**COMMITTEE ON EARTH OBSERVATION SATELLITES**

**Working Group on Calibration & Validation (WGCV)**

# MINUTES OF THE 28th WGCV MEETING

***WGCV-28 Included the 3rd Joint Session of the CEOS Working Groups on Information Services and Systems (WGISS) and Calibration & Validation (WGCV)***

# WGCV-28

***Sanya, China, February 26th –28th, 2008***

**Hosted by:**

**National Satellite Ocean Application Service (NSOAS)**

**and**

***Center for Space Science and Applied Research* (NMRSL/CSSAR/CAS)**

***China***

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# Acronyms

| | |
|---|---|
| AATSR | Advanced Along Track Scanning Radiometer |
| AMSU | Advanced Microwave Sounding Unit |
| ASTER | Advanced Spaceborne Thermal Emission and Reflection Radiometer |
| AVHRR | Advanced Very High Resolution Radiometer |
| BNSC | British National Space Centre |
| Cal/Val | Calibration / Validation |
| CAS | Chinese Academy of Science |
| CBERS | China Brazil Earth Resources Satellite |
| CCRS | Canada Centre for Remote Sensing |
| CEOP | Coordinated Enhanced Observing Period |
| CEOS | Committee on Earth Observation Satellites |
| CGMS | Coordinating Group for Measuring Satellites |
| CHRIS/PROBA | Compact High-Resolution Imaging Spectrometer / Project for On-Board Autonomy |
| CONAE | Comisión Nacional de Actividades Espaciales |
| COSPAR | Committee on Space Research |
| CRT | CEOS Review Team |
| CSA | Canadian Space Agency |
| CSSAR | Center for Space Science and Applied Research |
| DEM | Digital Elevation Model |
| DGVM | Digital Global Vegetation Models |
| DN | Data Number |
| EDC | Earth Resource Observing Systems (EROS) Data Center |
| ENVI | ENvironment for Visualizing Images |
| Envisat | Environmental Satellite |
| EOS | Earth Observing Satellite |
| ERS | Earth Resources Satellite |
| ESA | European Space Agency |
| ESRIN | European Space Research Institute |
| ESSAC | Earth Systems Science Advisory Committee |
| ESSP | Earth System Science Pathfinder |
| ESTEC | European Space Research and Technology Centre |
| FAO | U.N. Food and Agriculture Organisation |
| FAPAR | Fraction of Absorbed Photosynthetically Active Radiation |
| GCM | Global Circulation Models |
| GCMD | Global Change Master Directory |
| GCOS | Global Climate Observing Systems |
| GEO | Group on Earth Observations |
| GEOSS | Global Earth Observation System of Systems |
| GHz | Gigahertz |
| GIFTSS | Government Information From The Space Sector |
| GMES | Global Monitoring for Environment and Security |
| GOFC | Global Observation of Forest Cover |
| GOFC/GOLD | Global Observation of Landcover Dynamics |
| GOME | Global Ozone Monitoring Experiment |
| GTOS | Global Terrestrial Observing System |
| HIRS | High Resolution Infrared Radiation Sounder |
| IGOS | Integrated Global Observing Strategy |
| IGOL | IGOS Land Theme |
| ISPRS | International Society for Photogrammetry and Remote Sensing |
| IPO | Integrated Program Office |
| ISSMAP | *In situ* Sensor Measurement Assimilation Programme |
| IVOS | Infrared and Visible Optical Sensors |
| JAXA | Japan Aerospace Exploration Agency |
| JERS | Japanese Earth Resources Satellite |
| LAI | Leaf Area Index |
| LCCS | Land Cover Classification System |
| LPV | Land Product Validation |

| | |
|---|---|
| MOBY | Marine OPtical BouY |
| MERIS | Medium Resolution Imaging Spectrometer |
| MHz | Megahertz |
| MODIS | MOderate-Resolution Imaging Spectro-radiometer |
| NASA | National Aeronautics and Space Administration, USA |
| NDVI | Normalized Difference Vegetative Index |
| NESDIS | National Environmental Satellite, Data, and Information Service |
| NIST | National Institute of Standards and Technology, USA |
| NOAA | National Oceanic and Atmospheric Administration, USA |
| NPL | National Physical Laboratory, UK |
| NPOESS | National Polar-orbiting Operational Environmental Satellite System |
| NPP | NPOESS Preparatory Project |
| NWP | Numerical Weather Prediction |
| OCG | Observations Coordination Group |
| PILPS | Programme Intercomparing Land Process Schemes |
| RADARSAT | Radar Satellite |
| ROLO | RObotic Lunar Observatory |
| SAR | Synthetic Aperture Radar |
| SIRCUS | Spectral Irradiance and Radiance responsivity Calibrations using Uniform Sources |
| SIT | Strategic Implementation Team |
| SNO | Simultaneous Nadir Observations |
| SPOT | Systeme Probatoire pour l'Oberservation de la Terre |
| SRTM | Shuttle Radar Topography Mission |
| TGARS | Transactions on Geoscience and Remote Sensing |
| TIFRI | Technology Innovations for Radiometer Instruments |
| TM | Terrain Mapping |
| TOPC | Terrestrial Observation Panel for Climate |
| UK | United Kingdom |
| UNEP | United Nations Environment Programme |
| USGS | United States Geological Survey |
| WGCV | Working Group on Calibration and Validation |
| WGEdu | Working Group on Training and Education |
| WGISS | Working Group on Information Systems and Services |
| WMO | World Meteorological Organisation |
| WTF | WGCV / WGISS Test Facility |

**Introduction, Logistics and Adoption of Agenda for WGCV-27** (Changyong Cao and Martha Maiden)

The WGCV Chair Changyong Cao and the WGISS Chair Martha Maiden introduced the participants. The Chairs recognized the *CEOS/SEO* representative Ivan *Petiteville (ESA)* and the participating for first time country and agency representatives. The role of CEOS/SIT in coordination of the CEOS agencies to support GEO in its realization of the space segment of GEOSS was discussed. The logistics of the meeting and the needs of the participants were discussed.

A change in the traditional WGCV meeting agenda was proposed. In addition to the traditional reports and WGCV contributions to GEOSS, the meetings included also: panel discussions with moderators and invited keynote speakers, leading experts/scientists on specific issues/tasks. The goal change would help establish the connection between decision makers and leading experts for specific action items/tasks.

**The WGCV-28 Agenda (Annex A) and Goals were approved as presented.**

# ***Session 1: Welcome, Introdictions and WGCV Reports***

## 1. Welcome from the official WGCV-28 hosts Acad. J. Jiang (NMRSL/CSSAR/CAS), and Prof. X. Jiang (NSOAS)

Our hosts, ***Acad. J. Jiang*** *(NMRSL/CSSAR/CAS)*, and ***Prof. X. Jiang*** (NSOAS), welcomed the WGCV group and expressed his pleasure in meeting the WGCV28 participants. Acad. J. Jiang gave a "*General Introduction to China's Space-Based Earth Observation System*". Prof. X. Jiang *(NSOAS)* presented an "*Overview of the National Satellite Ocean Application Service (NSOAS), China*" and discussed the agency goals, programs, satellite instruments and capabilities. For more details, please see their presentations at the WGCV28 web page.

The **WGCV Chair, Changyong Cao** thanked the hosts for their kind remarks, informative presentations and for organizing the meeting.

## 2. WGCV-28 Chair's Report (*Changyong Cao*)

***Changyong Cao*** presented the WGCV Chairman Report. The Report included short introduction and background on WGCV as a framework for the current and planned activities, and an update on the WGCV subgroups, structure and leadership. It emphasized the new role of CEOS/WGCV in the GEOSS era, and the associated changes in the WGCV agenda and plans.

**CEOS WGCV Subgroups Chairs (update):**

- Atmospheric composition (ACSG) Chair – Dr. B. Bojkov, NASA;
- Infrared Visible Optical Sensors (IVOS) –Dr. N. Fox, NPL/UK;
- Land Product Validation (LPV) –Dr. F. Baret, CNES/France;
- Microwave Sensors (MW) – Dr. C. Buck, ESA;
- Synthetic Aperture Radar (SAR) – Dr. Satish S*rivastava*, CSA;
- Terrain Mapping (TM) – Prof. J. Peter Muller, UCL.

The report addressed the WGCV priorities, which are as follows: 1) The WGCV will support calibration and validation activities in support of the GEO tasks, particularly through the focused work of the WGCV subgroups; 2) The WGCV will actively contribute/lead a number of GEO tasks such as DA-06-02, to facilitate the establishment and application of uniform radiometric and geometric standards; 3) The WGCV will

encourage traceability to international standards; 4) The WGCV will seek CEOS endorsement and support for joint calibration and validation campaigns.

**The following major CEOS events and developments since WGCV27 were reported:**

WGCV participated at the GEOSS Workshop on Interoperability and Biodiversity, IGARSS, July 23-27, Spain, 2007. Participation of WGCV members and their papers contributed to the work of the standards & calibration breakout group.

WGCV's efforts on developing data quality assurance strategy is recognized as one of the early achievements for GEOSS. This work was among GEO's first 100 Steps to GEOSS reported at ministerial summit.

A GEO-CEOS Workshop on Cal/Val was held in Geneva, Oct. 2-4, 2007. Nearly fifty participants actively discussed the required steps and issues for establishing a Data Quality Assurance Strategy for GEO within 4 sessions. A second workshop would be held in May 2008.

The 21st CEOS Plenary was held in Hawaii, Nov. 12-15, 2007. CEOS SEC announced the participation of two new members: Spain's Center for the development of Industrial technology (CDTI), and the China Center for Resources Satellite Data and Applications (CRESDA). During the plenary was discussed the GEOSS space segment support, in dialogue with GEO, and were presented reports from the SBA coordinators, virtual constellations, and working groups. The following organizational changes were announced: CEOS CEO transferred leadership from Jean-Louis Fellous to Ivan Petiteville; the CEOS SIT chairmanship transferred from Volker Lebig (ESA) to Mary Kicza (NOAA); the CEOS chair has changed from Barbara Ryan (USGS) to Pontsho Maruping (S. Africa). Further details, the presentations and reports are available from the special CEOS 21th plenary website http://www.ceosplenary2007.com/materials_agenda.htm.

**The following WGCV accomplishments during the past year were reported:**

1) WGCV is leading cross-cutting GEO task (DA-06-02) to develop a data quality assurance strategy for GEOSS with a broad participation from its members and the cal/val community. WGCV organized the GEO-CEOS Workshop on Cal/Val (Sponsored by GEO and ESA, Oct. 07). At the meeting progress was made toward developing the framework and guidelines for cal/val; identified key elements for a data quality strategy to achieve interoperability for GEOSS. Consensus was reached that quality assurance should be incorporated into satellite programs. Reported was the establishment of a cal/val portal by ESA as a first step towards harmonization. The Chair expressed gratitude to BNSC/NPL, GEO, ESA for hosting the WGCV meeting and workshop and thanked all participating agencies. At the GEOSS workshop and also the workshop co-sponsored with IEEE at IGARSS07 were discussed the issues related to cal/val standards, consistency, and interoperability. WGCV coordinated the activities and reporting related to data quality assurance.

2) WGCV actively contributes toward the CEOS IP Climate Actions. This is an excellent opportunity for international collaboration through CEOS. Major progress was reported in two Priority-1 actions. Project 1: FCDR (T-4): Quantified the measurement consistency among AVHRR, MODIS, and ATSR for generating Fundamental Climate Data Records (FCDRs) (NASA, NOAA, ESA, CCRS/CSA, USGS) and documented in a journal paper (submitted). Project 2: Benchmark Mission Planning (A-5, C-7): Includes active studies on TRUTHS (NPL) and CLARREO (NASA).

3) WGCV actively provides CEOS constellation support throughout the work of its members.

Further details can be found in the supporting materials from the meetings and the subgroup and countries and agencies reports.

Considering the stated above CEOS developments and WGCV progress, the Chair discussed the WGCV's role and placement in the CEOS and GEO structure, plans and implementation. CEOS's organizational structure includes: The CEOS Chair and secretariat (SEC) and the CEOS/SIT (Strategic Implementation Team); the working groups: WGCV, WGISS and WGedu; the 4 Constellations (LSI, AC, PC, OST); and the 9 SBA coordinators. Since CEOS was formally recognized as the space segment of GEOSS (GEO), the role of WGCV has changed. Traditionally WGCV has provided a technical forum for cal/val information exchange. The new role of CEOS as a space arm of GEO drove WGCV to become the cal/val work force for CEOS and GEO, working to realize GEO tasks, actions, deliverables, and milestones. GEO and CEOS/SIT have begun addressing resource issues.

**The Chair described the WGCV Current and Future Challenges:** As more and more satellites are launched, data quality assurance becomes increasingly more important. Some of the challenges the Cal/Val community is facing, addressed by the Chair include: 1) Technical challenges, such as: stringent cal/val requirements for climate change detection, with required stability on the order of 0.1K per decade; and lack of standards for data quality and on-orbit SI traceability. 2) Resource - getting sustained agency support for cal/val is challenging. The work could only be accomplished by leveraging on existing project funding and by ad hoc contribution on voluntary basis. The need is to complete many tasks with limited resources.

To meet these challenges, the following agency commitments were requested:

1) Endorsement and support: All satellite programs should include adequate support for cal/val. They should establish quality assurance framework based on best practices, included in the Cal/Val portal; support further development and use as the entry point for Cal/Val information; develop CEOS endorsed Cal/Val reference sites; establish data policy for the access and use of Cal/Val data; support recalibration for generating FCDRs (agencies involved); provide adequate resources for additional CEOS IP tasks (e.g.: Priority-2 climate action on ocean sensor cal/val (o-18) next year).

2) Coordination on benchmark measurement missions (climate action A-5): 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 constellation?)

3) Other recommendations: Invest in comprehensive pre-launch calibration (especially for SARs) to facilitate post launch calibration/validation.

**WGCV participation in CEOS/SIT tasks for GEO**: The chair stated that WGCV have participated in the CEOS/SIT GEO tasks and targets remapping (~160 Questionnaires provided details on expected 2008 results). At the CEOS-GEO Task SIT Workshop Feb. 20-22, 2008, Washington DC, the participants included: SBA coordinators, constellation leads, and working groups chairs. As a result, WGCV has been assigned 10 Actions for 2008.

**WGCV GEO tasks in the order of deliverables in 2008.** The work of WGCV toward GEOSS and GEO tasks was reviewed, addressing the list of GEO Tasks with WGCV contribution (in Appendix B). Significant progress on the GEO DA-06-02 tasks was reported. WGCV has developed strategy, listed preliminary actions and established timeframe and milestones to accomplish the task. The task lead Stephen Ungar was highly prized. Other GEO tasks that WGCV is contributing were also reviewed. The subgroup chairs were asked to report the subgroup activities contributing to the GEO tasks.

**WGCV and CEOS Climate Actions:** It was stated that Mitch Goldberg (NOAA) is the CEOS Climate SBA lead. He will coordinate efforts between CEOS, GCOS and WMO. Current emphasis is on creating satellite-based climate data records through international collaboration (which involves coordinating efforts between WGCV and GSICS and between GSICS and RSSC-CM). The importance of cal/val for constructing CDRs can not be overemphasized.

**WGCV's strategy and long term planning are reflected in the vision, mission and values statements of the group, as stated below by the Chair:** *Vision:* Empower the Earth Observation community by developing a data quality assurance strategy to foster sustained high quality observations and associated error characteristics, "*in order to improve monitoring of the state of the Earth, increase understanding of Earth processes and enhance prediction of the behavior of the Earth system". Mission:* Lead the development of the data quality assurance strategy for GEOSS, beginning with space-based observations and evaluating expansion to in-situ observations, taking account of existing work in this arena. Develop the framework, guidelines, standards, best practices and recommendations for this task to ensure long-term confidence in the accuracy and quality of Earth observation data and products. *Values:* Enhance coordination and complementarity, to promote international cooperation, and to focus activities in the calibration and validation of Earth observations for the benefit of the GOESS, the CEOS members, and the international user community.

**WGCV Priorities for 2008:** 1) Continue leading DA-06-02, in which a major milestone is the workshop in May. 2) Develop framework, guidelines, best practices, and procedures. 3) The Cal/val portal requires further development. 4) The Cal/val site classification/documentation is in progress. 5) Joint experiments are required for R&D on selected stable radiometric reference standards. 6) WGCV needs to develop "Standards and

recommendations handbook", which would greatly facilitate the cal/val process. 7) Further CEOS constellation support, and GSICS coordination. 8) Deliverables to be further discussed, include: DEM interoperability, Product harmonization, Microwave instrument cal/val and others.

**WGCV Support to CEOS Constellations**

The CEOS initiative "CEOS Virtual Constellations" was discussed and was reported that WGCV is presently contributing to: 1) the Atmospheric Composition constellation led by Dr. Ernest Hilsenrath (WGCV contribution lead by ACSG with chair Bojan Bojkov); 2) Land Surface Imaging (LSI; WGCV contribution lead by Greg Stenssas, Stephen Ungar and the LPV Chair Frederick Baret); 3) Precipitation (WGCV contribution is lead by MSSG and its chair Christopher Buck); 4) Ocean Surface Topography (TBD). It is believed that WGCV has a lot more to offer to the Constellations, such as the development of standards, calibration/Validation Sites, and inter-satellite calibration using the SNO method.

**The new WGCV Project *"Cross calibration at Dome C"*:** CEOS/WGCV Joint Experiment was introduced. The experiment includes simultaneous Nadir Overpass between EOS/Hyperion and MODIS/AVHRR. It is conduced as collaboration among NOAA, USGS, and NASA. Reported was that the first data sets have been acquired and are being processed. The experiment is anticipated to be useful for resolving spectral issues in the intercomparison between AVHRR and MODIS. Provides an example for consistency checking across satellites, complements the Cal/Val Portal. Supports both data quality assurance for more consistent observations, and potentially climate quality instrument stability. It can also prove potentially useful for the CEOS constellations as well.

**The discussed upcoming events in 2008 include:** 1) CEOS/SIT-21, April 23-24, MA, USA. 2) The second GEO/CEOS workshop on Cal/Val Workshop, May 2008 at NIST, Washington DC (organized by Marie-Claire and Pascal); 3) IGARSS, Boston, July 6-11, Invited WGCV paper. 4) ISPRS, Beijing, July 2008, TMSG. 5) SPIE, readiness for GEOSS, Aug. 10-14, San Diego. 6) WGCV 29: Avignon, France. 7) WGCV new Vice chair nomination. 8) CEOS/SIT-22, Sept. 16-18, Tokyo. 9) CEOS 22nd plenary, Nov. 10-13, Cape Town, SA. 10) SPIE Asia Pacific GEOSS/CEOS Conference, Noumea, New Caledonia, Nov. 17-21, 2008.

**WGCV GEO tasks (see Appendix B)**

## 3. WGCV Secretariat update (*Petya Campbell*)

- Minutes from WGCV-27 were reviewed, approved and adopted as presented.
- Open Action Items from previous meetings were reviewed and the following table reflected their status.

**WGCV Current Action Items and Action items in support of GEO tasks:**

| | | |
|---|---|---|
| WGCV25-3 | **NIST** to generate for the CEOS best practices: a description of the Total Solar Irradiance Workshop. | WGCV26 open in progress |
| WGCV26-1 | **WGCV Secretariat** to generate a "WGCV suggested cal/val practices" web page and populate it with the materials generated by WGCV. The materials will be transferred to the Cal/Val Portal | Ongoing |
| WGCV26-5 | **WGCV Subgroup Chairs**, to review with the SG members the ***seed questions*** describing QC and cal/val processes, focus of the GEO/CEOS Cal/Val Portal Workshop, and prepare to address them. In addition, similar request to be made to the wider WGCV membership. | CalValWS07 |
| WGCV27-1 | **WGCV Subgroup Chairs** (SG) to review with the SG members the *list of GEO tasks in which WGCV is participating* (attached), and to generate a summary of the activities in which the members are participating, relevant to the listed GEO tasks. | WGCV28 |
| WGCV27-2 | **WGCV Secretariat**, to contact the CEOS constellation leads and request that the constellation teams evaluate their cal/val requirements. | WGCV28 |

| GEO Task | Actions Description | Due Date | POC | Leading Agency or Organization | Agency and Organization Participation |
|---|---|---|---|---|---|
| DA-06-02 | 1) Develop a consolidated worldwide cal/val site database, to be included in the CEOS cal/val portal. 2) Establish a WGCV consensus on uniform cal/val schemes and criteria. 3) Expand further the cal/val portal in both content and functionality | 10/30/2008 | P. Lecomte and/or N. Fox | ESA/NPL | ESA, USGS, NASA,NOAA, BNSC/NPL |
| DA-06-02 | 1) Complete the assessment of the measurement consistency of MODIS, ATSR and AVHRR. 2) Generate recommendations for data recalibration. | 10/30/2008 | J. Xiong | NASA | NASA, ESA, NOAA, CCRS, USGS |
| DA-06-02 | 1) Perform a joint experiment using Dome C for cross calibration. 2) Assess the feasibility of establishing Dome C as a CEOS radiometric reference standard. 3) Determine it's stability, and suitability for climate change studies and data calibration. | 10/30/2008 | C. Cao | NOAA | NASA, ESA, CNES, NOAA, USGS |
| DA-06-02 | To develop further the framework and guidelines for data quality assurance, hold the 2$^{ond}$ GEO-CEOS Workshop on cal/val. | 10/30/2008 | P. Lecomte | ESA | All WGCV members |
| DA-06-02 | Develop a CEOS/WGCV standards and recommendations handbook. | 10/30/2008 | C. Cao | NOAA | All WGCV members |
| DA-07-01 | Further expand the EO data portal, to include fused 30m ASTER-SRTM WMS layers for additional sites, expand the DEM representative set for instrument cal/val and intercomparison at the cal/val sites (Note: to be updated after WGCV28). | 10/30/2008 | Jan-Peter Muller | WGCV/TM | WGCV/TM, BNSC/UCL, JAXA, ESA, NASA, CNES, USGS. |
| DA-06-04 | 1) Continue developing the strategy for generating consistent biophysical products from medium resolution sensors. 2) Evaluate global land cover classification at regional scale. 3) Update the BELMANIP, and intercompare the fAPAR products. (Note: to be updated after WGCV28). | 10/30/2008 | Frederick Baret | WGCV/LPV | WGCV/LPV, CNES, NASA |

The CEOS WGCV website was reported to have been recently updated. Future upgrades will be conducted as necessary information becomes available.

# 4. Reports from the WGCV Subgroups

## 4.1 Atmospheric Chemistry Subgroup *(Bojan Bojkov)*

***Bojan Bojkov***, the Chair of the Atmospheric Chemistry subgroup presented the report from the AC subgroup. The report included summaries of the 2007 subgroup activities, review of AC missions, and provided recommendations to WGCV and CEOS for resolving some of the issues.

**Described are the ACSG focus and background:** The focus of ACSG is atmospheric chemistry (for example ozone, nitrogen dioxide) and composition (for example aerosols and greenhouse gases). ACSG consists of 15 members from space agencies and other relevant agencies and organizations with experience in calibration, algorithm development, ground based instrumentation, modeling and validation. ACSG is a forum that fosters interactions between mission scientists and data users, recommends network validation sites, develops comprehensive validation methodologies involving ground-based and space-borne assets, and specifies comprehensive and consistent multi-mission validation datasets.

