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Dr. Sergio Finzi

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LANDSAT-2 SATELLITE FOLLOW-ON INVESTIGATION No. 28790
AGRICULTURAL RESOURCES INVESTIGATIONS
IN
NORTHERN ITALY AND SOURTHERN FRANCE
(AGRESTE PROJECT)

PT. 1

First Progress Report

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August 15th – November 15th, 1975

PART I

Italian test - sites

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LIST OF INSTITUTES AND ORGANISATIONS INVOLVED IN THIS PHASE OF RESEARCH

- Biology Group-Ispra of Directorate for Science and Education	BGI
- Centro di Applicazioni delle Tecnologie Avanzate - Napoli	CATA
- Ente Nazionali Risi - Mortara	ENR
- Istituto Nazionale delle Piante da Legno - Torino	INPL
- Istituto Sperimentale per la Cerealicoltura - Vercelli	ISC
- Istituto di Sperimentazione della Pioppicoltura - Casale Monferrato	ISP
- Joint Research Centre - Ispra	JRC
- Istituto per la Geofisica della Litosfera - Milano	IGL

1. INTRODUCTION

The part of the AGRESTE Project's investigation concerning the Italian test sites is being conducted in a two-phase approach 1) pre-launch, 2) post-launch and continuing investigation.

The activity herein reported (post-launch) has to be considerated the continuation of the preceeding one (pre-launch) which was carried out since 1973 by the Joint Research Center-Ispra in collaboration with the Biology Group of the Directorate-General for Science and Education and the Italian Institutes and Organizations.

A condensed description of the pre-launch phase is also herewith enclosed, as a necessary premise for a correct understanding of the following post-launch activity.

Should a more detailed information be requested on some specific sectors of the pre-launch investigation, it can be obtained looking up in the corresponding AGRESTE PROJECT reports (see annexed list).

2. PRE-LAUNCH INVESTIGATION

2.1. Investigated Fields

During this preparatory phase the research was carried out aimed at providing the different co-investigating staffs with the necessary background needed for correctly solving the problems connected with the future LANDSAT-2 - aircraft combined R.S. programme.

Depending on the principal objectives of investigation, some specific items were considered, taking into account their importance and the possibility of tackling them on the basis of the available technical means.

The principal effort was devoted to determine the methodologies in ground observation, airborne survey and data processing.

Among the four fields of investigation (rice, poplars, beeches and conifers) the following were considered for the AGRESTE's pre-launch effort:

- Irrigated crops : rice
- Artificial forest: poplars

This priority was suggested by reasons of relative importance and considering the limited amount of resources allocated for this phase of research. Rice and poplars are, in fact, two significant "food-and-wood" subjects for Southern-Europe. They co-exist in a same artificial eco-system on test-site N°1, the most suitable for a joint effort to be produced by the JRC-Ispra and the Italian Institutes.

2.2. Research carried out and results gained at JRC-Ispra and on test-site N°1

2.2.1. RICE INVESTIGATION

2.2.1.1. Correlating rice bio-mass and yield with reflectance in the LANDSAT channels

The first campaign aiming to ascertain the possibility of establishing a correlation between standing rice bio mass and some radiometric functions was carried out on the J.R.C. lysimeters at Ispra. A limited number of cells were cultivated with rice treated with different amount of a fertilizer (nitrogen) having a strong influence on the plant growth.

The analysis of the collected data (weight of overground bio-mass and reflectances in the four LANDSAT channels, measured by means of an EXOTECH mod. 100 radiometer) showed that there should be a linear correlation between total overground bio-mass (including panicles) and the ratio ρ_7/ρ_5 between reflectances in channels 7 and 5 .

These results, though encouraging, did not allow to state that the ratio ρ_7/ρ_5 is a direct indicator of the standing biomass, because in the lysimeter cells the variations in biomass were obtained only by variations of nitrogen. It is possible, even probable that in these conditions the radiometer may see the "quality" of the biomass (i.e. the amount of clorophyll depending of the amount of nitrogen) rather than the "quantity" of biomass. In order to solve the problem it seemed convenient to devote the campaign of ground tests of 1974 mainly to trying to separate the effects of actual biomass and nitrogen on radiometric measurements.

For this, two different sets of experimental fields have been considered: fields in which the same variety of rice has been cultivated starting from the same density of plants, but treated with different amounts of nitrogen ; fields in which the same variety of rice has been cultivated with the same amount of nitrogen, but starting from a different density of plants. The collection of data on such experimental fields has been carried out mainly from July to October 1974. Here, only the final synthesis is reported, in the following sections.

2.2.1.1.1. Effects of nitrogen on rice biomass

The tests have been performed on seven experimental fields, at Vercelli, prepared and controlled by ISP. The results can be summarized as follows:

- The differences in amounts of nitrogen have been constantly detected in the four LANDSAT channels. It is possible to state that reflectance in channel 7 and 6 increases, while reflectance in channel 5 and 4 decreases with the nitrogen contents.

- The growth of rice plants produces significant variations in the reflectance values, which can be considered as useful indicators of the vegetation development.
- The final total above-ground biomass is a linear function of nitrogen given as fertilizer.
- The ratio ρ_7/ρ_5 is a function of the total above-ground biomass. The function which can link the ratio ρ_7/ρ_5 observed in different periods of the vegetative cycle to the final total overground biomass can always be assumed to be linear. But the coefficient of correlation is very close to 1 in a stage near to flowering time, whilst it continuously decreases towards harvesting time. This suggests to consider the period just after flowering as a good one for yield prediction.
- The rice yield depends on nitrogen fertilization. The "efficiency" of production (ratio between grain and total biomass) cannot, at this stage of research, be determined by radiometric means;

2.2.1.1.2. Experiments on variable density rice plants

The tests have been performed at Valeggio on ten experimental fields prepared and controlled by the ENR. The results can be summarized as follows:

- Reflectances ρ_4 and ρ_5 are generally insensitive to biomass variations. Reflectances ρ_6 and ρ_7 show saturation already starting during the tillering stage. This should mean that in channel 7 and 6 the radiometer sees only the horizontal green surface and not the total biomass; the inner biomass is shielded by the external layers of vegetation.

  In the period in which the growing of the biomass can be detected, the reflectance ρ_7 is more sensitive than the ratio ρ_7/ρ_5.

- The ratio ρ_7/ρ_5 is a good indicator of the plant development, during the vegetative life, with a particular sensitivity at full flowering time.

- The common open field rice cultivation shows a wide variability both in halms density (about 20%) and in rice production (about 30%).

- The yield prediction probably cannot be made by evaluating the total biomass performing only vertical measurement on vegetation with the radiometer.

- It might be possible to find a differential time-dependent model based on the sensitivity of ρ_7/ρ_5 to the growth of the plant.

2.2.1.1.3. Discussion of results

The main purpose of the research was to ascertain whether the total rice standing biomass could be evaluated by means of radiometric measurements in the four LANDSAT channels. This in fact is the first problem to be solved on the way towards the realisation of yield prediction models.

The question can be summarized as follows: does the radiometer see the quantity or the quality of the standing biomass? At this stage of the research it seems that the second hypothesis is the right one. In fact it is true that in Vercelli a linear correlation has been found between reflectance and biomass (in particular the ratio ρ_7/ρ_5), but, probably, only because a similar correlation exists between reflectances and nitrogen content. That is to say, the weight of total biomass is proportional to the amount of nitrogen; the amount of nitrogen is proportional to a reflectance function. The radiometer sees only the amount of nitrogen, and in this case it would be an instrument only useful for an indirect measurement of the biomass.

Unfortunately the common rice cultivations are not characterized by different amounts of nitrogen. Hence, the results obtained in Vercelli, although very useful for production optimisation, seem to give only a partial contribution to yield prediction.

In conclusion, it seems possible to state that a direct evaluation of standing biomass is not possible on common rice fields by means of only vertical radiometric measurements. In this situation, once rejected the way of the direct "easy" evaluation of biomass, it seems convenient to devote any care to the fact that the ratio between reflectances in channels 7 and 5, plotted against time, is in any case a good indicator of the plants development throughout their life. This means that there is a basic possibility of describing tha plants growth by means of radiometric functions and , hence, of prediction of biomass amount and yield by a differential time-dependent model.

The problem is to individuate significant parameters linked to the plant development and to tray to correlate them to some radiometric functions throughout the vegetative life of rice.

The model should be conceived in such a way that the wide variability both in plants density and in rice production (observed in open fields) might be taken into account. At this purpose a serious statistical description of an open rice field should be done.

References (1) (2) (3) (4) (5)

2.2.2.2. Thermal behaviour of rice fields affected by a yellowing-disease

This research has been performed by ENR and IGL with the assistance of the JRC in the Trecate area. The interest of investigating the potentiality of R.S. in this domain depends on the strong loss in yield to a rice disease called "Giallume" which causes yellowing of leaves and growth stunting in rice plants.

