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Satellite Remote Sensing in Austria and the European Center for Earth Observation

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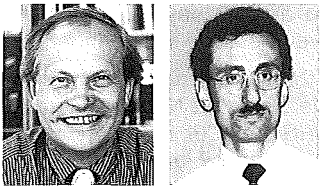

Satellite Remote Sensing in Austria and the European Center for Earth Observation

Franz Leberl and Rainer Kalliany, Graz

Abstract

We present a snap-shot of current remote sensing activities in Austria. It has been compiled in response to European Union plans for better remote sensing data management. The Austrian community, when scaling it by the total population of the country, is smaller than those of most of the other member states in the European Union. It comprises a total of about 40 persons, of which about 25 actually work predominantly as practitioners of the field. Activities are centered in the academic community and in (semi-) governmental research laboratories, but scarcely are in private industry or in applications areas. Specific project funding is nearly non-existing from Austrian sources.

Austria's remote sensing community is hardly operating on problem domains beyond its geographic borders, although there exist some exceptions. Ongoing work therefore addresses national or regional environmental and Earth resources issues, but hardly any issues of continental or global scope.

Earth scientists in Austria generally are concerned about the lack of sufficient geometric resolution of satellite images. Details are said to be too coarse, i.e. pixel size is too large to be applicable in ongoing Austrian landbased studies. Resolutions of no worse than 3 meters are being called for. Yet there is also consensus that even current satellite images could be useful if time series and change analyses were becoming easier to perform and were to increase in demand.

Zusammenfassung

Dieser Bericht stellt die gegenwärtige Lage der Fernerkundung in Österreich vor. Dies wird durch die Tätigkeit der Europäischen Union ausgelöst, welche dabei ist, Maßnahmen zur Verbesserung der Anwendung der Fernerkundung zu ergreifen. Die österreichische Fernerkundungsszene umfaßt etwa 40 Personen, von denen etwa 25 in der Fernerkundung arbeiten. Die Aktivitäten sind in akademischen Einrichtungen und (halb-) öffentlichen Forschungslabors verankert. Es bestehen kaum nennenswerte Aktivitäten in der Industrie oder den Anwendungsgebieten. Es besteht derzeit nur geringfügige Projektfinanzierung aus österreichischen Quellen.

Österreichs Teilnehmer am Fernerkundungsgeschehen befassen sich, mit einigen Ausnahmen, mehrheitlich mit Problemstellungen aus dem eigenen Land. Daher werden Fragestellungen der nationalen oder regionalen Umwelt und natürlichen Hilfsquellen bearbeitet, kaum aber Themen von kontinentaler oder globaler Bedeutung.

Geowissenschaftler in Österreich beklagen häufig die beschränkte geometrische Auflösung der Fernerkundungsdaten aus Satelliten. Bilddetails seien zu grob, Pixel seien zu groß, sodaß sie für österreichische Anwendungen ungeeignet erscheinen. Auflösungen von zumindest 3 Meter werden gefordert. Man ist allerdings sehr wohl der Meinung, daß auch die gegenwärtigen Satelliten wertvolle Dienste leisten würden, wenn Zeitserien und ÄnderungsAnalysen einfacher durchzuführen wären und es diesbezüglich zu einer verstärkten Nachfrage käme.

1. Center for Earth Observation

1.1 Background

The Directorate General XII of the European Union EU in Brussels is the European Ministry of Research and operates the Joint Research Center JRC in Ispra (Italy). Through this organization's offices, the EU has embarked on a program to improve the usefulness of remote sensing data in the geosciences. In 1992 it has initiated a project called Center for Earth Observation CEO with the aim of improving the ground segment and dissemination of remote sensing data.

Customarily one denotes the satellite data acquisition as "space segment", and the receiving installations on Earth as well as the related data processing and distribution of the data as "ground segment". In Europe it is the European Space Agency ESA which operates the space segment and the vast majority of the ground segment. From ESA the data is transferred to so-called "value-added companies" such as Spot Image, EurImage, Geospace etc. for further exploitation. These companies may convert the ESA-issued data into information for use in a specific application, or – if they are members of ESA's distribution-network – they also sell unprocessed data to users capable to exploit themselves.

There generally is concern that the investment in the space segment, not only by ESA as representative of its member countries (of which Austria is one), but also by national programs of the large space agencies (France, Germany and others) are insufficiently being used in the various potential applications. This has led to plans to improve the acceptance of satellite remote sensing data.

1.2 The European Union's Contribution

The European Union is now entering into the foray to complement ESA and is proposing to assume a new role of manager of the remote sensing ground segment. The result would be a so-called "European Earth Observation System" EEOS, consisting of ESA's space and ground segments, and of an additional segment which improves the usefulness of remote sensing data from both ESA and non-ESA, and to establish a very modern computerized European data network to which anyone in Europe can subscribe. This new segment is called "Center for Earth Observation" - CEO. In short, this CEO is:

- software operating on data that ESA and non ESA sources provide;
- information and data that derive from raw material by ESA and others, both from space, aircraft and other platforms;
- a collection of methods, procedures and advice in catalogs to demystify the more complex procedures users may want to employ with remote sensing data;
- a digital catalog of successful applications of remote sensing data and methods;
- a set of addresses of people and institutions with specific expertise in certain application areas, willing to share their expertise.