**The Chair reported on the status of the following current composition missions:**

***Current:*** ESA Envisat (3/'02): 3 AC instruments (GOMOS, MIPAS, SCIAMACHY) operating well; fuel depleted in 2010/11 timeframe; NASA Aura (7/'04): nominal operations of AC instruments (HIRDLS, OMI, MLS, TES); platform fuel through 2015; A-Train: Aqua, Calipso, CloudSat, Parasol (and Aura) operating nominally; MetOp-A (10/'06): GOME-2 and IASI operations nominal; ERS-2 GOME, NOAA-16/17/18 SBUV/2, Odin OSIRIS/SMR, SCISAT-1 ACE

***Failures:*** EarthProbe (EP) TOMS: transmitter failure in December 2006; shutdown in May 2007

***Up-and-coming:*** JAXA/NIES GOSAT: global CO2 and CH4 measurements, to be launched in August 2008; NASA Glory mission: aerosols/black carbon, to join A-Train December 2008; NASA OCO: global CO2

measurements; instrument problems; to join A-Train December 2008; NSMC/CMA FY-3a with SBUS and TOU ozone instruments, to be launched April 2009; ESA ADM-Aeolus: wind and aerosols, to be launched June 2009; NPOESS Preparatory Project (NPP) launch scheduled for October 2009, in A-Train orbit.

**2007 sub-group activities:** ACSG actively participated in the preparations and significantly contributed to the GEO/CEOS Cal/Val Workshop and the preparatory meeting held in April 2007. The workshop was attended by a number of the sub-group members.

Significant progress was reported in the synchronization of ESA and NASA atmospheric composition cal/val activities/priorities, including: Mission planning, ground based ozone calibration, NO2 inter-comparison, aerosol/H2O lidar homogenization/inter-comparison; In situ and satellite data sharing, formats and data requirements (information content); and NASA AVDC, ESA GECA (including cal/val leading experts).

ACSG coordinated the GHG mission validation preparations. The initial focus was on carbon dioxide (CO2). Participants included NASA, ESA, JAXA/NIES, TCCON, NDACC, plus aerosol teams. The coordination meeting was held in May 2008 at CalTech for OCO and GOSAT.

Currently ACSG is preparing a workshop on the evaluation of data assimilation for data product generation and validation. The workshop is organized by NASA, ESA, NILU and it is planned for the Spring 2009 at NASA GSFC or ESA ESRIN (TBD). The workshop focus is on tropospheric ozone.

**Status of past recommendations**

WGCV-27-1: ACSG recommends that WGCV promotes the improvement of TOZ calibration of Brewer and Dobson networks among the member agencies.

Background: This is essential for establishing trends and for the development of new tropospheric ozone products. The side by side Dobson and Brewer (incl. reference instruments) operation and calibration transfer will result in a “homogeneous” network. Timeline: ASAP (preferably Sept. 2007 for European campaign at Huelva, Spain).

WGCV-27-2: This recommendation addresses the Ozone X-sections issues. X-sections are thought to be the major remaining uncertainty in ozone retrievals. The goal is to have a common X-section reference baseline. Therefore, ACSG recommended that WGCV expresses, and encourages among the member agencies, support of the on-going activities at U. Bremen for highly resolved GOME/GOME-2 X-section work on O3, NO2 and SO2. Status: Currently ESA is supporting the efforts through INM, DWD, FMI; and NASA with NOAA ESRL. 8 campaigns are planned in the 2008-2012 time period, involving European, US and African sites. The first campaign is scheduled for July 2008 at Arosa, Switzerland. The second campaign is planned for September/October 2008, at Izaña, Canary Islands, Spain.

WGCV-27-3: laboratory cross-section measurement. ESA is supporting the efforts at the University of Bremen. It is to be completed by 2010.

WGCV-27-4: NO2 ground-based instrument intercomparisons. Status: lead by NASA-ESA, the plan is to include European, US, Chinese and Japanese teams. It is supported by UAV and possible ultra-lite aircraft. The effort is delayed to Summer 2009 due to site selection and organizational constraints.

WGCV-27-5: Data sharing/requirement coordination: Encourage new missions: to follow Envisat/Aura data exchange across existing and future AC missions (incl. greenhouse gas missions), and to follow homogeneous data reporting by leveraging on existing efforts such as undertaken by NDACC. Status: On-going through the AVDC and GECA projects with an objective to integrate the GHG validation datasets.

**Activities:**
*Green House Gases:* Applicable GEO tasks: EC-06-01 (carbon cycle), DA-07-03 (constellations), DA-07-04 (sensor web for in situ). Status: Numerous science/experimental products already available: Envisat-Sciamachy, Aura-TES, Aqua-AIRS, etc. Two upcoming missions with CO2 focus: GOSAT (JAXA/NIES) and OCO

(NASA). Need for validation data from satellite and ground-based instruments. ESA-JAXA/NIES-NASA through WGCV/ACSG are working towards inter-agency data sharing of satellite datasets for validation. The effort is trying to identify and formulate satellite needs/requirements from ground-based assets and aircraft. The agencies are arranging for timely ground (and aircraft) data availability and are identifying key targets (stations) for routine sub-setting. ACSG is organizing a meeting May 16 at CalTech bringing agencies and ground-based teams together for planning/kick-off.

*Validation protocols:* Applicable GEO tasks: DA-06-02 (data quality), DA-06-04 (data/metadata), DA-07-03 (constellations). Status: The ACSG members are active in a large number of AC cal/val protocol activities, including: WMO total ozone instrument calibration improvements. NDACC profile measurement  information content reporting. Evaluation of GMES Service Element for Atmosphere (PROMOTE) validation methods (ozone and UV, AQ, aerosols, GHG, air control support) and the fitness for purpose of actual validation with respect to user requirements. PROMOTE Validation Protocol (and other GSE protocols): top level definition of validation principles applicable to all PROMOTE services. EC FP6 IP GEOMon: Better integration of groundbased and satellite data, including validation and data assimilation. ESA GECA: generic user requirements and related Cal/Val operations, small but effective consortium of experts in atmospheric validation. Ad hoc working groups are focusing on water vapor, ozone etc. The ACSG contributions include: Formulation of space-borne instrument validation data need; Defining validation/evaluation criteria (co-location, information content, etc.); Developing in situ and satellite data "FOV" interpretation tools; Fostering/promoting in-situ validation capability improvements; Organizing field campaigns addressing specific validation capabilities such as network instrument discrepancies; Defining metadata, and file packaging and most importantly content information for in situ data; Providing routine co-located satellite data to ground and campaign. Validation protocols evolution: Now, many recent/new algorithms, particularly addressing Societal Benefit Areas such as Health (air quality) and Weather (tropospheric ozone), rely on some form of post L2 processing/merging using domain filling/transformations, model evolution, chemistry-transport data assimilation, neural networks, etc. In addition to the original L2 algorithm inputs (RT models, climatologies, constraints on profile shape, assumptions on atmospheric variability), these "hybrid" algorithms also have additional inputs such as from meteorological fields, the use of kinetic parameters, etc. The nominal validation approaches of these hybrid products usually exclude rigorous validation of the hybrid algorithms and algorithm inputs themselves. They rely on in-situ validation datasets - which for new species may be very limited - and even on simple visualization and statistical analysis of the final product without use of any independent observation. The ACSG data assimilation workshop (2009) will attempt to quantify this issue for the most commonly measured species tropospheric ozone.

**The chair presented the following ACSG recommendations to WGCV-28**

ACSG Recommendation #1 to WGCV (ref. EC-06-01, action 3): Recommend ACSG GHG validation coordination efforts to be supported by space agencies.

ACSG Recommendation #2 to WGCV (ref. EC-07-03): Recommend ACSG GHG validation efforts for carbon dioxide as a new project for the Atmospheric Composition Constellation (ACC).

ACSG Recommendation #3 to WGCV (ref. DA-06-02): CEOS validation protocols and methodologies for Cal/Val should be consistently used along the entire data product generation chain, including the production of hybrid level-2, level-3 and level-4 data products using numerical models, data assimilation systems, etc.

## 4.2 Infrared and Visible Optical Sensors *(Nigel Fox)*

The IVOS Chair, ***Nigel Fox***, presented the report from the IVOS subgroup.

**IVOS Mission statement**: 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.

**IVOS Logistics and organisation:**

Meetings are held at least annually (nominally 9 monthly). The group has 50 *email members but 15-30 attend the meetings.* The group have established password protected document store and workspace (at **http://ceoswgcv-ivos.org**). Attendance is encouraged through the development of key policy items and it currently considering holding a bi-annual "conference/workshops" linked to existing meetings.

Key Activities include:

- information exchange,
- developing and addressing GEO task DA 06-02 (Data Quality Assurance strategy), initiation of Cal/val portal (for communication),
- the establishment of cal/val "best practises",
- identification and classification of "test sites" for sensor performance evaluation,
- WGCV Lead on CEOS climate Action A5, C7 (*Benchmark mission to establish SI traceable measurements in orbit).*

The need for establishing CEOS "Reference Standards" with test sites being an example was stated and discussed/demonstrated. The first set of standards which were proposed and accepted by WGCV for formal endorsement (a set of eight for radiometric gain) have been provisionally called "Landnet":

- Railroad Valley Playa, NV, USA, North America (Dr. Kurtis J. Thome, kthome@email.arizona.edu),
- Ivanpah, NV/CA, USA, North America (Dr. Kurtis J. Thome, kthome@email.arizona.edu),
- Lspec Frenchman Flat, NV(Mark C. Helmlinger , mark.helmlinger@ngc.com, Northrop Grumman Space Tech., USA ),
- La Crau, France, Europe (Patrice Henry, patrice.henry@cnes.fr, CNES, France),
- Dunhuang, Gobi Desert, Gansu Province, China, Asia (Fu Qiaoyan, fqy@cresda.com, CRESDA, China),
- Negev, Southern Israel, Asia (Arnon Karnieli, karnieli@bgu.ac.il, Ben Gurion University, Israël),
- Tuz Golu, Central Anatolia, Turkey, Asia (Selime Gurol, selime.gurol@uzay.tubitak.gov.tr),
- Dome C, Antartica (Dr. Stephen Warren. sgw@atmos.washington.edu).

In addition a set of five "invariant desert sites" were selected as standards for stability and also the Moon, all were accepted by CEOS WGCV as CEOS reference standards.

It was noted that there was a need for more detailed characterisation and the establishment of additional criteria to priorise the selection of future sites. ESA are funding a study to support this analysis to complement that carried out already by USGS and the IVOS team. A recommendation was made to encourage agencies to view and provide data to cal/val community over these core sites starting with radiometric gain and stability as an

immediate priority. It was also requested that a link be made of the USGS test site catalogue to CEOS/GEO cal/val portal. It was noted that further work was needed to establish "best practise" guidance on site characterisation and their use as well as consideration for "Governance" principles.

The report was largely a summary of the recent IVOS 19th meeting hosted by the University of Arizona in Tempe, USA, February 5-8, 2008. As indicated above this meeting had focussed on "test sites" uses/classification, "Standards" and best practises and GEO/CEOS tasks. Agency reports presented at the IVOS meeting by: ESA, JAXA, NIST, Leicester University, and Univ. of Arizona were summarised and discussed.

*In conclusion:* The IVOS membership is very active in a wide range of disciplines, and an active source of debate. The wide breadth and diversity of its members provides fruitful potential to pilot concepts envisaged in the GEO QA strategy. The chair noted that there is a need to ensure discussion between meetings. The recommendations below were generated at the IVOS sub-group.

**IVOS 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. The following associated actions were discussed: 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.

**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. The following associated actions were discussed: 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. The following associated actions were discussed: 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. Associated actions include: 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. The action associated with it is: 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.

Regarding CEOS Climate Action A5: CEOS plans 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.

### 4.3 Microwave Sensors *(Christopher Buck)*

**Christopher Buck, Chair WGCV-MSSG, presented the Microwave Sensors Subgroup (MSSG) report.**

The chair reported on the last Microwave Sensor Subgroup Meeting, which has taken place at ESA/ESTEC, 22-23 January 2008. At this meeting the activities of the MSSG have been re-launched. At the meeting were present more than 20 attendees from across Europe and the US. This event has given chance to (re-)establish "ground rules" and structure of the subgroup, and to encourage active participation in CEOS and CEOS/WGCV and hence GEO, GEOSS. The meeting has included key presentations invited from a number of leading experts. It has generated interest, opinions, discussion

and the desired level of participation. Major issues facing cal/val of microwave sensors were addressed. Second MSSG meeting to be held preferably the autumn 2008, possibly at ESRIN or CESBIO (TBD).

The terms of reference for the MW Subgroup were reviewed, as follows: *Mission:* To foster high quality calibration and validation of microwave sensors for remote sensing purposes. These include both active and passive types, airborne and space borne sensors. *The objectives* of the Microwave Sensors subgroup, beyond those of the WGCV, are to: 1) Facilitate international cooperation and co-ordination in microwave sensor cal/val activities by sharing information on sensor development and field campaigns; 2) Promote accurate calibration and validation of microwave sensors, through standardization of terminology and measurement practices; and 3) Provide a forum for discussion of current issues and for exchange of technical information on evolving technologies related to microwave sensor cal/val. *Microwave Sensor Subgroup Strategy/Plan:* The action plan of the MW subgroup was reported to have been considered by the members and revised to currently include: The work of the subgroup is based on spaceborne microwave sensors and airborne microwave sensors where they support space missions. The subgroup embraces all microwave sensors, both passive and active, with the exception of synthetic aperture radar. The subgroup is concerned not only with the calibration and validation issues of currently operating (spaceborne) sensors but also with the next generation of sensors. The subgroup is committed to supporting the general activities of CEOS WGCV and the tasks passed to it by GEO etc. Currently the intention is to meet at least once a year in order to communicate the latest findings amongst the members of the subgroup and to support the completion of tasks

**The ASCAT system on METOP was presented and its goals and capabilities were discussed:** The prime objective of ASCAT is the measurement of wind speed and direction over the oceans (using CMOD5 Model). The secondary objective is to provide useful data for Ice & Land applications (e.g. Sea Ice Extent, Permafrost Boundary, Desertification, etc.). It includes six antennas producing six beams (three beams observe left swath & three beams observe right swath), with a symmetrical beam configuration between left & right swaths (fore Beam 45º, Mid Beam 90º, Aft Beam 135º from satellite heading). Each beam measures radar backscatter cross-section, which could be viewed as a follow-on from ERS-1 & ERS-2 AMI-SCAT, but with two 550km swaths (left & right) instead of single 500km swath. The measurement techniques are different - ASCAT uses long FM pulse instead of ERS's short pulse, and the RF power amplification is different as well - ASCAT SSPA instead of ERS TWT. Measurement configuration includes two 550km swaths with incidence angle range of 25° - 65°, 3 fan beam antennas looking towards each swath, Real-aperture radar (C-band (5.255GHz), VV polarization). The scientific value of the data is directly related to the quality of the radiometric calibration. Therefore achieving, maintaining and demonstrating excellent radiometric calibration is of the utmost importance. ASCAT calibration is performed using three active calibration point targets with internal time delays and with very accurately known point target cross-sections - the ASCAT transponders. The expected performance was reported to be: Δ Gain ± 0.05dB, Δ Elevation Angle ± 0.08º, and Δ Azimuth Angle, Δ Skew Angle ± 0.0025º. Given good satellite, instrument and transponder performance, ASCAT may well be the best calibrated spaceborne radar ever [*sic*]. Plots routinely produced by Eumetsat reports routinely centre frequency 5.255GHz and bandwidth ~200k Hz.

**SMOS**

SMOS: will be the first mission to deliver global fields of soil moisture and sea surface salinity. SMOS's FOV is 755km, 3x6, 33°, 0.875λ. At each integration period (2.4s) a full scene is acquired. Average resolution is 43km, offering global coverage. A given point of the surface is thus seen with

several angles and the maximum time (equator) between two acquisitions is 3 days. This is an EXPLORER Mission, which means new concept, new instrument, and new measurements. This is a challenge since no data and algorithms exist. It will require extrapolation from higher frequency results and/or local ground measurements. Cal/Val is a challenge. Validation may be relatively easy over the oceans and relatively impossible over land. Long term measurement networks are subject to drifts, and consistency and special events are to be considered. Field experiments offer snapshots with high spatial resolution over a footprint. SMOS Calibration Issues include monitoring of the long term trend of the signal needed for identification of long-term calibration drift or degradation of the system. There is a need for an external target stable both temporally and spatially.

**The MSSG Chair summarised the Cal/Val Requirements of Space-borne Microwave Radiometers. The detecti**on of long-term climate trends using satellite radiometer data requires accurate calibration and validation of the observed signals (i.e. including absolute bias & drift corrections), which requires the following: Internal (on-board calibration), External (independent) calibration reference targets (to bracket the range of expected Tbs), Inter-satellite biases must be corrected during periods of mission overlap, Verification of calibrated Tbs over time using external calibration database comprised of time-series data from reference sites (e.g. Dome-C), Characterization of <1/day variations in performance requires sub-daily Tb's sampling (i.e. high-lat. sites advantageous for polar orbiting satellites).

**Discussed were the following Potential Large External Calibration Sites:** Sandy desert (e.g. Sahara - Deep penetration depth, temporal stability of the Tb, underground structure TBD); Rocky/mixed desert (e.g. Gobi - Shallow penetration depth, azimuthal effects and vegetation TBD); Rainforest (Amazon - Volume scatter, effects of rain cells on the canopy equivalent moisture TBD); "Stable" ocean areas (Effects of the wind/salinity at L-band TBD); and Antarctica (Dry atmosphere, large penetration depth & temporally stable, low azimuthal anisotropy). A detailed characterisation of Dome-C and review of the sources of data were presented (se presentation for details).

**MSSG Recommendations**

Background: European organizations in particular, are generally not very good at releasing data and too often national and commercial interests block cooperation in data sharing. The MSSG calls for more openness in data policy. Instrument cal/val plans as input to GEO-10 (best practices) can serve as inspiration to others.

Recommendations:

1) The MSSG recommends to store cal/val plans in open repository (e.g. CEOS cal/val portal).

2) Recommendation for cross-calibration of ASCAT, SeaWinds, Indian and Chinese scatterometers and check for overlap. Further, it is requested that Eumetsat provide info to MSSG subgroup on all scatterometer missions.

### 4.4 Terrain Mapping *(Jan-Peter Muller)*

***Jan Peter Muller***, Chair WGCV-TMSG; presented the Terrain Mapping Subgroup (TMSG) report.

The TMSG vice chair *Veljko Jovanovic* (NASA/JPL) has resigned and new candidates are being considered.

The following major GS activities are being organized: 1) Joint ISPRS-CEOS-GEOSS Special Session 18 (SS-18) on "Global DEM Interoperability" will be held on 10 July at ISPRS08 Congress in Beijing Convention Centre; and 2) Joint ISPRS-CEOS-GEOSS one-day workshop (venue tbd) on "Practical Aspects of Global DEM Interoperability" to be held on 2 July 2008 in Beijing.

It was reported that the most critical task for the group at the present is GEO Task DA-07-01 Global DEM Inter-operability. The objectives of the tasks are to facilitate interoperability among Digital Elevation Model (DEM) data sets and the end goal is to produce a global, coordinated and integrated DEM. This global DEM should be embedded into a consistent, high accuracy, and long term stable geodetic reference frame for Earth observation. This activity shall also include coastal zone bathymetric maps in shallow waters (~30-40 m), DEMs of DTED1-class (3 arc-seconds, ≈90m), now updated to 1" (≈30m) for the generation of topographic maps and land use/land cover maps at scale 1/50,000 or 1/100,000. The specific steps/objectives toward reaching the goal include: Request input from system operators and data users (GEO members or participating organizations) regarding their experience on interoperability, Compile list of current DEM data and its specifications, Based on the above results, develop the first "GEOSS Interoperability Guidance on DEM data"; and Submit this document for review to the GEO plenary. It was reported that at the present there re 40 members of task (UK, US, AU, DE, FR, IT, ES, JP, CN, KR, ES, WMO, OGC).

The TM chair stated that global DEM is required for 6 of the 9 societal benefit areas, as identified by the 10 year Implementation Plan of GEOSS. The currently available DEMs were stated to include: 1) SRTM C-band DEM produced at DTED-2 (1 arc-second≈30m) but only publicly available (apart from the conterminous US) at DTED-1 (3 arc-second≈90m), 2) BUT, there are significant gaps/voids in the coverage even after ("edited" or "finished") V2 of the product was produced and SRTM is only available for the region from 60ºS-56ºN. They are not free of gaps. The data that can be used to fill these gaps includes: SRTM-X (available at 1", ≈30m) but only for subset strip areas (Europe example shown) after height adjustments made for the differences between the SRTM-X and C-band datums; and ERS-1/2 tandem available at ≈30m (most of Europe available from DLR, SARMAP/Telespazio, UCL) but problems with WV effects remain in all cases. In the future SPOT-5 could improve the DEMs and fill the gaps, but at the presence the data is at a very high cost. The task would require fusion of multi source DEMs. The following steps to achieve that were identified: 1) 'fill in' voids in SRTM DEM using ASTER, 2) Use improved SRTM DEM to remove artefacts (e.g. clouds) in ASTER DEM, 3) 'fill in' remaining voids using interpolated SRTM DEM layer. An example of data fusion of ASTER and SRTM for the Terrain modeling of the 3 Gorges area of China was provided. Assessment of the potential of multiple ASTER DEMs to fill gaps using one of the CEOS-WGCV-TMSG test sites was described.

The TM Chair reported on the Joint US-Japan project to create a global 30m ASTER-DEM: It was reported that the National Aeronautics and Space Administration (NASA) and Japan's Ministry of Economy, Trade and Industry (METI), in cooperation with the U.S. Geological Survey (USGS) and METI's Earth Resources Data Analysis Center (ERSDAC), have announced plans to produce a global digital elevation model (DEM) from stereo data acquired during the past 8 years by Japan's Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) that flies on the U.S. Terra spacecraft. The ASTER Global DEM (GDEM) will have 30m postings, and it will cover land surfaces between 83N and 83S with estimated accuracies of 20 m at 95 % confidence for vertical data (elevation) and 30 m at 95 % confidence for horizontal data (geolocation). METI and NASA have accepted an invitation from the Group on Earth Observations (GEO) to contribute the ASTER GDEM to the Global Earth Observing System of Systems (GEOSS), and it will be available at no cost to users from around the world. It is very likely that some (unknown number of) gaps will still exist due to persistent cloud cover or lack of contrast in the stereo images.

CEOS-GEOSS members are encouraged to contribute to filling gaps by providing DEM sources, Web Processing Services, and Web Validation Service. CEOS-WGCV-TMSG has 4 test sites outside of the US, given that the largest site (Puget Sound) is likely to be covered by activities at USGS. For each of these sites, 3rd party information is available which consists of one or more of the following: DEM at

higher resolution and of better accuracy (around 1m vertical and <1m in plan); Kinematic GPS tracts (plan <10m, Zrms≈1-3m); Land cover information at 30m. Standardized methods have been developed for assessing the accuracy of input satellite-derived DEMs which will be applied to ASTER GDEM data. TMSG very keen to obtain from CEOS members similar "ground truth" information for other areas, particularly in Africa, South America, Australasia, Antarctica so that a wider range of land cover types can be covered. It is preferred if such information is in the public domain but willing to work with 3rd party agencies to either (a) keep © data restricted or (b) have 3rd party agencies perform QA and not release proprietary/restricted DEM information. NASA's ICESat-GLAS lidar with a 70m footprint every 170m would be an ideal (OGC) source of global validation points. It would also enable the penetration depth from InSAR and stereo to be quantified.

The following outstanding issues to resolve were stated: Very few of the invited CEOS-GEOSS partners are willing and able to contribute height pixels to a free and unrestricted global dataset at 30m? The role for CEOS-WGISS is in promoting this GEOSS task in the context of the GDTT, Web Processing Services, provision of WMS, WCS, WFS data servers. It is necessary to ensure that there is a similar level of effort for producing global bathymetric data over continental shelves.

