CEOS IVOS Sub-group
(Infrared, Visible and Optical Sensors)

Report to CEOS WGCV 31

Chair: Nigel Fox
National Physical Laboratory
UK

with support from BNSC

IVOS

IVOS MISSION statement

Mission

“To ensure high quality calibration and validation of infrared and visible optical data from Earth observation satellites and validation of higher level products”

IVOS Terms of Reference

1. **Promote international and national collaboration in the calibration and validation of all IVOS member sensors.**

2. **Address all sensors (ground based, airborne, and satellite) for which there is a direct link to the calibration and validation of satellite sensors;**

3. **Identify and agree on calibration and validation requirements and standard specifications for IVOS members;**

4. **Identify test sites and encourage continuing observations and inter-comparison of data from these sites;**

5. **Encourage the preservation, unencumbered and timely release of data relating to calibration and validation activities including details of pre-launch and in flight parameters.**

Workplan/operational mechanisms

- **Meetings at least annual (nominally 9 monthly)**
  (email members ~ 50, attendees (15 to 30)
- **Key Activities**
  - **Information exchange**
    - Pre-flight and post-launch
  - **Focus on developing and addressing GEO task DA 09-01-a (former DA06-02)**
    (***Data Quality Assurance strategy***)
    - Cal/val portal (for communication)
    - Establish cal/val "best practises"
    - Comparisons to underpin (Terrestrial and Space)
    - Identification and classification of "test sites" for sensor performance evaluation
    - Benchmark missions
    - "operational cal/val"
  - **Prioritise activities to focus on needs e.g. "Land surface imager constellation"**
    - Now extending to Ocean colour constellation as well
    - Land and Ocean surface temperature

Operational Structure

- Agency reports bi-annually (3 day meetings)
- Theme Champions
  - Test sites Chander/Goryl
  - Portal Goryl
  - Surface temperature Corlett
  - Atmospheric Corrn Thome
-
- IVOS as Conduit for existing "community expert groups"
  - Need to increase engagement
- Serving Cal/val needs of constellations
  - Comparisons
  - Need recognition/promotion

CEOS IVOS 21

Aug 11-13 2009, Lethbridge, Canada

Hosts: Professor Phil Teillet, University of Lethbridge

Attendees 23

increasing – driven by momentum in CEOS

CEOS IVOS 22, Pretoria, South Africa May 11-13 2009

Hosts: CSIR and DST

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IVOS 21:Meeting topics / work plan progress

- Organisation reports (new attendees)
- Pre-flight cal/val plans and strategy
- Post-launch
    - Reference standard test sites
        - Land
        - Water
        - Ocean colour
- Land/Sea surface temperature
- QA4EO
    - Comparisons
        - Brightness T, surf Reflect, Sat via Dome-C , RT codes
    - Best practises
    - Governance
    - Promotion
- New projects/activities

IVOS

CEOS “Reference Standards” IVOS “test sites”
First priority

- Community need
  - Compile a list of consolidated worldwide Cal/Val test sites
  - Compile a appropriate subset of CEOS endorsed reference standards
- Gather complete site characterization data and information
  - Define core measurements (eg. Instruments)
  - Create an operational network of sites (eg., aeronet, Landnet)
- Encourage agencies to acquire, archive, and provide data to the Cal/Val community over CEOS reference standard test sites
  - Develop online calibration data access infrastructure
  - Create tools to identify the potential co-incident image pairs (NASA SEO)
- Establish traceability chain for primary site data & “best practice” guidance on site characterization and its use
- Mechanism for long-term maintenance for all CEOS community

CEOS "Reference Standards" IVOS "test sites"

Comparison to (or with) provides quantitative evidence of traceability

Lead: Gyanesh Chander (USGS)

KEY CHARACTERISTICS

- **Well defined (fit for purpose) to suit application, with documented traceable knowledge of key characteristics**
- **Used with an agreed method**
- **Where appropriate traceable to SI**
- **Can in principle be "intrinsic" in nature (as part of the method) e.g. Rayleigh scattering**
- **Can provide cal/val information directly or facilitate transfer**
- **Internationally agreed**
- **Evidence of stability for typical duration of use (for application)**
- **Does not have to be an artifact**

1st priority: land radiometric gain (value/stability)

CEOS Reference Standard Test Sites

Remote Sensing Technologies - Satellite

CEOS Reference Sites

A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

Content

Choose A Radiometric Site

I. CEOS Reference Standard Test Sites

II. Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

1. Dome C, Antarctica
2. Dunhuang, China, Asia (POC reviewed)
3. Lspec Frenchman Flat, NV, USA, North America
4. Ivanpah, NV/CA, USA, North America
5. La Crau, France, Europe
6. Negev, Southern Israel, Asia (POC reviewed)
7. Railroad Valley Playa, NV, USA, North America
8. Tuz Golu, Central Anatolia, Turkey, Asia (POC reviewed)

Home

Test Site Gallery

Radiometry Sites

Geometry Sites

CEOS Reference Sites

Acronyms

References

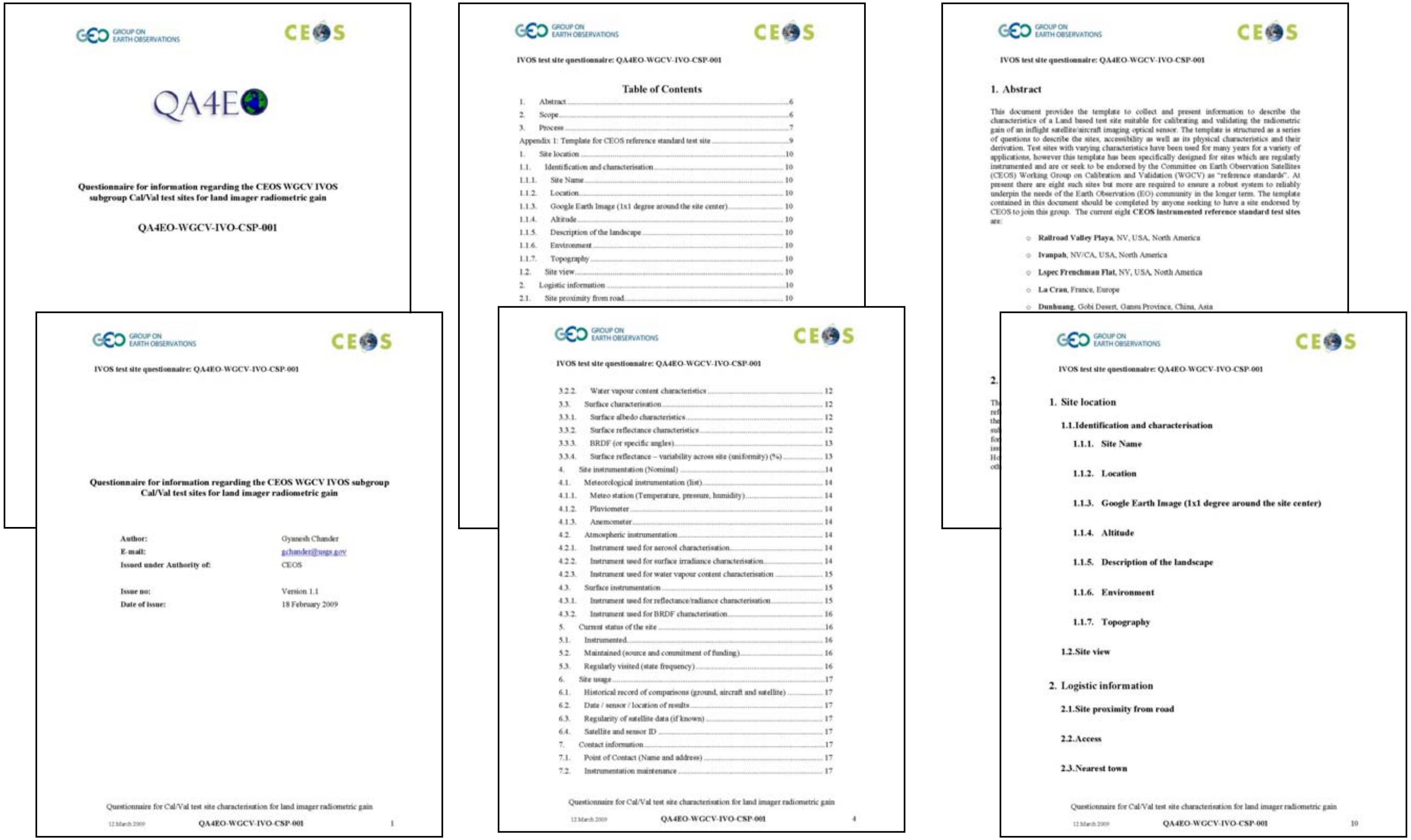
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

CEOS WGCV:IVOS "instrumented sites" (LandNet)

Reference stds for radiometric gain (land imagers) Ideally Need Ten!

- **Standardised procedures to aid characterisation (and for new sites)**
- **Comparisons of "field measurement" techniques to ensure consistency**

Questionnaire for Information Regarding the Cal/Val Test Sites



QA4EO

Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

QA4EO-WGCV-IVO-CSP-001

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Table of Contents

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

1. Abstract

This document provides the template to collect and present information to describe the characteristics of a Land based test site suitable for calibrating and validating the radiometric gain of an inflight satellite/aircraft imaging optical sensor. The template is structured as a series of questions to describe the sites, accessibility as well as its physical characteristics and their derivation. Test sites with varying characteristics have been used for many years for a variety of applications, however this template has been specifically designed for sites which are regularly instrumented and are or seek to be endorsed by the Committee on Earth Observation Satellites (CEOS) Working Group on Calibration and Validation (WGCV) as "reference standards". At present there are eight such sites but more are required to ensure a robust system to reliably underpin the needs of the Earth Observation (EO) community in the longer term. The template contained in this document should be completed by anyone seeking to have a site endorsed by CEOS to join this group. The current eight CEOS instrumented reference standard test sites are:

- Railroad Valley Playa, NV, USA, North America
- Ivanpah, NV/CA, USA, North America
- Lspec Frenchman Flat, NV, USA, North America
- La Crau, France, Europe
- Dunhuang, Gobi Desert, Gansu Province, China, Asia

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Questionnaire for information regarding the CEOS WGCV IVOS subgroup Cal/Val test sites for land imager radiometric gain

Author:	Gyanesh Chander
E-mail:	gchander@usgs.gov
Issued under Authority of:	CEOS
Issue no:	Version 1.1
Date of issue:	18 February 2009

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain
12 March 2009 QA4EO-WGCV-IVO-CSP-001 1

IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain
12 March 2009 QA4EO-WGCV-IVO-CSP-001 4

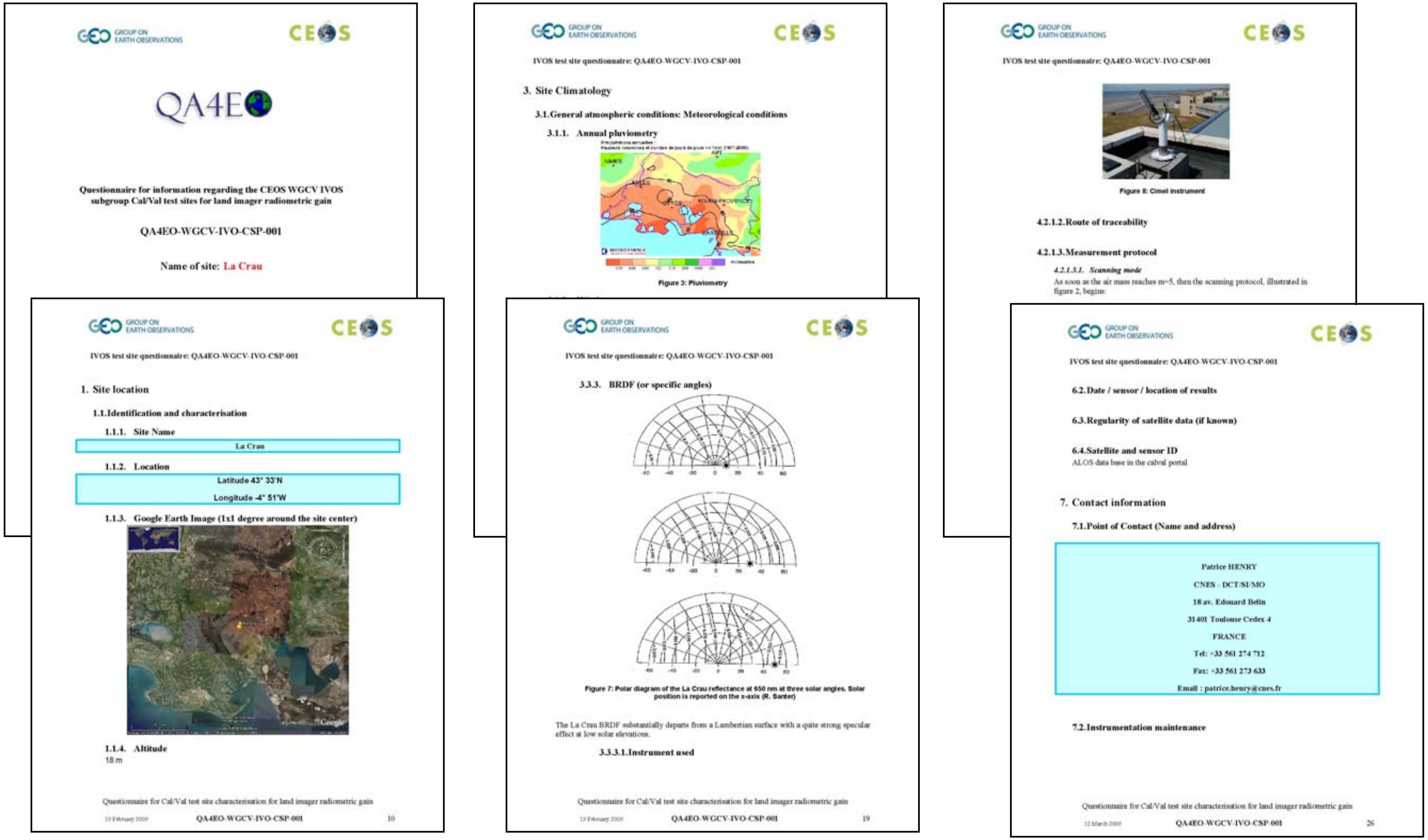
IVOS test site questionnaire: QA4EO-WGCV-IVO-CSP-001

1. Site location
1.1. Identification and characterisation
1.1.1. Site Name
1.1.2. Location
1.1.3. Google Earth Image (1x1 degree around the site center)
1.1.4. Altitude
1.1.5. Description of the landscape
1.1.6. Environment
1.1.7. Topography
1.2. Site view
2. Logistic information
2.1. Site proximity from road
2.2. Access
2.3. Nearest town

Questionnaire for Cal/Val test site characterisation for land imager radiometric gain
12 March 2009 QA4EO-WGCV-IVO-CSP-001 10

