Interoperable GMES services for marine and coastal areas

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Abstract
The lack of a pan-European infrastructure for uniform access and distribution of environmental data is a severe problem in all types of risk and crisis management. In marine and coastal areas, environmental risk and crisis situations such as oil spills and harmful algal blooms is an international problem where many countries can be affected. Thus, users in several countries and organisations need access to the same data, including observations, derived parameters and predictions of future conditions. Interoperable services necessitate standardisation of system communication protocols and harmonisation of data and metadata formats. The services presented in this paper are based on established web-GIS and web services standards, and have been developed in line with INSPIRE recommendations. Proof-of-concept has been demonstrated through sample services to selected users in coastal areas of Europe, and feedback and experiences made will be used to further develop the systems into sustainable GMES services.

Keywords:
Web-GIS, Web Map Server, GMES, INSPIRE, interoperable services, marine pollution

1. Introduction
The services presented in this paper are based on systems developed in earlier RTD projects, notably DISMAR (Data Integration System for Marine Pollution and Water Quality, EC FP5 IST contract no. IST-IST-2001-37657, 2002-2005), MASS GSTP (Multi Application Support Service System General Support Technology Programme, ESA 2001-2003, MASS-ENV (MASS-Environment, ESA 2001-2005) and ISAC (ESA 2004-2005). These systems are now being further developed in the InterRisk (Interoperable GMES Services for Environmental Risk Management in Marine and Coastal Areas of Europe) project.

The InterRisk project aims to develop a pilot system for interoperable GMES monitoring and forecasting services for environmental risk management in marine and coastal areas. The InterRisk pilot will consist of an open system architecture based on noted GIS and web standards in line with INSPIRE recommendations (Smits et al., 2002), and integrate services for several European regional seas. The pilot system will be validated by users who need data on oil spills, harmful algal blooms and other marine pollution events, in Norwegian, UK, Irish, French, German, Polish and Italian coastal waters.
The InterRisk services will include basic services like satellite data processing, in situ data delivery, ocean model simulations, metadata catalogue access, as well as complex services like oil drift prediction and ecosystem modelling. The network of InterRisk services will be embedded in the European Space Agency's Service Support Environment (SSE) (ESA, 2004), which provides the underlying infrastructure. This will enable service providers to make their data products and services available to the GMES user community through a common portal. In addition, value-adding companies can develop new services by combining existing ones and deliver these new services through the same portal. End-users are free to choose from all available services, selecting the one(s) best suited for their needs. It is expected that the developed components, both services and infrastructure, can be used to build up sustainable GMES services.

The rest of this paper is organised as follows. Section 2 outlines the concepts and technological foundation for the InterRisk system. Section 3 describes intermediate results from the demonstrations in two regions and the initial development of a pan-European service. Section 4 concludes the paper.

2. Service concepts

In pollution monitoring and forecasting, it is desirable to incorporate data from all available sources to obtain the best possible basis for decision-making. The InterRisk services are based on this concept, integrating remote sensing data from satellites and aircrafts, in situ observations from vessels and buoys, as well as predictions made by numerical models. Each data source go through a series of processing steps, including initial acquisition, quality control and archival, generation of derived and combined products, and distribution of these products through a standardised web-GIS (Figure 1).

This concept facilitates multiple providers – multiple end-users service networks where a provider can reach a number of end-users (clients), and an end-user can seamlessly access products from many providers. The existing processing chains for data and product generation, which are typically performed by legacy systems using non-standard or proprietary data and metadata formats, can be retained by the service providers. To serve their products through the InterRisk portal, they need only establish a WMS compliant node publishing these in one of the standard data and metadata formats endorsed by the OGC (OGC, 2008). The end-users on the other hand, can access all available products using a common web browser; no extra plug-ins needed.

Figure 1: DISPRO service chain.
At the heart of the service network, the InterRisk portal mediates all end-user requests to respective providers, and delivers the desired products back to the end-users. The network of providers can grow dynamically. As soon as a new WxS node becomes operational, it can register its products with the portal, which will then offer them to interested end-users. The InterRisk portal also provides additional services for both providers and end-users (Figure 2). For instance, providers can chain existing services to generate new value-added products, and end-users can search for services covering a certain area or interest and/or within a certain thematic application (such as “oil spills”).

**Figure 2:** The InterRisk SSE architecture.

The chosen approach has several benefits. As mentioned above, it supports many-to-many networks of providers and end-users, and there is no need for special software on the end-users part. Furthermore, the chosen OGC standards are widely adopted by both academia and commercial actors, and mature software tools are available for setting up a WxS compliant node. This also includes open source tools, of which the University of Minnesota MapServer is the most commonly used. Adhering to established standards and use of proven tools will reduce the initial development costs as well as the maintenance costs, and contribute to the developed services becoming sustainable.