The approach to the research consisted in using both an on-ground thermo-camera and an airborne I.R.-dual channel scanner facility. Most of the ground observations were performed by mounting the thermo-camera on a special 23-meter high cherry-picker in order to look at the diseased fields from different altitudes and inclination angles.
It has been found that an anomalous thermal behaviour exists in diseased biomass compared to healthy one.

The thermo-camera was also operated for some days from pre-dawn to sunset continuously, in order to find the time of day at which the max. thermal contrast occurs between healthy and diseased areas. The strongest contrast, corresponding to some Kelvin degrees of black-body temperature, was detected around one o'clock in the afternoon. On the basis of the above results, some aerial photographic-and-I.R. scanner surveys over the test area were performed at the same time on different days.

The aerial thermographs confirm and extend the results gained with the thermo-camera. A lot of ground control carried out on the 87 ha.s test-area during the observations helped in interpretating the thermal maps of the diseased zones. The research confirmed that a real time synoptic monitoring of the disease is possible by means of repetitive aerial surveys.

References (3) (4) (6) (7) (8) (17)

2.2.2. POPLAR INVESTIGATION

2.2.2.1. Photographic and radiometric aerial investigation on poplar plantations.

Three items of investigation were considered and studied by ISP in collaboration with J.R.C.:

- identification of poplar afforestations from the landscape, with a particular reference to discrimination be - tween the sorrounding cultivated forest species such as willows,
- inventory of poplars in different plantation productivity classes,
- phenologic identification.

Some aircraft surveys were considered indispensable as a preliminary stage of investigation. An experimental area of 10 km^2 was chosen on the test-site N°1 (Frassineto Po) and some N and IR/colour photographic flights were performed at different dates in order to take advantage of the corres - ponding seasonal phenologic characterization (dimension, colour and precocity in fall of leaves). This imagery (scale up to 1:100,000,), correlated with a suitable amount of ground observations, led to the conclusion that the regular row arrangement together with the linear plantation outlines enable the recognition of poplars in almost two classes of various ages even from high altitude. Each class corresponds to a different range of crown dimension, often strongly contrasting in colour with the ground underneath. Values of ratio of crown area (red) to the open ground (blue) have been evaluated for different classes.

It was also found that IR-false-colour allows far better than N-colour the discrimination of poplars from willows and the recognition of certain types of poplars with characte - ristic foliation or early leaf fall patterns. It came out from these results that a probability exists that LANDSAT would be successful in poplar identification by suitable rationing of MSS channels.

A flight over the same test-site was performed using the EXOTECH mod. 100 radiometer. The aim of this experiment was to obtain in - formations on spectral response in the 4 MSS bands from two diffe- rent altitudes (2,500 m and 4,500 m). From an altitude of 4,500 m the patch view by means of 1° FOV corresponds to the best ground resolution element of the LANDSAT satellites.

The EXOTECH mod. 100 radiometer and the following instrumentation were mounted on an aircraft:a N-colour Super-8mm film camera, 2 sets of N and IR-colour photographic cameras, a magnetic recorder for the simultaneous 4-tracks-radiometric signal recording.

The ratio ρ_7/ρ_4 was chosen because it is expected to be a good in- dicator for standing biomass. Comparing the elaborated results with ground observations it came out that different types of forestry ve getation give different values of the ratio $\rho 7/\rho 4$. In particular , increasing values of the above ratio correspond to increasing age (and timber volume) of poplars.

It could be concluded that a correlation is possible between age classes of poplars and radiometric data; poplar plantations can be distinguished from the willow-tree afforestations.

References (3) (4) (5) (9)

2.2.2.2. Laboratory spectral signature definition

Spectral signature definition of poplar leaf surfaces was made for defining peculiar features which allow remote sensing of different varieties of plants and for being eventually used as input data in mathematical models describing the relationships between the measured spectral reflectance of the ensemble and the specific spectroradiometric character and the geometric location of every individual canopy component.

With such a goal in mind some laboratory measurements of reflectance versus λ in the range from 370nm to 800nm have been made by ISP and JRC for leaves of different varieties of poplars, (populus alba 58-57, populus deltoides 69/55, populus euroamericana I 214), of "salix alba" and "robinia" which grown in the same habitat on the poplar test-area controlled by I.S.P. on test-site N°1.

The measurements have been performed at JRC's laboratories using a Cary 14 spectrophotometer equipped with the cell space total diffuse reflectance attachment.

It was found that the "salix alba" leaf can be distinguished from poplar-leaves. It appeared also that some difficulties will arise for what concerns differentiation between poplar and "robinia" leafs for which an extension of the spectral signature study to the near infrared region might be of resolutive interest.

Reference (5)

2.2.3. SATELLITE DATA PROCESSING DEVELOPMENT

2.2.3.1. Correcting satellite data for atmospheric effects

The problem of correcting LANDSAT-2 satellite and high-altitude aircraft MSS data for the masking effects of atmosphere has been considered at the J.R.C. since 1973. An experimental approach was adopted, which allows to obtain the atmospheric parameters by means of some direct measurements on ground.

Referring to the four LANDSAT optical bands i the conversion of CCT radiance data Lpi from the satellite into reflectance data ρ_{oi} is obtained measuring several atmospheric parameters, (i.e. H_{sky}=sky irradiance, H_{sun}= sun irradiance, H_{oi}=sun irradiance outside the earth atmosphere, T_i=atmospheric transmittance, m=air mass traversed by the sun radiation at different sun angles θ_z).
An EXOTECH mod. 100 radiometer was used.
Measurements of H_{sun} were performed at an altitude of about 2670 m on the Swiss Alpes. The most part of the other measurements were made at Ispra.
The data correcting methodology has been completely set-up. This procedure has twofold advantage:

1) satellite data are expressed in the same scale as ground reflectance measurements;

2) signature of ground objects become independent from atmospheric conditions and sun position.

An error evaluation has also been performed. This estimation reveals that the accuracy of the reflectance values calculated from satellite data on the basis of ground measurements of atmospheric working parameters is of the same order of the accuracy of ground reflectance measurements.

References (3) (4) (5) (10) (11) (12) (13)

2.2.3.2. Software preparation for processing LANDSAT data

Using some LANDSAT-1 magnetic tapes the software indispensable for the forthcoming LANDSAT-2 investigation has been prepared. A certain amount of application work has also been performed.
The following results have been obtained.

2.2.3.2.1. Work on the (PSU) software

a) PSU-package preparation

At the end of 1973 we obtained a copy of the software developed by the Remote Sensing Group of the Pennsylvania State University (PSU) for the same computer and the same system as that in use at Ispra (IBM 370/165). This software is made by four types of programs:

1) Data Management and Retrieval Routines, which re-elaborate the data from the original NASA tapes in a form suitable for interpretation and successive elaboration (i.e. visualisation by grey-map print out): Programs TPINFO, SUBSET, MERGE, NMAP, UMAP, MAPCOMP.

2) Routines, computing the multivariate, statistical parameters to be used in 3 and 4: program STATS.

3) Feature Selection/Data Reduction Programs, which minimise and/or optimise the flow and dimension of LANDSAT's four channel data to be used in 2.1.2.4.

4) Automatic Classification Programs, which cover the range of classical discriminant analysis algorithms (supervised and unsupervised classifiers).

The work for implementing the PSU software allowed the J.R.C. to first process LANDSAT-1 tapes in February 1974, using the retrieval routines TPINFO, SUBSET, NMAP, UMAP and then to gain progressive experience in the automatic classification problem.
Some programs of extensive use have completely been rewritten in order to improve their efficiency and flexibility: NMAP, UMAP, RATIO.

b) PSU derived programs

On the basis of NMAPX (a version of the PSU-NMAP Routine rewritten and improved by the J.R.C., two programs for experimental purpose have been written:

- NMAPW: an extension of NMAPX which allows images to be transformed freely within the colour space. Moreover, NMAPW produces optionally statistical data for chosen test areas, histograms for every channel and/or cluster images in a logarithmic scale for all pairs of channels. These features have been used for experiments on finding atmospheric correction parameters and for reducing shadows in mountaineous areas.
- CLASSW: a classifier derived from NMAPX, which uses the input cluster limits given for pairs of channels to assign the points into classes on a boolean-type decision rule. In connection with NMAPW it has been used for a first classification of poplars using a test area with questionable statistics.
- CLAPIX: as a maximum likelihood classifier, is optimal for normally distributed data with diagonal covariance matrix. It may be seen as an improved CLASS or a simplified PARAM algorithm, thus filling a gap in the set of classifiers in the program package of PSU.

2.2.3.2.2. Other programs

- RHOMAP

This program was written by J.R.C. in order to transform radiance data, given in form of count rates on the NASA tapes, into ground object reflectance. The objects signature becomes less dependent from temporal illumination conditions as defined by sun position and optical transmittance of the atmosphere. Input of RHOMAP are NASA-LANDSAT (or MSS aircraft) data and a number of atmospheric parameters (total irradiance on the ground, transmittance, path-radiance) for each considered band. The atmospheric parameters can be obtained either from ground measurements or from atmosphere-model calculations (RADTMO).

