Simulation of ERS-1/OPS by the use of Airborne Spectroradiometer

H. Watanabe, T. Osanai
Japex Geoscience Institute, Inc.
2-17-22, Akasaka, Minato-ku, Tokyo Japan
Commission Number VII

1. Introduction

Several sets of OPS (Optical Sensor) bands to be mounted on Japanese ERS-1 (Earth Resources Satellite-1) were simulated and evaluated. Simulated data were produced by the use of ASR (Airborne SpectroRadiometer) of GER (Geophysical Environmental Research, Inc., USA). Data acquisition was conducted in Death Valley, California and in Comb Ridge, Utah. Evaluation of these simulated dala contributes to the finalization of OPS specification. In this study, ground truth using field spectrometer IRIS was also conducted to check ASR data.

2. Acquisition of ASR data and ground truth by IRIS

(1) Description of ASR

ASR that we used in this study is capable to measure radiance, along the track line (Image data is not available for this sensor). Major parameters of ASR are listed in Tab. 1.

(2) Description of data acquisition

Aircraft is AZTEC-E, and the two test sites, Death Valley and Comb Ridge, were selected, considering the degree of vegetation cover and the types of soil/rock. Major parameters of data acquisition are listed Tab 2. Airborne data aquisition was conducted from May 24 to May 27 for Death Valley, on May 31 and June 1st for comb Ridge, both in 1986. During the flight radiance, data on the ground surface were measured by the use of IRIS with equal time interval in order to correct the incident solar energy. After preliminary check of ASR data, ground truth using IRIS was conducted for the targets which are located at the cross points of two track lines and also for the targets including interesting spectral curves.

(3) Analysis of rock sample.

Some rock samples, against which we measured on site-spectra by IRIS, were sent back to Japan. Samples including clay minerals or carbonates rock were analysed by XRD ; carbonate and evaporites, by X-ray fluorescence analysis ; and volcanics, micro scope using thin section.

(4) Comparison between ASR data and field spectra by IRIS

For ASR data, only radiance data were available. So, all the data were divided by the spectra that is supposed to have no spectral absorption. They will be called pseudo-refleclance data hereafter, and they are compared with a set of IRIS spectra for the corresponding site. One example is show in Fig.1. This site is basically an outcrop of limestone partially covered by low vegetation. However, the absoption at 2. 35 um is well expressed both on ASR and IRIS spectra.

(5) Comparison between IRIS spectra and analysis of rock samples.

Example for limestone is shown in Fig. 2. As shown in this Figure, IRIS spectra, XRD and X-ray fluorescence analysis indicate the existence of calcite. In almost all the results, IRIS spectra and analysis of rock samples are consistent.

3. Simulation of ERS-1/OPS

(1) Flow chart for simulation

Flow chart is shown in Fig. 3. In this flow, the attenuation of the solor energy from the aircraft to ERS-1 is supposed to be negligibly small, based on the results by the LOWTRAN5 simulation.

(2) Analyis of ASR data

① Check of level of radiance data

DN values of ASR data were converted to radiance data by the conversion table supplied by GER. For the short wavelength infrared (SWIR) region, radiance spectra by ASR, IRIS and LOWTRANS 5 are shown in Fig, 4. ASR and IRIS spectra show similar curves and LOWTRAN 5 is also very similar except the regions of water absorption.

② Estimation of noise

GER measured the dark current of ASR by shutting out incident light. From these resulits, noise for ASR is estimated negligibly small in comparison with ERS-1.

③ Correction of solar energy difference caused by data acquisition time

Data acquisition of ASR were conducted between 10 AM and 3 PM in local time. This caused the difference in incident energy to ASR. So, by the use of IRIS measurement of solar energy during the flight, ASR radiance data were fitted to that at 10 A.M. in mean solar time.