**CEOS Plenary is recommended by WGCV and WGISS to support GEOSS task DA-07-01 through the following actions:**

1) Encourage all CEOS member space agencies that are creating global EO-DEMs to consider making these DEMs or different DEM subsets (e.g. small groups of pixels identified in ASTER GDEM as missing) publicly available through OGC-compliant servers;

2) Encourage all CEOS member space agencies to liaise with their national mapping agency to provide DEM test sites with publicly available "ground truth" data for assessment of global EO-derived DEMs;

3) Encourage each EO-DEM data supplier to provide web-GIS facilities for the reporting of "Known Issues" including the delineation of areas of "bad data" which can later be flagged as such and compared against and substituted by other datasets;

4) Ensure that resources are made available so that all published DEM datasets can be re-processed if "Known Issues" identify bad data and these cannot be replaced from another source

5) Encourage all member agencies to develop continental-shelf bathymetry programs and request CEOS member agencies to encourage their relevant international and national body to make publicly available their bathymetry heights using the mechanisms proposed for land DEM or something consistent with these principles.

### 4.5 Land Product Validation (Frederic Baret, Jeffrey Morisette & Sebastien Garrigues)

**Frédéric Baret,** the Chair of LPV presented the subgroup report. Fred Baret is the LPV chair, while Sebastien Garrigues is the vice-chair.

**The working definition of LPV for validation is:** the process of assessing by independent means the quality of the data products derived from the system outputs. LPV operates under this definition, with the understanding that validation activities should consider user accuracy needs and feedback to algorithm improvements.

**Mission statement and goals:** to foster quantitative validation of *higher level global land products* derived from remote sensing data and relay results so they are relevant to users; to increase the *quality and efficiency* of global satellite product validation *via* developing and promoting international standards and protocols for field

sampling, scaling, error budgeting, data exchange; to provide feed-back to international structures (GEO/GEOSS) for: requirements and achievements on product accuracy and definitions of future mission.

**The LPV web site has been continuously maintained and updated** by Jaime Nickeson, NASA GSFC.

**The land products currently targeted include:** Land cover (including change detection); Fire (active/ scars); Energy (LST/ albedo/ PAR/ SWR/ LWR); Vegetation (LAI/ fAPAR/ fCover/ VIs/ biomass); Soil (moisture, soil type, etc.).

Higher level products at 10x10 km2 include: CCRS, ECOCLIMAP, GLOBCARBON, CYCLOPES-V31, MODIS-C4; not yet considered - Evapotranspiration, Net Primary Productivity, Vegetation Phenology.

**Recent LPV's accomplishments include:**

- Last meeting of the group held in Davos March 2007,
- Two publications on validation and intercomparison of MODIS c4 and CYCLOPES v3 LAI and fAPAR products (1) Weiss, M., F. Baret, S. Garrigues, R. Lacaze, and P. Bicheron. 2007. LAI, fAPAR and fCover CYCLOPES global products derived from VEGETATION. part 2: Validation and comparison with MODIS Collection 4 products. Remote sensing of Environment, 110:317-331); and (2) Garrigues, S., R. Lacaze, F. Baret, J. Morisette, M. Weiss, J. Nickeson, R. Fernandes, S. Plummer, N. V. Shabanov, R. Myneni, and W. Yang. 2008. Validation and Intercomparison of Global Leaf Area Index Products Derived From Remote Sensing Data. *Journal of Geophysical Research*, accepted

**Future plans include:**

- Contributions to GEO/GEOSS and future meetings.
- Preparation of a global validation exercise publication,
- Preparation of a paper showing an approach to build up a virtual constellation for MR products.
- Preparation of a paper on fAPAR definition, ground measurement and validation of current products (MODIS, CYCLOPES, JRC)
- Development of devices for continuous ground monitoring of fAPAR and LAI.
- Organization of the WGCV 29$^{th}$ meeting in Avignon, September 2008.

**GEO Support:** LPV contributes to 14 GEO Tasks. The specific contributions are so numerous that can not be listed this report. The work is summarized into a table of tasks, activities and achievements, kept current by the chair. The table is available in the LPV subgroup report (please see at the WGCV, WGGCV28 web page) and at the LPV web site.

The LPV Chair presented LPV's LAI validation effort. The methods developed and published in 2006 have been applied and the validation results published in 2007 and 2008 (citations above). But… Updates are needed with new product versions - an on line validation exercise. The number of validation sites is still small, Suggested is a continuous increase of number of sites (new sites and inclusion of processed archive sites) to get closer to stage 3 validation. A problem also is that there are very little 'continuous' ground LAI measurements – the use of PAR@METER devices is encouraged. Also, dew to a lack of interpixel homogeneity for some sites may be needed to revise the BELMANIP. The next group of products to validate are fAPAR products.

The LPV efforts toward virtual constellation products were presented and discussed. The objective of the work is to develop consistent products from several sensors to allow simple fusion, within the framework of GEO/CEOS virtual constellations, and GEOLAND_2. Approach: Evaluated was the performances of neural networks when trained with several inputs and outputs and application for comparison of CYCLOPES/VEGETATION and MODIS (reflectance and LAI). In the 2001-2003 timeframe were sampled 397 BELMANIP sites. General consistency between original products was established, with better results for reflectances than for LAI. Neural networks showed good capacity to "learn" the algorithms. In conclusion, the innovative approach allowed easy fusion of observations coming from several sensors. The high importance of the training data base (LAI) was emphasized. The approach can be applied to any product (even albedo!). Does not require absolute reflectance calibration or strong spectral consistency between sensors: just temporal and spatial stability! Allows the application over instantaneous observations (including or not atmosphere). It requires good geometrical consistency. It was initially implemented in GEOLAND_2 project (EC) for Long

Time Series (as opposed to Near Real Time). The results are published in: Verger, A., F. Baret, and M. Weiss. 2008. Efficiency of neural networks for consistent calibration of LAI products from input reflectance coming from several sensors: Application to CYCLOPES/VEGETATION and MODIS data. *Remote Sensing of Environment*, accepted for publication.

Plans for future activities include: fAPAR products validation, Continue collecting ground validation, Test and exploit PAR@METER devices for continuous fAPAR/LAI monitoring, Products PSF characterization, On line validation (CALVAL portal), Populate cal/val portal (definitions, best practices).

**Plans for future meetings include:** Albedo meeting at AGU in the fall 2008, Soil moisture (SMOS) TBD; Temporal signature in remote sensing. January 2010??

**LPV recommendations:**

Monitoring progress of previous recommandations : Recommend agencies to support the continuity and expansion of product validation activities to be able to quantify the associated uncertainties and allow fusion between similar products; Encourage agencies to prepare subsets of data/products for global product intercomparison activity as described by CEOS/WGCV/LPV . Needed is more consistency in geometrical formats (grid/projection/datum). Needed are resources for implementation of the 'on line validation tool' in the CAL/VAL portal.

### 4.6 SAR *(Satish Srivastava)*

The SAR subgroup Chair, ***Dr. Satish Srivastava***, presented the report for the subgroup activities.

**Mission**: to foster high-quality synthetic aperture radar imagery from airborne and space borne SAR systems through precision calibration in radiometry, phase, and geometry, and validation of high level products. **Objectives**: Act as a forum for international technical interchange on the evolving methodologies, techniques and equipment of SAR data processing, calibration and validation, To determine standard definitions and calibration-validation requirements for SAR systems, To support changes in CEOS formats and user products as appropriate, To facilitate international cooperative programs in the calibration and validation of SAR systems, To educate the SAR community. **The CEOS SAR Subgroup Action Plan includes:** an annual Workshop/Meeting, setting up of standard CAL/VAL sites for inter-sensor comparison, and the determination of calibration requirements and techniques for Polarimetry, Interferrometry, POLInSAR. The group supports GEO task DA-06-02.

**Annual Workshops/Meetings include**: 2007 – 7th Advanced SAR Workshop, hosted jointly by CSA and CEOS WGCV SAR Subgroup in Vancouver, Canada; 2006 – Coordinated by University of Edinburgh in Edinburgh, UK; 2005 – Jointly Coordinated by DSTO and University of Adelaide in Adelaide, Australia; 2004 - Coordinated by ESA in Ulm, Germany; 2003 – Coordinated by CSA in Saint-Hubert, Canada; 2002 – Coordinated by BNSC in London, UK.

**The 15th CEOS SAR Workshop/Meeting (2007)** was held September 11-13, in Vancouver, Canada and hosted by the Canadian Space Agency (CSA), and held jointly with CSA's ASAR Workshop 2007. The organizing committee included: Canadian Space Agency, CEOS WGCV SAR Subgroup, Defense Research and Development Canada, Canada Centre for Remote Sensing and MacDonald, CEOS and Detwiller & Associates (MDA). The ASAR 2007 Workshop included the following topics: Next Generation SAR Systems, New SAR Missions, Innovative SAR Concepts, SAR Hardware and on-board Processing, Polarimetry and Interferrometry, Signal Processing Techniques, SAR User Requirements, SAR Calibration, Validation, Emerging SAR Applications, SAR Data Formats, Calibration Targets, Calibration Performance of on-going Missions, and RCS Models and Scatterometers. There were 134 Participants from 13 countries and 98 presentations were made. Workshop Proceedings have been produced and are distributed on CD to attendees by CSA. For details visit www.space.gc.ca/asc/eng/events/2007/asar.asp.

The next SAR workshop will be hosted by DLR. A 3-day Workshop to be held at DLR facilities in Oberpfaffenhofen, Germany in last week of October or first week of November 2008, which is back to back with TerraSAR-X/TanDEM-X Science Meeting.

**SAR Natural Calibration sites**

International Amazon Rainforest Site: Data is routinely collected and analyzed for calibration monitoring of SAR satellites including RADARSAT-1. Radiometry of the site remains stable as observed from RADARSAT-1. NASA/JPL polarimetric data and RADARSAT-1 data have been analysed by MDA in preparation to use the site for full polarimetric calibration of RADARSAT-2.

Canadian Boreal Forest Site**:** The site is located in the Hearst Region, Northwestern Ontario landmass, Hudson Bay basin. The eco-type is Boreal Forest-Barrens transition, including the following species: boreal spruce, balsam fir, jack pine, poplar, birch, tamarack, and cedar. Since January 2003, RADARSAT-1 data is routinely collected and analyzed for radiometric characterization of the site. Major progress has been made in characterization for summer and winter months for a wide range of incidence angles at C-band. Initial results indicate that it can be used as a complimentary site to Amazon site for calibration but with a reduced accuracy.

**Multi-Transponder Sites in Canada:** In the Fall 2006, ESA relocated an ENVISAT ASAR Transponder in Resolute Bay, in the vicinity of a RADARSAT Transponder. Currently both Transponders are used simultaneously by ENVISAT. In 2007 another ENVISAT ASAR Transponder was relocated in Ottawa, again in vicinity of another RADARSAT Transponder. There are two potential sites in Canada for inter-sensor comparisons for C-band SARs (e.g., RADARSAT-1 and 2, ENVISAT).

**Recommendations from SAR Subgroup**:

Since 5th Advanced SAR Workshop (2003), one action on CEOS SAR Subgroup is to determine calibration specification for Polarimetric SAR. The subject has been debated in subsequent CEOS SAR Workshops. In 7th Advanced SAR Workshop (2007) the group concluded the discussion by recommending the following set of calibration specification, considering measured results obtained in recent polarimetric SAR missions and emerging application needs:

| Parameter | Threshold | Goal |
|---|---|---|
| System Stability (short and long term) | <1 dB | <0.5 dB |
| Cross-Talk | <-25 dB | <-35 dB |
| Channel Amplitude Imbalance | <0.4 dB | <0.2 dB |
| Channel Phase Difference | <2 to 5 deg | <1 deg |
| Channel Registration | <0.1 pixel | ❑ |
| Noise Equivalent Sigma Zero (NESZ) | X band: <-20 dB, C band: <-25 dB, L & P bands: <-30 dB | X band: <-23 dB, C band: <-30 dB, L & P bands: <-35 dB |
| Faraday Rotation (~2.5 deg) | Significant for L band, Insignificant for C and X bands | |

In response to the GEO Task # DA-06-02 Questionnaire were provided he following information:

**1) Identify current activities contributing to this task, and the significance.**

SAR Subgroup is contributing to this GEO activity in exploring, characterizing and monitoring natural sites for calibration of Synthetic Aperture Radar (SAR) instruments. In addition a couple of man-made sites have also be developed in Canada by installing C-band calibration transponders from CSA and ESA. Other potential natural sites may also be explored.

2) **Identify actions and/or deliverables related to the activities described above (these actions will be reported to CEOS). What is the identifiable result of the action?** *(May be a multiyear activity, however please include action/deliverable to be completed in 2008).*

SAR Subgroup has established a geographical site in Amazon as the CEOS Standard site for SAR calibration. This site is routinely used for calibration and its radiometric stability monitored. In addition, a site in Boreal forest of Canada is also being characterized at C-band. Analysis results will be reported at annual CEOS SAR Workshop.

3) **Identify any issues (current/potential data gaps, data sharing problems, funding, etc)**

Data from various SAR missions could not be freely distributed because of data policy restrictions of individual space agency/data provider. Development and maintenance of man-made sites is difficult as funding is a big issue. Resources are lacking for acquisition, processing, analysis and archive of data. Similarly, resources will be required for development and maintenance of associated analysis and information distribution tools.

4) **Identify actions and/or deliverables needed to address the issues described above (these actions will be reported to CEOS). Specify when action needs to be completed. What is the identifiable result of the action?**

Spaces agencies need to commit resources (personnel and funding). If these resources are in place, a detailed investigation of natural sites could be done for SAR missions operating in different frequency bands and for different polarizations. Similarly, standard man-made test sites could be developed to handle multiple polarizations and frequencies.

5) **Identify key international organization(s) already assigned to work on this task from the satellite perspective. Are there any outstanding issues CEOS can help address in coordination with these organization(s).**

Space agencies that have space SAR missions, e.g., ESA, CSA, JAXA, DLR etc. are contributing to this task more or less on an agency basis and not collectively. There should be commitment for all concerned space agencies to support the above task as a dedicated team effort.

# 5. Country and Agency Reports

**Canada** *(Satish Srivastava)*

***Dr. Satish Srivastava,*** CSA representative and WGCV/SAR SG chair presented a summary of the current activities of the Canadian Space Agency.

**RADARSAT-1 Program Status**

The satellite is in its twelfth year of operation and funding is available to continue operations until March 2009. Data is received and processed at 38 ground stations with 25 archive facilities globally. As of Jan. 1, 2008, it has completed 63,461 orbits, planned 293,183 user requests corresponding to a total acquisition of 571,100 minutes of SAR data. The average system performance maintained is better than 95%. As a member of International Charter Space and Major Disasters, RADARSAT-1 has provided data for **121** Charter emergencies to date. The image quality and calibration is maintained better than system specification. Multiple coverage campaigns have been completed under baseline Background Mission, including (using Radarsat-1 and -2): multi-polarization coverage of continents and polar caps; Canadian site-specific data acquisitions for agriculture, environment, forestry, natural hazards, etc. Currently is providing ongoing four-season coverage of the Arctic Basin, in support of IPY.

Radarsat has provided data for a special project, entitled: Hurricane Watch. The program has started in 1999, operates from June 1st to November 30$^{th}$. Hurricane Watch monitors North Eastern Atlantic, North Eastern & North Western Pacific regions to acquire RADARSAT-1 data of tropical cyclones. It has generated unique archive of 589 Hurricane Watch images, of which 221 images capturing the eye or edge of cyclones. CSA has announced an opportunity (AO) "*Innovative research and development of applications using RADARSAT-1 Hurricane SAR data",* to give access to 160 images from archives to the scientific community.

**SCISAT Program Status**

SCISAT was launched in August 2003 The satellite measures numerous trace gases, thin clouds and aerosols in the stratosphere, thereby enabling a more comprehensive understanding of the several chemical processes that play a role in stratospheric ozone depletion.

SCISAT's capacity to receive science data was augmented from 1.1 GB (gigabytes) to 2.9 GB per day by employing two Canadian stations and those of US and European partners. During the last fiscal year alone (Apr. 1, 2007 – Jan. 31, 2008) the amount of science data collected was - FTS: 556.8 GB, Imager: 82.5 GB, MAESTRO: 21.6 GB. The collected data is routinely provided to the science team. Intensive data analyses by scientists have produced a number of new results that have been disseminated at international scientific conferences and through the publication of peer-reviewed scientific papers.

**RADARSAT-2 Program Status**

RADARSAT-2 is the most advanced commercial C-Band SAR satellite, developed in a partnership between Canadian Space Agency (CSA) and MacDonald Dettwiler & Associates (MDA). It was successfully launched December 14$^{th}$ 2007. RADARSAT-2 characteristics include: 7 years design life, C-band (5.405 GHz) imaging frequency used, expected spatial resolution of 3-100m, polarization modes: single (HH, VV, VH, HV), Dual (HH/HV, VV/VH) and Polarimetric, right and left looking. The first images of RADARSAT-2 were presented.

**RADARSAT Constellation Program (RSATC)**

The plan is for a constellation of 3 satellites (RSATC-1, 2 and 3), which will be positioned in the same orbital plane, equally spaced 15 to 30 minutes apart. Each of the satellites will take ~5-year development and starting in 2012 one satellite will be launched every year. The goals are to provide daily and complete coverage of Canada's land and oceans at 50 m resolution, and facilitate maritime surveillance, disaster management, coherent change detection, and to ensure RADARSAT-2 continuity. Reported was that phase A is completed.

**Chinook Mission and SWIFT**

The effort goal is the Development of an instrument called SWIFT (Stratospheric Wind Interferometer for Transport) to better understand the global atmospheric circulation. SWIFT will provide the means to validate complex climate and weather models. The definition phase was completed in 2005 and the preliminary design phase was completed in 2006. Budgetary constraints and CSA internal priority reviews have made it necessary to optimize the requirements and address key technical risks. CSA currently exploring alternative approaches for Chinook Mission implementation.

**7th Advanced SAR Workshop of CSA**

The 7th Workshop was hosted jointly by CSA and CEOS WGCV SAR Subgroup. It was held on September 11 - 13, 2007 in Vancouver, Canada. The 134 Participants included members from 13 different countries. In all areas of SAR technologies and advanced applications 98 papers were presented. The Workshop Proceedings have been produced and are distributed on CD to attendees

Advanced SAR workshop is one of the few major SAR events and it confirms the leadership of Canada in this niche technology. For workshop details visit

www.space.gc.ca/asc/eng/events/2007/asar.asp

**Project DELTA**

Recently there was an announcement of opportunity (AO) for Project DELTA (Differential Elevations, Levees and Terrain Assessment) - a collaborative effort between CSA, USGS and NASA. The project calls for innovative research and development into the application of RADARSAT-1 interferometric data for subsidence mapping in New Orleans. 23 Proposals were accepted from PIs in 11 countries and the first progress reports from the PIs were received in September 2007. RS-1 data acquisitions completed in January 2008. Final reports are due the end of April 2008. User workshop TBD.

**TIGER INITIATIVE**

This is an activity in support of the World summit on Sustainable Development WSSD. It is Canada's contribution to water management in Africa. The effort supports 7 projects with $ 3.4 M / 3 yr. The projects

include: for North Africa and the Nile Basin the "Nile Rive Awareness Kit (RAK) – Hatfield" and the "Integrated Aid System for IWRM – IUCN"; for South and East Africa the "River Basin Management – I.E.S." and "Mosquito and Malaria – Noetix", for Western Inter-Tropical region of Africa the "Satellite Hydrogeology – Golder", the "RBRE – Vexcel (Microsoft)" and the "StereoSat Africa – Viasat".

**Canadian GEO/GEOSS Participation**

Canada is an active member of GEO, playing a leadership role with South Africa as co-chair of the Task Force for the Report on Progress. EOS-IV represents a significant opportunity for Canada to influence international Earth Observation (EO) investments in Canadian priority areas such as the North. EO is a core business of CSA and it is working with other govt. departments in underpinning policy decisions in areas of security, sovereignty and environment

The interdepartmental Canadian GEO Secretariat **(**CGEO) was established in 2005, with the following functions: i) Administer Canada's engagement in International GEO (30%) - correspondence, official comments, delegation support, etc.; ii) Coordinate the development of a Canadian Strategy for Earth Observation (70%) - advance the principles of GEO/GEOSS within Canada, coordinated EO data collection, data policies and infrastructure to support improved data access and interoperability; facilitate the transformation of EO data into information for decision support; and ensure the engagement of the end users to realize societal benefits.

**CNES** *(Patrice Henry)*

***P. Henry***, the CNES representative gave an overview of the in-orbit calibration activities of CNES for visible and NIR sensors.

**1) CNES background in calibration activity**

CNES has developed different calibration methods over natural targets for visible and NIR optical sensors, including: Rayleigh scattering over ocean, Sun glint over ocean, Deep convective clouds (DCC), Stable African deserts, Antarctica (Dome C site), Autonomous calibration station (for high resolution), and Lunar calibration.

Most of the methods are used on an operational basis, for monitoring the CNES sensors calibration (SPOT, VGT, POLDER…), inter calibration with other sensors (MERIS, SeaWiFS, AVHRR, MODIS, Formosat2, Kompsat2…).

**2) Calibration monitoring activities for CNES missions:**

POLDER 3 on-board PARASOL (A-train) has a routine calibration monitoring using DCC calibration (every month). Regular calibration check includes other methods as well: Rayleigh scattering, sun glint, desert sites (every 6 months). VGT2 on-board SPOT5: there was a misfunctioning of the on-board calibration device, so a routine calibration monitoring is conducted using desert sites (every month) and regular calibration check is done with other methods : Rayleigh scattering, sun glint, Antarctica sites (once a year). For the high resolution instruments on-board SPOT4 & SPOT5, is conducted routine calibration monitoring over desert sites and calibration campaigns over La Crau and Negev desert (twice a year).

IIR on-board CALIPSO (A-Train) conducts calibration monitoring using on-board device. IASI on-board METOP relies on routine radiometric, spectral calibration and regular performance checks, and IASI / AIRS inter-calibration.

Some of the activities soon to come, include recalibration of VGT1 data to insure with VGT2 a consistent set of data over 10 years; and the preparation of Pleiades and Venμs in-orbit calibration.

**3) Cal/Val activities in cooperation with other agencies**

The FORMOSAT2 calibration for NSPO started in 2005. It includes calibration monitoring over deserts, absolute calibration over La Crau, programming gains optimization using the worldwide CNES data base. Kompsat2 Cal/Val activities for KARI are in progress, targeting Geometric calibration, FTM assessment, radiometric calibration… The calibration of MERIS for ESA includes desert, rayleigh and glitter calibration on

an operational basis. Other inter-calibration activities conducted in the framework of GSICS include MODIS and AVHRR.

The recent results from 2 years of PARASOL calibration over DCC, VGT2 calibration monitoring over desert sites and the Validation of MERIS calibration, using Rayleigh scattering and sun glint methods were discussed.

**DMCii / SSTL** *(Stephen Mackin)*

The DMCii/SSTL report was presented by ***Stephen Mackin***, Chief Scientist, DMC International Imaging Ltd.

**1) Calibration and QA/QC:**

The report included an overview of the current calibration and QA/QC approaches, the problems were discussed and revised approaches were proposed.

**Calibration:**

Current satellite calibration approach Currently all satellites used in constellation have independent absolute calibration over RRV, which requires a lot of co-ordination and a lot of field work with higher costs. Older satellites have gravity-gradient booms so can only point at Earth. So the Moon is out of the question. Currently for absolute calibration is used data acquired at the Railroad Valley Nevada (RRV). For large linear arrays only nine pixels can be calibrated over RRV. DOME-C in Antarctica is used after that to transfer absolute calibration of the nine pixels to the rest of array. Of consideration are the need of lots of overpasses and flat and stable target. The Pacific at night is used as dark reference. Problems arise in the co-ordination and data collection, which result in variable quality of the final calibration. The newer satellites launched late in the year (two planned for October 2008) will miss the 2008 Absolute Campaign over RRV. As result, small variations in response are noticeable among the satellites in the constellation.

