NORWAY

NATIONAL REPORT

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(The Norwegian Association for Cartography,
Geodesy, Hydrography and Photogrammetry)
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Abstract:
National report from Norway for the period 1988-1992, on photogrammetry, remote sensing, digital mapping and GIS.

Key words: National Report 1992, Norway, NKTF.

1. Introduction

This report is prepared by Norges Karttekniske Forbund, NKTF, The Norwegian Association for Cartography, Geodesy and Photogrammetry. NKTF is the Norwegian member of ISPRS.

The report gives a short introduction to the most important developments and changes during the 4-year period 1988-1992. The largest changes has taken place within digital mapping and GIS.

2. Map-production in Norway 1988-1991

Only the main map series are included in the following.

2.1 Topographic map Norway 1:50000 (series M711) and related products

The map series is produced by the Norwegian Mapping Authority (Statens Kartverk SK). The series consist of 727 sheets, and were completed in the period. The yearly amount of revision is 35-40 sheets.

A completely digital production line for the maps has been established. Up till now 28 sheets have been put into an "all-digital" form.

A digital "names" database contains all the names from the maps, a total of 340000 names. The database was completed in 1991, including a gazetteer.

All contours, spotheights and water borders have been digitized and stored in databases. From these a DTM covering the whole of Norway has been generated. The grid size is approximately 100x100m. The accuracy of the DTM is 6,5 meters RMSE, according to recent investigations.

In 1990 the establishment of a digital road data bank was started. This is done from new aerial photography in scale 1:40000. The accuracy requirements for position and height is ± 2m. The data are already used for planning of timber transportation, hopefully giving a reduction in costs of 20-30 million kroners a year when the database is finished. This database will also serve as the road part of the digital map database.

2.2 Economic map of Norway, scales 1:5000 and 1:10000

The Economic map of Norway is planned to cover 185000 km^2, 60% of the total land area. 163000 km^2 will be mapped in scale 1:5000 and 22000 km^2 in scale 1:10000. By 1. january 1992 more than 176000 km^2 had been mapped. According to present plans, the entire series will be completed by 1994.

The updating is going on, but only densely populated areas can be handled.

Digitizing the content of Economic map is in focus. At the moment 15% of the property-content has been digitized and put into a database.

All new sheets and all updating are now made with digital output.

2.3 Municipal maps, scale 1:500 - 1:2000

Municipal maps are produced for local needs. The annual production within a community varies. The average annual production for Norway has been approximately 400km^2 for the scale range 1:500 - 1:1000 - 1:2000. All new maps are now digital.

2.4 Norwegian polar mapping

Norwegian Polar Research Institute is responsible for mapping the Norwegian Artic and Antarctic areas.

Svalbard. The topographic main map series of Svalbard in scale 1:100000 is planned to cover the entire island group in 63 sheets. By 1992 55 sheets had been constructed.

Bjørnøya. A new map in scale 1:50000 was issued in the period 1988-92.

Jan Mayen. The island is covered by two sheets in scale 1:50000. A new sheet in 1:100000 with revisions and a new datum has been issued lately.

Bouvetøya. The island is covered by one sheet in scale 1:20000.

Peter I Øy. The island is covered by one sheet in scale 1:50000, published in 1988.

Dronning Maud Land. Parts of this area are covered by maps in scale 1:250000. 32 sheets have been issued. (7 sheets in 1988-1992).

Major parts of Svalbard were covered by aerial photography in scale 1:50000 in 1990. Central parts were also covered with scale 1:15000. False color film (IRC) was used. Maps are constructed on a Wild A7, with both analog and digital output.

Norwegian Polar Research Institute uses satellite data for mapping; and for ice, geology and vegetation studies. The Institute acquired an interactive digital image processing system in 1988. In Dronning Maud Land five of the sheets are also issued as satellite image maps (1:250000) based on Landsat MSS data. At the moment a SPOT-based map at 1:100000 is under work. KFA-1000 images are under investigation for future mapping. At Svalbard two of the sheets in 1:100000 are printed with topographic map on one side and satellite image map on the reverse.