(3) Execution of simulation

After above mentioned procedure, simulation was executed by the flow chart in Fig. 3. The 256 ($2\times 2\times 2\times 4\times 4\times 2$) sets of simulation parameters were tried for 6 categories listed in Tab. 8 The supervisors were selected as they show respectively characteristc spectra. Classification was executed for the data showing typical spectral features, and also for those showing intermediate featues. Two examples of the results are shown in Tab 4-a and 4-b.

(4) Evaluation of the results.

① Number of bands

Rate of correctly classificd data significantly decreases when the number of band changes from 5 to 3.

② Band width and noise

Rate of correct answer is higher for narrower band width for the cases of no noise data. However, if the noise for ERS-1 level is added, this rate shows the highest value for the band width of 100nm through 150nm. This tendency becomes unclear for the case of 3 bands or for the 6 bits data

③ Data acquisition time

For the data with noise, the rate of correct answer is lower at 10 A.M. than noon. This tendency is more significant for 5 band case than for 3 band case.

④ Data with typical spectra and miscellaneous data.

For miscellaneous data, the above-mentioned tendencies become ambiguous.

⑤ Number of bits

Decrease in bit mumber from 8 to 6 is equivalent to noise addition

(5) Recommendation for ERS-1/OPS

From the above evaluation, following specification is recommended:

① Band width: 100mn (for the actual S/N)

② Central wavelength
5 bands 〔2.08, 2.15, 2.20, 2.33, 2.38μm〕
4 bands 〔2.08, 2.20, 2.33, 2.38μm〕
3 bands 〔2.08, 2.20, 2.33μm〕
5 bands are the most recommendable, because the rate of correct answer decreases significantly in other cases.

③ Bit number
8 bit data are preferrable.

(6) Discussion

① In this study, we have not discussed visible and near infrared (VNIR).

② ASR data were limited to VNIR and 2μm region, However, this region is also important.

③ Actual specification of ERS-1/OPS is slighthy different from the recommendable specification. So, continuos evaluation effort of this specification will be needed.

(7) Acknowledgement
This study was funded by Technology Researc Association of Resources Remote Sensing System(RRSS). We would like to express our thank to RRSS.

Tab. 1 Major Parameters of ASR

• VNIR 0.4μm - 1.00μm
  number of bands 512
  band width 1.5nm
  detector si

• SWIR 1,952μm - 2.494μm
  number of bands 64
  band width 8.6μm
  detector PbS

• IFOV
  Along trach 0.172deg
  Cross track 1.72 deg

• Interval of Ddata Acquisition
  0.033sec 10 data are integrared to be 1 record for along track
  (0.33sec interval for 1 record)

• Aerial Photo for Tracking
  One shot for every 10 records by 35mm film

Tab. 2 Specification of Flight Lines and Altitude for ASR Data Acquisition

Death Valley

Abs Alt [ft]	Alt. fm ground [ft]	Spatial resolution [mxm]	No. of Lines	Total Line Length [km]
4,000	2,000	20.1 × 18.3	33	408.0
10,000	8,000	25.6 × 73.2	15	129.6
18,000	16,000	32.9 × 146.4	14	185.6
		Total	62	732.2

Comb Ridge

Abs Alt [ft]	Alt. fm ground [ft]	Spatial resolution [mxm]	No. of Lines	Total Line Length [km]
6,500	2,000	20.1 × 18.3	23	259.2
12,500	8,000	25.6 × 73.2	5	64.0
20,500	16,000	32.9 × 146.4	12	19.2
		Total	40	342.4

Tab.3 Parameters of Simulation

1. Supervisors only (195) , Data including misc data (396)

2. with / without noise

3. 8 bits / 6 bits

4. bandcombination (central wavelength, in μm)

case1	2.05, 2.15, 2.20, 2.33, 2.38
case2	2.08, 2.20, 2.33, 2.38
case3	2.08, 2.20, 2.33,
case4	2.06, 2.19, 2.34 (RRSS plan)

5. band width

   50 / 75 / 100 / 150 [nm]

6. data acquisition time
   10 A.M./ 12 A.M.

