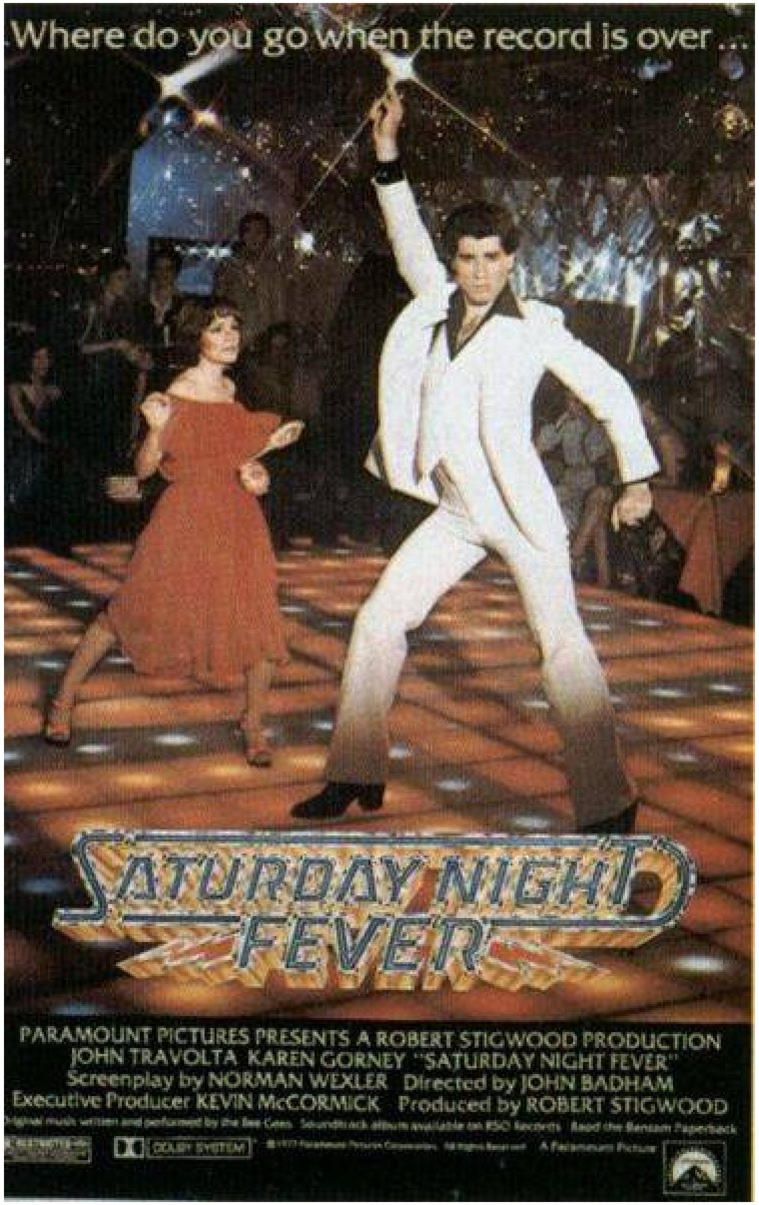
Progress in Field Spectroscopy

Ted Milton, Michael Schaepman,
Karen Anderson, Mathias Kneubühler
and Nigel Fox

University of Southampton, UK
University of Wageningen, Netherlands
University of Exeter, UK
University of Zurich RSL, Switzerland
UK National Physical Laboratory

1976...


Where do you go when the record is over ...
SATURDAY NIGHT FEVER
PARAMOUNT PICTURES PRESENTS A ROBERT STIGWOOD PRODUCTION
JOHN TRAVOLTA KAREN GORNEY "SATURDAY NIGHT FEVER"
Screenplay by NORMAN WEXLER Directed by JOHN BADHAM
Executive Producer KEVIN McCORMICK Produced by ROBERT STIGWOOD

1976...

IGARSS 2006 : Progress in Field Spectroscopy

JPL Portable Field Reflectance Spectrometer (1975)

1975

Appendix E

Portable Field Reflectance Spectrometer

A. F. H. Goetz

I. Purpose

At the start of this ERTS investigation and through involvement in other ERTS research in progress, it became obvious that field measurements of surface spectral reflectivity would be necessary to:

(1) Determine the effects of atmospheric absorption and scattering on ERTS spectral image values.

(2) Establish a set of criteria for quantitative image analysis through computer image processing.

(3) Assist in the selection of the best set of spectral bands for geologic mapping in future missions.

(4) Establish the correlation between field-measured surface spectral reflectance and the necessarily small, selected samples measured in laboratory reflectance equipment.

To span the wavelength range of the Skylab S-192 multi-spectral scanner (MSS) in the reflective portion of the spectrum and ERTS MSS bands required a spectral coverage of 0.4 to 2.5 μm. However, no instrument marketed covered the spectral range at the resolution desired or was sufficiently portable for field work in remote areas. In fact, existing specialized systems required a vehicle and generator power to record and analyze data.

The system described here was designed to meet the following criteria:

(1) Backpack, field-portable.