- RADTMO

This code package was made available to the J.R.C. by the courtesy of the NASA's Goddard Space Flight Centre. The code calculates spectral radiation properties in a one-dimensional layered atmosphere, irradiated at the top by a constant flux with given incidence angle. The atmosphere is bounded by a lambertian reflecting ground.

A modification has been introduced by J.R.C. into the program, which allows the evaluation of the aerosol density in the lower part of the troposphere (below 5 Km) from visual range.

- PATRAM, ATRAM

These codes were written by the J.R.C. for the evaluation of the measured atmospheric parameters. PATRAM calculates the path radiance from almukantar measurements of sky-radiance. ATRAM calculates the transmittance of the atmosphere from the measurements of sun irradiance at different sun zenith distances.

- Image Processing Using Spatial Information

  For experimenting image manipulation, using spatial as well as spectral information, the program IMAN has been written and is going to be extended. IMAN allows level-slicing, mask generation and masking, arithmetic and logic operations on images, line-printer display, memory allocation and disc-memory communication, image parameter calculation and setting, Fourier-transform and general arithmetic and control commands.

- CLAPIX

  A classifier has been written which assumes independent data in a max. likelihood decision rule. The classifier has been used to verify the spatial separation between the rice classes mentioned above.

2.2.3.3. Applications for LANDSAT-1 imagery

Investigations were undertaken on rice and poplars along the Po and Ticino valleys and on the rice zone between these two rivers. For the whole year 1974 only two LANDSAT-1 Satellite scenes were available: one of October 7th 1972 and the other of May 10th 1973. Both of them cover a relevant part of the test-sites n°1, mainly on the Eastern-side. Most of the 1974 work was performed on the May scene.

Parallel work has been undertaken for the October scene with a higher level of difficulty because the general contrast of this scene is rather weak. Some preliminary and encouraging results have been obtained for rice classification. Poplar recognition (closed fields) leads to the same success as for the May scene.

Some of these results have been visualized by means of a OPTRONICS PHOTOMATION apparatus which converts digital tape information into photographic slides. Each satellite resolution element (pixel) is represented in this visualization by means of a rectangle whose dimensions have been selected in order to minimize the geographic deformation of the picture.

2.2.3.3.1. Test of classification performance applied to the Province of Varese.

In order to test the performance of the PSU package, a supervised classification was performed using the codes NMAP, UMAP, STATS and PARAM. From NMAP and UMAP (based on a texture scheme, able to map the uniformities zones and the contrast zones of a scene) seven categories were identified (town, two types of water (Lake Maggiore, Lake Varese), swamp, high and low vegetation and highly reflecting objects).

With the results of STATS a region of about 27 x 27 Km^2 around Lake Varese was classified. The data were taken from the ERTS-1 passage of October 7th.

The results were:

Water surfaces of lakes of even small dimensions (lake Ganna) were correctly classified. Water quality was clearly distinguished: i.e. lake Comabbio was recognized as water type "lake Varese", whereas lake Monate was classified of type "lake Maggiore". Small areas of high vegetation (poplar plantations at the border of lake Varese) were correctly distinguished from surrounding low vegetation (meadows).

2.2.3.3.2. Comparison of classification methods applied to artificial eco-systems starting from digitised reference maps.

Two reference maps, for rice and poplars respectively, were constructed and digitised starting from the data given by the Institutes. Rice fields cut out of 1:6000 photo-reduced cadastral maps have been assembled. These maps refer to some broad rice-cultivated areas, controlled by ENR and poplar - afforestated areas controlled by ISP. On this basis a quantitative study on the efficiency of the various classification methods was then be possible (percentage of correct classified pixel for each class).

a) Rice fields

The LANDSAT data investigated concern a rectangular zone taken from the scene of May 10th, 1973. Number of pixels investigated (4 channels): 11,160. The reference map gives a rice coverage of 40.7% with a max. error estimated at 1%.

We report some results :

- Level slicing on channel 7 (near-infrared), (program NM APX):

Rice coverage	Calculation time (CPU)
39.6%	5 sec

- Classification using Euclidian distance and various angular thresholds for the classes (program D-CLASS):

Threshold	Rice coverage	Calculation time (CPU)
18°	35%	5 sec
21°	38%	5 sec
24°	43%	5 sec

- Classification using linear discriminant functions for the classes, adjusted by iteration over the training sets (non parametric linear classification program NPAR)

Rice coverage	Calculation time (CPU)
34.9%	7 sec

- Clustering of the zone (unsupervised classification):
  Five classes of water were recognized in the rice fields, with a global result as follows:

Rice coverage	Calculation time (CPU)
34.8%	11 sec

In the case of "water inventory" a simple level slicing on channel seven gave, as expected, the better result. The water investigated was, however, very inhomogeneous and the unsupervised clustering results are very interesting in this respect. The programs NPAR and CLASS give acceptable results, the threshold value for water in D-CLASS has to be rather large in order to include all the water subclasses and a more accurate investigation will be done to determine it, using LANDSAT-2 data.

b) Poplar plantations

A rectangular zone of the same LANDSAT scene of May 10th, 1973 has been investigated (4 channels). Number of pixels investigated: 6,248.

The reference map gives for poplar fields with crown coverage above 25% (age 3 years) a cultivated area of 8.3%, referred to the total area of the zone (estimated error on the last figure: some %).

The results are the following:

- Classification using maximum likelihood with normal distribution for the classes (program PARAM),

Poplar coverage	Calculation time
7.5%	18 sec

- Using DCLASS (Euclidian distance):

Threshold	Poplar coverage	Calculation time
9°	8%	5 sec

- Using CLUS (unsupervised classification):

Poplar coverage	Calculation time
13%	7 sec

In an actual recognition problem on vegetation, the PARAM algorithm gives the more reliable results. The clustering approach gives poor results, mainly because the random sampling of points is not sufficient for a small zone; an integral clustering of all the points would be necessary in this case.
It is being developed with already encouraging results.

References: (4) (5) (14) (15) (16)

3. POST LAUNCH INVESTIGATION

3.1. Research objectives and task distribution in the considered period.

Special enphasis has been put in the investigation concerning the main sectors of the AGRESTE's research : rice and poplars. In this framework the research has been carried out towards the following specific objectives:

1) Rice investigation
   - measurements for correlating reflectance with biomass and yield;
   - radiance behaviour of diseased plants;
   - ground-truth acquisition.

2) Forest investigation
   - ground-truth acquisition

3) Aircraft and satellite data processing
   - atmospheric correction data acquisition;
   - development of some new utility and data processing programs.

The distribution of tasks is summarized in Table 1.

3.2. RICE INVESTIGATION

3.2.1. Rice reflectance measurements in greenhouse conditions

3.2.1.1. Aim of the experiment . Experimental set-up

Reflectance measurements on rice plants have been performed in collaboration with ISC in a greenhouse at Vercelli, where rice has been grown in 40x40 cm^2 pots. The aim of the experiment was to obtain spectro-reflectance data related to phenological stages of rice, so as to pinpoint the most significant radiometric features of rice. This has been performed also in preparation of a MSS aircraft flight and for acquiring more