All this software, data, information etc. is planned to be available and distributed through the information highways as they either already exist or are being put in place over the next few years. CEO is meant to go into operation by 1999.

In a nutshell one might be able to describe the European initiative for a CEO as an effort to give users the equivalent of a newspaper subscription; however instead of a newspaper the user receives the latest information about the land, at his fingertips, and very quickly after it has been collected by a sensor. Part of the subscription is a service to answer any questions the subscriber may have about the information.

The activities of the EU are reflected in initial studies, for example by U.K.'s National Remote Sensing Center *(NRSC, 1993)* or by a French leaded group *(Scot Conseil and Smith Ldt., 1994).*

1.3 Financing, Implementation Issues

CEO currently is in the planning stage. A team of 15 persons is operating in Ispra and has issued a series of contracts to European industry to support the planning effort. Funding is from the JRC-budget which, in turn, is part of the DG-XII budget in Brussels. A committee consisting of experts from all member countries of the EU (the first author is the Austrian delegate in this CEO Steering Committee) is supervising the planning effort which is to be completed by mid 1995.

Then the implementation will begin under funding from the so-called "4th Framework program" of the EU's research efforts. It is anticipated that as part of the Environment and Climate program, one of the research programs of the EU to be competed for, the CEO will receive a total of 120 million ECU from Brussels, of which about 60 Million ECU in direct support, and another 60 Million ECU in shared cost support. "Shared cost" has Brussels pay 50% of a project (i.e. 60 Million ECU) and the executing agencies need to worry about the remaining 50% (once again 60 Million ECU). This then will lead to an implementation cost of a total of 180 Million ECU.

For Austrian participation this means the national funds must be made available to obtain some of the contracts. On average for every 2 ECU brought in as a contract, Austrian sources would have to augment this by a 3rd ECU.

Implementation is planned to be a complex web of projects at JRC, under contract to JRC and as shared cost actions orchestrated by JRC. Implementation is to begin towards the end of 1995 and go on for 4 years. The CEO-system is to go into effect gradually and is meant to be in full operation by the end of 1999.

At that time any user in Europe may subscribe to the CEO and receive a customized package of data and services. There exists the notion that ultimately the users will pay for the subscription and will thereby make CEO a fully funded and successful operation that no longer will need the financial support from the EU.

1.4 *Status of Plans and Implementation in Austria*

Members of the CEO supervising committee have the responsibility to stimulate their national participation in CEO, and to help assess the current status in this area. The plans for CEO are still fairly preliminary and change monthly. While thus even for an insider it is difficult to summarize the plans, it is fairly clear that "Center" is the wrong name for the planned organization, since there will be no centralized system. Instead it is planned that in each participating EU-country there will be one or more participating institutions which focus

- on the country's needs,
- on one or more applications disciplines of relevance to the entire European scene,
- on the creation of one or more standard information products from "raw" data inputs, again of interest either to the country and/or to any of the subscribers to CEO.

Studies report *(NRSC, 1993)* that a fully accepted system may have as many as 10,000 users in the current EU member states. This would translate in Austria to full acceptance with 200 users subscribing to CEO.

1.5 *Austria's Current and Potential Role*

This report was compiled as part of the CEO preparatory work. A first step in CEO planning was to assess the current use of remote sensing data in all of Europe. The expert committee members were invited to summarize their observations about remote sensing in their respective countries. The following reports the findings in Austria. At a separate occasion, and as a second step, it is necessary to review the current availability of a data network infrastructure in Austria. A set of reports is being prepared *(Leberl and Haselbacher, 1994; Leberl and Kalliany, 1994)*.

As will be shown, Austria has one of the least developed remote sensing scenes among all EU member countries. Therefore Austria would be a prime target for the EU's efforts to improve the acceptance of remote sensing data and methods. Austria has some very significant issues to consider due to its exceptional geographic situation with an important portion of high alpine terrain. This would seem to qualify Austria to become an expert in high mountain remote sensing issues.

Austria is also unique in its political structure into small districts which hold authority over many of the land issues that in other countries are dealt with at the national level. Therefore Austria can contribute a view that could lead to a highly distributed CEO, more so than without Austria.

2. Definition of Remote Sensing in Austria

2.1 *Terms*

The assessment of the size of a field or market is a very soft topic since it can vary so much just by changing the definitions of the field or market. We therefore begin by defining the area of remote sensing as it is being used in this report. The term "Earth Observation", often used in the European context, is a synonym for "Remote Sensing". We employ the definitions of the Austrian Working Group for Remote Sensing (Arbeitsgruppe für Fernerkundung AGFE) that is organized with the help of the Austrian Space Agency ASA in Vienna. This working group has a narrower definition of remote sensing than may be customary elsewhere. In many instances one may understand remote sensing to include classical photo interpretation in the Earth sciences, and of course both aerial and space borne imaging of the environment. In some instances one will also subsume parts of geodetic satellite surveying as used in the global positioning system, or include gravity and magnetic surveys. In many instances one will include meteorological sensing as part of remote sensing.

