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Integrated Weather, Sea Ice and Ocean Service System (IWICOS)

Extended System Report

IWICOS Report No. 4

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Executive Summary

The overall objective of IWICOS is to develop a prototype marine information system that will provide a single-entry access to integrated meteorological, sea ice and oceanographic (met-ice-ocean) products in electronic form, and to demonstrate this prototype for a group of users working in fisheries, sea transport, exploitation of marine resources in Northern European waters, or whose work is related to sea ice monitoring on a scientific or pre-operational basis.

Results from user requirements studies, conducted before and during the project, have been used to extract and synthesise recommendations for facilities and features needed in the IWICOS System. A general system architecture with three main subsystems: Production, Brokering and Presentation, has been defined based on these recommendations. This architecture supports a service chain where multiple producers can deliver data and information products through a common broker. Within this architecture, each producer can maintain separate (legacy) production systems, which can run on various computer platforms. Producers can also retain internal formats up to the point where products are submitted to the broker for advertisement to potential customers and to an in-house server for Internet distribution. Then, the products must be standardised. First, through adhering to a standard metadata specification, and secondly, through making the observed, derived or predicted met-ice-ocean parameters available in a standard data format.

The IWICOS metadata specification ensures that all products are described in a consistent and self-describing manner, which can be queried and processed by computer algorithms. This specification is developed using XML Schema, a widely accepted standard for metadata definition, supported by a number of public domain and commercial tools for preparation and validation of metadata. The IWICOS specification captures all relevant metadata attributes for the developed met-ice-ocean products, but is still small compared to many general-purpose standards for geographical data sets. The issue of keeping the metadata to a minimum is an important requirement, in particular for all users operating at sea and being dependent on low-bandwidth and expensive communication means.

A number of new product types have been generated for the Extended System, e.g. augmented sea ice thickness maps, multi-prognosis of numerical predictions and products based on new sensors like QuickSCAT and NOAA AMSU. However, since all products are accompanied by metadata organised according to the same specification, they can be announced via the common Broker. Furthermore, as all products are stored in standard formats (BSQ, GRIB, Shapefiles or XML), they will be compatible between different producers and End-User Systems.

The Broker lies at the core of the IWICOS system, holding the central repository of metadata for all products. It provides facilities for receiving metadata from Producer Systems, and for maintaining these metadata in a database. It also provides query facilities that enable End-User Systems to retrieve metadata for all products that satisfy given criteria. The Broker is developed using freely available software: Apache web server, Apache Tomcat servlet container, Apache SOAP communication protocol and MySQL database. The Broker runs on Linux OS and the service programs are written in Java. The communication is secured using SSL encrypted HTTP protocol (HTTPS).

Different End-User Systems provide customised display and analysis facilities for target end-user groups, and consist of a Client and Façade subsystem. Some of these are thin clients that rely on having a server generating all data and information in a form ready for presentation. Others are thick clients, which download full (or partial) data sets and products, and contain tools for both analysis and presentation. A third category is a so-called balanced client, which include some analysis and presentation tools, but still uses a server for certain types of processing such as map drawing. The Façade may be used to tailor data to a specific client, e.g. by reducing its size by compression before transmitting it via a low-bandwidth connection, or to perform format conversion before transmission.

Compared to the first (baseline) version of the IWICOS System, the Extended System has advanced the solution by: (1) upgrading to the latest version of standards and protocols used in software development, (2) revising the IWICOS metadata standard to cater for new product types (although it turned out that only minor changes were needed), (3) implementing secure data transfer to the Broker by means of standard encryption techniques, (4) enhancing the functionality of the End-Users Systems, and (5) making more and new types of met-ice-ocean products available. By means of the Extended System, four full-scale demonstrations have been carried out for different end-user groups in different geographical regions, yielding valuable experience and feedback for future development.

Contents

1 Introduction

1.1 User groups and their requirements

The background and motivation for the IWICOS project is the general requirement from a wide range of users of met-ice-ocean data to have easier access to services and data provided by meteorological offices, ice information centres and oceanographical institutes. This means that monitoring and forecasting products in digital format should become easily available on Internet and that marine communication systems should be used to send text, images and graphical products to users at sea. Ship captains have expressed a clear requirement to have more integrated information available on the bridge. Ideally, all information should be accessible in digital form via one system, which is easy to operate and avoid to use many different computer systems onboard a ship.

In previous sea ice projects, user requirements for ice information have been identified for different regions and for the main users categories such as ice-going vessels, cargo vessels, fishing boats, oil companies, shipping companies, sea transport administrations, national ice and weather centres, research activities and other marine operations under rough conditions. The study refers to the main results from these projects covering the Baltic Sea, Greenland waters and the Northern Sea Route. These requirements have been supplemented by results from a dedicated user investigation in Iceland and the Design Workshop where invited users stated their opinion on how the IWICOS prototype should be developed.

The requirements for sea ice information are closely related to meteorological and oceanographical parameters. For example, the temporal changes in the ice conditions are always driven by atmospheric forces (winds, air temperature) or ocean forces (currents, waves, tides, ocean temperature). This means that ice data should in principle be accompanied by atmospheric and ocean data that govern the behaviour of sea ice. The requirements are related to products and their quality, time-space coverage, methods of delivery, timeliness, regularity and costs. There are different products that cover various spatial and temporal scales, for example short-term and long-term weather forecasts, ice maps for strategic or tactical operations. The cost-benefit ratio is an important factor that determines which product or service a user selects in a given situation.

The meteorological information needed by users at sea can basicly be divided into three groups:

- Tactical information, consisting of observations (ground observations and satellite products), very-short-range forecasts (nowcasting, < 3 hours) and warnings, issued whenever needed.
- Strategic information where traditional weather forecasts, issued at least two times a day as text according to WMO standards (up to 24 hours) are the most important item. These forecasts might be supported by prognostic charts from numerical models but they should be enhanced in such a way that they are in agreement with the worded forecast.
- Planning information is mainly based on medium range weather forecasts (up to 10 days). Such forecasts may be presented as fields but forecasts beyond day 4 should preferably be expressed in probabilistic terms, based on EPS (Ensemble Prediction System).

1.2 Recommendations from the user requirement studies

- IWICOS should recognise that the marine user community may have different needs for information, may work in different regions and have different educational background.

- The IWICOS system must be able to combine information from different sources in a flexible way. Consequently, it should be possible to construct user defined displays and combinations of information.

- IWICOS should provide an integrated system enabling users to access and display all information with one system. It is important that users do not have to worry about sources of a given information layer and formats. Today, much of the information already exists, but must be collected from different sources and may exist in different forms that obstruct easy combination of information layers from different sources.

- It is important that the IWICOS system has a user friendly interface so difficulties with understanding and using the system will not obstruct the application and dissemination of the system. Therefore the user interface must be developed by means of known industry standards or public domain tools.

- IWICOS should aim at adopting existing standards for data presentation, e.g. standard colour coding of ice charts and standard symbols for presentation of meteorological information and ensure source independence and seamless display of data from different sources.

- IWICOS must disseminate products using standard technologies and standard data exchange formats.

- IWICOS must acknowledge the limitations of marine communication systems and the cost of using them and must adopt methods to effectively handle these problems.

- IWICOS should provide a range of products with different levels of information, aimed at different user groups. In both demonstration periods a representative set of free products should be prepared and advertised through the IWICOS web site, to raise awareness of the service and allow for a wide audience to give feedback on the products and IWICOS prototypes developed.

- The cost of the met-ice-ocean products is another important aspect in the end-users' evaluation of IWICOS. Some products will require high-priced input data and/or a significant amount of processing and therefore be expensive to generate, while others may be produced by means of low-cost input data and simple, automated processing tools. Whether or not a product is to be delivered in near real-time will also have a large impact on its cost. As information needs will differ between various user groups, and also depend on the type of activity carried out, the user should be able to select and change the level of service requested to best match the current situation.

1.3 From initial data products to client products

Products in this context means both met-ice-ocean data at various processing levels ranging from initial data sets (meteorological observations and forecasts, satellite data, ice data, etc.) to client products which are based on various presentation methods to bring essential information to the customers (text, images, graphical products, etc.). In this project we define initial products to be a set of met-ice-ocean data sets that are available among the partners and used to develop various methods for combination and presentation of the data sets in user-friendly ways (Figure 1.1). These presentations are defined to be the client products, and they are dependent on the client capability to transfer, display and manipulate with the data sets.

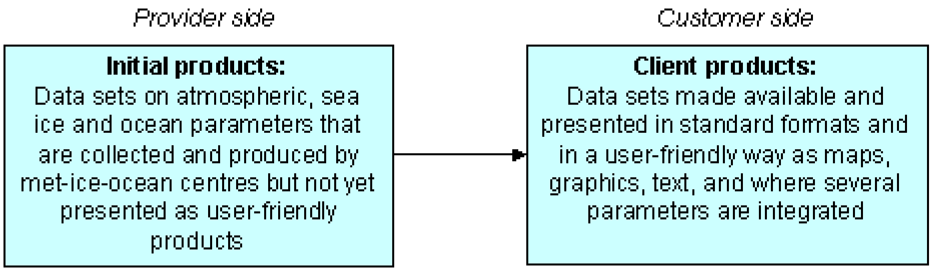


Figure 1.1 Definition of initial products and client products. Client products can either be produced by a central server on the provider side and be downloaded for display the user's PC, or they can be produced locally after downloading initial products from a central server. The latter option makes it possible for the user to carry out own operations on the data and make his own client products provided that he has necessary software for such operations.

The partners have selected and developed a set of initial and client products for the IWICOS baseline system. In these products data from several sources are integrated and presented, and in some cases meteorological, oceanographical or sea ice data are combined and displayed on top of each other using GIS. The client products must be tailored to the geographical regions, the communication limitations and the specific user requirements in these regions, while other products will be more or less similar in all regions. For example, wind fields and air temperature can be used together with ice data, showing the dynamics of the ice fields. Use of GIS technology is an important element in the integration of several data types. Ice kinematics algorithms can be improved by including wind forcing, and ice type classification can be made more reliable if the time series of ice data from the preceding days and weeks are made available. The products can be divided into the following main groups:

- Near-real time products that are used for monitoring and are available on regular basis (hourly, daily, weekly, etc.)
- Forecasts of weather, ocean and ice conditions which may be supported by output from numerical prediction models,
- Archived products giving statistical information about mean and extreme conditions as well as snapshots of interesting events, and
- Experimental products

An example of archived products is a set of several thousand SAR quick look images of Arctic sea ice available from a database, which give many examples of detailed ice images in different parts of the Arctic. Other archived products are ice charts, AVHRR and SSM/I data and meteorological statistics. Improvements in operational ice monitoring are expected by the introduction of SAR images and ice classification from SAR images, providing better resolution in the ice maps. During IWICOS the digital GIS information about ice properties in the routine ice chart will be combined with SAR image classification algorithm. Daily and archived SSM/I ice maps, combined with AVHRR, SAR and other data products, are developed for presentation on Internet. Ice drift and wave forecast visualisations are developed in the Baltic Sea and in Icelandic waters.

Improved visualisation of the data is under testing in all study regions, Access to the products will be possible in several ways. In the Baltic Sea, products are sent out to icebreakers and some ships using communication satellites and cellular telephone system. In Icelandic and other waters ice and weather information is sent to fishing vessels by a special developed information system, the MaxSea system, which communicates via INMARSAT.

In general, the products are developed to serve two different user types: the “active” users who need to have a **thick client** in order to download different types of data for own processing and presentation; and the “passive” users who work with a **thin client** which is sufficient for a user only wants readymade products which can easily be downloaded without further processing. A combination of the two types of clients, called **balanced client**, is also developed where the user has some limited possibilities to carry out operations on the products, but without the full software package which a thick client will need.

1.4 IWICOS architecture

The logical architecture for IWICOS (and most dynamic multi-producer GIS-systems) can be divided into three subsystems as shown in Figure 1.2.

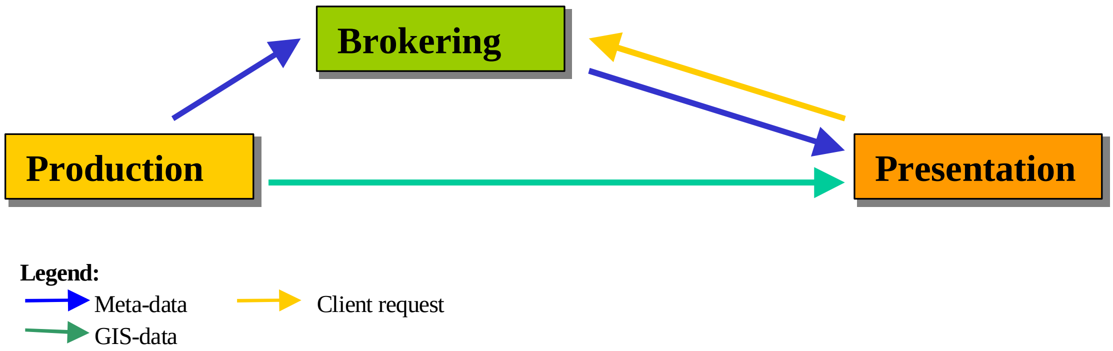


Figure 1.2 The reference architecture for IWICOS.

The main subsystems include the ***production***, ***brokering***, and ***presentation*** of GIS-products. The actual tasks in these subsystems are determined by decisions related to issues such as distribution, delivery mechanisms (push/pull) and client model (thin/thick). In the production subsystem the GIS-data is produced and packed for delivery with a meta-data description of the product. The brokering subsystem receives this information (or plain meta-data and GIS-data address) and the user needs (either a profile or a request).

Communication with other servers for locating and collecting data is also possible if the distribution solution supports this. Presenting the GIS-products provides the user a view of the products and means for selecting them. In the *thick-client* model the products can be customised and new user defined views created.

It is clear that many choices over technologies and solutions that are to be used have to be defined at the architecture definition phase. In the following sections we will discuss these issues and present a few alternative approaches to the division of tasks and distribution in the architecture.

Production Subsystem

The Production subsystem produces the raw-data or refines it to useful products. Within the reference architecture we do not define whether or not the production should have a dedicated server, we simply identify that for IWICOS system such functionality is essential. The need for a server is further discussed below. Closely related to the need of a server is the question of data-storage, it must be decided whether the data is stored in production subsystem, or brokering subsystem, or in both of them. Anyhow, to begin with at least the meta-data has to be passed on from the production.

Brokering

The main task for the Broker is to establish contact between Clients and Producers. This can occur in many forms, which are discussed on following sections. The storage issue above concerns also the Broker. It can be argued that a Broker is not needed at all. However, if a Broker is used, it should be responsible for locating other Brokers and Producers in addition to meta-data (and product-data) brokering. Thus, if no Broker is used, other means of locating services should be applied.

Presentation

The task for the client software is to present the data to the user. There are, however, two approaches to this task. The first one, called *thin-client* approach, is just to provide ready-made presentations of the data. The other one is the *thick-client* approach, which may include complicated processing of the data to gain a presentation that is customized for that particular user. Both thin and *thick-client*s should be supported, due to the heterogenity of IWICOS users. Lately this division to *thick*- and *thin-client* systems has become a bit ambiguous, due to the Java-applet clients that have both *thick*- and *thin-client* properties. Based on this trend we define a *thick-client* to be a client that requires a separate installation process to be accomplished on the target computer before the client can be used.

Service chain illustration

The flow of data from the providers to customers forms a service chain that will supply both thin clients and thick clients (Figure 1.3). The initial data products are transformed into client products through different processing in production and brokering servers, and client software. In this chain, the data that the user needs, are produced, processed for delivery, selected and presented to the user in the form of client products. The base for identifying the useful data and the varying processing it requires, is the meta-data that describes the attributes of the actual data, such as its location, time, nature and origin. Extensible Markup Language (XML), XML Schema and Resource Definition Framework (RDF) provide a good base for the definition of the meta-data presentation (Karttunen 1999, Lassila 1999). The main components in the service chain are the subsystems of the reference architecture described above. However, these subsystems consist of smaller separate processes to be described in Chapter 4. After each processing the data is shifted to the next phase, in these interfaces the data should preferably be presented using open industry standard formats (if possible). In the service chain both client types can be served, by providing the data for client software on different levels of processing. In a *thick-client* the final processing of data is done by the client software and in *thin-client* this is done by the broker server. Thus *thick-client*s receive a kind of 'bulk-data' and *thin-client*s receive final products.

The use of the open industry standard formats in data transfers forms natural connection points for additional processing that may be applied on some data. Such processing will actually widen the service chain concept to a *service graph*. All data is not necessarily treated similarly and value added services can be provided by external service producers that apply some specific processing on the data that is not usually available in the basic service.

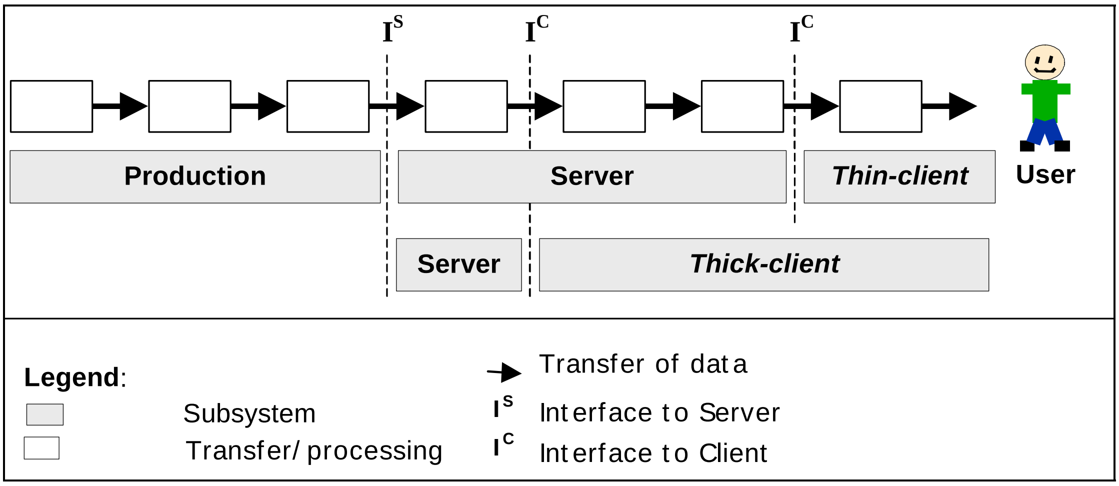


Figure 1.3 The service chain for Client-Server GIS-systems.

2 The partners' role and contribution

The synergy between the partners can be described in terms of their different expertise, product development and the different geographical regions in which they work. The main contributions from the partners are:

- **DTU/DCRS:** Daily ice concentration fields from SSM/I for specific regions as well as for the whole Arctic and Antarctica. In addition weather forecasts from NCEP are downloaded and prepared for access via DCRS' Internet browser. DTU/DCRS develops integrated products by combination of SSM/I and NCEP wind and wave forecasts as well as other satellite data for distribution via their Internet browser (balanced client). DTU/DCRS' primary role is, as research and development institution, to lead the development of the Java-based Internet service, which the other partners are using.

- **DMI:** producer of sea ice charts in the Greenland Sea based on NOAA AVHRR and RADARSAT SAR images. SSM/I data are used as supplementary information. Provider of weather forecasts for the Greenland areas as well as other areas as required by other partners. DMI develops integrated weather and ice chart product for the Greenland area based on a thick client solution. DMI has operational responsibility and delivers various products to users in the Greenland area.

- **IMO**: National Weather Service (NWS) responsible for official marine weather services in Icelandic waters under the auspice of WMO. Provider of weather observations, weather forecasts and warnings in Icelandic and English, numerical prediction data on weather and ocean waves and sea ice charts based on observations. IMO works closely together with RADIOMIDUM in the distribution of products to end-users.

- **RADIOMIDUM (subcontractor)** has specialised in selling and servicing fishfinding- and navigation systems to the Icelandic fishing fleet, with an emphasis on software and communication solutions. The company has developed a dedicated Information Service System, called "Viewer, as well as the first Electronic Fishing Logbook. The Information Service System includes, among other things, weather forecasts and other met-ice-ocean information.

- **FIMR:** provider of ice and ocean services in the Baltic Sea: ice charts in the winter season, sea surface temperature, water level data, wave data and forecasts. FIMR receives weather forecasts and other atmospheric information from Finnish Meteorological Institute and use this information as input to the ice and ocean services. FIMR develops new met-ice-ocean products for the Baltic Sea in close cooperation with VTT.

- **VTT**: research institution that develops end-user systems, communication solutions and new products that are used by FIMR and other operational services in the Baltic Sea. VTT has a key role in design of the IWICOS architecture and developing the common IWICOS modules that all partners are using.

- **NERSC:** research institution that develops various marine SAR application products, including a pilot system for SAR ice monitoring in the Arctic. NERSC products include, among others, SAR image quick-looks with derived parameters (e.g. interpretation, classification and ice motion). NERSC uses DTU's and DMI's products for the Arctic as a supplement to its own products.

All the data products come from a relatively small number of initial data products (some types of satellite data, meteorological fields, wave fields and other fields from atmospheric and ocean models). The number of products becomes higher because there are different standards and techniques for presenting the data. For example an ice chart for Greenland waters is presented in a different way than an ice chart in the Baltic Sea because the are different standards and agreements. Therefore several client products can be different, technically, whereas the information content can be similar. In IWICOS, we only need relatively few products (both initial and client products) to demonstrate the prototype system we are developing. On the other hand, with agreed standards for products and their metadata, it is easy to incorporate many different types of client products based on the same initial data sets. One of the objectives of IWICOS is to allow a wide range of client products to be accessible via the clients, which constitute the end-user systems.

3 The IWICOS metadata standard

3.1 *Background*

The IWICOS metadata standard has been developed specifically for the IWICOS project. Several existing standards have been investigated and tested including the comprehensive 'Standard for Digital Geospatial Metadata' (FDGC-STD-001-1998) established by the Federal Geographic data Committee (FDGC, 2000). However, none of the existing standards fully match the IWICOS product assemblage. The varied nature of IWICOS products combined with the fact that many of the investigated existing standards consist of superfluous components when considering the IWICOS requirements urged the development of an IWICOS specific standard. Establishing an IWICOS specific standard at the same time adds flexibility to the IWICOS system, meaning that the standard continuously can be adapted and extended to meet the requirements of new IWICOS products.

3.2 *Methods*

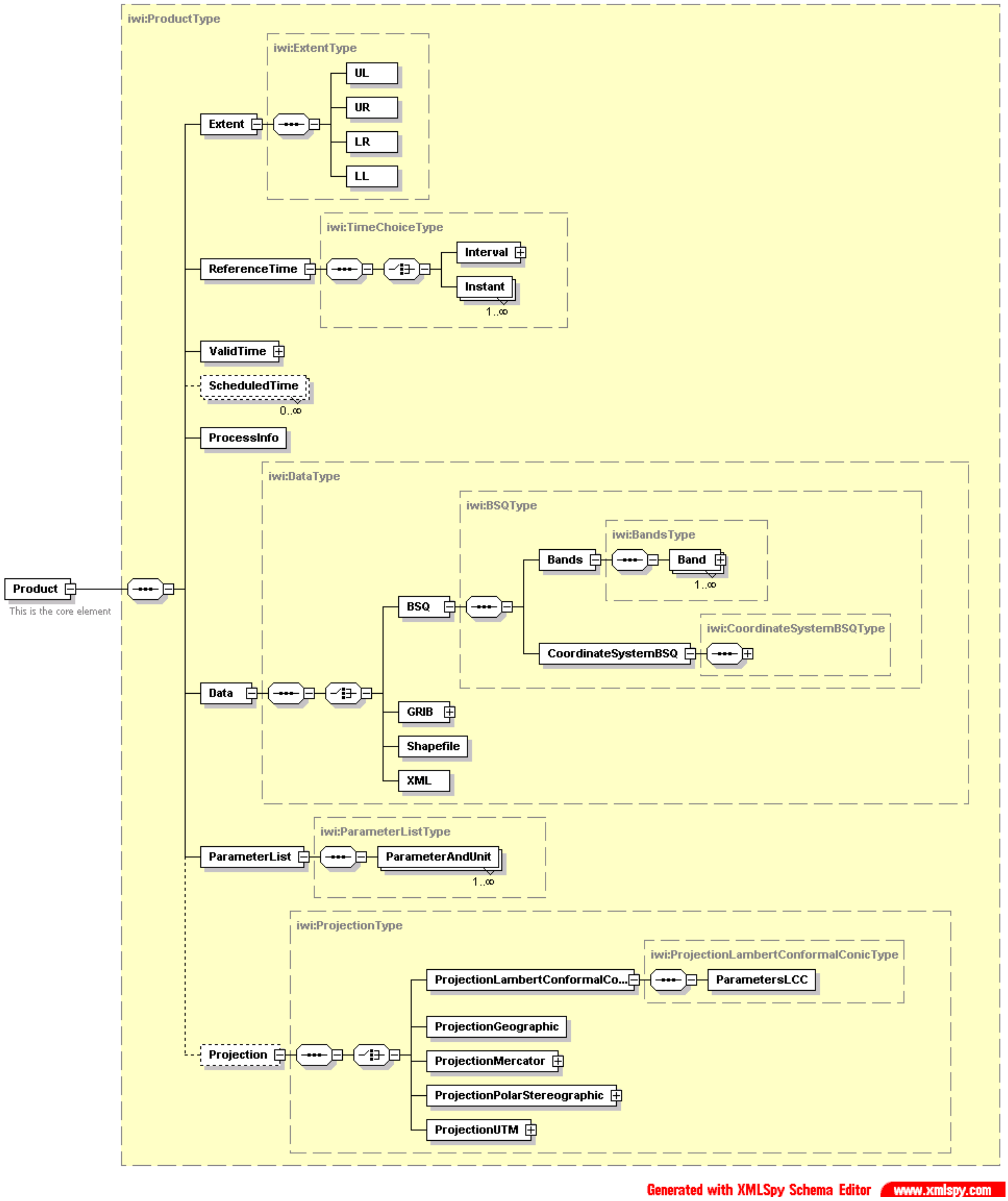
The development of the IWICOS metadata standard has been carried out by means of XML and XML Schema in accordance with W3C recommendations (see W3C Recommendations 2000a, 2001a, b and c). The metadata definition itself consists of XML Schemas and the metadata files are XML documents instantiated from these schemas. The XML Schema definition consists of 17 schema files connected through common namespace declarations. The division into separate schema files are made as a database-like division into themes in order to simplify the development environment and ease revision/updating. Once the core structure of the schema definition has been established the maintenance of the IWICOS metadata standard is not laborious. The implementation of new products/parameters, units, projections etc. is quite easily accomplished. Thus, the IWICOS metadata standard has been continuously updated and extended to match IWICOS product requirements. All metadata XML documents are validated against the schema definition prior to release. This ensures that metadata files are IWICOS standard compliant and can be exchanged and understood by product servers, Broker and end-user systems.

3.3 *Content model*

The schema definition is build around a core element named 'Product'. From this core element a tree structure emerges consisting of child elements in an element-on-element structure with each element being associated with a set of attributes. Part of the content model for the schema definition is shown in Figure 3.1.

As can be observed from Figure 3.1 the IWICOS metadata standard consists of 8 generic child elements connected to the core element 'Product'. A short description of each generic element follows:

- **Extent:** Defines the bounding geographical coordinates of the product
- **Reference Time:** Especially used for numerical prediction products where it defines the time of analysis
- **Valid Time:** Especially used for numerical prediction products defining the valid time (analysis + prognosis)
- **Scheduled Time:** Defines the time for next similar product
- **ProcessInfo:** Comprises information concerning data origin, quality and producer information
- **Data:** Comprises the actual data information for the four IWICOS exchange formats
- **Parameter List:** Defines the parameter(s) and corresponding units
- **Projection:** Defines the data projection - a set of 5 frequently used projections have been implemented



Name	Type	Use	Value
Availability	xsd:boolean	required	
FileLocator	iwi:LocatorType	required	
FileSizeInBytes	xsd:nonNegativeInteger	required	
Compression	iwi:CompressionType	optional	

Figure 3.1 Part of the IWICOS Schema Definition content model. In the upper part of the diagram the core element 'Product' are shown together with a set of child elements. As an example, the lower part of the diagram (the table) shows the attributes related the element ‘Data’.

3.4 Changes to Extended System Version

The metadata definition has been updated in order to meet requirements for the extended system in terms of new products and modified broker architecture. Updated features concern structural changes, improved handling of time statements, amendments to parameter and unit lists and a general update according to World Wide Web Consortium recommendations.

In more detail the following updates have been accomplished:

1) New type, 'ParameterList', has been added for specification of one or multiple parameter/unit pairs. This type has been positioned at product level, see figure Figure 3.1.

2) Amendment to time specification - an attribute ‘TempResolution’ has been added to the 'Interval' element. TempResolution is a duration type and the value given for this attribute has to follow the W3C specification for duration types (see http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/#duration). This modification allows for specification of multiple time statements with regular time spacing. One example of this would be prognoses from numerical prediction iterations. Then ‘min’ and ‘max’ attributes define the limits and ‘TempResolution’ defines the time spacing.

Another change is the allowance for multiple time statements using the 'Instant' element, where maximum occurrences have been set to 'unbounded'. This can be used for irregular time spacing, thus specifying each time statement as an 'Instant'.

