Project title: Energy-Specific Solar Radiation Data from Meteosat Second Generation (MSG): The HELIOSAT-3 Project

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WP 4020

HELIOSAT-3

CLIMATOLOGY PROCESSING CHAIN

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ABSTRACT

This document reports on the activities held in Armines in the WP 4020 "Climatological Processing Chain".

This WP aimed at realising, implementing and testing a chain for the routine processing of MSG data with emphasis on climate research and atmospheric applications. The major tasks were:

- integration of retrieval data and basic MSG data into processing chain,
- conditioning of the processing system (set up of look-up tables etc.),
- implement intelligent mechanisms for effective and user-friendly access to results,
- definition of different product levels (primary, secondary, ..) according to customer needs,
- quantify benefits of the improved/new products.

These tasks of WP 4020 are similar to those of WP 4010 but with the addition that the targeted application in WP 4020 is oriented towards long-term irradiance data with an emphasis on climatology-related topics (long-term time series, GIS, cartography). This implies the set-up of a parallel processing chain since the single steps have to be performed on different data sets, with different goals (i.e. user needs) and under different time constraints.

Actually, these tasks were not achieved in their integrality in the framework of the project Heliosat-3, mostly because of the delays in previous WPs, caused themselves by delays in satellite operations. Nevertheless, a number of activities were held that will benefit to the establishment of the climatological chain which will take place even if the project is finished.

In brief, these activities were:

- construction of an hybrid chain, working in real time since February 2004,
- gaining experience in MSG operation, real-time acquisition of MSG data, daily management of troubles,
- testing, validating some solutions in computer system, database structure, processing speed,
- testing some solutions in image processing and ground albedo management,
- preparing an operational chain: design and modeling,
- test exchange of data with DLR,
- providing outputs of the hybrid chain to selected customers for testing.

Conclusions are:

- the hybrid method can process efficiently MSG data,
- it can run very fast, every 15 minutes,
- the same chain can operate also off-line,
- several tools have been tested and improved,
- testing customers provide some feedback on products.

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Table of Contents

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1. INTRODUCTION

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2 DESCRIPTION OF THE CLIMATOLOGICAL HYBRID CHAIN HELIOCLIM-2

HelioClim is a family of information systems that convert satellite data into irradiance and disseminate it. HelioClim-2 is a follow-on of the HelioClim-1 that performs on Meteosat-7-like data and covers the period 1985-2005. HelioClim-2 process MSG data; it is an intermediate chain for preparing the HelioClim-3 chain that fully exploits the capabilities of the MSG data. It is foreseen to operate HelioClim-2 from 2004 to 2005 and HelioClim-3 from end 2004.

As shown in Figure 1, the chain HelioClim-2 is made of two automata, each on a separate PC. The first automata performs the reception of the MSG data via a receiving station, the second performs the processing of the data and the dissemination via a Web server. The PCs are running under Linux operating system.

Reception Automata

This PC performs the following operations:

- receiving MSG data in HRIT format [acquisition every quarter-hour, listening to 200 MB, four channels written on disk, including VIS1 and VIS2],
- conversion into PNG format,
- write the two visible images on a shared disk (approx. 10 MB per quarter-hour).

(these three points are performed by a software provided by David Taylor, United Kingdom)
In addition, the automata takes care of the disk space.

The receiver is a low-cost one, based on the Eumetcast dissemination system. Only eight bits are used to code the signal compared to the original ten bits. The digital numbers are computed from the readings of the receiver by multiplying the latter by 4 and adding 2. Then, they are converted into radiances Lvis1 and Lvis2 (W m-2 sr-1) for each visible band of MSG, using calibration coefficients available in the header of the images.

Processing Automata

This PC performs processing operations and controls and contains an Apache Web server that disseminates the database.

1. Processing and control operations:

- Fetch input images on a shared disk. The YCID is a key parameter in recognizing an image.
- Convert PNG images into Minimage format.
- Control each input image. In case of rejection, fetch another couple of images.
- Create Meteosat-7 pseudo-radiances (image format)
- Filter and downsampling by a factor 3*3
- Compute cloud index n and ground albedo (image format)
- Correction of n for glitter
- Conversion of n into irradiance I, code I into byte (image format)
- Store I into the database HelioClim-2
- End of day, compute daily value for irradiance
- Control hourly and daily values. At the end of month, control monthly values.

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2. Runs an Apache Web server

3. In addition, the automata takes care of the disk space.

The processing algorithm converting image data into irradiance is the Heliosat-2 method. The Apache Web server is published into the SoDa Web service as an available service; the SoDa Service is the preferred means to disseminate irradiance values.

