Project No. 249024

NETMAR

Open service network for marine environmental data

Instrument: Please tick	CA	✓ STREP	IP	NOE

ICT - Information and Communication Technologies Theme

D5.2.2 Data Processing Services – Semantically Enabled Processing Services

Reference: D5.2.2_Semantic-Processing-Services_r1_20120731

Due date of deliverable (as in Annex 1): M0 + 30
Actual submission date: 31 July 2012

Start date of project: 1 February 2010   Duration: 3 years

Plymouth Marine Laboratory

Revision 1

European Commission
Information Society and Media

	NETMAR
	Open service network for marine environmental data
	Project Reference: 249024
	Contract Type: Collaborative Project
	Start/End Date: 01/03/2010 - 31/01/2013
	Duration: 36 months
	Coordinator: Prof. Stein Sandven
	Nansen Environmental and Remote Sensing Center
	Thormøhlensgate 47, Bergen, Norway
	Tel.: +47 55 20 58 00
	Fax. +47 55 20 58 01
	E-mail: stein.sandven@nersc.no

Consortium

The NETMAR Consortium is comprised of:
- Nansen Environmental and Remote Sensing Center (NERSC), Norway (coordinator).
  Project Coordinator: Prof. Stein Sandven (stein.sandven@nersc.no)
  Deputy Coordinator: Dr. Torill Hamre (torill.hamre@nersc.no)
  Quality Control Manager: Mr. Lasse H. Pettersson (lasse.pettersson@nersc.no)
- British Oceanographic Data Centre (BODC), National Environment Research Council, United Kingdom
  Contact: Dr. Roy Lowry (rkl@bodc.ac.uk)
- Centre de documentation de recherche et d'expérimentations sur les pollutions accidentelles des eaux (Cedre), France.
  Contact: Mr. François Parthiot (Francois.Parthiot@cedre.fr)
- Coastal and Marine Resources Centre (CMRC), University College Cork, National University of Ireland, Cork, Ireland.
  Contact: Mr. Declan Dunne (d.dunne@ucc.ie)
- Plymouth Marine Laboratory (PML), United Kingdom.
  Contact: Mr. Steve Groom (sbg@pml.ac.uk)
- Institut français de recherche pour l'exploitation de la mer (Ifremer), France.
  Contact: Mr. Mickael Treguer (mickael.treguer@ifremer.fr)
- Norwegian Meteorological Institute (METNO), Norway.
  Contact: Mr. Øystein Torget (oysteint@met.no)

Author(s)

- Peter Walker, PML, (petwa@pml.ac.uk)
- Morten Stette, NERSC, (morten.stette@nersc.no)
- Torill Hamre, NERSC, (torill.hamre@nersc.no)
- Declan Dunne, CMRC, (d.dunne@ucc.ie)

Document approval

- Document status: Revision 1
- WP leader approval: 2012-07-30
- Quality Manager approval: 2012-07-31
- Coordinator approval: 2012-07-31

Revision History

Issue	Date	Change records	Author(s)
Draft 1	2012-07-19	First draft of the report.	Peter Walker
Draft 2	2012-07-23	Added CMRC input.	Declan Dunne
Draft 3	2012-07-30	Incorporated feedback from quality control.	Peter Walker
1	2012-07-31	Final version approved by coordinator.	Torill Hamre

Executive Summary

The NETMAR project will develop a pilot European Marine Information System (EUMIS) that will enable users to search, download and integrate satellite, in situ and model data from ocean and coastal areas. EUMIS will be a user-configurable system offering flexible service discovery, access and chaining facilities based on open and widely adopted web GIS standards. To support smart search, it will use a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data, which are marked up using different, but semantically related, keywords. To support dynamic generation of new composite products and statistics suitable for decision-making, it will use web processing services that can be chained together to form workflows that perform a series of operations on input data chosen by the user.

The EUMIS pilot will target the needs of four user communities:
- Arctic operators, environmental authorities and fishery management
- Oil spill drift forecast and shoreline cleanup assessment services in France
- Ocean colour – Marine Ecosystem, Research and Monitoring users
- The International Coastal Atlas Network (ICAN)

Each user community will have a customised pilot that provides the products and services needed for their line of work. The NETMAR partners have had close contact with selected users in each community to identify and document their needs. These user requirements have been described as a series of use cases and a joint list of requirements [PTS+11], which forms the basis for the EUMIS development. As part of this process, the NETMAR partners have also identified a number of data delivery and processing services that are necessary for each pilot.

This document identifies the *processing services* which are provided by the NETMAR partners for the EUMIS pilots and which have been *semantically enhanced* to allow tools, such as the service chaining editor developed within NETMAR, to intelligently validate workflows. These processing services cover all the requirements identified during the use case specification process. Specifically, for pilot 1, a sea ice type classification service, and for pilot 3, a service comparing ocean colour data from satellites or models with measurements from measurements from on site buoys are implemented. These services are offered through a WPS (Web Processing Service) interface, which is an open standard for web processing services; the semantic metadata enhancements remain compatible with this standard and could still be used with services that do not support this metadata.

The NETMAR project has also developed a range of processing services some of which are generic "toolkit" processes such as *reprojectImage* which will convert an image from one projection to another, optionally changing the resolution allowing 2 images using different projections to be compared or merged. These generic processing services can be built into service chains to provide more complex services such as comparing a satellite image and a model output (Figure 4-1). Where a particular, non-generic, need has been identified a specific processing service has been developed to answer it. Using a combination of these generic and non-generic services a non-technical user can simply develop sophisticated processing chains using a simple GUI (Graphical User Interface) service chaining editor developed by the NETMAR project. The generic processing services have not been semantically enabled as they may act on a wide range of inputs rather than being tied to specific NETMAR vocabularies. The example processing chains developed using both the generic and NETMAR specific processing services demonstrate how semantic and non-semantic services may be seamlessly combined.

It may be argued that the functions provided by the processing services can also be found in a traditional GIS program. However, many scientific users will not have GIS software installed on their machine and would probably not want to allocate the time required to learn its use. The remote processing services approach allows researchers to develop workflows without installing any more software than a standard web browser; as the workflows are not tied to particular client machines they may be easily shared with other users within the community. The service based approach also allows providers to develop complex algorithms which may themselves be workflows and make them available to users without having to release installation packages or code.

These processing services are freely available with no (or few) access restrictions; however, the data used by the processing services may come from a variety of sources, not just the NETMAR partners, and may contain sensitive information and be restricted to specific users. Processing services will be made available using standard methods (OGC WPS) allowing usage by any compatible applications not just the EUMIS portal itself. As a research project, NETMAR is not directly addressing issues of federated identity and delegation of authority. However, it will continue to monitor work on these issues during the lifetime of the project and will attempt to follow the most widely adopted standards where access control is required.

Contents

1. Introduction

1.1. Background and project linkage

NETMAR aims to develop a pilot European Marine Information System (EUMIS) for searching, downloading and integrating satellite, in situ and model data from ocean and coastal areas. It will be a user-configurable system offering flexible service discovery, access and chaining facilities using OGC, OPeNDAP and W3C standards. It will use a semantic framework coupled with ontologies for identifying and accessing distributed data, such as near-real time, forecast and historical data.

