AntSDI: The Coolest SDI on Earth? - Towards a Spatial Data Infrastructure for Antarctica

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SUMMARY

Antarctica is the coldest, driest and most inaccessible continent on earth. The extreme climate, the remoteness and the sparse human presence distinguish the white continent from the rest of the world. Yet we argue there is an urgent need for a an Antarctic Spatial Data Infrastructure (AntSDI).

Scientific activities in Antarctica are coordinated by the Scientific Committee on Antarctic Research (SCAR). The SCAR Geospatial Information Group coordinates mapping and geospatial information management in support of research in Antarctica. The current endeavour of the group is to establish AntSDI.

This paper introduces the institutional background for AntSDI and describes existing components of AntSDI such as the SCAR Feature Catalogue, framework data sets, the SCAR composite gazetteer of Antarctica and the Antarctic Master Directory.

Critical for the success of AntSDI is the open standards based approach, the focus on enabling specifications and procedures and capacity building within the information community.

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1. INTRODUCTION

Antarctica is the coldest, driest and most inaccessible continent on earth. The extreme climate, the remoteness and the sparse human presence distinguish the white continent from the rest of the world. Yet we argue there is an urgent need for a an Antarctic Spatial Data Infrastructure (AntSDI).

Antarctica plays a key role in many scientific questions – of which those related to global climate change are probably the most prominent examples. In most of the related research activities the spatial component is crucial. This ranges from not getting lost during field work to advanced data mining in and across extensive spatially enabled data bases.

Scientific activities in Antarctica are coordinated by the Scientific Committee on Antarctic Research (SCAR). The SCAR Geospatial Information Group coordinates mapping and geospatial information management in support of research in Antarctica. It has started to operate as one of the oldest working groups of SCAR in 1958 as Working Group Cartography to provide Antarctic research activities of the International Geophysical Year 1958/59 with cartographic reference material. Almost five decades later the challenge of the SCAR Geospatial Information Group is to create and promote the Antarctic Spatial Data Infrastructure.

This paper first describes the institutional background for AntSDI and the users and data producers of AntSDI. In the following already existing components of AntSDI are presented and discussed.

2. BACKGROUND OF ANTSDI

2.1 Institutional Background

The institutional background for AntSDI is set by the SCAR constitution which calls SCAR member countries to facilitate free and unrestricted access to Antarctic scientific data (SCAR 2004).

2.1.1 The Scientific Committee Antarctic Research

The Scientific Committee on Antarctic Research (SCAR) is the leading independent organization for facilitating and coordinating Antarctic Research. SCAR was formed in 1958 during the International Geophysical Year. It is an interdisciplinary body of the International Council for Science (ICSU). Currently 28 countries are full members and four countries are associate members. Additionally to its primary scientific role, SCAR also provides scientific

advice to the Antarctic Treaty Consultative Meetings and other organizations on issues of science and conservation related to the management of Antarctica and the Southern Ocean. In that role, SCAR has made many recommendations which have been included into Antarctic Treaty instruments and into the various international agreements which provide protection for the ecology and environment of Antarctica.

The Antarctic region as defined for the purpose of SCAR includes "Antarctica, its offshore islands, and the surrounding ocean including the Antarctic Circumpolar Current, the northern boundary of which is the Subantarctic Front. Subantarctic islands that lie north of the Subantarctic Front and yet fall into SCAR's area of interest include Ile Amsterdam, Ile St. Paul, Macquarie Island and Gough Island" [SCAR 2004].

The scientific business of SCAR is conducted by three Standing Scientific Groups which represent the scientific disciplines active in Antarctic research, namely geosciences, life sciences and physical sciences. Expert Groups within the Standing Scientific Groups address specific research topics. The Expert Group on Geospatial Information operates in two programmes – Geodesy and Geographic Information. The terms of reference of the Geographic Information programme are:

Understanding that geographic location is a fundamental element for integrating and communicating Antarctic science knowledge, the GI group aims to create an Antarctic spatial data infrastructure (AntSDI) by:
- Providing Antarctic fundamental geographic information products and policies in support of science programs
- Integrating and coordinating Antarctic mapping and GIS programs
- Promoting open standards approach to support free and unrestricted data access
- Promoting capacity building within all SCAR nations.

The Geographic Information programme operates a range of Geographic Information projects and the vision is to establish AntSDI.

2.1.2 Antarctic Treaty System and the Committee on Environmental Protection

The whole complex of arrangements established to coordinate relations among states with respect to Antarctica is called the Antarctic Treaty System (ATS). The ATS includes the Antarctic Treaty itself, the Protocol on Environmental Protection to the Antarctic Treaty, two separate conventions for the Conservation of Antarctic Seals and on the Conservation of Antarctic Marine Living Resources, and recommendations adopted at meetings of the Antarctic Treaty Parties.

