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OpenGIS® Web Map Services - Application Profile for EO Products

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i. Preface

The Open Geospatial Consortium (OGC) is an international industry consortium of more than 320 companies, government agencies, and universities participating in a consensus process to develop publicly available geo-processing specifications.

This profile started as an initiative funded by the British National Space Agency (BNSC) to define conventions for the Earth Observation (EO) community to use OGC Web Services. The objective is to tightly define how OGC Web Service specifications can be applied by data providers to ensure that the inventory level visualisation of EO data is carried out in a truly interoperable way.

ii. Document terms and definitions

This document uses the specification terms defined in Subclause 5.3 of [OGC 05-008], which is based on the ISO/IEC Directives, Part 2. Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this specification.

iii. Submitting organizations

This profile is being submitted to the OGC by the following organizations:

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v. Revision history

Date	Release	Description
05-July-2006	0.1.0	Initial version submitted for discussion

vi. Changes to the OpenGIS® Abstract Specification

The OpenGIS® Abstract Specification does not require changes to accommodate the technical contents of this document.

vii. Changes to the OpenGIS® Implementation Specifications

This document defines a Level 1 profile of the OGC WMS 1.3 implementation specification and, as such, provides only a specific use case without extensions or changes.

viii. Future work

Improvements in this document are desirable to provide additional examples for KVP and SOAP bindings, and to provide conformance testing.

Foreword

This document is a candidate profile of the OpenGIS Web Map Service 1.3 Implementation Specification / ISO Web map server interface Draft International Standard 19128.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The OGC shall not be held responsible for identifying any or all such patent rights.

This document includes two annexes: Annexes, A and B are normative.

Introduction

The WMS configuration proposed in this profile is intended to support the interactive visualization and evaluation of Earth Observation (EO) data products. The profile sets out to describe a consistent Web Map Server (WMS) configuration that can be supported by many data providers (satellite operators, data distributors …), most of whom have existing (and relatively complex) facilities for the management of these data. In addition, this profile is intended to compliment the OGC Catalogue Services Application Profile for EO products by showing how WMS servers may be used to evaluate products identified through catalogue discovery prior to their ordering.

The target audience for this document includes Web map users, client developers, service implementers, and system testers. The candidate specification encompasses two interrelated views that reflect different viewpoints on a Web map service. Each viewpoint focuses on different areas of concern:

- *Enterprise* – describes the general capabilities of the service in light of functional and nonfunctional requirements (for WMS users and system testers);
- *Information* – defines the kinds of information handled by the catalogue and the policies to be enforced (for WMS users, developers and testers).

OpenGIS® Web Map Services – Application Profile for EO Products

1 Scope

This application profile document describes how:

a) WMS layers, sample dimensions and nested layers can be used to manage the hierarchy of EO product information from the collection level, down through individual products to the sample and quality bitmask dimensions;

b) the WMS GetMap operation can be used to support interactive browse and the full evaluation of sample coverage and quality information.

This OGC™ document specifies a constrained, consistent interpretation of the WMS specification which is applicable government, academic and commercial providers of EO products.

2 Conformance

3 Normative references

The following normative documents contain provisions that, through reference in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

[1] OGC 06-042, OpenGIS® Web Map Service (WMS) Implementation Specification, version 1.3

[2] OGC 05-008, OGC Web Service Common Specification, version 1.0

4 Terms and definitions

For the purposes of this profile, the definitions specified in Clause 4 of the OWS Common Implementation Specification [OGC 05-008] shall apply. In addition, the following terms and definitions apply.

4.1 data clearinghouse

collection of institutions providing digital data, which can be searched through a single interface using a common metadata standard [ISO 19115]

4.2 data level

stratum within a set of layered levels in which data is recorded that conforms to definitions of types found at the application model level [ISO 19101]

4.3 dataset series

collection of datasets sharing the same product specification [ISO 19113, ISO 19114, ISO 19115]

4.4 identifier

a character string that may be composed of numbers and characters that is exchanged between the client and the server with respect to a specific identity of a resource

4.5 layer

basic unit of **geographic information** that may be requested as a **map** from a **server**

4.6 map

portrayal of **geographic information** as a digital image file suitable for display on a computer screen

4.7 metadata dataset

metadata describing a specific dataset [ISO 19101]

4.8 metadata entity

group of metadata elements and other metadata entities describing the same aspect of data

NOTE 1 A metadata entity may contain one or more metadata entities.
NOTE 2 A metadata entity is equivalent to a class in UML terminology [ISO 19115].

