

AN OPENGIS WEB MAP SERVER FOR THE ESA MULTI-MISSION CATALOGUE

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ABSTRACT:

This paper describes the development and use of a Web Map Service (WMS) interface to the ESA Multi-Mission Catalogue (MUIS). This interface is compatible with the OpenGIS Consortium (OGC) version 1.1.1 specification so that browse products can be returned as geocoded images in a well-know geographic projection. This will allow them to be displayed on a web browser and merged with other EO and GIS data available from servers already supporting the OGC WMS interface.

MUIS contains over 200.000 browse image products from a large number of sensors flying on-board ESA and Third Party Mission satellites. The images represent a wide variety of sensor types, such as SAR, sweep scanners, push-broom scanners and conical scanners.

The browse images in MUIS are stored in their original sensors coordinate system. This makes it necessary for the WMS server to rectify them to match the geographic projection requested in a WMS query. This process is performed on-the-fly. The full set of EPSG namespace projection codes are supported in the rectification, in addition to the OGC specified AUTO namespace projections. The rectification is based on a rigorous geometrical model for the space/image acquisition, taking sensor model and orbital constraints into account. The acquisition model is reconstructed from the browse metadata. It also makes orthorectification possible, by using an on-line global DEM.

The Open GIS Web Map Server for the MUIS catalogue will enable WMS compatible clients to utilize the ESA products in an easy and standardized way.

1. INTRODUCTION

The OpenGIS WMS interface specification provides an easy way to query Geographic Information and retrieve it as a graphic representation other the Internet. The query hides the structure of the data on the server side and can serve in a transparent and similar way various types of data be they raster (for e.g. satellite data) or vector (coastlines, fire location...).

The query allows a precise control over the required geographic projection, bounding box and returned image dimension so that a client application can easily retrieve and merge information from distributed servers possibly maintained by various organizations.

The following picture (Figure 1) illustrates the potential benefit resulting from the use of a WMS interface. On the left side, a map of fires detected in Northern Spain is displayed. These fires have been detected by the ATSR2 instrument on-board the ERS2 satellite. The actual ATSR2 frame used for that detection shown on the left represents what a user can already obtain today via the existing MUIS interface (EOLI). On the right all data have been merged using a simple client accessing the various data sets via OGC WMS interfaces easing the interpretation of the satellite image and showing in this particular case that what could have been originally interpreted has smoke from the stand-alone image is much more likely to be clouds unrelated to the fires.

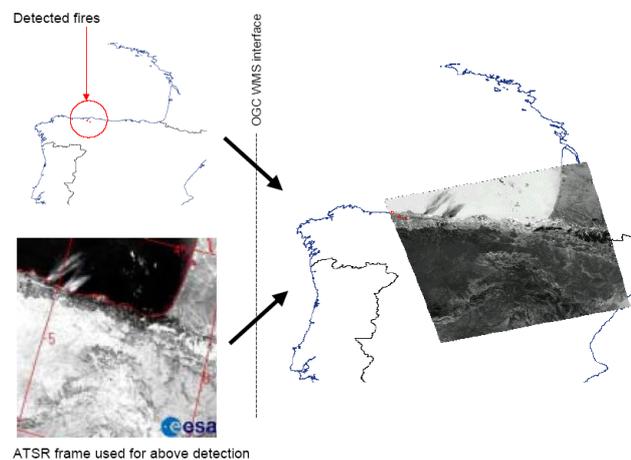


Figure 1. Example of a WMS interface usage

The WMS Image Server (WIS) provides such a WMS interface to the MUIS satellite image archive, so that its browse images can be made available to WMS clients (Figure 2). The WMS Image Server was developed for ESA by Spacemetric, with SaabTech as subcontractor.

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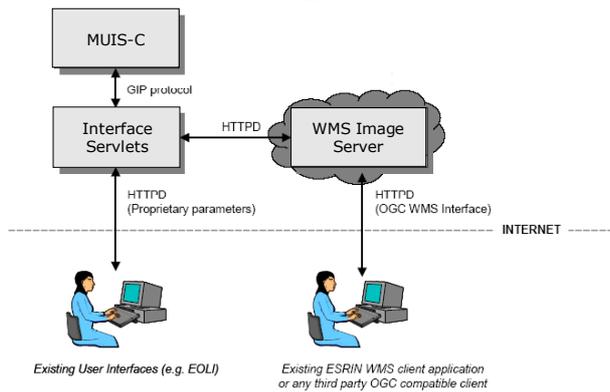


Figure 2. MUIS and WMS Image Server

2. WMS PROTOCOL

The OpenGIS Consortium (OGC) has released the Web Map Service (WMS) Implementation Specification. This specification defines a syntax for World Wide Web (WWW) Uniform Resource Locators (URL's) to invoke queries for maps and georeferenced data.

