DEVELOPMENT OF WEB-BASED ICE INFORMATION SYSTEM

S. Li [a,] *, C. Xiong [a], Z. Ou [b]

[a] Dept of Civil Engineering, Ryerson University, 350 Victoria St., Toronto, Ontario, Canada - (snli, cxiong)@ryerson.ca
[b] Canadian Ice Service, Environment Canada, 373 Sussex Dr., Ottawa, Ontario, Canada - Ziqiang.Ou@ec.gc.ca

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ABSTRACT:

Sea ice data has significant scientific value for climate studies, environmental impact studies, and engineering studies for the construction of facilities in Arctic waters, as well as support for tourism and fishing planning. Large collections of such data are acquired, compiled, produced and maintained by national and international agencies such as the Canadian Ice Service (CIS). However, current data dissemination and distribution practices do not foster an easy access to and use of the data, especially given the huge amount of archived sea ice data and the nature of their spatial changes and frequent temporal variations. This paper reports an effort in developing a web-based ice information system using geographical information system (GIS) technology. The system provides web-based tools to facilitate the exploration, visualization, analysis and downloading of historical sea ice data. The CIS Archive and related services are examined for the system design and development.

1. INTRODUCTION

Sea ice data has not only significant scientific values for climate studies, but also practical use for legal claims and other applications such as tourism and fishing planning, environmental impact studies, and engineering construction design and planning (CIS 2006). The data faces the problems similar to that of other arctic scientific data, such as potential of extinction if not well protected and archived, inaccessibility to the user communities, and relative difficulties in using it by researchers without sophisticated information technology skills (Sorensen et al. 2001, Tang & Wong 2006).

The World Wide Web (the Web) provides an excellent platform to disseminate data and information about ice in its many forms, e.g., sea ice, lake ice, river ice and icebergs, covering different waters, and, to some extent, to facilitate the online use, analysis and visualization of such data. With the support of web mapping, geographical information system (GIS) and spatial databases, better approach may be developed for these purposes. An examination of existing ice data management practices reveal that majority of organizations only use the Web as a simple data dissemination platform, while a few started to incorporate mapping, GIS, animation and scientific visualization techniques to provide more ice data, ice mapping and other related services.

Examples include ArcIMS Antarctic GIS for ice mapping (http://ims.geog.canterbury.ac.nz/anta/basic/viewer.htm), an interactive display of current daily and weekly products and icebergs from the US National Ice Centre (NIC) (http://www.natice.noaa.gov/), and the arc research mapping application (ARMAP), a suite of online, interactive maps and services that support Arctic science and that has sea ice coverage (http://armap.org/). However, these recent systems provide only limited simple functions for accessing and visualizing ice data. Data downloading is pre-defined and pre-packed with no support for users to define their own area of interest, etc.

The development involving web-based mapping/GIS is still in its early stage, requiring further investigations into related database design, technology and service evaluation, usability study, related policies, etc. The study reported in this paper examines the data available at Canadian Ice Services (CIS), identifies the need of serving these data online as well as their target user groups, evaluates the existing approaches of making this kind of data online, and designs and develops a prototype web-based ice information system. It is expected that the study will provide some preliminary recommendations to CIS for the future improvement to its online ice data services. The outcomes should be of interest of other similar organizations.

2. CIS SEA ICE DATA ARCHIVE

The Canadian Ice Service (CIS) of Environment Canada is responsible for providing the most timely and accurate sea ice and iceberg information under the Canadian Federal Ice Program (CIS 2006). Figure 1 shows the regions with ice information coverage, namely Western Arctic, Eastern Arctic, Hudson Bay, East Coast and Great Lakes. Among the data compiled and produced by the CIS Integrated Spatial Information System for Ice Service (Ou 2002), image analysis charts, ice and iceberg charts, regional ice analysis charts and bulletins and other text documents form the main body of sea ice data archive. There are some derived ice climatology products available online as well, e.g., 30-year Ice Atlases, Departure from Normal Ice Charts. The historical sea ice archive data compiled by the Canadian Ice Service and updated

* Corresponding author.

on a daily basis contains abundant information about sea ice coverage and changes over the last 40 years.
Currently, not all data in the Canadian Ice Service Archive can be assessed and obtained directly online. CIS website provides limited online access to the following data: daily ice analysis charts, regional ice charts, daily iceberg charts, and ice thickness data Canadian stations. Table 1 summarizes online access status of these data in terms of colour, available time period and data format. Since most charts data are provided as GIF graphics (except for B&W weekly regional ice charts), analysis and further processing of the data is not possible. Other data collections are provided off-line, requiring users to place orders through CIS's client service office.

