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

Report to CEOS WGCV 36

Chair: Nigel Fox
National Physical Laboratory
UK

with support from UKSA

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.

6. In the context of calibration and validation encourage the full consideration of "traceability" in all activities involved in the end-to-end development of an EO product including appropriate models and algorithms.

Operational Structure

- **Agency reports to be encouraged but not presented except in exceptional circumstances or if a new member.**
- **Detailed Technical theme each meeting (0.5 – 1 day)**
- **Community technical workshops ~ tri-annual**
- **Theme Champions**

Sector themes:

- Land (reflectance) – Chander USGS
- Ocean (reflectance) colour – Zibordi JRC
- Surface temperature – Corlett Uof Leic

Also more general activities at plenary
e.g. sensor pre-flight calibration

Cross-cutting

- Atmospheric corn – Thome NASA
- Geo/Spatial Quality – Helder UofSD
- Geometric image Quality – TBD
- Sensor to Sensor biases – Fox NPL
- RT code – Widlowski JRC
- Communication/portal – Goryl ESA

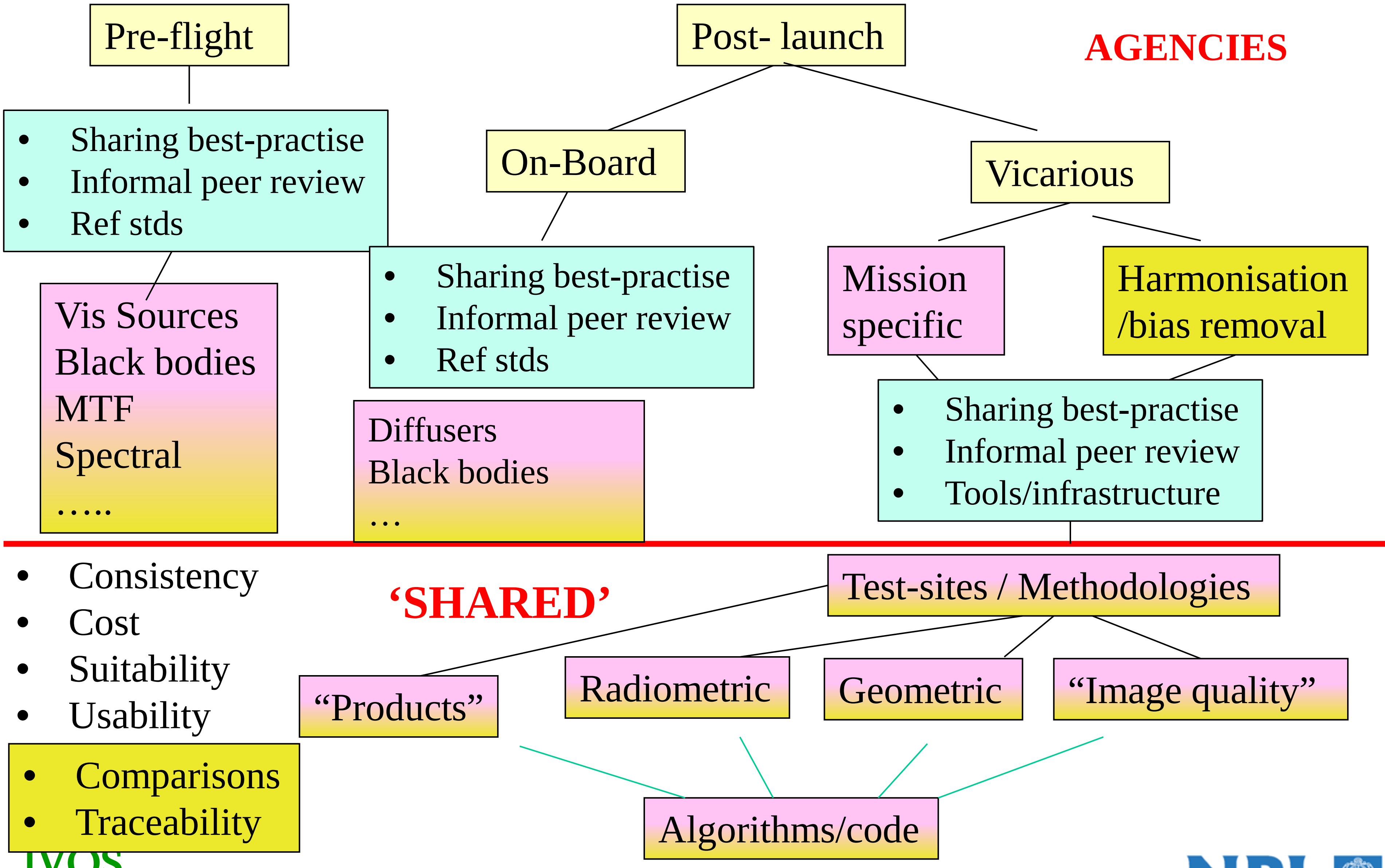
Focus task groups

- WG 4 cross-comparisons Bouvet ESA
- Libya 4 - Henry CNES
- LandNET prototype - Bouvet ESA

- **IVOS as Conduit for existing "community expert groups"** - **Need to increase engagement**
- **Serving Cal/val needs of IVOS relevant constellations**

•IVOS - **e.g. org of comparison, interface to CEOS**

Work plan for optical sensors: (land/ocean)



IVOS: Vision

To facilitate the provision of 'fit for purpose' information through enabling data interoperability and performance assessment through an 'operational' CEOS coordinated & internationally harmonised Cal/Val infrastructure consistent with QA4EO principles.

- ***Pre-flight characterisation & calibration***
- ***Test – sites***
- ***Comparisons***
- ***Agreed methodologies***
- ***Interchangeable/readable formats***
- ***Results/metadata - databases***

Key Infrastructure to be established and maintained independent of sensor specific projects and/or agencies

CEOS IVOS 25

Mar 19-21 2013

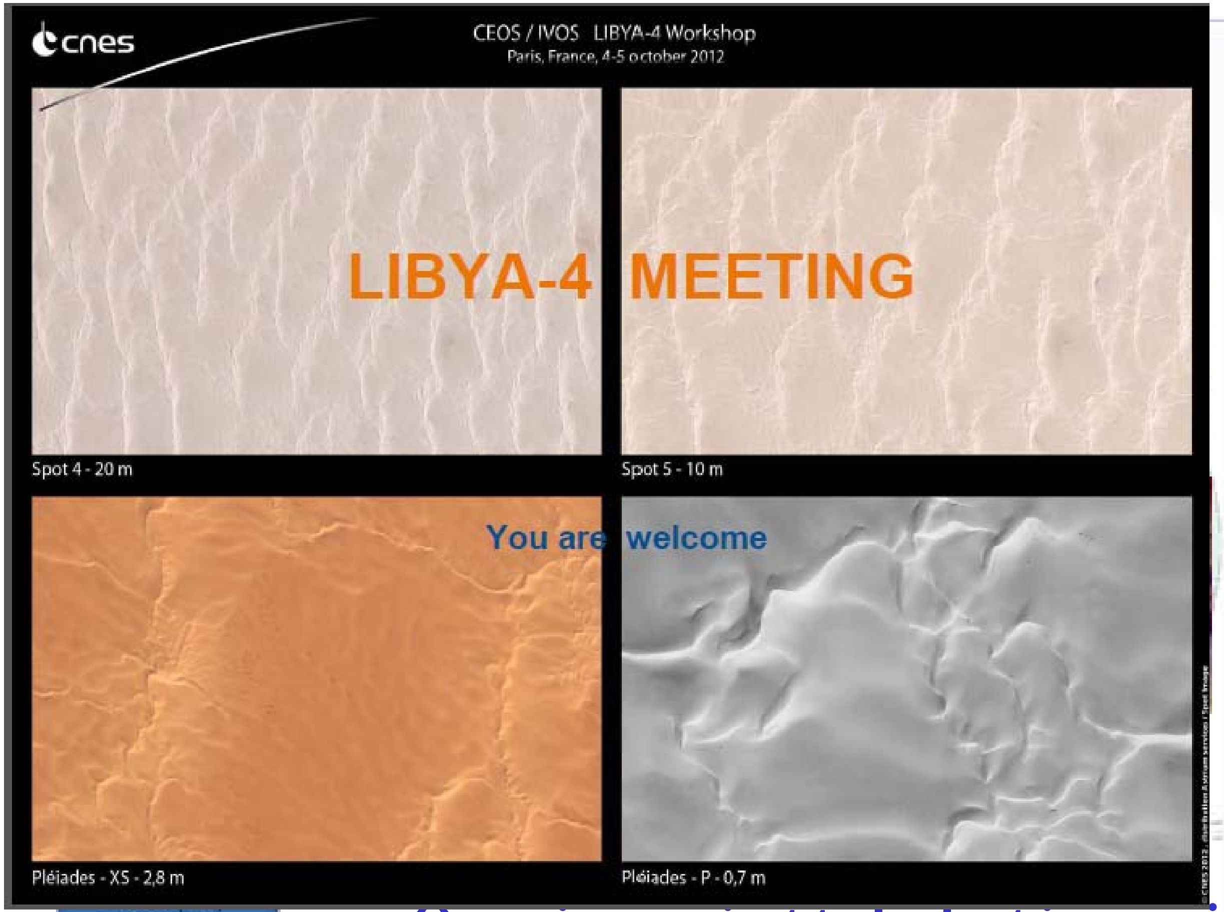
ESA – ESRIN (Frascati, Italy)

- Attendees: 25 + 7 Made use of web for external participation
- Highly productive
- Team well motivated to coordinate and deliver an international shared work plan
- Several new collaborative initiatives
- Follow-ups to recommendations agreed
- Plans for inter meeting webex discussions

IVOS

CEOS IVOS workshop on: Libya 4 (Oct 4-5 2012 CNES Paris

CEOS 'non-instrumented' Test sites for Stability and sensor to sensor cross-comparison



- **25 attendees**
- Working meeting
- Focus on one site
- Share ideas
- Different sensor
- Cal/comparison methods
- Site characteristics – observed/modelled
- High and medium res
- What can & might be achievable?

