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

Report to CEOS WGCV 30

Chair: Nigel Fox
National Physical Laboratory
UK

with support from BNSC

IVOS

NPL

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**
  - **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

IVOS

NPL

CEOS IVOS 20

Dec 9-10 2008, Tsukuba Japan

Hosts: Jaxa

IVOS team prepare for launch

Attendees 20 (+ 3 intended)

increasing – driven by momentum in CEOS

CEOS IVOS 21, Lethbridge, Canada Aug 11-13 2009

Hosts: University of Lethbridge (Phil Teillet)

IVOS

NPL

Meeting topics

- Organisation reports
- 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

NPL

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)

IVOS

NPL

CEOS WGCV:IVOS “instrumented sites” (LandNet)

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

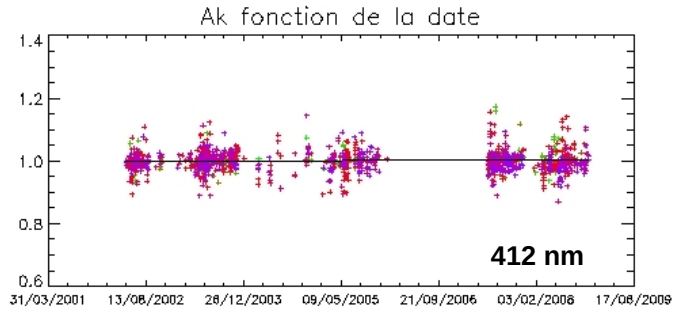
- Standardised procedures to aid characterisation (and for new sites)
- Comparisons of “field measurement” techniques to ensure consistency

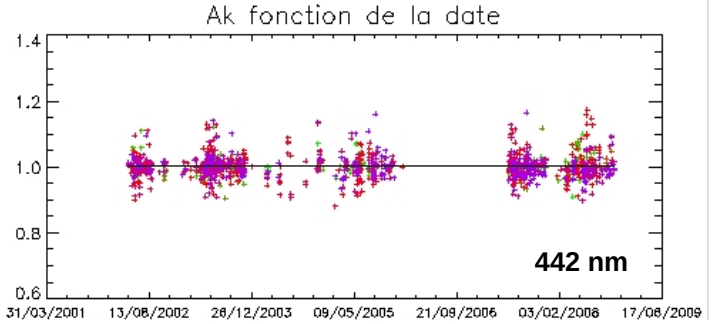
QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

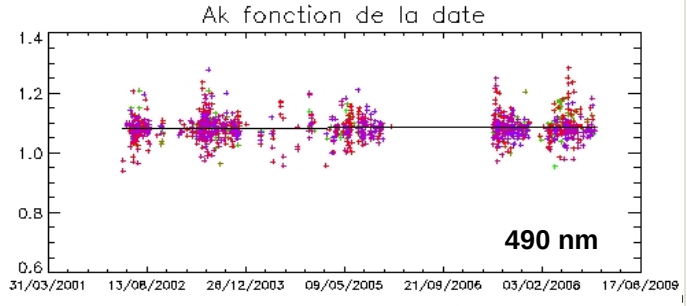
CEOS WGCV IVOS: “stability” Reference standards

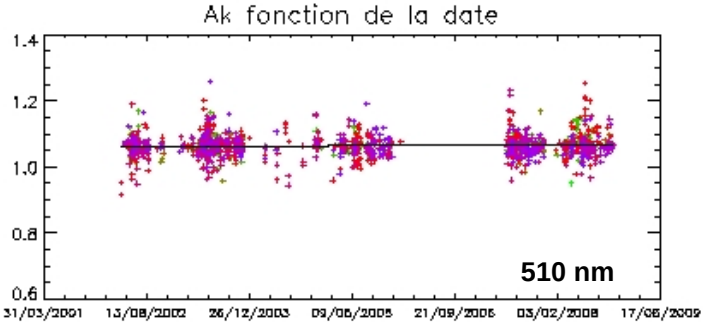
QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

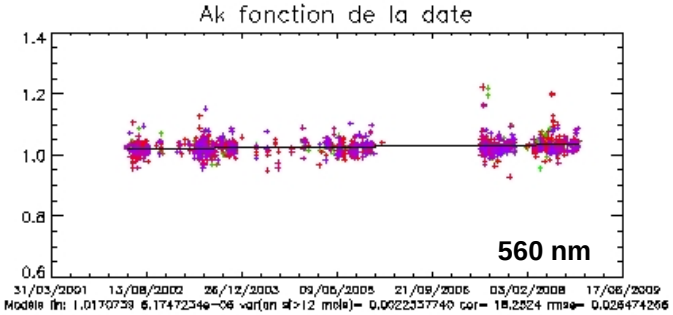
Results of the multi-T calibration (MERIS/MODIS)

