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A.* INVESTIGATION OF TECHNIQUES FOR CORRECTING ERTS DATA FOR SOLAR AND ATMOSPHERIC EFFECTS,

B. GFSC #MMC655

Principal Investigator: Dr. R. H. Rogers

OBJECTIVE

The objective of this experiment is to establish a radiometric calibration technique that will permit the absolute reflectance characteristics of ground targets to be determined from ERTS spacecraft data.

1. Intermediate Goals

The accomplishment of this objective is entailing the pursuit and accomplishment of intermediate goals that include:

- Development and evaluation of techniques to determine absolute reflectance of large natural and man-made targets from ground-based spot sampling with hand-held radiance measuring instruments.
- Development and evaluation of techniques to determine absolute target reflectance from ERTS data by the measurement and removal of the solar and atmospheric parameters derived from ground-based radiant power measurements.
- Establishment and evaluation of the capability of procedures for deriving atmospheric parameters needed to correct ERTS signal directly from spacecraft measurements.
- Determination of the capability of data processing techniques to extend in time (repetitive coverage) and space the absolute calibration of the spacecraft data.
- Development and evaluation of computer software, techniques, and procedures for transforming the ERTS computer-compatible tapes (CCT) into a new set of tapes and images which have been corrected for solar and atmospheric effects.

* To facilitate progress review paragraph numbering in agreement with Contract Article II, Item 2.

(E72-10326) INVESTIGATION OF TECHNIQUES FOR CORRECTING ERTS DATA FOR SOLAR AND ATMOSPHERIC EFFECTS Bimonthly Progress Report R.H. Rogers (Bendix Corp.) 21 Dec. 1972 11 p CSCL 03B G3/13 N73-14314 Unclas 00326

- Inter-comparison of the capabilities of correcting the ERTS data for solar and atmospheric parameters and effects by candidate radiometric calibration techniques that include: (1) transference calibration, (2) ground-based radiant power measurements, (3) use of spacecraft data alone (no auxiliary inputs), and (4) radiation transfer models.

C. There are no serious problems impeding the progress of this investigation and this program is on schedule and within budget.

D. ACCOMPLISHMENTS

Although major activity since 1 October 1972 has been focused on completing the design and build of the Radiant Power Measuring Instruments ($RPMI_s$) other significant events have included: a visit by the ERTS scientific monitor, Dr. Robert S. Fraser, first field measurements with RPMI, and development of additional software and techniques for processing ERTS tapes. Specific goals achieved during this period included:

- Completed the RPMI design and fabrication of engineering model and four manufactured units (See section E and Attachment 1).

- Visit by ERTS scientific monitor Dr. Robert S. Fraser on 20 October 1972.

- Field data gathering with RPMI engineering model in Delaware Bay area on Friday, 27 October 1972, off Cape Henlopen at 38° 46'N, 74° 59'W at the time of ERTS overpass (1107 EDT; 1007Z5).

- ERTS data handling software and techniques completed—not charged to contract but applicable capabilities.

  Screening — ERTS CCTs are presently being color coded and viewed on computer driven moving window TV display. When area of interest is located the tape is stoped and a computer generated gray scale map is produced on line printer showing scene viewed on TV.

Editing — This function is now performed by locating target boundaries on computer gray scale map using resolution element and scan line count numbers. Inputting boundaries of interest to computer permits data on tape within boundaries to be recorded in computer files for additional computations and analysis.

Target Statistics — Computations on areas of interest within each ERTS channel now include; mean signal, standard deviation and covariance matrix.

Decision Imagery — The first automatic decision image using spectral data in each of the 4 ERTS MSS bands was accomplished. For the test case considered we simply automated the separation of land from water — the results were dramatically displayed on moving window display — when water was assigned one color and land another.

Activities planned for the next reporting period include:

- Travel to Goddard to check RPMI calibration against the HOVIS sphere.
- Complete calibration of all RPMIs.
- Continue (1) field data gathering with RPMIs to determine their capability and to correlate instrument measurements with meteorological data, (2) analytical studies to identify most promising radiation transfer models and computer techniques for extracting atmospheric parameters from ERTS data.
- Meet with ERTS scientific and technical monitor in January to review RPMI, discuss measurement techniques, atmospheric models, and plans for field test program.

E. Significant results during this time period included the completion of the development of the RPMI — see Attachment 1a for summary and 1b for details of results. These attachments were prepared to facilitate processing by the National Technical Information Service and are responsive to GSFC Spec. S-250-P-1C dated March, 1972 and Supplements.

F. No release of information or request for permission to release information has been made during the reporting period.

G. A study is recommended for developing plans, justification and cost associated with supporting ERTS PIs with standardized instruments and techniques for measuring and recording solar and atmospheric parameters — Please see Attachment -2 for additional details.