4.9 metadata schema

conceptual schema describing metadata

NOTE ISO 19115 describes a standard for a metadata schema. [ISO 19101]

4.10 metadata section

subset of metadata that defines a collection of related metadata entities and elements [ISO 19115]

4.11 operation

specification of a transformation or query that an object may be called to execute [ISO 19119]

4.12 parameter

variable whose name and value are included in an operation **request** or **response**

4.13 portrayal

presentation of information to humans [ISO 19117]

4.14 profile

set of one or more base standards and - where applicable - the identification of chosen clauses, classes, subsets, options and parameters of those base standards that are necessary for accomplishing a particular function [ISO 19101, ISO 19106]

4.15 sample dimension

dimension other than the four space-time dimensions [OGC 06-042]

4.16 service interface

shared boundary between an automated system or human being and another automated system or human being [ISO 19101]

4.17 state

condition that persists for a period

NOTE The value of a particular feature attribute describes a condition of the feature [ISO 19108].

4.18 transfer protocol

common set of rules for defining interactions between distributed systems [ISO 19118]

5 Conventions

5.1 Abbreviated terms

Some frequently used abbreviated terms:

API Application Program Interface

CEOS Committee on Earth Observation Satellites

EO Earth Observation

HTTP HyperText Transport Protocol

ISO International Organisation for Standardisation

N/A Not Applicable

OGC Open Geospatial Consortium

UML Unified Modeling Language

W3C World Wide Web Consortium

WCS Web Coverage Service

WMS Web Map Service

XML eXtensible Markup Language

5.2 Document terms and definitions

The following specification terms and definitions are used in this document:

a) shall – verb form used to indicate a requirement to be strictly followed to conform to this specification, from which no deviation is permitted

b) should – verb form used to indicate desirable ability or use, without mentioning or excluding other possibilities

c) may – verb form used to indicate an action permissible within the limits of this specification

d) can – verb form used for statements of possibility

e) informative – a part of a document that is provided for explanation, but is not required

f) normative – a part of a standards document that is required

g) annex – an auxiliary part of a document

h) clause – a major part of a document

i) subclause – a secondary part of a clause or annex

6 Overview and Context

6.1 Background

The acquisition of EO data is subject to a range of factors which effect the degree to which a product is fit for purpose. For optical EO these factors include cloud cover, snow cover, atmospheric aerosols, low illumination angles, sun glint off the ocean or ice surface and suspended sediment in the water column. For imaging radar the usefulness of products can be affected by wind speed, presence of surfactants and soil moisture. It is therefore important to potential users that they can evaluate EO products prior to ordering and (where applicable) purchase.

A number of WMS features make them a good choice for EO data providers wanting to open up their product inventories for evaluation:

- open, Web service specifications are widely and simply supported using common place Web browsers;
- Web maps provide a geocoded view of data frequently acquired as ungeocoded scan lines;
- the WMS interface supports roam and zoom functionality not available with a simple image thumbnail;
- use high levels of image compression reduces bandwidth requirements relative to WCS whilst allowing effective visual inspection;
- the serving of products via highly compressed images ensures that the original data is protected from unauthorised use.

Unfortunately, practical application of WMS technology is hindered by two issues:

1. inconsistent interpretation of the WMS specification in the context of EO data;
2. server instances are typically configured to return just a single representation using a sub-set of the dataset. Some or even most, of the dataset is not made available for evaluation.

To illustrate the first point, consider the use of WMS ‘layers’. A layer is defined as the basic unit of geographic information that may be requested as a map from a server. A literal interpretation would be that a each individual EO data granule (dataset) should be handled as a WMS layer. With large inventories of EO products (>10,000) this results in bloated responses to GetCapability requests. An alternative interpretation is that a WMS layer should represent a collection of datasets sharing the same product specification (i.e. a dataset series). In this context, individual datasets can be retrieved and presented using their acquisition time.