EUMIS will also enable further processing of such data to generate composite products and statistics suitable for decision-making in different marine application domains. The processing services will also be realised using standard OGC protocols, notably WPS (Web Processing Services), and a simple to use service chaining editor will be developed as part of EUMIS. The service chaining editor will be run in a common web browser and allow users to compose their own workflows that generate new products customised to their needs. Figure 1-1 illustrates how observations, derived parameters and predictions are retrieved from a distributed service network through standard protocols, and delivered through the EUMIS portal using ontologies and semantic frameworks to select suitable products and where new products can be generated dynamically using chained processing services.

Figure 1-1 The NETMAR Service Network
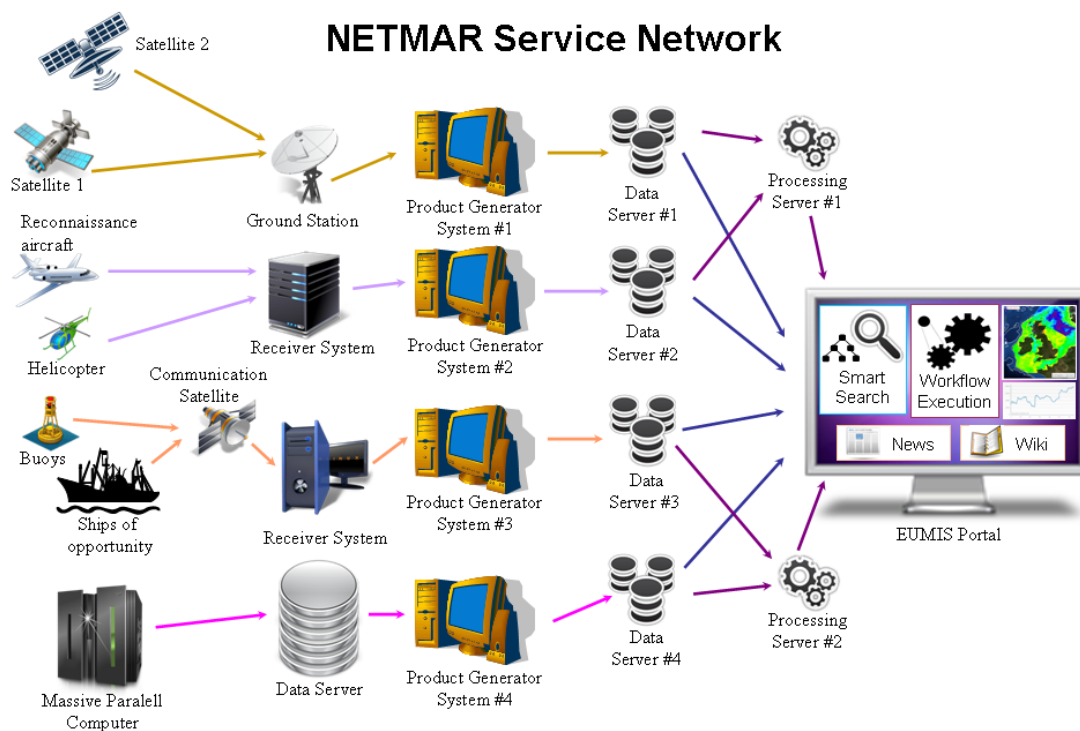
The pilot EUMIS will target four user communities by developing the following pilots:
- Pilot 1: Arctic Sea Ice and Metocean Observing System
- Pilot 2: Oil spill drift forecast and shoreline cleanup assessment services in France
- Pilot 3: Ocean colour – Marine Ecosystem, Research and Monitoring
- Pilot 4: International Coastal Atlas Network (ICAN) for coastal zone management

We have had close contact with selected users in each of the targeted communities to identify and document their needs for data search and retrieval, processing and visualisation. The user needs have been defined through a set of concrete use cases specifying how the user will carry out a specific operation to solve a real-world problem and how this functionality will be tested [PTS+11]. As part of this analysis we have identified data processing services required to provide the information needed by the user. These processing services cover all the requirements identified during the use case specification process [PTS+11].

The processing services, identified as user requirements through interviews and discussions with users (WP1), analysed and clarified as part of system architecture design (WP2), will feed into the EUMIS development (WP6) as components of service chains, and will support the evaluation of the project via the EUMIS portal in the user testing phases. Many services are also available for external use, and thus may be included in dissemination (WP7).

1.2.   Objective of this report

This report documents the processing services provided by each of the NETMAR service providers (Table 1-1) that are directly related to the testing of the pilots, those services providing or using semantic metadata are highlighted in bold. Many other processes exist and may also be used, but are not directly related at this point.

Pilot	Requirement	Service	Provider
1	Arctic sea ice classification	**getIceClassMapsAsar**	NERSC
3	Compare in situ and satellite data	v.sample r.math	PML
	Compare model and satellite data	reprojectBBOX intersectBBOX reprojectImage mergeImages **compareChlImages**	PML
4	Shaded relief map creation	**gdaldem-hillshade**	CMRC

Table 1-1 User requirements and corresponding NETMAR processing services

Inputs and outputs are listed for each service. Where services wrap an existing piece of software such as GDAL or GRASS, exceptions raised by the software will be returned within the WPS and SOAP error constructs; in other cases specific exceptions will be raised explicitly within the service's code and returned in the same way.

1.3.   Terminology

ASAR	Advanced Synthetic Aperture Radar
ENVISAT	Earth Observation spacecraft, launched in 2002
GDAL	Geospatial Data Abstraction Library
GRASS	Geographic Resources Analysis Support System, an open source, free software Geographical Information System
KVP	Key-Value Pair
OGC	Open Geospatial Consortium
OPeNDAP	Open-source Project for a Network Data Access Protocol
RDF	Resource Description Framework
SOAP	Simple Object Access Protocol

W3C   World Wide Web Consortium
WPS   Web Processing Service

1.4. Organisation of this report

Table 1-1 provides a summary of the processing services provided by the NETMAR partners. Section 2 gives an overview of how NETMAR's processing services make use of semantic metadata. The following sections provide detailed breakdowns of the processing services provided for each pilot. These will comprise a brief description of the context of the pilot, a brief discussion of the operations (use cases) that need processing services, and all information required to access the individual services (usage restrictions, access URLs and parameter names).

2. Use of semantic metadata within NETMAR processing services

A semantically enabled processing service will make use of semantic metadata (metadata specifying the meaning of a dataset and its units) provided for its data inputs and produce outputs that also contain semantic metadata. If this metadata is provided then the semantic processing can take place otherwise the processing service should fall back to a non-semantic processing approach, for instance by not checking parameter types.   The detailed recommendations as to how this data should be provided and processed are given in NETMAR Deliverable D5.3.2 [NM122].

2.1. Data service metadata requirements

Data inputs to semantic processing services must provide semantic metadata such that the processing service can verify the type of data input parameters. This is achieved by creating an RDF fragment containing this information (using standard vocabularies) and providing a link within the existing metadata to the fragment which could be stored on a separate server.

2.2. Processing service metadata requirements

The processing service case (as implemented by an OGC WPS) is slightly more complex in that a WPS process can both provide outputs (similar to a data service) and also expect inputs. Luckily the ProcessDescription element allows Metadata elements within both DataInputs and ProcessOutputs elements that can be used for this purpose.

