

# WEB-BASED MODEL FOR ANALYSIS OF TIME SERIES REMOTELY SENSED DATA

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## ABSTRACT:

Powerful computer-based tools exist to process and analyse data collected by terrestrial remote sensing scientists, but in many cases there is a lack of interoperability between the processing tools which leads to problems for application scientists. A Web-based model is introduced to address the problem of interoperability by developing a data model which allows integration of both available sources of data and analytical tools. The application is flexible in terms of functionality, allowing scientists to produce their own data sets, add user-specific tools and create customized output according to their needs. The value of the proposed tool for the research community is that it will remove the necessity for the scientist to be involved in how the data are managed or formatted, and leave them to focus on data analysis and interpretation.

## 1. INTRODUCTION

Scientists often need to interpret a large amount of data to draw conclusions about certain phenomena. This interpretation process requires the use of different computer based tools to address different aspects of a research problem. Addressing a particular research topic demands not only the use of existing tools, but also the production of programming solutions in order to complement what has already been done. This work introduces a framework that consists of a Web-based model, which in the first instance has been implemented for the analysis of MODIS time series data sets, but may be adapted for other applications.

## 2. COMPONENTS AND FUNCTIONALITIES OF THE WEB BASED MODEL

The schematic diagram shown in Figure 1 identifies the components of the Web-based model proposed in this work and the interaction between them. The scientists and programmers can interact with both the database and the web based interface in order to prepare the data and add the required functionalities according to a given research topic. The integration of external sources of data, as well as existing data processing and analysis tools is also allowed.

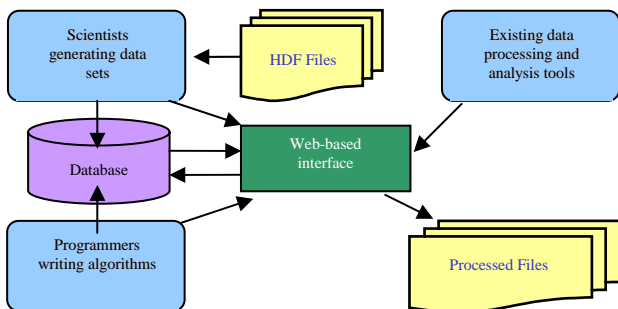


Figure 1: Schematic diagram of the Web-based model

The functionalities of the model presented in this work and their current status are depicted in Table 1.

FUNCTIONALITY	STATUS
Database creation and maintenance	The creation of data sets is already available, whereas the developing of maintenance features is still in progress.
Integration of existing data and processing tools	The automated generation of scripts for the Modis Reprojection Tool (MRT) is already implemented and the integration of other ancillary tools is still in progress.
Modis data edition	Basic edition capabilities are already implemented for the Modis Cloud Mask Product.
Modis data analysis and processing	Analysis and processing of Modis Cloud Mask Product is already implemented.
Report generation with graphs, charts and tables	The developing of report generation capabilities is still in progress.

Table 1. Functionalities of the Web based model

## 3. A DATABASE APPROACH

Relational Database Systems provide a method for storing data in an application-independent manner, which means that the data is held in such a way that modifications to the structure of the database will not affect any of the programs used to access the data. In a different approach, the same information may be held in several files and directories. Apart from wasting disk space, this makes the operations on the data more time consuming.

The idea behind using a Database System for storing MODIS data relies on the fact that within a database the data is stored in way that makes it easily accessible. Another key concept of this approach is flexibility, as developments can progress around a database in an incremental way.

The Relational Database System chosen for this work was Oracle 10g Express Edition (Oracle Database XE) which is free to develop, deploy and distribute. The database was tested in both Windows XP and Unix-based operating systems. Additional tests were made using MySQL and PostgreSQL which are both open source database systems.

### 3.1 Building Datasets

The model presented in this work allows scientists to produce their own datasets which can be processed at any time from its creation. Metadata are used to describe the information associated with these datasets. In fact, metadata describes how and where a particular set of data was acquired, and how the data is formatted. This gives relevant information not only to the scientists, but also to the programmers, who are developing the different functionalities within the model, in order to interact with the data. For example, an image is just a matrix of numbers without associated metadata to describe what is being represented.

## 4. WORKING EXAMPLE: CLOUD COVER DATA

As a working example, we focused on the Modis Cloud Mask Product which indicates whether a given view of the earth surface is obstructed by clouds or optically thick aerosol. All Modis Standard Products are in the Hierarchical Data Format (HDF) which is a physical file format for storing and sharing scientific data (Weaver and Singh, 2002). The Cloud Mask Product is generated at 1 kilometre and 250 metres spatial resolutions. There are two Modis Cloud Mask data product files: MOD35\_L2, containing data collected from the terra platform, and MYD35\_L2, containing data collected from the Aqua platform (Modis, 2007).

### 4.1 Modis Data Processing Tools

Tools for working with Modis data are freely available from the Internet. A number of these tools were integrated into the framework being developed (Table 2).

