# A METEOSAT SECOND GENERATION receiving, processing and storing images system developed by engineer students

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***Abstract*— In this article, we present how we managed to build a low cost, homemade, up and running receiving station able to store almost a year of data from Meteosat Second Generation satellite. After a presentation of the context of the study, we will detail the hardware and software aspects of the station, followed by the educational stake, which links students and scientists working together. In the conclusion we will explain how this station led us to be involved in our first international project called AMMA (African Monsoon Multidisciplinary Analysis) and how we are going to realize an autonomous meteorological alert system which will forewarn of approaching thunderstorms and start recording ground images of this phenomenon.**

## I. CONTEXT OF THE STUDY

The Ecole Supérieure d'Informatique d'Électronique et d'Automatique (E.S.I.E.A) has always encouraged its students to be completely involved in practical implementation of their work. The work presented in this article illustrates that educational concept by a clear example. This article shows how "innovactor" undergraduate students could be involved in a Research and Development project.

Among the research departments of ESIEA there is one dedicated to image processing (Acquisition et Traitement des Images et du Signal - ATIS dept.). Developing applications using remote sensing data is one of many activities of this department. To have an independent and granted access to the images, we have developed some receiving stations. Thanks to resolution 40 of the World Meteorological Organization, Research and Education organizations like us are allowed to receive data directly from meteorological satellites in real time [1], [2]. An exhaustive list of meteorological satellites can be found in [3], [4]. In this article, we detail technical and educational aspects and present the first application of our latest receiving station dedicated to the most recent and powerful geostationary satellite : Meteosat Second Generation (MSG). The main characteristics of this satellites are :

- 11 spectral channels (0.6, 0.8, 1.6, 3.9, 6.2, 7.3, 8.7, 9.7, 10.8, 12.0, 13.4 $\mu m$), size 3712x3712 pixels, sampling distance $3km$ (nadir),
- 1 High Resolution Visible channel, size 11136x5568 pixels, sampling distance $1km$ (nadir),

Fig. 1. Overview of the homemade system

- 10 bits for each pixel's radiometry depth,
- time sampling : 15 minutes.

Figures 4 and 5 show two examples of received images.

The project concerning EUMETSAT satellite reception started in 2002. At that time, first team was working on Meteosat First Generation [5], [6]. Last year another team managed to install a small receiving station for Meteosat Second Generation. This year our main aim was to upgrade the station by adding a storage archive, develop software solutions to make our station system autonomous, create a local network architecture to easily and securely access the stored images and develop a monitoring device to view via internet network the status of each part of the system [7].

## II. TECHNICAL ASPECTS

### A. Architecture

The project can be split into three main independent tasks : receiving, processing and storing the data. To complete these tasks, we choose to use three computers linked together

| Machine / Components | Receiving | Processing | Storing |
|---|---|---|---|
| CPU | P4 2.4 GHz | P4 2.8 GHz | AMD64 244 |
| RAM | 1GB | | |
| Network Card | Gigabit | | |
| OS | Windows XP | Linux | Linux |
| Misc. | DVB Card | | $12 \times 250$GB |

TABLE I

THE MAIN HARDWARE CHARACTERISTICS OF THE SYSTEM.

Fig. 2. Receiving and Processing Computers

through a gigabit ethernet switch. Figures 1 and 2 show a part of the homemade system. These computers do not require specific hardware and can be acquired easily in every computer shop at low cost. The table I resumes the main hardware characteristics of our system.

Each computer was assigned to a particular task. This way, the system is less vulnerable (if one computer is down, the two remaining continue their tasks) and it is easier to perform maintenance operations.

### *B. One Computer, One Task*

*1) Receiving:* Meteosat Second Generation (MSG) sends data every 15 minutes to dedicated receiving stations called primary ground stations [8]. The main one is located in Usingen, Germany. The German station resends all received data to Hotbird 6 telecommunication satellite, after pre-processing. To catch all these information from Hotbird 6, it is necessary to be registered. The web site of EUMETSAT organization and the document [9] give all details. For the 15 minutes receiving rate, we use a 100cm (40in.) standard parabolic antenna, connected to one of our computers by a common DVB (Digital Video Broadband) Card. We strongly recommend to use the one preconise by EUMETSAT. Computer's only job is to receive data and to store it onto its 120GB buffer hard disk drive. In order to force the computer to do only this task, we use the Tellicast Eumetsat's piece of software.