On-going project to look at improving effect of surface BRF

- Groups to evaluate use of CNES BRF
- Spectral reflectance of site

IVOS

25 th Meeting: objectives

Information exchange and facilitating international collaboration on Cal/Val related activities

- **Review actions/progress on work plan/activities**
  - All sub themes
  - Conclude on strategy to establish land network of test sites for radiometric gain
  - Progress on comparisons and methodologies
    - Particularly 'Miami 4' brightness temperature (underpinning SST)
  - Progress from and review of 'Libya 4' meeting – CNES (Oct 2012)
- **Interactions of IVOS with other CEOS/GEO activities**
  - WG-Climate
  - Constellations
  - GEO
- **Progress towards an internationally coordinated Cal/Val infrastructure**
  - QA4EO
  - Portal
  - Tools/systems/databases
- **workshop planning**

- **Membership, actions, and intra-meeting progress**

IVOS theme on RT codes

"Focus is on activities that verify the quality of RT models or where validated RT models are used to assess the quality of retrieval algorithms and cal/val methodologies."

- atmosphere: I3RC (clouds – late 1990s)
- land: RAMI (vegetation – late 1990s)

so far RT models are physics-based

RAdiative transfer Model Intercomparison

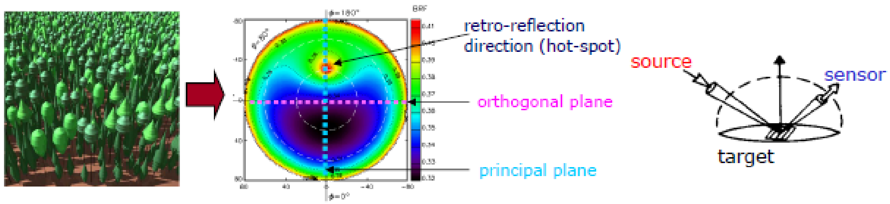
To assess the quality of the physics contained in RT models one must work under fully controlled experimental conditions:

- plant & canopy architecture
- spectro-directional properties
- illumination conditions

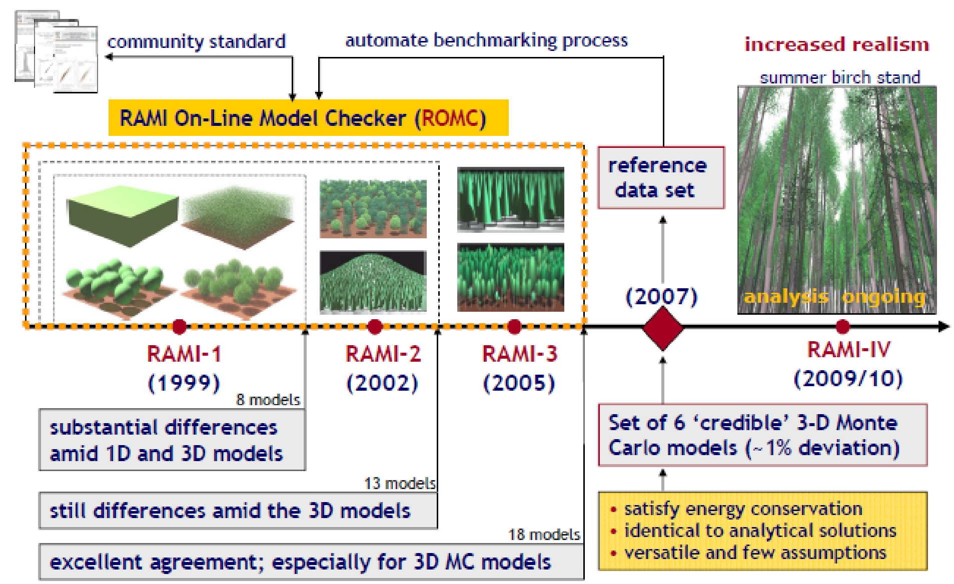
Must also verify sub-components of target RT quantities

RAMI evaluates RT models in forward mode (no atmosphere)

$$BRF_{\Omega_0/\Omega} = \frac{\Phi_{\Omega_0/\Omega}(\text{target})}{\Phi_{\Omega_0/\Omega}(\text{Lambertian})}$$

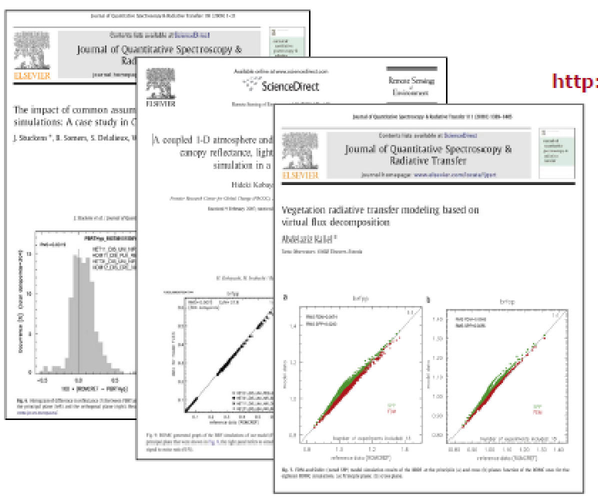


RAdiative transfer Model Intercomparison



Pinty et al. (2001, 2004) JGR; Widlowski et al., (2007) JGR, (2008) RSE, (2013) JGR – under review

RAMI On-line Model Checker



http://romc.jrc.ec.europa.eu/

Currently 33 models registered in ROMC

Plan: 2013 – 2014

New test cases:
- RAMI4PILPS
- RAMI-IV
- MetEOC

New functionalities:
- more graph types
- better interface
- user vs modeler

The ROMC enables users to autonomously assess the quality of RT models in quasi real time against the reference data from RAMI-3.

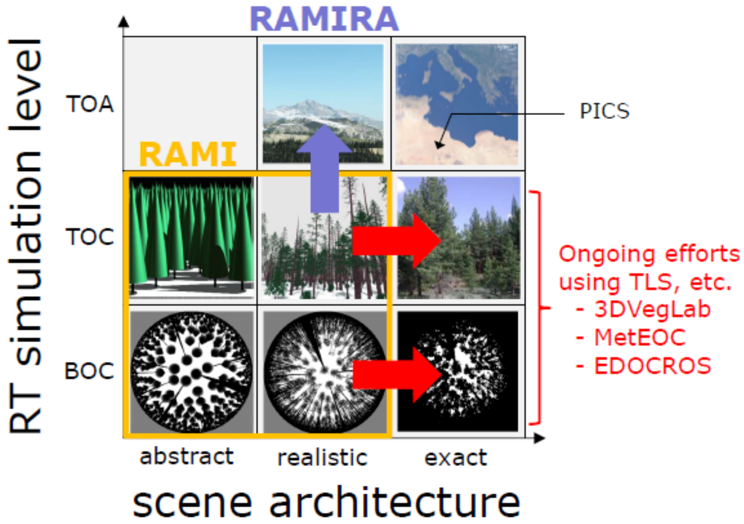
Widlowski et al., 2008 (RSE):

RAMI-IV outlook

- *Publish analysis of RAMI-IV abstract cases (2013)*
- *Complete analysis of RAMI-IV 'actual' canopies*

- *Expand RAMI OnLine Model Checker to larger set of experiments (RAMI4PILPS, MetEOC), add new graph types and improve user interface*
- *Compare model simulations of BRFs for 3D artifical targets against actual measurements acquired under controlled experimental conditions (MetEOC)*

next steps…



RAMIRA (LAI, FAPAR, albedo)

- *Generate large number of structurally & spectrally realistic canopies*
- *Use credible RAMI model to simulate TOC (and one/two atmospheric models) to get TOA BRFs/radiances for different:*
  - *sensors (spat. res., PSF, bands, etc.)*
  - *illumination & view geometries*
  - *atmospheric conditions*
- *If needed simulate multi-temporal data (under identical or varying conditions)*
- *Provide GS or PI's with simulated data as required by their retrieval algorithm*
- *Analyse returned results against truth.*

RAMIRA (LAI, FAPAR, albedo)

Benefits:

- *Allows to evaluate all retrieval algorithms under identical conditions.*
- *Allows to evaluate retrieval algorithms against own/ambient definition of ECV*
- *Reference not affected by unknown biases (as is the case for in situ ECV estimates)*
- *QA process is neutral (JRC not a space agency & bound by its mission statement)*
- *Cheaper than actual field campaigns*
- *Process apt for automation*
- *Test dataset can be gradually expanded*

RAMIRA

JRC cannot invest time and resources into the preparation of datasets for a given sensor without commitment from PI or GS to participate (within given timeframe).