3) The schema definition as a whole has been updated according to W3C recommendation update (see http://www.w3.org/TR/xmlschema-0/, http://www.w3.org/TR/2001/REC-xmlschema-1-20010502/ and http://www.w3.org/TR/2001/REC-xmlschema-2-20010502/)

4) Parameter and Unit enumeration list has been updated with following parameters:
ParameterV1_0.xsd enumeration addition -> 'StageOfDevelopment'
ParameterV1_0.xsd enumeration addition -> 'FormOfIce'
UnitV1_0.xsd enumeration addition -> 'SIGRID_code'

At the time of writing, the updated schema definition can be found at:
http://www.dmi.dk/pub/IWICOS/metadata/newdef/

4 Interoperability, communication and client capabilities

4.1 Interoperability

The IWICOS interoperability is based on a common description of available products and their features presented in XML. These metadata descriptions are submitted to the Broker. The customers can base their product selection on the metadata description, and then retrieve the actual products from the Producer Servers with the help of a Facade subsystem. Finally, Client Software is used to acquire a presentation of the product data (Figure 4.1).

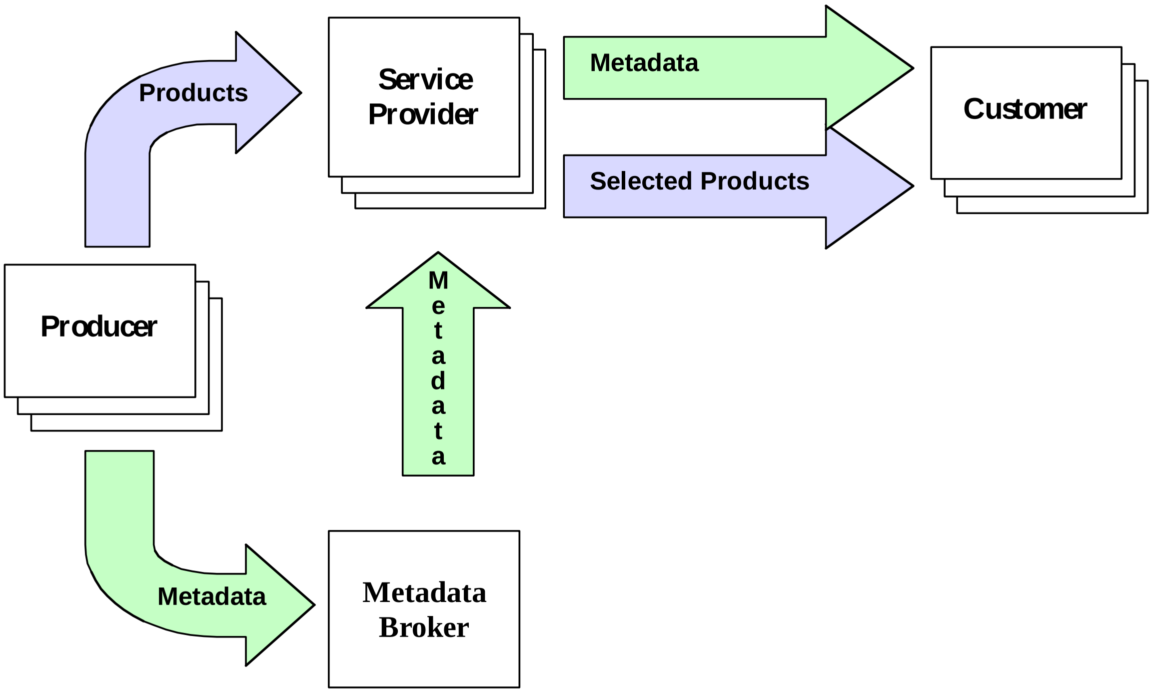


Figure 4.1 The IWICOS Service Chain.

4.2 Architecture

The Producer Server integrates the IWICOS system to the producer's existing production process. It communicates with the Broker using specific small stub programs designed for the messaging between these components.

The Producer Server consists of two parts (Figure 4.2):

a. An active part, that informs the Broker of the events that occur in the production process, such as a new product becoming available or an old product getting outdated.
b. A passive part, that is basically a web server where the active part places it's output for the Broker (the metadata) and the Facades (the product data) to retrieve.

The set of data formats for the communication between the Producer Servers and the Facades was limited to Binary Sequential Files (BSQ), GRIB (GRIdded Binary), Shapefile, and XML for reducing the complexity of the implementation. Within the End-User Systems (Facade and Client Software pair) there are no such limitations. The Facades can use the base types listed above to generate products in any format. Basically the End-User System is a black box - the subsystems outside should and shall not be interested in what happens there.

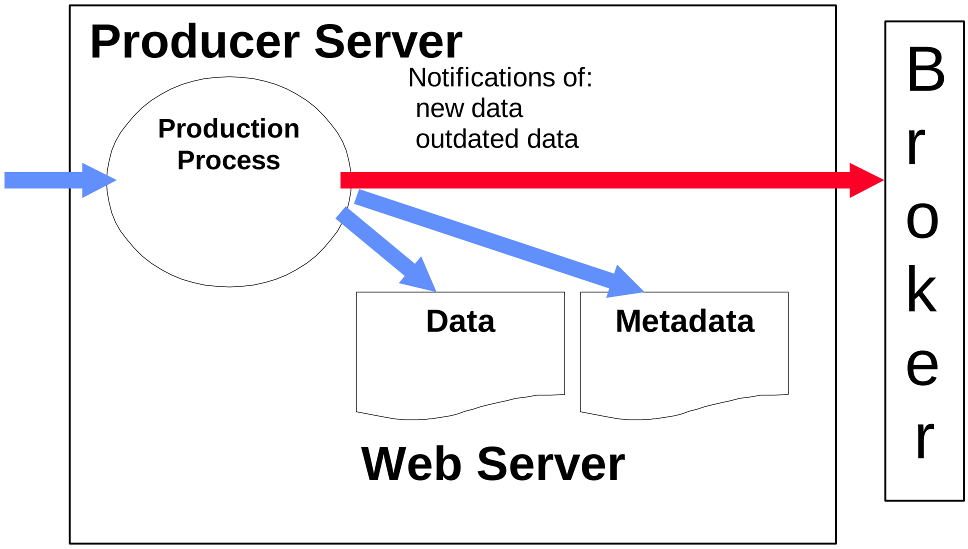


Figure 4.2 The IWICOS Producer Server Components and Internal Data Flow.

The Broker provides two interfaces for metadata operations. One is intended for the Producer Servers for managing the Broker's metadata content. The other one is the query interface for the End-User Systems through which they can access the Broker's metadata content. The Broker is based on freely available components: Apache web server, Apache Tomcat servlet container, Apache SOAP implementation and MySQL database. The Broker runs on Linux OS and the service programs are written in Java. The communication is secured using SSL encrypted HTTP protocol (HTTPS).

The Broker is divided into three main components: the Database, a storage for metadata; the Metadata Parser, that will process the metadata descriptions of the new products and store them to DB for later access by queries; and the Query Engine that will interpret the queries posed in an XML format to SQL and execute them on the DB and return the results for the caller (see Figure 4.3).

The Broker communication is implemented with the Remote Procedure Calls (RPC) implemented over the Simple Object Access Protocol (SOAP). The RPC uses a small program called a *stub* in both ends of the communication, which will marshal the required parameters and return values of the call. Example of stubs is shown in Figure 4.4.

The Facade implementations can vary a lot. For a simple web-browser based client it will be closely integrated to the Client Software and the distinction between the facade and the Client Software is not so clear. On the other hand, the Facade may be a very complicated element containing reasoning of user needs based on a profile, product generation based on the products provided by the Producer Servers, and filtering of unnecessary components of products (e.g. layers with unnecessary data content).

The Client Software is intended for presenting the acquired data and the implementations have a range from thin to thick clients. All types of clients (thin, balanced and thick) will be tested in the demonstrations during the project.

The IWICOS Architecture is illustrated by the four following communication scenarios between the various subsystems:

1. **Producer Server - Broker,**
2. **Facade - Broker,**
3. **Facade - Producer Server, and**
4. **Facade - Client Software**.

These are explained in more detail below.

Producer Server - Broker

In this scenario the Producer Server manages the Broker metadata content with the following operations: *newProduct*, *outdatedProduct*, and *productList*. The operations are used for informing the

Broker of new and outdated products, and acquiring of a list of the producer's products that have metadata stored to Broker.

Facade - Broker
In this scenario the Facades execute queries on metadata at the Broker to gain a list of products that might be applicable for user needs. This interface contains a single operation called *query*. However, it is more complicated than the previous scenario hence the parameter and reply content is more dynamic. We will get back on this issue in Section 6.1 describing the Broker implementation for the Baltic Sea.

Facade - Producer Server
In this scenario the Facades acquire the actual product data based on the metadata retrieved in the previous scenario. The product data at the passive (web-server) part of the Producer Server is accessed using the HTTP-protocol and thus is not very complicated to implement.

Facade - Client Software
This scenario is actually a black-box one - the decision of what protocols and other means of communications to use here is left for the designer of the Client Software - Facade pair. In the scope of the IWICOS System it is enough for us to know that such implementation is present.

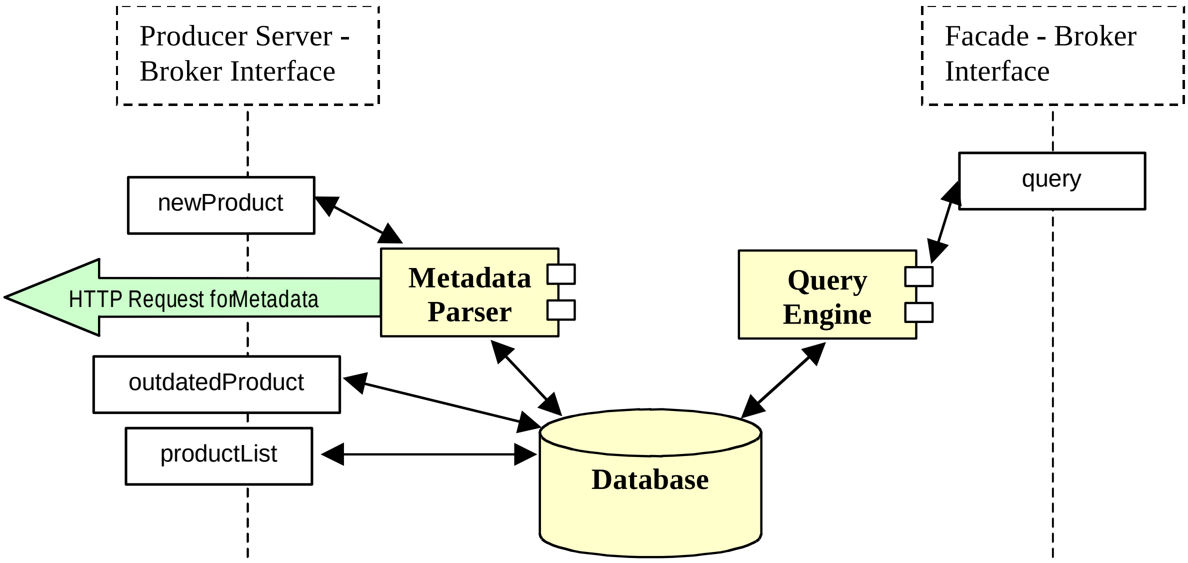


Figure 4.3 The Broker Internal Structure.

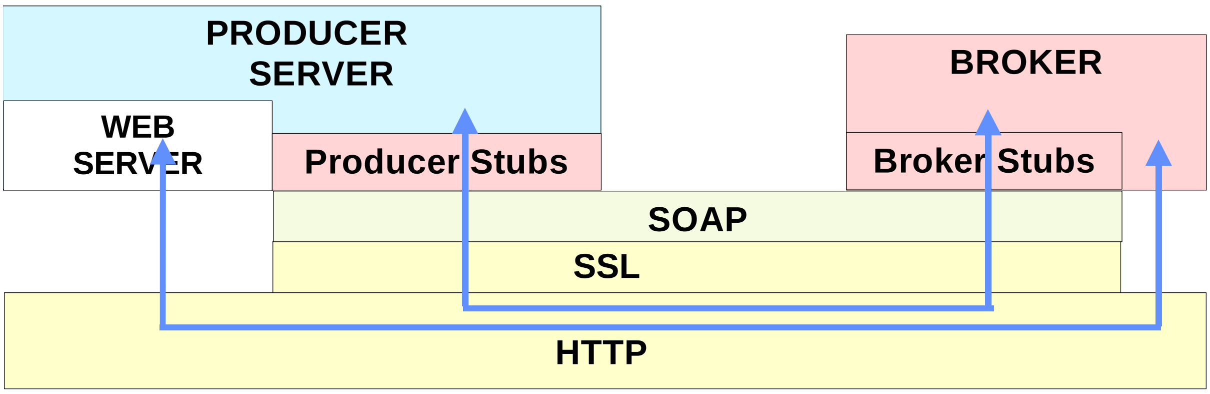


Figure 4.4 Stub Example - The IWICOS Producer Server and Broker Stubs.

4.2.1 Certificate authentication

In the Extended System the data communications between the Broker and the users (Facade) is encrypted using the HTTPS protocol (HTTP with SSL), which is based on public key cryptography (RSA, Engelschall). However, encryption in itself makes no assumptions about the identities of the sender and the receiver of the data. To properly integrate security in the system, Broker handles strong authentication as well, using digital certificates to confirm the identities of the parties. This is done in the complete, mutual fashion: Broker authenticates the users (client authentication), and the users authenticate the Broker (server authentication). The authentication is used both in the software-run operational usage and in accessing the Broker website. It could also be possible to use the authentication technology in charging for the Broker services.

In the set-up phase user creates his own certificate using a freely available tool, such as OpenSSL (Engelschall). For Broker to accept the certificate, it must be signed by a trusted Certificate Authority (CA). A special Broker CA was set up for this purpose. The Broker CA should be thought of as a separate instance in regard to the Broker server, although they are actually run by the same organisation (VTT), in fact on the same machine. This is feasible inside a trusted workgroup such as IWICOS. When the user group diversifies, using a third-party CA company could become necessary. After having his certificate signed the user installs it into his system, along with the Broker CA's own certificate. The latter makes the user's computer accept the connection to Broker, by accepting the Broker server's certificate that is signed using the same CA certificate. After the set-up has been completed, encryption and authentication are handled automatically (Figure 4.5).

While the implementation methodology is currently complex and even a bit rough, it does succeed in providing high security. The Broker runs Apache web server that is enhanced with mod_ssl package (ModSSL). This handles both the encryption and the certificate authentication. The Broker CA signs the certificates using the OpenSSL tool. Using a self-established CA gives the advantage of total control and independence of any third parties. It also saves costs by allowing the Broker users to arrange the authentication without expenses.

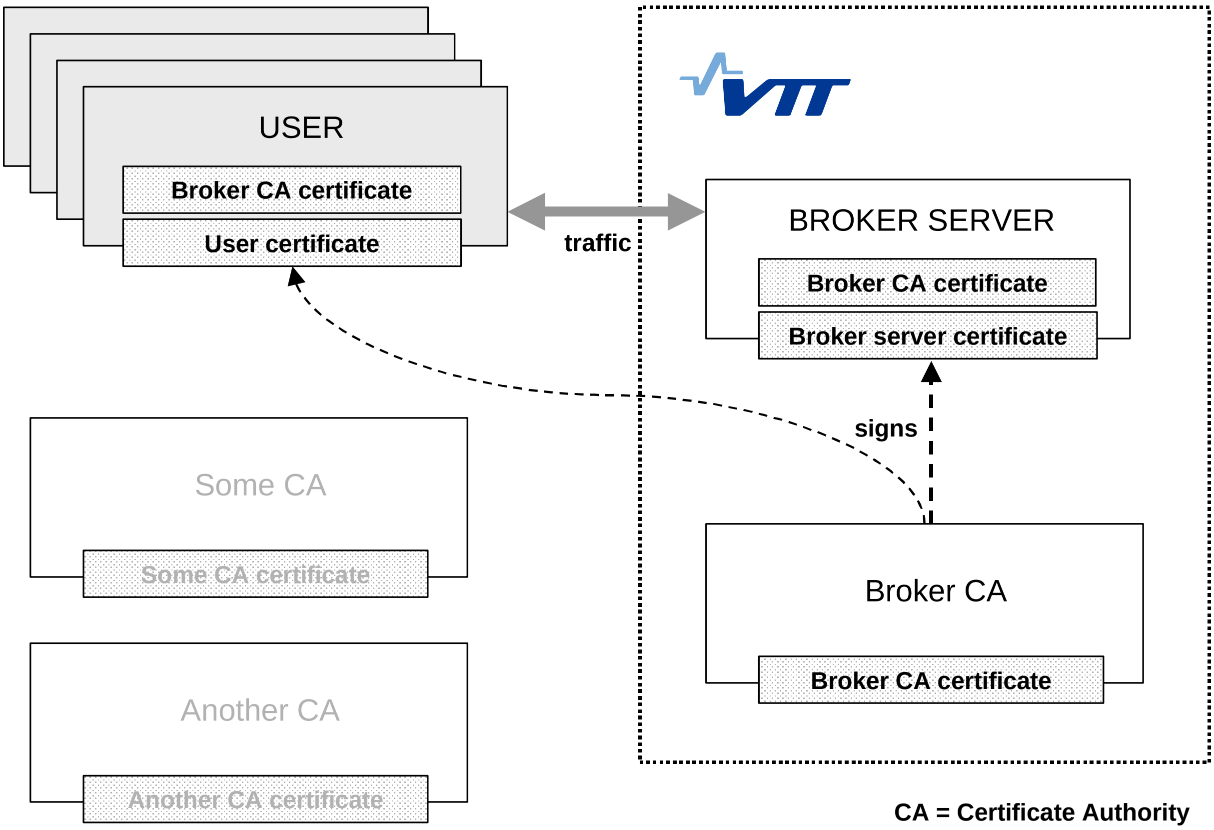


Figure 4.5 Certificates are used in the Extended IWICOS System to make sure that the communicating parties are properly identified.

4.3 Communication possibilities

Basically the requirements for IWICOS communication capabilities fall into two categories. First category is the communication between the Producer Server, Broker and Facade components that will occur in a stable high-band Internet environment. The second category is the communication within the End-User System (Client Software and Facade). This category is more complicated since the means and capability of the communication may vary a lot. The parties may communicate with a high-band internet connection (a web-client), a costly high-band satellite connection, or narrow-band radio or cellular phone connection. A summary of different shore-ship communication possibilities is given in Section 4.4.

The first scenario is under a rapid change, although the communication capability is likely to remain at approximately the same level, but the way of using this capability is changing. New Internet technologies are developed with an aim to solve the problem of describing, discovering, selecting, and using the various services automatically. This trend known as the Semantic Web or Web Services is evolving rapidly.

In the second scenario there will not likely be any dramatic changes in the near future. The Satellite connections are likely to remain expensive and thus scarce. The cellular phone network coverage will be limited and out of scope for the sailors at high seas, although the GPRS and other new technologies may improve the bandwidth.

Considering these categories/scenarios our natural conclusion is to concentrate on the first category, with a preparatory view for the future technologies. Our approach to implementing an interoperable metadata services introduces the use of SOAP, SOAP RPC and extensive use of other XML related technologies where applicable (see Figure 4.6). The SOAP was selected to be the basis for our implementation after we had already designed the system architecture - virtually the architecture would have been quite the same even if we had known this in advance.

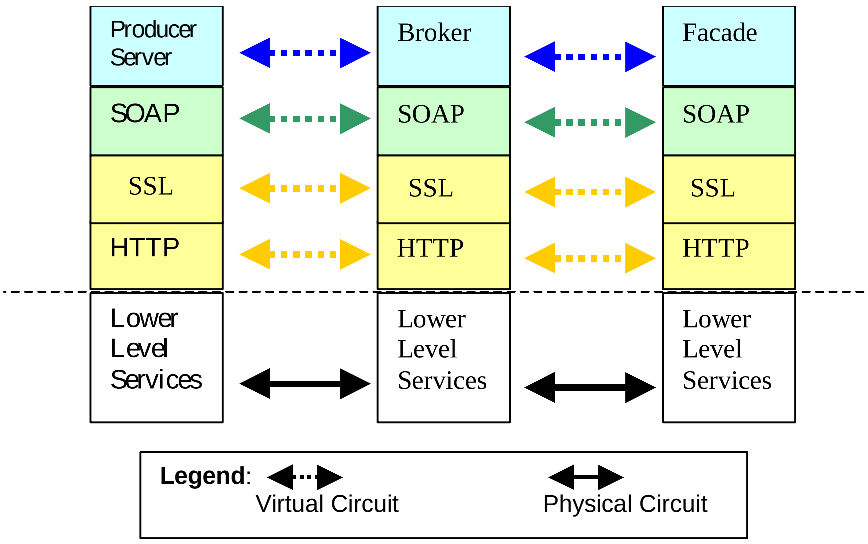


Figure 4.6 The SOAP Based Communication in the Broker Interfaces.

The Simple Object Access Protocol (SOAP) is an open standard that supports the interoperability of autonomous systems. Since it can be run over the Hypertext Transfer Protocol (HTTP), it helps to resolve the communication problems that occur when the applications have to operate through the firewalls of different organizations. The security issues are controlled by applying Secure Socket Layer (SSL) on the HTTP communications, the SSL encrypts all the traffic among end-points based on two-key technology. Furthermore, SOAP supports RPC for invoking services on the service. SOAP messages can contain data packed in XML format, so they provide an ideal platform for implementing a tailored messaging service. Due to the XML approach the SOAP messages are easy to understand when compared to their binary correspondents such as CORBA, DCOM and RMI. The character-based nature of the messages introduces the requirement for encoding and decoding at the ends of communication, however this is relatively easy task when compared to the cost of the transmission itself. The SOAP is also a fundamental building block in the yet to come Semantic Web technologies, that will probably utterly change the way we look at implementation of interoperability.

4.4 Shore – ship communication limitations

To update the information regarding the capabilities at sea, a Questionnaire was sent to selected potential users in the Baltic Sea and for users in the Greenland Sea. The purpose was to recheck the capabilities that the potential users at sea have at the moment and also to have a forecast of the situation two years from now on. In the Baltic sea the target group are shipping companies that have cargo or passenger ships navigating in the Baltic Sea all year around. As the Baltic sea is relatively small, many ships find it sufficient only to use terrestrial communication means such as GSM. Still, satellite communications is increasing. The questionnaire was brief on purpose and aimed at providing basic information on what telecommunication equipment ship has on-board and what kind of communication program is used. The reason for this is that potential IWICOS customers hardly want to purchase any special equipment just to get the services provided by IWICOS, or this kind of requirement would severely restrict the number of potential IWICOS users.

The questionnaire indicates that E-mail is used on almost all ships at the moment, and is estimated to be used 100% within two years. All ships in the shipping companies interrogated, have GSM-data, but GSM data is limited to use when the ship is within reach of the base station (maximum of 30 km approximately from the nearest base station because of delay restrictions). Although this may seem to be a severe restriction, for ships whose route is mainly in the Baltic sea, the time when out of reach will be about 10 hours, and for the passenger ferries regularly navigating in this area even less than this. When looking at the answers from the Greenland Sea the situation is quite different. In this area the ships are out of reach of the cellular phone system 95% of the time, thus the need for satellite communications is much higher here. The questionnaire and the answers are given in Appendix A.

The Icelandic survey, the results of which is presented in Table 4.1, shows that satellite traffic is expected to triple within the next two years. In the Baltic area NMT-450 service will phase out (support for NMT-450 will cease in Finland by the end of 2002). The role of the TETRA system at sea is still unclear.

High speed satellite links at sea are still not common, but in the Baltic Sea within 2 years of time a third of the ships in the shipping companies that replied to the questionnaire, will have a high speed link, either on permanent or on-demand basis. This will enable use of more detailed images and maps for a larger user group at sea.

Table 4.1 Communications Systems in Iceland today and 2003 (predicted). Revised November 2002.

Comm. System	Data transm. speed	Coverage	2001 Installations July 2001	2001 Data connected	2003 Data connected	Diff. in numbers	%
GSM	9.6 Kbs	Domestic	20	15	200	185	94
NMT (Nordic Mobile Telephone)	4.8 Kbs	Domestic	1.200	250	100	-150	-77
Tetra	14.4 Kbs	Domestic	2	2	35	33	17
Vsat	2 mbs	N-Atlantic	1	1	3	2	1
Inmarsat-A	9.6 Kbs	Up to 77 lat.	1	1	0	-1	-1
Inmarsat-B	9.6 Kbs	Up to 77 lat.	6	6	6	0	0
Inmarsat-B (HSD)	64 Kbs	Up to 77 lat.	0	0	2	2	1
Inmarsat-F4	64 Kbs	Up to 77 lat.	0	0	10	10	5
Inmarsat-C	Store/forward	Up to 77 lat.	225	225	225	0	0
Inmarsat-MiniM	2.4 Kbs	Up to 77 lat.	20	20	40	20	10
Iridium	2.4/10 Kbs	Global	15	5	85	80	41
Emsat	4.8 Kbs	N-Atlantic	20	20	25	5	3
Globalstar	9.6 Kbs	Up to 77 lat.	5	0	5	5	3
HF-Radio data	0.5 Kbs	N-Atlantic	0	0	5	5	3
			1.315	**545**	**741**	**196**	**100**

4.4.1 Summary of relevant satellite communication possibilities

As indicated in the questionnaire, there are users that are out of reach of the cellular phone network 95% of the time. If HF-communications are left out, satellite communications are the only possibility. In the Baseline System Report some of the alternatives were described in more detail.

To summarize, the satellite systems can be divided based on the orbiting height of the satellites. Geostationary satellites are positioned at a height of 35,786 km above the surface of the earth, thus being positioned at a fixed position in the sky relative to the surface of the earth. In principle three satellites can cover the earth up to a latitude of about 70ºN, although users like Royal Arctic Shipping Line have reported successful communications up to 76ºN. The long distance to the satellite causes a round trip signal delay of about 0.5 s, which affects interactive communication possibilities.

Medium earth orbit height satellites have an orbit height of about 10.000 km and LEO (Low Earth Orbit) satellites have a height of only 1.000 km. Less height causes less coverage per satellite, thus a LEO system with full-time coverage must consist of many satellites (IRIDIUM consists of 66 satellites)

4.4.2 INMARSAT systems

The INMARSAT satellites are geo-stationary. The most important INMARSAT systems are:

INMARSAT-A is the original INMARSAT analogue system. Using a modem, the system can offer a data rate of up to 9.6 kbit/s. INMARSAT-A is widely used on around 18000 ships of all types
INMARSAT- B is the digital successor of INMARSAT-A. Data communication speed is 9.6 kbit/s and up to 64 kbit/s if the High Speed Data service is used.

INMARSAT -C is a low cost data transfer service operating at 600 b/s. The user is charged by volume of data instead of connection time. INMARSAT-C can be used for sending messages up to 32 kbytes in length. The terminal is small and weighs only 3-4 kg.

INMARSAT Mini-M is capable of data communications of 2.4 kbit/s. The maritime version of the antenna is gyro-stabilized. The cost of a call is about $2.70 per minute.

4.4.3 VSAT-systems

Very Small Aperture Terminal (refers to the antenna pointing accuracy needed) systems are used for providing a fixed communication channel from ship to shore and vice versa either by using a dedicated satellite receiving station at the center or by using a gateway provided by the operator. VSAT systems are suitable for applications where large volumes of data need to be transmitted at regular intervals or continuously. On-board a 1,2 m - 1,5 m stabilized antenna is needed.

For ships on the move in different geographical areas, it may be necessary to contract several service providers, as no company is offering global coverage.

It is estimated that for VSAT to be a viable option, users need to be on Inmarsat-B HSD for over one hour a day (depends on contract length, size of fleet etc.)

VSAT systems are used by the new Finnish multipurpose icebreakers and by some passenger ferry lines in the Baltic Sea.

4.4.4 LEO-systems

The main systems that are based on LEO satellites, and operate in the North Atlantic region are Iridium and Globalstar.

Globalstar consists of 48 satellites and provides a data transfer rate of 9.6 kbit/s. For IWICOS users the main limitation is the maximum latitude of 70ºN. This is the limit for continuous operation. When going further north the service is not available all the time and at a latitude of 78N, the connection is possible to establish only 10 - 15% of the time. Thus Globalstar resembles INMARSAT with respect to the coverage. The price for the equipment is around 2.000 € and the cost for calls is 1.0 - 2.0 € per minute.

The **Iridium** constellation consists of 66 operational satellites and seven spares orbiting in a constellation of six polar planes. This gives a full coverage of the earth.

The data communication capability of Iridium is 2.4 kbit/s. This puts practical size limits to a file to be transmitted. The cost for calls is $0.50 to $1.50 per minute (Iridium to Iridium or iridium to PSTN line), and a maritime grade phone costs about US $3.000.

IRIDIUM offers emulation software that enables the client computer to use standard e-mail applications and web browsers to establish a connection over Internet. The emulator performs automatic establishment of the connection and compression of the data to be transferred, which makes transfer of text data more efficient. The connection to the Internet is established through a dedicated Iridium gateway.

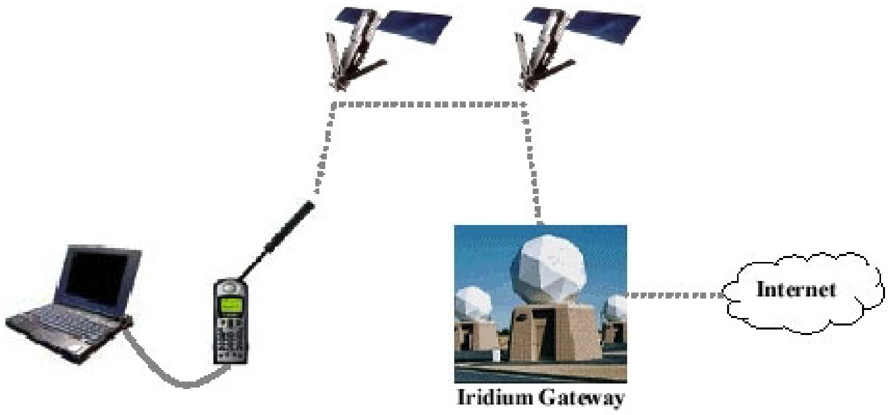


Figure 4.7 IRIDIUM Direct Internet Data Connection.

