

CEOS-WGCV-IVOS meeting 27

ONERA, Toulouse, France. 18th – 20th November 2015



Attendees:

See Appendix A

Agenda

See Appendix B

Presentations

Soon from: <http://calvalportal.ceos.org>

And till March 10, 2016 <http://filexch.npl.co.uk/cgi-bin/download.pl?id=rbrcitnzoglvsdppxbzy>

1 Introduction

The meeting was chaired by *Nigel Fox*. Minutes were taken by *Emma Woolliams*. The meeting was hosted by Françoise Viallefont of ONERA.

Nigel Fox reviewed the subgroup's mission, terms of reference, vision and reviewed previous actions. Kurt Thome gave a presentation on behalf of the CEOS-WGCV chair. Xavier Briottet's presentations on ONERA were given on Friday morning but are included here instead.

Presentation	By
Welcome and introduction to the subgroup	Nigel Fox
WGCV Chair's note to IVOS	Kurt Thome on behalf of Albrecht von Bergen
ONERA The French Aerospace Lab	Xavier Briottet
ONERA Airborne sensor facilities (check)	Xavier Briottet

Nigel Fox emphasised that it was important that the subgroup always be written as CEOS-WGCV-IVOS in all descriptions of it.

AP.2015-1	Everyone to review presentations etc that mention this group to ensure that it is written in full as CEOS-WGCV-IVOS.	Next meeting
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Discussion following Xavier Briottet's presentations

The sand BRDF measurements taken 18 years ago had limited spectral points and only from nadir to 60° and not back-scattering. The facility has been developed so it can measure the back scattering – a capability few laboratories have – and there may be interest in remeasuring the original sand samples. There are a lot of ONERA facilities and capabilities and ONERA is keen to work with others, so it is possible for the community to discuss access to these facilities. The spectral database has been developed with support of the French Ministry of Defence, so access to this needs formal agreement, but it should be possible in many cases.

1.1 Review of recommendations from last meeting

R.2014-1	IVOS recommends to INSITU-OCR that they collaborate with and report regularly to IVOS on the aspects of their work relating to the calibration and validation of the sensors.	This has started
R.2014-2	IVOS recommends a research activity with other WGCV WGs and GSICS to develop best practice guidelines on obtaining spectral information and doing the combination of the sensor spectral response with the surface reflectance and the associated uncertainties.	This is still desired, but not much has been done
R.2014-3	IVOS recommends a PICS workshop linked to the next IVOS meeting where results will be presented of a comparison of methods based on a reference data set. This should be organised with GSICS	This happened at this meeting
R.2014-4	IVOS recommends a workshop with GSICS on sensor-to-sensor comparisons held back-to-back with the PICS workshop but distinct from it	A preliminary to this held at this meeting with the proposal for a follow-up initially agency level workshop to define scope
R.2014-5	IVOS recommends a 3-day workshop on pre and onboard calibrations.	This is now being organised as a CEOS WGCV event
R.2014-6	IVOS recommends that WGCV put out a regular newsletter	This is still encouraged, but not yet done looking for a volunteer to lead
R.2014-7	IVOS will have a secret ballot by email to decide on the IVOS vote where votes will count from those who have attended at least two meetings or workshops in the last three years. The process will be reviewed by one other independent person, but otherwise will remain secret.	This was done

1.2 Review of Actions of last meeting

Reviewing the action list from the previous meeting.

Action Point	Action	Status
AP.2014-1	Nigel Fox to update slide of theme areas to make Jeff Czapl-Myers land reflectance theme lead and to correct typing error in "atmospheric correction"	Done,

AP.2014-2	Nigel Fox to organise a teleconference on solar spectra best practice with the aim of defining our requirements and to develop best practice on how to handle different spectra. Nigel to prepare the agenda to ensure that we focus on our needs.	This was not done and needs to be coordinated with WGCV as a whole and GSICS
AP.2014-3	Nigel Fox to chase people with solar spectral to provide data to Alessandro for the calval portal, including data beyond 2500 nm	To follow above
AP.2014-4	Nigel Fox to update the CEOS WGCV workplan document to make clear the distinction between the activities of IVOS and those of specific working groups where there is potential overlap and conflict in cal/val activity.	done
AP.2014-5	Jeff Czapla-Myers to contact Marc Bouvet about the ESA project to obtain PICS sand samples and to discuss ways for other IVOS (and LPV) members to collaborate with ESA on this task.	ESA has now issued an ITT relating to this
AP.2014-6	Marc Bouvet to discuss with WGCV to scope a joint project on spectral combination of surface reflectance and sensor bands	To potentially follow a telecom discussion with GSICS and other WGCV grps particularly LPV
AP.2014-7	Nigel Fox to contact Patrice Henry and ask him to organise a teleconference to define a test data set for comparison activity for PICS and to set up a PICS-workshop with the next IVOS meeting where results of the comparison can be shared	Completed
AP.2014-8	Marc Bouvet to talk with Andreas Hueni about his SPECCHIO spectral database to see if it is suitable to support RADCALNET	Completed
AP.2014-9	Marc Bouvet to talk with Gabriela Schaeppman-Strub about the Namibia albedo tower site and whether this can be used as part of the search for a fourth RADCALNET site	Completed -
AP.2014-10	Marc Bouvet to discuss with CNES and VITO an intercomparison of Rayleigh and Glint methods	Completed - to be discussed on Friday
AP.2014-11	Anyone with responsibility for geo-spatial test sites to provide Dennis Helder with information for the UGSC catalogue of test sites	Further information still desired
AP.2014-12	Sébastien Wagner to send Nigel Fox information about the webex meeting on the lunar calibration workshop and Nigel to distribute it to the group	Completed, workshop happened
AP.2014-13	Emma Woolliams to send everyone a link to the current uncertainties training course so people can be added to the waiting list	Completed – the course will soon be available online, see here .
AP.2014-14	Nigel Fox to discuss with WGCV possible dates for a workshop on pre and onboard calibration	Done but as yet none defined
AP.2014-15	Nigel Fox to add to the GSICS-IVOS interaction list the possibility of joint activity on achieving a common reference for sensor comparisons	Superseded by AP.2015-3
AP.2014-16	Nigel Fox to ensure that GSICS is aware of the dates of our workshops and telecons so that GSICS can participate	Completed

AP.2014-17	Nigel Fox to make sure that there is a way for IVOS SG members to be aware of the dates, times and topic for the monthly GSICS web meetings (send link to allow people to register on the email and newsletter)	Completed – interactions between IVOS and GSICS significantly improved.
AP.2014-18	Nigel Fox to discuss with CEOS-WGCV having a newsletter and a champion for the website and then to request this community for a volunteer to champion the work of the group through the website and newsletter with the support of Alessandro Burini.	Action completed (discussed) – conclusion still needed and WGCV is keen for subgroups to have these
AP.2014-19	Nigel Fox to arrange for the QA4EO secretariat to contact DongHan Lee about building the example presented into a QA4EO case study and to contact Philippe Goryl about building an example based around user needs	Not complete – needs doing
AP.2014-20	All to suggest other case studies for QA4EO	Still needed and ongoing
AP.2014-21	Nigel Fox to arrange a web-based vote for IVOS to choose the IVOS vote for WGCV vice chair and in the invitation for the vote to include the presentations by the two candidates	Completed
AP.2014-22	Nigel Fox to discuss with ONERA and others on the plan for a week-long IVOS meeting and working groups	Completed

2 Vicarious radiometric calibration/validation of land products

Nigel Fox gave a short summary of this morning's and previous days PICS workshop. There is sufficient progress in the individual groups that it is time for some coordinated efforts and agreed we will set up a thematic task group, likely to be led by CNES and in collaboration with GSICS to coordinate the work.

