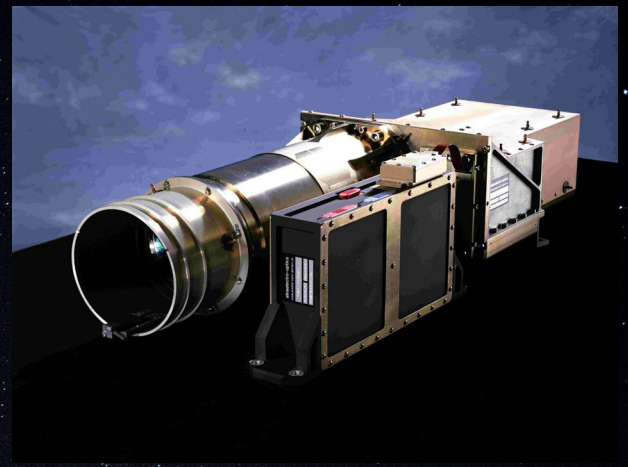
SURREY

DOING SPACE DIFFERENTLY



CHRIS

Conception to Operational Mission

Dr Mike Cutter

Contents

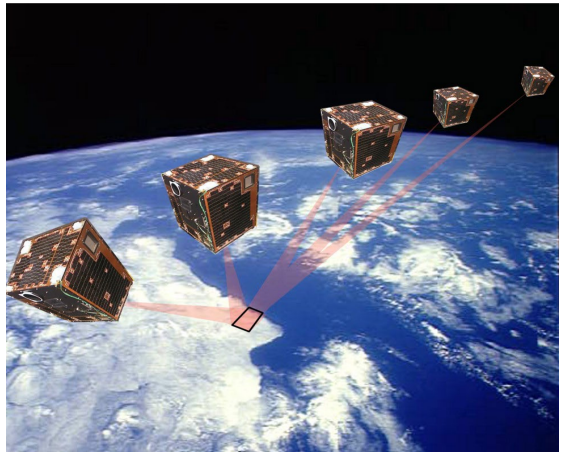
- Background
- CHRIS Overview
- Calibration Considerations
- Operational Programme
- Application Snapshots

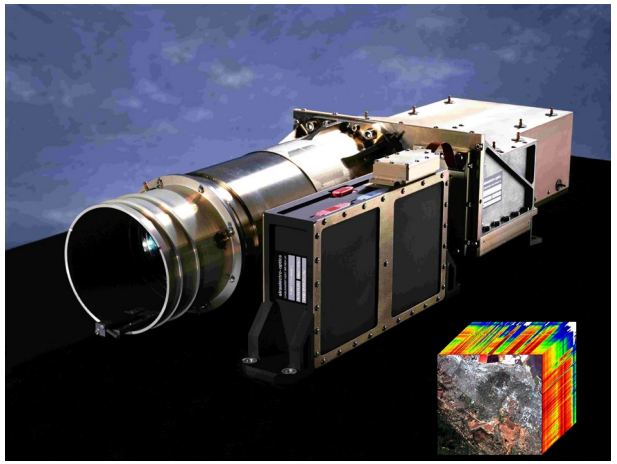
Background

- ESA studies (mid-1980s to mid-1990s)
  - Background studies: 2nd Gen Meteosat/MERIS/Spectra (EE)
  - Payload study for smallsat: potential test beds for advanced avionics.
- ESA PROBA Payload Announcement of Opportunity
  - AO issued in 1996 for the PROBA platform's principle payload.
  - Benefit: 18 month in-orbit technology demonstration.
- CHRIS Proposal submitted 1997
  - PIs: Mike Barnsley (Swansea Univ.) & Jeff Settle (ESSC, Reading Univ.)
  - Pushbroom image acquisition – more compact than multiple array soln.
  - Forward motion compensation (x5) reduces size of optics by x2.2
  - Required agile platform to achieve multi-angle imaging (no mechanisms)
  - Instrument budget £1.3M: provided from BNSC and company funds.

CHRIS Overview

- Observational Parameters
  - Hyper-spectral instrument (14kg, 8W, 790x260x200mm)
    - GSD: 17m (highest resolution of civil system in-orbit in 2001)
    - Swath width: 13km @ perigee
    - Spectral range: 400 to 1050nm
    - Spectral bands: ≤ 62 bands
    - Signal-to-noise ratio: 200 (@ 0.2 albedo, 17m, 10nm)
    - Programmable: spectral & spatial dimensions
  - PROBA-1 highly agile small platform (roll, pitch & yaw)
  - Multi-view angle observations of each target (+/- 55º, +/- 36º, 0º)

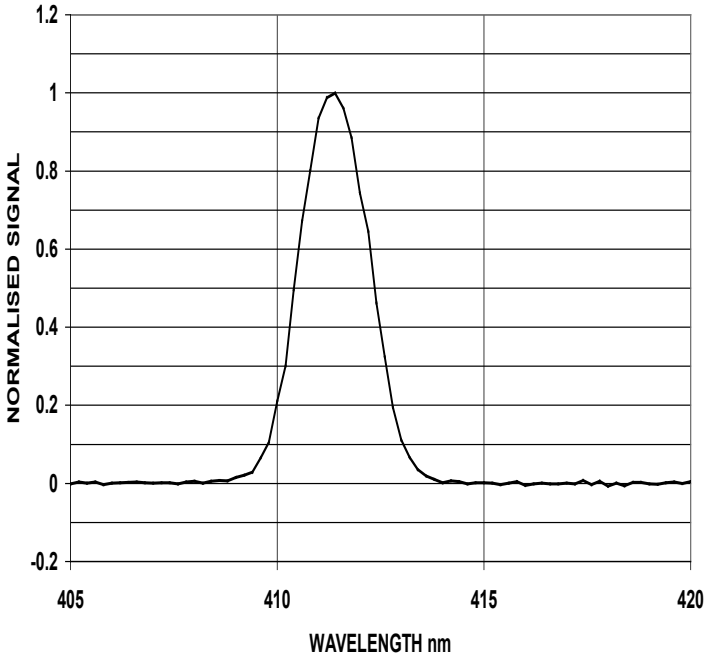


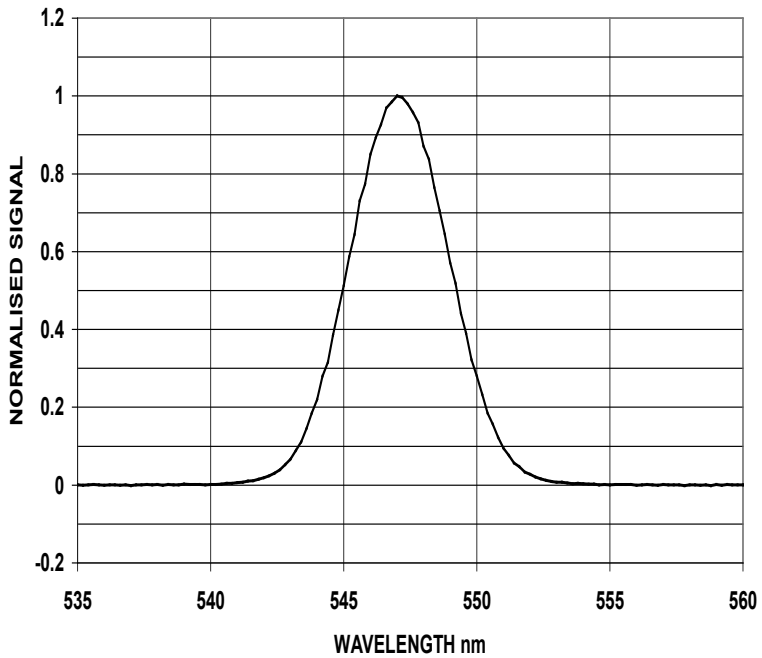


Calibration Considerations

- CHRIS – limited platform volume to add calibration hardware
  - Small solar calibration device: only samples partial aperture
  - On-board LEDs for testing electronic gain, linearity & saturation in-orbit.
- Pre-launch calibration included:
  - Absolute spectral response (NPL)
  - Spectral & spatial resolution
  - Linearity & saturation
  - Wavelength calibration
  - Relative electronic gains (1,2,4,8)
- Post-launch
  - Wavelength calib.: O_2 (762nm) absorption line & Fraunhofer line (430nm)