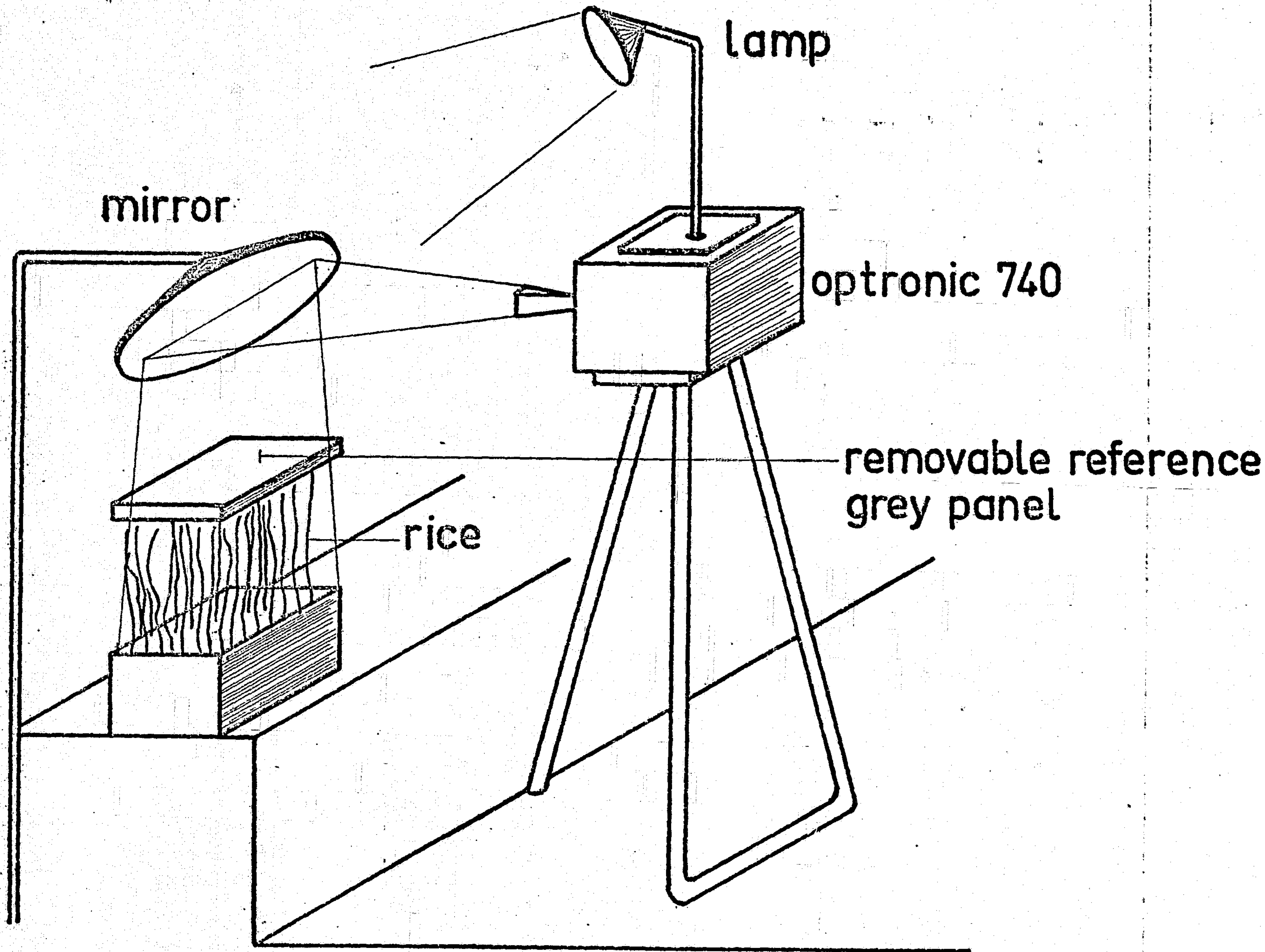


Fig. [illegible] 1 [illegible] set - up in the greenhouse

TABLE 2.

Sample Nº	Type/ Fert.	4.12.74	18.12.74	3.1.75	10.1.75	20.1.75	3.2.75	14.2.75	6.3.75	6.3.75	14.3.75	27.3.75	18.4.75	10.5.75
		6	18	34	41	51	65	76	96+	96	104	117	130	161
1	A/40				.0716 .0633 .1190 .1323	.0734 .0671 .1315 .1517	.0806 .0645 .1780 .2002	.0550 .0449 .1425 .1647	.0688 .0562 .2389 .3136	.0687 .0581 .2419 .3126	.0586 .0419 .1934 .2446	.0720 .0621 .2119 .2515	.0752 .0768 .2007 .2648	.0881 .1110 .3234 .4464
2	R/140				.0574 .0509 .1108 .1200	.0681 .0645 .1249 .1390	.0617 .0516 .1446 .1712	.0508 .0395 .1401 .1825	.0712 .0616 .2569 .3266	.0702 .0613 .2559 .3245	.0521 .0480 .2079 .2733	.0691 .0822 .2342 .2884	.0830 .0861 .2008 .2713	0.1004 0.1117 0.2629 0.3359
3	A/140				.0755 .0645 .1393 .1652	.0719 .0693 .1187 .1284	.0712 .0622 .1646 .1027	.0560 .0440 .1752 .2151	.0597 .0513 .2434 .3131	.0613 .0495 .2361 .3200	.0706 .0714 .2665 .3385	.0866 .0901 .2798 .3542	.0843 .0755 .3459 .3015	0.0819 .0913 .2375 .2046
4	R/40		0.0656 0.0683 0.0950 0.1000		.0763 .0668 .1495 .1774	.0738 .0640 .1455 .1644	.0706 .0554 .1702 .2052	.0441 .0348 .1480 .1786	.0647 .0605 .2298 .2795	.0643 .0577 .2209 .3017	.0606 .0591 .1891 .2471	.0747 .0850 .2454 .3133	.0653 .0594 .2022 .2572	.1070 .1114 .2616 .3137
5	R/40		0.0625 0.0643 0.1026 0.1096	.0914 .0822 .1616 .1799	.0730 .0593 .1595 .1892	.0868 .0786 .1833 .2262	.0624 .0498 .1422 .1704	.0480 .0361 .1539 .1901	.0795 .0755 .2501 .3009	.0783 .0686 .2400 .2960	.0460 .0377 .1400 .1045	.0826 .1011 .2171 .2707	.0851 .0862 .2112 .2611	.1203 .1391 .2573 .3119
6	R/140		.0622 .0607 .0850 .0882	.0864 .0864 .1236 .1251	.0628 .0576 .1063 .1201	.0837 .0771 .1501 .1666	.0679 .0579 .1366 .1577	.0418 .0345 .1271 .1573	.0469 .0359 .1242 .1596	.0422 .0377 .1248 .1578	.0357 .0424 .0988 .1284	.0485 .0469 .1677 .2063	.0532 .0407 .1951 .2588	.0785 .0927 .2192 .2726
7	A/140		.0826 .0656 .0881 .0930	.0919 .0935 .1486 .1565	.0673 .0598 .1141 .1255	.0947 .0851 .1651 .1809	.0563 .0462 .1169 .1315	.0423 .0366 .1323 .1574	.0358 .0272 .1331 .1709	.0336 .0277 .1342 .1609	.0474 .0508 .1379 .1807	.0533 .0402 .2072 .2885	.0573 .0466 .2430 .3296	.0912 .1191 .2332 .3033
8	A/40				.0658 .0588 .1030 .1079	.0954 .0939 .1547 .1696	.0604 .0541 .1251 .1424	.0502 .0393 .1578 .1895	.0419 .0336 .1558 .2018	.0421 .0338 .1558 .2005	.0324 .0323 .0973 .1266	.0488 .0426 .2050 .2775	.0523 .0462 .2150 .2804	.0557 .0646 .2071 .2795
9	R/140	0.0849 0.0987 0.1021 0.0887			.0629 .0545 .1124 .1232	.0923 .0800 .1453 .1539	.0533 .0463 .1113 .1289	.0468 .0370 .1282 .1504	.0335 .0273 .1113 .1397	.0343 .0283 .1122 .1405	.0306 .0331 .0933 .1228	.0461 .0441 .1619 .2131	.0540 .0560 .1972 .2500	.0548 .0499 .2373 .3202
10	A/40		.0642 .0643 .0895 .0852	.0901 .0946 .1154 .1231	.0959 .0837 .1482 .1553	.0988 .0950 .1443 .1521	.0544 .0478 .1084 .1233	.0621 .0449 .1249 .1453	.0353 .0324 .1167 .1366	.0365 .0312 .1009 .1381	.0492 .0540 .1260 .1648	.0517 .0466 .2010 .2659	.0649 .0073 .2191 .2754	.0600 .0671 .2255 .2906

+) Data acquisition by

confidence in measurement techniques with the Optronics Model 740 spectro-radiometer over the 300 to 1050 nm wavelength region with a bandpass of 5 nm and an accuracy of $\pm$ 5%.

The physical arrangement of the experimental apparatus is shown in Fig. 1; the spectro-radiometer is placed on a tripod and views the rice from directly above by means of a mirror placed at 45°, 50 cm above the rice pot. A Philips 1 kW fotoflux lamp was used to increase the incident radiation.

Each radiance measurement $R_r(\lambda)$ from a rice pot was referred to the measured radiance $R_p(\lambda)$ of a reference grey panel, the reflectance $\rho_p(\lambda)$ of which was previously measured in the J.R.C. laboratories by means of a spectro-photometer Cary 14. It was possible in this way to obtain the reflectance of the rice pots as a function of :

$$\rho_r(\lambda) = \frac{R_r(\lambda)}{R_p(\lambda)} \rho_p(\lambda)$$

which is independent of the spectrum of the lamp as well as of the absorption of sun radiation by the glass of the greenhouse.

3.2.1.2. Measurement campaign characteristics

Two rice varieties, Arborio and Roma, which are the most widely cultivated ones in test-site n°1 have been considered in connection with two fertilisation conditions of different contents of N_2, respectively 40 or 140 Kg of N_2 per hectare, whilst the contents of P and K was maintained constant at 90 kg per hectare.

Radiance spectra from sample and panel were recorded with an X-Y plotter connected to the radiometer's amplifier output and to a synchronous motor attached to the monochromafor automatic wavelength scanning. The recorded curves were digitised at JRC and the resulting punched paper-tapes were fed into a computer program which completed the data processing.

The behaviour of rice reflectance was followed during the greenhouse growing cycle of the plants and an attempt to find a correlation between N_2-fertilization contents and other biological parameters (e.g. vegetative stage, leaf area, water content, mean dry weight of leaves and rice production) is in progress.

