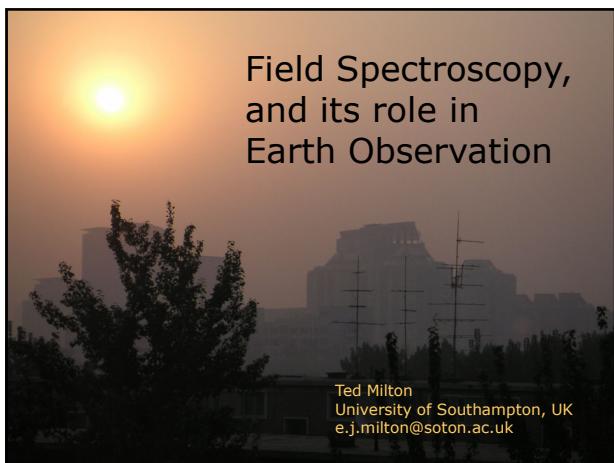


**Field Spectroscopy,  
and its role in  
Earth Observation**



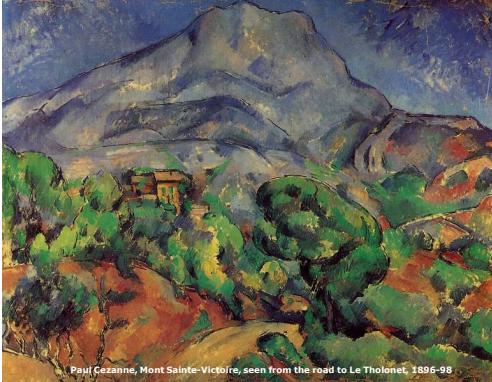
Ted Milton  
University of Southampton, UK  
e.j.milton@soton.ac.uk

**Making Sense of the Scene**



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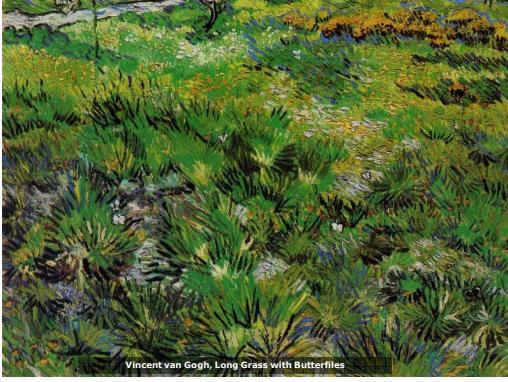
**Making Sense of the Scene**



Paul Cézanne, Mont Sainte-Victoire, seen from the road to Le Tholonet, 1895-98

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**Making Sense of the Scene**



Vincent van Gogh, Long Grass with Butterflies

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**Making Sense of the Scene**



'Boreal' created using the 'Persistence of Vision' Ray Tracer  
by Norbert Kern (2004)

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**Making Sense of the Scene**

- First we see, then we measure.
- "Nature is too green and badly lit"  
(François Boucher, 1703-1770)
- What we see is not the complete picture.




Boucher, Madame de Pompadour, Wallace Collection

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### Role of Field Spectroscopy in 'scaling-up'

- Scaling-up from individual elements of the scene to areas the size of a pixel.
- Based on physical units: radiance, irradiance and reflectance.
- Traceability of measurements is important – need to standardise methods and materials.

## Principles of Field Spectroscopy

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### Proximate Field Spectroscopy

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### Relocating samples to the lab

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### Recreating Sun and skylight indoors

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### Measuring the BRDF

(Bidirectional Reflectance Distribution Function)

**BRDF is**

- an inherent property of the surface.
- conceptual, not measurable.
- a mathematical function, not a single value.

... a mathematical function “relating the irradiance incident from one given direction to its contribution to the reflected radiance in another direction” (Nicodemus et al., 1977)

BRDF vs 'reflectance factor'

What we actually measure is the 'Hemispherical-Conical Reflectance Factor' (HCRF)

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Incident light from the Sun and the sky

Reflected light from the surface contained within a 3D cone

Measurement of reflectance factors

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- 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.