R.2015-1	IVOS recommends to WGCV that it creates PICS task group in collaboration with GSICS and potentially LPV/TM to enhance collaboration and create a common work plan, with the initial focus likely to include the means to improve the characterisation of the sites.	
AP.2015-2	Nigel Fox to organise the formation of a new task group on PICS	WGCV meeting

This was followed by a series of presentations on RadCalNet as it stands today following from the RadCalNet task group meeting held on the previous day at CNES and some potential new RadCalNet sites once it is operational.

Presentation	By
RadCalNet Status	Marc Bouvet
JPL automated site at Railroad Valley	Carol Bruegge
South African artificial target plans	Derek Griffith
Baotou instrumented desert site	Lingling Ma

Discussion after Marc Bouvet's presentation

There is no accuracy requirement defined for a site to become a member or what is to be expected from RadCalNet when operational and it is not, necessarily, expected that the uncertainties currently achieved for dedicated vicarious calibration campaigns will necessarily be improved. However, by being automated, it will allow for a much larger number of match ups to average, which should

reduce any random component (unaccounted environmental) uncertainty. It will also allow measurements over different sites and be readily available to organisations who do not do their own dedicated field campaigns and be a framework upon which harmonisation from cross-comparisons can be encouraged.

Sites have not been reviewed or selected to see if some sites are more appropriate than others for, e.g. different spectral regions. The instrumentation on each site is different (although providing a common minimal set of characterisation data, and the surfaces are different. Not all sites will do the full spectral range from 400 nm to 2500 nm. There will be information on the uncertainties on all sites for all times and for all wavelengths, so users can review this and select for their own application needs.

RadCalNet is still at prototype stage and the initial processes will not be perfect at this stage. Our priority is to make RadCalNet operational as soon as possible with a minimal but robust set of outputs. Techniques and details will be refined after this.

Downwelling irradiance is done in different ways at different sites – based on measurement (e.g. La Crau) or atmospheric parameters (AERONET).

3 Other vicarious calibration methods

This section discussed the lunar calibration workshop and other calibration methods. We finished day one after the first presentation.

Presentation	By
Outcome of the GSICS/CEOS-WGCV-IVOS lunar calibration workshop	Sebastien Wagner
Calibration and drift monitoring of reflective solar bands	Sebastien Wagner

Discussion after lunar calibration workshop presentation

There may be another GSICS lunar workshop organised late next year (2016) or the year after, depending on progress.

If we're going to use the moon as a post-launch target, then we should think about this at pre-launch stage too e.g. to do calibration on a target of the equivalent observed size of the moon for some pre-launch comparison. This has not yet been discussed in many space agencies or within CEOS.

Does GSICS have plans to do something with PICS? (other than the moon being a PICS!). At the moment the activities in the VNIR (to 2200 nm) emphasis is on the deep convective clouds, next will be the moon, then Rayleigh Scattering. The desert PICS will be later, although the long-term aim is to get a blend of methods to get an overall product as each method has different conditions. The nice thing about the moon for geostationary satellites is that it regularly goes into the field of view. Some of the Meteosat satellites have moved their location and no longer see the desert PICS and others never will. The moon is always seen.

The moon can be used for MTF validation, too, though not at the high resolution of other methods.

Discussion after drift monitoring presentation

When switching between MODIS and VIIRS – will there be a step function? There shouldn't be a large one, but there may be a small one. We will need to work out how to address properly the move to the new reference so it is smooth. In the infrared this is being done with a "double transfer".

There was a general feeling that what GSICS is doing is useful for CEOS-WGCV-IVOS and vice versa, the links between the two groups should be increased.

4 Discussion on sharing data and methods

This session was an initial conversation on the need for a communal approach to sensor-to-sensor harmonisation coefficients (and/or calibration coefficient changes). The conversation was wide ranging and brought up many topics where there were differing opinions. This conversation should be considered an opening conversation that highlights some of the topics to discuss; we are a long way off reaching a community consensus view. It is likely that this conversation should be continued in a future day-long workshop.

Emma Woolliams gave a short presentation of questions to open a discussion. The presentation discussed that there were a wide range of techniques used for sensor comparison, calibration and harmonisation – PICS, RadCalNet, natural phenomena (Rayleigh, sunglint, clouds) and other methods. These methods are investigated by the different space agencies and there are workshops and technical meetings discussing these independently of each other (e.g. the PICS workshop held earlier this week). The presentation asked two main questions – how to share the results of these different comparisons in a way that was common and allowed easy “comparison of comparisons” and the potential to draw community wide conclusions on biases and what ‘references’ made sense.

Presentation	By
Conversation on sensor-to-sensor harmonisation coefficients	Emma Woolliams

This discussion followed on from a discussion at the end of the PICS workshop in the context of databases. Patrice Henry had opened that discussion with the statement that “We see in all these presentations similar graphs showing comparisons and degradation, but they are all slightly different”. The results for a sensor may depend on the processing conditions, so should be labelled by, e.g. Collection number. It is also important to provide information on solar models assumed, spectral interpolation (and correction) methods etc. And how the comparison is done (to a reference?, to an onboard calibration?, to other vicarious calibration? degradation since the start?, degradation since a particular time?). Finally it’s important to understand whether the graph shows A / Ref or Ref / A.

Patrice Henry had asked participants how these comparison data were stored (either images over test sites, or comparison results themselves) – CNES uses the Sade database, ESA uses the DIMITRI database, EUMETSAT has an internal database for PICS and for DCC comparisons, VITO has Proba-V comparisons and JPL has MISR comparisons in internal databases. The USGS has a “large database” with comparison information and RAL is systematically collecting data over PICS and other reference sites for comparisons and storing this in a database.

There was a general (but in some cases cautious) agreement that this information could, to the benefit of the whole community, be more widely shared. The Earth Observation community (including, especially the data users) is changing in focus and approach from considering sensors in isolation to considering a system-of-systems, with users combining data from multiple sources (even from different technologies). We are responding to this shift, and Kurt Thome emphasised that “we have to communicate better between ourselves and to the wider community about how sensors are harmonised.”

Kurt Thome felt that GSICS were ahead of us in this, with their work on, e.g. the GIRO/ROLO lunar model and the lunar calibration database. It was generally felt that GSICS may be ahead because of their working model with known users who are eager for this information) and because they have people who have taken the lead and “made it happen”. The lunar comparison workshop was also extremely well focussed with the format constrained by the definition of the lead organisation.

