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

Report to CEOS WGCV 28 & (WGISS)

Chair: Nigel Fox
National Physical Laboratory
UK

with support from BNSC

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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*)
- **Established IVOS web site for communication http://ceoswgcv-ivos.org**
- **Tried using a wiki for discussion forum on key topics (not yet successful)**
- **Key Activities**
  - **Information exchange**
  - **Focus on developing and addressing GEO task DA 06-02**
    (***Data Quality Assurance strategy***)
    - Initiation of Cal/val portal (for communication)
    - Establish cal/val "best practises"
    - Comparisons to underpin
    - Identification and classification of "test sites" for sensor performance evaluation
  - **Prioritise activities to focus on needs "Land imager constellation"**
  - **WGCV Lead on CEOS climate Action A5, C7**
    (*Benchmark mission to establish SI traceable measurements in orbit*)

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CEOS IVOS 19

Feb 5-7(8) 2008
Tempe Arizona

Hosts: University of Arizona Remote Sensing Group
Co Sponsor: USGS

Evaluating a “test site”!

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Meeting objectives

- To exchange information - agency reports on progress

  (reduced time - noting significant number at IVOS 18)
- Focus on “test sites” uses/classification
- “Standards”
- Best practises
- Comparisons (Ocean and Land)
- GEO/CEOS tasks
- Recommendations

ESA reports:

- Sentinels progress

- Cal/val Infrastructure (GECA)

- Cal/Val strategies for MERIS &ALOS

- Data access e.g. G-POD Grid processing on demand)

-Reprocessing plans MERIS/AATSR

- GMES service development

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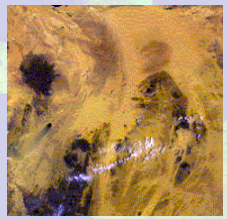
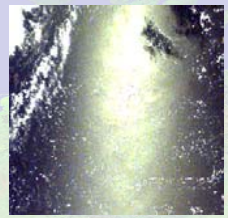
Calibration verification – MERIS

Calibration of MERIS using natural targets
CNES (Claire Tinel, Patrice Henry, Olivier Hagolle) – MERIS QWG 15th.

- Calibration Methods
  - 3 calibration methods are used to validate MERIS calibration


Deserts


Sun glint


Rayleigh

  - These calibration methods are used operationally at CNES
    - for POLDER 1, 2, 3, VEGETATION 1 and 2,
    - for SPOT satellites, MERIS, FORMOSAT-2 and KOMPSAT-2

GMES service demonstration

GlobCarbon, GlobColour and GlobCover have all release large global data sets in the last 6 months

• GlobCarbon - 6 years of LAI, burnt area, fapar, etc (See http://dup.esrin.esa.it/projects/summaryp43.asp)

• GlobColour - 10 year oc timeseries (www.globcolour.info)

• GlobCover - MERIS-FR mosaics for 2005/6 (http://www.esa.int/due/ionia/globcover/)

ATSR World Fire Atlas mapped lots of fires in Greece in August, and showed the number of fires to be much more than in the past (http://www.esa.int/esaEO/SEMMGZLPQ5F_index_2.html

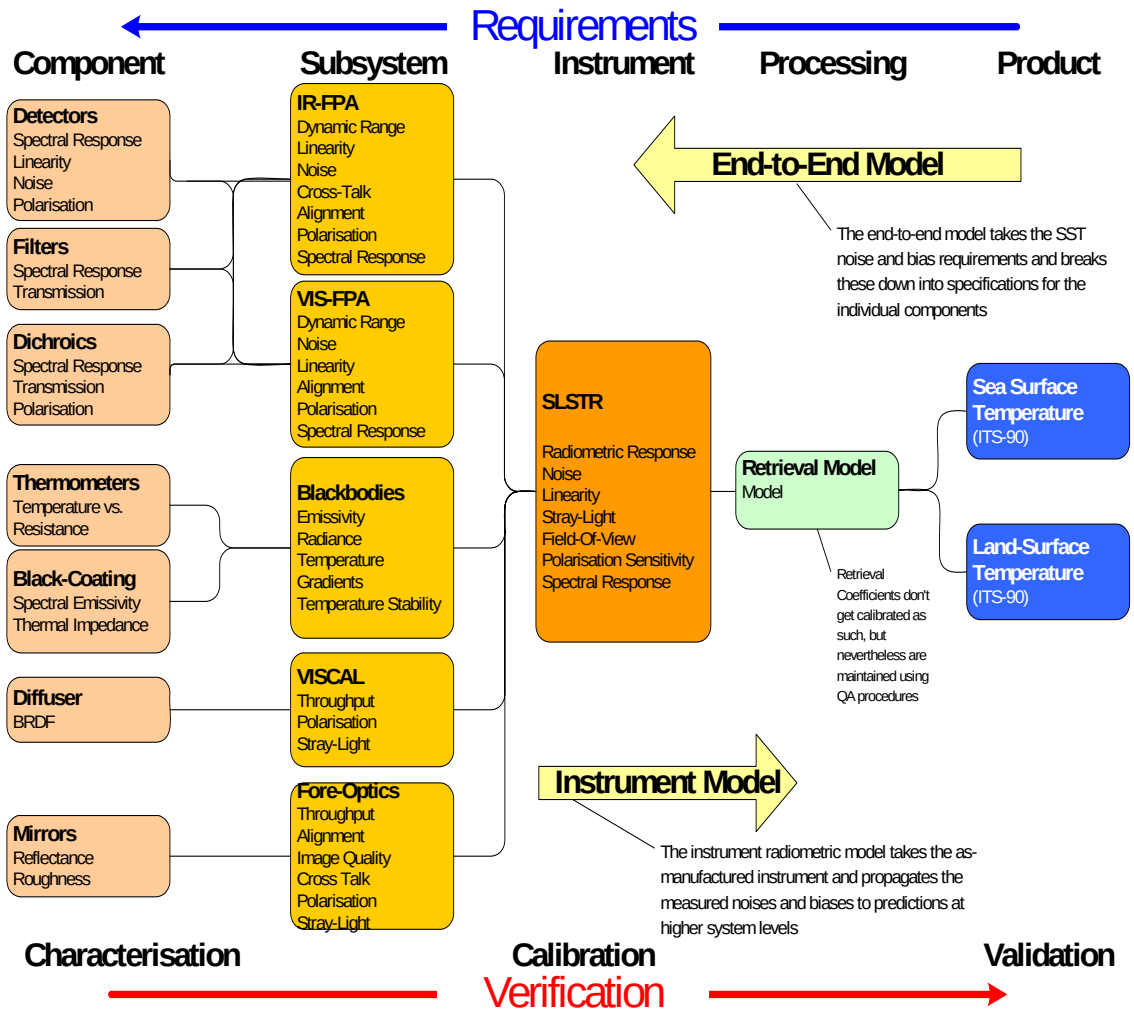
MEDSPIRATION - A Contribution to the GODAE/GHRSST-PP project
Medspiration is a real-time service for the production and delivery of high-resolution sea surface temperature from all available satellite sensors.
http://www.medspiration.org/