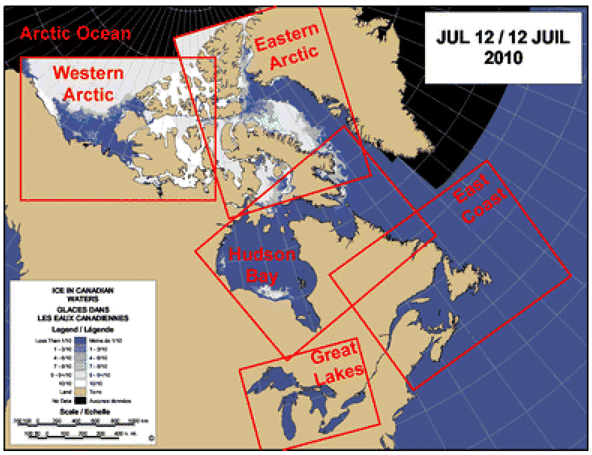

Figure 1. Coverage of sea ice data provided by CIS (source: Canadian Ice Service, http://ice-glaces.ec.gc.ca/).

Type of Data	**Colour**	**Ava. Time**	**Format**	
			.e00	.gif
Daily Ice Analysis	B&W	1999	no	yes
Charts	WMO	2003	no	yes
Ice Thickness Data		1947	Excel/Txt	
Daily Iceberg Charts	B&W	1968	no	yes
Weekly Regional	B&W	1968	yes	yes
Ice Charts	WMO	2003	no	yes

Table 1. CIS archive data with online access.

Although not all are available online, most of the data in the CIS Archive are in digital format and can be obtained in ".e00" format. The data shares a number of problems identified in Tang and Wong (2006) with respect to the sea ice data from the US national ice centre. Among them, the major problem is for users to easily identify specific data subsets for their analysis and download the data. Use B&W weekly regional ice charts as an example. CIS provides data dated back to 1968, with each weekly chart downloaded as one .e00 file. If many data sets are needed, the downloading process is not easy to do and to track.

3. SYSTEM DESIGN CONSIDERATIONS

The project aims at developing tools for data access, online analysis, and visualization of historical (legacy) ice data and information. These tools should be transparent and easy to use with the necessary ability to examine data in three dimensions and across time.
Arctic sciences often require special analytical modelling and simulation software functionality, such as 3D and 4D dynamic modelling; finite element modelling; volumetric analysis; time series modelling; and fluid dynamics (Sorensen et al. 2001). While the first stage of this project was to focus on data access problem and providing some basic analysis functions, more advanced spatiotemporal analysis capabilities are among the further considerations. Through an extensive review of existing ice data services online, review of relevant literature and discussions with CIS staff, we have identified the following as the fundamental requirements for the proposed web-based sea ice information system:

- Find/Browse – search for the required ice data;
- View/visualize – view data layers as a whole or by attributes, as well as using other geographical visualization techniques;
- Examine – evaluate data by checking metadata;
- Manipulate/Analyze – detect changes, analyze trends, create graphs, etc.;
- Download – select/pack data by area/time, e.g. user-defined area of interest (AOI) and time frame (TF); and
- Communicate/Collaborate – create/annotate customized view of data for sharing with others (e.g., send through emails).

4. PROTOTYPE DEVELOPMENT

In this section, we briefly describe and illustrate how the above requirements are implemented into a research prototype.

The objective of this prototype development was to: 1) design and develop a spatiotemporal database that manages over 40 years ice data held by CIS and is able to support spatiotemporal queries on these data; and 2) design and develop a web-based spatiotemporal ice information system (WebSIIS) for online access to that database. WebSIIS should permit:

1) spatiotemporal query of ice data according to predefined or user-defined criteria, e.g. user-defined time frame (TF) or area of interest (AOI);
2) extraction and packing of ice data based on the user-defined TF and/or AOI; and
3) web-based analysis and mapping of ice data with multimode visualization

The prototype is developed mainly on ArcGIS Server platform. An Oracle Database Server is used to manage ice data and the other related textual data. When the user requests normal data for example history news or text reports, the flash client will directly connect to the Oracle database to fetch the data. If the user queries for spatial ice data, the system will connect to ArcSDE middleware to fetch the data from the Oracle database. Figure 2 illustrates the conceptual architecture of the system.

Adobe Flex was used to build a web RIA interface in Adobe flash format (*.swf). The interface uses ArcGIS Server Flex API to implement ice mapping components within Adobe RIA platform.

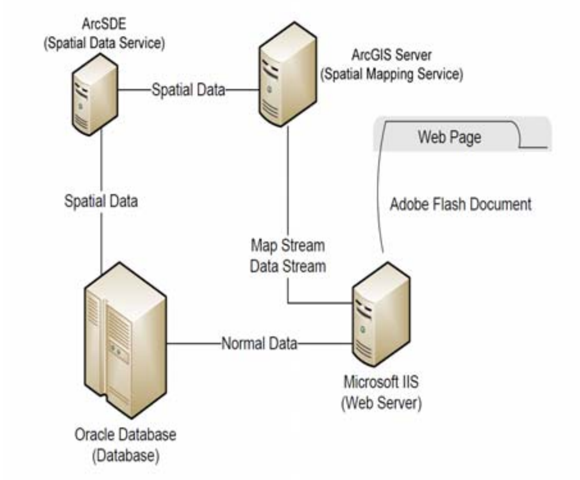

Figure 2. Conceptual architecture of web-based SIIS [source: (Xiong 2010)].

