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Some results of microwave measurements during the INTERCOSMOS complex experiments GEOEX, TELEGEO and CARIBE

1. Introduction

The main goals of the INTERCOSMOS complex experiments in the years 1984 - 1988 were the acquisition of spectral object signatures from different altitudes for vegetation covered surfaces and soils.
We used the radiometer facilities of the Central Institute for Physics of the Earth (CIPE) (fig. 1) which can either be operated by our mobile ground measuring complex or by aircraft missions (plane, helicopter) in low altitudes. An x-band microwave radiometer designed and manufactured by the Technical Highschool Ilmenau (GDR) was integrated in the radiometer complex in 1986. This radiometer measures the microwave radiation emitted by the objects at a frequency of 10,4 GHz and a half width of 500 MHz. The angle of aperture is about 15°.
For airborne and field missions the microwave radiometer has been installed in such a way to enable simultanous recording with the spectrometers operating in the VIS, NIR, SWIR and TIR part of the electromagnetic spectrum.
Some results of the investigations conducted will be presented below.

2. Experiment GEOEX

The experiment GEOEX was carried out on the territory of the GDR in July 1986. The radiometer complex was used on an agricultural test site (size about 2 x 5 km^2) north east of Potsdam (fig. 2). The area is typical with its landscape features for the internal lowland of the GDR. In the southern part of the area, crossed by the Havel channel, the groundwater is elevated up to near the surface level. Marshy soils in the center are typical, on the border, however, where fluvial sands are conserved by the glaciofluvial valleys, humus gleys could be found. In the northern direction there is a ground moraine plateau with local diapirs of sand at domes. Here loamy underlaid sands are encountered that are partly slack or ground water influenced and have a different top sand layer thickness (fig. 3). The usable water capacity of the soil up to 1m under field is at most 160 mm, because of the strongly changing thickness of sand the soil moisture regime as a whole is a decisive yield factor. The considerable heterogenity of the soil features in the test area is expected to give a remarkable time-spatial differentiation in yield formation of the agricultural crops.

On two days during the experiment airborne radiometer missions with six lines per flight were conducted. During the period of the measuring dates there was dry weather, the moisture of the upper soil layers measured at a total of 32 ground control points decreased of 2 - 5 % (fig. 3). At noon the temperature of the upper soil which on the first date was still at 25°C on the average had increased to about 30°C on the second date. The vegetation too faced shortage of water, the plant moisture decreased of 4 - 18%, the temperature of the leaf surfaces increased from 17°C to 23°C on the average. In part however these changes can also be deduced by the process of beginning senescence.

In the measurement profile the Havel channel was first stressed significantly with brightness temperatures of 180 K. Important vegetation areas were a small forest, a field of sugar beets as well as rows of trees along the road and field path. Corn and grassland for the given microwave band is opaque, so a differentiation of soil moisture over these fields was not expected. The microwave signal, however, shows a different increase of the brightness temperature during the time of both dates indicating the decrease of moisture on major parts of the test sites investigated (fig3). Areal extrapolation made from the flight lines showed only some areas near the channel with a exceptional behaviour.

The decrease of the brightnes temperature indicating an increase of moisture for plot 570 (sugar beets) can be explained by the stepping plant growth considering the sugar beet plant structure with relatively large and mainly in the horizontal direction orientated leaves. Previous investigations on sugar beet leaves showed an emissivity value of $\varepsilon = 0.86$ at $\lambda = 3$ cm. Hence they turned out to be clearly discernable from soil. The lower value of the microwave signal on the second date can therefore be explained by an increase of plant cover degree because of the plant growth. Based on the emissivity values which were obtained in the preinvestigations on sugar beet leaves and soil as well as the field measurements of temperature and moisture for plants and soil during the airborne missions the plant cover degree takes the estimated values shown in fig. 4 which coincides well with the terrestrial estimations.