A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

La Crau, France



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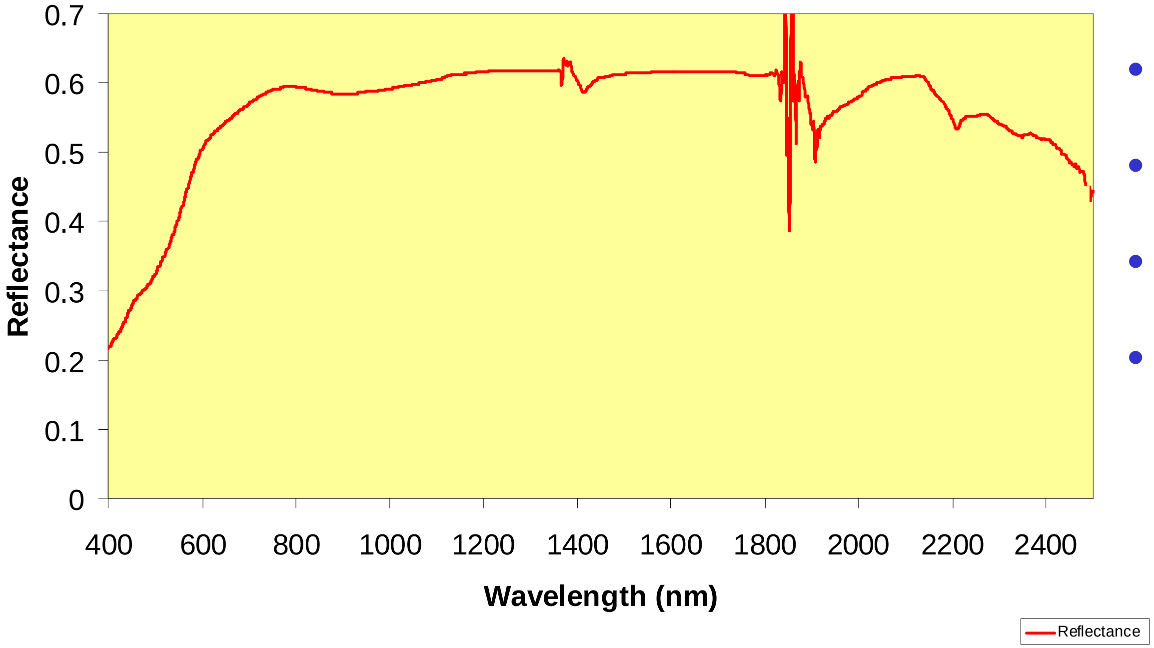
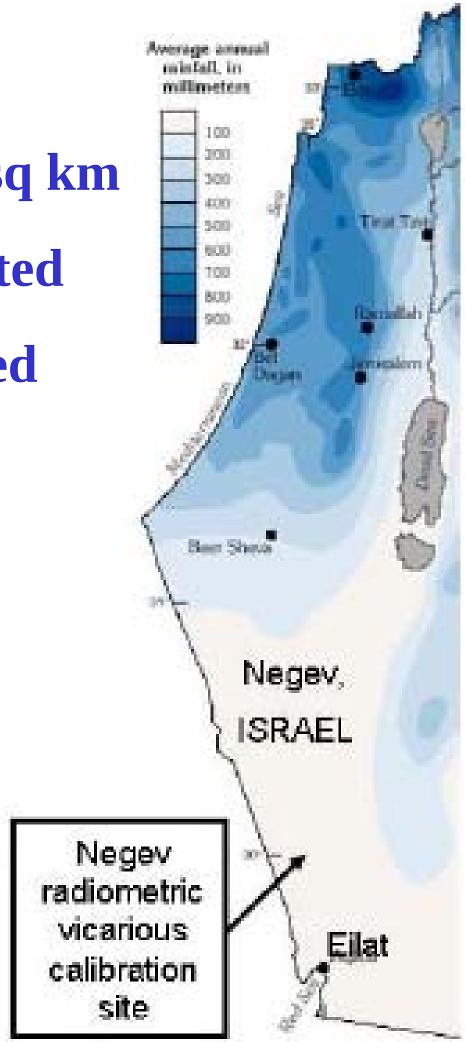
Negev Desert (Landnet site) Arnon Karnieli
Ben Gurion University Israel



- **Bright**
- **Small 0.2 sq km**
- **instrumented**
- **documented**



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CEOS WGCV IVOS: “stability” Reference standards

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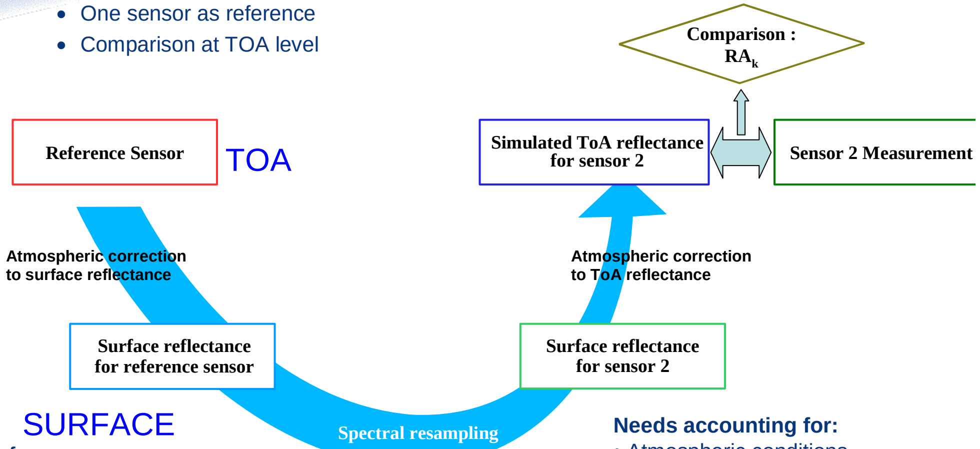
SADE data base: Cal/stability tool

Calibration Method Using Deserts Sites

- Compare two sensors :
  - One sensor as reference
  - Comparison at TOA level



Needs accounting for:
- Atmospheric conditions
- Spectral discrepancies
- Directional effects
  - Similar geometry of acquisition ($|\Delta\theta s|<2°$, $|\Delta\theta v|<2°$, $|\Delta\varphi|<5°$)

References
- GSICS/EP-1, Geneva, Oct 2006 (P.Henry)
- GSICS/GRWG-II, Darmstadt, June 2007 (P.Henry)
- GSICS/GRWG-III, Camps Spring, Feb 2008 (C.Tinel)

- CNES to provide open access to SADE
  - CEOS and GSICS
  - regular updated secondary dataset
- Sensors to be added by request
- ESA (IVOS) to link SADE and Landnet

IVOS

Opening the SADE databas

? References to previous presentations
- GSICS[1]/EP-1, Geneva, Oct 2006 (P.Henry)
- GSICS/GRWG-II, Darmstadt, June 2007 (P.Henry)
- GSICS/GRWG-III, Camps Spring, Feb 2008 (C.Tinel)
- GSICS/GRWG-IV, JMA Tokyo, Jan 28-30, 2009 (P.Henry)

? Database content : 3 levels
- Measurements (Visible and NIR)
  - Sensors : Polder1, Polder2, Parasol, SPOTs, SeaWiFS, VEGETATION 1&2, AVHRR, MERIS, MODIS, ...
  - Targets : Deserts, Ocean, Sun Glint, Clouds (DCC) and Snowy sites
  - Associated Meteo Data
- Elementary Calibration Results
- Vicarious Calibration Results

? Only desert measurements are used for intercalibration
- CNES proposes to provide access to desert data to GSICS members WEB interface
- Simple data format (ASCII, to be discussed)

1: Global Space-based Inter-Calibration Satellite to improve and harmonize data from operational weather satellites

Opening the SADE database (II

? Export measurements available on Desert sites (possibly Dôme-C)

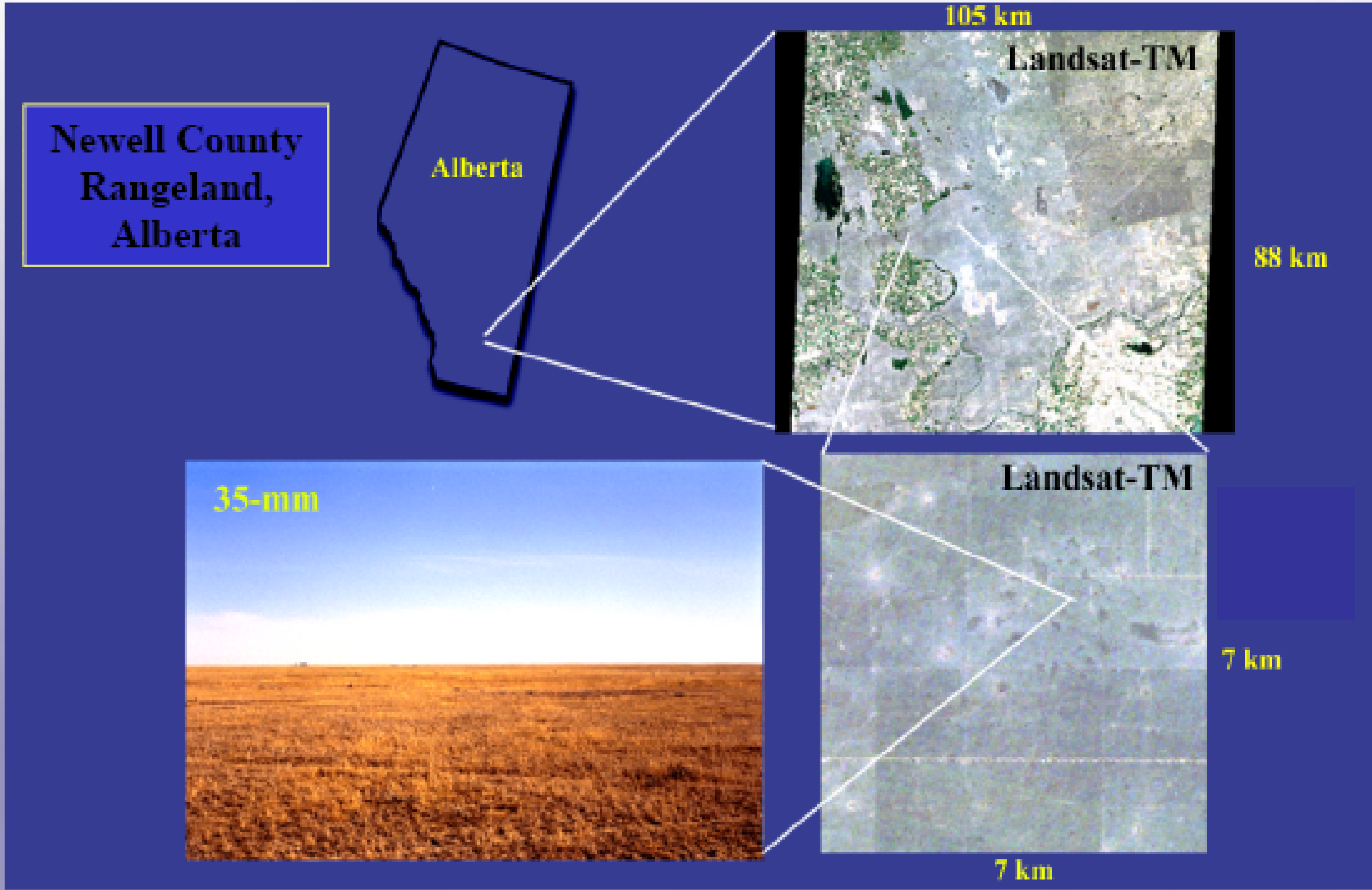
? Existing SADE export format

	Field Name	Unit
common to all bands	Area size	—
	Latitude	deg
	Longitude	deg
	Solar azimuth angle	deg
	Solar Zenith angle	deg
	Water Vapour content	g.cm-2
	Ozone content	cm.atm
	Surface Pressure	mbar
	Surface Wind Speed	m.s-1
	Aerosols	
	NO2	
	CHP1	
	CHP2	
	Date/time of the measurement	
	Product Reference	

+ Bands Characteristics

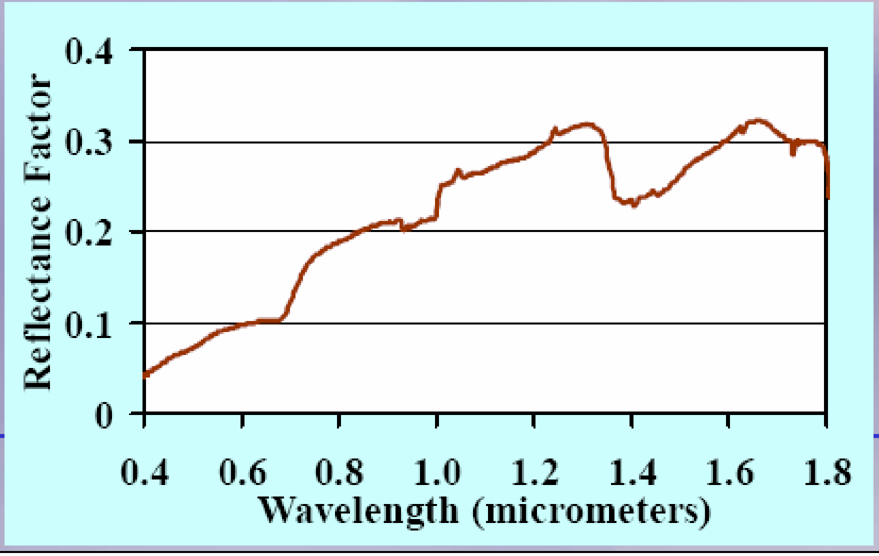
	Field Name	Unit
Band 1	Band Id	
	Measurement Id	
	Measurement value = average	
	Measurement std.dev.	
	Viewing azimuth angle	deg
	Viewing Zenith angle	deg
Band 2	Band Id	
	Measurement Id	
	Measurement value = average	
	Measurement std.dev.	
	Viewing azimuth angle	deg
	Viewing Zenith angle	deg
...	Band Id	
	Measurement Id	
	Measurement value = average	
	Measurement std.dev.	
	Viewing azimuth angle	deg
	Viewing Zenith angle	deg

Newell County Rangeland Alberta Test Site



Why Consider Rangeland?

- Newell County rangeland, Alberta (NCRA)
  - ➢Relatively uniform vegetation cover over large tracts of land
  - ➢Low-productivity dry mixed short-grass prairie
  - ➢Reflectance spectrum consistent with browner appearance
  - ➢Advantage: lower reflectances
  - ➢Disadvantage: likelihood of reflectance anisotropy effects



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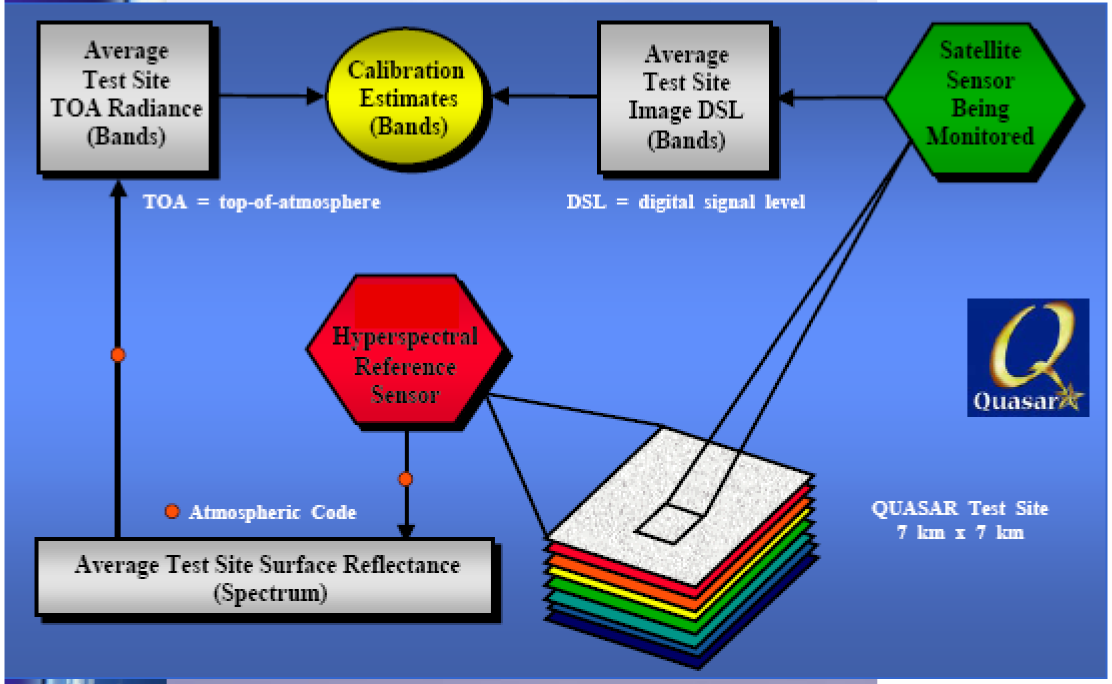
Quality Assurance and Stability Reference (QUASAR) Monitoring (1998)

