RAYMAN: INTEROPERABILITY USE OF METEOROLOGICAL OBSERVATION

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ABSTRACT:

The observation of atmospheric phenomena enables generating of knowledge about the weather and meteors occurrence in a region. When this information is georeferenced it becomes useful for a great number of professional and public activities in the field of e.g. building, infrastructures, aeronautics, biota, tourism, agriculture and energy. At the present time access to that information is limited. Few meteorological agencies apply geo-Standards, hindering the development of GIS tools for monitoring, threshold alerts and decision support helping. This work describes how public agencies publish meteorological data and the solution developed at the Spanish Electrical Network (REE) to store the information provided by the Spanish Meteorological Agency (AEMET). The implemented solution enables the access to the weather observations collected by the meteorological agency and the rays captured by the detection network in a interoperable way and the exploitation, by as well a desktop GIS capable of connecting with Oracle-Spatial database as through the interfaces of the OGC standardized services (WMS, WFS and SOS).

INTRODUCTION

The national meteorological agencies carry out several activities related to the weather and the meteor: observation, information, certification and forecasts. They observe and register temperature, rainfall, wind, ultraviolet radiation, pollution, etc. They periodically get satellite images with radar observations and passive sensors of electromagnetic radiation and they detect and locate rays.

The storage of observations enables the climatic characterization of a region from a statistical viewpoint and allows issuing reports and certifications in addition to providing expert services. In order to be able to forecast the weather, complex numerical models are used that combine different atmospheric information sources and non-linear equations to forecast the dynamic behavior of the atmosphere based on the current status (Pennsylvania State University - The PSU/NCAR mesoscale model, 2008; Kalnay, 2003).

Traditionally the calculation methods used in engineering to determine the types of superficial drainage of communication pathways, to determine whether a particular building requires a ray protection system, to calculate the climatic severity in different zones (both in summer and winter), to calculate the distribution and pressure of wind on buildings, to determine solar radiation (to calculate the thermal sensors in the erection of buildings) or to determine the best type of crop for a region (Almorox, 2007), are carried out based on formulae or well documented rules that use temporally added and spatially extrapolated meteorological data. These data are climatic zone isolines, maps of ray density on the ground, tables of provincial climatic severity, compass cards or tables of prevailing winds, isolines with rainfall intensity isolines, runoff correction curves, water distribution, etc.

In addition to the scope of engineering, building and agronomy, agroforestry, renewable (wind-powered, solar) energies, air navigation and civil defense in general are other very important fields that demand application models in which data are not grouped together by periods; they require to integrate and interoperate the meteorological information with the geoscience information in real time (Arctur, 2009), thus the meteorological data interchange becoming an important objective in a global setting (Tandy, 2009). The INSPIRE Directive (Infrastructure for Spatial Information in Europe), in agreement with these considerations, has established data subjects and has classified them in three priority levels (Annex I, II and III). Annex III covers the meteorological information: atmospheric conditions, meteorological geographical features and oceanographic geographical features.

The motivation

The context of the project presented here are the needs of the REE which is the user of both the atmospheric data registered by the permanent meteorological stations and the detection of rays as provided by the AEMET. The areas of the company interested are classified in two groups. The first group is related to the consequences that meteorological factors have on the operation of the electrical network. The second group is related to the treatment, analysis and dissemination of the information within the company. To the first group belong the Management of Facility Maintenance and the Management of Operations. To the second group belong the Department of Statistics and Information (in charge of publishing various periodic reports and the statistical analysis of the data on the Transportation Network) and the Department of the Environment where the Cartographic Management Unit lies that publishes this type of information as another layer in the different corporate GIS.