Patrice Henry warned us to be careful about taking the concept of harmonisation too far. Different sensors all have their own unique challenges and each mission makes sense only “within its own environment”. The experts on the mission are needed to make sense of the comparison data – there should never be one method, one reference, one place to perform the calibrations. And calibration

should always be in the hands of the sensor agency. He was also concerned that providing everything openly and publically could both create misunderstandings as inexperienced and naïve users over-interpreted the provided data and may also provide commercial advantage to some commercial companies.

Nigel Fox felt that these two views – the need to be open and provide users with more information – and the need for satellite operating agencies to be in full control of their own calibrations (and how/when these are updated) and to be able to keep the details of the calibration and decision making process private, were not necessarily in conflict. It is not so much about finding a common place to do common work in a formulaic manner, but to have a common place to store results in a common manner with the necessary metadata to make clear the conditions and constraints of the results and to provide references to papers and other public documents that describe comparison methodologies that underpin the decisions and facilitate capacity building in developing agencies. How the information is used to provide any interpretation across the results is a related but separate topic that should be treated independently.

There are working groups – in GSICS and CEOS-WGCV – which consider the different methods separately – e.g. the Rayleigh scattering working group of GSICS and the PICS workshop we had this week, as well as the RadCalNet WG. Perhaps one thing that is missing is to have a higher level technical discussion about how the different methods can/are used in combination and in effect a comparison-of-comparisons.

There was also a brief conversation on reference standards. Tim Hewison from EUMETSAT (representing GSICS) was interested in Emma Woolliams's comments about how the metrology community run formal intercomparisons and analyse these in such a way that there was a "global mean reference". Tim Hewison was interested in how this could apply to GSICS comparisons – to create a synthetic or mean reference that would be stable over time and not be tied to individual sensors. He was interested in further work on this.

There was also a conversation on the meaning of harmonisation. Emma Woolliams described how the FIDUCEO project (a European Union project working on providing metrologically traceable uncertainties to some historical sensor level-1 products) had defined three possible meanings for "harmonisation" and that a confusion between these definitions was often underneath disagreements. Harmonisation could mean "translation" – the translation of the data of one satellite as though it had been taken by another. On the other hand it could mean that the differences between sensors is understood (e.g. because of spectral mismatch) and that the data agrees once these differences are taken into account (there is no unknown bias). Finally harmonisation can refer to the possibility to combine data from two very different sensors (e.g. a SAR and a visible sensor) at the level-2 level to obtain a data product (such as forest carbon) because it is known that both sensors have been analysed with similar rigour and have reliable uncertainty statements. Within the FIDUCEO project there is a strong dislike of the first of these definitions (translation), with a view that wherever possible a means to full interpret apparent biases even if as a result of differences in initial calibration should be the priority. Of course in some circumstances, particularly operational applications like meteorology consistency may be the priority as opposed to absolute accuracy

There was a feeling that this should be discussed further. Some people proposed a new working group, perhaps in collaboration with GSICS. But others expressed concern that this might overcomplicate things at this stage and that we were not yet ready for this (and busy with, and with resources focussed on, other activity, such as RadCalNet). The final decision was to create an initial discussion forum with a very limited membership – probably limited to formal CEOS members and limited initially to the optical sensors and perhaps chaired by NPL to provide neutrality – to discuss what the main questions are, what the scope of any wider discussion might be and the best approach to achieve this. This would probably be followed up with a technical workshop to consider calibration coefficients.

R.2015-2	IVOS recommends the establishment of a depository/database to collect information on the choice, values and reasons for the radiometric gain corrections and calibration results	
R.2015-3	IVOS recommends holding a workshop on radiometric gain corrections and calibration results, this should initially be scoped out by a subgroup of CEOS members	
AP.2015-3	Nigel Fox to organise a CEOS member discussion about the establishment of workshops on calibration coefficients	WGCV meeting

5 Sensor-to-sensor cross comparisons

Presentation	By
Use of RadCats for Landsat-8 and Sentinel-2A validation	Jeff Czapla-Myers
OCO-2/GOSAT vicarious calibration over Railroad Valley	Carol Bruegge
Sensor-to-sensor cross comparison uncertainty limits	Javier Gorroño

Discussions

There was a question about the spatial uniformity of Railroad Valley. There is significant non-uniformity. For RadCaTs the analysis is based on an average of the four GVRs. For RadCalNet it's over a smaller $50 \times 50 \text{ m}^2$ area. The results Jeff Czapla-Myers showed were from the ESA-provided Sentinel-2 data.

6 Sensor inflight calibrations

Presentation	By
Kompsat-3A radiometric calibration/validation	Donghan Lee
Status of S-NPP VIIRS Solar and Lunar Calibration	Jack Xiong
Radiometric Uncertainty Tool to allow user derived per pixel uncertainty values for Sentinel 2.	Javier Gorroño
Radiometric image quality of Sentinel 2	Sophie Lacherade
Infrared in-flight Radiometric Calibration	Laurent Poutier

Discussion

There was a brief discussion on the Kompsat-3A use of the Baotou site for MTF determination and how applicable this was with the bar targets that are designed for SAR applications, but have low contrast in the visible. This will be continued later.

Note that Sentinel-2 shows significant changes from the pre-flight calibration. The new calibration factors are with ESA and will be used on the product by the end of this month.

After Laurent Poutier's presentation on infrared measurements, Nigel Fox encouraged ONERA participation in the FRM4STS comparison.

7 MTF measurements

This section opened with an overview of the MTF workshop that took place on Monday.

Presentation	By
Summary of the MTF workshop on Monday	Françoise Viallefont

Main results of workshop

To provide:

- An exhaustive list of checkerboard targets
- A fairly exhaustive list of bridges
- A list of other recommended natural sites

Lists to be given in order of decreasing interest, according to class of spatial resolution. It is hoped that this catalogue will encourage systematic acquisitions over common sites (as for radiometric sites). Maintenance of checkerboard targets will be included.

A reference dataset will be prepared and provided on a website. This will include both actual images over reference targets and synthetic images. These actual and synthetic images will be shared to test data analysis methodology and to allow for a comparison of techniques. Eight institutes will process data in the test dataset and there will be an internet workshop in June 2016 to discuss the initial results.

Discussion

There was some concern about the expressed desire to list recommended sites in true priority from “best” downwards. The discussion agreed that there are likely to be a set of equivalent targets, particularly for artificial sites, but that for natural sites there will, generally, be a preference order.

R.2015-4	IVOS recommends to WGCV the establishment of a reference dataset of CEOS recommended sites for MTF and to encourage agencies to collect data over these and to share results with the community.	
R.2015-5	IVOS recommends the establishment of a pilot project to carry out a comparison of inflight MTF retrieval methods through distribution of synthetic and real images.	
AP.2015-4	Françoise Viallefont to follow up the workshop on MTF and ensure that the database is collated and the data processing comparison is performed	Next meeting

This was followed by:

Presentation	By
Sentinel 2 geometric image quality	Florie Languille

Discussion after this:

Will the Sentinel-2 GRI be global? Within this year this will be done by CNES for all Europe. Next year it will be done for the rest of the world.

