

Cartographic Activities In Sweden 2015- 2019

National Report to
the international Cartographic Association's 18th
General Assembly 2019 Tokyo Japan

kartografiska.se

Introduction 2015-2019

The national report of Sweden is published by the Swedish Cartographic Society (Kartografiska Sällskapet) addressed to the delegates of the General Assembly 2019 of the International Cartographic Association in Tokyo, Japan.

In Sweden, maps and geographic data are produced by national and regional agencies, municipalities, commercial enterprises, scientific institutions, organizations, and individuals.

The focus in this report is geographic information displayed in a variety of presentations, but all of them using cartographic knowledge and design. The publishing of traditional maps and map series has been extended and added by production of more specialized map products, made possible through the use of new techniques for data capture, information processing, map production and presentation.

The articles in this report are produced by the contributing organizations and companies themselves, reflecting their points of view. The Swedish Cartographic Society is, apart for its own contribution, only responsible for the final editing and publishing of the report.

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The Swedish Cartographic Society

(Kartografiska Sällskapet, KS)

The Swedish Cartographic Society, Kartografiska Sällskapet, was founded in 1908, and is most probably one of the oldest of its kind. The Society's goal is to increase the interest in cartography and other topics related to mapping or the use of maps in Sweden and to try to encourage a development in the area. One of the society's most important issues are to support the members in their daily professional role by assisting them with different kinds of opportunities to meet colleagues and to seek new networks and educational opportunities.

A main activity of the society is to organize an annual conference called "Kartdagarna" or the "Swedish Map days". On initiative from KS a bigger conference was arranged during the spring of 2019 together with four other sister organizations in Sweden. We all want to participate and encourage development in geographical information and so called geodata overall to increase different kinds of community benefits. By planning this year's event we decided that the main theme for the congress was housing, Digital community building. The Congress was named Position 2030 and were held in the end of March 2019 in the capital of Sweden, Stockholm, and arranged together with a fair that presented products and services from more than 30 companies and authorities. The conference program included seminars about techniques, visualisation, educations, management, pricing, politics and strategies in housing, infrastructure and environment. The conference

also included map exhibitions. Social arrangements are an important part of the conference. In this year's congress and fair there were more than 1,100 participants.

Committee board

The committee board consists of a president, a vice president, a secretary, a treasurer, seven members, and two deputies. In 2008-2013 Peter Wasström was president. In 2014-19 the president is Ann Eriksson and the secretary is Johan Schärdin. The international contact person is Peter Wasström. The society and its six sections are governed by the rules of the society. KS represents Sweden in the International Cartographic Association (ICA), and has participated in all the General Conferences and Assemblies since in Paris 1961.

The 2,000 members are professionals, students, retired members, and individuals with a common interest for maps. About one hundred of these are members from abroad. Anyone who wants is accepted as a member of the Society. The annual fee is SEK 150, SEK 100 for retired, and SEK 50 for students.

Other activities

The Swedish Cartographic Society is organised in six sections: Cartography, Historical maps, Geographical Information Systems, Photogrammetry and Remote Sensing, Geodesy and Education. Each section has responsibility for its respective disciplines and among other things the sections arrange seminars, exhibitions and study visits in different places in Sweden. Four times a year the Swedish Car-

tographic Society publishes the cartographic journal “Kart & Bildteknik”, English name “Mapping and Image Science”.

As mentioned earlier KS arranges map exhibitions every year together with the Swedish Map Days. The winning maps from Position 2030 together with the winning maps from the Map days of 2018 will be sent to the map exhibition at ICC 2019 in Tokyo, Japan. KS communicates with members through the site www.kartografiska.se, a newsletter called “E-aktuellt” and social media, for example Facebook, over the year. Members of the board also visit the Nordic countries and it has become a tradition to organize joint courses in summertime. Over a couple of days every year there is an internal planning seminar to discuss strategic issues. More than 100 students get every year scholarships to participate in the Map days. Scholarships are also given every year to members who want to join international conferences.

Awards

The medal of Olaus Magnus

The medal of Olaus Magnus was founded in 1948. It is given to a deserved person who has made considerable work for the interests of KS.

Margareta Elg, April 28, 2016

Reason: For many years, she has both cared for the map as a means of expression and as an information carrier, and through her broad activities she has conveyed her cartographic knowledge and her commitment to both established and new map users.

Clas Tollin, March 30, 2017

Reason: For his long standing and appreciated work on registering, making available and analyzing the geometric maps, Sweden’s oldest surveying maps.

Clas-Göran Persson, March 22, 2018

Reason: For a long time and for leading positions he has purposefully worked for the development of geodesy, measurement technology and cartography in a national context. His efforts to expand the SWEPOS network and to establish the measurement uncertainty concept in Swedish measurement activities have been significant. He has also made decisive contributions to the development and modernization of *Handbok till mätningstekniken*, HMK (the Handbook for the Measurement Order), now the Handbook on Measurement and Map Questions, in the formation of Utvecklingsrådet för landskapsinformation, ULI (the Development Council for Landscape Information) and in the preparatory work for the national laser scanning. He has also supported the geodetic research and education activities as an adjunct professor of geodesy at the Royal Institute of Technology.

The award of innovation

Hack4Sweden, 2016

Reason:

Hack for Sweden is a unique combination of creativity, technology and governmental collaboration with the aim of offering the largest social benefit for private individuals, organizations, companies and authorities based on the large and open data set available in the country.

John Ljungkvist and Daniel Löwenborg (Uppsala University), 2017

Reason:

For the app "Augmented history - Gamla Uppsala". The app applies geographical information technology, research results and digital gaming technology to give visitors a virtual window on how Gamla Uppsala looked during its flowering period in the 7th century AD. This is the first time this type of technology is used to visualize a cultural heritage in Sweden in a pedagogical and generational way.

Mats Troeng and Joakim Svensk, 2018
Reason:

For the purpose of analyzing and using open geographic data and with considerable computing power, MapAnt has created a large-scale and detailed map of the whole of Finland, which is accessible to everyone.

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Historical Section

The Historical Section of the Swedish Cartographic Society consists of a board of four persons, whose main duties are to arrange a session at the annual conference Kartdagarna and to acquire papers to the society journal *Kart & Bildteknik*. In addition, study visits are arranged. Conference papers tend to be either on

the history of cartography proper or on the use of "historic"

maps as a source for research within quite diverse fields, ranging from urban agriculture,

and the design of forestry plans, to family history. Section members attend conferences like

the International conference for the History of Cartography (Antwerp 2015, Amsterdam 2019),

Members are occasionally consulted on matters of cartographic history and historical cartography.

The Swedish Association for Map Archivists (Kartarkivarieföreningen) has been inactive as

an organization for some years. But scholarly archival competence (including the still unsolved

problem of long-term preservation of digital data) is available within the historical section, and

presentations on archival matters and questions are regularly included in Kartdagarna.

Sweden is lacking a university chair in the history of cartography, so the field has a rather weak

academic support. But some research is carried out within e.g. the National Archives including

the Military Archives, university institutions in history, human geography, agrarian history, the Committee for the History of Cartography within The Royal Swedish Academy of Letters and History and Antiquities (Kungl. Vitterhets Historie och Antikvitets Akademien).

Recent theses dealing with History of Cartography:

Forss Charlotta (2018), *The old, the New and the Unknown. The continents And the making of geographical knowl-*

edge in seventeenth-century Sweden. Höglund, Mats (2017), Kampen om fredsmilen. Kartan som makt- och kontrollinstrument i 1655-års reduktion.

Hallgren, Karin (2016), En kåhläppa ej att räkna. Kökväxtodlingen i 1700-talets jordbrukssystem.

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Geodetical Section

RTK positioning with centimeter accuracy based on Network-RTK services covering the whole country, is probably the most used geodetic survey technique in Sweden today. In major construction projects the fundamental network, consisting of fixed reference points, has been replaced by GNSS-based densified network of reference stations integrated in the ordinary Network-RTK service and realtime data broadcasts for RTK survey.

Height measurement using GNSS is still increasing and the benefit of an accurate geoid model is obvious. Due to the postglacial land uplift affecting Scandinavia there is also a need of land uplift

models for adjusting GNSS (“geometric”) heights to correspond with the height system (“gravimetric heights”). To get these technologies to function properly together requires knowledge of these methods. For several years the geodetic section of the society has focused on subjects related to geodetic reference systems and GNSS.

The section’s focus has been on

- The operation, expansion and services of SWEPOS, the Swedish national network of permanent reference stations for GNSS. Several private RTK-services are more or less integrated with and in the network.

- Identify benefits of including Galileo with GPS and also Glonass in GNSS usage.

- Effective use of the Swedish national reference frame SWEREF 99 and the national height system RH 2000 (ETRS89 and EVRS realizations, respectively).

- The improvement of Swedish geoid models and land uplift models.

The number of educated surveyors, geodesists and engineers at the level of Master of Engineering does not fulfil the need on the market. This problem is not new and the Swedish Cartographic Society is conscious of the problem and supports efforts to turn this negative trend. The Cartographic Society continues to pay attention to this and support universities and stu-

dents to participate at the annual conference “Kartdagarna”. Referring to geodetic knowledge we also try to make geodesy more accessible and understandable for a wider community.

International coordination is becoming increasingly important at both strategic and practical levels.

International projects, especially at the Nordic level and within the Baltic Sea Region, have benefited from that the geodetic infrastructure now has a sustainable design. It is also obvious that geodesy has a role in the discussion of global climate change and the mobile mass market’s need for reliable and ever more accurate positioning of autonomous vehicles and the use of drones.

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Cartographic Section

The Cartography Section consists of a board of four members, whose main duties are to arrange sessions, map exhibitions and sometimes a cartographic quiz at the technical exhibition for the annual conference Kartdagarna. The section members are involved in planning and the work of making the

program of Kartdagarna. The section also acquires papers or proposals of papers to the society journal Kart & Bildteknik. In addition, study visits are occasionally arranged. The Swedish National Report to the ICC is taken care of by members of the Cartography Section and also the cartography part of the society website.