The WMS protocol was developed as an open standard for transferring maps and georeferenced data over the Internet. Servers compliant with this standard make it possible to visualise maps using a standard Web browser. Servers can be specialised, for example the WMS Image Server is specialised on satellite images. The user can access multiple servers at the same time and in that way combine many types of information. Figure shows how a coastline server, a height map server and a satellite image archive are accessed from a user GIS. The result is a combined map.

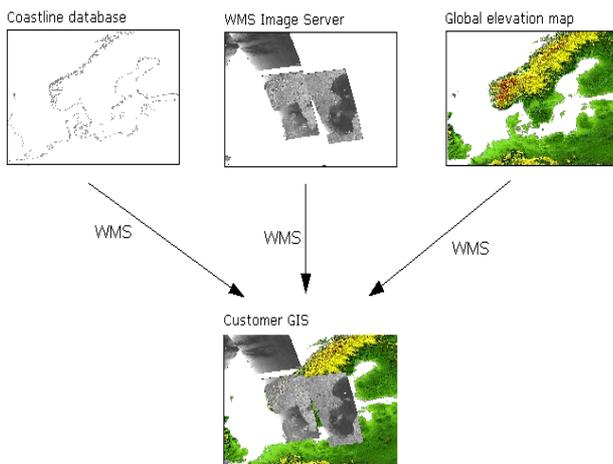


Figure 3. Multiple WMS servers used by a WMS client

The WMS specification is already supported by several vendors, and already there exists open source servers as well as specific implementations such as the WIS described here. Thanks to this it is very easy for any owner of data to publish

them on the internet and share them with other GIS information via this common and simple interface.

The WMS protocol is based upon HTTP requests. The WMS Image Server responds on three types of requests:

GetCapabilities: A request for a specification on what type of information can be requested from the server.

GetMap request: A user-selected spatial request for a mosaic of satellite images. The user can specify what sensor, time period, type of mosaic and enhancement of the mosaic.

GetFeature request: A metadata request for a user selected feature (image) in the mosaic.

The WMS servers will also deliver an error message if there is an error in the request or in the processing of data. Error messages can be delivered in images or as XML files.

3. MUIS CATALOGUE

The ESA Multi-Mission Catalogue (MUIS) contains over 200.000 browse image products from a large number of sensors flying on-board ESA and Third Party Mission satellites. The images represent a wide variety of sensor types, such as SAR, sweep scanners, push-broom scanners and conical scanners. Table 1 shows the missions and sensors handled in the present version of the WMS Image Server.

ERS SAR	IRS-P3 MOS
ERS ATSR-1	CHRIS PROBA
ERS ATSR-2	SeaStar SEAWIFS
JERS OPS	TERRA MODIS
Landsat TM	ENVISAT ASAR
Landsat MSS	ENVISAT AATSR
NOAA AVHRR	ENVISAT MERIS

Table 1. Imaging missions and sensors in the MUIS catalogue

The MUIS protocol is ESA specific and is used by client software's for direct access of browse images in the archive. The WMS Image Server uses the MUIS protocol to access metadata and browses for processing. The protocol is based on servlets.

4. SERVER DESIGN

The WMS Image Server was designed to handle a large number of simultaneous requests from WMS clients. Each request sent to the WMS Image Server involves heavy image processing and there was a need to keep response times to a minimum. The image processing algorithms was optimized and a cache system was added to the server. The cache system is used to save both metadata and images for reuse making the server response times dramatically shorter. A timeout handler was also included to make it possible to interrupt requests demanding too large datasets.

The system is divided into three main modules:

1. The WMS communication interface
2. The geoserver module for rectification and mosaicking
3. The catalogue communication interface.

The geoserver module is designed to handle all concurrency issues and is also responsible for issues such as scalability and fault tolerance. At an early stage it was decided to try application server technology, in particular JBoss. This approach was successful and the design of the system could benefit from qualities of the JBoss application server such as fault tolerance, scalability and load balancing. The application server technology is a proven technology and it is now shown that it also works with massive parallel image processing. The selected JBoss solution makes it possible to scale the system from a single computer to many computers working in a cluster.

The main functionality of the WMS Image Server can be summarised in the following steps

1. Parse the WMS client request.
2. Compile and send an inventory retrieve search in MUIS for browse metadata that fit the request.
3. Filter and process the retrieved metadata.
4. Send requests to MUIS for all browse images needed for the requested map.
5. Construct a rigorous geometric model for each browse image.
6. Rectify each browse image to the required map projection.
7. Merge all rectified images in a mosaic, using the required blending modes and layer priorities, and code it to the required image file format.
8. Compile the WMS map response and dispatch it to the WMS client.

