A Step Beyond Visualization: Applying User Interface Techniques to Improve Satellite Data Interaction

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Abstract. In this paper, we discuss the potential of applying interaction techniques to manipulate GEO satellite data. The proposed study shows the potential of Meteosat Second Generation (MSG) data in refining the mesoscale analyses incorporating HCI techniques, as natural interaction resources. Moreover the software tools used to develop the interaction layer,is based on open source codes. Open source codes are also used for geolocation and geographical information systems, written for the transformation of MSG data into input files. This feature have demonstrated a great flexibility and ease of use. The study open up an avenue for successive validation and refinement of the analyses together with their improved implementation for operational nowcasting and very short range forecasting applications.

1 Introduction

The information provided by geostationary (GEO) satellites is very important for the Earth and its atmosphere. In fact, the satellite sensors receive radiation from the Earth and its atmosphere in several visible (VIS) and infrared (IR) spectral bands, from which several Earth and atmospheric parameters are retrieved such as cloud top temperature, water vapour absorption. GEO satellite data need to be properly evaluated in order for them be useful for operational use and climate change adaptation plans.

Several variational data visualization tools or systems are available nowadays but they are implemented in centres where large computational resources are available and are generally used for global analysis. These sophisticated technologies for visualization are essential for bridging the gap between such systems and users. For Kerher [3] typical visualization tasks cover visual exploration, visual analysis and presentation. In other words, visualization is concern to generate static images that can represent GEO satellite data. Furthermore, going beyond the visualization analysis, complex data manipulation requires solutions "out-of-core" including hardware and software techniques [2].

For Jennifer Ouellette [1], today's big data is noisy, unstructured, and dynamic. The idea is to reduce large, raw data sets of many dimensions to a compressed

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representation in lower dimensions without sacrificing the most relevant topological properties. So, it is necessary to combine many things and create something greater that is new and different. During the last few years, new advanced methods of data manipulation provided by Human Computer Interaction (HCI) techniques, have been developed and applied in entertainment, health and military fields. So, it is possible to manipulate data with interactivity features as pointers for navigation, immersive resources or remote control. To what extent such new methodologies can be successfully applied to GEO satellite data, such as the cloud cover analysis and humidity analysis packages.

The evolution of HCI techniques enables us to go further than graphical user interfaces or pixels on bit-mapped displays. Immersive environments, natural interaction user interfaces and interactive surfaces are example of approaches to supporting collaborative design and simulation to support a variety of spatial applications [4]. For example, e-Health systems can offer to physicians complex models visualization (as human body 3D models) and also makes easier the data manipulation without touchable controls, using natural interaction resources. At this way, physicians can interact with patient data as exams or clinical reports, during a medical procedure [5].

Going back in time we can observe that visualization tools based just in one dimension (text) gave space to GUI (Graphical User Interface). The use of GUIs opened space to think about hierarchical visualization and manipulation of complex data. Today a great variety of HCI techniques can be used to enrich the interaction with complex data. Visualization issues can be addressed and we can also have other tools for data analysis using new approaches for user interfaces.

In this paper, we discuss the potential of applying interaction techniques to manipulate GEO satellite data. The proposed study shows the potential of Meteosat Second Generation (MSG) data in refining the mesoscale analyses incorporating HCI techniques, as natural interaction resources. Moreover the software tools used to develop the interaction layer,is based on open source codes. Open source codes are also used for geolocation and geographical information systems, written for the transformation of MSG data into input files. This feature have demonstrated a great flexibility and ease of use. The study open up an avenue for successive validation and refinement of the analyses together with their improved implementation for operational nowcasting and very short range forecasting applications.

2 Visualization versus Interaction

Scientific visualization is a research area that integrates images, diagrams, or animations for representation with specific areas of scientific application. Visualization through images has been an effective way to relate the scientific questions that the methods and tools are designed to explore [16]. These methods and tools are used to depict some information that is beyond direct or everyday experience. For instance, the complex meteorological interactions that occur in a developing thunderstorm, hurricane, or tornado.

If some decades ago user interfaces were all about how to visualize things, today the concern of any user interface is the better way to interact with these. Graphics, images, videos, 3D objects, animations are used to share any kind of digital information. Also, the Internet is not open to only computers anymore. Internet access is a feature of modern cell phones, domestic equipment, cars, and many other devices. This is changing the way that society deals with digital content. It is transforming user's needs, actions and reactions [17]. If sometime ago users were used to navigate between tons of text data, today users want to go further and inside data in any format of representation.

