ARTIFICIAL SATELLITES. METEOROLOGICAL SATELLITES

Liviu Leontie[1], Adrian Timofte[2], Diana-Corina Bostan[3], Sorin Bostan[4]

Key words: satellite, conceptual models, MSG 1, METOP-A, Jason-2.

Abstract. The importance of the satellite in various fields of activity has triggered its continous improvement, having as a result the emergence of more and more varied products and the increase of the resolution of other products. Together with the RADAR and LIDAR, the meteorological satellite is one of the most useful means in the activity of the meteorologist. The perspective it gives on the atmosphere above a certain area of the world, be it night or day, or whether the information is for the surface of the Earth or in altitude, allows us to establish the synoptic context in due time and increases the precision of weather feorecasts.

Introduction

This paper tries to emphasize the importance of the satellite in various domains linked to environment. Judging from a meteorological point of view, until not long ago, the satellite was just another means of sounding the atmosphere. The access to the information given by the satellite was rather delayed because of technology. Nowadays, things are very different: the satellite has become irreplaceable in the activity of a forecaster and not only.

The temporal and spatial resolution have been greatly improved and there have been launched in space both geostationary satellites and polar satellites. The flow of data thus obtained has increased greatly and the access to information is now free.

Moreover, if the satellite systems provide the greatest accuracy in the higher part of the atmosphere (because they "look" downwards), the ground systems offer the greatest accuracy in the lower layer of the atmosphere (because

[1] "Al. I. Cuza" University of Iasi, România, lleontie@uaic.ro
[2] Regional Forecast Center, Bacau, România, sprvbacau@meteoromania.ro
[3] University of Bucharest, România
[4] Industrial High School "Letea", Bacau, România

they "look" upwards). By combining them, one could therefore obtain an accurate profile from the surface up to the limit of the atmosphere. This is important especially when there are clouds, since the satellite system cannot penetrate the clouds, in order to get to the surface and the ground system cannot penetrate any higher because of the clouds.

Hence, the RADAR, LIDAR and satellite techniques do not mutually exclude but, on the contrary, they complete one another.

1. Experimental details

The information given by the satellite is now to a great extent combined with the information given by the meteorological RADAR and by the LIDAR. If until now we were somehow conditioned by the data received only from one instrument (device), now, through the combination of satellite imagery with NWP (Numerical Weather Prediction), a satellite image can be analyzed in conceptual models that help us get a 3D visualization of the state of the atmosphere at a synoptic scale. At this moment, there are up to 60 such conceptual models, which are completely described in SatManu (a manual used in satellite training by the EUMETSAT- European Organization for the Exploitation of Meteorological Satellites).

The visualization of those described above is possible by means of Satrep Online, which is a product of EUMeTrain and sponsored by EUMETSAT. The main purpose of the EUMETSAT is to deliver weather and climate-related satellite data, images and products–24 hours a day, 365 days a year.

The meteorological satellite is an artificial satellite of the Earth, provided with special equipment, in order to meet the requirements of the proposed aim efficiently, and has special space movement characteristics. The board of a satellite has special equipments installed and sensors having different spectral channels, situated in visible (VIS), infrared (IR) and water-vapor (WV) domains.

According to the trajectory that a satellite describes around planet Earth, satellites are classified in geostationary and polar satellites. The former are situated at an approximately 36,000 km height and revolve at the same time the Earth does and pursue the same region on the surface of the Earth all the time. The latter, through their movement, intersect the axis of the Poles.

The sensors that can be found on board of such a satellite can be active or passive. The passive sensors measure the solar energy; for instance, the solar radiation is reflected (usage of the sensor in the VIS domain) or absorbed, or retransmitted by the targets at the surface of the Earth (usage of the sensor in the IR domain). In the case of the active sensors, they produce their own energy in order to illuminate the target and thus, the radiation reflected by the target is received and measured.

2. Results and discussion

Since 2000 and until now, both geostationary and polar satellites have been launched. We shall consider here three satellites: MSG 1 (Meteosat Second Generation), METOP-A and Jason 2.