(2) Complete coverage of the spectral region 0.4 to 2.5 μm with moderate resolution ($\Delta\lambda/\lambda$ = 0.02 to 0.04).

(3) Stability over a wide range of temperatures.

(4) Digital data recording.

II. The System

The portable field reflectance spectrometer (PFRS) system consists of a separate optical head and amplifier-recorder assembly (see Fig. E-1). In the field, the electronics pack is worn continuously by the operator. The optical head, mounted on a tripod, is hand-held, but is carried on a pack frame when moving from area to area. A hand-held meter indicates the signal level and is used to set gain levels. In operation, all results are reduced to spectral reflectance values for comparison of areas measured under various lighting conditions.

A. Optical Head

An artist's view of the optical head is shown in Fig. E-2. In sequence, the beam enters the instrument at the left

Fig. E-1. Portable field reflectance spectrometer in operating position. Backpack contains the amplifiers, power supply, and digital recording electronics. Optical head contains the chopper, circular variable filter, thermoelectrically cooled detectors, and preamplifiers

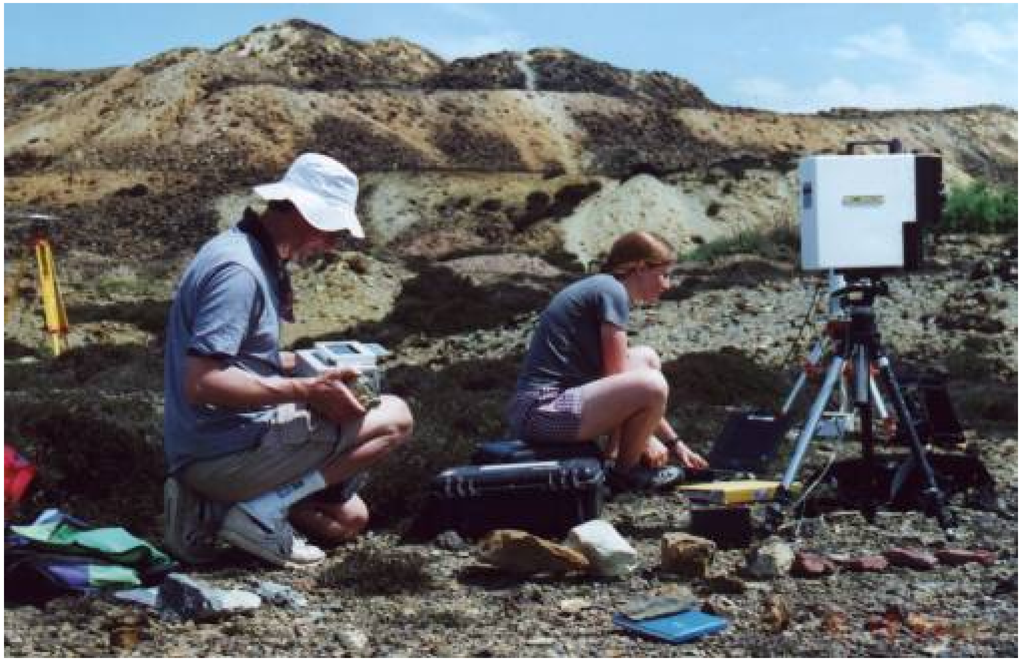
Progress in Field Spectroscopy – since late 1980s

- Deering (1989)
- Milton (IJRS, 1987)
- Slater (IEEE, 1985)

- Progress in Instrument Design
- Progress in Methodology
- Progress in defining the Role of FS