3. Experiment TELEGEO

The experiment TELEGEO took place on two test sites in Poland in 1987. The radiometer complex including the microwave radiometer was used on the test site Narev in the east of Poland near Bialystok from the 15.5. to the 30.5.1987.
The scientific program of the complex experiment was aimed at investigating the impact of drainage measures over the last 20 years in a territory comparable to the Havel depression area near Potsdam. Of special interest in interpretating the microwave radiometer data was the profile section of the Narev flood plain which is used as grass land. Because of the river nearness a remarkable changing water influence could be expected. In addition to the CIPE radiometer complex a soviet microwave radiometer with a wavelength of $\lambda = 30$ cm could be used in the experiment. This supported the conclusions about the wavelength dependency of the vegetation influence, i.e. for corn fields and pasture this influence was significantly lower at the greater wavelength. The same tendency is also valid for the profile sections shown as example. While the vital grassland vegetation masks the soil almost entirely in case of the 3 cm radiometer the higher moisture content in the depression and with decreasing distance to the river is clearly deductable for the 30 cm microwave signal (fig 5). Trees while not being unambigously identified in the 30 cm

band can be detected in the 3 cm band because of the size and orientation of the leaves. For the 3 cm band a classification of the profile across the lowland meadows to the river results only in open watering places (where free water was already observed on the meadow) whereas for the 30 cm band parts of the meadow with different moisture content can be recognized (fig. 6).

4. Experiment CARIBE

In April 1988 the experiment CARIBE was conducted in the republic of Cuba. Venue of the experiment was a test site near Bayamo in the eastern part of Cuba. There rice is cultivated on an area of about 140 ha. Special interest deserved the microwave data for investigating the flooded rice fields. The area was divided into 12 large rice tables (subfields) with the rice on the northern six tables aged one month and the southern six tables aged about two months. The top water level differed from 5 cm to 10 cm depending on the micro relief of the plates. First measurements were carried out from a height of about 10 m at locations with different plant densities. These differences are characteristic for sown rice and could be expected to be higher for rice aged one month compared with rice aged two months. A definite relationship to the projective plant cover degree was detected by the microwave measurements (fig. 7). As the differences of the cover degree influence other vegetation indicators too, e.g. the vegetation index or the feature of curvature VM 2 which has been often used by us strong correlations exist between the features determined. In analyzing the profile data these correlation can also be used to locate areas deviating from normal conditions, e.g. to isolate dry areas (fig. 8).
So the area cultivated with one month aged rice and lower plant cover degree values under normal conditions (field is flooded) is characterized by decreasing vitality feature and increasing microwave signal. Dry areas however cultivated with rice from one to two months age are characterized by a lower value of the vitality feature and simultanously by a low microwave signal.

5. Conclusions

During the INTERCOSMOS-experiments for microwave measurements only a passive 3-cm radiometer could be used. The expected difficulties in determining soil moisture parameters because of the strong influence of the green vegetation in this given waveband were found. In general, the only 3-cm radiometer is not very suitable for soil moisture detection. Nevertheless the derivation of plant moisture and soil moisture parameters is possible in some special cases. Relative changes could be detected by repeated measurements within a time interval of 5 - 10 days. In some special cases the degree of soil coverage by plants easily can be measured with a microwave radiometer in the 3-cm waveband. For quantitative investigations asa minimum a second radiometer in the 20-30-cm waveband isnecessary, which is less influenced by the vital plants.

Field measuring complex BMK/FE-3 for the acquisition of spectral data under in-situ conditions

Central Institute for Physik of the Earth
Telegrafenberg A 17
Potsdam 1561

Basis vehicle - ARO 240

Cantilever - measuring height: max 8m
load capacity : 35 kg

Fieldspectrometer: 0.4 - 1.1 um, 40 bands spectralresolution 8-15 nm

Multibandradiometer: 0.4 - 12.5 um, 8 bands app. TM-compatible

Microwaveradiometer: 3cm (10.4 GHz)
bandwidth: 0.5 GHz

Data recording: digital on magnetic cass.

