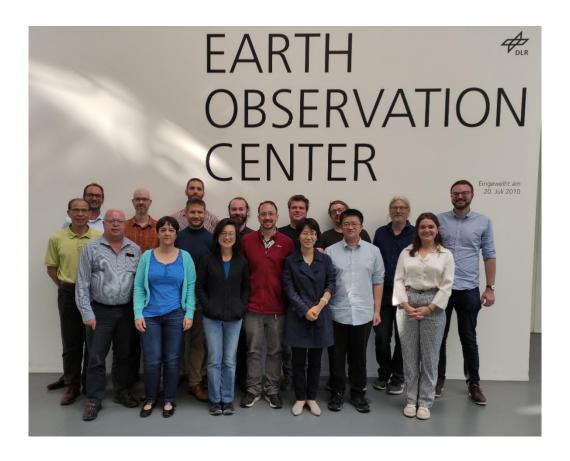# CEOS-WGCV-IVOS Meeting 35

DLR, Oberpfaffenhoffen, Germany. 26 – 30 September 2023

Attending in person:

- Nigel Fox (NPL, chair)
- Sam Hunt (NPL)
- Dave Smith (RAL)
- Steffen Dransfeld (ESA)
- Marc Bouvet (ESA)
- Christian Fischer (DLR)
- Maddie Stedman (NPL)
- Stefanie Holzwarth (DLR)
- Simon Hook (NASA)
- Ian Lau (CSIRO)
- Cindy Ong (CSIRO)
- Jeff Czapla-Myers (U. Arizona)
- Jack Xiong (NASA)
- Pieter De Vis (NPL)

- Paul Green (NPL)
- Stefan Adriaensen (VITO)
- Cody Anderson (USGS)
- Raquel De Los Reyes (DLR)
- Aga Bialek (NPL)
- Ning Wang (AIR CAS)
- Lingling Ma (AIR CAS)
- Martin Bachmann (DLR)
- Andreas Baumgartner (DLR)
- Emiliano Carmona (DLR)
- Marc Seifert (OroraTech)
- Diogo Rio Fernandes (OroraTech)

Joined online:

- Jamie McMillan (SatVu)
- Joris Blommaert (VITO)
- Maximilian Brell (GFZ)
- Hirokazu Yamamoto (AIST)
- Aimé Meygret (CNES)
- Steve Brown (NIST)
- Esad Micijevic (USGS)
- Miguel Pato (DLR)
- Grit Kirches (Brockmann Consult)
- Bahjat Alhammoud (ARGANS)
- Birgit Gerasch (DLR)
- Manik Bali (NOAA)
- David Sitton
- Kara Burch (I2R Corp)
- Mary Pagnutti (I2R Corp)
- Robert Ryan (SSAI)
- Samantha Lavender (Pixalytics Ltd)
- Raviv Levy (NASA)
- Fangfang Yu (U. of Maryland)

- Sophie Coustance (CNES)
- Vincent Leroy (Rayference)
- Arthur Dick (CNES)
- Dagmur Müller (Brockmann Consult)
- Emilie Delogu (CNES)
- Frank Goettsche (KIT)
- Morgane Chapelier (CNES)
- Leonardo De Laurentiis (ESA)
- Mark Irvine (INRAE)
- Sébastien Marcq (CNES)
- Yoshiro Yamada (NPL)
- Gunter Schreier (DLR)
- Taeyoung Choi (NOAA)
- Camille Desjardins (CNES)
- Paolo Castracane
- Eyal Ben-Dor (RSL-TAU)
- Awais Ahmed (Pixxel)

All presentations are available at: IVOS Meetings

1   Introduction

The meeting was chaired by *Nigel Fox*. Minutes were taken by *Maddie Stedman* and *Sam Hunt*. The meeting was hosted by *Martin Bachmann* of DLR. All the presentations are available for download from the Cal/Val Portal (IVOS Meetings).

Presentation	By	Filename
Welcome from DLR	Tanja Kraus	01_Kraus_Intro.pdf
Welcome	Nigel Fox	02_Fox_Intro.pdf

Tanja Kraus, DLR, welcomed us to the meeting and thanked everyone for participating in person or online. She gave an overview of DLR activities in the EO domain. Participants in the room introduced themselves and those online introduced themselves in the text chat.

In Nigel Fox's introductory presentation he gave a general introduction to the meeting and the mission of the subgroup and its work in the last year since the last workshop.

He described the objectives of the meeting as information exchange up and down through CEOS, reporting on progress on projects, developing interactions with activities in related groups, update on work-plan, discussing new project ideas and collaborations, and communications. Nigel introduced specific activities that the group aims to respond to during the meeting including CEOS solar Spectral Irradiance impact, CEOS-FRM, uncertainty/traceability, and TIRCalNet.

1.1 Review of actions from last meeting

Action Number	Action	Date	Status
AP.2019-2 Carried over AP.2018-1	Nigel Fox to ensure we hold a half to one day workshop to evaluate state-of the art on sensor L1 interoperability and the different methods used for comparisons to prioritise a work plan	To be done after the completion of the template AP 2019-17/18	Hoping to progress to this type of workshop once we have agreed on a template for presenting validation. Presentation later in the agenda.
AP.2019-5 carried over AP.2018-4	Steffen Dransfeld and Nigel Fox to explore prospect of an end-to-end benefit of Cal/Val for SST (Linking FRM4STS and SLSTR/ATSR+ series)	We should try to do this	
AP.2019-6 carried over AP.2018-19	Patrice Henry to work with Nigel Fox to create a "news story" on PICSCAR that shows the link to WGCV priorities.	Perhaps we should still try to do something here	
AP.2022-1	Nigel Fox to email the mailing list to encourage a volunteer for leadership of the geo spatial image quality task group and to appoint a leader before the next meeting. And for the new chair to organise a teleconference to define the scope and strategy for the task group.	Next IVOS	
AP.2022-2	Anyone interested in participating in the vocabulary working group to contact Emma Woolliams	Next IVOS	
AP.2022-3	Anyone with recommendations for the BIPM-WMO joint workshop "Metrology for Climate Action" to contact Emma	26th September	DONE
AP.2022-4 (Reformatted AP.2019-17)	Nigel Fox and Emma Woolliams to review the template that was developed in 2019 on presenting the different methods, and to produce a fresh table template, alongside a workflow of how the table is filled in, reviewed and published.	Next IVOS	Done see later presentations
AP.2022-5	NOAA VIIRS team (Jason Choi) will talk to NOAA management (Changyong Cao) on this PISCSCAR future action on VIIRS data.	Next IVOS DONE	DONE
AP.2022-6	Patrice Henry and Rajendra Bhatt to discuss ways that PICSCAR can relink to the ongoing GSICS activities in a time efficient manner (link to Dave Doelling and Fred Wu)	Next IVOS	To be discussed at future meetings.