H. Standing order forms have not been changed.

I. Attachment of ERTS Image Descriptor Forms is not applicable as yet.

J. Data product form submitted 20 June 1972 to technical monitor.

K. Work to date conforms to schedule.

ATTACHMENT - 1a

SUMMARY OF SIGNIFICANT RESULTS

DISCIPLINE: Sensor Technology

SUBDISCIPLINE: Ground Truth

@ABS The author has identified the following significant results.

The design and fabrication of five Radiant Power Measuring Instruments (RPMIs) for ERTS ground truth have been completed. These instruments will be deployed in concert with ERTS overflights to obtain radiometric measurements needed to determine solar and atmospheric parameters that affect ERTS radiance measurements. With these parameters, the accuracy and capability of various procedures for transforming ERTS data into absolute target reflectance signatures will be evaluated.

The RPMI is a rugged, hand-carried instrument accurately calibrated to measure both downwelling and reflected radiance within each ERTS multispectral scanner (MSS) band. A foldover handle permits a quick change from wide angle global or sky irradiance measurements to narrow angle radiance measurements from sky and ground targets. These measurements yield ground truth site reflectance and permit calculation of additional parameters such as beam transmittance between spacecraft and ground, and path radiance (path reflectance).

ATTACHMENT - 1b

DETAILS OF SIGNIFICANT RESULTS

DISCIPLINE: Sensor Technology

SUBDISCIPLINE: Ground Truth

The design and fabrication of five Radiant Power Measuring Instruments (RPMI) for ERTS ground truth have been completed. This report provides the characteristics and pictures of this instrument.

The Radiant Power Measuring Instrument (RPMI), Model 100, provides an ERTS investigator with a capability of obtaining radiometric measurements needed to determine solar and atmospheric parameters that affect the ERTS radiance measurements. With these parameters, ERTS data can be transformed into absolute target reflectance signatures, making accurate unambiguous interpretations possible.

The RPMI is a rugged, hand-carried instrument accurately calibrated to measure both downwelling and reflected radiance within each ERTS multispectral scanner (MSS) band. A foldover handle permits a quick change from wide angle global or sky irradiance measurements to narrow angle radiance measurements from sky and ground targets. These measurements yield ground truth site reflectance and permit calculation of additional parameters such as beam transmittance between spacecraft and ground, and path radiance (path reflectance).

Summary of Characteristics

- Spectral Bands: All measurements made in ERTS MSS bands (0.5 to 0.6 micron (μ); 0.6 to 0.7μ; 0.7 to 0.8μ; and 0.8 to 1.1μ). Bands formed by bandpass filter in switched turret followed by silicon detector.

- Field of View: Two modes

  1. 2π steradian field of view through removable diffuser.
  2. Handle permits 6.0° circular field of view for sky and earth measurements.

- Sensitivity (Measurement Ranges):

  10 range scales permit irradiance measurements from 0.01 to 300.0 watts/meter^2 and radiance measurements from 0.01 to 300 watts/(meter^2 · steradian).

- Calibration Accuracy:

  1. An absolute accuracy of ±5% is maintained over the field operating ranges for a period of over 1 year.
  2. Relative (band to band) accuracy is ± 2.0%.
  3. Repeatability ± 0.5%.

- Frequency Response:

  0 to 1.0 Hz on meter.
  0 to 20 Hz at BNC output.

- Controls: Irradiance/Radiance, Range (10 positions), Band Select (6 positions include the 4 ERTS MSS bands, and a closed and an open position), Meter Zero, Battery Test, and ON/OFF Switch.

- Meter: 3 1/2-inch taut band 1.0% hand calibrated, mirrored scale; scaled 0 to 1.0 and 0 to 3.0 with 50 and 60 divisions, respectively.

- Power Source: 9.0-volt batteries; battery life while operating – 50 to 100 hours.

- Environmental Specifications:

  1. Sealed against dust and humidity to 100%.
  2. Shock and vibration expected in field and aircraft environments.
  3. Storage -55°C to +80°C.
  4. Operational -20°C to +70°C.

- Size: 4 x 7 x 8 in. (10 x 18 x 20 cm).

- Weight: 5.8 pounds (2.6 kg) with batteries.

Measurement Modes

Global Irradiance (H) - 2π steradian field of view for measuring downwelling (incident) radiation in bands identical to ERTS MSS.

Sky Irradiance (H_{SKY}) - Global Irradiance minus direct sun component, in every ERTS MSS band. Angle from zenith to sun is also measured in this mode.