This trend is also improved by the diversity of formats to represent data in the digital world. The evolution of the user interfaces brought news ways to visualize and interact with computer based applications in several areas. Ishhi et al. illustrates this evolution using an iceberg metaphor as we can see in Fig.01.

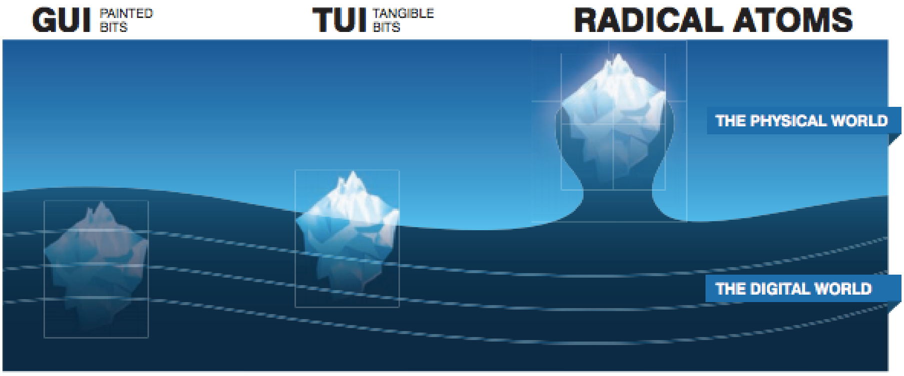


Fig. 1. Iceberg metaphor [4]

The iceberg metaphor puts the GUIs (Graphical User Interface) through the surface of the water.GUIs are typically based in screens and users can interact with them through remote controls such as a mouse, a keyboard, or a touch screen. The main functions of a GUI includes the visualization of digital information. A step forward a TUI (Tangible User Interface) is like an iceberg. It means that there is a portion of the digital world that emerges beyond the surface of the "water" into the physical world. Tangible interfaces can be seen as a complement to GUIs, working embodied in the physical world. This feature allows the use of physical manifestations, making easier and natural the direct user interaction (the "tip of the iceberg"). The last level – radical atoms – represents the vision of Ishii for the future of user interfaces, in which all digital information has physical manifestation so that we can interact directly with its.

In fact the current user interfaces technologies enable us to go further than graphical user interfaces or pixels on bit-mapped displays. Immersive environments, natural interaction user interfaces and interactive surfaces are example of approaches to supporting collaborative design and simulation to support a variety of spatial applications [4].

For example, e-health systems can offer to physicians' complex models visualization and also makes easier the data manipulation. At this way, physicians can visualiaze patient data as exams or clinical reports in real-time. More than that, they want to see the data moving into realistic models which are touchable and interactive. Sometimes, the "realistic" feature is not enough, they want to see a hair size structure in a wall size with more details that our eye could notice in the real environment.

Let's check the scenario shown in Fig.02 that illustrates the adoption of innovative user interfaces for enriching the user experience using a telemedicine tool [05].The tool provides the possibility to manipulate 3D objects, especially human anatomical structures, while viewing other streams, such as video. We analyzed this work into three levels: the plan mode, the switchable mode and the touchable mode. The plan mode is the pixels-based one, the visualization is the main goal (see Fig.02 (a)). As we can see in Fig.02 (b) the next step was the addition of several streams at the same time. Also, higher quality for projection area and a switchable structure was addopt. In this case, the user interface is more versatile and engaging even pixels-based. The "touchable" mode denotes theintegration of 3D models, live video and natural interaction controls. In this example the use of natural interaction controls (using Kinect to manipulate 3D objects) makes easier the manipulation of human body models by the professor. So, the professor can use his own hands to go inside the models, interacting with them and their detailed structures as tissues and cells, for instance. (see Fig.2 (c)).