A first data evaluation has been performed by integrating the measured radiances over the four MSS LANDSAT's channels and calculating the corresponding reflectance values. These data are presented in Table 2 . The first column gives the sample N_0, the second the type of rice (A=Arborio, R=Roma) and the fertilisation index (40 = 2.3 g calcium cyanide, 140 = 8.05 g calcium cyanide per pot). Values of reflectance in the four LANDSAT channels (in the order 4, 5, 6, 7 from above) are given as a function of date of measurement. Below the date the number of days is given after germination of rice.

3.2.2. Measurement campaigns on rice fields and lysimeters for correlating reflectance with biomass and yield

The conclusions deduced after the 1974 campaign suggested to carry on the research for rice plant development model in two different areas:

- on lysimeter cells, where data can be collected during time at short intervals (few days), on exactly the same well controlled clusters of plants;

- on a real open field, where data concerning biomass distribution can be collected weekly on a significant numbers of points, in order to obtain a statistical description of the field variability.

3.2.2.1. Measurement campaigns description

The campaigns have been runned from July to October 1975. The data collected by BGI on the JRC lysimeters (2 x 2 m) concern:

- phenologic stage, weight of wet and dried biomass (main stem and tiller: leaves and panicles),
- weight of dried dead leaves,
- halms density,
- leaves surface from the insertion level,
- nitrogen content in leaves and panicles,
- reflectances in the four LANDSAT channels.

An EXOTECH mod. 100 radiometer vertically attached at a special crane-rail mobile tower has been used. Radiometric measurements in continuous band have also been performed during a certain interval of vegetative cycle. The instrument employed was the OPTRONICS mod. 740 spectro-radiometer (300 - 1050 nm range).

The data collected by ISC and JRC on open field at Vercelli concern:

- halm density,
- weight of wet and dried biomass,
- reflectances in the four LANDSAT channels.

The measurements have been performed on sixty points each time. In this case both the EXOTECH mod. 100 and the radiometer developed at the JRC (see 3.2.5.) have been used. The instruments were being carried through the fields by means of an expecially equipped tracked farm truck.

This measurement campaign produced a total amount of about 50.000 data. Processing and analysis of data will be performed in the next months.

3.2.3. Thermal behaviour of a diseased rice lysimeter

3.2.3.1. Description of the experiment

The results obtained by ENR and IGL during the pre-launch phase showed a close correlation between total radiating power and zones of rice fields affected by "yellowing": a significant increase in radiated energy corresponding to some degrees centigrade of black-body radiation was detected with respect to healthy zones.

To obtain more complete information on the radiation behaviour of healthy rice and rice affected by disease, an experiment has been carried out by the same Institutes' staff in June and July 1975 on the JRC's lysimeters at Ispra.

A lysimeter with five cells, each of 2 x 2 m with a central separated area of 1 x 1 m was used. The cells were filled with earth from the rice fields and into them were transplanted 25 day old rice plants of the Balilla variety, previously cultivated in a ENR greenhouse. 10 days after the transplanting, a plant carrying infected aphids was planted in the centre of each of three cells and the central square metre of each cell was covered with a fine-mesh gauze. After 3 days the gauze was removed and all the cells were treated with insecticide.

The measurements started on the fifth day after the infection, one series at 13.00 h and one at 24.00 h (solar time) and were continued without interruption until the 19th day after the infection. A cherry-picker was used carrying on board an EXOTECH mod. 100 radiometer (day measurements) and an AGA thermovision mod. 750 heat-camera (day-and-night measurements). A photographic camera with N-color-films and IR-color films was also used.

3.2.3.2. Discussion of results

The experiment confirmed that "yellowing" of rice is detectable in the (3-5 μm) wavelenght region. No appreciable contribution seems to be given by the pure reflective part of the spectrum.

The first symptoms of the disease in the thermal infrared were noticed on the 13th day after the infection; there were no symptoms in the cells which were not infected. A slight difference was already detected in the thermal behaviour of the central zone of cell n°3 and of the peripheral zone of cell N°1 (both artificially infected) by the 7th day after infection.

On the 9th day this difference was such as to show at least 2°C thermal difference between the central "suspect" zone of cell n°3 and the surrounding plants. The possible influence of the presence of water can be excluded, in that the significant measurements were made at the time of maximum thermal contrast (13.00 h solar time).

On the other hand, the measurements at night-time did not seem to have such a significant thermal difference compared to the ones at day-time.

Thus the results of the previous experiments seem to be confirmed, with the addition of the possibility of "fore-warning" of the progress of the disease. Again, the contribution of the measurements at night time seems to be of little use.

3.2.4. Ground-truth acquisition. Reflectance signature measurement made from helicopter

For what concerns the irrigated crops (rice) the control on ground for purpose of automatic classification has been made by ENR.

Each rice field has been located on 1/6000 scale maps, derived from cadastral maps. These maps have been photographed and a mosaic of the concerned zone is being built up by JRC. For instance, for the province of Pavia (to which special attention was paid in view of LANDSAT flights) a very careful survey has been carried out on a surface of 57,298 hectares out of a global agricultural surface of 218,646 hectares.

Supplementary inquiries have been carried out by questioning the farmers (examination of the farm registers, determination of the successive cultivations) in order to ascertain, as far as possible, the actual on-ground situation at the time of the LANDSAT passing.

3.2.4.1. Reflectance signature measurement from helicopter

In correspondance with the atmospheric parameter measurements also reflectance of rice fields on the Chiappona test-area was measured from a helicopter at the dates listed in Table 2. The instrumentation used was the EXOTECH 100 filter radiometer together with a TEAC-4 track portable recorder and a Nikon camera with panchromatic film mounted on the view-finder of the radiometer. Before the start of the helicopter the radiance from a grey reference panel was registered by the recorder. During each flight (height: 1000 ft) radiance measurements from a fixed sequence of points in the fields were registered and photographs were taken through the view-finder. The field of view used was 15° corresponding to a ground patch of ca. 80 m in diameter. The reflectance of the various rice field patches will be evaluated by referring to the reference panel and the values will be compared with the reflectance calculated from the digit numbers on the NASA tapes by use of the measured atmospheric parameters.

The ordered NASA tapes corresponding to the ground and helicopter measurements are listed in Table 2.
Contemporary with the atmospheric parameter and the reflectance signature measurements the ENR took conventional agronomic ground truth on the fields. The following parameters were determined:

- water level and surface temperature
- temperature inside the canopy
- biomass (forest and dry weight)
- phenological stage
- size of halms and panicles
- no of halms/m^2
- chromatic appearance
- presence of alghae
- final production
- meteorological data (radiation, precipitation, wind direction, wind direction and velocity, humidity, temperature).