3. Development of photogrammetry

3.1 Cameras and photography

Aerial photography in Norway is performed by two private companies. They operate 4 airplanes and 4 cameras with alltogether 7-8 lens cones.

A new generation of cameras like Wild RC20 and Zeiss RMK Top has been put into use. Electronic interfaces (e.g. RS232) makes it possible to connect equipment like PC's or GPS-receivers. This has already been useful. There is a trend towards using more sofisticated, GPS-based, navigation systems.

There is now a slight trend towards more use of normalangle cameras (c = 30 cm), and also more use of colour diapositive films.

The use of forward motion compensation is an established procedure. The users of the images are reporting that the image quality is significantly better than some years ago.

Some experiments have been performed with different shapes, sizes and colours for targets.

3.2 Aerial triangulation

Measurements for aerial triangulation are mainly done in analytical plotters. In 1988 the block adjustment was mainly done with the method of independent models, using software like PATM or ATM. Now in 1992 there is a trend towards using bundle block adjustment, the proportions being roughly 50%/50% at the moment. This development, in addition to more use of robust methods, has clearly improved the quality of aerial triangulation. This is needed due to the higher requirements caused by the transition from analog to digital mapping.

GPS has been used in aerial triangulation three times, with photography in 1988, 1990 and 1992.

3.3 Stereoinstruments and map production

There has been a steady change from analog plotters to analytical stereoinstruments. But quite a number of analog plotters are still in use. The proportions are roughly

analog plotters: analytical instruments = 65%:35%

In 1988 most maps were delivered to the customers in analog form, even if some digital technique was used in the production process. But now in 1992 nearly all maps are produced and delivered to the customers in digital form, accompanied with a plot of the data. Also there is a slight trend towards a slightly rough checkplot of the data being sufficient as an analog map. The change of production process has been remarkable during the last 4 years. For quality fair drawing there is a tendency to use rasterplotters instead of drawing machines.

This trend has caused that most of the analog plotters have equipment for production of digital maps.

Superimposition, like Videomap, is regarded as a definite advantage. Other means of verification used by the operator during plotting is graphical screen and/or plotting table. In densely built areas with much detail, the plotting table is preffered by some operators due to the more limited resolution of screens.

3.4 Changes of the map

All maps made in the '90ties are basically digital.

The content in large scale maps has increased by approximately 10%, due to increased number of objects required for inclusion in the maps.

The accuracy requirements for maps has been increased considerably, like:
1988 Analog map 1:1000 Position accuracy required ± 30 cm
1992 Digital map 1:1000 Position accuracy required ± 12 cm.
For other scales the requirements has become more differentiated, sometimes relaxed.

Digital maps of 1988 were often on "spaghetti"-form. Today maps are required to be fully thematized, with no gaps in lines or junctions. The users are more conscious about digital data, requiring them to be delivered on a standard exchange format, mostly the norwegian SOSI-standard. The data from the producer will be put directly into the geographic information system of the user.

Much effort has been put into making standards for map content, data formats, and exchange formats.

A few projects with close range photogrammetry has been performed in the period 1988-92, one of them being the "as-built"-documentation of an oil drill rig.

3.5 Production of analytical plotter AP190

The AP190 is an inexpensive instrument based on the optics of a special mirror stereoscope, an encoded measurement system, an electronic interface, and a personal computer. It provides interior, relative, and absolute orientations of full format photos and maintains a stereomodel, free of y-parallax in the digitizing mode. This simple instrument has been generally applied as a photo-digitizer and has found applications from measuring tree heights to serving as a data capture device for Geographic In-

formation Systems.

In January of 1986 Carto Instruments A/S was established to produce and market the AP190 as a photo-digitizing system. Marketing began in 1987. The system sells for under 250.000 NOK. Forty systems have been delivered worldwide to date.

3.6 Metrology Norway System

The company Metronor A/S is developing and marketing the on-line photogrammetric system Metrology Norway System (MNS).