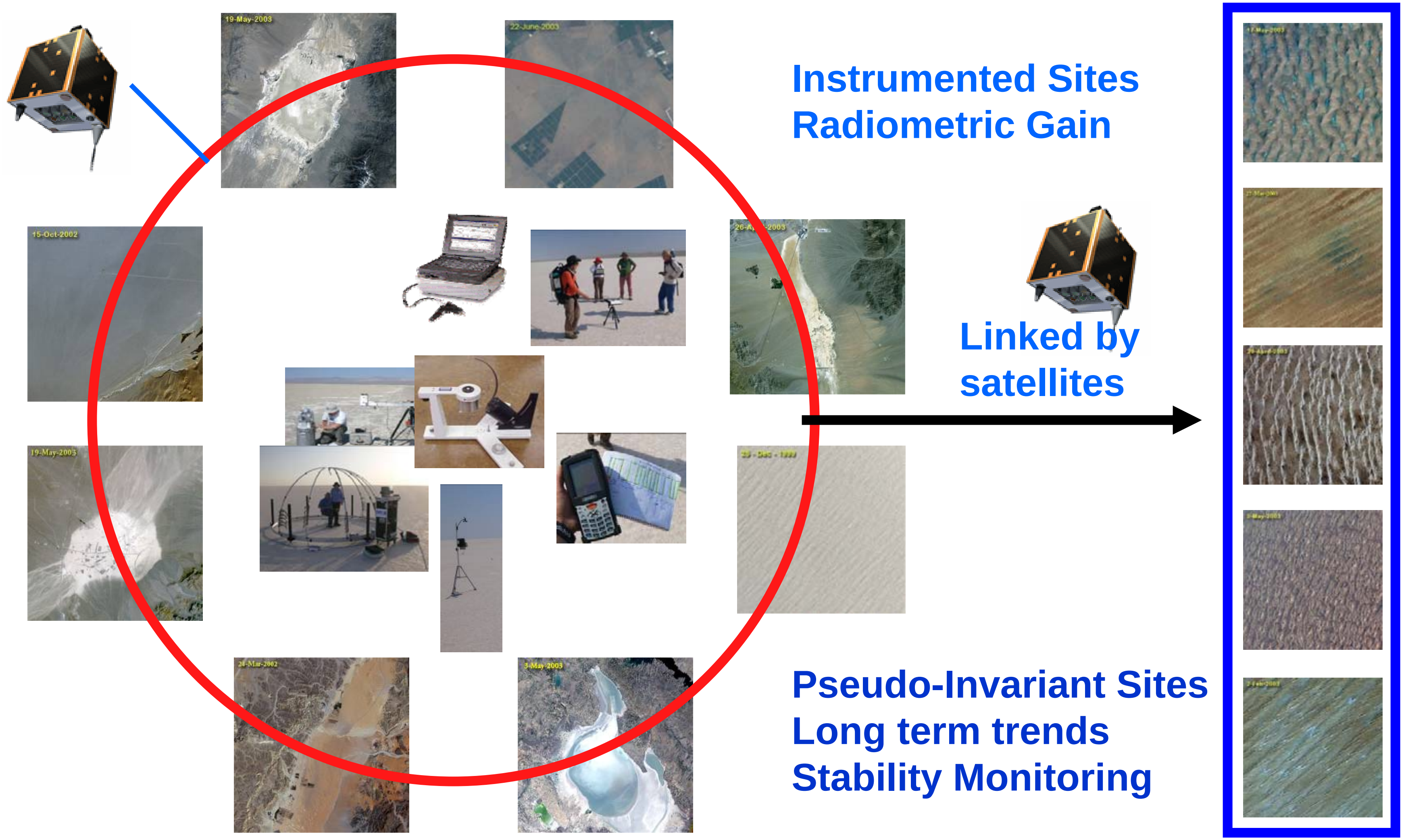
$Y = 1.026\ X - 1.26\ (r^2 = 0.990)$



Towards A Network of Reference Standard Sites for Post-Launch Calibration

- Establish a global instrumented and automated network of test sites (GIANTS) (Teillet et al., 2001).
- Support a small number of well-characterised benchmark test sites and data sets.
- Standardize a core set of surface sensors, measurements and protocols.
- Process all data sets identically at a central 'secretariat'.
- Supplement other calibration approaches, reduce the effort required, and provide consistency.

Operational "calibration service"



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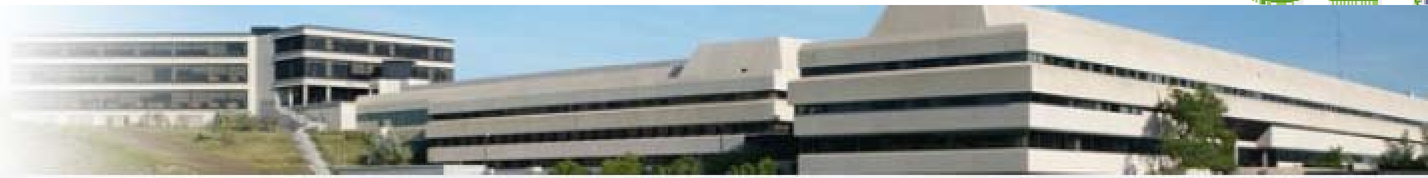


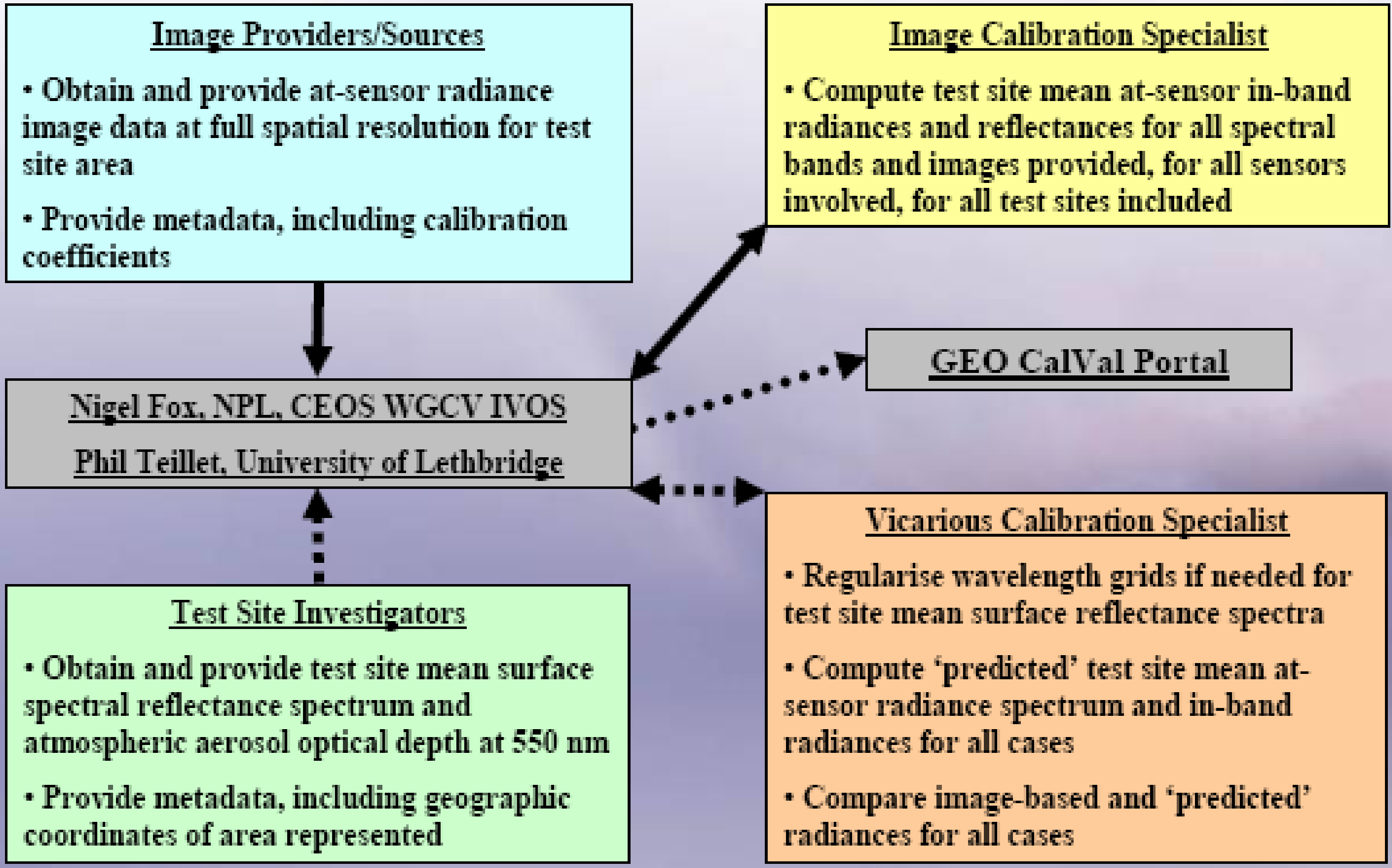
Concatenation of Terrestrial Reference Standard Sites for Systematic Post-Launch Calibration Monitoring of Multiple Space-Based Imaging Sensors

Philippe M. Teillet
Department of Physics and Astronomy, University of Lethbridge

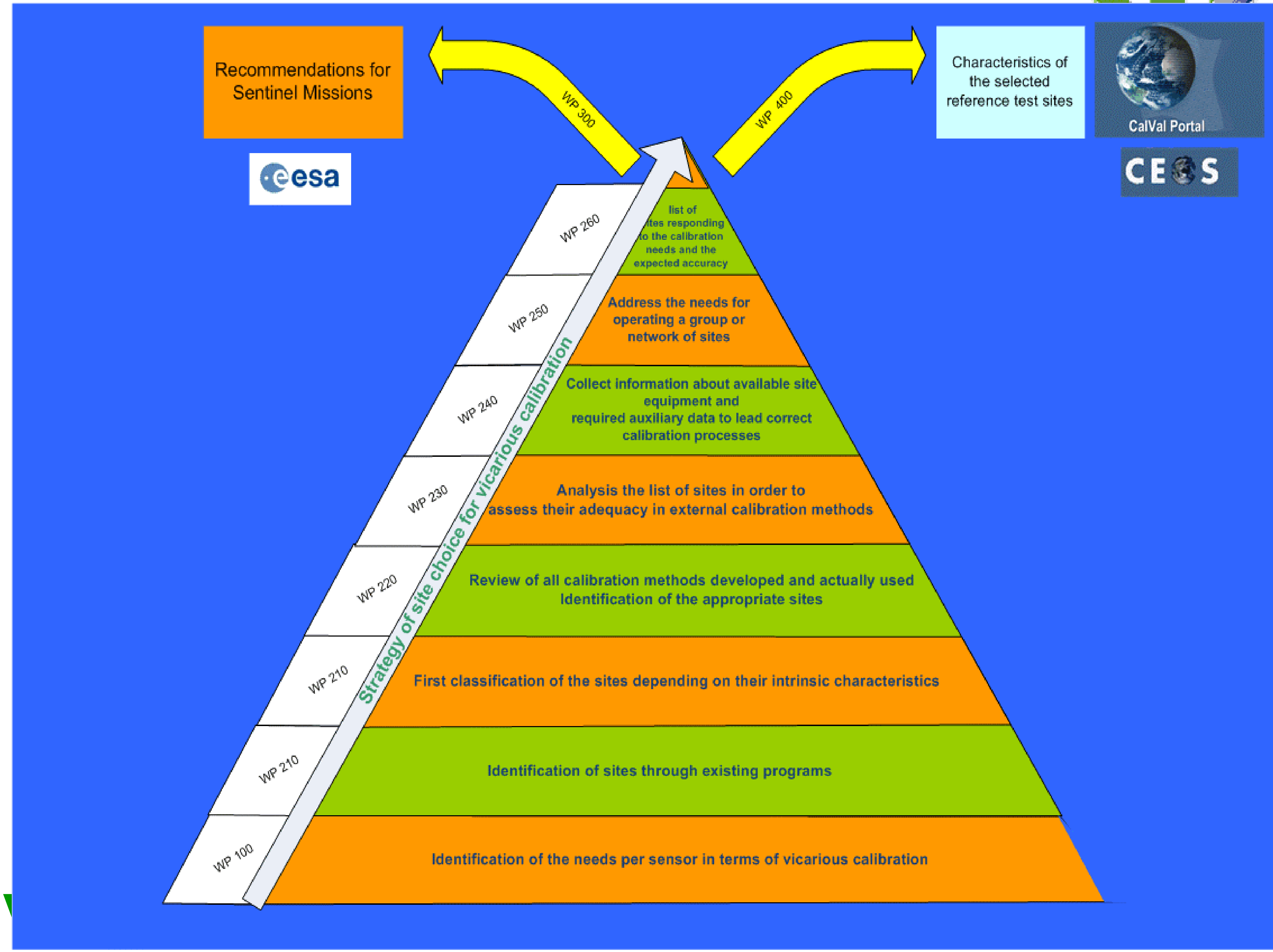
Nigel P. Fox
National Physical Laboratory, UK

IVOS

Flow Chart Summarizing the Concatenation Pilot Study Concept



STUDY to Support TEST Site project



Documents

13 docs available on

ftp.vega.co.uk

directory: DeliveriesFor ESA

Username: calib
Password: 73392418

Project Reference	Summary	Prepared
Item no. 06.187.34 in the ESA list of Intended ITT	Statement of Work of °ITT AO/ ESRIN/AO/1-5300/07/I -OL	ESA/ESRIN
Deliverables		
CALIB-TN-WP110-VEGA_001	This document describes a classification of sensors based on the **needs of external calibration in terms of radiometry, geometry, spectral, and image quality**. Three classes are reviewed: Low spatial resolution optical sensors, High spatial resolution optical sensors, atmospheric sensors.	VEGA, Armines, GAEL, ETH
CALIB-TN-WP120-BRIX_001	This report addresses the **identification of sites used for external calibration of space borne microwave remote sensing instruments - synthetic aperture radars [SAR], radar altimeters, and microwave radiometers.**	BRIX
CALIB-TN_WP210-ARMINES_001	This document describes the existing **sites for on Orbit MTF and SNR** assessments	Armines
CALIB-TN-WP210-VEGA-001	This document aims to identify a **selection of natural sites used for radiometric calibration** by analysing the existing programs managed by various agencies or countries.	VEGA
CALIB-TN-WP210-GAEL_ETHZ_001	The objective of this work package is to identify and define a strategy of **selection of geometric calibration test sites**	GAEL
CALIB-TN-WP221-WP223-VEGA_001	This document describes the class of sensors and associated **radiometric and spectral calibration methods**	VEGA
CALIB-TN-WP222-GAEL_ETH_001	This document describes the **geometric calibration validation methodologies** in order to propose some requirements regarding the test field configuration.	GAEL
CALIB-TN-WP224-ARMINES_001	This document describes the **calibration methods used to estimate and to assess the SNR**	Armines
CALIB-TN-WP240-VEGA_001	This document describes the **site equipment and required auxiliary data** to lead correct calibration processes	VEGA
CALIB-TN-WP260-VEGA_001	This document describes the **detailed error balance for each vicarious calibration method.**	VEGA
CALIB-TN-WP310-VEGA_001	This document provides with **recommendations for the radiometric and spectral calibration of Sentinel 2 and Sentinel 3 sensors.**	VEGA
CALIB-TN-WP310-GAEL_001	This document provides with **recommendations for the geometric calibration of Sentinel 2 sensors.**	GAEL
CALIB-TN-WP410-VEGA_001	This document describes the links between the project and the Cal/Val portal	VEGA