Tab.4-a Example of Simulation

Central wavelength 2.08 / 2.15 / 2.22 / 2.33 / 2.38
Band width 50
Bit number 8
Time 12 AM
(Supervisors only, without moise)

A \ B	1	2	3	4	5	6	7	8	9*
1	24	0	0	0	0	0	0	0	0
2	0	36	0	0	0	0	0	0	0
3	0	0	42	0	0	0	0	0	0
4	0	0	0	24	0	0	0	0	0
5	0	0	0	0	21	0	0	0	0
6	0	0	0	0	0	16	0	0	0
7	0	0	0	0	0	0	15	0	0
8	0	0	0	0	0	0	0	17	0

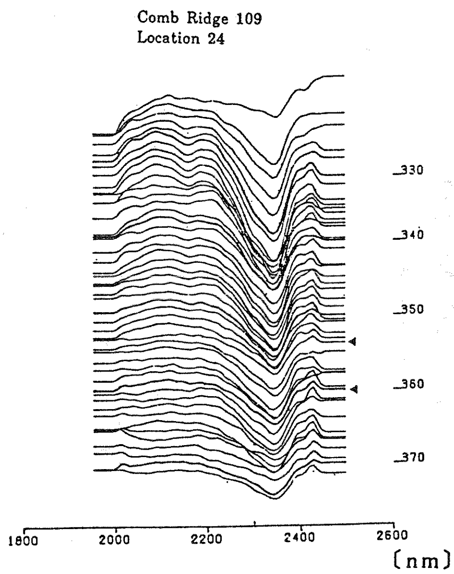
A : Actual Class B : After Classification
9* : unclassified
rate of correct answer for all data 100%
rate of correct answer for limestone 100%

Tab.4-b Example of Simulation

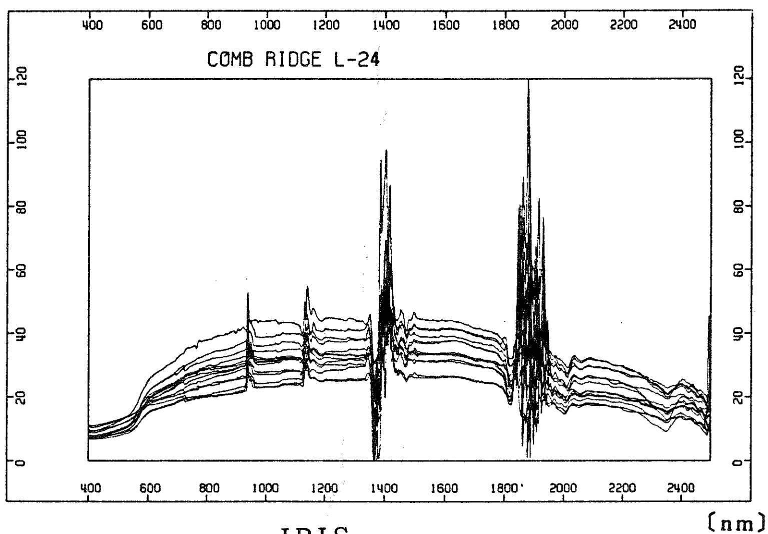
Central wavelength 2.06 / 2.19 / 2.34
Band width 100
Bit number 6
Time 10 AM
(Misc data, with noise)

A \ B	1	2	3	4	5	6	7	8	9*
1	32	8	1	5	1	1	0	0	2
2	13	26	7	13	0	21	0	12	1
3	0	0	37	3	0	2	0	0	0
4	5	4	8	38	0	3	0	0	0
5	0	2	0	1	22	4	0	5	11
6	0	4	4	3	0	27	0	3	0
7	11	6	2	12	0	0	7	0	2
8	0	0	0	0	1	0	0	23	3

A : Actual Class B : After Classification
9* : unclassified
rate of correct answer for all data 53.5%
rate of correct answer for limestone 28.0%



ASR spectra



IRIS spectra

Fig.1 ASR Pseudo-Reflectance Data and IRIS Reflectance Data for the Site including Limestone