Progress in Instrument Design

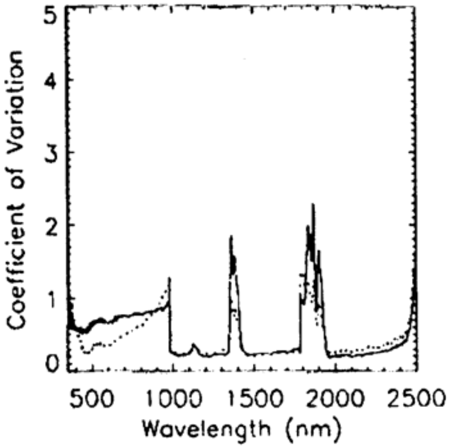
Instrument design challenges

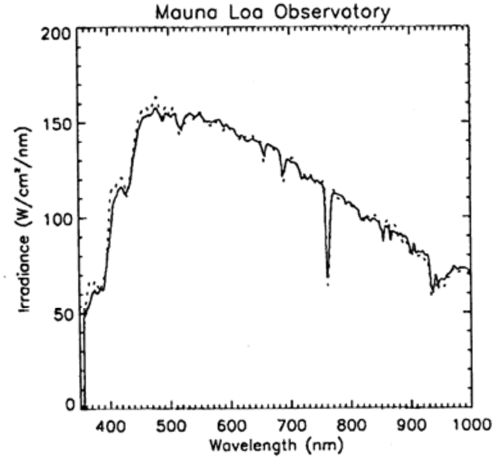


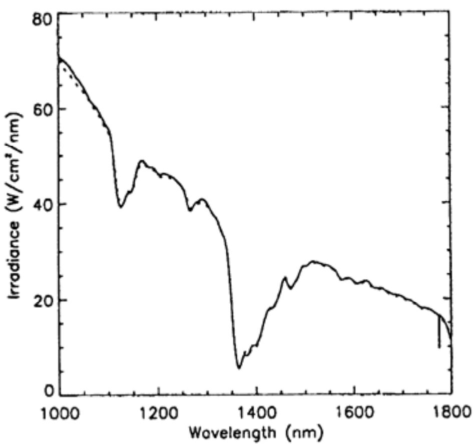
- SNR in SWIR
- Temperature
- Polarisation
- Field-of-view
- Radiometry

- Spectron SE590 : Markham et al. (1995)
- ASD PSII : Markham et al. (1995)
- GER 3700 : Schaepman and Dangel (2000)
- ASD FieldSpec FR : Kindel et al. (2001)

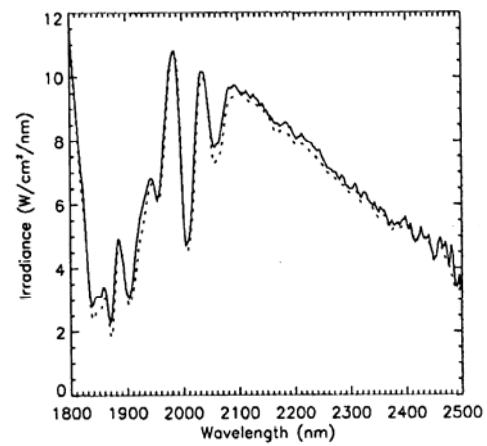
Solar radiometry using an ASD FieldSpec FR







Kindel et al.
Applied Optics, 2001



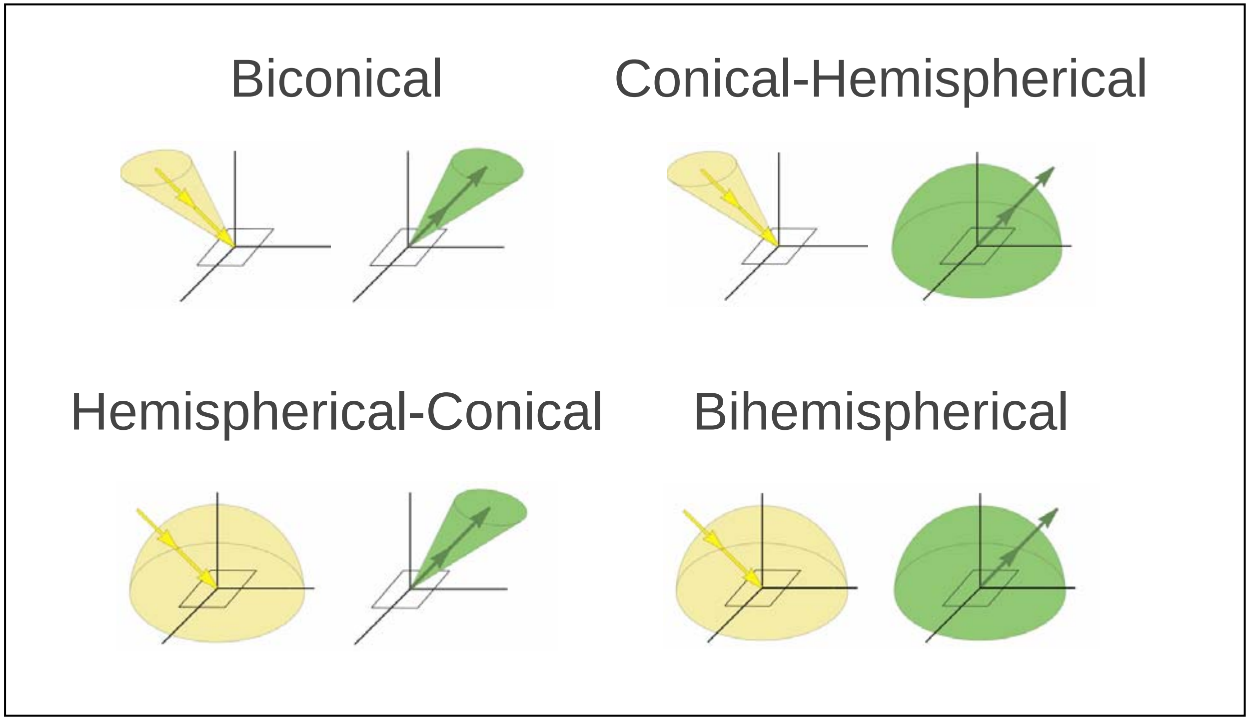
Some outstanding issues...