(STFC) RAL

- AATSR Cal status
- ATSR archives
- Cal site experience
- Cal strategies for

BBR of Earthcare
& SLSTR Sentinel 3

SLSTR Calibration Overview



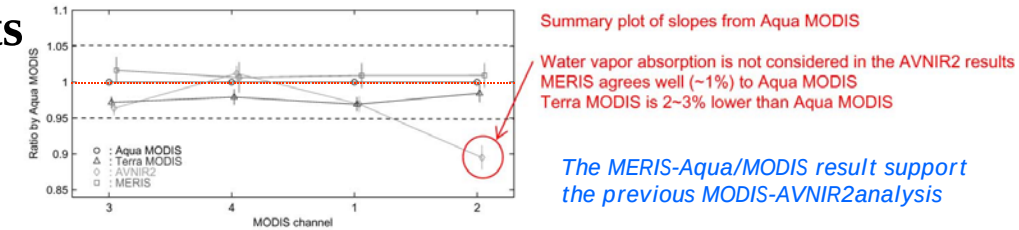
Radiometric (cross and vicarious) calibration sites

JAXA

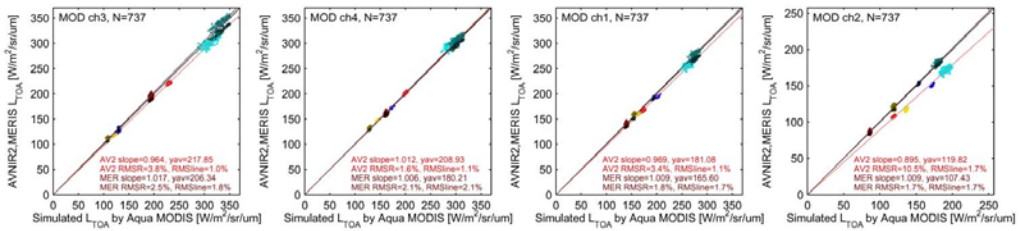
Test site	Center Lat	Center Lon	Note
Asia			
RAKhali (Saudi Arabia)	21.00	51.00	150m
Tuz Golu (Turkey)	38.75	33.35	900m
Africa			
Lybie (Sahara)	28.90	23.75	120m ESA?
Mari (Sahara)	19.12	-4.85	370m ESA?
America			
WhiteSands (U.S)	32.50	-	1310
Ivanpah Playa (U.S)	35.50	106.20	890m
LunarLake (U.S)	38.40	115.40	1910m
Railroad Valley (U.S)	38.50	116.20	1420m
Ely (U.S)	38.33	115.69	1500m
Salar de Uyni (Bolivia)	-20.20	-67.60	3660m ESA?
Arizaro (Argentine)	-24.57	-67.70	3570m ESA?
Oceania			
Alice Springs (Australia)	-23.70	133.80	670m
Lake Frome (Australia)	-29.00	139.75	14m
Tinga Tingana (Australia)	-30.75	139.83	2m
Polar snow field			
Antarctica	-80.00	40.00	3600m
Greenland (Denmark)	70.00	-40.00	2880m
Ocean			
Indian Ocean	-25.00	100.00	No insitu
MOBY (U.S)	20.82	156.98	NOAA
South Pacific	-30.00	100.00	No insitu
Space			
Moon	NA	NA	

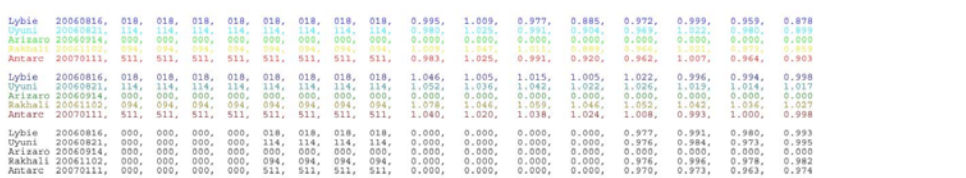
Note: The gain mode for CalVal conflicts sometimes to one for

3.2 AVNIR-2, MODIS and MERIS Comparison



The MERIS-Aqua/MODIS result support the previous MODIS-AVNIR2analysis





-Future mission plans

GOSAT, GCOM-C Earthcare, ALOS fo

- AVNIR-2 Cross-comparisons
- AVNIR-2 in-flight cal lamp drifts
- Test sites (details)
- PRISM stripe noise correction

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NIST

CLARREO (IR)