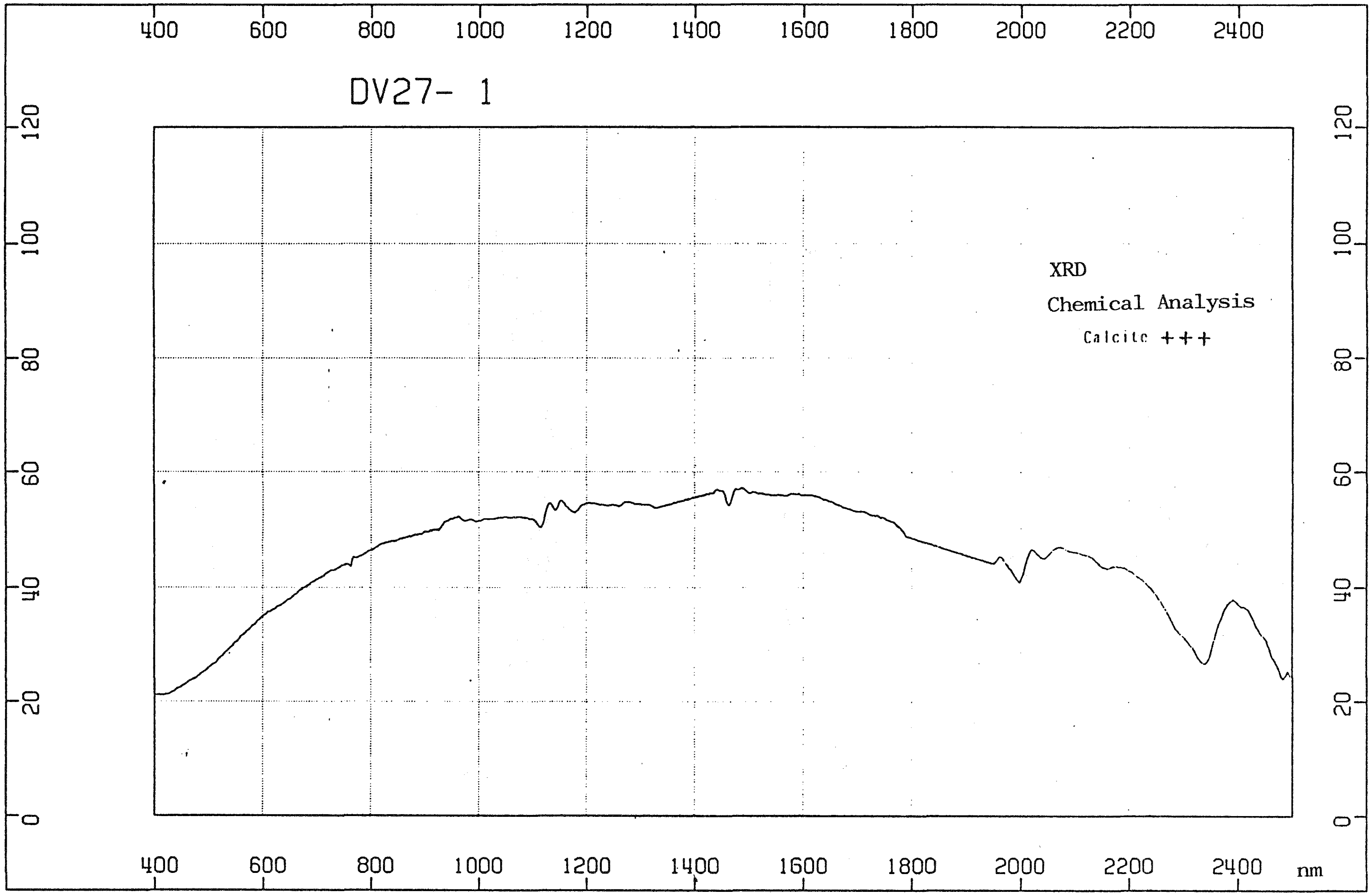


Fig.2 IRIS Reflectance Data of Limestone
and Results of Rock Analysis