2.3. Uncertainty metadata

Uncertainty metadata is handled using a similar approach to the other semantic metadata. However, whereas the semantic metadata for a layer in a WMS applies to all instances of that layer (for instance data for different days) the uncertainty information will vary depending on the actual data. To allow for this the uncertainty metadata provides a rule by which the uncertainty information for a dataset may be retrieved rather than the uncertainty itself. The actual uncertainty information would be held elsewhere (probably with the data). See D5.3.2 for more details.

2.4. Semantic metadata usage

Semantic metadata is used with NETMAR in 2 ways.

Firstly, it is used within the simple service chaining editor to verify connections within workflows to ensure that a process is provided with compatible data inputs. For instance, the editor would not allow SST data (which might itself be the output of another process) to be added as input to a process that was defined as expecting Chlorophyll as its input. The detailed recommendations as to how this data should be provided and processed are given in NETMAR Deliverable D5.3.2.

Secondly, individual processes may actively verify their inputs for semantic compatibility at run time by taking the semantic metadata of their inputs and querying the NETMAR vocabulary services to check for compatibility, for instance a service which required Chlorophyll would use an agreed name, say CHLA, to signify this. A service providing a specific type of measurement might use a different name, say

CHLMOOC5, but the semantic resource would be able to identify this as a type of Chlorophyll so it could still be used by the process. This method is also documented in D5.3.2 [NM122]. In this case the individual process is responsible for carrying out the checks and should be able to fail back to a suitable default action if semantic metadata is not available. This allows services to be used within other environments than NETMAR workflows.

It should also be mentioned at this point that a large number of the services developed with the project are generic GIS style processes and, as such, do not have specific data level semantics associated with them, these services can only perform loose type checking as they do not have specific phenomena associated with them. It is just as reasonable to reproject a Chlorophyll map as it is to reproject an SST map. At present only **getIceClassMapsAsar** [section 3.4.1], **compareChlImages** [section 4.4.3.4] and **getIceClassMapsAsar** [section 5.3.1] provide or make use of semantic metadata. With the development of the service chaining editor and orchestration engine it is expected that workflows built using these generic services will be packaged as WPS services themselves and, if they are built around specific data, will make use of semantic data (one possibility is for entry and end point processes to be used within a workflow to ensure that the correct data is supplied to the generic processing services and that the output from the chain is flagged with the correct semantic metadata.

3. Services for Pilot 1: Arctic Sea Ice and Met-ocean Observing System

3.1. Description of the user group

The Norwegian Meteorological Institute is responsible for the national sea ice service in Norway. Through the operational Sea Ice Service situated in Tromsø, sea ice charts are produced using satellite information. The Sea Ice Service advises ship and icebreaker captains/ice pilots, shipping companies, national authorities, regional environmental agencies, national ice services on current and future sea ice conditions.

TOTAL E&P, Paris, is an oil company that, among others, operates in ice covered ocean areas such as the Arctic Ocean. Having access to timely and accurate observations as well as forecasts of ice and met-ocean conditions are crucial for both exploration and exploitation activities.

3.2. Work context

The Arctic Ocean and the adjacent sub-Arctic seas, including Europe's northern frontiers, have become more important as a result of the global warming and increased economic activities related to energy exploration, marine resources and transportation. Improving sea ice monitoring and forecasting, as well as the scientific understanding of the sea ice as part of the climate system is important for many user groups including European agencies and organisations (e.g. EEA, EuroGOOS). Reduced ice extent in this area during the summer period may lead to increased ship transport to and from Europe and Asia, and changes in sea ice conditions have impact on the overall sea ice climate of the Arctic Ocean as well as increasing the risk for major environmental accidents in this vulnerable environment.

There is an increasing supply of sea ice information from satellites, in situ platforms and modelling systems that can be exploited by several users groups. Both operational users and scientific users need to combine data from the available observing systems as well as from modelling systems in order to make the best possible assessment of the present and forthcoming ice situation, e.g. by assimilation of observations into forecasting models.

Still, the problems of accessing relevant information about the current sea ice situation and the how the situation develops over time remain. Typically, the data needed must be compiled from several data centres, which offer different formats that cannot readily be integrated in the user's own systems. This makes it time consuming to combine information from different sources to give a more complete picture of the current situation than can be provided from a single source. Thus, to support safe and efficient operation of the increased activity in the Arctic Ocean and adjacent seas, access, discovery and processing of information on sea ice and related data needs to be improved.

3.3. Use of processing services

Pilot 1 has defined two use cases [PTS+11]:
- P1-UC1: Develop new improved sea ice service
- P1-UC2: Search and retrieval of sea ice and met-ocean data

Both use cases need access to the most recent as well as historical ice information such as ice concentration, ice drift and ice types, in the area of interest. Ice parameters, such as these, are often obtained by processing and analysing of satellite imagery. For instance, different classification algorithms can be used to extract ice type from a radar satellite image. An algorithm based on Neural Network techniques classification of ice types in ENVISAT ASAR imagery was first developed as part of PhD thesis [Zak09] and later enhanced in the EC FP7 MyOcean project [MYO11]. Using this algorithm new ice type maps can be computed on the fly when requested by the users.

For the first use case, ice type maps are generated dynamically when a user searches for ice parameters within an area and time range that is covered by an ENVISAT ASAR image. In the second use case, the processing service generating ice type maps is part of a larger service chain that combines ice parameters from multiple sources, including observations, derived parameters and predictions, into a new and improved ice chart.

3.4. Processing service descriptions

3.4.1. Arctic sea ice classification service

The Arctic sea ice classification service selects an ENVISAT ASAR scene based on a given date, and computes the corresponding ice classification map. The process runs a Python algorithm performing a neural network based classification of ice types in the image. The ice types are colour coded in the image returned. The resulting grid is the same as the original ASAR image and based on the satellite track.

Service Type	WPS
Description	The Arctic sea ice classification service selects an ENVISAT ASAR scene based on a given date, and computes the corresponding ice classification map.
Provider	NERSC
Access Restrictions	Freely available
Status	Testing
Catalogue Service URL	http://nport.nersc.no:8081/geonetwork/srv/en/main.home
Service URL	http://wps.nersc.no/cgi-bin/iceclass.cgi?request=getcapabilities&service=wps
Service WSDL	http://wps.nersc.no/cgi-bin/iceclass.cgi?WSDL

As an example, the following URL will produce the ice map shown in Figure 3-1:

Example URL:
http://wps.nersc.no/cgi-bin/iceclass.cgi?service=wps&version=1.0.0&request=execute&identifier=getIceClassMapsAsarGeoTIFF&datainputs=%5Bscenedate=20120328191054%5D
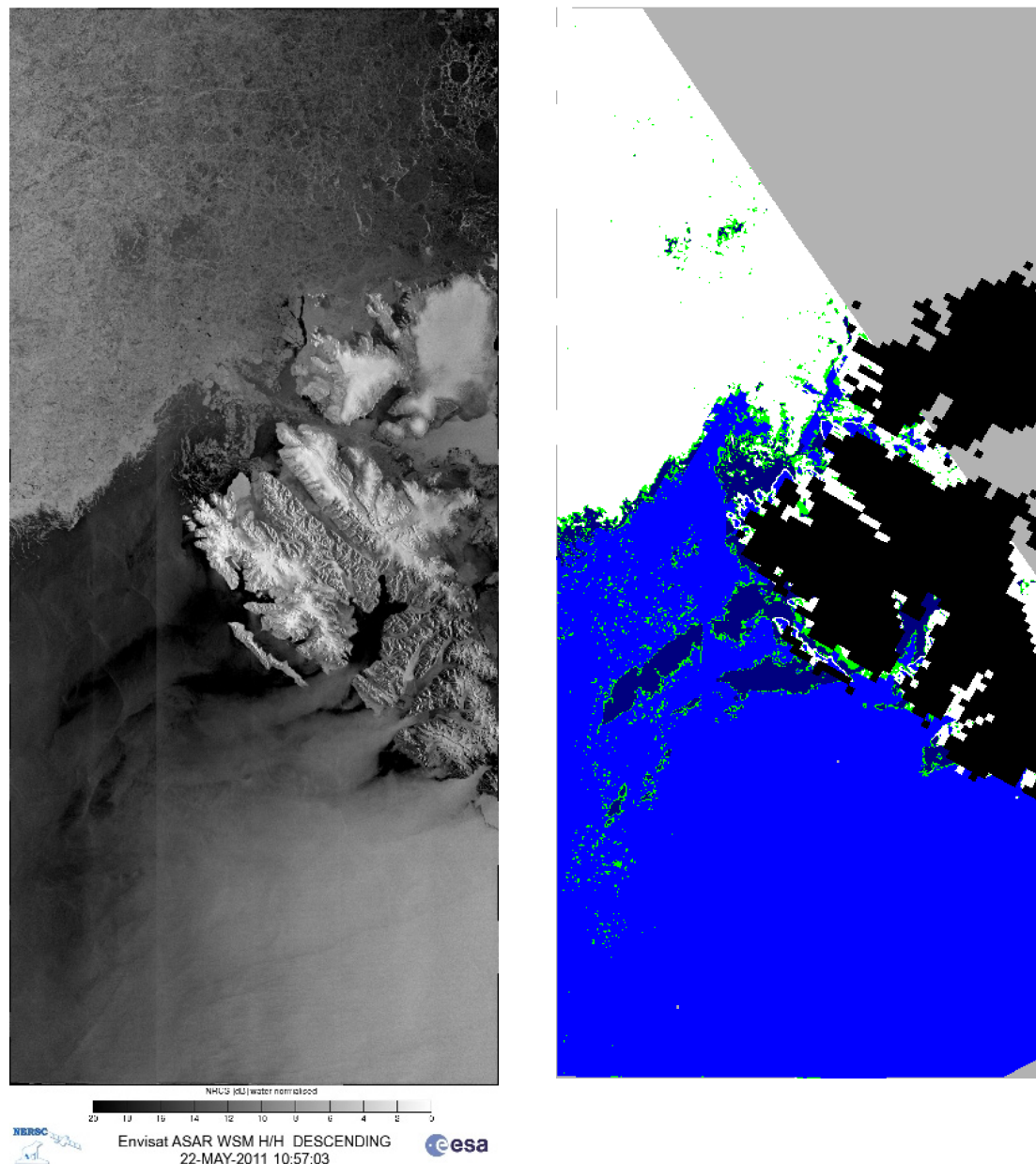
Figure 3-1 Example of ASAR image from 22 May 2011 (left) and the classified ice types (right). Legend: White: Ice; Blue: Open Water; Black: land, Green: undefined.

3.4.1.1.   getIceClassMapsAsarGeoTIFF

Process	getIceClassMapsAsarGeoTIFF
Call Type	Synchronous/Asynchronous
Return Type	Stored on server or returned as GeoTIFF file
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://wps.nersc.no/cgi-bin/iceclass.cgi?service=wps&version=1.0.0&request=describeprocess&identifier=getIceClassMapsAsarGeoTIFF

3.4.1.1.1.   Input parameters

Parameter	scenedate
Description	The date of the ASAR scene in the format YYYYMMDD.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

3.4.1.1.2.   Output parameters

Parameter	IceClassMap
Description	Raster image. The resulting GeotIFF image consists of ice types for the given region and date (in grayscale colour coding).
mimeType	image/tiff
dataType	ComplexData (raster-base64)
Units (URN)	SDN:P061::UPCT
Units (Text)	[fast Ice, very close drift ice, close drift ice, open drift ice, very open drift ice, open water]
SeaDataNet Name (URN)	SDN:P011::SICECSAT
SeaDataNet Name (Text)	Coverage (by area) of ice on the water body by image analysis

3.4.1.1.3.   Exceptions

Exception Code	Description
NoSuchScene	No scene available for date requested

3.4.1.2.   getIceClassMapsAsar_list

getIceClassMapsAsar_list returns a list of available ice maps. These may then be retrieved using getIceClassMapsAsarGeoTIFF.

Process	getIceClassMapsAsar_list
Call Type	Synchronous/Asynchronous
Return Type	Returned as text
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://wps.nersc.no/cgi-bin/iceclass.cgi?service=wps&version=1.0.0&request=describeProcess&identifier=getIceClassMapsAsar_list

3.4.1.2.1.   Input parameters
N/A

3.4.1.2.2.   Output parameters

Parameter	Output
Description	Output text data
mimeType	text/plain
dataType	ASCII

Example URL:
http://wps.nersc.no/cgi-bin/iceclass.cgi?service=wps&version=1.0.0&request=execute&identifier=getIceClassMapsAsar_list&responseform=IceClassMapList.txt=%5boutput=@asreference=true

3.4.1.2.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4. Services for Pilot 3: Ocean Colour - Marine Ecosystem, Research and Monitoring

4.1. Description of the user group

User group 3 consists of a number of different communities with a common interest in marine ecosystems.

National observatories and networks:
The Western English Channel Observatory (WECO) comprises sampling sites south of Plymouth where a range of biological, chemical physical and optical measurements are taken. Its objective is to draw together long-term in situ measurements; ecosystem modelling studies; and Earth Observation (EO) and integrate these using web-based Geographic Information System (GIS) technology.

The Chlorophyll Global Integrated Network (ChloroGIN) project aims to promote in situ measurement of chlorophyll in combination with satellite-derived estimates.

Modelling community:
Marine Ecosystem Evolution in a Changing Environment (MEECE) is a 4-year EC FP7 project that started in 2008 and includes 21 partners around Europe. MEECE aims to use a combination of data synthesis, numerical simulation and targeted experiments to boost knowledge and develop the predictive capabilities needed to learn about the response of marine ecosystems.

Operational community:
The French authorities (Prefectures) have a responsibility for operational monitoring of algal blooms.

4.2. Work context

Researchers in ecosystems need to be able to identify and use long-term time series to quantify ecosystem responses to natural variability, climate change or the impact of anthropogenic activities. Examples may include comparing long term change in zooplankton concentration to water temperature or relating optical properties to chlorophyll concentration.

There is also a need to compare the coupled physical and biological models which are being run in hindcast mode with historical EO data for validation, enabling future forecasts to observe the impacts of climate change such as changes in primary production or ocean acidification. This can be achieved using in situ data sets such as the Continuous Plankton Recorder (CPR); long term sampling stations, such as in the western English Channel, in operation for over 100 years, and satellite remote sensing for which SST data have been continuously available for approximately 30 years and ocean colour for approximately 12 years.

Operational users may find it useful to compare, in near real time, contemporary satellite and in situ data in order to provide input to water quality monitoring systems, for example, on phytoplankton chlorophyll-a concentration. Phytoplankton blooms occur each year in the Gulf of Biscay and English Channel from early spring to autumn; because some species in these blooms can cause disturbance in human activities such as aquaculture (oysters, mussels) or human health problems, regular monitoring of these areas is coordinated by Ifremer.