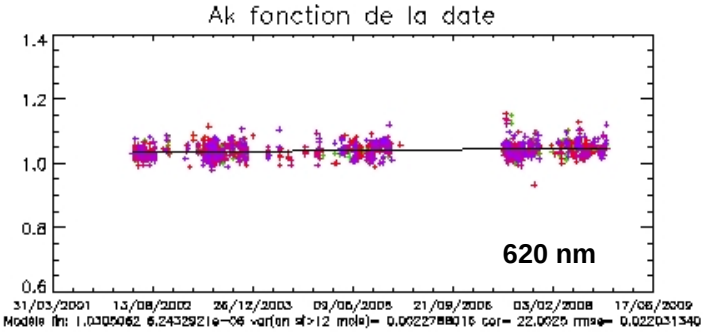




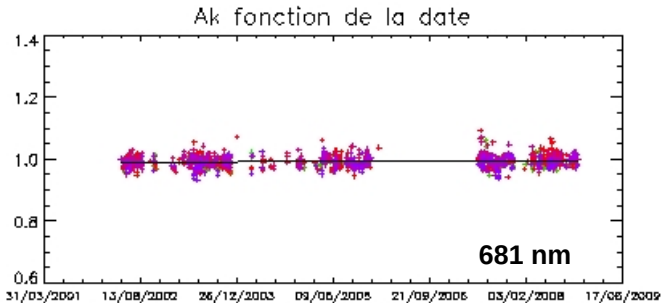


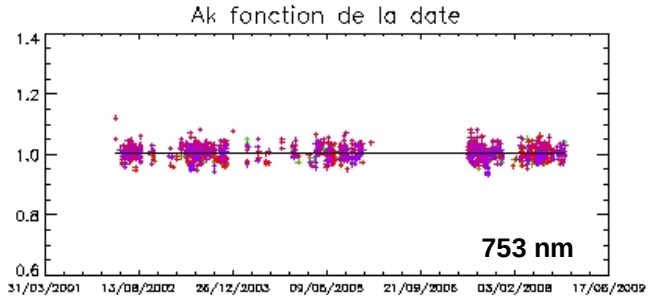


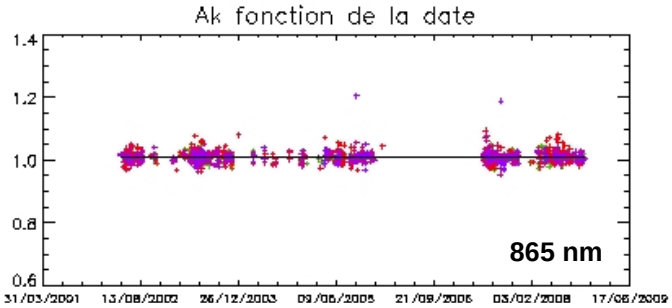


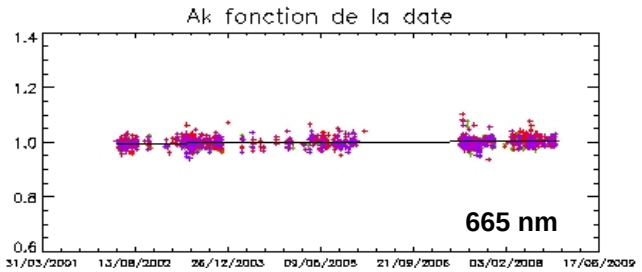


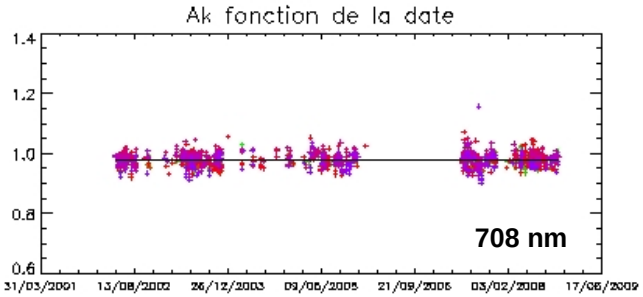
Results of the multi-T calibration

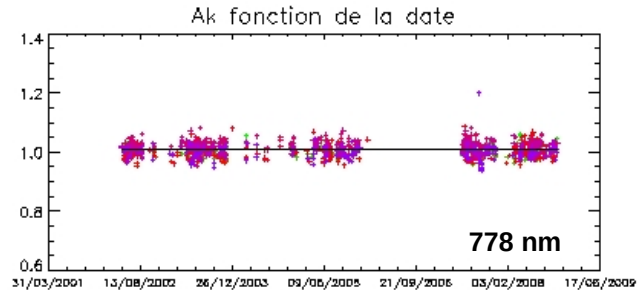


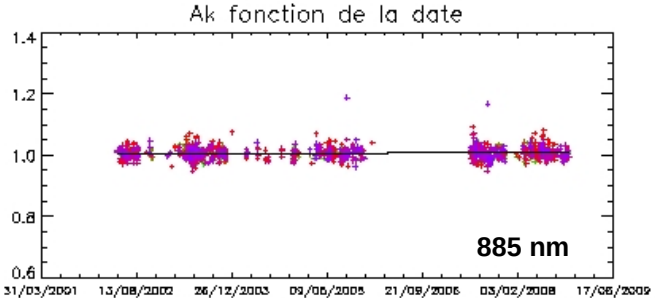












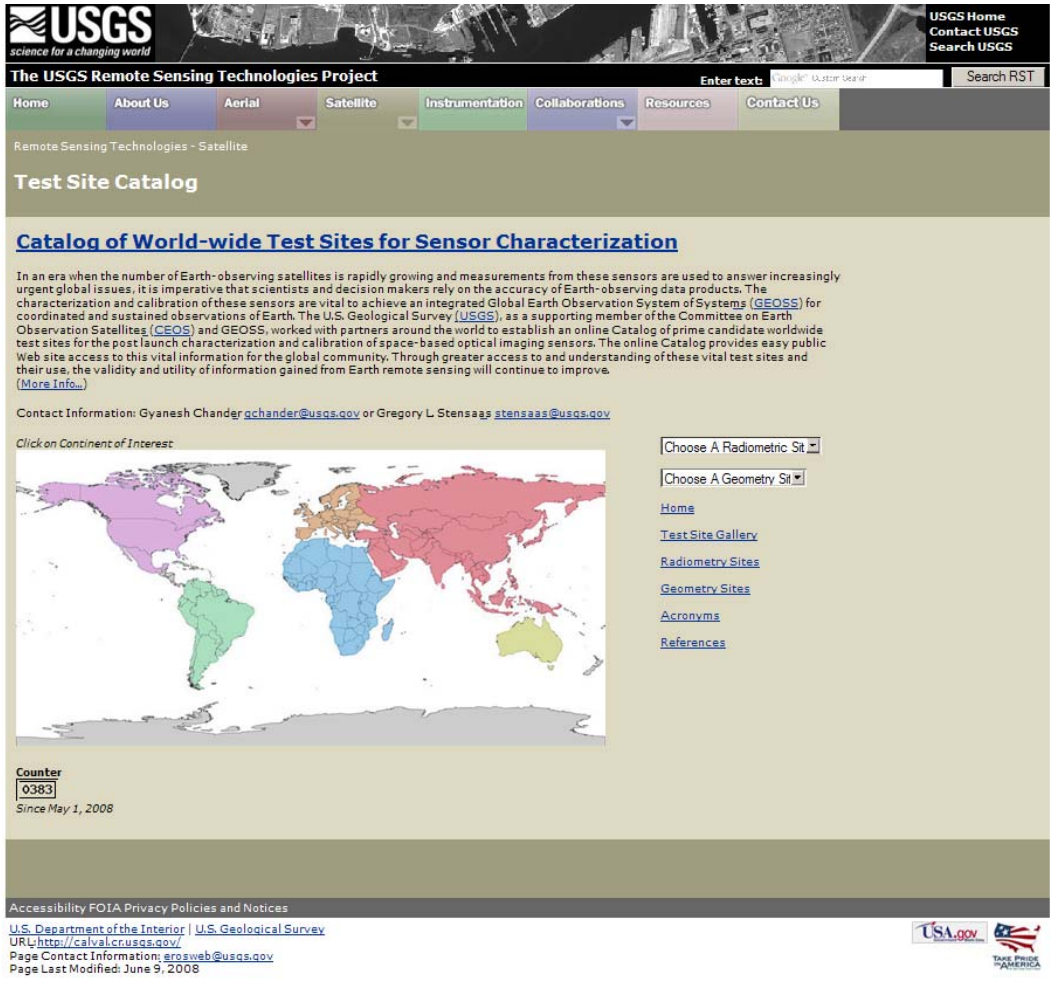
Results of the cross-calibration MERIS/MODIS

