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NATURAL RESOURCES INVENTORY AND LAND EVALUATION IN SWITZERLAND

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**ORIGINAL CONTAINS
COLOR ILLUSTRATIONS**

SCIENTIFIC INVESTIGATION SUPPORT

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Item(s) No. 1

1. INTRODUCTION

In accordance with our Technical Monitor this quarterly report combines the first two quarters of our LANDSAT-2 research project from the receipt of the first data on May 23rd until November 23rd 1975.

1.1 Participants

The project is carried out primarely by a joint research group of the Department of Geography, University of Zurich (Prof. H. Haefner) and the Department of Photography, Swiss Federal Institute of Technology, Zurich (Prof. W.F. Berg). The following persons are engaged in the project:

- Klaus Seidel, Ph.D.	project leader	
- Robert Binzegger, Ph.D.		(part time)
- Rudolf Gfeller, Ph.D.		(until March 31st, 1975)
- Arthur Funkhouser, M.S.		
- Jürg Lichtenegger, M.A.		(since November 1st, 1975)
- Daniel Nüesch, M.A.		(part time)
- René Muri		(part time)
- Karl Stänz		(part time)
- Hans-Peter Stirnemann		(part time)
- Fritz Fasler, M.A.	system specialist	(part time)
- Anton Paschke	system specialist	(part time)
- Otto Matt	system specialist	(part time)

Dr. Klaus Itten, having spent one year as a visiting researcher at GSFC in 1974 (ESA-grant)returned to the Department of Geography, University of Zurich, and is continuing his specific research on the comparison of different existing image processing systems to operationally classify snow covered areas (3.1).

In addition the following institutions participated in the research project:

- Department of Geography, University of Berne (Prof.B.Messerli/Dr.M.Winiger)
- Swiss Institute of Snow and Avalanche Research, Weissfluhjoch (Prof.M.de Quervain)
- Swiss Meteorological Institute (Dr.A.Piaget)

1.2 International contacts

Various international contacts could be established or strengthened during the reporting period:

Dr. K. Seidel participated in the "4th Annual Remote Sensing of Earth Resources Conference at the Space Institute of the University of Tennessee/Tullahoma" from March 24th to 26th, 1975 and visited several other institutions in the US, such as Office of Remote Sensing, Pennsylvania State University; EROS Applications Assistance Facility, Bay St. Louis, Miss.; Jet Propulsion Laboratories, Pasadena, Calif. etc.

Prof. H. Haefner attended the "Earth Resources Survey Symposium" from June 8th to 12th, 1975 in Houston and visited the Space Technology Center, University of Kansas, Lawrence and the L.B.Johnson Space Center in Houston.

Dr. K. Itten presented the findings of his research (3.1) at the "Workshop on Operational Applications of Satellite Snowcover Observations" from August 18th to 20th in South Lake Tahoe, Calif. and visited the Stanford Research Institute (Dr.W.Evans), the School of Earth Sciences, Stanford University (Prof.R.Lyon) and the GSFC.

The Department of Photography, Swiss Federal Institute of Technology, Zurich, organized a Symposium on "Digital Image Analysis, which attracted quite a many researchers not only from Switzerland but from abroad as well.

At the "10th International Symposium on Remote Sensing of Environment" in Ann Arbor from October 6th to 10th, 1975 Mr. D. Nüesch presented a status report by Prof. H. Haefner et al. on the applications of remote sensing in Switzerland with special reference to our LANDSAT-activities.

Permanent contacts and exchanges of ideas and results regarding our LANDSAT-studies are taking place with the "Euratom Ispra" (Dr.B.Sturm) and the "Deutsche Forschungs- und Versuchsanstalt für Luft- und Raumfahrt", Oberpfaffenhofen, Germany.

2. TECHNIQUES

2.1 Data coverage

For a complete coverage of Switzerland two frames each on three following days are necessary (Fig. 1). During the reporting period the material listed in Fig. 2 was received.