The presentation was well received and a comment was made that while we (in IVOS) have discussed a lot about the difference in the radiometry between the sensors, it is good to see how much improvement the registration can create. Users need for this for the products for comparison with Landsat-8.

8 Ocean Colour

Presentation	By
Requirements for in situ radiometric measurements supporting ocean colour system vicarious calibration	Giuseppi Zibordi
IOCCCG and OCR-VC updates and status	Hiroshi Murakami
FRM-4SOC (Sentinel-3 status presentation, slide 9)	Phillippe Goryl

Discussion following presentations:

What is the main explanation for MOBY having best result? The uncertainties are lower for two reasons – the site is physically more stable (very little biology and stable over time) and the instruments are better calibrated (they got an NMI (NIST) involved ten years earlier than anyone else in the remote sensing community). The site is unique in its long term stability, a recent search to find alternative sites found nothing better.

Discussion on IOCCG white paper and report

Action from last WGCV-39:

In order to strengthen the cooperation, the sub-group IVOS will evaluate the IOCCG documentation and consider endorsing IOCCG's Cal/Val related recommendations as a starting point for future discussion and sharing of information.

IOCCG requests IVOS to review and endorse:

- *INSITU-OCR white paper*
- *The agency mapping exercise*
- *The IOCCG report #13 mission requirements for future ocean-colour sensors*

Nigel Fox led the discussion and made clear that while the group can and should discuss and review these and provide comments, we do not have within CEOS-WGCV-IVOS the authority to “endorse”.

To initiate discussion having read the documents the following observations were made by the IVOS chair.

Mission requirements: The document is a good document and covers everything that needs to be covered at the top level for a mission, its observational satellite and associated infrastructure.

It was suggested that an enhancement would be to have a few more paragraphs on the underlying concept of vicarious calibration and more particularly if this were the correct term and that a better choice would be System Vicarious Calibration as suggested in Zibordi presentation or vicarious adjustment.

Another general comment: it would be helpful to define whether standard or expanded uncertainties when considering absolute accuracy. This should be clarified.

On page 86 the document clearly describes the value of CEOS-WGCV-IVOS and this is extremely helpful and positive for us as well.

White paper: The recommendations cover everything that are needed. On page 4, it would be helpful to make clear the needs for vicarious calibration as previously described above and again the choice of name for the activity. On page 7 there is concern about the phrase “enforce quantification of uncertainties”; CEOS has expressed concern about the use of the word “enforce” which suggests legal requirements. Is this too strong? It is likely to be removed at some point – it becomes one organisation telling another how to spend its money, which cannot be done. However, the original wording came from the agencies, so we can only comment will leave it for now.

On page 9, there was concern about the phrasing of R3.1. The sense of the meeting was that if you are doing traceability properly, then there will be uncertainties that are reliable, whatever the method and therefore it is not necessary to define the method. The recommendation suggests that common calibration schemes will create SI-traceability; this is not right. By all doing it the same way, you will get increased consistency, but could actually harm SI-traceability as there isn't a chance to test the systematic sources of uncertainty.

However, we understood from Giuseppe that many of the users this document is aimed at think that they can buy an instrument and simply use it in water without going through this process. The

objective is to enforce that these parts of the community work in a more organised way and do SI-traceable calibrations. This is why methods are defined.

This is accepted, however, the concern remains with the implication in the wording that to achieve SI traceability it requires everyone to use the same method and this should perhaps be rewritten as it can easily be taken out of context and misunderstood particularly for other domains.

On Page 3/4 there is a recommendation for the establishment of a working group on satellite sensor calibration for OC. Nigel Fox proposed the addition of a sentence saying: “The working group should have as a minimum a close relationship with CEOS WGCV where there is significant synergy and common expertise on relevant sensor pre-flight calibration”

This led to some significant discussion. There was some concern within CEOS-WGCV-IVOS that it may be inappropriate to have a task group on satellite sensor calibration or comparison which was specific to an end application. Calibration and validation (especially pre-flight and on-board calibration, both mentioned within the document) is a generic problem for all applications and treating this at an application specific level at best is a waste of resource and at worst could lead to contradictory approaches. While these concerns were widely recognised, there was also a sense that this suggested OC working group was being set up for a group of people with specific knowledge talking about specific problems. They are working with unique issues and need to get specific answers in timescales that are hard to achieve in more generic discussions.

It was recommended that this task group work extremely closely with IVOS and perhaps should be under the WGCV umbrella rather than under the OCVC. At least there should be a formal collaboration with IVOS that brings IVOS members into the working group and collaborations. OCVC (and the other virtual constellations) should be encouraged to bring calibration problems to WGCV for joint discussion. In this way WGCV becomes a service organisation to the VCs, responsive to their calibration needs.

We encourage the group to exist, and recognise the particularly challenging needs of the Ocean Colour community, but would like the text to include the need and associated benefit to collaborate with WGCV.

A proposed response to the OC community is attached as appendix C to these minutes and any comments from the IVOS community on that proposed response should be sent to IVOS chair.

AP.2015-5	Nigel Fox to prepare formal response to the INSITU-OCR white paper and the IOCCG Report #13	Their deadline
AP.2015-5A	Comments from IVOS members on proposed response to be sent to IVOS chair	March 1

Phillippe Goryl presented from ESA perspective that the ESA response to the INSITU-OCR white paper is to issue an ITT for FRM4SOC (Fiducial Reference Measurements for Satellite Ocean Colour). This project will develop and run comparisons for ocean colour vicarious calibration. Contact Craig Donlon at ESA ESTEC if you wish to be involved.

9 Atmosphere

Presentation	By
MACCS: an Operational Atmospheric Correction Tool for SENTINEL-2 and LANDSAT time series	Camille Desjardins
SDSU Modtran atmospheric correction anytime anywhere (SMACAA)	Dennis Helder
Atmospheric correction discussion	Kurt Thome

Discussion

There was a discussion on MACCS to understand wavelength of AOT comparisons (550 nm) and where the comparisons were done over (La Crau only).

The newly created Atmospheric Correction cross-cutting task group of WGCV is taking the planned comparison activity forward and also creating a test dataset with guidance notes on how to use atmospheric radiative transfer codes so that new-starters can ensure that they are using the code correctly.

10 WGCV

Presentation	By
CEOS-WGCV Update to IVOS (at back end of Atmosphere presentation)	Kurt Thome

WGCV is having increased input from the Virtual Constellations asking for support with Cal/Val activities. There hasn't been a good way to handle these requests, so the WGCV structure is being reviewed with the introduction of a "task approach" – an ad-hoc group to achieve a particular goal within a subgroup or between subgroups, with an identified "task lead". There will be a short definition phase to clarify task and layout plan of work.