*2) Processing:* During reception, another computer begins the treatment process. The aim is to transform data heap into viewable images. To do so, we created an up and running chain which executes all our treatment and storage algorithms. As far as the treatment process is concerned, five steps are needed

| NAME | LANGAGE | ACTION |
|---|---|---|
| none | Bash | downloads file parts from the receiving computer (now we call it server) with Samba protocol (due to server's OS which is Windows) |
| Hglue | C | transforms *HRIT* data into *.hdr* (headers) and *.wvt* (wavelets) files. |
| DW | Bash & C++ | transforms *.hdr* and *.wvt* into *.pgm* (portable gray map) image file. |
| Bzip2 | Unix distrib | compresses with the best ratio *.pgm* files into *.pgm.bz2* compressed files |
| none | Bash | tranfers *.pgm.bz2* compressed files to the storage server via nfs (Network Files System) protocol (last computer) with a specific filenaming : year/month/day/channel/ msg1__-image_name.pgm.bz2 |

TABLE II

THE MAIN STEPS OF THE DATA PROCESS

to achieve this task. These steps, and the software development language used, are detailed in table II.

*3) Storing:* After processing of the data, the compressed image files are stored in the storage computer. The compression of the data is indispensable. In fact, the non-compressed output files represent an astonishing amount of bytes : 5 DVD (20GB) a day. For this reason we used bzip2 compression before transfering files to the storage server. Doing that, we gain up to 70% hard disk space, but the price to pay is the need to always uncompress the data before access to the image. Therefore a dedicated processing computer is needed for applications which work with a large part of the image database. But in facts, investment in a dedicated computer costs less than investment in a most complicated storage solution. Although the compression is very efficient, the amount of data is still enormous : about 2 DVD a day (6GB), which means 2.2 TB a year of compressed data. In order to save the non-stop incoming image flow, we constructed a "home made" huge server (figure 3) which has 12 hard disks SATA of 250 GB each (sticked together into 2 arrays RAID of 2TB and 1TB). On one hand, the 2TB RAID-5 partition is used only for storage and can save nearly one year of data, on the other, the 1TB RAID-0 partition is used to archive results computed from the stored images.

### *C. Resolving Problems*

Four main problems appeared to us during our building of the station. Some of them are not yet solved, but it's only a matter of time.

- *OS and Software Heterogeneity* : we chose to use Linux OS instead of Windows OS because of the difficulty of the Windows' Samba system to manage huge files counter to Linux's NFS file system. As far as programming is concerned, we shall very soon reprogram all our software in a C/bash solution.

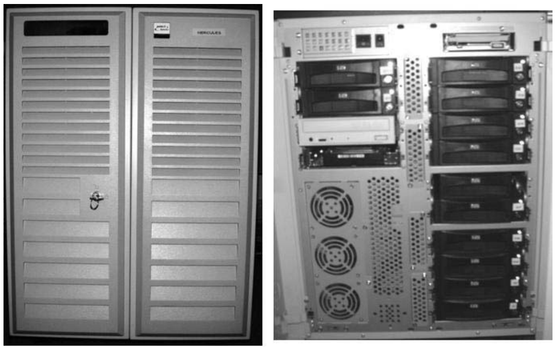

Fig. 3. 3TB Storage Computer

- *Classification of files* : due to size and number of files, we choose to organise automatically received data by year/month/days/channel.
- *Monitoring* : it is obvious we cannot stay 24h a day in front of the station and check if everything is going well. A powerful and simple tool was developped in order to monitor all the computers. Accessible from outside (ssh), it warned us many times at home, so we had enough time to prevent data from being lost. Obviously, the data itselft are only available on local network.
- *Using the data* : we develop tools to easily and securely access the data on the local network. With this protocol, our partners have just to work on algorithms and not on the way to access the data and how to protect them from bad manipulations. They came to us with the algorithm on their computer, then the processing is done localy and the results can be stored on the partner's computer.

## III. Pedagogical Aspects

### A. Involving students

That kind of project allows students to utilize their theorical lectures on a concrete high technology application. This project also allows our students to work with scientists and better understand what the research world looks like.
In facts, this project includes a technical part, but also a comercial and an economic part (the students are responsible for the budget) and an estimation of quality of the entire work (this article is a part of the estimation). In other words, this is a real Research and Development project realized by undergraduate students. For some of them, it can be the beginning of a research worker career.

### B. Melting skills

The multi-disciplinary character of the work leads students to melt different skills. This is an important step to acquire a pluridisciplinal scientific and engineer background. This pedagogy by achieving concrete goals all along the project and the challenge to be at a competence level in adequation with the needs of the scientific world permit students to go much more further than more classical lectures do.