4.3.   Use of processing services

Pilot 3 has defined three use cases [PTS+11]:

- P3-UC1: New data service
- P3-UC2: Compare satellite and in-situ time series data
- P3-UC3: Compare satellite and model data

P3-UC1 relates to the simple service chaining aim of NETMAR and demonstrates how the processing services defined in this document may be combined using graphical tools to produce sophisticated workflows with no user coding required. The simple service chaining editor is documented in NETMAR deliverable D6.4 [NM121]

These workflows are shown in use in the other 2 use cases, comparing satellite, model and in situ data. Figure 4-1 shows a workflow developed for P3-UC3 that uses the *reprojectImage* and *compareChlImages* services to take an overlapping model output and satellite image using different projections and produce a statistical comparison of the common area.
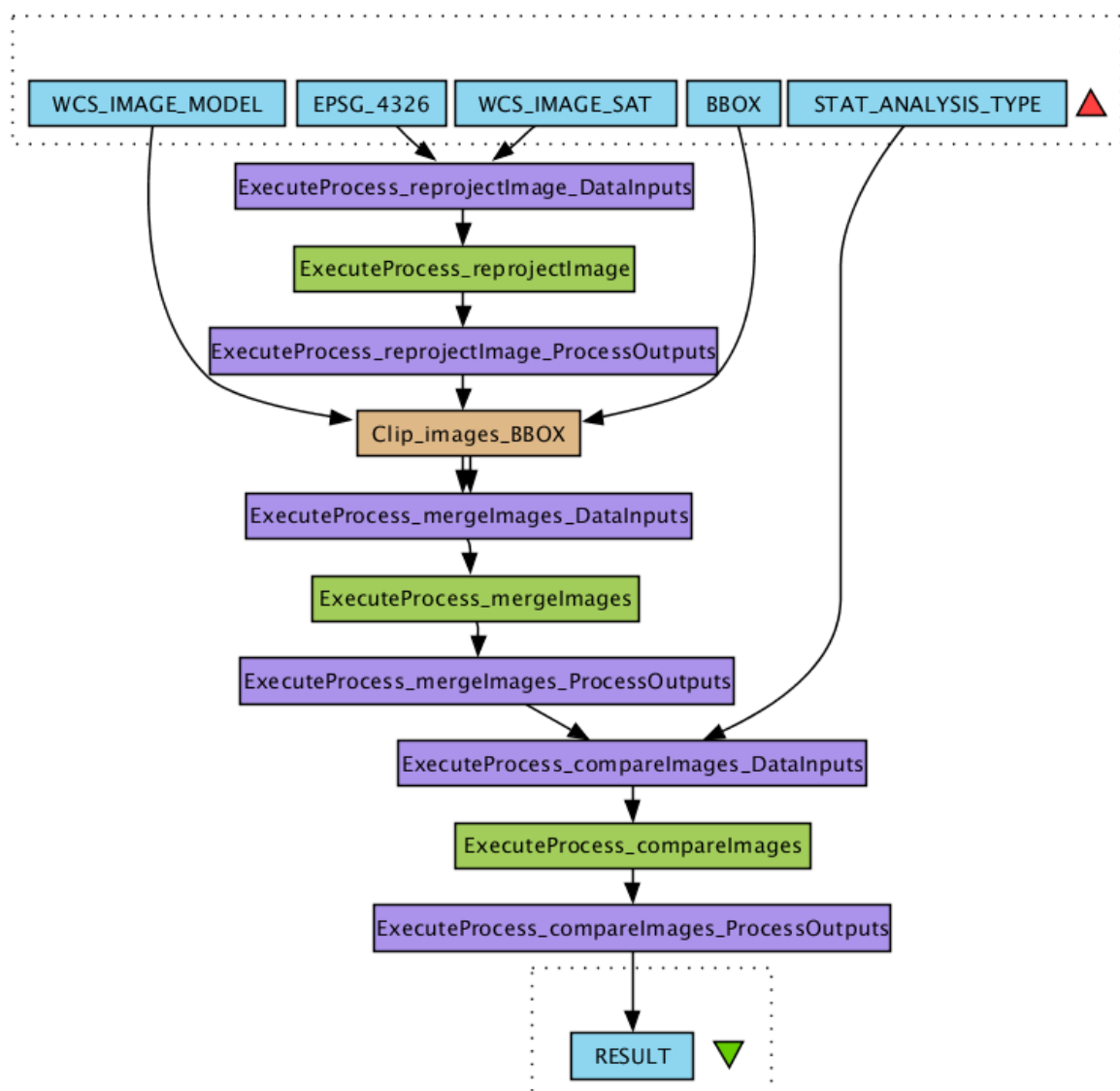
Figure 4-1 A service chain to compare a model with a satellite image.

The ability of WPS to return only a reference to the result data allows the actual movement of data between services and workflow server to be minimised, as where two services are directly chained, the second will take its input directly from the first.
This example was developed using the third party workflow editor, Taverna Workbench, showing that the extensions to PyWPS developed by NETMAR make it possible for users to use general standards based tools with the NETMAR processing services.

4.4. Processing service descriptions

4.4.1. GRASS raster service

The GRASS Raster Service provides a WPS interface to the standard GRASS raster processing functions. These provide a very useful "toolbox" which can be used within service chains to convert and subset data in to formats required by the more specific processing services developed explicitly for the pilot. Processes used within the pilot will be listed below but for a full list of all available processes please use the GetCapabilities link provided.
Note, as discussed in section 2, semantic metadata is not provided for these services as they may be applied to a wide range of data.

Service Type	WPS
Provider	PML
Access Restrictions	Freely available
Status	Testing
Catalogue Service URL	http://rsg.pml.ac.uk/csw
Service URL	http://rsg.pml.ac.uk/wps/raster.cgi?request=GetCapabilities&service=WPS
Service WSDL	http://rsg.pml.ac.uk/wps/raster.wsdl http://rsg.pml.ac.uk/wps/raster.cgi?WSDL

The following link shows an example execution of the r.math process to remove features below 100 from an elevation map using an HTML KVP call and returning the output image directly to the browser:

http://rsg.pml.ac.uk/wps/raster.cgi?request=Execute&service=wps&version=1.0.0&identifier=r.math&RawDataOutput=output&datainputs=[a=http://rsg.pml.ac.uk/wps/testdata/elev_srtm_30m.tif;math=output=if(a>100,a,0)]

The before and after images are shown in Figure 4-2.
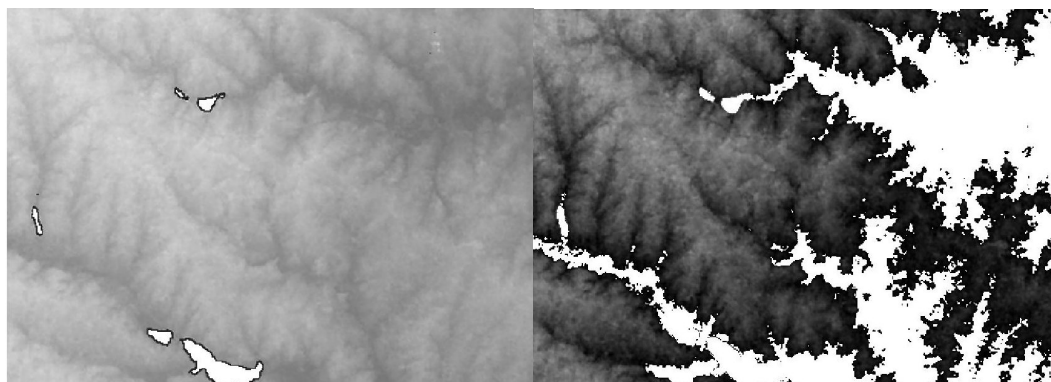
Figure 4-2 Images before and after processing.