Tool	Description	Limitations
Modis Reprojection Tool (MRT)	Tool for reprojecting Modis images into standard map projections.	Not suitable for processing a large amount of images at once.
HDF View	Tool for browsing and editing HDF files.	Very basic editing capabilities.
HDF Tool	Multifunctional data processing and visualization tool for Modis data.	Not suitable for processing a large amount of images at once.

Table 2. Modis data processing tools used in this research

### 4.2 The Modis Cloud Mask Scientific Data Set

The Modis Cloud Mask Scientific Data Set (SDS) is part of the science parameters of the Modis Cloud Mask Product and contains the cloudiness information. Each pixel in the Cloud Mask is assigned 6 bytes (48 bit array). Individual bits or group of bits are set to denote various cloud conditions and characteristics for that pixel. Table 3 gives a description of the information stored in the first byte of the Cloud Mask SDS.

Bits	Field Description	Bit Interpretation Key
0	Cloud Mask Flag	0 = Not Determined 1 = Determined
1-2	Unobstructed FOV Quality Flag	0 = Confident Cloudy 1 = Probably Cloudy 2 = Probably Clear 3 = Confident Clear
3	Day / Night Flag	0 = Night 1 = Day
4	Sunglint Flag	0 = Yes 1 = No
5	Snow / Ice Background Flag	0 = Yes 1 = No
6-7	Land / Water Background Flag	0 = Water 1 = Coastal 2 = Desert 3 = Land

Table 3. First Byte of the Cloud Mask Scientific Data

The information encoded in the Unobstructed FOV Quality Flag has four possible combinations, as can be seen in Table 4. This information indicates the probability of clear sky for every pixel in the image.

Value of Bit 2	Value of Bit 3	Bit Interpretation Key
0	0	Cloud
1	0	66% Probability of Clear
0	1	95% Probability of Clear
1	1	99% Probability of Clear

Table 4. Possible values of the Unobstructed FOV Quality Flag

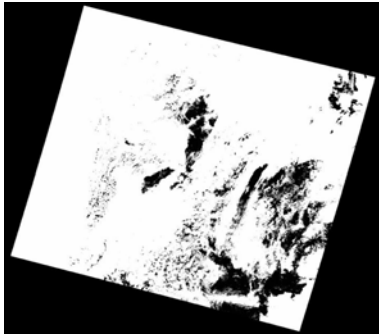
### 4.3 Bit Extraction Process

An algorithm was written to perform the bit extraction. It takes Modis Cloud Mask Product file as an input, while the output overwrites the value of the first byte of the Cloud Mask SDS for every pixel in the image, taking into account only the values of the second and third bit which have the relevant information.

The image in Figure 2 covers the United Kingdom and surrounding areas and shows the information stored in the first byte of the Cloud Mask SDS (Table 3) which corresponds to a Modis Cloud Mask Product HDF file. The resulting image after performing the bit extraction is shown in Figure 3.



Figure 2. Image before performing the bit extraction



Confident Clear	Probably Clear	Probably Cloudy	Confident Cloudy
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Figure 3. Image after performing the bit extraction

January 2005 is 0-41% and the range for September 2005 is 0-65%.



Probability of clear sky				
Low				High

Figure 5. January 2005

### 5. DATA ANALYSIS

After processing a set of images corresponding to a given year, two stacks of binary files were produced with the intention of calculating the cloud cover probability in a given region. The pixel values of the images within the first stack indicate whether the Cloud Mask Algorithm was executed or not. Whereas the pixels values of the images within the second stack indicate cloudy areas or a high probability of clear sky. The analysis process is shown in Figure 4.

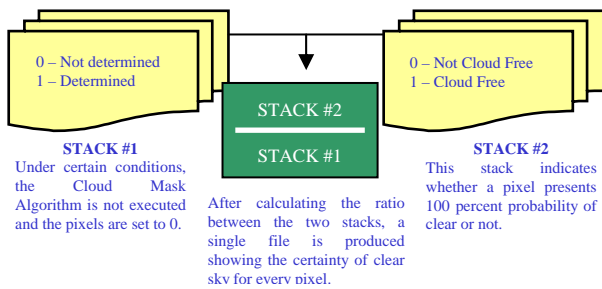


Figure 4. Data analysis process

### 6. RESULTS

The values of the pixels in the images (Figure 5, Figure 6) show the percentage of cloudy days across England, Scotland and Wales corresponding to January and June 2005. The darker areas suggest higher probability of clouds, while the brighter areas indicate higher probabilities of clear sky. The range for



Probability of clear sky				
Low				High

Figure 6. June 2005

## 7. CONCLUSIONS

After processing remotely sensed data within the framework proposed, the following advantages are noted:

- Easy creation and maintenance of large data sets.
- Faster processing of data sets.
- Flexibility for integrating existing ancillary tools.
- Easily adaptable programming solutions to existing processes.

The model proposed in this work has some limitations that are being addressed in order to improve the overall performance. The redundancy in the information stored in the database will be reduced after optimizing the data analysis process. The integration of existing data processing and analysis tools has also to be improved.

Further work will expand the model in order to perform the processing of other Modis product files. We will continue to test the bit-extraction algorithm on other years, and we will also work on speeding up the processing time of the images which will allow faster processing of data for longer periods of time.

## REFERENCES

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