AP.2022-7	Patrice Henry to organise a PICSCAR online workshop and publicise it to bring in new participants.	End 2022	Pre next IVOS
AP.2022-8	Steffen Dransfeld to check whether Sentinel-3 should be included in the list for self-assessment of the synergy SDR products for CARD4L and to discuss with Cody Anderson	End 2022	Presentation later this week will give update
AP.2022-9	Emma Woolliams to compare the intrinsic interpolation method her team has used in comparison to the results Mary Pagnutti and Bob Ryan presented on per pixel uncertainty for Landsat. And to include Esad Micijevic in those discussions.	End 2022	Emma has started some discussions
AP.2022-10	Nigel Fox to set up a half day discussion group either online or at the next IVOS meeting to consider Sentinel and Landsat per pixel uncertainty efforts	Next IVOS	Uncertainty discussion scheduled this week (but not specific to Sentinel/Landsat)
AP.2022-11	Nigel Fox and Cody Anderson to set up a discussion on the curation and dissemination of uncertainty data information (volume / formats) to link WGCV and WGISS, particularly for imaging sensors.	Early 2023	Discussion this afternoon to progress this.
AP.2022-12	Nigel Fox and Odele Coddington to discuss getting solar irradiance spectrum onto the Cal/Val portal with notes to users about encouraging the use and being clear about the use. Also to consider how to get it	End 2022	Discussion scheduled for tomorrow to progress this.
AP.2022-13	Nigel Fox and Odele Coddington to organise a working meeting and then a wider virtual meeting specifically about using the solar irradiance spectra and the impact of the choice / change of spectrum on communities and operational sensors.	Early 2023	Discussion scheduled for tomorrow to progress this.
AP.2022-14	Steffen Dransfeld and Aimé Meygret to produce a draft roadmap and a summary of the topics for discussion to work towards a CEOS reference network for LST to be shared by those interested in this work	End 2022	Presentation on Thursday about progress

Carried over actions

| AP.2019-2 Carried over AP.2018-1 | **Nigel Fox** to ensure we hold a half to one day workshop to evaluate state-of the art on sensor L1 interoperability and the different methods used for comparisons to prioritise a work plan | Hoping to progress to this type of workshop once we have agreed on a template for presenting validation – |

		presented in IVOS 35.
AP.2019-5 carried over AP.2018-4	**Steffen Dransfeld and Nigel Fox** to explore prospect of an end-to-end benefit of Cal/Val for SST (Linking FRM4STS and SLSTR/ATSR+ series)	We should try to do this
AP.2019-6 carried over AP.2018-19	**Patrice Henry** to work with Nigel Fox to create a "news story" on PICSCAR that shows the link to WGCV priorities.	Perhaps we should still try to do something here
AP.2022-1	**Nigel Fox** to email the mailing list to encourage a volunteer for leadership of the geo spatial image quality task group and to appoint a leader before the next meeting. And for the new chair to organise a teleconference to define the scope and strategy for the task group.	Next IVOS
AP.2022-2	**Anyone** interested in participating in the vocabulary working group to contact Emma Woolliams	Next IVOS
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AP.2022-7	**Patrice Henry** to organise a PICSCAR online workshop and publicise it to bring in new participants.	Should still be done Early 2024
AP.2022-8	**Steffen Dransfeld** to check whether Sentinel-3 should be included in the list for self-assessment of the synergy SDR products for CARD4L and to discuss with Cody Anderson	End 2023
AP.2022-9	**Emma Woolliams** to compare the intrinsic interpolation method her team has used in comparison to the results Mary Pagnutti and Bob Ryan presented on per pixel uncertainty for Landsat. And to include Esad Micijevic in those discussions.	In progress
AP.2022-10	**Nigel Fox** to set up a half day discussion group either online or at the next IVOS meeting to consider Sentinel and Landsat per pixel uncertainty efforts	Before Next IVOS

2   CEOS Level Initiatives

Presentation	By	Filename
CEOS-WGCV Initiatives/Activities	Cody Anderson	03_Anderson_WGCV.pdf

Roadmap Towards an Assessment Framework for CEOS Fiducial Reference Measurements (FRM)	Nigel Fox	04_Fox_FRM.pdf
CEOS/GSICS Preflight workshop	Nigel Fox	05_Fox_CEOS_GSICS_Workshop.pdf
JACIE/VH RODA Quality Initiatives	Cody Anderson	06_Anderson_JACIE_VH-RODA.pdf
SITSat task group	Nigel Fox	07_Fox_SITSat.pdf

2.1 CEOS-WGCV Initiatives/Activities (C. Anderson)

- **Presentation given by Cody Anderson.**

The presentation covered overview of CEOS-WGCV activities relevant to the IVOS subgroup.

Nigel encouraged IVOS members to pass feedback to him or Cody for representation at future WGCV meetings.

Martin emphasised the importance of having a consistent definition of surface reflectance across missions – which Cody presented as an WGCV Action Item.

2.2 Roadmap Towards an Assessment Framework for CEOS Fiducial Reference Measurements (FRM) (N. Fox)

- **Presentation given by Nigel Fox.**

The presentation covered the background and progress of WGCV-led activities towards an assessment framework for CEOS FRMs. Nigel encouraged IVOS members to contact him if they'd like the links or further information on the FRM framework presented.

Jamie McMillan enquired how information on qualified FRMs will be made available. Nigel said that the intention is to create a searchable catalogue/database of all CEOS FRM qualified measurements on the Cal/Val portal. Jamie asked about the standardisation of data ingestion and data output for this database. Nigel said that users will be expected to fill in fields in a common format following guidance that will be made available, this will be through an online template. Nigel said it's impractical to constrain the data of the FRM itself, i.e., the output results of the FRM, to a set format but there will be a requirement that it is in a 'reasonably' usable and accessible format.

There was discussion about the impact of these developments from previously used definitions of FRM – from the original definition by Craig Donlon.

Dave Smith asked how the proposed definition would handle cases of products where FRM quality isn't achievable, e.g., fire radiative power. Nigel commented that process could provide encouragement to develop those measurements.

Dave asked if there are examples of measurements that are Class A-D in the proposed CEOS FRM standard. Nigel said that groups currently running FRM-type measurements, such as RadCalNet, would be contacted to complete the self-assessment as case studies.

Aga Bialek said there may be confusion in communities with existing "FRMs", predating the CEOS-FRM definition. Nigel responded that the CEOS-FRM standard builds on previous FRM definitions, with some additional points. He emphasised the need for having this clear standard to ensure the quality of measurements claiming to be FRM, which is currently quite varied. Sam Hunt commented

that the framework seems a natural maturation of previous efforts to define and create FRMs. Nigel stated that the framework is expected to evolve over time.

Sam Hunt asked how the process by which assessments against the proposed framework would be completed. Nigel confirmed that the process begins with a self-assessment phase followed by a verification process run by CEOS, similar to that used in CARD4L. This will then become a continuous process involving feedback from users etc.

Action number	Activity	Date
AP.2023-1	Interested **IVOS members** to review the proposed CEOS-FRM standard.	Next WGCV meeting
AP.2023-2	**Nigel Fox** to contact groups running FRM-type measurements to ask them to complete the proposed CEOS-FRM standard self-assessment as case studies	Next IVOS

2.3 CEOS/GSICS Preflight workshop (N. Fox)
- **Presentation given by Nigel Fox.**

The presentation covered an overview of the agenda and objectives of the upcoming CEOS/GSICS Pre-flight workshop.

Nigel invited IVOS members to contact him if they are interested in being involved in the workshop, with a particular interest on including more groups from industry.

Dave Smith said that industry often has set/proprietary processes that can make engagement challenging, therefore it would be necessary to ensure they understand their active participation in the workshop would be valuable. Nigel said that one of the objectives of this effort is to improve the transparency and visibility of key calibration and characterisation techniques used by industry. This is of particular importance as we move forward with climate-focussed missions, with more demanding requirements on uncertainty and traceability.

Action number	Activity	Date
AP.2023-3	**Nigel Fox** to draft first announcement for the upcoming planned CEOS/GSICS Pre-Flight Workshop presented on Tuesday and share with IVOS members.	Oct 2023
AP.2023-4	**Anyone** to contact Nigel Fox to express interest or recommendations of people to join the scientific committee for the upcoming planned CEOS/GSICS Pre-flight workshop presented at IVOS 2023 on Tuesday.	Following dissemination of first announcement (see AP.2023-3)

2.4 JACIE/VH-RODA Quality Initiatives (C. Anderson) (15 mins)
- **Presentation given by Cody Anderson.**

The presentation provided an update on the JACIE/VH-RODA quality initiatives and engagement with the commercial sector.