In the current review we limit the definition to uses of remote sensing images as they were originally defined in 1961 at the Environmental Research Institute of Michigan (ERIM, then Willow Run Laboratories) by the concept of "Remote Sensing of Environment", and focus in particular on data from space. Thus we exclude on one hand classical photo interpretation and photogrammetry, and on the other hand the use of non-imaging sensors. Meteorological imaging is included in this definition of remote sensing. Nonimaging sensors are typically not found under the heading of remote sensing. Therefore geodetic sensing from space or atmospheric sounding are typically not listed as remote sensing topics in Austria.

2.2 *Method of Data Collection*

This report will explain the "market" for current remote sensing in Austria and present the views of members of the community regarding the future of the field. Data were compiled by writing to all addressees of ASA's remote sensing mailings, and by following up with telephone calls. Fortunately (only from that specific point of view!) the universe of Austrian current remote sensing activists is small enough, so that a single individual can remain in telephone communication with all its players.

3. Organizational Structures

3.1 The Austrian Space Agency

The coordinating body for Austrian space activities, and thus for satellite remote sensing, is the Austrian Space Agency ASA. One ASA-cooperator is in charge of Austria's international involvement in remote sensing affairs, in particular vis-a-vis ESA. Attached to ASA is the above mentioned national Remote Sensing Working Group AGFE comprised of every one interested in the topic. This Working Group was founded in 1982 and the current membership runs at about 34 persons. Recently chairmanship has been transferred from Prof. Dr. K. Richter, Graz University of Technology, to the first author.

3.2 Coordination by the Ministry of Science and Research

The federal Ministry for Science and Research takes overall responsibility for research strategies, and one senior ministry official holds the office of national coordinator of space activities, as a parttime job. The same government official is also in charge of unrelated topics such as energy research and environmental technology development. Remote sensing is therefore just a small part of this office's responsibility. Major policy issues relating to space activities are the responsibility of a fairly large commission (the Space Committee) with a charter to advise the Council of Ministers.

3.3 Research Funding

Research funding occurs through about five separate channels. First, a National Program for Space Research is being administered by the Academy of Sciences, with heavy emphasis on telecommunications, scientific flight-hardware and a small element of remote sensing. In 1994, of a total of öS 25 Million (ECU 1.75), about öS 1.4 Million (ECU 100,000) were spent on remote sensing research.

Second, there are about three federal ministries (Science & Research, Agriculture, Environment) which have been sponsoring projects of remote sensing technology in the hope of transferring methods into "suspected" applications. However, while there had been various projects done in previous years, none of these ministries was active in 1993/4.

Thirdly each province runs its separate research fund. Some of these sponsor small remote sensing research projects. This is particularly true for the province of Styria where remote sensing is an activity of the province's research center Joanneum Research.

Fourth, there exists a federally funded national scientific research agency (the Federal Science Foundation FWF) through which a series of smaller projects and one larger initiative have been funded in the past at several universities. In 1993/4 no project was active under this fund.

Finally, ESA has been and continues to be a sponsor of Austrian software development projects and of some research into the application of remote sensing. ESA projects are so far carried out at Styria's Joanneum Research, focussing on software engineering, and at the University of Innsbruck with a focus on snow and ice studies.

4. Current Activities and Centers of Excellence

Table 1 summarizes the activities in remote sensing in Austria, whereby the work in 1993 is being reviewed. The following is a discussion of details from the review.

4.1 Three Centers of Excellence

From activity levels observed in 1993/4, there exist three active Centers of Excellence for research in satellite remote sensing in Austria:

- Institute for Meteorology and Geophysics at Innsbruck University, focusing on mapping and understanding snow and ice, in particular as it responds to microwaves;
- Institute for Digital Image Processing of Joanneum Research in Graz with clearly the largest research effort in remote sensing that is ongoing today in Austria.

At these institutions there exists an ongoing and funded program for research that is well-connected with the European and overseas research communities. In addition, Austria is home to a single successful remote sensing business:

- Geospace/Dr.L.Beckel, Bad Ischl and Salzburg, renowned for satellite image atlases and maps.

4.2 Specialization

It is evident from a review that there are three specializations in Austria:

- snow & ice-monitoring with microwave-sensors;
- rectification and geometric image processing;
- satellite cartography.

All three specializations derive from the geographic domination of alpine terrain. Snow and ice studies are the focus of the small team at Innsbruck University/Institute of Meteorology and Geophysics, under leadership of Doz. Dr. H. Rott. Image rectification is a serious issue with images of highly accentuated terrain, as it is the case in the Alps. This work is the specialization at the Institute of Photogrammetry and Remote Sensing at Vienna University of Technology under Prof. Dr. Ing. K. Kraus. At Styria's Joanneum Research, it is also geometric image processing, augmented by application studies, that represent their work.

The third specialization is a result of an emphasis at the Academy of Sciences which has been operating a separate group for satellite cartography, initially formed by its founding director, Prof. Arnberger, and under the leadership of Dr. L. Beckel who later converted his expertise into a successful commercial venture. Also involved was Dr. M. F. Buchroithner, who later assumed the leadership role at the Joanneum Research in Graz but in 1993 accepted a chair at the University of Technology Dresden (Germany). Another geographer using remote sensing data is Prof. Seger at University of Klagenfurt, supporting regional planning with space-image maps. Prof. Csaplovics performed some remarkable studies on desertification in Africa *(Csaplovics, 1992),* but in the meantime he also was called to TU Dresden.