Radiance from Narrow Solid Angles of Sky - Handle serving as field stop permits direct measurements through a 6.0° circular field of view. This mode is also used to measure direct beam solar irradiance.

Reflected Radiation - Used with small calibration panels, cards, to obtain direct measurement of truth site reflectance. Same field of view as above.

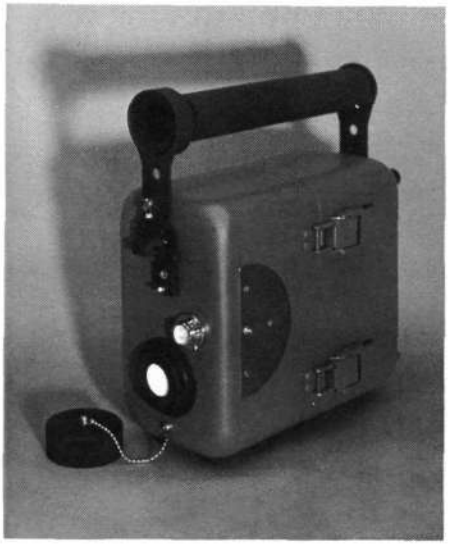
Packaging (See pictures on following page)

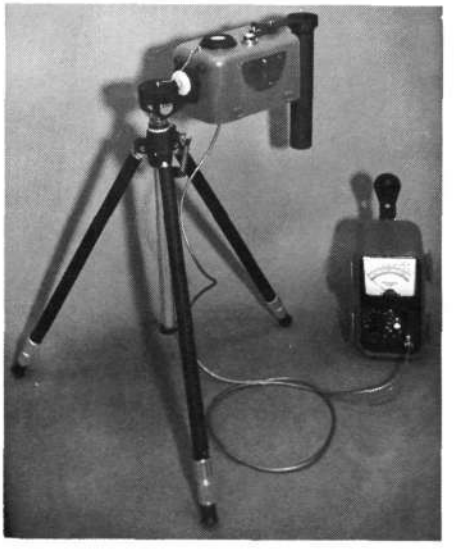
- Handle joins sensor head and meter assembly to form compact unit.
- Sensor head, containing filter wheel and silicon detector, is separated from meter assembly by 6 ft of shielded cable. Sensor head is threaded with standard tripod mounting (1/4-20 tapped hole) to facilitate pointing at sky and ground.
- Bubble level and sun angle measuring device are integral parts of sensor head.
- Foldover handle attached to sensor head permits immediate change from the wide 2π steradian field of view to a narrow one.
- Separate meter assembly facilitates accurate meter reading and permits remote monitoring.

Options

- Filter to match ERTS RBV bands, EREP experiments, etc.
- Circular field of view from 1.0 to 6.0°.

ERTS - Radiant Power Measuring Instrument





ATTACHMENT - 2

RECOMMENDATION

A study is recommended to develop plans, justification and cost associated with supporting all ERTS PIs with standardized instruments and techniques for measuring and recording solar and atmospheric parameters.

A first look at this program indicates that if NASA had a quantity of RPMIs (number to be determined in recommended study) then all ERTS PIs could be supported with a ground truth instrument in a very cost-effective manner. That is, with careful scheduling by NASA, a few instruments together with standardized forms for recording measurements could be cycled through many if not all ERTS investigators. NASA or a Contractor would maintain and keep the instruments calibrated. Calibrating all of the instruments against a common source such as the HOVIS sphere and utilizing a standard format for recording RPMI measurements would then make it possible for NASA and other PIs to correlate and compare the results of all ERTS experiments.

Justification:

Initial estimates indicate that the RPMI or other instruments of equivalent performance in small quantities (10 or less) is too expensive for the typical PI. A dozen or more RPMIs if scheduled and handled much like the Data Collection Platforms and NASA aircraft could be utilized by many PIs therefore making the effective cost per PI small.

This program which would provide PIs with instruments and techniques for measuring and recording solar and atmospheric parameters would provide benefits that include:

1) Standardization of the measurement and recording of atmospheric parameters which are essential if the observations and reports of large numbers of PIs are to be correlated and compared by NASA and other PIs in a meaningful way.

2) Improvement in manual image interpretation would result by PIs using RPMIs to measure reflectance of test sites directly and/or measuring atmospheric parameters and transforming ERTS data to reflectance units. This will permit the PIs who have knowledge of and have compiled catalogs of spectral reflectance of targets pertinent to their studies to extend the use of this information to ERTS imagery.

3) Improvement in computer techniques based on recognizing target spectral characteristics would result if RPMI measurement were used to remove spectral variations due to atmospheric effects from data prior to processing. The benefits in this case includes reduced number of training sites needed and the frequency sites need to be selected to achieve a given level of classification performance.