Three initial tasks as a test bed for this:

- Cloud masking task group (Bojan Bojkov, ESA)
- Atmospheric Correction (Bojan Bojkov, ESA and Eric Vermote, NASA)
- Digital Elevation Models (to be confirmed)

These are cross cutting. Cloud masking is different for IVOS, microwave subgroup and atmosphere people, but by bringing everyone together a better result is expected. Similarly for atmospheric correction, which will bring radiative transfer experts in with land experts.

11 GSICS interface

Presentation	By
WGCV-GSICS Interactions	Sebastien Wagner on behalf of Tim Hewison

GSICS has created subgroups around technical areas (VIS/NIR, IR, Microwave, UV) to allow for more focussed discussions and activity. The VIS/NIR and IR subgroups link closely with the activity of IVOS with several possible areas for collaboration and joint work (see slide 3).

GSICS will be producing some newsletter special editions on lunar calibration and deep convective clouds and would welcome articles by IVOS members.

There will be a joint workshop on pre-flight and on-board calibration organised by WGCV.

Discussion

Topics of collaboration:

- Moon as calibration reference for imagers; GSICS is leading here and IVOS will get involved
- LEO-LEO cross-calibration; IVOS has strong activity in VNIR activity (RadCalNet, PICS, ...). IVOS has never addressed thermal infrared LEO-LEO cross-calibration. It may help if GSICS could contribute this to our meetings as they have more expertise.
- Using hyperspectral sounders for band-to-band correction; this is a key topic for IVOS and we are keen with joint activity. Application – NASA tool on SBAFs from hyperspectral imagers has been created within GSICS, this could be presented. This is based on measurements from atmospheric sensors, so we should include that community, too.

- Reference solar irradiance spectrum; some work was done previously, and a follow up is now needed.
- Surface measured test-sites, PICS etc; GSICS are interested in the determination of consensus Key Comparison Reference Values for PICS, as well as for the moon (where some work is already happening at 0.6 μm). This would be useful for GSICS and they recognise IVOS experience in this. IVOS had a comparison activity 3 years ago over Libya-4 and a couple of other PICS; this is summarised in a document on the calval porta <http://calvalportal.ceos.org/ceos-wgcv/ivos/wg4> including the reference datasets. We are beginning to work on a project to take this further and it is useful to know that GSICS is interested.

AP.2015-6	Everyone to consider preparing articles for the GSICS newsletters, particularly on DCCs and lunar calibration	Their deadline
AP.2015-7	Nigel Fox to ask GSICS to present on thermal infrared cross calibration methods at our next meeting	Next meeting
AP.2015-8	Nigel Fox to organise discussions on SBAFs based on hyperspectral imager measurements bringing in GSICS and atmospheric sensor expertise, possibly as a WEBEX meeting. Kurt Thome to talk to the right people at NASA to support this.	Next meeting
AP.2015-9	Nigel Fox to set up a meeting on solar irradiance spectrum, starting with discussions with GSICS-UV meeting	WGCV meeting

12 New optical sensors

Presentation	By
JAXA new optical sensors	Hiroshi Murakami
Status of Sentinel-3	Philippe Goryl

Sentinel-3A is due for launch around the 26th December 2015. (Understanding at the meeting, it is now expected to be February 2016).

13 Infrared comparison activity (FRM4STS)

Presentation	By
FRM4STS: Fiducial Reference Measurements for validation of surface temperature of satellites	Nigel Fox

FRM4STS comparison – anyone considering taking part should register, through the website (<http://www.frm4sts.org/events/event-1-laboratory-intercomparison-exercise/>) before 31st December. There will be a web discussion on this during January 2016 and a conference on workshop on surface temperature measurements 7-9 March 2017.

14 Recommendations and Actions

We reviewed the recommendations and actions – see appendix.

There was a short discussion about whether the recommendation for a radiometric gain correction workshop (R.2015-3) should be just for IVOS or considered a WGCV meeting, and whether it should be in collaboration with GSICS. These things should be discussed in the initial meeting of CEOS members (see AP.2015-3).

This discussion also covered the need for the wider workshop. There are lots of calibration coefficient changes happening. The information on how those changes are made and why, is not clearly visible to the community and there is a need to provide that information to the community – simply the current basis of calibration coefficient changes and how they are determined. This could

be collated in a single location, for example as a table per mission with links to documents with calibration strategies.

WMO has a database called OSCAR online – they are setting up links on that database on instrument information pages. It may be appropriate to collaborate with them to see if that meets the needs. <http://www.wmo-sat.info/oscar/>. This information could be on the landing pages of the agencies on there.

Note that these coefficients are often product or application oriented, for example the difference between “Collection 5 of MODIS” and “Collection 6 of MODIS”.

The GSICS working group meeting is during the last days of February, first days of March 2016.

15 Calval Portal

Presentation	By
Cal/Val Portal Status Updates	Philippe Goryl
SADE-MUSCLE status	Aimé Meygret

The Cal/Val portal is not very active and not being supported by the community as a whole. ESA has supported a significant upgrade, but most information on it relates to ESA projects. There is a strong need for IVOS to communicate to the wider community, and a strong recommendation from CEOS-WGCV for a CEOS-WGCV Bulletin.

There was a discussion about why the CalVal portal is not used as much as it could be, and it was clear that this was not fully understood. Perhaps there is a need to do some research into this. It is also hoped that an active CalVal Bulletin issued by CEOS-WGCV would both provide material for the CalVal portal and would remind people to go to the CalVal portal.

AP.2015-10	Philippe Goryl to talk to Alessandro about the reasons for the problems with the CalVal portal and for him to set up a webex to encourage the subgroup to consider the communication strategy, newsletter and calval portal	WGCV meeting
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This was followed on discussions of other databases and tools, including on the need for a prediction tool, e.g. over the RadCalNet and PICS targets and an ongoing updated summary for the key sites. A comment was made that COVE could play a role in this at least in terms of the underpinning information.

16 Date and location of next meeting

There was an invitation to host the next CEOS-WGCV-IVOS meeting in Beijing. The most popular date was the week of the 18th – 21st July 2016 as this is the week immediately after IGARSS 2016, also in Beijing. Note that the microwave subgroups of CEOS-WGCV and GSICS are also meeting in Beijing that week.

At the next CEOS-WGCV-IVOS meeting there will be working group meetings for the RadCalNet WG, for the new PICS WG and for the MTF WG. It may be necessary and possible to overlap the MTF WG meeting with the RadCalNet meeting, but would be preferable not to.

AOE encouraged the MTF and RadCalNet WG meetings to take place in Baotou in order to allow people to visit the test site, but there were also those who did not want the additional travel this would require. It may be possible to organise an optional day of visiting the site, perhaps in the weekend between the IGARSS and CEOS-WGCV-IVOS meetings.