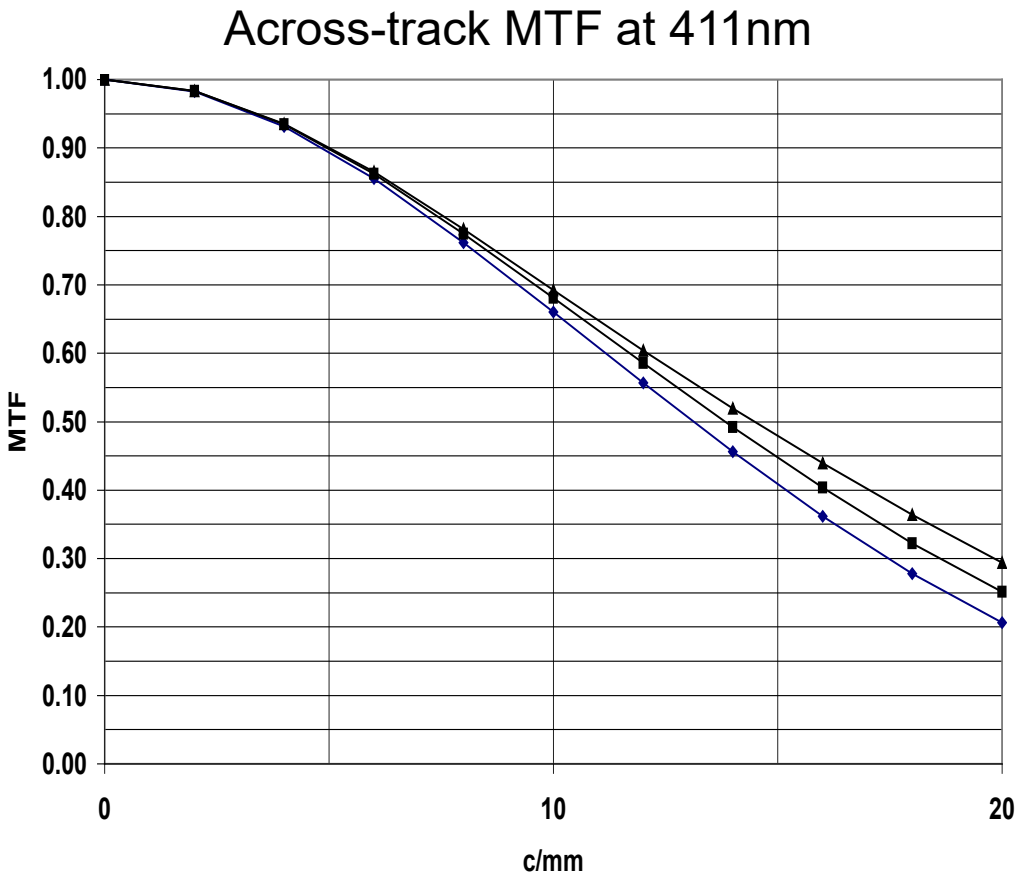
Spectral Resolution

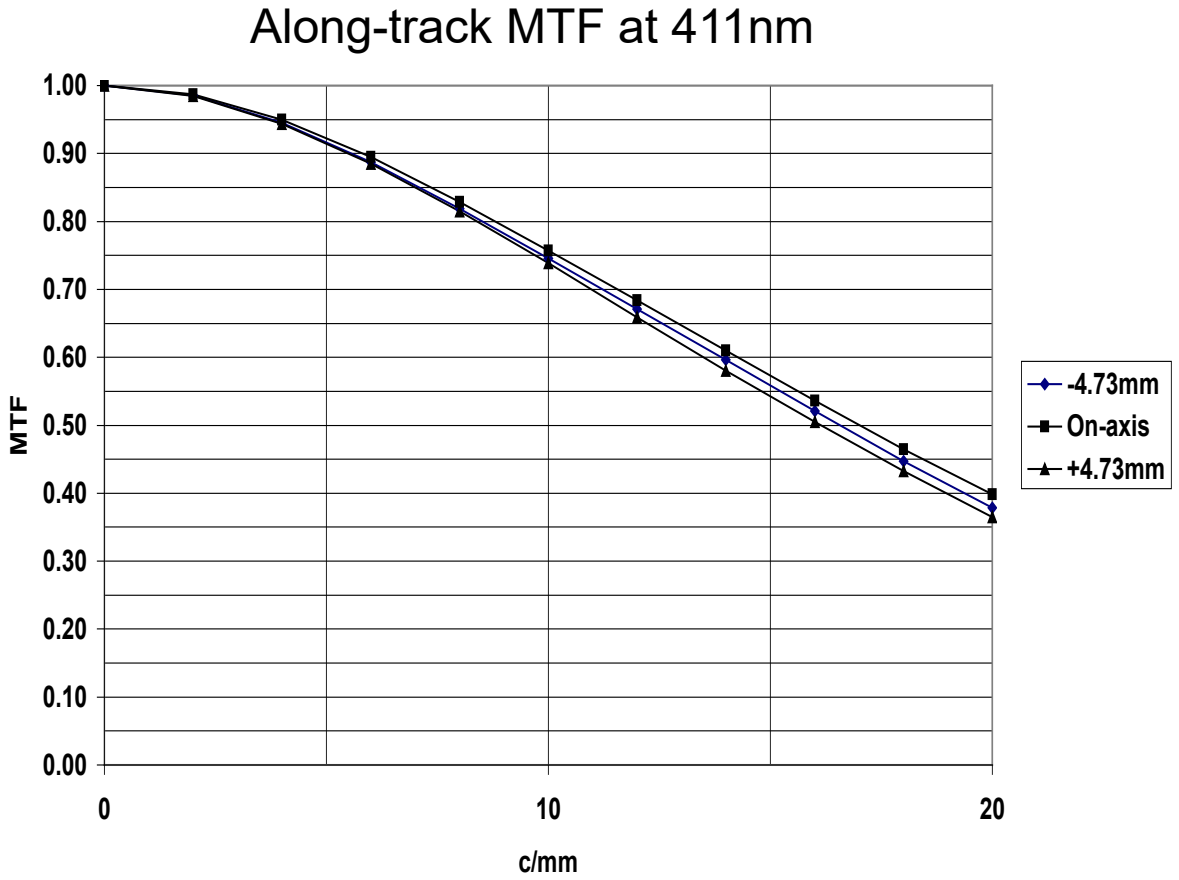




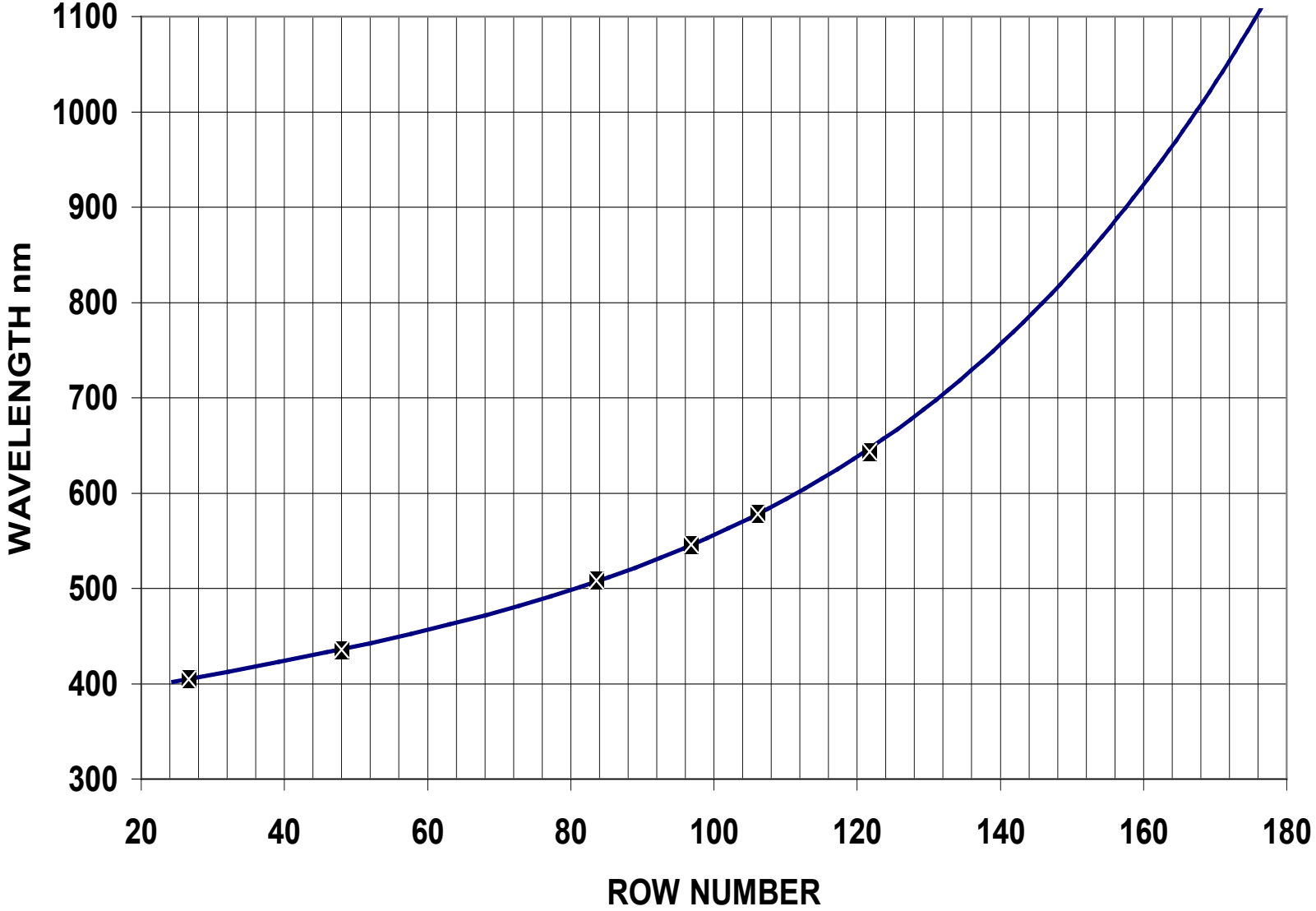
WAVELENGTH	FWHM
411 nm	1.99 nm
547 nm	4.33 nm
900 nm	10.86 nm

Modulation Transfer Function (MTF)





Wavelength Calibration



Instrument Build => Operational Programme

- CHRIS capable of producing 10 images/day (24/7) **but** had only 2 PIs
- 1998/9: CHRIS was in final build phase: urgent need to increase user community and crucially formulate **vicarious calibration campaigns**.
- 1999: with BNSC/ESA support a data exploitation AO issued
- 2001 PROBA successful launched, followed by commissioning phase.