Members of the Cartography section regularly attend the ICA conferences and are also responsible for the Swedish contributions to the International Map Exhibitions at the ICC.

The section is cooperating with other sections when it comes to education in cartography. Swedish universities have no chair in cartography and the possibilities to learn cartography become scarcer and scarcer.

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The Educational Section

The section for educational matters in the Swedish Cartographic Society (KS) was formed in 2006. The aims of the section include:

- work with educational matters relating to cartography, geodesy, GIS, photogrammetry and remote sensing on all levels, both nationally and internationally.

- promote increased competence development in cartography and related fields in Sweden, such as land surveying, spatial planning, geomatics, computer science, earth science and geography.

The Educational Section also actively takes part in the annual conference, Kartdagarna, the biggest conference of its kind in Scandinavia.

Among the recurring activities arranged by the educational section is the aim to arrange an annual conference or workshop for lecturers and others, where educational matters are discussed. The aim is to facilitate the sharing of experiences, to improve collaboration opportunities, networking and competence development, and to enhance course quality and recruitment of new students. The location of the venue varies in order to encourage diversity among the hosting educational institutions and to reach new participants. The most recent workshop was arranged in cooperation with the "Position 2030" conference in Stockholm in 2019. The presentations are normally published afterwards on the website of the Swedish Cartographic Society.

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The Geographic Information Systems Section

The section communicates advantages of GIS and geographic information, especially the use of open data.

The GIS section consists of a board of four people with GIS experience from different areas like municipalities, state agencies and private companies. Its main duties are to arrange sessions at the Swedish annual conference Kartdagarna (Mapping Days) and to acquire papers to the professional journal "Kart & Bildteknik".

In addition, the section has been involved in the work to get the Cartographic Society more active in social media.

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The Photogrammetric and Remote Sensing Section

The Photogrammetric and Remote Sensing Section consists of a board of four members. The main duties are to

arrange sessions for the annual conference Kartdagarna and to acquire papers to the society journal Kart & Bildteknik. Every second or third year, the section organizes a seminar in photogrammetry and remote sensing. The seminar focuses on practical cases and new research and technology. Later years, the focus has been on dense image matching, UAVs, mobile mapping, laser scanning, automation and use of Sentinel satellite imagery. The interest for the seminar is large and seems to have an important role when it comes to educating and presenting new products and technology for surveyors and similar professions.

The national laser scanning of Sweden is now at its second round, focusing more on forestry applications. The new laser data is free for download and gives new possibilities for users and more examples of products and applications.

The National Land Survey has updated their camera which leads to higher resolution in images and image products for all city areas of Sweden. The images have four channels giving more possibilities for vegetation analyses. The municipalities have an increased usage of photogrammetric stereo software which gives them better possibility to update and maintain the primary map data base, hence increasing the general interest in photogrammetry.

Sweden has a large program for data exchange between governmental and other official organizations, including municipalities. This put higher demand on standardization, both in data structure, metadata and exchange formats. To ensure good quality and standardized data formats, the Nation-

al Land Survey, the National Transport Administration, some municipalities and companies are cooperating, defining Product Specifications and support for procurement and delivery of aerial imagery, LiDAR data, ortho photo, elevation models, etc.

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Lantmäteriet -

The Swedish mapping, cadastral and land registration authority

Lantmäteriet is a governmental agency, originating from 1628.

The mission for Lantmäteriet is to give support for creating an efficient and sustainable use of Sweden's real property, land and water. The organisation has three main activities, which also form the organisational structure with three divisions: Cadastral Services, Land Registration and Land and Geographic information services (Geodata). Support for these activities is provided by Corporate functions.

Lantmäteriet has about 2,200 persons in the staff and 50 offices in Sweden. The head office is situated in Gävle.

Cadastral Services

Lantmäteriet is the governmental cadastral authority. There are also 39 municipal authorities that carry out cadastral procedures and services.

The Cadastral authorities carry out cadastral-procedure activities, deals with regional coordination of geographic and property information, and provide different types of services, which are closely linked to their official duties.

The cadastral services comprise real property formation through formal cadastral survey and maintenance of the real property register. Common tasks are sub-division of land into plots for building houses and recreational homes and reallotment to ensure the availability of land for building roads, railways and public utilities. The division has a staff of approximately 1,050.

On the central level the division of Cadastral services has the responsibility for the supervision of, and to give support to, the regional Cadastral authorities. The most important task is to support the real estate formation process. That includes issues, such as, law amendment, quality control, competence development, and development of techniques and methods in order to shortening the handling of cases and reduce the costs.

Land Registration

Land registration and related activities, such as the handling of stamp duty and fees are the responsibility of the Land Registration Division.

The division is responsible for checking registration transactions with regard to ownership, mortgages and other rights and charges and registering them in the Land Register section of

the Real Property Register. The division also handles the collection of stamp duty and fees for these transactions. The major part of our activities is carried out in seven local offices each of which is responsible for handling registration transactions within its geographically defined area. The main office in Gävle is responsible for leading and coordinating registration activities.

The division has a staff of approximately 220 made up of central management and personnel at the seven local offices. There is contact information for the respective offices in the menu to the left.

Land and Geographic Information Services (Geodata)

The Geodata division collects, stores and administrates geographic and real property information. This also includes the analysis and establishment of demands and the needs of such information in society. The collection is carried out by Lantmäteriet and often in co-operation with other public authorities including the local ones. An important task is to make the information available and used by a broad spectrum of users thereby contributing to efficiency, improvement and renewal in all sectors. The division is responsible for basic information subdivided into information areas for topography, geodesy, real property information and images. The operations also include dissemination activities and cooperation, advisory services and support to other producers and users in society. Geographical information and real property data from Lantmäteriet help to benefit the society in many ways.

For instance, it may be used in the production of data concerning the effects of climate change, or to provide expert knowledge for construction work. Maps and other geographical information have also taken on increasing significance on mobile and tablets, thanks to all the apps which describe the geographical locations of various phenomena. In this regard, Lantmäteriet perceives major social development potential and has for a couple of years been working on possibilities to open up geographical data and addresses for free use. Licensing costs and distribution conditions present the greatest restriction in the present system involving financing by users.

Open, reliable geographical data would simplify matters for users and encourage market actors to develop innovative services. Lantmäteriet carried out an analysis of this in 2013, and this work continued in 2014 in cooperation with, among others, the aim to the Swedish Association of Local Authorities and Regions with the aim to devise a joint action plan.

Corporate Functions

The Corporate functions consist of a Staff unit and Supporting units with a staff of approximately 450.

The Director General's Staff unit works with strategic issues and long-term planning. The unit consists of five functions: Strategic planning and information, Finance and control, Human resources, IT strategy, and Legal matters. The unit has in total 20 staff members, including the Director General and his assistant.

The Corporate services is working with more operational issues, consist

of seven units: Development and IT, Finance, Communication, Human resources, Sustainability, Information control and International.

The Swedish SDI

Lantmäteriet's role as coordinator of the Swedish spatial data infrastructure (SDI) has gradually been strengthened and Lantmäteriet is responsible for the co-ordination of the national infrastructure for geodata. Sweden has a well-functioning national infrastructure for geodata. This means that it is easy to search for and find geodata and services. Geodata from different sources can be accessed via services and can easily be combined. State authorities, municipalities and other geodata producers have worked together to make geodata simple to use. This infrastructure is an important national asset for development, and its geodata is freely available to the whole of society. Geodata is created, administered and made available by the public and private sectors within shared frameworks, thus contributing towards openness, availability and compatibility.

An overall national strategy and reform agenda makes it clear how geodata can contribute towards process efficiency, towards the environmental work and the 17 sustainable development goals in Agenda 2030, and towards innovation, growth and competitiveness in both the digital economy and the physical economy.

Knowledge about the opportunities offered by digitisation and the benefits of open data is well established among politicians and decision-makers. Significant economic and legal barriers

are removed through regulations and reforms. The fragmentation of public sector data sources has been reduced through a combination of standardisation work and the establishing of national services for the dissemination of data from national, regional and local level.

Core geodata is national, open, up to date, standardised, of the required quality, easily accessible and efficiently used. National and local government have clearly stated infrastructure assignments that give the public sector processes and the business community access to the best possible data.

In this vision of Sweden, the public sector processes are characterised by transparency, interactivity and good collaboration between authorities, businesses and citizens. The collaboration around the national infrastructure for geodata:

- Promotes innovation and growth within industry.
- Enables public sector processes to be digitised and streamlined.
- Contributes in providing citizens with a good, secure and sustainable living environment.

The key to success is a long-term approach to the assignment and financing, as well as a continuous, highly effective, cross-sectoral national and regional/local collaboration between public sector geodata producers and key public and private users.

The public sector undertaking for the national geodata supply is long-term but need to be reviewed regularly to secure that the most requested geodata are made available in society.

Services for access to geodata are known, easily accessible, usable and stable over time, so that users can

make long-term investments in their use.

The national infrastructure for geodata (NSDI), will make it easier to access geodata, and thereby maximize the benefit for society from the geodata that exist in Sweden.

- Lantmäteriet aims to create the preconditions for increased use of geodata.

- Lantmäteriet will also make it possible to exchange and combine geodata from different sources, which is a precondition for efficient collaboration, both between users in the public sector and in the interaction between companies and the public.

- By making greater use of geodata Lantmäteriet creates better preconditions for sustainable development and greater competitiveness in the business community, public administration and society in general.

The Geodata Advisory Board

The Geodata Advisory Board, established by the Swedish government, advises Lantmäteriet in its coordinating role regarding geodata. The Geodata Advisory Board will:

- Contribute to the work with the National geodata strategy for the collective maintenance of geodata.
- Highlight issues of common national interest within the geodata field.
- Contribute to the development of the national and international infrastructure for geodata for example by supporting the implementation of standards.
- Contribute to increased coordination between authorities concerned in issues regarding development of information and providing information.
- Contribute to the coordination of the

infrastructure for exchange and access to geodata in Sweden.