- Total cost of ownership
- Sunlight-readable screens
- Optical fibres
- Steps in spectra

http://fsf.nerc.ac.uk/

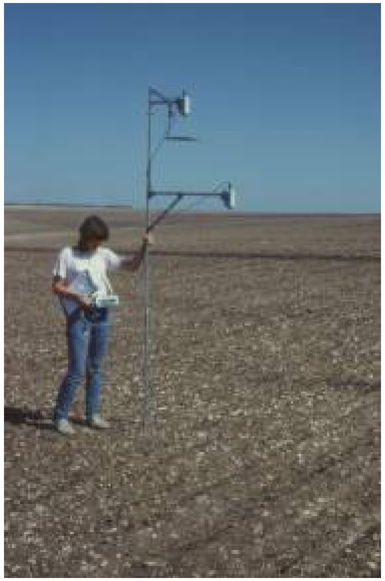
Progress in the Methodology of Field Spectroscopy

Of the nine geometric configurations described by Nicodemus et al. (1970), four are measurable in the field and/or lab :



in practice... Reflectance Factors

Reflectance Factors, pros and cons



- Convenient in the field.
- Standardised methodology.
- Spectral reflectance curves.

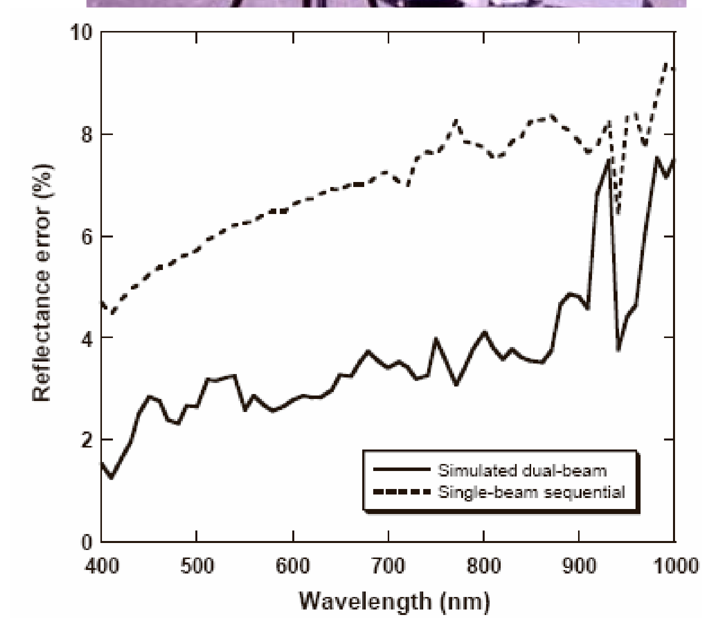
- Reference panels need calibrating (spectral and angular).
- Reference panels deteriorate over time.
- Reflectance factors are not an inherent property of the target.

... need to pay more attention to the spectral irradiance distribution.

Quantifying the irradiance spectrum - 1

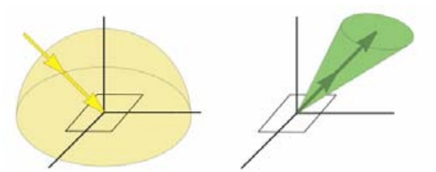
Simultaneous measurement

Simultaneous estimation



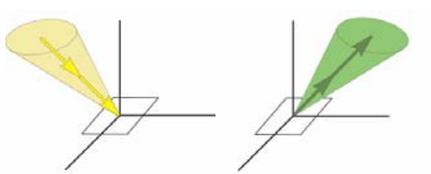
Representations of the angular irradiance distribution

Hemispherical-Conical



The standard geometry for measurement of Reflectance Factors.

Biconical



The desirable geometry for measurement of non-Lambertian surfaces.

- Direct-to-Diffuse ratio must be measured as well.
- Aerosol Optical Thickness from sunphotometry.
- Sky irradiance distribution (measured or modelled).
- Traceability to SI requires radiance, not reflectance.

Quantifying the irradiance spectrum - 2

Quality metrics for Field Spectroscopy

Repeatability

A property of the instrument. Defined by the precision of a series of measurements of a stable source, e.g. integrating sphere for spectral radiance.

Reproducibility

Depends on the instrument and how it used in the field. Methodology affects reproducibility.