Bande	A_k/A_{ksol}	σ (%)
412 nm	1.001	3.5
442 nm	1.003	3.7
490 nm	1.084	4.1
510 nm	1.065	3.6
560 nm	1.027	2.7
620 nm	1.041	2.3
665 nm	0.999	1.8
681 nm	0.993	1.9
708 nm	0.979	2.3
753 nm	1.006	2.3
778 nm	1.009	2.3
865 nm	1.010	1.9
885 nm	1.007	1.9

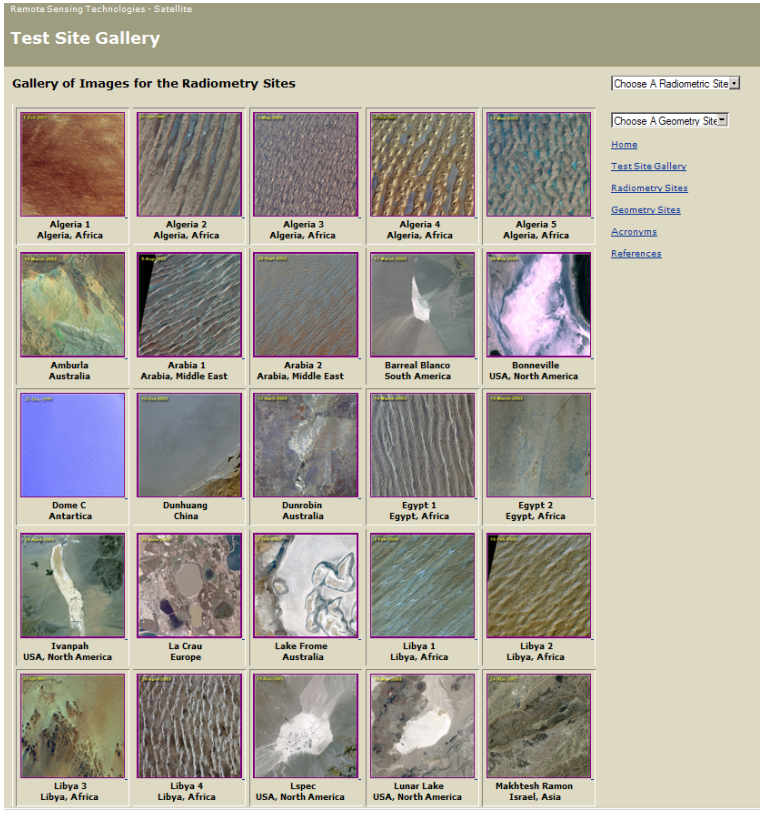
Invariant Sites, CNES SADE data base: community access

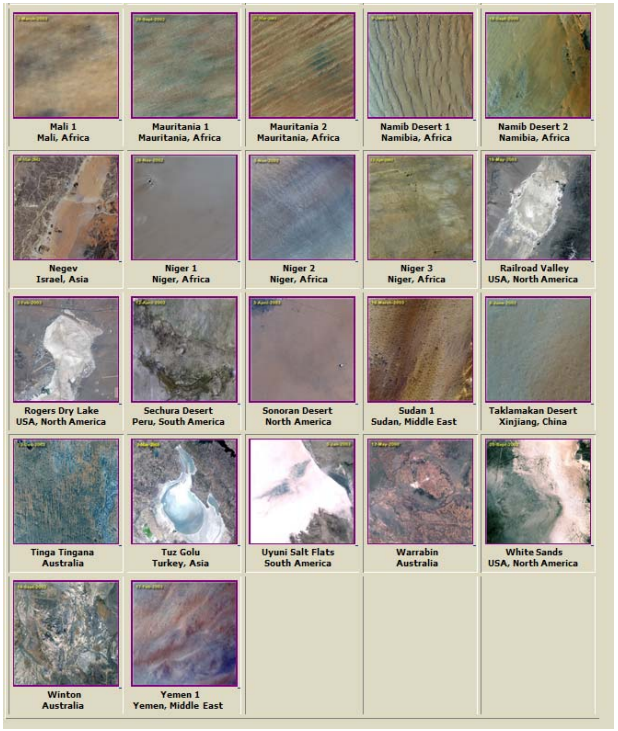
- SADE database info on sites and sensor observations
- Database not easy user interface
- CNES establishing a new interface for GSICS and CEOS WGCV (Jan 10)
  - Not real time
  - Updated 3 or 6 monthly
  - Searchable
  - Welcome other sensors

http://calval.cr.usgs.gov/sites_catalog_map.php



Test Sites Gallery





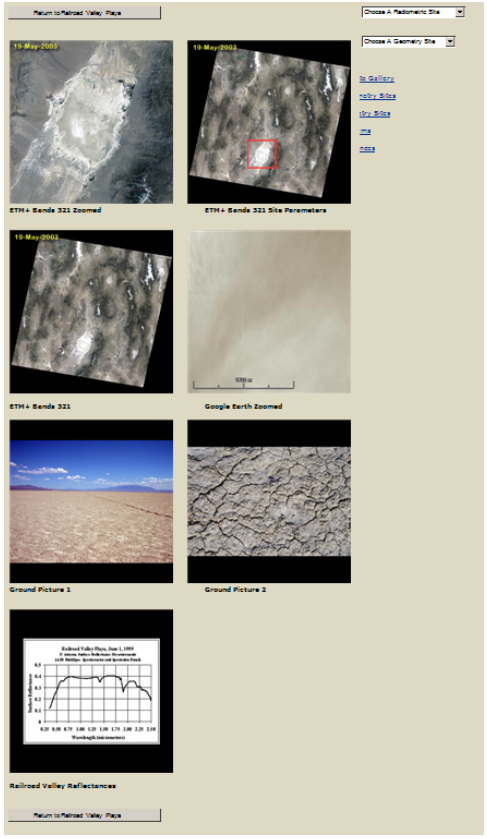
A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

CEOS Reference standard sites Special golden ID

IVOS

NPL

Online Catalogue Example: Railroad Valley Playa, North America



GEO

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

CEOS

IVOS

NPL

Test site template

GEO GROUP ON EARTH OBSERVATIONS CEOS

QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

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

QA4EO-WGCV-IVO-CSP-006

Name of site: Shizafon Playa, Negev, Israel

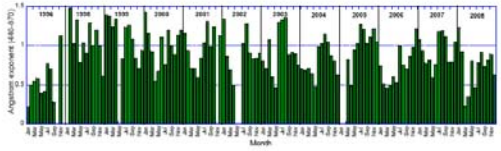


Figure 11: Seasonal (upper panel) and year-to-year variability (lower panel) of Angstrom exponent (processed from the AERONET data).