- 2003: 1st CHRIS Workshop held at ESTEC - established 3 user groups:
  - Land (Mike Barnsley), Atmos. (Jeff Settle) & Marine (Sam Lavender)
- Major increase in PIs led to need for: image prioritisation, streamlined data access & archiving (ESRIN) and preparation of “Data format document”. Furthermore, Kiruna ground station added to increase data access.
- Further workshops: ESRIN (2004 – 2006, 2010) & Tel Aviv (2009) and the rest is history.

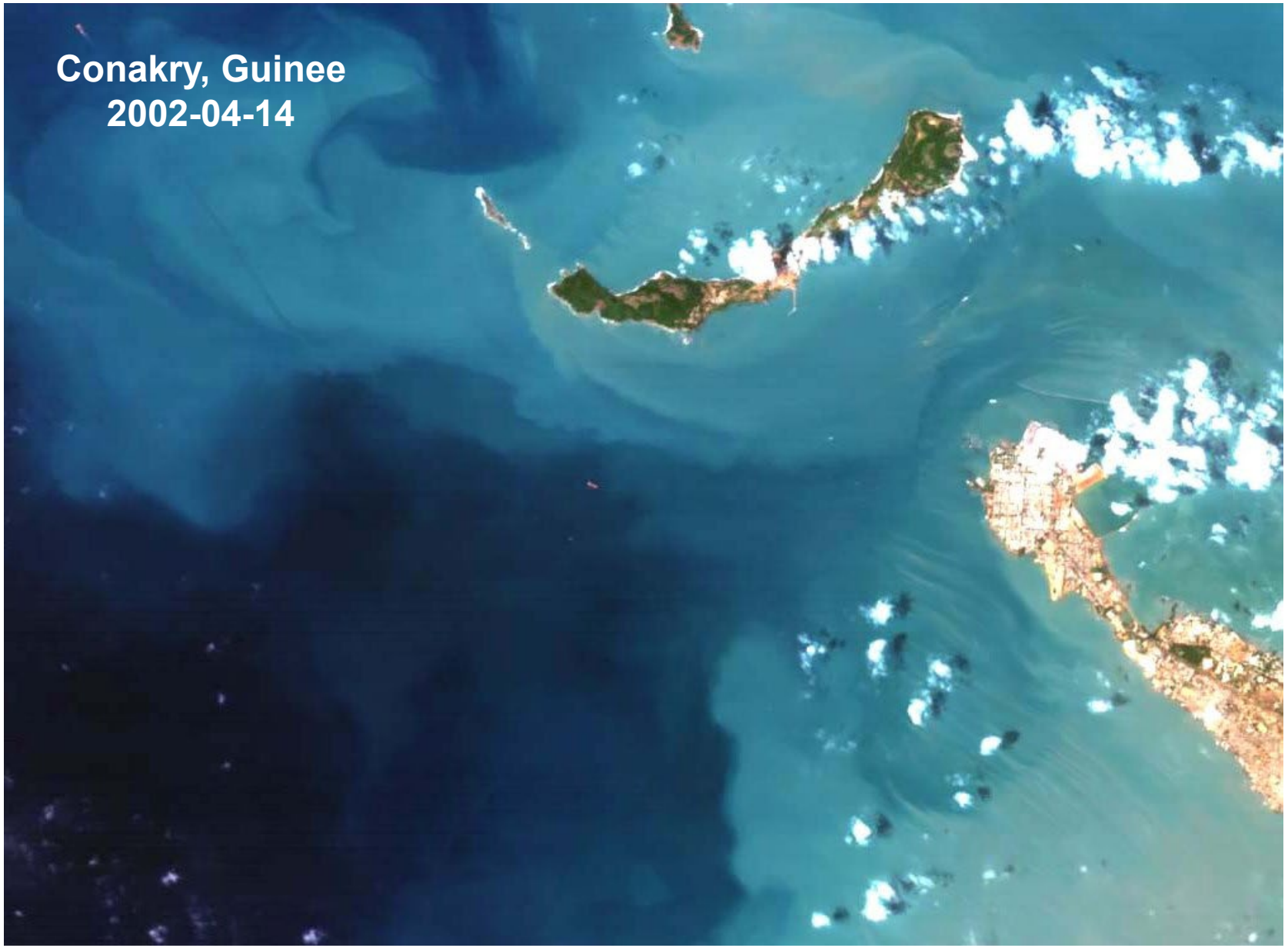
CHRIS Imaging Modes

Programmed modes

Mode	No. of bands	GSD (m)	Swath Width	Applications
1	62	34	Full	Aerosols
2	18	17	Full	Water
3	18	17	Full	Land
4	18	17	Full	Chlorophyll
5	37	17	Half	Land