Whilst both interpretations can be justified, the resulting WMS server configurations are incompatible, seriously hindering the client to server and community wide interoperability.

6.2 Challenge

Using WMS technology to present EO datasets for evaluation is not straightforward. EO data products are usually derived from an instrument onboard a satellite containing one or more sensors[1]. Data are frequently acquired simultaneously in several wavebands and/or polarizations of electromagnetic radiation (see Figure 6-1). Higher level products may also contain coverage of bio/geophysical parameters derived from the original sample datasets. Additional background and quality information are commonly stored as bitmasks which are critically important to evaluate the extent of usable data within a product coverage. As a consequence, EO products often contain far more information than can easily be presented in a single, static RGB view.

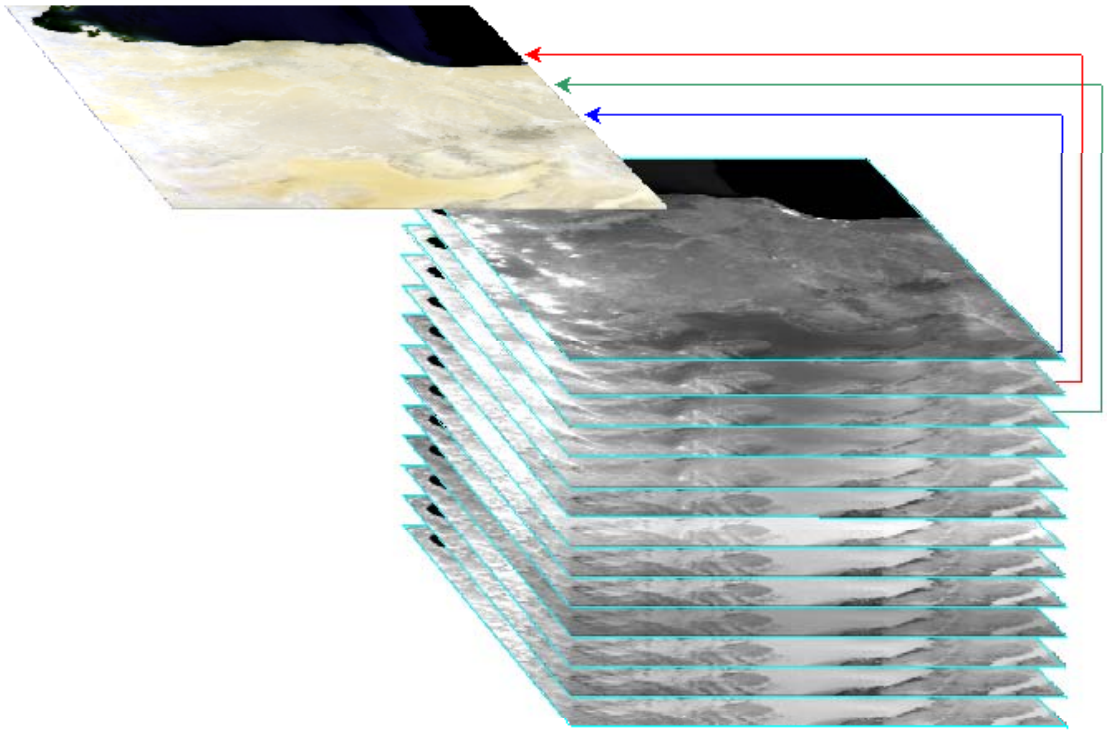


Figure 6-1: Example stack of data coverages in the sample dimension of an EO product. Note: Only a fraction of the sample information can be visualized using a static RGB image.

The situation is even worse for the spatial metadata held in a parallel stack of bitmasks (see Figure 6.2) because the bitmask information cannot be added to a static RGB image without obscuring data and other bitmask information.