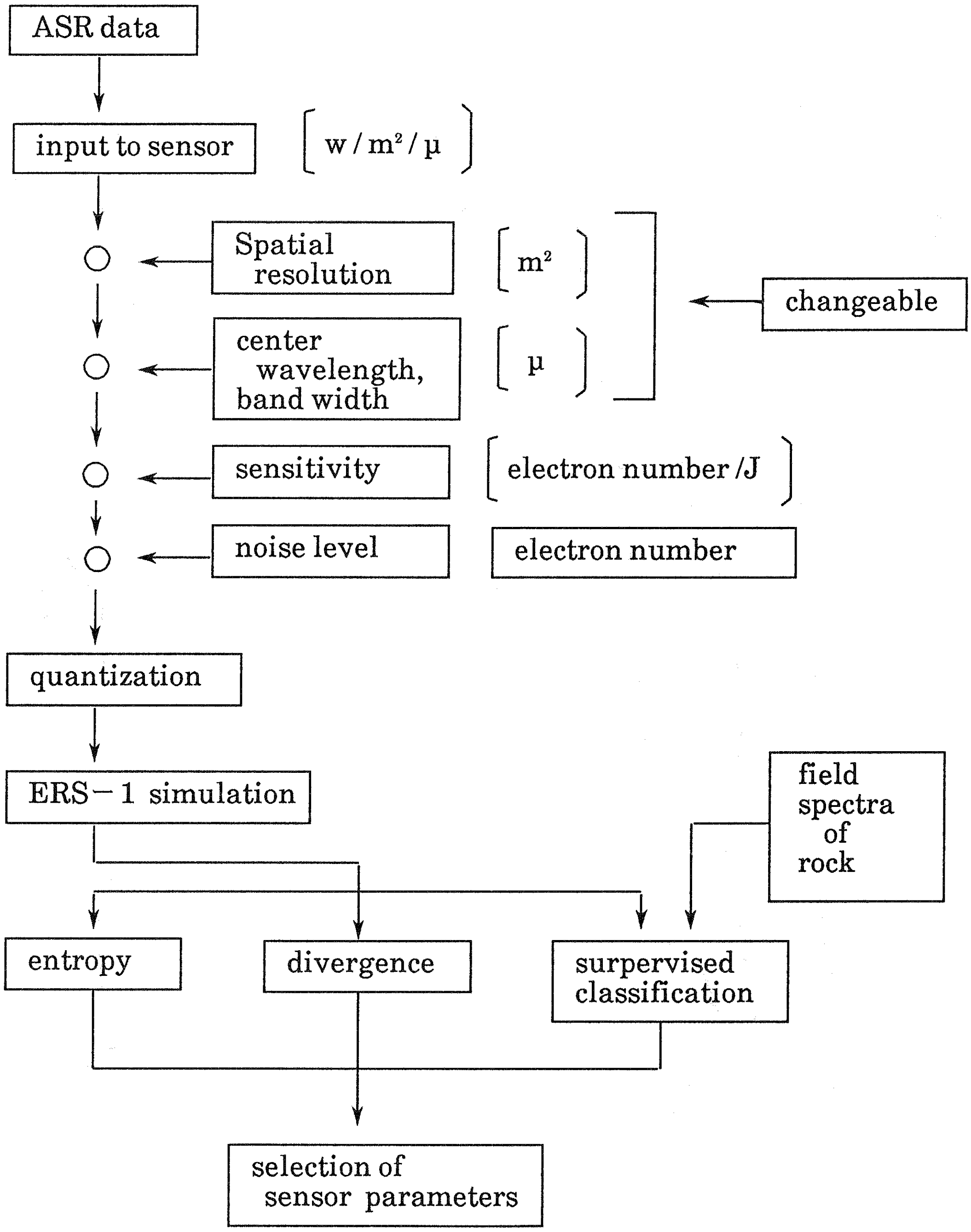


Fig.3 Flow Chart for the Evaluation of ERS-1/OPS