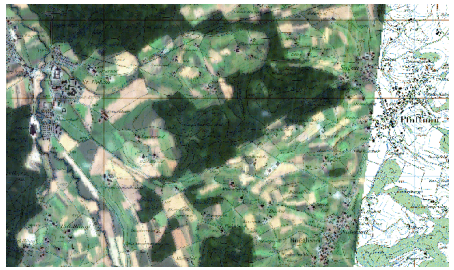
With only 2 PIs it would have been feasible to keep band selection flexible but with 100 + PIs it became essential to established "fixed" bands as detailed in the "Data Format Document".

Application Snapshots

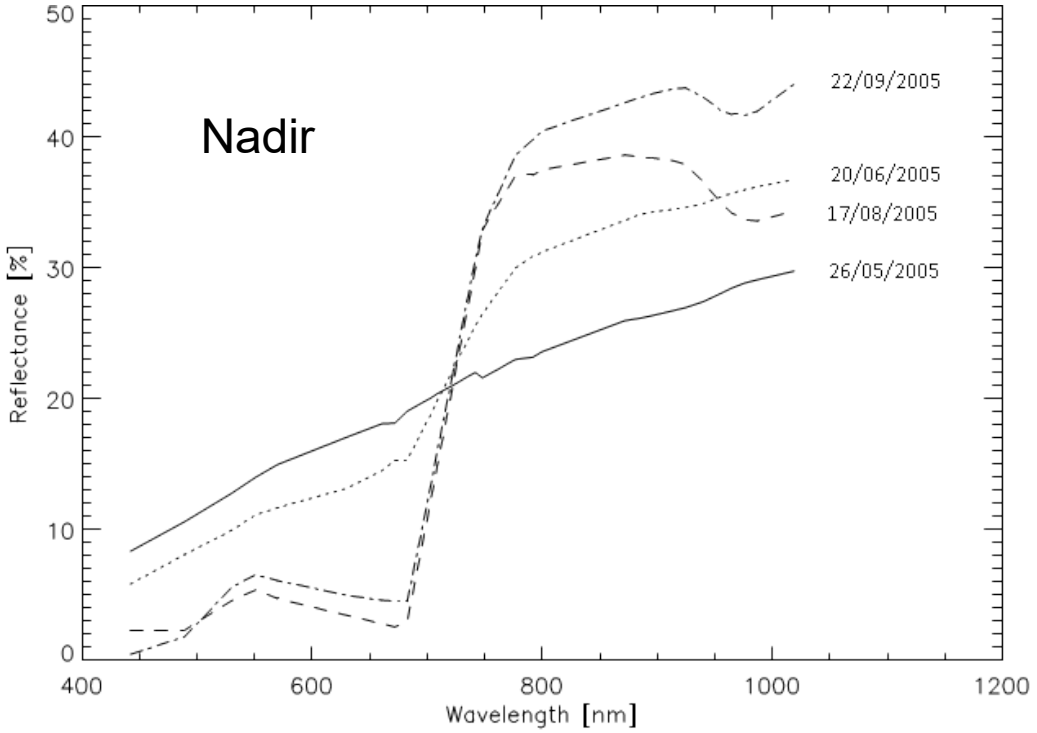


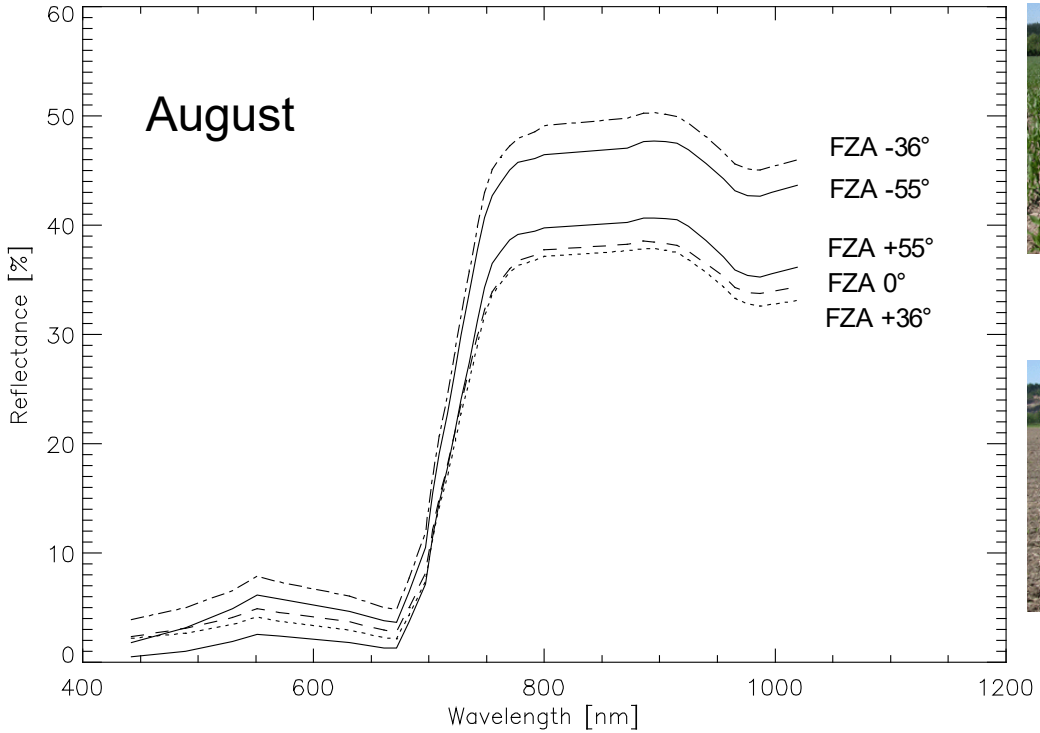
Temporal & Angular Canopy Reflectance