[1] The same applies to Remote Sensing instruments used on airborne platforms

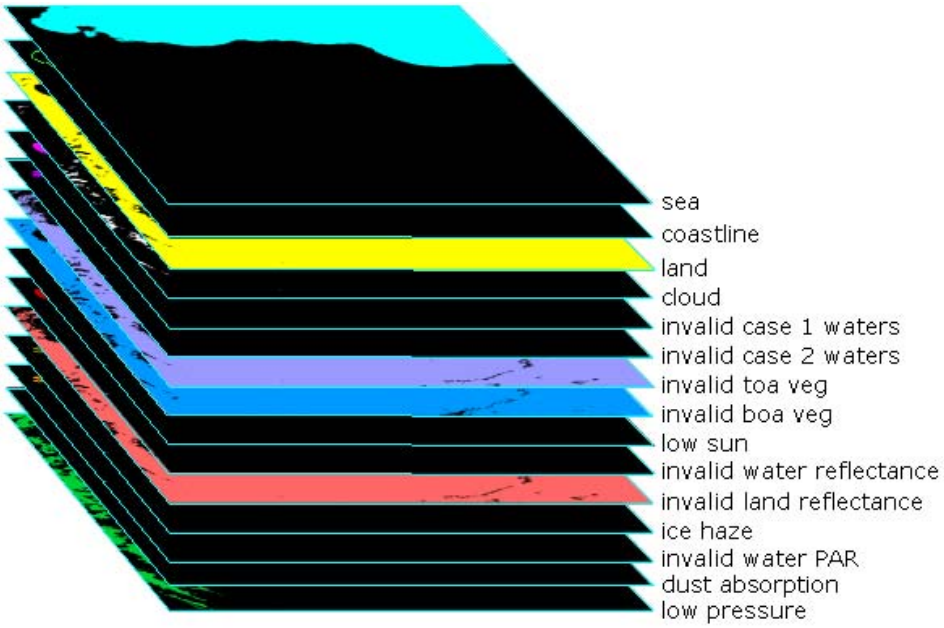


Figure 6-2: Example spatial metadata (bitmask) stack from an EO instrument.

Meeting the twin challenges of true interoperability and the full evaluation of the spatial elements of EO products (interactive browse), requires the definition of a consistent, constrained, interpretation of the WMS specification. This task is carried out in Section 7.

7 Constraints and Conventions of WMS Usage for EO Products

7.1 Approach

The definition of a consistent, constrained, interpretation of the WMS specification has two aspects:

1. mapping the spatial data and metadata structure of EO datasets to WMS metadata elements;
2. defining how a profile compliant WMS server will respond to GetMap requests.

These aspects are, respectively, addressed in sub-sections 7.2 and 7.3.

Mandatory constructs and behaviour are defined to provide a simple WMS profile that will allow for basic (default) representation of EO products in an interoperable way. Additional, optional, elements of the metadata model and WMS server behaviour are defined to cater for the full interactive browse and evaluation of EO products.

7.2 Metadata Model

The metadata model provides the basic framework, the skeleton, of a WMS instance. Defining a WMS metadata model for EO products is therefore a prerequisite for an application profile that is unambiguous whilst allowing interactive viewing of all of the spatial information within EO products. Figure 7.1 provides a view of how the normal arrangement of EO products can be mirrored using appropriate WMS metadata elements and attributes.