Characteristics of Sensors which can Benefit from Test Sites

- Radiometric Gain
- Radiometric Stability
- Modulation Transfer Function (MTF)
- Signal-to-Noise Ratio (SNR)
- Stray light (Adjacency effects)
- Spectral
- Uniformity (Flat field)
- Polarization
- Geometric Stability
- Geolocation
- Camera model
- Band-to-band
- Internal Geometry
- Temporal effects

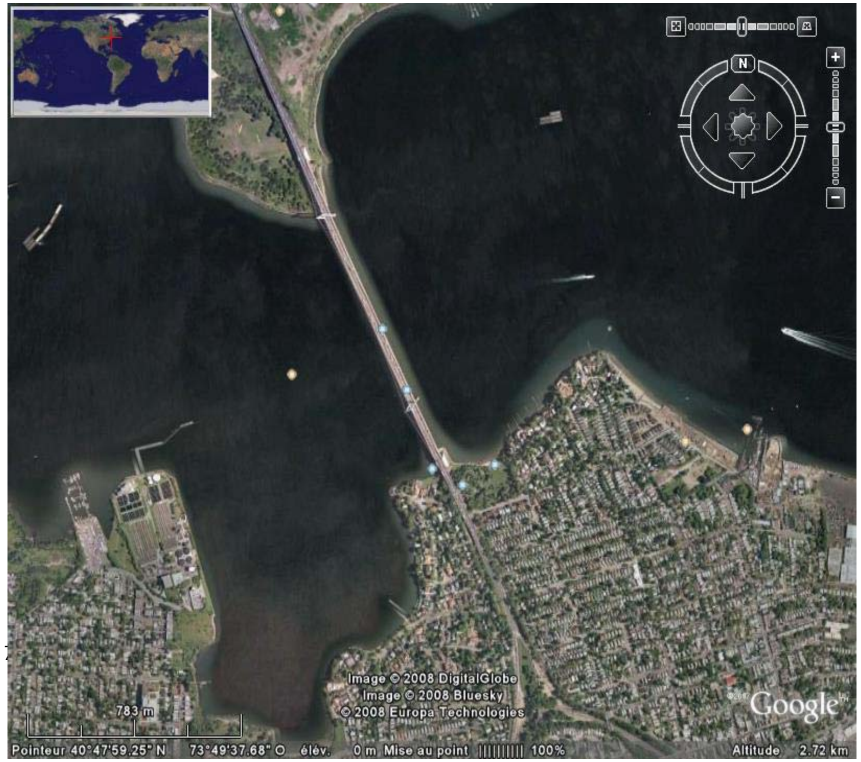
MTF

Three types of methods

➢Target based methods (absolute method)
➢There exists an other image of a "rich" landscape (e.g. urban area) (same spectral band, co-registred) ⇒ Bi-resolution methods (relative or absolute method)
➢Specific on-board device meant to assess MTF

Most of the absolute MTF in-orbit measurement methods are based on image analysis from acquisition(s) of specific well known targets. Those targets can be either:
➢ dedicated targets such as "on-purpose" painted surfaces, single or multiple spotlights, convex mirror array, etc.;
➢ artificial objects such as bridges, buildings, runway painted lines, etc.;
➢ or even natural objects such as fields, stars, etc.

The two main targets used for MTF estimation: ·
The pulse target
The edge target



Identify key requirements for MTF sites

Likely to lead to best practice guidance based on ESA study with examples as proposed by community

Issues/Actions

- **Establish and agree classification criteria for core sites ("best" standards)**

- Encourage agencies to view and provide data to cal/val community over core sites starting with <u>radiometric gain and stability</u> as an immediate priority (in ongoing manner)

- Prediction tool for Sat overpass on test sites (COVE)

- Methods for linking sites, propagation of data to satellites, access to information ESA and IVOS

-Potential issues of service cost?

- Calendar of measurement campaigns Portal

- Resource for test sites Agencies

- Establish optimum instrumentation specification for core sites

-Automation

- - Identify sites and associated key characteristics for all other cal/val tasks

- Establish "Governance" principles

QA4EO Procedures: Land imagers

-Establishing a Land reference test site

- Proposing and Documenting a reference test site

- Radiometric Characterisation of a land site

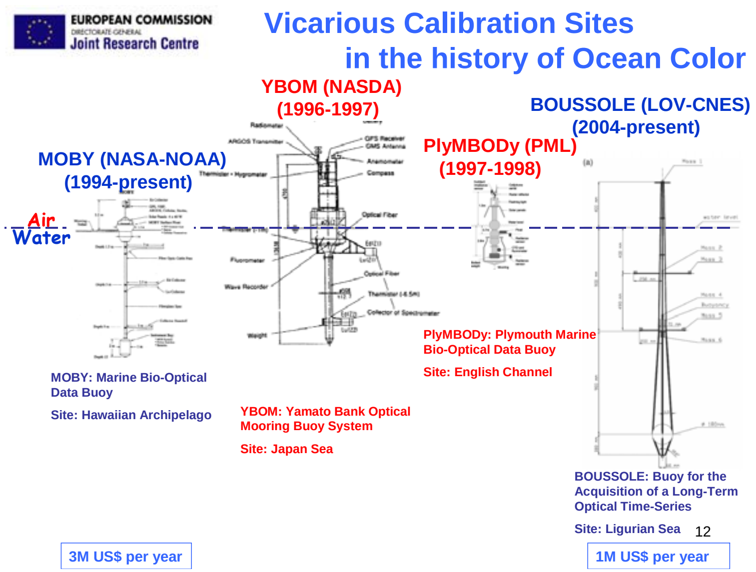
- Use of Rayleigh scattering for Gain evaluation

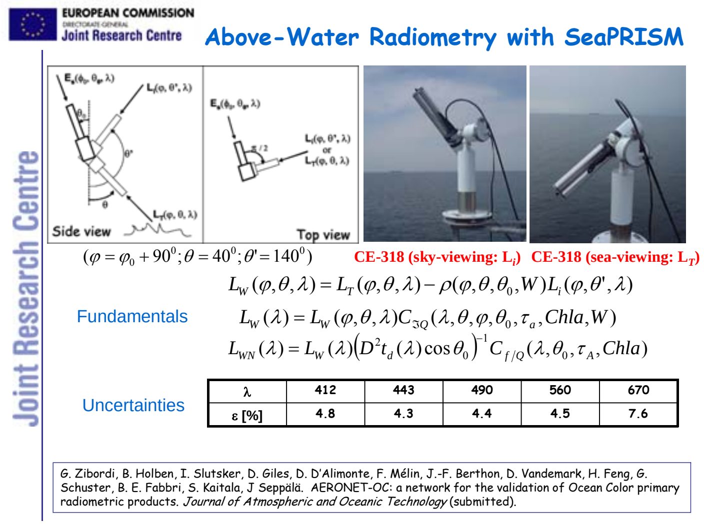
- Use of Moon as a calibration standard for Satellites

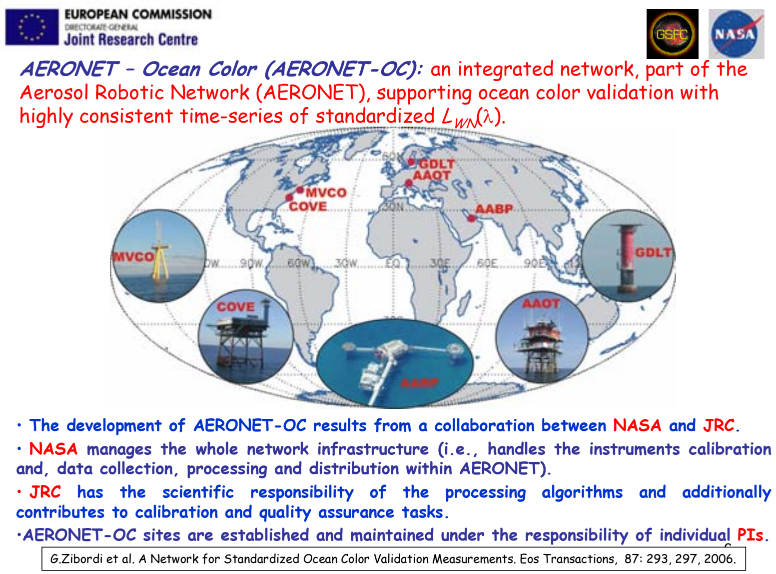
- Protocol for Cross-comparison of Satellites

- Protocol for comparison of ground measurement techniques for test-sites

OCEAN COLOUR: test sites







Procedures endorsed for:

- Aeronet OC site selection
- Immersion factor calibration

IVOS

Ocean Colour Radiometry – Virtual Constellation (OCR-VC): *CAL-related items* (1/1)

Murakami JAXA

- OCR-VC is revising the final draft of "Implementation Strategy and Plan" to be approved at the CEOS SIT in September 2009
- The document mentions the required components and accepted practices for an OCR calibration program:
  - accurate pre-launch calibration and characterization of the sensor;
  - a procedure for vicarious calibration using data from the NASA/NOAA Marine Optical Buoy (MOBY) or ESA's MERMAID data base (incl. Acqua Alta Oceanographic Tower (AAOT) and BOUSSOLE);
  - clearly defined measurement protocols;
  - a process for field and calibration equipment traceable to national standards;
  - highly accurate atmospheric correction procedures; and
  - processes for monitoring in-orbit instrument stability (e.g. by routine viewing of the moon).
- New IOCCG working group on Level-1 requirements for ocean colour sensors led by NASA will address pre-launch and on-orbit requirements including vicarious calibration and on-orbit calibration.

LINK to IVOS being established – CEOS SIT

- Workshop at JRC

Specific European Ocean Color CEOS-WGCV initiative (by *ESA-MVT, JRC, …*):

July 2010: Pilot for Full open CEOS comparison

Assessment of *in situ* radiometric capabilities for coastal water remote sensing applications (ARC)

Activity: Comparison of state-of-art *in situ* radiometric measurement and processing methods thorough successive laboratory/field experiments performed during different seasons/years.

Site: Acqua Alta Oceanographic Tower (stable platform equipped with specialized deployment systems, but only granting access to a limited number of people).

Requirements: proven *i.* use of assessed measurement methods and consolidated technology, *ii.* near-real time data processing; *iii.* generation and handling of calibration files, *iv.* determination of uncertainties.

Operational plan: pre-field absolute radiometric calibration of instruments at the JRC; field measurements at the AAOT with daily data processing and analysis; open workshop on data processing schemes, measurement results and uncertainties (six months after each laboratory/field experiment).

OCEAN COLOUR: actions

Driven by JRC and OCR-VC as an output "customer" also GOCI

- In-situ cal/val protocols largely OK for class 1 (open waters)

- Protocols need to be modified improved written to address class 2 (coastal waters) (European lead as issue greatest by OC community but facilitated and reported to IVOS (QA4EO) and IOCCG)

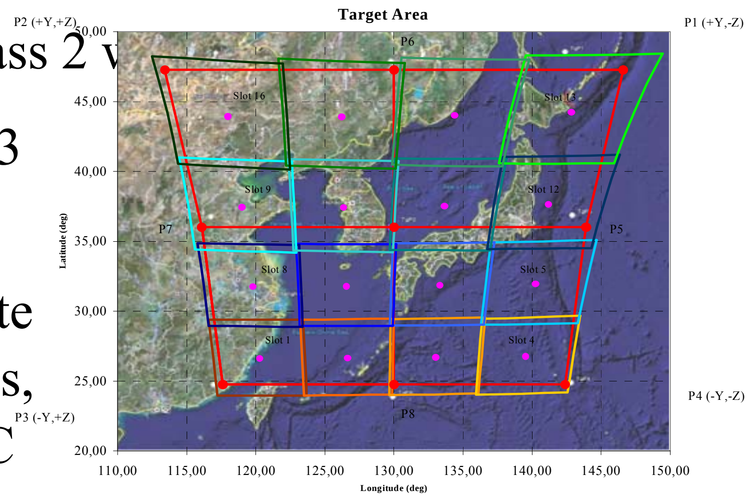
- Establish formal reference standards and methods

- Comparisons and operational procedures to ensure consistent quality data from ground teams

    - Organise pilot comparison of in-situ meas (class 2 v

    - CEOS comparison in GOCI footprint (2012/13

- IVOS to take responsibility to establish appropriate Reference standards, encourage QA4EO procedures, Harmonisation by comparisons for CEOS OCR-VC



IVOS

NPL

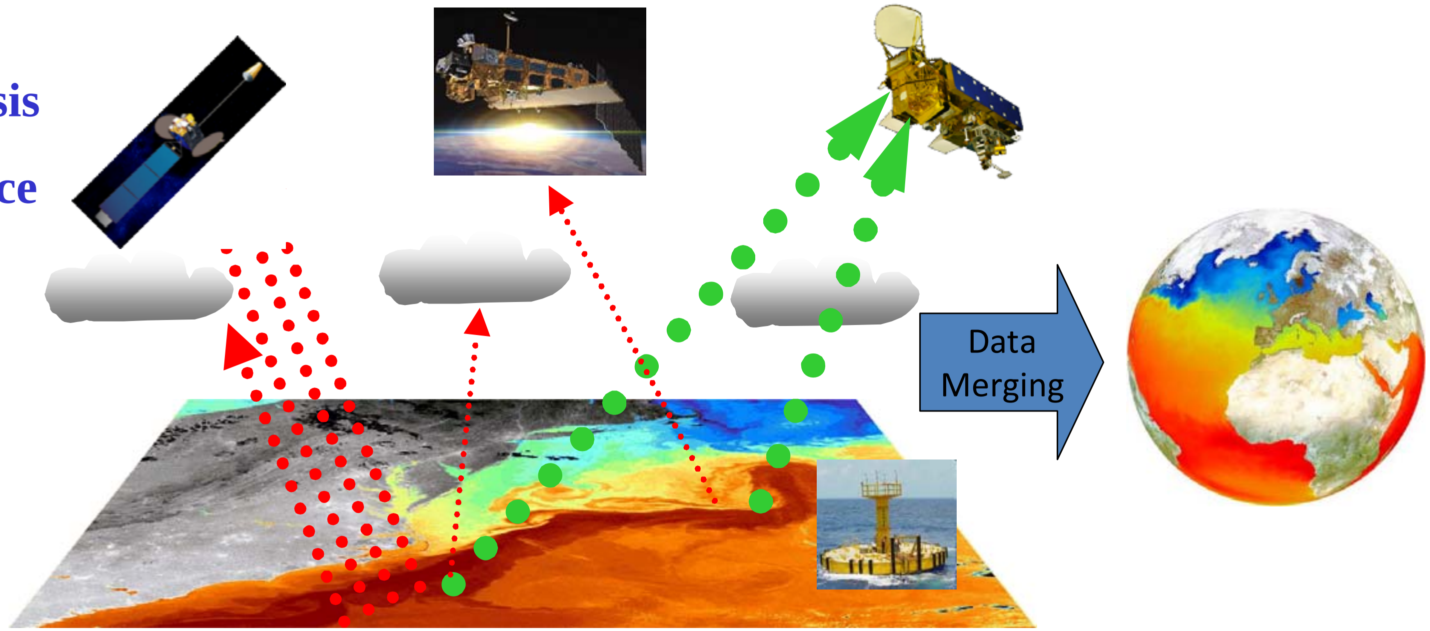
Surface Temperature: G Corlett Leicester University

Example of coordinated operational cal/val network/service

New group to coordinate Cal/val for SST within GHRSST

- **common methods**
- **references**
- **uncertainty analysis**
- **QA4EO compliance**

GHRSST builds on EO complementarities



- Polar Orbiting infrared has *high accuracy & spatial resolution*
- Geostationary infrared has *high temporal resolution*
- Microwave Polar orbiting has *all-weather capability*
- In situ data provide *the reference in all weather conditions*

IVOS

Reference sources

- Ship-based radiometers
  - Completely traceable to agreed SI standards through national metrology institutes
  - Duplicate the nature of the satellite SST measurement
- Surface drifting buoys
  - Uncertainty not always traceable to an SI temperature standard
  - Significantly improved global coverage compared to other potential reference datasets.
  - Under certain conditions is representative of the SST provided by the satellite after the application of a simple adjustment for the thermal skin effect
- Moored buoys
  - TAO/TRITON/PIRATA arrays are considered separately from other moored buoys because they are in the open ocean and far from the coastal regions which often present particular difficulties for the accurate measurements of SST from space, and where most other moored buoys are deployed
- Conventional ship measurements from engine room intakes or hull-mounted sensors
- Other satellite data
- L4 analyses

ent results: AATSR versus reference sources

	Daytime		Nighttime	
Reference Source	Number of match-ups	Standard deviation (K)	Number of match-ups	Standard deviation (K)
Drifting buoys	8301	0.33	10682	0.32
Moored buoys	884	0.56	1115	0.41
TAO/TRITON/ PIRATA	235	0.31	443	0.27
Ships	3367	1.16	3720	1.11
Radiometers	392	0.34	688	0.24

Data from Peter Minnett (RSMAS), Werenfrid Wimmer (NOCS) and ESA L2P MDB

How to LINK?