4.3 Other Land Remote Sensing Work

Various Earth science organizations in Austria, by participating in national or international programs, have taken a look at remote sensing to assess the usefulness of satellite remote sensing data in Austria. As a result, beyond the three "Centers of Excellence" there exist several institutions of higher learning or research with typically no more than one individual actively pursuing research in remote sensing. Table 1 reveals that a total of some 40 persons consider themselves experts in the field of remote sensing. Of those, 23 are actively working in the field as researchers, and additional 5 work commercially. The scientific output in 1993 on remote sensing (according to our narrow definition) consisted of 50 papers, mostly printed in congressproceedings. When reviewing the outcome of an institution's remote sensing work, one receives the general and most often voiced concern about insufficient geometric resolution of remote sensing images from space. A certain enthusiasm is therefore encountered when Russian space photography at resolutions of 3 meters (or better) is available. There are recommendations that such data lend themselves to substitute the national orthophoto map series of Austria; it could result in a far more frequent repetition rate and would support the national program for map updating.

Opinions vary regarding the ability to employ satellite images at current resolutions for mapping and environmental studies, even if taking advantage of the frequent coverage, particularly since the European satellite ERS-1 routinely produces data of the entire country at regular time intervals. Generally, many investigations are set up with one individual coverage; the technical skill and capabilities are missing to actually employ repeat multi-temporal coverages, and such efforts ignore also benefits that may arise from the data synergy between optical and radar images.

4.4 Geodesy, Meteorology, Atmospheric Studies

Austria is very active in the area of geodesy. Geodetic work is not only supported by sizeable groups of academic staff at the two Universities of Technology Vienna and Graz, but also by a group at the Academy of Sciences' Institute for Space Research. However, while geodesy is part of ESA's definitions for a program of Earth observation, this is not an explicit element of CEO nor of the narrow focus of AGFE. Therefore also Table 1 excludes these activities.

Meteorology has a strong European presence through the operational activities in EUMETSAT, an organization separate from ESA. This is testimony to the fact that meteorology is not only well organized but also that it enjoys full acceptance of satellite observations. Therefore one must expect that it will not be part of CEO's focus, but will be of peripheral concern in the

Institution	Contact Persons	Personnel [1]	Contracts in ECU [2]	Publications [3]	Focus General	Focus Specific	Desired Application	Data Requirements
Joanneum Research, Graz	Pölzleitner Raggam	6 (0 / 6)	320,000 (120,000)	10 / 1	Radar, Environment	Software, Applic.Studies	Software, Land Use, GIS-Data	High resolution, Various Sensors
University of Innsbruck	Rott	3 (1 / 2)	75,000 (8,000)	6 / 3 1	Snow & Ice, Radar (SAR)	ERS-1, micro-wave signatures	Monitor alpine Snow & Ice	Multi-frequ. & Multi-pol. - SAR
Agricultural Univ., Wien	Schneider	2 (1 / 1)	30,000	2 / 0	Forest, Land Use	Radiometry, Data-Fusion	Monitoring of Vegetation	High-Resolution Optical Images
Research Center Seibersdorf	Steinnocher	3 (0 / 1)	75,000	1 / 0	Environment, Land Use	GIS-Data Collection	Environmental Planning	High Geometric Resolution
TU Vienna, Photogrammetry	Kraus Jansa	4 (2 / 1)	20,000	4 / 0	Geocoding, Classification	Setup of Geo-coded Databases	Support Diverse R.S.-Applications	High Geometric Resolution
TU Graz, Photogrammetry	Kaufmann Kostka	4 (1 / 1)	20,000	8 / 1	Education, Cartography	NOAA, ERS-1, KFA-3000	High Mountains, Radar-Applications	SAR- and High Resolution Data
TU Graz,[4] Computergraphics	Leberl Kalliany	2 (.1 / 1)	2,000	5 / 1	Data-Networks, Automation	Radargrammetry, Automation	Monitoring Snow, Ice & Environment	Multi-Sensor-Datasets
University of Klagenfurt	Seger	3 (1 / 0)	10,000	1 / 1	Geography, Cartography	Meso-Scale Space-Maps	Interpretation for Regional Planning	High Resolution, Multi-Repetition
Academy of Sciences,Vienna	Beissmann	1 (1 / 0)	10,000	4 / 1	GIS-Data Generation	High Mountain Cartography	Interpretation of multiple Datasets	High resolution Multispectral
Environmental Agency, Vienna	Zirm Knappitsch	2 (1 / 0)	0		Environment, Land Use	Land Cover, GIS-Data	CORINE Land Cover (EU)	Highest Resolution
Federal Geologic Agency, Vienna	Seiberl	1 (.1 / 0)	0		Geology, Hydrology	Environmental mapping	Geological structures	Multi-Sensor Datasets
Federal Mapping Agency, Vienna	Kilga	3 (1 / 0)	0		National Mapping, Geodata Base	Map Updating, Orthophoto Maps	Satellite Ortho-photo Map Series	Highest Resolution (1m)
Health Research Institute, Vienna	Pillmann	3 (0 / 1)	110,000	1 / 0 1	Vegetation, Forest	Aerial Photo Interpretation	Environmental Computer Science	IR, Highest Resolution (1m)
Total (R & D Sector)		37 (9 / 14)	672,000 (127,000)	42 / 8 2				
Geospace, Bad Ischl / Salzburg	Beckel	6 (0 / 5)	no data		Commercial use of R.S.-data	Space Image Maps and Atlases	Map-edition, GIS-data-generation	High-Resolution, Multispectral

Table 1: Active Participants in the Remote Sensing Scene in Austria in 1993

1) Total number of R.S.-Experts at the institution; in brackets personnel actually working on R.S.-Projects, funded by hard / or soft money.