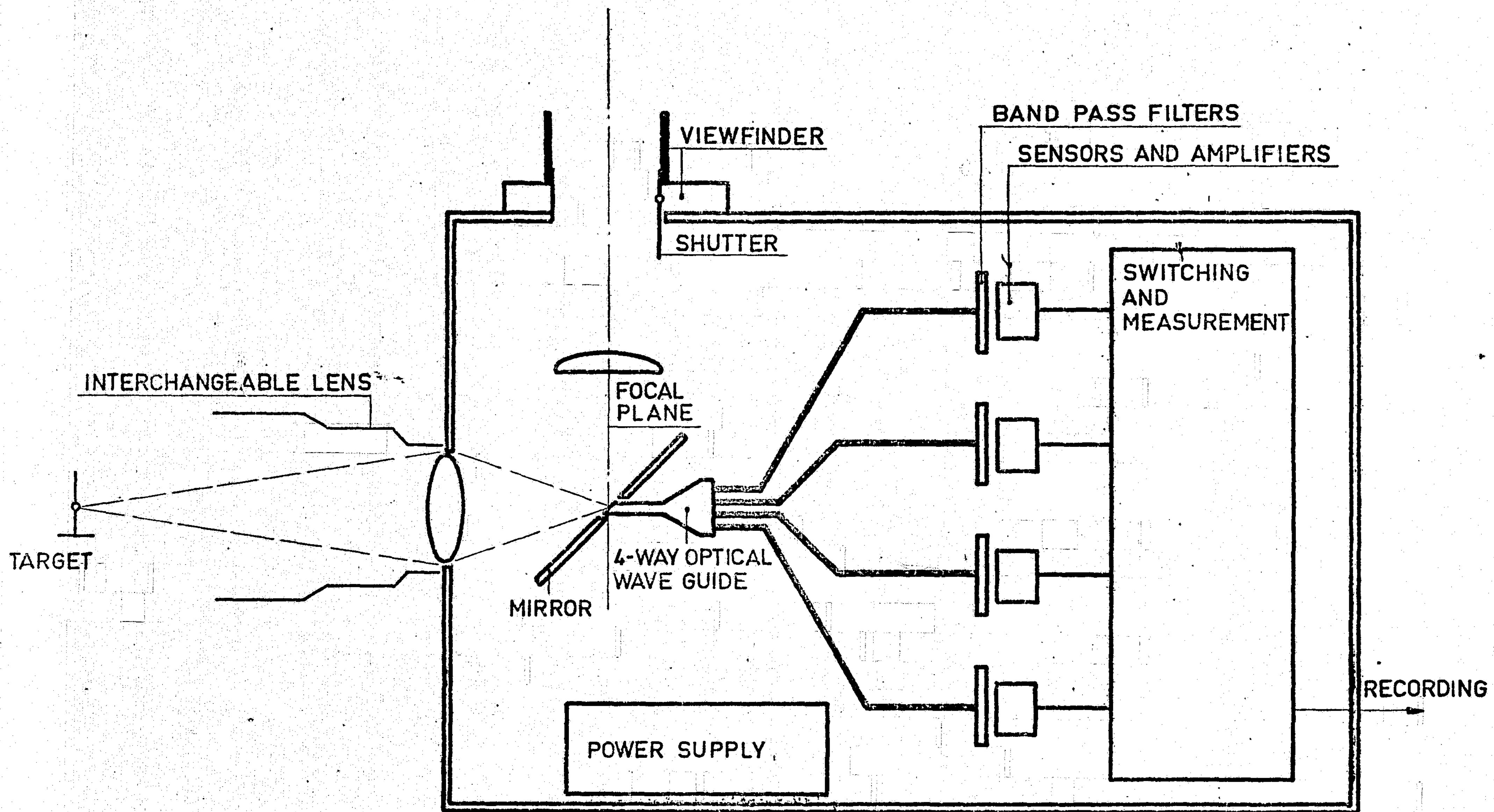


Fig. 2 : Optical layout of the radiometer.

3.2.5. Realisation of a LANDSAT 4-channel field radiometer

The technique of radiometric measurement of landscape features, either from fixed points or seen as strips of ground from low altitude aircraft, over the agri - cultural-forest areas of the Italian test-sites had in volved up till now a single type of radiometer, the EXOTECH model 100, consisting essentially of 4 inde - pendent filter optics, aligned with a common centering view-finder.

Due to misalignment of the 4 channels of the EXOTECH mod. 100 radiometer and due to the necessity to moni- tor incoming sun radiation during field work, the ne- cessity to develop a radiometer which obviates the difficulties met in the pre-launch measurement pro - gram with the EXOTECH model 100 emerged.

3.2.5.1. Technical description of the JRC radiometer

The 4-way optical waveguide is the basic component which characterises the performance of this radiome - ter. The principal optical layout is shown in Fig. 2.

The main body of the guide subdivides into 4 seconda- ry branches, each of which carries a quarter of the incident radiation to the sensors.

The entrance section of the guide is accurately po - sitioned with respect to the focal plane of the objec tive passing through a hole made in the mirror of the view-finder. Thus, the incident radiation passes di - rectly from the target to the entrance of the optical guide which transmits it to the sensors.

To allow the operator a view of the scene being exa - mined, the radiometer is equipped with a reflex view- finder,with shutter. The operator sees, in the field of the view-finder, a dark circular area in the centre of the scene, corresponding to the part analysed by the sensors. It is in this way possible to aim the radiometer exactly the zone being investigated.

The view-finder is also equipped with a manually controlled shutter with the function to eliminate as much as possible the entrance of light through the area of the view-finder during the measurement, in conditions of strong surrounding light.

The sensors used are of the type "Silicon photodiodes " with integrated low-noise operational amplifiers.

3.2.5.2. Use of the instrument

The radiometer has been mainly used for the production of radiometric signal profiles in the four LANDSAT channels; the instrument is also particularly suitable for surveys of targets of small size. Aiming in this case is made easier by the design of a view-finder which, as previously described, displays the area being measured.

In Table 3 the values are reported of the nominal FOV's as a function of the used lens.

Lens	Nom. FOV
500 mm F. 1.8	1°
300 mm F. 4	0.2°
Plane	about 50°

Table 3

The use of an opal glass instead of a lens for measurements of the 2 steradian radiation is foreseen.
A diaphragm with which the objective is provided allows a continuous attenuation in the incident radiation.

When the instrument is being used in conjunction with a second radiometer, so as to have a continuous monitoring of a reference panel during the measurements, the use of the optical attenuator facilitates standardisation between the outputs of the 2 radiometers.

The available outputs for the recording on the multiple connector have a level of 0.1 V equivalent to the full scale of the instrument's range. In cases of measurements at high levels, above the range of the internal instrument, the recording outputs supply a potential which is always linear with the incident radiation up to a maximum value of 10 V. In such operating conditions it is necessary at the start to by-pass the internal instrument by means of the channel switch.

References: (9) (18) (19)

3.3. FOREST INVESTIGATION

3.3.1. Ground-truth acquisition

3.3.1.1. Poplars plantations (test-site N° 1)

The following activity has been carried out during the first six months of 1975 by ISP:

1) A series of surveys related to a test area of about 90,000 hectares suitably chosen in the Po valley zone between the towns of Chivasso and Pavia, which has been designated as land to be permanently under poplar culture;

2) Following the specific request to JRC, a series of investigations on two forest regions of particular interest for the interpretation of the LANDSAT data were begun.

As regards the first series of surveys, about 35,000 hectares have been examined, for which the real distribution was provided of plantations divided into the last 3 of the 4 classes of ground coverage indicated in the density scale drawn up by the Institute, specifically:

- 1st	class of	ground	coverage		0 ÷ 5%
- 2nd	"	"	"	"	5 ÷ 25%
- 3rd	"	"	"	"	25 ÷ 80%
- 4th	"	"	"	"	≥ 80%

The surveys were made by interpretation of the aerial photographs made with infrared film on scale 1:34,000 in June, 1973. The results were supplied as aerophotogenerated maps on scale 1:50,000 on which the exact areas of poplar plantations, divided into the 3 proposed classes, were marked in colour. In the same zone an area of "supertest" was selected and surveyed photographically on scale 1:18,000. The whole region was divided solely by inspection of the photographs into the following classes:

1) Non-forest area,
2) Forest area divided into:
   a) natural forest,
   b) man-made forest, consisting entirely of poplars, distributed over the above-mentioned classes of ground coverage,
3) Water divided into rivers and rice paddies.

The collected data have been presented as a percentage of the total land area.

The specific surveys requested by ISP to JRC, which were the subjects of the second series of investigations, were carried out exclusively by means of ground surveys. They were directed towards finding the topographical extent on scale 1:25,000 of

a) a number of poplar plantations in the Torre d'Isola (Pavia) region, comprising 25 hectares which were the object of specific radiometric surveys with EXOTECH rad. in 1973,

b) the whole area termed "wooded" in the Participanza di Trino, which constitutes one of the largest forested areas of the Po plain(about 500 hectares).

In this last region poplar plantations are distributed among the natural forest, the natural composition of which was also indicated on the final maps.

3.3.1.2. Beech Forests (test-site N° 3)

Since 1973 INPL is carrying on a sistematic forest inventory on a 150.000 ha.s zone of the test-site N°3. The investigated zone is situated between 600 and 2.000 meters altitude. Beech-woods are the most diffuse forestal class. A"point" inventory technique, particularly suited for uneven ground areas, has been set-up by INPL. The method consists in fixing on 1/25.000 scale map a set of sampling points corresponding to a square-meshed grid, whose expanse depends on the requested inventory accuracy. A 25 ha.s (500x 500 m) grid element was chosen by INPL. The grid points are also transferred on some other geologic and/or vegetation maps and aerophoto-generated mosaics. The characteristics of each projected point (i.e. its environmental conditions) are interpreted and codified by means of Hollerit punched cards.

The following informations are considered: altitude, topographic characteristics, exposure, slope, geologic and vegetation characteristics, together with the typical forestry parameters (type, age, density etc. of different forestal classes).