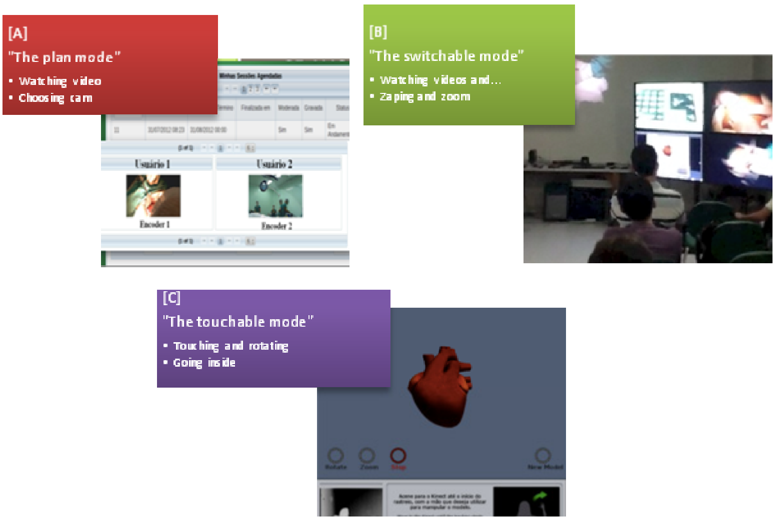


Fig. 2. Telemedicine Scenario

Interaction instead just visualization is something common in the presented cases. The innovative ideas from Ishii [4] or the real examples from e-health systems [5] showed to us that taking part in user interfaces is more than a user desire, is a user need. In complex data, as GEO satellite data, it is a challenge and also an opportunity to go further and understand the behavioral aspect of data.

3 GEO Satellite Data

GEO imagery data portray a variety of data types, including visible, infrared and water vapor. The image products, especially from the SEVIRI data is distributed to the user mainly through the EUMETCast system [18], provide the forecaster with a great deal of information, including winds, precipitation, and so on. The EUMETCast system is destined to the retransmission to users in various points on the planet, of codified data and products originating from meteorological, oceanographic, and environmental satellites, via telecommunication commercial geostationary satellites in different frequencies. The concept of this dissemination service is based on the standard technology of Digital Video Broadcasting (DVB).

The antennas of the EUMETCast system users are basically divided into two types, which are destined to the Ku band reception via the Hotbird-6 satellite, and the antennas destined to the C band reception via the AtlanticBird 3 and SES-6 satellites. The C band transmits in the cover areas of Africa and South America. While the transmission in Ku band is for Europe. The minimum diameter of the antennas is in the 2.4 m order for the South American continent and 80 cm for the European continent, in Ku band. The basic antenna components are a parabolic reflector of 2.6 meters, supply with LHC polarization, and a universal LNB amplifier to amplify the signals of low-level potential, and cables for connections. To receive the signal, the antenna is pointed to NSS-806 satellite. The SES-6 is located at 40.5º west.

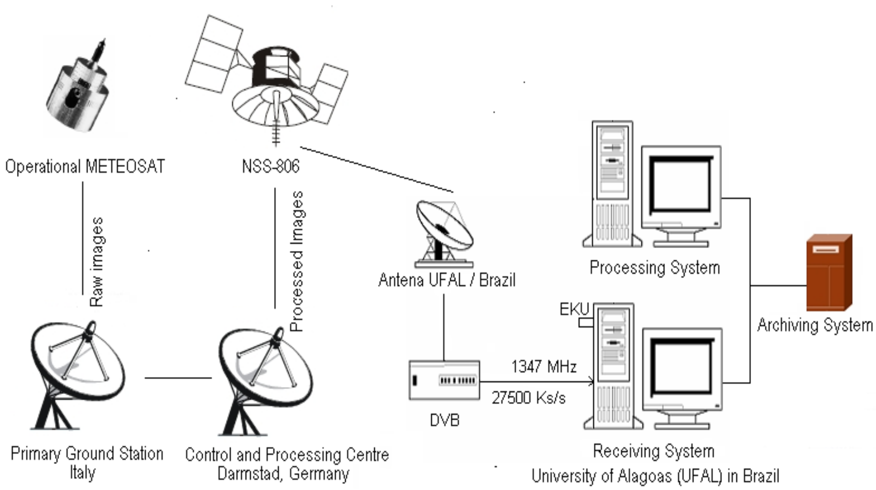


Fig. 3. Overview of the broadcasting ground reception and processing system at the University of Alagoas (UFAL) in Brazil

The antenna of the user receives the PC signal and plaque (Technisat SkyStar2 TV PCI or other DVT plaque) identifies the packages (Packed ID-PID) which are transmitted in the MPEG-2 format for the EUMETSAT application, called T-System Tellicast. The PIDs are defined in the application of the DVT plaque, called

Setup4PC. And the transmission of the packages is achieved via the TCP/IP protocol (Transmission Control Protocol/Internet Protocol). After the transfer, the TelliCast verifies if the eToken key (EUMETCast Key Unit-EKU) is suitable for the recuperation of the archive [19].

The system-configuration, exhibits in Fig., provides a low cost alternative to the “non-traditional meteorological” user community in Brazil applying the MSG data to a multitude of important environmental science related applications. The MSG capabilities and current favorable data distribution policy-license agreement of EUMETSAT, for Research and Education Institutes like the Federal University of Alagoas (UFAL), have recently opened the way for new initiatives [20].