AP.2015-11	Nigel Fox to organise the next meetings of WGCV-CEOS-IVOS to take place in Beijing in the week 18th - 21st July 2016	May-16
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17 list of recommendations

Decision number	Decision
R.2015-1	IVOS recommends to WGCV that a PICS task group be set up to enhance collaboration and create a common work plan, with the initial focus likely to include the means to improve the characterisation of the sites
R.2015-2	IVOS recommends the establishment of a depository/ database to collect information on the choice, values and reasons for the radiometric gain corrections and calibration results
R.2015-3	IVOS recommends holding a workshop on radiometric gain corrections and calibration results, this should initially be scoped out by a subgroup of CEOS members
R.2015-4	IVOS recommends to WGCV the establishment of a reference dataset of CEOS recommended sites for MTF and to encourage agencies to collect data over these and to share results with the community.
R.2015-5	IVOS recommends the establishment of a pilot project to carry out a comparison of inflight MTF retrieval methods through distribution of synthetic and real images

18 list of actions

This includes the incomplete actions from the 2014 meeting

Action number	Activity	Date
AP.2014-3	Nigel Fox to chase people with solar spectral to provide data to Alessandro for the calval portal, including data beyond 2500 nm	
AP.2014-18	Nigel Fox to discuss with CEOS-WGCV having a newsletter and a champion for the website and then to request this community for a volunteer to champion the work of the group through the website and newsletter with the support of Alessandro Burini.	Done but need IVOS champion
AP.2014-19	Nigel Fox to arrange for the QA4EO secretariat to contact DongHan Lee about building the example presented into a QA4EO case study and to contact Philippe Goryl about building an example based around user needs	
AP.2014-20	All to suggest other case studies for QA4EO	
AP.2015-1	Everyone to review presentations etc that mention this group to ensure that it is written in full as CEOS-WGCV-IVOS.	Next meeting
AP.2015-2	Nigel Fox to organise the formation of a new task group on PICS	WGCV meeting
AP.2015-3	Nigel Fox to organise a CEOS member discussion about the establishment of workshops on calibration coefficients	WGCV meeting
AP.2015-4	Françoise Viallefont to follow up the workshop on MTF and ensure that the database is collated and the data processing comparison is performed	Next meeting
AP.2015-5	Nigel Fox to prepare formal response to the INSITU-OCR white paper and the IOCCG Report #13 following review by IVOS team comments due March 1	Their deadline
AP.2015-6	Everyone to consider preparing articles for the GSICS newsletters, particularly on DCCs and lunar calibration	Their deadline

AP.2015-7	Nigel Fox to ask GSICS to present on thermal infrared cross calibration methods at our next meeting	Next meeting
AP.2015-8	Nigel Fox to organise discussions on SBAFs based on hyperspectral imager measurements bringing in GSICS and atmospheric sensor expertise, possibly as a WEBEX meeting. Kurt Thome to talk to the right people at NASA to support this.	Next meeting
AP.2015-9	Nigel Fox to set up a meeting on solar irradiance spectrum, starting with discussions with GSICS-UV meeting	WGCV meeting
AP.2015-10	Philippe Goryl to talk to Alessandro about the reasons for the problems with the CalVal portal and for him to set up a webex to encourage the subgroup to consider the communication strategy, newsletter and calval portal	WGCV meeting
AP.2015-11	Nigel Fox to organise the next meetings of WGCV-CEOS-IVOS to take place in Beijing in the week 18th - 21st July 2016	May-16

Appendix A ; List of Attendees

Name	Organisation
Aimé Meygret	CNES, France
Angelique Gaudel	CNES, France
Bahjat Alhamoud	ARGANS Ltd, UK
Béatrice Berthelot	Magellnum, France
Bertrand Fougère	CNES, France
Brian Marldham*	NASA Goddard, USA
Brian Wenny	MODIS Characterization Support Team (MCST) Science Systems & Applications Inc, USA
Bruno Lafrance	CS Systèmes d'Information, France
Caixia Gao	Academy of Opto-Electronics, Chinese Academy of Sciences, China
Camille Desjardins	CNES, France
Carine Quang	CS Systèmes d'Information, France
Carol Bruegge	Jet Propulsion Laboratory, USA
Dennis Helder	South Dakota State University, USA
Derek Griffith	DPSS / CSIR, South Africa
Dong Han Lee	Korea Aerospace Research Institute, South Korea
Emmanuel Hillairet*	Magellnum, France
Emma Wooliams	National Physical Laboratory, UK
Florie Languille	CNES, France
Gerhard Meister*	NASA Goddard, USA
Giuseppe Zibordi	JRC, EU, Italy
Grit Kirches*	Brockmann Consult GmbH, Germany
Hirohazu Yamamoto	Geological Survey of Japan, AIST, Japan

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Note those with a * attended remotely.

Hiroshi Murakami	JAXA, Japan
Javier Gormoño	NPL, UK
Jeff Crapla-Myers	University of Arizona, USA
Julia Barsi*	NASA/GSFC, USA
Kurt Thome	NASA Goddard Space Flight Center, USA
Laurent Poutier	ONERA, France
Lingling Ma	Academy of Opto-Electronics, Chinese Academy of Sciences, China
Marc Bouwet	ESA/ESTEC
Nigel Fox	National Physical Laboratory, UK
Olivier Thepaout	CS, France
Philippe Gamet	CNES, France
Philippe Goryk	ESA
Renaud Fraisse	Airbus Defence and Space, France
Robert Kudola	DigitalGlobe, USA
Ron Morfitt*	USGS, USA
Satoshi Tsuchida	Geological Survey of Japan, AIST, Japan
Sebastien Marcq	CNES, France
Sebastien Saunier	Telespazio, UK
Sebastien Wagner	Eumetsat
Sindy Sterckx*	VITO, Belgium
Sophie Lacherade	CNES, France
Stefan Adriaensen	VITO, Belgium
Tim Hewison*	EUMETSAT
Tracy Scanlon	National Physical Laboratory, UK
Vincent Martin	CNES, France
Xavier Briottet	ONERA, France
Xiaoxiong Xiong	NASA Goddard Space Flight Center, USA
Yves Govaerts	Rayference SCS, Belgium

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Appendix B: Agenda



Infrared and Visible Optical Sensors (IVOS)
Subgroup to the Working Group on
Calibration and Validation (WGCV)

CEOS WGCV IVOS-27 Meeting

Nov 18-20, 2015

ONERA

Toulouse

→ → → → → DRAFT AGENDA

Wednesday, Nov 18

Location: ONERA

8:30 AM	Registration/Entrance Logistics		
9:00 AM	Continuance of PICS workshop		
10:30	Break		
	Continuance of PICS workshop		
~12:45	Lunch		
14:00	IVOS-27 Main Meeting		
14:00	IVOS chair Intro	Fox	Meeting intro <ul style="list-style-type: none"> • Brief Introductions • Objectives • Agenda • Actions • Terms of reference • IVOS report to CEOS WGCV-39 •
14:25	CEOS WGCV chair welcome	Thome on behalf of Von Barten	Welcome from CEOS WGCV chairs
14:30	Vicarious Radiometric Cal/Val of land imagers		
14:30		Henry	PICS workshop conclusion (formerly adopt Workshop outputs)
14:35		Bourvet	RadCALnet status
15:15	Candidates sites for future Radcalnet expansion		
15:15		Bruegge (JPL)	JPL automated site at RRV
15:30		Griffith (CSIR)	South African artificial target plans
15:45	Break		
16:15		Ma (AOE)	Baotou instrumented desert sites
16:30	Other vicarious cal methods		
16:30		Wagner (Emmetsat)	Status of Lunar calibration projects
16:45		Wagner (Emmetsat)	Optical sensor monitoring at Emmetsat
17:00	Sensor to sensor interoperability/Cross comparison		
17:00	DISCUSSION	Woolliam (NPL)	Establishing & reporting sensor to sensor harmonization (bias correction) coefficients
18:00	END of DAY 1		

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IVOS, a subgroup of the Committee on Earth Observing Satellites (CEOS) Working Group on Calibration and Validation (WGCV) whose mission is to ensure high quality calibration and validation of infrared and visible optical data from Earth Observing Satellites and validation of higher level products.