The stakeholders have also developed a generic framework for carrying out standardisation, which has been used to produce standards for many data themes, such as transport networks, hydrologic networks, utility networks, addresses and buildings.

The National Geodata Portal

The Geodata Portal is an entrance to web-based geodata and services. The portal offers the possibility to search, find and look at geodata from different sources.

It presents available geodata and where the user's data can be found. Users can in an assembled way access services and geodata from many organisations.

- The portal comprises a national metadata catalogue which describes available geodata, their quality and conditions for use. The catalogue is frequently updated by the producers.
- Geodata and services are accessed via the portal.
- The Geodata Portal is mainly aimed for professional users.
- The Geodata Portal is the entrance for Sweden's cooperation in Europe, according to the

INSPIRE directive

The Geodata Cooperation Agreement regulates a sustainable cooperation within the infrastructure for geodata, based on the completion of the National Geodata Strategy.

Parties in the cooperation can be:

- Authorities with an information responsibility according to the Swedish Act and Ordinance on spatial informa-

tion, based on the INSPIRE-directive.

- Municipalities, government agencies and other organisations with official duties.

The Geodata Cooperation Agreement presents how to handle organisation, steering, coordination and responsibilities as well as technical prerequisites, forms of supply and terms of use of geodata.

The parties in the agreement offer each other their geodata for official use for an annual fee.

Available geodata are presented and described in a product catalogue.

Municipalities, government agencies and other organisations which conduct official duties can join the geodata cooperation, and thereby get access to all geodata in the product catalogue, but only for official use.

Maps and geographic information

Lantmäteriet provides the society with digital maps, images and other fundamental geographic information. Land surveys, aerial photography and airborne laser scanning are carried out by Lantmäteriet and this leads to a production of different information for whole of the Sweden together with a cooperation with both central and local authorities in order to collect fundamental data and reliable geographic information.

Lantmäteriet offers different geodata services which are "machine to machine" services that allows to search, view and retrieve maps, images and property information into appropriate systems. The geodata services can be divided into two main types:

- Viewing services, aimed at users who only want to look at Lantmäteriet's

maps and images in their own systems or applications.

- Direct access services aimed at users who want to retrieve and show property information in their own systems or applications.

From 2018 Lantmäteriet does not anymore offer printed maps and now it's up to the market to offer printed maps by using data from Lantmäteriet. Instead Lantmäteriet have developed an e-service "Map Print", where you can select an area, download your own map and print the map by yourself in scale 1:10,000 or 1:50,000. "Map Print" offers the possibility to choose an area in the map, create a map book and open or save it in PDF format for printing. In the e-service "Map Search and Place Name", it's possible to view maps, orthophotos (processed aerial photos) and terrain shading. It's possible to search, view, zoom and pan in maps and images and to find information about properties, addresses and place names and heights for individual points across the country. You can also print or save your map as a PDF.



Example: Map Search and Place Name

Aerial images, satellite images and digital elevation model (DEM)

The nationwide aerial and satellite images provide valuable information about changes in the natural and built environment. Lantmäteriet has

produced aerial photographs of Sweden since the 1930's and have been involved in producing satellite images since the 1970's.

Aerial photography is mainly carried out in order to meet the needs for aerial photos and orthophotos within the national mapping program, but at the same time the activities are planned with the goal to provide other users with appropriate information. New aerial photos cover approximately 1/3 of Sweden every year. The used sensors simultaneously photograph black/white, true colour and infrared data sets. They are furthermore the first step in a complete digital production line in the mapping process, ending in digital archives and in further dissemination.

The aerial photography season starts in April and ends in September. It takes approximately three months from the flight to ready processed orthophotos, both in colour and false colour infrared, to be provided to users. The products, which also contains orientation data to be able to place the image in a coordinate system, is used for mapping, producing orthophotos, interpretation of vegetation and more. Digital aerial photos from different years, with the resolution 0.48 meters/pixel are available throughout Sweden. Aerial photos with a resolution of 0.24 meters/pixel are found across the southern part of the country, along the northern coast, and over larger urban areas (a total of about 44% of the entire country) as part of the national nationwide image supply program.

From 2019, the aerial images will have a resolution of 0.37 m / pixel and 0.15 m / pixel instead of 0.48 m / pixel and 0.24 m / pixel respectively.

The images are photographed with cover, which allows for stereo processing, such as 3D measurement. More examples of using digital aerial photos are:

- Updating of Lantmäteriet's map bases with photogrammetric methods, (measurement in 3D models).
- Production of orthophoto.
- Mapping for production of plans, maps, ownership boundaries, height curves / terrain models, 3D models etc.
- Interpretation of vegetation and analyses for e.g. forestry purposes, then the infrared colour range is used.

There are more than a million aerial photo negatives in the analogue image archive and there is an ongoing process to digitise all images.

The database of satellite imagery, Saccess, was released to the public in mid-2008. The contents of the database are national coverages from mainly Landsat and SPOT from the 1970's, 1980's, turn of the century, 2005 and yearly from 2007. The available data are either as satellite scenes or as mosaics in true colours or in IR-colours. Thanks to a unique cooperation between several governmental agencies and some private companies the data is available, free of charge, to organisations and the public in the Nordic countries.

The satellite database is a tool for studying the landscape changes that have taken place in just over three decades - for the benefit of, for example, agriculture and forestry, environmental analysis and planning, but also for interested public.

The nationwide data sets consist of optical multispectral data from satellites with a geometric resolution of 10 - 30 meters. The exception is the MSS data from the 1970's, which has a resolution of 80 meters.

The information in Saccess is available to all Nordic users on equal terms, regardless of whether these are authorities, companies or individuals. The information is easily accessible via the Internet and is free of charge thanks to special government grants for the construction and data collection.

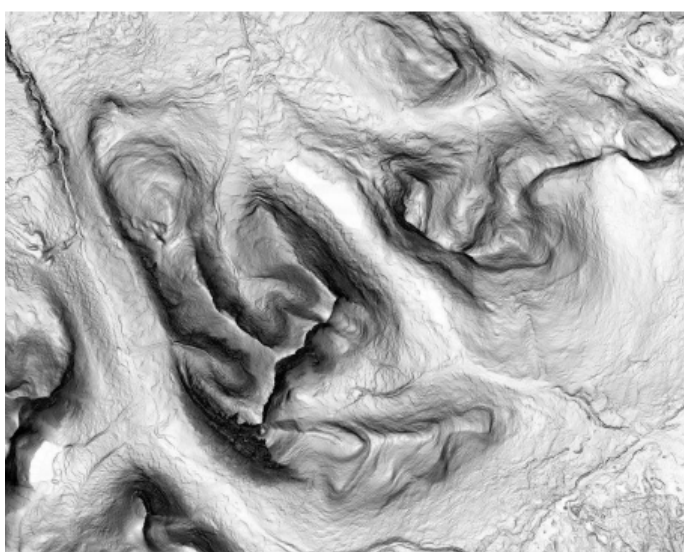
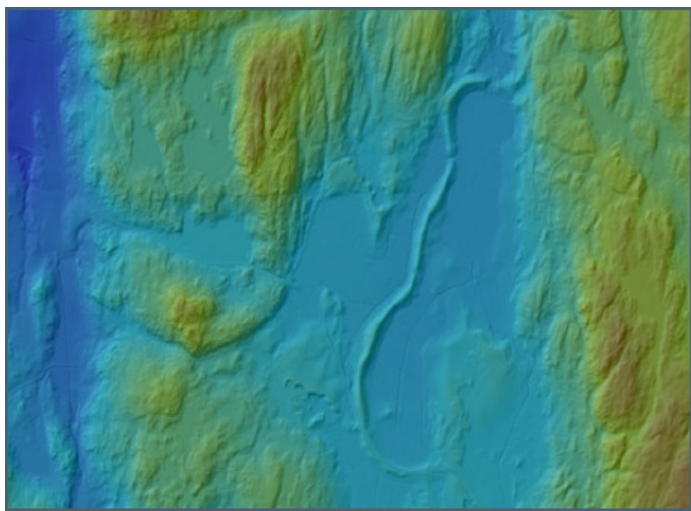
The database contains satellite data that is adapted to different types of users, e.g.:

- Raw data for experts.
 - Mapping images for the accustomed GIS users.
 - Cloudless mosaics for those who want to visualise a larger area than what is covered by a single image.
- The mosaics are made up of map-like images and are presented as infrared vegetation images partly in natural colours.

In 2009 Lantmäteriet started to produce a new digital elevation model, replacing the model made some 35 years ago. The production is carried out by air-borne laser scanning from a flight altitude of 2,300 m. Up to 2019 almost the whole of Sweden is scanned with a height accuracy of less than 0,5 m. With linear interpolation in a TIN (Triangulated Irregular Network), a grid is interpolated based on land classified points.

Examples of usage of elevation data:

- Climate adaptation measures, such as flood mapping.
- Detailed planning purposes.
- Building permits near water.
- Contingency planning for climate and environmental changes.
- Optimal location of wind turbines.
- Mobile telephone masts.



Examples: Elevation data grid 2+ and laser data

Historical maps

All real property changes take place via a cadastral process. The results of any property changes are mapped and/or documented and archived for future reference in a cadastral file stored at the county office since the middle of the 1700's. The cadastral file includes all historical and current information describing a property's characteristics and corresponding cadastral procedures. All rights which have been granted and decisions which have been made regarding new plans and alterations can be found in these dossiers. Lantmäteriet decided in year 2000 to

digitise all the historical maps. Lantmäteriet's archives contain maps and documents dating from 1630 and onwards. There were more than 2.5 million dossiers from cadastral procedures and other mappings. These documents have been digitised and made accessible via the Internet. The Historical Maps website is a presentation of large parts of Lantmäteriet's unique and invaluable collection of historical maps and cadastral dossiers. The collection comprises more than a million maps from all parts of Sweden and these are freely accessible in low resolution for the period prior to 1928. The archives contain not only Lantmäteriet's own dossiers, they also include decisions made by municipal authorities and county boards.