From this tabulation it is easy to recognize that the coverage is very inhomogeneous and not well suited for studies of dynamic processes such as changes in snow cover / land use etc. This fact was brought to the attention of NASA by letter of September 6th, suggesting that

- both frames of a daily cycle should be taken together always,
- preference should be given to the easterly orbit if possible (to reach a more continuous coverage of our main test areas in Grisons),
- a complete coverage of Switzerland (on three following days) would be of great interest (since never achieved with LANDSAT-1 and 2 until now).

2.2 Methodological aspects

Digital as well as analog processing of the LANDSAT-images was undertaken, but with a clear priority to the digital methodology, because of their greater flexibility.

The method including all preprocessing steps for geometric and radiometric corrections as well as for the output on film as developed during our LANDSAT-1 project was improved further (3.1). It may be summarized as follows:

To classify the data a multivariate procedure, the linear discriminant analysis was used. From well considered training groups criteria for the identification of the sites were computed stepwise, with given level of tolerance and each picture elemente assigned to just one of the training groups. The results were displayed on "single-symbol-separation-films" used for color overlay production.

For snow mapping all four MSS-channels are used as variables whilst for classifying land use features (3.2) six synthetic ratio variables were used in addition.

The accuracy of our method depends primarely on the selection of representative training cells. Therefore extensive ground observation and measurements were carried out (2.4/2.5) for our snow mapping studies. The ultimate goal would be to establish a comprehensive collection of samples, to minimize or even abolish ground truth in the future.

Fig. 3 summarizes the classification system and the computer programs for digital picture processing of LANDSAT-data as available today.

2.3 Aerial underflights

During several LANDSAT-passes underflights could be arranged. Unfortunately the satellite was not always covering our areas when a flight was undertaken. Therefore only for two dates matching images of LANDSAT and high altitude aircraft could be achieved. The technical data are the following:

- Camera: Oméra
- Objectives: f = 44 mm and 100 mm
- Film: panchromatic
- Quality of photography: good
- Altitude: approx. 12'000 m above sea level
- Scale: approx. 1:225'000 and 1:95'000
- Dates: April 22nd and August 8th, 1975

2.4 Ground truth

For all LANDSAT passes with good weather conditions extensive ground surveys were undertaken in the main test area of Grisons (between Davos and Lenzerheide), surveying and registering the following objectives:

- observation of position of temporary snow line (visible observations, photographs, mapping)
- observation of various snow-parameters at selected sampling points:
  = type of snow
  = characterization of snow surface (forms, cleanness, wetness, age etc.)
  = characterization of snow pack (granularity, wetness etc.)

= snow temperature (at surface)

= snow depth

= snow mass

= air temperature

= air moisture

= slope angle and exposure

= cloudiness

= daytime

This information will be of great assistance in selecting the "training cells" for the digital snow classification.

2.5 Measurement of spectral reflectance of snow

In addition an extensive measuring program was set up to get more information on the spectral properties of the snow surface. An EXOTECH-100 radiometer was used for this purpose on the ground as well as from a helicopter. During the melting period 1975 (February to June) measurements were carried out for about 20 different days on the ground and for two days from a helicopter in the vicinity of Davos.

Measurements under various conditions (sun angle, slope angle, exposure, sun, shadow etc.) were undertaken for six different snow types. In addition specific measurements for "dirty" snow covered partly with dust and sand were taken. At the same time ground observations as described in 2.4 were carried out at the measuring points.

Again the data will be processed further to improve our classification algorithms.

2.6 Laboratory equipment

For our digital processing the following specific equipment was at disposition:

- computer
  = CDC 6400/6500 with standard peripherals
  = IBM 370 with standard peripherals
- data output
  = OPTRONICS PHOTOMATION SYSTEM P 1700
  = computer prints

3. ACCOMPLISHMENTS

3.1 Snow mapping

Methods and results of our snow mapping project were reported in the ERTS-1 final report.[1)]

Regarding snow mapping emphasis was layed during the reporting period on

- evaluation of EREP-S-192 digital data for separation of snow and clouds
- improvement of methodology (2.2)
- careful selection of training cells by ground observation (2.4), ground measurements (2.5) and aerial underflights (2.3).

It is intended to continue snow mapping with the improved classification system to investigate changes in the areal extent of the snow cover. But for this purpose additional data of the same test area (2.1) is essential.