- *JRC would welcome if IVOS were to ask WGCV to place a request to CEOS plenary to support such a task.*

PIs and GS are likely to ask for funding in order to commit resources to this.

- *Are space agencies willing to support the RAMIRA effort (possibly financially)?*

Recommendation/request to CEOS SIT via WGCV

Agencies to provide the necessary resources to participate in an intercomparison effort of ECV (land products) ‘retrieval algorithms’ under controlled conditions using instrument-specific synthetic TOA datasets generated over highly realistic land sites (both vegetated and non-vegetated) with RAMI-verified Monte Carlo models of known accuracy and precision.”

Note: JRC will establish data set/protocol etc but needs to know that agencies will participate. Propose a letter to CEOS SIT advising of proposal and to endorse a letter calling for participation and subsequently ask agencies to encourage/support participation of those in there area of influence

CEOS

Climate Data Records of Sea-Surface Temperature

Peter J Minnett
University of Miami, Miami, USA

Gary K Corlett
University of Leicester, UK

Nigel Fox
National Physical Laboratory, UK

UNIVERSITY OF MIAMI
ROSENSTIEL SCHOOL of MARINE & ATMOSPHERIC SCIENCE

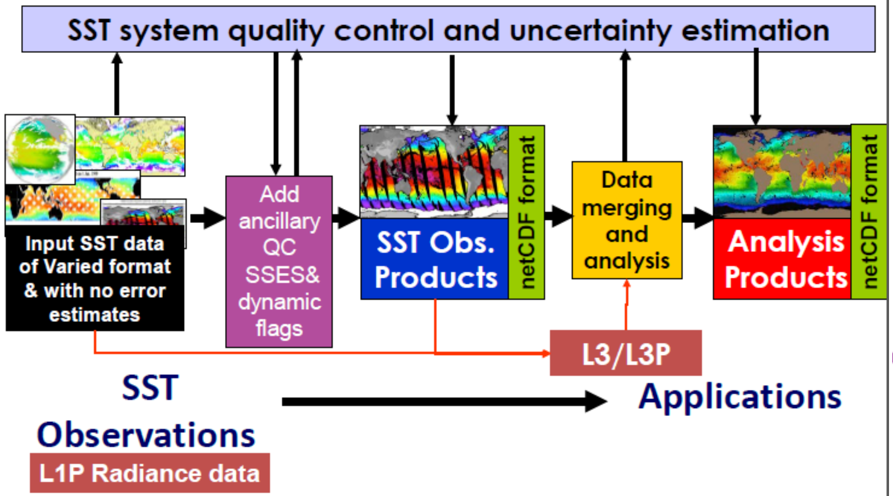
CEOS IVOS-25 Meeting March 19-21, 2013 ESA ESRIN

University of Leicester

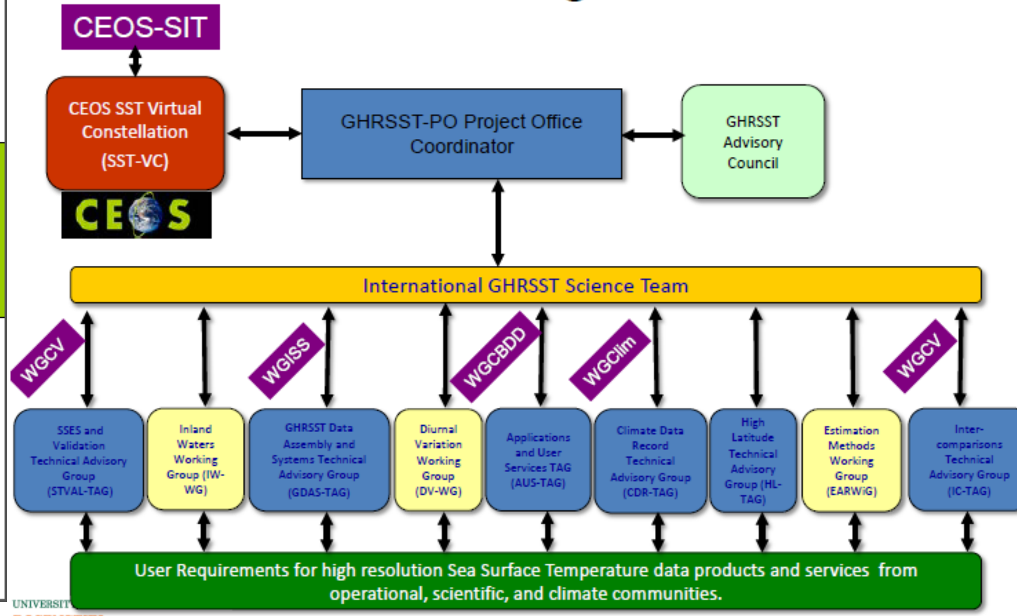
IVOS

NPL

The GHRSST Strategy



GHRSST ST Organisation



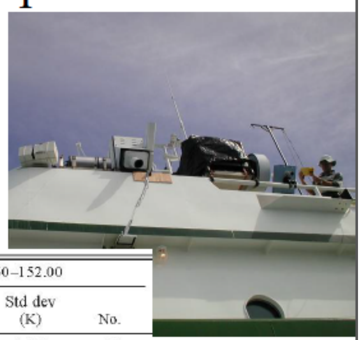
Miami –II at sea comparisons

270 JOURNAL OF ATMOSPHERIC AND OCEANIC TECHNOLOGY VOLUME 21

TABLE 1. Infrared radiometers deployed on the R/V *F.G. Walton Smith*

Radiometer	Agency	Waveband (μm)	Detector	Sea-view angle (°)	Sky-view angle (°)
M-AERI	RSMAS	3–18	Cooled HgCdTe	55	55
ISAR-5	JRC/EEC[a]	9.6–11.5	Heitronics KT15.85D[b,c]	43	43
SISTeR	RAL/UK[d]	10.3–11.3	Pyroelectric	40, 45	40, 45
JPL NNR	NASA/JPL[e]	7.8–13.6	Thermopile	45	No sky view
CIRIMS	APL[f]	Up: 9.6–11.5; down: 7–16	Heitronics KT11.85[b]	40	40
DAR011	CSIRO	10.4–11.4	Pyroelectric	45	45 (backward)
TASCO	CSIRO	8–14	Thermopile	45	45

[a] European Commission Joint Research Centre (JRC)
[b] The Heitronics radiation pyrometer is based on a chopped pyroelectric detector.
[c] The ISAR-5 Heitronics is modified to allow the measurement of temperatures down to −100°C.
[d] Rutherford Appleton Laboratory (RAL).
[e] National Aeronautics and Space Administration (NASA).
[f] Applied Physics Laboratory (APL), University of Washington.



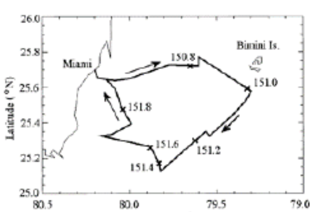


FIG. 1. The track of the R/V *Walton Smith* during the 2-day cruise. The times are day of year plus decimal days (UTC). Day 151.0 is equivalent to 2000 LT 30 May.

Time	150.50–152.00		
Radiometer pair	Mean (K)	Std dev (K)	No.
MAE–ISA	0.002	0.135	80
MAE–SIS	0.046	0.066	144
MAE–JPL	0.007	0.114	148
MAE–DAR	−0.008	0.076	149
ISA–SIS	0.038	0.101	79
ISA–JPL	0.026	0.142	81
ISA–DAR	0.007	0.114	80
SIS–JPL	−0.048	0.099	144
SIS–DAR	−0.053	0.074	144
JPL–DAR	−0.014	0.103	148

Barton, I. J., P. J. Minnett, C. J. Donlon, S. J. Hook, A. T. Jessup, K. A. Maillet, and T. J. Nightingale, 2004: The Miami2001 infrared radiometer calibration and inter-comparison: 2. Ship comparisons. *Journal of Atmospheric and Oceanic Technology*, 21, 268-283.

Miami – III Overview

Sea-surface "brightness temperature":

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

Process: Follow Guidelines of QA4EO …DQK 004

- invitation (facilitate for all)
- protocol
- blind measurements
- results and uncertainties
- analyse and publish

Recommendation 5: Comparisons to ensure a Globally consistent post-launch Cal/Val framework for CEOS sensors

Background All sensors require as a minimum post-launch verification of performance - L1 radiances & L2 products as appropriate

- Calibration of most optical sensors drifts
- Long term data continuity and operational services require sensor harmonisation
- CEOS role to facilitate international harmonisation through shared infrastructure
- Post-launch cal/val test-sites and campaigns must be carried out in a consistent and traceable manner which requires as a minimum regular comparison across and within geographical regions & it is the duty of CEOS agencies to facilitate access to such comparisons for the benefit of all

Recommendation 5 Following the success of the three previous CEOS comparisons of radiometers in support of satellite derived SST measurements (Miami 1, 2 &3) it is timely (5 yrs) that the next comparison be organised for 2014. This will be timely to serve the needs of the new SST VC and the expected launch of some new sensors.

- Resources are required from one or more agencies to enable effective detailed planning and preparations to commence in early 2013.
- CEOS IVOS and SST-VC and GHRSST have started initial planning and may look to build upon and extend the previous exercises to include more direct linkage to satellite sensors.