4.5 Client capabilities

Client Software visualizes the weather and ocean information to the user. It retrieves the data from Façade, which has already tailored the data into a proper form (Figure 4.8)

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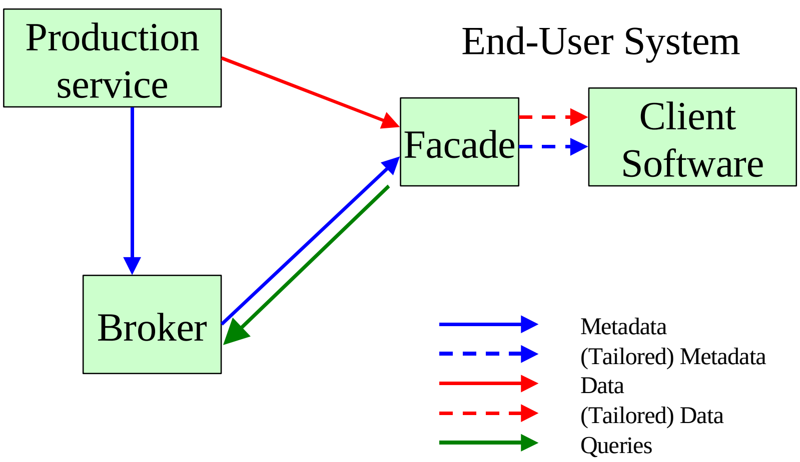


Figure 4.8 The data flows between Client Software and Façade.

Façade can be understood as a server for the Client Software. Façade and Client Software may not be located in the same physical location, and the communication link between Client and Façade varies from high-speed Internet connection to low bandwidth cellular phone link.

Client Software includes the following functions:

A Receive/Retrieve data from Facade

Client Software has to be able to communicate with Façade. User queries are delivered to Façade, and meta data and weather-ocean data are received in return.

B. Display meta data

Client Software is responsible for presenting the meta data to the user and providing means for product selection. Predefined profiles may also be used to retrieve the purposeful data. In that case, some means for profile input are provided.

C Generate presentation (thick-clients)

As thin clients mainly present the image data received from the server as such, thick clients are able to generate a visualization from raw data received.

D Allow customisation of the presentation (thick-clients)

Users typically want to combine some data and filter out some aspects of data. (E.g. User may want to see weather forecast and an ice-image combined on the screen, or want to view only the wind field instead of whole weather forecast).

Is the client thin or thick?

The users of the IWICOS system will have a variety of communication capabilities in use. There are several ways to distribute the load between server (Façade) and client in order to get the most out of the communication link's bandwidth. One way is to give all computational tasks to a *heavy server* and let a *thin client* only take care of the presentation. This *thin client model* needs a broad bandwidth connection as all the images are created on server side and delivered to the client.

The other way around is to have a *light server* delivering raw data to a *thick client*, which produces the images needed for presentation. The communication line is burdened only when the raw data files are transmitted to the client.

The third solution is the balanced model where a *semi-heavy server* performs all the demanding calculations and a *semi-thick client* takes care of the rest of the tasks. A Java-applet client can be considered as an example of the balanced model, as it may present ready-made images and generate customized views out of raw data.

Table 4.2 summarizes the different ways of distributing the tasks between client and server. The tasks include creating map images out of raw GIS data, creating overlay composite images, displaying the images, browsing the map (pan and zoom) and executing spatial queries (E.g. give me wind data for Baltic Sea area! What forecast data are available for tomorrow? Etc.). According to the table a thin client retrieves images and presents them as such on the screen. In the balanced model a client retrieves raster and/or vector data and draws images according to user's setting (zoom level, geographical viewport etc.). A thick client draws the images out of the raw data, which the server delivers to the client as such.

Table 4.2 Possibilities to distribute the load between client and server.

	Thin client	**Balanced**	**Thick client**
Façade/Server tasks	Map drawing Overlay drawing Map browsing Query	Query Map drawing Overlay drawing	File serving
Data transferred	Raster images	Raster / vector	Raw GIS data
Client tasks	Display	Display Map browsing Query input	Display Map drawing Overlay drawing Map browsing Query

5 Examples of products for the Extended System

Table 5.1 lists a selection of products developed for the IWICOS Extended System. These products are further described in the following sections.

Table 5.1 IWICOS Extended System Products.

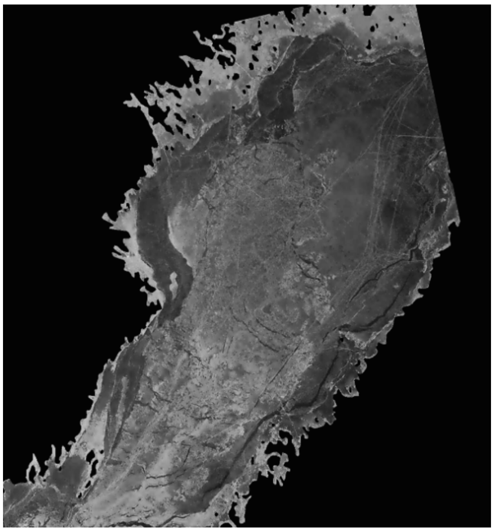
Product	**Area**
Forecasted images	Baltic Sea
Classification of SAR ice images	Baltic Sea
Overlay of ocean parameters	Greenland Sea and Icelandic Waters
Multi-prognosis of numerical predictions	Greenland Sea and Icelandic Waters
Ice analysis	Greenland Sea
Overlay of SAR image and ice analysis	Greenland Sea
Graphical interface to textual forecasts	Icelandic Waters
Ocean wave forecasts	North Atlantic Waters
Ice accretion forecasts	North Atlantic Waters
Meteograms	Icelandic Waters
Sea Ice maps	Icelandic Waters
AMSU combined product	Greenland/Icelandic Waters, Arctic Ocean and Antarctic Continent
QuikSCAT sea ice product	Arctic Ocean and Antarctic Continent
SAR quick-looks with derived ice parameters	Arctic Ocean
Ice concentration – time series of monthly means	Arctic Ocean

5.1 Forecasted images

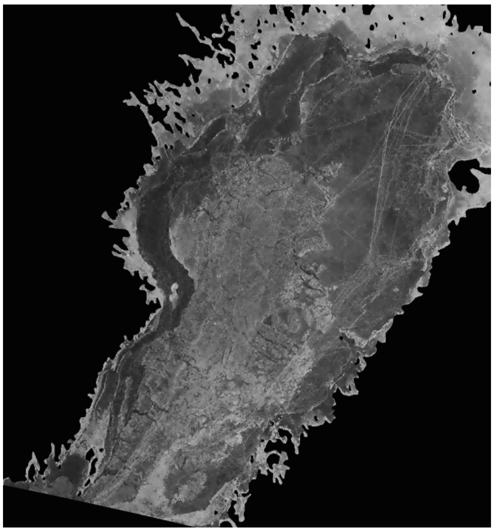
The idea behind visualizing ice drift forecasts using real satellite images, was to try out the feasibility of the approach, which, if successful, would provide a method to improve the usefulness of satellite images for route planning. If ice drift could be predicted reliably, the position of leads and cracks could be predicted for at least the near future. The functionality could also be used to synchronize images acquired with a time interval between them.

In the work the ice drift forecasts in the form of speed and direction, were integrated to spatial ice drift predictions. This prediction was calculated from the time of image acquisition to the predicted time. Testing of the software was first done using calculated ice drifts, which had been manually estimated from a pair of sequential images. The results from this test are shown in the Figure 5.1(a)-(d). Then the tests were continued using real images and real ice drift predictions from the Northern Baltic Sea area. The predicted results are shown in Figure 5.1 (e)-(f).

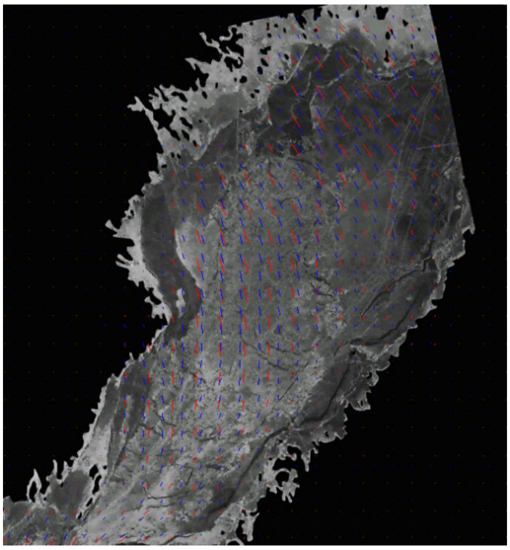
The results with the simulated material was promising, but when real data was used, the predicted image did generally not correspond to the observed situation well enough to justify a continued development of the product. The weakest link was the inaccuracy of the ice drift forecast. If the forecast accuracy is improved, the developed method, algorithm and implementation, could be very useful when combining the information in images with the ice drift forecast. The implementation (in Java language) proved to be robust, although a little slow for large images.



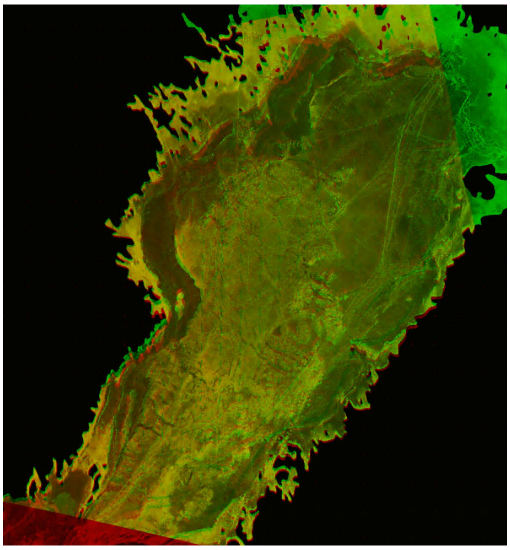
(a) Original image. 6.3.2001



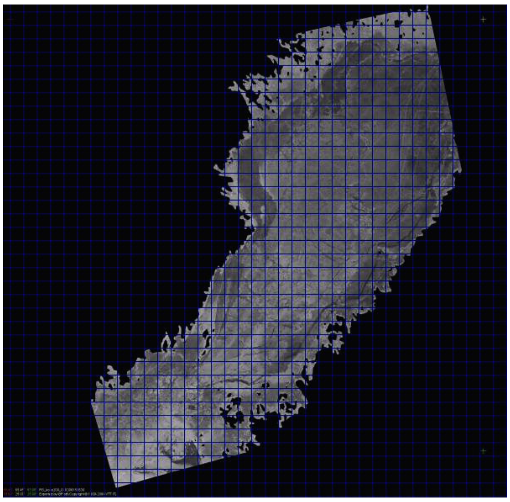
(b) Target image 8.3.2001.



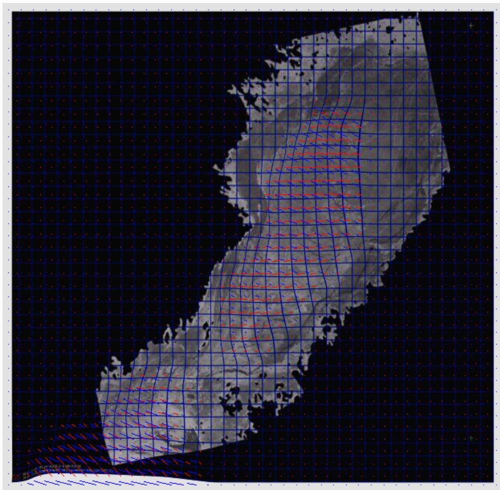
(c) Deformed image.



(d) Combined image (red: deformed image, green: target image).



(e) Original image (March 6, 2001).



(f) +36 hours prediction applied.

Figure 5.1 Observed and forecasted images in the Northern Baltic Sea.

5.2 Classification of SAR ice images

The software that presents the digital ice charts produced at the Finnish Ice Service and SAR images in the same projection (Mercator) and resolution has been developed at FIMR. The software is also capable of generating an image of any ice parameter of interest, if the information about the parameter is provided in the digital ice chart. Currently such parametres are: sea surface temperature, mean ice thickness, maximum ice thickness, minimum ice thickness, and degree of deformation of the ice field. These images are, however, in quite coarse resolution.

The digital ice chart is drawn manually combining SAR and NOAA image information with ground truth. The nominal resolution of the digital ice chart is about 1 km. Also very coarse air temperature and wind images based on the information from the coastal weather stations can be generated by the software.

One objective of the project was to improve ice thickness maps based on the digital ice chart using the simultaneous SAR information. The developed algorithm proceeds as follows. A segmentation of the SAR is compared with the ice thickness segments derived from the digital ice chart. The segment boundaries close to SAR segment boundaries are adjusted to correspond the segment boundaries found in the SAR image. For each segment in the digital ice chart, the corresponding SAR data is used to interpolate between thickness minimum and maximum corresponding to SAR segment mean intensity minimum and maximum, respectively. As a result we get a more detailed thickness map (augmented thickness map), which can be used visually or as an input to different models, e.g., the ice forecasting model.

In addition, the automated operational sea ice classification algorithm has been improved by developing the incidence angle correction (Makynen et al. in press, Makynen et al. 2002, Karvonen et al. 2002) applied before the actual automated classification, improving the texture analysis using Independent Component Analysis (ICA) (Karvonen et al. 2001), and also improving the adjusting of the parameters of the preliminary segmentation (Karvonen 2000). These changes have been tested and will be integrated to the operational algorithm.

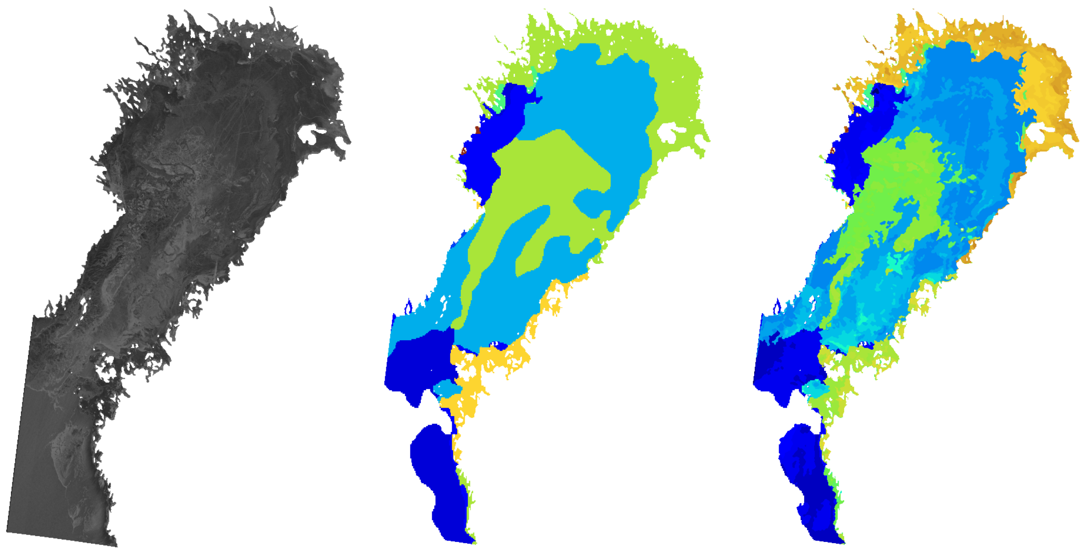


Figure 5.2 A RADARSAT ScanSAR Wide image (© Radarsat), January 25th 2002 [left], and the ice thickness image derived from the digital ice chart of the same day [middle], and an augmented thickness map, based on the simultaneous SAR data [right]. The thickness is coded from blue colour (thin) to red (thick), open sea and land areas are shown in white.

5.3 Overlay of ocean parameters

Figure 5.3 shows an overlay of seven different ocean parameters in the Greenland Sea.

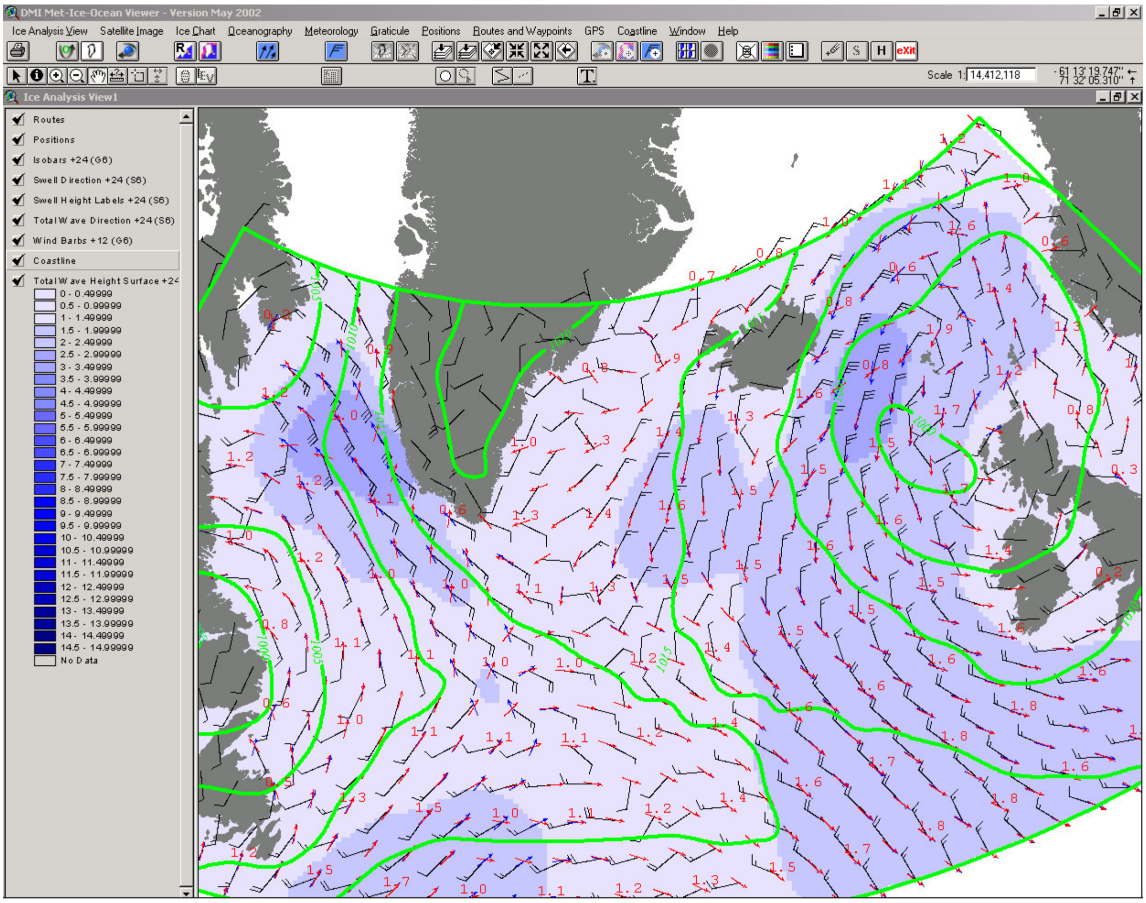


Figure 5.3 An integrated case revealing the strong advantage of having more than one way of representing each parameter. In this case 7 parameters are presented at the same time: Total Wave Height (the coloured surface); Total Wave Direction (blue vectors); Swell Height (red text labels); Swell Direction (red vectors); Wind speed and direction (black wind barbs); MSL Pressure (green isobars).

5.4 *Multi-prognosis representation of wind and pressure*

Figure 5.4 shows prognoses of wind and pressure at +12, +24, +36 and +48 hours. Associated GPS information related to the ship route is overlaid.

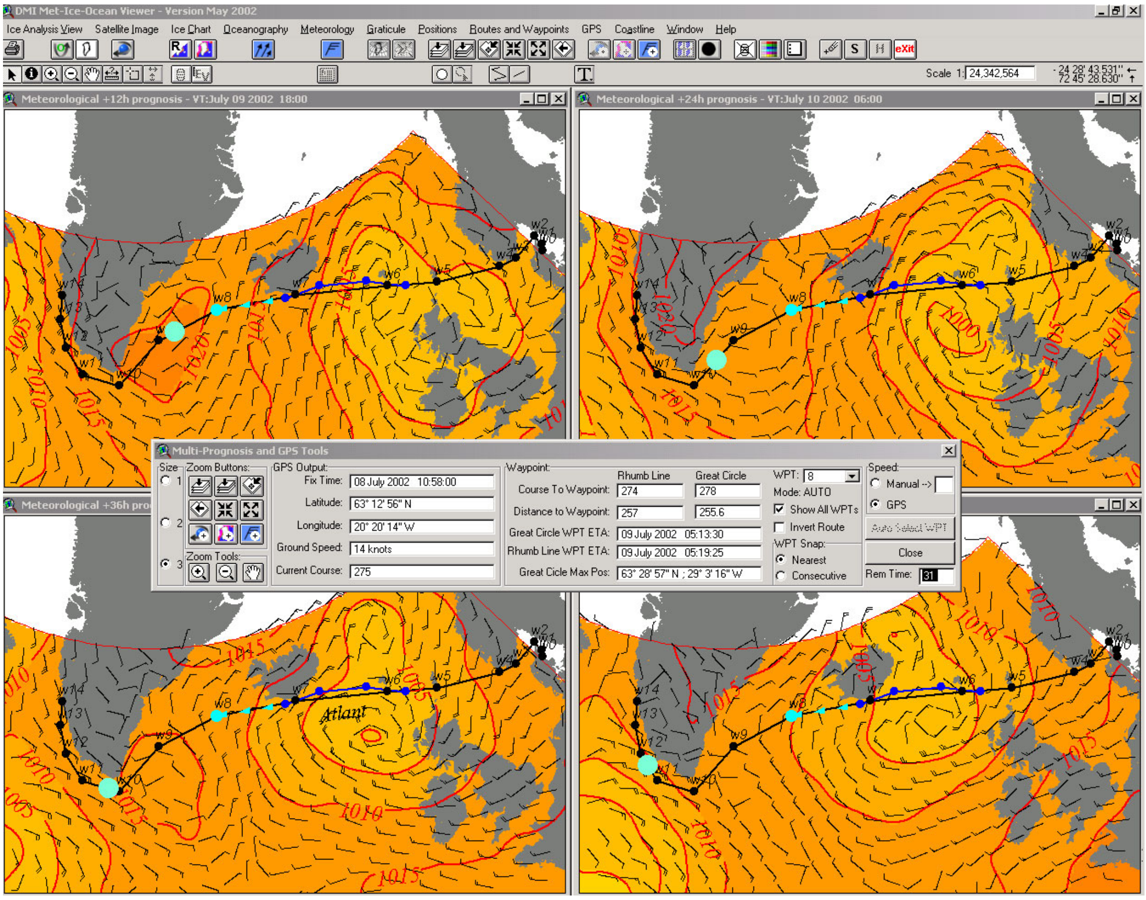


Figure 5.4 Multi prognosis representation of wind and pressure (+12, +24, +36, +48 hours). At the same time the GPS information is derived and presented partly graphically and partly through the dialog. GPS information is related to the route (shown as black) and information on distance and course to waypoints are presented. Black dots are waypoints at the route ; blue dots indicate vessel positions at various GPS readings; small turquoise dots show the nearest waypoint from ship position; large turquoise dots show the estimated ship position at the time of prognosis.

5.5 *Ice analysis from the Greenland Sea*

Figure 5.5 shows an example of ice analysis in the Greenland Sea.

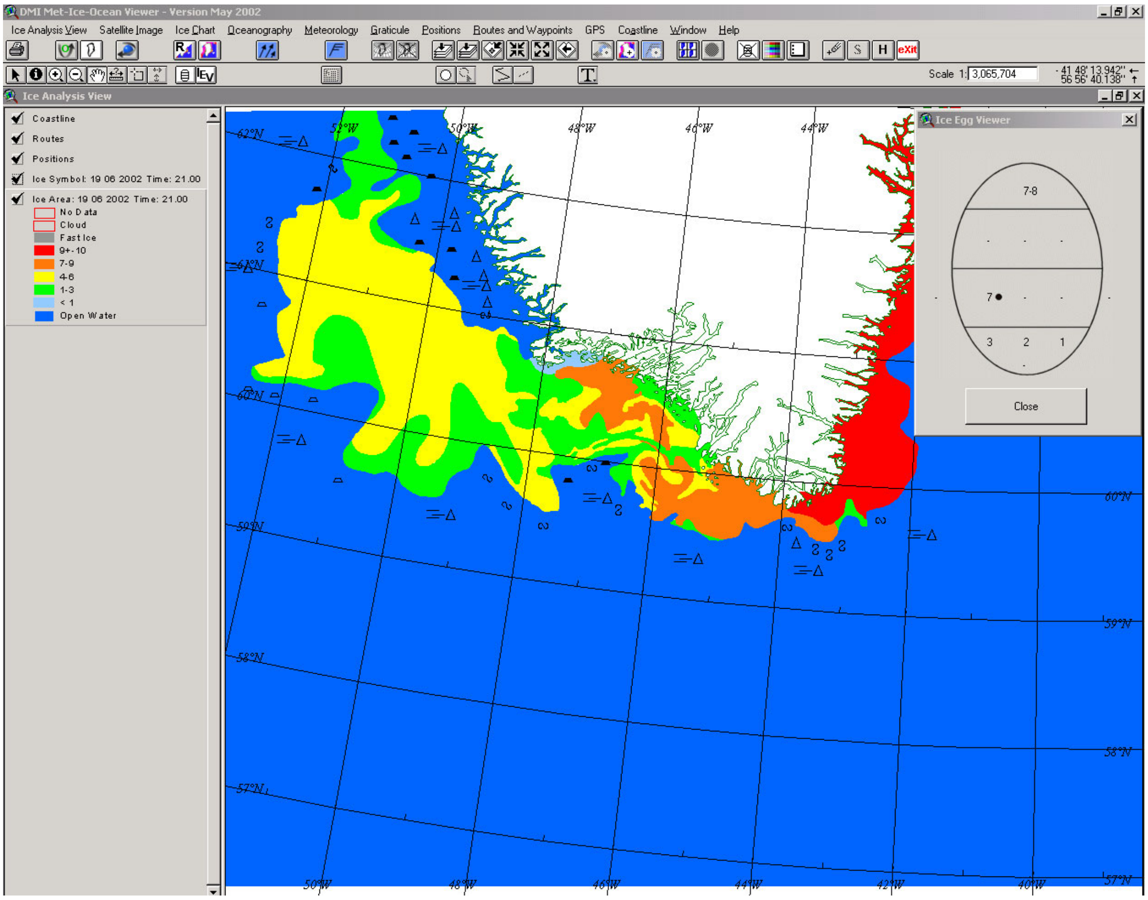


Figure 5.5 An ice analysis from 19th of July 2002 represented by a colour code. The Ice Egg Viewer is shown in upper right corner. Clicking ice polygons will reflect the WMO ice egg codes in the Ice Egg Viewer. A graticule has been applied on top of the ice analysis.

5.6 Overlay of RADARSAT SAR and ice analysis from the Greenland Sea

Figure 5.6 shows an example of a RADARSAT SAR image with an ice analysis chart overlaid.

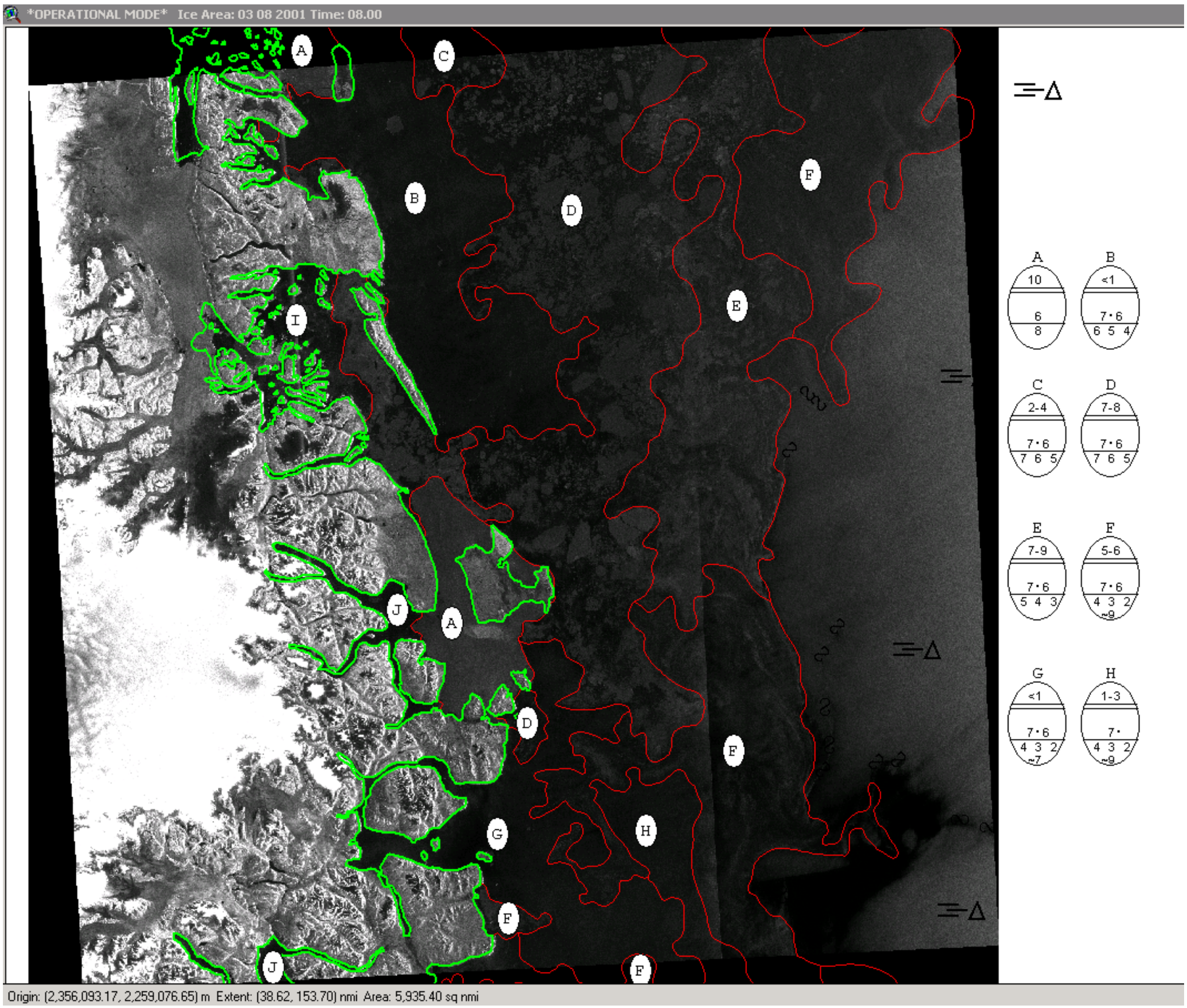


Figure 5.6 Close up on RADARSAT image and a DMI Ice Analysis from 3/8 - 2001 covering the area around ‘Danmarkshavn’. Ice areas are outlined (red) on top of image and ice information is given as ‘on-map-placed’ ice eggs.