Examples: Village Duvemåla, 1843, and town Landskrona, round 1910.

Historic orthophotos

Lantmäteriet's aerial photographs are used primarily for the production of maps. The images are also used in search services by other companies such as Eniro and hitta.se. When aerial photographs are corrected geometrically, they are referred to as orthophotos. Today even older pictures can be transformed into orthophotos at the correct scale. Historical orthophotos are produced from older, prior to 1995, scanned aerial images that are geometrically projected to an orthogonal, i.e. scaled, map projection supported by a height model.

Being able to compare aerial photographs taken 50 years apart is not just an exciting prospect in visual terms. It also makes it possible to track changes in environments and communities to a detailed level. It is clear how a coastline has changed, but it is also easy to track old centres of pollution such as petrol stations and creosote factories. It is easy to see how vegetation has changed and map how waterways have become overgrown. Interest in these historical documents has grown over the past few years and expects still to increase.

The goal is to create nationwide layers of these historical orthophotos for different reference years, for example 1960. The term reference year here refers to a year plus minus about 5 years. Reference year 1960 is the oldest image material where it has been possible to achieve a national coverage, though with some supplementation of images from previous years than 1955 and later than 1965. The corresponding reference year 1975 is under con-

struction.

In the aerial archive there are 1.2 million negatives, as well as a large number of aerial photographs on paper and microfilm. Lantmäteriet works continuously to scan these images, determine their geographical positions and thus create digital orthophotos across the country. The goal is to create nationwide layers for different reference years.

These older orthophotos can be used for example:

- Monitoring of changes in vegetation and settlement.
- Identification of old rowing passages that had previously been carved.
- To locate old landfills of environmentally hazardous goods around industries and other potential and now invisible environmental risks.
- As a basis for rebuilding wetlands.

Example: Historic orthophoto

Geodetic infrastructure

Lantmäteriet provides both networks consisting of control points in the terrain and a network of permanent reference stations for GNSS positioning. SWEREF 99, which is connected to the global ITRF, is the national reference frame for three-dimensional positioning in Sweden. A national height system, RH 2000, based on a nationwide levelling program, is available for accurate elevations.

For the transformation of heights obtained from GNSS-measurements to levelled heights the geoid model SWEN08_RH2000 has been developed. Lantmäteriet recommends local authorities and other providers of local control networks to use the nation-

al reference frames. SWEPOS is the Swedish network of permanent GNSS stations, providing real-time services on both meter level (DGPS/DGNSS) and centimetre level (Network-RTK), as well as data for post-processing.

An automatic post-processing service is also available. SWEPOS has nationwide coverage and consisted in 2019 of about 400 stations. The SWEPOS network-RTK-service has more than 1,300 unique daily users. Applications for SWEPOS services are e.g. detail measurements, setting out, machine guidance.

SWEPOS stations and other stations used in the positioning services International cooperation is an important part of Lantmäteriet's geodesy activities. This applies to collaboration with European and international bodies as well as participation in EU projects. It is often about cooperation within official organisations where Sweden as a country member.

Standardisation within Geodata

A standardisation program for geodata has been running within the Swedish Standards Institute (SIS) since about 30 years. Through this program Sweden has been active in the international standardisation work the International Standardisation Organisation (ISO). In ISO there are 150 countries represented and the number of established standards currently amounts to almost 25,000. Lantmäteriet is involved world widely in standardisation and Lantmäteriet holds the chairman post for ISO TC211, which is the part of standardisation about digital geo-

graphical information.

Digitalisation

The possibilities and expectations of digitization in public Sweden is a part of Lantmäteriet's work. We live in the midst of digitalisation's era and with the help of smart phones and constant internet connection, new products, services and business models have replaced and competed out yesterdays. Everywhere, these changes take place, which totally alter our behaviour and we are all within a digital transformation.

Managing digitization is necessary for all companies and authorities. Digitization can be perceived as a threat but should instead be perceived as an opportunity to develop the business to create new products and services for new markets, while at the same time making existing processes more efficient. Job opportunities disappear but more can be created.

Lantmäteriet is working within the digitalisation on several areas, such as block-chain, the community building process is and others. Here Lantmäteriet has taken a lead in Sweden within the area that Lantmäteriet works in.

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The Swedish Maritime administration (SMA, Sjöfartsverket)

Organization and mandate

In Sweden the Hydrographic Office, responsible for hydrographic services, is organized under the Swedish Maritime Administration (SMA, in Swedish Sjöfartsverket). The Hydrographic Office is responsible for hydrographic surveying in Swedish waters and publication of official nautical chart products in electronic and paper format and maritime safety information such as Notice to Mariners. Most of the Hydrographic Office 115 employees are located in Norrköping, but approximately 35 of the staff are on-board on the SMA's own survey ships, which are operating in all Swedish waters. Most of SMA's activities are financed through dues on ships and cargoes.

As a coastal state Sweden has ratified the United Nations Convention on the Law of the Sea (UNCLOS) and the Conventions for the Safety of Life at Sea (SOLAS). Related to hydrography these two UN conventions require that the coastal state's waters must be charted so relevant nautical charts and publications can be published to secure navigation in and passage through the coastal state's waters. The Swedish government has mandated these tasks through its instruction to the SMA. Through these instructions, the SMA is also representing Sweden in the International Hydrographic Organization (IHO).

International co-operation

Shipping is a global market dependent on international standardized nautical products. Therefore, a hydrographic office is dependent on international interaction. The intergovernmental co-operation in hydrography is performed through the IHO, by the member states and the IHO secretariat in Monaco. Within the IHO, the member states co-operate on standardization, development of exchange formats and distribution system in all matters related to hydrographic surveying, printed and electronic nautical charts and other matters related to hydrography in both global and regional aspects.

Regional aspects are organized through regional hydrographic commissions such as the Baltic Sea Hydrographic Commission (BSHC). All countries surrounding the Baltic Sea are member states in the BSHC, which is very active in international work and analyses. Some of the BSHC activities are coordinated with HELCOM which is the governing body of the "Convention on the Protection of the Marine Environment of the Baltic Sea Area" – more usually known as the Helsinki convention. Since a considerable part of the Baltic Sea has never been surveyed with modern methods a common plan; the HELCOM Hydrographic Resurvey plan has been developed for the purpose of surveying shipping routes and ports of the Baltic Sea. This survey plan, with time schedules, was decided upon by the member states environmental ministers in October 2013 in the HELCOM ministerial declaration. In the case of Sweden this means that all waters used by commercial shipping must be surveyed, accord-

ing to the IHO-standard, in the year 2020. Other actions within the BSHC includes coordination of vertical reference levels for nautical products and water level information, coordination of international paper and electronic charts in the Baltic Sea and co-operation on a bathymetry portal. The Baltic Sea Bathymetry Database <http://data.bshc.pro/> has been developed by the hydrographic offices of the countries surrounding the Baltic Sea under the leadership of the SMA. A 500 m grid of bathymetry data is available for viewing and downloading at the portal. The bathymetry datasets for the Baltic Sea has also been reused for the EU-portal on bathymetry EMODnet bathymetry <http://www.emodnet-bathymetry.eu/> and the global GEBCO bathymetry model https://www.gebco.net/data_and_products/gridded_bathymetry_data/ which in turn is used by e.g. Google Earth.

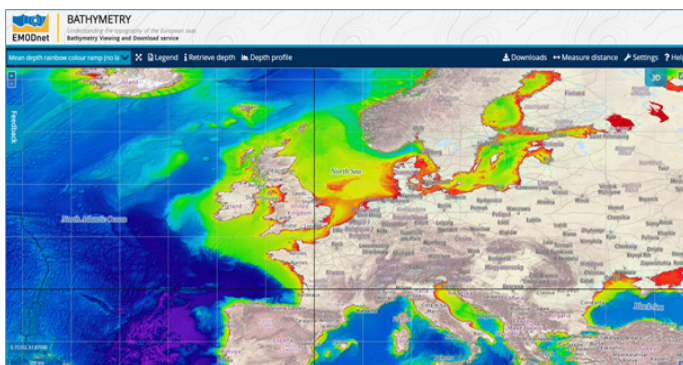


Figure 1 The EU-portal on bathymetry EMODNet Bathymetry for viewing and downloading bathymetry in European waters. SMA has coordinated data for the Baltic Sea.

National co-operation

Co-operation with other Swedish Authorities as well as the commercial shipping sector is essential for the

SMA. There is an established successful cooperation with the Swedish mapping, cadastral and land registration authority (Lantmäteriet) where one important example is the compilation of a common coastline for use in both parties' official products. Successful co-operation is also established with the Swedish Agency for Marine and Water Management, the Geological Survey of Sweden as well as the Swedish Meteorological and Hydrological Institute and others involved in marine environmental and spatial planning issues.

Hydrographic surveying

Bathymetry is primarily used for nautical products to secure safe shipping. However many other sectors of society are dependent on bathymetry. Examples are mapping of the marine environment, marine spatial planning and efficient preventive measures for protection from the effects of the expected future climate change in the coastal zone. Also in the shipping sector high resolution bathymetry can be used in other ways than just nautical charts. The fuel consumption of a vessel is strongly influenced by its speed and the depth of water under the keel. Fuel consumption begins to increase in water ten times the vessel's draught. A vessel with 10 m draught can be affected at a depth of 100 m. In a comparatively shallow area such as the waters around Sweden there would be a possibility of reducing fuel consumption by finding deeper routes in the Baltic Sea. Providing the shipping sector with high resolution bathymetry in order to find these deeper routes will help shipping to be more cost efficient and at the same time reduce the environment

impact. A precondition is modern hydrographic surveys.