The Antarctic Treaty was established in 1959 and signed by 12 states. Today the Treaty has 29 consultative parties and 20 acceding states (Antarctic Treaty Secretariat 2005). The foremost purpose of the Treaty is to ensure "in the interest of all mankind that Antarctica shall continue forever to be used exclusively for peaceful purposes". It provides "freedom of scientific investigation in Antarctica" and promotes "international cooperation in scientific

investigation in Antarctica", it bans "any measures of a military nature" and prohibits nuclear explosions or nuclear waste disposal (quotations after U.S. Department of State, 2002). The Treaty applies to the area south of 60° South.

Environmental protection has always been one of the major topics of cooperation between the Antarctic Treaty members. In 1991 the Protocol on Environmental Protection to the Antarctic Treaty was signed and entered into force in 1998. This protocol to the Antarctic Treaty established the Committee on Environmental Protection (CEP). The functions of the CEP are to provide advice and formulate recommendations to the Antarctic Treaty parties in relation to the Protocol including application and implementation of environmental impact assessment procedures, means to minimise and mitigate environmental impacts, procedures for response actions to environmental emergencies, the operation of the Antarctic Protected Area system, and the collection, archiving, and exchange of information related to environmental protection (ATCPs 1991).

Both the Antarctic Treaty System in general and the CEP might benefit from AntSDI with respect to reporting requirements (inspections of stations, emergencies, etc.) and especially with respect to the Antarctic Protected Area system. In terms of positions for example many protected areas currently only have a rough description of their limits. AntSDI would support both sound spatial data management as well as spatial information exchange.

2.1.3 The Committee of Managers of National Antarctic Programmes

In 1988 The Committee of Managers of National Antarctic Programmes (COMNAP) was established to facilitate liaison between the managers of national agencies responsible for the conduct of logistics operations in support of Antarctic science. COMNAP has its expertise in the realm of operational implementation of activities in Antarctica, safety, technology and information sharing (Fowler, 2000). The membership currently includes twenty-nine countries from the Americas, Africa, Asia, Europe and Oceania.

COMNAP and SCAR are closely connected in a co-operative relationship. This is reflected in biannual coordinated meeting arrangements, in joint task or planning groups and in the joint response or input to the Antarctic Treaty Consultative Meetings (ATCMs) when appropriate.

Dealing with conduct of logistics operations and related information exchange, air safety, waste management, and the like activities of COMNAP members could directly benefit from AntSDI. Benefits might include enhanced information sharing and reporting procedures, immediate access to critical data through web services, improved reporting e.g. to assess cumulative effects of activities at specific sites, and so on.

2.1.4 Joint Committee on Antarctic Data Management

The Joint Committee on Antarctic Data Management is a joint committee of SCAR and the Council of Managers of National Antarctic Programmes (COMNAP). It was established in 1997. Its purpose is to advise SCAR and COMNAP on the management of Antarctic data.

JCADM coordinates the development of the Antarctic Data Directory System, which is composed of the Antarctic Master Directory (AMD), and the National Antarctic Data Centres.

2.2 AntSDI users and Data Producers

The primarily concern of SCAR is to facilitate scientific work in Antarctica. Consequently the user community consists of researchers from a wide variety of disciplines within life sciences, geosciences and physical sciences. Typical use cases for spatial data are cross-discipline analysis such as feeding grounds of seals compared to sea ice extend. Naturally we have to deal with a broad user community and a variety of application domains. This has implications for example on a common feature catalogue.

For specific areas of interest framework data such as base topography is produced by organizations with established procedures and well defined standards for mapping. But another characteristic of the user community is that large amounts of data are produced by the scientists themselves - users at the same time are producers as well. As a consequence of having many small groups from entirely different disciplines as data producers there are almost no common standardised procedures on data collection. Although the use of GPS has become prevalent in the last years positional accuracy of data still varies greatly and most often it is undocumented.

Increasingly data are re-used by other research groups for entirely different purposes than the producers intention. Data accessibility over the internet here becomes both a blessing and a curse. Fairly often it is difficult or impossible to judge whether available data is fit for the envisaged purpose. Metadata plays a crucial role. Currently the only endorsed metadata standard is the DIF format. As a matter of fact most institutions adhere to a proprietary standard (if at all).