The challenge

The need of REE to verify whether meteorological factors may have affected the electrical network operation requires the

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meteorological data to be able to interoperate with the data of its infrastructures from a geographic viewpoint. At the present time the data observed by AEMET cannot be spatially integrated with the REE data since its form (images and tables integrated in websites) and its periodic publication (every 6 hours) does not allow interoperation with any type of spatial data. This fact has motivated both organizations to set up an agreement to interchange data in a plain ASCII format. The data received periodically from AEMET by ftp protocol must be collected, processed and stored in a spatial database for its subsequent exploitation. In some cases they are georeferenced data such as ray detection. In other cases data are linked to meteorological stations whose position is fixed and known.

The next section of this paper shows how the national meteorological agencies in Europe provide the observation information in their Web portals; the initiatives put forward by interest groups (civil aeronautical sector, the World Meteorological Organization – WMO, NOAA, USGS, UN) to define a conceptual model, a battery of geospatial standards and their profiles. In another section the technical solution is presented, designed, implemented and based on geospatial standards, used in RAYMAN Project and related work carried out to the coordination and standardization being presently developed in this domain in Europe. The paper concludes with some reflections about proposed solutions and future works.

CURRENT ACCESS TO METEOROLOGICAL OBSERVATIONS IN SPAIN

For users interested, the atmospheric observations provided by public institutions such as AEMET, the permanent station network of the Agroclimatic Information System for Irrigation (SIAR) and the meteorological stations of the Traffic Authority or other non-professional networks of automatic stations such as Meteoclimatic, offer weather information in quasi real time and historical data in the form of dynamic websites. In some cases the data shown are tables, in others graphs generated from the observations. This is undoubtedly useful and it is an important achievement for the Information Society. However, this type of dissemination of meteorological information is only designed to be interpreted and used by persons: data tables, graphs in map form over which meteorological conditions are symbolically and numerically represented, image sequences showing electrical discharges in the form of rays, satellite images captured by sensors of electromagnetic radiation of the visible spectrum and adjacent low resolution bands, low resolution images captured by radar sensors, graphs of the compass card type, etc. Figures 1 to 6 show some examples.

obsFrance.csv

	A	B	C	D	E	F	G
1	indicatif OM	echeance	temperature	temps prese	direction du	force du ven	pression
2	7005	13/01/2010 0:00	-12	-999	100	62	100060
3	7005	13/01/2010 6:00	-20	71	120	46	99970
4	7005	13/01/2010 12:00	-6	10	150	36	100110
5	7005	13/01/2010 18:00	8	-999	130	31	100300

Figure 1. Example of data in spread sheet format (source http://france.meteofrance.com/france/observations)

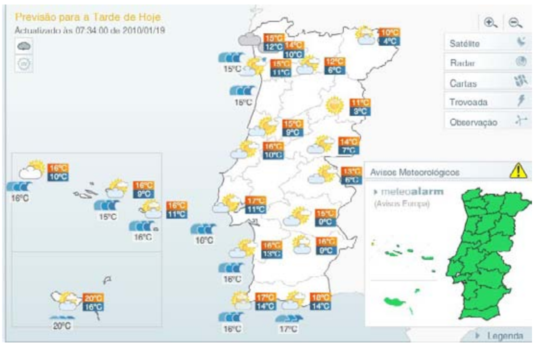

Figure 2. Example of weather observation as web application (source: Instituto de Meteorología, IP, Portugal)

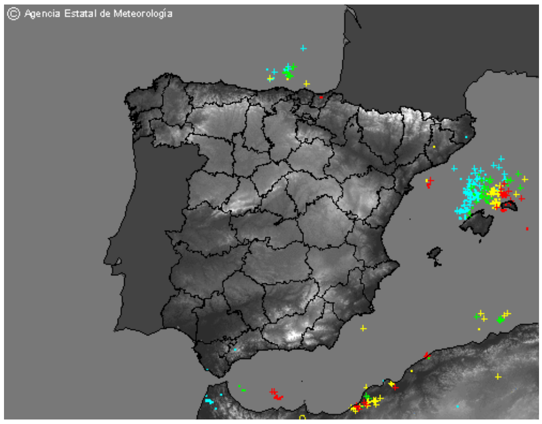

Figure 3. Image example of rays detected in 6 hour periods in gif format as part of an animation (source AEMET)