CHRIS reflectance from maize



August 2006



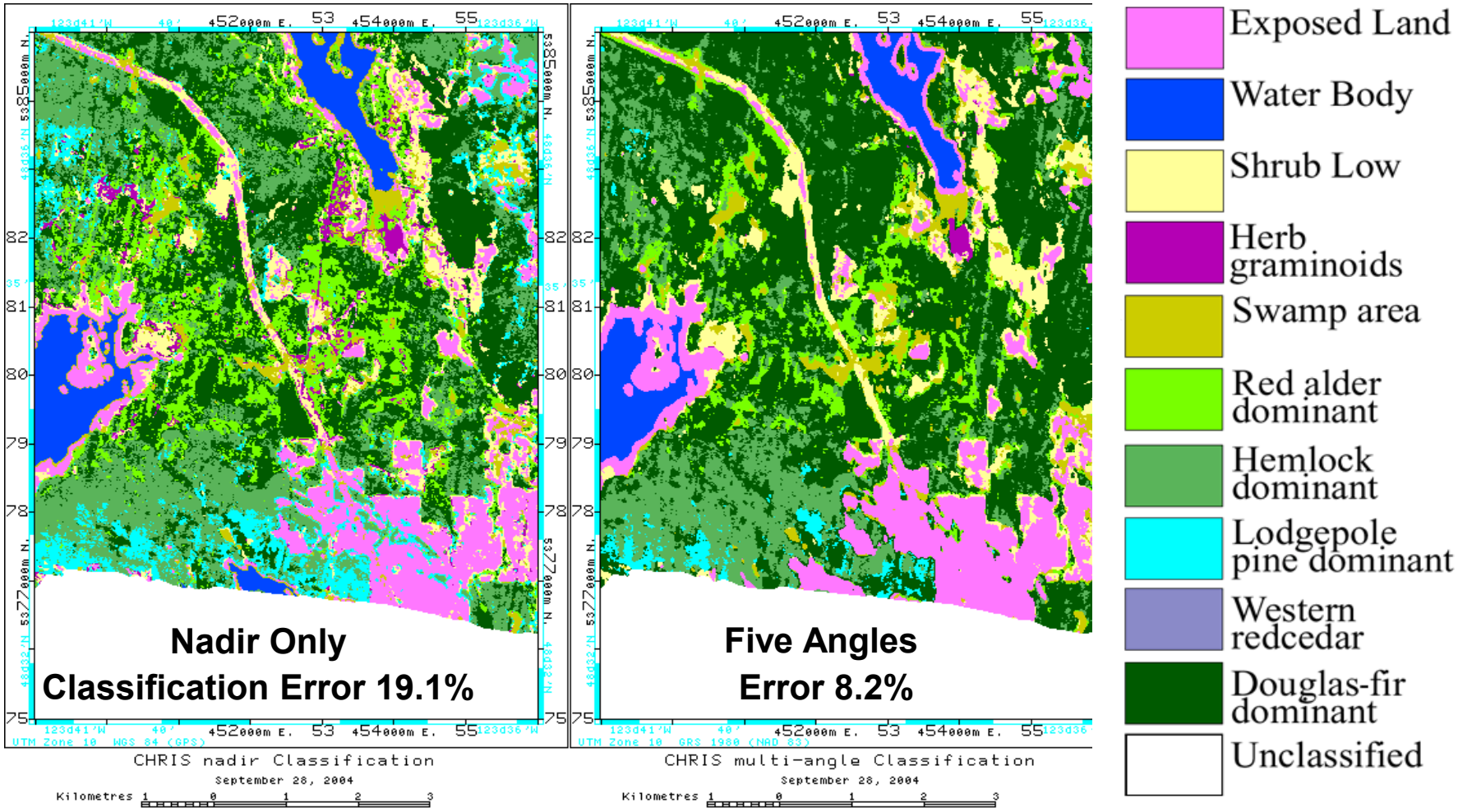


June 2006

May 2006

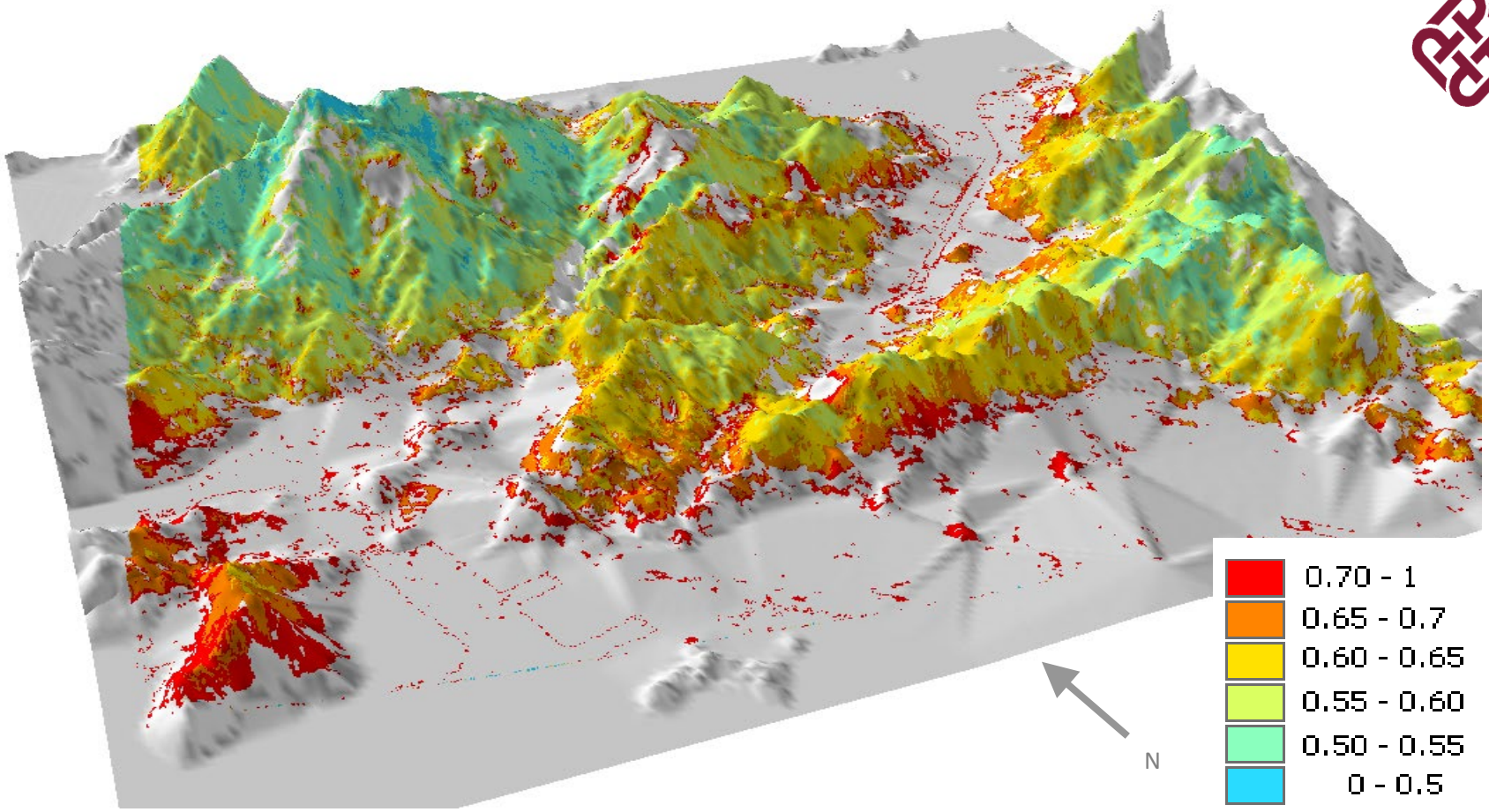
Source: Mathias Kneubühler et al, RSL, Univ. Zürich, Switzerland

Classification results in Canada



Courtesy of David Goodenough & Andrew Dyk, Natural Resources Canada (NRC), Canada