MNS is a new, absolute 3D coordinate and geometry measurement system. MNS is based on the use of high resolution CCD video cameras that through a patented factory calibration method have been converted to become on-line photogrammetric cameras. MNS measures the spatial XYZ coordinates of special Light Emitting Diodes (LEDs) or points of reflected laser light as seen by the cameras. The patented Metronor Light Pen is a unique hand-held device which endows the system with the complete functionality of a Coordinate Measurement Machine (CMM). The Light Pen contains several LEDs and a tip mechanism that accepts the same type of probe tips (i.e. ruby ball or pointer) employed on conventional CMMs. By placing the interchangeable probe tip of the Light Pen on an object, the user is able to instantly digitize any selected point on the object. If the object is CAD-based, the normal-to-the-surface deviation between the physical point and the nominal CAD reference is instantly computed. Applications for the mobile CMM include both off-line and in-line quality control, prototype assembly, rapid digitization of free form surfaces, as well as surveying and geometrical verification of assembly fixtures and welding stations in production cells.

MNS can be brought on-site and initialized in minutes. Measurements with the Light Pen are fast, and with the use of lasers, MNS can measure the coordinates of hundreds of points in just a few seconds.

A dual-camera MNS achieves typical accuracy of 0,1 mm in most applications.

The company Metronor A/S was established in 1988, and has at the moment 8 employees.

4. Development of Remote Sensing

The big event in earth observation in 1991 was the launch of the european radar satellite ERS-1. The imaging radar SAR is functioning very well.

The national ground station for ERS-1 data at Tromsø Satellite Station was built before the launch, and is equipped with the fastest SAR processor in Europe, the CESAR processor. Processed SAR images are transmitted from Tromsø to the users via the NORSAT B satellite.

The main use of ERS-1 data is for sea and ice monitoring, where a number of interesting projects are going on.

Even if ERS-1 is the new, interesting satellite, the main sources for satellite imagery still are Landsat and SPOT. The data used are mainly in digital form, the proportions begin roughly:

digital data:film = 60%:40%

In the 1980ies digital image processing was often run on minicomputers (Dipix Aries, Terragon 4000, Context Vision GOP 300). Then we had in Norway a change to using PC's (and Erdas). At the same time the number of institutions using satellite data increased to approximately 30. Now we are changing again, to UNIX-workstations. The trend has been towards faster computers with larger capacity. Standard, "off-the-shelf" hardware is preferred. Software has improved, with Erdas still being the most popular system.

A few experiments has been conducted using airborne imaging spectrometers like CASI. They do have some advantages, and only the time will show if these are larger than the disadvantages.

4.1 Remote Sensing at Fjellanger Widerøe A/S

Fjellanger Widerøe A/S was the SPOT distributor in Norway. From 1991 the distributor of SPOT imagery for all Nordic countries is Satellite Image Corporation in Kiruna, Sweden. But Fjellanger Widerøe still has their archive of SPOT data.

The company is in a process of lowering the interest for remote sensing and increasing the interest for GIS. They are acquiring a VGA-version of Erdas with Live-link to Arc/Info.

For some of the customers Fjellanger Widerøe performs image processing and/or produces satellite image maps.

4.2 Remote Sensing at Geological Survey of Norway(NGU)

NGU has two PCs with Erdas and Arc/Info software. In addition NGU has an Intergraph UNIX workstation with the same kind of software.

The equipment is used in projects where geological structures are interpreted from digital Landsat MSS- and TM-data, and then integrated with geophysical data collected from airplane, helicopter, existing records and/or field observations.

One of the projects has yielded interesting results with regard to structural-geological interpretation and in particular to the detection and monitoring of environmental stress caused by the Ni-Cu mining activities in the Nikel-Zapoljatnjy region of Kola.

5. Development of GIS and Digital mapping

Map production in 1988 was mainly an analog process, but with some digital techniques involved. The map itself was mainly an analog product.

Today in 1992 the situation is completely reversed. The map production process is with few exceptions fully digital. And the product is the digital data, even if a plot usually is delivered in addition.

But of course, there are still a large amount of analog maps older than 2-3 years in storage.