Figure 4. Example of satellite images in jpg format as part of an animation (source MeteoFrance)

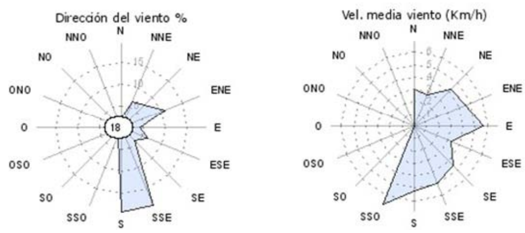

Figure 5. Compass Wind Rose (source MeteoClimatic)

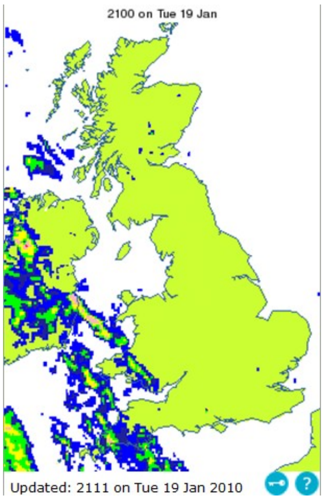

Figure 6. Radar images (source: Met Office UK)

Although the Spanish setting has been described, because of the scope of the RAYMAN Project the websites of the various European meteorological agencies have been visited and have been found to be similar. In some cases they offer information arranged by society and industry segments (United Kingdom, the Netherlands) and in others downloading of data through ftp services (Germany) is provided, and as a common nexus graphs, tables and animations are used.

On the demand site there are a significant number of professions that need data coming from trustworthy, public sources: engineers, architects, scientists, lawyers, agronomists, biologists and meteorologists. All of them would like to have standardized, hence extended mechanisms of access to weather/meteorological information. In many cases temporal series of data are required to carry out studies of densities, isoceraunic levels, average pluviometry, regression curves, etc. As a response to the demand, many governmental or non-governmental agencies foresee in the possibility of accessing the data stored in text files, spreadsheets o even in databases either free or by a fee.

Another group of more demanding users need to access the observations in near-real time. This group includes the managers of facilities: transportation and communication infrastructures, gas, electricity, telecommunications, emergency units, etc. The immediate knowledge of certain meteorological events allows finding out the causes of failures or faults in the systems in some cases and in others, perhaps more importantly, taking operative decisions on the infrastructures concerned.

As an example, the knowledge in real time of wind speed in different regions would allow inferring the generation capacity of wind power plants and balancing consumption with the production of other energy sources. This is one of the services offered by the UK Meteorology Office (http://www.metoffice.gov.uk/energy/renewables.html).

Another example would be the knowledge in real time of the ray discharges which allows inferring the evolution of a storm and having information in advance so that the involved organizations can act preventively in those zones.

The most used example to highlight the importance of access in real time to weather information is the management of contingencies due to disasters: fires, flooding, etc. The capability of access to temperature, wind and humidity observations may help in planning the tasks of the emergency teams and their actions.

As the last example, the Air Traffic Management (ATM) in the framework of the Single European Sky (SES) is trying to standardize the Aeronautical Information Exchange Model (AIXM) and it is adopting the family of standards ISO 19000. Merging of real-time meteorological information with the own management is a strategic mainstay in SES (Lepori & Hart 2009).

In addition to ATM and emergencies, the industrial consortiums are promoting standardization of the mechanisms of information exchange and exploitation of Web services. We should mention here the Single European Sky ATM Research Consortium (SESAR) for the aeronautical world (AIXM) and OGC for Web access to sensor data (Sensor Web Enablement – SWE). Recently a workshop (Lepori & Hart, 2009) has taken place in Toulouse, France, in which different players in these fields have shared their experiences and impressions and they have set about working to define and develop standards and good practices.