IVOS

Planning for 'Miami IV' (not necessarily in Miami)

- **A Laboratory comparison of instruments (in environmentally controlled conditions for range of expected observed variables (NPL/RAL/Miami all poss options)**
- **Limit number of instruments to representatives of a participant**
- **Ensure that formal linkage to SI traceability is achieved as part of the process through an NMI (NPL/NIST).**
- **Ideally include pre-flight satellite calibration black bodies.**
- **Comparison to be conducted/analysed (pilot) by independent organisation ideally an NMI**
- **Comparison of radiometers to be made on Ocean (ideally over a range of temperatures and sea state conditions) Baseline proposal to carry out series of bi-lateral (or more) using ships of convenience in transects over the Ocean. Providing linkage between comparisons can be made with a series of 'common radiometers**
    - can facilitate on-going process with new participants able to join the comparison and demonstrate linkage (degree of equivalence) with other participants at any time.
- **A host agency needed to fund overall logistics/analysis etc (ESA indicated their willingness) with individuals organisations responsible for self-funding their participation (with support from their local CEOS agencies).**
- **Could include Land radiometers for linked comparison**

Next steps: Letter to SIT

Following acceptance of recommendation at plenary to announce plan for Comparison and request for support from agencies to:

1/ Provide logistics etc for comparison – (probably ESA Plus others welcomed)

2/ Commit to Support participation of appropriate teams in comparison activities including ship based deployment

Time frame: 2014 start

Post launch cal val

Interoperability

Bias assessment/removal

Sensor drift monitoring/correction

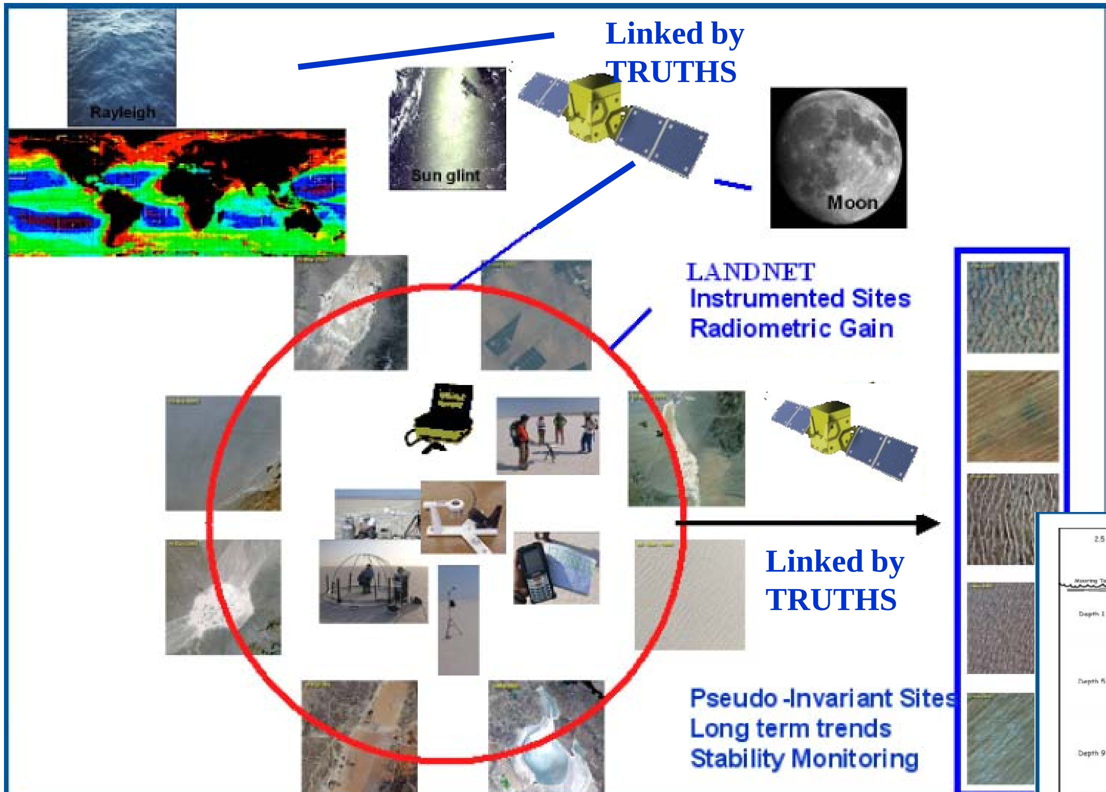
End to end performance check

Vision: Operational calibration service through "CEOS standard" sites/methodologies

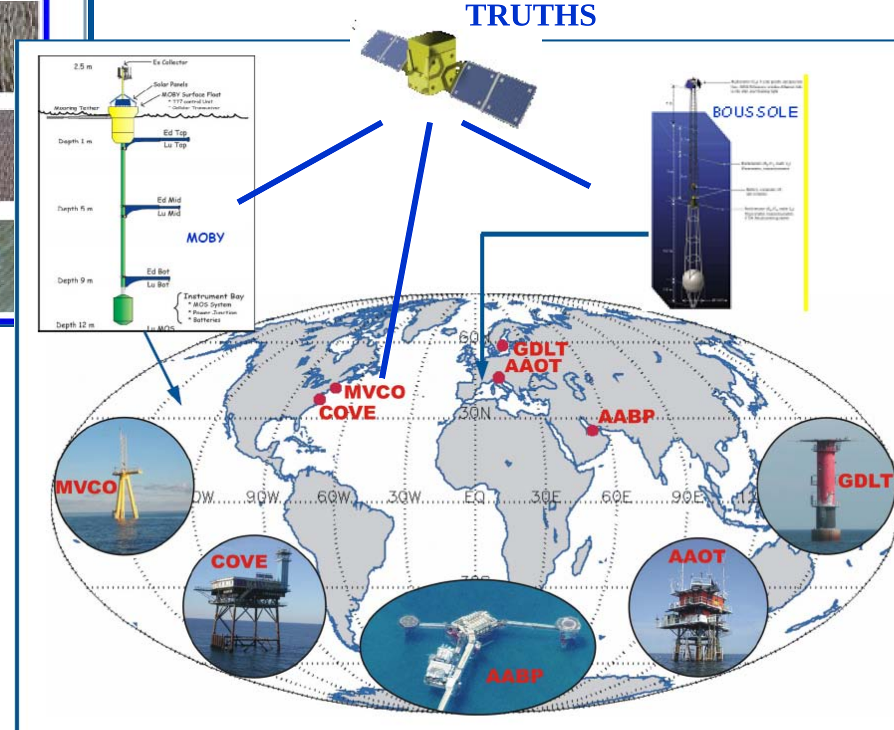
Networks of test sites and methodologies can become operational calibration service

improved through use of reference standard SI traceable sensor e.g. TRUTHS/CLARREO

(Part of Climate architecture doc)



Linked by TRUTHS



CEOS endorsed test sites for Land and Ocean can be used as standards to cross-compare between sensors and to ground data providing each site is compared to each other

IVOS

CEOS infrastructure: Needed to support interoperability and long term data continuity & reliability

- **'Test sites' / Intrinsic methods** - with documented methodology including how to do uncertainty assessment
  - Facilitate sensor performance testing/correction
  - Sensor to sensor bias evaluation/removal

- Catalogue of 'sites'/methods and relative usefulness for sensor/application
  Major progress (radiometric aspects)
- Access to results of sensor comparisons to/or using site/method
  Have a data base template plan to start populating and analysis method
  Will need CEOS infrastructure (SADE, DIMITRI, CAL/VAL portal)
- Longevity of site availability (non-mission specific)
  Key area of concern
- Comparability of information from use of site/method
  Have identified minimum instrumentation for Land
- Evidence to underwrite 'site' characteristics/usefulness
  Regular comparisons between sites/methods 'traceability'
- Operationally delivered activity
  need autonomous data collection/provision from site (& sensor) & analysis
  data policy, (Aeronet like)