2) Value of R.S.-related contracts from outside the institution in ECU; occasionally in brackets amount of ESA-funds (as part of total).

3) Number of R.S.-related publications in 1993: Printed in Conference-proceedings / or journals; occasionally number of books in second line.

4) The Institute for Computergraphics at TU Graz was founded from scratch in October 1992, therefore just starting its activities in 1993.

CEO-context. Austria is a member of EUMETSAT. Austria's Zentralanstalt für Meteorologie is an active user of satellite data, and is also an interested observer of the remote sensing scene at large, but their use of data is much different from all other R.S.-applications in Austria. Therefore this institution is not included in Table 1.

Atmospheric remote sensing may be considered part of meteorology, using both imaging and nonimaging sensors. A particular effort in this direction exists in Austria through its Institute for Space Research at the Academy of Sciences, where a separate department of atmospheric issues exists. However, the focus is on planetary atmospheres and non-imaging sensors. Therefore, these activities are of lesser interest in the CEO's Earthcentered context and are excluded from Table 1.

5. Plans and Expectations

5.1 Issues in Need of Attention

Since 1985, Austria has witnessed four national initiatives which partly were based on satellite, partly on aircraft imagery. They variably were therefore classified as "remote sensing" initiatives. They give a focal point for interests and needs in Austria to which remote sensing should respond.

The first initiative was a project based on aerial infrared photography which was analyzed to locate areas covered by vineyards. The result was a cadastre of active vineyards, relevant for tax purposes. While the source material was analog aerial photography, it yet sometimes was lumped into the remote sensing domain.

The second initiative is the only one which may be denoted "remote sensing" under the definition of CEO and of this report. It started in 1985 and consisted of a national "remote sensing" effort, focusing on image analysis. The research-program had 7 participating institutions, a budget of öS 18 million (1.25 million ECU) through six years and a somewhat fragmented collection of individual projects that makes it difficult to summarize its findings *(Kraus et al., 1991)*. In essence, this program permitted various Austrian researchers for the first time to take a close look at remote sensing, and to assess the usefulness of thenavailable satellite and aircraft-images. One may well state that the current specializations in remote sensing as mentioned above would not exist had there not been this program, which ended in 1991.

Another initiative addressed forest damage and was not based on satellites, or even on digital images *(Schneider, 1989)*. Instead it was based solely on aerial photography. Yet it led to developments in digital image processing, since one goal of the national program was to assess forest damage automatically by means of digitized photography and computer processing of such digital images *(Pinz, 1991)*. The project has lost some of its momentum due to the cost of covering all of Austria's forests on 1:15,000 aerial photography and to then analyze all those data.

The last initiative was an outgrowth of the Austromir project, a cooperation with Russia for an Austrian visiting the MIR space station in 1991. This resulted in MIR-photography of Austria with two camera-systems *(Kalliany, 1992; Kalliany et al., 1992)*. Films of MKF-6MA at scale 1:3.200,000 were scanned to create the input for an almost 100% coverage of Austria with mid-scale digital orthophotos. By simultaneous collection of meteorological data, airborne imagery and spectrometer-measurements on ground, efforts for a radiometric calibration of the dataset were made. *(Kalliany, Ekker, Pammer, 1993)*. In addition, KFA-1000 colour-images at scale 1:400,000 with up to 5m resolution proved the high potential of such imagery for cartography and landuse-studies.

5.2 Consensus in the Community

No national remote sensing program is going on at this time in Austria. Yet one will find general consensus among the experts that remote sensing actually holds more potential than is currently materializing. In particular there is agreement that:

- activities in remote sensing should not only continue, but increase;
- remote sensing is valuable in observing long term trends in the environment, in particular in high alpine regions and in national parks;
- environmental monitoring and change detection are promising fields in Austria.

Austrian experts in remote sensing would like to exercise pressure to improve the geometric resolution of satellite remote sensing data. Russian space photography is often considered superior material for applications in Austria and represents as a role model for the requirements of Austrian users of remote sensing data *(Klostius, Kostka, Sulzer, 1994)*. The drawback of this imagery is that terms of distribution, frequent coverage and access still are rather uncertain.

6. Global programs

Satellite remote sensing has its major and largely undisputed role to observe the Earth for the study of global phenomena. One often finds the major global issues listed as follows:

- population growth and urban management,
- loss of soils,
- loss of bio-diversity,
- change of the atmosphere.