Swedish waters cover an area of 165,000 km², mostly comparatively shallow. Archipelagos are widespread and are a challenge to seafarers and especially challenging to surveyors. As a result of a successful projects co-financed by the European Commission TEN-T and CEF programmes most of the counties surrounding the Baltic Sea has managed to speed up the surveying of its waters up to the applicable IHO standard. In the beginning of 2011 only 25 % of Swedish waters were charted according to this standard. In the end of 2018 as much as 65 % of the Swedish waters have been surveyed up to the standard thanks to the co-financing from the European Commission.

The IHO Standard for Hydrographic Surveying (S-44) means surveying with full seafloor coverage. Specific harbour areas, where the margin between the vessel and the seafloor can be very small, are controlled to a higher accuracy by bar sweeping which is a mechanical method of detection. The main method of surveying elsewhere is multibeam echo sounding which gives a wide, complete and accurate picture of the seafloor. High-resolution bathymetry is produced and the method gives a high probability of detecting small objects. The SMA has five vessels at its disposal with a staff of 35 surveyors which is sufficient to crew four vessels continuously. The two largest vessels run 24 hours per day, 7 days per week, weather permitting.

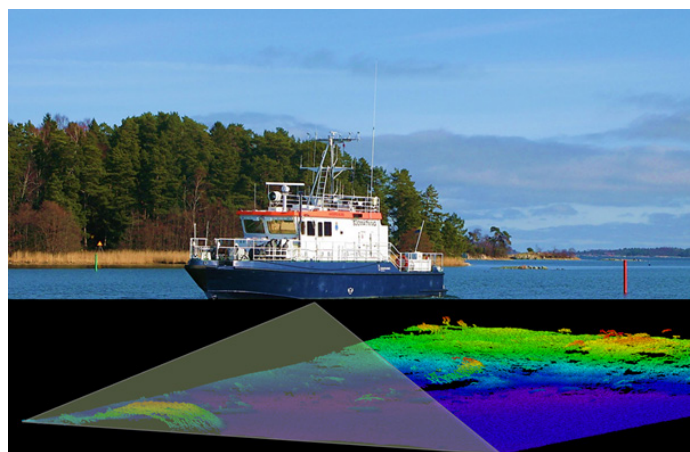


Figure 2 Hydrographic surveying is performed with multibeam echosounder, which gives a wide, complete and accurate picture of the seafloor. The SMA survey vessel Anders Bure.

Cartographic activities

In order to produce user-friendly nautical products for commercial mariners, the leisure craft market, navy users, the fishing industry and other usage complex information must be compiled into a fully readable and understandable chart. When selecting the most important information from a high resolution bathymetry data set generating readable depth contours and the most important depth figures nautical cartographic skills are essential. Mariners are fully dependent on the nautical chart when navigating, since the dangerous obstacles below the surface are invisible and only revealed in the chart. The nautical chart is in that sense more of an infrastructure than just a map. Cartographic judgement must be applied when all type of products are being produced; paper charts as well as electronic charts.

Paper nautical charts

Paper charts covering Swedish and adjacent waters are produced by the

SMA, i.e. Skagerrak and the Baltic Sea, including Kattegat and the Gulf of Bothnia. Paper charts are also published covering the four largest lakes in Sweden (Vänern, Mälaren, Vättern and Hjälmaren) as well as the three largest Swedish canals. Users are urged to navigate using charts of the largest possible scale as essential navigational information may have been omitted in the smaller scale chart depending on the purpose of the chart. Paper charts are produced in the following scale ranges:

- 1:300,000 – 1:1,500,000. The scale is usually 1:500,000.

Charts are used for planning and navigation in open seas.

- 1:180,000 – 1:300,000. The scale is usually 1:250,000.

Charts are used for navigation in coastal waters.

- 1:40,000 – 1:180,000. The scale is usually 1:50,000.

Charts are used for inshore- and coastal navigation.

- 1:10,000 – 1:40,000. The scale is usually 1:25,000.

The charts cover areas of heavy traffic, narrow archipelagos, harbours and approaches.

Small craft charts

The SMA also supply charts in a smaller format mainly for the leisure craft market. Each edition contains 36-66 pages in size A3 and are attached with a spiral-binder and printed on a water-resistant paper (Pretext). The contents are the same as in ordinary charts with some additional information about marinas and other services important for the leisure craft users.

Electronic Navigational Charts

The vector based Electronic Navigational Chart (ENC) are used in the Electronic Chart Display and Information System (ECDIS) which is the approved system on-board commercial ships. In the ECDIS the ship's position is shown as well as other ships positions using GNSS and AIS (Automatic Identification System). The UN agency the International Maritime Organization (IMO) has decided upon carriage requirements of ECDIS and the regulation require most ships engaged on international voyages to be equipped with ECDIS. Swedish official ENCs are produced by the SMA in usage bands similar to the scale bands described for paper charts above.

The use of electronic charts is steadily increasing as an alternative to paper charts. In order to use ENC instead of paper charts the system must fulfil the requirements specified in the IMO Performance Standards for ECDIS. Swedish waters are completely covered by ENCs which is also the case in all neighboring countries. Official Swedish ENCs are distributed via a global distribution center, PRIMAR, which is a part of the Norwegian Hydrographic Service with head office in Stavanger, Norway. PRIMAR serves as a center for ENC-distribution to the shipping sector and the end users receive continuously updated ENCs. In the case of Sweden the SMA distributes 1,500 updated ENCs in a typical year. Examples are changes in harbours and fairways, new under water cables and pipelines or changed bathymetry information as a result of the hydrographic surveying. Updates are available for the end user by an online service. The

SMA also produce electronic charts for the leisure craft market, which are widely used in chart plotters.

Quality improvement

The nautical chart of today is a comprehensive and complex data set showing a detailed shoreline, detailed information on bathymetry, characteristic landmarks, fixed and floating navigational aids etc. A navigator needs as much information as possible but at the same time not too much information since it would overload the chart with misleading information of lesser use for navigation. This is valid for paper charts as well as electronic charts. The ability to show the vessels position, given from GNSS, on top of the electronic chart requires an improved accuracy of the chart information than was the case when charts were only available as a paper product. Quality improvement of the content in the chart products is one of the major challenges and where SMA puts in a lot of effort. Improvement of accuracy is concentrated on the most crucial themes for mariners. As described previously hydrographic surveys are performed in all areas used by commercial shipping and will result in updated and accurate depth information in the charts. The coastline is continuously improved through the co-operative project with Lantmäteriet where the old coastline in charts is replaced with new photogrammetric surveyed coastline. The joint coastline project is a part of a larger challenging project, which makes a major quality improvement, and its goal is to change the vertical reference level in all chart products. A common vertical reference level (Baltic Sea Chart Datum 2000 – BSCD2000)

for the whole Baltic Sea has been agreed upon in the BSHC. Due to post glacial land uplift since the end of the last ice age, there is a need to refer the depth information to a more up to date vertical reference level. Improvement in positioning of nautical objects such as lighthouses and buoys also contributes to greater accuracy of the nautical chart products. The new vertical reference level has been implemented in 20 % of the Swedish chart products, which cover the northern coast of Sweden.

Publications

In spite of the fact that a modern nautical chart contains a large amount of information there is still a need of supplementary information in the form of publications containing information which usually cannot be presented on a chart. The following are the essential ones for merchant shipping produced by the SMA:

- Swedish Notices to Mariners (NtM), Swe: Underrättelser för sjöfarande, (Ufs) gives information in the form of updates or warnings so the end users are able to update their paper charts. The publication is available as a downloadable pdf at www.sjofartsverket.se/ufs.
- Notices to Mariners volume A (Swe: Ufs A) is a compilation of general information of nautical interest.
- Kort 1/ INT 1 contains symbols, abbreviations and terms used on Swedish and international charts.
- Navigational Warnings in the Baltic Sea area: As a supplement to in particular the Ufs, special navigational warnings are broadcasted through NAV-TEX. The SMA is the coordinator for navigational warnings in the Baltic Sea.

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Swedish Meteorological and Hydrological institute

(Sveriges Meteorologiska och Hydrologiska Institut, SMHI)

SMHI, the Swedish Meteorological and Hydrological Institute, is an expert agency under the Ministry of the Environment. Through expertise in meteorology, hydrology, oceanography and climatology, SMHI contributes towards greater public welfare, increased safety and a sustainable society.

SMHI administers and develops information about the weather, water and climate that provides social functions, trade and industry and the general public with knowledge and qualified decision guidance. National and international cooperation are extensive.

SMHI offers tailored products and services that form the basis of important decision guidance for different activities. General forecasts and warnings, industryspecific services, simulations and analyses, statistics, climate studies and research assignments are just a few examples.

SMHI's activities are primarily financed in three ways: through grants, through commissions from other agen-

cies and through business activities on commercial terms. There are distinct lines of activity that naturally are different, yet still based on the same fundamental principle, to contribute to greater public welfare, safety and a sustainable society.

SMHI has an annual turnover of more than SEK 640 million and has approximately 640 employees.

From observation to decision guidance

Air and water are essential for life on earth and an important part of our environment. SMHI makes its observations and measurements at ground-based observation stations, with balloon-borne instruments as well as from aircraft, ships and buoys. Satellites, weather radar and lightning sensors supply spatial information. Collected data are structured, processed and analysed using very powerful computers.

SMHI makes forecasts, produces decision guidance for the community and follows up climate and environmental development. SMHI's operations run around the clock every day of the year. Warnings in the event of extreme weather events are an important task.

SMHI provides a wide range of forecasting and professional services tailored to the needs of different users. In addition to industry-specific forecasting services, a large part of the assignments deal with climate and environmental issues related to air and water. Some examples are tailored climate analysis for urban planning, decision guidance for wind power and providing design data for water flows and water

levels. Customers can be found nationally and internationally in the areas of social structure, energy, environment, shipping, media and capacity development. Target groups include commercial customers, agencies and individuals.