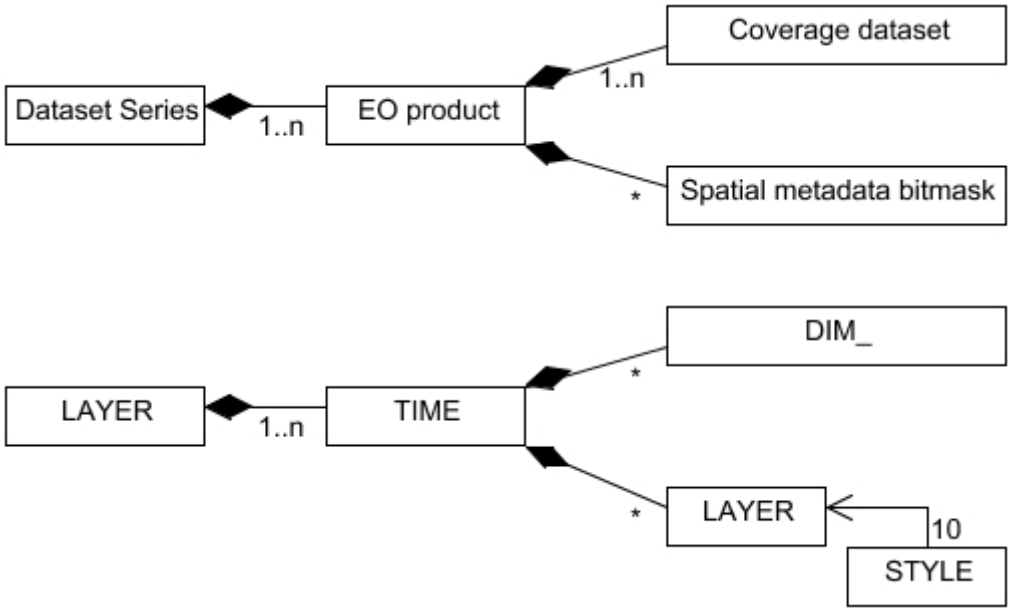


Figure 7-1: UML class diagrams showing how the organisation of EO spatial information maps to the proposed WMS metadata model. Note the use of multiplicity on the class associations.

The handling of service metadata for EO products defined here is in line with Annex C (Handling multi-dimensional data) of the WMS 1.3 implementation specification (OGC 06-042). The overview for the WMS 1.3 handling of multi-dimensional data concludes: "*The server may declare a single name for the layer and enumerate available times and wavelength bands in its service metadata. A client then adds additional parameters to the GetMap request to request a specific time and band.*"

7.2.1 Mandatory service metadata

For EO datasets a LAYER service metadata element shall be used to represent each dataset series / dataset type. For instance, all products of type 'MERIS instrument, Level 1b, Reduced Resolution' would be described as a dataset series and represented by a single LAYER element in the service metadata of a WMS instance.

The service metadata shall define a TIME dimension for each LAYER element, e.g.:

```
<Dimension name="time" units="ISO8601">
   2002-05-01/2006-09-17/PT100.6M
</Dimension>
```

The use of the mandatory TIME dimension to retrieve maps from individual EO products is defined in Section 7.3.

EO WMS instances shall support default maps of a given dataset series (see Section 7.3.1 below) but no specific service metadata is defined for these default views.

7.2.2 Coverage dataset service metadata

If an EO WMS instances supports the interactive selection and viewing of dataset coverages within a given dataset series then one or more sample dimensions shall be define in the service metadata of the associated LAYER element. For instance, consider a WMS instance that supports interactive browsing of a series of polarimetric Synthetic Aperture Radar datasets. The sample dimension within the LAYER element of the dataset series might be defined as:

```
<Dimension name="polarization_(intensity)" units="" multipleValues="1">
   HH, VV, HV, VH
</Dimension>
```

It is possible that more than one sample dimension may be required. Consider the description of a Level 2 EO product containing a mixture of reflectance and biophysical coverage datasets. The example below shows how this could be handled by defining two sample dimensions in the service metadata:

```
<Dimension name="wavelength" units="nano metres" unitSymbol="nm"
 multipleValues="1">
   412.5, 442.5, 490, 510, 560, 620, 665
</Dimension>

<Dimension name="biophysical_parameters" units="">
   case_1_chlorophyll_concentration, bottom_of_atmosphere_veg_index
</Dimension>
```


7.2.3 Spatial metadataset (bitmask) service metadata

Subtle variations in values across coverage datasets can be presented as greyscale or colour image maps in a number of ways (see Section), often through Red Green Blue (RGB) colour combination. Bitmasks, however, represent spatial metadata flags that are either 'on' or 'off'. As such, it is more appropriate to present bitmasks in the spatial metadataset stack of an EO product in single colour maps that mask the underlying map of coverage datasets as shown in Figure 7-2 below. For consistency, a predefined set of colours need to be defined for use to generate bitmask maps.

