

Airborne Hemispheric Spectrometer

A New Dimension of Hyperspectral Sensing

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Geography and Environment

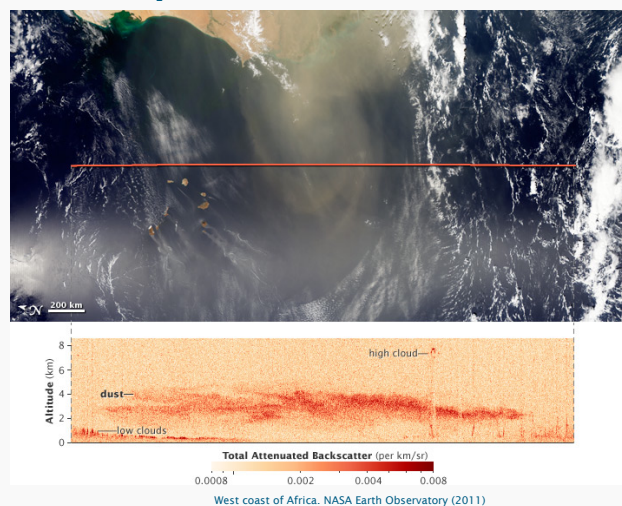
Introduction

- Technology Proof of Concept Programme under NERC Technologies Theme Action Plan (TAP)
- New and innovative technology concepts with potential applications to environmental science.
- Defines within NASA-defined Technology Readiness Levels (TRL) 1 to 4

NERC's Strategy

- **Earth System Science TAP:** Quantify forces and feedbacks that drive the Earth System (Object #3f)
- **Environment, Pollution & Human Health TAP:** Improved measurement and monitoring of the distribution of pollutants and pathogen at required time and space scales (Object #1)
- **Climate System TAP:** Improve and expand observations to validate climate change detection and prediction (Object #3)

Lower Atmosphere



History

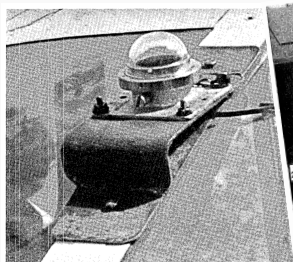


Fig. 1. Roof pyranometer.

Howard and Barton, Instrumentation for Remote Sensing of Solar Radiation from Light Aircraft. *Applied Optics*, Vol. 12, Issue 10, pp. 2472-2476 (1973) vol. 12 (10) pp. 2472-2476

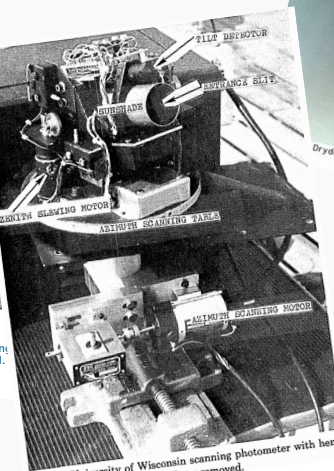


Fig. 1. University of Wisconsin scanning photometer with hemispheric dome removed.

Twitty et al. Aerosol size distributions: remote determination from air-borne measurements of the solar aureole. *Appl. Opt.* (1976) vol. 15 (4) pp. 980-989



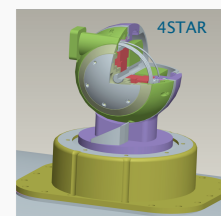
Fig. 1. Radiometer mounting on X-15 body.

Band and Block, Spectral Radiance Measurements of the Earth from High Altitudes. *Appl. Opt.* (1965) vol. 4 (3) pp. 355-358

Observation Pattern

	Sun Tracking	Sky Scanning
Atmospheric parameters	Atmospheric Transmittance	Scattering phase function
	Aerosol Optical Depth	Asymmetry parameter
	Ångstrom exponent	Aerosol size distributions
	Aerosol Extinction	Aerosol sphericity
	H ₂ O & O ₃	Aerosol absorption
		Cloud optical properties