These issues are interrelated. Earth observation from space holds promise to support humanity's efforts to cope with these problems. In fact, if satellite remote sensing were to be redundant in these domains then a major justification for putting satellites into orbit would vanish. The observation of the atmosphere, the oceans, the ice surfaces and the land on a global scale are clearly possible with remote sensing. However, large efforts are still necessary, to set up and operate global monitoring systems so that they successfully support the diagnosis of dangerous global trends and to help in monitoring any effects of therapies.

It is particularly the industrialized and wealthy nation's responsibility to partake in the solution of these problems. However, when reviewing the Austrian scene one must notice, that this major and fundamental promise of remote sensing does not draw much interest in the community. Established organizations in Austria do not have a charter to look beyond Austria's borders.

There exist individual efforts in Austria to study global change through observation of snow & ice (University of Innsbruck) and through observations of the atmosphere (University of Graz). A nearly private initiative is map some remote regions of the world in the context of high-alpine cartography (Graz University of Technology). What is missing is to explicitly commit funds for Austrian organi- zations and researcher participating in observation campaigns to study the global environment.

7. Comparing Austria to Other ESA-Nations

Table 2 attempts to characterize some key Earth observation elements in each of the member countries of the EU/EEA or ESA. In every country a major rallying point for a national remote sensing effort is emphasized. There is no doubt that all other countries (except Ireland) operate a much more significant remote sensing program than Austria does. In Germany, a work force of perhaps 2000 people is concerned with Earth observation. When calibrating this with the total population, it represents an 8 times larger effort than Austria's with its 23 full-time active persons. Even Switzerland, with a comparable geography and no major ESA or EU facility on its territory, operates a total remote sensing effort that seems to be about 3 times the Austrian one, if scaled by population. A major factor is the involvement in developing countries and a very focussed group of experts at the University of Zürich (see Table 3).

Country	Focal Point
Austria	Mapping of alpine environment (see also Table 1)
Belgium	Cooperation in France's SPOT Program
Denmark	Microwave Sensing with SAR Involvement in JRC-Developments
France	ESA-HQ (400 Employees), French Processing & Archiving Center F-PAC
Germany	ESOC/Darmstadt, MOMS, X-SAR, DLR, ENVISAT-Instr., D-PAC
Ireland	Inactive in ESA Remote Sensing
Italy	ESRIN, ENVISAT-Instr., I-PAC
Netherlands	ESTEC (2000 Employees and Contractors), ENVISAT-Instr.
Norway	National ENVISAT Ground Station
Spain	S-PAC for ENVISAT/Maspalomas
Sweden	Large Ground Stations in Kiruna
Switzerland	Climate Research and Land Use (see also Table 2)
U.K.	U-PAC
Associated Members	
Canada	Planning National ENVISAT-PAC
Finland	Responsibility for GOMOS Global Product

Table 2: Space and Remote Sensing Activities in Member Countries of ESA, Characterized by ENVISAT (Follow-On of ERS) - Related Work.

The most striking number about Austria's remote serving activities is obtained when considering project funding. It seems that this was as low as AS 8.5 million (ECU 670,000) in 1993. Most remote sensing work was done as either part of regular academic research without specific funds, or under foreign (ESA or EU) sponsorship.

Institution	Focus	Personnel
Swiss Federal Research-laboratory for Forest, Snow and Landscape, Birmensdorf	Forest-damage, Forest-ecosystems	4
University Zurich, Group Nuesch/Haefner	SAR: Geocoding, Interferometry; 3D-visualization	8
University Zurich, Group Itten	Development Aid (Technology Transfer), Spectrometry, Optical Sensors	10
University Zurich, Group Haefner	Natural Resources, Snow-Monitoring	4
ETH Zurich, Group Seidel	Snow & Ice	4
University Bern, Group Baumgartner	Snow-Monitoring and -Mapping	3
University Bern, Groups Schanda, Kämpfer, Mätzler	Atmospheric Research, Microwaves	5
ETH-Lausanne, Group Musy	Hydrology, Land-Use	2
University Basel, Group Parlow	Climatic Models, Land Use	3
UNEP/GRID, Geneva	Geographic Databases	3
Swiss Meteorologic Agency	Meteorology, Climatic Research	5
Federal Agency for Statistics	Area-Statistics, Land Use Statistics	2
Federal Agency for Environment, Forest and Landscape (BUWAL)	Environmental Protection	1
Paul Scherer Institute, Group Keller	Atmospheric Pollution, Surface Temperature	1
Total		55

Table 3: Working groups and personnel in Switzerland's Remote Sensing

8. Outlook for Earth Observation in Austria

8.1. Scenario for a market in Austria

The European Union's focus on data networks, data access and applications demonstrations as proposed in CEO hold the promise to visibly stimulate the international scene. The following potential users of remote sensing exist in Austria:

- about 100 district offices and municipal administrations in charge of environment, forest, agriculture, land use and local planning;
- 9 provinces with about 5 offices each having responsibilities for the environment, planning, natural resources etc.;
- at least 5 federal ministries, also with responsibilities for environment and health, for forestry and agriculture, aid to developing countries, economic development and scientific research;
- several national institutions of research with some responsibility for environmental issues (FZ Seibersdorf, Joanneum Research, Academy of Sciences, Boltzmann Society etc.);
- more than 9 energy producing utilities based on alpine water resources and concerned with protecting the environment against pollution;
- about 8 institutes at universities with some interest in remote sensing;
- a national mapping agency and a national office for the environment, with the explicit task of mapping and monitoring the land;
- tourism agencies and recreational management of glaciers, national parks etc.;
- at least 18 vendors of Geographic Information Systems software (GIS) and services;
- a diversified industry with interests in agriculture and renewable / non-renewable resources.