Interesting results occurred from the research by Dr. K. Itten on the feasibility of three different existing image processing systems to operationally classify snow covered areas.

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1) HAEFNER, H.: Snow Survey and Vegetation Growth in High Mountains (Swiss Alps) and Additional ERTS-Investigations in Switzerland. Type II Final Report, January 1975.

LARSYS Version 3 was used first to obtain a digital snow cover classification. With the supervised, statistically proven method, seven major ground cover classes were distinguished.

The overall achieved classification accuracy regarding to the training areas amounted to 92 %. The process with LARSYS Version 3 is stepwise, well defined, and the result is - good ground truth given - quite accurate. But the whole procedure is very time consuming and in that sense costly. It is therefore very questionable whether to use this approach for operational snow mapping at all.

Having gained much experience with the data, the STANSORT-2 system of the Stanford University was used to check the feasibility of a highly interactive semi-supervised clustering as an approach to the snow mapping problem. Within very short time, by comparing intermediate results with different density slicing and cluster tolerance factors, with known test area patterns, a classification very similar to the one obtained with LARSYS could be achieved. The fast evaluation of intermediate results via the b&w TV-screen was a main advantage and time saving factor. The simple and thus fast cluster algorithm proved to be very successful in this specific application.

The third and probably one of the most advanced systems in operational image processing tested, was the Image-100 of General Electric. The same CCT's and test area, and part of the same ground truth were used again. A classification into the same classes was achieved in an extremely short time. The simple and fast parallel epiped classifier was used, and the classwise intermediate results were controlled immediately on the color TV-screen. With Image-100 only 1 or 2 training areas were used for each ground cover class. This together with the relatively coarse classifier is an explanation for the somewhat different results compared to the classifications by LARSYS and STANSORT.

The results of the comparative study are summarized in Fig. 4.

3.2 Land use mapping

Significant results could be gained from the research on land use mapping with the general aim of applying LANDSAT-MSS-data as information source to thematic mapping.

The test site is an area of approx. 26 x 39 km in the Po-Valley near Milano. It is almost flat land which means that no influences by relief are present and not considered in this study. The overpass of October 7th, 1972 (E-1076-09442) provided again the best suited data.

The following land use categories were considered:

Land use category	abrevation for group (as listed in figures 5-6-7)
(1) Water	SEE
(2) Built-up areas	GRO, KLE, HEL
(3) Fields, cultivated with dead vegetation and bare soil	TOT
(4) Fields, cultivated with living vegetation	LEB
(5) Forestry	WAL

A careful selection and delineation of the training cells was achieved by field observation as well as statistical tests to reach homogeneous groups representing a single land use category. To characterize a special category it was sometimes necessary to use different subsets (e.g. for built-up areas).

Applying a stepwise discrimination analysis (BMDO7M) it was possible to weight the variables and to determine the most suitable ones for a separation of the different categories, which is used first. A classification based strictly on the 4 original MSS channels as variables showed that only channel 5 and 7 were needed for an optimal separation (Fig. 5), whilst by adding 6 ratio variables the following succession in the use and importance of the variables was achieved: 7/5 - 6 - 7/6 - 4 (Fig. 6).

The results show that by using the original LANDSAT-variables only the categories "TOT" and built-up areas ((GRO, KLE, HEL) were separated with the lowest accuracy, but that by adding the ratio variables an improvement of about 7 % could be achieved. On the other hand the separation of the built-up areas (GRO, HEL, KLE) against water (SEE) worsened.

Therefore the use of ratio variables does not always improve the classification, which consequently cannot be done in a single run. It is always necessary to experiment with slightly changed initial choices, both for variables and learning sets used. According to each task, appropriate choice will ensure optimum sharpening of the classification groups and distinct separation between them.

Having established the training cells and the algorithms the entire test area was classified. Fig. 7 shows the corresponding classification matrix.

Finally the results were reproduced in cartographic form (scale 1:200'000) with the photomation film-write system. By preparing color overlays (instead of black and white prints) a clear presentation of the different categories could be gained. For this purpose three black and white overlays were printed for:

1) Categories GRO/SEE/WAL -------- cyan
2) Categories GRO/KLE/HEL -------- magenta
3) Categories KLE/WAL/LEB -------- yellow

By combining the three overlays, a color composite was prepared (Fig. 8) showing the different land use categories in the color specified in Fig. 7 . Fig. 8 shows the final classification of the test site and the output in form of a colored thematic map.