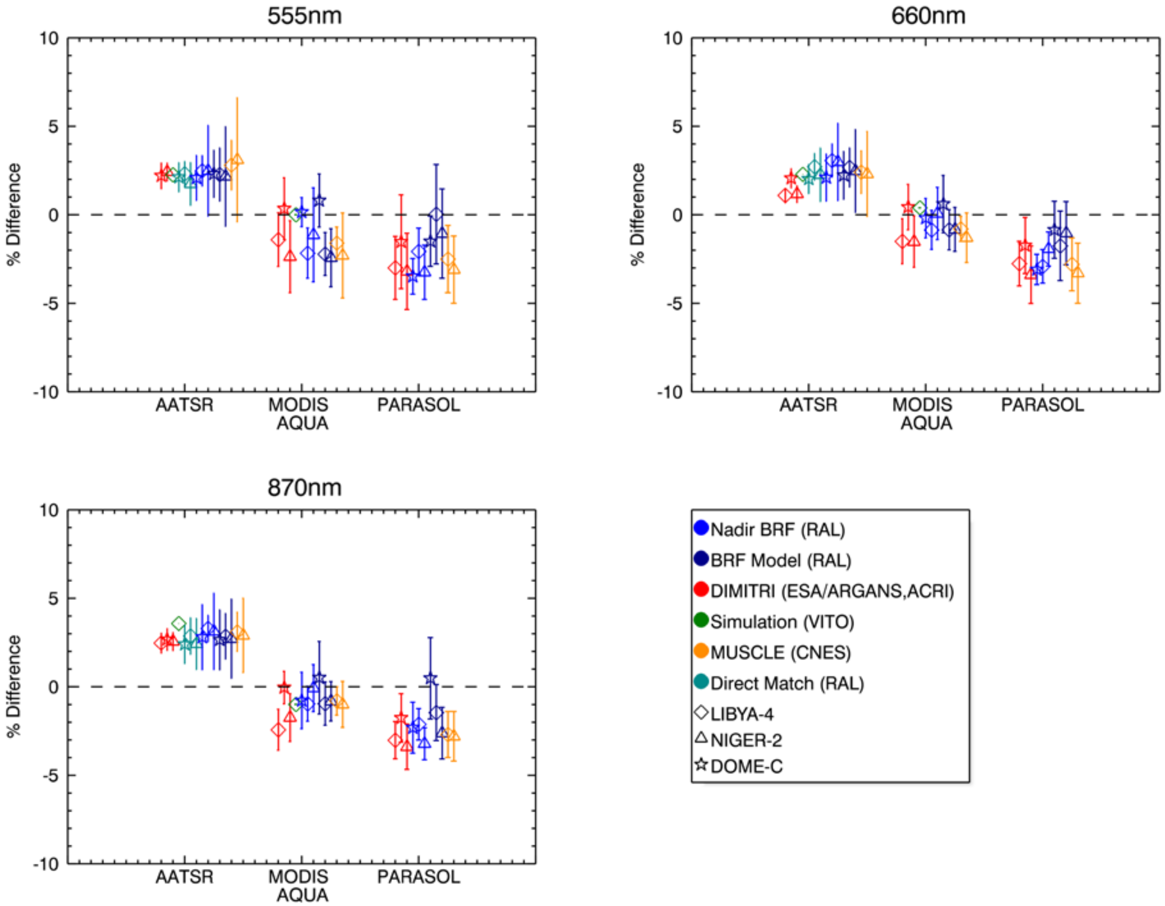
IVOS

CEOS IVOS Working Group 4: Fixed Sites

Methodology intercomparison initial results summary

Chair: (Marc Bouvet)

The results: including a correction for Type B uncertainties identified



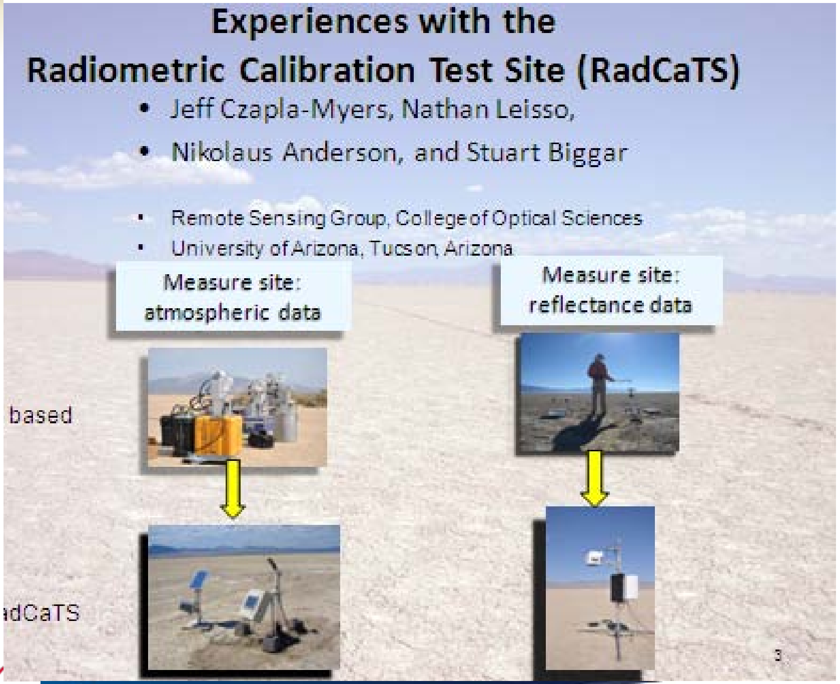
- Here a correction for Type B (=systematic) uncertainties identified is added to the results from DIMITRI and RAL

Ground characterised test sites

Landnet approach

Automated ground measurement approaches are a useful means for radiometric calibration

- Many success stories
  - MOBY and Boussole
  - Stennis Space Center facility
  - JPL facility at Lake Tahoe and Frenchman Flat
  - UofA at RRV Playa
- Allows data to be collected at the convenience of the sensor scheduler
- Allows intercomparisons between sensors without need for coincident data collections



cnes

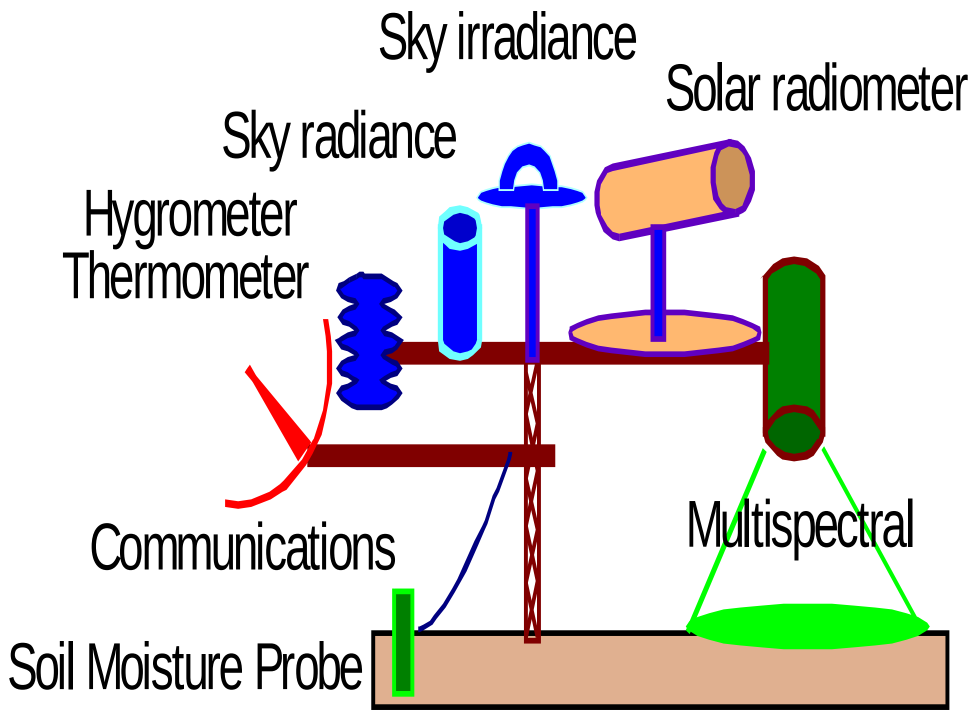
Pleiades

Pleiades calibration over the La Crau calibration site

CEOS/IVOS24 – EROS data Center – Sioux Falls - May 2012

ROSAS

LANDNET: CEOS autonomous network of ~5 (minimum) instrumented (traceable) test-sites



Set up costs ~ $80k – 500 k
- systems exist others low cost options under development

Need annual long term maintenance ~ 0.5 person year 20+ years

Central coordinating facility
- QA / Data collation /processing …

Regular traceability and comparisons (appropriate facilities and reference standards)

Minimal specification of equipment on site:
- **Master and nodes (1 per ~500 m2)**
- **May not always need atmosphere measurements**
- **~ Min 10 channels**

K Thome NASA

IVOS

Protocol development

A key portion of automated processing is development of protocols

- Not just a measurement
  - No commercially-available radiometers will current satisfy a Landnet
  - Not feasible to outfit multiple sites with identical instrumentation
- Develop basic measurement scenarios
  - Surface parameterization
    - Spatial sampling
    - Spectral sampling
    - BRDF
  - Atmospheric parameterization
- Site Selection

Data product

Propose that goal should be to develop a model image of the site

- At-sensor radiance for a given sun-sensor geometry
  - Hyperspectral at 10-nm intervals from 350-2500 nm
  - 20-m spatial resolution
  - Cover the full test site area (several km in size)
- Standard and on-demand product
  - Standard image produced for five preselected times during the day
  - On-demand product based on user preference for sun- sensor geometry
- Includes accuracy assessment for data product

Landnet accuracies

Minimum set of measurements needed for a reflectance-based approach

- Impact of assumptions on uncertainties must be evaluated
- Numbers of data collections is key factor
- Sites with reflectance > 0.2
  - Site reflectance is most important
    - BRDF
    - Spectral
    - Spatial
    - Temporal
  - Aerosol effects can be viewed as random
    - Aerosol absorption changes with time

Way forward

Propose the following minimum approach for discussion purposes

- Goal should be to work for IVOS-approved result in place for Sentinel 2 launch
  - Inter comparison opportunity with Landsat 8
  - Moderate resolution makes site selection less difficult
- Two independent sites should be developed
  - Demonstrates "net" part of Landnet
  - One site should be an already-existing site to leverage past knowledge
- Coordinated processing scheme
  - CEOS-led distribution
  - Emphasis on processing and data quality protocols

Prototyping LandNET

New focus group – Marc Bouvet ESA (chair)   Patrice Henry (CNES), Kurt Thome (NASA), Nigel Fox (NPL) ??? (AOE/CAS)??