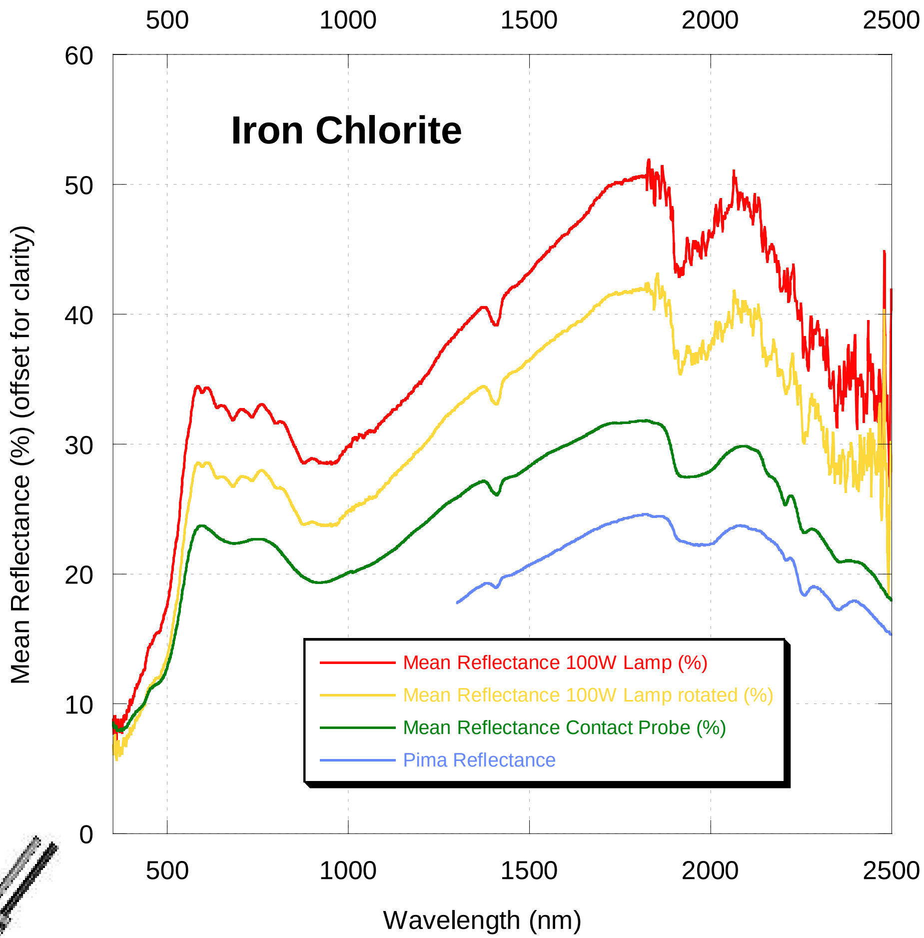
Terminology

Unique description of the measured quantity, not only using proper radiometric terms but also geometrical-optical terms (geometry of incoming and reflected radiance).

Accuracy

Closeness of the measurement to the 'true' value. Requires clear definition of the measurand and a demonstrably unbroken chain of traceability to the primary standard, with known uncertainty at every step.

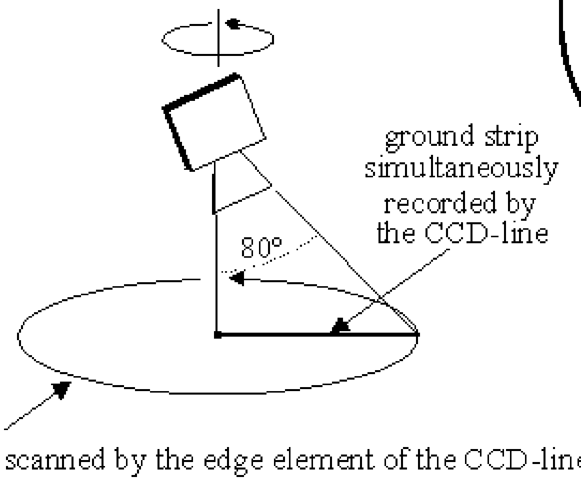
Roles of FS : 1. 'Spectroscopy in the field'

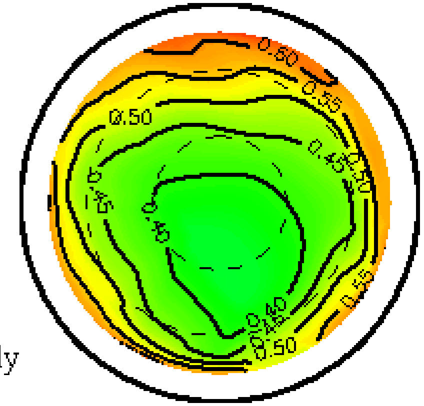


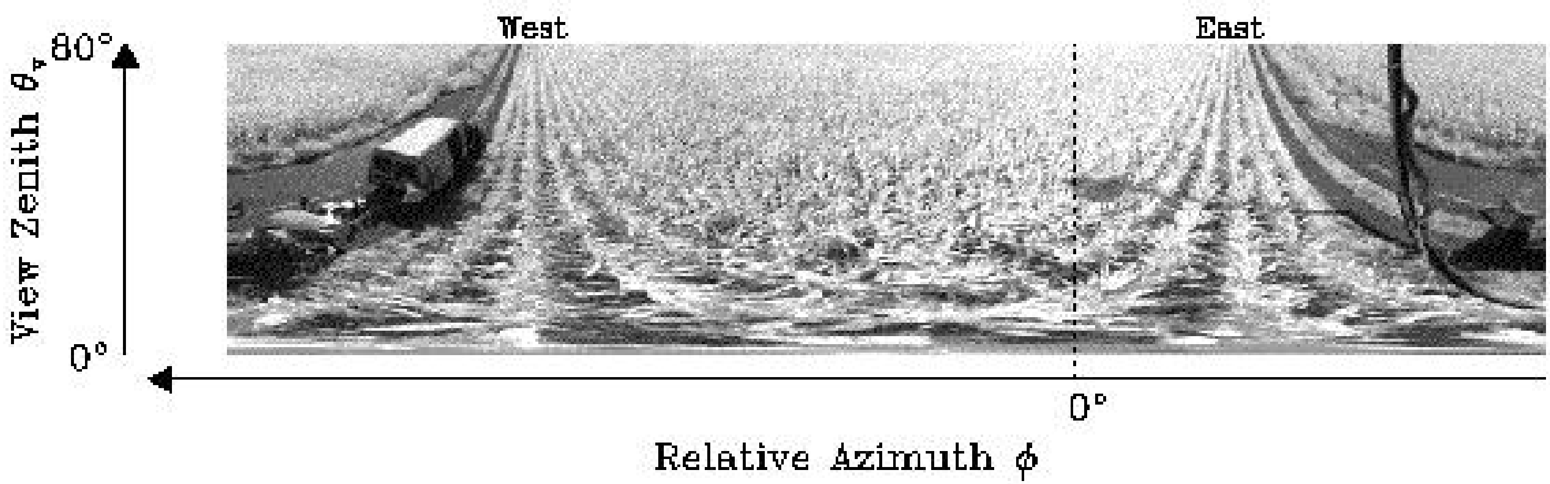
Role #2 : Measuring the radiation environment