The most critical conclusions from the workshops about services are related to: their predictions and different time spans; the large number of prediction layers of a model over a long time; the capability of including more dimensions beside space, time, altitude in the WMS; vertical coordinate systems; some domain CRS of its own; and the definition of visualization styles. It seems that in this workshop little attention has been paid to the Web services of access to sensors. Furthermore, some of the presentations are critical about as well the WFS as the SOS for overburdening clients with data encodings.

METHODOLOGY

The methodology for georeferencing and publishing the weather and meteor data coming from AEMET in an interoperable way is strongly related with the application developed. Each methodology step is associated with the created software.

The software was created as a Windows service (Daemon) based on JAVA. This service runs periodically and launches a thread process that carries out the following operations:

a) Setting up connections to the data store and to ftp with the new raw data: If there are not previous connections to the ftp server working as the mailbox or the Oracle Spatial database, new connections are created.

b) Converting and uploading new raw data into the spatial data base format: Requesting the list of all the files contained in the directory of the predefined ftp to check whether there are pending files containing either the rays stored by time intervals (5 minutes), the observations of temperature, wind and daily rainfall or the monthly meteors; Checking the current time to determine if one is within the time window comprised between two consecutive threads to keep on processing files, so that if ray files exist, one is read, its content interpreted, a geometry is created with latitude and longitude.

c) Storing rays of special interest: A spatial query is made to the line type layer of the electric transport network. If as a result of the query, the distance is lower than a determined threshold, it is estimated that the ray is in the proximity of an electrical infrastructure and it will be stored doubly in a general table of rays and in another table of recent hour rays near the facilities.

d) Backup the original raw data: Once the file has been processed, the ray file in the ftp is moved to another folder acting as a backup. If there are more files to be processed and we are within the time window, the process is repeated with another file.

e) Checking for daily data: If we are within the first 5 minutes of an hour and this hour is later than 4 a.m. (the daily data of temperature, wind and rainfall are deposited at this time), the existence of a file with a fixed name in ftp is checked. If it does exist, it will be processed (if this had not been done as yet), and stored in the three tables of highest and lowest temperatures, highest wind speed and orientation, and rainfalls. These data may have different granularity levels: hourly or daily. In both cases they are interpreted and stored.

f) Checking for monthly data: Finally check the existence of a file with a fixed name; it is deposited every month and it contains the meteors produced: fog, snow, hail, etc. The sole interest of this data for REE is fog. If the file exists, it will be processed, the data stored in the Oracle table and the file in the ftp mailbox moved to backup-folder.

The position of the observations of temperature, wind, rainfall and fog is established by means of a set of relationships with a table containing identifiers of the stations, their data and position. Figure 7 shows graphically the objective of the developed service.

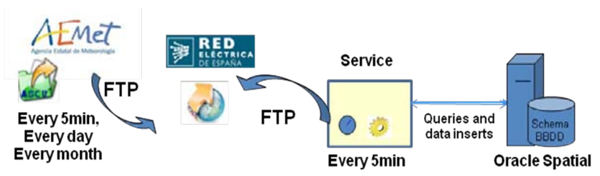

Figure 7. Data loading architecture

Figure 8 shows the class diagram of developed service. It shows that the service launches a thread periodically. This thread is responsible for all the operations. Two classes have been defined to handle the connection with Oracle data base and the ftp server. Another two classes handle the proximity computation between ray position and electrical circuits or to parse and store temperature, wind and rainfall daily files. The RaysRead, FogRead, ReadTemp&Wind classes take over the processing of the three types of interchange files (formats) and they store the observations in a vector structure for each type: Ray, Fog, Rainfall, Wind and Temperature.

The figure 9 shows the diagram of activity performed by the service; operation forks and sequences performed by the different collaborating objects may be seen.