NISTstars

Climate change portal

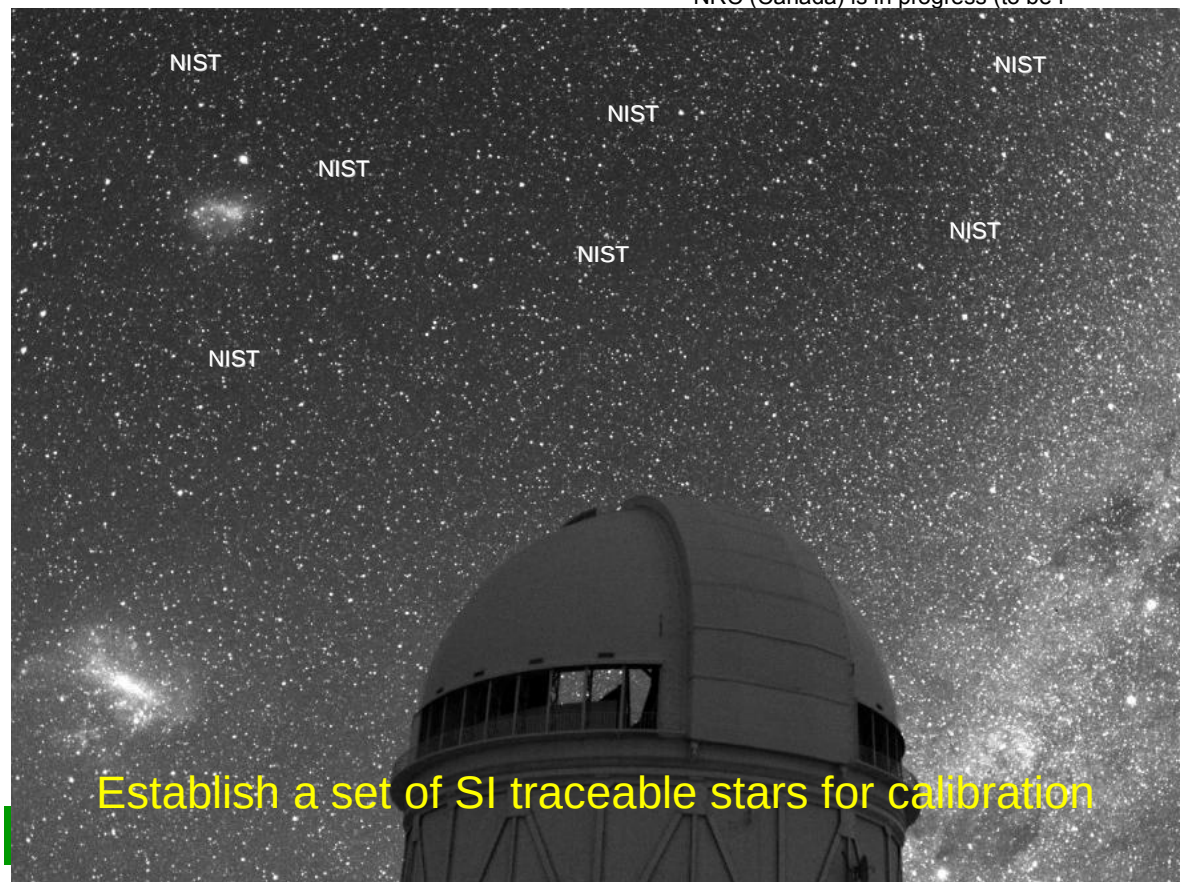
LUSI

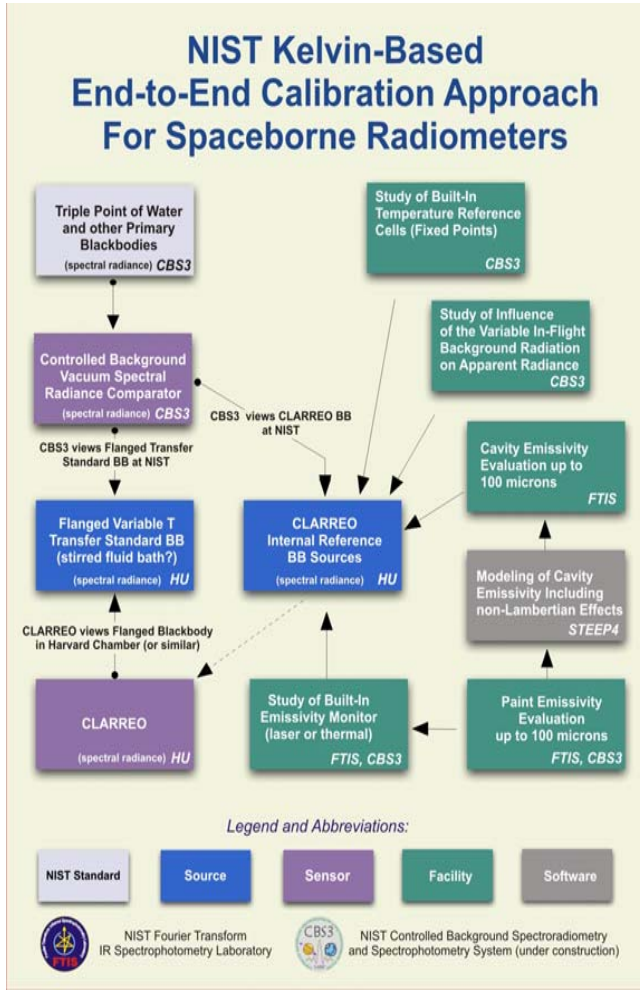
To support climate and other research, including proposed CLimate Absolute Radiance and Refractivity Observatory (CLARREO) mission:

Realization/ validation of the IR spectral radiance scale for near-ambient radiation sources in laboratory conditions:

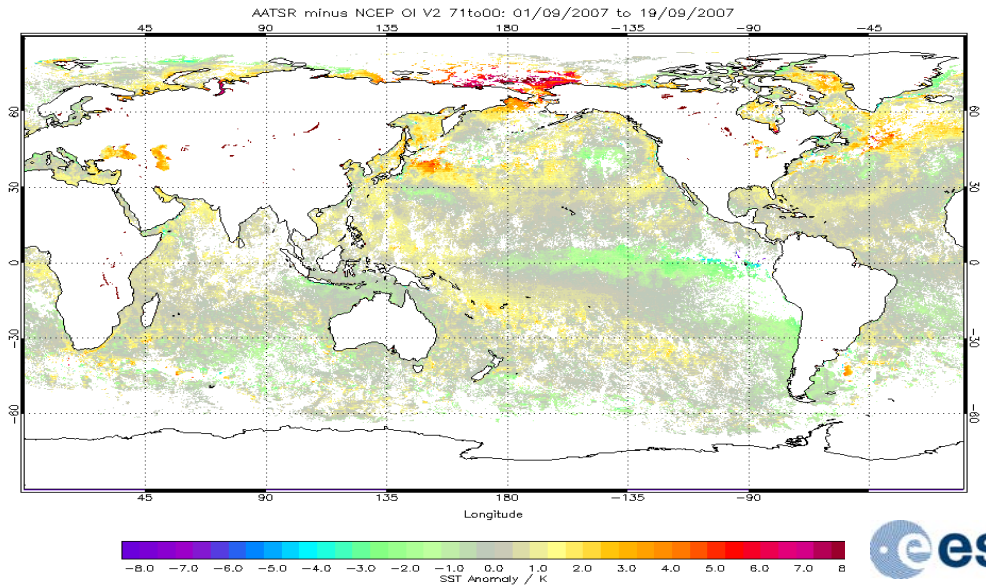
Scale realization and AIRI/FTS internal comparisons (accomplished in 2007).

Validation via comparison with other NMI's including PTB (Germany), NPL (UK) and NRC (Canada) is in progress (to be f





Why do we validate SSTs?



Leicester University

- Validation of SST

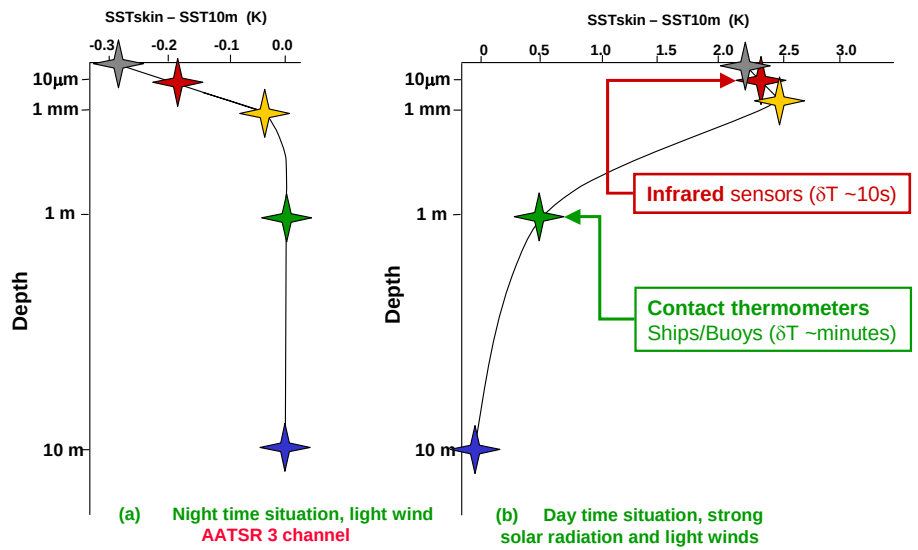
  (proof of results)