The change to digital production and digital products has caused a drastic change of equipment and procedures at the map producers.

Many of the users foresee use of GIS in the future, but only few are well under way using GIS.

The Norwegian Mapping Authority is putting large resources into the establishment of an insfrastructure for the distribution of geographical data. Many public organisations are producing maps. One of the goals is to establish standards and formats so that data can easily be exchanged. Routines are needed for coordinated collection, updating and administration of map data on different levels and scales.

One goal is that by 1996 the main parts of the maps belonging to the Mapping Authority shall be in digital form. A service, named National Geographic Information Center (NGIS) shall by then be operational, giving the users easy access to the data.

5.1 Software for GIS and digital maps.

Quite a number of different systems are in use.

- **SysScan** is a Norwegian Company producing and marketing GIS software. SysScan has sales and support offices in England, Ireland, Malaysia, Northern Ireland, Norway, Singapore and Sweden. 80% of the sales are abroad. Their main system is TELLUS. It was developed as a raster system, but is now an integrated raster/vector system. TELLUS runs on UNIX workstations. It can be delivered either as a GIS toolset or tailored to the customers requirement. TELLUS is basically a system for the larger users.

- **Arc/Info** probably is the most popular system among advanced GIS users.

- **Pumatec** is a norwegian product, developed under quite some years. It is vectorbased, running on PC's under Windows, and is easy to learn and use. It started as a map-system, but GIS-functions were added later on.

- **Terrasoft** is a canadian system for GIS, vectorbased and developed for PC's. It has found quite some users, especially among forestry organisations in Norway.

- **Intergraph** is fairly new on this market in Norway, but is selling some of their Microstation and MGE packages.

- **Phocus** from Zeiss Germany is used in photogrammetric production on Zeiss analytic stereoinstruments.

- **VG-kart** is norwegian. It is a good and popular system for mapping purposes.

- **Fysak** is a mapping system developed by the Norwegian Mapping Authority.

- **System 9** is known by few people, but *they* like it very much.

6. Education and Research

6.1 Education

Education at technician level (photogrammetric operators), is given at the "Rud Vocational School". This school offers the opportunity for up to two years training in surveying subjects, including some 120 hours of theory and 400-600 hours of practical training in photogrammetry. Four students complete this course every year. In addition, there are institutional training seminars at map production organizations.

At engineer level, no education of photogrammetrists exists.

At university level, photogrammetry is taught at two universities, The Technical University of Norway (UNIT-NTH) and the Agricultural University of Norway (NLH, Aas). The study lasts for 4,5-5 years. At both universities basic courses in mathematics, statistics, physics, informatics etc. are given during the first years. Then follows a common core of courses in the mapping sciences. At the end of the studies the student may specialize in geodesy, photogrammetry, cartography or remote sensing, and then finalize with a M.Sc. thesis. Each year, 15-20 students takes their Masters Degree within the mapping sciences.

Courses in remote sensing and mapping from satellite imagery are well established at both universities.

Courses in Geographical Information Systems are recently established. At UNIT-NTH there are one lecture course and one exercise course in GIS. At NLH, Aas there are one introductory course in GIS, attended by 52 students in 1991. And then GIS is included in an advanced course in digital cartography.

At NLH, Aas a GIS laboratory was established in 1991. It has 8 PC's, one Intergraph workstation, one Sun workstation with X-terminal, three digitizers and two plotters. The software used are ArcInfo and Intergraph; and Pumatec, VG-Kart and other norwegian software.

Some post graduate courses in the mapping sciences are also given, as the basis for a 3 year study for the Dr. Engineer Degree (Ph.D). Approximately 10 students are working for their Ph.D.

6.2 Norwegian research programmes on mapping and remote sensing

Two important research programmes have been running, funded from government. The satellite *mapping* program SATMAP, together with its predecessor, ran from 1982 to december 1989. The sister program SATOBS ran from 1986 to december 1989, and was more specifically devoted to *remote sensing* and *surveillance*. The governmental funding was up to 19 mill. NOK a year at the most.