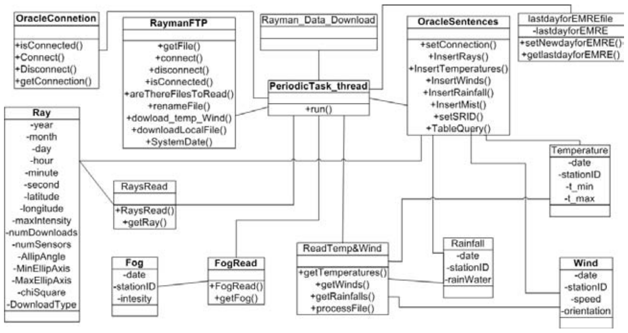

Figure 8. Class diagram of the Rayman_data_download service

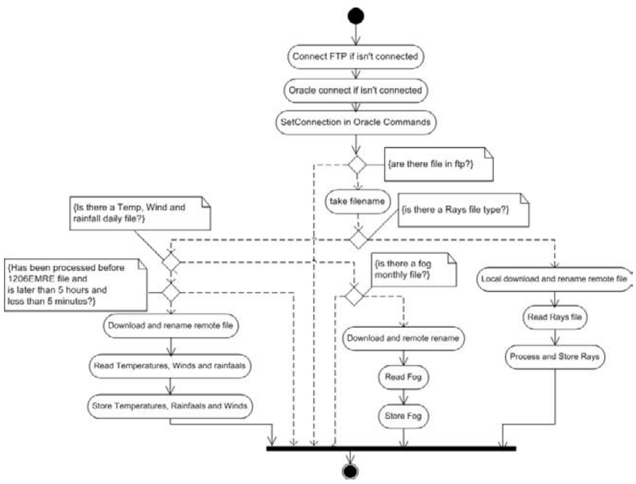

Figure 9. Activity diagram of the Rayman_data_download service

Figure 10 shows the class diagram of Rayman data model showing their relationships. Rays are registered in two tables: Rays and RaysNearCircuits. Rays table register all the rays and it's useful as a historical repository for queries when planning a new infrastructure. The RaysNearCircuits table store the most recent rays detected nearly of electrical network infrastructure in order to facilitate his visualization and retrieval. In similar way meteorological stations and detected rays are related to through external keys with regions and provinces administrative divisions and with maintenance areas of the REE. MeteoStations class contains descriptive and location information of each one stations carrying out observations. The other four classes have already been described.

To display this information in a graph on a map reference and to interpret visually the relationship with REE infrastructure, the OGC-WMS service has been selected. In order to obtain the spatial and temporal filtered data sets and exploit them in office environments and GIS applications, the OGC-WFS service has been selected.

Both services can be implemented with different solutions: Mapserver, deegree, ArcGIS, GeoMedia. The type of license, the simplicity and usability of Geoserver to manage data stores, layers, styles, and the configuration of the services have motivated their choice.