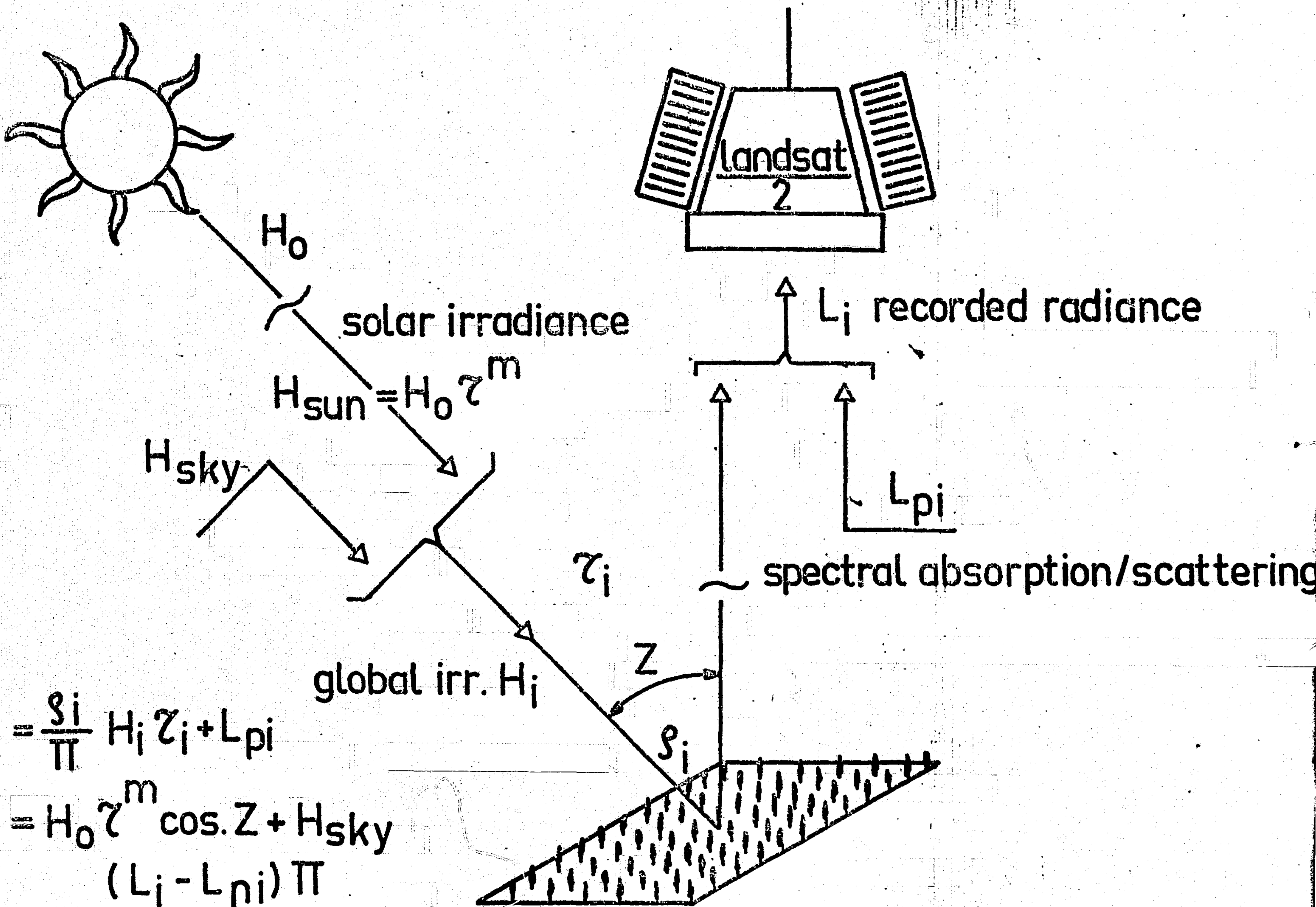
The 1975 work is in progress following the above investigation lines. The entire test-area has been by now aero-photographed (pancromatic and IR-color) and is being systematically investigated by stereoscope.

3.3.1.3. Conifer afforestations (test-site N° 2)

A complete ground-truth aerial photographic survey has been made by JRC in October on the conifer afforestation of Dormelletto close by the Lake Maggiore (test-site N°2). This area(19 Km in lenght) was flown over by the MSS flight of August 7th. A set of two Hasselblad (IR-Color and N-color) has been mounted on a helicopter flying at an altitude of a 1000 m.

3.4. SATELLITE DATA PROCESSING AND INTERPRETATION

On the basis of the imagery (transparencies) so far received from NASA, some digital tapes have been ordered (see 3.2.4.1., Table 2). In the meantime the activity on satellite data processing and interpretation is in progress as far as acquisition and processing of atmospheric correction data, development of new utility programs and of an interactive video system are concerned.



1) $L_i = \frac{\rho_i}{\pi} H_i \tau_i + L_{pi}$

3) $H_i = H_o \tau^m \cos. Z + H_{sky}$

4) $\rho_i = \frac{(L_i - L_{pi})\pi}{\tau_i (H_o \tau^m \cos Z + H_{sky})}$

Fig. 3 : Distribution scene of atmospheric parameters

Date	Band No.	Global Irradiance $H(mW/cm^2)$	Transmittance	Path radiance L_p $(mW/cm^2 sr)$	Equivalent reflectance $(L_p \pi / H \tau)$
22-4-75	4	6.19	0.35	0.32	0.46
	5	9.18	0.44	0.31	0.25
	6	7.72	0.55	0.20	0.15
	7	10.50	0.62	0.19	0.09
28-5-75	4	9.12	0.56	0.28	0.18
	5	12.13	0.63	0.24	0.10
	6	9.67	0.71	0.15	0.07
	7	12.59	0.74	0.13	0.04
3-7-75	4	9.65	0.63	0.27	0.14
	5	12.98	0.70	0.22	0.08
	6	10.67	0.77	0.12	0.05
	7	12.88	0.79	0.11	0.03
21-7-75	4	9.22	0.75	0.21	0.10
	5	13.07	0.79	0.16	0.05
	6	10.71	0.85	0.08	0.03
	7	12.96	0.85	0.07	0.02
8-8-75	4	7.44	0.37		
	5	10.16	0.45	to be	
	6	8.44	0.55	evaluated	
	7	10.34	0.59		
13-9-75	4	7.85	0.83	0.17	0.08
	5	10.69	0.87	0.12	0.04
	6	8.75	0.91	0.06	0.02
	7	10.41	0.90	0.05	0.02

Table 6-1 MEASURED ATMOSPHERE PARAMETERS

3.4.1. Acquisition of atmospheric correction data.

A technique based on ground-measurement of solar irradiance and sky irradiance by means of the EXOTECH Mod. 100 radiometer was developed by the JRC for determining the transmittance and the path radiance of the atmosphere. These measurements provide experimental data which allow the elimination of the masking effect of the atmosphere from digital LANDSAT data prior to data interpretation.

The sketch in Fig. 3 shows the distribution scene of atmospheric parameters as well as the most important algorithms which are being used.

A systematic on-ground measurement campaign of atmospheric parameters for several sufficiently cloud-free LANDSAT-2 passages over test-site N°1 (rice, poplars) is therefore being carried out during 1975 (see 3.2.1., Table 2).
The measurements were performed at the farm "La Chiappona" , near Mortara, where are some super-controlled fields by the staff of the ENR.

Results of these measurements are shown in Table 4.
These values indicate that the masking effect of the atmosphere varies considerably from one day to another and is not negligible.

References: (13)

3.4.2. Implementation of an interactive software package

From the beginning of JRC's activity in the field of data processing of satellite data, we felt that some sort of non-computer interaction should be considered as alternative to the bench processing.

In fact, after a period of practice with the ORSER-software, comprising a set of programs for data processing, mapping and several sophisticated classification procedures, the most important drawback of ORSER appeared to be the consumption of much machine—and analysts time. Consequently the decision was taken to develop an interactive system, compatible with the structure of the existing batch programs, which should permit a much faster and more flexible analysis of teledetection data.

The interactive system to be developed should take in account some limitations imposed by the teleprocessing actually operative at JRC. These restrictions plus the requested flexibility towards future installation of more sophisticated terminals made modular programming imperative. This should be considered an advantage but requires a well disciplined organisation.

The first programs developed can be compared with ORSER programs like TPINFO, SUBSET, SUBTRAN etc. They take care of the construction of subsets on disk-units, the maintenance of library files, the display of contents of disks and other book-keeping tasks.

A second group of programs developed, consists of service routines commonly used by all interactive programs.

They execute tasks like: program flow between modules, input-output operations, time interrupt circuit, formatting connection with specific terminals, etc.

A third group of programs is characterized by the fact that they are independent of terminal input/output. The functions are: mathematical operations, data-checking,

Table 5

	DATES	FILM-FOG	GRAY-LEVELS I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
ERTS-1	06.02.73	255	273	285	309	339	377	428	496	599	750	970	1336	1856	2630	7000	12000
ERTS-1	05.02.73	230	296	313	344	388	431	488	586	723	888	1163	1600	2330	3600	6900	11000
ERTS-1	05.11.73	270	360	365	383	410	447	489	556	670	730	840	1059	1795	2530	5015	11600
LANDSAT-2	14.06.75	360	333	340	356	385	438	480	555	656	784	978	1705	2470	3680	5700	8200
LANDSAT-2	13.09.75	196	177	192	193	201	217	239	260	297	370	473	660	1015	2530	5250	9000
LANDSAT-2	03.07.75	350	326	334	340	360	390	445	480	580	746	915	1590	2250	3600	6100	10250

sorting, etc. These routines serve batch programs as well interactive program working in teleprocessing mode.

The last group of routines are the conversational programs themselves. They consist of a logical series of questions, they accept the responses of the user, test their validity and distribute the required actions.