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Thursday 19 November			
	Sensor to sensor cross-comparisons		
09:00	□	Czaplar-Myers (U of Arizona)	Use of test site for calibration of Landsat 8 OLI and Sentinel 2 MSI
09:20	□	Bruegge (JPL)	Use of test site for calibration of CO2 and GOSAT
09:40	□	Gorrone (NPL)	Sensor to sensor cross-comparison uncertainty limits
10:00	Sensor in-flight calibration and uncertainty assessment		
10:00	□	Lee (KARI)	Kompsat 3A Radiometric Cal/Val
10:20	Break		
10:45	□	Xiong (NASA)	Status of S-NPP VIIRS Solar and Lunar Calibrations
11:00	□	Gorrone (NPL)	Radiometric Uncertainty Tool to allow user derived per-pixel uncertainty values for Sentinel 2
11:20	□	Moritt (USGS)	Status of Radiometric Cal of Landsat 8 and comparison of OLI with Sentinel 2 MSI
11:40	□	CNES	Radiometric image quality of Sentinel 2
12:00	□	Poutier (ONERA)	Infrared in-flight Radiometric Calibration
~12:20	Lunch		
13:20	Sensors (new/current status)		
13:20	□	Murakami (JAXA)	JAXA Optical sensors
13:40	□	Goryl (ESA)	Status on Sentinel 3
13:50	Satellite Surface temperature Validation		
13:50	□	Fox (NPL)	Progress on FRM4 STS (Miami IV) comparisons for Land, Ocean and Ice temp validation
14:10	GEO-SPATIAL image quality		
14:10	⊗	Helder (SDSU) / Viallefont (ONERA)	Progress on MTF best practices, test site catalogue etc (summary and conclusion of workshop)
14:50	⊗	CNES	Sentinel 2 Geometric image quality
15:10	Break		
15:30	Ocean Colour		
15:30	⊗	Zibordi (JRC)	Uncertainty requirements for in-situ radiometric measurements supporting ocean color system vicarious calibrations
15:50	Including Discussion	Zibordi (JRC) / Murakami (JAXA)	IOCCG and OCR-VC updates and status IVOS review of white paper and plans (initiate)

16:30	□	Goryl (ESA)	FRM4 SOC (ESA plans to support OC-validation)
16:35	Atmosphere effects on Radiometric Cal		
16:35	□	Thome (NASA)	Update on radiometric correction and CEOS/WGCV projects
16:50	□	Helder (SDSU)	SDSU-Modtran atmospheric correction anytime anywhere (SMACAA)
17:10	□	CNES	MACCS: an Operational Atmospheric Correction Tool for SENTINEL-2 and LANDSAT time series
17:30	End of Day 2		
☺			
Friday 20 November			
8	Formal Welcome and Host Presentation □		
09:00	□	ONERA	Welcome and overview of institute and activities
09:30	WGCV and cross-cutting activities		
09:30	Including Discussion	Thome (NASA) (WGCV vice-chair)	Update on WGCV activities/plans/structure and IVOS inputs/interactions --> Cloud --> DEM --> Carbon strategy --> Climate --> Constellations --> GSICS --> Work plan
8	Discussion	Fox	New IVOS and/or collaborative projects · WGCV/GSICS ¶ And/or Recommendations ¶
10:45	Break		
11:15	Discussion	Goryl (ESA)	Cal-Val-Portal & communication of groups activities
11:40	8	CNES/ESA/USGS/NASA/ ?	Update on status of cross-calibration databases and tools
11:45	8	Fox (NPL)	Review of actions / meetings
12:00	8	All	Proposal/offers for Next meeting ¶ Topics for discussions
12:10	8	All	AOB
12:30	□	End of Meeting · Lunch	

Appendix C

Draft response of Review of documents for CEOS VC- OCR

(note the source documents are contained in meeting presentations folder)

CEOS WGCV IVOS thanks IOCCG for the opportunity to review the two documents related to radiometric Cal/Val of Ocean colour sensors. The mandate of CEOS WGCV is to coordinate efforts and where possible and appropriate provide support to CEOS member agencies on Calibration and Validation issues. The IVOS sub-group of CEOS WGCV performs this function for 'optical' sensors (UV, VIS, SWIR, TIR) concentrating on Pre- and inflight Cal/Val of radiometric (largely Level 0 to Level 1(x) and associated parameters which play a direct role in the process, more recently it has also taken on activities related to aspects of image quality and geometric characteristics of a sensor and its products. In general it does not play a major role in the validation of higher Level products except where these might relate to what might be considered a primary radiometric measurement for example the use of IR radiometers for validation of satellite derived sea/land surface temperature.

It performs its role through the best efforts and resources of its members which are in effect provided to group on a 'voluntary basis' (individual organisations may of course be funded by other agencies). The wide scope of its activities means that its membership consists of experts from both publicly and privately funded organisations and its detailed work is often carried out through smaller sub-grouping of individuals/organisations some of which are entities in their own right and which interface with CEOS WGCV and in this case IVOS to exchange information and to ensure appropriate coordination and consistency of approach across differing but related domains.

For example, the Group on High Resolution Sea Surface Temperature (GHR SST) reports on its progress to IVOS and makes use of IVOS expertise for radiometric validation and is currently organising the forth of a series of comparisons to ensure international harmonisation of such measurements. In a similar manner, the procedures and methods used for pre-flight radiometric calibration of many optical sensors are very similar, differing sometimes in specific details and/or degree of uncertainty needed. However, the synergy and shared expertise on the underpinning principles even where applications may differ has proven to be highly beneficial. However, to address some of the details effectively again often requires separate focussed meetings of the relevant experts.

The following is the result of an initial review from some IVOS members, followed by discussion at CEOS WGCV IVOS 27 and a subsequent consensus on the content of this note. In making comments and/or editorial suggestions we recognise that there has been some time since the documents were drafted and that these may already have been superseded in practise. We have also limited our review and comments to our area of expertise, radiometric Cal/Val and not to any underlying science questions or validation of any bio-geophysical parameters or operational aspects etc.