4 Representing Satellite and Climate Data

How should MSG data be displayed on a computer screen? The processing of a full set of data of all 12 images: (i) Data acquisition stage (via EUMETCast system), (ii) Data decoding stage (calibration) and (iii) Data scientific processing stage (rectification, normalization), plus extraction of nowcasting products, is performed within a few minutes so that the data are available to the weather forecasters in near real-time. Nowadays computer capacities and processing time are no longer an issue and storage capacity for large volumes of satellite data is also no problem, not even so much from a financial point of view.

New applicative tools allow the forecaster to combine data types into single displays. For instance, Nocke et al. [2] highlights that designing intuitive and meaningful visual representations in climate context faces a variety of challenges. The first thing to consider is the heterogeneity and diversity of climate related data. The most common view of climate data uses the gridded format. Grids are used to group data and can aggregate information just using columns and lines or adding colors. But this is not the best way to make spatial and temporal information understandable. So, using 2D-maps or 3D objects is a way to represent multivariate and region-based information.

The interpretation of MSG images can be strongly supported and facilitated when multispectral image data are presented in appropriate combinations of the colors red, green and blue (RGB). Fig. 4 shows the RGB image that is composed from MSG channels as follows: red: 12.0 - 10.8 μm, green: 10.8 - 8.7 μm, blue: 10.8 μm. For more details as regards RGB images, please refer to www.lapismet.com. This product detects deep convection (dark red color).

In meteorology, the best kind of external representation might be one that emphasizes the qualitative aspects of the data. One good example of this is the winds, shown in Fig. 4. Winds are often referred to according to their strength, and the direction from which the wind is blowing. A wind barb shows both wind speed (by the number and length of the barbs) and direction (by the direction of the major line). Thinking about general users, vector fields do not speak for themselves. After all there is a lot of simultaneous information going on: speed, direction, and temporal and spatial data. A new design for presenting this data is introduced in [10]. A resource calledreal-time wind animation provided by HINT.FM [11] uses computer models to compile data and then overlays the wind flow on a map.

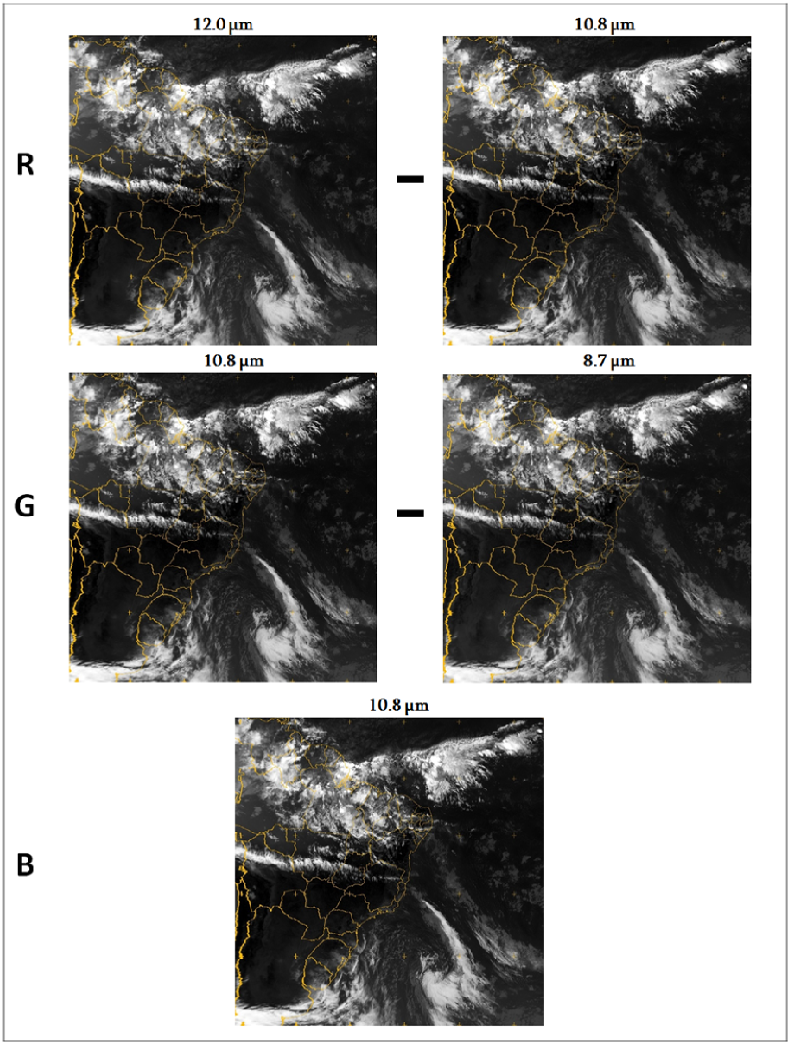
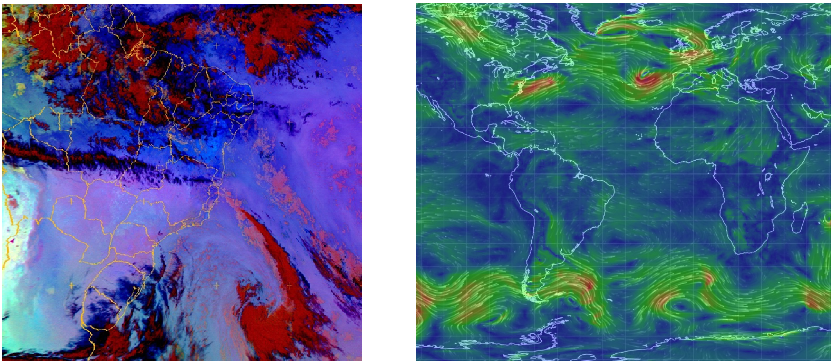