The results were verified in the field and with existing topographic and land use maps.

4. SIGNIFICANT RESULTS

Significant results could be achieved in the methodology of snow mapping and in land use mapping from digital MSS-data.

Methodology of snow mapping

Applying the same LANDSAT-data to three different image processing systems (LARSYS, Vers. 3; STANSORT-2 and GE-IMAGE-100) the following results for snow mapping in forested mountainous terrain could be gained:

Generally observable is a tradeoff between the classification accuracy and the time or money needed in the three different approaches. While the control and accuracy achieved with LARSYS is remarkable, time and effort to perform the processing favourize the systems STANSORT and IMAGE-100. A substantial increase in the applicability of satellite data to operational snow mapping could be demonstrated by connecting a multispectral approach with digital image processing techniques. It is believed that for the future a highly interactive, specially designed system together with a skilled applications expert will provide maximum operational use in satellite snow cover observations.

Land use mapping

A system was developed to operationally map and measure the areal extent of various land use categories for updating existing and producing new and actual thematic maps showing the latest state of rural and urban landscapes and its changes.

The processing system includes:

- preprocessing steps for radiometric and geometric corrections
- classification of the data by a multivariate procedure, using a stepwise linear discriminant analysis (BMD07M) based on carefully selected training cells. In addition to the 4 MSS-bands synthetic ratio variables are used to improve the classification. The importance of the variables (in accordance to their order of succession considered in the classification)was: 7/5 - 6 - 7/6 - 4.

- output in form of color maps by printing black and white theme overlays of a selected scale (e.g. 1:200'000) with an Optronics photomation system and its coloring and combination into a color composite.

The method was applied to a test area in the Po-Valley near Milano, Italy.

5. PUBLICATIONS

The following publications were already forwarded to NASA:

1. BINZEGGER, R.: ERTS-Multispektraldaten als Informationsquelle für thematische Kartierungen, Diss. Univ. Zürich, 1975.

2. GFELLER, R.: Untersuchungen zur automatisierten Schneeflächenbestimmung mit Multispektral-Aufnahmen des Erderkundungssatelliten ERTS-1, Diss. Univ. Zürich, 1975.

3. HAEFNER, H. + MESSERLI, B.: Erderkundung aus dem Weltraum - Das schweizerischen ERTS- und EREP-Satellitenprojekt, Geographica Helvetica 3/75.

4. WINIGER, M.: Untersuchung der Nebeldecke mit Hilfe von ERTS-1-Bildern. Geographica Helvetica 3/75.

5. GFELLER, R. + SEIDEL, K.: Automatisierte Schneeflächenbestimmung mit digitalen Multispektraldaten des ERTS-1, Geographica Helvetica 3/75.

6. HAEFNER, H. + GEISER, U.: Kartierung von Höhengrenzen zwischen Mt.Blanc und Gotthard-Massiv mit Skylab-EREP-Aufnahmen, Geographica Helvetica 3/75.

Publications in print:

1. SEIDEL, K. + GFELLER, R. + BINZEGGER, R.: Snow and Vegetation Classification by Means of Digital LANDSAT-MSS-Data, Proc. 4th Ann. Remote Sensing of Earth Resources Conf., Univ. of Tennesse, Tullahoma (1975).

2. ITTEN, K.: Approaches to Digital Snow Mapping with LANDSAT-1 Data, Proc. Workshop on Operational Applic. of Sat. Snowcover Obs., South Lake Tahoe (1975).

3. HAEFNER, H. + ITTEN, K. + SCHANDA, E. + WINIGER, M. + SEIDEL, K.: Applications of Remote Sensing in Switzerland, Proc. 10th Int. Remote Sensing of Env. Symposium, Ann Arbor (1975).

6. PROBLEMS AND RECOMMENDATIONS

The main problem for our project is as already mentioned (2.1) the unsystematic and insufficient coverage of our test site, which does not permit to map the actual changes of the extent of the snow cover during a certain time period. The necessary recommendations as stated in 2.1 are to give priority to the easterly orbit of Switzerland (Fig. 1) and to always take data of both scenes during a single orbit.