5.7 *Graphical interface to textual forecasts*

The IWICOS-approach to the text forecasts is intended to give the user a quick estimate of the expected wind speed which is the most important factor in the weather forecast. On a map showing the forecast areas each area is coloured according to the highest wind speed forecast on the area during the whole forecasting period. When a new or amended forecast has been issued the colours will be updated. To read the forecast itself the user clicks on the area on the screen and the text forecast will pop up.

It can not be seen from the map if a strong wind indicated in an area is already blowing there or if it is expected by the end of the forecasting period. But if the area is coloured blue only light winds are expected during the whole period and some times this information might be sufficient for the user.

The colour scale is chosen in best possible agreement with ideas presented in the EUMETNET-project called EMMA which was started in October 2002. The aim of this project is to coordinate weather related warnings within Europe.

Figure 5.7 shows presentation of textual weather forecasts for Icelandic forecasts areas.

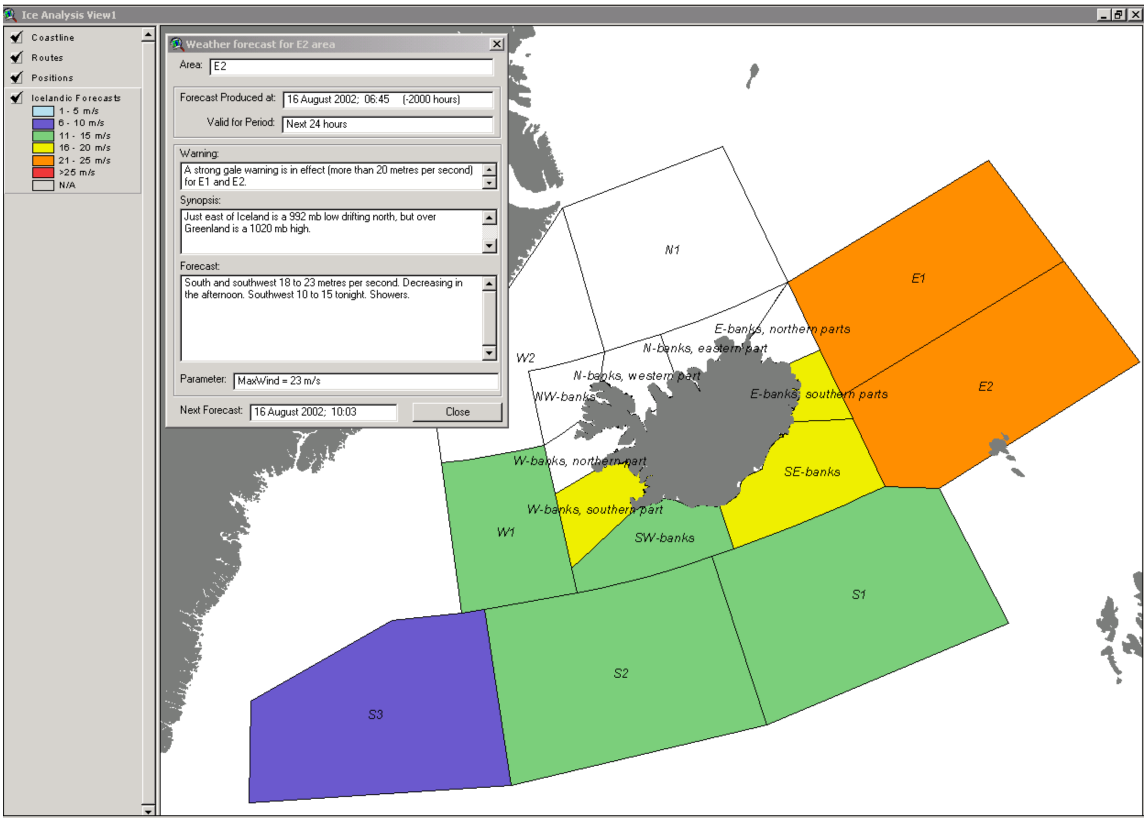


Figure 5.7 Presentation from MIO of textual weather forecasts for Icelandic forecasts areas. Colours correspond to expected maximum wind speed. The individual forecasts are displayed when mouse clicking the individual polygons.

5.8 Ocean wave forecasts

Ocean wave forecasts, as presented here, are a pure numerical product. The significant wave height, mean wave direction and mean wave period are calculated by means of a numerical wave model coupled to an atmospheric model. The maps which have been used in the IWICOS project are based on the models at ECMWF (European Centre for Medium range Weather Forecasting) which are run once a day. New forecast is normally available early in the morning and this forecast will not be updated or amended even if it appears not to fit with observations or other information.

The forecasting range could be stretched so far as to ten days but deterministic numerical forecasts should normally not exceed four or five days. For medium range forecasts (up to a week) probabilistic presentation is preferable.

The significant wave height is given by a colour scale going from dark blue where the sea is calm to red where the highest waves are forecast. The mean wave direction is indicated with an arrow and a number near the arrowhead gives the mean wave period in seconds.

Validation of these forecasts against wave buoys off the coast of Iceland has shown them to be quite reliable.

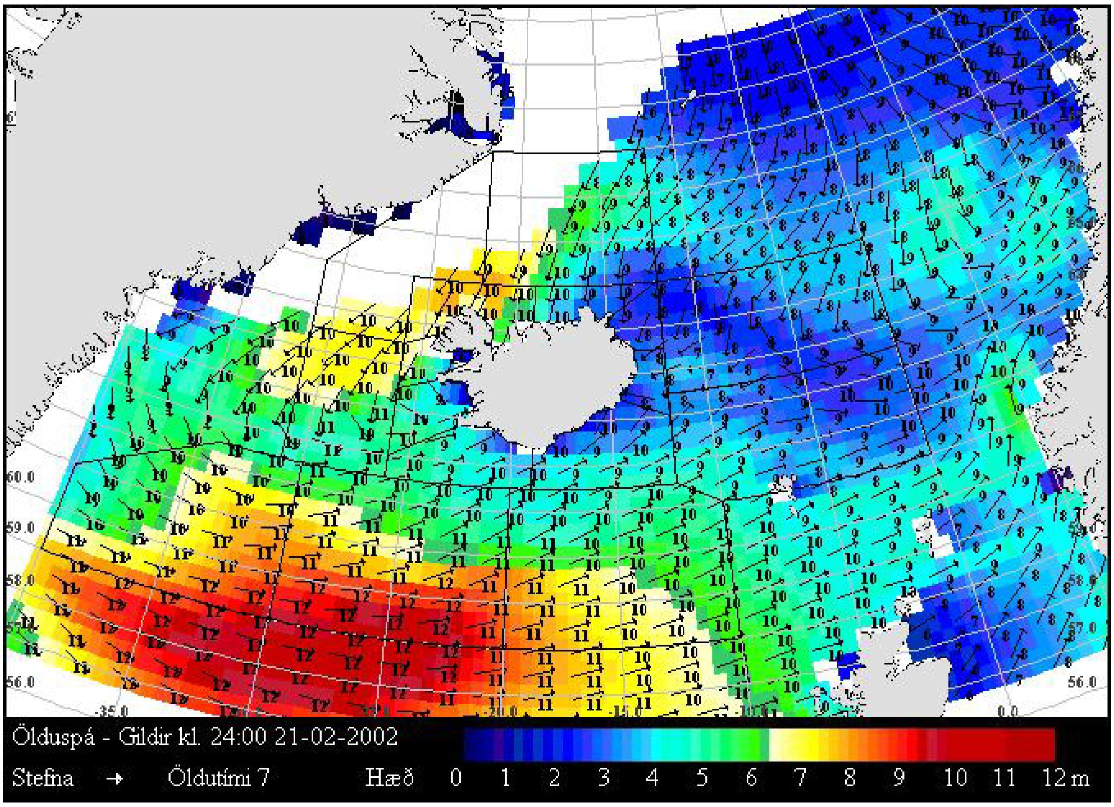


Figure 5.8 Numerical forecast of ocean waves. Significant wave height in meters is indicated by a colour scale, mean wave direction is shown with an arrow but mean wave period in seconds is given by a number. The forecast is based on the ECMWF wave model.

5.9 Ice accretion forecasts

Ice accretion on ships is a real hazard in polar and sub-polar waters and has lead to many accidents when ships capsized under the weight of the ice accumulated on the ships superstructure. Warnings for the risk of icing are therefore very important.

During the fifties at least four trawlers capsized because of icing in North-Atlantic waters and were lost with their entire crews. In the following years an empirical method was developed to forecast the risk of icing. This method, named after its developer, H.O.Mertins, has since then been widely used by many meteorological offices. It is based on graphical diagrams and is not immediately suited for numerical forecasts.

Another method, presented some twenty years later by J.E. Overland, is based on algorithms where the main factors governing the rate of ice accretion on ships, wind speed, air temperature and sea temperature, are used as an input. These factors can easily be taken from numerical forecasts and automatic icing forecasts, based on this method, are therefore technically very easy.

These algorithms were based primarily on reports from vessels that were 20 to 75 meters long and the output shows an expected icing class and rates of ice accretion for vessels that are steaming into the wind. The icing classes are defined in Table 5.2.

In Figure 5.9 an icing forecast is shown. It is a 48 hours forecast based on a numerical weather forecast made by the ECMWF model.

Table 5.2 Icing class and icing rate.

Icing Class	None	Light	Moderate	Heavy	Extreme
Icing Rates (cm/hour)	**0**	**<0.7**	**0.7-2.0**	**2.0-4.0**	**>4.0**

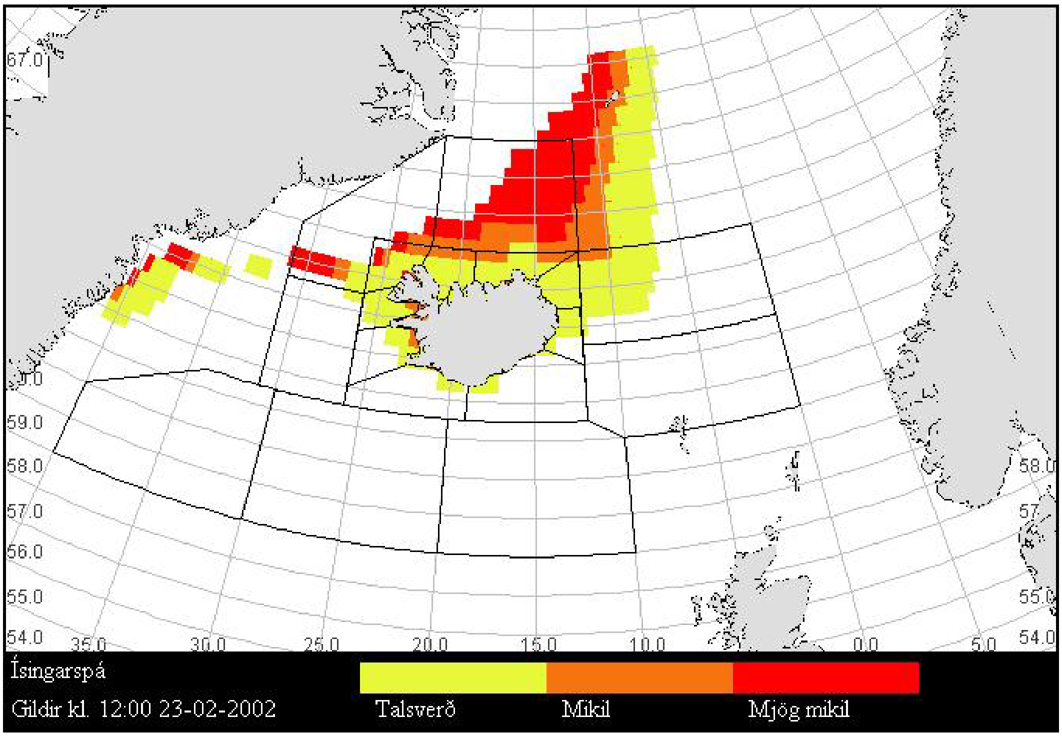


Figure 5.9 The map shows forecast icing classes calculated by the algorithm of Overland described in the text and *Table 5.2*. The icing classes are Moderate (yellow), Heavy (orange) and Extreme (red).

Maps of forecast icing classes would probably be very useful for seafarers for planning of operation in polar and arctic areas. They should also be a good guidance for forecasters who have to issue warnings for icing risk.

5.10 Meteograms

Local forecasts presented as time series of weather parameters may be considered as an alternative to textual weather forecasts for defined forecasting areas and to weather maps showing the distribution of a limited number of weather parameters at a fixed time. A graphical presentation of the time series can give a very clear picture of the expected changes of weather at the selected place.

Forecasting diagrams (meteograms) are normally produced by interpolating the weather and/or ocean parameters for a point from nearby gridpoints from a series of numerical weather prediction charts. In a meteogram for a synoptic weather station the observations can be used to enhance the forecast by some kind of statistical post-processing. Kalman filtering is used here to remove bias from the forecasts of temperature and wind speed. Meteograms made from direct model output can also be produced for any point in the ocean but quality control for such products is difficult because of the lack of observations.

Figure 5.10 shows a meteogram for the synoptic station Stórhöfði in Vestmannaeyjar off the south coast of Iceland. The forecasting range is six days but this selection of weather parameters is aimed at the general public rather than seafarers. A meteogram specially designed for seafarers should include at least wind speed and direction, air pressure and temperature, and possibly also sea temperature and wave parameters such as wave height, direction and period. Such meteograms will be developed at the IMO in near future.

Meteograms for coastal stations would be useful for small boats operating near the coast.

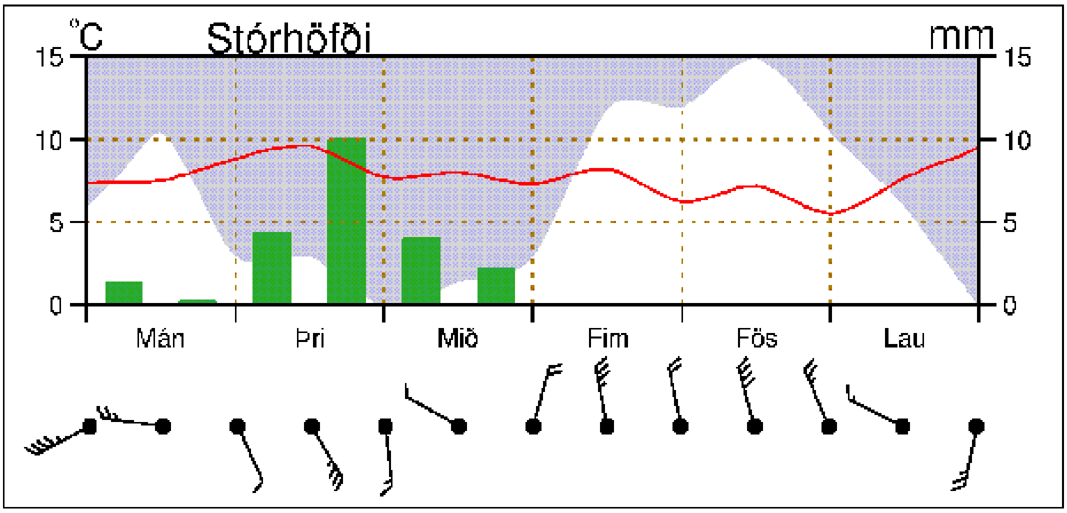


Figure 5.10 A meteogram showing a six days forecast for the synoptic station Stórhöfði off the south coast of Iceland. Wind speed is shown with flags where one whole barb denotes 5 m/s and a half barb 3 m/s. Air temperature is shown with a red line and accumulated precipitation with green columns. Cloud cover is shown with a bluish background.

5.11 Sea ice maps

The sea ice maps shown in Figure 5.11 are based on satellite images, both high resolution images from NOAA polar orbiting satellites and Quikscat. The mapping method is developed at the University of Iceland, Science Institute using ArcGIS software. The images were retrieved from Kongsberg Satellite Services in Tromsö, Norway.

The main ice edge and the maximum known ice extent is shown on the charts. The ice concentration is indicated and every map does also contain a warning that ice might be present outside the known limit.

Such ice charts would be useful for ships operating near the ice edge. In principle it should be possible to issue the charts every day but in overcast conditions it may be impossible to distinguish the ice edge through the clouds.

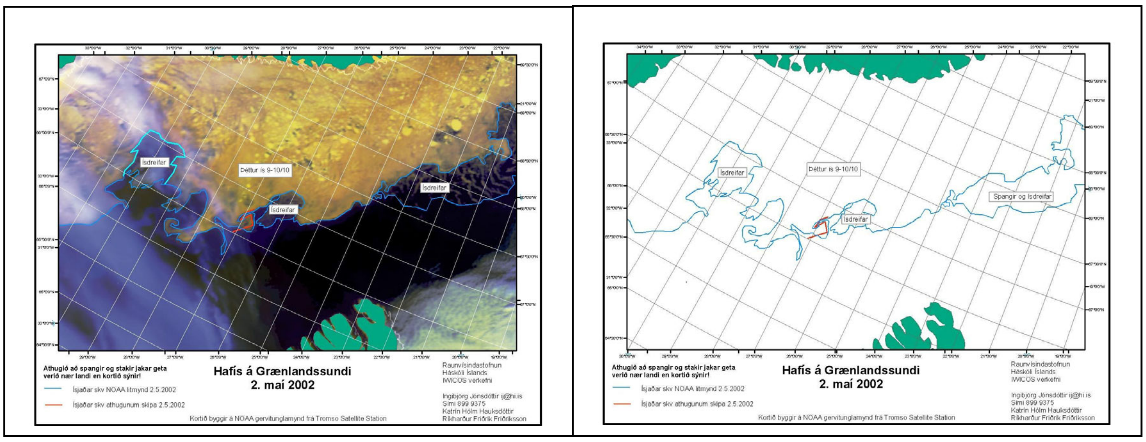


Figure 5.11 Ice charts based on satellite images. On the left chart the underlying satellite image is shown but on the right chart the image has been removed. The ice edge is drawn with a blue line but the red line shows the ice edge according to observations from ships.

5.12 AMSU combined product

In order to fulfil one of the main user requirements from the baseline system user requirement study, DTU/DCRS has started producing mosaics of high frequency (89 GHz and 150 GHz) satellite passive microwave data in near real time. The original more accurate ice concentration products derived from SSM/I data can only be delivered with a delay in the order of 36 hours, and some users requested shorter delays. The quality (accuracy) of the new product is not as high as the quality of the SSM/I based ice concentrations, but it can be delivered with only 3-6 hours delay, so it works fine as a supplement. The vector overlay facility allows the user to overlay more accurate ice concentrations from the SSM/I data of the day before, or two days before.

Figure 5.12 shows an example of the AMSU passive microwave product and Figure 5.13 a combination of AMSU passive microwave data and wind forecast from NCEP.

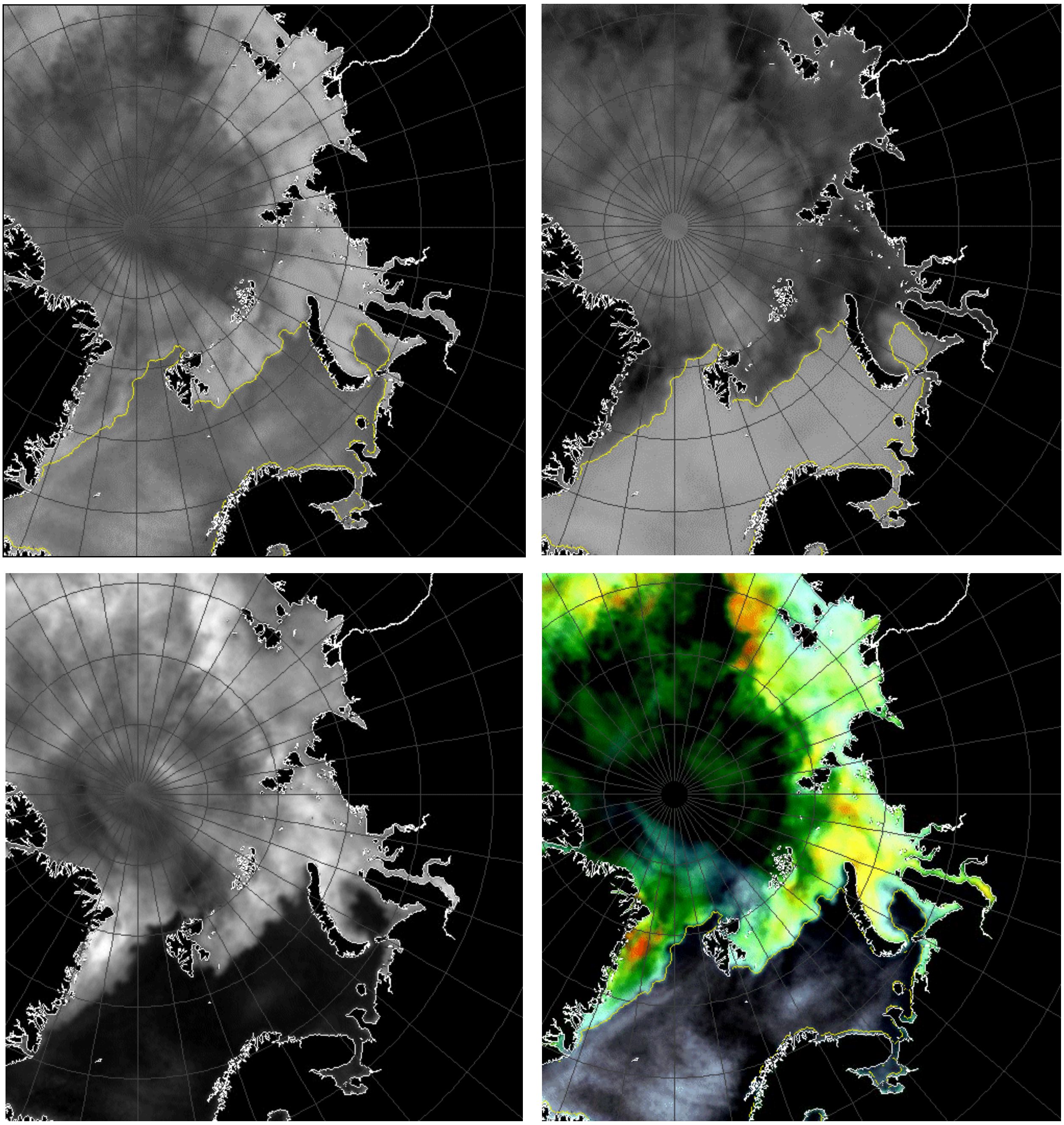


Figure 5.12 AMSU passive microwave products generated in the DTU/DCRS processing chain. These products are generated within a few hours of satellite acquisition, and provide a very useful overview of the large scale ice conditions. Top left is the 89 GHz channel image, upper right is the difference between 150 and 89 GHz, and lower left is the ratio of the same two channels. The lower right image shows an HIS colour combination of the three other images.

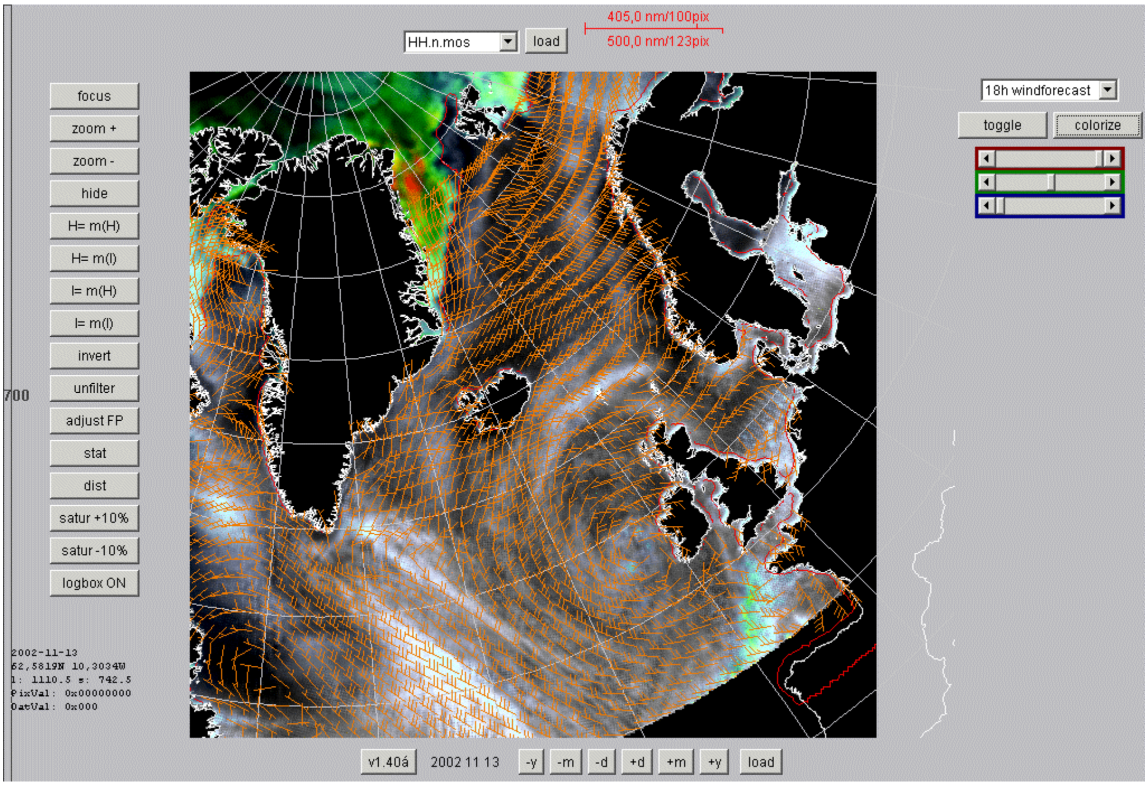


Figure 5.13 Example of the AMSU combined product overlaid with wind forecast from NCEP.

5.13 QuikSCAT sea ice product

DTU/DCRS has in collaboration with DMI, began near real time processing of QuikSCAT scatterometer data, so these products are now also available within 4-6 hours after acquisition.

As a consequence of user demand, DTU/DCRS has also started producing near real time satellite products for the Southern Ocean, so we now cover the polar regions of both hemispheres. Figure 5.14 and Figure 5.15 show examples of our new Antarctic products.

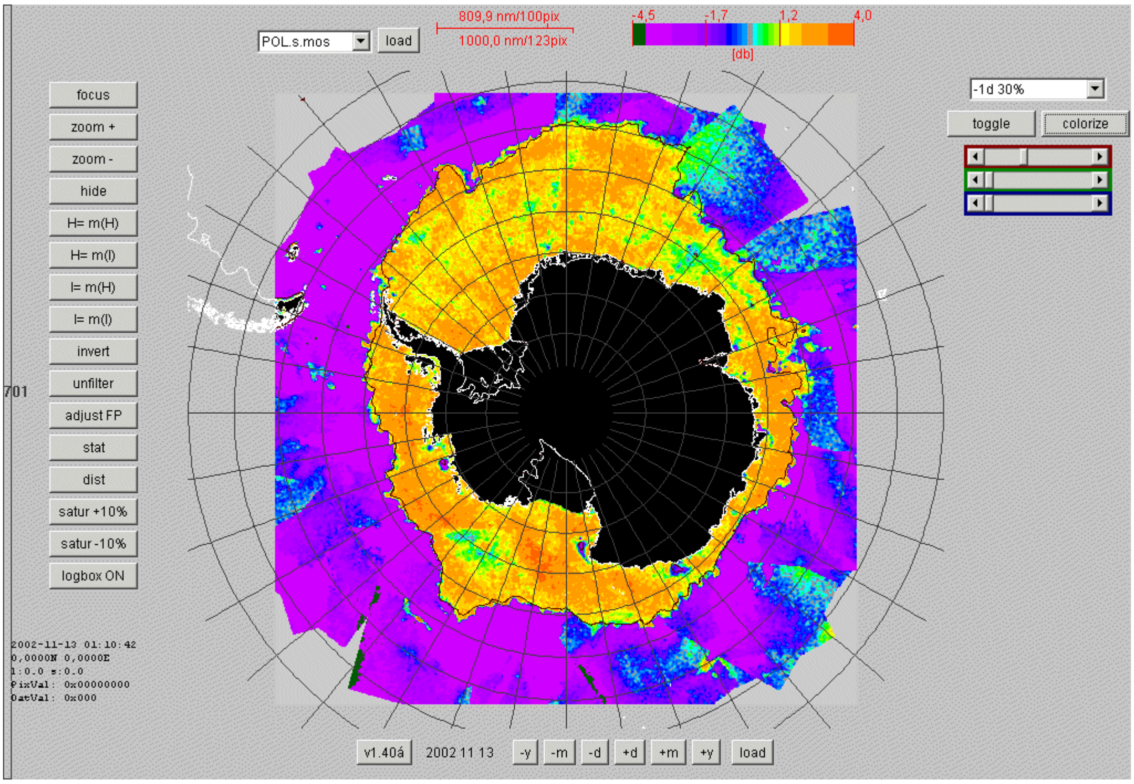


Figure 5.14 QuikSCAT polarization ratio image of sea ice around the Antarctic continent.