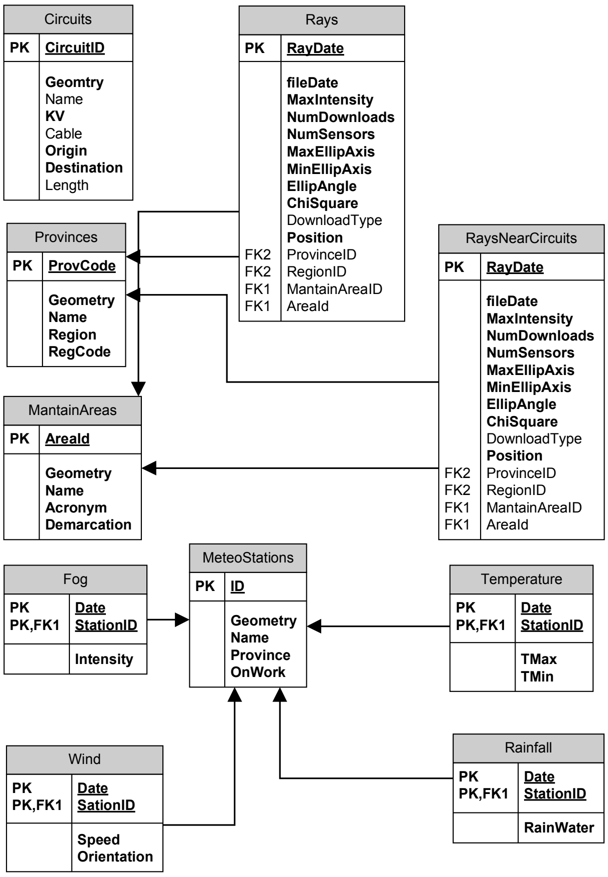

Figure 10. Class diagram for the entities and views of Rayman

Web application developed to exploit stored information and offered as OGC standard services, use the OpenLayers library enriched with a set of features. These features are designed to enable temporal filter selection or to facilitate the geographic framing and real-time display of dynamic information coming into the system.

RESULTS

After having built the data store and after having developed the Daemon taking care of loading the data, the exploitation of the information in a interoperable way can be started.

The standardized way of sharing this information allows its exploitation by several kinds of software. These could be a wide range of applications, from heavy desktops GIS clients to lightweight web clients, as the ones shown in the next images. These lightweight web clients were developed as an alternative form to test the proposed architecture.

The architecture developed in this project is shown in Figure 11. This figure also shows other services (SOS, SAS and WNS), which will be implemented in the near future, in order to test the OGC SWE technologies.

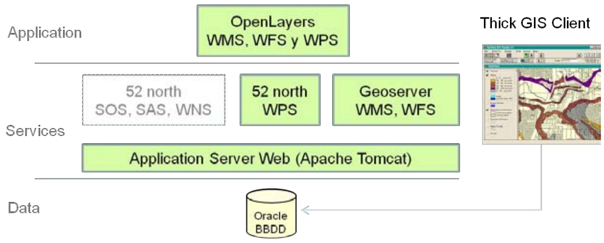

Figure 11. Implemented service and application architecture

Figures 12 and 13 showed two screen hunters on which the weather data, owner data (REE) and reference cartography of external providers are interoperating.

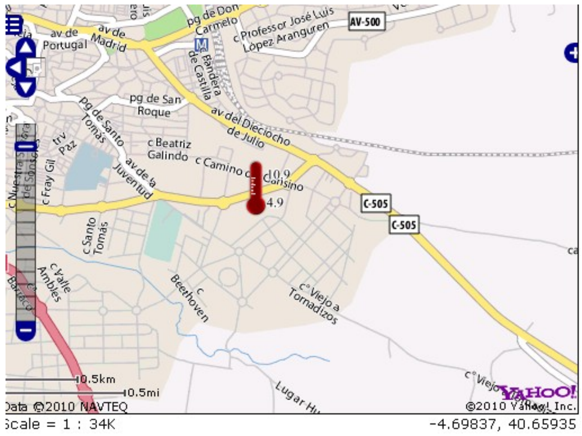

Figure 12. View of standardized data over Yahoo Maps. Meteorological information (Temperatures)

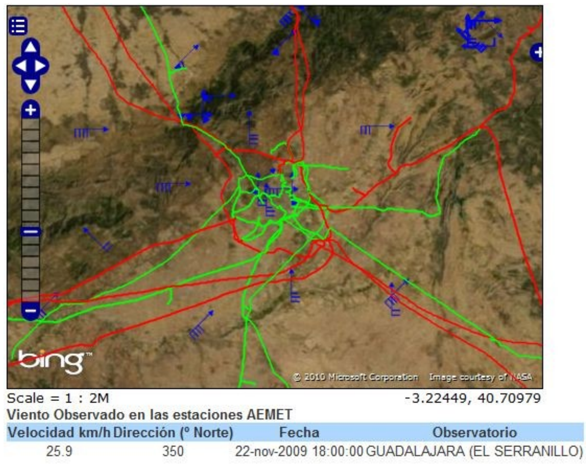

Figure 13. View of standardized data over MS-Bing. Meteorological information (wind speed and direction, blue arrows) and the Electricity Network (high voltage, black and blue lines)