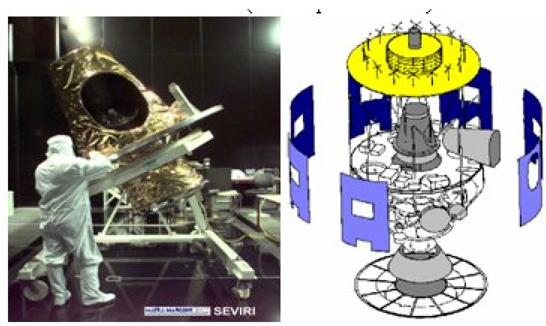

Fig. 1 - Spinning Enhanced Visible and Infrared Imager

Fig. 2 - The display of instruments on the board of METOP-A satellite

In the month of August of the year 2002, MSG 1 was launched in space from Kouru. In August 2003, Romania becomes the 7th state cooperating with EUMETSAT. At the end of January 2004, the satellite became operational and thus major improvement have been made to the activity of satellites. What is remarkable for this particular satellite is the fact that an advanced radiometer (SEVIRI- Spinning Enhanced Visible and Infrared Imager, presented in Fig. 1) was installed on board, which ensures 12 channels (as compared to only 3 channels ensured in the past); further improvement was made if we consider the spatial resolution, which is now of 3 km, respectively 1 km (as compared to 5 km, respectively 2.5 km); the temporal resolution is of 15 minutes (as compared to 30 minutes) and the radiometric resolution now ensures 1024 levels of gray (as compared to the 256 levels of gray in the past).

In October 2006, the first of the three satellites for the Polar System EUMETSAT (EPS) was launched from the Baikonur Cosmodrome in Kazakhstan. Once it entered the orbit, the satellite took the name of METOP-A. It is provided with exceptional equipments, among which we emphasize (see Fig.2) IASI (Infrared Atmospheric Sounding Interferometer), GOME-2 (Global Ozone Monitoring Experiment), and MHS (Microwave Humidity Sounder).

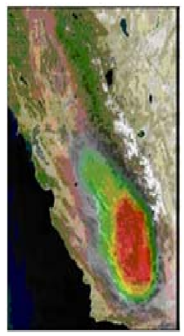

Fig. 3 - Area with a high ammonia concentration

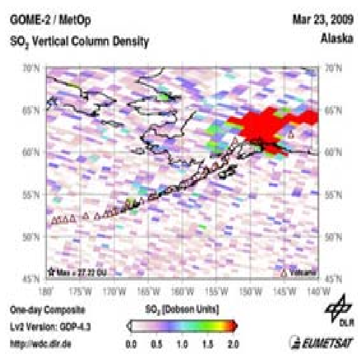

Fig. 4 - Measurements of SO_2 by means of GOME-2

By means of IASI, the first complete mapping of ammonia sources has been achieved. The work was performed by scientists of the *Université Libre de Bruxelles*, in collaboration with colleagues of the France's *Centre Nationale de la Recherche Scientifique (*CNRS) and the *European Commission Joint Research Centre* in Ispra, Italy. The researchers have initially found some "hot spots" above some agricultural areas in Asia, Europe and North America. Although IASI was not initially designed to ensure the ammonia detection in the atmosphere, the scientists developed a new methodology to help isolating the "ammonia signature" from the background noise of the device. By filtering and data gathering during one year of continuous observations (more than one million IASI soundings per day, 10-20 per cent of which are for ammonia observations), the researchers were able to obtain maps of ammonia concentration (Fig. 3) and compare them to recent atmospheric models. This work has highlighted an underestimation of ammonia sources provided by the current inventory for agricultural valleys of the Northern hemisphere, particularly in America (e.g. San Joaquin in California and Snake River Valley in Idaho) and Europe (Po and Ebro valleys in Italy and Spain, respectively). The most significant differences were found in Central Asia, where some sources that do not exist in current inventories were identified.