- Issues with validation

- Use of AATSR to provide benchmark

VOS, University of Arizona, Tempe, USA, 6th February 2008

Definitions of SST



From Craig Donlon (Met Office)

-New group for Val under GHRSST-pp under GODAE

- Maintenance of cal/val teams

- Need to have regular comparisons

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Kurt Thome: Univ of Arizona

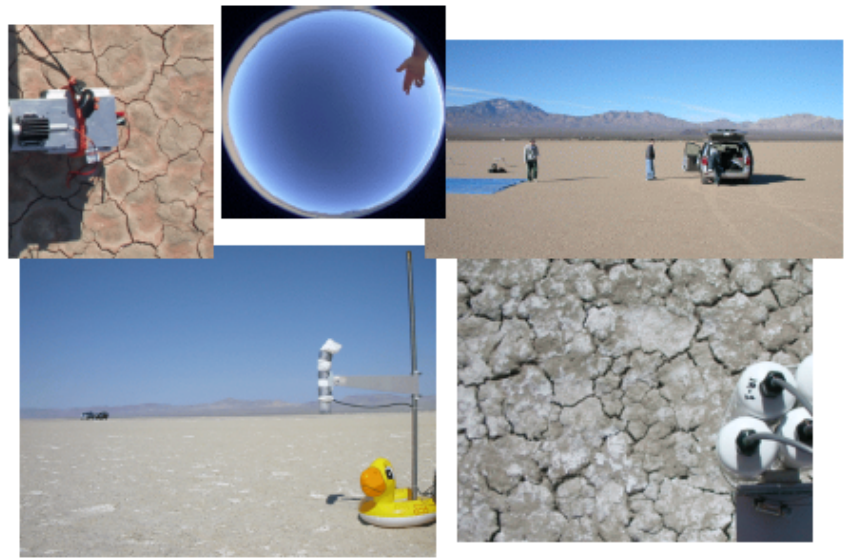
-Challenges of site characterisation

- Equipment reliability

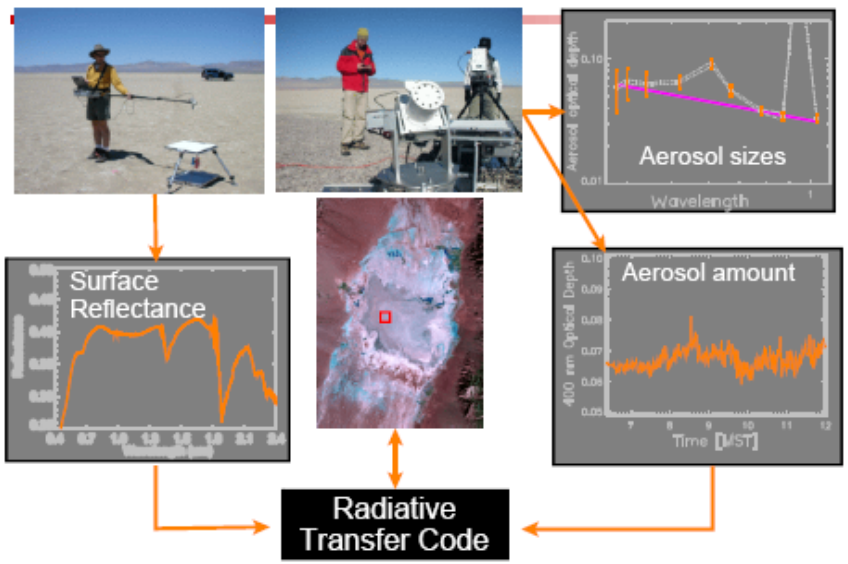
-Personnel sampling issues

- Weather

Natural test sites



Reflectance-based approach



- Sites need to be visited at times

-Costs of maintenance and development planned

- Traceability fundamental

Recommendations

Recommendation 1.

Recognising the existence of biases between sensors, and the need to combine data sets from different sensors for operational and long term studies it is critical that any (normalisation to a designated “reference sensor) is fully documented and transparent. Since often the cause for bias differences is unknown it is recommended that a non-normalised data set is also maintained and archived as well as any bias-removed data.

Recommendation 2

In defining new missions, agencies are encouraged to ensure that the requirement (and ability where practicable) to cross-compare with existing similar sensors (e.g. common channels) is built into the commissioning programme of the sensor. In particular where two nominally similar sensors are being built for simultaneous flight (similar orbits differing phase) it is important to ensure that a requirement is established to ensure commonality of performance between them.

Recommendation 3

When application specific task groups of experts are established for cal/val e.g. the recently formed group for SST validation, they are encouraged to take advantage of the infrastructure of CEOS WGCV to provide a framework to promote their activities and ensure that maximum benefit can be obtained for the community as a whole through the sharing and use of best practises in terms of QA.

Recommendation 4.

Recognise that regular comparison of instrumentation and methodologies is an essential component of any data quality strategy, providing evidence of maintained traceability. This requirement includes the key instrumentation and associated methods used to validate/calibrate performance of sensors through ground based measurements. In particular, it is noted that it is timely to repeat the highly successful comparison of IR radiometers used for SST measurements (Miami) and also to initiate a similar comparison for Land based spectroradiometers.
Such comparisons will require commitment from agencies to support participation and also to sponsor the organisation and necessary infrastructure.

- **Actions**
  - IVOS has established two working groups with coordination from NPL (Land and Ocean) to establish appropriate protocols, plans and cost for such comparisons. The location for the Ocean comparison is to be defined, whereas the Land comparison is baselined to take place at the new “core site” in Turkey.
- - Potential sponsor agencies are sought to support the above planning and subsequent comparisons
- - Ocean to occur in spring 2009, and Land, Summer 2010 with pilot activities in 08/09.

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DATA QUALITY STRATEGY

GEOSS: seamless & continuous delivery of information products to meet needs of societal themes

Interoperability arrangements to allow combination of disparate sources of data

Data policy

Accessibility	Suitability
Availability	Reliability

Fit for purpose

Strategy:
Establish set of guidelines based on"best practises" to be endorsed by CEOS, under auspices of GEO and implemented by the agencies

All data products must have associated with them a Quality Indicator based on a documented quantitative assessment of its traceabilty to an agreed reference standard (ideally tied to SI).