Figure 14 shows the appearance of the Web application developed. Here you can see the shortcuts to the individual and joint display of weather information and reporting. In the same figure can be stood the new feature developed for defining temporary filters. Figures 15 and 16 shows date and time selecction on temporal filtrer and real time filter options. Finally Figure 17 show report interface develop to export information in data format commond used in office or GIS tools.

Figure 14. View of Web application interface based on GoogleMaps showing Ray information and the Electricity Network

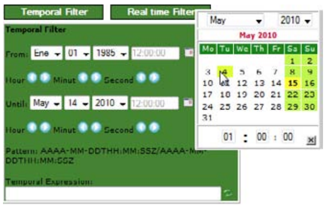

Figure 15. View temporal filter tool developed

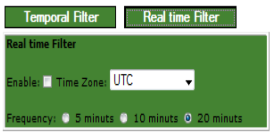

Figure 16. View Real time parameter selection developed

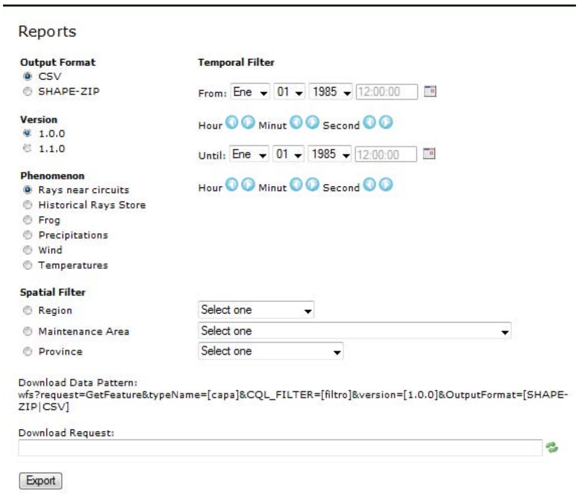

Figure 17. Report interface developed

CONCLUSIONS

The Conclusions of this work have been classified in two groups: the ones related to the Windows service (Daemon) and the ones related to the interoperability provided by the proposed architecture.

In the first group, the Rayman_data_download service has been designed to bear with different work load rhythms caused by the variable number of rays that may be produced in every time window in some atmospheric circumstances, the breaks or interruptions of the ftp service causing the buildup of data files to be processed and the delays that may occur when depositing the daily or monthly data files. After a sufficiently long testing period, different problems have been identified and solved. As an example, in certain periods of heavy storms a considerable number of rays may be registered in the time window that cannot be processed and stored in the database at the same speed. Launching different execution threads allows dodging this problem to a certain extent. Using the threads to process 'delayed' data files in the face of interruptions in the connection with the ftp service represents another problem which has been solved by restricting the number of files a thread may handle to the number that the thread can process in its time window. If it has not been possible to process them all, the next thread carries on with the work at the point the previous one had left it.

The second relates to the interoperability provided by solution to exploit weather data together with another type of georeferenced information. The designed solution being already implemented allows exploiting weather data from GIS applications, thus avoiding or decreasing remarkably the effort needed during the stage of preparation of the data such as the conversions of formats, data models or spatial reference systems. At the present time we are working on adapting to the 52North Project so that the SOS, SAS and WNS services will be able to exploit data stored in Oracle with the data model appropriate for RAYMAN. When the proposed architecture will be fully developed, conceptual tests will be carried out on the SWE services that should bring value to the needs of REE. Another work that has been done is related to pipe weather data access service with processing services and presentation services in a web client interface (WPS).

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