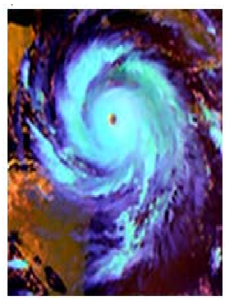

Fig. 5 - Dean Hurricane in the Gulf of Mexico on the 20th of August 2007

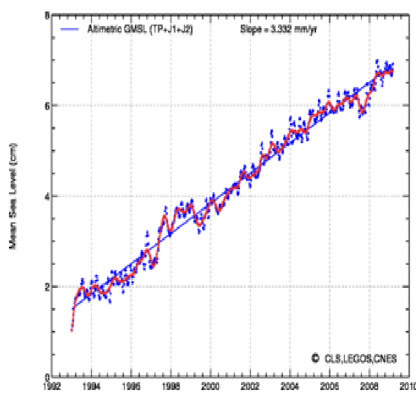

Fig. 6 - Mean Sea Level evolution

GOME-2 is a device installed on board of the polar satellite METOP-A, by means of which the sulfur dioxide (SO_2) emitted of the Mount Redoubt volcano in

Alaska was monitored (Fig. 4). The volcano began erupting on March 23, 2009, after 20 years of inactivity and is still unstable.

The MHS on board of the METOP-A satellite measures atmospheric water vapors to determine vertical atmospheric humidity profiles. The capacities of the MHS device are illustrated by the Dean Hurricane. This AVHR composite of METOP-A shows the structure of the clouds of Dean Hurricane in the Gulf of Mexico on the 20th of August 2007 (Fig. 5).

The data given by EUMETSAT Jason-2 are now routinely used for the continuous monitoring of the global Mean Sea Level (MSL). Figure 6 presents the MSL evolution as measured by altimetry satellites since TOPEX/Poseidon and continued by Jason-1 and now by OSTM/Jason-2. Each point is the result of 10 days cycle measurement.

Conclusions

If until now the satellite was limited only to identifying the main type of clouds or to identifying the areas in which convection is initialized, it is now a perfect means for the monitoring of the environment, giving weather and climate-related satellite data.

Through the combination of satellite imagery with NWP (Numerical Weather Prediction), a satellite image can be analyzed in conceptual models that help us get a 3D visualization of the state of the atmosphere at a synoptic scale.

Due to the fact that the satellite has become an indispensable instrument of monitoring the environment and considering the fact that technique has become more and more advanced, the equipments on board of satellites were greatly improved, resulting in spatial, temporal and radiometric resolutions which could have hardly been imagined thirty years ago. Both the geostationary satellites and polar ones were provided with high technology instruments (IASI, GOME-2, MHS etc.).

By means of IASI, scientists were able to obtain maps of ammonia concentrations. With the help of GOME-2, the SO_2 can be monitored (recent SO_2 emissions of Mount Redoubt volcano in Alaska). The MHS allowed the measuring of atmospheric water vapors in order to determine vertical atmospheric humidity profiles and the data provided by Jason 2 are nowadays constantly used in the monitoring of the global Mean Sea Level (MSL).

References

Diana-Corina Bostan, *Identificarea principalelor tipuri de nori in imaginile de satelit (in nuante de gri)*, Bucuresti, Sesiunea Anuala de Comunicari Stiintifice

Alina Hofnar, 2005, *Sisteme Satelitare*, Administratia Nationala de Meteorologie

Alina Hofnar, 2005, *Convectie pe timp de zi*, Administratia Nationala de Meteorologie

Alina Hofnar, 2005, *Identificarea cetii*, Administratia Nationala de Meteorologie
J. Kerkmann, 2008, *Meteosat Metop Jason*, EUMETSAT
K. Dieter Klaes, 2008, *Meteorological products based on EPS/Metop*, DWD-EUMETSAT-ZAMG Training Seminar on Satellite Meteorology BTZ Langen
K. Dieter Klaes, 2008, *Physical Basics of Remote-Sensing with Satellites*, DWD-EUMETSAT-ZAMG Training Seminar on Satellite Meteorology BTZ Langen
Section 1.01 Lieven Clarisse, Cathy Clerbaux, Frank Dentener, Daniel Hurtmans & Pierre-François Coheur, 2009, Global ammonia distribution derived from infrared satellite observations*, Nature Geoscience, Published online: 21 June 2009 doi:10.1038/ngeo551*
Sabina Stefan, Doina Nicolae, Mihaela Caian, 2008, *Secretele aerosolului atmosferic in lumina laserului*, Ars Docendi, Bucuresti, pag 337-338
Volker Gärtner, 2008, *Satellite Systems*, EUMETSAT
http://www.eumetsat.int/Home/Main/Media/Features/713666?l=en
http://www.eumetsat.int/Home/Main/Media/Features/709792?l=en
http://www.eumetsat.int/Home/Main/Media/Features/709255?l=en