Comparisons

Procedures

Reference standards (with method of use): Including designation of "test sites"

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All data products must have associated with them a Quality Indicator (QI) based on a documented quantitative assessment of its traceabilty to an agreed reference standard (ideally tied to SI).

Follow guidance doc. Draft exists

To establish a QI for a satellite sensor derived data product requires a knowledge of sensor performance and this can best be evaluated through the following guidelines:

Pre-flight:

- **Traceably calibrate all sub-systems**
- **Perform "end to end" system calibration**
- **Maintain witness samples of key components for later testing as necessary**

Post launch: Evaluate sensor performance for following aspects:

- **"Characteristics" compared to pre-flight**
- **Biases to other in-flight sensors"**
- **"Stability" of products (in mission, & link to history and future)**

Can be best achieved through comparison to "CEOS standard" using a "CEOS method"

e.g. LAND imager constellation

Characteristics e.g "Gain"
- On board standard
- CEOS core test site
- Rayleigh scattering
- Clouds
- Moon
- …..

Bias
- SNO
- CEOS core test site
- CEOS invariant standard

Stability
- CEOS invariant standard ("Standard Desserts", Moon)
- CEOS core test site (accuracy)
- On board standard

CEOS "Reference Standards" IVOS

Comparison to (or with) provides quantitative evidence of traceability

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**

Existing CEOS IVOS specific standards: use of "Thuillier" Solar irradiance spectrum for radiative transfer

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Test sites as “reference standards”

- **Relatively large number being used by agencies, some commonality**
- **Radiometrically usually used for Verification of performance or as transfer medium as uncertainty too large for calibration**
- **Key role - need to improve performance and consistency of use – “prioritise” some sites (different for characteristics, sensor type, resolution etc**
- **IVOS definition: test sites must be geographically fixed - includes distributed components e.g. moored buoys, “networks” (e.g. fixed aeronet)**
- **Need to identify characteristics of sensors/data products that can be evaluated using a “test site” → leading to requirements on the test site → → identify potential sites → classify → CEOS Endorse → ALL Agencies view**

•BIG TASK!

- **Focus efforts on a key priority to start:**

Land Imager constellation – Radiometric Gain (med to high resolution sensors)

(*uniformity, Linearity and stability*)

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Optical sensor characteristics benefiting from a “test site”

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

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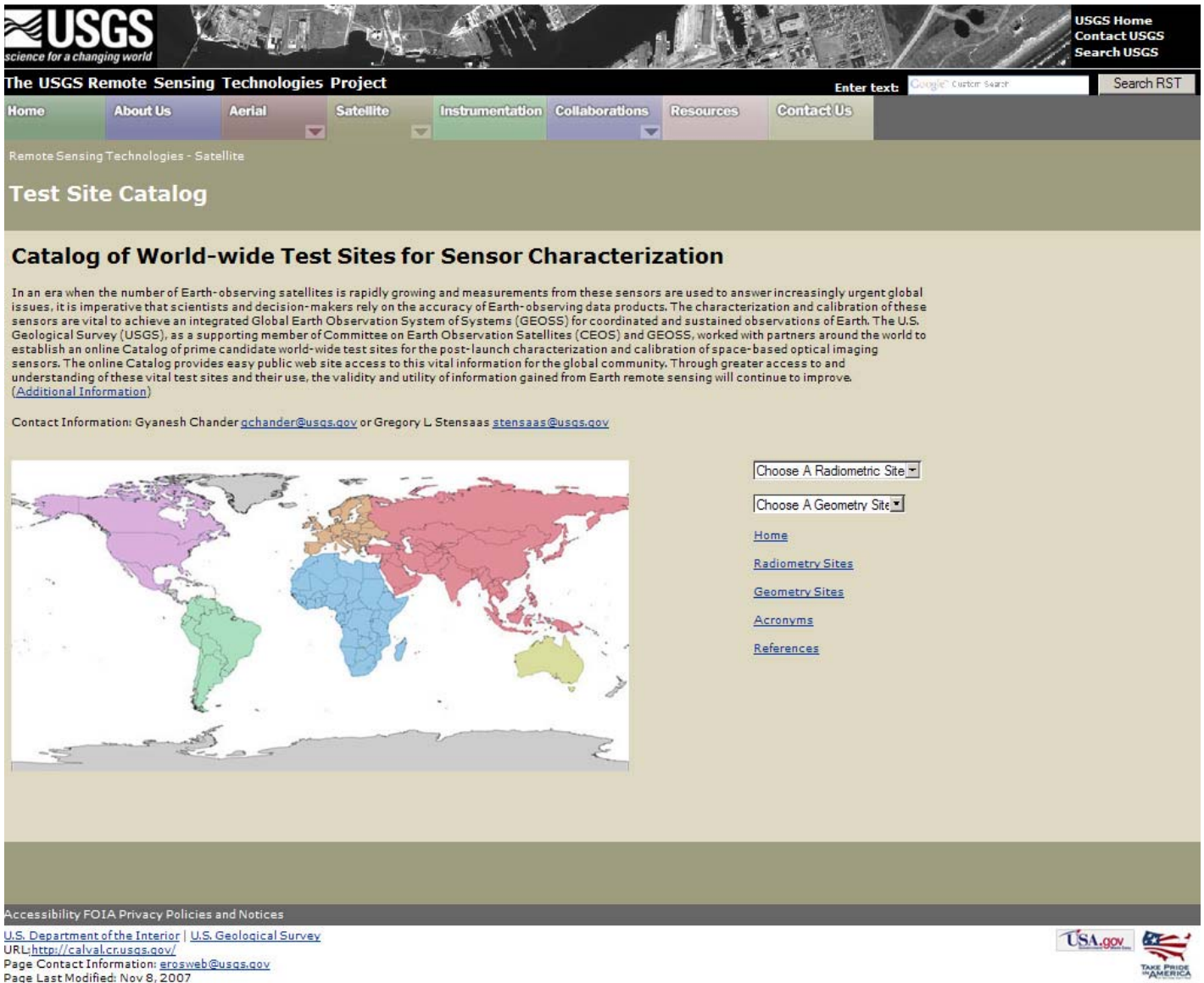
Initial Process started 2006: USGS initiated a data base (catalogue)

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



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Radiometry Sites

USGS
science for a changing world
USGS Home
Contact USGS
Search USGS

The USGS Remote Sensing Technologies Project
Enter text:
Search RST

Home | About Us | Aerial | Satellite | Instrumentation | Collaborations | Resources | Contact Us

Remote Sensing Technologies - Satellite

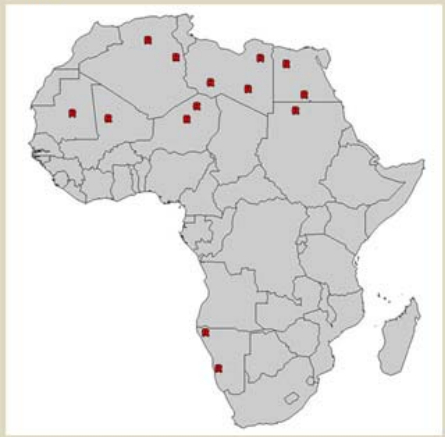
Radiometry Sites

Distribution of World-Wide Radiometric Sites - There are 14 sites available in Africa, 5 in Asia, 6 in Australia, 1 in Europe, 7 in North America, and 3 in South America.