How to establish overall uncertainty?

IVOS

IR Test Sites (1)

- Type1: Radiance at sensor calibration/validation
  - There only needs to be a few of these types of site, they should be heavily instrumented and usable year round.
  - These should be homogenous sites, e.g. Tahoe and Salton Sea
  - Suggest 2 additional land sites one for low temps and one for high terrestrial temps.

IR Test Sites (2)

- Type 2: Radiance at surface, surface temperature, surface emissivity
  - These sites are intended to test the algorithms be they T-E separation or atmospheric correction.
  - They should include permanent sites as well as sites of opportunity.
  - For the radiance at surface and surface temperature, water sites are preferred.
  - For land surface emissivity, then a range of sites that exhibit a range of emissivities with spectral features across the wavelength range are desired.
    - For the emissivity sites you just need an emissivity measurement.
    - JPL has put together 12 emissivity sites which they have measured and enable validation at 1km footprints.
  - For the radiance and temperature sites you need accurate surface skin temperatures at the time of the overpass.
    - This requires surface-based radiometric observations.

Threshold

- The continued provision of data from at least one ship-borne radiometer.
- The provision of regular demonstration of traceability to national standards.
- The continuation of the SST expert group.
- A link to the DBCP needs to be maintained to ensure the data is of sufficient quality for satellite SST validation.

From Threshold to Goal

- Provide additional radiometer deployments to cover retrieval extremes
  - Large air-sea temperature differences; Tropospheric aerosol; High tropospheric water vapour; etc.
- Ideally supported through dedicated SST validation activities, but could still be mission specific
  - Recognise need for overlap analysis and support for CDR development
- Implement regular inter-comparisons

From Goal to Breakthrough

- Provide sufficient radiometer deployments to use as a global reference source
  - Provides complete independence from *in situ* record
- Supported through dedicated SST validation program
  - Managed and operated by GHRSST
- What about microwave?

Land Surface Temperature

- New activity started within LPV sub-group
  - Originally led by Ana Pinheiro (NCDC)
- LPV and IVOS must work together
  - No benefit in duplicating activities
- Agreement to deal with radiometry within IVOS, and other issues in LPV.
  - Cloud screening?
- Now taken on by Simon Hook (JPL)
  - Website (http://lst.jpl.nasa.gov)

Steps Towards Standardisation

- We have one well established area and one growing area
  - Little standardisation exists in either area
- Progress towards this is very slow but we are making progress
  - Helped now that GSICS have endorsed QA4EO
- Aim is to have SST validation protocol for IVOS 22
  - LST likely to take longer

CEOS Infrared spectral emitted radiance comparison

April/May 2009 key sponsors: ESA and NASA (+ participants)

Hosts: University of Miami & NPL (pilot/coordinator: NPL)

Objective:

- Establish degree of equivalence between participants
- Ensure robust traceability to SI (via NIST and NPL)
- Establish protocols to facilitate future comparisons

To be carried out following QA4EO guidelines:

- radiometers and black bodies

- lab and ocean

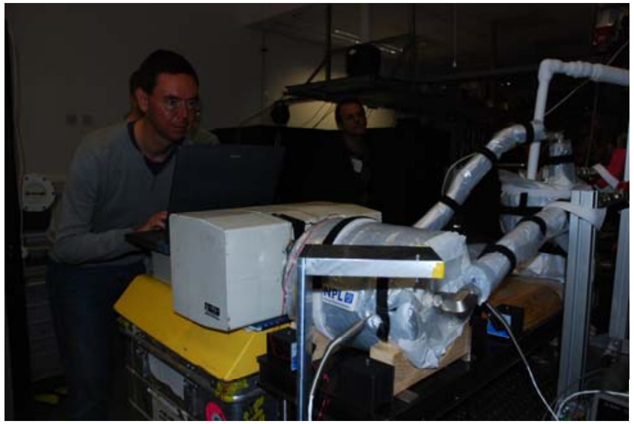
15 radiometers

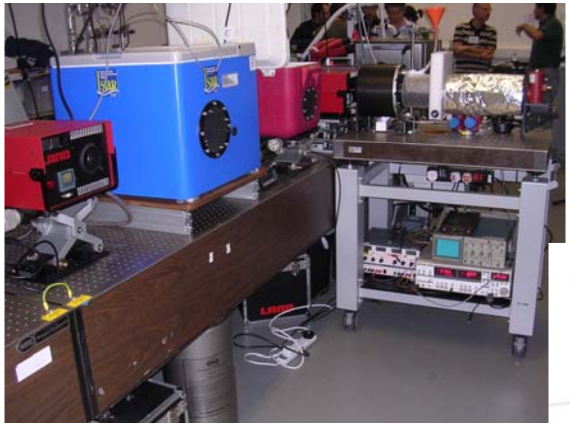
5 black bodies

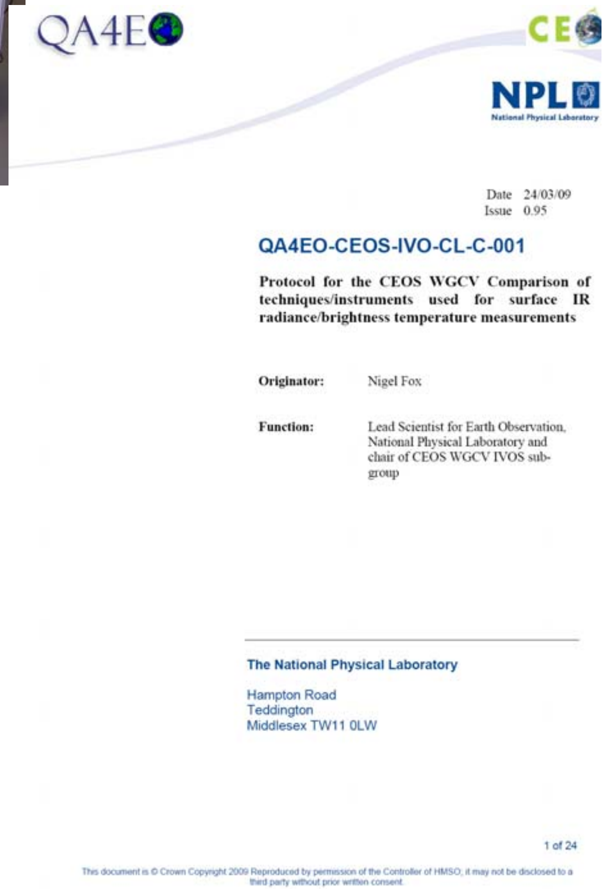
9 participants plus NPL and NIST for traceability

IVOS

CEOS






QA4EO

CEOS

NPL
National Physical Laboratory

Date 24/03/09
Issue 0.95

QA4EO-CEOS-IVO-CL-C-001

Protocol for the CEOS WGCV Comparison of techniques/instruments used for surface IR radiance/brightness temperature measurements

Originator: Nigel Fox

Function: Lead Scientist for Earth Observation, National Physical Laboratory and chair of CEOS WGCV IVOS sub-group

The National Physical Laboratory

Hampton Road
Teddington
Middlesex TW11 0LW

1 of 24

Lab based temps from 10 to 30 ºC (nominal)

Link between UK and US via radiometers

Awaiting data and uncertainties

IVOS

China participate at NPL June 2 (visa difficulties for US)

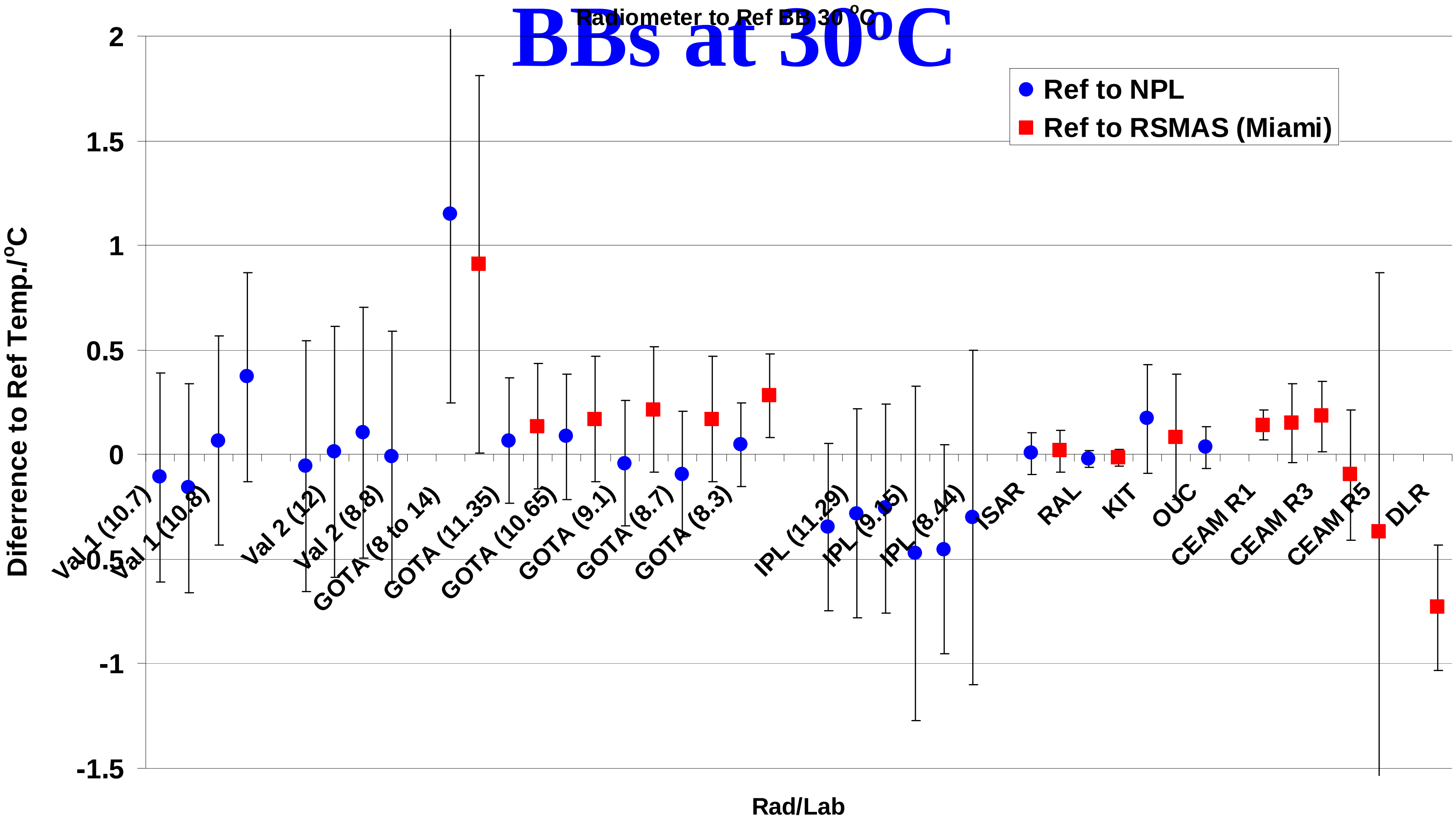
NPL

Uncertainties

Parameter	Type A Uncertainty in Value / %	Type B Uncertainty in Value / (appropriate units)	Uncertainty in Brightness temperature K
Repeatability of measurement	0.12K / 0.040%		0.12K
Reproducibility of measurement	0.06K / 0.020%		0.06K
Linearity of radiometer		0.10K	0.10K
Primary calibration		0.20K	0.20K
Drift since calibration		-	-
RMS total	0.13K / 0.045%	0.22K	0.26K