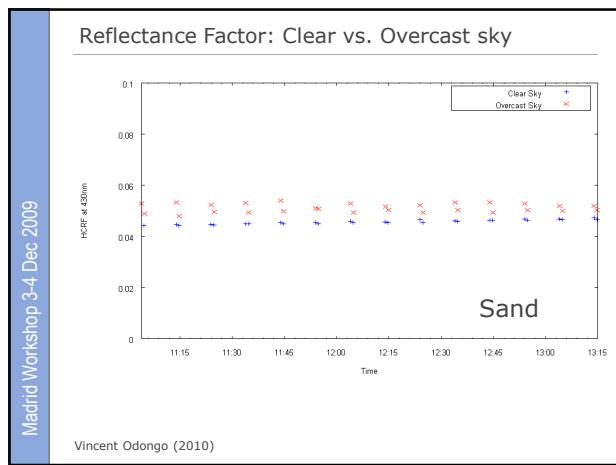
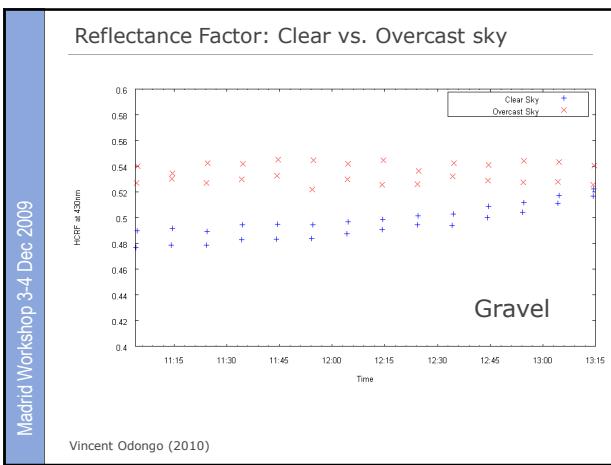
Automated Tramway for Spectral data collection

Sand

White tile (shiny)

Gravel

Reference tile (matt)



Reflectance Factor: Clear vs. Overcast sky

White tile

Time

Clear Sky  
Overcast Sky

HCF at 433nm

11:15 11:30 11:45 12:00 12:15 12:30 12:45 13:00

13:15

0.5 0.55 0.6 0.65 0.7 0.75 0.8 0.85 0.9 0.95

NERC NCAE01 CHILTON FIELD EXPERIMENT – JUNE 2006									
ASD FIELD SPECTRA – Instrument N4406 – Brokley Field, Red Pag, 15 June 2006									
Site	BK	REFERENCE PANEL	WAVELENGTH	ILLUMINATION	DATE	FOREGROUND	1"	8"	COS
					15/06/2006	FO JUNIOR	5.35 nm	5 nm	None
OPERATOR	R = Richard								
INSTRUMENT	0910	Mode					3.5nm	5nm	
							Rate	WAVE Ref	
Time	DPF	DG	W	FILENAME	DESCRIPTION	DATE	PROCESSED FILERNAME		
				Room	Ext				
10:55:54	10:56:55	10:56:55	BK/R	BK/R_ASD0061	001	Specimen			
11:00:10			BK/R	BK/R_ASD0061	002	Specimen			
11:00:37			BK/R	BK/R_ASD0061	003	Specimen			
11:01:18			BK/R	BK/R_ASD0061	004	Specimen			
11:01:34	11:02:55	11:02:55	BK/R	BK/R_ASD0061	005	Specimen			
11:02:55			BK/R	BK/R_ASD0061	006	Specimen			
11:04:13			BK/R	BK/R_ASD0061	007	Specimen			
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11:44:04	</								

# Development of Field Spectroscopy 1970 - 2010

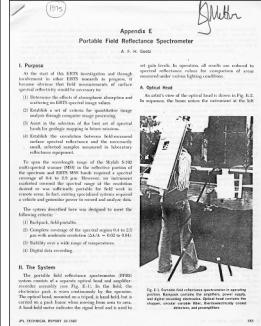
A black and white photograph of the ISCO Field Spectroradiometer (1969). The device is a rectangular, metal-cased instrument with a control panel on top. The panel features a small digital display, several control knobs, and a large circular meter with a scale. A power cord is visible on top of the unit.