Pegrum et al., 2006 (this conference)

Goniospectrometry using a CCD array





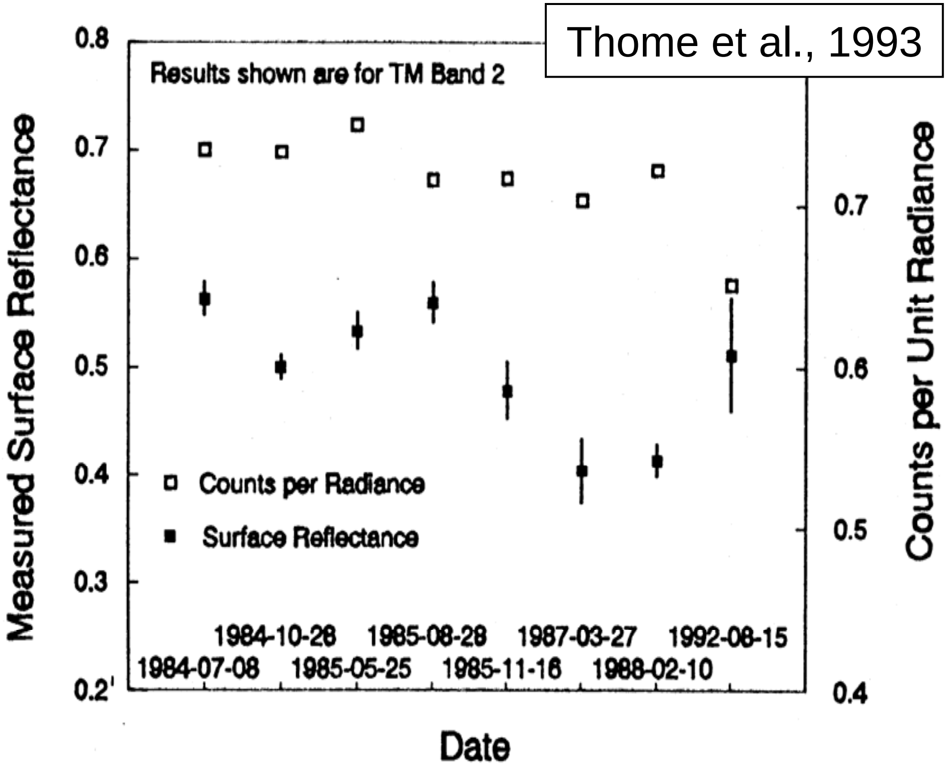


Roles of FS : 3. Vicarious Calibration

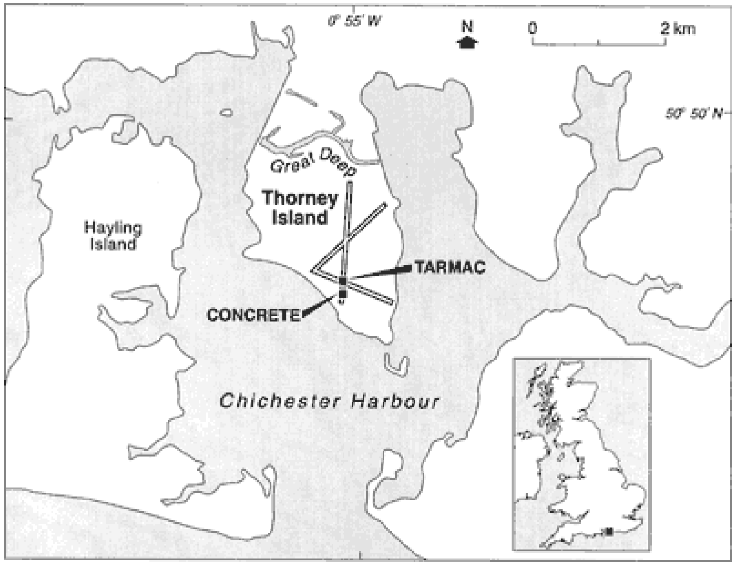
An Instrument Package for Vicarious Calibration ?