A few of the projects under the programmes:
- NAVSTAR GPS used in aerial triangulation.
  Very accurate and promising results.
- VEGSAT, Vegetation mapping from satellite in forested, mountainous and polar areas.
  Succesful mapping of reindeer grazing areas.
- A GIS-project to reduce the gap between available technology and the utilisation of GIS technology in the public sector.
- FGIS: The main objective is to develop specifications for an open, nationwide database system for geographical information.
- HYBRID GEOREC: A software package for automatic raster-vector conversion of topographic maps.
- Cartographic zoom: A software system for on-line generalization of maps during zooming on graphical screens.

6.3 Department of Surveying and Mapping, University of Trondheim

Industrial photogrammetry: A complete procedure has been developed for test-field calibration of analog and digital cameras using automatic recognition of targets and bundle adjustment. The project has been a cooperation with the department of Data Processing [Åmdal et.al. 1990, Hådem, 1989].

Industrial photogrammetry: The department has contributed to the development of a digital photogrammetric station (Metrology Norway System) for high precision industrial measurement, applied by the company Metronor AS [Hådem & Åmdal 1992, Åmdal 1992].

Remote sensing in forestry: The aim of the project is to develop complementary methods for forest inventory by the use of satellite remote sensing. These methods are planned to classify only those areas in the forest that actually are interesting compared with the latest inventory. By these methods the complete and ordinary inventory is planned to be undertaken with longer intervals. The projects is a cooperation between the section of forestry at a regional college (NTDH) and the department.

6.4 Department of Mapping Sciences, Agricultural University of Norway

A GIS-laboratory, and education in GIS, was established in 1991, see section 6.1. A book of lecture notes on GIS was issued in 1992: Ø.Andersen: "GIS Geographic Information-System". ISBN 82-557-0376-4. 195p.

Three projects on using GPS in aerial triangulation have been carried through/are under way. Software for position determination from GPS observations (pseudorange, doppler and carrier phase) was developed, and aerotriangulation software was modified for the input of GPS-observations.
- GAFF- project. Photography in 1988, see [Andersen 1989, Hals 1989]. Very promising results.
- GAFF2-project. Photography in 1990. Larger image scale than in GAFF. Report to come in 1992.
- GAFF3-project. Photography in 1992. Improved technology compared to GAFF2. Preliminary report expected in 1993.

Two software packages for block adjustment have been developed; one for adjustment by independent models, and one for bundle adjustment.

A project on satellite imagery used for geology:
Hildur Håkås: Digital processing of SPOT data applied to Quaternary geologic mapping compared with conventional methods.

Satellite imagery for monitoring of fires on the African savanna: This project has as goal the development of methods for using digital satellite data from NOAA (AVHRR) to monitor bush-fires during the dry season on the African savanna [Langaas].

Interpretability of High Resolution Satellite Imagery: This project is a comparative study of KFA-1000 and SPOT HRV satellite imagery [Dick 1989]. Included in the project is development of quantitative methods for expression of the content of detail.

Russian Satellite Imagery of Norway: This is an investigation of the geometric accuracy of a KFA-1000 satellite image [Maalen-Johansen 1991].

The importance of the methods used for geometric correction of satellite imagery: This project investigates the quality of satellite imagery rectified with different procedures.

Presentation of satellite images on PC's with standard VGA-graphics: This project also includes a search for optimal datacompression of satellite imagery.

Geometric-optical modelling of forest canopies: This project has analyses of Landsat TM and Spot imagery, based on mathematical modelling of the reflection from forests. The method will give information on the amount and density of vegetation.

On the courses and teaching in satellite mapping, see [Dick 1992].

Close-range videometry: In this digital close-range photogrammetric project a mono videocamera system for measuring dynamic processes was designed and calibrated [Maalen-Johansen 1992].

6.5 GRID-Arendal

GRID-Arendal, one of the current 5 major GRID-centres in the global network, is primarily concerned with assembling, processing and supplying information concerning the status of the environment in Norway/the Nordic countries with adjacent seas, and in the polar regions.