Cody invited IVOS members to submit abstracts for VH-RODA in the next few weeks if interested.

2.5   SITSat Task Group (N. Fox) (15 mins)
- **Presentation given by Nigel Fox.**

The presentation described the concept of SITSats (SI-Traceable Satellites) and provided an overview of the recently-formed WGCV-level SITSat Task Group and its objectives/planned activities.

Nigel clarified to Steffen that it is initially a task group not a CEOS Working Group, so will report to GSICS and CEOS through WGCV.

Action number	Activity	Date
AP.2023-5	**Anyone (agency representatives only)** to contact Nigel if interested in being involved in the CEOS-WGCV SITSat Task Group.	Feb 2023 & on-going

3   Uncertainty Assessment and Delivery Discussion

Presentation	By	Filename
Landsat 8 OLI & TIRS L1T Radiometric Pixel Uncertainty Estimation Update	Mary Pagnutti	08_Pagnutti_Landsat.pdf
Uncertainty Assessment and Delivery	Sam Hunt	09_Hunt_Uncertainty.pdf

3.1   Landsat 8 OLI & TIRS L1T Radiometric Pixel Uncertainty Estimation Update (M. Pagnutti)
- **Presentation given by Mary Pagnutti.**

The presentation provided an update on the Landsat 8 OLI & TIRS L1T radiometric pixel uncertainty estimation.

Jack Xiong asked whether geometric and radiometric uncertainty are combined along both axes (along & across track), Mary said yes.
Sam Hunt asked if the Landsat uncertainties are being compared to very high resolution as a reference. Mary said this would be a valuable comparison but for some cases of very high resolution data it would be challenging to have enough information (on algorithms used, SI-traceability etc).

Nigel Fox noted that it would be useful to have some dialogue between NPL (Nigel Fox / Maddie Stedman / Emma Woolliams) on topics presented here – Maddie will get in contact with Mary.

3.2   Uncertainty Assessment and Delivery (S. Hunt, E. Woolliams)
- **Presentation given by Sam Hunt and Emma Woolliams.**

The presentation covered an overview of handling uncertainties in EO data, including frameworks and tools in existence/development for uncertainty assessment and delivery.

Sam Hunt and Cody Anderson opened a discussion on building an uncertainty budget (pre-launch characterization, transfer to orbit, monitoring, how to expand uptake of uncertainty best practices, already on-orbit sensors). Cody offered the question to the group for what the optimum level of uncertainty information to provide with products is.

There was discussion about the stage of the mission to set uncertainty requirements. Dave Smith noted that often the starting point for missions (e.g. ESA) is the simulation of the processor algorithms before you get to pre-launch characterisation. Can be a challenge to work alongside industry to define this information. Andreas Baumgartner noted the importance of establishing the uncertainty

requirements at the early stages of the mission for adoption by industry. Steffen Dransfeld agreed that uncertainties often aren't included in the initial requirements of a mission so can be overlooked by industry. Emma Woolliams suggested an iterative process throughout the phases of a mission leading up to launch. Raquel De Los Reyes suggested deriving uncertainty requirements for the applications and working back from these to mission requirements – Marc Bouvet agreed and commented that the traceability of mission requirement from science application requirement is routinely done in the early stages of the mission. Andreas pointed out the difficulty in this approach for instruments with many use cases, e.g. imaging spectrometers. There was general agreement with Nigel's suggestion that the goal should be to set uncertainty requirements per application.

Martin Bachmann initiated discussion concerning the feasibility of providing uncertainties per pixel per band and the potential extent of increase in amount of archive data. Several mitigations to this were highlighted:

- Pieter De Vis pointed out that uncertainty data can be stored with reduced precision (fewer bits), so it needn't double the data volume as feared.
- Dave Smith highlighted how metadata standards, such as the "digital effects tables" described by Sam in his presentation, can enable efficient storage on complex uncertainty information.
- Sam Hunt described how uncertainty information can be evaluated "on-the-fly" rather than stored, as for the S2-RUT tool.

Sam Hunt said that this highlights the need for standardisation/guidance on how to provide uncertainty information in a space efficient way, to ensure can be practically delivered.

There was discussion on what communication is optimal to engage with industry on uncertainty requirements. Simon hook said it would be useful to have clear guidance for industry about what parameters are required to enable uncertainty calculations, and noted this would be beneficial for cost estimation by industry/agencies. Sam Hunt and Nigel agreed and said that it could be an objective of the CEOS/GSICS Pre-Flight workshop presented by Nigel to develop a template alongside industry of the information needed, how to measure it and a preferred format. Dave Smith noted the potential issue of private companies selling satellite data that are separate to the engineers building the instruments. Dave suggested the starting point is to discuss with New Space providers what their market is, and Steffen recommended we encourage communication between New Space and their users about their requirements, rather than strict requirements coming from us. Dave highlighted the importance of clear definitions of mission accuracies and uncertainties and the dissemination of these to engineers to avoid miscommunication between agencies and industry.

Cody Anderson noted that there are two different industry perspectives:

- Government agencies setting the requirements for industry for the data they want to buy
- Industry selling data that has requirements set by themselves.

Cody said that engaging with this second perspective is challenging as the uncertainty information (e.g. pre-flight characterisation) often isn't available, initiating discussion on what can be done for existing sensors where the necessary pre-flight calibration and characterisation information is not available, a common problem when engaging with New Space missions. Nigel and Pieter De Vis commented on the limits this poses to what can be achieved. Pieter De Vis suggested that approaches such as vicarious calibration and sensor-to-sensor cross-calibration could still facilitate a robust uncertainty budget in this case, with Dave Smith noting that this would likely lead to very high uncertainty budgets for many New Space missions.

Marc Bouvet described the approach used in the FLEX mission to validate simulated output errors with the uncertainty budget provided by industry – this involved using an instrument simulator and GPP to mimic the performance budget and simulate errors. Sam Hunt commented that a similar approach is

being used for the TRUTHS mission, and suggested it could be worthwhile to formalise this to utilise the approach in more missions to perform validation at each step of the mission lifetime.

The need for guidance on handling categorical uncertainty budgets for the processing from L1 to L2 was highlighted by Grit Kirches. Emma Woolliams confirmed this is being actively worked on, particularly for the cases where more complicated algorithms (e.g. involving machine learning) are used.

Emma recommended the creation of a small technical working group with international representation to address the key uncertainty principles at different stages of mission lifetimes, and discuss how a workflow could be developed around that. Emma suggested this eventually lead to guidelines that space agencies could give to industry. There was general desire for a longer meeting to discuss these topics further, see AP.2023-6. Simon Hook emphasised the need to provide requirements for a standard set of measurements to be performed in the pre-flight characterisation within the next year in order for it to be included in specific upcoming missions. Nigel and Jack noted that this is similar to the aims of the CEOS/GSICS Pre-Flight workshop but at present this workshop is intended to focus of solar reflective domain, rather than TIR. Since IVOS an additional day has been added to the workshop focussing solely on TIR.

Marc Bouvet commented that there are two separate problems for us to address:
- Requirements for pre-flight characterisation to facilitate the development of robust uncertainty budgets
- The development of a common framework for how to report information about the collection of data that contributes to the creation of uncertainty budgets.