Instrument	Purpose
1. Constant panel set-up	Time series of irradiance spectra (plus direct/diffuse).
2. Mobile spectrometer	Spatial variation of reflectance
3. Goniospectrometer	Angular variation of reflectance
4. Sky camera	Permanent visual record
5. Sun photometer	AOT and EWT

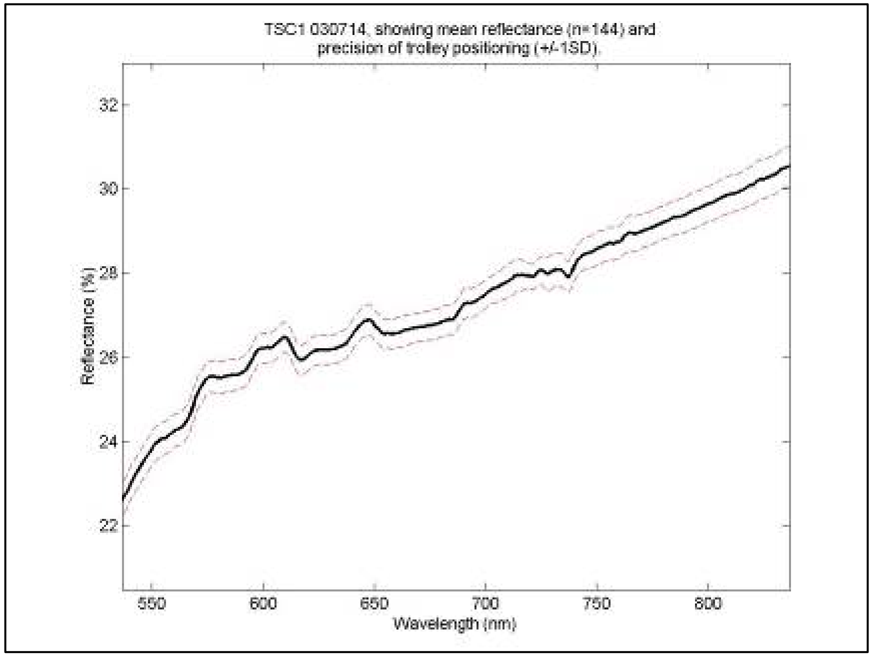
Seasonal change in playa surface properties



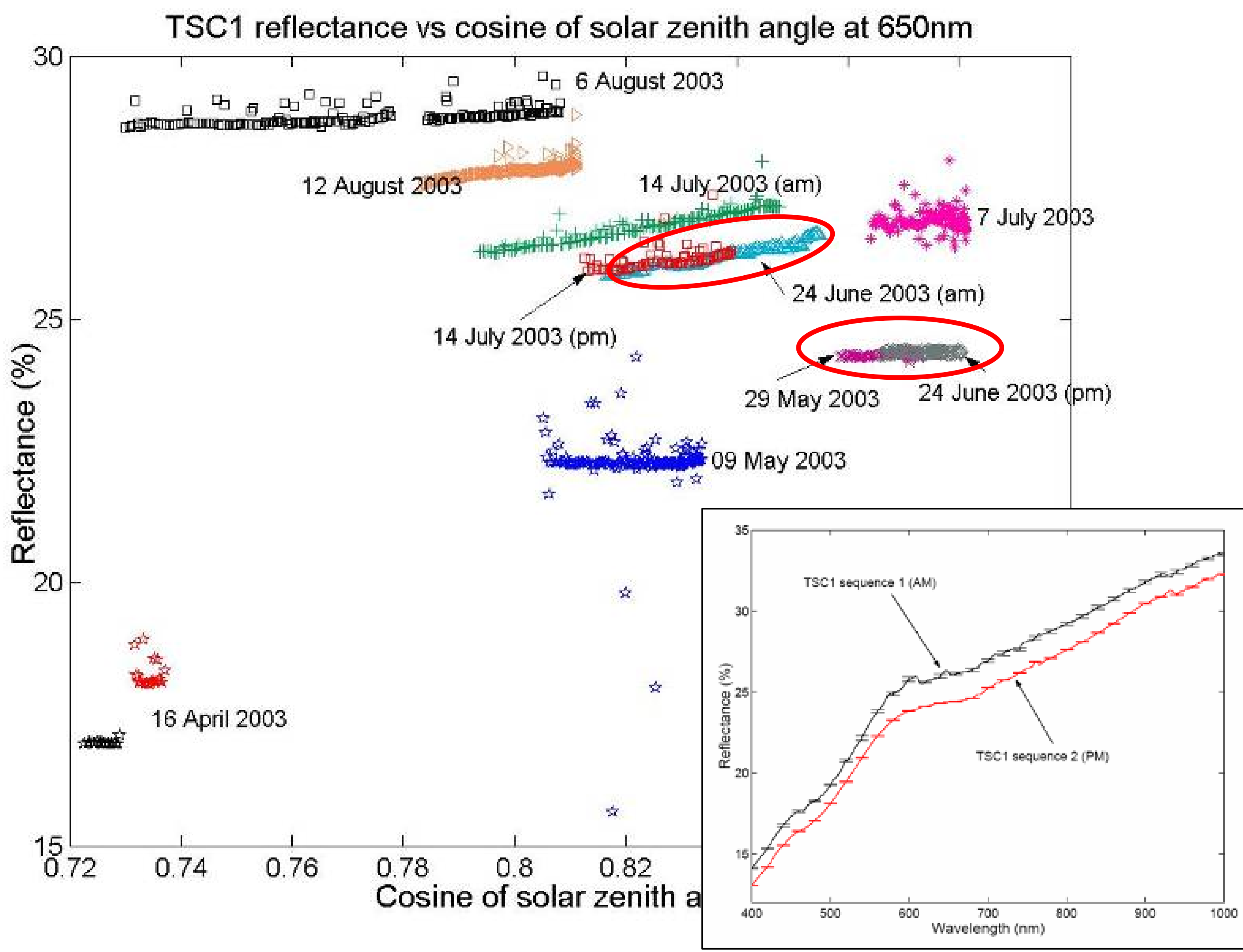
Environmental sources of uncertainty in VC