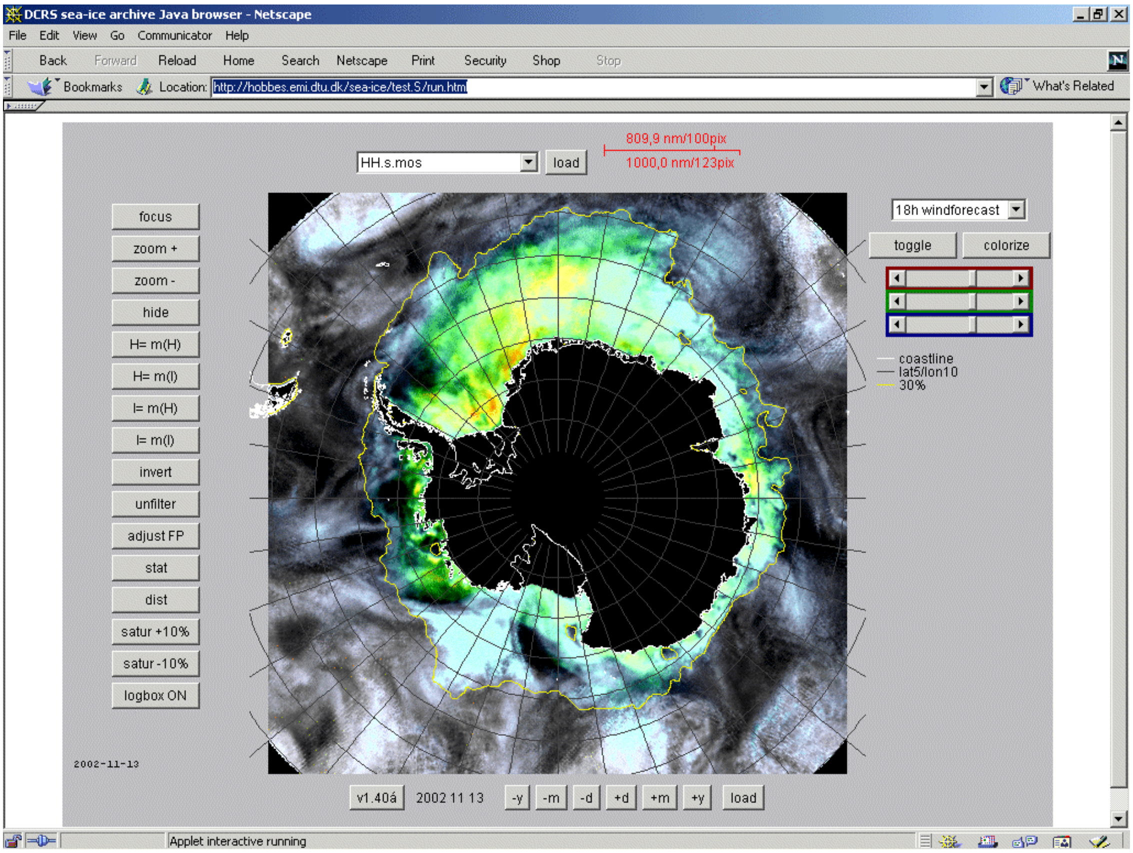


Figure 5.15 Example of AMSU combined product in the DTU java browser (see chapter 6).

5.14 SAR quick-looks with derived ice parameters

SAR-based products for the Arctic Ocean include: (1) SAR quick-looks, (2) ice motion derived from SAR images, and (3) ice type classifications extracted from SAR data. Figure 5.16 shows an example of the ice motion and ice type classification product. The ERS-2 SAR image was acquired on 17 April 2000 in Storfjorden at Svalbard (Spitsbergen).

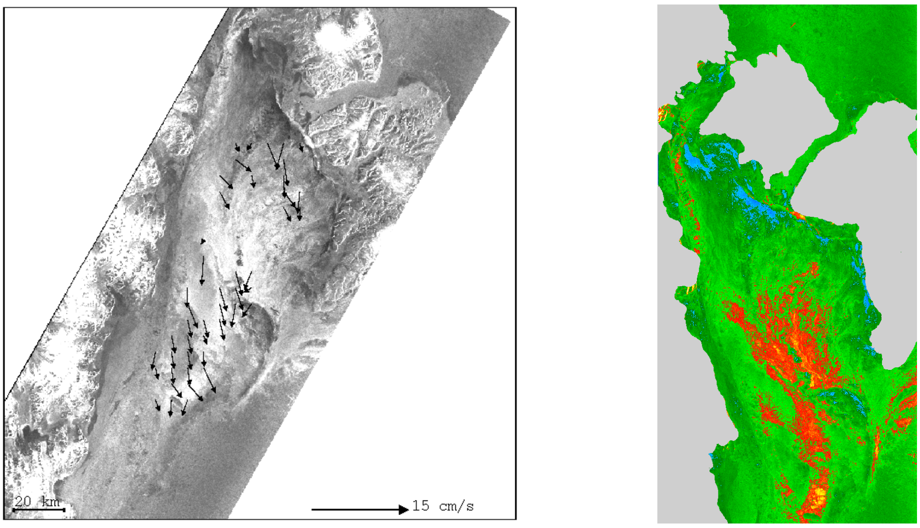


Figure 5.16 Ice motion vectors overlaid on geo-referenced SAR image and ice type classification of the same image. Colour coding of ice classification: blue=open water or thin ice; green=first-year ice; red-yellow=rough first-year ice.

5.15 Ice concentration – time series of monthly means

A long time series of ice concentration in the Arctic Ocean has been derived from SSMR and SSM/I satellite data (Johannessen et al., 2000), and can be used for climate studies. An example of monthly means of multi-year ice coverage in January for the 1990s is shown in Figure 5.17.

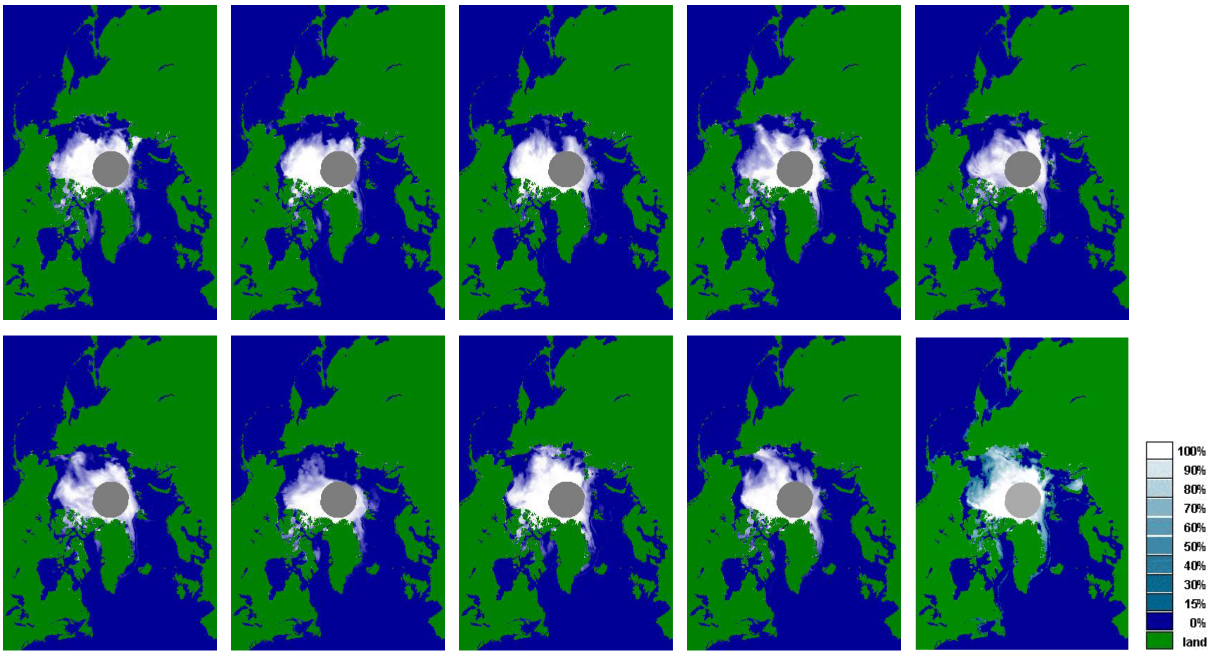


Figure 5.17 Monthly means of multi-year ice concentration in the Arctic for January month in the 1990s. Ice concentration is derived from SSM/I satellite data using the NORSEX algorithm.

6 End-User Systems (Façade and Clients)

End-User Systems provide customised display and analysis facilities for target end-user groups, and consist of a Client and Façade subsystem. Some end-users required use of pre-existing software or development using specific software packages. As a result, different End-User Systems have been developed for different user groups. However, all End-User Systems are developed within the framework of the overall system architecture, including use of the IWICOS metadata standard and the standard communication and security protocols built into the common Broker.

Some of the End-User Systems are thin clients that rely on having a server generating all data and information in a form ready for presentation. Others are thick clients, which download full (or partial) data sets and products, and contain tools for both analysis and presentation. A third category is a so-called balanced client, which include some analysis and presentation tools, but still uses a server for certain types of processing such as map drawing. The Façade may be used to tailor data to a specific client, e.g. by reducing its size by compression before transmitting it via a low-bandwidth connection, or to perform format conversion before transmission. The End-User Systems developed in the Extended System are described in subsequent sections.

6.1 End-User System for accessing near real-time observation and forecast data using low-bandwidth communication channel

This End-User System consists of a thick client GIS and a profile-based Façade. The Façade provides the client software with relevant data files coming from different data producers. Because of the low-bandwidth communication link between the Façade and the Client software the file sizes are kept to minimal, and the Façade selects only the most relevant files for downloading. The files are delivered once, and a thick client software generates the images needed for presentation, when the user pans, and zooms the view, or browses the time.

Profiles, defined by users, control the actions of the Façade. A profile describes user's preferences regarding data products, area of interest, data type, and some details about the capabilities of the client software and data communication channel. Based on the information in profiles the Façade knows what kind of data it must look for, and where it should send the files. The Façade uses the catalogue services provided by the Broker subsystem to query metadata about different products.

This system was built using freely available components, such as semantic web technologies, SOAP and XML, server side scripting technology, PHP, MySQL database, and Java programming language. The End-User System was demonstrated in operational use in March 2002, when satellite image data, weather forecasts, and buoy observations were delivered to research vessel Aranda during its North Atlantic expedition.

6.1.1 Façade

Figure 6.1 depicts the architecture of the Façade, which consists of two logical subsystems, the Metadata & Product Manager, and the Profile Manager. The former is responsible for getting the metadata, selecting and downloading the products, and delivering them to the users. The latter provides the Client Software with methods for inputting and editing the profile data.

The two subsystems are divided further in several submodules, which take care of different functions of the Facade. As the user inputs and edits the profile data the Client Software communicates with the Profile Server, which stores the profile data in the database. The Profile Retriever is responsible for getting the latest profile data for the use of the submodules inside the Metadata & Product Manager. The Metadata Retriever communicates with the Broker, and finds out what kind of data there are available for the area, time extent, product type, and other parameters defined in the profile. The Product Selector contains the intelligence for selecting the products, which are retrieved from the producers and prepared for sending to the Client Software. The Product Retriever performs the downloading of the files, and finally the Product Sender handles the outputting of the data for the Clients.

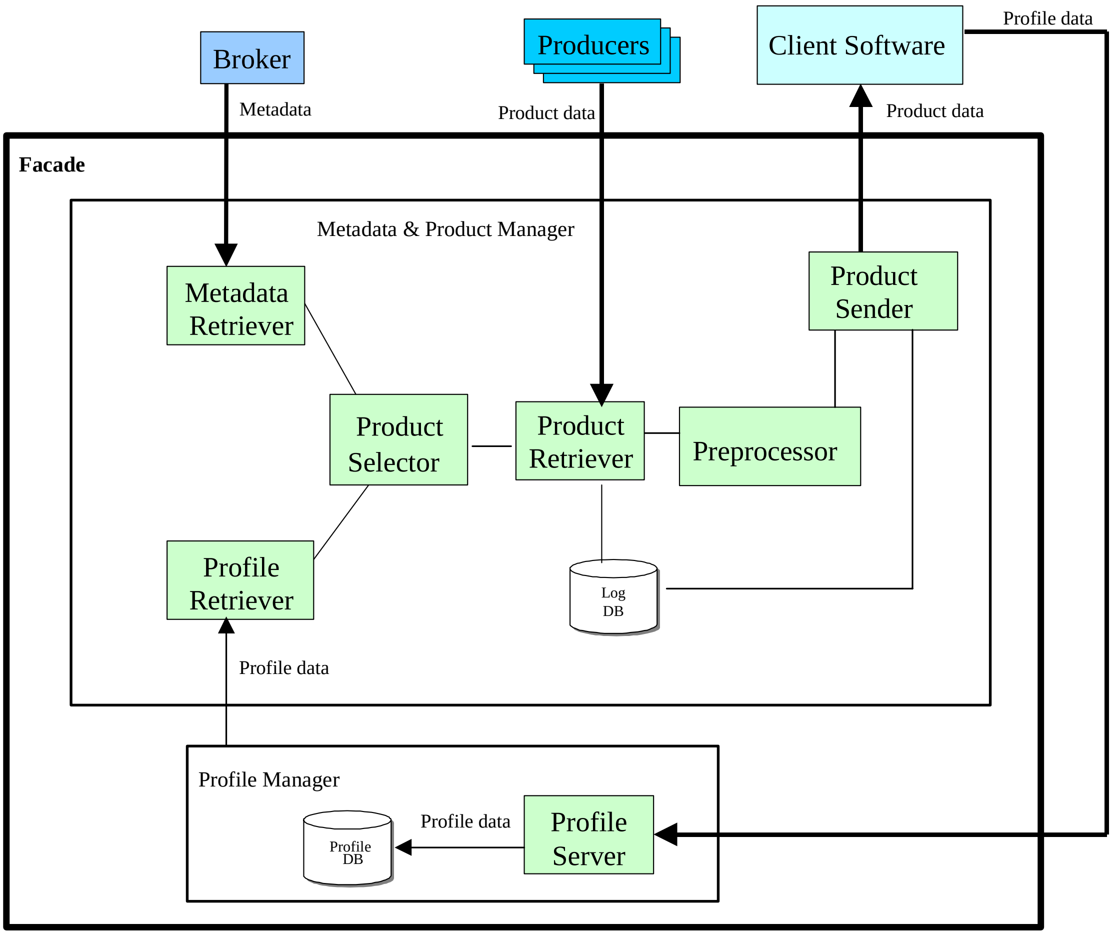


Figure 6.1 The Façade architecture. See text for an explanation.

6.1.2 Profile

The profiles are created and edited with a web browser based user interface, which is implemented using an HTML-embedded server side scripting language, PHP. As user requests for the profile management web pages, a dynamic web page containing the relevant profile attributes is created. This is illustrated in Figure 6.2. The profile data the users feed into the system are stored in a MySQL database, which is shared between the subsystems of the Façade.

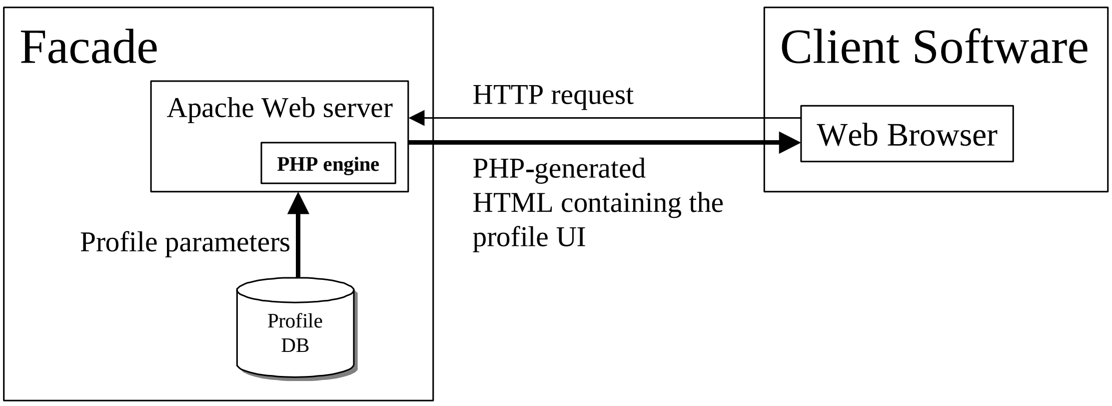


Figure 6.2 The profile editing user interface is implemented using PHP.

Profiles are edited as the needs for data change. For example, if a ship's route plan changes suddenly, the profile must be updated in order to have the relevant files transmitted to the ship. These updates are made directly from the ships at sea, or they can be handled by shipping company operating the ships.

Figure 6.3 shows an example of a web-based user interface for editing the profiles. In this view some properties concerning the products are given. The properties define the minimum and maximum spatial size of the products, the area of interest, preference values for different producers and data types, and some limits for the maximum number of files presented in the web page created for the user. Some parts of the profile are not visible to a normal user, and are edited by an administrator of the system.

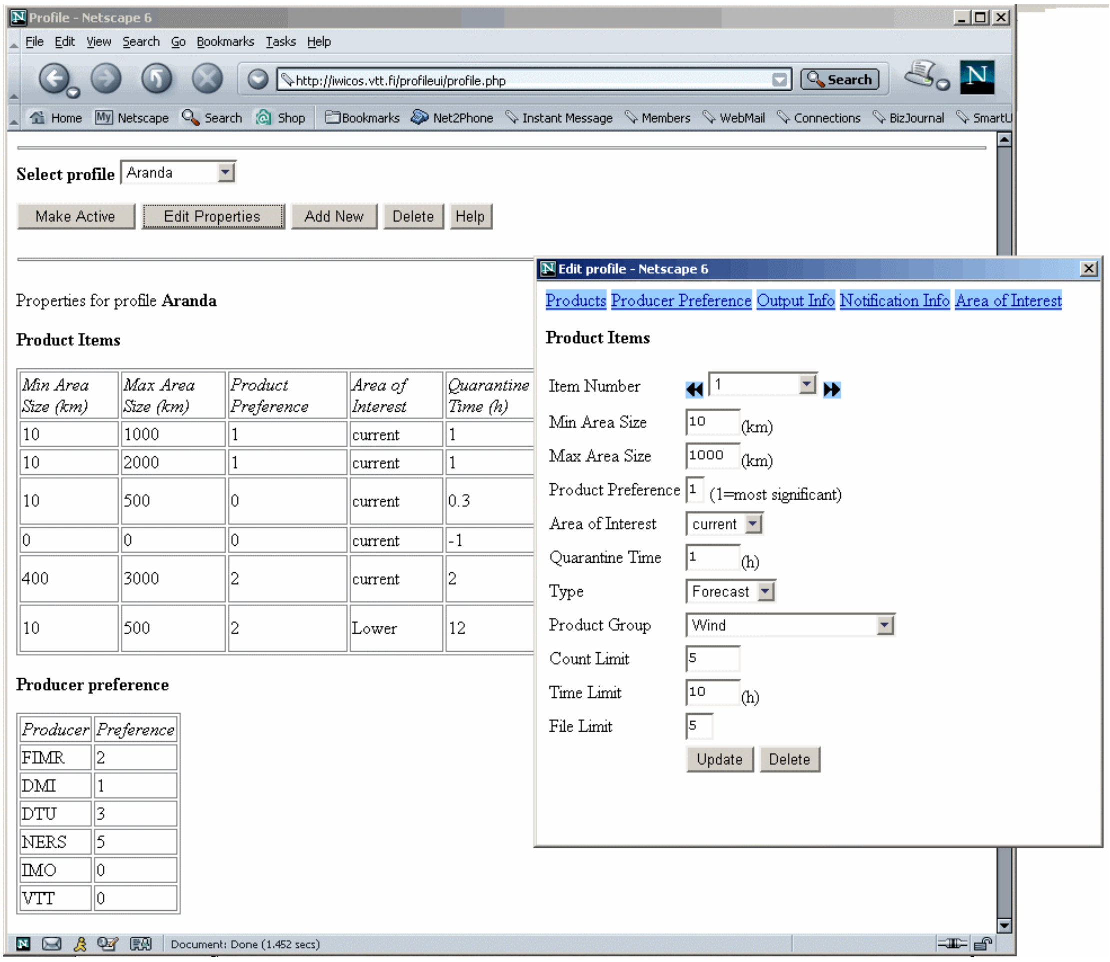


Figure 6.3 An example of a PHP created user interface for accessing and editing the profile data in the database.

6.1.3 Client software

On the Client side a web browser software and a GIS are needed for editing the profile, downloading the files, and presenting the data products to the user.

The Façade creates a web page from where the user downloads the files. By this way part of the selection logic is given to the user, and this simplifies the task of choosing appropriate files on the Façade's side. The user actively retrieves a list of available files, which the Façade created based on user's preferences, and selects the most suitable ones for downloading. The Façade attaches some metadata in the web page, which describe the contents of the files, categorizes the file list by the data type, and sorts the files by their relevance to the user. Figure 6.4 shows an example web page created by the Façade.

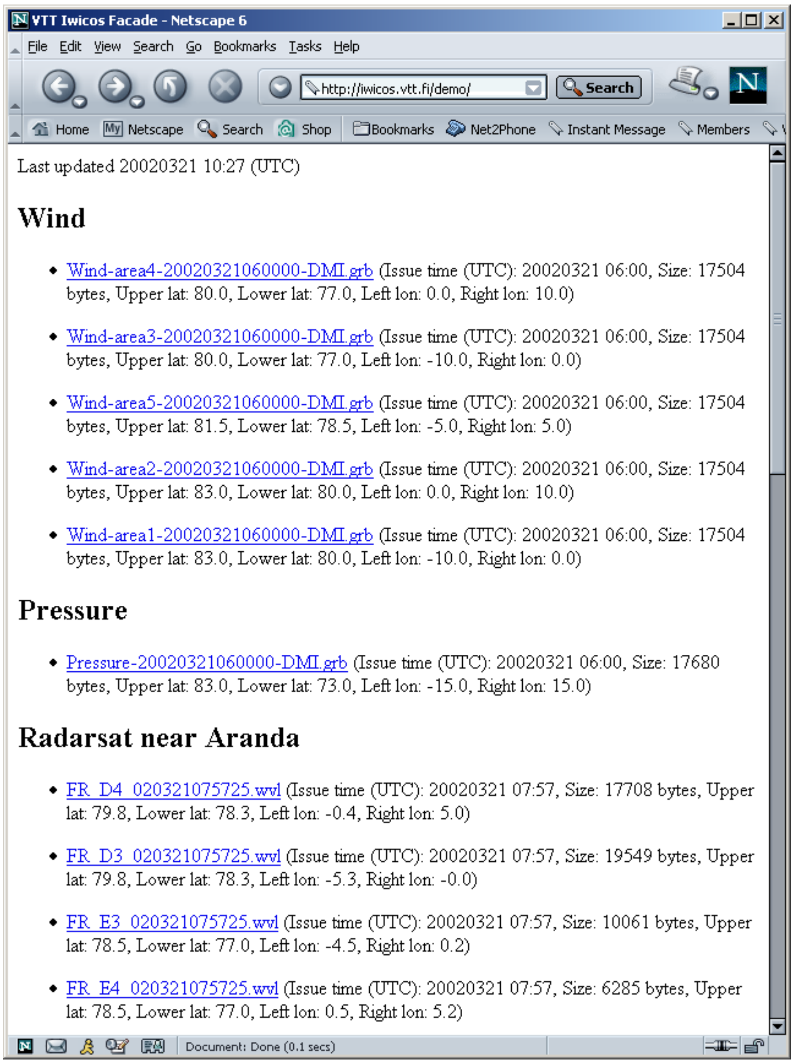


Figure 6.4 An example web page created by the Façade.

If wanted, the Façade sends a notification whenever new items have been added to the web page. A notification is possibly redirected to a mobile phone as a GSM or Iridium short message, and is therefore limited to 120 characters in length. The Façade tries to be restrictive regarding sending notifications, even though there would be many updates in the web page in a short period of time. The user would not take the advantage of the notifications if too many messages jammed the mobile phone.

After the files are downloaded a GIS is used to view the files. Figure 6.5 shows an example of such a system, the ViewIce program, which was used in Aranda demonstration.

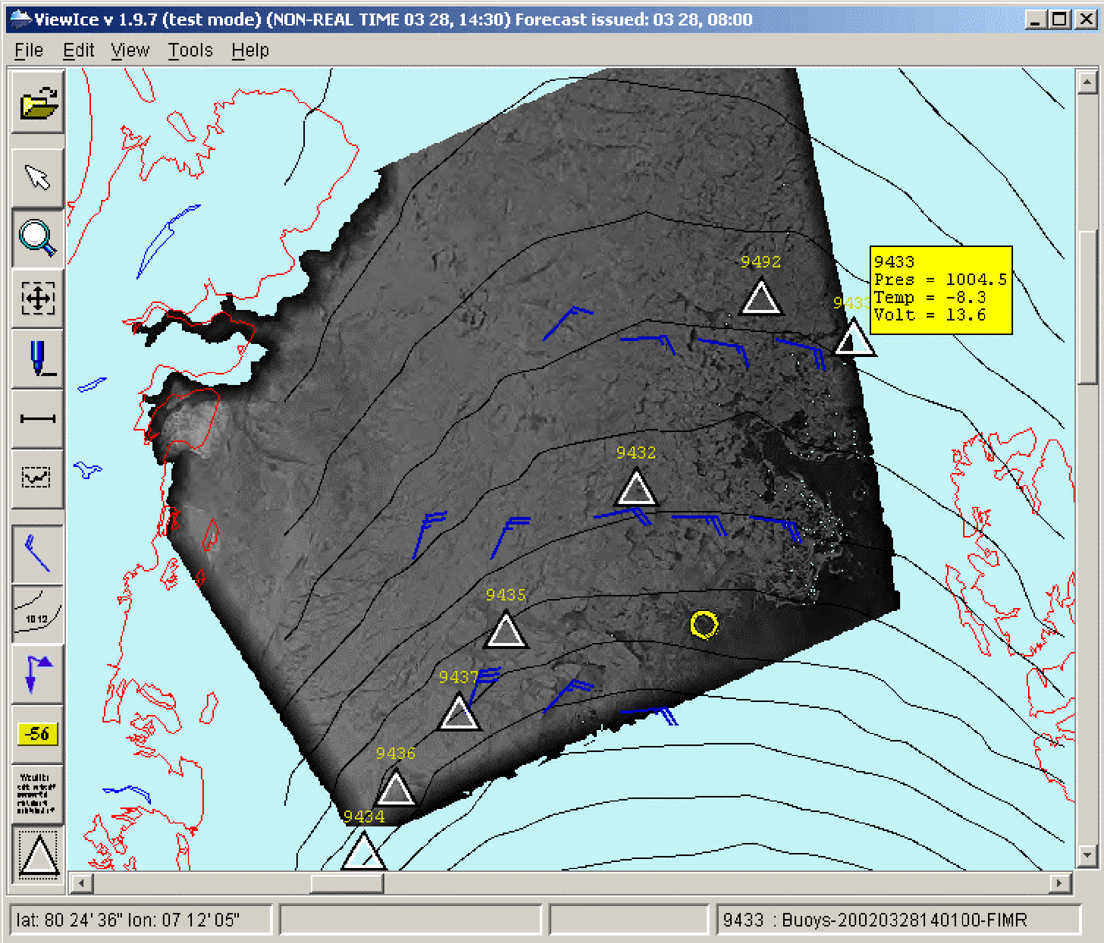


Figure 6.5 ViewIce presenting Radarsat image, buoy observations (triangles), wind and pressure forecast, and ship's location (yellow ring).

6.2 The Met-Ice-Ocean Viewer (a thick client solution)

6.2.1 Users

The 'Met-Ice-Ocean Viewer' or in short the MIO Viewer has been tailored to handle and present digital meteorological, oceanographic, sea ice data and satellite imagery, primarily to users onboard ships. MIO Viewer is foreseen to serve users that are considered 'off-line' users, i.e. users who only have access to data through narrow bandwidth connections. This group of users need to carry out both tactical and strategic route planning which involves analysis of sea ice-, weather- and ocean information. Today, this information is available but almost entirely as separate information layers. Users are interested in integrating weather, ocean and sea ice information in a more user friendly way and consequently benefit from the synergy that often will emerge when combining these data. By integrating different met-ice-ocean products in the MIO Viewer and combining these in a common presentation environment the user has a valuable tool when interpreting surrounding weather, sea ice and ocean conditions. Thus, the application is intended as a decision support and route-planning tool.