All processing is performed on-the-fly. Figure 4 illustrates the parallel process flow design.

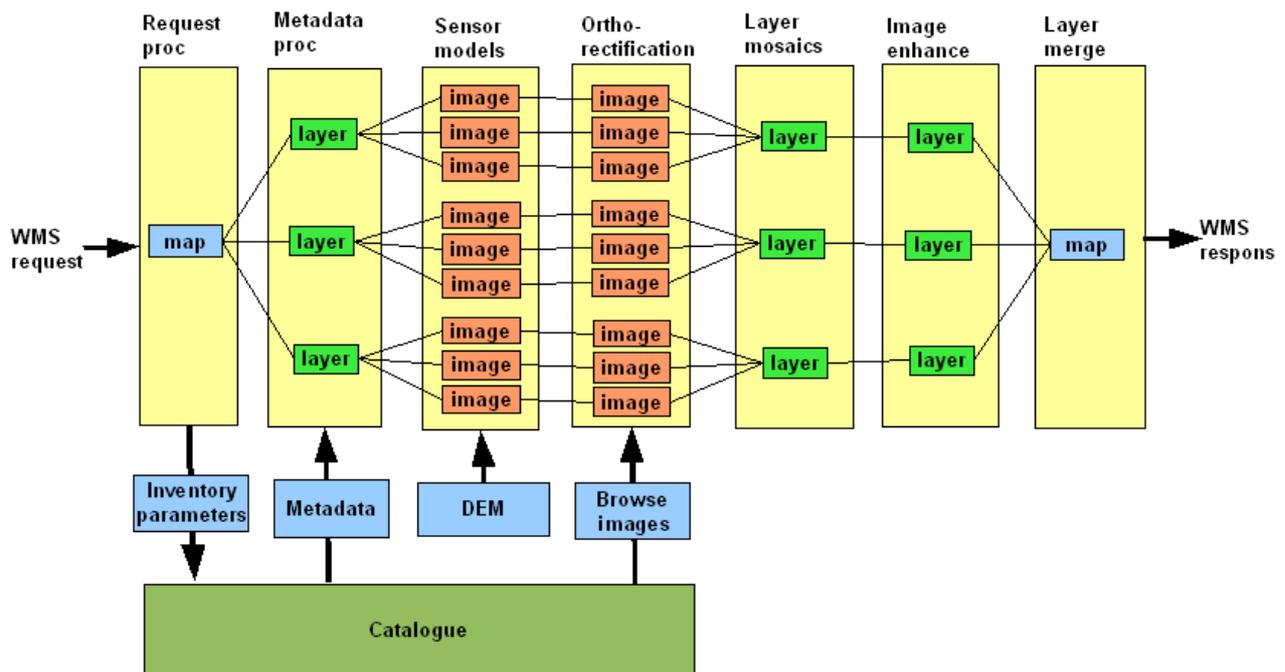


Figure 4. The WMS Image Server process flow

5. GEOSERVER MODULE

The geoserver module handles all the metadata and image processing tasks.

5.1 Sensor models

The metadata retrieved for a browse is used to reconstruct a rigorous photogrammetric model for the image viewing geometry (Figure 5). To be able to achieve this, it is necessary to also know nominal parameters for the satellite orbits and instruments involved for each browse. This data is stored in a configuration file.

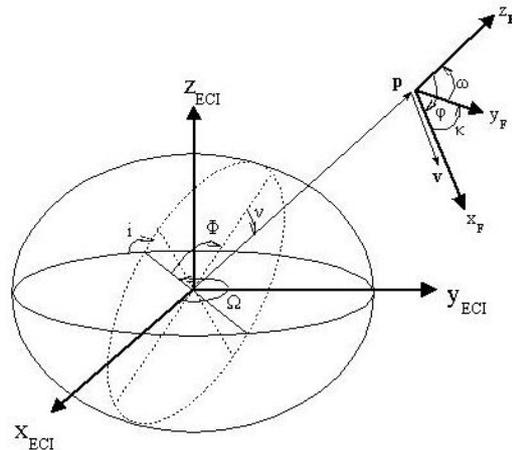


Figure 5 Rigorous acquisition model build in inertial space

The model is used to transform image coordinates in the browse image to the ground coordinate system, and vice versa. The rigorous 3D viewing model makes it possible to use a global DEM to make true orthorectification possible if required. The GLOBE 30' DEM is available on the server for this purpose.