4.4.1.1.   r.resample

r.resample resamples the data values in a user-specified raster input map layer name (bounded by the current geographic region and masked by the current mask), and produces a new raster output map layer name containing the results of the resampling. The category values in the new raster output map layer will be the same as those in the original, except that the resolution and extent of the new raster output map layer will match those of the current geographic region settings (see g.region). r.resample is intended for reinterpolation of continuous data to a different resolution rather than for interpolation from scattered data (use the v.surf.* modules for that purpose).

The method by which resampling is conducted is "nearest neighbour" (see r.neighbors). The resulting raster map layer will have the same resolution as the resolution of the current geographic region (set using g.region).

Call Type	Synchronous/Asyncronous
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/raster.cgi?service=WPS&request=Describe Process&version=1.0.0&identifier=r.resample

4.4.1.1.1.   Input parameters

Parameter	input
Description	Name of an input layer
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

Parameter	grass_resolution_ns
Description	This parameter defines the north-south resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	grass_resolution_ew
Description	This parameter defines the east-west resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

4.4.1.1.2.   Output parameters

Parameter	output
Description	Raster resampled image
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf

| dataType | ComplexData (raster-base64) |

4.4.1.1.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.1.2.   r.math

A WPS compatible front end for r.mapcalc which will process up to 8 raster maps.
r.math expects its input to have the form:

   result = *expression*

where *result* is the name of a raster map layer to contain the result of the calculation and *expression* is any legal arithmetic expression involving existing raster map layers, integer or floating point constants, and functions known to the calculator.
r.math is a very powerful operator and can be included in many difference workflows (for instance it might beused to mask maps in order to provide regionalised statistics).

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/raster.cgi?service=WPS&request=Describe Process&version=1.0.0&identifier=r.math

4.4.1.2.1.   Input parameters

Parameter	**a,b,c,d,e,f,g,h**
Description	Input Layer (each letter represent a different WPS input)
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

Parameter	**grass_resolution_ns**
Description	This parameter defines the north-south resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	**grass_resolution_ew**
Description	This parameter defines the east-west resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	math
Description	String containing the r.mapcalc expression(s) to evaluate, referencing the inputs and the output by name: e.g. output=(sin(a)+cos(b))
mimeType	text/plain
dataType	ComplexData (text)

4.4.1.2.2.   Output parameters

Parameter	output
Description	Calculated raster
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

4.4.1.2.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.2.   GRASS vector service

The GRASS Vector Service provides a WPS interface to the standard GRASS vector processing functions. Processes used within the pilot will be listed below but for a full list please use the GetCapabilities link provided. Note, as discussed in section 2, semantic metadata is not provided for these services as they may be applied to a wide range of data.

Service Type	WPS
Provider	PML
Access Restrictions	Freely available
Status	Testing
Catalogue Service URL	http://rsg.pml.ac.uk/csw
Service URL	http://rsg.pml.ac.uk/wps/vector.cgi?request=GetCapabilities&service=WPS
Service WSDL	http://rsg.pml.ac.uk/wps/vector.wsdl

4.4.2.1.   v.sample

v.sample samples a GRASS raster map at the point locations in the input file by either cubic convolution interpolation, bilinear interpolation, or nearest neighbour sampling (default).

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/vector.cgi?service=WPS&request=DescribeProcess&version=1.0.0&identifier=v.sample

4.4.2.1.1.   Input parameters

Parameter	input
Description	Data source for direct OGR access
mimeType	text/xml (GML2.1.2/KML2.2),application/dgn,application/x-zipped-shp
dataType	ComplexData (XML,base64)

Parameter	layer
Description	Layer name for direct OGR access. A single vector map can be connected to multiple database tables. This number determines which table to use. Numerical value as string
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	column
Description	Name of attribute column to use for comparison.
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	raster
Description	Raster map to be sampled
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

Parameter	grass_resolution_ns
Description	This parameter defines the north-south resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	grass_resolution_ew
Description	This parameter defines the east-west resolution of the mapset in meter or degrees, which should be used to process the input and output raster data. To enable this setting, you need to specify north-south and east-west resolution.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	grass_band_number
Description	This parameter defines band number of the input raster files which should be processed. As default all bands are processed and used as single and multiple inputs for raster modules.
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#integer)

Parameter	z
Description	Sampled values will be multiplied by this factor
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#float)

Parameter	method
Description	Interpolation method (nearest,bilinear,bicubic)
mimeType	N/A
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

4.4.2.1.2.   Output parameters

Parameter	output
Description	Output Layer
mimeType	text/xml(GML2.1.2,KML2.2)
dataType	ComplexData(XML)

4.4.2.1.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.3.   GDAL and other tool based services

As well as the GRASS integration documented above, NETMAR has developed wrappers for commonly used GDAL functions that allow the power of GDAL to be used in a web processing environment. This, in combination with custom services developed for the pilot but re-usable elsewhere, provides another useful toolkit.

Service Type	WPS
Provider	PML
Access Restrictions	Freely available
Status	Testing
Catalogue Service URL	http://rsg.pml.ac.uk/csw
Service URL	http://rsg.pml.ac.uk/wps/generic.cgi?request=GetCapabilities&service=WPS
Service WSDL	http://rsg.pml.ac.uk/wps/generic.wsdl

An example execution of the gdalinfo process using the HTML KVP style of call is provided below:

http://rsg.pml.ac.uk/wps/generic.cgi?request=Execute&service=WPS&version=1.0.0&identifier=gdalinfo&datainputs=%5Bmm=True;input=http://rsg.pml.ac.uk/wps/testdata/elev_srtm_30m.tif