Choose A Radiometric Site
Choose A Geometry Site

Home
Radiometry Sites
Geometry Sites
Acronyms
References

Africa



Asia

Australia

Europe

North America

South America

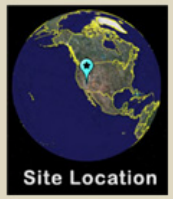
On-line Catalogue Example: Railroad Valley Playa, North America

Site Location: Railroad Valley Playa

Radiometric PREV NEXT

Location (City, State, Country):	Ely, Nevada, USA, North America
Altitude above sea level (meters):	1435
Center Latitude,Longitude (Degrees):	+38.5 , -115.69
Landsat WRS-2 Path/Row:	40 / 33
Size of Usable Area (km):	10 x 10
Owner:	Bureau of Land Management (BLM)
Researcher:	Dr. Kurtis J. Thome Email Researcher

View Additional Photos



Download L7 ETM+ GeoTiff Data

Download Google Earth KMZ File

Purpose:	Radiometric, vicarious calibration test site, with large homogenous regions
Description:	Dry-lake playa, spatially homogeneous, consisting of compacted clay-rich lacustrine deposits forming a relatively smooth surface compared to most land covers, although it has a lower spatial uniformity compared to the Ivanpah and Lunar Lake sites. The surface composition is comparable to those of Ivanpah and Lunar Lake; however, all three sites suffer from the presence of iron absorption (Fe3+) in the visible part of the spectrum, characteristic of playas in this region of the US. *Google Earth :* Slightly patchy (in colour and intensity) across the playa.
Support Data:	Strong linear road features and oil drilling structures (no lat/long. available)
Suitability:	Recommended for 15m GSD and larger, VisbleUV to SWIR. Solar reflective and emissive, sub-meter to 2km GSD
Limitations:	Soft surface composition, spatial and spectral variation, possible hot spot effects, periodic snow and water, cloud cover increases in winter, remote location for ground-based studies