Fig. 1

Interkosmosexperiment Geoex-1986

Testsite Potsdam-Falkenrehde

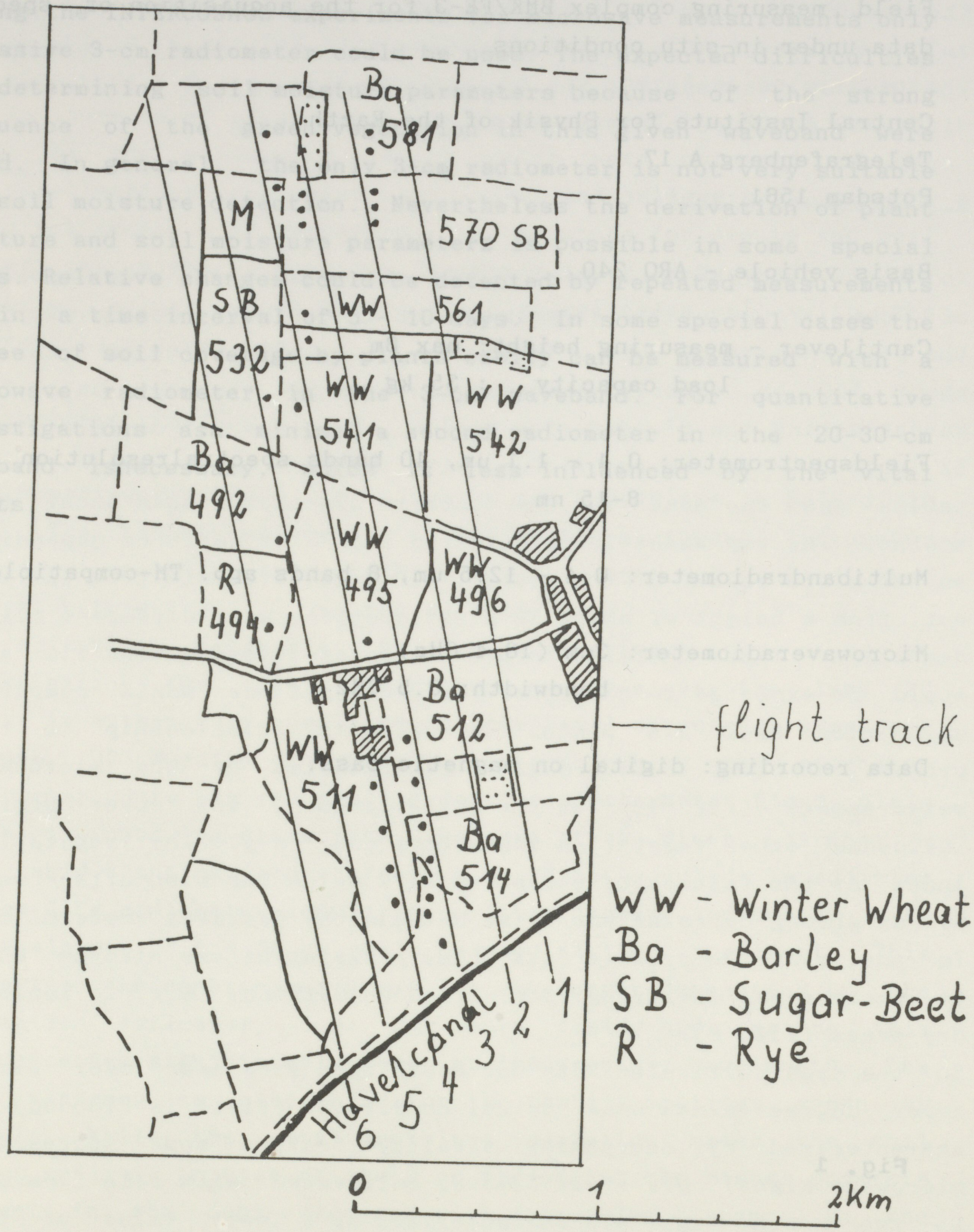
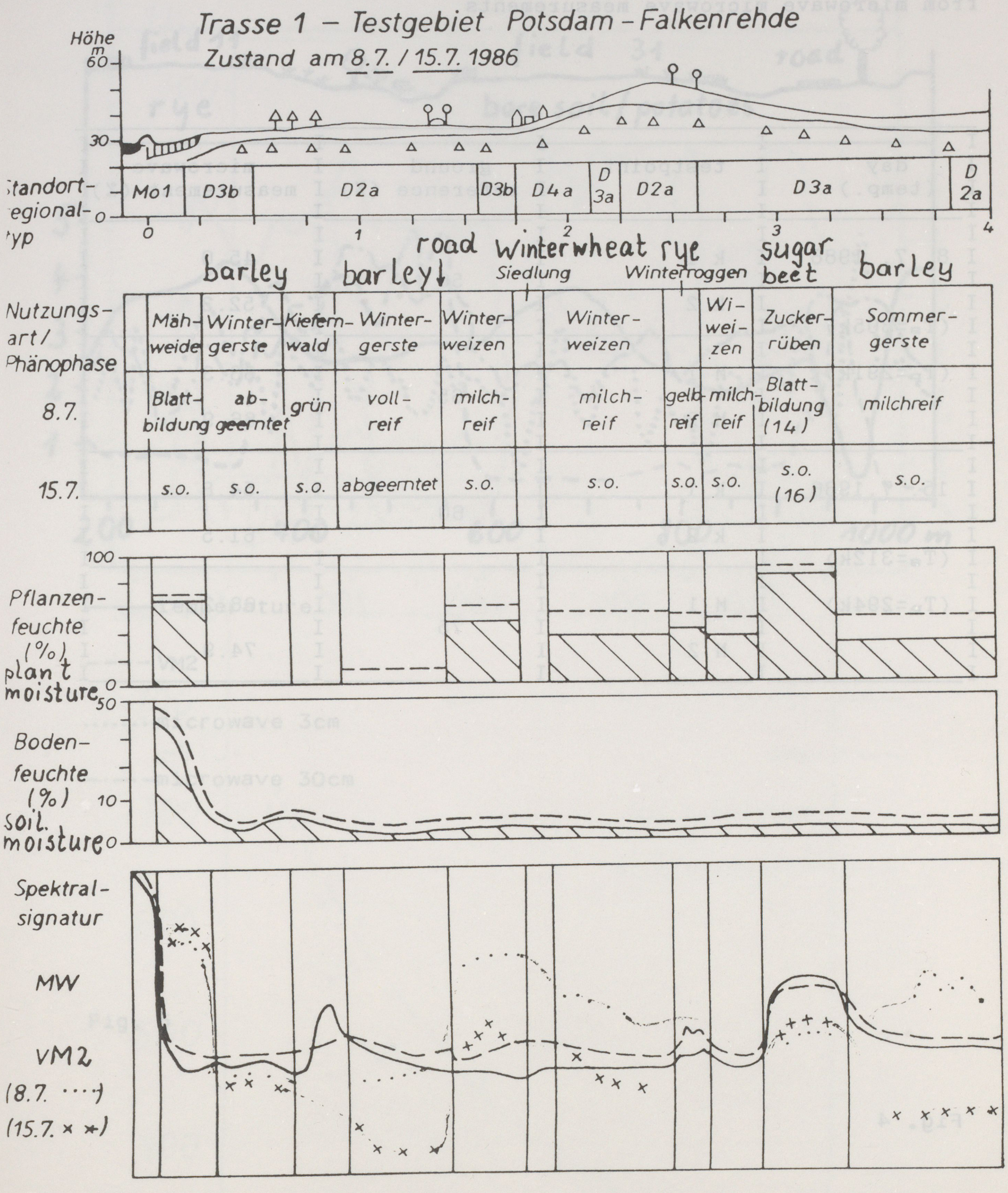