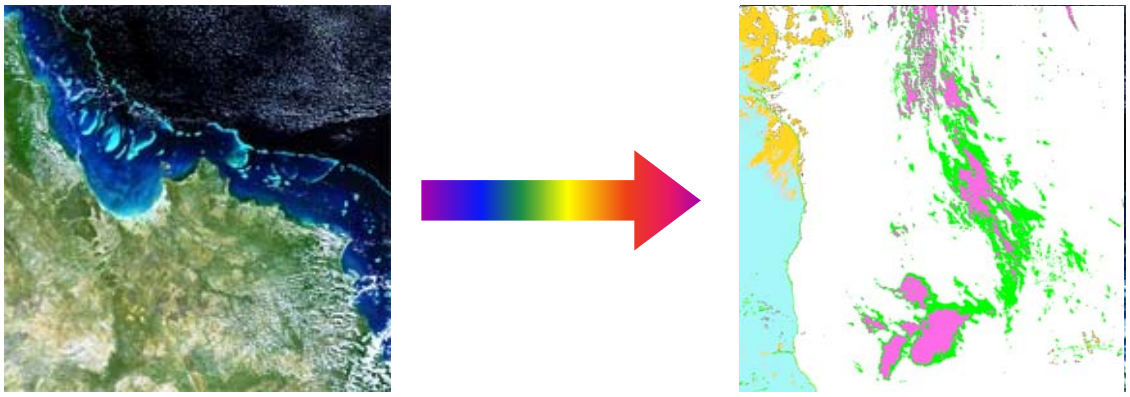


Figure 7-2: Application of four bitmasks to an EO dataset coverage false colour composite map. Note that four contrasting colours have been chosen to represent the bitmasks.

Sample dimensions cannot be used to represent the bitmask stack as the assignment / reassignment of colours to sample dimensions is not supported in the WMS 1.3 implementation specification. To provide the required degree of flexibility, each bitmask shall be represented as a nested LAYER element (see Figure 7-1). Each bitmask LAYER shall in turn contain a STYLE element listing the following 10 predefined colours:

```
<Styles=white,yellow,orange,red,magenta,blue,cyan,green,brown,black>
```

7.3 GetMap Request/Response

Where the service metadata model provides the skeleton for this WMS profile, the definition of the GetMap request/response adds the functional muscle that ultimately delivers the rendered image maps back to a user's client application. The default behaviour needed to support consistent WMS handling for EO products is defined in Sub-section 7.3.1. The behaviour needed to support interactive browse and evaluation of EO products is defined in Sub-section .

7.3.1 Presentation of default coverage maps

This subsection covers the client – server handling of the mandatory service elements without reference to specific coverage dataset or spatial metadataset elements. Sub-section 7.2.1 defined the use of LAYER elements to identify dataset series with the TIME dimension used to identify individual EO products. An example GetMap request is given below with the principle parts of the request shown in bold.


```
http://eoltd.co.uk/mapserver.cgi?VERSION=1.3.0
     &REQUEST=GetMap&CRS=CRS:84
     &BBOX=78.105,24.913,94.794,36.358
     &WIDTH=560&HEIGHT=350
     &LAYERS=MER_RR__2P&STYLES=&FORMAT=image/png
     &TIME=2002-07-01/2002-07-31
```

When no coverage dataset sample dimensions or bitmask sub-layers are defined in the GetMap request then the WMS server shall respond by returning a default map of the requested EO product(s). The nature of the image returned shall depend on the type of EO dataset series specificities in the LAYERS section of the GetMap request, as illustrated in Figure 7-3.

Figure 7-3: Default server responses to a GetMap request:

- **SAR intensity map returned as a greyscale image;**
- **Optical product map returned as an RBG false colour composite;**
- **Bio/geo-physical parameter map returned as a pseudo-colour image, with colour legend.**

7.3.2 Presentation of dataset coverage maps

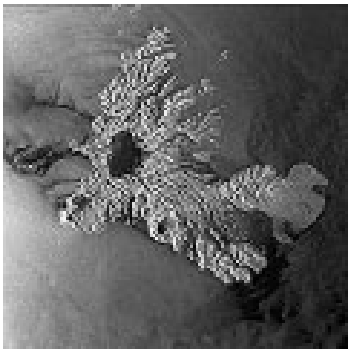
As with the default server response, specification of sample dimensions in a GetMap request shall return the requested sample dimensions as one of:

- a greyscale map
- an RGB false colour composite or
- a pseudo-colour map with colour legend.

The type of rendering carried out by the WMS server shall depend on the number of sample dimension values requested. Only one or three sample dimension values may be specified per GetMap request. If any other number of sample dimension values is requested then the server shall issue a service exception (code = InvalidDimensionValue).