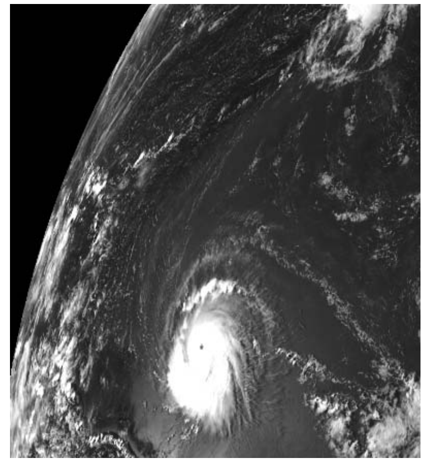

Fig. 4. Cyclone Image received by our station (ESIEA ©EUMETSAT)

### C. Melting study levels

The main contributors of this project are students in last undergraduate year. But a part of the work is done by younger students under the responsability and the management of the most experimented ones... and obviously the pedagogical team too. This is an original way to apply theorical management lectures seen during studies. It also permits to easily transmit the acquired experience between students and to have each year an operationnal students team to go further.

## IV. The next step: participate to international research projects

Almost all of the technical problems posed by the MSG receiving, processing and storing system are now resolved. The "savoir-faire" acquired during this experience allows us to be confident in the development of other MSG systems for partners and be confident for developping new applications using that kind of new data.
In this context we were asked to take part of one experience in the AMMA project. AMMA (Afrikan Monsoon Multidisciplinary Analyses) is a coordinated international project to improve the knowledge of the West Afrikan Monsoon and its variability [10].

Among all the experiments, we participate to the one concerned by the observation of African Monsoon phenomena from experimental ground rainfall radars. Unfortunately, due to technical limitations, these radars are unable to record continuously. Therefore our work is to realize an autonomous meteorological alert nowcasting system. It will forewarn of coming thunderstorms to start the records. This system is composed of a satellite receiving station and a processing chain using these images for the forecast. This new project began this year in February.

## V. Conclusion

This year we made a big step forward concerning the reception of satellite data. After creating a low cost station able to store almost a year of images, we created efficient

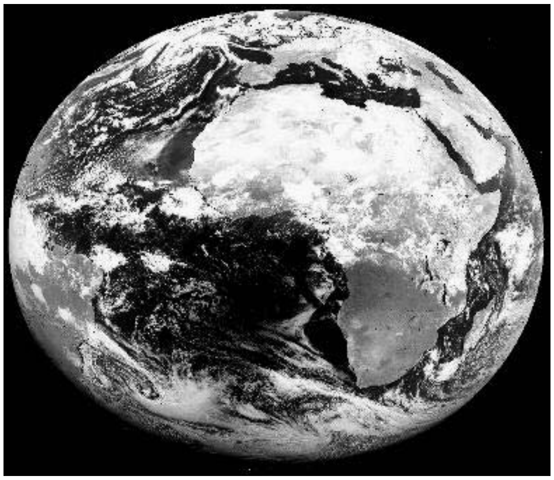

Fig. 5. A full disk METEOSAT image (ESIEA ©EUMETSAT)

software to process and store data received from the satellite. In addition to the great pedagogical adventure, it allowed us to work with students and scientists on international project like AMMA on a safe and reliable station.
We are very confident for the future of the station that ought to lead us to new challenges on international projects without annoying us with technical defects and letting us concentrate only on algorithms and science.

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## REFERENCES

[1] "WMO resolution 40," http://www.nws.noaa.gov/im/wmo40.htm, 1995.
[2] G. Escleyne *et al.*, *Utilisation pédagogique des images des satellites météorologiques*. Ministère de l'Education nationale, de la recherche et de la technologie, 1998.
[3] F. Verger, *Atlas de géographie de l'espace*. Belin, 1997.
[4] L. Beaudoin, "Sélection de données satellitales optiques pour la photo-interprétation," Ph.D. dissertation, E.N.S.T.-Paris, 2001.
[5] *Meteosat WEFAX dissemination-TD03*, EUMETSAT, 2002.
[6] L.Beaudoin, M. Imbert, A. Jumelet, J. Ruget, O. Hayot, and P. Doucy, "Receiving images directly from meteorological satellites in an engineer'school: technical and pedagogical aspects," in *IGARSS*, 2003.
[7] L. Chabardes, *ESIEA Meteosat Second Generation station, User handbook*, ESIEA, 2005.
[8] *MSG system overview-TD07*, EUMETSAT, 2001.
[9] *MSG image data dissemination-TD08*, EUMETSAT, 2003.
[10] T. Lebel, J. Redelsperger, and C. Thorncroft, "The international science plan for AMMA," http://amma.mediafrance.org/international/index, 2004.