Action number	Activity	Date
AP.2023-6	**Nigel Fox, Sam Hunt, Cody Anderson and Steffen Dransfeld** to set up a task group & organise a longer meeting(s)/workshop (~1 day) on the curation and dissemination of uncertainty data information (volume / formats). Meeting(s) to be held before/after another meeting(s), JACIE and perhaps IGAARS. This could include representatives from the user community, New Space and CARD4L, depending on scope of meeting(s) - first meeting at JACIE with smaller group, more open meeting to follow (potentially at IGAARS).	In next 6 months – Mar/July
AP.2023-7	**Nigel Fox and Jack Xiong** to decide if thermal infra-red domain should be included in discussions at CEOS/GSICS pre-flight workshop on requirements for pre-flight calibration & characterisation to facilitate creation of robust uncertainty budgets. One option is to add an additional day to the workshop for discussion of TIR.	By the end of the year **Done and agreed**

4 Sensor Status

Presentation	By	Filename
Lunar calibration/comparison of NOAA NPP 20 & 21 (VIIRS)	Jack Xiong	10_Xiong_VIIRS.pdf

Sentinel-3 Status	Steffen Dransfield	11_Dransfeld_S3.pdf
Copernicus optical sensors L1 validation	Bahjat Alhammoud	12_Alhammoud_S2_S3.pdf
Cal/Val methodology for the SatVu HotSat-1 MWIR thermal imager	Jamie McMillan	13_McMillan_SatVu.pdf
Recalibration of HJ-1B thermal infrared historical image using ERA5 reanalysis data	Ning Wang	14_Wang_HJ-1B.pdf

4.1   Lunar calibration/comparison of NOAA NPP 20 & 21 (VIIRS) (J. Xiong)

- **Presentation given by Jack Xiong.**

The presentation covered calibration performance monitoring of SNPP, NOAA-20, and NOAA-21 VIIRS using the ROLO lunar irradiance model.

Martin asked whether the issues identified with the SWIR band are apparent in other types of comparisons. Jack confirmed this may relate to the pre-fight calibration.

Nigel asked if Jack was making use of an enhanced ROLO model he had recently seen presented at the NEWRAD meeting. Jack said he's not aware of the exact update Nigel is referring to, but regularly engages with Tom Stone, USGS (owner of the ROLO model). Cody said that this model is still under development and will be later released.

4.2   Sentinel-3 Status (S. Dransfield)

- **Presentation given by Steffen Dransfield.**

The presentation presented a status of the performance of the S3-OLCI and S3-SLSTR L1 products.

Jack warned that for on-going comparison to AQUA/TERRA-MODIS one should be aware that these satellites have now entered a drift phase as they reach end of life, so their performance may be degraded. Dave said they use historic AQUA-MODIS data to evaluate a BRDF model for PICS Libya-4 – so the comparison is via that model, not directly to recently acquired data.

4.3   Copernicus Optical Sensors L1 Validation (B. Alhammoud)

- **Presentation given by Bahjat Alhammoud.**

The presentation provided an analysis of Copernicus optical sensor L1 performance using vicarious validation techniques available in the DIMITRI toolbox.

Dave Smith encouraged Bahjat to verify he is including up to date values of methane levels in his models for the comparisons to the S3/SLSTR S6 band. 6S and Modtran uses old methane values which can result in a big difference in modelled TOA radiance.

4.4   Cal/Val methodology for the SatVu HotSat-1 MWIR thermal (J. McMillan)

- **Presentation given by Jamie McMillan.**

The presentation covered the calibration and validation approach for the SatVu HotSat-1.

Steffen Dransfeld asked if there were any user requirements for what uncertainty levels would be acceptable. Jamie said their initial target is visual products (not quantitative), with quantitative products with uncertainties a goal for the future. At these stage user requirements may emerge.

Dave Smith asked if they have a processing model that will gives a baseline of what they're uncertainty budget will look like. Jamie said this is something they are currently working on, starting with some studies of particular effects.

Simon Hook asked if their expectation is to be able to get validation data from community. Jamie confirmed this is the case, as they don't plan to make field measurements themselves. They do have concerns about the availability of this data.

Simon also asked if they will get enough measurements at night, to avoid solar contamination. Jamie said they expect there will be.

Jamie raised a question about if there is any prospect of a maturity assessment of CEOS-ARD compliance, rather than just pass/fail, as meeting the requirements is not feasible for them. Cody Anderson said are Threshold/Goal levels, but these are pass/fail.

4.5 Recalibration of HJ-1B thermal infrared historical image using ERA5 reanalysis data (N. Wang)
- **Presentation given by Ning Wang.**

The presentation covered the calibration of the HJ-1B data archive against ERA5 reanalysis data.

Dave Smith asked if the scatter seen in the comparisons to MODIS, is due to instrument noise or other effects. Ning said he expects this is likely due to a combination of instrument noise and the orbit drift of the HJ-1B platform causing matchup uncertainties.

Simon Hook asked which MODIS LST the comparisons were against. Ning said he would check but he thought it may be MOD21 rather than MOD11.

5   Hyperspectral

Presentation	By	Filename
DESIS Spaceborne Hyperspectral Instrument Calibration	Emiliano Carmona	15_DLR_DESIS.pdf
EnMAP Mission Overview: status, calibration and quality control	Miguel Pato, David Marshall, Raquel de los Reyes, and Martin Bachmann	16_DLR_EnMAP.pdf
TIMELINE: ~40 years of NOAA/MetOp AVHRR reprocessing and harmonisation	Martin Bachmann	17_Bachmann_AVHRR.pdf
Sensor Development & Cal/val Activities	Christian Fischer	18_Fischer_FIREBIRD.pdf
Image transformation between imaging spectrometers	Andreas Baumgartner	19_Baumgartner_HySpex.pdf
ENMAP Data Product Validation	Maximilian Brell	20_Brell_EnVAL.pdf
Hyperspectral Cal/Val Resources	Cindy Ong	21_Ong_CEOS_Hyperspectal.pdf
CNES Activities for Hyperspectral	Aimé Meygret	22_Meygret_CNES_Hyperspectral.pdf

5.1 DESIS Spaceborne Hyperspectral Instrument Calibration (E. Carmona)
- **Presentation given by Emiliano Carmona.**

The presentation covered the calibration of the hyperspectral DESIS instrument.

Nigel Fox asked if they're directly using the nominal RCN TOA nadir product for their vicarious calibration, or custom processing of the RCN BOA with info from site owners. Emiliano confirmed they're using both. Marc Bouvet asked if this custom processing adjusts the geometry of the RCN nadir data to match that of DESIS. Raquel said they attempt this, but highlighted the results could be significantly improved if they were provided with a BRDF model of the sites.

Bahjat Alhammoud asked if they had an explanation for the temporal gain variation, which is particularly significant in the 400-500 nm channels. Dave Smith commented that they had a similar situation for ATSR due to build up of water ice on the cryogenic detectors, resulting in an oscillation pattern in the instrument responsivity. Raquel De Los Reyes asked if this effect had a gradient with wavelength. Dave replied that the shorter the wavelength the faster the period of the oscillation observed, the rate of which depending on the contaminant. Dave commented that in the DESIS case it's unlikely to be caused by water ice due to the instrument temperature being above 150K, noting that the contaminant may be affecting any point of the optical chain. Nigel commented that given DESIS is on the ISS it could be affected by a range of contaminants – likely a hydrocarbon.

5.2 EnMAP Mission Overview: status, calibration and quality control (M. Pato, D. Marshall, R. De Los Reyes, M. Bachmann)

- **Presentation given by Miguel Pato, David Marshall, Raquel de los Reyes, and Martin Bachmann.**

The presentation covered an overview of the EnMAP mission and current status, including it's on-orbit calibration, quality control and instrument monitoring.

Jack Xiong asked if the lunar observations they compare are integrated irradiance of the full lunar disc. Miguel Pato said that they use the average radiance instead. Jack asked if the two lunar observations agree, and Miguel confirmed that they do not at present.

Jack asked if they use different illumination levels of their lamps to characterise non-linearity. David Marshall responded that they do this by varying the integration time, using 150 total time steps in the VNIR and 40 in the SWIR.