3.2.2. Water vapour content characteristics

3.2.2.1. Water vapour content origin

The expected origins are long-range transport from the Mediterranean sea and evapotranspiration. Figure 6 (see below) presents seasonal peaks of the water vapour content during summer time. During the summer period moist air masses can reach the Negev desert, also temperature reaches maxima in this period that strongly stimulating evapotranspiration.

3.2.2.2. Seasonal variation of the water vapour content

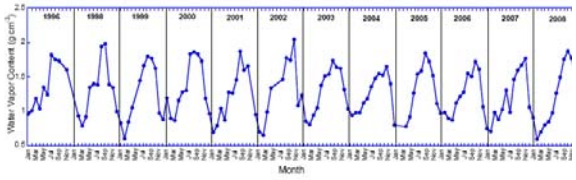


Figure 12: Seasonal and year-to-year variability of water vapour content as retrieved from the AERONET measurements at 935 nm.

3.2.2.3. Mean and accuracy

Overall mean of water vapour content is 1.3±0.35 (±Std Error).

1.1. Identification and characterisation

1.1.1. Site Name

Shizafon Playa, Negev, Israel

1.1.2. Location

Latitude: 30°06'47" N

Longitude: 35°00'34" E

1.1.3. Google Earth Image (1x1 degree around the site center)

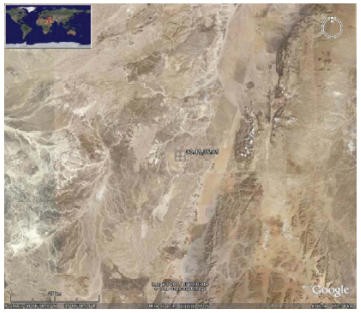


Figure 1: Location of Shizafon Playa in the Israeli Negev desert.

1.1.4. Altitude

340 m

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

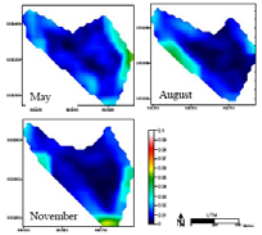


Figure 14: Spatial variability of reflectance at Shizafon Playa for SPOT-4 band 3.

3.3.2.3. Mean reflectance at Nadir (full spectrum)

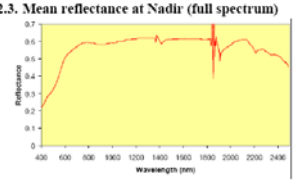


Figure 15: Spectral variability of the reflectance, note the high and flat reflectance values throughout the spectrum.

3.3.2.4. Uncertainty of reflectance (please give breakdown of uncertainty contributions)

IVOS NPL

1) IVOS contribution (e.g. Land radiometric gain)

- **Complete descriptor information on CEOS endorsed reference standard sites and define characteristics for future candidate sites**
  - Define key “classification characteristics” (discriminators) per application
  - Send the questionnaire to the Cal/Val community to get comprehensive information regarding the test sites that will be included on the portal
- **Establish optimum instrumentation specification for “landnet” (CEOS referenced sites)**
- **Establish “best practice” guidance on site characterization and its use**
  - Establish traceability chain for primary site data
- **Provide an Assessment of pseudo-invariant Test sites in the Context of a Global Network of Quality-assured Reference Standards**
- **Establish “Governance" principles**
- **Create a operational network of land sites (“landnet”)**

- Will refine selection criteria for CEOS reference sites following completion of site descriptor templates,

- Encourage regular viewing of sites (landnet and invariant) LSI constellation

-Need standardised sensor specifications

- methods for matching footprints and spectral

- Require annual declaration by “site owner”/poc of maintained criteria

Optical sensor characteristics benefiting from a “test site”

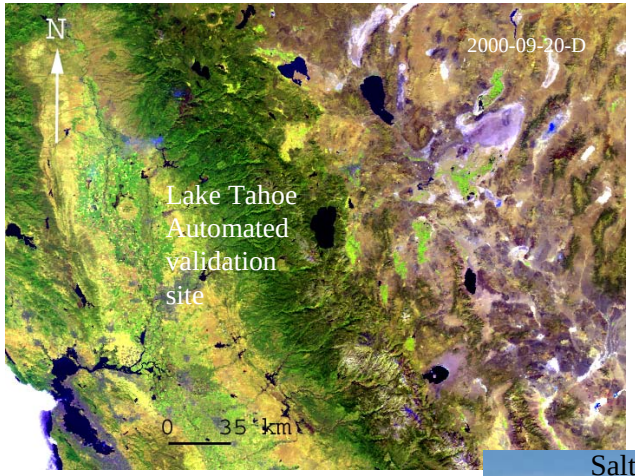
Next priority?

- Gain land surface temp
- Linearity
- Stability
- MTF
- Uniformity (Flat field)
- Stray light (Adjacency effects)
- Polarization
- Spectral
- SNR
- Algorithms
- Geo location
- Camera model
- Band-to-band

IVOS

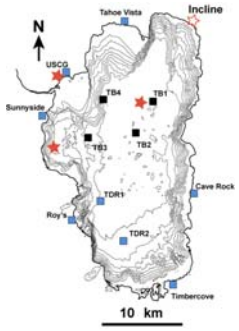
NPL

Proposal for CEOS Water based reference standard for brightness temp



Why Lake Tahoe?

- Large 35 km x 16 km
- High 2 km
- Available year round (does not freeze in winter).
- Homogenous compared with land.
- Large annual temperature range 5-25 C.
- Freshwater (kind to instruments!)
- Good infrastructure and easy access.

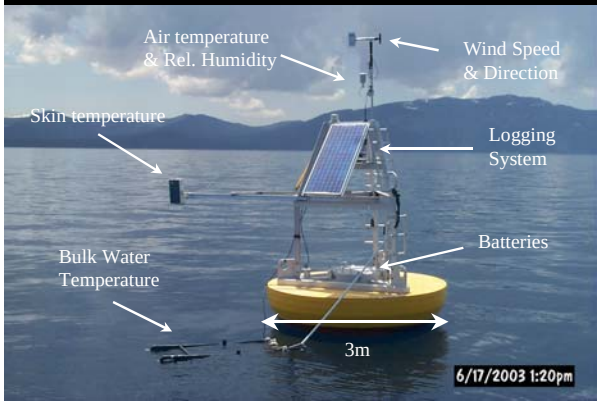


Site Layout and Measurement Stations

Salton Sea, Platform

http://calval.jpl.nasa.gov

TB3 Installed 11-04-2002



IVOS

NPL

OCEAN COLOUR: test sites

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Vicarious Calibration Sites in the history of Ocean Color