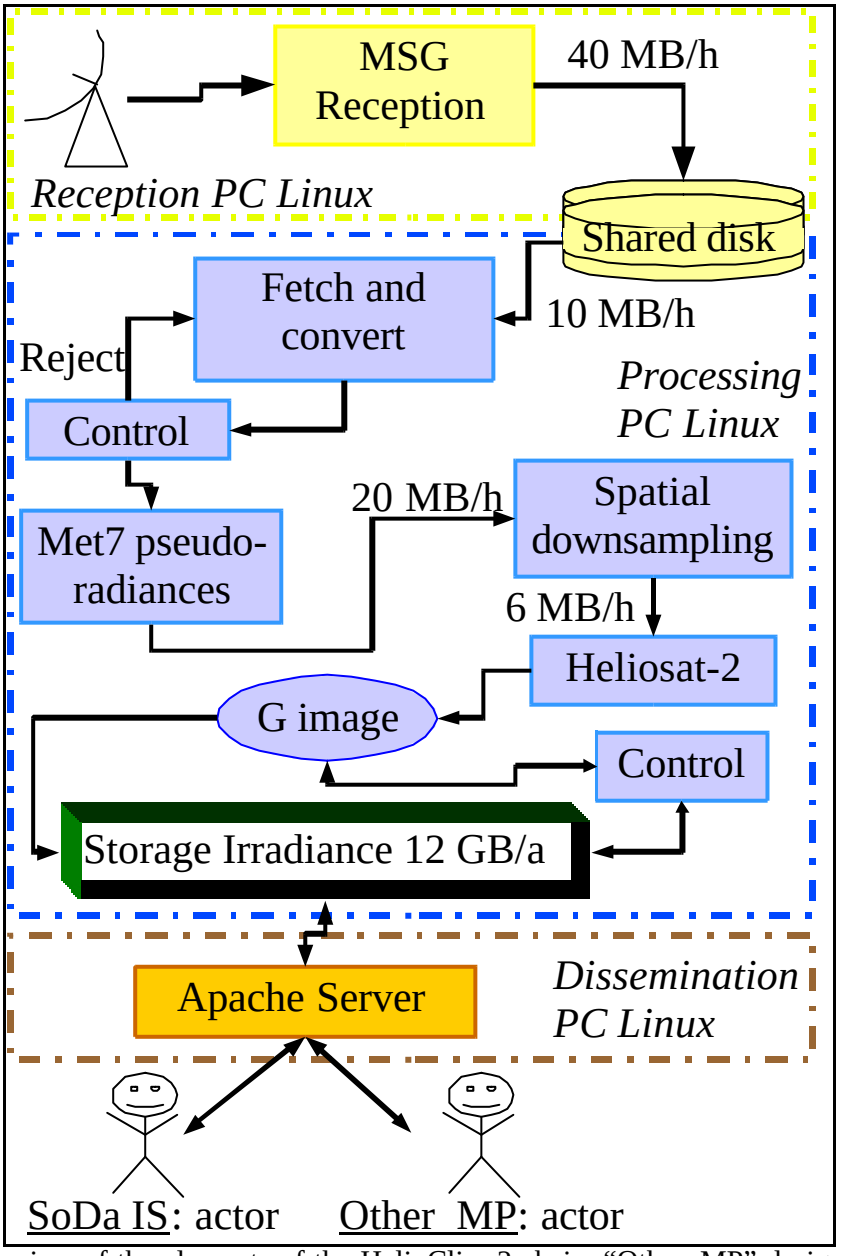

Figure 1. Overview of the elements of the HelioClim-2 chain. “Other_MP” designates possible direct access to the database outside the SoDa service.

3 OPERATIONS IN 2004 – LESSONS LEARNED

The hybrid climatological chain was run in an operational mode on the 1st February 2004. Only one image is processed per hour. Since this date, the system has been running with a few interruptions.

Interruptions were due on the one hand to Eumetsat. The causes were a dysfunction of the satellite or of the acquisition system at ground. This happens 3 to 4 days per year. On the other hand, accidental shut-off of the power line at Ecole des Mines causes the loss of several days of data.

The first lesson learned is that there is a need for another source of Meteosat data. This permits to cope with the loss of data due to an error at Ecole des Mines. The data lost in 2004 were obtained by the partner DLR. Two other sources were identified and links established in case of need: the University of Oldenburg and an school for engineers in Paris.

Obtaining data from another source needs to have an off-line processing chain. The on-line chain was created in such a way that it can also work off-line and thus can accommodate different sources of data, provided the format is the same.