The operational programs developed until now can perform: construction of histograms, calculation of simple statistics, group-maps, ratio-maps, automatic generation of level slicing schemes and some organizational operations . The introduction of real statistical data extraction, cluster analysis, simple and sophisticated classification programs can be expected in brief time.

3.4.3. Development of new utility and data processing programs

3.4.3.1. Geometrical corrections of computer-generated maps.

Work on a program (MAPEDIT) for linear geometric corrections of a digital map is in progress. The program will have the following characteristics. The input map may be in any of the map output formats in use at the JRC (implemented for one of the three formats currently in use). The transformation matrix may be given directly or may be calculated given the coordinates of three non-collinear points in scanner relative position units as well as in length units referred to a given map; the output will have the scale of that map (both options are already implemented). Several reference triangles might be given; the program calculates the transformation matrix for each of them and then uses the mean matrix; the standard deviation matrix is printed (implemented). The program does not perform rotations on the input data, but the rotation angles between output map and reference map are calculated and printed (implemented). For points given on the reference

map, the scanner relative coordinates are calculated (implemented) and cross marks are output on the corresponding points (not yet implemented). The output may be on printer (implemented) or on a tape used as input to an Optronics Photomation device.
An application has been made to typical scene along the Po river (super controlled test-area by ISP).

3.4.4. First analysis of LANDSAT-2 images and comparison with the same ones taken by ERTS 1.

This comparison has been made by IGL, who was formerly PI for ERTS-1 applications. The following preliminary remarks can be given:

1) Spatial resolution. LANDSAT-2 satellite images seem to have an higher geometrical resolution compared with the same ERTS-1 frames. In particular we observed that normally 50-meter sized objects are detectable even with low radiometric contrast.

2) Spectral resolution. Because of the higher band's separation we noticed an improvement in the spectral resolution too.

3) Photographically the 70 mm images show a variable film-fog, generally higher than in ERTS 1 images.

The reported Table 5 show some relative values of density of the 15 gray steps. The first three examples refer to ERTS-1 images, while the other three ones refer to LANDSAT-2 images. As one can see the photographic quality of ERTS- 1 gray scale seems to be better than the same of LANDSAT-2 .

LIST OF REFERENCES

(1) A. AGAZZI and G. FRANZETTI; "Effects of Rice Biomass and Yield on Reflectances in the LANDSAT Channels" - AGRESTE Project Report No. 15, 1975

(2) J.E. COLWELL; "Grass Canopy Bidirectional Spectral Reflectance", Ann Arbor, Michigan, 1974

(3) "Agricultural Resources Investigations in Northern Italy, Southern France and Madagascar", paper presented by R. CASSINIS, S. GALLI DE PARATESI, M. GUYADER at the Symp. on European Earth Resources Satellite Experiments, Frascati (Italy), Jan. 28 - Feb. 1., 1974

(4) "Agricultural Resources Investigations in Southern France and Northern Italy" Authors of the European Communities, of the French and of the Italian Institutes. Paper presented by G.M. LECHI at the 9th Intern. Symp. on Remote Sensing of Environment, Ann Arbor, April 15 - 19th, 1974

(5) Joint Reseacrh Center of European Communities. Objective 2.53.0 Remote Sensing of Earth Resources. Progress Report 1974

(6) C. DE CAROLIS, G. BALDI, S. GALLI DE PARATESI, G. LECHI; "Thermal Behaviour of some Rice Fields affected by a yellowing type Disease; 9th Int. Symp. on Remote Sensing of Environment, Ann Arbor, April 15 - 19, 1974

(7) C. DE CAROLIS, G.M. LECHI (1974); "Rilievi da terra e dall'aereo nell'infrarosso fotografico e termico su campi di riso affetti da "giallume", I. Rilievi da terra. "Il Riso, XXIII (I), 19 - 41

(8) G.M. LECHI, C. DE CAROLIS (1974); "Rilievi da terra e dall'aereo nell'infrarosso fotografico e termico su campi di riso affetti da "giallume", II. Rilievi dall'aereo." Il Riso, XXIII (2) 159 - 172

(9) E. GATELLI "Methodology for the Correlation of the Signals of a 4 Channel Radiometer MSS/ERTS Carried out by Plane and the Investigated Area", report EUR-1626, Report of the Project AGRESTE N°1, Febr. 1974

(10) B. STURM; "Determination of Beam Transmittance and Path Radiance in the four Bands of the ERTS-Satellite", Proceedings of DFVLR - Seminar on Remote Sensing, April 7-11, 1975, at Porz-Wahn (Germany)

(11) R.H. ROGERS, K. PEACOCK; "Machine Processing of ERTS and Ground Truth Data", LARS Conference on Machine Processing of Remotely Sensed Data, October 16 - 18, 1973 at Purdue University, BSR 4084 (July 1973)

(12) B. STURM; "Preprocessing Algorithms for Radiometric Corrections and Texture Spatial Features in Automatic Land-Use Classification", X Michigan Symp., October 1975

(13) G. MARACCI, B. STURM; "Measurements of Beam Transmittance and Path Radiance for Correcting LANDSAT Data for Solar and Atmospheric Effects", paper presented at the "Cinquièmes Journées d'Optique Spatiale", Marseille, October 14 - 17, 1975

(14) J. MEGIER; "Classification Automatique des Données sur Satellite LANDSAT Appliquée à l'Agriculture et à la Sylviculture" - Cinquièmes Journées d'Optique Spatiale, Marseille, October 14-17th, 1975

(15) J. MEGIER; "Classification Methods Used in the Framework of the AGRESTE Remote Sensing of Earth Resources Programme (AGRESTE Project Report N° 16)

(16) J.H. HERZOG, B. STURM; "Preprocessing Algorithms for Radiometric Corrections and Texture Spatial Features in Automatic Land-use Classification - 10th Int. Symp. on Remote Sensing of Environ - ment, Ann Arbor, October 6 - 10, 1975

(17) B. STURM, W. MEHL; "Ein Programmsystem zur Verarbeitung und Aus-wertung von ERTS Daten". Erderkundung Symposium of DFVLR-DPG, Porz-Wahn, 7-11 April,1974

(18) C. BONVINI, E. GATELLI; "Examination of the Characteristics of the Radiometer EXOTECH mod. 100. Report EUR/C-IS/172/74/i, 1974

(19) E. GATELLI; "Development of a 4-Channel Radiometer for Paralaxe-free LANDSAT Ground-truth Measurements with variable field of view. AGRESTE Project Report N°14, July 1975

TABLE 1

	ACTIVITY	PLACE	SPECIFIC OBJECT.	ENR	INPL	ISC	ISP	JRC	LGT
RICE	Spectroradiometric Measurement and Interpretation	Laboratory	1)a					CARY 14	
		Greenhouse	1)a			OPTRONICS 760		OPTRONICS 760	
		Lysimeters	1)a					Cherry-picker + EXOTECH 100	
		"	1)b	Cherry-picker + AGA 750 EXOTECH 100					Cherry-picker + AGA 750 EXOTECH 100
		Field	1)a					JRC's rad: EXOTECH 100 WANG 2200 B	
		Data Proc. Center	1)a					CALCOMP + IBM 370/165	
	Conventional Measurements	Greenhouse	1)a			Agron. measur + Lab. Anal.			
		Lysimeter	1)a					Agron. measur. Photogr. obs. + Lab. Anal.	
		"	1)b	Photogr. obs.					Photogr. obs.
		Field	1)a	Agron. and meteor. obs. + Lab. Anal.		Agron. meas. + Lab. Anal.		Photogr. obs.	
	Anal. Dig. Mapping and Interpretation	Data Proc. Cent. and Institutes	3					IBM 370/165 + OPTRONICS(*) PHOTOMATION	LGT's False Color Composer + Electr. TV Density Anal.
	Ground-truth	Field	1)c	Field obs. + cadast. maps				Helicopter EXOTECH 100 Hasselblad Mosaic prep.	
	Instrumentation Development	Laboratory	1 2					4-channel portable field radiometer	
FOREST	Anal. Dig. Mapping and Interpretation	Data Proc. Cent. and Institutes	2)a					IBM 370/165 + OPTRONICS(*) PHOTOMATION	LGT's False Color Composer + Electronic TV Density Anal.
	Ground-truth	Field	2)a		Ground obs. + stereoscopic photointerp. + Punched cards		Field obs. + aerophoto. Interpretat. + maps	Helicopter + Hasselblads + Photointerp.	
DATA PROCESSING APPLICATIONS	Atmospheric Corrections	Field and Data Proc. Cent.	3)a					EXOTECH 100 + IBM 370/165	
	Development of New Utility Programs, Classif. Algorithms, etc.	Data Proc. Cent.	3)b					IBM 370/165	
	Interactive mode video system	Data Proc. Cent.	3)b					IBM 370/165 + Tektronics Video Terminal	

TASK DISTRIBUTION AMONG THE AGRESTE CO-INVESTIGATORS INVOLVED IN THE 1975 ACTIVITY

(*) Courtesy of Eidgenoessische Technische Hochschule Zuerich