Fig. 2



Trasse 1 – Testgebiet Potsdam-Falkenrehde
Zustand am 8.7. / 15.7. 1986
Höhe m
60
30
0
Standort-regional-typ
Mo1
D3b
D2a
D3b
D4a
D 3a
D2a
D3a
D 2a
0
1
2
3
4
barley
barley
road
Winterwheat
rye
sugar beet
barley
Siedlung
Winterroggen
Nutzungs-art / Phänophase
Mäh-weide
Winter-gerste
Kiefern-wald
Winter-gerste
Winter-weizen
Winter-weizen
Wi-wei-zen
Zucker-rüben
Sommer-gerste
8.7.
Blatt-bildung
ab-geerntet
grün
voll-reif
milch-reif
milch-reif
gelb-reif
milch-reif
Blatt-bildung (14)
milchreif
15.7.
s.o.
s.o.
s.o.
abgeerntet
s.o.
s.o.
s.o.
s.o.
s.o. (16)
s.o.
100
Pflanzen-feuchte (%)
plant moisture
0
50
Boden-feuchte (%)
soil moisture
10
0
Spektral-signatur
MW
VM2
(8.7. ····)
(15.7. × ×)

Fig. 3

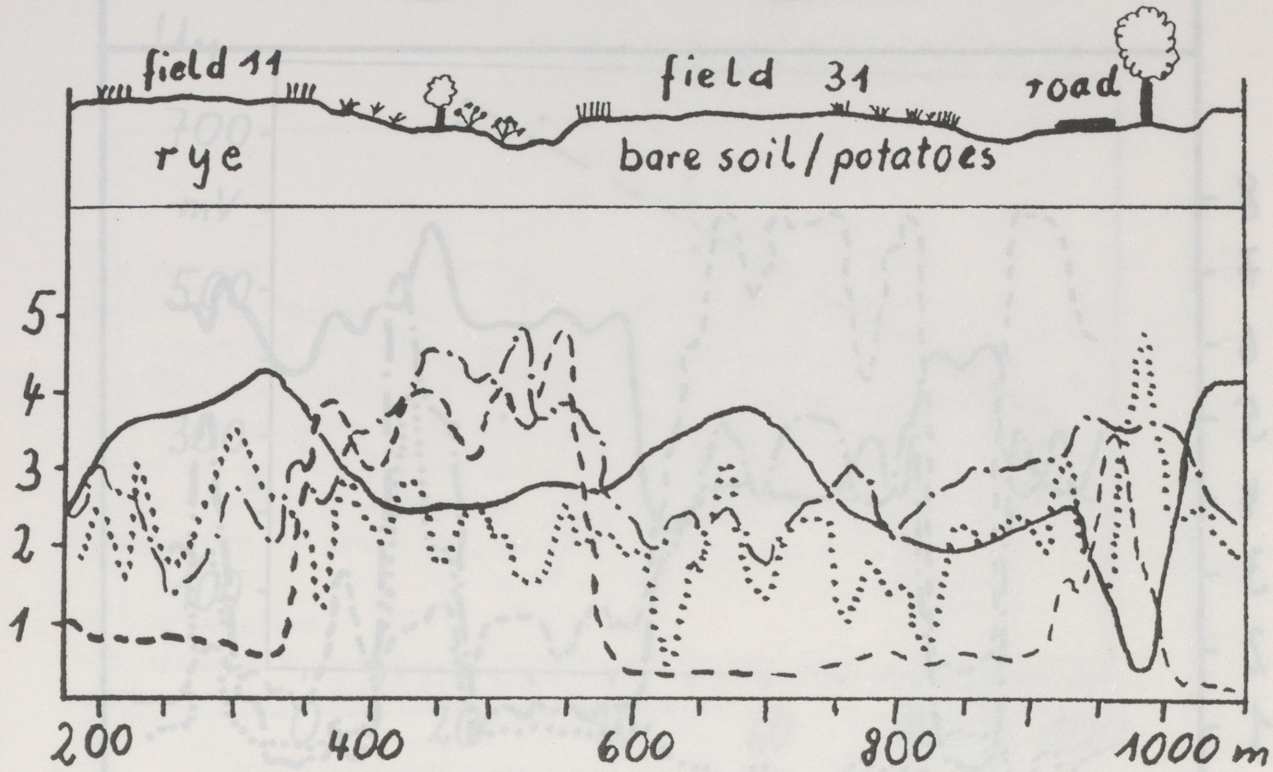
Interkosmos-Experiment Geoex-86

Ground coverage of sugar-beet testpoints

from microwave microwave measurements

day (temp.)	testpoint	ground reference (%)	microwave measurement (%)
8. 7. 1986	k 1	50	45.0
(T_s=305k)	k 2		52.3
(T_p=291k)	M 1	65	63.3
	M 2		66.9
15. 7.1986	k 1	60	54.8
(T_s=312k)	k 2		61.5
(T_p=294k)	M 1	75	68.2
	M 2		74.9