This seems to encompass a universe that is commensurate with studies assessing perhaps 10,000 users of remote sensing in the whole of the European Union *(NRSC, 1993)*. Austria with its nearly 8 million people, in a Europe with 350 million, would have to have more than 200 participants. The above list is the pool from which to draw these users.

However, these numbers are not necessarily relevant for Austria, since this country

- has a fairly high population density,
- is very well mapped,
- and maintains numerous dense conventional networks for the collection and reporting of environmental and other land-related data.

In this sense Austria does not suffer from a problem in need of a solution. Remote sensing will only become an accepted technology if it is capable of improving the observation of the land over methods currently in place.

8.2. Progress in sensor technology

Obviously there are two generally acknowledged advantages of remote sensing methods:

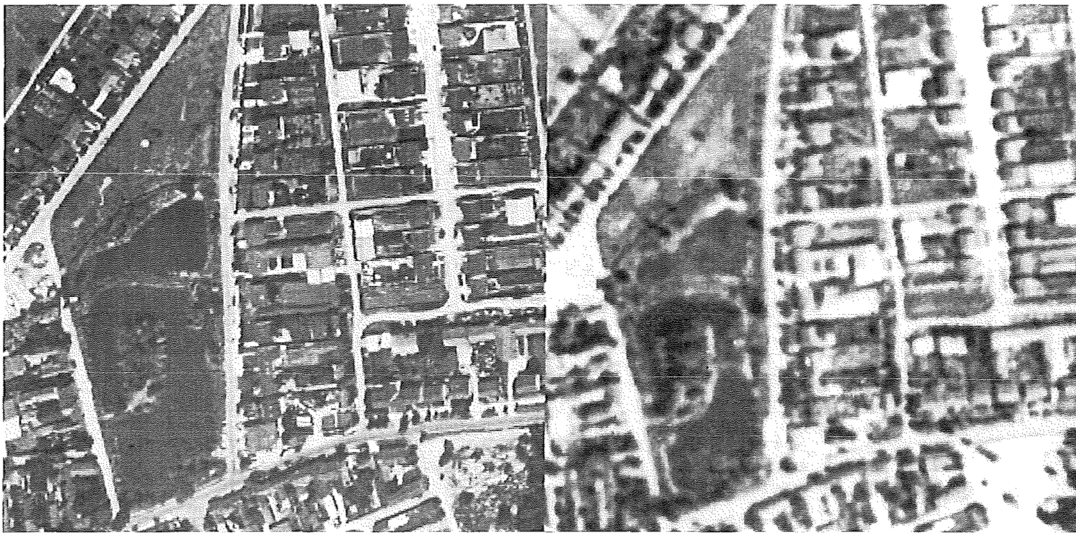

Figure 1: Comparison of sections of an aerial photograph 1:30,000 (2nd generation-product scanned) and right the same section from a Russian KFA-3000-image 1:80,000 (from 3rd generation-product). Area covered is 850 m by 850 m (1m pixelsize) in Illmitz/Burgenland. (Sindhuber and Herbig, 1994)

- Coverage of large areas by a single image,
- Frequent acquisition at low additional expense.

Specifically, remote sensing has to "compete" with aerial photography, which offers very high resolution, but is a rather costly and timeconsuming tool for mapping and land-use inventories. While the spectral range of optical remote sensing devices is superior, there existed until recently only data at comparatively poor geometric resolution, a feature acknowledged to be a striking drawback. Only in "cases of emergency", when there is no aerial imagery available, is the Bundesamt für Eich- und Vermessungswesen (the national mapping agency) using panchromatic SPOT-data for updating their 1:50,000-maps, supplemented by additional fieldwork. While the SPOT data have 10m-pixels, the same agency is expecting that imagery like the Russian KFA-3000-photography (at a resolution of 1 to 2m), may replace their current aerial photos 1:30,000 for updating work. Investigations at Vienna University of Technology (see comparison in Figure 1) and at Universities in Graz *(Klostius, Kostka, Sulzer, 1994)* also are supporting this view. With only minor losses in quality, but great gain in efficiency, such imagery also could supplement the already existing Austrian orthophoto map 1:10,000.

Current drawbacks of the Russian photographs are that they are not based on a satellite with a constant orbit, and that data-acquisition is infrequent; therefore a desired image often will not be available. Because there obviously is a promising market opening up, there exist efforts in the US, France and Germany to put instruments with similar geometric resolution – but using digital technology – into orbit.

The next step in this direction will be taken by Germany, putting their MOMS-02-sensor in the Russian space-station MIR in 1995. Thus, at least for 18 months a frequent coverage of Austria with 6m-pixels (panchromatic) and 4 spectral channels with 18m-pixels will be possible. Additionally, this sensor offers inflight-stereo-capabilities (with a convergence-angle of 43°) for generation of digital elevation models. There is an Austrian initiative being set up, for these data to be exploited by a heterogeneous group of scientists together with specialists among possible applications such as mapping, agriculture, regional planning and so on.