IOCCG Report N13

This is considered to be an excellent document, providing a rigorous and consensus review of requirements needed to be carried out/established to meet the science driven specifications of the Ocean Colour community. It treats all aspects of the mission requirements and provides a summary of the critical radiometric characterisation, calibration and validation issues (pre- and in-flight) in which we full concur. It was refreshing to note how the concept of SI traceability and good documentation was incorporated and highlighted and appropriate reference to various generic community initiatives that have been developed in recent years e.g. QA4EO. From a CEOS WGCV IVOS perspective we also noted how the document identified the relationship and role of CEOS WGCV IVOS (p86) in helping to address the objectives identified.

The only real critiques are:

- where uncertainty or accuracy requirements are specified there should at some point in the text be an indication as to what confidence level these refer to e.g standard or expanded uncertainties
- Vicarious adjustment and Vicarious Calibration are used interchangeably throughout the document. Given the nature of what is being done it would seem that vicarious adjustment is the most appropriate term and the use of the word ‘calibration’ in this context can be misleading and confusing, particularly since this can lead to a perception that the sensor can now be considered to have an accuracy of 0.5%.. As an alternative, proposed by Zibordi of JRC, the term ‘system vicarious calibration’ could also seem appropriate.
- On page 56 reference is made to solar irradiance as an input to calculate reflectance it states the uncertainty is <1%, we think that there may be some conjecture to this value and whilst it in the spectral domain of interest to Ocean colour it is certainly stable to <1% but as an absolute value to SI this may be much higher than the 1% and indeed there may also still be some much smaller but potentially significant variance dependent on the choice of origin of the spectrum and so this should always be stated and referenced.

INSITU-OCR White paper

This is again considered a rigorous strategy document linked in some ways to the previous document. However, we again have a few comments which we feel may be of value to the document, its readership and objectives. Before addressing specific comments it is worth noting and clarifying the objective of the strategy as stated below the title ‘working towards consistency and accuracy’. We understand these objectives, but as we are sure the authors are aware the route to achieve consistency is not necessarily the same as the one to achieve accuracy. Some of the later comments will reflect this nuance and perhaps try to propose alternative wording to some of the recommendations which might help to facilitate both.

Again noting the authors of the document, we recognise that the following point is understood and assumed however for a wider audience it is perhaps something worth emphasising as it is often not interpreted in the manner it should be.

- R1.1. (and elsewhere) reference is rightly made to the need for calibration and characterisation traceable to SI standards. The metrological definition of SI traceability is very clear (http://www.bipm.org/utis/common/documents/jcgm/JCGM_200_2012.pdf)

*property of a **measurement result** whereby the result can be related to a reference through a documented unbroken chain of **calibrations**, each contributing to the **measurement uncertainty***

and similarly what is meant by a ‘reference’ and ‘calibration’ etc. However, this is not always implemented consistently. Whilst it is not necessary that a National Metrology Institute (NMI) is directly involved or that the reference used in any measurement comes directly from an NMI, where it doesn’t ie. from a secondary organisation, the evidence must exist to show that the calibration links back to an NMI are appropriate and that in both cases the uncertainty derived on any measurement traceable to the reference (both at any secondary supplier and also in final use with the satellite sensor) has the appropriate ideally independently assessed’ evidence from the measurement process itself.

A formal link to the reference above or conceptually QA4EO as an intermediary, and/or a glossary to emphasise the critical meaning of SI traceability would be valuable.

- R1.3 In principle CEOS WGCV has been explicitly established to do the activities indicated and in the context of Ocean Colour satellite sensors this work is carried out through its IVOS sub-group. However, given the broad scope of IVOS it may be considered that there is not enough dedicated time within its normal annual plenary meetings to have the detailed discussions that might be needed on a regular enough basis. However, as in common with other specific activities this is usually accommodated by separate meetings held under the auspices of CEOS WGCV IVOS adjacent to the plenary meeting or elsewhere at a location and time of convenience to the group of experts involved with a report made at the plenary

meeting which in turn is fed up to the CEOS WGCV plenary itself, together with any recommendations/requests. Although there are some OC specific sensor calibration needs or at least some that need to be carried out with greater rigour than for other applications, for many agencies the relevant experts may be the same for a range of applications and so there may be some benefit in a slightly wider scope for some meetings.

CEOS WGCV IVOS would thus recommend that as a minimum any ‘sensor calibration group’ report its progress and activities at CEOS WGCV IVOS plenary meetings and ideally be aligned formally as a task group within its structures. It could of course also report in parallel to VC-OCR and/or IOCCG.

- R1.4 We would encourage a change in the terminology from Vicarious calibration to vicarious system calibration or vicarious adjustment or some other similar phrase to make very clear at the outset that what is being done is a vicarious calibration of a sensor and its integrated processing chain. The short hand ‘vicarious calibration’ as indicated above for the other document can lead in isolation to a misunderstanding and interpretation of the perceived resultant TOA 0.5% uncertainty and its global applicability.

Here we note the proposal to use commonly agreed vicarious adjustment approaches and sharing of processing modules. This will of course enhance inter-mission consistency as indicated as the objective, and may be the correct goal. However, this may lead to the propagation of undetected errors, within a single sensor or the full ensemble of sensors and minimise opportunity for an innovation and overall improvements in the longer term.

- R1.5 We consider this rightly to be a desired goal for all sensor domains and we should look to encourage its broad adoption.
- R2.2. Note CEOS WGCV has recently established cross-cutting task groups focussing on in particular Atmospheric correction models, methods and associated input parameters.
- R2.3 Whilst we might agree with the sentiment the use of the word ‘enforce’ in the recommendation may not be easily accepted by space agencies as it implies some form of regulation. Perhaps ‘Encourage’ would be an option.
- R3.1 Whilst we largely agree with the background statement we disagree with the conclusion that is drawn if the stated objective is SI traceability and not simply consistency. Whilst it is true that different instruments and processing codes, measurement protocols may lead to inconsistencies. Fundamentally if traceability is carried out and evidenced in an appropriate manner through a consistently rigorous QA process so that assigned uncertainties are valid for the same effective measurement (noting different sampling strategy may need a bias correction) and proven then merged products and information are readily achieved by applying appropriate biases and weightings to the data. This fundamentally is how traceability works, forcing a common instrument and/or process on everyone limits innovation, and whilst it tends to lead to consistency it does not necessarily lead to traceability and may limit the opportunity to identify some potential error sources which might otherwise propagate in an uncontrolled way into the future.

However, we understand that the principle concern is to avoid problems where the QA is not fit for purpose and yet data is used!!.

Depending on the objective (consistency or traceability, with the latter including consistency in the definition of the measurand to be reported on, we would suggest a change in the wording of the recommendation to be something like:

To ensure consistency and interoperability to multiple-sensors funding agencies should enforce common measurement protocols with indicative sources of error and guidance on means to assess uncertainty, unifying processing schemes and rigorous quality assurance criteria which for traceability should include robust documented evidence of the uncertainty of the instrumentation and its usage to SI reference standards. Comparison exercises should

be considered as the means to provide the evidence of degree of equivalence between measurement teams and to SI units. To promote the uptake of best practise in calibration, measurement methods, Quality assurance and data processing, comparisons, which may include round robins on specific aspects, should include training opportunities and ideally the participation of an NMI or at least reference standards direct from an NMI to minimise the traceability chain..