specification

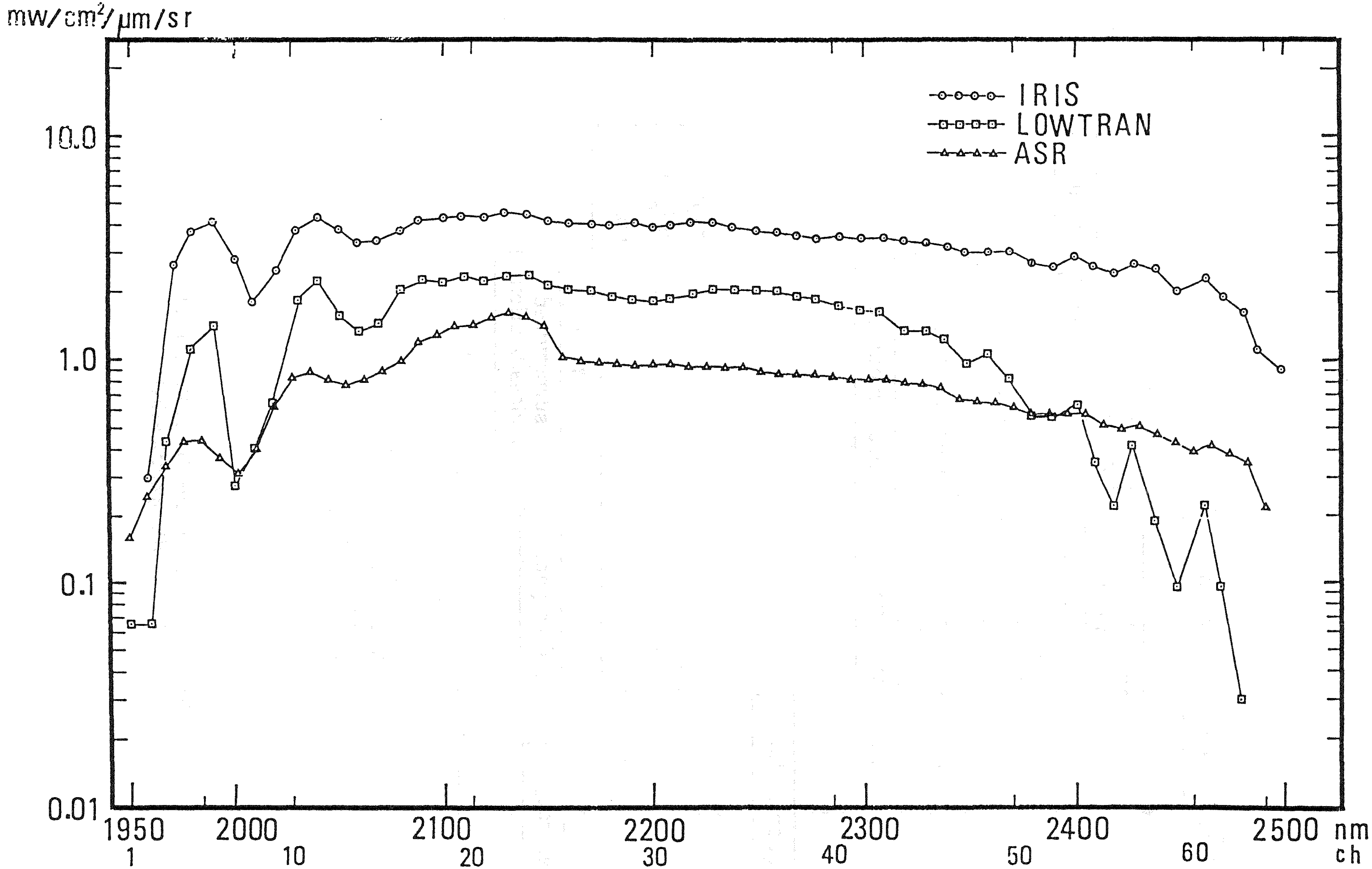


Fig.4 Radiance by ASR, IRIS. and LOWTRAN 5