6.2.2 Changes to the extended system version of MIO Viewer

Several changes have been applied to the extended system version of MIO Viewer. On a generic level these can be divided into changes related to:

1. *Data*: Changes has been applied to MIO Viewer in terms of which data are supported. The parameter 'visibility' has been removed due to poor quality for Greenland waters. New parameters

added are ‘Height of Primary Swell’, ‘Mean Direction of Primary Swell’ from the ECWMF Wave Model and weather forecasts from Icelandic Meteorological Institute in text form.

2. *Data interface*: The interface to data has been modified so that new parameters can be added more easily,’ compared to the baseline version. This is especially the case for meteorological and oceanographic parameters from numerical prediction models. A GPS interface has been developed for acquisition of real time positions and waypoint related information.
3. *Presentation*: The presentation environment has been extended to include multi window presentation for multi prognosis of weather and ocean data. This is especially useful in connection with GPS related information. Single parameter presentation has been improved through new representation methods including text labelling of point data. Options have been added for defining colour and density of text labelling, colour and size of point and line features.
4. *Special functionality*: The route module have been extensively developed to include options for easy creation, editing, file operations, browsing, etc. This has been developed in close connection with the development of the GPS module.
5. *User interface*: The user interface has been extended through new dialogs, menus, buttons and tools. New interface parts concerns, in particular, the route module and the GPS module, but also general features like zooming and shortcuts to important functionality.

6.2.3 ES Products and Concepts of Presentation

Currently the client system supports a number of products, which addresses marine users. The system can be extended to include more products/parameters if required by the user. Currently supported products are listed in Table 6.1.

Table 6.1 Products currently supported by the MIO Viewer.

CATEGORY	PRODUCT/PARAMETER	INPUT FORMAT
Satellite Imagery	RADARSAT	ERDAS, MrSID, BSQ
Satellite Imagery	NOAA AVHRR	ERDAS, MrSID, BSQ
Satellite Imagery	DMSP	ERDAS, MrSID, BSQ
Sea Ice Data	Sea Ice Analysis	Shapefile
Meteorology	Mean Sea Level Pressure	ASCII
Meteorology	Air Temperature (2 meter)	ASCII
Meteorology	Wind Speed/Direction (10 m)	ASCII
Met/ocean	Text Forecasts and warnings	XML
Oceanography	Significant Wave Height	ASCII
Oceanography	Mean Wave Direction	ASCII
Oceanography	Mean Direction of Primary Swell	ASCII
Oceanography	Mean Height of Primary Swell	ASCII

The presentation of products seeks to follow known standards for viewing sea ice, meteorological and oceanographic data as defined in World Meteorological Organisation, 1970, World Meteorological Organisation, 1992 and World Meteorological Organisation, 1994. Thus methods of presentation includes isoline representation for almost all parameters and point symbols for certain parameters, like wind barbs for wind data and vectors for wave data. Additionally, a couple of new methods for presenting data have been introduced. In parallel to isoline representation many parameters can be represented by a continuous surface which are mapped to a colour table. Non-interpolated data can be represented by a label indicating the exact value at the particular point. Options exist for defining the density and colour of such a label representation of a given parameter. A strong advantage of having several presentation methods for the same parameter is that more parameters can be combined still avoiding a ‘visual mess’. For example, in the case of pressure and wind speed it would be difficult to interpret isobars and isotachs at the same time, but representing one with isolines and the other by a coloured surface eases the interpretation.

6.2.4 Presentation Forms

Ice Chart

Sea ice analyses consists of ice edges, boundaries and information concerning the nature of the sea ice expressed in SIGRID codes. The ice analyses are translated into ice charts using WMO nomenclature when presented by the client, e.g. by using ice eggs or presenting ice concentration through colour codes and hatching. In the case of ice concentration no official WMO standard exists at the moment for translating concentration levels into different colours. Currently, a colour table proposed by International Ice Charting Working Group is used.

Mean Sea Level Pressure:

- Isobars are shown at intervals of 5 mbar and the 1000 mbar isobar is included.
- Continuous surface in colour with same intervals as the isobar representation.
- Text labelling of data points.

Air Temperature (2 meter):

- Isotherms are shown at intervals of 2ºC.
- Continuous surface in colour with same intervals as the isotherm representation.
- Text labelling of data points.

Wind (10 meter):

- Isotachs are shown at intervals of 5 m/s.
- Continuous surface in colour with same intervals as the isotach representation.
- Wind barbs are used for point indicators.

Significant Wave Height:

- Isolines for height are shown at intervals of half a meter.
- Continuous surface in colour with same intervals as the isoline representation.
- Text labelling of data points.

Mean Wave Direction:

- Mean Wave Direction is presented as vectors where propagating direction is given by an arrow and length of the arrow is proportional with the wave height.

Significant Height of Primary Swell:

- Isolines for height are shown at intervals of half a meter.
- Continuous surface in colour with same intervals as the isoline representation.
- Text labelling of data points.

Mean Direction of Primary Swell:

- Mean Direction of Primary Swell is presented as vectors where propagating direction is given by an arrow and length of the arrow is proportional with the swell height.

Text forecasts, synopses and warnings:

Forecasts and warnings in text form are presented using dialog text boxes. The textual forecasts are hooked up on a map presenting forecast areas and at the same time showing the expected maximum wind speed through a colour code. When clicking the mouse in a specific area the dialog will show the forecast, the synopsis and warnings if any.

6.2.5 Facade

The end-user system consists of a Facade-Client pair. The Facade acts as an interface between the client and the product server and, among other things, handles data conversion from IWICOS Exchange formats to client specific formats, see Figure 6.6. In the case of the MIO Viewer the facade converts meteorological and oceanographic data in WMO GRIB format to an ASCII text format which can be directly read by the MIO Viewer. Furthermore, the facade will be able to make image format conversion, e.g. from BSQ to MrSID resulting in a considerable size reduction which is preferable when sent through narrow bandwidth communication lines.

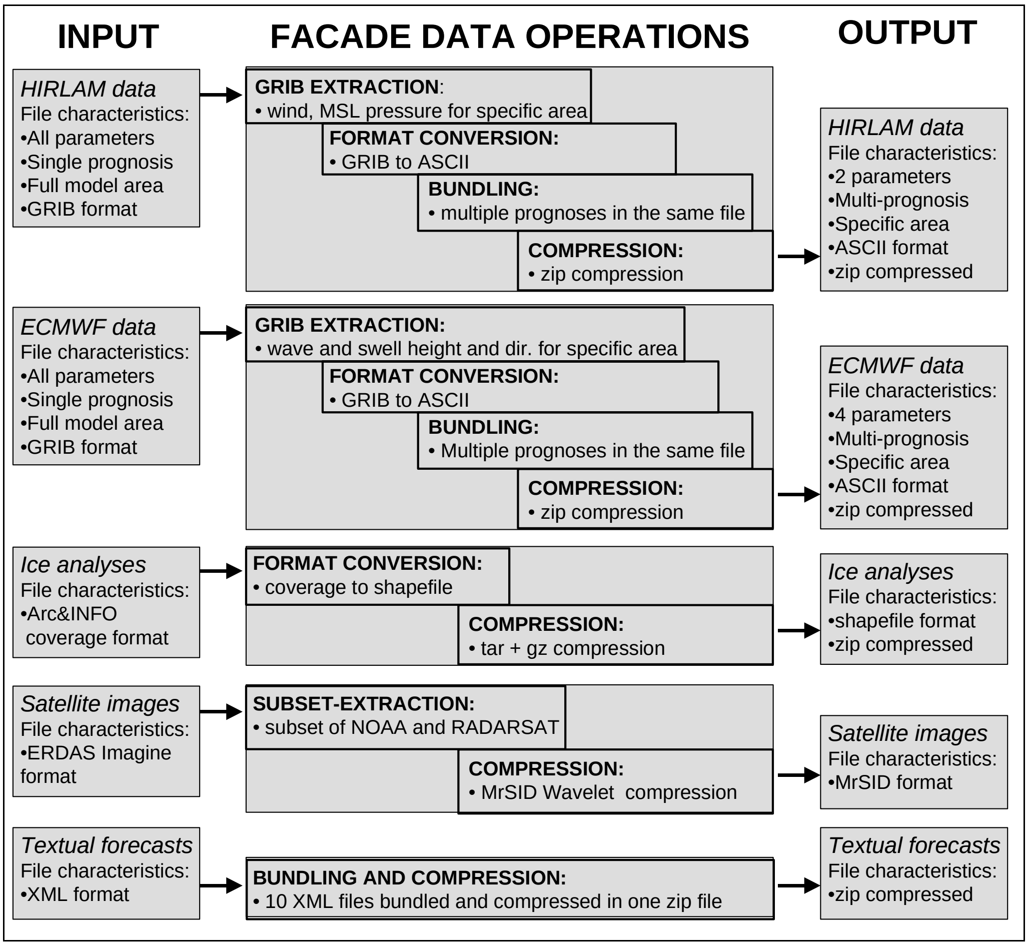


Figure 6.6 A schematic representation of the Facade data operation module.

Currently, no interface exists for querying metadata at the Broker directly from the client. Instead, data provision is based on a data product profile as predefined by the user and the provider in collaboration. The data product profile is then adjusted from time to time according to sail routes, weather, ocean and sea ice conditions and data availability.

6.2.6 Client Architecture

The MIO Viewer client is a customised and expanded version of the Geographical Information System 'ArcView' developed by ESRI Inc. The MIO Viewer data handling and processing depends on the input data. A schematic representation of MIO Viewer steps is shown in Figure 6.7.

The processing tasks are related to numerical predictions of meteorological and oceanographic parameters, to textual weather forecasts and to input parameters from GPS. Numerical predictions are read as ASCII formatted data and then follows a three step processing sequence leading to three different products, one raster product and two vector products:

- Step 1: Converts from ASCII to vector format, the output being a point shape file.
- Step 2: Based on the point shape file generated in step 1 an interpolation is performed producing a Grid Surface in the ARC/INFO GRID format. The interpolation function is a spline function. The spline function ensures a smooth (continuous and differentiable) surface, which applies well to the large-scale variations that are dominant for most parameters presented.
- Step 3: Based on the Grid surface a contouring is performed producing isobars, isotherms, isotachs and isolines for wave and swell height.

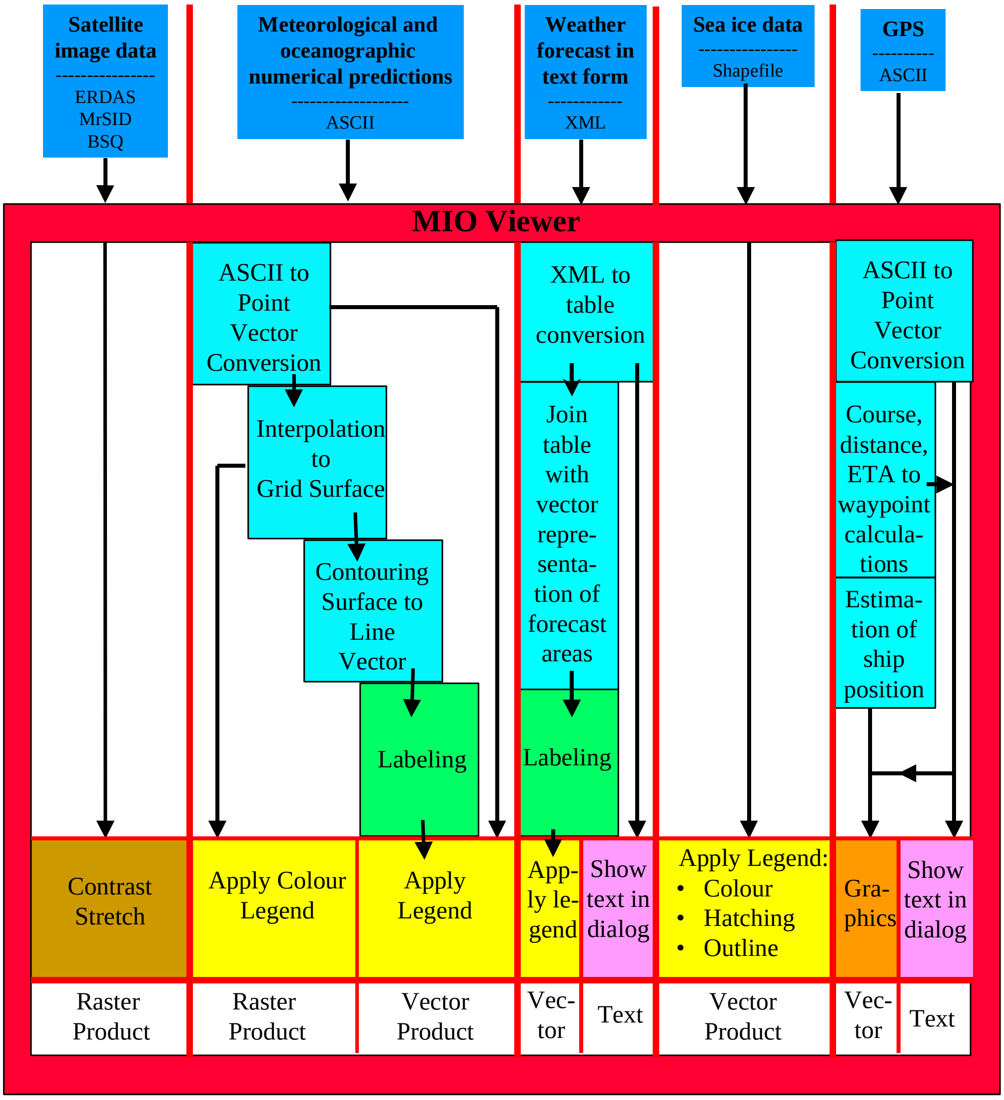


Figure 6.7 MIO Viewer processing chain and display process.

Textual weather forecasts are read as XML formatted text and stored in a virtual table with a record for each forecast area. When the display process is initiated the table is joined with a vector representation of the individual forecast areas and the result is a combination of a vector representation of the forecast area with expected maximum wind speed and a presentation of textual information through a dialog, providing the forecast, the synopsis and warnings if any.

GPS information in terms of position, vessel speed, course and position fix time is used for presentation and for calculations of derived parameters. First the positional information (ASCII format) is converted to point features and thus visually indicating the ship track. Then the actual ship position is related to route/waypoint information and subsequently distance, course and ETA is calculated for the nearest waypoint. Finally the expected ship position at time of prognosis is calculated. Distance, course, ETA for nearest waypoint and expected ship position are all calculated for both rhumb line and great circle geometry. All parameters are shown graphically in one or more prognosis windows and additionally as text in a dialog. The GPS information and waypoint related calculations are done automatically at a user specified time interval.

Image data in the format of ERDAS, MrSID or BSQ is directly read by MIO Viewer and can be presented and visually manipulated using image contrast enhancement through an image legend editor.

Ice charts in the form of shape files are directly read by MIO Viewer and is presented using a colour code, hatching code or outline legend option.

6.2.6.1 Client Functionality

The MIO Viewer utilises a substantial part of the basic ArcView functionality and furthermore, has been extended and customised to include functionality specifically developed for use by the marine user group (see Figure 6.8).

The functionality as seen from the user perspective will be a mix of the basic GIS functionality as provided by ArcView and the IWICOS specific functionality developed using the Avenue scripting language. The IWICOS specific functionality can be divided into two parts, a data functionality part and a navigation/route planning part. The data functionality part is associated with the presentation of data products and extraction of their information content.

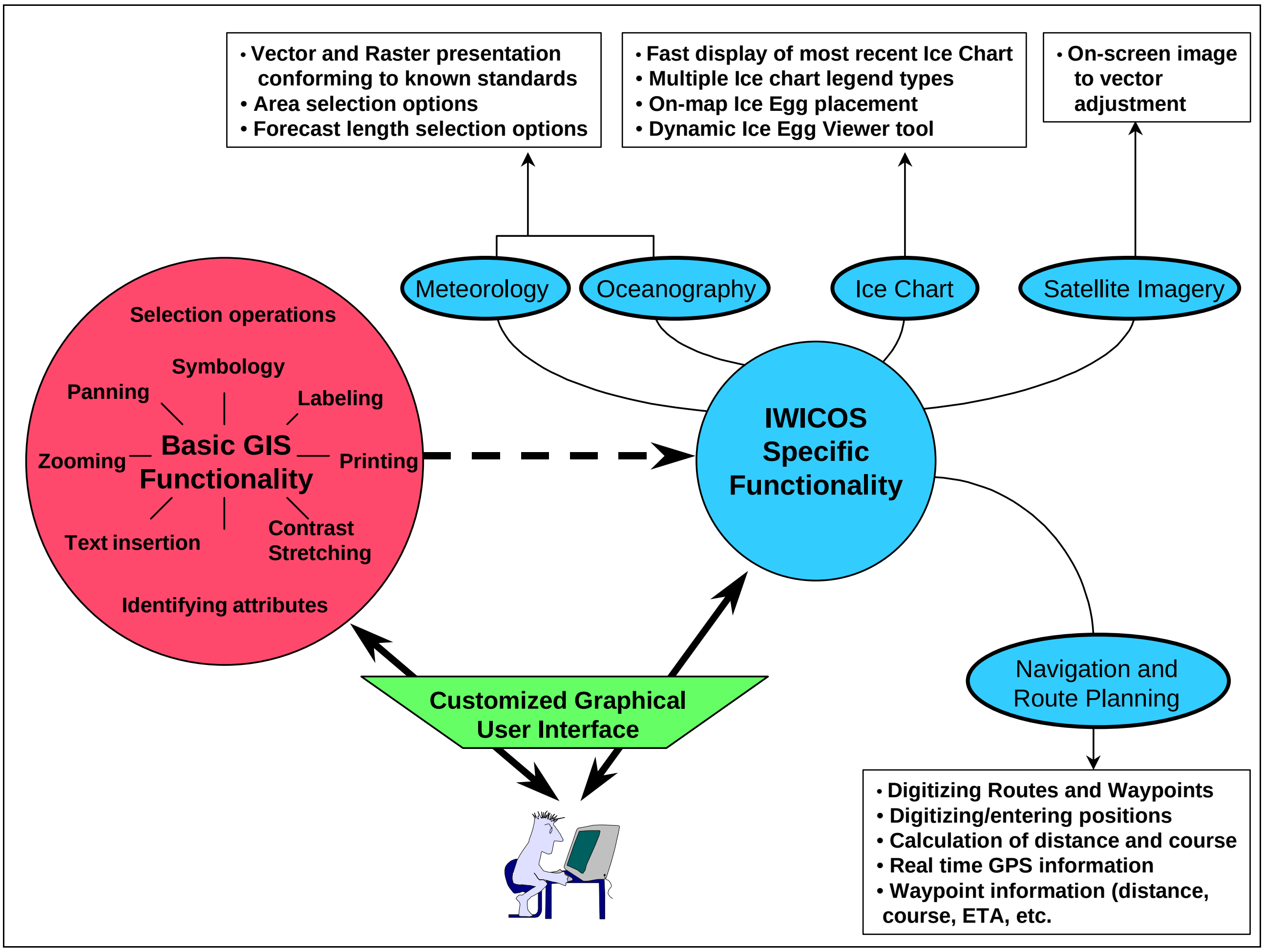


Figure 6.8 Generic functionality overview of MIO Viewer.

The navigation/route planning module is used to obtain information related to routes and positional information directly read from GPS. Routes are either digitised using mouse or entered using keyboard. Following information can be derived from the GPS and route module:

- Listing of waypoint coordinates

- Distance and course between waypoints
- Real time positioning from GPS
- Course and distance to nearest waypoint on route as both great circle and rhumb line calculations
- ETA estimations for waypoints based on GPS speed
- ETA estimations for waypoints based on user defined speed
- Prediction of the ship position at the route at time of prognosis (weather or wave) based on GPS or manual speed as both great circle and rhumb line estimations.

All functionalities are available to the user through a customised graphical user interface

6.2.6.2 The Graphical User Interface

The user interface has been customised in order to make application - user interaction intuitive and user friendly. This implies that certain basic ArcView interface parts have been adapted and new interface parts added in the MIO Viewer application. The main features having been considered in the user interface customisation process can be listed as:

- A clear, simple and logical design of the functionality environment.
- Functions should be accessed through menus, buttons and dialogs in accordance with other Windows applications.
- Fast access and shortcuts to certain important functions.
- Exhaustive information content in error and warning messages.

Dialogs have been widely used for interfacing between presentation environment and actual data, e.g. when loading a meteorological parameter or an ice chart, see Figure 6.9. Metadata are provided in dialogs in a form that gives a clear and precise overview of data thus, easing and speeding up the selection process as performed by the user. E.g. when a certain ice chart is wanted for presentation the user gets a list of available charts including information on valid date, valid time, area, primary source, secondary source and comments if any.

Several other generic user interface parts have been developed:

- Dialog for generating user specific met/ocean products (point shape files, GRID and contour shape files)
- Dialog for deletion of met/ocean products
- Dialog for easy change of colours and size of point and line symbols
- Dialog used for GPS and waypoint related information
- Dialog used for obtaining textual forecasts, synopsis data and warnings
- Tools for selecting and digitizing positions and routes
- Dialog with tools for generating and browsing routes and route files
- Route editing tools
- Ice egg viewer dialog
- Buttons used as short cuts to frequently used functionality such as loading met, ice and ocean data
- Pop up menu choices used as short cuts to frequently used functionality such as zooming, panning, deselecting etc.

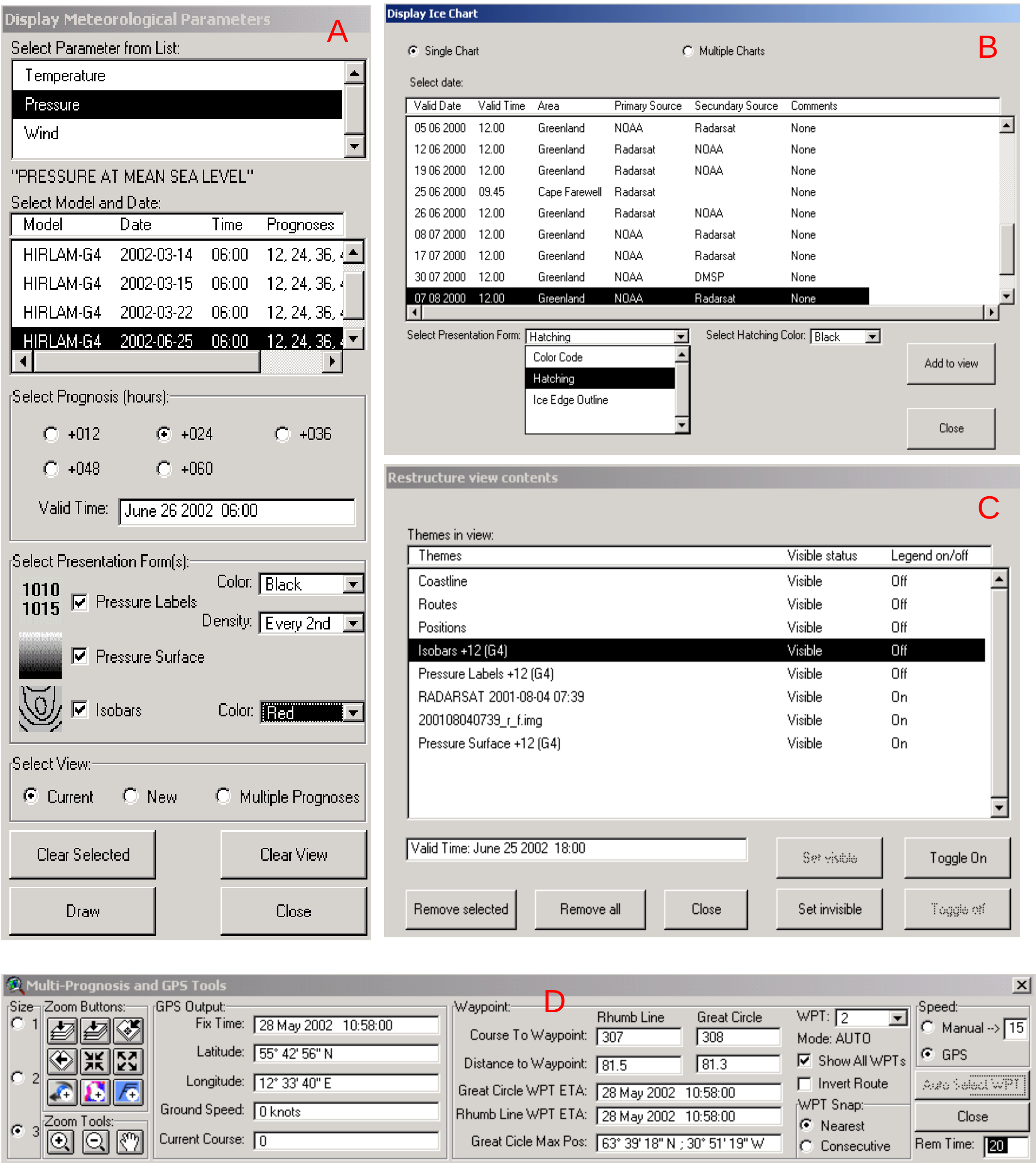


Figure 6.9 Examples of user interface in form of dialogs. A) used for presenting meteorology, B) used for presenting ice charts, C) used for controlling contents of views and D) used for GPS and waypoint information.

6.3 The ArcIMS Thin Client Solution

The thin client described in this section thin client is based on a commercial product called 'ESRI's Internet Map Server' (ArcIMS). The system architecture for the ArcIMS implementation is represented schematically in Figure 6.10.

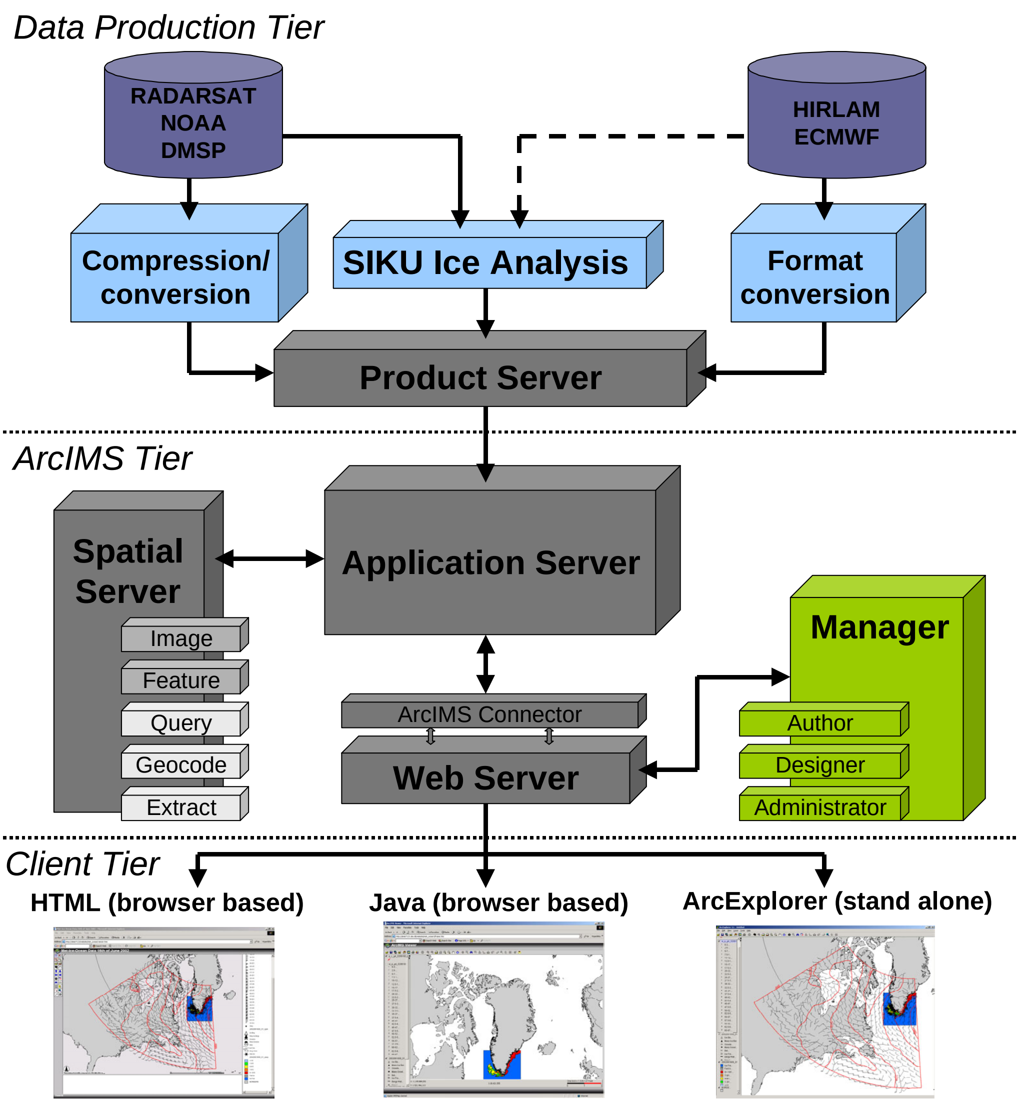


Figure 6.10 Schematic representation of the ArcIMS implementation within IWICOS.

The ArcIMS architecture can be divided into three generic tiers: a) a data production tier, b) an ArcIMS tier and c) a client tier. The production tier includes a database level, an analysis level and a product storage level. In this case the levels are exemplified trough a database consisting of satellite imagery and numerical predictions of weather and ocean data. Data extracted from the database partly founds the basis for conducting sea ice analysis resulting in an ice classification product and partly enters the product storage environment as products themselves. Once ready on the product server the products can be accessed by the ArcIMS Application Server, schematically represented in the ArcIMS tier. The ArcIMS Application Server supports a restricted set of formats, among these are Shapefiles for vector data and BSQ, MrSID, IMAGINE, GIF, JPG, TIFF, BIL, BIP and BMP for images. The restricted set of formats implies that format conversion takes place between database level and product storage level.