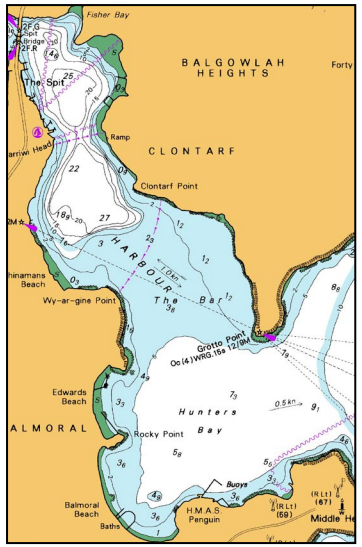
Atmospheric Measurements - Kowloon

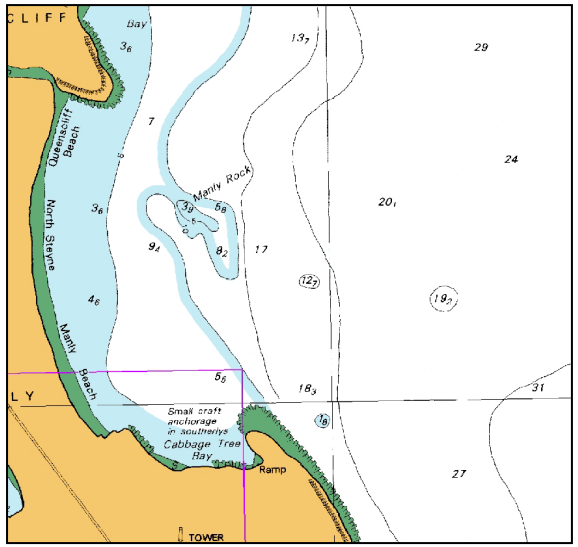


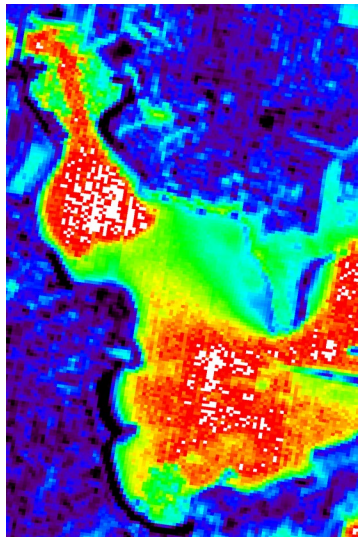
AOT (Aerosol Optical Thickness) image draped over DEM of CHRIS image area looking NNE, from the flat, urbanized Kowloon Peninsula over the mountainous New Territories. AOT determined using a modified MODIS Dense Dark Vegetation (DDV) algorithm using bands at 490nm, 661nm and 1019nm bands

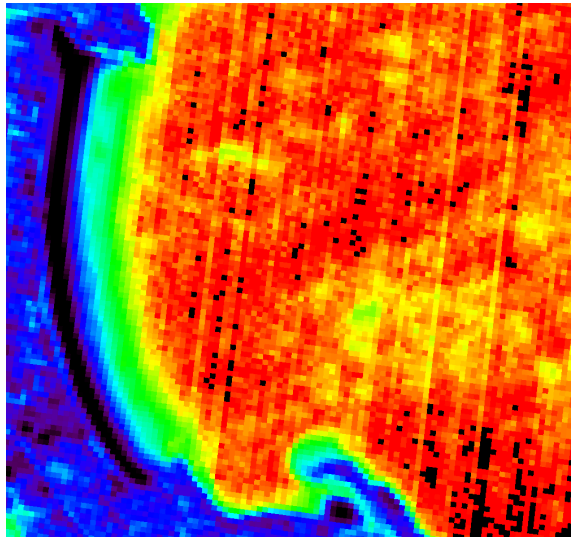
Courtesy of Janet Nicol, Polytechnic University, Hong Kong

Bathymetric mapping in turbid waters



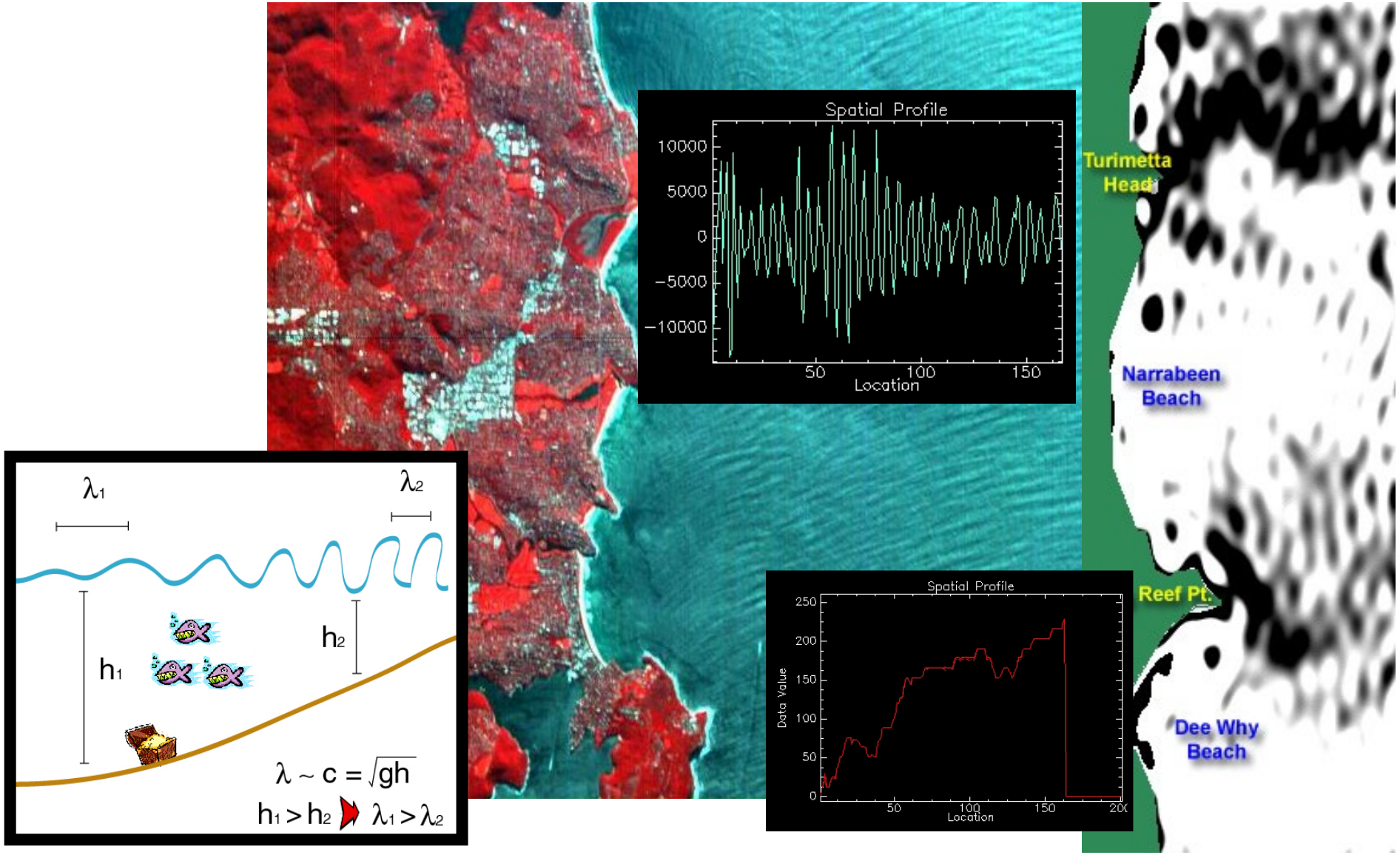






Courtesy of Ray Merton, University of New South Wales, Australia

Bathymetric mapping in turbid waters



Courtesy of Ray Merton & Scott Rowe, University of New South Wales, Australia

Multiple Thanks

- Funding source (UKSA (formerly BNSC))
  - Steve Briggs/David Leadbeater/Mark Churchyard
- Principle Investigators
  - Mike Barnsley/Jeff Settle/Sam Lavender/Luis Guanter/Heike Bach/Ray Merton + +
- Platform Engineering & Operations (ESTEC/ESRIN/Verhaert)
  - Richard Creasey/Frederic Teston/Pierrick Vuilleumier/Jean Loup-Bezy/Steven Delwart/Dirk Bernaerts/Etienne Tilmans/Christain Baijot
- Programmatics/Data Archiving/Workshops (ESTEC/ESRIN/RSAC)
  - Evert Attema/Malcolm Davidson/Bianca Hoersch/Roberto Biasutti/Mike Wooding/Peter Fletcher/Tim Pearson
- Data Processing (SSTL/DMC/Airbus)
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- Instrument (SSTL (Sira Technology Ltd))
  - Dan Lobb/Mark Skipper/Trevor Woods/Gordon Hopkinson/Bob Cockshott

Thank You!