Choose A Radiometric Site

Choose A Geometry Site

Home

Radiometry Sites

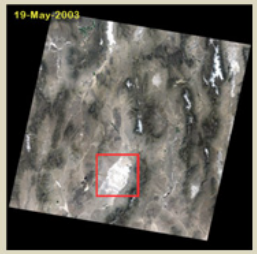
Geometry Sites

Acronyms

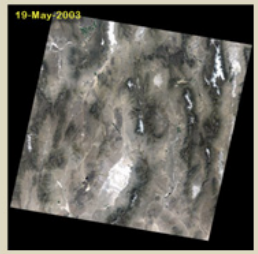
References

Return to Railroad Valley Playa

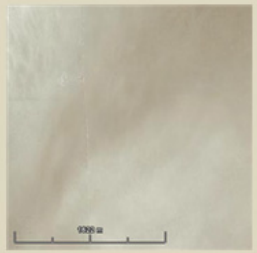
ETM+ Bands 321 Zoomed



ETM+ Bands 321 Site Parameters

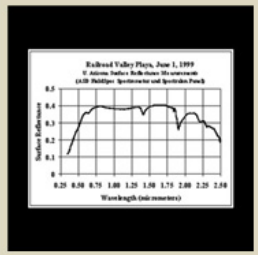


ETM+ Bands 321

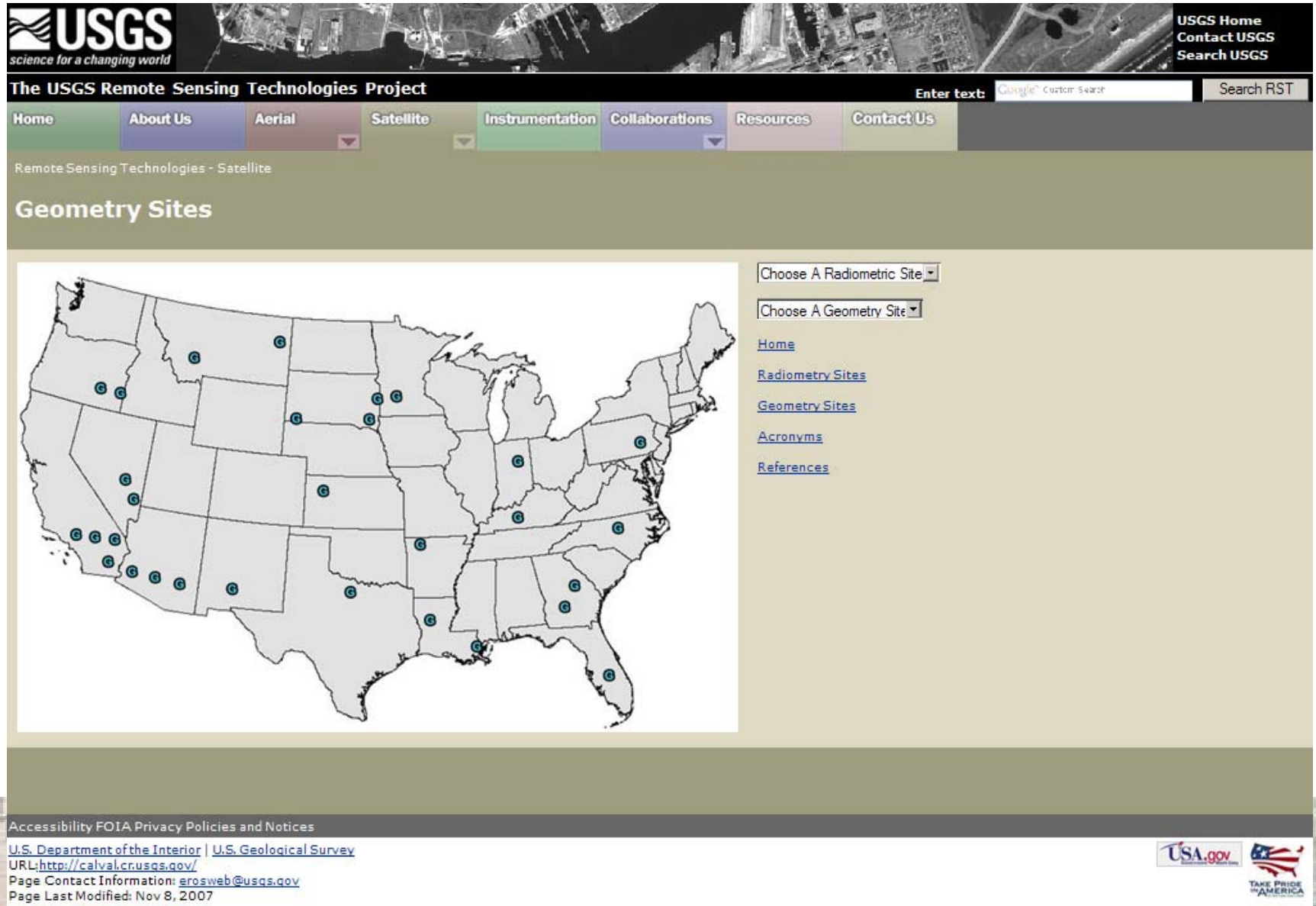

Google Earth Zoomed


Ground Picture 1


Ground Picture 2


Railroad Valley Reflectances

Geometry Sites



Site classification

TEMPLATE for Site Information

- **Purpose/application**
- **Location/contacts etc**
- **Description**

  E.g Terrain type
- **Imagery**

  photos, satellite
- **Status**

  instrumented, visited, funding …
- **Meteorological constraints**
- **Data policies (ground and satellite)**
- **Surface characteristics and "traceability"**
- **Historical useage**

REQUIRE minimum 10 CORE SITES for Radiometric gain

Discriminatory information

- **spatial uniformity of reflectance**
- **Value of reflectance**
- **Accessibility**
- **Data policy**
- **Level of Instrumentation**
- **Cloud free days**
- **…..**

IVOS decision: must be maintained and instrumented

8 sites meet criteria: "LANDNET" others to be encouraged following additional criteria selection

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IVOS core

“Landnet” sites for radiometric gain

Railroad Valley Playa, NV, USA, North America
- oDr. Kurtis J. Thome (kthome@email.arizona.edu)
- oUniversity of Arizona, USA

- **Ivanpah, NV/CA, USA, North America**
  - oDr. Kurtis J. Thome (kthome@email.arizona.edu)
  - oUniversity of Arizona, USA
- **Lspec Frenchman Flat, NV, USA, North America**
  - oMark C. Helmlinger (mark.helmlinger@ngc.com)
  - oNorthrop Grumman Space Tech., USA
- **La Crau, France, Europe**
  - oPatrice Henry (patrice.henry@cnes.fr)
  - oCNES, France
- **Dunhuang, Gobi Desert, Gansu Province, China, Asia**
  - oFu Qiaoyan (fqy@cresda.com)
  - oCRESDA, China
- **Negev, Southern Israel, Asia**
  - oArnon Karnieli (karnieli@bgu.ac.il)
  - oBen Gurion University, Israël
- **Tuz Golu, Central Anatolia, Turkey, Asia**
  - oSelime Gurol (selime.gurol@uzay.tubitak.gov.tr)
  - oTUBITAK UZAY, Turkey
- **Dome C, Antartica**
  - oDr. Stephen Warren (sgw@atmos.washington.edu)
  - oUniversity of Washington, USA

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IVOS proposed “dessert standards” for stability and extrapolation

- Selected by prioritised by history, stability and high resolution
- Identification: SADE database of CNES, prioritised with Landsat 5 and 7

- Libya 1 (SPOT1, SPOT2, SPOT4, SPOT5, Formosat 2, Kompsat 2)
- Algeria 3 ((SPOT1, SPOT2, SPOT4, SPOT5, Kompsat 2)
- Algeria 5 ((SPOT1, SPOT2, SPOT4, SPOT5)
- Mauritania 2 (SPOT4, SPOT5, Formosat 2, Kompsat 2)
- Libya 4 (SPOT4, SPOT5)

Actions

- **Identify sites and associated key characteristics for all tasks**

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

ESA Study to support with USGS and IVOS team

- **Encourage agencies to view and provide data to cal/val community over core sites starting with radiometric gain and stability as an immediate priority**

- **Link USGS catalogue to CEOS/GEO cal/val portal**

- **Establish optimum instrumentation specification for core sites**

- **Establish “best practise” guidance on site characterisation and its use**

- **Establish “Governance” principles**

Recommendation 5

Recognising the need to establish international accepted Reference standards where necessary to facilitate interoperability between agencies and missions by ensuring that biases and sensor performance and dependent data products can be assessed in a consistent manner, CEOS WGCV proposes that the following (together with an associated operational best practice) are adopted as international reference standards for their associated characteristics and subsequently used by agencies. The Moon and “CEOS standard Desserts” as reference standards for radiometric gain stability and the “CEOS Landnet test sites” for gain assessment on Land imagers.

- **ACTIONS**

  CEOS IVOS to provide coordinates of LandNet sites on cal/val portal
- CEOS IVOS to provide operational guidance for use of the reference standards
- CEOS IVOS to provide defining characteristics of the associated standards on the cal/val portal
- Agencies to encourage the viewing of such sites in existing and future missions.
- Agencies to ensure resources are made available to maintain and develop such standards and to encourage the development of others to complement the existing LandNet sites to ensure adequacy in number and geographical distribution.

Recommendation 6:

To allow data products from an optical sensor to be ascribed an appropriate quality indicator, CEOS WGCV recommends that agencies evaluate and make accessible to the Cal/val community, the results of assessments based on CEOS endorsed best practises. For optical imagers this would require sensor performance to be evaluated through an endorsed method. Currently for radiometric gain these are: the use of a core test site, Rayleigh scattering, cloud, sun-glint, Moon.

It further recommends that as a minimum this should include cross-comparison with other appropriate sensors using a CEOS endorsed method e.g. SNO, the moon, reference test site utilising where appropriate an endorsed reference standard.

Actions:

- IVOS to make available endorsed guidelines through GEO/CEOS cal/val portal
- Agencies to support the preparation and distribution of such guidelines based on existing best practises
- Agencies to encourage the use and publication of results following use of these guidelines

Recommendation 7

To ensure that current, historical and future data sets can be seamlessly linked requires an accurate evaluation of uncertainty traceably referenced to an internationally agreed standard. Whilst the infrastructure to allow full (on demand" assessment of performance of sensors and derived data products is established it is essential that a means to cross-compare is established and maintained. This is particularly critical where temporal gaps in data records may occur due to operational constraints. It is thus recommended that agencies are encouraged to establish and make available to the CEOS Cal/Val community regular observations of the full set of appropriate CEOS reference standards e.g core test sites, invariant deserts, Moon.

In particular, it recommends that agencies carry out a detailed cross-comparison exercise using one of these targets, DOME C during the winter of 08/09 using the CEOS endorsed guidelines.