3. EXISTING COMPONENTS OF ANTSDI

3.1 Building on Open Standards

Given the multinational context of SCAR activities the implementation of standards and specifications developed on national standards is not acceptable for most players. We therefore believe that ISO and OGC based standards and specifications are much easier to implement and do have greater acceptability.

SCAR has Liaison status to TC211 to ensure consideration of specific Antarctic concerns and to be able to actively participate in the development of early test bed applications. Relevant ISO TC 211 standards that are being used or are under consideration to establish AntSDI include for example ISO 19110, ISO 19115, or ISO 19136 .

Data portrayal and data access services are based on OGC specifications. OGC interface specifications for web services (e.g. OGC Web Feature Service, OGC Web Map Service) and

GML have become widespread and are implemented in many software packages. The available open source software implementing OGC interfaces allows institutions with a reduced budget to participate in AntSDI .

3.2 SCAR Feature Catalogue

Under the SCAR Spatial Data Model project coordinated by the Australian Antarctic Division the SCAR Feature Catalogue is being developed to support common content structure and common semantics for Antarctic spatial data. The feature catalogue "promotes the dissemination, sharing, and use of geographic data through providing a better understanding of the content and meaning of the data." (ISO 2004). The SCAR Feature Catalogue follows ISO/FDIS 19110 (ISO 2004) and currently describes approximately 400 feature types with their definitions and attributes. Given the broad information community it applies to and the wide variety of application domains the catalogue currently has a flat structure with no build in hierarchies to provide maximum flexibility. Defining relationships between features should be the next step to improve the semantic content of the SCAR Feature Catalogue. Relationships between features presumably will be defined as associations. A draft GML application schema implementing the SCAR Feature Catalogue is under development.

3.3 Framework Data

At present there exists framework data which complies to the semantics and the content structure of the SCAR Feature Catalogue at continental scale and at larges scales for particular areas which are in the focus of scientific and other activities. These data are already available (or will be available in the near future) by OGC Web Services.

The flagship of the products of the SCAR Expert Group on Geospatial Information is the Antarctic Digital Database (ADD), a continent wide dataset including the coastline, elevation, and location of stations. The Antarctic Digital Database was created and is managed by the Mapping and Geographic Information Centre of the British Antarctic Survey. The first edition was published in 1993 on CD ROM, the current version is available for download on the Internet (ADD 2004). The ADD is being transformed to implement the SCAR Feature Catalogue and will be made available as an OGC Web Feature Service. This work is supported by the Cybercartographic Atlas of Antarctica Project of Carleton University, Canada.

There are numerous medium to large scale spatial data bases that cover parts of Antarctica. Many of these databases are available online as downloadable data sets or through online atlases. Examples of online atlases include the USGS Atlas of Antarctic Research (USGS, 2004) or the Australian Antarctic Division Atlas (AADC, 2004). The spatial data from the Australian Antarctic Division already implements the SCAR Feature Catalogue and is accessible as OGC Web Feature Service.

The SCAR King George Island GIS (SCAR KGIS) project provides framework data for King George Island, Antarctica. King George Island is one of the most crowded places in Antarctica with permanent stations from eight countries. The KGIS project has been established by the SCAR Expert Group on Geospatial Information to support collaboration amongst nations and research groups active on the island (Vogt et al. 2004). KGIS is managed and hosted by the Department of Physical Geography, University of Freiburg, Germany. The project provides a spatial database which implements the SCAR Feature Catalogue. The data is made accessible as downloadable data, through an interactive online map viewer and also as OGC Web Map Service and OGC Web Feature Service (IPG, 2005).

3.4 Place Names

The standardisation of the Antarctic toponymy is a complex item not easily solved. Antarctica does not fall under the sovereignty of any one nation. There are many national gazetteers for Antarctic place names. This lead to multi-naming of features and there is no agreement on how to solve this issue. In 1992 the need for a composite gazetteer of Antarctica was recognized by the SCAR Working Group on Geodesy and Geographic Information. The results of the work programme which evolved provide the scientific community with two products. One is the SCAR Composite Gazetteer of Antarctica (SCAR 1998), the other a set of SCAR recommendations to be followed when proposing new names, and, additionally, guidelines when selecting one name from a list of synonyms for a given feature (Sievers and Thomspon, 1995).