MOBY (NASA-NOAA) (1994-present)

Air
Water

MOBY: Marine Bio-Optical Data Buoy

Site: Hawaiian Archipelago

YBOM (NASDA) (1996-1997)

YBOM: Yamato Bank Optical Mooring Buoy System

Site: Japan Sea

PlyMBODy (PML) (1997-1998)

PlyMBODy: Plymouth Marine Bio-Optical Data Buoy

Site: English Channel

BOUSSOLE (LOV-CNES) (2004-present)

BOUSSOLE: Buoy for the Acquisition of a Long-Term Optical Time-Series

Site: Ligurian Sea

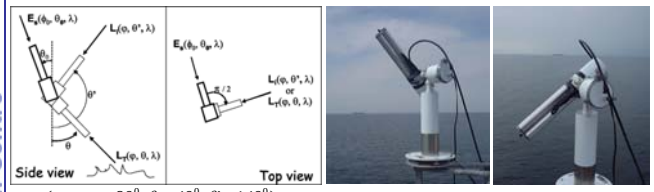
3M US$ per year

1M US$ per year

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Above-Water Radiometry with SeaPRISM

Joint Research Centre



$(\varphi = \varphi_0 + 90^0; \theta = 40^0; \theta' = 140^0)$ CE-318 (sky-viewing: L_i) CE-318 (sea-viewing: L_T)

Fundamentals

$$L_W(\varphi,\theta,\lambda) = L_T(\varphi,\theta,\lambda) - \rho(\varphi,\theta,\theta_0,W)L_i(\varphi,\theta',\lambda)$$

$$L_W(\lambda) = L_W(\varphi,\theta,\lambda)C_{3Q}(\lambda,\theta,\varphi,\theta_0,\tau_a,Chla,W)$$

$$L_{WN}(\lambda) = L_W(\lambda)\left(D^2 t_d(\lambda)\cos\theta_0\right)^{-1} C_{f/Q}(\lambda,\theta_0,\tau_A,Chla)$$

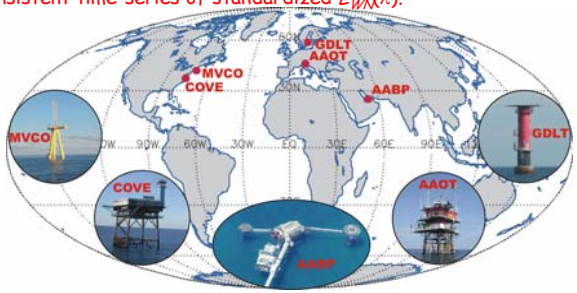
Uncertainties

λ	412	443	490	560	670
ε [%]	4.8	4.3	4.4	4.5	7.6

G. Zibordi, B. Holben, I. Slutsker, D. Giles, D. D'Alimonte, F. Mélin, J.-F. Berthon, D. Vandemark, H. Feng, G. Schuster, B. E. Fabbri, S. Kaitala, J Seppälä. AERONET-OC: a network for the validation of Ocean Color primary radiometric products. *Journal of Atmospheric and Oceanic Technology* (submitted).

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

AERONET – Ocean Color (AERONET-OC): an integrated network, part of the Aerosol Robotic Network (AERONET), supporting ocean color validation with highly consistent time-series of standardized $L_{WN}(\lambda)$.



- The development of AERONET-OC results from a collaboration between NASA and JRC.
- NASA manages the whole network infrastructure (i.e., handles the instruments calibration and, data collection, processing and distribution within AERONET).
- JRC has the scientific responsibility of the processing algorithms and additionally contributes to calibration and quality assurance tasks.
- AERONET-OC sites are established and maintained under the responsibility of individual PIs.

G.Zibordi et al. A Network for Standardized Ocean Color Validation Measurements. Eos Transactions, 87: 293, 297, 2006.

Proposal to establish Aeronet-OC as CEOS reference standards for Ocean Colour + probably MOBY and Boussole.

(NEED PROCEDURES)

OCEAN COLOUR: actions

Driven by JRC and Kordi (GOCI) with OCR-VC as an output "customer"

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

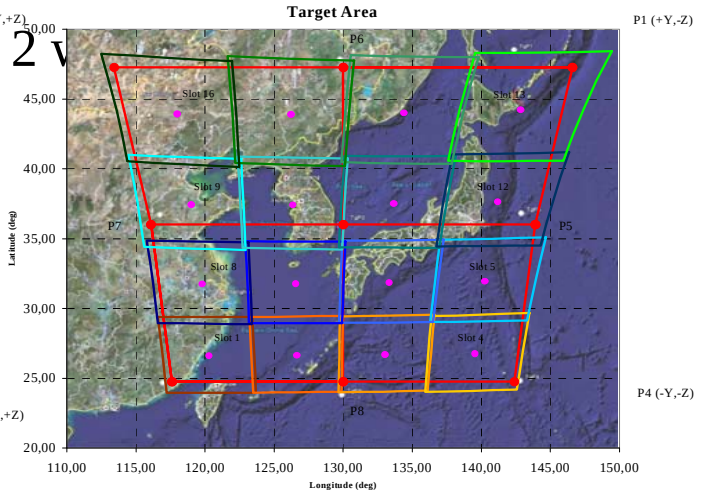
- Protocols need to be modified improved written to address class 2 (coastal waters) (European lead as issue greatest by OC community but facilitated and reported to IVOS (QA4EO) and IOCCG)

- 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 (2010/11



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

IVOS

NPL

Land and Ocean surface temperatures

– G Corlett Leicester Univ.

-Active communities outside of CEOS

- Recognise high level framework from CEOS (QA4EO) and reporting/coordination if needed e.g. comparisons.