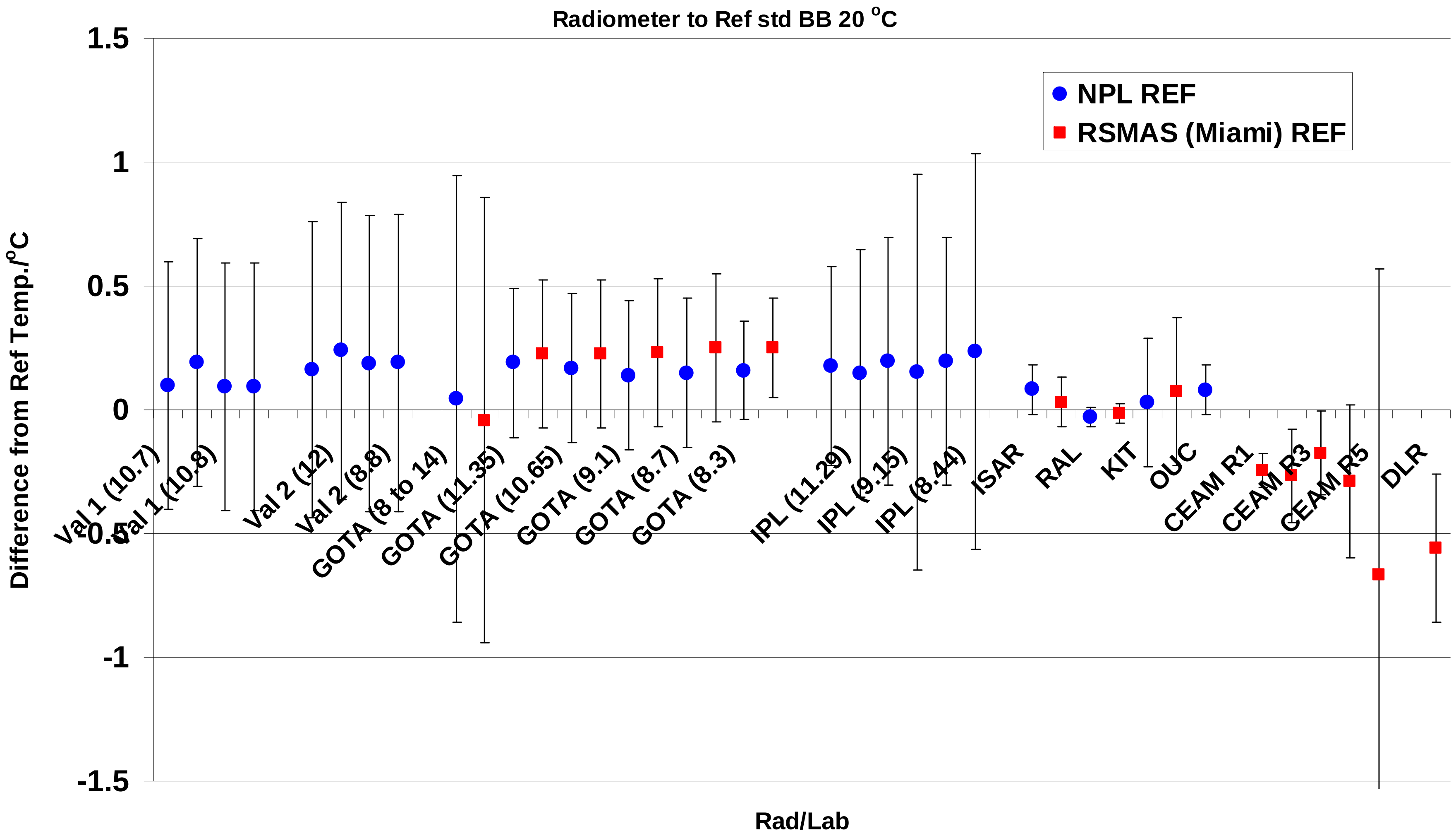
Few provided this level of detail

Difference to NPL and RSMAS BBs at 30°C



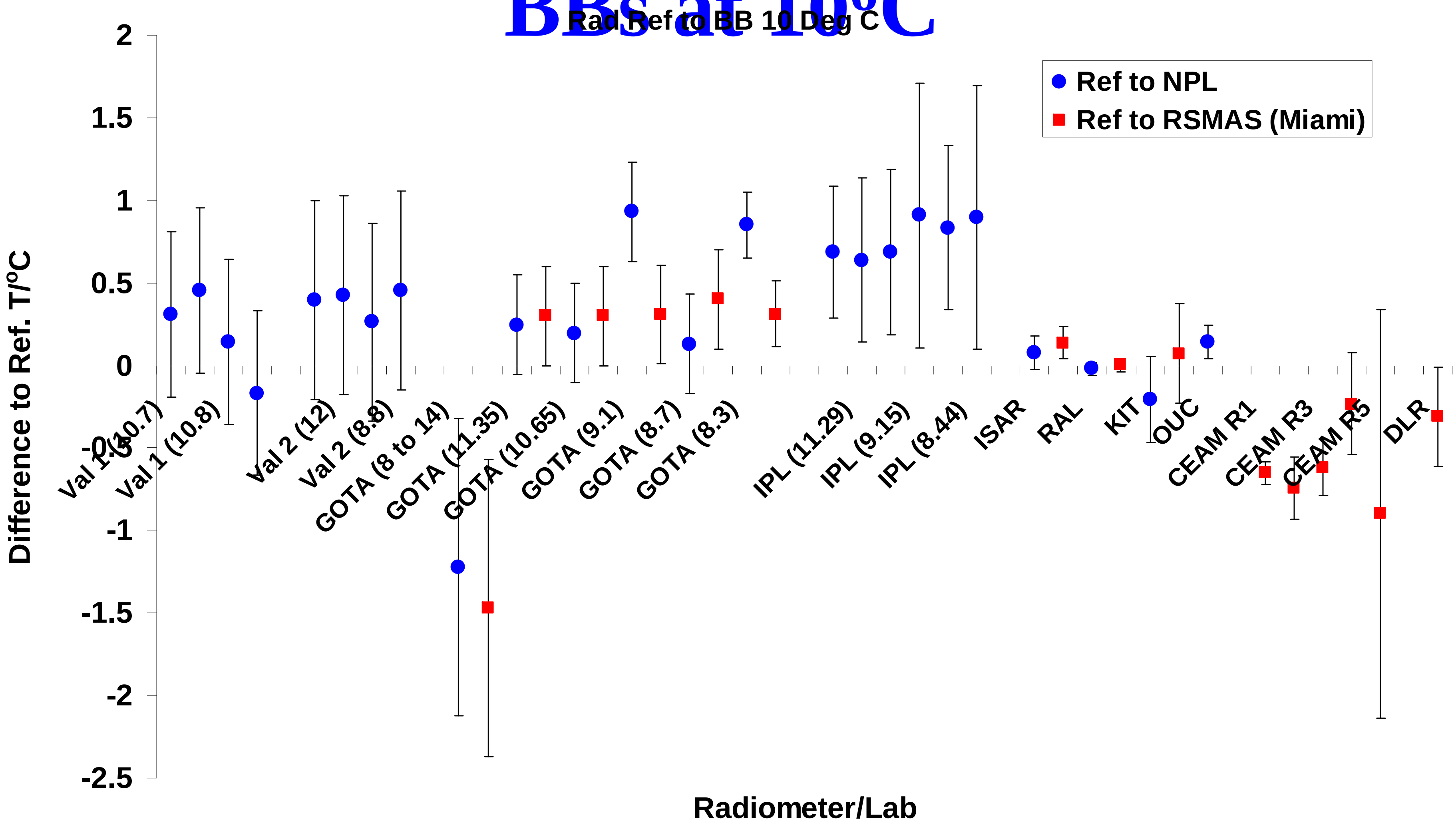
IVOS

Difference to NPL and RSMAS BBs at 20ºC

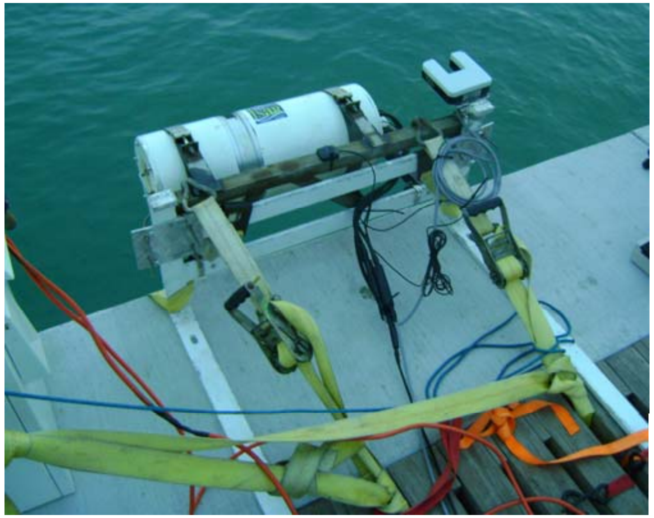


IVOS

Difference to NPL and RSMAS BBs at 10ºC

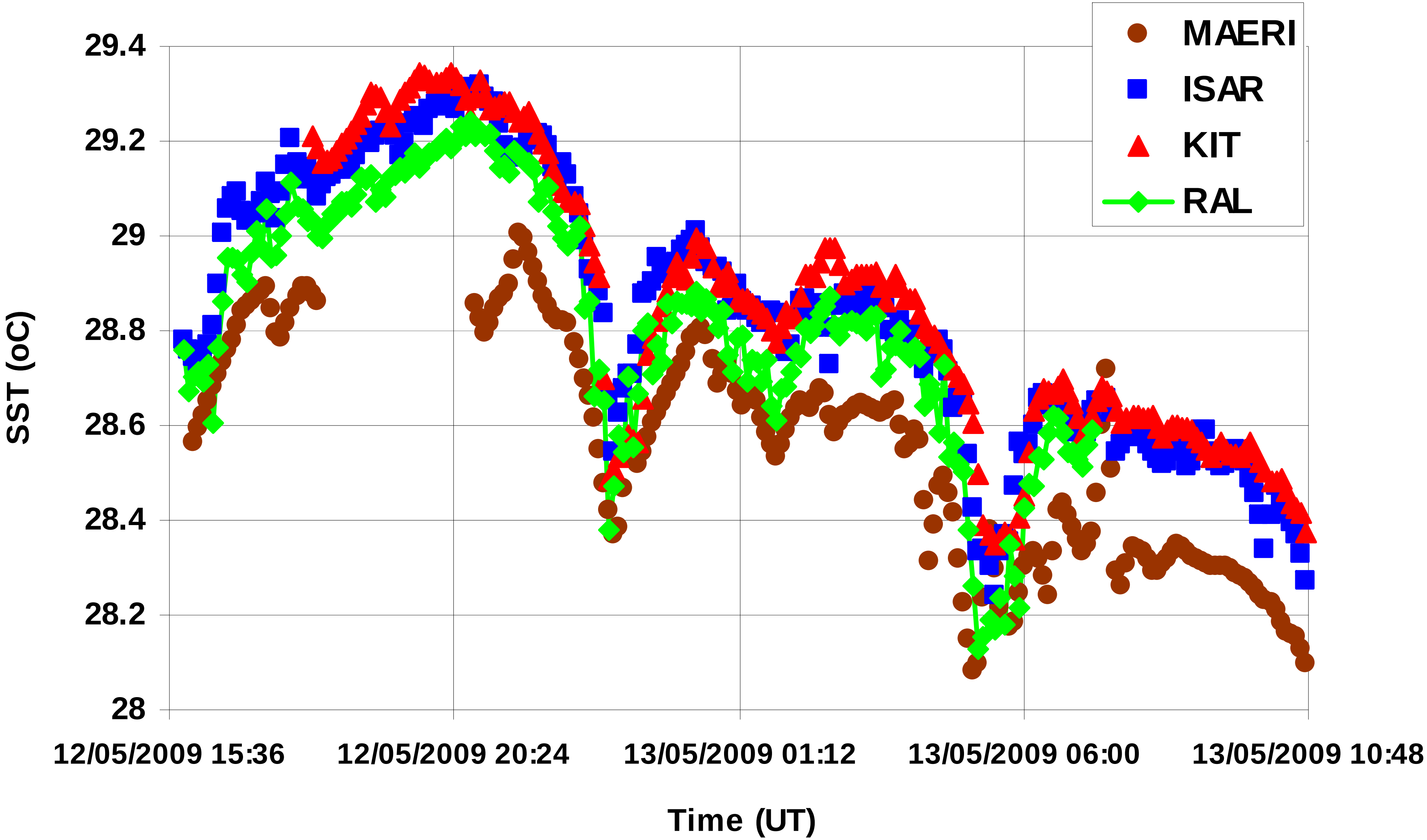


IVOS



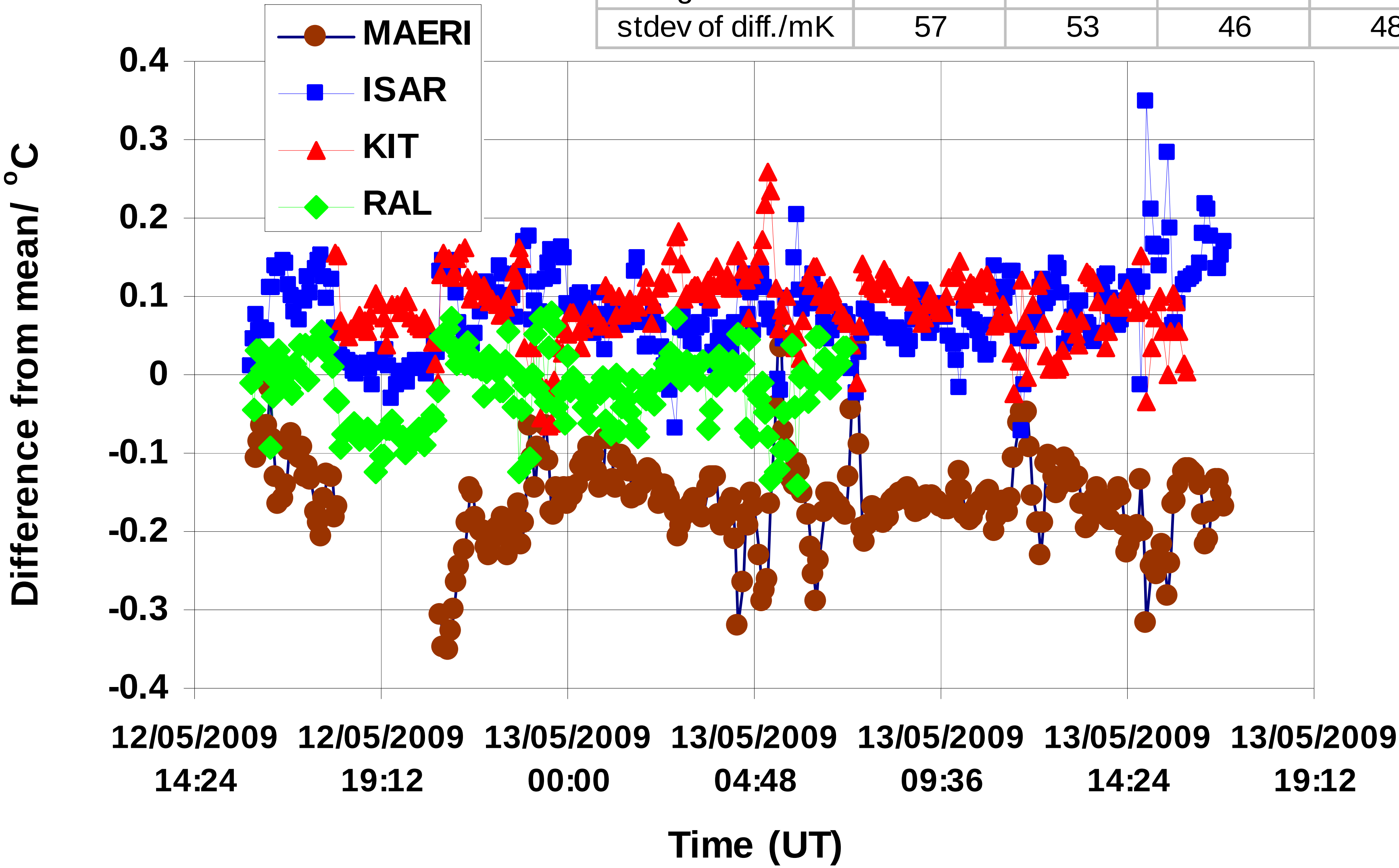
IVOS

Outputs of the four continuously-reading radiometers



Difference from mean

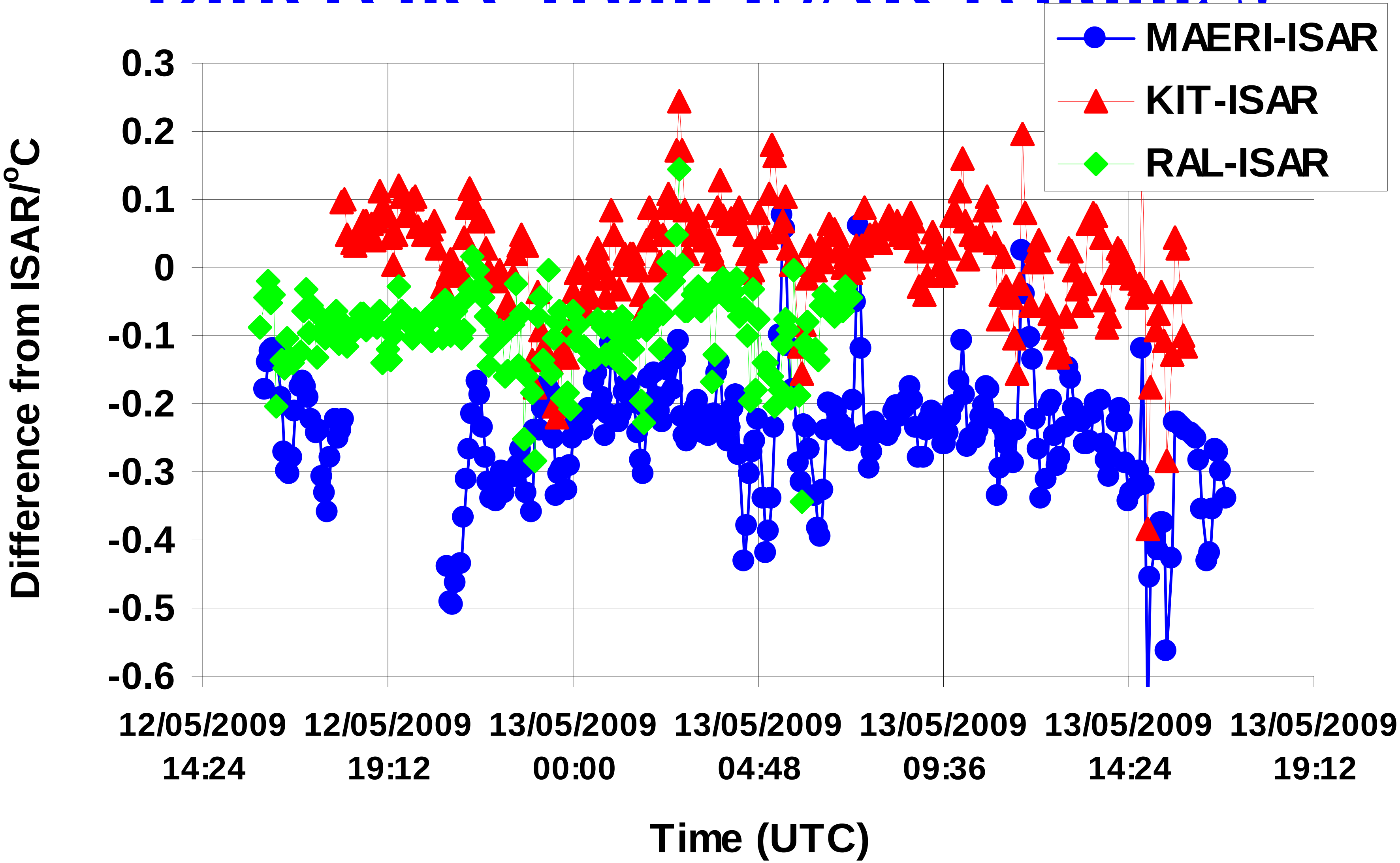
	MAERI	ISAR	KIT	RAL
average of diff/mK	-161	79	87	-19
stdev of diff./mK	57	53	46	48