The process produces the following XML response, showing information on the input file:

```
<wps:ExecuteResponse
   xsi:schemaLocation="http://www.opengis.net/wps/1.0.0
http://schemas.opengis.net/wps/1.0.0/wpsExecute_response.xsd"
   service="WPS" version="1.0.0" xml:lang="en-CA"

serviceInstance="http://rsg.pml.ac.uk/wps/generic.cgi?service=WPS&request=GetCapabilit
ies&version=1.0.0"
   statusLocation="http://rsg.pml.ac.uk/wps/wpsoutputs/pywps-131054745080.xml">
<wps:Process wps:processVersion="1.0">
  <ows:Identifier>gdalinfo</ows:Identifier>
  <ows:Title>GDALinfo command</ows:Title>
  <ows:Abstract>GDALinfo command to check image properties</ows:Abstract>
</wps:Process>
<wps:Status creationTime="2011-07-13T09:57:37Z">
  <wps:ProcessSucceeded>PyWPS            Process            gdalinfo            successfully
calculated</wps:ProcessSucceeded>
</wps:Status>
<wps:ProcessOutputs>
  <wps:Output>
    <ows:Identifier>stdout</ows:Identifier>
    <ows:Title>Standard Output from gdalinfo</ows:Title>
    <wps:Data>
      <wps:ComplexData mimeType="text/plain">

Driver: GTiff/GeoTIFF
Files: ./pywpsInput1HLa_a
Size is 500, 450
Coordinate System is:
PROJCS["Lambert Conformal Conic",
    GEOGCS["NAD83",
        DATUM["North_American_Datum_1983",
            SPHEROID["GRS 1980",6378137,298.2572221010002,
                AUTHORITY["EPSG","7019"]],
            AUTHORITY["EPSG","6269"]],
        PRIMEM["Greenwich",0],
        UNIT["degree",0.0174532925199433],
        AUTHORITY["EPSG","4269"]],
    PROJECTION["Lambert_Conformal_Conic_2SP"],
    PARAMETER["standard_parallel_1",36.16666666666666],
    PARAMETER["standard_parallel_2",34.33333333333334],
    PARAMETER["latitude_of_origin",33.75],
    PARAMETER["central_meridian",-79],
    PARAMETER["false_easting",609601.22],
    PARAMETER["false_northing",0],
    UNIT["metre",1,
        AUTHORITY["EPSG","9001"]]]
Origin = (630000.000000000000000,228500.000000000000000)
Pixel Size = (30.000000000000000,-30.000000000000000)
Metadata:
  AREA_OR_POINT=Area
Image Structure Metadata:
  INTERLEAVE=BAND
Corner Coordinates:
Upper Left  (  630000.000,  228500.000) ( 78d46'27.41"W, 35d48'34.59"N)
Lower Left  (  630000.000,  215000.000) ( 78d46'28.63"W, 35d41'16.54"N)
Upper Right (  645000.000,  228500.000) ( 78d36'29.89"W, 35d48'33.08"N)
Lower Right (  645000.000,  215000.000) ( 78d36'32.01"W, 35d41'15.03"N)
Center      (  637500.000,  221750.000) ( 78d41'29.49"W, 35d44'54.91"N)
Band 1 Block=500x4 Type=Float32, ColorInterp=Gray
  Metadata:
    COLOR_TABLE_RULES_COUNT=5
    COLOR_TABLE_RULE_RGB_0=-3.265445e+01 1.183994e+01 255 255 0 0 255 0
    COLOR_TABLE_RULE_RGB_1=1.183994e+01 5.633433e+01 0 255 0 0 255 255
    COLOR_TABLE_RULE_RGB_2=5.633433e+01 1.008287e+02 0 255 255 0 0 255
    COLOR_TABLE_RULE_RGB_3=1.008287e+02 1.453231e+02 0 0 255 255 0 255
    COLOR_TABLE_RULE_RGB_4=1.453231e+02 1.898175e+02 255 0 255 255 0 0


    </wps:ComplexData>
    </wps:Data>
  </wps:Output>
</wps:ProcessOutputs>
</wps:ExecuteResponse>
```

4.4.3.1.   gdalinfo

Wrapper for gdalinfo command. It returns image properties as extracted from the file by the gdalinfo command.

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/generic.cgi?service=WPS&request=DescribeProcess&version=1.0.0&identifier=gdalinfo

4.4.3.1.1.   Input parameters

Parameter	input
Description	Input image to be analysed
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

Parameter	stats
Description	Read and display image statistics. Force computation if no statistics are stored in an image.
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#boolean)

Parameter	mm
Description	Force computation of the actual min/max values for each band in the dataset.
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#boolean)

4.4.3.1.2.   Output parameters

Parameter	stdout
Description	Standard output from gdalinfo
mimeType	text/plain
dataType	ComplexData (text)

4.4.3.1.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.3.2.   reprojectCoords

reprojectCoords wraps gdaltransform to reproject a list of coordinates from one projection to another.

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/generic.cgi?service=WPS&request=DescribeProcess&version=1.0.0&identifier=reprojectCoords

4.4.3.2.1.   Input parameters

Parameter	Cords
Description	List of input coordinates in the form "x1 y1, x2 y2, x3 y3 …"
mimeType	-
dataType	ComplexData (text)

Parameter	inputSRS
Description	Input SRS in format suitable for gdaltransform
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	outputSRS
Description	Output SRS in format suitable for gdaltransform
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

4.4.3.2.2.   Output parameters

Parameter	stdout
Description	List of output coordinates in the form "x1 y1, x2 y2, x3 y3 …"
mimeType	text/plain
dataType	ComplexData (text)

4.4.3.2.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.3.3.   reprojectImage

Uses gdalwarp to reproject an image to a new projection. It will optionally change the resolution of the output image to allow it to match an existing grid.

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing

Describe Process URL	http://rsg.pml.ac.uk/wps/generic.cgi?service=WPS&request=DescribeProcess&version=1.0.0&identifier=reprojectImage

4.4.3.3.1.   Input parameters

Parameter	inputImage
Description	Input image to be reprojected
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

Parameter	inputSRS
Description	Input SRS in format suitable for gdal
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	outputSRS
Description	Output SRS in format suitable for gdal
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	outputExtent
Description	Output extent in the form "leftx bottomy, rightx topy"
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	outputResolution
Description	Output resolution in the form "xres yres"
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

Parameter	outputHeight
Description	Output image height. Cannot be used with outputResolution. If 0 then will be calculated to match outputWidth
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#integer)

Parameter	outputWidth
Description	Output image width. Cannot be used with outputResolution. If 0 then will be calculated to match outputHeight
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#integer)

Parameter	noData
Description	List of source no data values in format suitable for gdalwarp
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

4.4.3.3.2.   Output parameters

Parameter	outputImage
Description	Reprojected image
mimeType	image/tiff,image/geotiff,image/png,image/jpeg,application/x-erdas-hfa,application/netcdf
dataType	ComplexData (raster-base64)

4.4.3.3.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

4.4.3.4.   compareChlImages

compareChlImages runs a number of predefined statistical comparisons on the 2 bands of the input image.

Call Type	Synchronous/Asynchronous
Provider	PML
Access Restrictions	Freely available
Status	Testing
Describe Process URL	http://rsg.pml.ac.uk/wps/generic.cgi?service=WPS&request=DescribeProcess&version=1.0.0&identifier=compareChlImages

4.4.3.4.1.   Input parameters

Parameter	inputImage1
Description	Image to be compared
mimeType	image/geotiff
dataType	ComplexData (raster-base64)
Units (URN)	SDN:P061::UMMC
Units (Text)	mg m-3
SeaDataNet Name (URN)	SDN:P25::CHLA
SeaDataNet Name (Text)	The amount (mass or quantity of matter) of the pigment chlorophyll-a per amount (volume or mass) of a body of water

Parameter	inputImage2
Description	Image to be compared
mimeType	image/geotiff
dataType	ComplexData (raster-base64)
Units (URN)	SDN:P061::UMMC
Units (Text)	mg m-3
SeaDataNet Name (URN)	SDN:P25::CHLA
SeaDataNet Name (Text)	The amount (mass or quantity of matter) of the pigment chlorophyll-a per amount (volume or mass) of a body of water

Parameter	statType

Description	Name of statistic to produce (ROC, Kappa, Wavelet SS, Wavelet MSE)
mimeType	-
dataType	LiteralData (http://www.w3.org/TR/xmlschema-2/#string)

4.4.3.4.2.   Output parameters

Parameter	stdout
Description	An array of statistics suitable for plotting
mimeType	text/plain
dataType	ComplexData (text)

4.4.3.4.3.   Exceptions

Exception Code	Description
InvalidInput	The input image could not be opened
DimensionMismatch	The 2 input images have differing dimensions
InvalidStatistic	An unsupported statistic type was requested

5. Services for Pilot 4: The International Coastal Atlas Network (ICAN)

5.1. Description of the user group

In recent years significant momentum has occurred in the development of Internet resources for decision makers, scientists and the general public who are interested in the coast. A key aspect of this trend has been the development of coastal web atlases (CWA), based on web enabled geographic information systems (GIS).