GRID-Arendal is also working with global environment presentations and scenarios, and lends its technical support to the expansion of the GRID network.

GRID-Arendal does not produce primary data, but procures relevant data from a wide number of monitoring programs and natural resource surveys, compiles the data, analyzes it, and disseminates an information product for decision-makers and the general public.

Work initiated by GRID-Arendal:
- Construction and development of a meta-database model for the Arctic.
- Presentation of ice-cover dynamics in the Barents Sea over a 20-year period.

- Pilot project on sulphur and pH values in air, soils and water in Norway.
- Presentation of data from European Monitoring and Evaluation Programme, i.e. long-range transported air pollution, in the Nordic countries.
- Cooperation with several environmental data projects in the Baltic Sea catchment area.
- Presentation of soil moisture and vegetation scenarios based on changes in atmospheric CO_2 on a global scale.

6.6 VIAK-IT

The company VIAK Information Technology is working with mapping, system and software development, geographic and environmental information technology and international engagements (more than 25 years of international experience). At present VIAK-IT is responsible for image processing projects in several African countries.

The most extensive is currently a complete revision of the 1:50000 national topographic map series of Uganda. 306 map sheets are being revised using SPOT satellite data. The satellite scenes are divided and put together in a mosaic to fit map sheets units. The image map sheets are then visually interpreted.

Thematic maps are produced illustrating changes observed since the last production of topographic maps in Uganda (1960s). The same images are in a separate project also being used to assess the current amount of woody biomass in Uganda.

The visual interpretation is carried out by local personnel under VIAK supervision. The whole exercise will be finished in approximately one and a half years from 1992.

An other successfull project was the writing of the first Nordic textbook on GIS:

Tor Bernhardsen: "A textbook on Geographic Information Systems". ISBN 82-991928-0-3. 244p.

An enlarged english version will be published in 1992.

6.7 Nansen Environmental and Remote Sensing Center (NERSC)

The research at NERSC covers among others:

- Monitoring and forecasting of ocean currents, water quality, sea ice, wind and waves by integrated use of remote sensing, field observations and numerical models.
- Development and validation of remote sensing methods and numerical methods.
- Application of remote sensing techniques in vegetation mapping and geology.
- The Seasonal Ice Zone Experiment (SIZEX) is an ERS-1 validation program for sea ice monitoring and forecasting in the Barents and Greenland Seas. Repeated SAR images provide a unique tool to study ice edge processes.
- The Norwegian Continental Shelf Experiment (NORCSEX) is studying ERS-1's ability to monitor ocean current fronts, eddies, marine winds and long gravity waves. Another objective is to obtain a better understanding of the ocean circulation on the Norwegian continental shelf.
- Monitoring and forecasting products developed in the NORCSEX and SIZEX programs will be implemented in the Norwegian operational Ocean Monitoring and Forecasting Program (HOV).

6.8 Remote Sensing at the Norwegian Computing Center (NR)

Satellite remote sensing at NR started in 1982 as a project funded by The Royal Norwegian Council for Scientific and Industrial Research. Since then, NR has continously been involved in remote sensing projects.

The combination of remote sensing and geographic information systems (GIS) has proved to be valuable.

Most projects today are carried out on workstations with UNIX and X-windows, while C and C++ are used for software development.

Some of the projects are:

- Forestry: The possible use of contextual classification of satellite data in forestry, has been examined. The results showed that satellite imagery are unsuitable for economic classification of forests by cutting class, but mapping of clear cuttings and the growth of newly planted forest areas are candidates for satellite monitoring.
- Monitoring water quality: The project used Landsat Thematic Mapper data. Water quality measurements were collected by boat while the satellite image was acquired. The results showed high correlation between image data and water quality parameters.
- Snow coverage in mountain areas: For several years now, NR has provided Statkraft (the largest Norwegian hydroelectric company) with analyses of images from the AVHRR sensor in the NOAA weather satellite in order to determine the snow coverage throughout the melting season.
- Classification and mapping of sea ice in polar areas: Norway has strong scientific and economic interests in the Arctic. The radar satellite ERS-1 can be used to make observations in this region indepent of weather and light conditions. The experiments showed that four different categories of ice could be discriminated. Up to date ice maps showing the location and the movement of the ice would highly benefit shipping in the Arctic. NR has developed a prototype of a monitoring system designed to detect ice concentration, ice edge and ice motion from ERS-1 SAR images. (Ice maps are provided today, but these are low resolution maps updated and distributed only once a week).
- Revision for topographic maps: Keeping the topographic maps in scale 1:50 000 up to date, is a problem also in Norway. Satellite imagery may be a source for up to date information, but the low spatial resolution of non-military satellites makes it impossible to gain the accuracy obtained from aerial photos. However, maps updated by coarse features could be published between the main revisions using dedicated graphical symbols for the new details in order to highlight the higher uncertainty attached to them.
- Monitoring soil erosion: Under the North Sea agreement, Norway has undertaken to cut the discharge of nutrient salts to the North Sea by 50% by 1995. One of the main sources of pollution is nutrient salts from fields tilled in the autumn. The government wishes to reduce this tillage in regions vulnerable to erosion, and therefore wants to monitor these areas. Experiments showed that fields can be classified as plowed, autumn grain, harrowed, stuble and pasture by Landsat TM images. But one problem is that it may be difficult to obtain cloud-free images during the autumn in Norway. Experiments with ERS-1 SAR images showed that it is possible to distinguish between ploughed and heavily harrowed fields in one class, an other areas in another class. Consequently ERS-1 can be used for the monitoring.

6.9 The Foundation of Applied Research at the University of Tromsø (FORUT)

Since 1988 FORUT has been steadily preparing for the SAR-data from ERS-1. Since the launch in 1991 data has been read down in Tromsø on a daily basis. Projects are:

- Improvements and corrections of earth observation data. Corrections due to terrain relief are among these, and should be performed shortly after satellite overpass.

- Extraction of environment parameters from the data.

- Interpretation and presentation of environment products based on data from radar and optical sensors.

- Terrestrial and Marine Environmental Mapping and Monitoring using Multisensor Data (TERMOS).
  The overall strategic objective of TERMOS is to develop further the existing knowledge in Tromsø in the fields of:
  - fundamental earth observation method and product development.
  - operational, terrestrial and marine environmental mapping and monitoring.

  The technological objective is to develop products for environmental mapping and monitoring using optical and microwave (Synthetic Aperture Radar SAR) earth observation data in combination with additional digital information (map, in-situ information). TERMOS will focus both on terrestrial and marine applications.

- SAR-Optical Vegetation Mapping.
  The application potential of optical satellite data is strongly reduced due to strong weather dependence. Therefore, the near-future availability of all-weather microwave remote sensing data represents a major step towards operational monitoring and forecasting applications. The objective of the project is to develop methods for remote sensing mapping and monitoring based on a combination of optical and SAR data.

- Mapping the air pullotion inpact on the natural environments in the Norwegian-Russian border areas using Landsat TM data.

- Mapping the reindeer grazing effects on the environment in Finnmark, Northern Norway, using Landsat data.

- Vegetation studies in Korpfjell, Sør-Varanger, by use of CASI imaging spectrometer.
  The CASI data was acquired in July 1991. The main objectives of the work have been to assess the new capabilities of using CASI imaging spectrometer for vegetation mapping, and to obtain and interpret spectrometer signatures from vegetation types in the Korpfjell area, close to the Russian border.
  The high geometric resolution of the CASI data image the natural heterogenity better than Landsat TM. Unsupervised classifications and comparisons of CASI data with previously processed Landsat TM data from the same area show that the CASI data seperate the complete vegetation cover into more vegetation classes than Landsat TM data. Comparisons of supervised and unsupervised techniques applied to the Korpfjell data also showed that the unsupervised techniques are preferably compared to the supervised techniques. This is due to the CASI's capability of imaging the natural heterogenity, which in turn will cause problems during the training stage in the supervised technique.

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