The ArcIMS generic tier consists of several sub-tiers – for a full description of these see the IWICOS Design Document, deliverable D1. The 'outcome' of the ArcIMS generic tier is a set of 'MapServices'. A MapService is a process that runs on the ArcIMS spatial server. It provides instructions to the spatial server on how to draw a map when a request is received. ArcIMS supports two types of MapServices:

Image and Feature. MapServices are authored and controlled using the ArcIMS manager module. In this module tools are available for authoring, generating web sites and administering the MapServices. Authoring MapServices are done through a 'Map Configuration File' which is written in ArcXML (an ArcIMS adapted XML vocabular). A DTD exists for the ArcXML specification which means that all map configuration files can be validated prior to MapService establishment. Authoring of map configuration files have been done using the XML editor software 'XMLSpy'.

6.3.1 Clients and their capabilities

The capabilities of clients are closely connected to the type of MapService. Of the three standard clients supported, the HTML client is the simplest and the easiest applicable client. It is restricted to present only Image MapServices using the image rendering capability of the spatial server. When a request is received a map is generated on the server and the response is returned as a JPEG, PNG or GIF image. A new map image is generated each time a client requests more information. The tools that are available through an HTML viewer includes zooming, panning, feature identification, spatial selection, querying attributes, buffer analysis, distance measuring and printing. Special symbols like wind barbs can be represented using TrueType Fonts and rotated using an ArcXML method specified in the map configuration file.

The Java viewer actually comes as both a standard viewer and a custom viewer. Both are capable of presenting 'Feature MapServices' using the spatial server's feature streaming capabilities. In this way more processing is performed on the client and requests are only sent to the ArcIMS spatial server when additional data is needed. Feature streaming allows for more functional capabilities on the client side such as labelling, change of appearance and spatial selection. Feature streaming sends shape files in a compressed binary format to a Java Applet in the client web browser. Feature streaming is a temporary format that remains only as long as the Java Applet is open. The Java Applet receives instructions on how to assemble the data once it is received. Besides providing the same tools which are available through the HTML viewer, the Java viewer has tools such as *map tips* (displaying attribute information on mouse-over event), *map notes* and *edit notes* which are the users suggestions to additional data or edits to original data, modification of *layer properties* like changing symbols and colours, user defined *labelling* and addition of locally residing data.

Whereas the HTML client is directly deployable in standard web browsers, the Java viewers require client side installation of a Java Runtime Environment and a one-time download for the ArcIMS viewer components in order to make the Applet communicate with the server.

The third client 'ArcExplorer' is a stand alone client that requires installation of Java Runtime Environment and installation of ArcExplorer itself. ArcExplorer has much of the same features as the browser based Java viewers and furthermore, is a convenient tool for presenting local data residing on the client machine.

6.3.2 Testing

Within IWICOS several tests have been conducted concerning client/server performance in relation to a variety of MapServices and types of clients. ArcIMS have mainly been used to serve an archive of sea ice data for the Greenland and Icelandic waters. The archive consist of weekly ice analysis covering all Greenland waters for the years 2000 and 2001. Based on this archive a set of statistical data have been produced which includes parameters like *frequency* and *minimum/maximum extents* of sea ice for different concentration levels throughout the year 2000. These statistical data has then been authored using ArcIMS and presented using the HTML client. An example is shown in Figure 6.11. The client is also capable of presenting meteorological and oceanographic parameters as point and isoline features (see Figure 6.12).

The tests conducted with ArcIMS has shown limitations in the server performance and some difficulties with file handling, especially when installed on a Sun Solaris platform. Although these tests have revealed some problems and limitations to the amount of data that can be served, there is, from the authors point of view, a potential for distributing met-ice-ocean information through the ArcIMS. The server side manager environment is well functioning and provides good administrative possibilities for handling MapServices. On the client side the capabilities of out-of-the-box solutions means that data can be presented conforming to standards like WMO. However, more testing and server side configuration are required before the system becomes operational.

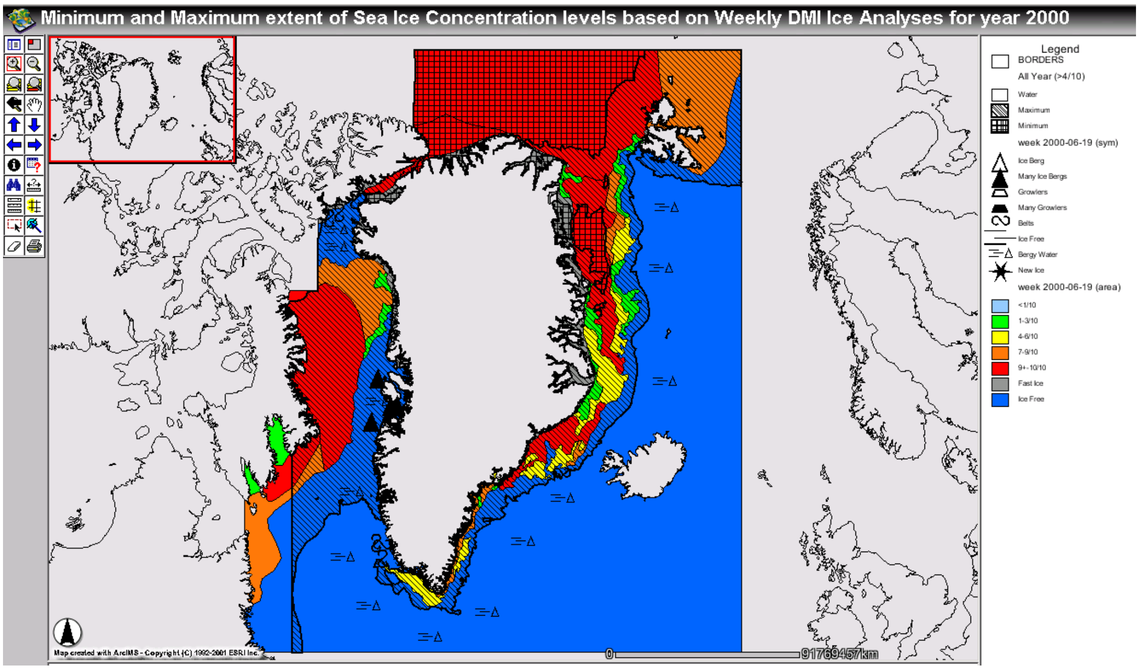


Figure 6.11 Example of the HTML viewer showing sea ice information. The coloured ice chart is a situation in June represented as a weekly chart, overlayed by a hatched layer indicating minimum/maximum limits for ice concentration > 4/10 for year 2000. Note other client features like the toolbar to the left, the legend to right and an overview map in upperleft corner.

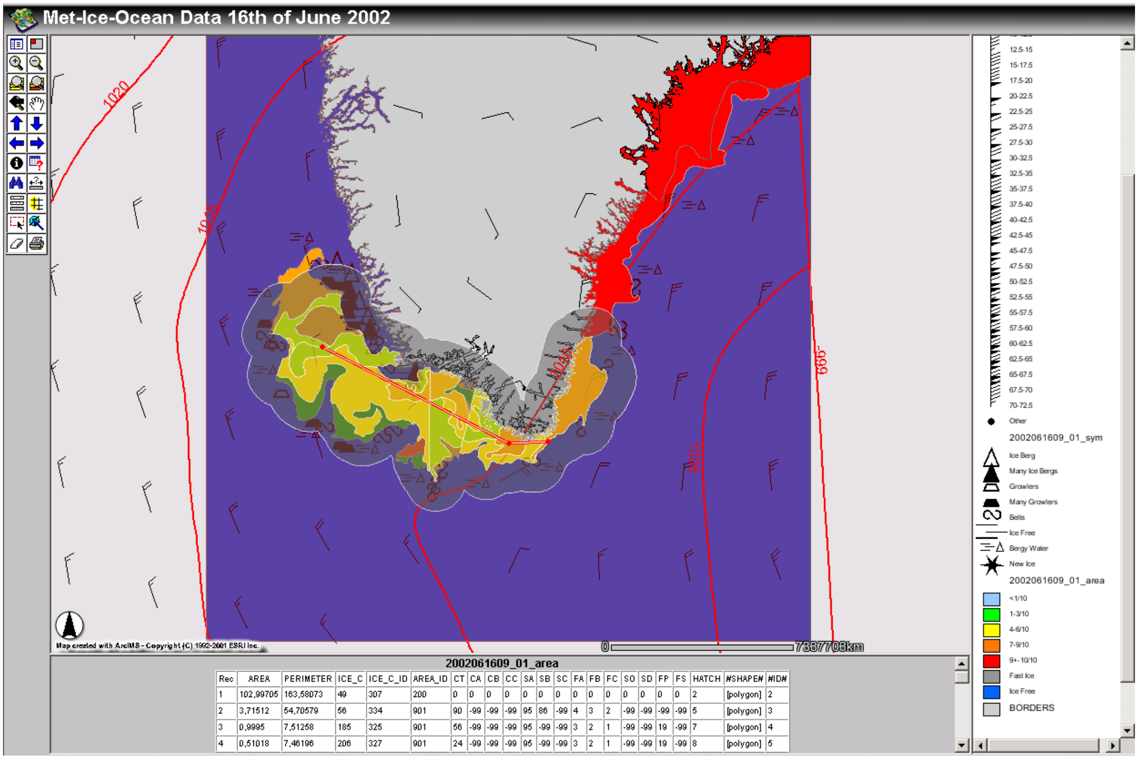


Figure 6.12 An ice situation at Cape Farewell from 16th of June 2002. Wind barbs and MSL Pressure are shown for the same day. A 50 km buffer has been applied to a selected set of the ice areas circumventing Cape Farewell. Attribute information of selected ice features are shown at the bottom of the viewer.

6.4 *The DTU Façade – Balanced Client System*

The target user group for this client has evolved over time as new users were attracted by the available service and facilities. It now includes the following user groups:

1. Scientists involved in polar research
2. Operational ice centers
3. Polar research institutions
4. Shipping companies
5. Fisheries
6. Insurance companies
7. Oil companies

These users all access the service via the Internet. The capabilities in terms of available bandwidth vary a lot. The system was originally developed for Internet access via standard 56K telephone modems. Over the past couple of years we have expanded some of the data and in particular the coverage to larger areas, so an ISDN or ADSL connection is preferable although the 56K modem connection will still work. In order to allow the user to interactively select and combine datasets from the data archive, a JAVA applet was developed. It will run in a standard web browser with JAVA support such as Netscape or MS Internet Explorer or using Sun's appletviewer.

The main purpose of the demonstration was to show that a valuable service can be built around freely available data sources (Primarily of US origin), and requiring no software licences for the full client functionality.

A variety of coarse resolution near real time satellite data sources were identified and processing chains were established.

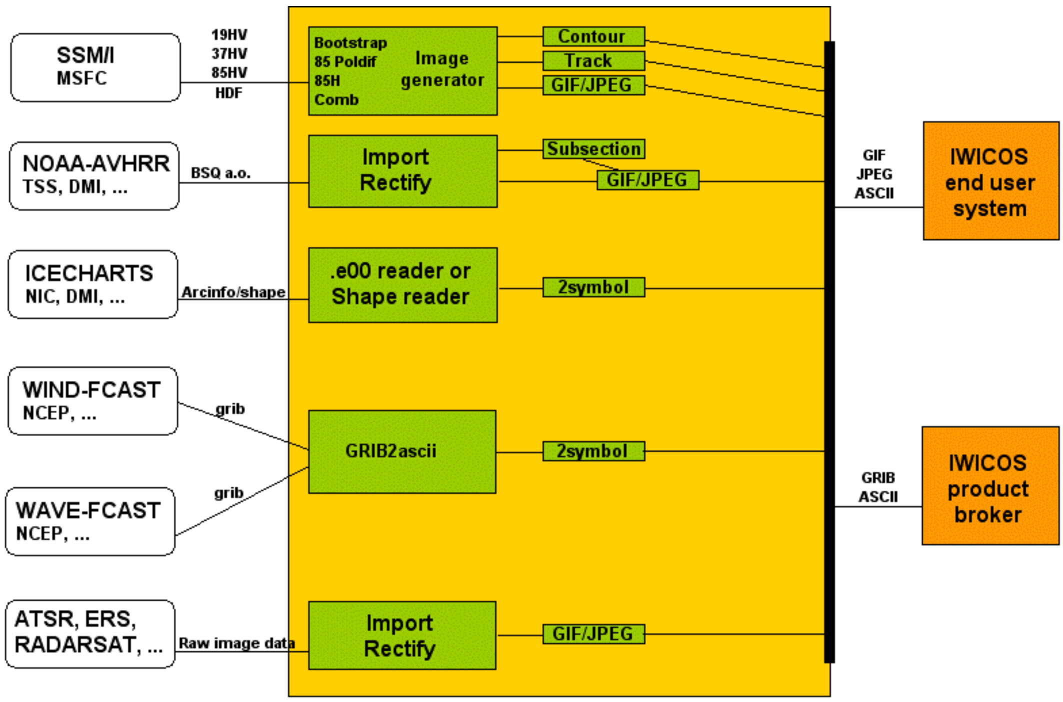


Figure 6.13 DTU processing chains.

6.4.1 *Data sources*

All data are automatically gathered from the Internet. We are continuously looking for new data sources, to expand our coverage, to become independent of single sources, and to be able to include new facilities, higher resolution and/or more timely data.

The main sources are:

SSM/I data
The Global Hydrology Resource Center (GHRC) provides both historical and current Earth science data, information, and products from satellite, airborne, and surface-based instruments. The GHRC acquires basic data streams and produces derived products from many instruments spread across a variety of instrument platforms. The GHRC is supported by NASA and is the data management and user services arm of the Global Hydrology & Climate Center (GHCC) in Huntsville, Alabama.

QuikSCAT data
Quikscat scatterometer data are provided by IWICOS partner DMI. The data are provided as ascii files containing latitude and longitude coordinates, HH and VV backscatter as well as wind speed and direction.

AMSU data
The Cooperative Institute for Research in the Atmosphere, CIRA was established at Colorado State University in 1980 to increase the effectiveness of atmospheric research in areas of mutual interest between the National Oceanic and Atmospheric Administration (NOAA), Colorado State University and other groups.

CIRA operates an extensive satellite earthstation. CIRA's earthstation first collected GOES weather data in 1980. Since then, CIRA's earthstation has collected from each succeeding GOES satellite. Currently, CIRA collects GOES-8, and GOES-10. In addition to GOES, CIRA also collects conventional surface and upper air data, Meteosat, AMSU and AVHRR data. These data products are collected in their high resolution form for CIRA researchers.

NOAA AVHRR data
Tromsø Satellite Station AS. TSS operates two ground stations for downloading, processing, disseminating and storing of data from polar orbiting satellites. Based on data from satellites, TSS offers earth observation products and monitoring services to customers within our coverage area, in near real-time.

Sea Surface Temperature data
Top Karten. Zusammenstellung von für Europäer interessanten Wetterkarten (Analysen und Prognosen, Beobachtungen, Satbilder usw.). Die meisten selbst erzeugt. Original data from NOAA.

Wind and Wave forecasts

The Marine Modeling and Analysis Branch is part of the Environmental Modeling Center, which is responsible for the development of improved numerical weather, marine, and climate prediction modeling systems within US NCEP/NWS. Provides analysis and real-time forecast guidance (1-16 days) on marine meteorological, oceanographic, and cryospheric parameters over the global oceans and coastal areas of the US.

Digital Ice Charts
The National Ice Center (NIC) is a multi-agency operational center representing the Department of Defense (Navy), the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the Department of Transportation (Coast Guard). The NIC includes personnel from the National Environmental Satellite Data Information Service (NESDIS) within NOAA.

6.4.2 The Client (JAVA browser)

The JAVA applet supports among others the following capabilities when accessing the DTU/DCRS façade:

- Access to data archive via the internet
- display of colour and B&W satellite imagery
- display of colour coded derived digital ice maps
- user controlled colour & greyscale manipulation
- user controlled zooming in & out

- lat,lon co-ordinates of any point at the click of the mouse
- user controlled addition of (vector) overlays showing
  - coastlines
  - lat/lon grids
  - bathymetry
  - contours of ice concentration
  - contours of ice concentration from past
  - other auxiliary data (cruise tracks, float tracks, SAR frames,.......)
- User controlled vector overlay colouring
- user controlled adjustment for misregistration
- combine data from different sensors
- combine data from different dates/times
- reasonable data transmission times e.g. data compression of large files
- platform independence or something that would work with most potential customers!
- Parameter values (such as temperature or ice concentration) at the click of the mouse
- Easy shift (shortcut) to another date

Figure 6.14 shows the layout of the browser.

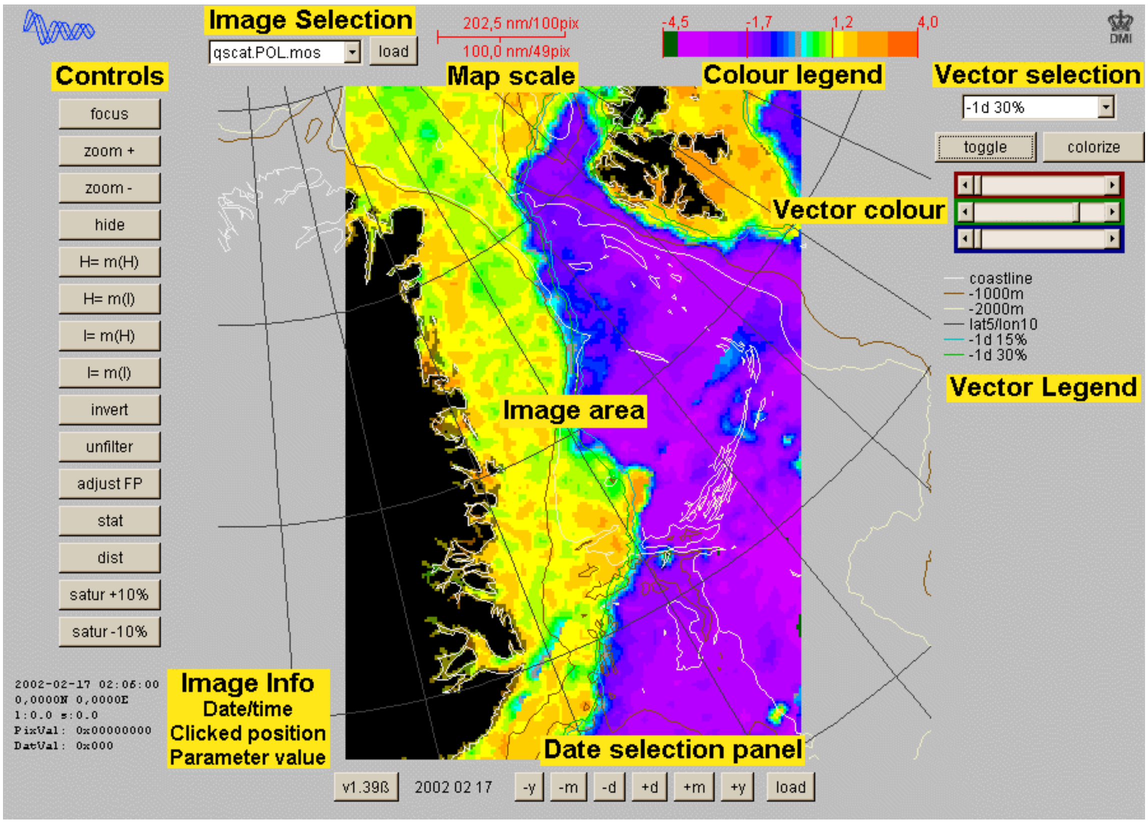


Figure 6.14 The screen layout of the DTU/DCRS JAVA browser for weather, ice and ocean information.

Examples of main users within the target user groups:

1. **Scientists involved in polar research**
   a. University of Iceland (IS)
   b. University of the Witwatersrand (ZA)
   c. Harvard University (US)
   d. Universite Catholique de Louvain (B)
   e. Svalbard University (N)
   f. Maritime University of Gdynia (PL)

    g. Universität Hamburg (D)
    h. Southampton University (UK)

2. **Operational ice centers**
    a. Danish Meteorological Institute
    b. Finnish Institute for Marine Research
    c. Icelandic Meteorological Office
    d. US National Ice Center
    e. Norwegian Meteorological Institute
    f. UK Met office
    g. Canadian Ice Service
    h. German Ice Service (BSH)

3. **Polar research institutions**
    a. British Antarctic Survey (UK)
    b. Arctic and Antarctic Research Institute (RU)
    c. Woods_Hole_Oceanographic_Institution (US)
    d. Scott Polar Research Institute (UK)
    e. Institut français de recherche pour l'exploitation de la mer (IFREMER)
    f. Alfred Wegener Institute (AWI)
    g. Baltic Sea Research Institute (Warnemünde)
    h. Deutsche Klimarechenzentrum
    i. Norwegian Polar Institute
    j. Department of Fisheries and Oceans (CDN)

4. **Shipping companies**
    a. Armada_Argentina
    b. Murmansk_Shipping_Copmany
    c. Princess Cruises

5. **Fisheries**
    a. Numerous internet providers from Norway, Iceland, Greenland, Russia.
    b. Ocean Prawns A/S

6. **Insurance companies**
    a. Bergens Skibsassuranseforening (N)
    b. Unitas Gjensidige Assuranseforening (N)

7. **Oil companies etc.**
    a. Exxon
    b. British Petroleum
    c. Kolenergo Murmansk
    d. Boliden Minerals (S)
    e. Greenlands Power Supply
    f. Statoil

6.5 Thin and thick clients designed for fisheries in Icelandic waters

6.5.1 Introduction

The biggest group of users of met-ice-ocean information in Icelandic waters are the fishermen. They can roughly be divided in two groups:

- Small boat owners, operating near the coast, often within range of mobile phones and arriving to the harbour daily.
- Captains/owners of bigger and better equipped vessels operating far from the coast for longer periods, out of range of mobile phones.

These two groups have similar needs for information but their possibilities to access data are quite different. Many small boat owners have the possibility to use the Internet most of the time while the captains of the bigger ships have to rely on satellite communication. It is therefore natural to develop two clients, thick and thin, to fulfil the needs of Icelandic fishermen for met-ice-ocean information.

6.5.2 Products available in both clients

Several products have been developed and they will be made available in both clients. Since the clients will from the beginning be used as important tools in the operational marine weather services offered by IMO these products will be improved and new products will be developed and included in the system.
The following products have already been developed:

- Graphical interface to traditional text forecast where forecasting areas are coloured by maximum windspeed
  - Gives a quick overview over the weather situation
  - Some times the coloured area might be sufficient
- Ocean wave forecast maps, significant wave height, mean wave direction and mean wave period
  - Useful for all kind of vessels at all distances from the coast to avoid dangerous situations
- Ice accretion forecast, colour code used to indicate rate of icing
  - Three icing classes shown: Moderate - Heavy - Extreme
  - Useful to vessels operating in areas where there can be risk for icing
- Forecasting diagrams (meteograms)
  - Show local weather forecasts for coastal stations as time series
  - Useful for vessels operating close to the coast, mainly small boats
- Sea ice maps
  - Show ice edge and concentration
  - Useful for vessels operating near the ice edge or in the ice

6.5.3 The thin client

The thin client is developed at IMO as a web site where as many as possible of the products seafarers need will be made available. The target user group is mainly small boat owners and other seafarers operating relatively close to the coast. A strong emphasis is placed on avoiding "heavy stuff" in order to make it possible to use mobile phones (GSM/GPRS) to access the web and download the products. The client will also be used at home before sailing and by the seamen's families while they are out at sea.

Figure 6.15 is a screen capture from the thin client showing the graphical interface to textual forecasts. Different products can be selected on the yellow horizontal bar. The area "Austurdjúp" (the red one) has been selected, a storm warning (Viðvörun) is displayed in the upper left corner and the text of the forecast itself below. Date and time of the forecast is given, also the time when the next forecast should be expected.

An icing forecast is shown in Figure 6.16. Consecutive forecast maps with six hours intervals can be selected from the turquoise horizontal bar.

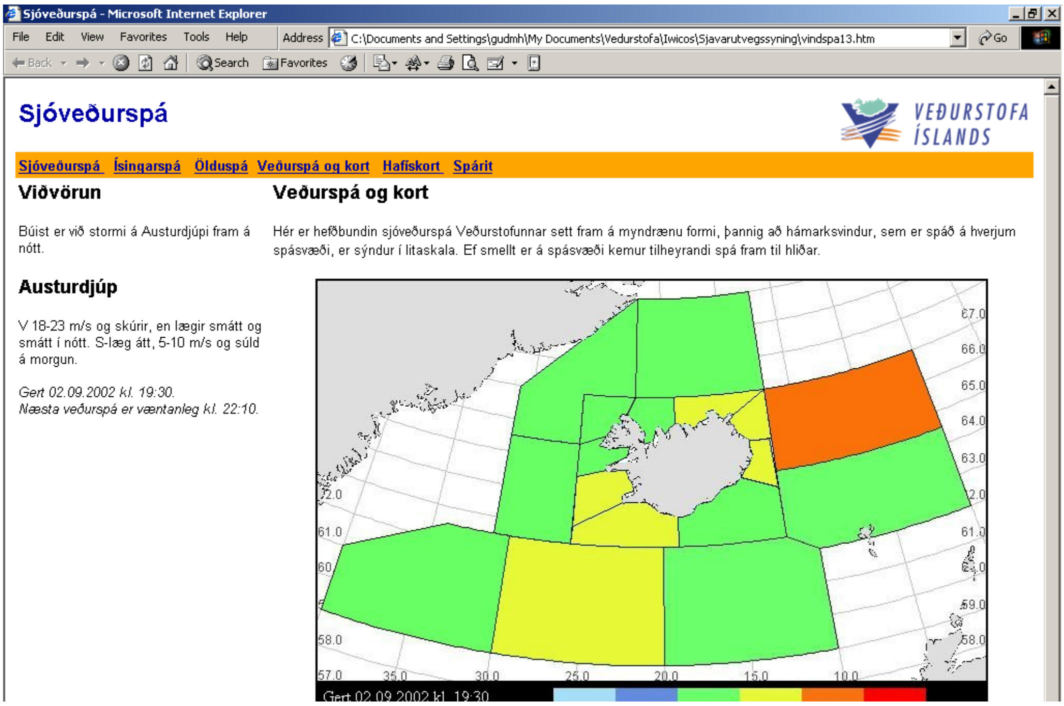


Figure 6.15 Screen capture from the thin client showing forecast areas coloured according to forecasted wind speed.

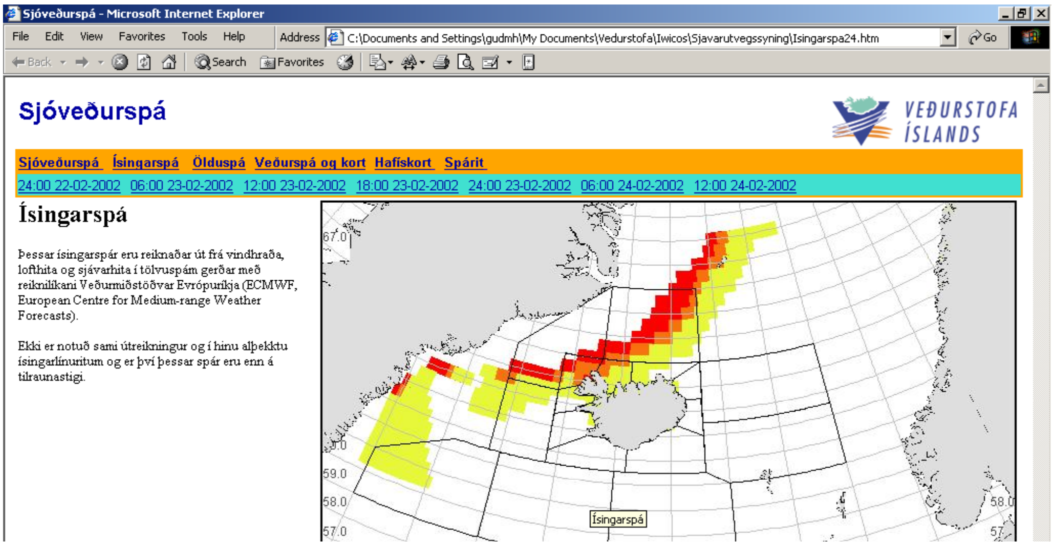


Figure 6.16 Screen capture from the thin client showing icing forecast.

6.5.4 *Birtir, the thick client*

The thick client is developed by Radiomidun and has been given the name Birtir (The Viewer). The software is installed on a PC onboard the ship. The target user group is captains of larger ships, out of reach for domestic communication. Several communication possibilities, such as Inmarsat Mini M, Iridium and Emsat can be used and the data is sent to the boat as an email attachment. The selection of met-ice-ocean products which will be made available through Birtir will be mainly the same as for the thin client but a range of other products will also be offered in Radiomidun's Service Bank.

In the beginning it was planned to integrate IWICOS products in existing Integrated Navigation Systems on board fishing vessels (like MaxSea), but due to various problems (technical and commercial) it was decided to design and develop a dedicated viewer “Birtir”. The viewer is a part of an Integrated Information System, which consists of an Ordering System (over the Internet) and the Viewer “Birtir”.