Fig. 1: LANDSAT-orbits of Switzerland with main test area for snow mapping in Grisons.

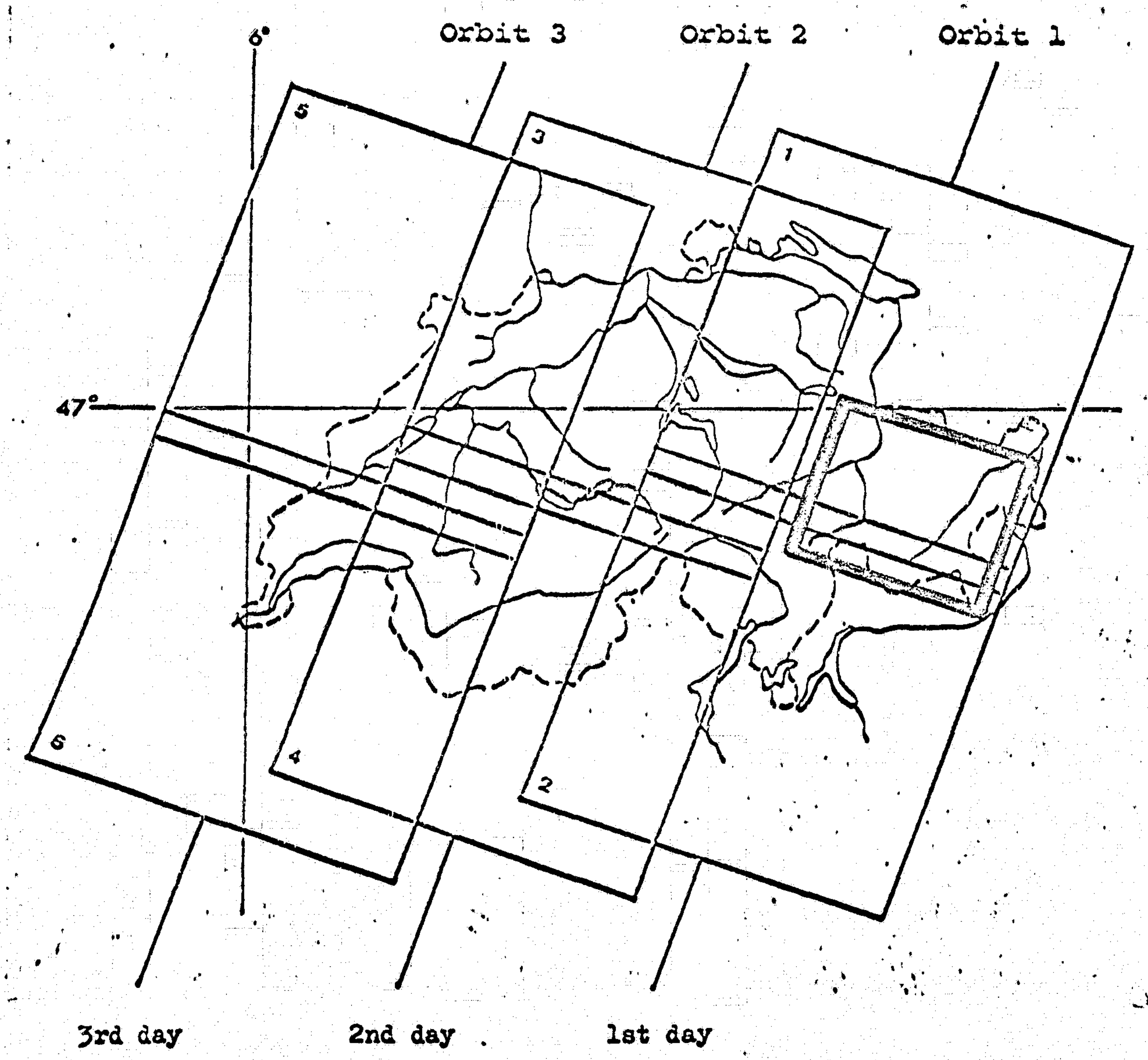

Fig. 2: LANDSAT-2 scenes received during reporting period (index as in Fig. 1)

date	scene (index according to Fig. 1) X = black&white image 0 = CCT						Quality good	unsatisfactory
1975	1	2	3	4	5	6		
April 22nd	XO						X	
April 23rd			XO				X	
April 24th					X	X	X	
June 15th		X						X
July 3rd		X						X
Aug. 8th	X						X	
Aug. 9th			X				X	
Aug. 27th				X			X	
Aug. 28th						X	X	
Aug. 28th						X		X
Sept. 13th		X						X