Proposed calibration approach It is proposed to concentrate efforts on a single satellite "Gold" standard, with 6-10 good acquisitions per season over RRV (Landsat suggestion was 4-6). As spacecraft in the constellation are in more than one orbital plane, transfer the calibration from one to another could be done using the Antarctica site (DOME-C). Intersection of acquisitions would likely occur over same site within 30 seconds to a minute of each other, others would occur within tens of minutes, but the atmospheric conditions are usually very stable so this should not present a problem. New satellites launched late in the season can have updated calibration for at least three months using cross-calibration over DOME-C. The approach gives uniform calibration across the constellation and excellent absolute when the "Gold" standard is well calibrated.

**QA/QC**: Current QA/QC Currently a few automated checks are conducted with a lot of manual intervention. Decisions are pass / fail and hence low quality data can be above the border and still pass. There is a lag between a problem being seen in the data and its identification and correction. QA/QC procedures can be quite ad-hoc in nature and hence only specific to a limited range of problems. There is a variable level of control within the processing chain. Revised QA/QC The proposal is based on the results from an ESA study led by NPL on Multi-Mission Generic Quality Control, and covers more than the level products generation, also covers pre-launch and any validation activities and it would ensure full end to end QA / QC. While QA forms part of the modules in best-practice protocols (methods), QC are elements between modules that evaluate the processing result; both resulting in full traceability throughout the entire processing chain. The revised QA/QC is generated from simple modules with directly associated QC. The protocols within a module encapsulate the QA, so modules are aggregated into larger modules. Error budget and traceability are included. Generic level for creating thin operational structures and physical structure for implementation are proposed. Modules carry out the operation (dark current measurement for example). The protocols used for operation are "Accepted Protocols" validated to some degree by the community. The standards used for the operation are "Accepted Standards" and are again validated. Traceability allows simulation of the processing chain with suitable parameter files. The advantages of the revised QA/QC include: Provides a generic "thin" framework for building new processing and QA/QC procedures rapidly and in a systematic manner. Can be easily translated to corresponding physical implementation structures with addition of instrument specific modules as required.

Each module has a defined protocol which encapsulates best practice in terms of operation. Each module has a defined error budget for quantitative estimation within a structured QA/QC scheme. Modules use defined standards (quantified error) when necessary. As each module has an error budget, the overall quantified error can be traced throughout all operations. Out of bounds conditions or trends leading to out of bounds conditions can be identified and localised easily within the structure. Remedial QC can be performed to reduce the effects of instrumental ageing without human intervention or re-processing (in some cases). Modules can be simply replaced by updated modules as required (with improved protocols or QC) without affecting the rest of the processing chain. Additional modules can be added to deal with unusual system behaviours without affecting the rest of the system. Modular structures can be created rapidly using a point and click interface. By adding simulation elements (instrument parameter files, scenario files) it is possible to populate the modular structure and assess errors prior to launch or to simulate changes in procedures.

**2) Satellite launches from SSTL (2208-2009)**

**The following satellite launches from SSTL, planned for the 2008-2009 time period**, were reported: Deimos-1 (Spain) 22m three band imager, UK-DMC-2 (UK) 22m three band imager, NX (Nigeria) 22m three band imager, NigeriaSat-2 (Nigeria) 5m four band imager with 2.5m PAN, Five Rapideye Satellites (Germany) 6.5m five band imager.

**3) Conclusions**

**Calibration needs:** The new program envisages the need for a South American test site supported in the same manner as RRV. There is a need to be more closely involved with the Franco-Italian group at DOME-C (met. records, snow measurements, sun photometer and any BRDF); a need to expand cross-correlation activities with other (non-SSTL) systems with on-board calibrators; and a need to have automated test sites throughout the world eventually with accuracies approaching the RRV example.

**QA/QC:** An automatic method is being developed that provides full traceability in the QA / QC process. The structure is modular with a proposed point and click interface. The structure will allow simulation of pre-launch through level processing through validation. There is a NEED for additional support in developing this area with trial implementations with other groups.

### CBERS Radiometric Calibration and Validation in IRSA *(Xingfa Gu)*

Dr. Gu Xingfa presented the CBERS program report and focused on the calibration and validation issues of the data and products.The report was generated by Dr. Gu Xingfa, Zhu L. , Li X., Gao H., and Li L. from the Institute of remote sensing applications, CAS.

**1. CBERS Introduction**

The China-Brazil Earth Resources Satellite (CBERS) was jointly developed by China and Brazil since 1988. The first CBERS (CBRES-01) was successfully launched on October 14, 1999. The second one (CBERS-02) was on October 21, 2003. CBERS-02B was successfully launched on September 19, 2007. All these satellites were relegated to China Center for Resources Satellite Data and Applications (CRESDA) and switched to application and routine operation stage.

CBERS characteristics include: sun-synchronous recurrent and frozen orbit, altitude: 778Km, repeat cycle :26 day. For details on the payloads on CBERS-02 and CBERS-02B visit http://www.cresda.com/cn/products.htm

**2. Calibration Work**

Vicarious calibration for CBERS was performed jointly with CRESDA. Vicarious calibration was performed at Dunhuang site in Gansu province on Aug. 18 and Aug. 25, 2004. The Dunhuang test site used in this work is located in 20 km northwest of Dunhuang in Gansu province. The coordinates of it are 40.08°N latitude and 94.38°E longitude. It has been in use for vicarious calibration since the mid-1990s.

The Huailai test site was built by IRSA near to Beijing. Coordinates: 40.4°N, 115.7°E. In-situ measurements were conducted at Huailai in Hebei province on May 4, 2004 and on June 18, 2005. DaliLake, Gonggeer, Sunite Zuoqi and Erlianhaote in Inner Mongolia were chosen as potential test sites for C&V science

research because of good atmospheric conditions and surface lambert condition, and convenient traffic (near to Beijing).

The Qinghai Lake is used as a test site for vicarious calibration of IRMSS. It has a good lambertian feature, dry atmosphere and high visibility. The coordinates of it are 36.75°N latitude and 100.37°E longitude.

**3) Cross Calibration for CBERS**

Radiometric cross-calibration of the CBERS-02 CCD camera with the TERRA MODIS using the images acquired over Dunhang on August 19, 2004. The research demonstrated that the traditional method with single calibration site was inappropriate for CCD camera, since its four spectral bands have offsets. Based on the offsets achieved by the cross-calibration for image acquired on August 19, 2004. Cross-calibration method was used to calibrate the historical data of CCD from Apr. 2004 to May 2005. With the MODIS as a reference sensor, the radiometric cross-calibration was performed for CBERS-02 WFI based on the images acquired over Huailai on May 4, 2004 using four targets. Absolute radiometric calibration of CBERS-02 IRMSS thermal band

The radiometric cross- calibration against TERRA MODIS corresponding channel and the in-flight field calibration at Lake Qinghai: water surface radiometric calibration test site of China on Aug. 17, 2004 are carried out in this research. Radiometric cross-calibration of CBERS-02 IRMSS thermal band against TERRA MODIS selected 6 times synchronous images of two sensors passing through Lake Qinghai and Lake Taihu from August to December, 2004 to compute the cross calibration data.

**4. MTF Compensation for CBERS**

A new approach was presented to determine the in-flight MTF of CCD camera on CBERS-02 by constructing ideal tarps scene and MTF resulted from this method were compared to those of other common methods. This new technique was stated to be similar to the technique of two-image comparison. However, instead of using a high resolution image, it uses a simulated an ideal tarps image. During the synchro field work at Dunhuang calibration site on August 19, 2004, a black tarp was designed to be imaged as 3×3 pixels on CCD image. Surface spectral data were sampled for the tarp and the gravel sands at Dunhuang site, which were used to simulate the ideal tarp scene. The MTF values determined from the Korea scene image pair were applied to calculate the half bandwidths of the WFI imager and perform the MTF compensation for WFI images, since the image had richest information and had little relief. The results demonstrated that the instant field view of the WFI were 317m, 304m and 320m in the cross-orbit, along-orbit and 45º-orbit directions respectively. And as expected, the restored image contained more details than the original one.

**5. Field experiment for CBERS02B Validation**

After CBERS02B was successfully launched on September 19, a field experiment for reflectance and VIs (Vegetable Indexes) measurements was conducted in Binyang, of Guangxi municipality, China on Nov. 8 -12, 2007. Spectrum and LAI of four crops and vegetables, including rice, sugarcane, cassava and jasmine, were measured using ASD and LAI2000. Comparison of VIs derived from experiment and from CBERS02B images was conducted for validation.

6. **Quantitative Application for CBERS**

Dr. Gu stated that in China the quantitative application research of satellites data is not popular enough. Thus, it is urgent to consider how to systematically construct the civil aeronautics remote sensing system, assimilate application requirements in the process of remote sensing quantification, and improve the earth observing ability and quantitative level. CBERS02 RS Application can supply a reference and demonstration for the quantitative application researches of Chinese satellites data, such as FY, HY, Resources, HJ etc.

The following examples of CBERS-02 quantitative applications were presented: thin cloud removal for CBERS-02 image, biomass estimation, cotton pixel identification and surface evapo-transpiration estimation. For more details, please see the presentation.

**ESA** *(Pascal Lecomte)*

The ESA report was presented by ***Pascal Lecomte***. The ESA report focussed on Sensor Performance, Product and Algorithm development and harmonisation, in the context of Product and Processes harmonisation.

**2008 Cal/Val Work Plan**

The proposed activities are divided into three main lines: 1) Ground Segment Components, including development of ESA components in support to SPPA and Cal/Val activities. 2) Sensor Performance, Products and Algorithms, including: routine long loop sensor performance, Quality Control, Verification and Algorithm development activities. 3) Calibration and Validation Activities: Activities supporting Calibration and Validation. The context of study and the development contracts was described. For details pleas see ESA's presentation (slide 3).

**Status of activities (High-Level)**

| | | |
|---|---|---|
| Multi-Mission Processing (GAMME) | | Development Terminated |
| ANGLE – Multi Mission Amalfi | | End contract by July 2008 |
| Generic Environment for Cal/Val Analysis Sep.07-Mar.10 | Cal/Val Data Centre | URR Apr. 08 |
| | Quality Product | QIAP Mar. 08 |
| Operational & Centralized Auxiliary Data Access (OCADA) Dec.07-May 09 | | URR Apr. 08 |
| Multi-Mission Generic Quality Control Standards Apr. 06-Mar. 08 | | Final Report Mar. 08<br>Demonstrator Summer 09 |
| SPPA Architectural Evol. towards GMES Oct.08-Oct.09 | | URD Apr. 08 |
| Cal/Val Portal | | Version 2.1 Mar. 08<br>Further release Jul. 08 |
| Cal/Val sites Dec.07-Jan.09 | | Report #1 Mar. 08 |
| GMES Product Harmonization study (φ1) Oct.07-Oct.08 | | Intermediate report Apr. 08 |
| Sentinel IPFs (SAR – MSI - OLCI, SLST - RA) | | Planned start spring 2008 |

**Sensor Performance, Products & Algorithms (SPPA)**

1) GECA objectives are as follows. Top-Level Objective: To contribute to Cal/Val standardisation & traceability in support of CEOS, GMES and GEOSS. High-level objectives also include: To harmonise/standardise correlative data - the building on the common Envisat/Aura (and recently NDACC) standard. To support collocation and intercomparisons are being developed toolboxes and libraries for cal/val teams and also centralised bulk operations on data sets. The support of data access for Cal/Val contributes to standardisation of inter-data-centre exchanges, and to implement data access rules as defined in protocols. The support of correlative data originators presents providers to multiple centres with a single drop-off point, and arrange for further dissemination.

GECA project definition phase involved presentations and subsequent interactions during and after three CEOS-WGCV-ACSG subgroup meetings, and direct collaboration with NASA on project requirements specification. The project deliverables will be: documents describing proposals for standardisation of correlative data and standardisation of data centre inter-operability; algorithm description for 'canonical' data handling processes; server tools and client libraries for 'canonical' data handling (including conversion between collaborating but not-yet harmonised standards); on-line facilities for data query and access; cal/val data storage at the GECA server; demonstrable inter-operability of data centres; a proposed single upload portal with quality control and multicast capabilities for further distribution. Further collaboration has been sought with several other CEOS agencies in the course of the initial user requirements review phase. In addition to NASA, also EUMETSAT has already participated to the first project meeting.

The User Requirements Review (URR) phase has been doubled with respect to initial planning, due to the large variety in detailed requirements between geophysical/instrumental domains, which led to interesting findings worth exploring deeper in this phase. The URR meeting will be held in April.

The GECA project also includes a study and development to connect Sources and Users of Quality Information (called "QIAP": Quality Information and Action Protocol"). The need is to convert selected categories of quality information records and actions into electronic form; enable traceability of quality-related interventions; provide support to humans and machines at the input and output ends of the quality information chains… and do all the above in a manner that only intervenes with user consent.

GECA's Best Practices - The GECA contribution to formulation and implementation of Cal/Val best practices is three-fold: 1) It contributes to formulation of guidelines for the description of correlative observations, including recommended auxiliary observations and parameters, to allow interpretation by independent peer cal/val scientists. This part of the project builds on a heritage from earlier ESA, NASA and EC projects. 2) It provides intercomparison support utilities (a server-side environment and client-side libraries and toolboxes) with default configuration aligned with already formulated best practices (e.g. criteria formulated CEOS subgroups, but also from GMES Service projects like PROMOTE). 3) The implementation of domain-specific best-practices in a common environment will contribute to proliferation to other domains

Sensor Performance, Products & Algorithms.

2) SPPA Architectural Evolution towards GMES: The objective will be achieved by: identifying all interfaces towards the Sentinel G/S elements and towards the wider GMES EO architecture; identifying gaps in the architecture by mapping the SPPA interfaces and elements to the existing set-up; including a definition of resources, processes and communication links (not only taking care of the technological issues) to support coordination and information flow; producing a critical analysis of the current SPPA organization for ensuring products quality control, focussing specifically on the activities close to the daily operations as covered today by the DPQC service; specifying the SPPA evolution roadmap taking the existing system to the target architecture. The SPPA Architectural Evolution towards GMES was described – please se details in the ESA presentation at WGCV28 (slide 10).

**Quality Harmonization Projects**

The ESA representative described the following projects:

1) Cal/Val Portal:

Main changes which have been introduced in the CalValPortal since the last WGISS/WGCV meeting in Munich include: WTF sites have been integrated into the Portal. MERIS and AATSR data are systematically extracted over these sites and can be downloaded from the portal; WTF data have been physically moved to Brockmann. The software to read the products, extract the meta data and generate quick-looks is currently being developed (ENVI reader for AVHRR averaged products and SPOT VGT is already completed). The CalVal Portal has been re-organised to better support information access. A new section on sites has been introduced. This gives technical information on all supported sites, provides the "site characterisation template" developed by IVOS and links to USGS site database. A new section on "Ressources" combines and extends information

previously scattered throughout the portal, such as: tools (Software and online services), workshops (announcements, presentations, minutes), links (Weblinks to other CalVal resources), literature (Publications, reference documents), methods section has been extended by documents on SAR (based on ASAR CalVal), sensorML has been fully integrated. In cooperation with the Open GIS Consortium the SensorML specification has been further elaborated in order to support Earth Observation sensors. A set of 10 sensors is now described in SensorML, available both as formatted html pages as well as SensorML XML files. Version 2.1 of the portal will be released in March. It will include the WTF data (see above). A newsletter has been prepared that shall inform the users about changes in the CalValPortal and future extension plans.

Evolution for the next four months: A faster quality control system will be implemented to have quicker update cycles of the Portal with new data, links, documents etc. Instead of several days, new information submitted to the Portal will now be checked and published within one day. Support to geometry validation will be provided. Revision of supported sites would be conducted: more sensor data will be made available for the supported sites, including historic products. The number of supported sites will be reduced.

Support to SMOS calibration phase. The Cal/Val Portal will support the L1a,b,c and L2 products for all CalVal sites. Some of the sites are floating, i.e. we have to extend the site concept. Correlative data will come with some delay and have to be distributed as well. L1c and L2 products will be treated normally, i.e. integration into the EO data repository, accessible via catalogue search, QL and meta data. Child products have to be extracted for CalVal sites. The L1a and b data will not be registered but distributed through a project page download mechanism. In the long term, support to Calibration and intercalibration results will be included. A new Webservice tool will be developed for this purpose.

The portal will be moved to a Content Management System (CMS). This will allow interactivity and faster updates of content and strict quality control (where required) to ensure highest standards.

2) Cal/Val Sites

Cal/Val sites will be established. The goal of the project is the identification and characterisation of the calibration test sites. The project started in December 2007 and would end in early 2009. It is lead by Vega (F) with Richard Santer, Gael, ETH, Brix System, Armine.

*Calibration = Radiometric calibration, geometric calibration, Image quality*

The project includes four phases: Phase 1 – Analysis of the external calibration requirements; Phase 2 – Selection and Identification of test sites calibration; Phase 3 – Generation of a strategy for external calibration; and Phase 4 – Integration into the CalVal portal. Cal/val sites have been classified based on their type and cal/val methodology. Please see for more details on the site classification ESA presentation slide 15.

3) GMES Requirement Definition for Multi-Mission Generic Quality Control Standards

The objectives include:

a) Establish a baseline specification of QA /QC tools and procedures needed to ensure implementation of “best practise” for operations of future sensors/missions in the “multi-mission” environment. This will affect all sensor technologies and the ground segment. It will be realised via analysis of existing missions. It is needed to meet needs of applications as specified by users. An appropriate adoption/adaptation of practises of the non-EO industrial sector would be required.

b) Identification of a set of (if possible) generic “quality reporting indicators” and/or a means of “certification” of data products and their production, appropriate to the needs of their application and those of all stakeholders in the EO sector – data producer and user.

4) Conclusions:

ESA has made significant progress towards a coherent QA system based on Envisat. But still lacks clear full easily accessible documentation and the evidence of traceability is inconsistent and not rigorous. A survey of the stakeholders indicates broad satisfaction with delivered services but recognises the need and desire to

establish QA framework based on documented evidence, but not keen on ISO prefer system implemented and administered by agencies. Proposed is the adoption of QA framework based on the requirement to document procedures and quantitative evidence of traceability to international standards, which is consistent with GEO/CEOSS workshop conclusions.

The implementation strategy would establish tools/databases to provide access to information e.g. GECA, portal; it will organise a team (internal or external) to review documentation/evidence, organise comparisons, provide guidance/training on analysis etc. A potential two stage "certification scheme" is envisioned. A requirement driven system architecture, based on a set of linked (interchangeable) documented modules, mapping the "flow of data" from collection to delivery (through software allows full process simulation) is proposed.

Stated was that quality indicators are crucial to services and "information products" but are generally bespoke to a requirement but can and should be based on statistically derived measures to allow commonality of understanding.

**Product Harmonization Project**

The goal is product harmonization. Project description: "Data Harmonization" is considered a prerequisite for interoperability among spatial information systems; it will allow Europe to realize its objectives for a sustainable and interoperable functioning of GMES.

The implementation tasks include: Classification of sensors/products per GMES applications; Gather the sensors/products which give similar information; Survey of existing program/project RISE Glob-program (ex: Globcover) Medspiration; Identify coordination among project and the need in term of harmonization. According to the classification per products, identified will be parameters that can be harmonized across products/missions. Format harmonization – generic.

Project status: It was initiated in October 2007 on a 1 year contract.

**GS Components Harmonization Projects**

1) IPF sentinels: Currently the procurement of the data processing facility in the case of Sentinel-1 and of the processing prototypes in the case of Sentinel-2&3 is being carried out. The definition of the Sentinel-1/2/3 missions Products and Algorithms is on the way. Project status: to be initiated in early 2008; the intended duration of 4.8 years for Sentinel 1 and 4 years for Sentinels 2/3.

2) Amalfi Multi-Mission (ANGLE): The project would implement a multi-mission facility for the systematic end-user product quality control. The scope is to ensure that all data provided to users independently of the distribution process (media on-request, NRT on line, subscriptions, etc) has been quality checked before delivery. For this purpose, AMALFI MM shall become an integrated element in the multi-mission ground segment. AMALFI MM will also provide the means to monitor the quality of the products distributed to the users at any ESA facility. AMALFI MM will initially cover the following missions: ERS SAR, ENVISAT, ALOS, Cryosat. Project status: To be initiated in early 2008

3) Operational and Centralized Auxiliary Data Access (OCADA): It provides a way towards the harmonization and optimization of the Auxiliary Data (AD) handling within ESA Ground Segments, covering present and future ESA EO operational missions (from Envisat to GMES Sentinels). This is a way to guarantee completeness, availability and accessibility of auxiliary information, reducing the external interfaces to the GS and optimising the data-flows. Demonstration of the underlying concept would be conducted through the OCADA project (part of the generic elements developments for the ESA multi-mission PDGS).

Within the overall ESA PDGS/SPPA context, the OCADA multi-mission system shall: provide a common internal source for Auxiliary Data gathered from multiple and heterogeneous sources; be able to guarantee provision of and access to auxiliary information (mainly for support to EO instrument data processing chains); allow "proactive" maintenance of handled datasets; and cover AD gathering, handling, managing, integrity checking, configuration controlling, transforming/ reformatting and distributing responsibilities.

Project planning includes two phases: 1) design, implementation and validation of the system on a single mission in a non-operational environment (1yr); and 2) configuration and validation of the system for a multi-mission operational environment (6m). The project KO has been held in December 2007.

Status: The system interfaces analysis and definition, are in progress to identify the involved external entities and the processes to be associated with them (Aux. Data exchange mechanisms).

### **INPE** *(Leila Fonseca)*

The INPE represenative, ***Dr. Leila Fonseca, Brazil*** presented the report from the Brasilian space agency (INPE).

The report focussed on the Joint Mission between INPE(Brasil) and CRESDA(China). The INPE absolute calibration efforts were described. A vicarius reflectance-based method have been applied, using two test sites – one in China and one in Brazil. The cal/val sites include in China: Gobi Desert, and in Brazil: Eduardo Magalhães city (Bahia). The efforts were led by Dr. Flavio Ponzoni.

The time table of the satellite acquiisitions was presented as follows: 15/08 => SPOT; 18/08 => CBERS-2; 19/08 => SPOT; 20/08 => SPOT; 21/08 => CBERS-2; and 24/08 => CBERS-2. The data were collected on 03/10 (off nadir 7o ), 06/10 (nadir).

Cal/Val data acquisition in China Gobi Desert (Dun Huang) included atmosfere characterization: using Photometer solar CIMEL (direct Irradiance), chinese Photometer solar(difuse Irradiance) and equipments to measure weather parameters; measurements of spectra (using an ASD) from surface materials, black and bright targets.

In Brazil cal/val acquisitions were made at Luis Eduardo Magalhães (BA). The reference surface covered agricultural lands. Spectral surface reflectance properties were deterined. To determine surface Isotropy 15 radiometric samples were collected from the same surface fraction at 07:40, 08:30, 09:00, 11:00 and 11:40 pm. Spatial homogeneity was assessed using 85 radiometric samples collected from a large surface fraction. Measurements were collected on October 3$^{rd}$ and 6$^{th}$. Preliminary results were presented in a summary table (see INPE presentation, slide 19).

Discussed were some of the encountered problems. Stated was that in Brasil there are no good natural test sites. Therefore, the activitis depend the availability of the area (farmer). The farmer needs to prepare the soil. Weather conditions are also difficult – frequently cloudy and rainy weather. Theresore, an international cooperation is critical to perform joint absolute calibration. An evaluation of the absolute coefficients is considered in order to improve the data quality.