Marc Bouvet asked if there was any explanation for the spatial pattern of the gain variation on the detector. David said they didn't have an explanation with this, but it may be due to the location of contaminant build up.

Jack asked if they had any means to monitor the degradation of their calibration solar diffuser. Martin said that there is no spare reference diffuser onboard, though they may be able to monitor this with lunar observations. David commented that degradation occurs for all calibration units so isn't limited to the solar diffuser.

Cody Anderson asked if there's any signal coming from any of the dead pixels. Martin said that there are different categories for the dead pixels, e.g. hot, cold, no signal, flickering, stuck etc. These are all excluded in the processing.

Nigel asked approximately how many of the dead pixels were identified in the pre-flight characterisation and how many developed on-orbit. David said that the number of dead pixels approximately doubled between pre-flight and orbit.

Martin Bachmann noted that at previous IVOS meetings there has been interest in MTF and PSF, but Nigel commented that some key people for that discussion are not present in this meeting and that we were looking for a new champion to take the lead going forwards.

Dagmar Müller asked if any water targets are used for the vicarious calibration or validation. Max Brell will present an update on the vicarious validation later this morning, but said there is no vicarious calibration for EnMAP using water targets, only validation.

Bahjat Alhammoud asked for clarification of the colour code in the about spectra over Libya-4 shown in the presentation, and Max said that the different colours represent three different days. Bahjat asked why the radiometric stabililty with respect to the PICS is so different between the days for the water absorption bands. Miguel replied that the absolute difference was small but due to the absorption feature in these bands, the relative difference is much larger.

5.3 TIMELINE: ~40 years of NOAA/MetOp AVHRR reprocessing and harmonisation (M. Bachmann)
- **Presentation given by Martin Bachmann.**

This presentation covered the TIMELINE project, that performed a harmonisation of NOAA/MetOp AVHRR data in the VNIR and TIR domains.

Simon Hook asked if they had retrieved LST over the US as well Europe. Stefanie Holzwarth said for now it was limited to Europe due to data access. Simon said he may have access to the US dataset, and so there could be potential to process this.

Sam Hunt asked if they have compared their visible calibration to other recalibrations attempts for AVHRR. Martin said they think there is opportunity to learn from other more detailed AVHRR analysis, which is beyond the scope of their work, for example, the work of Jon Mittaz within the FIDUCEO project.

Jack Xiong asked how their comparison of AVHRR to simulated reference handled orbit drift in the earlier sensors – leading to widely varying viewing geometry. Martin said he has been in contact with CNES who have provided him with BRDF kernels for the sites. Jack commented that since MODIS is now on a drifting orbit they will also have to take this into account.

5.4 Sensor Development & Cal/val Activities @ DLR-OS (C. Fischer)
- **Presentation given by Christian Fischer.**

This presentation covered an overview of cal/val activities at DLR, including geometric calibration & MTF measurements, and radiometric calibration. Activities undertaken on a number of instruments were described, including FireBIRD, DESIS, and CO2Image.

5.5 Image transformation between imaging spectrometers (A. Baumgartner)

- **Presentation given by Andreas Baumgartner.**

This presentation covered the calibration of airborne instrument HySpex, including results of the geometric calibration, spectral calibration, and non-linearity correction. It also included a description of a method to spectrally regularise hyperspectral imagery.

Raquel asked if this work requires laboratory measurements. Andreas confirmed this and commented that accurate characterisation of the instrument in the lab pre-flight is needed (e.g., SRF shape as well as band central wavelengths and bandwidths).

Raquel commented that atmospheric correction models typically assume there is the same SRF all bands, so the method of spectral regularisation would be useful to prepare the data for this.

5.6   EnMAP Data Product Validation (M. Brell)

- **Presentation given by Maximilian Brell.**

This presentation covered the validation activities for the EnMAP mission, including field-, image- and model-based validation methods.

Nigel questioned the use of the word "homogenisation", instead recommending "harmonisation". Homogenising means mixing but here they mean 'make consistent with'.

Nigel asked for clarification on the meaning of the terms "accuracy", "precision" and "uncertainty" used in the presentation. It was clarified that:

- the accuracy represents the mean error between the satellite and reference in situ measurements,
- precision represents the random measurement noise (the standard deviation of the bias) – an estimate of the consistency between the different sites,
- the uncertainty is the accuracy and precision added in quadrature. There was general agreement that uncertainty is not the correct term for this metric.

Nigel emphasised the importance of making clear what the different terms represents.

In this presentation results were shown for several different sites with different methods and processing – it was noted that using a reference like RadCalNet, where consistency is ensured between sites, would result in clearer equivalent plots. Maximilian commented that for these results uncertainties that are random between sites will cancel out – systematic uncertainties are therefore plotted. Dave Smith commented that the uncertainty of EnMAP's calibration should also be considered for these metrics.

Miguel Pato asked what should be used in absence of uncertainty information for the reference measurements. Nigel questioned the value of the reference measurements without any associated uncertainties. Pieter De Vis commented that if multiple references are used then the standard deviation of those could provide an estimate of the uncertainty.

Miguel Pato commented that the uncertainty values presented here are used as estimates of the uncertainties of the L2A products, rather than the actual uncertainties, and the results show that these estimates are in line with requirements.

Cindy Ong commented that generally field measurement teams don't have the capacity or knowledge for what data needs to be collected to facilitate the calculation of robust uncertainties. Clear guidance for assessing uncertainty for field surface reflectance measurements would be helpful. Nigel questioned if this guidance has been provided as part of ESA's FRM4VEG and if so, this should be made more visible and transparent.

Action number	Activity	Date

AP.2023-8	**Nigel Fox** to confirm whether an international protocol has been defined in FRM4VEG to provide guidance for assessing uncertainty for surface reflectance field measurements. If so, Nigel Fox to consider how to increase visibility and transparency of this guidance.	Next IVOS

Simon Hook commented that the challenge presented by using several different field measurements is that each has a different uncertainty resulting not only from how it was done, but also the conditions at the time.

Grit Kirches commented that uncertainty associated with the validation method should also be taken into account.

5.7   Hyperspectral Cal/Val Resources (C. Ong)

- **Presentation given by Cindy Ong.**

This presentation covered an overview of Hyperspectral Cal/Val resources available, including the SRIX4Veg activity as part of FRM4Veg and the ACIX and CMIX intercomparison exercises, hyperspectral instrumentation and hardware in use.

Raquel asked about the differences between land and water for the ACIX intercomparison exercise. Nigel said that in many cases both the parameters and algorithms used are different for water and land, it's not simply a case of using the same algorithm with different values of AOD/WCV.

5.8   CNES Activities for Hyperspectral (A. Meygret)

- **Presentation given by Aimé Meygret.**

The presentation described CNES's activity in the hyperspectral domain, 2007 to present, including PRISMA-S2 cross-calibration and preliminary EnMap-S2 cross-calibration results.

Aimé confirmed to Cindy Ong that the prototype CIMEL sun photometer mentioned in the presentation covers the spectral range 400 nm – 2500 nm.

Bahjat Alhammoud asked how the spectral adjustment is performed for the S2-PRISMA cross-calibration. Aimé said that they use the SRFs provided – using the mean SRF across the track for the hyperspectral sensor and the ESA-provided SRFs for S2. However, Aimé noted that for comparison over Hypernets sites, the PRISMA SRFs per across-track pixel are used as the sites are smaller.