Actions

- IVOS to publish list of invariant standards and methods for their use on Portal
- Agencies to incorporate within acquisitions schedules regular observations of CEOS reference standards
- IVOS to establish protocol for comparison of optical imagers over Dome C
- Agencies to plan to take observations and make available results over DOME C according to guidelines of CEOS IVOS in winter 08/09

Recommendation 8

Recognising the criticality of post-launch calibration/performance verification for the delivery of QA data products for both operational and scientific missions it is essential that agencies seek to ensure that such support activities e.g. core test sites and their associated traceability and developmental needs are established and maintained in a coordinated way for the good of the EO community. In particular when considering operational activities and long term studies (e.g climate change) which require datasets beyond the life of any single mission, it is essential that such Cal/Val activities are supported in a manner that ensures their continued operation beyond the life of any single mission.

Action

- **CEOS WGCV to identify key activities and associated costs**
  CEOS agencies consider ways to coordinate/share resource in an equitable manner for the good of GEOSS.

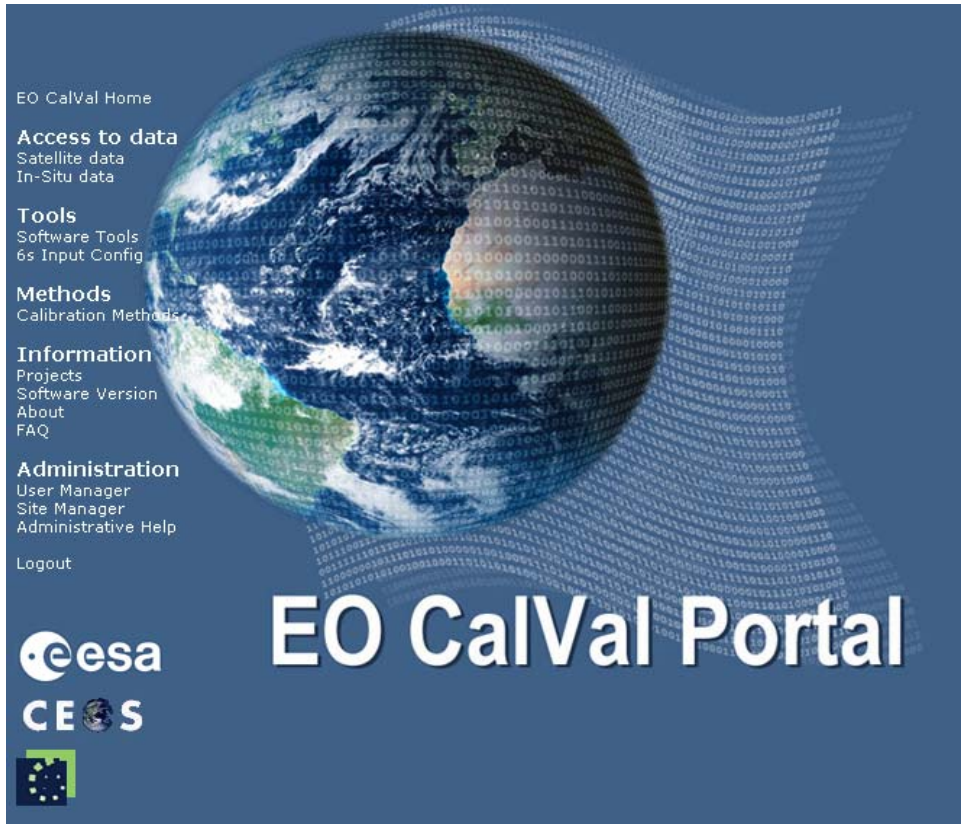
Proposed:

- **Establishing named individual for each piece of information to maintain “Quality responsibility”**

- **Standards/best practises must be endorsed or at least approved**

- **Add disclaimer that named individuals are responsible for maintenance of information content**

- **Adding “tutorial” to guide first time users**



http://calvalportal.ceos.org.

IVOS

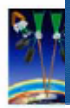
NPL

CEOS Climate Action A5

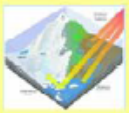
CEOS will plan by 2011 to make absolute, spectrally resolved measurements of radiance emitted and reflected by the Earth to space for information on variations in both climate forcings and responses.

Climate Absolute Radiance and Refractivity Observatory (CLARREO)

Climate Absolute Radiance and Refractivity Observatory
(CLARREO)
Launch: 2010-2013
Mission Size: Small

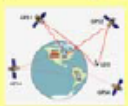


Absolute spectrally resolved IR radiance

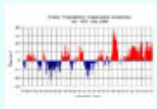


Incident solar and spectrally resolved reflected irradiance

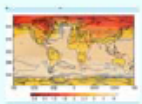
Absolute calibration for operational sounders



Pressure/ temp/ water vapor profiles



Benchmark climate record to improve climate predictions



Changes in sea level, storm patterns, and rainfall associated with temperature pattern changes

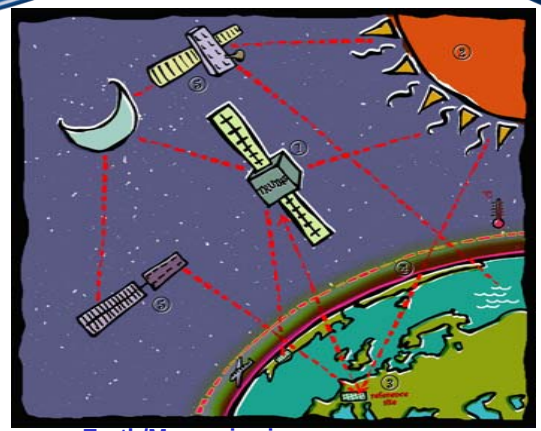
Ozone and surface radiation forecasts and public advisories

TRUTHS: Traceable Radiometry Underpinning Terrestrial- and Helio- Studies

Satellite based mission to:

- **make SI traceable high accuracy measurements of solar radiation incident on, and reflected from, the Earth**
- **transfer its unprecedented calibration accuracy to other satellite-based EO instruments through the calibration of reference targets such as the Sun, Moon and the Earth's deserts**
- **Supporting measurements of land processes, ocean colour, Earth radiation budget, atmospheric chemistry and aerosol distribution**

NPL



Earth/Moon viewing

baseline

- **Wide spectrum (380 to 2500 nm)**
- **Spatial resolution ~ 25 m (multi-angle)**
- **Spectral radiance uncertainty <0.5% (using novel in-flight calibration system)**

Endorsed at CEOS plenary 21

In the context of A-5 and GEOSS data QA, space agencies should consider how best to coordinate, collaborate and implement the complimentary "international benchmark reference" mission proposals: TRUTHS and CLARREO (Benchmark/calibration constellation?)

IVOS

NPL