Research and development

SMHI conducts applied research in meteorology, hydrology, oceanography and climate.

The research department develops knowledge, models and tools that describe processes in the atmosphere, in the sea and on land. These are needed to improve SMHI forecast models and decision guidance for practical public welfare.

A great deal of the research conducted by SMHI is climate related. Researchers develop climate models, produce climate scenarios and participate in impact and adaptation studies. Mathematical models and methods that utilise data from satellites, radar systems and other observations are key in the research.

SMHI's research is mainly externally funded. Researchers collaborate in Swedish research projects, EU projects and other international projects.

Climate work in focus

SMHI runs a national centre of knowledge for adaptation to climate change on behalf of the government at SMHI. The role of the centre is to act as a hub for knowledge about climate change and to be a meeting place for actors involved in climate change adaptation.

SMHI is the contact point in Sweden for the UN's climate panel, the Intergovernmental Panel on Climate Change (IPCC). As the contact point, SMHI coordinates the Swedish IPCC work and establishes contacts with the IPCC Secretariat in Geneva. Responsibility also entails nominating Swedish experts for the IPCC work. This can be in the role of author, reviewer or participating in workshops and other meetings

Operational mapping at SMHI

SMHI is a large producer of maps and geospatial information. Operational daily mapping of meteorological, hydrological and oceanographic parameters based on numerical models, satellite data, radar sensors and in-situ observations generates an extensive range of maps and charts. Products are presented on the institute's own web page, in mobile applications and via external portals and web services. Geospatial data can be accessed via an open data interface and downloaded in a range of different formats, both gridded and vector.

The product portfolio for meteorology include a range of weather forecast maps, such as precipitation, temperature, cloud cover, wind and air pressure. Hydrological maps include soil water content and river flow, evaporation and snow depth. The state of the oceans around Sweden is presented using maps of, for example, sea ice extent, surface water temperature, harmful algae blooms and deep-water oxygen content.

SMHI also produce future climate scenario maps illustrating projected climate change and its impacts. These maps are often used by other Swedish authorities for climate adaptation planning. Statistical maps based on long data series describe averages for different climate variables and visualizes anomalies and trends.

SMHI is host for the Swedish Water Archive (SVAR) and is responsible for maintaining geospatial information defining surface water bodies such as lakes, rivers and catchment areas. The institute is also national data archive for marine environmental monitoring data and is an active partner in a number of national and international networks around geospatial data exchange and remote sensing.

Map 1: Interactive map showing real time precipitation intensity measured by radar. Data is updated every 5 to 15 minutes, and also show lightning flashes during thunderstorms. The time slider allows the user to follow the advancement of the rainfall as it moves (in this case) east.

Map 2: This interactive map shows wind conditions and air pressure isobars from a meteorological model, along with the latest wind observations. The time slider allows the user to slide backwards to see analysis and observations from the past 12 hours, or forward to see the forecast for the next 48 hours. The forecast is updated four times per day. Users can also choose to view other parameters by clicking on the tabs above the map (wind, waves, sea currents, sea surface temperature & ice, weather).

Map 3: This map shows current water content in waterways (rivers and streams) compared to normal conditions for a given day. Orange colors means there is less water than normal, and blue shades indicate a higher than normal water flow. There is a new map generated daily, and by clicking the box in the lower left corner, the user gets an animation of the past few months.

Map 4: This series of maps show measured (observed) annual mean temperature for Sweden along with projected temperatures in the future, based on two of IPCC:s climate scenarios (RCP4,5 and RCP 8,5).

Map 5: Toxic blue-green algae, also known as cyanobacteria, blooms in the Baltic Sea during summer. This map, based on analyzed satellite imagery, shows where cyanobacteria is gathering at the surface. The map is updated daily in the summer months.

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Geological Survey of Sweden (Sveriges geologiska undersökning, SGU)

Organisation

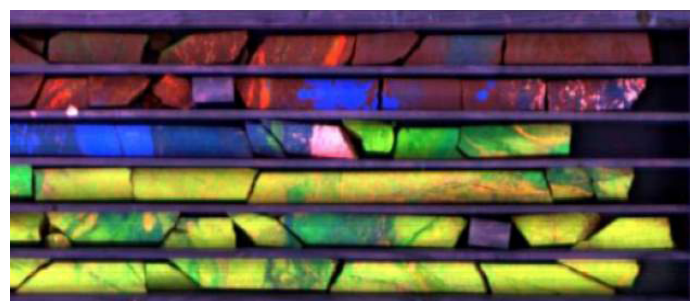
The Geological Survey of Sweden (SGU) is the central government agency responsible for questions relating to soil, bedrock and groundwater in Sweden. SGU is organised to meet society's need for geological information. SGU has an economic-political as well as an environmental-political task from the government. The SGU head office is based in Uppsala. SGU also has branch offices in Göteborg, Luleå, Lund, Malå and Stockholm.

Brief history

Geological Survey of Sweden was founded in 1858 with the purpose of carrying out geological mapping of the whole country during a period of 20 years. At around the same time, geological surveys were formed in many countries. Some of the main goals in Sweden was the inventory of ore deposits and other natural resources as well as to map soil types for an agricultural land expansion. At the beginning and during the first 50 years, at most 11 people were permanently employed at the same time. As a comparison at the end of 2018 roughly 300 people were permanently employed at SGU. Over the years, the society's need for

geological information has changed. The geological models i.e. how the geology is described and interpreted have also changed as well as with the terminology and methods for making assessments and interpretations. SGU's main task has been to produce geological maps with descriptions. The maps were excellent records that presented a model of the geological conditions, with descriptions of methodology, interpretations and the different premises within a map area that were investigated. These maps and descriptions are still the basis of SGU's geological information.

During the first 150 years, most of SGU's geological information was published in standardised map series with different geological themes (soils, bedrock, geochemistry) often on a scale of 1:50,000. More and more users wanted the geological information to be available in digital form. During the years 1999-2008, SGU therefore worked for a mapping plan with the main purpose of producing needs-adapted geological information for the whole of Sweden. The mapping of geological information was carried out by processing and possibly re-interpreting existing geological information, gathering new data



An image of a drill core box. The picture is made with data from the long wave portion (LWIR) of the infrared spectrum. Three infrared bands are reproduced here as an RGB image, which shows differences in mineral compositions.

through aerial image interpretation and overview field checks, as well as selecting and generalizing geological information in the areas where detailed data were available.

Web services with thematic maps

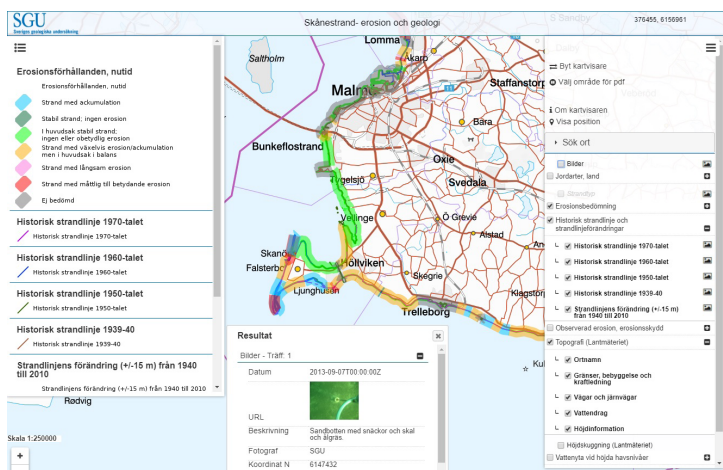
In recent years the map production has undergone the transformation from hardcopy maps to digital services. During the last decades, SGU has developed thematic map viewers to provide a quick and simple overview of SGU's data where the information can be used and combined with other location-related information of the users who so desire. Most of the services are published as map services, which enables external players to directly integrate the services into their own. Thematisation meets the more specific needs of different stakeholders. Essentially, the thematisation has been done by combining different types of exist-

ing information in map services. The map viewer has also been modernised and mobile adapted to meet new needs, but also to meet increasing demands for cyber security.

An example of more user-oriented maps is the map service for the assessment of erosion along the coast of Skåne. With climate change and rising sea levels, the coasts sensitivity to erosion will increase, especially in the southern part of Sweden where there already is extensive erosion. The information from the project is an example of SGU's thematic products that are based on information on the extent of the soils and are primarily intended to be used as a basis for assessing erosion sensitivity, but it also benefits as a basis for planning for the coastal zone and for questions about soil and seabed use in municipal overview planning.

SGU's geological information consists not only of maps, descriptions and databases. SGU has a large collection of drill cores which in 2017 consisted of more than 3 million meters of drill cores from more than 18,000 boreholes from all over Sweden and new drill cores are added continuously. As part of the focus on improved documentation for the mineral industry, more than 200,000 meters of drill core from the northern counties, and about 20,000 meters from other parts of Sweden are scanned.

The information from the scan can be used in geological knowledge building, mineral exploration and ore-related research. Exploration companies, researchers and other stakeholders will have access to a virtual archive with data that can give an increased understanding of the bedrock and ore de-



View from the map viewer Skånestrand. The geological information for the beach and the shallow coast are combined in a "seamless" surface. The map viewer contains both basic geological information and interpretations that are the basis for the assessment of erosion sensitivity. The many photographs are also an estimated subset that are freely available in the map viewer.

posits in northern Sweden. The result of the scan is presented via the map viewer where showing the positions of the drill holes of the scanned cores as well as metadata of cores. In the map viewer there are links to reports, bore-hole log and a link to the overview of the images.

Open data

Together with other Swedish authorities, SGU has a responsibility to manage large amounts of geodata, information that is becoming increasingly important today. The provision of these has to a large extent been done to other authorities, municipalities and the business sector through a fee procedure and through deliveries in proprietary formats. Over the past 5 years, together with other authorities, SGU have made a lot of information to available as open data. Most of the groundwater information as well as environmental data is now available as open data and can be used by anyone to further develop these services in their own systems and thereby make it possible to increase benefit and innovation in society.