Sensors	NASA AATS-14	
	NASA 4STAR	
	NERC HemiSpec	



Example of Airborne Sunphotometer



Jetstream-31 With NASA 14-Channel AATS (Ames Airborne Tracking Sunphotometer), ARM Climate Research Facility

Hemispheric Scan

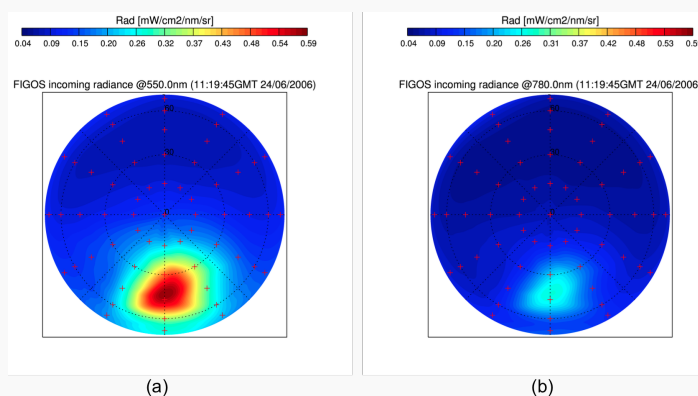
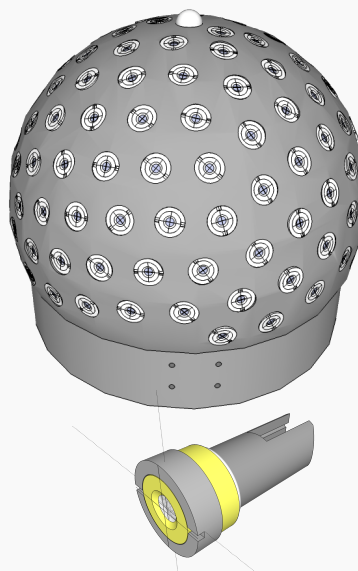


Figure 2 A polar plot of sky radiance distribution at 550nm (a) and 780nm (b). The data were acquired with the dual-view FIGOS in Gilching (close to Airport Oberpfaffenhofen), Germany, during GonioExp '06, the Goniometer Campaign in collaboration of RSL, DLR and TU Munich. Courtesy of RSL, University of Zurich.

Hyperspectral Skydome

- Design highlights
 - No moving parts
 - Sampling rate ~ 1 second
 - Capable of maintaining consistent output at $< 15^\circ$ angular tilt
 - Hyperspectral VNIR
- Components
 - DOM (Skydome)
 - NAP (Narrow Angle Probe)
 - WAP (Wide Angle Probe)
 - MCS (Multi-Channel Spectrometer)
 - AHRS (Attitude & Heading Reference System)

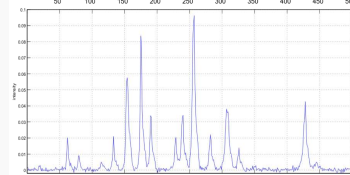
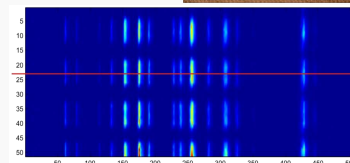
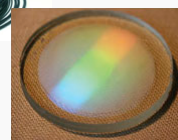


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Multi-Channel Spectrometer

- Transmission based volume phase holographic (VPH) transmission grating spectrometer
- Coupling with 144 optical fibre bundle, each of which has customised $60 \mu\text{m}$ core diameter
- VNIR between 470 and 915 nm
- Minimal cross talk between fibers