Fig. 4



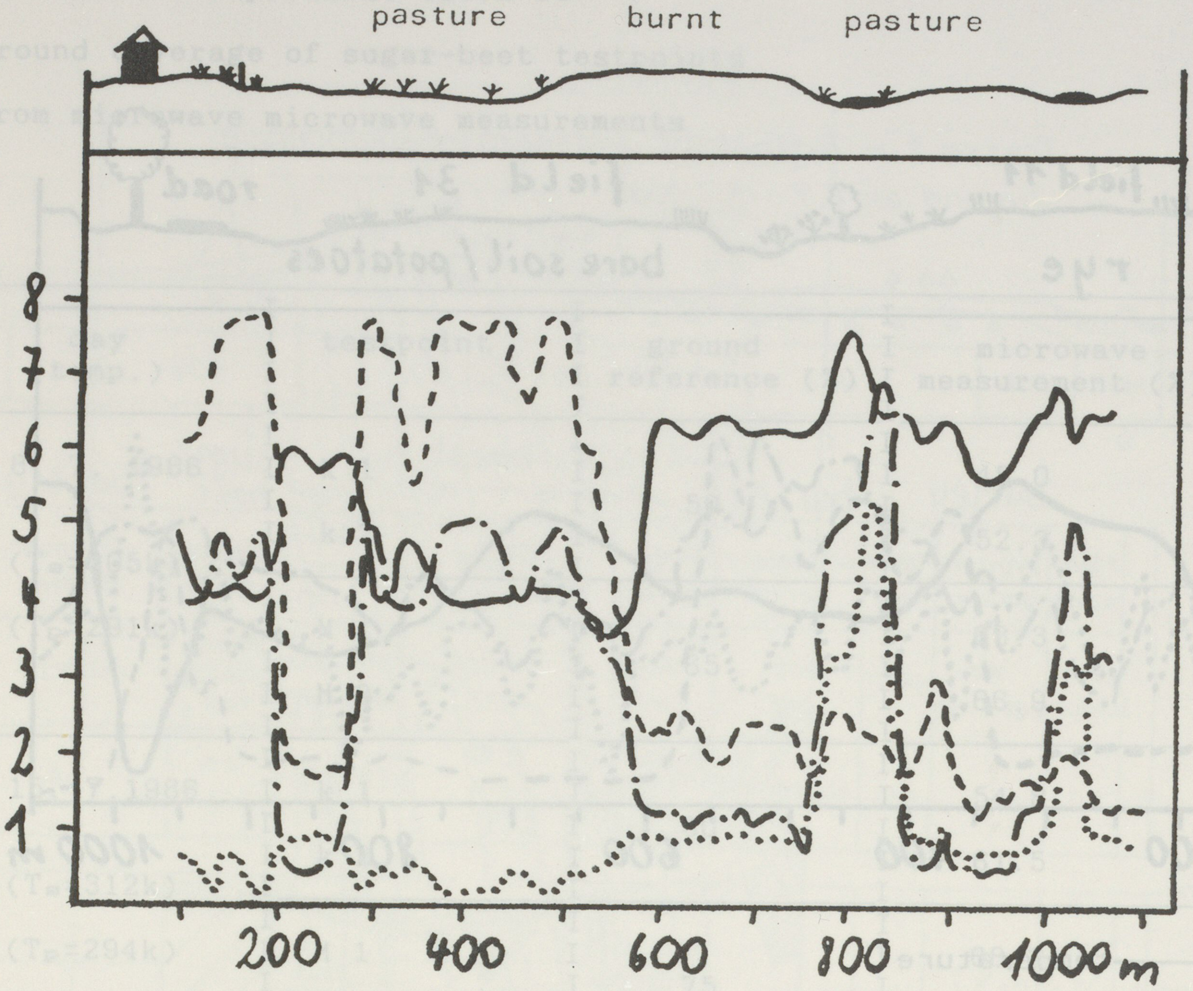
———temperature

----VM2

.......microwave 3cm

—·—·—microwave 30cm

Fig. 5



——— temperature of the surface

----- VM2

.... microwave 3cm

—·—·-microwave 30cm

Fig.. 6

Interkosmos experiment CARIBE-88

Testsite Puente Guillen (Bayamo)