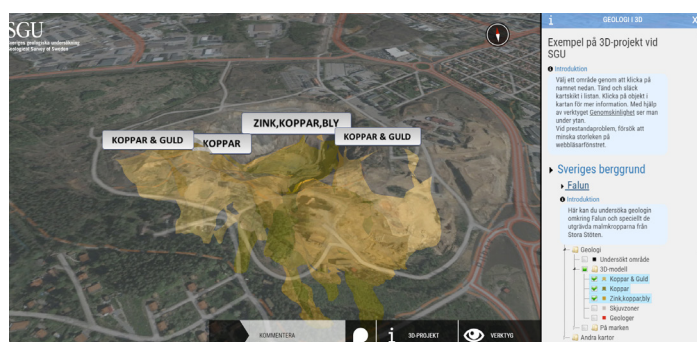
Hack for Sweden

SGU has been involved in Hack for Sweden, which is a national hackathon organized by around thirty national government agencies. Hack for Sweden was first held in 2014 and has been repeated yearly since then. All agencies contribute with their specific open data to the project and developers were invited to participate during a weekend to develop applications using the data. The winners were awarded with the “Hack for Sweden Award” for the most

creative combination of different data sets.

Web cartography

Web viewers and services provide great possibilities to present geological information at different scales and at different levels of detail. They also allow the combination of data sets that have not traditionally been combined, and a variation in which data sets are shown depending on the map scale. The visualisation of geological information on screen, however, also provides challenges, and the migration from paper to computer screen has provided more user-friendliness but also fewer opportunities to produce advanced cartography. SGU's geological data consists of a combination of geological surfaces, lines and points which needs to be shown together with topography. Some of the map viewers, e.g. bedrock maps, share the principles of cartography with our printed maps. Other map viewers have been more adapted to on-screen viewing. The symbols and colours used build mainly on the long tradition of symbolising geological features but have in some instances been adapted to international standards. SGU have developed a designated web cartography for about 20 of our 30 map viewers. Unique for the web cartography is, for example, that a certain fea-



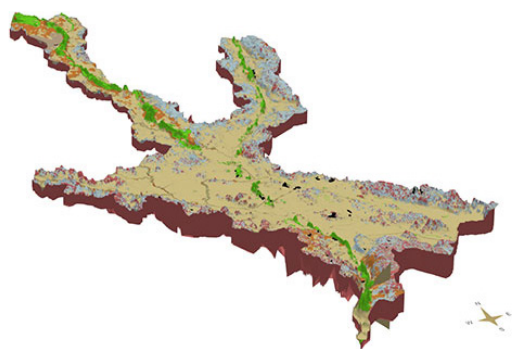
Example of 3D visualization of the Copper mine in Falun

ture may be shown with one symbol at a small scale but with a different symbol, or even several symbols to provide more detail, on a large scale. The use of patterns on polygons is a traditional way to visualise geological surfaces, and this has also been implemented in our map viewers.

SGU is a member of a technical committee which is coordinated by the Swedish Standardisation Institute (SIS) and is participating in a national standardisation project on web cartography. One aim of the project is to increase the awareness of cartographic opportunities on the web. Secondly, the project aims to provide guidelines for maintaining the quality of web-based cartography when presenting data subsets in combination with subsets provided by external geodata producers.

3D models to make it easier to explain geology

With the help of a web-based 3D map tool, SGU has developed a way to visualize geological information in three dimensions. By visualising geological formations in 3 dimensions, the understanding and usability of the somewhat complex geological information increases.



3D visualization of the esker of Uppsala an example of making geology simple

SGU, in collaboration with Uppsala Vatten, has developed a three-dimen-

sional soil storage model for the parts of the Uppsala river used for Uppsala's water supply. The model makes it easier to understand how the groundwater supply in the ridge looks and how any contaminants spread. In this way, the model contributes to securing Uppsala's water supply. SGU has also developed a 3D model over the old copper mine in Falun. The models are presented with the web-based map tool City Planner, a tool that is normally used for community planning. In the map tool, it is possible, among other things, to follow the extent of rock types and soil layers in depth and horizontally, drilled wells in depth and a lot of other information.

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Swedish Association of Local Authorities and Regions, SALAR (Sveriges kommuner och landsting, SKL)

Organisation

The Swedish 290 local authorities and 21 regions operate under a well-developed constitutional self-governance system. To perform their duties, they use geographical data and maps in several ways. There is also considerable need to use different maps for a variety of activities and operations.

The role of local authorities in providing basic large-scale geographic data becomes more important as its usage increases for both old and new applica-

tions, where GIS offers good support. There is also municipal co-operation within regions as well as between the municipalities and the state, in order to provide society with high quality controlled geographic data. The majority of local authorities produce and update geographical databases or maps within their individual organisation. In most cases, they are part of the town planning committee. Other local authorities purchase this service from commercial companies, while others do so in co-operation with other local authorities. 900 000 people are employed in the local authorities and 280 000 in the regions, which together is equivalent to 25 % of the total sum of the national labour force. 0,5 % of the employees in the municipals and 0,7 % in the regions work within the field of community planning.

Co-operation

Most local authorities have formed groups which comprise the most frequent internal and external users of maps and GIS data and deal with matters of co-operation, technical development and financing. There are also regional groups which focus on mapping-and/or GIS-development. There is also extensive co-operation between both the Swedish Association of Local Authorities and Regions (SALAR) and the National Land Survey Authority (Lantmäteriet) concerning for example, collaboration in constructing national databases. A framework agreement for this arrangements was drawn up in 2001. This framework has been renegotiated twice in order to include more up to date

higher quality data and to increase efficiencies. The co-operation concerns e.g. sharing of addresses, buildings, other topographic objects and quality improvement of the cadastral record. Normative agreements have also been developed which the local authorities may use as a base, while engaging in individual agreements with Lantmäteriet. There are a similar set of agreements in place with the Swedish Transport Administration concerning the road network.

Since 2011, Lantmäteriet, together with the Geodata Advisory Board (other Swedish public sector authorities and SALAR) has run a national geodata infrastructure cooperation, which is also a part of the European infrastructure and the Inspire-directive. 264 of the 290 local authorities and eight of the 21 regions are members which facilitates co-operation as well as easy and integrated access to information within the geodata sector. The Geodata Advisory Board conduct their work according to their extensive National strategy and action plan. The cooperation is now underway to be developed through new laws, new standards and new technics for higher benefits in Swedish society. Lantmäteriet, together with SALAR and local authorities, concluded 2018 a project, entitled Svensk geoprocess, to develop specifications for geodata on nine different data themes used in the planning and building process. The results are now enlarged and processed within the action plan of the Geodata Advisory Board. The discussion on open data in Sweden is now opposed of the security discussion. The security matters have not until recently been put into public

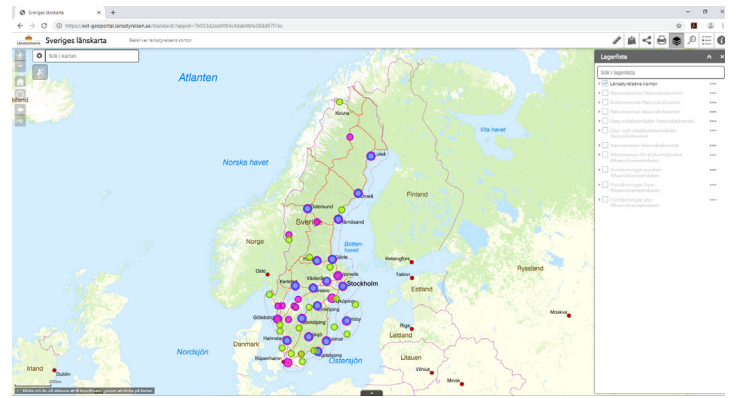
focus. The open data issues are raised primarily by users, but also by Lantmäteriet and some larger municipalities. In spring 2019, SALAR performed an inquiry to all municipalities about their providing of open geodata. Although a high participation, there were just a few responders indicating that they provide open geodata, the rest mostly because of lack of financing and resources. On the other hand, quite few indicated that they experienced a demand from citizens and private companies for open geodata.

Development

E-government is of increasing importance for the delivery of all sorts of activities within the local authorities as well as the increase in applications. The issue of national specifications of requirements for common functionalities for adoption in various administrations is in focus.

Development of GIS-applications as e-services are constantly in progress. GIS-technology is commonly used within municipalities. Many local authorities have a GIS controller to stimulate and encourage the use of GIS in all sorts of activities within the organization.

GPS technology is commonly used. Examples include aerial photography, digital aerial images, orthophotos and photogrammetric mapping systems. LIDAR is the standard method for assembling data for growth areas as well as for studies of climate change problems, as this method generates digital terrain models as well as digital surface models at a reasonable cost.



Altitude data is used, for example, for three-dimensional city models and for production of orthophotos. In order to provide a high-quality overview of proposals on spatial planning and infrastructure, many local authorities, have utilized virtual reality and augmented reality technology. Other authorities have commenced transforming their data into three dimensions models for the purpose of visualising the urban environment in a more natural manner. To facilitate the processes of planning and building permits, oblique aerial imaging systems are used in some municipalities.

For smaller mapping projects and for the production of 3D-citymodels, small unmanned aerial vehicles (UAV), drones, are used. Several municipalities owns them and consultants offer services using UAV.

The changeover to SWEREF 99 and RH 2000, which are the Swedish realization of the European reference systems ETRS89 and EVRS, is nearly completed as for SWEREF 99 within the municipalities. In June 2019, out of a total of 290 municipalities, 289 had changed to SWEREF 99 and 237 to RH 2000.

the County Administrative Boards.

Through the “Geodatakatalogen” you get access to:

- About 1500 regional GIS-related layers provided by the separate Counties.
- Over 40 harmonized layers with national coverage of which many also are provided as OGC WebMapServices (WMS).
- Three datasets consisting of INSPIRE-specified information in WMS-format with ATOMservices
- Over 100 web map applications (regional, national and thematic)

Technical development

Due to an enterprise agreement with ESRI our GIS environment is based on server and client software from ESRI.