The model also includes transformations to the required map projection in the request. The full set of EPSG namespace projection codes are supported, in addition to the OGC specified AUTO namespace projections.

5.2 Orthorectification

The geometric relationships in the sensor model are used to control the rectification of the browse to the required output map frame. Before the rectification, the browses are stripped from non-image areas, such as decorative frames. During rectification, nodata areas are handled, to eventually be made transparent or background coloured. The rectification projects the image to the ellipsoid or to the DEM (orthorectification), depending on the style set in the request. Orthorectification can be of great importance, especially for SAR images, even at the small scale of browse images (Figure 6).



Figure 6 Orthorectified ASAR image over India and Nepal

A special challenge was how to make possible the rectification of images with such a large degree of variation in layout as browses from the MUIS catalogue. The browses represents all from a few swath's, up to a full orbit's acquisition. To handle an image representing a whole orbit, passing the datum line, and biting itself in the tail, required the development of special rectification algorithms (Figure 7).

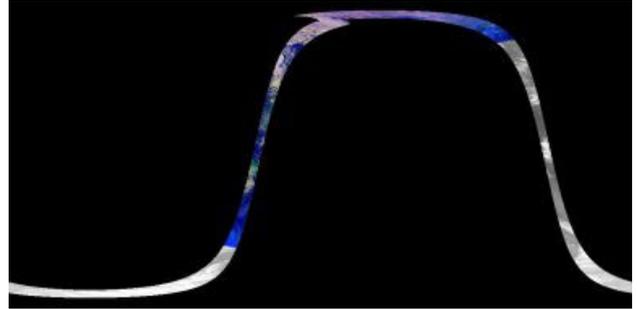


Figure 7. One single AATSR browse image covering a complete orbits revolution, rectified to the Plate-Carrée projection.

5.3 Mosaic

All rectified browse images are merged in a mosaic. The method of blending in overlap areas can be selected by a special vendor specific tag in the GetMap request. The possible selectable blending modes in the request are:

1. Most recent pixel
2. Closest to centre of time interval
3. Pixel average
4. Pixel of lowest luminance

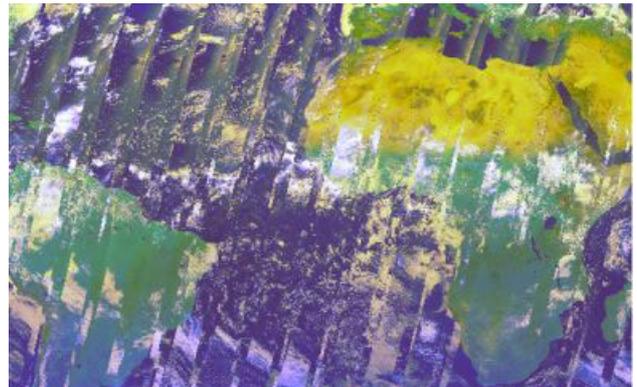


Figure 8 Two weeks of AATSR acquisitions mosaic, using the most recent pixel blending option

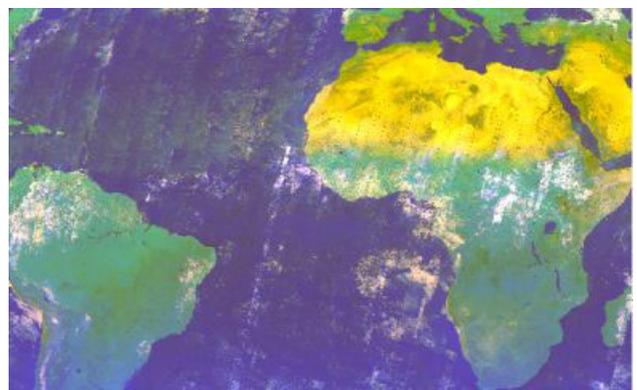


Figure 9 Two weeks of AATSR acquisitions mosaic, using the pixel of lowest luminance blending option

If the request is for several layers, the layers are stacked on top of each other in the order requested. There are optional methods for per layer image enhancements that can be set in a configuration file. If there is a time-out exception before all browses have been retrieved, the missing browses are indicated by drawing their wire-frame outlines on top of the mosaic.

The returned image file format is selectable as JPEG, PNG or GeoTIFF. The addition of GeoTIFF as an output option makes it possible to easily integrate the result in other GIS systems.

6. CONCLUSIONS

The WMS Image Server implementation was very successful and has already proven a valuable tool for exploring the content of the MUIS archives. Figure 10 is an example of an inventory of new images acquired during last week.