- **Identify small group of test sites/operators/experts**
  - **La Crau (CNES)**
  - **Rail road Valley (NASA/UofA)**
  - **A new ESA/CNES site (to be found and established) (start summer 2013)**
  - **China???**
- **Establish protocols and strategy for a network of automated test sites**
  - **Measurements**
  - **Formats**
  - **Traceability**
  - **Processing to a product (sensor)**
  - **Coordinating/traceability lab**
- **Collect/analyse/compare data sets (<50 m resolution sensors) over all sites**
  - **Landsat 8**
  - **Spot/Pleiades?**
  - **China?**
  - **Sentinel 2 (future)**

IVOS

Involvement of China test site in LandNET

Prospect

- **The extension of the Cal&Val test site**
  - New equipment developing and distribution
  - A complete target system for performance assessment
  - Supporting the calibration and validation for VIS, NIR, SWIR, TIR and LiDAR payloads
- **Technology and method research**
  - Test site basis data collection and database construction
  - A multi-level and multi-scale calibration and validation system building
  - Accurate vicarious calibration methods research

Comparisons: Cross-comparison data base workshop Action A2

Towards establishing a 'CEOS harmonisation coefficient'

- Establish fully sort-able database for sensor comparisons (based on any declared method) with any reference standard (site, sensor, "method" etc)
  - Some baseline QA criteria in terms of data population.
- Access to data open to all CEOS but no publication without agreement
- WG to be established to define and agree method of analysis of all data
  - bandwidths, uncertainties (weightings from methods), outliers …
  - Means to present results: - to a ref sensor, to a mean of all, to a community defined value
  - Look to take full benefit of GSICS established processes
  - Chaired by IVOS chair
- Populate data base with summary of comparisons for sensors (outputs of SADE, Dimitri etc
- Excel pro-forma on cal/val portal

IVOS

Band Name	Sensor Under Test		Sensor Secondary Band		Reference TOA Reflectance Factor		Ration Sensor/Reference		N. of Samples	Measurement Uncertainties	
	Nominal Band Centre (nm)	Nominal Bandwidth (nm)	Secondary Band Centre for band to band comp (nm)	Nominal Bandwidth of secondary band (nm)	Mean	Std Dev	Mean	Std Dev		Type A (Statistical Random)	Type B (non-statistical)
V555	555	20			25.4177	8.3181	1.0276	0.0072	42	0.001110984	
V659	659	20			26.7018	8.3104	1.0192	0.0075	42	0.001157275	
V870	870	20			25.9726	7.6947	1.0258	0.0077	42	0.001188136	

Additional Information

AATSR Drift Corrections Applied

Filtered For

VZA <5 degrees

SZA<80 degrees

SAZ<90 degrees

Time Coincidence <1 day

No Ozone Correction Applied

Atmospheric code used (if appropriate)

IOCCG CEOS

*I*nternational *N*etwork for *S*ensor *In*-*T*ercomparison and *U*ncertainty assessment for *O*cean *C*olour *R*adiometry (*INSITU-OCR*)

working toward high accuracy and consistency of essential climate variables from multiple satellite ocean color missions

…a joint CEOS/IOCCG initiative…

Giuseppe Zibordi and Sean Bailey

in collaboration with

David Antoine, Philippe Goryl, Bertrand Fougnie, Menghua Wang, Bryan Franz, Carol Johnson, Hiroshi Murakami, Ewa Kwiatkowska, Young Je Park , Prakash Chauhan

European Commission · NASA · IOCCG · esa · cnes · NOAA · NIST · JAXA · EUMETSAT · KORDI · इसरो isro

Background and Rationale

- The Ocean Color Radiometry - Virtual Constellation (OCR-VC), developed in the context of the Committee on Earth Observation Satellites (CEOS), aims at producing sustained data records of well calibrated and validated satellite ocean color radiometry to assess the impact of climate change in coastal and open sea waters.

- Within this framework, the *International Network for Sensor Inter-comparison and Uncertainty Assessment for Ocean Color Radiometry* (INSITU-OCR) initiative aims at integrating and rationalizing inter-agency efforts on satellite sensor inter-comparisons and uncertainty assessment for remote sensing products. Emphasis is placed on requirements addressing the generation of Ocean Color Essential Climate Variables (ECV) as proposed by the Global Climate Observing System (GCOS).

Calibration, characterization and temporal stability

- **Ensure comprehensive pre-launch sensor calibration & characterization**

  All satellite ocean color sensors should undergo a comprehensive pre-launch instrument calibration and characterization traceable to SI standards to ensure continuation of the current time-series of OC ECVs.

- **Provide open access to calibration and characterization data**

  Agencies should provide open access to the pre- and post-launch instrument calibration and characterization data for all ocean color sensors.

- **Establish a permanent working group on satellite sensor calibration**

  Experts from ocean color mission calibration teams should meet regularly to review calibration and characterization methodologies and results, cross-calibration studies, and address instrument issues.

- **Maintain at least one long-term vicarious calibration site**

  Maintain at least one long-term vicarious calibration site (but multiple sites are encouraged) with SI traceable radiometry pursuing the objective of producing and delivering highly accurate measurements collected under ideal measurement condition in a region representative of global ocean observations. Vicarious calibration should be reassessed whenever the instrument calibration or OCR retrieval algorithm is modified.

- **Support calibration teams**

  All agencies should consider that a fundamental requirement for the OCR-VC is to maintain support for the calibration team throughout the life of the mission.

- **Continuously assess and correct sensors degradation**

  All ocean color missions should have at least one suitable system to monitor the temporal degradation and episodic changes in sensitivity of the instrument. Additionally, Space Agencies should commit to support continuous assessment and correction for temporal changes in instrument radiometric performance, and to quantify uncertainty in the temporal calibration.

Development and Assessment of Satellite Products

- **Distribute calibrated and un-calibrated data**

  In addition to distribution of calibrated data (i.e., Level 1B), the Space Agencies should promote the distribution of un-calibrated data (e.g., Level-0 or Level-1A) and the sharing of tools necessary to apply the calibration and characterization information.

- **Support permanent working groups on algorithm topics**

  It is recommended that the Space Agencies support international working groups on OCR related algorithms and associated uncertainties. This is a fundamental step in view of achieving consensus on the most effective and consistent approach for multi-mission satellite application.

- **Enforce quantification of products uncertainties**

  Enforce quantification of uncertainties on a pixel-by-pixel basis in satellite OCR and derived products.

- **Promote the development of regional bio-optical algorithms**

  Promote programs for the development of regional bio-optical algorithms with emphasis on the definition of uncertainties and inter-regional merging of products. When existing data sets would not suit the purpose, new field programs should also be enforced for generating the required measurements.

- **Provide open access to source code for processing algorithms**

  It is recommended that the Space Agencies create the ability to process the data from their respective missions through a common set of algorithms and to make the source code for those algorithms open and available for review and implementation by others.

Development and Assessment of Satellite Products (cont.)

- **Establish and maintain long-term field measurement programs**

  Long-term measurement programs should be established and maintained beyond any individual mission. These should rely on consolidated instruments, calibration methods and measurement protocols. In situ data designated to support satellite ocean color validation programs should be globally and seasonally distributed, and cover a broad range of water types.

- **Encourage community validation protocols**

  The definition, implementation and application of common validation protocols should be strongly encouraged. This should translate into the construction of matchups using identical criteria as well as reporting results through identical statistical measures.

- **Generate Level-3 data products**

  It is recommended that Space Agencies produce data sets of global, binned (Level-3) OCR and derived products. The binning strategy and spatial/temporal resolution of these Level-3 ECV data sets should be identical, including the use of a unified naming convention.

- **Agree on inter-agency consistent ancillary data**

  It is recommended that the Space Agencies agree on the use of a consistent set of ancillary data sources for the production of ECVs from ocean color sensors.

In Situ Data

- **Improve traceability of *in situ* measurements**

  Funding agencies should enforce common calibration schemes and measurement protocols, and additionally unify processing schemes and quality assurance criteria to ensure consistency and traceability of in situ measurements to SI standards. Inter-comparison exercises should be considered as the means to enforce traceability by promoting state-of-art on instrument calibration, measurement methods, data processing, and quality assurance. Practical implementation of inter-comparisons may entail a series of round-robins on specific topics together with training opportunities.

- **Ensure continuous consolidation & update of measurement protocols**

  Measurement protocols should be consolidated as a result of a critical review and update of those currently documented in peer-review literature or already included in compilations produced by former programs. Consolidated protocols should then be published using modern communication methods.

- **Enforce the definition of uncertainty budgets**

  In situ data should be linked to uncertainty budgets determined in agreement with defined protocols and accounting for a comprehensive range of uncertainty sources. Ideally these uncertainty budgets should include contributions from calibration, processing, deployment restrictions, and environmental conditions.

- **Define and implement community quality assurance schemes**

  Define and implement quality assurance schemes for in situ data. These criteria should be specific for the different quantities and should take benefit of ancillary information provided with the data itself (e.g., cloud cover or sea state in the case of radiometric data), empirical thresholds, closure between inherent and apparent optical properties, models estimate.

In Situ Data (cont.)