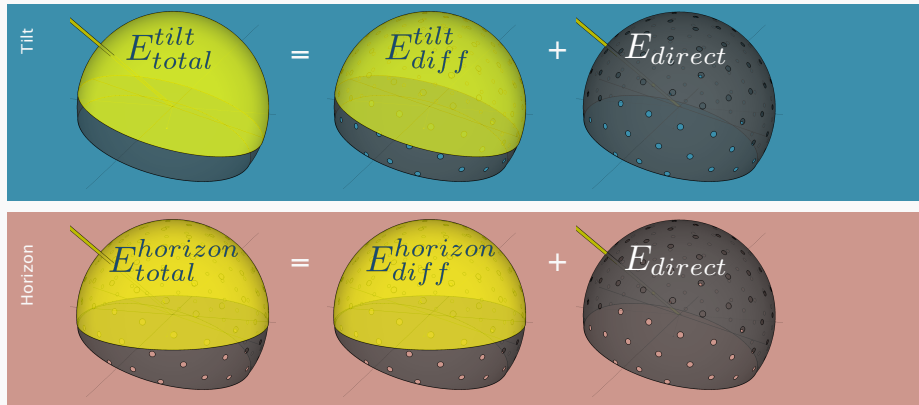


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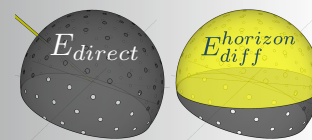
Processing Flow (Level2)

$$E_{total} = E_{diff} + E_{direct}$$

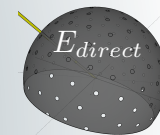


Processing Flow (Level3)

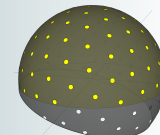
Direct-to-Diffuse Ratio



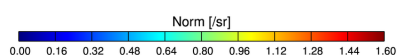
Aerosol Optical Depth & Extinction



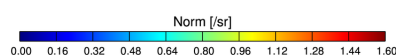
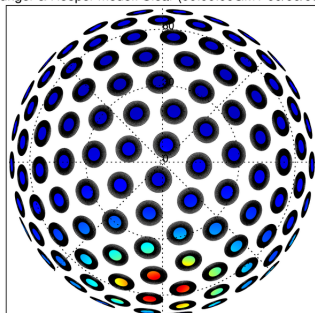
Aerosol & Cloud Properties



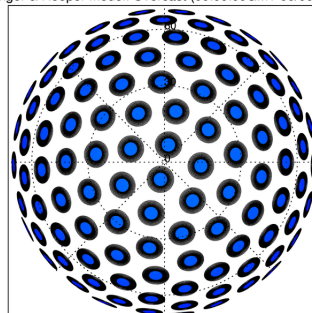
Radiometric Sensitivity



Brunger & Hooper model: Clear (00:00:00GMT 00/00/0000)



Brunger & Hooper model: Overcast (00:00:00GMT 00/00/0000)



Challenges

- Mechanical & optical tolerance of NAP, WAP and DOM
(Off-axis error $<\pm 0.5^\circ$ introduces up to 2% measurement uncertainty)
- Radiometric and spectral calibration within <3%
- Spherical integral of x143 NAP over the skydome
- WAP diffuser design with known angular response
- With radiative transfer model SCIATRAN, sensor model verifies retrieval algorithms, as well as uncertainty layer.