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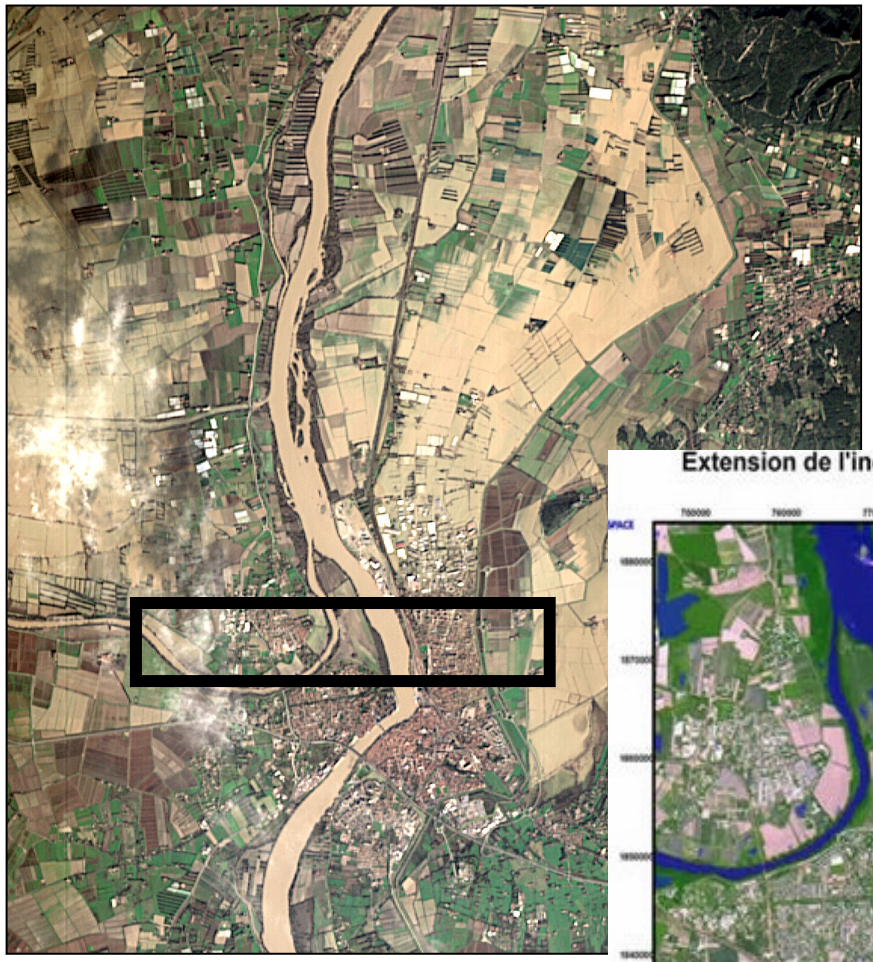
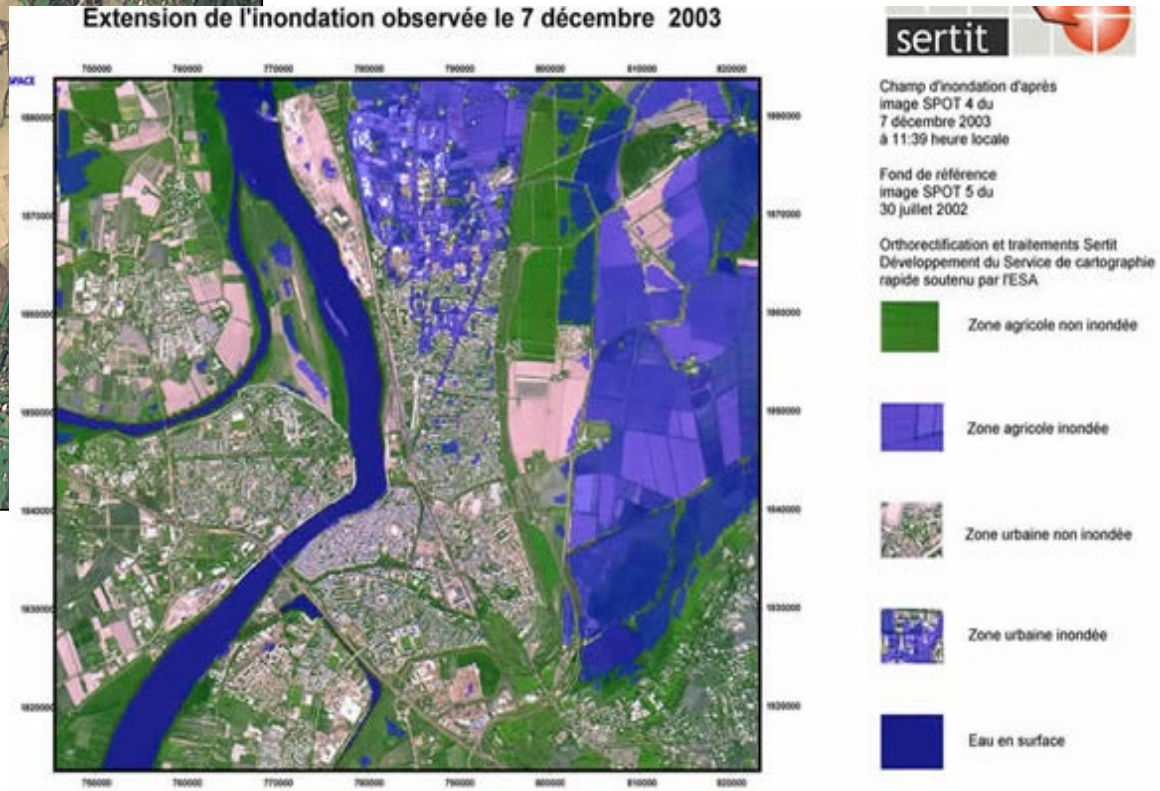
Disaster management - Floods