IVOS

	MAERI-ISAR	KIT-ISAR	RAL-ISAR
average of diff from ISAR/mK	-248	14	-92
stdev of diff. from ISAR/mK	90	78	58

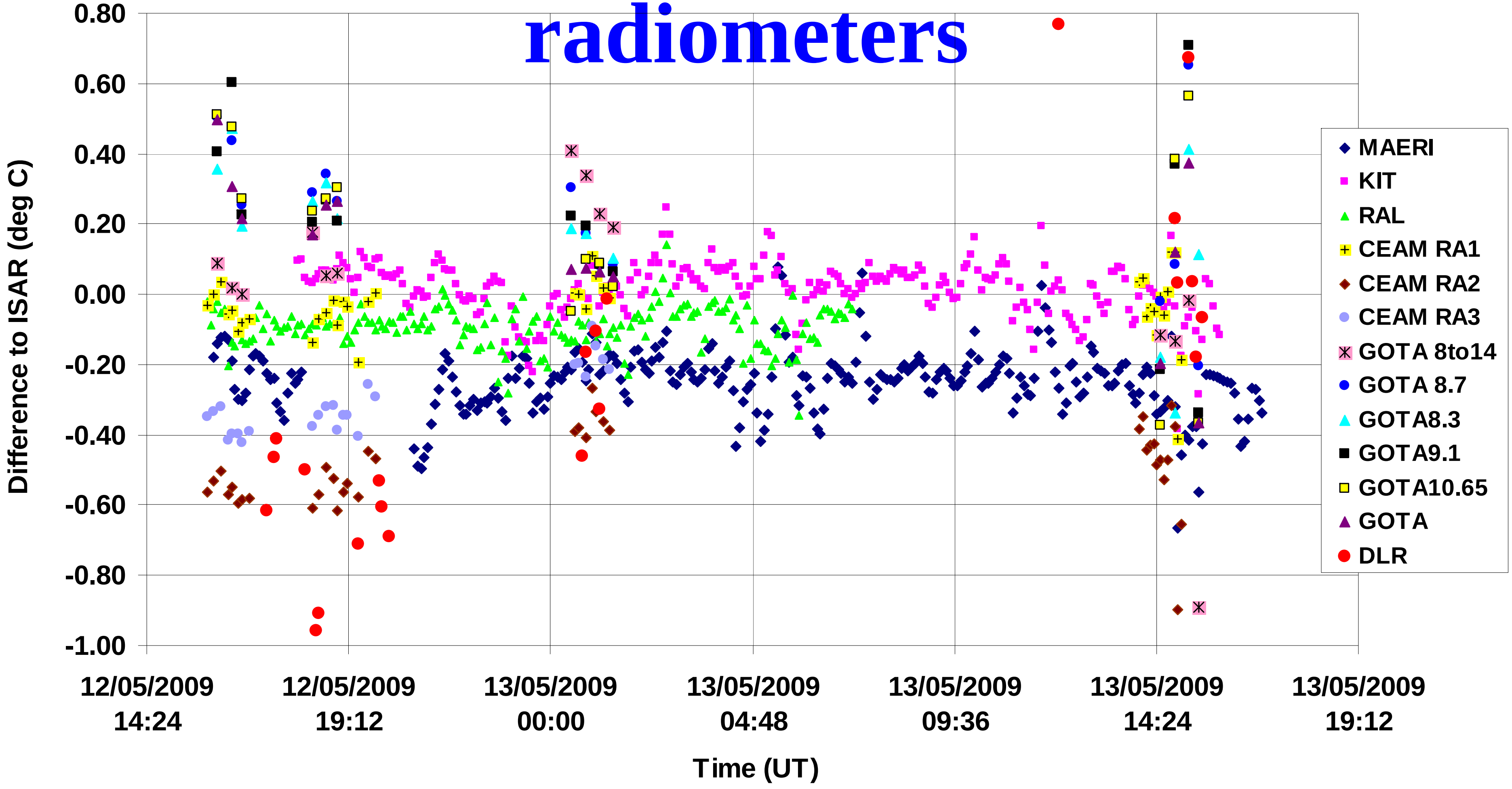
Difference from ISAR readings



IVOS

NPL

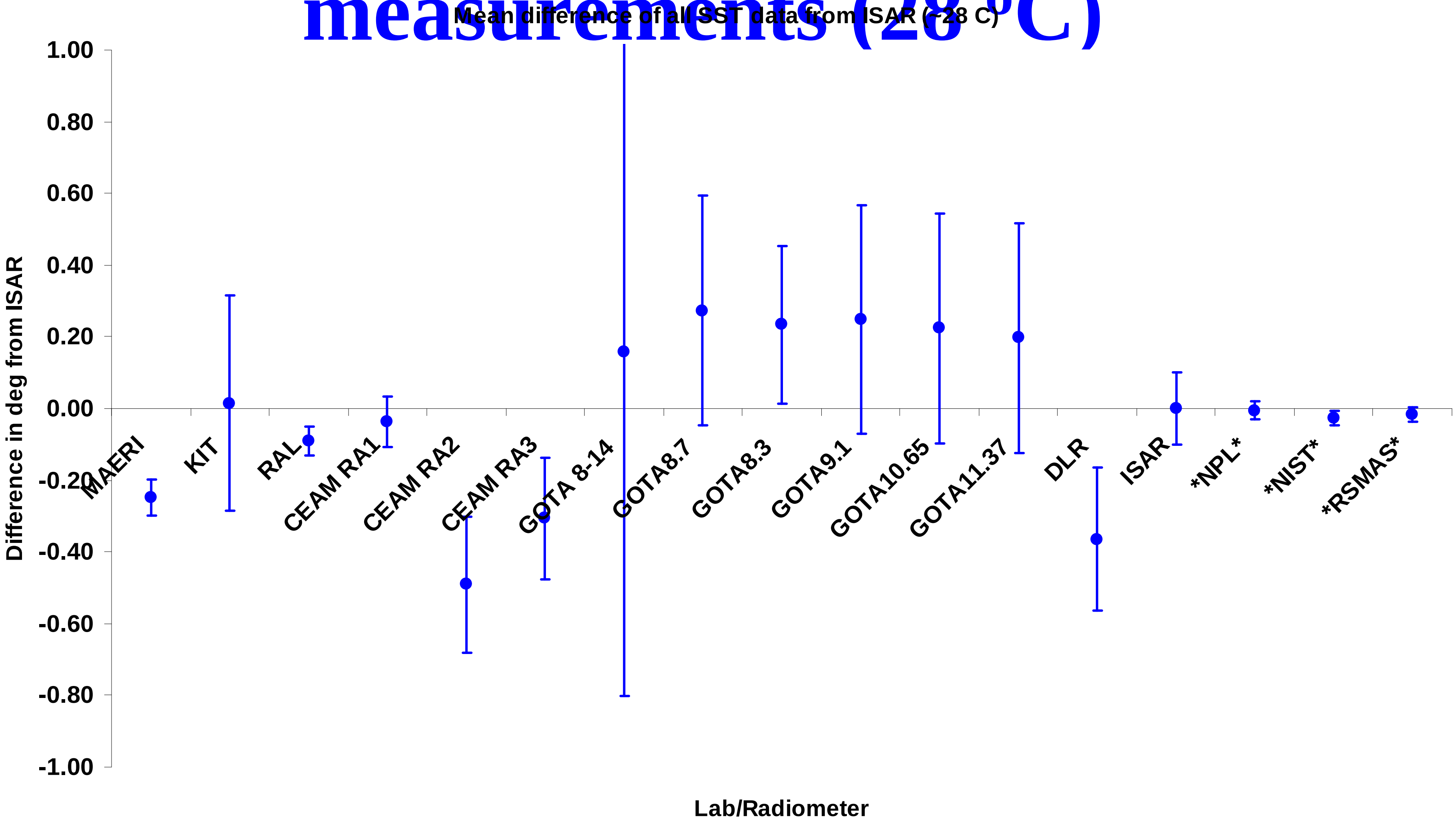
SST measurement summary: all radiometers



IVOS

NPL

Mean difference of SST measurements from ISAR measurements (28 ºC)



IVOS

Issues

- Obtaining resource for joint common activities highly challenging
- VISAs
- Results and descriptions quickly
- Uncertainties and their meaning and getting detailed breakdowns
- Cancellations!
- Number of radiometers per participant

Positives

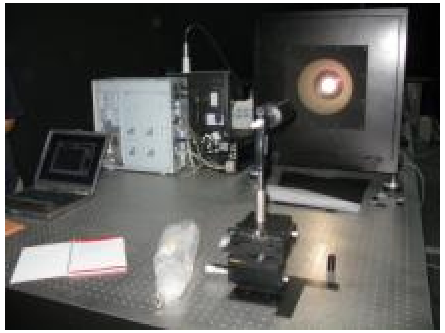
- **Seen as important by community**
- **Excellent learning opportunity**
- **Clear knowledge of bias and traceability**

Next steps:

- Complete analysis
- Publish results
- Compare with previous and consider timescale for repeats
- Need for any variation on type of measurements

2009 CEOS Pilot Campaign

The objectives are:



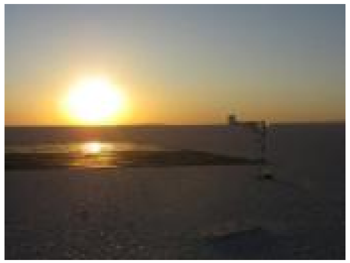
- Evaluate differences in field instrument primary calibrations

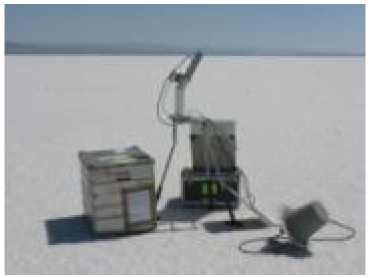
- Evaluate differences in methods for characterising and assigning “radiometric value” to a site, for multiple view angles

- Establish formal traceability of Tuz Gölü reference site based on an evaluation of all comparison results.

•Minimum specifications for characterisation/instrumentation for a CEOS “reference standard”

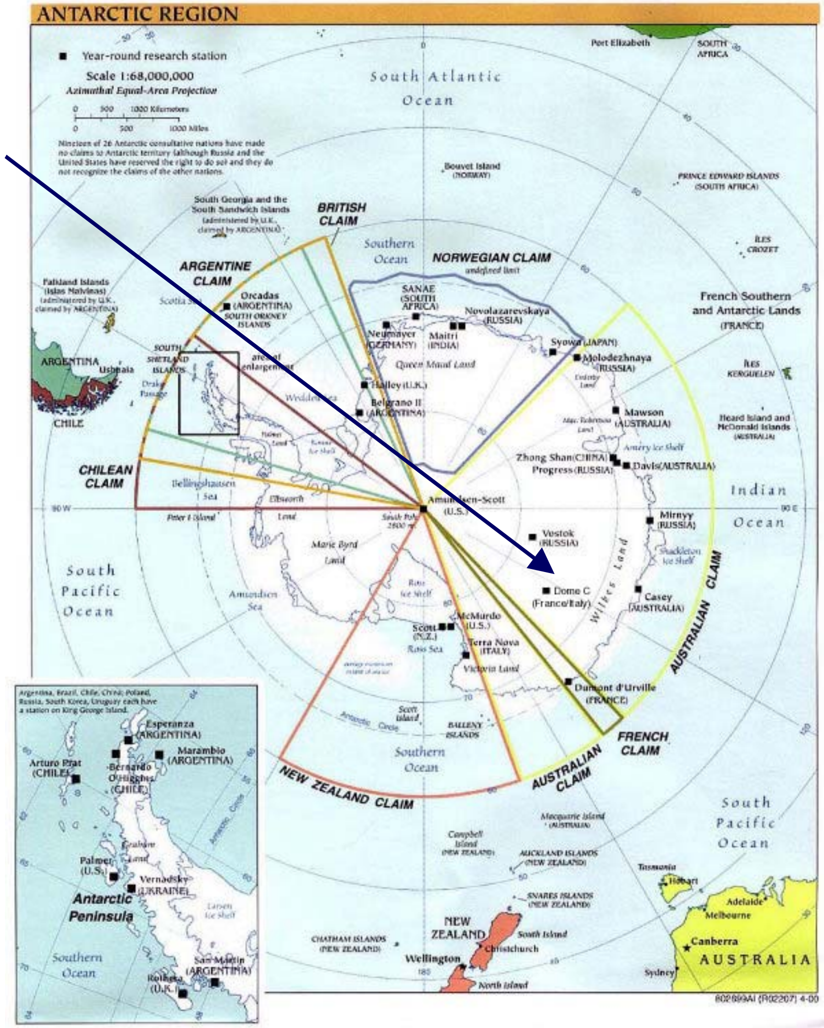
IVOS





Dome C

- Concordia Station, located on Dome C, is run jointly by France and Italy.
- During the summer there are about 40 to 50 people on station.
- During winter ~ 13 people on station

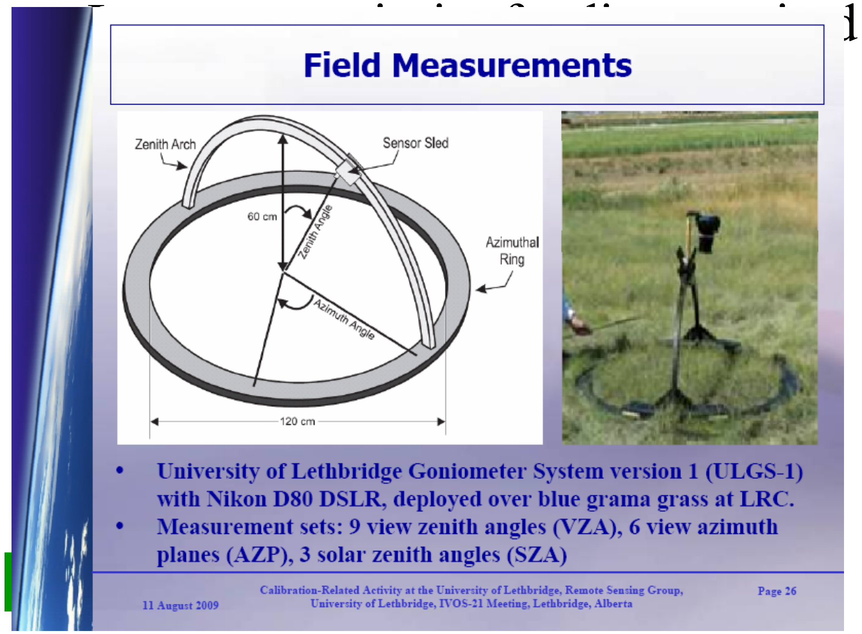


Altitude 3250 m, 10,600 feet
Max Temp -18°C on summer afternoons

Photo courtesy Stephen Hudson, Univ. of Washington

NEXT STEPS: Comparisons

- Full results of all comparisons shortly on portal
- All Data also available for alternative analysis
- Comparisons for Land ground teams (Tuz-Golu) Aug 2010 invitation sent – Need to encourage participation
- Sensor to sensor comparison (Tuz-Golu, Dome-C, Landnet, invariants Invitation to participate
- Seeking to do detailed BRF meas at DOME-C (Italy/NPL)
- Workshop to review Oct/Nov 2010 and strategy development