flooded rice

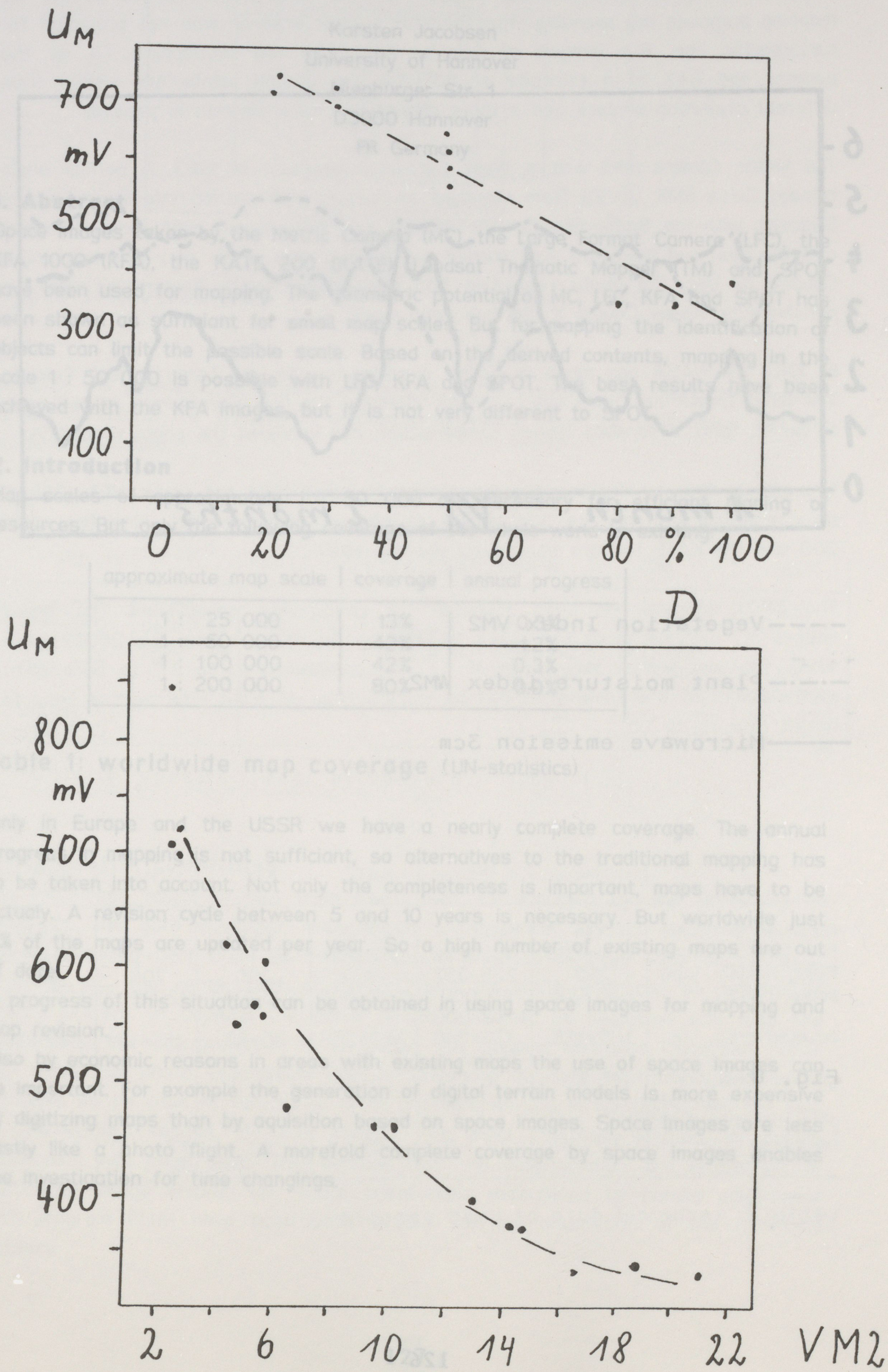
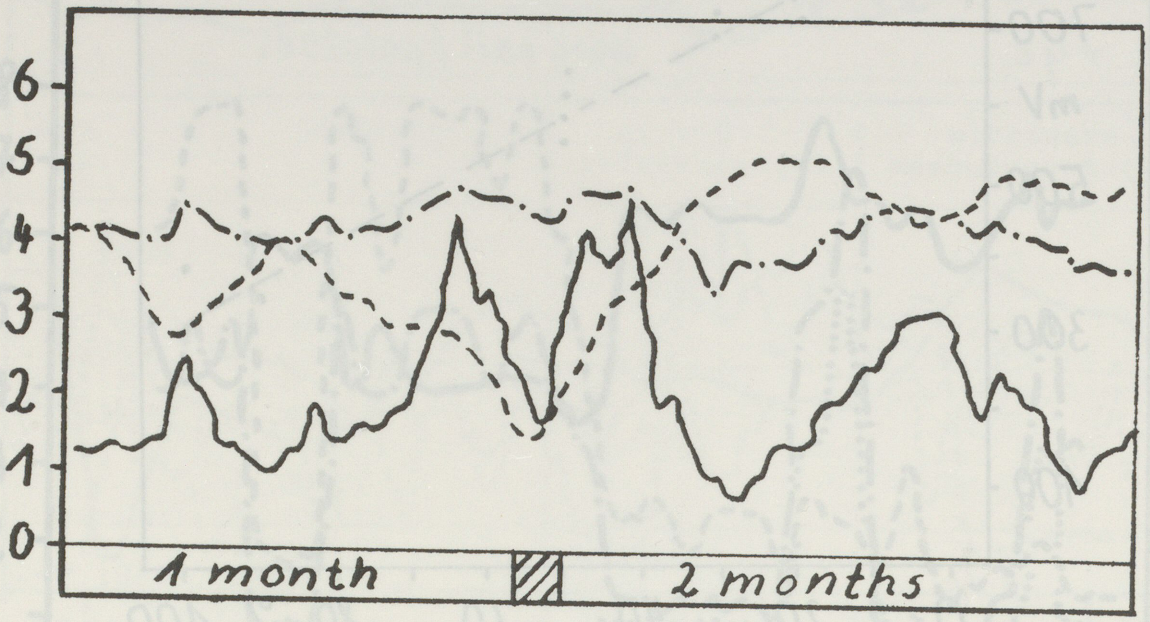


Fig. 7

Interkosmos experiment CARIBE-88

Testsite Puente Guillen (Bayamo)

flooded rice



----Vegetation Index VM2

—·—·—Plant moisture index WM2

———Microwave emission 3cm

Fig. 8