7 Dec. 2003
Arles (France) Floodings

Since end 2003: Image provider for International Charter

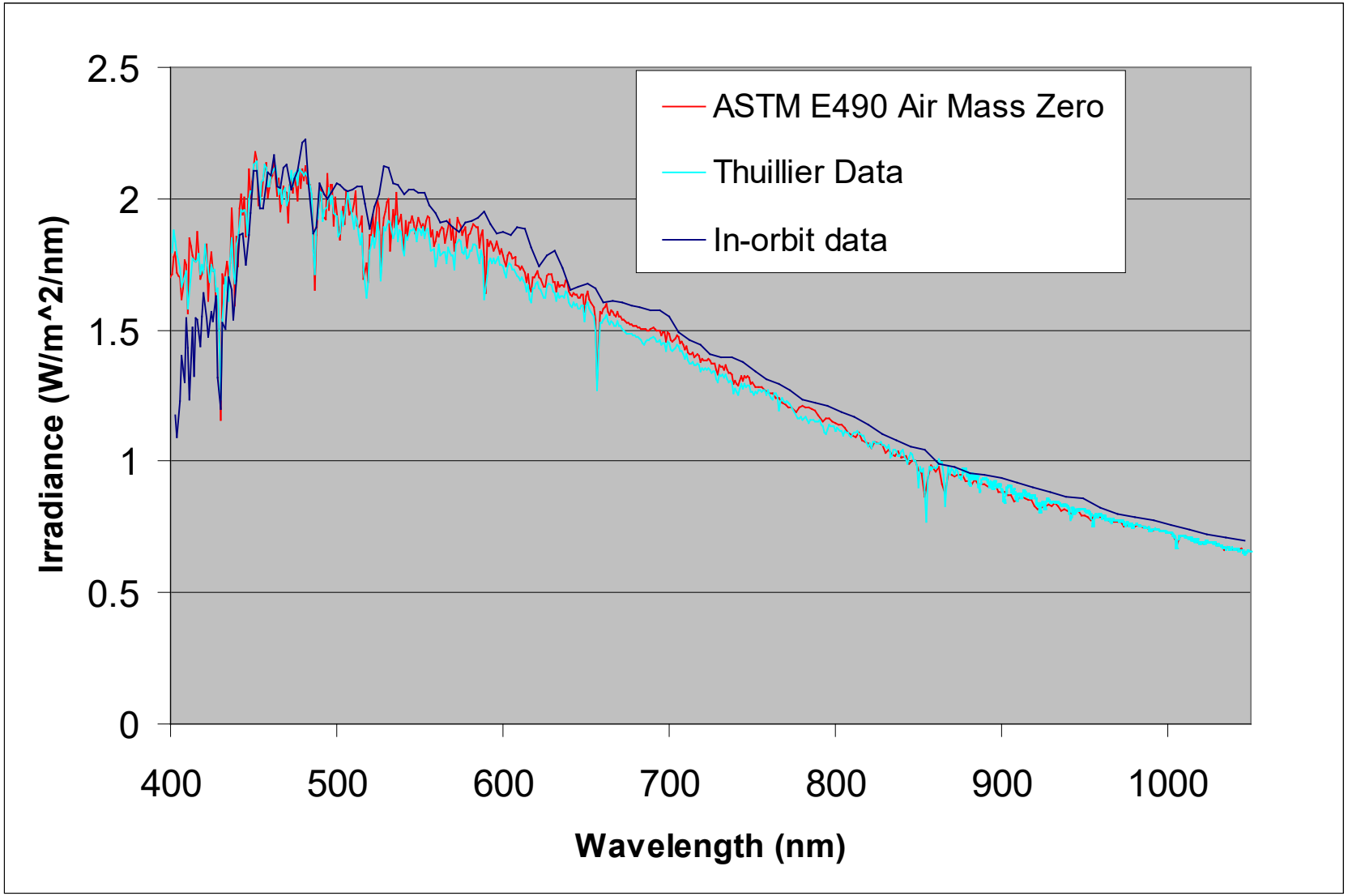
International Charter Space and Major Disasters



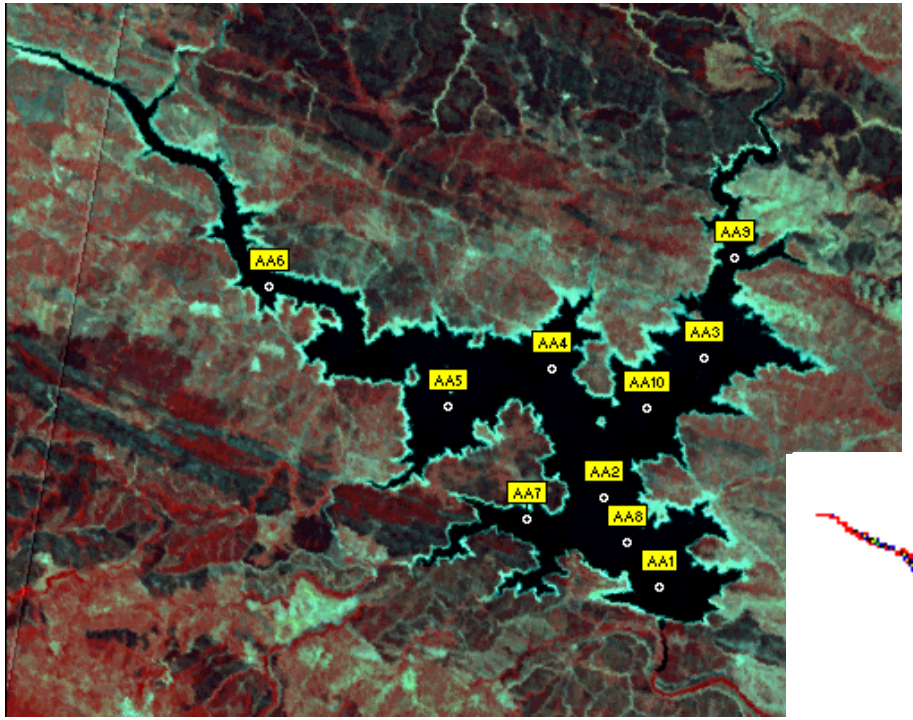
Other Results

- Spatial registration (frown)
  - < +/- 0.1 pixel, no measurable change seen with 10˚ C change in temperature.
- Spectral registration (smile)
  - +/- 0.01 pixel, no measurable change seen with 10˚ C change in temperature.
- Out-of-band stray light
  - < 0.1% of the average CCD signal
- Noise
  - < 70 electrons (rms)
- Dark signal
  - <50 electrons @ 0ºC
  - 300 electrons @ 20ºC

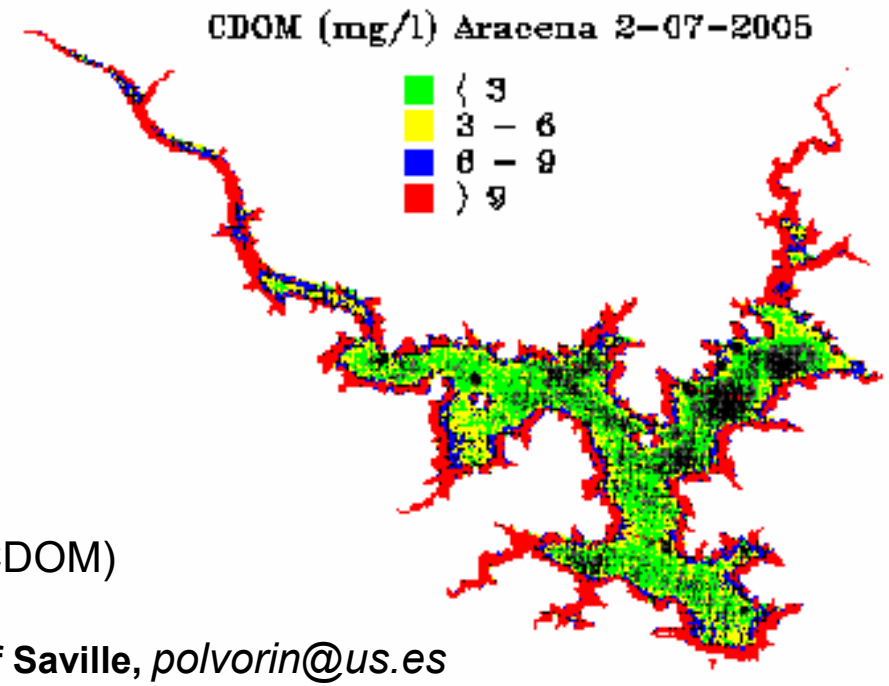
In-Orbit Solar Measurement



Inland Water Quality Assessment



Aracena Dam, Spain



- Chlorophyll-a
- Total suspended solids (TSS)
- Turbidty
- Coloured dissolved organic matter (CDOM)

Courtesy: A. Polvorinos, University of Saville, *polvorin@us.es*