The Composite Gazetteer of Antarctica (CGA) was collated by Italy. Every reasonable effort was undertaken to include all existing officially recognised Antarctic names in the CGA, and to have the data authorized and validated to the maximum extent possible. The CGA now is an invaluable resource to find named locations in Antarctica. The database contains all the place names officially given to Antarctic (i.e. south of 60° South) geographic features by 23 countries, with the addition of the Antarctic undersea features taken from the General Bathymetric Chart of the Ocean. The database currently includes 35272 official names, corresponding to 17668 geographic features (PRNA, 2005). The CGA currently does not contain information on the hierarchy of place names. The overall positional accuracy of the gazetteer entries allows to use the CGA for small and medium scale applications. For a couple of reasons (precision with which coordinates are recorded, methodology with which coordinates had been acquired, etc.) one has to be cautious when using the CGA in large scale applications (Vogt, 2004).

At present the CGA is available as downloadable data base. There is although a web interface that provides for interactive search for place names and the respective coordinates (PRNA, 2005). The next step in terms of accessibility should be to make the CGA available as a web service for machine to machine communication to provide services for finding place names in a given area and services for geocoding of named locations.

3.5 The Antarctic Master Directory

SCAR as an organization relies on the activities and contributions of its members, especially in terms of financial resources. With its current budget it seems impossible for SCAR to manage a data clearinghouse for AntSDI on its own.

The SCAR endorsed metadata catalogue for Antarctic data is the Antarctic Master Directory (AMD) which is in the responsibility of JCADM. It is a directory that contains data set and service descriptions including descriptions of spatial data sets. The AMD is currently hosted by the Global Change Master Directory and is accessible through its own portal (AMD, 2005). For the GCMD and consequently for the AMD the DIF and SERF are the standards to describe data sets and services (GCMD, 2004a, GCDM, 2004b).

The success of the AMD depends on the commitment of data managers and producers, i.e. in many cases the scientists themselves. Although Antarctic research scientist are the major beneficiaries of such metada they have not been very successful as originators of this metadata.

Currently the AMD has to act as a portal with limited capabilities to enable discovery of Antarctic spatial data sets and services and to make available access information to these. Should the AMD become a successful clearinghouse for AntSDI there is a need to enforce the link to substantial parts of the producer and user communities as well as the need to establish technical specifications (e.g. search protocols) which allow for machine access to the directory.

4. RESULTS AND CONCLUSIONS

AntSDI currently includes standards, policies, technologies and certain framework data sets necessary to harmonize Antarctica-related geospatial databases and to provide services that are able to deliver spatial information required by the Antarctic science user community.

Following the terminology of Rajabifard (Rajabifard et al, 2003) the concept of AntSDI can be regarded as one of a second generation SDI with a focus on data use and data applications. The main technology used for AntSDI are web services in order to leverage the underlying information technology and infrastructure of the Internet along with ongoing developments in web service technology.

Development and application of AntSDI are based on open and shared specifications. The specifications are available for everyone interested in using or participating in AntSDI. These specifications are built on international standards where applicable and available.

The current approach is to establish a working spatial data infrastructure for the Antarctic science community. We aim at providing open standards, open specifications and rules of procedures to establish a web services based infrastructure which can be implemented at low

cost and minimum effort at institutions willing to contribute to AntSDI. The development is driven by a couple of larger institutions which have made available the funds for pilot projects and implementations. To be successful and to positively impact on science (and other activities) in Antarctica AntSDI now needs to accumulate a critical mass of accessible spatial data, services and useful applications.

The next step in developing AntSDI should focus on capacity building in smaller institutions. This should promote that new data and services are being added to the infrastructure which in turn supports the development of science applications that exploit the new data and services.

AntSDI enables organizations to participate at various levels, e.g. by contributing spatial data and information, metadata, services and applications without the need for centralized administration and access. Organizations keep the responsibility for their own content.

AntSDI is promoted by the SCAR Expert Group on Geospatial Information. Consequently the foremost goal of AntSDI is to support scientific activities in Antarctica and research related to Antarctica. The scientific context relaxes the constraints in terms of reliability, liability and other legal and economic issues. According to the SCAR constitution all data should be made available free without any access restrictions. The main issue for the scientific community in this context is intellectual property rights.

Spatial data in many regions of Antarctica still is scarce. Most of the spatial data stems from or is produced in support of scientific activities, and is managed in scientific data centres. Currently there is no other Spatial Data Infrastructure for the Antarctic continent in place. Thus it is excepted that the ATS and CEP, COMNAP and other bodies such as the International Association of Antarctic Tour Operators (IAATO) can greatly benefit from AntSDI, too. Ultimately this would require to settle questions related to liability and, of course, financial resources to ensure reliability of critical services.

The vision of AntSDI is to provide the reference for the spatial components of the data management plans of the coming International Polar Year (IPY 2007/08) activities and beyond. The challenge for AntSDI is that it has to be created and that it must operate in a multi-national, multi-disciplinary context.

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