- **Establish and maintain centralized repositories for *in situ* data**

  Centralized open access data repositories should be established, supported and maintained beyond any individual mission's life. Repositories should ideally have the capability of indexing data as a function of their fitness for specific applications (e.g., vicarious calibration, bio-optical modeling, and validation). Suitable mechanisms should be put in place to warrant data submission (e.g., requesting timely data delivery for field data produced within the framework of measurement programs funded by Space Agencies, or creating benefits like full processing and quality assurance of submitted data, or, where appropriate, convincingly recommending authors exploiting archived data to contact contributors and offer co-authorship).

- **Design and implement community processors for *in situ* data**

  Design, implement and apply community consensus processors for in situ data. This development should proceed through incremental steps, for instance by initially creating open access libraries and requesting manufacturers to adopt common (or user definable) data formats.

- **Agree on priority variables to be collected**

  A list of variables considered essential for satellite ocean color applications should be defined and considered with high priority by any field program.

- **Establish general coordination mechanisms for field campaigns**

  Establish a coordination mechanism to allow for a continuous exchange of information on forthcoming field activities to create opportunities for collaboration including instrument exchange, field training, inter-comparisons. The coordination should be instrumental in ensuring the collection of prioritized in situ variables meeting the basic needs for satellite ocean color applications.

Information Management and Support

- **Ensure accessibility and distribution of large data volumes**

  The entire archive of satellite data products should be freely and easily accessible in a timely manner. Space Agencies should enter into data sharing agreements so that the source data for all missions are provided to their partner Agencies as means of facilitating inter-mission comparisons, to provide mirror sites for improved user access to the data and to act as a data-loss risk reduction mechanism.

- **Establish processing capabilities for calibration & validation activities**

  Establish appropriately scaled processing system architectures and computer infrastructures to support substantial reprocessing for calibration and validation analyses, in addition to operational processing and regular re-processing.

- **Ensure accessibility to documentation**

  A minimum set of documentation on missions/data products should be made available. This should include documentation on the implementation of the instrument characterization and calibration and associated pre- and post-launch data, the relative spectral response functions for the instrument bands, and the derivation and validation of Ocean Color ECV algorithms.

- **Establish common data formats**

  It is recommended that a common data format be agreed upon for the storage of the satellite data produced by all Space Agencies. A good example is netCDF with CF compliant metadata. At a minimum, tools should be provided by the Space Agencies to allow users the ability to easily read the files – whatever the format.

- **Provide support for open source data processing and visualization**

  Space Agencies should support the development and distribution of open-source data processing and visualization software, including the source code used in the generation of mission Ocean Color ECVs.

IVOS concern – Recommendation to CEOS SIT

Noting that CEOS WGCV (through its sub-groups) was established to be the focal point for CEOS agencies, VC, WGs etc on Cal/Val issues related to sensors and associated products it is a concern that NEW groups need to be formed to address the same issues.

- IVOS asks CEOS WGCV to make reference to the proposed initiative of INSITU-OCR acknowledging its support for the proposed actions and strategy but suggesting that radiometric discussion and coordination of Cal/Val of OC sensors (pre-flight and post-launch) should be carried out under the auspices of CEOS WGCV and in particular its IVOS sub-group
    - IVOS notes and encourages 'experts' to meet and discuss at locations to suit and not necessarily at IVOS plenary but that they report and act through it.
    - Example of SST –VC

CEOS

GODDARD SPACE FLIGHT CENTER

Atmospheric Correction Discussion

Kurt Thome

CEOS/IVOS 25

Frascati, Italy

March 19-21, 2013

NASA/Goddard Space Flight Center

Kurtis.thome@nasa.gov

Why IVOS?

Many subgroups in CEOS and other multi-agency groups rely on atmospheric correction

- End result is an understanding of how atmospheric effects alter the calibration process in vicarious methods - TOA radiance
- Accuracy of correction depends on knowledge of atmospheric conditions - Atmospheric Composition Subgroup
- Correction depends on surface BRF - Land Prdoucts Validaton Subgroup
- IVOS goals do not care about the quality of the inputs
  - Emphasizes sensivity to the inputs
  - Knowing the accuracy of input
- IVOS does not want to be distracted by retrieval algorithms but to concentrate on RT codes

Standard data set

Standard data set to allow groups to evaluate their processing approaches

- Web access to standard input and result from an established group using these inputs
  - Good tool for groups initiating new field programs
  - Good tool for groups implementing a new radiative transfer approach
- Rely on an artificial data set
  - Allows coupling of aerosol optical depth and surface reflectance
  - Can limit impacts from input parameterization
- Risk is that it drives users towards simply matching the standard results

Atmospheric parameterization

Agreed to the following list of parameters used as inputs to the radiative transfer models

- Spectral optical depth (total, component)
- Aerosol optical depth at 550 nm
- Angstrom coefficient (also known as power law exponent)
- Junge parameter
- Surface pressure
- Column water vapor amount
- Column ozone amount
- Aerosol type (colloquial model as well as real and imaginary index of refraction, minimum/maximum radius)
- View-sun geometry
- Surface height
- Sensor height

Standard data set

Recommend that the base input data set on a clean aerosol over a moderately bright surface

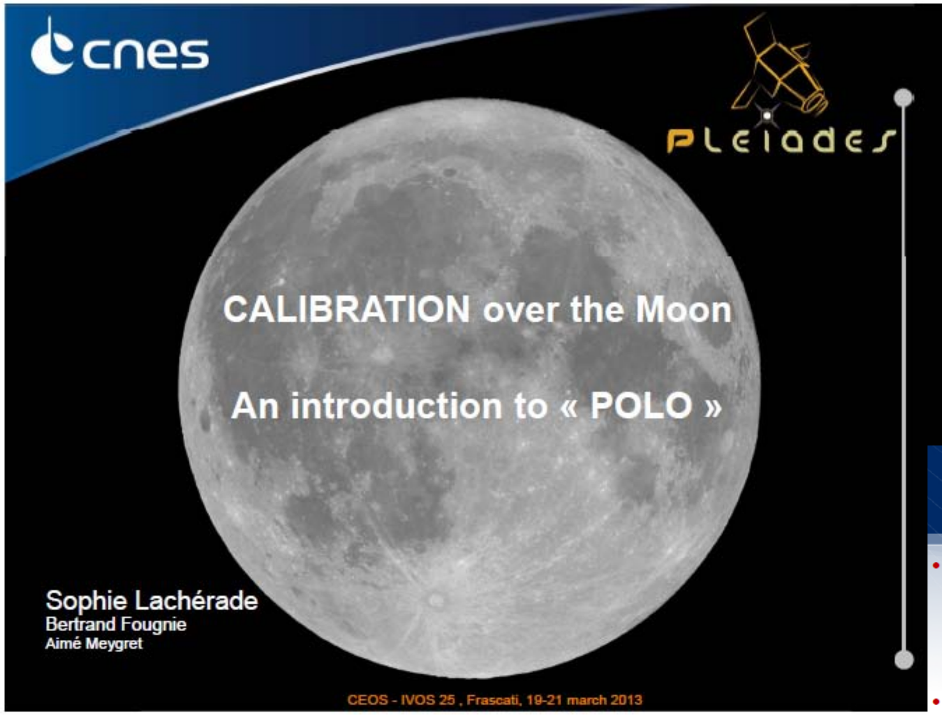
- Low aerosol absorption reduces impact of aerosol composition selection
- Modest aerosol loading (0.1 at 550 nm)
- Spectral reflectance constant with wavelength
  - Initial input of 0.4 reflectance
  - Second case with 0.05 reflectance
- 45 degree view angle (no ambiguity on elevation versus zenith)
- 60-degree solar zenith angle (large difference in radiance if elevation versus zenith angle confusion)
- Lambertian surface
- Radiance output at 1-nm intervals