A GetMap request for a single dataset in the sample dimension shall be served by either a greyscale image or (for a geo/bio-physical parameter) a pseudo colour image with colour legend.

&DIM_SAR=INTENSITY



&DIM_MDS=17

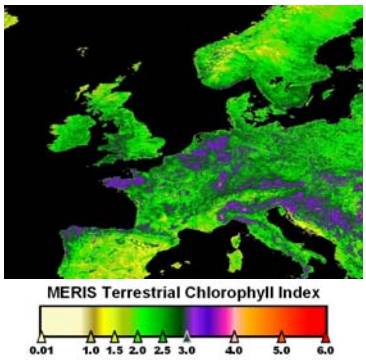
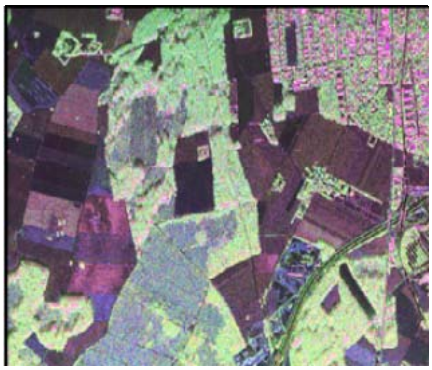


Figure 7-4: Example GetMap requests/responses based on specifying a single sample dimension dataset:

- **SAR intensity map returned as a greyscale image;**
- **Bio/geo-physical parameter map returned as a pseudo-colour image, with colour legend.**

A GetMap request for three sample dimension datasets shall be served by a false colour composite with each of the datasets contrast stretched (see Figure 7-5 for examples).

DIM_POLARISATION=HH-VV,HV+VH,HH+VV



DIM_WAVELENGTH=665,510,412.5

Figure 7-5: Example GetMap requests/responses based on specifying a single sample dimension dataset:

- **E-SAR L-band polarimetric intensity map returned as an RBG false colour composite;**
- **MERIS (optical) product map returned as an RBG false colour composite.**

7.3.3 Presentation of metadataset coverage (bitmask) maps

As noted in Section 7.2.3, the spatial metadataset (bitmask) stacks are defined using layers nested within each dataset series layer. This nesting shall be reflected in the name of each nested bitmask layer by using the parent layer name to prefix the nested bitmask layer names. For instance, the bitmask `CLOUD` within the dataset series `MER_RR__2P` would have the layer name `MER_RR__2P_CLOUD`. An example GetMap request is given below:


```
http://eoltd.co.uk/mapserver.cgi?VERSION=1.3.0
     &REQUEST=GetMap&CRS=CRS:84
     &BBOX=78.105,24.913,94.794,36.358
     &WIDTH=560&HEIGHT=350
     &LAYERS=MER_RR__2P,MER_RR__2P_CLOUD,MER_RR__2P_ABSOA_DUST,
              MER_RR__2P_ICE_HAZE,MER_RR__2P_SUSPECT
     &STYLES=,CYAN,ORANGE,MAGENTA,GREEN
     &FORMAT=image/png
     &TIME=2002-07-01/2002-07-31
```

Note that the parent dataset series layer is listed with the bitmask layers and that the corresponding styles list has a blank (default) entry for the parent dataset series layer.

Annex A
(normative)

Abstract test suite (to be completed)

A.1 Basic WMS for EO products

A.1.1 Basic WMS Client

A.1.1.1 GetMap request

A.1.2 Basic WMS Server

A.1.2.1 GetCapabilities response

A.1.2.2 GetMap response

A.2 WMS for interactive browse of EO products

A.2.1 Basic WMS Client

A.2.1.1 GetMap request (dataset coverage)

A.2.1.2 GetMap request (spatial metadata / bitmasks)

A.2.2 Basic WMS Server

A.2.2.1 GetCapabilities response

A.2.2.2 GetMap response (dataset coverage)

A.2.2.3 GetMap response (spatial metadata / bitmasks)

Annex B
(normative)

WSDL Specification (to be completed)

Bibliography

The following references are informative, not normative.

[3]