- We use ESRI’s ArcSDE for a “standardized” repository with internally produced Geodata.
- We provide Geoservices, both internal and external, by the use of ArcGIS Server.
- We have approximately 1,500 installations of ArcGIS Desktop.
- We distribute our webmap applications through Portal for ArcGIS.
- Portal for ArcGIS is also the platform for data access for our mobile GIS usage, we use Survey 123 and Collector for ArcGIS as our main mobile GIS applications.
- Datacollection and aerial photographing with drones are an upcoming trend.
- The demand to have GIS-components integrated in administration systems are rising as well, to make this integration easier we have developed a generic map API.

Collaborations and forums

- Participation in the national SDI collaboration and the National Geodata Advisory Board.
- Participation in a geodata exchange collaboration, with the purpose of improving the quality of web services for end users.

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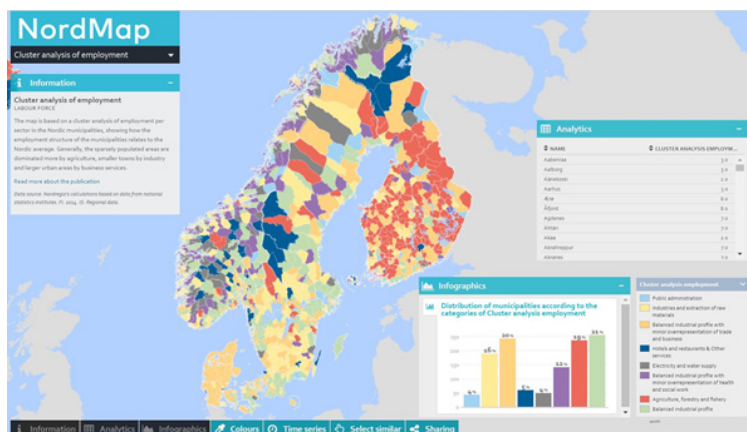
Nordregio

Organisation and mandate

Nordregio is one of the institutes funded by the Nordic governments under the cooperation framework of the Nordic Council of Ministers. Nordregio is recognised and respected as a leading Nordic and European research institution within the broad research fields of urban and regional development studies. Nordregio conduct solution-oriented and applied research, addressing current issues from both a research perspective and the viewpoint of poli-

cymakers and practitioners. Nordregio also works on commissioned projects that help policymakers and practitioners to tackle economic, social, planning and governance challenges. This involves active participation in European, Nordic and national research programmes (e.g. ESPON, Horizon 2020, Interreg, NordForsk, Formas, The Research Council of Norway).

Operating at the international, national, regional and local levels, Nordregio's research covers a wide geographic scope, with an emphasis on the Nordic and Baltic Sea Regions, Europe and the Arctic. As a strategic research institute, Nordregio is required to adjust the research competences to meet the needs of our main stakeholders, including the Nordic Council of Ministers and the national and regional authorities are responsible for regional development in the Nordic countries, Faroe Islands, Greenland and the Åland Islands.



Nordregio's primary research focus and competence areas are:

- Regional Rural and Demographic Development
- Urban Planning and Sustainable Development
- Regional Innovation and Green Growth
- Governance and Policy: Regional

Reforms and Strategies

GIS and cartographic activities

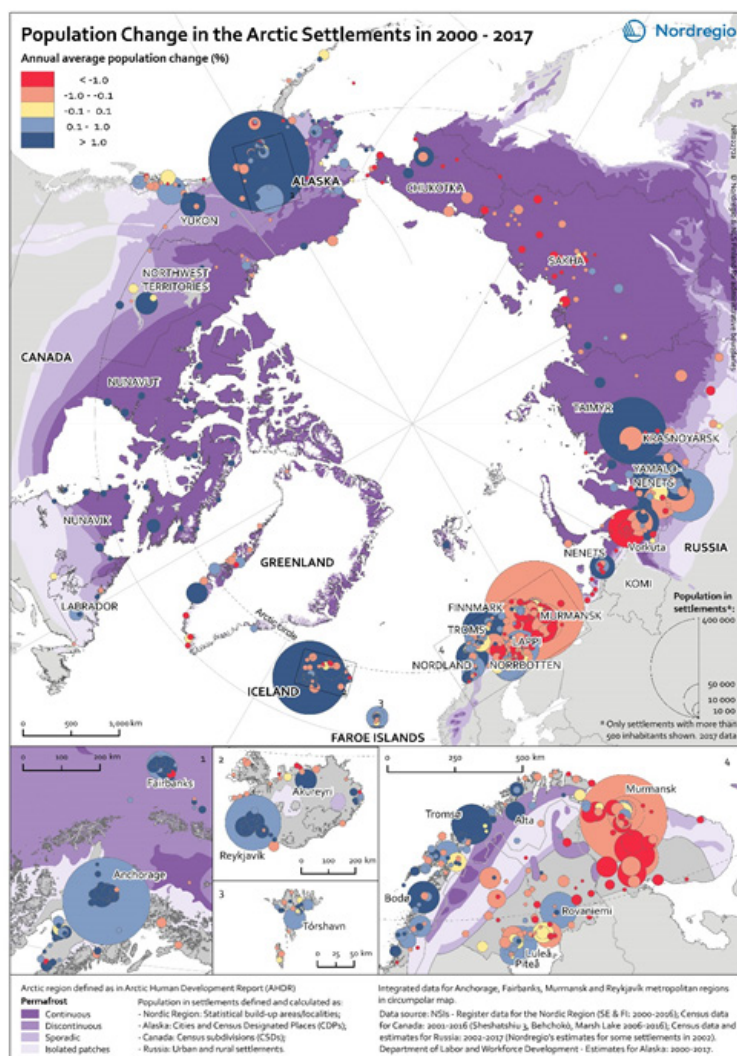
One of the core competences at Nordregio is the harmonisation of local area statistics from different sources for the purpose of building cross-border indicators. These activities are mainly carried out by the GIS staff; a department which has grown from four employees in the beginning of 2015 to seven employees by mid-2019.

A lot of the data collected is represented in maps. The map is essential in helping to visualize research findings, making complex statistical data easily assessable and understandable for stakeholders working in the field of regional development. For the Nordic wide purpose, a set of core indicators are monitored continuously. These are demographic indicators like population structure and migration; productivity indicators like GDP and PPP; or labour force indicators like employment rate and education. These statistics are presented at the highest geographical resolution possible, which in the Nordic countries generally means municipality level. Every other year these maps are published in the report State of the Nordic Region, where the maps are also supplemented with expert comments from the research staff at Nordregio. The next issue of State of the Nordic Region is planned to be published in early 2020.

In addition to the printed publications, the core indicators are accessible for researchers and stakeholders through an interactive WMS called NordMap. The tool can be used on desktop computers, laptops and tablets. NordMap

supports a variety of functionalities:

- Pick an indicator from the library and choose which colours to represent the classes
- Generate high-resolution image for printing
- ‘Infographics’ showing the classification histogram
- ‘Time series’ show development trend for many indicators
- ‘Select similar’ is a function that allows the user to identify municipalities or regions with a similar profile



Selection of GIS activities “in the pipeline”

- Update the regional geodatabase in line with administrative boundary

changes in Norway 2020

- Formalising a collaboration between the Nordic NSIs on harmonising population data at grid level
- Building capacity to model accessibility across the Nordic region using road network data and destination points

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Hydrographica

Hydrographica is a highly specialized private company producing nautical charts exclusively for pleasure cruising purposes. Hydrographica charts are complementary to the official Swedish HO charts, in areas where a more detailed product is needed.

Organization

Hydrographica is privately owned and employs at present 7 persons. Three of them are qualified cartographers with a background as lecturers in cartographic education at Stockholm University. Hydrographica was founded in 1983 and is based upon a surveying technique using aerial photointerpretation/photogrammetry in bathymetric mapping.

Chart production

Hydrographica produces charts over marine and coastal areas as well as over inland lakes. Production of inland lake charts are normally initialized

by local yacht clubs or local authorities wanting a professional chart over Swedish inland waters where no ordinary HO chart exists. From 2000 Hydrographica also have a permission from military authorities to survey coastal areas where ordinary surveys are old and/or unreliable. Hydrographica now produces large scale marine charts, and at sea the Hydrographica charts are a parallel to the orienteering maps on land.

At present, Hydrographica have produced about 30 Swedish inland lake charts at various scales, and 105 marine charts at a scale of 1:10,000. All charts are planned, produced and published within Hydrographica. The in-house competence spans over the whole production chain. All Hydrographica marine charts are printed on polyart, a synthetic paper with excellent properties for use at sea.

Surveying techniques

Chart production starts indoor with aerial photo interpretation and photogrammetry. Hydrographica have developed a technique where water depth down to 4-5 meters normally can be penetrated and measured with high accuracy through stereoscopic analysis of aerial photos. Bathymetric contours for 2 and 3 meters can be drawn and water depth on separate shoals can be established. All photo interpreted data must be confirmed through field surveys, but the field work can be considerably more efficient since the positions of all shoals are already mapped with high precision. For field surveys Hydrographica owns 6 boats for shallow water mapping specially equipped with suitable echo-sounders, side scan sonar, positioning tools and other navigation aids.

Cooperation

Hydrographica cooperates with the Swedish Maritime Administration and supplies data to international chart producing companies such as Garmin, Navionics, Jeppesen a.o. Hydrographica is a MapTech acknowledged partner in producing digital raster versions in BSB-format. Paper charts published by Hydrographica reach the market through a substantial amount of retailers in Sweden, but also through Hydrographicas own website, a system that is highly appreciated and well-functioning. Digital versions of Hydrographica charts can be downloaded directly from the website. Hydrographica also cooperates with a nautical publisher in producing guide books for pleasure cruising along the Swedish coast.

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