6   Impact of Solar Irradiance Spectrum

Presentation	By	Filename
Solar Irradiance Spectrum: Discussion	Nigel Fox	23_Fox_TSIS.pdf

6.1   Solar Irradiance Spectrum: Discussion (N. Fox, P. De Vis, M. Bachmann)

- **Presentation given by Nigel Fox, Pieter De Vis, Martin Bachmann.**

The presentation covered an introduction to the topic of Solar Spectral Irradiance in reference to the transition from Thuiller to TSIS as the CEOS recommended solar irradiance spectrum. Nigel encouraged discussion on the topics of adoption of recommended spectrum for CEOS, location of recommended spectrum, potential impact of choice/change of spectrum for L1 and L2, and what should be done in terms of communication to users.

Pieter De Vis presented an analysis of the differences between Thuiller and TSIS spectra up to TOA radiance. Martin Bachmann presented a similar analysis also including the Fontenla spectrum.

Several potential issues resulting from inconsistent spectra were pointed out.
- Martin said that comparisons of current missions to heritage missions, for example AVHRR, which have products based on outdated solar irradiance spectra could cause an issue.
- Raquel pointed out the potential issue of a different solar irradiance spectrum being used for calibration or retrievals to that used in the processing of the data (e.g. EnMAP). Marc commented that this issue is resolved by including the in-band solar irradiances in the L1 radiance products, enabling users to evaluate and work in reflectance, but Raquel said for EnMAP this data is not included in the product due to potential licensing issues.
- Marc Bouvet noted the potential issues for using solar diffusers for radiance calibrations that have been characterised in reflectance, particularly when the information of solar irradiance used is not provided.
- Pieter commented that although the solar irradiance used is not an issue for harmonising in reflectance, there are cases when we'd want to harmonise in radiance, in which case it is an issue.

There was some discussion about the availability of different spectra and the possibility of making them available on the CEOS Cal/Val portal. The group noted that this is particularly relevant for products using MODTRAN, which by default uses the Fontenla spectrum (although Miguel clarified that there is the option for the user to select the spectrum to use). The Fontenla spectrum was generally agreed to be difficult to access without a MODTRAN licence. Martin commented that they can't access the Fontenla irradiance spectrum and if they could its licensing is unclear. Christian recommended Martin contact Airforce Research Lab for currently available solar irradiance spectra. Nigel noted that the licensing is much clearer for TSIS than Fontenla. Nigel and Steffen agreed that CEOS's role is simply to make a recommendation and communicate this recommendation to the user, not to provide access to all possible options. However, Dave Smith and Pieter De Vis commented that it would be useful for users to have the other spectra to be able to perform corrections for the transition to using TSIS in existing processing chains. It was suggested by Pieter that CEOS could provide a spectrum of the differences between the spectra to enable users to perform corrections, but Nigel pointed out the difficulties that may arise from this, e.g. maintenance, the quantity of slightly varying spectra etc.

There was general agreement that this highlights the need for clarity in processing of products, and the question was raised as to how best to communicate this. Dave commented that not all users are aware of the Cal/Val portal, and so communication, including from space agencies to their customers, is key. Nigel pointed out that the proposed CEOS recommendation on solar irradiance is that data providers should make users aware which spectrum was used and the impact of this. Nigel questioned to what extent CEOS and space agencies should try to make the relevant literature more visible to users. Steffen said that from ESA's perspective, they will communicate an announcement to users when the S3 data is reprocessed with the new TSIS spectrum. Nigel raised the question as to how to engage on this topic with New Space users, and there was general agreement that there should be an announcement at the next JACIE. Cody Anderson also suggested that an abstract on this topic is submitted to VH-RODA.

Action number	Activity	Date
AP.2023-9	**Pieter De Vis**, with **Martin Bachmann**, to submit an abstract to VH-RODA 2023 on the change of CEOS-recommended solar irradiance spectrum with the authorship of CEOS WGCV IVOS.	VH-RODA abstract deadline (mid Oct)

Nigel made the comment that for products that don't include the uncertainty associated with the solar irradiance spectrum in the L1 product uncertainties, the transition to the TSIS spectrum would result in an improvement in absolute uncertainty. Nigel noted that this would encourage users to support the change in spectrum. However, Nigel said he thinks that some missions, e.g. S3 and MERIS, quote their uncertainties with respect to the solar irradiance spectrum, and so this improvement would not be apparent to the user. Dave Smith commented that he thinks some products, e.g. SLSTR, do include the solar uncertainty.

Dave Smith raised the question as to whether the work being performed by Rayference is in radiance or reflectance – the answer was not known by the members present.

Fangfang Yu said that in the 2022 GSICS meeting it was agreed to recommend TSIS1-v1 as the reference and it was later questioned whether to swap this to TSIS1-v2 following the CEOS recommendation of this spectrum. Nigel commented that the only difference between TSIS1-v1 and TSIS1-v2 is that v2 extends further in the thermal infrared and so they can be used interchangeably. Nigel also confirmed that the CEOS recommendation is not expected to change again in the near future, and this will only happen if a spectrum with lower uncertainties is made available (conceptually from TRUTHS for example in the 2030s).

Action number	Activity	Date
AP.2023-10	**Nigel Fox** to update CEOS Cal/val portal website to add some examples of difference between solar irradiance spectra and make clear the difference between TSIS1-v1 and TSIS1-v2.	End of this year

Aimé Meygret suggested that space agencies should provide products in reflectance rather than radiance, in light of problems like this. Steffen Dransfeld said that this is being discussed for S3 but they are planning to extend the solar zenith angle range beyond 90 degrees, for which reflectances cannot be provided.

Action number	Activity	Date
AP.2023-11	**Nigel Fox** to plan a discussion on whether L1 products calibrated in reflectance should still be provided in radiance.	Next IVOS

7   Comparison Tools / New Space Services

Presentation	By	Filename
DIMITRI-Database for Imaging Multispectral Instrument and Tools for Radiometric	Bahjat Alhammoud	24_Alhammoud_Dimitri.pdf

Intercomparison: QA4EO DIMITRI-Evolution Project Outcomes		
Sensor performance assessment	Sam Hunt	25_Hunt_CEOS_Cal_Monitoring.pdf
Site selection for newspace	Cody Anderson	26_Anderson_Newspace_Cal_Sites.pdf
L1 Calibration Method Capability Database	Nigel Fox	27_Fox_Cal_Method_Database.pdf

7.1 DIMITRI-Database for Imaging Multispectral Instrument and Tools for Radiometric Intercomparison: QA4EO DIMITRI-Evolution Project Outcomes (B.Alhammoud)

- **Presentation given by Bahjat Alhammoud.**

The presentation covered an overview of the DIMITRI-Database, including improvements made for the new V4.x.

Diogo Rio Fernanes asked if DIMITRI also includes functionality of a general reader, e.g. generating data in a specific format that can then be read by DIMITRI. Bahjat said for DIMITRI to be run the sensor-specific reader needs to be developed – this could in theory be done for any sensor. Diogo from New Space would like a generic reader in DIMITRI so don't have to develop a new one per sensor. Dave and Marc commented that there are challenges associated with defining a generic data format, e.g. the differing geometries of sensors. Marc said there's an internal format and guidelines available for developing a reader in DIMITRI. Dave said that making data available in netCDF is beneficial.

7.2 Sensor Performance Assessment (S. Hunt)

- **Presentation given by Sam Hunt.**

The presentation provided an overview of the matchup generation and harmonisation pipeline, and related Python tools, currently in development by NPL and U. Reading. The presentation showed a mock-up of a proposed CEOS Cal/Val dashboard tool using this matchup pipeline.

Cody Anderson asked if the matchup database will find the imagery. Sam said that it consists of multiple steps:

1. Modelling the orbit
2. Catalogue look up
3. Adding the products to a database
4. Querying of this database at a later date

Cody commented that they have undergone similar work and expressed interest in discussing further.