Fig. 3: Computer programs for digital image processing of LANDSAT-MSS-data. (after SEIDEL, 1975)

MMM3 - TRANSLATION 9-TRACK TO 7-TRACK

DASH - COMPUTATION OF SCANLINEFACTORS AFTER GRAMENOPOULOS (1973)

DASH2 - NORMALISATION BY SCANLINEFACTORS
(DUE TO DIFFERENT SENSITIVITY OF THE 6 SENSORS IN THE RECORDING SYSTEM)

TOTRAF - STRUCTURING INTO BLOCKS (128x128 PIXELS) WHICH CAN BE CALLED BY AN INDEX (RANDOM ACCESS)

- RAFHIS - STATISTICS OF BLOCKS
- RAFPRI - OUTPUT PRESENTATION OF BLOCKS BY CHARACTER-OVERPRINT (STANDARD LINEPRINTER)
- RAFSYM - OUTPUT PRESENTATION OF BLOCKS OF GIVEN LEVELS BY GIVEN CHARACTERS (LINEPRINTER)
- RAFFL - OUTPUT PRESENTATION OF BLOCKS WITH STANDARD FILMPLOT DEVICE
- RAFUNT - STATISTICS OF ANY SUBSET OF A BLOCK
- BBRUED - 3-DIMENSIONAL PRESENTATION AT THE INTERACTIVE DIGIGRAPHIC DEVICE (BELLBOX)

TOTRAH - STRUCTURING LINEWISE FOR SUBSEQUENT SUBSETTING (BLOCKED BINARY)

- ERTUNT - CREATES ANY SUBSET OF A TOTRAH-FILE FOR FURTHER ANALYSIS OR OUTPUT-PROCEDURES
- OPTER2 - CREATES OUTPUT FOR THE PHOTOWRITE SYSTEM (PHOTOMATION MADE BY OPTRONICS)
  OPTIONS: ORIGINAL CHANNELS OR ANY RATIO, SCALE AND SKEW
- UNTSTA - STATISTICS OF ANY SUBSET OR TRAINING AREA
- UNTDIS - SELECTION AND PREPARATION OF THE TRAINING AREAS FOR STEPWISE DISCRIMINANT ANALYSIS
- UNTHIS - STATISTICS OF COMBINED SUBSETS WITH HISTOGRAM
- B7MM - STEPWISE DISCRIMINANT ANALYSIS OF DATA PREPARED BY UNTDIS
- CLA7MM - CLASSIFICATION OF A PICTURE ARRAY WITH THE DISCRIMINANT FUNCTION GENERATED BY B7MM
  OUTPUT FOR PHOTOWRITE SYSTEM PHOTOMATION

Fig. 4: Comparison of classification results (number represent areas in percent). (after ITTEN, 1975)

Cover Type	LARSYS Ver.3	STANSORT-2	GE Image-100
Dry Snow	31.8	30.8	30.9
Metamorph.Snow	22.1	22.5	21.1
Forest w.Snow	27.2	27.8	27.1
Interzone	9.4	11.2	4.6
Bare Forest/Veg.	6.2	6.0	10.4
Shadow + Water	0.4	0.2	0.2
Total Snow Covered Area	85.8	86.7	81.4
Total Area Bare of Snow	11.3	11.8	12.9
Unclassified Area	2.9	1.5	5.7
Accuracy/Testfields	92 (calc.)	90 (est.)	87 (est.)