6.1 Performance

The performance is very good, even on low-end computer systems. The WMS Image Server was installed at ESRIN on a dual processor Intel Xeon server. Examples of response time for a GetMap request is less than 1 sec for a single browse, and 20 sec for a large mosaic including 200 browse images.

6.2 WMS protocol

The GetCapabilities request has been found not fully suitable for handling a whole set of satellite images like the MUIS Catalogue. The time specification could be improved to better suit satellite imagery. The definition of today with the use of the term CURRENT could improve this matter. Other question in the same area is how to describe periodic data, with missing data in the series.

REFERENCES

OpenGIS Consortium Inc., 2002. Web Map Service Implementation Specification version 1.1.1.
<http://www.opengis.org/techno/implementation.htm>

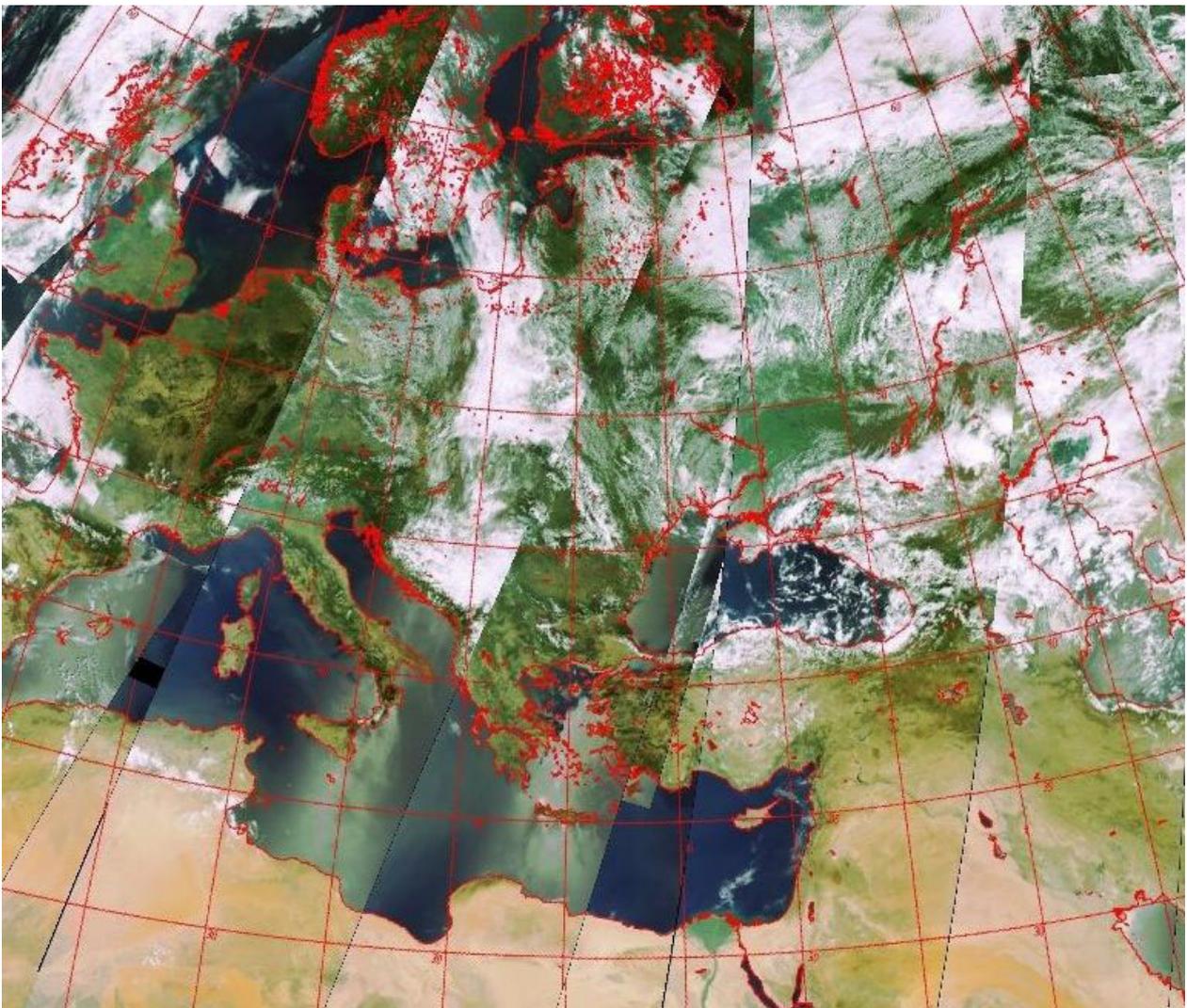


Figure 10 Last weeks acquisitions of MERIS images, presented in the UTM projection.