlights the last operations allowing quick access to the features of interest to the user (e.g., Google Maps® superposition of the MSG SEVIRI HRV channel for a particular day);
- **History data:**
  The program highlights the most recent queries to the database by date and data type (e.g., display of Rapid Update product for a selected event);
- **List and management of products created by the user.**
  the system stores the procedures used to create a specific product so that the same procedure can be applied to other case studies.

Each user can also view the widgets created by the system administrator mainly to notify the user of:
• new features made available in the tool;
• problems due to system failure and description of the impact of such failures on the products created or used by the user;
• incorrect use of the user interface.

4.1 ARCHIVE

The Archive section of MAMS allows the access to the entire database where all data are stored (Figure 4).

Figure 4: The image archive interface allows querying the database and viewing the images rapidly, and downloading images and animations.

It provides a manageable and intuitive graphical interface (in the left-panel) to query and quickly select all the available images of the different products available in the database. For each selection the user can visualize the images individually or view the time series animation for the selected images. Moreover, it is also possible to directly download the selected images/animations in png/gif format.

All archived images can be mapped on Google Maps® (Figure 5). On the panel on the left it is possible to query the database to select the data that will be displayed (on the right). It is possible to overlap different types of data over the same map, and analyze each meteorological event through the superposition of data from different sensors and of NWP model outputs. It is also possible to adjust the transparency of the various images to improve the visualization. Figure 5 shows an example of archive mapping: the MSG Water Vapor channel (6.2 μm) image is displayed with the superimposed LINET lightning data and Rapid Update precipitation product or the Southern Mediterranean event of the 30 August 2013 at 22:45 UTC.

4.3 REAL TIME OPERATION

The Real Time Operation section allows to analyze the weather situation in real time on the Google Maps® platform. It is possible to select all available products in real time and overlap them for multi-sensor analysis purpose. The workspace consists of four parts:
Figure 5: The archive mapping interface allows to map and overlay data and archived images.

Figure 6: Example of overlapped data in the real time operation section.

- A top bar (present in all sections), containing the main menu to navigate through the various sections of the MAMS Tool, the user account information, and the current time/date in UTC;
- A left panel containing all available products that can be overlapped within the Google Maps® environment;
- A central panel including the Google Maps® visualization system (allowing the user to zoom in and out, navigate, and change the type of map);
• A right panel where information about the selected products are shown.

In the Real Time section only the latest acquired images for each product are available. For the NWP model outputs the forecast fields at the current time can be displayed. It is therefore possible to compare in real-time the forecast fields (i.e., precipitation) with the observations (i.e., satellite precipitation estimate, or lightning) and evidence biases or timing and/or location errors (i.e., location of the most intense precipitation area) among the different data.

In Figure 6 an example of the Real Time Operation section workspace is shown. The real time situation available on 12 September 2013 at the 15:33 UTC is represented showing the MSG SEVIRI HRV channel, the latest Rapid Update precipitation rate (available at 15:15 UTC in this case), the precipitation rate estimate from the closest (in time) AMS/MHS overpass, and the LINET lightning data acquired in the previous 15 minute interval (between 15:00 and 15:15 UTC).

All products available in real time can be also mapped on Google Earth® to allow the three-dimensional visualization and animation of the latest acquired data. In Figure 7 an example of the visualization on Google Earth® for the event of 25 October 2011 is shown, with the precipitation rate estimate from the Rapid Update together with the lightning data from LINET Network.

5. CONCLUSIONS

The Multisensor Atmospheric data Mapping System (MAMS) is a user-friendly web-based tool to archive and visualize different types of atmospheric and meteorological data. The system has been developed and is currently used at CNR-ISAC of Rome to allow multi-sensor analysis of interesting precipitation events. MAMS has been developed in collaboration with the Italian Department of Civil Protection with the main goal of being able to analyze simultaneously real time images and animations representing different meteorological fields and, eventually, to react promptly to the evolution of severe storms. Strengths of MAMS tool are:

- All available information on one platform.
- Archive and data visualization obtained from various sensors.
- Full access to the archived data.
- Fully configurable user interface.
Comparison of instrumental measurements with estimates obtained from NWP models and retrieval algorithms.

Compare data with different spatial and temporal resolution and combine the different sources of information.

Geolocate different meteorological and atmospheric data on Google Maps® and Google Earth®.

Ability to export animations (gif format).

Ability to export products and animations in Google Earth® (kml format).

Real time utility for short-term prediction of heavy precipitation events for civil and environmental protection purposes.

Capability to ingest different typologies of data and formats.

Possibility to create new products (overlapping some of the data contained in the archive) and save the procedure.

Full support for tablets, computers and smart-phones.

REFERENCES


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