### 3. Examples of regional demonstrations

#### 3.1 Harmful algal bloom monitoring and forecasting in Norwegian Waters

The Norwegian Harmful Algal Bloom (HAB) service, NORHAB, aims to deliver daily information for monitoring and assessing algal bloom situations along the coast of Norway. Fish farming is an important industry in these waters, and having a system for early warning of HAB situations is of large economic interest (Folkestad et al., 2007). For this purpose a combination of remote sensing data covering large areas but with a resolution of approx 1 km, and ferrybox instruments mounted onboard vessels providing much better spatial resolution but only at sample points along the vessel track, is useful.

Figure 3 illustrates how the web-GIS can be used to overlay chlorophyll-a products derived from satellite and in situ sensors, respectively. Ocean colour sensors are affected by cloud conditions, and while they provide coverage of large areas of the
North Sea, as shown in the lower, left part of the map in Figure 3, data cannot be obtained in cloud covered areas. In such cases, ferrybox measurements can be used to assess the situation, as illustrated in lower, right area of the map where the track of ferrybox data is shown as a line across an area covered by clouds. Water samples taken by the ferrybox systems can also be used to identify the species or species occurring in a high concentration area is toxic or not. For periods with cloudy weather, weekly averages of satellite-derived chlorophyll-a are used to increase the coverage of the area of interest.

There are currently three service providers in the NORHAB portal: NERSC, the Meteorological Institute of Norway (met.no) and the Norwegian Institute for Water Research (NIVA). In Figure 3, the MERIS product is delivered by NERSC, while NIVA delivers the ferrybox data. Met.no provides standard meteorological and ocean-ecosystem forecasts for the NORHAB service.

**Norwegian Harmful Algal Bloom Service (NORHAB)**

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Figure 3: Overlaying Envisat MERIS chlorophyll-a data with Ferrybox observations.

### 3.2 UK and Irish Water Quality and HAB services

Figure 4 illustrates how data from many providers can be combined in the UK and Irish Waters InterRisk portal. Remote sensing data are provided by PML and NASA, the latter is not a member of the InterRisk consortium but can still provide data as they offer a WMS compliant data server. PML also provides several other products: background data such as bathymetry and coastline is overlaid on top of the raster layers, as are in situ data from offshore stations.

Several providers offer model forecasts. The UK met office provides forecasts of chlorophyll-a in the English Channel, while met.no also provides standard meteorological forecasts (wind) for UK and Irish Waters. Met.no also provides phytoplankton forecasts from an ocean-ecosystem model covering a large part the North Sea including northern UK waters. The same WMS server at met.no is used for delivery of the model forecasts to both the NORHAB portal and the UK and Irish Waters InterRisk portal. This illustrates that once a provider has established a WMS compliant
data server, he can deliver data to any portal, without any further development or maintenance costs on the provider side.

**Figure 4:** Combining data from many providers in the UK and Irish Waters InterRisk portal.

### 3.3 A pan-European test service in the InterRisk SSE portal

As a first attempt to set up a pan-European service in the InterRisk SSE portal, GKSS registered layers of remote sensing images, in situ observations and satellite-derived parameters. Figure 5 illustrates how these layers can be combined in this portal. The Envisat MERIS chlorophyll-a data are covering UK and Irish Waters, as well as a significant part of the North Sea overlapping the Norwegian and German demonstration areas.

In situ ferrybox data from NIVA are overlaid on the remote sensing data, showing chlorophyll-a concentrations along the ship track from Oslo in Norway to Newcastle in the UK. Finally, an Envisat ASAR wind product is included, covering the Gulf of Finland. This example illustrates how cross-country and regional services can be set up in the InterRisk SSE portal. In an operational service, more products will of course be needed and updates must be done in near-real time, but the mechanisms for making all products available and displaying selected layers in a web-GIS viewer are in place.

### 4. Summary and conclusions

We have established national portals for HAB and oil spill monitoring and forecasting, and currently demonstrating these to selected end-users in the target areas of the InterRisk project. Experiences from a service provider’s point of view are generally positive; standardised tools are available for setting up services and portals and once
OGC compliant nodes are in operation they can provide products to multiple portals with no extra effort on the provider’s side. Feedback from end-users will be collected as the demonstrations run, and will be used to improve the services and portals.

We have also made a first attempt to set up a pan-European service using sample layers from the providers in the consortium. This service has to be extended with more layers before a demonstration to end-users can be conducted, but the first test shows that the InterRisk SSE portal is capable of offering pan-European datasets provided such are registered.

![Image](image.png)

**Figure 5:** Overlaying layers from different data distribution services in the InterRisk SSE portal.

**Acknowledgements**

This work has been supported by the EC FP6 IST Programme (contract no. 035253) and partners of the InterRisk consortium.

**References**