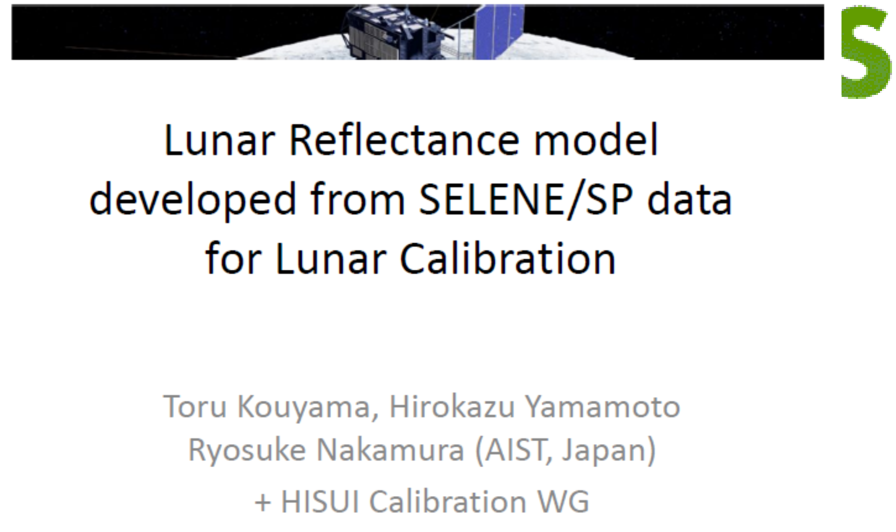
Action/Request to SIT

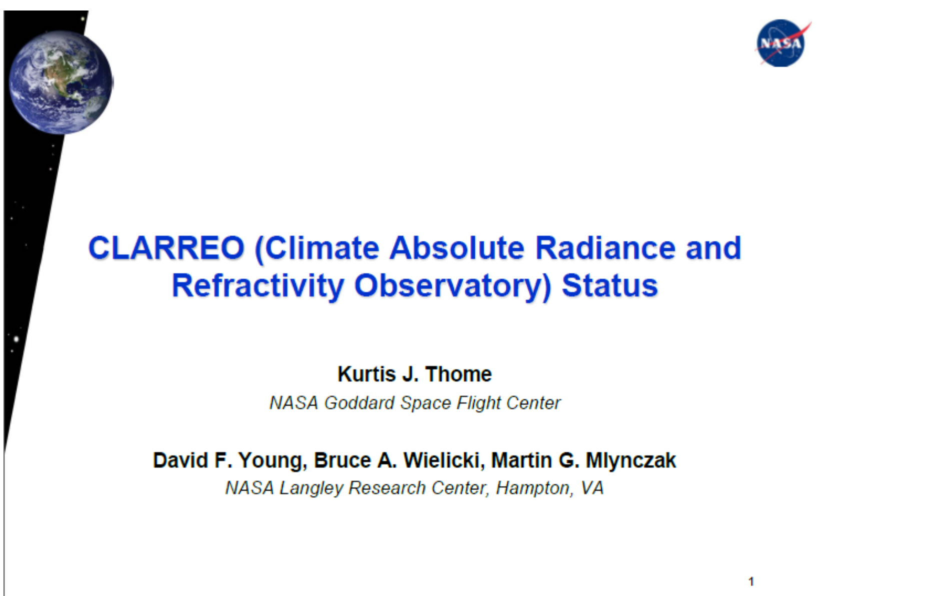
Note: Critical importance of linking TOA satellite measurements with BoA ground data – particularly for Cal/Val

- Atmospheric correction one of the largest sources of uncertainty in process
- Cal/Val uses RT models/codes in less stringent manner than for AC applications
- Many codes, many different ways of using
- Formal comparison using standardised set of input parameters to be used by participants in their 'favoured manner'
- K Thome NASA will produce data set and collate results from all wishing to participate.
- CEOS SIT to endorse activity and encourage participation.
  - Likely to include a few specialists from AC group as well

Other on-going activities







QA4EO A QUALITY ASSURANCE FRAMEWORK FOR EARTH OBSERVATION

NPL

IEEE TRANSACTIONS ON

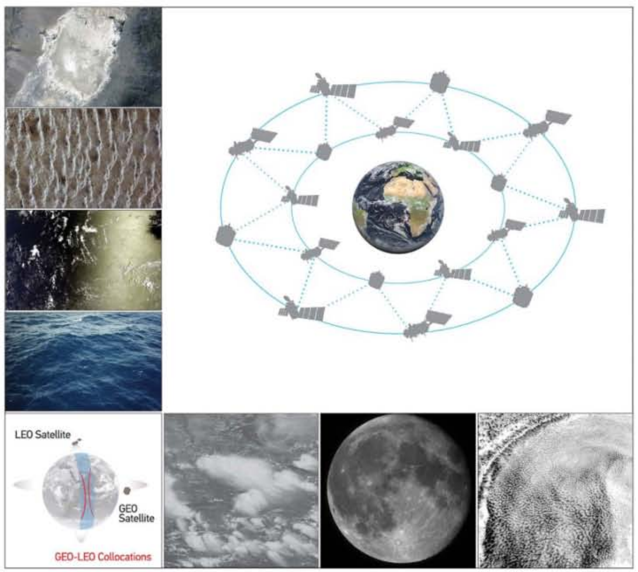
GEOSCIENCE AND REMOTE SENSING

A PUBLICATION OF THE IEEE GEOSCIENCE AND REMOTE SENSING SOCIETY

MARCH 2013 VOLUME 51 NUMBER 3 IGRSD2 (ISSN 0196-2892)

PART I OF TWO PARTS

SPECIAL ISSUE ON INTERCALIBRATION OF SATELLITE INSTRUMENTS



(Top and bottom corner) Symbolic global network of Earth observing satellites connected by intercalibration and schematic illustration of the GEO and polar LEO satellites and distribution of their collocated observations. (Left column and bottom row) Examples of natural targets used as calibration references.

IEEE

Table of Contents:

Gyanesh Chander USGS led effort

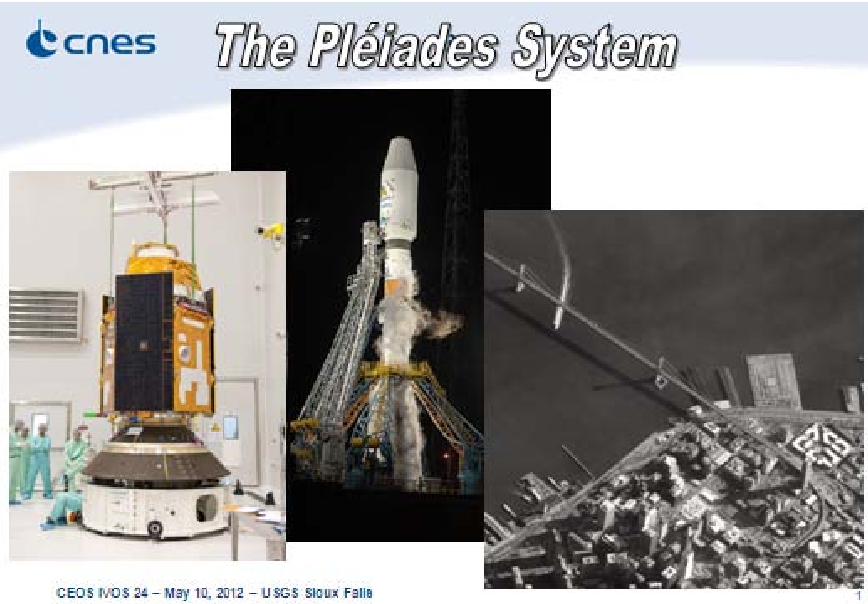
IVOS

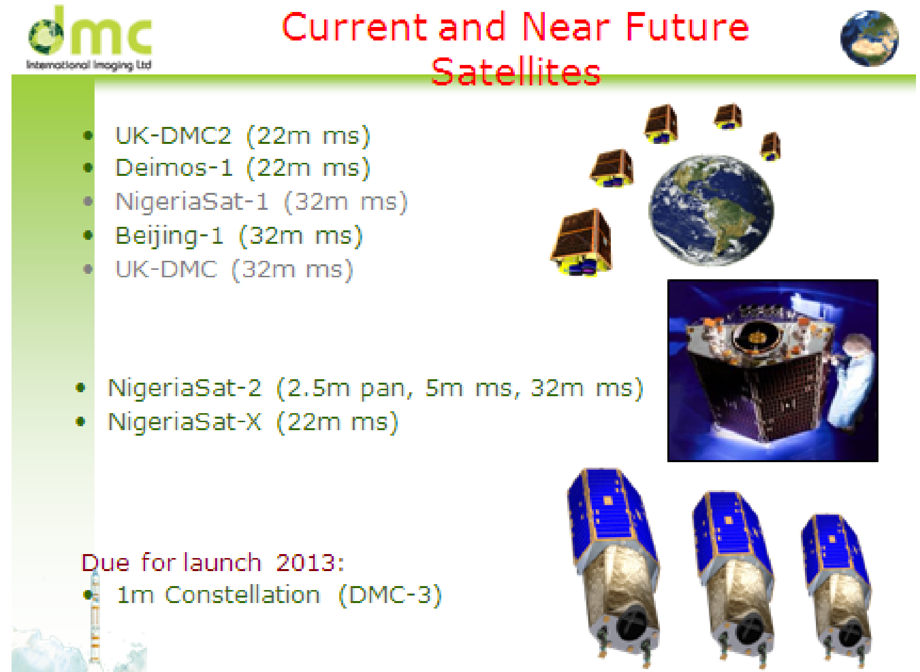
Manuscripts Received

- There has been a lot of interest in the community with regards to the special issue topic
- There was an overwhelming response and close to 60 manuscripts were submitted
- **40 Manuscripts were accepted for publication**

- Example of the contributors
  - ARGANS, CAS, CMA, CNES, ESA, EUMETSAT, ISRO, JAXA, KMA, JMA, MIT, NASA, NOAA, SDSU, USG, etc.
- Example of the sensors covered
  - AVHRR, AMSU, (A)ATSR, CLARREO, ETM+, FY-2/2C/D/E/3B, GOES, HIRS, Hyperion, IASI, Jason-2/OSTM, MODIS, PROBA, SCAIMACHY, Sentinel-2, etc.

Sensor Pre- and on-board calibration





IVOS technical workshop

Planning starting for next IVOS technical workshop

Topic: Pre-launch and on-board calibration of satellite sensors

Date/location: To be reconsidered in light of travel constraints

Summary / Future activities

CEOS WGCV IVOS

- **working successfully on a number of collaborative projects**
  - **Needs CEOS agency support – particularly for comparisons**
  - **Unclear how to progress with actions/recommended and endorsed by plenary**
  - **Most could be labelled as QA4EO**
- **Will initiate inter- 'plenary meeting' using webex ~ 3 monthly**
- **Looking to review status/value of CEOS endorsed 'Reference solar irradiance spectrum'**
- **Will look to greater coordination with GSICS**
- **Looking for volunteers to host IVOS 26 (Spring 2014)**
- **Still needs to have increased active participation from all agencies**