- Technical Expertise and detailed discussion in external groups e.g. GHRSST

- New protocols and procedures being written particularly LST (immature) aim to be QA4EO compliant

- Utilise QA4EO logo in activities where appropriate in validation communities

- Need to establish LST comparison following SST

- Terminology needs to be defined temperature (radiometric, kinetic)

- Coordination with LPV (IVOS cal and LPV (Val)

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

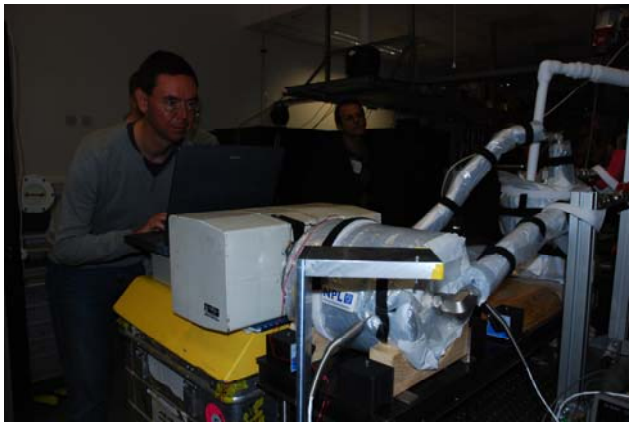
15 radiometers

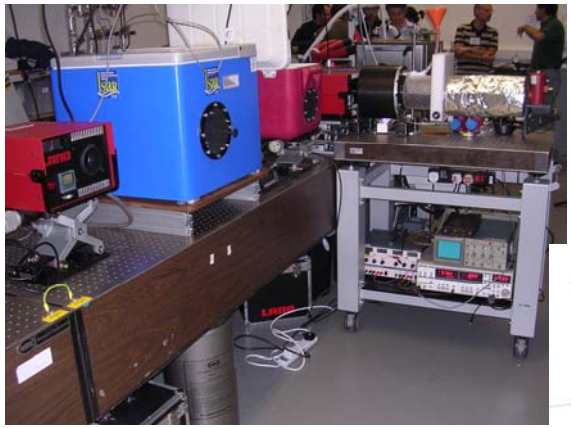
5 black bodies

9 participants plus NPL and NIST for traceability

IVOS

NPL





QA4EO

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

Lab based temps from 10 to 30 ºC (nominal)

Link between UK and US via radiometers

Awaiting data and uncertainties

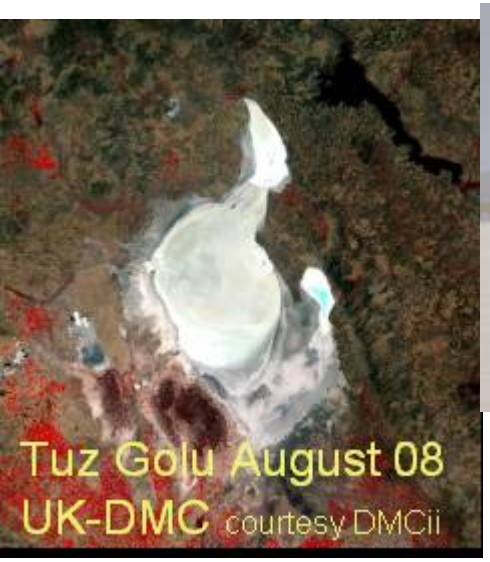
China participate at NPL June 2 (visa difficulties for US)

IVOS

Land surface: solar reflected radiance comparison

Plan:

- Use Tuz Golu as an accessible CEOS reference standard test site
- Carry out preliminary evaluation and establish draft protocol Dec 2008
- European pilot comparison for Summer 2009 (August 23 to 28)
- CEOS comparison Summer 2010



AUG 08 campaign
NPL & Tubitak Uzay

Draft protocol reviewed May 20 – CNES/ONERA, DLR, TU, RSL

Pilot NPL

Lab, Ground, aircraft and satellite comparisons

IVOS

NPL

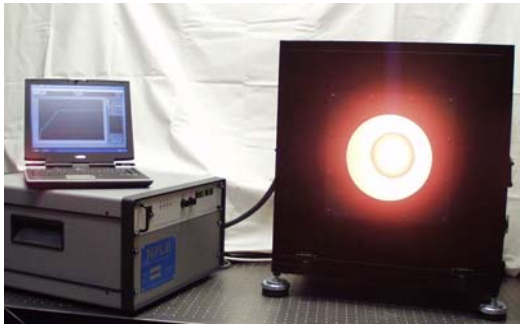
Comparison objectives

1. **Evaluate differences in field instrument primary calibrations**
   a. Reference standards used and traceability (based on “Laboratory” information)
   b. On-site calibrations/validations
2. **Evaluate differences in methods for characterising and assigning “radiometric value” to a site, for multiple view angles**
   a. Small area for high-resolution imagers
   b. Large area for medium-resolution imagers
3. **Establish formal traceability of Tuz Gölü reference site based on an evaluation of all comparison results.**
4. **Establish “best practice” guidance for above and/or knowledge of variance between methodologies.**
5. **A multi-sensor (satellite and aircraft) comparison linked to the ground calibration derived from the multi-team comparison.**
6. **Identify the minimum and ideal specifications for characterisation/instrumentation for a CEOS “reference standard”**

Comparison 1: Cross-comparison of all instrumentation (identify and removal of biases from other comparisons)

•All radiometers will be characterised using TSARS,
NPL standard radiance source _____ at TU Laboratory, Ankara
All FOV being used by participants

•Nadir and 30º measurements of a Lambertian panel diffuser,
NPL reflectance reference standard _____ at TU Laboratory in Sun
all radiometers to view all panels within 30 minute period with repeat.



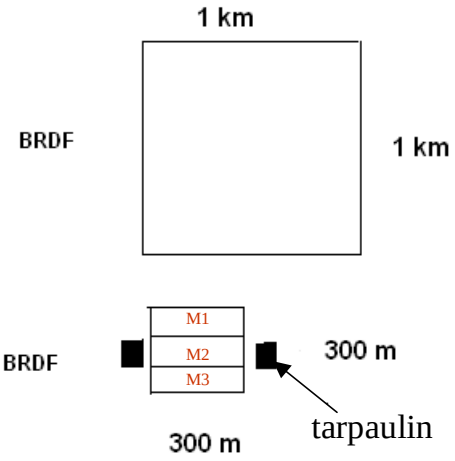
IVOS

NPL

Comparison 2:

- **Radiance/reflectance measurements at nadir, by each participant using own panel for 150m*150m targets & 1000*1000m site (by rotation on different days)**
- **All participants will characterise the same target at the same time (sun angle) but on different days using their own method & sampling strategy**
- **Participants results will be provided as "site values" for surface and using a normalised data set, as TOA for nominated satellites with uncertainty budgets.**