Fig. 4. MSG channels

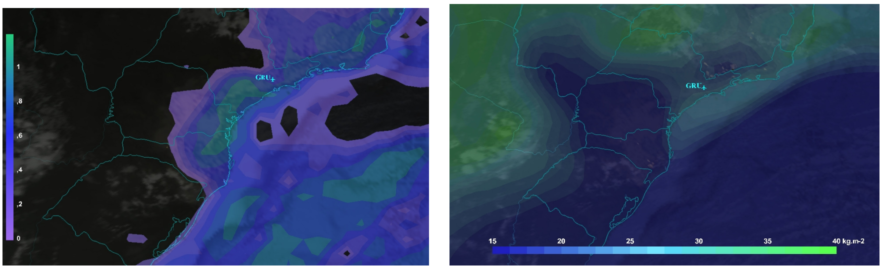
Even using animation techniques, in the user point of view, it is still a passive visualization. Let's check some interactive examples. By using ChronoZoom [14], was developed a solution to illustrate changes in climate from the beginning of the planet through today. This solution includes images, diagrams, graphs, and time-lapse movies that illustrate changes in the environment. Using timeline users can do their own virtual tours at any speed and level of detail they want. This timeline is an interactive resource to manipulate the data.



(a) (b)

Fig. 5. In (a) MSG RGB composite image and (b) wind data representation

Another possible interactive feature is the integration. Fig. 5 (a) and (b) shows integration of SEVIRI IR10.8μm image with both the Low Cloud Cover and Total Column Water Vapor fields (derived from the Numerical Weather Prediction (NWP) data), respectively. In particular, the two NWP fields reproduce the structure generated in SEVIRI RGB composite (Fig.5 (b)). However, it is uncertain if the two NWP fields are sensitive enough to discriminate between low *stratiform* water clouds and fog cover.



(a) (b)

Fig. 6. In (a) Brightness Temperature SEVIRI IR10.8μm in conjunction with the Low Cloud Cover map (ECMWF parameter). GRU (Guarulhos' international airport). In (b) Brightness Temperature SEVIRI IR10.8μm in conjunction with Total Column Water Vapor map (ECMWF parameter). GRU (Guarulhos' international airport).

Erlebache G. et al. (2001) states that the future of visualization includesa multidisciplinary approach involving many fields. Visualization ubiquity collaboration and visualization displays are highlighted fields. Also, exchange of visual data becomes as ubiquitous as exchange of text documents and graphics [12].

5 Discussion

The next generation of applications is going beyond user interfaces based in pixels. Science fiction is becoming even more day-by-day things. Movies as "Minority Report", "Matrix", "The 6th Day" presented us products that we can also buy today. As we discussed above GUIs are giving space to 3D images, sensitive surfaces, embedded interaction resources. Using our hands, muscles or brain to control application is a reality that can favor the creation process of user interfaces.

New formats and technologies bring new possibilities. The design of effective user interfaces is a challenge and also a great opportunity to promote multidisciplinary and innovative solutions what stimulate the participation of several skills integrated in a creative team.

The approach presented in this paper integrates metereology with computing techniques. We are exploring the brand new possibilities of user interfaces to offer innovative solutions for climate data. It's clear that there is a huge gap between take care of a ton of data and interacting with them. So, interaction techniques to facilitate the exploration of climate data is a multidisciplinary opportunity. We believe that today we are a step beyond visualization and satellite data interaction is a key point to the development of user interfaces for big data applications.

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