Following an incremental prototyping approach, our first step of the development has focused on the following functions:

<u>Real-time Access to Current Ice Conditions</u>: This function allows access to the latest ice conditions, including latest daily ice analysis charts, daily iceberg/hazard bulletins, daily iceberg analysis charts, regional ice charts, etc. This kind of information about the latest ice conditions are organized on the first page shown when the system is first started.

<u>Access to Historical Daily and Weekly Charts</u>: daily ice analysis charts, daily iceberg charts and weekly regional ice charts.

This function allows user to select types of ice coverage maps or charts by region and time or time frame. Users have options to browse a list, or perform a search. The selected data can be viewed as they are overlaid on top of a base map showing political boundaries and other relevant features. Figure 3 shows how ice data layers are selected and viewed by browsing a list of available layers. The basic mapping functions such as zoom in, zoom out, pan and overview are provided by ESRI ArcGIS server.

Figure 3. View/selection of ice data layers.

<u>Ice Coverage Visualization</u>: provide interfaces for user-defined animation of ice coverage changes and ice coverage mapping by attributes, etc.
Understanding changes of ice coverage is important in may related studies. Tools allowing people to view the changes and perform what is called "visual" analysis should be of valuable use. In addition, ice data contains a rich set of attributes, primarily elements embedded in egg codes. To be able to view the distribution of these attributes over ice coverage polygons is also useful for researchers to gain better understanding of ice conditions. This function provides tools for both. Figure 4 illustrates the animation of changes between ice coverage at four different times.

Figure 4. Animation of sea ice coverage.

<u>Ice Data Downloading</u>: allows users to select geographical extent and temporal range, data format conversion, data packing, etc.

As mentioned above, if the complete ice data archive is online, downloading the data may become time-consuming and labour intensive (Tang & Wong 2006). To make the data downloading more efficient, two options are provided. One is to allow users directly search/select the data needed from the archive. The system then packs up the selected data into a ZIP file for the user to download (see Figure 5). The second option is to allow users to define an area of interest (AOI) and a time or a time frame, and the system then extracts data within the defined area and packs up the data for the user to download. Figure 6 shows the interface where users can define an AOI on either a base map or an ice data layer. The boundary of the user-defined area is then used to extract data from all selected times. For proof of concept purpose, the tools only allows square or arbitrary polygon to be defined.

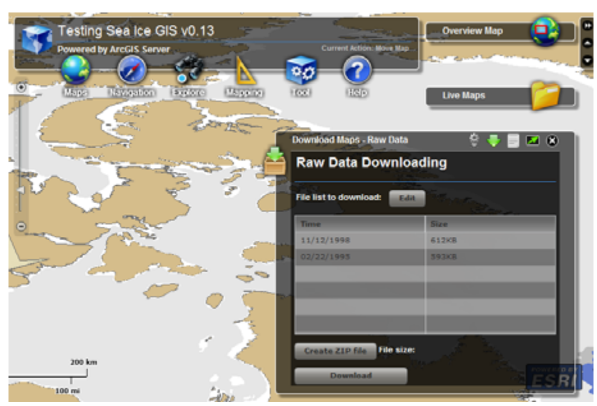

Figure 5. Sea ice data downloading.

Figure 6. Defining the desired area for ice data.

Graphing: CIS currently provides a web-based IceGraph tool (http://ice-glaces.ec.gc.ca/IceGraph103/?id=11874&lang=eng), which has been well-received by scientists around the world. This function implements the same graph tool within the new ice information system environment (see Figure 7).

Figure 7. Ice graph interface.

Others: printing, communication/collaboration (annotation, emailing, etc.)

The system provides some ancillary functions which allow users to print a copy of ice map, annotate particular interested areas which may have significant changes, and share the ice maps with others.

5. CONCLUDING REMARKS

The major objective of the project was to design and develop a web-based ice information analysis and mapping system for improving the Arctic sea ice information services currently provided by CIS, to help make the data in the CIS Archive more accessible and useable to research community and other interested users. For example, users can create maps of sea ice attributes, explore, analyze, and visualize spatial and temporal changes in sea ice characteristics over time and across the Arctic, and easily obtain ice data in their area of interest. CIS maintains two archive servers for the archive of sea ice data (Ou 2002). As the project development passes its preliminary stage and initial testing, access/connection to the CIS Archive Server becomes necessary. This will depend on the further discussion with CIS.

The prototype system and tools described in this paper are still in the preliminary development stage. Only a small set of ice data from the CIS Archive were used during the development. The further study on the performance and the development of advanced spatiotemporal analysis will depend on a good spatiotemporal database that can manage over 40 year's ice data. Although an Oracle database was used to mange geo-database that contains all ice data, the data structure itself is not a spatiotemporal one, causing several problems in initial development, such as data extraction and packing techniques.

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