### **JAXA** *(Keiji Imaoka)*

The JAXA report was presented by ***Keiji Imaoka,*** Japan Aerospace Exploration Agency (JAXA), Earth Observation Research Centre (EORC). The report focused on JAXA's Earth Observation plan The recent, current and future JAXA EO missions were presented (summary table is provided on the next page) and their status was discussed.

**Status of the Current Missions**

1. Advanced Land Observing Satellite (ALOS). ALOS mission objectives are follows: (1) Provide and update maps for Japan and other countries including those in the Asian-Pacific region (Cartography); (2) Perform regional observation for "sustainable development," harmonization between Earth environment and development (Regional Observation); (3) Conduct disaster monitoring around the world (Disaster Monitoring); (4) Survey natural resources (Resources Surveying); and (5) Develop technology necessary for future Earth observing satellites (Technology Development).

2. Advanced Microwave Scanning Radiometer for EOS (AMSR-E), mission objectives include: Multi-frequency, dual-polarized passive microwave radiometers for observing global climate and hydrology. Higher

spatial resolution compared to existing instruments (e.g., SSM/I). Addition of 6.9-GHz channels for estimating SST and soil moisture.

3. Tropical Rainfall Measuring Mission (TRMM): TRMM was launched in November 1997 to understand the global energy and water cycle by providing quantitative measurement of rainfall in the tropics.

4. Japan Meteorological Agency (JMA) geostationary satellites: The Multi-functional Transport Satellite (**MTSAT**) series fulfils two functions: a meteorological function by the Japan Meteorological Agency and an aviation control function by for the Civil Aviation Bureau of the Ministry of Land, Infrastructure and Transport. The MTSAT series succeeded the **Geostationary Meteorological Satellite series** (GMS-1~5).

**Future Missions**

1 GCOM-W/ AMSR2 - GCOM: Global Change Observation Mission; and AMSR2: Advanced Microwave Scanning Radiometer-2: Multi frequency and dual polarized passive microwave radiometer. Targets of GCOM-W are water-energy cycle, and will carry AMSR-follow on, AMSR-2. AMSR-2 will continue AMSR-E observations (water vapour, cloud liquid water, precipitation, SST, wind speed, sea ice concentration etc.).

2 GCOM-C/ SGLI; SGLI (Second Generation Global Imager): Targets of GCOM-C are carbon cycle and radiation budget, and will carry SGLI.SGLI will continue almost of the GLI observations (sea surface temperature, ocean colour, aerosols, cloud, vegetation, snow/ ice, and so on). The new SGLI features (250m (VN) and 500m (T) channels and two polarization/ multi-direction channels (P)) will enable improvement of land and coastal monitoring and retrieval of land aerosols.

3 Greenhouse gases Observing SATellite (GOSAT): The GOSAT aims to contribute to international treaties by monitoring the distribution of the density of greenhouse gases. GOSAT has been developed by JAXA, Japan's Ministry of the Environment (MOE), and National Institute for Environmental Studies (NIES). GOSAT carries Thermal and Near infrared Sensor for carbon Observations (TANSO) consists of the Fourier Transform Spectrometers (FTS) and the Cloud and Aerosol Imager (CAI).

4 Global Precipitation Measurement (GPM): The Global Precipitation Measurement (GPM) is a follow-on and expanded mission of the Tropical Rainfall Measuring Mission (TRMM) mainly initiated by NASA, JAXA, and the National Institute of Information and Communications Technology (NICT). The major sensors on the GPM core satellite are the Dual-frequency Precipitation Radar (DPR) and the GPM Microwave Imager (GMI). DPR radar will measure intense rain in tropics by 14GHz, and weak rain & snow in mid/ high-latitudes by 35GHz. The goal is for obtaining highly sensitive precipitation measurement and a calibration for constellation radiometers and sounders.

**Constellation Satellites**: Microwave Radiometers or Sounders will be installed on each satellite for frequent precipitation measurements.

1. EarthCARE/ CPR: EarthCARE has been defined with the specific scientific objectives of quantifying aerosol-cloud-radiation inter-actions. EarthCARE is a joint project between ESA and JAXA-National Institute of Information and Communications Technology (NICT). JAXA-NICT is responsible for: Cloud profiling Radar (CPR) development; CPR science data processing; Promotion of the science and application

Program Status: Mission Definition Review (MDR) / System Requirement Review (SRR) in the last month; A phase up review in this summer (TBD); System Definition Review (SDR) and JAXA Management Level Review by the end of 2007 (TBD).

2. ALOS Follow-On Concept (for disaster monitoring)

Current System Concept: Monitoring disaster area affected by earthquake, volcano, flood, etc. Observing the disaster affected area within 3 hr (6 hr in night). A satellite constellation of two optical sensor satellites and two SAR satellites; Higher spatial resolution: 1-2m (pan), 3-5m (multi), 5m (SAR).

ALOS Cal/Val status "Daichi" (Advanced Land Observing Satellite): Jan. 24, 2006: Launch by H-IIA #8 from TKSC; Jun. 11, 2007: 1.4 year (503 days) after launch.

Mission objectives: Cartography (1:25,000 scale), Regional environment observation, Disaster monitoring, and Resources surveying.

The instruments on board include: PRISM - Panchromatic Remote-sensing Instrument for Stereo Mapping; AVNIR-2 - Advanced Visible and Near Infrared Radiometer type 2; and PALSAR - Phased Array type L-band Synthetic Aperture Radar.

The geometric conditions of AVNIR-2 (Nadir) are similar to geometry in 16 days MODIS observations. AVNIR-2 and MODIS TOA radiance can be compared on satellite zenith angle θ (cross track angle).

The Latest ALOS calibration result can be find, in English, at:

http://www.eorc.jaxa.jp/hatoyama/satellite/data_tekyo_setsumei/alos_hyouka_e.html

### NASA *(Stephen Ungar)*

***Stephen Ungar,*** NASA EO-1 Mission scientist, presented the NASA agency report. The report focused on the Landsat Continuity Mission Program including current status, data gap issues and discussed potential solutions.

**Current Status**: The GEOCOVER-2000 30-m orthorectified Landsat dataset is publicly available. A Global Mid-Decadal Land Survey is needed for studying changes since 2000. Landsat-7 coverage is global, but each scene has data gaps. Landsat-5 coverage is not global and the satellite is 20-yr old!

**Future Prospects**: In few years (2009-2010) - Landsat-5 will be out of fuel, Landsat-7 has high risk of a gyro failure, No firm plans for next Landsat. NPOESS/OLI is unlikely, LDCM free flyer is probable (cautious optimism). A strategy for a 2010 global dataset is needed. Landsat-7 data alone are insufficient for producing high-quality, regional-to-global LCLUC products (Scan Line Corrector failed the end of May 2003; L-7 composites from 2-3 consecutive images are still inadequate for LCLUC studies in areas with persistent clouds and/or significant seasonal changes.

**Potential Solutions:** 1. Cobble together adequate-quality Landsat-7 composites with all available Landsat-5 scenes during 2004-2006 period for seasons compatible with the GEOCOVER-2000 data; 2. Fill the gaps with other Landsat-like data (ASTER, ALI, SPOT, IRS, CBERS, etc.); and 3. Principle of redundancy: for each pixel as much information as possible from Landsat-like sources: L-7, L-5, ASTER, ALI, etc. ALI, ASTER, SPOT May complement Landsat Scenes.

**Summary of Goals**

1) Develop a Global Mid-Decadal Dataset with Landsat-like spatial resolution
2) Develop a strategy for the post-L5 period
3) Gain experience in utilizing non-US sources so that a global high-resolution 2010 dataset can be developed when L-5 is dead and the next Landsat is yet unavailable.

### NIST *(Carol Johnson)*

***Carol Johnson,*** Optical Technology Division, Physics Laboratory, National Institute of Standards and Technology presented the NIST report. The report included contributions from David Allen, Steven Brown, Joe Rice, Eric Shirley, Allan Smith, Howard Yoon, Raju Datla, Keith Lykke, Gerald Fraser.

**SUMMARY STATEMENT: The NIST Optical Technology Division continues to support and/or partner with weather & climate related satellite programs. It maintains and improves radiometric tools, facilities and capabilities to do so.**

**NISTstars: SI traceability of exoatmospheric irradiance of stars.**

The goal is to establish a set of SI traceable stars for calibration. Current stellar light measurements are too inaccurate (2% to 5%), which presents a problem for various applications, such as: Earth sciences, weather & astronomical satellite calibration, atmospheric monitoring, fundamental astronomy, astronomical surveys, navigation and physics and cosmology. NIST plans to work with ACCESS team (Absolute Color Calibration Experiment for Standard Stars) to calibrate a telescope spectrograph system. There are 4 rocket launches planned to calibrate Vega, Sirius, and two dimmer (~9th magnitude) stars outside of the atmosphere for spectral

irradiance from 350 nm to 1700 nm. After that the plan is to use the 42" Hall telescope at Lowell Observatory in Flagstaff, AZ, to use these calibrations, along with atmospheric extinction, to extend the absolute calibrations to many other stars. NIST is also working with Chris Stubbs from Harvard to calibrate the Pan-STARRS telescope (Panoramic Survey Telescope & Rapid Response System) on Haleakala, HI, and other telescopes.

**Partnering with recently funded CLARREO Mission**

To support climate and other research, NIST is working with the CLimate Absolute Radiance and Refractivity Observatory (CLARREO) mission. The following activities are conducted in support of the mission: 1) Realization/ validation of the IR spectral radiance scale for near-ambient radiation sources in laboratory conditions. Scale realization and internal comparisons were accomplished in 2007. Validation via comparison with other NMI's, including PTB (Germany), NPL (UK) and NRC (Canada) is currently in progress and will be finalized in 2008. 2) To support pre-flight calibration of space radiometric instruments NIST is working on a design of the vacuum spectral radiance comparator. In 2008 we are planning to finalize the design and proceed with construction. 3) Support of in-flight monitoring to maintain and validate traceability of spaceborne instrumentation. 4) Cooperation with the School of Engineering and Applied Sciences (Harvard University) and Space Science and Engineering Center (University of Wisconsin-Madison) aimed at development of self-calibrating spaceborne blackbody. A demonstration study is planned for in 2008.

**NIST-NOAA-NASA-Collaborations for Climate Change (N3C3) Portal**

N3C3 will provide easy access to satellite sensor radiometric calibration related information. The contents cover optical and microwave sensors and include: proceedings of workshops, internal reports, articles on calibration methodologies, best practices and issues; adopted pre-launch and post-launch calibration methodologies and lessons learned for sensors past, present and those under development; NIST data on components for calibrations of interest; links to the CEOS CALVAL portal; links to NASA EOS and NOAA portals on sensors and their calibration issues.

Reported was the progress at NIST toward the development in Hyperspectral Imaging Projection capabilities (HIP).

An update was provided on the Marine Optical BuoY (MOBY) assumed by NOAA as of April 2007 - NIST radiance cal/val activities continue. MOBY is the basis of the vicarious calibration of SeaWiFS and MODIS Terra/Aqua. The plans are to continue MOBY and its successors to support future satellites. NASA has provided funding toward developing the next-generation optical sensor component, other funding is being sought.

Reported was that the aperture-area comparison related to total solar irradiance is complete. While a manuscript for a peer reviewed publication is being developed and it is in final stage, the discrepancies between TSI monitors remain unresolved.

The TSI Workshop (July 2005) Report is in preparation for NIST's Journal of Research.

**LUnar Spectral Irradiance and radiance (LUSI)**

The initiative is proposed in collaboration with Steven R. Lorentz, Thomas C. Stone, Dave Pollock and Joe Tansock. LUSI is a suite of instruments to develop the moon as an on-orbit SI-traceable absolute reference standard for satellite sensors. The problem is that the radiometric accuracy requirements of satellite sensors needed to understand and monitor climate change are very stringent. Measurements spanning the lifetimes of many instruments must be combined with low uncertainties to detect small changes over decadal time periods. Observing such small climatic changes is complicated by the significant changes in optical sensor performance due to launch and during operation in space. At reflected solar wavelengths a low uncertainty absolute on-orbit reference standard is needed to mitigate such sensor changes and to put all sensors on the same radiometric scale. With further development the moon could be that reference.

The plan is to: 1) Increase the spectral resolution of the instruments and cover 320 nm to 2500 nm continuous with a resolution of approximately 0.3 %. Continuous coverage allows SI-traceable calibration for all satellite instrument bands. High spectral resolution reduces sampling/interpolation errors when comparing sensors with

different spectral bands. 2) Measure the lunar radiance to facilitate calibration and characterization of high spatial resolution sensors. 3) Use Earth-based instrumentation deployable to high-altitude balloon platforms and high-altitude mountaintop observatories to mitigate the effects of the atmosphere. Such an instrument can be based on the latest technology and calibrated in a laboratory frequently unlike satellite sensors that must use space-qualified components and are difficult to retrieve.

**Peoples Republic of China, PRC** ***(Xiaolong Dong)***

The PRC report was presented by ***Xiaolong Dong***, NMRSL/CSSAR/CAS. The report focused on the evaluation and selection of sites for Microwave Radiometer Calibration**.**

Past, current and future missions with Microwave/MMW Sensors were reviewed. Past: Multi-mode Microwave Remote Sensor (SZ-4, 2002-2003). Current: Polar-orbit meteorological satellite (2007-2010); Chang'e-1 lunar satellite (2007-2008), Microwave sounder is one of the main payloads of Chang'e-1). HJ-1C Environment Satellite: S Band SAR. (2007). Future: FY-3A scheduled to be launched in 1st half of 2008; HY-2 ocean dynamic environment measurement mission (~2009); FY-4 geostationary meteorological satellite (>2010). Some of the current and near future tasks/plans (2007~2008) were described, including the development of CAL/VAL technologies for: 1) passive microwave/MMW sensors; 2) active microwave/MMW sensors; and 3) Research about the construction requirements of the CAL/VAL experiments.

**1) Considerations about the CAL/VAL Sites Selection and Construction for Spaceborne Microwave Remote Sensors**

Re-calibration and validation of MMV data by *in situ* data from ship borne microwave sensors was discussed. Objectives: Calibration, Correction of BT retrieval formula, and Application. Presented was a plan for future CAL/VAL of spaceborne MW/MMW sensors. China is now implementing a comprehensive plan for spaceborne microwave/MMW earth observation sensors. With development of new technologies, more and more Chinese missions of earth observation satellites with microwave/MMW sensors are being proposed or being carried into execution. For operational or experimental/operational applications, CAL/VAL becomes an essential requirement for Chinese EO satellites. As part of the implementation of earth observation program with microwave sensors and in a preparation for CAL/VAL, sites selection and consideration had been started and research had been conducted since 2004. For the Cal/Val sites over land and ocean the polarization difference for the emissivity with different frequencies and the brightness temperature precision for the different sites are compared.

**2) Evaluation and Selection of Sites for Spaceborne Microwave Remote Radiometers**

Calibration and Validation over the Takelimgan Desert -The main rationale for the selection of this site is that the desert is a large area, which fits well with the large FOV of spaceborne low frequency microwave radiometer. It is stabile and homogeneous from a viewpoint of microwave radiometry. Therefore, it's radiometric behavior can be predicted with a significant level of accuracy. It is relatively easy to access via a Sand Desert road. Airborne and field experiments can be carried out without too much difficulty. The need for vicarious calibration of low frequency spaceborne microwave radiometer by monitoring large areas of uniform, stable and known characteristics was addressed. This is especially true for the ongoing L band mission such as ESA SMOS. In tradition, tropical rain forest and calm ocean are used as two-point external calibration sites. But at lower frequency, especially L band, the stability and predictability of rain forest at spaceborne scale are in challenge. In this context, we therefore put forward a proposal to ESA SMOS mission to use the Takelimgan Sand Desert as another choice of vicarious calibration of MIRAS onboard SMOS. The proposal is approved and the desert has been selected as one of the two vicarious calibration sites of the mission (another is Dome C, which is taken care by Italian scientists; rain forest is still under investigation).

DUNHUANG Gobi - Gansu Province (for details see PRC presentation at WGCV26).

Amazon Forest - Surface temperature is obtained using AQUA-MODIS 5km Average; Atmospheric humidity/temperature contour is determined using ground based sounding; Surface Emissivity is well defined (for details see PRC presentation at WGCV26).

**Conclusions and suggestions:** 1) For the atmospheric transparent channels, Amazon rain forest can be very good warm target with high BT for microwave radiometry performance evaluations and validations; 2) Southern Yunnan Province and Coastal region of Fujian Province can be good transient calibrations sites after in situ atmospheric sounding corrections; and 3) *In Situ* observation facilities are necessary to provide cold target with low BT for microwave calibration sites on the ocean.

**NOAA** *(Fuzhong Weng)*

An update on the NOAA Satellite Calibration/Validation Program was presented by ***Dr. Fuzhong Weng***, Center of Satellite Applications and Research; National Environmental Satellites, Data and Information Services; National Oceanic and Atmospheric Administration.

Stated was that NOAA has over 20 years experience in Global Weather Forecast. Currently 33 satellites are being used and 9 are tested. The data is used in the NOAA Global Numerical Weather Prediction Models. An overview and time table of current and planned until 2020 missions was presented (see NOAA presentation at WGCV28 web page).

As major NOAA Cal/Val Accomplishments in FY07 were listed: the sustain operational POES&GOES Calibration, the support of WMO GSICS (Global Space-based Intercalibration System), the development of Cal/Val Plans for Future Instruments (e.g. GOES-R and NPOESS), and the inauguration of NOAA Cal/Val Program.

POES&GOES Calibration update: Continuing updates of POES and GOES visible and near infrared calibration coefficients. Work is being done on ocean color bands for NPOESS-VIIRS. Further joint work is planned with NIST on MOBY in 2008.

**GSICS** (Global Space-based Intersatellite Calibration System): GSICS is a part of the WMO (World Meteorological Organization) space program. Its main goal is to facilitate the generation of fundamental climate data records. GSICS will facilitate the development of RSSC-CM (Regional Specialized Satellite Centers-Climate Monitoring.

**Support WMO GSICS:** Three informative opportunities have arisen since April 1st. Articles include GSCIS organization and project overviews, science, meeting summaries, personnel, etc. and include contributions from Germany, Japan, and US. It was sated that NOAA needs your GSICS–related articles ... Articles of interest include: Organization and Project Overviews, New Science, Meetings and Awards, Personnel, Classifieds.

**GOES-R Cal/Val Update:** Currently the plan focuses on ABI (Advanced Baseline Imager). NOAA will refine the plans for GLM (Geostationary Lightening Mapper) and Space weather instruments this year. The calibration algorithm theoretical basis documents will be started this year. Product cal/val plans will be developed later.

Stated was that the **ASIC3 Workshop Report** has been released. The WGCV members requested that the report is made available to the group at the WGCV web site. Achieving Satellite Instrument Calibration for Climate Change is the reports focus. With more than 150 pages, this will be an important reference document for cal/val specialists. Recommended to put on the WGCV website and cal/val portal.

**NOAA Cal/Val Program** The program Vision was described as follows: Satellite observations are intercomparable and tied to international standards for weather, climate, ocean and other environmental applications. Goals include: Reduce the uncertainty in climate trend detection and prediction through vigorous calibration and reprocessing; Increase accuracy of satellite data for weather and environmental prediction models; Smoothly transition new calibration algorithms to operations; Develop common practices for calibration of Earth observation sensors; Achieve traceability to the International System of Units (SI); and Optimize sensor choice and design for achieving these goals. Major Program Components discussed include: Pre-launch (Pre-launch characterization, Common standards for vendor calibration, Traceability to system international units, New calibration models and algorithms); Post-launch (Maintenance of operational satellite calibration, Inter-and Intra-calibration of satellite sensors, Online monitoring system for satellite instrument trending, Inter-comparison of satellite observations with simulations); Product validation (Existing products from newly launched, New products from research satellites, Define validation sites, Consensus algorithm and

error budget models); and Impact assessment of new cal/val procedures (Climate trend analysis, Land cover analysis, Severe weather forecast).

**NOAA's Near-Term Cal/Val Priorities were stated as follows:** Integrated Calibration System for NOAA-18/ METOP-A instruments; Support to WMO Global Space Based Intercalibration System (GSICS); On-orbit Calibration of Satellite Observations; Maintenance of operational satellite calibration analyzing calibration target measurements; Inter- and Intra-calibration of Satellite Sensors; Online Monitoring System for Satellite Instrument Trending; Inter-Comparison of Satellite Observations with Simulations.

**Long-Term Cal/Val Priorities include:** Development of new calibration science and standard (Prelaunch Instrument Characterization and New Calibration Models, Science and Benchmark Sensors); Development of integrated product validation systems (Validation of Operational Products from New Satellites, Reference Sites for Product Validation, and Community Consensus Error Budget Models); Assessments of impacts from new calibration algorithms (Climate Trend Analysis, Impacts on NWP Analysis, Forecast and Climate Reanalysis).

**Recent Accomplishments presented include:** 1) Improved cal/val techniques as backbone supporting GEOSS, such as simultaneous nadir over-passing (SNO) for inter-sensor calibration, uses of hyperspectral instrument as reference for intra-sensor calibration, satellite instrument bias correction algorithms, postlaunch nonlinearity correction from SNO analysis, and vicarious calibration for POES/GOES visible and near IR channels. 2) Improved satellite imagery and products for severe weather now-casting, such as GOES-E/W imagery animation for hurricane track and intensity, Flash flood from AMSU and GOES, and Hurricane potential rainfall from AMSU TPW. 3) Improved uses of current satellite data in NWP models - More AIRS data used in NWP models, Increased use of AIRS, HIRS, SSMIS, AMSU-A data, Uses of MODIS wind products, and AVHRR NDVI in NCEP NOAH. 4) Improved uses of satellite data in climate trend analysis - Reconciled MSU tropospheric temperature trends, and Better ozone trend.

An update on the NOAA Integrated Calibration and Validation System, stated its main capabilities, as follows: Post-launch instrument noise and telemetry trending, Time series of SNO/SCO matched data from a pair of operational satellites, Time series of updated calibration coefficients with digital access, Inter-and-Intra instrument calibrations, Post-launch instrument response functions with digital access, Spatial and temporal distribution of biases of satellite radiances against radiative transfer calculation.

On-orbit Calibration and Verification of Satellite Observations at NOAA has the following objectives: Derive post-launch instrument noise equivalent delta temperature or radiance though analyzing calibration target measurements, Determine the optimal space-viewing of cold calibration target, Improve calibration algorithms for counts to radiance conversion with updated coefficients, Assess instrument geo-location biases and co-registration with recommended solutions for errors in satellite attitudes (e.g. pitch, roll, and yaw), Characterize systematic biases in radiances through rigorous forward radiative transfer modeling, Provide timeliness diagnostics of any instrument performance analysis with root cause analyses.

Inter-and Intra-calibration of Satellite Sensors aims at the development of an improved algorithms that efficiently and effectively extract SNO and SCO pairs from two satellites, and design of intra-calibration algorithms that can perform optimal spatial and spectral convolution. The goals is to provide to user communities with the high-quality SNO/SCO data from POES, NPP, NPOESS and Metop, FY-3 Series.

**In Summary:** Starting FY08, NOAA satellite cal/val program would be appropriated by US Congress for operational satellite calibrations. NOAA's program will turn instrument measurements into accurate environmental parameters, ensure high-quality satellite imagery for forecasts (e.g. hurricane tracking and monitoring), deliver accurate products for weather forecasts and environmental monitoring, and ensure the integrity of the climate data record from satellites.

### **Russia** *(Budarkin, Panfilov, Sapritsky)*

The report was provided by ***A. Burdakin***, All-Russian Scientific and Research Institute for Optical and Physical Measurements (VNIIOFI).