- Disused airfield in UK
- Concrete, Asphalt, Grass
- Mobile platform
- Dual-beam GER1500



Seasonal change in hemispherical-conical reflectance



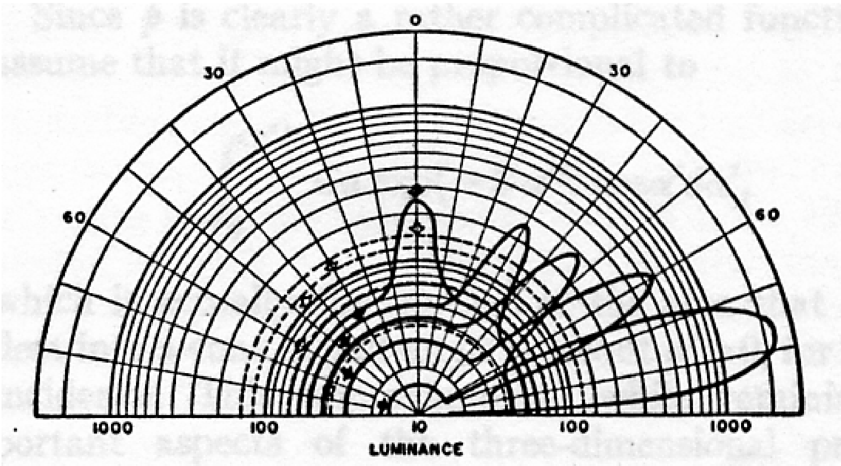
Conclusion

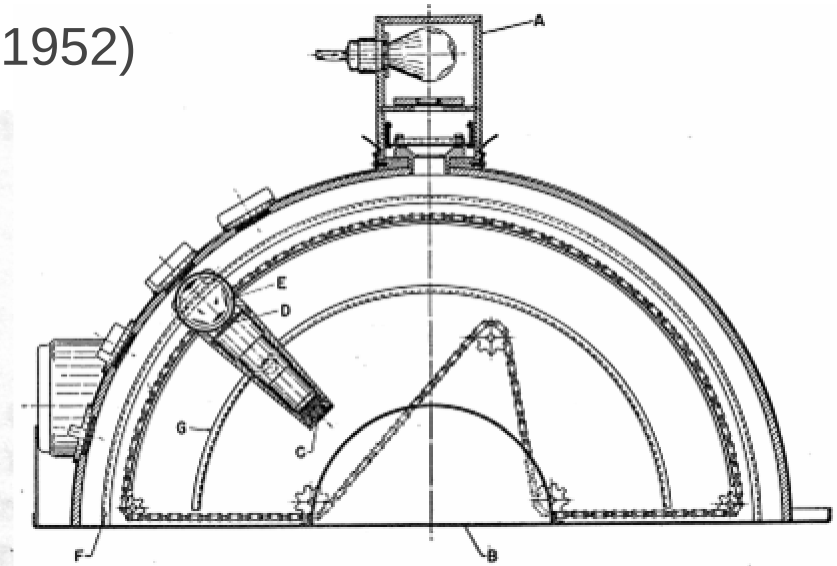
- High performance instruments now available.
- Clear roles for field spectroscopy.
- Methodological development slow.
- Combined geometrical-optical and radiometric terminology for spectroscopic measurements needs to be established.

- Dynamic processes, e.g. solar-excited fluorescence.
- ‘Spectral reflectance’ is a family of related measurands, not a single entity.
- Reflectance Factors are fine for some applications.
- BRDF is an unattainable goal in the field, but a set of measurements allowing the proper parameterization of the BRDF needs to be acquired.

Surface anisotropy 1952 compared with 2003

Knowles-Middleton and Mungall (1952)





Painter et al. (2003)