Comparison targets



Participants P1, P2, P3 & NPL

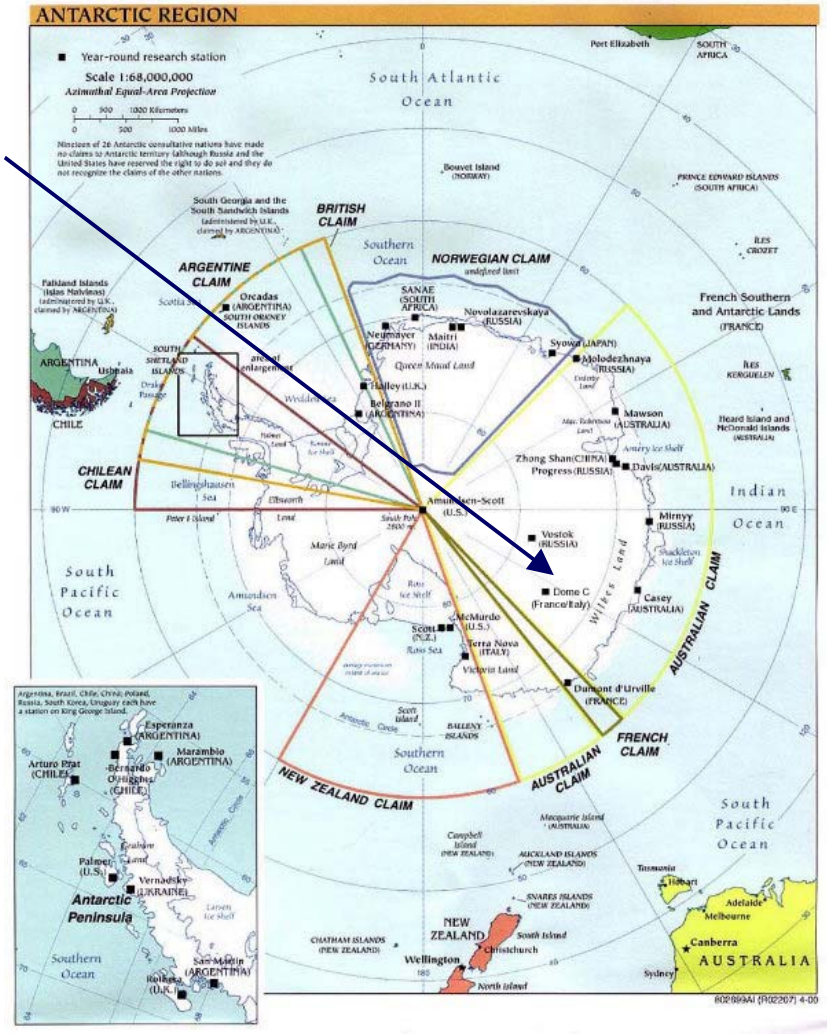
	M1	M2	1 km*1 km
Day 1	Cross comparison radiometers at TU, Ankara		
Day 2	Set-up Measurement Campaign at the site		
Day 3	P1	P2	P3
Day 4	P3	P1	P2
Day 5	P2	P3	P1
Day 6	one target view in the same time by P1, P2, P3		
Day 7	Cross comparison radiometers at TU, Ankara		

Site 1 Km^2
M1, M2, M 3 are 100m*300m

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

Photo courtesy Stephen Hudson, Univ. of Washington



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

CEOS comparison of satellite measured TOA radiance/reflectance using DOME-C

- Formal invitation to participate circulated to all CEOS agencies
- Request for acquisitions over DOME-C and associated sites during Dec 08 – Jan 09
- Also for sensor characteristics e.g. spectral response and uncertainty
- All data to be analysed and compared relative to a “comparison mean” and common methodology
- NOAA analyse Medium/large resolution & NPL (ESA) high resolution + some medium for linkage
- Analysis protocol drafted based on expertise of RAL, CNES, NOAA will do a pre-analysis of sensitivity to meteo conditions and angles based on actual data sets
- Although large interest not all were successful in obtaining data
- Following initial comparison, data sets to be available to community via portal for cal studies

IVOS

NPL

Optical Sensors with data sets:

ALOS

ASTER

ATSR+

AVHRR

CBERS-2B

CERES

CHRIS / Proba

DMC (suite of satellites)

Hyperion

Hyperion

Landsat

Meris

MISR

MODIS

Spot

Vegetation

IVOS

NPL

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Joint Research Centre

Update on the activities of the
Radiation transfer Model Intercomparison
(RAMI)

J-L. Widlowski and Bernard Pinty

CEOS, WGCV, 30th meeting, May. 26th – May 29th, 2009, Ilhabela, Brasil

Institute for Environment and Sustainability

IVOS

NPL

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

RAdiative transfer Model Intercomparison

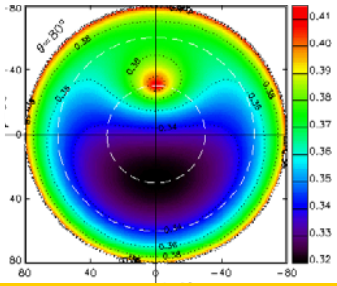
Joint Research Centre

Purpose of RAMI:

- to act as common platform for intercomparison efforts of canopy reflectance models,
- to document uncertainties and errors among models,
- to establish protocols for the evaluation of RT models,
- to foster scientific debate

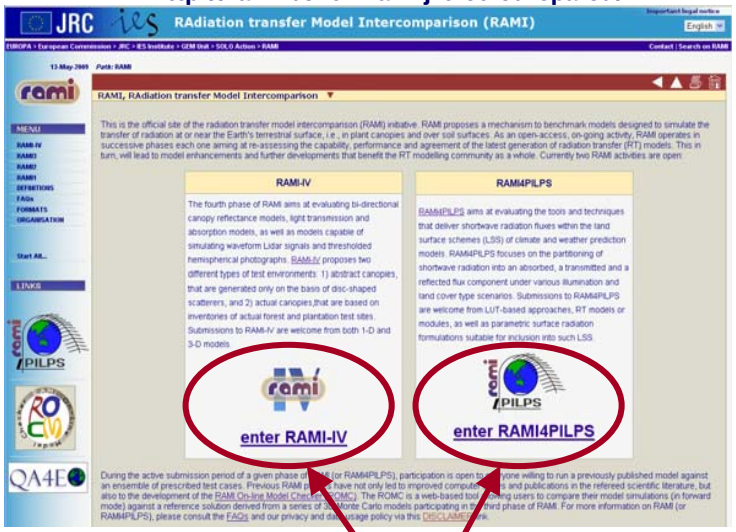
scene

radiative quantities



models evaluated in direct mode

http://rami-benchmark.jrc.ec.europa.eu/



currently two open activites:

- RAMI-IV
- RAMI4PILPS

Institute for Environment and Sustainability

Pinty et al., 2001, 2004 (JGR); Widlowski et al., 2007 (JGR), 2008 (RSE);