In the presentation Sam asked for volunteers from New Space to be beta testers for the system. Jamie McMillan volunteered on behalf of SatVu and queried the best way to follow the development of the matchup comparison system presented. Nigel Fox said that the tool will be made available via the Cal/Val portal if it becomes a CEOS tool. Sam said that in the meantime, the code is planned to be made open source and available on GitHub, likely in a separate repository to NPL's CoMet toolkit.

7.3 Site Selection for New Space (C. Anderson)
- **Presentation given by Cody Anderson.**

The presentation covered the site selection for New Space validation efforts.

Cody asked for feedback on his proposed list of reference sites, noting that New Space vendors will likely favour a shorter list than he proposed. Nigel Fox suggested we could define a core minimum set of sites – e.g., GONA, RVUS, Libya-1/4, Algeria-3 – while encouraging vendors to provide imagery for Cody's full list, so they can achieve lower comparison uncertainty.

Simon Hook asked if there was consideration of darker targets in the solar reflective domain, for example the Lake Tahoe site. Cody said the list did include 2 dark land sites, but they are less well characterised, agree water site could be a useful addition. Martin Bachmann pointed out water sites such as AAOT could be considered. Steffen Dransfeld proposed the Ocean Colour SVC sites, although Marc Bouvet questioned if this data was processed to TOA. Nigel commented that these would be valuable but perhaps not in the minimum core sites.

Cody suggested that it may be important to select sites of which imagery is of little commercial value, so vendors don't object to sharing the data.

Marc said that given the objective of the activity the core sites should be restricted to those providing TOA L1 data, to enable more simple analysis for vendors.

Cody agreed we could start with defining sites for L1 radiometric validation, and perhaps expand further down the processing chain. Simon pointed out how that will

Nigel said that the sites should focus on the new space sensor requirements, rather than expanding into wider variety of reference that may be aimed at sensors with stricter requirements, e.g., climate sensors.

Dave Smith wondered that given New Space vendors may typically use this for their calibration would validating against these sites be valuable. Nigel commented that this could have a positive effect, encouraging New Space vendors to make use of the available infrastructure.

Diogo Rio Fernandes said that as long as the sites have data available at TOA, they wouldn't object to contributing their data to this process. Steffen noted there is lower maturity in the TIR domain.

For geometry sites, Cody hoped they could find a set of sites that covered the US, Europe and Asia. Marc said it would also be valuable to capture a range of latitudes in order to observe changes in behaviour around the orbit. Nigel noted there is an ESA led activity also seeking to contribute to this from a European perspective.

7.4   L1 Calibration Method Capability Database (N. Fox)

- **Presentation given by Nigel Fox.**

The presentation provided an overview of a proposed framework for CEOS maintain a reviewed database of L1 Vicarious Cal/Val infrastructure.

Cindy Ong commented that the sites on the Cal/Val portal are listed as a catalogue of sites (other than the endorsed sites) so quantitative analysis on the quality of the sites would be particularly useful.

Nigel clarified to Cindy that the intention of the presented infrastructure is not performing a certification process, it is providing a review of the validation methods available and their respective performance capabilities. Nigel commented that the database format will enable users to sub-select methods.

Cindy commented that the variety of standards (e.g. ISO) makes it challenging for users to compare methods available. Nigel said the proposed database is not intending to offer an alternative to these standards, but improves transparency about the methods available for the user.

Dave Smith asked how this proposed infrastructure will interface with the existing list of sites on the Cal/Val portal. Nigel clarified that the database contains methods (that may be associated with particular sites) rather than the sites themselves. Dave recommended that this could link to the sites where appropriate.

Nigel clarified that the expectation is that the information required for the database will be filled out by owners rather than us.

Cody Anderson questioned how the database could be queried to get a list of useful methods – it could be . Nigel said that this infrastructure provides the information and review process for the methods that will enable the user to make their own decision.

Cody asked that as all RadCalNet sites, for example, share a common method, would that method require site-specific entries to the database. Nigel responded that although the steps of the method may be common, the uncertainty associated with using the method for each site will differ.

Dave commented that the proposed infrastructure will be a useful resource to users that are new to the domain in particular.

Leonardo asked if it will be possible to attach products to the methods. Nigel said this is not the intention for the database, and encouraged Leonardo to contact with Sam Hunt regarding the matchup 'data cube' concept presented by Sam earlier.

Action number	Activity	Date
AP.2023-12	**Nigel Fox** to contact Cody Anderson for further discussions on the proposed CEOS-reviewed method database.	Next IVOS

8   Test Sites / National Activities

Presentation	By	Filename
Modelling of TOA reflectance for stable field in NW China & calibration approach	Lingling Ma	28_Ma_China_PICS.pdf
Israel	Eyal Ben-Dor	29_BenDor_Israel.pdf
CSIRO Pinnacles (PIAU) update 2023 & SRIX4Veg-II	Cindy Ong/Ian Lau	30_CSIRO_Australia.pdf

8.1   Modelling of TOA reflectance for stable field in NW China & calibration approach (L. Ma)

- **Presentation given by Lingling Ma.**

The presentation described modelling of TOA reflectance for stable field sites in NW China, including uncertainty analysis for the model, & presented results of a validation and calibration approach using the model.

8.2   Vicarious Calibration activities in Southern Israel (E. Ben-Dor)

- **Presentation given by Eyal Ben-Dor.**

The presentation described vicarious calibration activities performed over Southern Israel, and presented results from case studies involving EnMAP, PRISMA, EMIT and DESIS.

Steffen Dransfeld asked if there would be scope to collaborate with LSTM in addition to the collaboration mentioned in the presentation with CHIME. Eyal said that this would be welcomed.

Jamie McMillan asked if there are plans to extend to medium-infrared site validation. Eyal responded that this is not part of the current planned activities.

8.3   CSIRO Pinnacles (PIAU) update 2023 & SRIX4Veg-II (C. Ong, I. Lau)

- **Presentation given by Ian Lau and Cindy Ong.**

Ian Lau presented an update on the status of the CSIRO Pinnacles (PIAU) site. Cindy presented an overview of the SRIX4Veg-II activity planned to be performed in Australia 2024.

Action number	Activity	Date
AP.2023-13	**Anyone** to contact Cindy Ong if interested in being involved in the SRIX4VEG-II activity scheduled in Australia in March 2024.	ASAP – by end of October

9   TIRCalNet

Presentation	By	Filename
TIRCalNet Update	Steffen Dransfeld	31_Dransfeld_TIRCalNet.pdf
Instrumented Site to TIR Cal/Val	Morgane Chapelier	32_Chapelier_TIRCalVal.pdf
TIR Cal/Val at La Crau	Sebastien Marcq	33_Marcq_La_Crau.pdf
Validation of Thermal Infrared Satellite Measurements Using Automated Validations Sites	Simon Hook	34_Hook_JPL_TIRVal.pdf
Monitoring the Health of the Earth (Pixxel)	Awais Ahmed	35_Ahmed_Pixxel.pdf
ASTeRN – Advanced Surface Temperature Radiometer Network	Dave Smith	36_Smith_ASTeRN.pdf
CEOS IR Radiometer Comparison	Yoshiro Yamada	37_Yamada_IR_comparison.pdf
Realtime Thermal Data for Highly Dynamic Events	Marc Seifert	38_Seifert_TIR.pdf

In this session Steffen Dransfeld led a discussion around the development of TIRCalNet, supported by a series of presentations.

9.1   TIRCalNet Update (S. Dransfeld)

- **Presentation given by Steffen Dransfeld.**

Steffen introduced the session with a presentation introducing TIRCalNet concept and providing a update on developments since the last IVOS meeting.

Dave asked if the uncertainty requirement of 0.1 K was necessary/achievable. Steffen said this is a longer-term goal to support climate studies.