Apart from digital optical sensors at significantly improved resolutions there also are new radarsensors going into orbit: ERS-2 (to be launched in 1995), and ENVISAT (1998) by ESA, as well as Radarsat (1995) from Canada or other Japanese or Russian satellites. Until now, the exploitation of this kind of data is suffering from poorly developed skills in complex processing and interpretation. Therefore, relevant methods have to be developed and introduced.

8.3. Progress in processing-methodology

It was only recently that the processing and display of remote sensing data required specific and rather costly hardware. Now, with inexpensive PCs and workstations, capabilities of displaying color raster images and equipment with diskcapacities in the gigabyte-range, this bottleneck is rapidly vanishing. This may support the expansion of the user-community. Also massive processing has become feasible: complicated algorithms, until now only tested with small data sets in sophisticated laboratories, may now go into application.

There are several capabilities which are more or less essential for successful application of remote sensing data:

1) Fast access to large datasets, local and via international networks,
2) Geocoding of any type of imagery,
3) Automatic generation of digital elevation models from stereo-imagery,
4) Flexible visualization and visual enhancement of multi-layer/multisensor image-stacks,
5) Automated detection of objects and extraction of geometric information by image processing,
6) Modelling of the entire imaging process for better exploitation of the data, as well as for radiometric calibration and correction,
7) Introduction of expert-knowledge-based and/or self-learning software-architectures for interpretation of multi-temporal and multisensor image-stacks.

In this breakdown, the tasks are ordered by increasing complexity. For some time to come they all still are going to be topics of research, as well world-wide as in Austria. Until now routine-like solutions hardly are available in an operational manner. But it seems to be essential for a broad acceptance of remote sensing data that basic operations (like items 1-4) are becoming routine, so that users do not need to worry about expertise in these areas. Only then the full exploitation of the whole range of information provided by various satellites will become a matter of course to the users.

9. Conclusion

For remote sensing in Austria, after early attempts in the eighties followed by some stagnation, now time has come to prepare for a breakthrough to operational applications. The small but expandable number of experts, the new sensors to come and the continuously increasing computing-capabilities are a good basis to accomplish the goal of operational use of remote sensing data. Properly processed remote sensing data will be a valuable tool for decision-making, specifically in a small alpine country like Austria.

To achieve the goal, we must start to raise funds, install task-oriented working-groups and contact the users. This will assure Austria's roll in the international and European remote sensing scene and in getting relevant benefits for the development of the economy and preservation of the environment.

References

[1] *Kalliany R., 1992*: Das Fernerkundungs-Experiment FEM während des Österreichisch-Sowjetischen Raumfluges AUSTROMIR. ÖZ, 80.Jhg/1, S.3-19, Wien.

[2] *Kalliany R., Schneider W. Eerme E. Lebedyev O., 1992*: Remote Sensing Experiment FEM - A Multisensoral Dataset for Radiometric and Geometric Analysis. ESA ISY-4,133-138. ISY Conference, Munich.

[3] *Kalliany R., Ecker R., Pammer A., 1993*: Digital Rectification of a Comprehensive Photographic Remote Sensing Dataset from the AUSTROMIR-Mission. 25th ERIM-Symposium, p.II,173-184, Graz.

[4] *Kraus K. et al., 1991*: FSP Fernerkundung, Endbericht. Österreichischer Fonds zur Förderung der Wissenschaftlichen Forschung FWF, Wien.

[5] *Klostius W., Kostka R., Sulzer W., 1994*: Das KFA3000 Bild als kostengünstige Datenquelle bei Aufgaben der regionalen Planung. VGi 4/94, 213-219. Wien.

[6] *Leberl F. and Haselbacher F., 1994*: Data Communications in Austria. A Remote Sensing Perspective. EEOS Workshop on Networks, ESRIN/Frascati.

[7] *Leberl F. and Kalliany R., 1994*: Earth Observation Data Services for Users – An Austrian Perspective. EEOS Workshop on Earth Observation User Information Services, ESRIN/Frascati.

[8] *Pinz A., 1991*: A Computer Vision System for the Recognition of Trees in Aerial Photographs. Proceedings IAPR-Workshop TC7, Maryland.

[9] *NRSC, 1993*: Feasibility Study for a CEO. Issue 2.1, CERP-0142, Report by NRSC/U.K. for JRC/Ispra.

[10] *Schneider W., 1989*: Verfahren, Möglichkeiten und Grenzen der Fernerkundung für die Inventur des Waldzustandes. Forstliche Bundesversuchsanstalt FBVA, Wien.

[11] *Scot Conseil and Smith Systems Engineering Ldt., 1994*: Use of Satellite Data for Environmental Purposes in Europe. Final report to the EC, Brussels.

[12] *Sindhuber A., Herbig U., 1994*: Erfassung der Landnutzung mit Fernerkundungsdaten f. Umweltmonitoring im Nationalpark Neusiedler See. VGi 4/94, 412-413.

[13] *Csaplovics E., 1992:* Methoden der regionalen Fernerkundung-Anwendungen im Sahel Afrikas. Springer, Berlin–Heidelberg–New York, 219 pages.

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