Another lesson learned is that it is necessary to install a system that creates synthetic irradiance data in order to fill the holes.

Experience shows that it would have been possible to process images every 15 minutes. Hourly averages of irradiance would have been constructed using four images instead of one, leading to a better accuracy.

The structure of the database was mostly correct. However, some changes were made to better account for the sunrise and sunset time.

The structure of the database does not allow for a precise management of the time; there is a gap between the middle of the hour and the exact time of acquisition. This gap depends upon the day and the position of the pixel within the field of view; it may amounts to 20-25 minutes. It is recommended to use a better sampling of the hourly value, e.g., every 15 minutes.

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4 FEEDBACK FROM CUSTOMERS

Some customers were sollicitated to gauge the products from the database HelioClim-2. Tests are underway and only very preliminary results were available in winter 2005 during the last months of the project Heliosat-3.

Drawbacks in the management of time were identified by some partners during the summer 2004, due to inconsistencies in time system in the various elements of the processing chain. This was corrected before sending data to customers.

One error was detected by customers working in Africa. The assessment of the ground albedo over very reflective desertic areas was not performed correctly, causing the irradiance to be much too low. The drawback was corrected in February 2005 and the database was reconstructed in February and March 2005.

Customers and partners compared the daily mean irradiance computed by the formula of Raschke and that computed by averaging the hourly averages for daytime. They also used ground measurements in that purpose. They strongly recommended not to use the formula of Raschke in the case of the database HelioClim-2 even if it gives good results for the database HelioClim-1 where hourly values are available every 3 hours only.

Another comment from customers deals with the time system. There is equal needs for data expressed in legal time, Universal Time Coordinated (UTC) and true solar time (TST). This should be taken into account in the dissemination of the data.

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5 PROVEN TOOLS

Several tools were implemented and tested and will be re-used for the chain to be constructed.

These tools are:

- a model for the vertical profile of irradiance (direct, diffuse) using the outcomes of the SOLIS clear-sky model,
- a model for the construction of a broadband channel Meteosat-7 like using the two visible bands of Meteosat-8 (Cros et al. 2005),
- a fast and reliable method for resampling and remapping MSG data to a canonical grid with cells of 5' in size,
- a proven concept of database structure. The allocation of room is made dynamically and depends for each cell of the daytime for a given month. Compared to a classical approach, the gain in space is a factor 2,
- the SoDa Web service has been proved to be an efficient tool for creating products from the database HelioClim-2 that are suitable to customers and for disseminating the irradiance in real-time to customers.

Reference:

Cros S., Albuisson M., Wald L., Simulating Meteosat-7 broadband radiances at high temporal resolution using two visible channels of Meteosat-8. To be published by Solar Energy, 2005.

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6 ACTIVITIES STILL TO BE DONE AFTER THE END OF HELIOSAT-3 PROJECT

Some activities are still pending at the end of the project Heliosat-3. They will be pursued with the aim of having a climatological chain using the Heliosat-3 algorithm running by the end of 2005. It will be in full operation in January 2006 and all archives (since 1st February 2004) will be re-processed with the off-line version of this chain. The resulting database will be called HelioClim-3.

Some work is still needed on the operation of the SOLIS clear-sky model in real-time for the whole field of view of Meteosat within 1 or 2 hours of computing time per day. It seems necessary to model the influence of the ground albedo in this model as well as on all-skies irradiance.

The climatological processing chain is shared between DLR and Armines / Ecole des Mines. Briefly, DLR will process satellite data to extract atmospheric parameters. These parameters will be transferred to Armines, where the irradiance and its components (spectral, diffuse, direct) will be computed. Part of this irradiance information will be flown back to DLR. Both DLR and Armines will archive their respective information. Tests have been made to exchange large amounts of data between DLR and Armines. Results indicate that the Internet channel may work as an operating channel. Nevertheless, tests are still to be performed with the relevant data and time rhythm during several days.

The concept of the database HelioClim-2 is complex but proves appealing because of the gain in space. This concept will be exploited to design the database structure for HelioClim-3. It will take into account the difference in concept of the processing chain between the hybrid chain and the Heliosat-3 chain. For the latter, it is planned to adapt the concept developed in the Heliosat-2 processing chain for the database HelioClim-1 where the processing is partly made during the acquisition process and the second part is performed on the fly, in real time, every time a request is made by a customer. This second part is actually performed in combination with the SoDa Service. The advantages of such a concept are mostly a gain of space for storage of the database: instead of storing irradiance data, one stores intermediate parameters that take less space.

The design of the climatological chain still needs to be made even if some detailed drawings have been elaborated by DLR and Armines.

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