## Role of FS in Education and Training

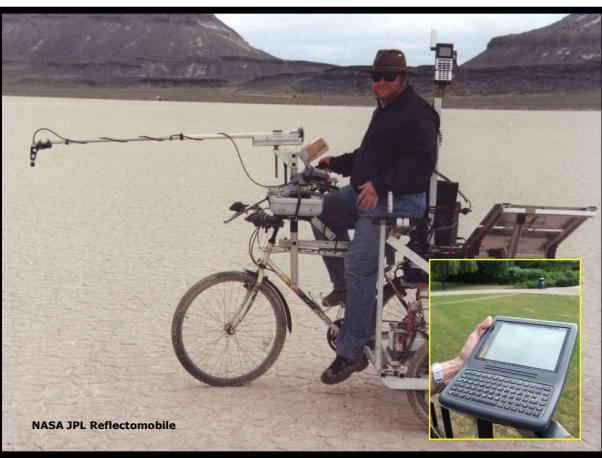


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## JPL Portable Field Reflectance Spectrometer (1975)



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NASA JPL Reflectomobile

## Fixed Geometry, Single Beam Instruments



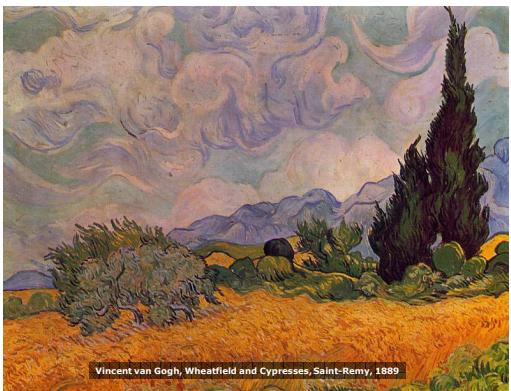
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## Solutions to the problem of tall canopies



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## The problem of sub-visual clouds



Vincent van Gogh, Wheatfield and Cypresses, Saint-Rémy, 1889

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### Demonstration of SAMS Spectral Analysis and Management System

<http://sams.casil.ucdavis.edu/>

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### The problem of sub-visual clouds

- Cause the amount of irradiance to change rapidly.
- Cause the angular distribution of irradiance to vary.

**Significant source of error**

Possible solutions:

- dual-beam methodology
- monitor or model the irradiance

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### Simulated dual-beam method

**Simulated dual-beam method reduced error by 50% compared with single-beam method.**

Milton & Rollin (2006)

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### Dual-beam HCRF and D:G ratio (parasol method)