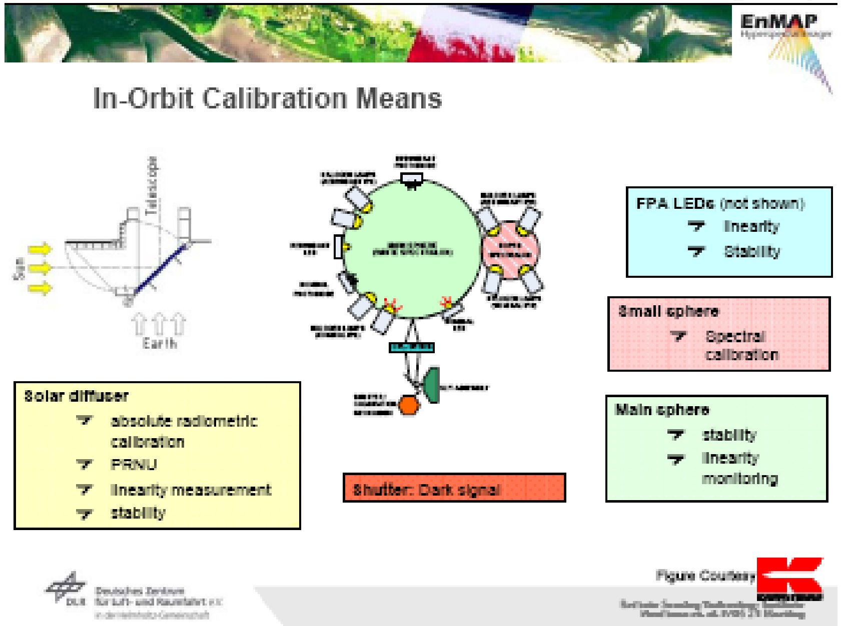
New comparison (Tuz Golu

Europe, Canada, Brazil confirmed

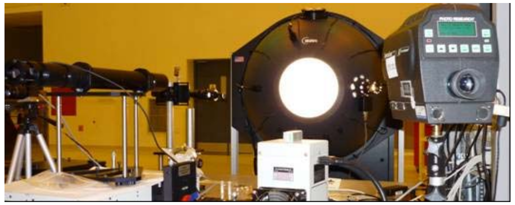
US interest (resourcing?)

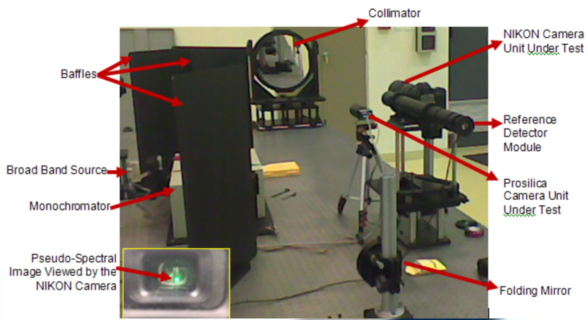
Includes BRF comparison

Pre-Flight: - New sensors



Preflight Calibration Facility





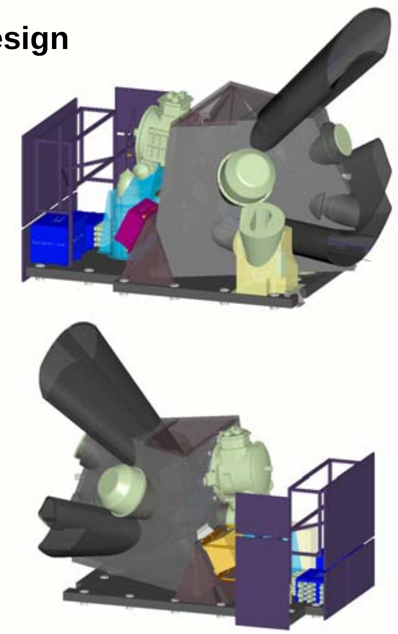
SumbandilaSat

Requirements for a Calibrated EO System

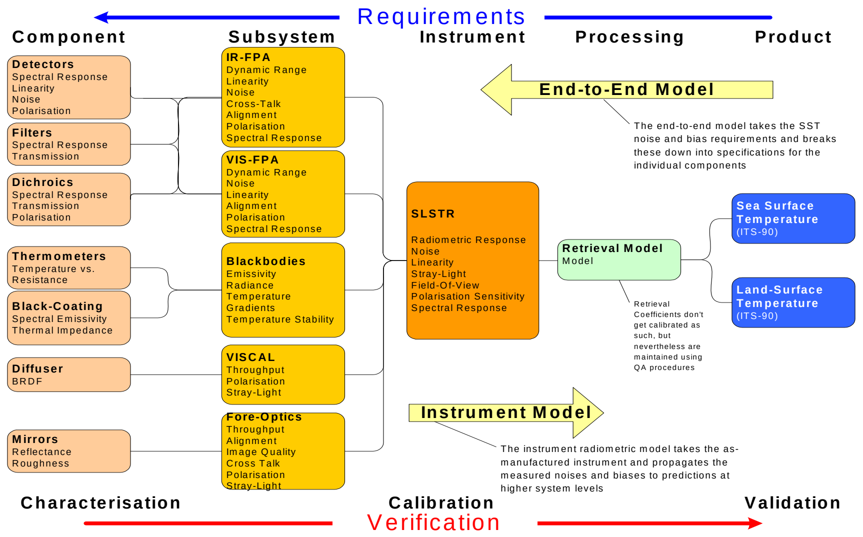
- At the 16th CEOS IVOS working group (November 2005) it was recommended that a calibrated earth observing system that should include the following elements
- On-Board Calibration Sources
  - Proven design concepts (Cavity Black bodies, diffusers)
  - Traceable to SI units
- Extensive Pre-Launch Activities
  - Subsystem characterization/calibration
  - Full instrument level test campaign
  - Sources traceable to SI units
- Sustained Post Launch Activities
  - In-Situ Measurements
  - Cross Calibration
  - 'Gold' standard measurements of test sites
- Radiative Transfer Code that enable comparison of calculated and observed radiances
  - Data Archive and Documentation
  - Maintain long term open access to archives, accessible, possibly through CAL/VAL portals
  - Pre-Launch Cal Val Data
  - Consistent common file formats

SLSTR Design

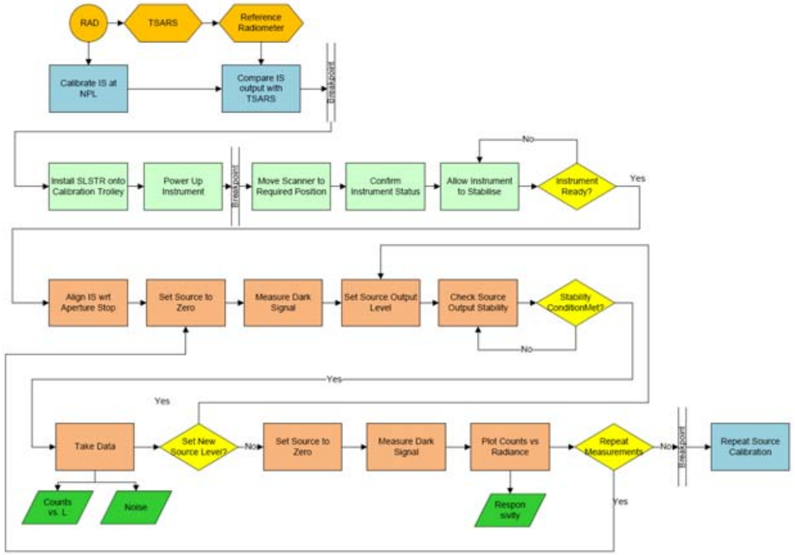
- SLSTR consists of two physical units:
  - SLOSU (Optical Scanning Unit) and CPE (Control and Processot Electronic). CPE is mounted on an inside satellite panel
- SLOSU is split between the OME (Opto-mechanical Enclosure) and DA (Detection Assembly)
  - OME comprises the instrument Baseplate, Structure, Fore-Optics, Scanning system , BlackBodies, Solar Channel Calibration system (VISCAL)
  - DA comprises the Focal Plane Assembly, Stirling Cycle Cooler Subsystem and Front End Electronics



SLSTR Calibration Overview

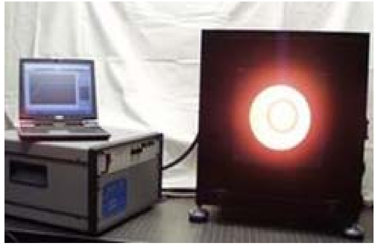


VIS-SWIR Channel Calibration Procedure

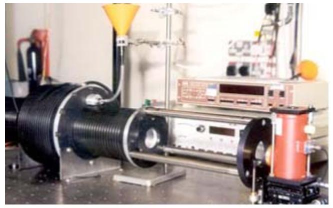


Traceability to primary standards

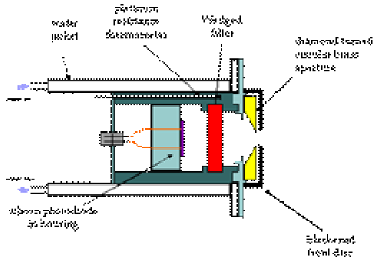
- Majority of calibration tests will be performed with Labsphere U2000-S integrating sphere.
  - 500mm uniform source integrating sphere with 200mm exit port
  - (2) motorised variable attenuators to provide continuous luminance adjustment
  - Luminance monitor and photometer
  - Ocean Optics CCD spectrometer for monitoring spectral radiance in the band up to 1100nm
- Traceability of radiance measurement to SI will be via Transfer Standard Absolute Radiance Source (TSARS)
  - Supplied by the UK National Physical Laboratory (NPL)
  - Radiometric accuracy 1% when calibrated by NPL against primary blackbody source.
  - Uniformity over 75mm port <0.4%
  - Stability <0.02% over 4 hours.
  - Used for GERB and GOME-2 calibrations



Source Calibration (2)



The Absolute Measurement of Black body Emitted Radiance, AMBER, and facility. This uses filter radiometers, with trap detector, to calibrate the blackbody against the primary cryogenic radiometer



The standard NPL filter radiometer, which is linked back to the primary cryogenic radiometer that underpins the optical metrological scales.

Conclusions

- To ensure continuity of existing datasets, the overall calibration strategy for the SLSTR instrument will be based on existing best practice procedures used for ATSR and similar instruments
- SLSTR design ensures that it can be calibrated
- IR channel calibration planning is well advanced
  - Tests to be performed in flight representative conditions
  - IR Calibration procedure is proposed as a recommended QA4EO best practice procedure
  - Existing calibration sources are to be used
    - Measurements to be performed against reference radiometers/detectors to verify radiometric performance
- Solar channel calibration is to be performed with instrument out of vacuum chamber
  - Necessitated by 2% radiometric accuracy requirement
  - Procedures under development – again could be recommended as candidate for QA4EO
- On-Orbit Calibration Plan will be adopting QA4EO best practice procedures where applicable

Science & Technology Facilities Council Space Science & Technology
CEOS IVOS Meeting – University of Lethbridge, August 2009

Use of same traceability route as post-launch cal/val and comparisons

Also development of QA4EO procedures

NPL

Atmospheric correction

Is in IVOS scope

Is topic important ?

-For land and Ocean viewing

- What are the critical issues?
    - Model/code used?
    - Parameters used in code
    - Ground to sat
    - Sat to ground
    - Real world variability (establishing obtaining parameters to use)
    - ……
- Best practise procedure
- Comparison?

-Champion to take forward - Kurt Thome NASA agreed to lead

QA4EO (CEOS) Documents: Best practises / Procedures complete or in draft

- Use of the Moon for in-flight calibration stability monitoring: T Stone USGS
- Questionnaire for information on IVOS test sites for rad gain land imagers: G Chander USGS
  - Completed templates for above (site pocs ~ 50% completed)
- Protocol for comparison of instrumentation used for cal/val of brightness temperature: N Fox
- Protocol for pilot Comparison of instruments and techniques for land surface reflectance: N Fox
- Protocol for analysis of satellite to satellite TOA radiance/reflectance comparison over Dome-C Mackin
- Procedure for establishing a land based reference test site: NPL/TU
- Best practise Guide to radiometric site characterisation: NPL/TU + IVOS
- Procedure for establishing Aeronet OC site G Zibordi JRC
- Procedure for determining "immersion factor" for water based radiance and irradiance instruments JRC
- Absolute calibration of in-flight sensors using Rayleigh scattering P Henry CNES
- Protocol for comparison of RT codes (RAMI) J-L Widlowski JRC
- IVOS 22 to consider a strawman of a data product creation to identify priority generic procedures for community

IVOS

New projects

Establish plans for CEOS OC comparison following European pilot

Pilot study for "operational cal/val" based on network of "landnet" sites (GIANTS)

- Request all agencies to acquire data over all accessible "landnet" sites at time of Tuz Golu comparison (7)

- Request all agencies to acquire data over five invariant sites in similar time scale

- Request ground site data from landnet sites during August (surface and TOA)

- Cross-compare using sensors as transfer standards

- Also need sensor spec response etc

- Review available tools for comparison (spectral response etc)

- Establish database for results, and overpass predictions, and calendar of campaigns

CEOS comparison of land surface reflectance at Tuz Golu (Aug 2010)

Land surface temp at Tuz Golu (Aug 2010)?

Atmospheric correction – best practise guidance

Recommendations

1. All CEOS endorsed reference standard sites should be incorporated into regular acquisition progammes of all appropriate sensors and the resultant data sets made available through the CEOS cal/val portal.
   - In particular acquisitions should be timed to match key ground comparisons e.g. Tuz Golu Aug 2010, Dome-C Winter 2010
2. Establish plans for an OC surface sites pilot comparison followed by a CEOS comparison in the timescale of 2011.
3. Agencies to support participation in the CEOS comparison of land surface reflectance in Aug 2010
4. Agencies to provide support to maintain (beyond individual campaigns) the CEOS endorsed reference standard test sites and provide access to the data derived from them, for the long term benefit of the community.

QA4EO Governance – IVOS operations

- QA4EO documents submitted to chair and distributed to IVOS team for peer review

  Future may need task groups to consider

- Future IVOS meetings to contain presented agency reports bi-annually
- 2010 (Spring/Summer) plan to hold a conference/workshop at JRC Ispra
- Encourage the use of the QA4EO logo where appropriate as a basis and framework for new cal/val activities e.g. comparisons, specifications, procedures etc particularly to new communities
- establish case studies for promotion
- Develop flexible slide set for presentations with examples of good and bad practise

CEOS WGCV IVOS workshop: To identify, quantify and verify the post-launch performance and relative biases of Earth Observation sensors

Joint Research Centre (JRC) Oct/Nov 2010

OBJECTIVES

•To carry out a detailed review of the results of sensor-to-sensor comparisons with emphasis on the outcome of the recent CEOS land based intercomparison/intercalibration exercises carried out using Dome C and Tuz-Golu but also others as appropriate.

- **To agree upon the relative biases in radiometric gain, between in-flight sensors and publish as CEOS endorsed values (bias correction factors).**
- **To agree on optimum procedures/strategy to ensure long-term stability of sensor performance characteristics and their relationship with observations of other sensors: past, present and future.**

To review existing and conceptual limitations to the uncertainty achievable in the post-launch calibration/validation of sensors through use of vicarious methods (solar reflective), and to identify priorities for the research efforts of the community.

CEOS WGCV request: For sensor list of relevance to IVOS

- Also seek POCs

- New data base on Portal for all sub-groups

-

IVOS