The report focused on the theme *"Maximum accuracy requirements for observation of Earth object's parameters and corresponding radiometric accuracy and stability of satellite instruments" (NISTIR 7047).*

Stated was that, when ensuring consistent and stable instrument radiometric scales, the goal is to meet the most stringent requirements for radiometric instruments that are used for precision monitoring of global climate change. Suggested was to use calibration devices based upon the phenomenon of phase transition of eutectic alloys or pure metals in both the ground calibration and the in-flight monitoring systems. The absolutely highest requirements are imposed in Thermal IR range – e. g. measuring SST with accuracy 0.1 K during decades for the purpose of monitoring long-term temperature trends. To meet such a demand consistency of instrument radiometric scales, once established on Earth, must be periodically verified on orbit. Proceeding from accuracy 0.1 K - the long-term stability of instrument radiometric scales on orbit must be at the level of the order of 0.01 K/decade in IR range.

Accuracy and stability of satellite instruments in spectral range 0.3 – 25 μm required for precision monitoring global climate change were as follows: For in-flight monitoring the following criteria were suggested: for spectral region 0.3–3.0 μm - Stability 0.1 %/d (moon as a test source); and for spectral region 3-25 μm - stability of 0.01 K/d. The development and use of onboard sources based upon phase transition of substances is suggested. Studies are required to select suitable substances (2006), determine their properties under the ground environment (2006), determine their properties under the space environment, and to design onboard sources. The development of a space-borne radiometric calibration facility is also considered.

A review of the current Russian activities, addressing metrological assurance of future GEOSS radiometric data compatibility, was presented. Ground activities included the development of a Russian set of standards for ground calibration of instruments operating within the spectral regions: 1) from 0.3 μm to 25 μm 2) from 0.3 μm to 3 μm, 3) from 3 μm to 25 μm. For in-flight monitoring, the preparation for a space experiment to study the effects of micro-gravity upon the melting/freezing phase transitions of eutectic alloys, was discussed.

Addressing in-flight testing was proposed that Small-size fixed points are used for developing standard spacecraft radiation sources in the Thermal IR wavelength range. The topic has been selected and studied and the results of the studies are published in *Metrologia 45 (2008) pp. 1 – 8.*

Stated was that the Russian Space Agency included the space experiment «Studying the effects of micro-gravity upon the melting/freezing phase transitions of eutectic alloys» into the long-term scientific program on board ISS (Russian segment, 2009 - 2011). The immediate goal of the space experiment is the development of fixed-point cells and procedures for testing thermal sensors on orbit. The final goal aims at the developing of a spacecraft radiometric testing systems based on standard fixed-point radiation sources for the purpose of monitoring long-term climatic trends.

**Conclusions:**

Developing standard radiation sources referenced to phase-transition fixed points for calibration of Earth observation IR sensors started as international project. The final goal of the project – ensuring metrological support for long-term monitoring thermal radiation data trends to draw reliable deductions on global climate change. For the purpose a number of eutectic fixed points in the temperature range ~ 280 - 310K was selected and studied under ground conditions. At the moment space experiment directed at studying phase transition in selected (Ga-based) eutectics under microgravity conditions onboard ISS is on the way. Russia and the representatives stated that it is the right time to again join efforts of international institutions.

### **Thailand** *(Raweewan Nutpramoon and Morakot Kaewmanee)*

The Thailand report was prepared by Raweewan Nutpramoon, Morakot Kaewmanee, Sitthisak Moukomla, and presented by ***Raweewan Nutpramoon and Morakot Kaewmanee***. The presentation focused on THEOS activities, and calibration and validation plan.

1. THEOS Mission and Specification: The THailand Earth Observation System (THEOS) is the first earth observation satellite of Thailand. System development started in July 2004, with a launch scheduled for October

2007 (by Dnerp). THEOS's specifications are as follows: 750 kg mass; Sun Synchronous orbit; 822 km altitude; 26 days repeat cycle; 10.00 a.m. mean local time; payload includes panchromatic telescope and multi-spectral camera (4 bands, NIR RGB, 0.45-0.90um); on-board memory of 51Gb; X-band data link and TT&C S-band link, attitude orbit control and 3-axis stabilized, star tracker orbit determination; Gyro, GPS, Magnetic Torque; Sun Sensor; and 5 Years design life time.

2. In-Orbit Test (IOT): The prime contractor EADS Astrium has the responsibility to perform IOT and image calibration and validation. GISTDA will control the satellite after the first year and will perform image quality monitoring during THEOS life time.

3. THEOS Radiometric Calibration Plan
Objectives: 1) Perform the in-flight measurement of radiometric parameters of the THEOS optical payload (to recover the actual radiometric content in the image from digital raw data); and 2) Verify the radiometric parameters meet the specifications.

To assess the level of dark signal the use of no signal producing area, such as Pacific or Atlantic ocean is considered. Pixel response non-uniformity (PRNU) will be studied using uniform areas at different uniform radiance levels (e.g. Amazon forest, Desert (Algeria, Arabia), Greenland ice field, etc.).

For absolute radiometric calibration a test site will be selected in Thailand (required is a feasibility study). The plans for assessment of THEOSs Modulation Transfer Function (MTF) include the use of test sites, such as edge (Salon de Provence), punctual target (Pong Hu) and radial (NASA, Stennis Center)

4. THEOS Geometric Calibration Plan:
Ground Sampling Distance & Swath width: To verify the ground sampling distance, swath width, and check the conformity with specifications is required a Level 1A image (all channels) over landscapes with ground control points, in TIF format.

Pointing Accuracy: To evaluate the pointing error in regard to the expected (i.e. commanded) are required Level 2A images (PAN channel only required), in TIF format, including map information.

Geolocation Accuracy: To evaluate the geolocation error (around 20 m for absolute localization and better than 5 m for the relative one) are required Level 2A images (PAN channel only required) over landscapes with ground control points, (typically 1 to 5 per image), in TIF format, including map information.

Band Registration: To evaluate the band registration performance obtained with the geometric corrections the goals are to reduce registration errors down to 0.2 pixel for PAN and MS channels, except the near-infrared band for which the errors may reach 0.4 pixel. Required is the use of Level 2A images (all channels) over heterogeneous areas (urban landscape typically).

GISTDA plans the following Cal/Val activities to guarantee the basic requirements of the satellite and to obtain enhanced satellite imagery and data higher quality: 1) Validate and verify the satellite and the satellite imagery data; 2) Calibrate the satellite; and 3) Identify & present the status of the satellite imagery data for Users community. Some of the considered Geometric test sites include: Chiangmai, Chainat and Nakhonratchasima.

### **USGS** *(Gyanesh Chander and Greg Stensaas)*

***Gyanesh Chander*** (SAIC/EROS/USGS) and ***Greg Stensaas*** (EROS/USGS) gave the USGS report.

An update on the mission status and calibration of the Landsat satellites was presented.

**Mission Status of Landsat 7:** Landsat 7 has been on orbit for 9 years, although designed for only 5 year mission life. Scan Line Corrector (SLC) malfunction occurred on May 31, 2003. The gaps represent a data loss of ~ 25% for any given scene. The SLC anomaly has not impacted the radiometric or geometric performance for existing pixels. New capability is being developed to improve the SLC-off data products. On May 5, 2004, Gyro #3 has been powered off due to anomalous gyro telemetry. The normal operations have been switched over to ETM+ Bumper mode on Apr 1, 2007.

**Mission Status of Landsat 5:** Launched on 1 March 1984**,** Landsat 5 has been on orbit for 25 years, although designed for only 3 year mission life. The spacecraft had a battery 2 anomaly in October, 2007 and a star tracer issue in June of 2007. The solar array issues were resolved and since August 2006 operations are normal. The TM sensor is functioning normally in a bumper-mode.

**Ladsat 7 Calibration update**
The band-to-band registration has been typically 0.05 pixels or better in line and scan direction (excluding band 6). The switch to bumper mode disrupted ETM+ sensor alignment calibration and degraded it's geodetic accuracy - pre-switch there were 97% scenes with better than 50 meters RMSE, while post-switch only 65% scenes had better than 50 meters RMSE. The relative detector-to-detector normalization, i.e., striping is less than ± 0.1%. The absolute radiometric accuracy is better than ± 5% (reflective) and 1 K (thermal). The noise has been stable over the mission life. The SLC failure had no significant impact on L7 ETM+ and the reflective band radiometry continues to be excellent.

**Landsat 5 Calibration Update**
Within-band within-scene internal stability: The scan-correlated shift (SCS) is up to 0.7 DN, but it is correctable with scan line-by-scan line background subtraction. The memory effect is currently up to 4 DN, and is corrected in the NLAPS processing. So me of the banding and striping issues remain to be resolved.

Between-date stability: There is an interference cycling caused from icing on B5 and B7. It is correctable with IC processing or LUT that includes interference cycling.

**Radiometric calibration processing:** Uses Gain Calibration History stored in Look-Up Table; Extracts and applies biases on a scan line by scan line basis, A scene is rescaled to Fixed Radiance Range (LMIN, LMAX). The look-up table was revised on April 2, 2007 to reflect the revised trends from Sahara desert site data obtained from ESA

**Landsat Web-enabled Data Pilot**: As of June 4 2007, the USGS will be releasing selected Landsat 7 image data (SLC-off, 2003 to present, < 20% cloud cover image data) of the United States (only) through the Web: http://glovis.usgs.gov/ or http://earthexplorer.usgs.gov/. These data are of high quality with limited cloud cover. This Web-enabled distribution of new and recently acquired data is a pilot project for the LDCM. The project will allow the Landsat data user community to help refine the distribution system planned for the upcoming LDCM. Each scene will be registered to the terrain, or 'ortho-rectified,' prior to being placed on the Web. Copies of these data will also be available on CD or DVD at the cost of reproduction. The pilot project will be carefully examined. Customer response will be evaluated and their insight will influence the future distribution system. The following recipe was recommended by LST for the Web-enabled LDCM pilot project and for Global Land Survey dataset: pixel size 15m/30m/60m, media type Download (no cost) or CD/DVD ($50), product type: L1T (terrain-corrected), output format GeoTIFF, map projection UTM, orientation North up, re-sampling Cubic convolution

**Future plans for Landsat Data Availability:** For FY08 is planned an expansion of Landsat 7 SLC-off data and continued additions to MRLC dataset. For FY09 is planned to complete GLS2005, and to have Landsat 7 SLC-on and Landsat 4/5 TM data available. For FY10 is planned to have the MSS data available. July 2011: This is the targeted LDCM launch readiness date, which is followed by 90 day on-orbit checkout and acceptance.

**Current project status of the Operational Land Imager (OLI)**
In January 09, 2007 NASA released Request For Proposals (RFP) for an Operational Land Imager (OLI). On Feb. 23, 2007 the proposals were received and the OLI contract was awarded to Ball Aerospace in July 2007. Since the contract award numerous subsystem peer reviews have been conducted. A successful Instrument Systems Requirements Review was completed. An Instrument Integrated Baseline Review was successfully completed, which formally baselines the plan for building the instrument. The flight optics, filters, detectors, and optical bench are in various phases of design and production. NASA successfully fended off a protest of the OLI award to Ball, without impact on the OLI development schedule. There is an on-going Requirements Optimization Exercise, which maximizes the probability of maintaining 39 month OLI development schedule.

**Landsat Science Team**

USGS is co-chairing and funding the Landsat Science Team. The 1st Science Team meeting was held in January 9-11, 2007; the 2nd June 12-14, 2007, and the 3rd is planned for January 8-10, 2008. The Science Team is funded to conduct research and provide feedback to the LDCM in the following areas: applied research in natural resource monitoring and algorithm development, participation in ground system requirements reviews, definition of product specifications, development of LTAP-8, instrument engineering, communications, outreach and policy recommendations.

**USGS LDCM Science Office**
The science office serves as a bridge between the user community (requirements) and engineering (systems development). It conducts applications research and algorithm development for: land surface monitoring, projections and re-sampling, prototype products and metadata, cloud cover assessment, and ancillary data required for LTAP-8 and product generation. The communications and outreach surveys the user requirements, generates peer reviewed publications, gives presentations at conferences and symposia, and participates in inter-agency working groups. On-going cross-calibration activities include: L7 ETM+ and L5 TM sensor, L5 TM and L4 TM sensor, L7 ETM+/L5 TM and EO-1 ALI sensor, L7 ETM+/L5 TM and Terra MODIS sensor, L7 ETM+/L5 TM and IRS-P6 AWiFS/LISS-III sensor, L7 ETM+/L5 TM and CBERS-2 CCD sensor, and L7 ETM+/L5 TM and ALOS AVNIR-2 sensor. Planned Cross-calibration Activities include: L7 ETM+/L5 TM with: CBERS-2B, ENVISAT MERIS, AVHRR MetOP, THEOS, DMC, Beijing1, Topsat, Cartosat-2, ResourceSat, RapidEye, Worldview, GEOEYE, SPOT. Presentations at Joint Agency Commercial Imagery Evaluation (JACIE) Workshop, 25-27 March 2008 are available at http://www.usm.edu/ncpc/jacie/.

**The real *issue* has been that there is no long-term U.S. commitment for providing Landsat-like data.** There is no U.S. commercial alternative and no resources to sustain an operational land imaging program for the U.S.

**The National Land Imaging Program:** In December 2005, the President's Science Advisor stated: "It remains the goal of the U.S. Government to transition the Landsat program from a series of independently planned missions to a sustained operational program…". In 2007, The Department of Interior accepted the role of leading the National Land Imaging Program (NLIP). The Land Imaging Interagency Working Group (FLI IWG) was generated to provide guidance on issues such as: Why does the U.S. need moderate-resolution land imagery? What are the key societal benefits of moderate resolution land imaging? What are the options for acquiring these capabilities or data? How should U.S. land imaging be managed and governed?

**Online Catalogue of World-wide Test Sites for the Post-Launch Characterization & Calibration of Optical Sensors.** A whitepaper is drafted that provides a comprehensive list of prime candidate terrestrial targets for consideration as benchmark sites for the post-launch radiometric calibration of space-based instruments. The next step is to work with international agencies and organizations to refine the list further and to provide additional key information needed to characterize each site. A parallel comparison to the CEOS cal/val sites was made. USGS recommends/advocates the coordination of world-wide Cal/Val sites, including ground control points; and the coordination and planning of vicarious calibration field campaigns. The agency generated an online catalogue that provides easy public web site access to this vital information for the global community. The catalogs layout is set up to help the user quickly locate the needed information available on the site - drop-down menus list locations so the user may go straight to a specific site; a map with clickable links provides another way to go to sites; the maps include a world map, where the user selects a continent, and a map of each major continent. Each of the calibration site pages contains the same fields for easy review. These fields include location, terrain elevation, center latitude/longitude, WRS-2 path/row, size of usable area, owner, researcher, purpose, description, support data, suitability, and limitations. Other features include: a small image of the globe depicting the position of the site, satellite images of the test site, previous/next button, sample Landsat images and Google KMZ files.

# *Session 2: CEOS/IP - Data quality assurance strategy for GEOSS*

**1. GEO-CEOS Workshop on Quality Assurance of Calibration and Validation Processes: Report**
*(Lecomte/Greening)*

Lecomte and Greening presented an overview and summary of results from the GEO/CEOS workshop in Geneva.

The workshop took place in Geneva, October 2nd-4th, 2007. During the workshop there were four sessions on: cal/Val site characterisation and classification, satellite and *in situ* Cal/Val data access, methodology and guidelines for Cal/Val, and harmonisation of Quality Information. These discussions need to be applied at the level of each sub-group, because the procedures are specific. While the guidelines shall be generic (i.e. one unique set of guidelines), the implication need to consider the specificity of each instrument sub-group.

The workshop discussions reached a consensus on the need for: 1) The establishment of Cal/Val best practices. What is required are CEOS endorsed guidelines (best practices), set under the auspices of GEO, for implementation by the agencies. These guidelines will allow data to have an ascribed 'quality' associated with it and will include all aspects of the data processing chain from acquisition to delivery & archiving. 2) A Cal/Val specific data policy and the allocation of the necessary resources through coordinated efforts of GEOSS members to implement the CEOS-endorsed guidelines & ensure the continued end-to-end operation and maintenance of the Cal/Val system.

Future plans include: Drafting of the 'Quality Control / Assurance and Best practice Guidelines on Calibration & Validation Processes' has begun. A second workshop will be held in Maryland, USA, hosted by NIST, May 6th to 8th, 2008. This workshop will tackle issues relating to the definition of the best practice guidelines and a first version of the document should be an outcome of this workshop. Discussions on how to 'endorse' the best practices are ongoing and will be a session topic just after the action review.

The workshop drafted the following recommendations:

1) The WGCV recommends that CEOS members support the establishment of a QA framework based on the identification and adoption of Cal/Val best practices that are necessary to allow data to have an ascribed 'quality' associated with it. These best practices should include all aspects of the data processing chain from acquisition to delivery and archiving and be based upon the demonstration of traceability to internationally-agreed reference standards. The established Cal/Val best practices should become published guidelines, endorsed by CEOS under the auspices of GEO and implemented by agencies to meet the needs of GEOSS.

2) The WGCV recommends that it should define a set of global Cal/Val reference (test) sites to be classified and endorsed by CEOS. These should span a variety of conditions in support of the characterisation needs of satellite sensors. The WGCV further recommends that all missions of member agencies should view a prioritised set of core sites as an integral part of the space segment and provide unencumbered access to the results to all CEOS members.

3) The WGCV recommends that CEOS members endorse the establishment of the Cal/Val portal and encourage its further development and use as the single 'point of entry' for all associated EO Cal/Val information. To facilitate this, the WGCV recommends that each agency establish a named individual to act as a local point of contact.

4) In view of its importance to CEOS and GEOSS, as a key tool towards the harmonisation of data quality, the WGCV also encourages ESA to provide the necessary resources for its continued maintenance and development.

5) The WGCV recommends the establishment of a data policy (code of use) for the use of Cal/Val data. This should be consistent with the GEOSS data sharing principles and guidelines.

The workshop produced a total of 21 actions (below): 16, for which the owner is an individual or an Agency; and 5 given to the sub-group leaders to be discussed during sub-group meetings.

| | **1st Cal/Val Workshop Actions** | **Responsibility** | **Due date** |
|---|---|---|---|
| 1 | Categories for the test site catalogue to be transformed into "equipped and maintained" and "non-equipped and non-maintained" rather than use "absolute cal", "pseudo-invariant cal" and "cross-cal". | Chander, IVOS Subgroup | 01 Nov 07 |
| 2 | Provide the current IVOS cal/val site list & baseline characteristics list as an example to the other subgroups | Chander | 15 Oct 07 |
| 3 | Review & establish test site template to define (best practices) requirements for test site identification within the subgroup domain. | WGCV Subgroups | WGCV-28 |
| 4 | Define criteria for test site classification for suitability for a particular application. | WGCV Subgroups | Next workshop |
| 5 | Formulate a request to the Constellation leads to evaluate their requirements for cal/val needs. | Bojkov, Stensaas, Campbell, Cao | 01 Nov 07 |
| 6 | Investigate Jim Butler's CEOS Information Server (http://spsosun.gsfc.nasa.gov/calval/index.html) and see if it contains any useful for the portal | ESA | 02 Nov 07 |
| 7 | Establish & define key cal/val terminology as an input into a WGCV dictionary. | WGCV Subgroups | WGCV-28 |
| 8 | Draft a recommendation regarding the need to maintain long-term archives of cal/val process data to support EO. | Fleig | 01 Nov 07 |
| 9 | Draft guidelines for writing best practise | IVOS | 30 Nov 07 |
| 10 | Formulate a draft list of key common best practises for cal/val. | WGCV Subgroups | WGCV-28 |
| 11 | Establish a committee to explore options on how we are able to establish authority for the endorsement of best practices for cal/val. | WGCV Chair | 05 Oct 07 |
| 12 | Include a discussion at the joint WGCV / WGISS meeting in February 2008 on the idea of adopting a standard set of best practises and the means to establish an authority to endorse them, possibly with a CEOS, ISO or similar stamp. | WGCV Chair | WGCV-28 |
| 13 | Define wish list of requirements for functionality from the cal/val portal and feedback to the cal/val portal maintainers (ESA). | WGCV Subgroups | WGCV-28 |
| 14 | Establish some mechanism to feedback portal development information to the subgroups (user community). | ESA | 01 Nov 07 |
| 15 | Make the cal/val portal front end a more CEOS / GEO one and change the website URL. | ESA / NASA | 10 Oct 07 |
| 16 | Draft a WGCV data policy (code of use) for cal/val data that will be consistent with the GEO data sharing & principles guidelines. | Stensaas, Bojkov | WGCV-28 |
| 17 | Present cal/val portal prototype to CEOS and GEO plenaries [but restrict open access until data policy (Action 15) has been agreed upon]. | WGCV Chair | CEOS & GEO plenaries |

| | | | |
|---|---|---|---|
| 18 | Review terms and definitions list used for the workshop. | Workshop Chairs | 10 Oct 07 |
| 19 | Distribute GEOSS data sharing principles & guidelines document | Rast | 05 Oct 07 |
| 20 | Evaluate the possibility of including MODIS tools and EOS field data to the cal/val portal | Morisette, Brockmann | WGCV-28 |
| 21 | Evaluate the potential of incorporating EO1 tools & data into the cal/val portal | Stensaas, Brockmann | WGCV-28 |

**2. GEOSS ADC Workshop Report** *(Ungar)*

*Dr. Stephen Ungar,* the GEO lead for Task DA-06-02, presented a summary and discussed the developments at the GEOSS ADC workshop.

The workshop was organized by GEO Task AR-07-02 "GEOSS Architecture Implementation Pilot (AIP)", and hosted by the European Commission at the Joint Research Centre (JRC) in Ispra, Italy, February 4-5, 2008. The Architecture Workshop preceded the 6th Architecture and Data Committee meeting (ADC-6) also hosted at JRC.

The Architecture Workshop was planned to be an interactive event to develop requirements for GEOSS Architecture developments. The workshop covered topics relating to the outcomes of the ADC core architecture tasks in 2007 and to develop plans for 2008. Participants participated in the refinement of topics that will become part of a Call for Participation in 2008. Scenarios in the workshop emphasized the needs of Societal Benefit Areas (SBA) to the service architecture in support of daily decision-support. The scenarios topics were identified through collaboration of the GEO User Interface Committee (UIC) and ADC.

The Architecture Workshop contributed to the overall process of the ADC. The AIP is a forum in which GEO ADC tasks can utilize the core architecture in developing task-specific portions of GEOSS. Development as part of AR-07-02 (e.g., registration and testing of services) is then "delivered" to the AR-07-01 as an operational capability. Coordination between tasks is therefore of high importance to GEOSS development. It was stated that the Architecture workshop emphasized coordination among GEO Tasks.

Dr. Ungar presented the agenda for the workshop (se details in the presentation) and focused on the “Inter-calibration scenario” session which he chaired (Breakout Session 1b). It was stated that the goals with the “GEOSS Harmonization of Sensor Observations” initiative is to establish a global, coordinated, comprehensive and sustained system of earth observing systems. The GEOSS architecture is being designed to facilitate coordinated access to data and products produced amongst all contributing systems. However, to effectively exploit information derived from disparate data sources, it is necessary to introduce consistency of content through guidelines to data providers for the appropriate characterization of the observing systems and their derived products. Ultimately, consistency can be provided through standardized “best practices”.

The “Inter-calibration scenario” session aimed at generating interactions across the GEO Community to identify standards and best practices for: calibrating and validating sensors. A dialog was led to determine what is needed to characterize sensor capabilities in a manner which satisfies GEO needs. Furthermore, discussed was how the Architecture Implementation Pilot can facilitate the CEOS Cal/Val Portal, as well as how the Cal/Val Portal can contribute to meeting the objectives AIP.