Fig. 5: Separation of training cells using the 4 MSS-bands as variables (in frames are subgroups, which together form the main land use categories). (after BINZEGGER, 1975)

step 1 (variable 7) category +	pixel	total pixels classified of each category							% of correct classification of each category	
		SEE	GRO	KLE	HEL	TOT	LEB	WAL		
SEE	116	112	4	0	0	0	0	0	96,5	100,0
GRO	1'067	30	993	44	0	0	0	0	97,0	97,0
KLE	1'025	0	257	631	15	122	0	0	88,0	88,0
HEL	117	0	1	8	60	39	9	0	59,0	59,0
TOT	998	0	0	113	412	458	15	0	47,5	47,5
LEB	1'002	0	0	0	78	3	921	0	92,0	92,0
WAL	736	0	0	25	393	306	12	0	0,0	43,0

step 2 (variables 7 and 5) category +	pixel	total pixels classified of each category							% of correct classification of each category	
		SEE	GRO	KLE	HEL	TOT	LEB	WAL		
SEE	116	113	3	0	0	0	0	0	97,5	100,0
GRO	1'067	1	947	119	0	0	0	0	100,0	100,0
KLE	1'025	0	186	713	0	121	1	4	87,5	87,5
HEL	117	0	0	10	97	10	0	0	91,5	91,5
TOT	998	0	0	144	8	777	25	44	80,5	84,5
LEB	1'002	0	0	0	0	11	937	54	94,5	100,0
WAL	736	0	0	0	0	13	12	711	96,5	100,0
MIV	1'011	0	0	14	2	363	449	183	80,5	98,5
FLU	341	140	107	51	0	3	0	40	41,0	87,5

Fig. 6: Separation of training cells using the 4 MSS-bands and synthetic ratio variables. (after BINZEGGER, 1975)

step 1 (variables 7/5) category+pixel		total pixels classified of each cateogry SEE	GRO	KLE	HEL	TOT	LEB	WAL	% of correct classification of each category	
SEE	116	102	12	2	0	0	0	0	88,0	100,0
GRO	1'067	115	650	62	238	2	0	0	89,0	100,0
KLE	1'025	0	97	504	326	95	0	3	90,5	90,5
HEL	117	0	46	16	52	3	0	0	97,5	97,5
TOT	998	0	1	268	35	620	2	72	62,5	69,5
LEB	1'002	0	0	0	0	7	799	196	80,5	100,0
WAL	736	0	0	0	0	41	95	600	81,5	100,0

step 2 (variables 7/5-6-7/6-4) category+pixel		total pixels classified of each category SEE	GRO	KLE	HEL	TOT	LEB	WAL	% of correct classification of each category	
SEE	116	105	11	0	0	0	0	0	90,5	100,0
GRO	1'067	21	944	102	0	0	0	0	98,0	100,0
KLE	1'025	0	119	798	0	106	0	2	89,5	89,5
HEL	117	0	1	6	102	8	0	0	93,0	93,0
TOT	998	0	0	111	1	850	9	27	86,0	89,0
LEB	1'002	0	0	0	0	36	930	36	96,5	100,0
WAL	736	0	0	3	0	22	9	702	95,5	99,5
MIV	1'011	0	0	24	1	535	330	121	85,5	97,5
FLU	341	95	146	71	1	2	0	26	28,0	91,5

Fig. 7: Classification matrix for land use mapping of total test area (including color of category represented in Fig. 8). (after SEIDEL/GFELLER/BINZEGGER, 1975)

group	size (pixel)	SEE	GRO	KLE	HEL	TOT	LEB	WAL
SEE	116	105	11	0	0	0	0	0
GRO	1067	21	944	102	0	0	0	0
KLE	1025	0	119	798	0	106	0	2
HEL	117	0	1	6	102	8	0	0
TOT	998	0	0	111	1	850	9	27
LEB	1002	0	0	0	0	36	930	36
WAL	736	0	0	3	0	22	9	702
Test Region	219780	613	15551	49942	1835	119392	16769	15678
Major Class		Water	Built-up Areas			Agriculture		Forestry
Types		Area Without Vegetation				Area With Vegetation		
Color		blue	vio-let	red	ma-gen-ta	white	yel-low	green

12 h

Fig. 8: Final classification and output in form of colored thematic map (1:200'000). Legend in Fig. 7. (after BINZEGGER, 1975)