A CWA has been defined by the ICAN (International Coastal Atlas Network) community as: a collection of digital maps and datasets with supplementary tables, illustrations and information that systematically illustrate the coast, oftentimes with cartographic and decision support tools, all of which are accessible via the Internet.

The application scope of CWAs is broad. Driving factors for CWA development include the need for:

- Better planning to cater for increased population pressures in the coastal zone (e.g. the UN estimate that by 2020 75% of the world's population will be living within 60 km of the coastal zone (United Nations, 1992; Shi and Singh, 2003).
- Decision support systems in relation to climate change scenarios in vulnerable coastal regions.
- Information to facilitate assessments of risk to natural hazards (including tsunamis and floods).
- Access to data and maps to support marine spatial planning (MSP) as a tool for better coastal and marine area management.
- Maps of jurisdictional boundaries for maritime territories in support of claims related to the United Nations Convention on the Law of the Sea (UNCLOS), which has a deadline for submissions of 2013.
- More efficient and effective coastal and marine area governance including access to relevant data and information.
- Information on resource availability and exploitation including habitat and species information, as well as ecological and community resilience.

The mission/strategic aim of ICAN is to share experiences and to find common solutions to CWA development (e.g., user and developer guides, handbooks and articles on best practices, information on standards and web services, expertise and technical support directories, education, outreach, and funding opportunities, etc.), while ensuring maximum relevance and added value for the end-users.

In 2007, the ICAN community selected the topic of **coastal erosion** as the main focus of a project to demonstrate semantic interoperability among selected coastal web atlas. However, it is recognised that there are many more topics that coastal web atlas can address. For the coastal erosion use case example, the following user roles were targeted (however other roles do exist):
- **Coastal Manager/Planner** (uses an inventory to take regulatory action; helps form policy guidelines as potential statutes or regulatory rules)
- **Private Property Owner** (seeks insight about adverse impacts to a property)
- **Emergency Responders** (need information about past, present, or future hazardous events)

- **Scientist** (investigates research questions for knowledge building, relevant for policy implications and decision support action)
- **Local CWA administrator** (supports other users with getting access to data, perhaps from own system or other systems)

5.2. Work context

The ICAN community wish to make their ongoing digital atlas developments more interoperable to better support data discovery, data visualisation, and data sharing across administrative, natural and thematic borders. However, at present, the ICAN community is not familiar with WPS technology. Therefore, a WPS demo is being developed to illustrate its potential. This demo processing service produces shaded relief maps for bathymetry digital terrain models (DTM). This WPS service was proposed to the ICAN community on 1st September 2011 at the ICAN-5 workshop in Oostende. The ICAN technical working group showed interest in learning more about this technology. Furthermore, it is proposed to make this service semantically enabled by ensuring that only datasets tagged with "elevation" or narrower are processed. Results of this NETMAR work will feed into the ICAN community via ICAN workshops, NETMAR deliverables, cookbooks, WIKI, etc.

5.3. Processing service descriptions

5.3.1.   Bathymetry image manipulation service

Processing service	Bathymetry image manipulation service
Service Type	WPS
Description	This service produces colour shaded relief maps for bathymetry digital terrain models (DTM).
Provider	CMRC
Access Restrictions	Freely available
Status	Testing, currently deployed on an internal machine
Catalogue Service URL	http://netmar.ucc.ie/geonetwork
Service URL	Deployed on an internal machine at present
Service WSDL	Deployed on an internal machine at present

5.3.1.1.1.   Input parameters

Process	gdaldem-hillshade
Call Type	Synchronous/Asynchronous
Return Type	Stored on server or returned as GeoTIFF file
Access Restrictions	Freely available
Status	Testing
Describe Process URL	

Input parameter 1	scale
Description	Ratio of vertical units to horizontal. If the horizontal unit of the source DEM is degrees (e.g Lat/Long WGS84 projection), you can use scale=111120 if the vertical units are meters (or scale=370400 if they are in feet).
mimeType	N/A
dataType	float

Input parameter 2	altitude
Description	Altitude of the light, in degrees. 90 if the light comes from above the DEM, 0 if it is raking light.
mimeType	N/A
dataType	float

Input parameter 3	azimuth
Description	Azimuth of the light, in degrees. 0 if it comes from the top of the raster, 90 from the east, etc.The default value, 315, should rarely be changed as it is the value generally used to generate shaded maps.
mimeType	N/A
dataType	float

Input parameter 4	zfactor
Description	vertical exaggeration used to pre-multiply the elevations.
mimeType	N/A
dataType	float

Input parameter 5	algorithm
Description	If set to true use Zevenbergen & Thorne formula, instead of Horn's formula, to compute slope & aspect. The literature suggests Zevenbergen & Thorne to be more suited to smooth landscapes, whereas Horn's formula to perform better on rougher terrain.
mimeType	N/A
dataType	boolean

Input parameter 6	inputzip
Description	Any GDAL-supported elevation raster passed as a zip file.
mimeType	application/zip
dataType	ComplexData (application/zip)
Units (URN)	SDN:P06::ULAA
Units (Text)	Metres
SeaDataNet Name (URN)	SDN:P25::ELEV
SeaDataNet Name (Text)	Elevation

5.3.1.1.2.   Output parameters

Output parameter 1	ShadedMap
Description	Geotiff colour shaded relief map (in grayscale colour coding).
mimeType	image/tiff
dataType	ComplexData (raster-base64) if synchronous. URL to Geotiff if asynchronous.

5.3.1.1.3.   Exceptions

Exception Code	Description
NoApplicableCode	General error in processing. Error message will provide more detailed information

6. References

[MYO11] MyOcean, http://www.myocean.eu.org/ (accessed 22 July 2011)

[PTS+11] Pladsen, Jan Ivar, et. al, 2011. D1.1 Use case specification and schedule for testing. NETMAR (Open service network for marine environmental data) Deliverable D1.1. European Commission Information Society and Media Directorate-General Grant Agreement Number 249024.

[NM121] Hamre, Torill et. al, 2012. D6.4 Second version of EUMIS subsystems. NETMAR (Open service network for marine environmental data) Deliverable D6.4. European Commission Information Society and Media Directorate-General Grant Agreement Number 249024.

[NM122] Walker, Peter et. al, 2012. D5.3.2 WPS Server – Fully semantically enabled processing services. NETMAR (Open service network for marine environmental data) Deliverable D5.3.2. European Commission Information Society and Media Directorate-General Grant Agreement Number 249024.

[Zak09] Zakhvatkina, Natalia, 2009. Arctic Ocean sea ice identification using satellite SAR data. PhD thesis, RSHU – Oceanography, St. Petersburg, Russia.