The coordination of the following related GEO tasks with CEOS WGCV (Committee on Earth Observation Satellites, Working Group on Calibration and Validation), was discussed: DA-06-02 (Data quality assurance strategy for space-based and related in-situ observations), CL-06-02 (Key Climate Data from Satellite Systems), DA-07-04 (Sensor Web Enablement for In-Situ Observing Network Facilitation), DA-07-05 (Higher Level Data Product Tools), and WE-06-02 (Space-based Global Observing System for Weather).

The efforts of WGCV towards refining the GEO Data Quality Framework were summarized, as follows. Over the past three years, the CEOS WGCV, in conjunction with participants in DA-06-02, has

developed a Data Quality Framework (DQF) for GEO. The CEOS Cal/Val Portal, a prototyping activity designed to test and refine the guidelines presented in the DQF, has been instituted under ESA sponsorship. This activity is an extension of the historic (and extensive) participation in the WGISS Test Facility (WTF) by WGCV. This task was the principle topic of the GEO-CEOS Quality Assurance Workshop held at the GEO Secretariat in Geneva last October. A follow-up workshop is to occur at NIST in Gaithersburg, Maryland during the first week of May. A scenario involving the use of a common Antarctic Cal/Val site (Dome C) for selected optical and microwave observing systems from several national agencies, was introduced at the Joint WGCV/WGISS Plenary held in Sanya China during the last week of February.

The participants were introduced to GEOSS architecture, information flow, and WGCV's contribution to GEOSS architecture. Role of WGCV, as stated, is to provide integrated data for decision models. Since inadequate integration of data sources can lead to disparate model outcomes and uncertainty in the decision process, it was stated that establishing Calibration and Validation guidelines is a necessary ingredient in achieving Data Interoperability.

Dr. Ungar stated that WGCV have outlined in a "White Paper" a proposal, to establish Calibration and Validation guidelines, to ensure effective interoperability of GEOSS member satellite data sources, based on the current space agencies collaboration agreements, common formats and standards. WGCV proposes that all GEOSS partners participate in the establishment of the following common practices: Document the methodologies used to derive and further process satellite measurements; Create and maintain, in conjunction with WGISS, an internet-accessible information database containing, on an instrument or satellite basis, links to all instrument characteristics needed for insuring inter-operability; Provide/publish Cal/Val reference methods in a readily accessible form. These activities will ensure that the various data are integrable. The approach outlined in the WGCV White Paper entitled "Data Quality Guidelines for Satellite Sensor Observations Relevant to GEOSS: Calibration and Validation Issues" has been crafted to ensure the quality assessment of space-borne instrument data in the context of a service driven global operational Earth observation remote sensing system.

This approach exploits ongoing work and available expertise among the CEOS working group members, and provides a mechanism for further development over the 10-year timescale of the GEOSS Implementation Plan.

Dr. Ungar summarised the findings from the workshop breakout sessions, as follows: The quality assurance strategy targets a narrow spectrum of users - end users are actually the providers. Validators would tend to focus on source and quality of data. Of importance was stated to encourage connectivity between Users and Providers, interactive feedback and between models and data providers. The need for establishing common approach to producing data used for inter-comparisons was stated.

Key data were characterized as: 1) Static data - consists of "best practices" documentation and observing systems descriptions/characterizations; and tentative data - consists of initial deposits of observations of validation sites and preliminary calibration parameters/coefficients

Frequently mentioned concerns have included: timeliness (from real time to paleo-data); access to initial data restricted to Cal/Val participants; traceability absolutely required; common practices in processing highly desired; and full disclosure if you wish to participate.

The mechanism for data distribution was described as follows: CEOS-GEO Cal/Val Portal provides entry point for inter-comparison data resides on provider's server, the portal hosts forum to provide feedback.

The need of test cases was expressed, to encourage providers to acquire data from a subset of proposed CEOS WGCV validation sites and supply these data to the CEOS-GEO Cal/Val Portal for evaluation purposes. Stated was the CEOS/WGCV decision that the: "*Initial test site be Dome-C in Antarctica … multiplatform, multi-national and multi agency"*.

**3. International collaboration for on-orbit SI traceable measurements** *(Fox)*

Dr Nigel Fox, Optical Technologies and Scientific Computing Team. Quality of Life Division, NPL, UK presented an update on the efforts toward establishing on-orbit SI traceable measurements. Described were the proposed "Benchmark missions to meet the needs of climate and land surface imager constellation".

**Climate action A5 (responding to GCOS):** ***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.***

In 2002, an NPL led a team (largely from CEOS IVOS) have submitted a proposal TRUTHS (Traceable Radiometry Underpinning Terrestrial- and Helio- Studies) to open ESA call. Benchmark mission is proposed to provide SI traceable measurements of incoming solar irradiances (total and spectrally resolved and reflected spectral radiances (0.01 to ~ 0.3% respectively). The goals include transferring its in-flight calibration accuracy to other sensors via calibrating a set of ground targets and the moon.

Under the NRC, US decadal survey 2007 similar mission CLAREO is being considered as one of four missions under consideration by NASA. Traceability to SI in orbit is key to *avoid high risk strategy needing data overlaps and instrument degradation.* Operationally can provide calibrations to other dedicated EO missions.

In a workshop in July 2007 were detailed the requirements and options. Ideally it will include 3 satellites (2 for IR, 1 solar reflective). International collaboration is required to implement it. TRUTHS was baselined to provide solution for solar band

**Required satellite accuracy/stability** (over 10 yrs) **for Climate change detection:** Total solar Irradiance <0.02 %, Solar spectral Irradiance <0.1 %, Earth reflected spectral radiance (380-2400 nm) <0.5 %, Emitted (brightness temp) to ~100 µm 0.1 K. LSI constellation requirement is <~1%.

It was stated that only a reliable (low risk) solution is to establish robust traceability to international agreed standards "SI units" in common with other terrestrial applications but must have traceability "in flight".

**Status of benchmark missions: CLARREO & TRUTHS**

With the benchmark missions calibration drift (spectral and gain) will be removed by performing calibrations in space directly against a primary standard using terrestrial methodologies adapted for space.

CLARREO's baseline concept is for IR to be global sampling, solar reflective to be targeted sampling and cross-calibration. Mission development studies are managed by Dave Young at NASA Langley. Mission optimisation includes: spectral, orbits, intercomparison strategy, sampling. Concept development includes: FTIR, blackbodies, (concentrating on IR domain).

CLAREO: CLimate Absolute Radiance and Refractivity Observatory

Goals: Support of in-flight monitoring to maintain and validate traceability of spaceborne instrumentation; 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 has been done in laboratory conditions. Scale realization and AIRI/FTS internal comparisons were accomplished in 2007. Validation via comparison with other NMI's including PTB (Germany), NPL (UK) and NRC (Canada) is in progress (to be finalized and reported in 2008). In 2008 is planned to finalize CLARREO's design and proceed with CBS3 construction. A cooperation between the School of Engineering and Applied Sciences (Harvard University) and Space Science and Engineering Center (University of Wisconsin-Madison) is aimed at development of self-calibrating spaceborne blackbody – a demonstration study is planned for accomplished in 2008.

TRUTHS: Traceable Radiometry Underpinning Terrestrial- and Helio- Studies

Baseline concept exists. Primary standard (cryogenic radiometer) under design/engineering model build (NPL (UK) and WRC (CH) (testing in 2009/10). Promoting the concept (seeking resource to optimise and launch) BNSC have indicated interest in seeking ways to support! His is timely, considering the new UK space strategy

development of implementation plan. This is a satellite mission with the objectives 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; and Supporting measurements of land processes, ocean colour, Earth radiation budget, atmospheric chemistry and aerosol distribution.

The mission would conducts Earth/Moon viewing in a wide spectrum (380 to 2500 nm), at spatial resolution ~ 25 m (multi-angle) and spectral radiance uncertainty <0.5% (using novel in-flight calibration system). The mission and calibration concept is demonstrated in the virtual world "Second life" at http://slurl.com/secondlife/NASA CoLab/244/110/23. TRUTHS "International Standards laboratory in space" removes uncertainty due to storage, launch and degradation and its mission provides this benefit, together with SI traceability, to all other EO optical sensors in the solar spectral domain.

**SI traceable absolute reference targets**

The set of proposed SI traceable reference targets include: Sun, Moon, network of ground sites. He concept utilises terrestrially implemented techniques and technology. The in-flight calibration concept is applicable to other missions. Its application can result in an order of magnitude improvement in measurement accuracy. It could provide a baseline for detection of climate change and reduce/relax the need for overlapping data sets.

The Quality Assure data should be used by 'decision makers' to describe the confidence in their decision process. The QA data can significantly improve the synergy between sensors. It provides the required tools to underpin GMES and GEOSS initiatives. Improved algorithms are required to allow quantitative measurement of bio-physical products. The efforts would provide data to improve understanding of natural solar induced variation on climate and compare with anthropogenic effects.

**Way forward**

As a first step was suggested to establish international collaboration based on climate requirements and the Land Surface imager constellation. To initiate the implementation of the QA strategy was suggested to design a study to optimise operational and detailed instrument requirements (baseline costing): IR (NASA supported), TRUTHS (BNSC/ESA), and CEOS SIT (project) ~£50 to 100k (6 months). It is also required to establish priority need and consequential funding proposal as "CEOS mission". With regard to that was proposed, as a WGCV recommendation to **CEOS plenary, that "***CEOS agencies endorse the concept of establishing a "CEOS calibration mission" through a collaborative international partnership to address the specific needs of Climate Action A5 and the future ongoing calibration needs of GEOSS. As a first step towards such a mission, resource is requested to support a small design study, focused on the TRUTHS concept to establish a "straw-man" as a basis for international collaboration".*

## 4. Calibration support to Constellations - the DMC experience *(Mackin)*

During 2002-2003 SSTL launched a constellation of small satellites for Disaster Monitoring (DMC). The presentation covered its calibration, some of the methods used, problems encountered and findings.

The DMC idea was developed in 1990's. The constellation is based on low cost micro-satellites owned as individual assets (by countries and commercial organisations). The satellites are utilized in constellation to maximise use of resources. Obviously this therefore requires some form of cross-calibration between sensors. It is a popular concept as the unused capacity is made available to the rest of the constellation for commercial contracts, also it increased temporal resolution, and generates redundancy in multiple platforms and ground-stations. Priorities of the constellation are Disasters - National, Partner, Commercial. The original constellation was four phased in orbit to give continuous overlap at equator, so can hit any point on the earth within 24 hours (more at higher latitudes). Sun sync orbit. Beijing-1 has been put into a slightly different orbital plane, so often overlaps with other satellites of the constellation, which is a major advantage in the cross-calibration.

**DMC description:** These are small satellites that are simple in design, but carry a band-set which has been the basis for applications development for more than 20 years. The aim is to make them at low cost to broaden the possibilities for nations wishing to have their own space capability. Currently, DCMii is designing

and launching enhanced DMC's and expect the constellation to grow significantly in the next five years, to the point that there may be 8-10 satellites in constellation.

A change in capabilities was noted. The newer satellites are agile, older satellites use a gravity-gradient boom…which has impacts on the calibration. Also attitude pointing control is limited although attitude knowledge is reasonable on the older satellites. DMC has 10,000 per band, two banks so 20,000 detectors in total per image band. The spectral bands are similar to the old SPOT bands 1, 2 and 3 and Landsat 2, 3, and 4. The filters for each band are produced by Barr Associates to have the same characteristics as Landsat ETM 2, 3 and 4. Total FOV is plus minus 26 degrees with 32m GSD at nadir. For calibration three types of images are collected: dark (deep space and Pacific Ocean at night), white (snow – Greenland and Antarctica) and absolute (RRV). In the NIR the sensors are more sensitive to snow conditions, while in VIS its possible ozone contribution could cause issues.

Dark images: Dark current is calculated on-board and subtracted (like MERIS OCL). However there is a residual feature pattern – a consistent residual that does not vary with integration time and is the same for deep space and Pacific at night. Hence for our older satellites we can use Pacific at night images.

Absolute Calibration Images: DMC have used the small footprint site at RRV. All data is processed by RSG in Arizona using the reflectance method. Last year several images over RRV were taken without ground teams and now the effects of using the automated on-site equipment on the calibration coefficients are examined. Using the 9 values (pixels) at RRV the range of values from each pixel are estimated and hence the uncertainty in terms of the variation, pixel to pixel within the array related to noise outside that from the surface measurements and atmosphere, such as shot noise and dark current noise. The rms error were reported in the order 1% of the signal level.

White Images: For the calibration is needed a broad, homogeneous, flat, well-characterised target that can be hit regularly that is very bright. DOME-C site in Antarctica is the primary. It is a very high flat plateau, with stable snow conditions, instrumented year round, and it is used by AVHRR and SPOT-VEG. Cross-array response is fairly constant, so the calibration can be transferred successfully. The focus are not the absolute units, but the uniformity of the response. There are already nine pixels with absolute calibration, so next is to make sure the rest are related uniformly to the nine calibrated pixels.

**DMC Calibration Stability**: To address this for all the Antarctic images was carried out an exercise to confirm that the band to band relationships are stable (DMC is concerned about some of the vegetation data products). So a ratio the spectral bands was derived, for all calibration images collected. In theory if the calibration of any single band is changing then the band ratios will change accordingly. However, if all bands change together obviously we can't detect this absolute change (hence the continued need for absolute calibrations), however we can detect the relative changes if they occur. Over 100 scenes were analysed (cloud free selected) and were reported variation of less than 0.34% r. m. s. across three years period.

Some problems identified during the manual QA/QC process: Residual vertical striping - There is a drift between the odd and even detector readouts that has increased by 0.35% over two years, it is primarily related to changes in the electronics. The dark current is removed on-chip by taking an average of the odd and even hidden pixels, due to the obvious differences between the processing chains it causes a small offset that can be seen to increase temporally during an image acquisition, hence there is a temperature dependence. Only affects old imagers - older images use a correction based on the average value. Also, a more recent problem with one satellite which is switched on just after passing through the SAA to collect images of the Amazon rain forest. On analysis it looks like a gain change on two bands on one bank of imagers. It produces a large offset between the odd and even detectors that shows visible striping. It only happens over the Amazon. Can be compensated by using the expected radiance values from the unaffected bank of imagers.

**Conclusions:**

Discussed were the future launch plans for the DMCs, needs and other activities.

Four new satellites are being launched in 2008/2009. For calibration will be used the well-calibrated "Gold" standard at RRV, and will be done based on 6-10 vicarious calibrations over RRV per year of a stable satellite

(UK-DMC). The satellites will be cross-calibration over Antarctica (especially of satellites launched in October 2008).

Needs: 1) there is a need of a Southern Hemisphere site used in the same manner as RRV (short term); 2) automation with more sites would make life much easier (medium term); 3) TRUTHS like approach would really reduce the uncertainty in the vicarious calibration process.

### 5. SPOT Cal/Val at Dome C site *(Henry)*

The CNES representative, Patrice Henry, presented a summary of the CNES calibration efforts over Dôme C site (Dôme Concordia, 75°S-123°E, Antarctica). Presented were the methods, operational procedures and was discussed the accuracy.

1) General description of the method: The method uses observations of stable snowy sites at high altitude (3200 m), with high accessibility (6 to 7 times a day) but limited to austral summer months. Depending on the data and goals there is either Multi-temporal calibration and/or inter-sensor calibration
2) Operating procedure: Systematic acquisitions are collected from mid-November to beginning of February. Due to the low amount of atmosphere, aw weak gaseous absorption correction (mainly O3) and no aerosol correction are required.
3) Accuracy: The accuracy of multi-temporal calibration is 1%, of sensor cross calibration: 1 - 2%. The procedure is in operational use for *VEGETATION* and in progress for PARASOL.

### 6. The Moon as a CEOS Radiometric Stability Standard *(Stone)*

Thomas C. Stone, U.S. Geological Survey, Flagstaff AZ, USA presented a proposal for using the Moon as a CEOS Radiometric Stability Standard.

**Introduction**:

Climate-quality EO data from solar-band radiometers require calibration stability of 1% over a decade (e.g. NISTIR 7047 — surface albedo). It is required for tracking performance changes in sensors and on-board calibration hardware at this level is a significant challenge at these wavelengths. The Moon presents a source of solar-reflected radiance that can be viewed by all Earth-orbiting spacecraft instruments. The lunar surface is exceedingly aged, thus providing favorable reflectance properties, such as smooth reflectance spectrum and photometric stability better than one part in108 per year (Icarus 130, 323-327). The inherent stability of the Moon is key to its use as a calibration source. It allows durable modeling of its variations in brightness (phase, non-uniformity, **...** ). In addition, lunar calibration is realized through use of a photometric model, which enables precise sensor response trending using a series of Moon observations, enables back-calibration using past observations, and enables cross-calibration of instruments having similar passbands.

**Lunar Model Development**

To attain adequate precision in the prediction capability of a lunar model, an extensive set of basis observational data is needed. It took >4.5 years, to capture the Moon's periodic behavior (JAOT 13, 360-375). Acquisition of an observational dataset, and substantial advances in lunar model development have been accomplished by the lunar calibration program at the US Geological Survey in Flagstaff, Arizona, under NASA sponsorship.

The USGS lunar model (ROLO model) involves the quantity of spectral irradiance. It is derived from spatial integration of Moon images, providing an advantage of increased signal-to-noise resulting from sample (pixel) summation. The model was developed empirically; observational data were fitted to ~1% mean absolute fit residual. This fit residual value (~1%) is an indicator of the model relative precision for predicting the variations in the Moon's brightness over the full range of geometric variables (phase and lunar libration), which is effectively independent of the absolute scale.

The SeaWiFS experience using the capability of Lunar Calibration was described. The SeaWiFS has observed the Moon >180 times, ~monthly since 1997. Comparison of a series of Moon observations against the lunar model reveals changes in sensor response over time. The series of SeaWiFS Moon observations, corrected

by USGS lunar model results, show monotonic degradation trends in all 8 bands. These data were fitted with exponential/ polynomial functions to model the trends. Time-dependent calibration corrections were derived from fitting the lunar observation data — the corrected response trends for the SeaWiFS bands are flat to 0.05% per 1000 days (Applied Optics 43, 5838-5854).

The WGCV Quality Assurance strategy (GEO Tasks DA-06-02) encompasses the need to evaluate sensor performance against an agreed reference. Calibration measurements and procedures need to demonstrate traceability to an internationally agreed reference standard (SI standards preferable). Documentation of the calibration activity provides evidence to support the claim of traceability.

Lunar calibration relevance to the WGCV QA strategy**:** The Moon provides an ultra-stable solar diffusing source that can be viewed by satellite instruments in orbit. Deriving sensor radiometric stability from Moon observations requires a model and special methods — these have been established. Comparison of lunar model results has a demonstrated capability to meet the calibration stability requirement for climate for solar-band instruments. Underpinning this capability is the inherent stability of the Moon. The Moon can provide a reference standard for radiometric calibration stability.

**Proposed Recommendation:**

It is proposed that the Moon should be a CEOS-endorsed reference standard for stability in calibration of radiometric instruments in the solar-reflectance wavelength range.

Considering the requirement that accompanying a calibration reference standard are documented procedures for its use, an established technique exists that enables calibration stability with high precision using a time-series of observations of the Moon.

**Implications for Earth Observation Satellites**

Endorsing the Moon as a reference standard for stability would cause effects on flight operations. Scheduling dedicated observations of the Moon at regular intervals would be required. It is recommended once per month (provides consistency in phase angle). For post-launch check-out are recommended many observations, to establish baseline sensor response. Instrument and spacecraft design would need to have the ability to view the Moon, preferably through nadir-view optics (for LEO spacecraft this normally requires an attitude maneuver), or a space-view port, e.g. MODIS. To be considered are possible scan mirror angle dependency and the limitations in spacecraft roll adds view opportunities.

### 7. Study of MODIS Calibration Stability Using a Ground Target *(Xiong)*

*Dr. Xiong*, Sciences and Exploration Directorate, NASA/GSFC, USA presented a case study of using Dome C as a CAL/VAL site. Additional contributors included: A. Wu (NASA/MCST), B. Wenny (NASA/MCST), and C. Cao (NOAA).

Background: Ground targets (or any targets other than on-board calibrators) are used to support on-board calibration, for independent validation and stability monitoring, sensor inter-comparison.

Requirements for a ground “calibration” target include: uniformity and radiometric stability (minimum environmental impact), site accessibility, ground measurements of radiometric traceability , and data availability.

Dome C is located on the Antarctic Plateau (75.1 S, 123.4 E). It is one of the most homogeneous land surfaces on earth in terms of surface temperature and emissivity. It is characterized with uniform reflectance; high altitude ~3200 m; minimal slope ~0.004%; extremely dry, cold & rarefied atmosphere; and surface temperature range of ~200-270 K

An automated Weather Station (AWS) is in operation at Dome C since ~1995 providing 10-minute averages of meteorological parameters (T, RH, WS, WD, P).

Applications for thermal emissive bands and for reflective solar bands were provided using MODIS and AIRS data. Issues and Challenges for spatial, spectral, temporal, environmental, high-quality ground measurements were discussed. Concluded was that a better ground BRDF model is needed.

**8. CEOS Atmospheric Composition (AC) Constellation** *(Hilsenrath, Langen and Zehner)*

The report on the CEOS AC Constellation was delivered by Ernest Hilsenrath (NASA Headquarters).

1) Background: CEOS has agreed to provide the space component for GEOSS and deliver data to meet the GEO SBAs: http://www.earthobservations.org/about/about_GEO.html. The Atmospheric Composition (AC) Constellation is one of four pilot projects to bring about technical/scientific cooperation and collaboration among space agencies that meet GEO objectives and also support national priorities. The AC Constellation study will identify mission(s) or data delivery that serves the science and application community that can be advocated by the CEOS agencies (NASA, ESA, CSA, NIVR, NOAA, Eumetsat, JAXA, etc). The AC Constellation study will prioritize user requirements and define missions or a "virtual" system consisting of space and ground segments including archives that meet user requirements. The AC Constellation considers only the space component of atmospheric composition science and applications, but recognizes the need for complimentary ground based measurements and modelling to fully address science priorities

2) Goal: The AC Constellation goal is to collect and deliver data to develop and improve predictive capabilities for coupled changes in the ozone layer, air quality, and climate forcing associated with changes in the environment.

3) Current status: Requirements for Atmospheric Composition measurements have been developed by national and international agencies and panels – e.g. NAS Decadal Survey, NASA Science Plan, USCCSP, CAPACITY, IGACO, GMES. These are mature and are supported by CEOS agencies in ongoing mission definition studies.

Atmospheric Composition supports five of the nine GEO SBAs: Health, Energy, Climate, Hazards, and Ecosystems. Specific users include: forecasting - National weather and environmental protection services; monitoring and assessment - Montreal and Kyoto Protocols, IPCC, WMO/UNEP, CCSP, PROMOTE (GMES), and collaborators and participants. The developing of the NASA Science Plan recognizes that partnerships are essential "...because of the complexity and breadth of these issues and that the atmosphere links all nations". NAS DS also recommends: "…leverage international efforts, teaming...missions…data access".

The participants with major assets for AC missions include: USA: NASA (Lead), ESA (Co-lead) and as participants USA: NOAA, .Netherlands: NIVR, Canada: CSA and MSC, France: CNES and Eumetsat, EU/GMES, Japan: JAXA, China: NSMC, CSSAR and CAST.