IVOS

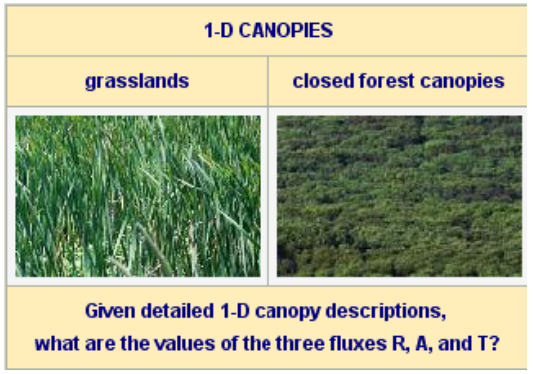
NPL

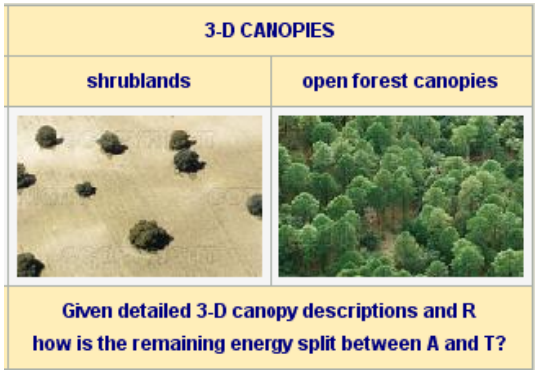
EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

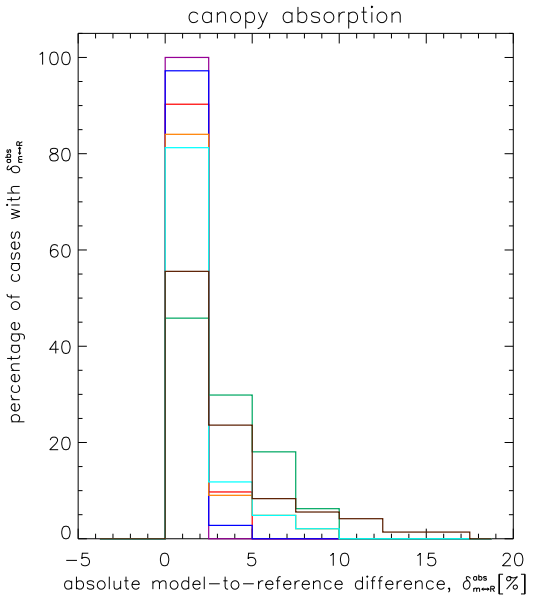
Ongoing activities: RAMI4PILPS

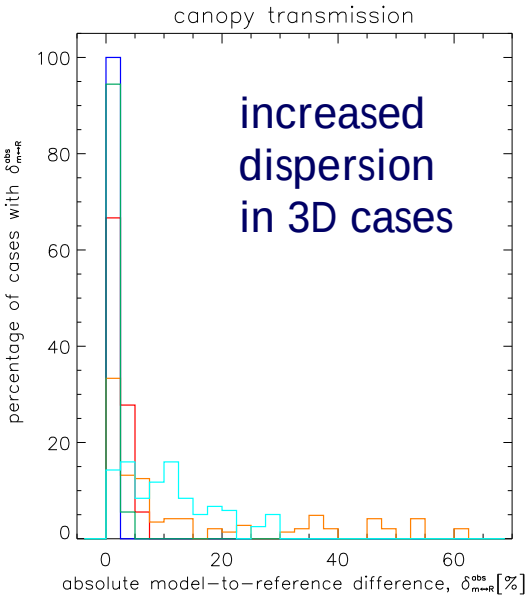
Joint Research Centre

- addresses quality of Land surface schemes in SVATs, NWPMs and GCMs
- deals only with shortwave fluxes
- so far 8 groups have submitted results:
  - model simulations are clustered with some outliers
- 2 evaluation modes:
  - forward mode for 1-D canopies
  - assimilation mode for 3-D canopies









http://rami-benchmark.jrc.ec.europa.eu/HTML/RAMI4PILPS/RAMI4PILPS.php

IVOS

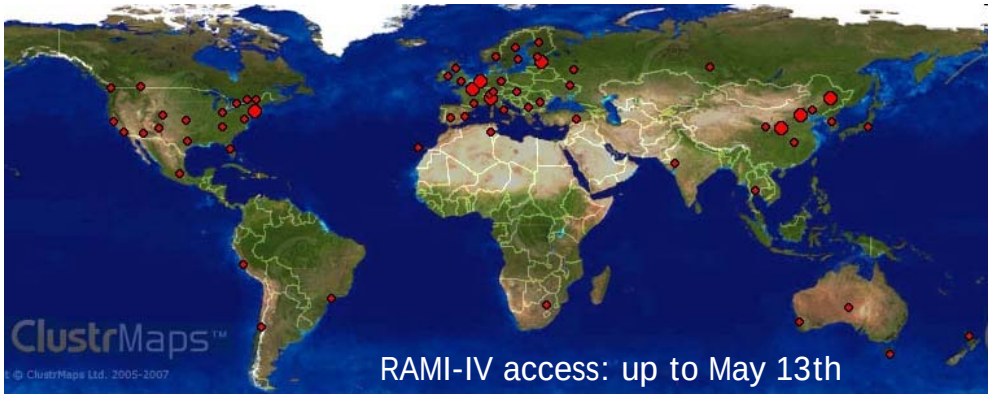
NPL

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

Ongoing activities: RAMI-IV

Joint Research Centre

- launched in Feb 2009,
- increased realism of spectral & structural canopy properties,
- increased realism of simulated 'data'

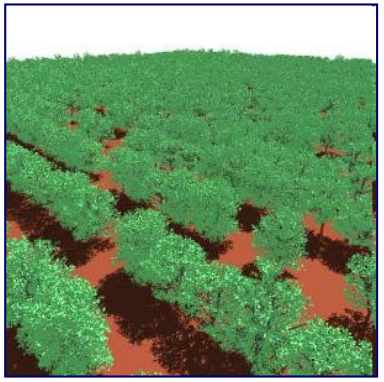


thresholded fisheye

birch stand

Scots pine stand

citrus orchard



IVOS

NPL

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 ChanderUSGS**
  - **Completed templates for above (site pocs ~ 50% completed)**
- **Protocol for comparison of instrumentation used for cal/val of brightness T: N Fox NPL**
- **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 NPL,NOAA,CNES,RAL**
- **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**

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

- IGARSS Special session on QA4EO (David Llewellyn Jones & Gyanesh Chander

- SPECIAL Edition Canadian Journal Remote Sensing (2011)

  "Terrestrial Reference Standard Test Sites for Post-Launch Calibration"

  Eds Phil Teillet and Gyanesh Chander

New projects

Establish plans for OC comparison

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**

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

“ “ Land surface temp at Tuz Golu (Aug 2010)?

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 2009 & Aug 2010
2. Aeronet-OC and Lake Tahoe to be endorsed as CEOS reference stnds and their use encouraged (see 1 above)
3. Establish plans for an OC surface sites pilot comparison followed by a CEOS comparison in the timescale of 2011.
4. Agencies to support participation in the CEOS comparison of land surface reflectance in Aug 2010