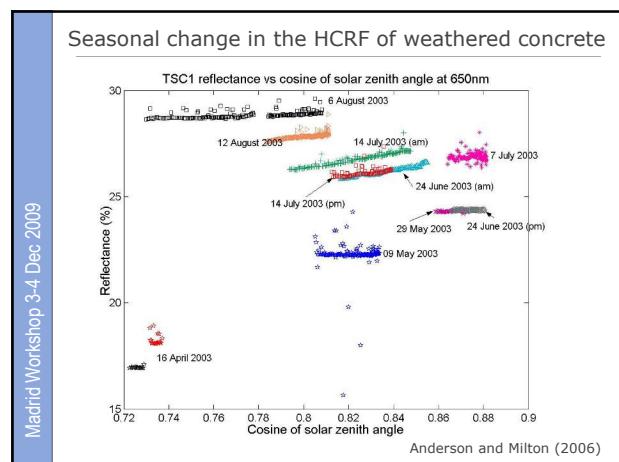
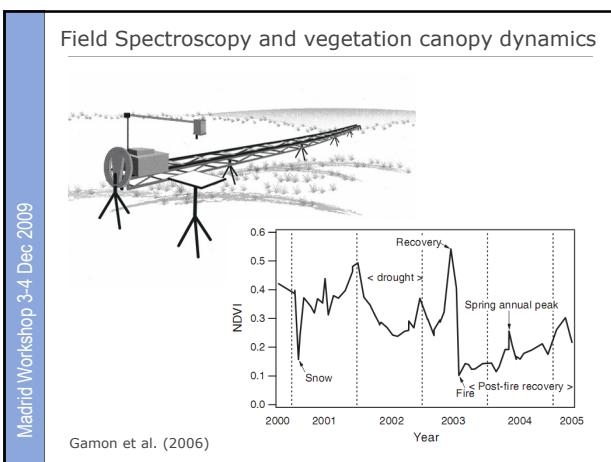
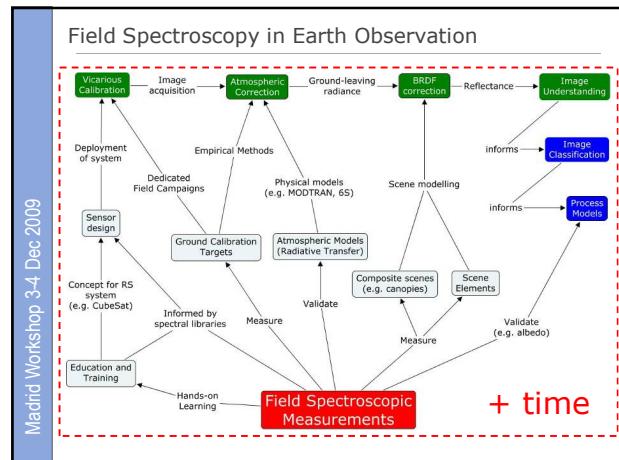
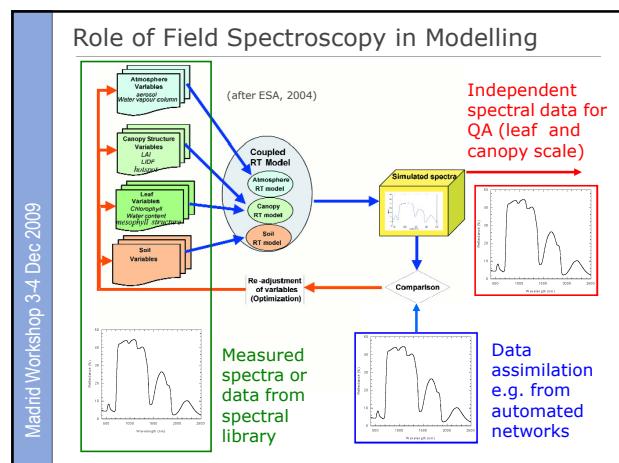
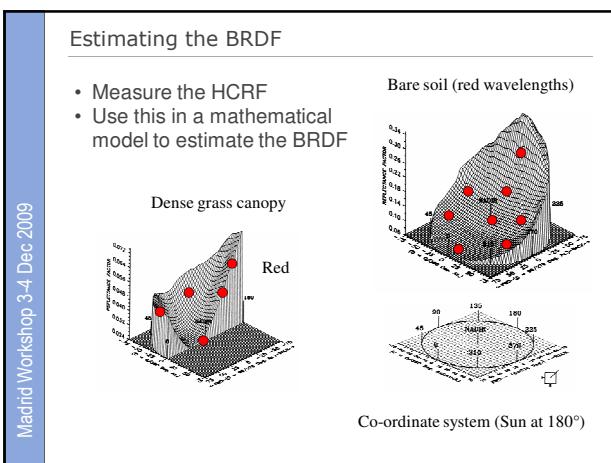
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### Variable Geometry Instruments

The NPL GRASS goniometer

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### University of Zurich RSL dual-beam goniometer





#### Roles for Field Spectroscopy in EO

- An effective tool for teaching the physical principles of remote sensing.
- Scaling-up from individual elements of the scene to areas the size of a pixel.  
Using those pixel-scale data to:
  - validate numerical models & perform sensitivity analysis
  - validate sensor calibration post-launch
  - correct remotely sensed data for the effect of the atmosphere.
- Complementary to imaging spectrometry – FS can give access to the dynamics of the scene. Link with processes and change.

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