Plans ahead

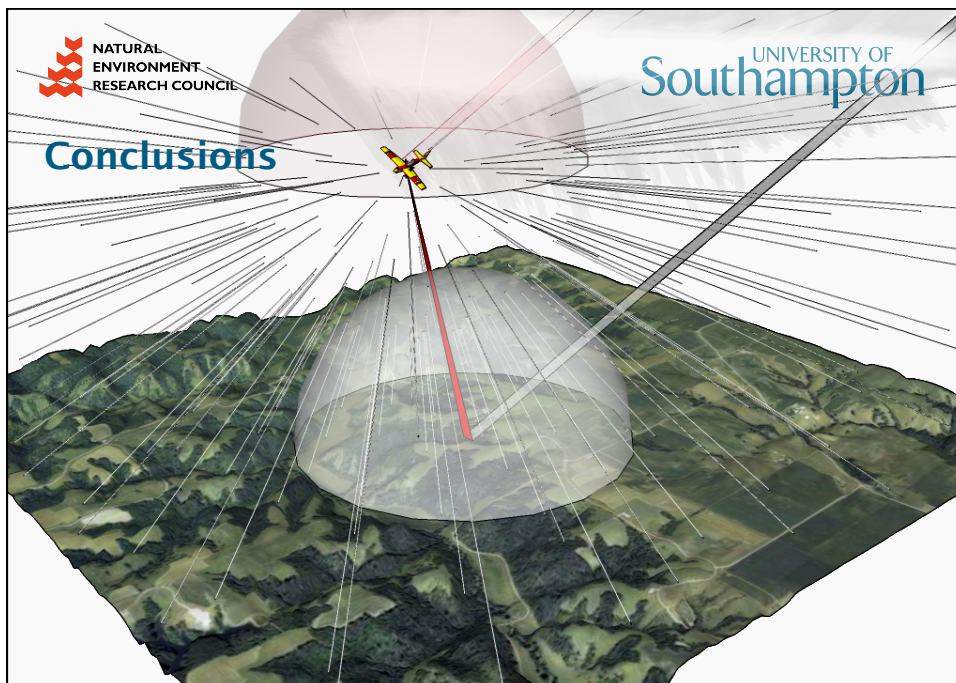
■ Technical

- Finalising manufacturing the prototype system (Oct 2011)
- System characterisation & quality control (Nov 2011)
- Acceptance test & laboratory calibration (Dec 2011)

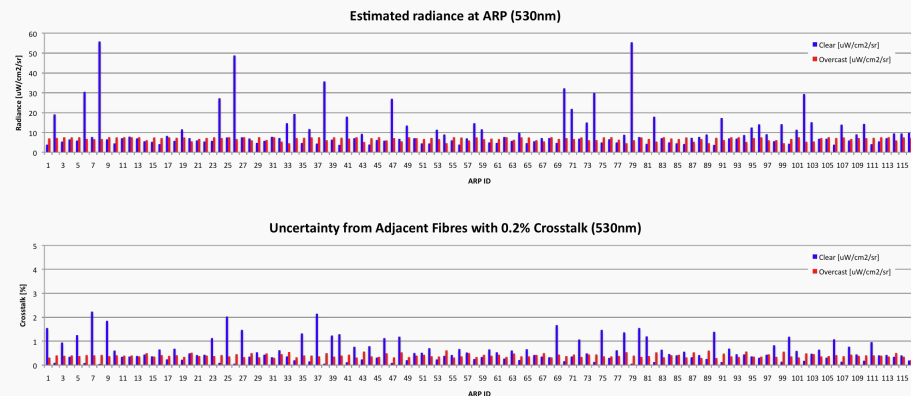
■ Scientific

- Radiative transfer model, i.e. SCIATRAN (Sep-Dec 2011)
- Field test with AERONET sunphotometer (Jan 2012)
- Field test on a motion platform (Feb 2012)
- Field test for other potential applications (Mar 2012)

Conclusions



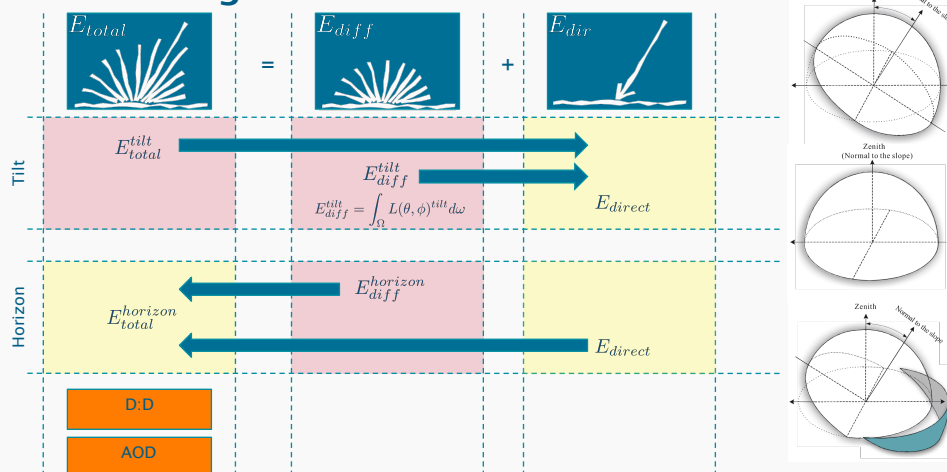
Radiometric Sensitivity



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Processing Flow



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