The currently existing AC space capabilities include: Aura, Envisat, ACE, ODIN, CALIPSO, Cloudsat, Terra/MOPITT/CERES, Aqua/AIRS/CERES, POESS/SBUV-2, POLDER, Metop/GOME-2/IASI. Some of the upcoming approved AC space capabilities include: OCO, GLORY, NPP/NPOESS (aerosol and ozone, no chemistry), EarthCARE, ADM-Aeolus, GOSAT, FY-3/SBUS-TOU, SWIFT, ESA EE Pre-Phase A: TRAQ (AQ), PREMIER (UT/LS), and A-SCOPE ($CO_2$). Currently under consideration is the use of high resolution multispectral nadir and limb imagers in coordinated orbits: GMES and NAS DS, NASA Mission Concepts for LEO, GEO orbits.

4) Plans for AC constellation implementation: 1) Establish a framework for long term coordination among the CEOS agencies where the "Constellation" concept will identify specific opportunities for meeting science and application requirements. 2) Assemble international Study Team consisting of CEOS Agencies with Atmospheric Composition interests and assets and authorized to commit resources. 3) A complimentary advisory group from science and application community will be established to insure the appropriate requirements are being considered. The advisory group will participate in establishing the constellation priorities. It will evaluate existing and upcoming missions, both operational and research and compare with requirements; develop a consensus for priorities based on and established user requirements and emerging societal needs from both operational and research communities; establish how existing and approved missions could work synergistically to meet the international user community requirements and in particular the GEO Societal Benefit Areas; define enhancement in the area of cal/val, quality control, and data accessibility and

interoperability, major rolls for WGISS and WGCV (ACSG and GEO/CEOS Cal/Val WS); develop rationale, strategy and standards for new mission(s) to meet requirements not being met and for possible new requirements. The strategy should include architecture, schedule, and possibly costs.

5) The first ACC Workshop, March 2007: The participants agreed on the AC Constellation concept and its objectives, on the space agencies and users to participate, on the specific goals and projects – near, mid and long term. Near term objectives (available today or very soon, and where collaboration concentrates on the refinement, use, access to and distribution of existing data products) target the development of combined and synergistic data set. Medium-term goals (feasible within a few years, where collaboration extends to product specification and interoperability) focus on the generation of improved data products and the definition of new mission architecture leading to a Constellation. Long-term plans (achievable within about ten years after original constellation concept is agreed on) target the agreement on the implementation of a Constellation and its architecture. The AC Constellation proposed to provide CEOS with a project, a demonstration in time for GEO Summit, November 2007. Currently the ACC work plan is in preparation.

6) ACC Definitions Studies: NASA has established the Systems Engineering Office to support all four Constellations. It will evaluate requirements, identify missing components, and evaluate end-to-end requirements for Constellation architecture.

ACC assessment is on the way to prepare a report on the ACC system priorities and requirements, to include "standards" (RT/algorithm, end-to-end cal/val, data interoperability). A preliminary assessment and gap analysis report is assessing existing and near-term planned ACC missions against system requirements.

7) Near and Mid Term ACC Projects: CEOS is very anxious to demonstrate the Constellation capabilities in time for GEO summit – Nov 2007. ACC is proposing near and medium term projects emphasizing synergistic and enhanced data products from multiple missions which include also a component for outreach and capacity building (all major GEO goals).

Project 1: High-quality tropospheric ozone products using two methods will be compared with each other. Total column ozone from TOMS, GOME, SCIAMACHY, OMI, GOME-2 minus stratospheric column ozone from SAGE, SCIAMACHY, MIPAS, MLS. Assimilation/ joint retrieval of radiances measured by nadir UV sensors and nadir IR sensors (AIRS, TES, IASI).

Project 2: Air-Quality assessment from multiple instruments for improved forecast and assessments. Envisat/Metop in morning orbits, Aura/Aqua/Parasol in afternoon orbits. They provide twice daily coverage for reflected sensors, four times for IR sensors. Provide diurnal variation of tropospheric species. CALIPSO/CloudSat provides 3-dimensional view of clouds and aerosols to help in the interpretation of AQ data (BL height, transport). Demo will be developed using $NO_2$ from SCIAMACHY/GOME-2 and OMI.

Project3: Assemble and array of AC products being developed CEOS agencies for near real time distribution. Products relevant to GEO SBAs and meet the following criteria; Availability, Quality and Functionality. A user workshop will be assembled to define data enhancements and distribution.

Project 4: Develop a global data product for fires and aerosols. This project will make use of the IDEA (Infusion of Satellite Data for Environmental Applications) project which is now operational http://idea.ssec.wisc.edu/). Extending the capability of developing fire, aerosol, and subsequent forecast guidance products for global operational purposes can use the IDEA prototypes and apply to multiple platforms.

Project 5: Long-term aerosol data set. Project will employ several international satellites where aerosol properties are measured in different ways with some overlap. Data will be of value for climate modeling, pollution inventories, and monitoring. Ground based observations will play a key role in validation and providing additional aerosol parameters.

8) Anticipated Constellation Benefits: The synergies provided by the Constellation should substantially improve accuracy and coverage of satellite data and result in improved Atmospheric Composition science and application capabilities. The Constellation would serve as an international scientific forum for debating priorities and formulating future Atmospheric Composition missions. It provides an opportunity for participating space agencies to cooperate in planning, developing, and operating future missions. The Constellation would allow for an efficient response to new requirements as the Earth system responds to climate change.

# ***Session 3*: WGCV Reporting to CEOS**

WGCV Reporting to CEOS includes the Update/Generation of New WGCV Action Items and Recommendations to CEOS *(All, Campbell, Cao)*

## 1. Current WGCV Action Items

During the WGCV-28 a number of new action items were generated, in addition to 3 action items remaining open from previous WGCV meetings, as listed in the following table.

| | | |
|---|---|---|
| WGCV26-1 | **WGCV Secretariat** to maintain a "WGCV suggested cal/val practices" web page, populated with the materials generated by WGCV. The materials will be transferred to the Cal/Val Portal. | Ongoing |
| WGCV27-1 | **WGCV Subgroup Chairs** (SG) to review with the SG members the *list of GEO tasks in which WGCV is participating* (WGCV Sec. will distribute updates), and to generate a summary of the activities in which the members are participating, relevant to the listed GEO tasks. | Ongoing |
| WGCV27-2 | **WGCV Secretariat**, to contact the CEOS constellation leads and request that the constellation teams evaluate their cal/val requirements. | Ongoing |
| WGCV28-1 | **WGCV Secretariat and Chair**, to review and update the table of WGCV 2008 deliverables for GEO/CEOS-SIT (ftp://uranus.eo.esa.int/pub/ceos/CEOS-GEO Work Table). | March 7 |
| WGCV28-2 | **All GEO task action leads**, deliver results by the agreed deadlines, and include an update on the task action in their reports at WGCV29. | WGCV29 |
| WGCV28-3 | WGCV agencies need to ensure resources are available and in some cases specific datasets, if the Global DEM task is to succeed. Specifically, some CEOS member agencies need to ensure that resources are made available for support for validation services (e.g. NASA to support GSFC to offer an ICESAT/GLAS validation service) and that other CEOS agencies (JAXA for ALOS-PRISM, ISRO for Carto-DEM, DLR for SRTM-X and TANDEM-X and CNES for SPOT Image Reference 3D) non-ASTER to be provided for (a) gap-filling ASTER-GDEM; (b) validation (EO-DEM data for up to 200 1 x 1 degree cells). | WGCV29 |
| Follows from above | JAXA to provide validated DEMs for sites on other continents (e.g. Africa, South America, Asia, Australasia, Antarctica) which can be established in different land covers and employed for validation of ASTER and final Global DEM | J-P Muller, to provide a list with coordinates |
| WGCV28-4 | NOAA to provide the ASIC3 report (or a link to it), to be posted by the WGCV Secretariat on the wgcv web site. | WGCV29 |
| WGCV28-5 | WGCV/SGs, to consider the identification of *Fundamental radiometric reference standards* and guidelines for long term global EO. | WGCV29 |
| WGCV28-6 | WGCV/TF (S. Mackin (DMCii) - POC, Kartikeyan (India), Gu and Tang (China) and NOAA (Weng, Cao) establish criteria for endorsement of WGCV/SG guidelines. | WGCV29 |
| WGCV28-7 | WGCV Sec., report of achievement to CEOS/GEO: WGCV/SAR establishing calibration specifications for Polarimetric SAR. Add on WGCV web site relevant publications/reports (or link to them). Addressing DA-06-02. | March 7 |
| WGCV28-8 | USGS (Stensaas and Chander) provide summary (1 p.) to WGCV Sec. on the cal/val sites for EO. | WGCV29 |

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|---|---|---|
| WGCV28-9 | USGS (Stensaas and Chander) provide to WGCV Sec. 1 page summary on the comparison of Landsat cal/val methods. | WGCV29 |
| WGCV28-10 | WGCV (USGS, Stensaas and Chander) to provide a list of potential calibration sites to the LSI Constellation Study Team. LSI compilation of cal/val sites would be part of an effort to define sites (environmentally sensitive, calibration, geohazard, etc.) that the agencies currently flying mid-resolution optical systems would agree to acquire (and make available) data over on a regular basis. Selection of the final list of such sites would be done by the agencies that sign the agreement on Acquisition of Mid-Resolution Data. Sites offered/proposed by the WGCV will receive priority consideration by the agencies that sign the agreement. | WGCV29 |
| WGCV28-11 | NOAA(Weng, Cao), to establish coordination between GSICS and the Cal/Val portal to link relevant activities/prototype projects. | WGCV29 |
| WGCV28-12 | **Nigel/IVOS** to generate a formal request for a joint NASA and BNSC Benchmark missions to meet the needs of climate and land surface imaging constellation. NASA to formally request BNSC's collaboration. Meiden and Ungar to help identify NASA/HQ person to contact David Williams, BNSC. (CLARREO, Dave Young NASA Langley and TRUTHS, Nigel Fox NPL) | WGCV29 |
| WGCV28-13 | IVOS (Nigel, Patrice, Cao, Xiong) to define by WGCV29 the protocol (procedures and activities) for CEOS instrument intercomparison exercise at Dome C site, to be conducted in the winter of 2008-09. Recommendation to CEOS requesting for agencies participation (Nigel and Petya to generate specific list of agencies and instruments). | WGCV29 |
| WGCV28-14 | S. Mackin DMCii, provide WGCV Sec. a summary (1p.) on modular QA/QC, for consideration by the SG, and potentially trail during the WGCV 2008-09 winter cal/val exercise at DOME C site. | WGCV29 |
| WGCV28-15 | **MW SG Chair (C. Buck)** to obtain information on scatterometer missions form Eumetsat. | WGCV29 |
| WGCV28-16 | WGCV members, to nominate future WGCV Vice Chair and TMSG Vice Chair. | WGCV29 |
| WGCV28-17 | **WGCV Tec. Sec.,** to help determine the dates of next WGCV29 (set meeting maker). | March 2008 |

## 2. Recommendations to CEOS

**WGCV28 Recommendation to CEOS Plenary** (provided by IVOS)

**WGCV requirement:**

To facilitate the identification of an optimum collaboration for implementation, requires a detailed design/optimisation review of the TRUTHS mission concept. This would result in a full set of instrument specifications optimised for functionality, accuracy and ability to establish traceability in-flight. Such a study would also consider the operational aspects of such a mission e.g. how best to transfer its calibrated spectral radiance values to other sensors with a particular emphasis on the mission ground-segment.

**Recommendation:**

CEOS agencies endorse the concept of establishing a "CEOS calibration mission" through a collaborative international partnership to address the specific needs of Climate Action A5 and the future ongoing calibration needs of GEOSS. As a first step towards such a mission, resource is requested to support a small design study, focused on the TRUTHS concept to establish a "straw-man" as a basis for international collaboration.

**WGCV follow up Action:**

CEOS WGCV IVOS sub-group to provide support to the study and ensure coordination with the broader CLARREO mission. Following the completion of the report the IVOS sub-group will identify potential collaboration opportunities between members based on the reports findings.

## 3. Date and Place of Next Meeting

The forthcoming WGCV-29 meeting will be hosted by Frederic Baret, LPV Chair, and sponsored by CNES and INRA. WGCV-29 will be held in September 2008 in Avignon, France.

# Annex A: CEOS/WGCV 28 Agenda

***Dates:*** *February 26-29, 2008*[†] ***Location:*** *Sanya, China* *Hosted by* ***NSOAS*** *and* ***NMRSL***

**Day 1: Tuesday, Feb. 26, 2008**

8:15 Registration

## *Session 1: Welcome and Introduction (WGCV and WGISS joint session)*

8:30 Introduction/Adoption of Agenda *(Cao and Maiden)*
8:40 Welcome and a General Introduction to China's Space-Based Earth Observation System *(Prof. Jiang, NMRSL/CSSAR/CAS)*
9:25 Introduction to the Satellite Programs of the State Oceanic Administration of China *(Prof. Jiang, NSOAS/SOA)*
9:55 China's Meteorological Satellite Programs *(Prof. Zhang, CMA)*

*10:30 - 10:45 Break*

10:45 Prioritizing GEO/CEOS Tasks/Resources for the Working Groups *(Petiteville, CEOS CEO)*
11:05 WGCV/Terrain Mapping subgroup report and WGCV&WGISS joint support *(Muller)*
11:30 Infrared and Visible Optical Sensors *(Fox)*

**** WGCV&WGISS Joint Session will reconvene on Thursday afternoon and Friday)****

*12:00 - 1:00 Lunch*

## *Session 2: CEOS IP – Progress reports*

1:00 WGCV Chair Report *(Cao)*
*The chair will review the progress made since WGCV27, as well as other CEOS activities. The current CEOS IP and GEO tasks addressed by WGCV will be introduced.*
1:30 Minutes from WGCV27 and Status of Current Action Items *(Campbell)*

***Session 2.1: Subgroup reports*** *(Chairs: Cao, Lecomte)*

*Note: The Land Product Validation (LPV) and the Atmospheric Composition (ACSG) Subgroups will report at the joint sessions on Thursday afternoon and Friday morning.*

1:45 Microwave Sensors *(Buck)*
2:10 SAR *(Srivastava)*

***Session 2.2: Country and agency reports*** *(Chairs: Cao, Lecomte)*
*Please note that as CEOS has become the space arm of GEO and is taking on GEO tasks, the reporting from individual countries and agencies have been greatly simplified. Each country/agency will provide a brief update (15 minute, or ≤ 15 slides) on the latest development/progress made since WGCV27. Contributions to the CEOS/IP or GEO tasks should be identified, and further addressed in later sessions (e.g. CEOS constellation support). Background information presented before can be included in the backup slides.*

2:35 Canada *(Srivastava)*
2:50 China *(Dong)*

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[†] *WGISS25 starts on February 25, one day before WGCV28*

*3:05 - 3:30* *Break*

***Session 2.2: Country and agency reports*** *(Continued)*

3:30 CNES *(Henry)*
3:45 ESA *(Lecomte)*
4:00 IRSA/CAS *(Gu, Zhu)*
4:15 India *(Kartikeyan, IAQD/SIPA)*
4:30 INPE *(Fonseca, Brazil)*
4:45 JAXA *(Imaoka)*
5:00 DMCii *(Mackin)*
5:15 NASA *(Ungar)*

*5:30* *Adjourn*

## *6:30 Welcome Dinner (Kindly hosted by NSOAS and NMRSL)*

**Day 2, Wednesday, Feb. 27, 2008**

8:30 NIST *(Johnson)*
8:45 NPL *(Fox)*
9:00 NOAA *(Weng)*
9:15 Russia *(Burdakin, Panfilov)*
9:30 Thailand/*GISTDA (Nutpramoon)*
9:45 USGS *(Dwyer)*

*10:00 - 10:30* *Break*

## *Session 3: CEOS/IP - Data quality assurance strategy for GEOSS*

*This session addresses the GEO task DA-06-02: Developing data quality assurance strategy for GEOSS*

10:30 GEO task DA-06-02: Current status, activities, issues and plans *(Ungar)*

***Session 3.1: GEO-CEOS Cal/Val workshop: Report*** *(Chair: Lecomte)*

10:50 Overview of first Workshop (*Lecomte*)
11:00 Reports from Subgroup chairs on progress within the subgroup topics
- 11:00 ACSG (*Bojkov*)
- 11:10 IVOS (*Fox*)
- 11:20 LPV (*Baret*)
- 11:30 Microwave (*Buck*)
- 11:40 SAR (*Srivastava*)
- 11:50 TMSG (*Muller*)

*12:00 - 1:00* *Lunch*

***Session 3.1: GEO-CEOS Cal/Val workshop report*** *(Continued)*

1:00 Presentation & discussion on Work plan (*Lecomte*)
1:30 Presentation & discussion on Guidelines framework (*Greening*)
2:00 Workshop #2 preparation *(Greening & Lecomte)*

***Session 3.2: Climate quality calibration for GEOSS*** *(Chairs: Cao, Lecomte)*

*In this session we will discuss projects, case studies, and potential standards towards more stable and consistent satellite measurements. It aims at establishing the link between DA-06-02 and other GEO tasks. It also addresses the climate SBA and GCOS IP actions, including CL-06-01, CL-06-02, and A-5, C-7, C-9, O-17, O-18, and T-4.*

2:30 **GSICS progress update and coordination** *(Weng)*

3:00 **Progress Update on Project 07-01:** Making consistent measurements from MODIS, ATSR, and AVHRR reflective solar bands for generating Fundamental Climate Data Records (FCDRs) (T-4, O-17) *(Xiong/Trishchenko)*

3:15 **Progress Update on Project 07-02**: International collaboration for on-orbit SI traceable measurements (A-5, C-7) *(Fox)*

*3:30 - 3:40 Break*

***Session 3.2: Climate quality calibration for GEOSS*** *(Continued)*

3:40 **Case studies:**

- Antarctic Plateau: A potential CEOS WGCV radiometric reference standard site *(Cao, Ungar, Xiong, Lecomte)*
- Develop a generic model for CEOS SI traceable Cal/Val sites *(Johnson)*
- The moon as a CEOS radiometric stability standard - a proposal *(Stone)*

4:40 **Roundtable discussion:** A review of CEOS radiometric reference standards

- The need for CEOS WGCV standards and standards technical committee
- Coordination with existing standards bodies
- Inventory of potential WGCV standards and documentation issues
- Develop a standards factsheet/handbook. Examples: Spectral solar irradiance for inter-comparisons (IVOS), Microwave sensor Cal/Val sites *(CSAR and MS), etc.*
- Formulate Subgroup Actions *(Campbell, All)*

*5:30 Adjourn*

## Day 3, Thursday, Feb. 28, 2007

### *Session 4: WGCV support to LSI constellation (Stesaas, Bailey)*

8:30 Cal/Val portal and Cal/Val sites for LSI *(Stesaas and Lecomte)*

9:00 Calibration support to Constellations - the DMC experience *(Mackin)*

9:30 SPOT Cal/Val at Dome C site *(Henry)*

*10:00 - 10:30 Break*

10:30 CBERS Cal/Val *(IRSA/CAS (Gu), INPE, CRESDA)*

10:50 JAXA LSI Cal/Val support *(Imaoka)*

### *WGCV Reporting*

11:00 Summary of achievements to be reported to the CEOS Plenary/GEO summit *(Cao, Campbell, All)*

11:30 New WGCV28 Action Items and Recommendations to CEOS *(Campbell, All)*

11:45 Date and time for next WGCV29 meeting *(All, Cao and Baret)*

*12:00-1:00 Lunch*

***WGCV and WGISS Joint Working Session*** *(Chairs: Cao and Maiden)*

1:00 ISRO missions and CEOS participation *(Kartikeyan, ISRO)*
1:30 WGCV/Land Product Validation (LPV) Subgroup Report *(Baret)*
2:00 Introduction to the development of international standards (*Wyn Cudlip, WGISS/BNSC)*
2:20 Ocean sensor Cal/Val *(Tang, SOA/NSOAS)*
2:40 Intercalibration scenario in collaboration with GEO/ADC *(Stephen Ungar, NASA EO-1)*

*3:00 - 3:30 Break*

3:30 Panel discussions: CEOS Working Group joint support to the LSI Constellation *(Maiden, Cao, Bailey, and Stesaas)*

4:00 CEOS Annual Conference: *Goals, Benefits and Discussion of Ideas (Petiteville, CEOS CEO)*

4:30 Joint WGISS&WGCV Recommendations/Requests to CEOS *(Maiden, Cao, All)*

*5:30 Adjourn*

**Day 4, Friday, Feb. 29, 2008**

***WGCV and WGISS Joint Working Session*** *(Continued)*

8:30 CEOS Atmospheric composition constellation: Cal/Val issues and support *(Hilsenrath)*
9:30 Atmospheric Composition Subgroup (ACSG) Report *(Bojkov)*
10:00 Aura Validation Data Center, WGISS Invited Presentation *(Bojkov)*

*10:30 - 10:45 Break*

10:45 **Panel discussions:** CEOS Working Groups - Joint support of the AC Constellation *(Hilsenrath, Maiden, Cao, All)*

**12:00 Closing of WGCV28/WGISS25** *(Maiden and Cao)*

*12:00 - 1:00 Lunch*

*1:00-5:00 Site visit of SOA ground station satellite facility*

# Annex B: GEO Tasks WGCV Participation

| | | | | | | |
|---|---|---|---|---|---|---|
| **Cross-cutting DA-06-02** | **1** | Complete the project assessing the measurement consistency of MODIS, ATSR, and AVHRR and provide recommendations for recalibration | 10/1/08 | J. Xiong | NASA | NASA, ESA, NOAA, CCRS, USGS |
| | **1** | Conduct a joint experiment using the Dome C site for cross calibration. Investigate the feasibility of establishing the Dome C and the moon as CEOS radiometric reference standards, as well as their stability for climate quality calibration. | 10/1/08 | C. Cao | NOAA | NASA, ESA, NOAA, CCRS, USGS |
| | **2** | Develop a CEOS/WGCV standards and recommendations handbook | 12/30/08 | C. Cao | NOAA | All WGCV members |
| | **1** | Develop a consolidated worldwide cal/val site database to be included in the CEOS cal/val portal. Establish a WGCV consensus on uniform cal/val schemes and criteria. Further expand the cal/val portal in both content and functionality | 10/1/08 | P. Lecomte | ESA | ESA, USGS, NASA,NOAA, BNSC/NPL |
| | **2** | Facilitate the coordination on the benchmark measurement missions. Identify POCs from space agencies to participate in WGCV meetings to explore coordination mechanisms. | 12/30/08 | N. Fox | BNSC/NPL | BNSC/NPL, ESA, NASA, IVOS |
| | **1** | Hold the 2nd GEO-CEOS Workshop on cal/val to continue developing the framework, guidelines, and best practices for data quality assurance. | 10/1/08 | P. Lecomte | ESA | ESA |
| Cross-cutting DA-06-04 | **2** | Continue developing the strategy for generating consistent biophysical products from medium resolution sensors. Evaluate global land cover classification at regional scale. Update the BELMANIP, and inter-compare the fAPAR products. Publish the results (Note: to be updated after WGCV28). | 12/30/08 | F. Baret | WGCV/ LPV | WGCV/LPV, CNES, NASA |
| Cross-cutting DA-07-01 | **4** | Further expand the EO data portal, to include fused 30m ASTER-SRTM WMS layers for additional sites, expand the DEM representative set for instrument cal/val and intercomparisons at the cal/val sites (Note: to be updated after WGCV28). | 10/30/08 | J.P Muller | WGCV/ TM | WGCV/TM, BNSC/UCL, JAXA, ESA, NASA, CNES, USGS. |
| Ecosystems EC-06-02 | **3** | Submit report that addresses progress related to *in situ* calibration and validation, reporting and access issues. | 2/29/08 | C. Cao | WGCV | ESA, NOAA, EUMETSAT |
| | **3** | Encourage coordinated development and provide framework for evaluating Global Land Cover products and maps. | 9/30/08 | C. Cao | WGCV | NASA, ESA, GTOS |

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