The Ordering System is accessed over the Internet, were the user orders various types of information packages. The most important information package is the weather information which was developed in the IWICOS project. Examples of other information packages are: daily news, currency rates and restricted fishing areas. The user decides, through the Ordering System, how frequent and at what hours the package is sent to the vessel. The background work of the Ordering System is to extract predefined and constantly updated XML files from the content providers; the IWICOS broker, Morgunblaðið (daily newspaper) and the Fishing Control, etc. The selection of met-ice-ocean products will mainly be the same as for the thin client, as well as the outlook.

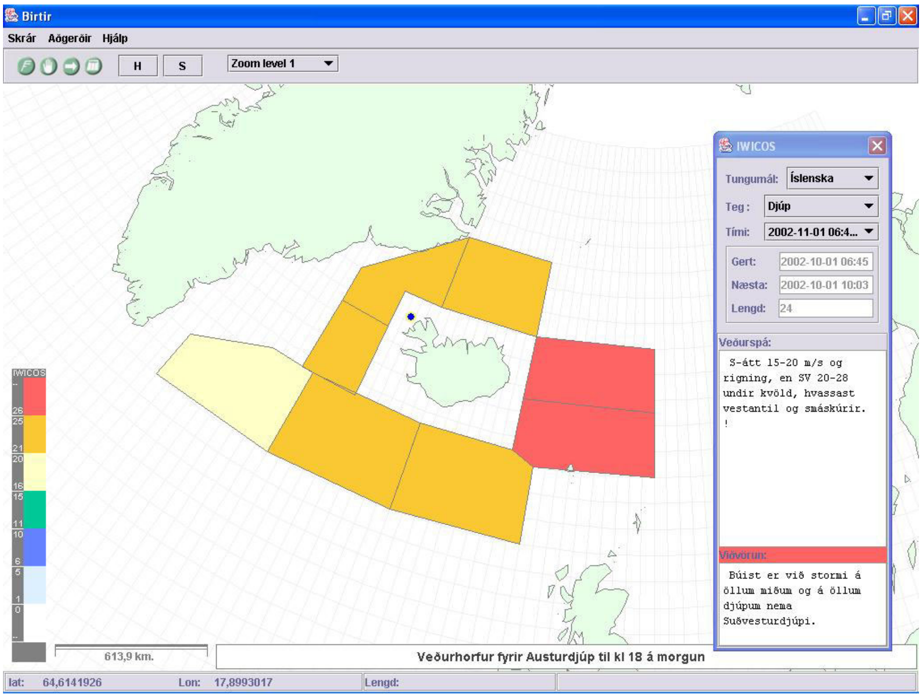


Figure 6.17 Screen capture from Birtir. Weather forecast for high seas has been selected.

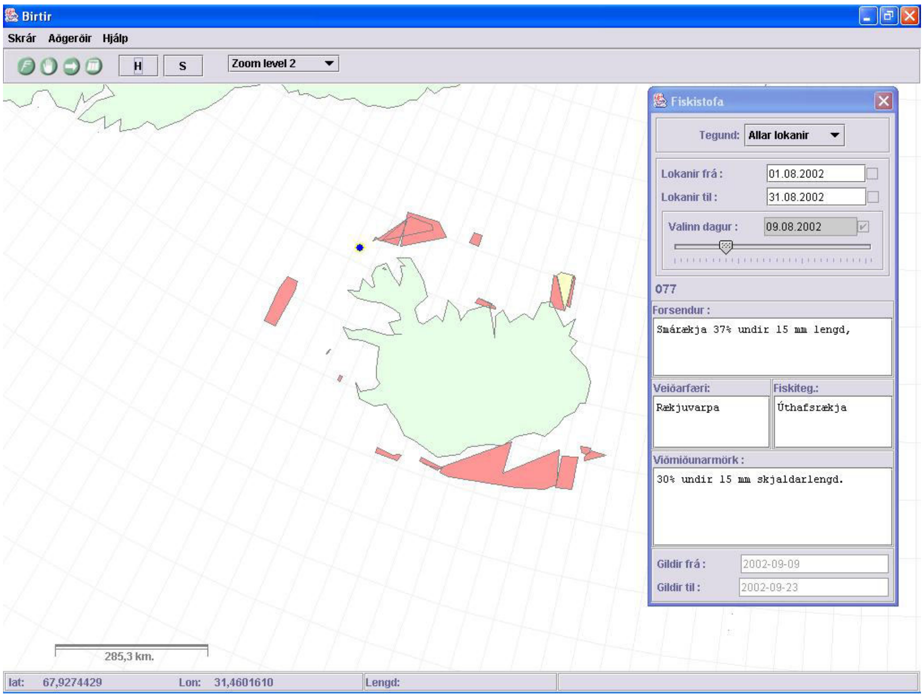


Figure 6.18 Example of fishing restriction areas.

6.5.5 *Data storage and development*

All IWICOS data at IMO are kept in a relational database, IBM's DB2. Text forecasts are generated in a text editor and then moved into the database and time stamped. Maximum forecasted wind is calculated from the text files by a C-program and stored in the data base in connection with the text files. The direct model output in GRIB files (Gridded Binary files), containing the numerical weather forecast and the wave forecast, is converted to ASCII-files by a C-program and then stored in database tables. The local forecasts (point forecasts) are interpolated from the direct model output and Kalman-filtered by a C-program and then stored in the database. Ice accretion is calculated inside the database by a Java procedure and stored in same kind of tables as the direct model output.

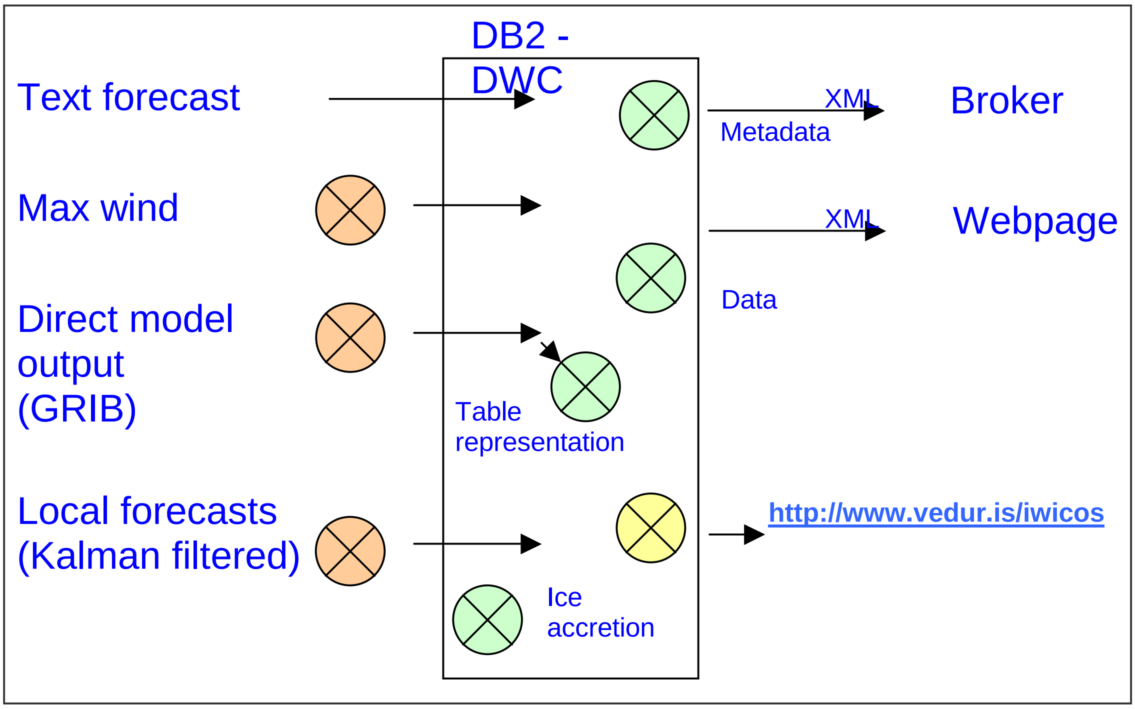


Figure 6.19 IWICOS environment at IMO.

6.5.6 *Application development*

IBM's Websphere Application Studio has been used for application development and all data generation inside the database and end user output is solved by Java-based stored procedures. Websphere was also used to generate Data Access Definition files from an XML-schema or a DTD schema with a direct connection to the database tables. This makes it very easy to automatically generate XML-files both for the Broker and for end user purposes.

6.5.7 *Job management*

For job management inside the database IBM's Data Warehouse Control Center was used. It starts the XML-extender to generate new sets of XML-files as soon as new data appears in the database tables and ensure that old data is outdated. The DWC is also used to start generation of maps and diagrams used by IMO's thin client.

It can also be mentioned that the DWC controls communication with the IWICOS-broker through the SOAP-protocol.

6.6 A thick client for sea ice studies

The Sea Ice Viewer (SIV) has been developed to support scientists and students in polar sciences. SIV will help users find relevant data and include analysis and presentation tools. To find data, users can define an area and time range of interest, as well as a list of parameters and which producer they prefer to get data from. Each of the four query criteria (area, time, parameters, producer) is optional, and any combination of them is allowed. Hence, many different types of queries can easily be constructed in the SIV application by using the same dialog window (Figure 6.20). When the user has given the search criteria, SIV generates an XML query, which is sent to the Broker. The result, another XML file, is then interpreted, and key metadata attributes extracted to e.g. display the location of a product on a map (Figure 6.21). In addition, SIV can display the full metadata description for any of the retrieved products after conversion to HTML format, and single image products in a separate window. The SIV application is still under development, and new features will be added up to the end of the project.

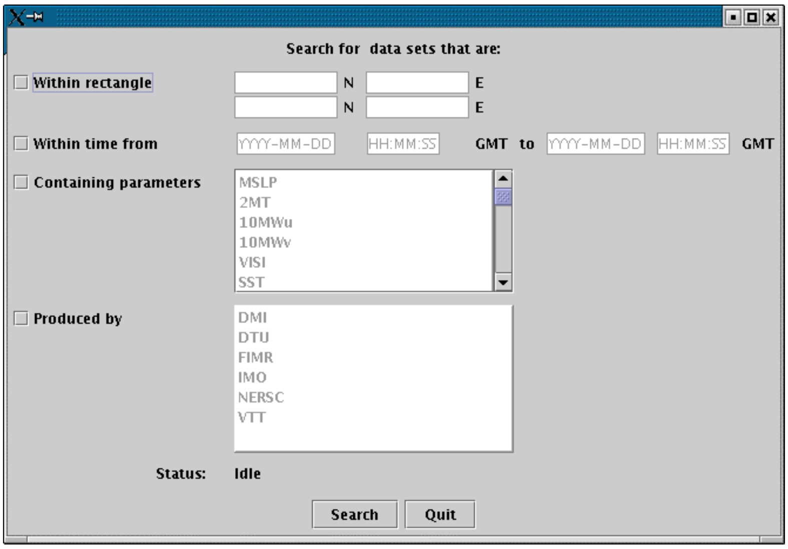


Figure 6.20 Query composition dialog in the SIV application.

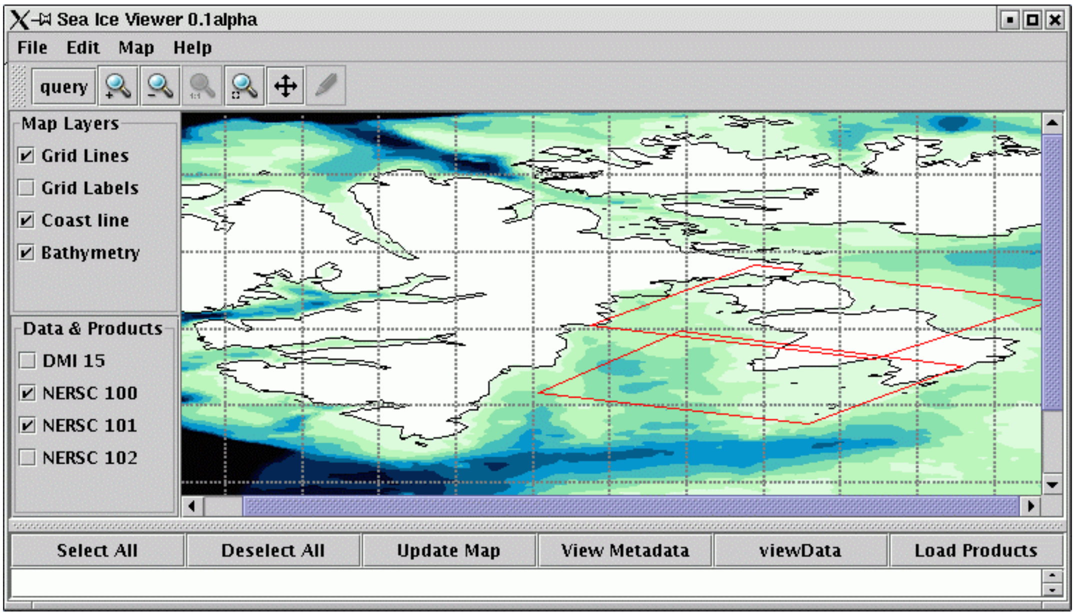


Figure 6.21 Main window of the SIV application.

7 Demonstrations carried out in 2002

Four full-scale demonstrations have been carried out in 2002 (Table 7.1).

The first of these was carried out for a scientific cruise in the Fram Strait in March. During this period the IWICOS Broker and End-User System (ViewIce client) were demonstrated to crew onboard the Finnish research vessel R/V Aranda, operating aroung 80ºN. Alltogether, the operators downloaded 196 files, of which 66 were satellite images, 73 wind forecasts, 25 pressure forecasts and 32 ice drift data files. The Iridium communication satellite was used for data transfer. The IWICOS System operated very satisfactory and the user feedback was positive.

The second onboard demonstration of the IWICOS System was done during Arina Arctica’s two cruises to Greenland Waters in May-July and August-September. DMI’s thick client, the MIO Viewer, was installed onboard the vessel and used operationally to display and analyse met-ice-ocean observed data and forecasts. Inmarsat-B and –C were used for communication, and a total of 185 data packages consisting of 11 satellite images, 11 ice analyses, 375 pressure forecasts, 375 wind forecasts, 300 wave forecasts, 300 swell forecasts and 13 textual weather forecasts (for Icelandic Waters) were downloaded to the ship. The IWICOS System and the MIO Viewer operated as planned, and the overall user feedback was positive.

The IWICOS project and Icelandic products and clients were demonstrated at a large exhibition in Iceland 4-7 September. The Icelandic Fisheries Exhibition 2002 had more than 18000 visitors, and about 800 exhibitors from 37 countries. During the exhibition, IMO’s thin web client and Radiomidun’s thick client were demonstrated, and an Icelandic IWICOS brochure distributed. Visitors marked at Captain/Owner were picked out and asked to answer a brief questionnaire. In total 95 captains/owners were interviewed.

The EMI Interactive Java client has been providing sea ice, ocean and meteorological products as a public service throughout 2002. This includes support of specific operations: Lance (March), Ocean Tiger (May) and JRC/BAS (October). Data and information has been generated for both Arctic and Antarctic areas. Users are located world-wide, and web logging mechanisms are being used to generate statistics for use.

Further information on these demonstrations can be found in the Demonstration and Validation Report (IWICOS Deliverable D6, IWICOS Report no. 5).

Table 7.1 IWICOS demonstrations in 2002.

Demonstration	**Client**	**Target user groups**	**Area**	**Time period**
Aranda expedition	ViewIce	Ice navigation support	Fram Strait	March 2002
Arina Arctica voyages to Greenland	MIO Viewer	Navigation	North Atlantic and Greenland Waters	June - September
Icelandic Fisheries Exhibition	Birtir (thin and thick client)	Fisheries	Icelandic Waters	September
Continuous web services	EMI Interactive	many	Arctic and Antarctic	continuous

8 Conclusions

This report has described the IWICOS Extended System, with focus on new features and technological solutions, compared to those of the Baseline System.

The IWICOS metadata specification was upgraded to the latest XML Schema recommendation and only a few minor additions to the structure were found necessary. Thus, the modifications needed in the various Producer Systems were small, and the effort put into defining an IWICOS metadata standard in the beginning of the project paid off.

The Broker was updated to handle the new metadata specification, and was also upgraded to use newer versions of standards like SOAP that had been established since the Baseline version. The implementation of secure data transfer was the most time consuming part of the Extended Broker development, and required more resources than originally planned. However, this feature will be an important component in a future operational version of the IWICOS System, justifying its inclusion in a prototype system.

Baseline products were refined and new products developed to meet the needs for better information on met-ice-ocean conditions for users at sea or decision-makers planning operations at sea. Feedback obtained during demonstrations has been generally positive, indicating that the chosen products were useful. Further development and improvement of products in cooperation with users is foreseen.

The development of enhanced End-User Systems included both support of new product types and of new functionality, and thus required much work. User feedback from the baseline system as well as continued contact with users during the extended system development phase were used in this process, to ensure implementation of high-priority features with a user-friendly interface. As the End-User Systems are the most ‘visible’ parts of the IWICOS System, making them easy to operate is crucial to the users’ perception of usefulness and value of the overall system.

On the whole, the Extended System has advanced the Baseline System solution by: (1) upgrading to the latest version of standards and protocols used in software development, (2) revising the IWICOS metadata standard to cater for new product types (although it turned out that only minor changes were needed), (3) implementing secure data transfer to the Broker by means of standard encryption techniques, (4) enhancing the functionality of the End-Users Systems, and (5) making more and new types of met-ice-ocean products available. By means of the Extended System, four full-scale demonstrations have been carried out for different end-user groups in different geographical regions, yielding valuable experience and feedback for future development.

9 Acknowledgements

The IWICOS project group members wish to express their appreciation of the involvement of the University of Iceland by Dr. Ingibjörg Jonsdottir, and gratefully acknowledge the help of all end-users who have contributed with constructive ideas during the project.

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- NOAA
- US National Center for Environmental Projection
- Tromsø Satellitstation
- US. National Ice Center
- Cooperative Institute for Research in the Atmosphere, Colorado State University

10 References

Engelschall, Ralf S., "mod_ssl: Introduction", http://www.modssl.org/docs/2.8/ssl_intro.html

Federal Geographic Data Committee (2000): Content Standard for Digital Geospatial Metadata Workbook Version 2.0. Federal Geographic Data Committee, Washington, D.C.

Johannessen, O. M., E. V. Shalina and M. W. Miles, 2000, "NORSEX CD-ROM: NORSEX Sea Ice Concentration in the Arctic, Nov. 1978 – Dec. 1999 Including MY Ice Concentration During Winter Months". Version 1.0, 27 November 2000. Nansen Environmental and Remote Sensing Center.

Karttunen, S., Nikulin, H., 'XML Applications as Middleware and Metadata for Workflow in Print and Cross-Media Production', VTT Information Technology, 1999.

Karvonen, J. 2000: "A Simplified Pulse-Coupled Neural Network Based Sea-Ice Classifier with Graphical Interactive Training", Proc. IEEE International Geoscience and Remote Sensing Symposium (IGARSS'00), v II, pp 681-684, 2000.

Karvonen, J., J. & Simila, M. 2001: "Independent Component Analysis for Sea Ice SAR Image Classification", Proc. IEEE International Geoscience and Remote Sensing Symposium (IGARSS'01), v. III, pp. 1255-1257, 2001.

Karvonen, J., Simila, M. & Makynen, M. 2002: "An Iterative Incidence Angle Normalization Algorithm for Sea Ice SAR Images", Proc. of the International Geoscience and Remote Sensing Symposium 2002 (IGARRS'02), 2002.

Lassila, Ora, Ralph R. Swick, 'Resource Description Framework (RDF) Model and Syntax Specification', W3C Recommendation, 1999.

Makynen, M., Manninen, T., Simila, M., Karvonen, J. &, Hallikainen, M.: "Incidence Angle Dependence of the Statistical Properties of C-Band HH-Polarization Backscattering Signatures of the Baltic Sea Ice", accepted for publication in IEEE Transactions on Geoscience and Remote Sensing.

Makynen, M., Manninen, T., Simila, M., Karvonen, J. & Hallikainen, M. 2002: "Incidence Angle Dependence of the Mean C-Band HH-Polarization Backscattering Signatures of the Baltic Sea Ice", Proc. of the International Geoscience and Remote Sensing Symposium 2002 (IGARRS'02), 2002.

ModSSL, mod_ssl, http://www.modssl.org

OpenSSL, OpenSSL, http://www.openssl.org

RSA, RSA Security, "SSL Basics for Internet Users", http://www.rsasecurity.com/standards/ssl/basics.html

Steen Andersen, Henrik, Halla Björg Baldursdóttir, Robin Berglund, Kristjan Gislason, Jyrki Haajanen, Gudmundur Hafsteinsson, Torill Hamre, Thor Jakobsson, Ingibjörg Jonsdottir, Ville Kotovirta, Morten Lind, Leif T. Pedersen, Roberto Saldo, Stein Sandven, and Ari Seinä. IWICOS Report No.2. NERSC Technical Report No. 204, December 2001.

Steen Andersen, Henrik, Halla Björg Baldursdóttir, Robin Berglund, Kristjan Gislason, Jyrki Haajanen, Gudmundur Hafsteinsson, Torill Hamre, Thor Jakobsson, Ingibjörg Jonsdottir, Kjell Kloster, Ville Kotovirta, Morten Lind, Tor I. Olaussen, Leif T. Pedersen, Roberto Saldo, Stein Sandven, and Ari Seinä. IWICOS Report No.1. NERSC Technical Report No. 189, September 2000.

W3C Recommendation (2000) a: Extensible Markup Language (XML) 1.0 (Second Edition). http://www.w3.org/TR/2000/REC-xml-20001006

W3C Recommendation (2001) a: XML Schema Part 0: Primer. http://www.w3.org/TR/2001/REC-xmlschema-0-20010502

W3C Recommendation (2001) b: XML Schema Part 1: Structures. http://www.w3.org/TR/2001/REC-xmlschema-1-20010502

W3C Recommendation (2001) c: XML Schema Part 2: Datatypes. http://www.w3.org/TR/2001/REC-xmlschema-2-20010502

World Meteorological Organization (1970). WMO Sea-Ice Nomenclature, WMO-No. 259.

World Meteorological Organization (1992). Manual on the Global Data-Processing System, Volume 1, WMO-No.485.

World Meteorological Organization (1994). Guide to the Applications of Marine Climatology. WMO-No. 781.

Appendix A: Summary of Questionnaire to the Users

To update the information regarding the capabilities at sea, a Questionnaire was sent to selected potential users in the Baltic Sea and for users in the Greenland Sea. The questionnaire indicates that E-Mail is used on almost all ships at the moment, and is estimated to be used 100% within two years. All ships have GSM-data, but this can be used only when the ship is within reach of the base station. For ships whose route is mainly in the Baltic sea, the time when out of reach is about 10 hours, for the passenger ferries even less than this, but in the Greenland Sea the ships are out of reach of the cellular phone system 95% of the time.

High speed satellite links at sea are still not common, but within 2 years of time a third of the ships in the shipping companies that replied to the questionnaire, will have a high speed link, either on permanent or on-demand basis.

The questionnaire and the answers are given below:

Questionnaire

Background: IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres. To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.		
Date:		
Shipping Company/ or Name of ship:		
Sea area (Baltic Sea , Greenland Sea etc..):		
Size of the ship(s) (DWT):		
Type of ship(s):		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)		
2) E-mail on-board (store-and-forward connection)		
3) Other data service, what?		
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge		
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)		
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)		
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL		
e) GSM-data connection		
f) NMT with modem		
g) INMARSAT-C (with data communication ability)		
h) other data connection - what kind? (ORBCOMM etc..)		
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours:		
Other comments:		

THANK YOU FOR YOUR COOPERATION.
PLEASE RETURN THE QUESTIONNAIRE TO: Robin Berglund, VTT,
PB 1201, FIN-02044 VTT or FAX: +358 (0)9 456 6027 (or by E-mail to robin.berglund@vtt.fi)

Replies

Background: IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres. To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.		
Date: 7.5.2001		
Shipping Company/ or Name of ship: Finnlines plc		
Sea area (Baltic Sea , Greenland Sea etc..): Baltic		
Size of the ship(s) (DWT): 6000-15000		
Type of ship(s): RoRo, RoPax		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)	7	20
2) E-mail on-board (store-and-forward connection)	23	23
3) Other data service, what?	3	23
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge		
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)		2
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)		
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL	3	3
e) GSM-data connection	23	23
f) NMT with modem		
g) INMARSAT-C (with data communication ability)		
h) other data connection - what kind? (ORBCOMM etc..)		
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours: 10		
Other comments:		

<table>
<tr><td colspan="3">Background:
IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres.
To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.</td></tr>
<tr><td colspan="3">Date:</td></tr>
<tr><td colspan="3">Shipping Company/ or Name of ship: Viking Line Abp (7 ships)</td></tr>
<tr><td colspan="3">Sea area (Baltic Sea , Greenland Sea etc..): Baltic</td></tr>
<tr><td colspan="3">Size of the ship(s) (DWT): about 10 000 - 45 000 (gross tonnage)</td></tr>
<tr><td colspan="3">Type of ship(s):): Ro-Ro passenger ferries</td></tr>
<tr><td>Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)</td><td>Situation now (April 2001)</td><td>Estimate 2 years from now</td></tr>
<tr><td colspan="3">Data communication applications used:</td></tr>
<tr><td>1) Web (Internet) access on-board (interactive connection)</td><td>6 of 7</td><td>Whole fleet</td></tr>
<tr><td>2) E-mail on-board (store-and-forward connection)</td><td>6 of 7</td><td>Whole fleet</td></tr>
<tr><td>3) Other data service, what?</td><td>On-line 24 h/day to shorebased network</td><td></td></tr>
<tr><td>4) None of the above.</td><td></td><td></td></tr>
<tr><td colspan="3">In the case of 1) ,2) or 3) what is the data connection based on:</td></tr>
<tr><td>a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge</td><td>6 of 7</td><td>Whole fleet</td></tr>
<tr><td>b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)</td><td></td><td></td></tr>
<tr><td>c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)</td><td></td><td></td></tr>
<tr><td>d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M) + EMAIL</td><td></td><td></td></tr>
<tr><td>e) GSM-data connection</td><td>Whole fleet</td><td>Whole fleet</td></tr>
<tr><td>f) NMT with modem</td><td></td><td></td></tr>
<tr><td>g) INMARSAT-C (with data communication ability)</td><td></td><td></td></tr>
<tr><td>h) other data connection - what kind? (ORBCOMM etc..)</td><td></td><td></td></tr>
<tr><td colspan="3">If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?</td></tr>
<tr><td>Time in hours: 10</td><td></td><td></td></tr>
<tr><td colspan="3">Other comments:</td></tr>
</table>

Background: IWICOS - Integrated Weather, sea Ice and ocean Service System aims at developing a prototype marine information system which will provide a single-entry access to meteorological, sea ice and oceanographic (met-ice-ocean) data and products in electronic form provided by weather forecasting, ice and research centres. To get a realistic view of the communications capabilities of the potential users of the system we would appreciate if you could answer the following questions.		
Date: 01. Feb. 2001		
Shipping Company/ or Name of ship: Royal Arctic Line		
Sea area (Baltic Sea , Greenland Sea etc..): Greenland Waters		
Size of the ship(s) (DWT: 4990, 4523, 5817, 9556, 9556		
Type of ship(s):): 4 containerships, 1 break bulk vessel		
Question: (If you represent only one ship the answer to most questions is YES/NO, otherwise the answer represents the NUMBER of ships having the requested capability)	Situation now (April 2001)	Estimate 2 years from now
Data communication applications used:		
1) Web (Internet) access on-board (interactive connection)	No	yes
2) E-mail on-board (store-and-forward connection)	Yes	yes
3) Other data service, what?	Skamlebæk radio (HF, Mufax)	
4) None of the above.		
In the case of 1) ,2) or 3) what is the data connection based on:		
a) High speed (64 kbit/s or higher) Web-access all the time (also at sea) with fixed charge	No	no
b) High speed (64kBit/s or higher) Web-access on demand (also at sea). Charge per minute connection time. (INMARSAT -B HSD)	No	yes
c) Medium speed link (9.6 kbit/s) on demand (INMARSAT -B LSD)	Yes (2 ships)	
d) Low speed link (2.4 kbit/s) on demand (INMARSAT MINI-M)+EMAIL		
e) GSM-data connection	Yes	yes
f) NMT with modem	Yes	yes
g) INMARSAT-C (with data communication ability)	Yes	yes
h) other data connection - what kind? (ORBCOMM etc..)	INMARSAT-A (3 ships)	
If you are using a cellular network (i.e. GSM data or NMT + Modem), for how long time is your ship(s) out of reach of the network during normal voyages/operations?		
Time in hours:	95 % of the time	
Other comments: see next page		

Data sent via	*Inmarsat*	*Mobile phone*	*VHF*	*HF*
Mufax	no	no	yes[1]	yes
Telefax	yes	yes[2]	yes[3]	no
email	yes	yes[2]	yes[3]	no

[1] Reception of Ice Charts as Mufax via VHF (Greenland VHF net) is possible, but requires special connection between Mufax and VHF.

[2] Reception radius is limited and determined by geographical position since antenna and mobile phone has to be within sight of one another. Furthermore a very stable connection is required.

[3] Reception is only possible coastwise and the connection has to be very stable. Thus it is not possible to maintain a stable connection where transmitters of VHF network overlap. Furthermore special equipment is required between VHF and Telefax and between VHF and computer.

NB: On the east coast of Greenland, the only option vessels have for receiving data is via Skamlebaek Radio (Denmark) as Mufax and, when situated below 70º N, through Inmarsat. Inmarsat guarantees communication up to 70º N although in reality it has shown possible to receive data up to app. 76º N. However the reception above 70º N depends on how stable the ship antenna is. This means that reception is weather dependant.