9.2   Instrumented Site to TIR Cal/Val (Chapelier)

- **Presentation given by Morgane Chapelier.**

Morgane presented a sensitivity analysis looking at the of the feasibility of making use of radiometer measurements for TOA TIR Cal/Val, using the CNES La Crau site as a case study.

Dave Smith asked if they intended to separately handle random and systematic effects, such as the instrument calibration, in the analysis. Simon Hook said he would describe their calibration approach in his presentation. Nigel pointed out instrument calibration uncertainty was included in the study, at 0.1-0.2K.

Dave asked how they would handle atmospheric column characterisation. Simon said they base this on parameters defining the state of the total column, as making supporting atmospheric profile measurements (i.e., by sondes) is not feasible.

Marc Bouvet asked how they handle emissivity characterisation, as this seems to be a dominant component of the uncertainty budget. Simon said this is a significant challenge for land sites, and requires supporting laboratory measurements. For this reason, Simon pointed out water sites are most suited for TOA calibration, however they are limited in terms of temperature range. Frank Goettsche agreed, pointing out heterogeneity is also a significant issue for land sites.

Jamie McMillan asked if the uncertainty analysis would be expanded to a more comprehensive GUM-style analysis as he felt some uncertainty components were missing. Simon said his presentation would touch on uncertainties from due to emissivity characterisation. Morgane said the uncertainty sources she has currently incorporated are from literature, but she would be open to expanding this in future.

9.3   TIR Cal/Val at La Crau (S. Marcq)

- **Presentation given by Sebastien Marcq.**

Sebastien presented the status of TIR Cal/Val at the La Crau site.

Dave Smith asked if the KT15's they have used are custom for their use. Sebastien said they are off the shelf.

Jamie McMillan asked how they planned to calibrate their new instrumentation. Sebastien agreed this was important, but they didn't have a specific plan yet. The JPL radiometer would be calibrated by NASA before and after the campaign. For the CIMEL and KT15's they will probably perform an annual calibration depending. The emissivity box they expected to use the manufacturer calibration.

Jamie said he was sceptical about their use of "thermabutton". Sebastien said this instrument was being used experimentally at the moment.

Diogo Rio Fernandes asked if the the varying overpass time of ECOSTRESS causes any issues in their analysis. Sebastien said this had not been a significant issue in the analysis.

Simon Hook asked if they had compared their measurements to the ECOSTRESS products. Sebastien said they planned to do this.

Steffen Dransfeld asked how much the CIMEL instrument cost. Aimé Meygret confirmed this was 53K euro, excluding the black body source (which is an additional 4K).

9.4 Validation of Thermal Infrared Satellite Measurements Using Automated Validations Sites (S. Hook)

- **Presentation given by Simon Hook.**

The presentation provided a review of JPL TIR product validation activities using automated validation test sites.

Jamie McMillan expressed interest in JPL providing full details for the uncertainty budget throughout the processing chain for the TOA product. Simon agreed that this would be useful but noted that a number of effects are considered, e.g. field of view, radiometric calibration, in the creation of the uncertainty budget, so would encourage input from others on how best to communicate this complex uncertainty information.

Jamie McMillan was impressed by the lab calibration of JPL instrumentation that was presented.

Jamie asked if there have been any efforts to improve the agreement of spectral emissivity measurements for sites, for example through a measurement comparison exercise led by an NMI. Simon agreed that this would be a useful activity but has not occurred yet. He commented that the best targets are water as the emissivity is known with greater accuracy than for land sites.

Sebastian Marcq asked Marc Bouvet if he had any samples from desert sites available for emissivity measurements. Marc confirmed he has sand samples from Saudi Arabia and other sites. Simon also expressed interest in having access to the samples.

Action number	Activity	Date
AP.2023-14	**Marc Bouvet** to send an email to anyone interested about site samples available for emissivity measurements.	Next IVOS

Cindy Ong asked what parameters are needed to perform the "RVal" method presented. Simon said that this method required the measured emissivity and atmospheric profile of the site. Cindy asked if it is sufficient to characterise the emissivity of a site by performing lab measurements of samples from the site, or if field measurements are also required. Simon said this depends on the site – for a site where emissivity varies significantly on a local scale, e.g. La Crau, field measurements are often needed. However, for a more homogeneous site, such as a sandy site, lab measurements of the samples will likely be sufficient.

Steffen asked about the maintenance of the sea instruments. Simon said that the instruments very often require being taken away from the site for repairs, due to effects like salty air. Simon recommended that electronics are coated in a layer of wax/chemical in an effort to protect them, but pointed out that additional challenges are also posed by the high salt level of the water impacting access to the instruments by boat.

9.5 The Health Monitor for Planet Earth (Pixxel) (A. Ahmed)
- **Presentation given by Awais Ahmed (Pixxel) and introduced by Pascal Schichor (European Space Imaging).**

This presentation provided an introduction to the Pixxel's planned constellation of high resolution hyperspectral satellites, designed to measure the VNIR for monitoring parameters linked to the health of the Earth.

Jack Xiong asked if the absolute radiometric calibration of the satellites relies on the use of RadCalNet or lunar measurements. Awais said that the absolute calibration of the satellites is tied to RadCalNet.

Martin Bachmann enquired if images over RadCalNet sites will be made available for validation efforts, Awais confirmed they plan to do this.

Andreas Baumgartner asked if the sensors are push-broom, and Awais confirmed this is the case, and explained that the satellite has two sensors for different wavelength ranges.

Sam Hunt asked about the pre-flight calibration performed. Awais said that pre-flight calibration is performed on ground using halogen lamps.

Cody Anderson asked what solar irradiance spectrum is used for the calibration with SPARC targets – Awais did not know.

Nigel encouraged engagement being CEOS IVOS and Pixxel moving forward. Awais commented that Pixxel expect to have representation at VH-RODA later this year.

9.6 ASTeRN – Advanced Surface Temperature Radiometer Network (D. Smith)
- **Presentation given by Dave Smith.**

This presentation covered an overview of the ASTeRN – including requirements definition, design, planned calibration activities, and deployment for the radiometers.

Jamie McMillan asked about environment testing performed for the instruments, and Simon Hook emphasized the importance of characterising the instrument performance at different temperatures as part of environment testing. Jamie recommended the use of an environmental chamber. Dave agreed that this would be valuable but noted that testing performed is dependent on time and cost. Simon noted the challenges posed by testing under different humidity conditions.

Simon questioned the use of custom filters vs a standard set of filters, and recommended using a set of filters for every satellite instrument as each will have a different spectral response. He also asked how they verify that the custom filters match the flight filters. Dave said they are in communication with the people that built the flight filters, and commented that there is space for extra filters that could be added as needed.

Simon was sceptical about how well the radiometer response matches the filter response due to the variability of emissivity - emissivity could change between measurements of the instrument and filter. Simon emphasised the issues associated with propagating any resulting errors through the processing chain. Dave thanked Simon for this comment and said he will discuss the issue further with Darren Ghent.

9.7   CEOS IR Radiometer Comparison (Y. Yamada)

- **Presentation given by Yoshiro Yamada.**

This presentation described the CEOS International Thermal Infrared Radiometer Comparison exercise led by NPL in 2022, including results from the exercise.

Simon Hook commented that the larger error seen for higher temperatures in the results presented likely arises due to these temperatures being outside the temperature range the radiometers were calibrated at. Yoshiro agreed but commented that the uncertainty would still be expected to vary depending on the temperature of the target.

Nigel observed that this exercise represents a good starting point for these activities, involving ideal conditions and an ideal comparison, and agreed with Simon's point that further efforts to perform intercomparison in other conditions would be worthwhile.

Jamie McMillan expressed interest in characterisation of the environmental sensitivity of the radiometers as potential future work. Yoshiro agreed but noted the practicality challenges this would pose.

9.8   Realtime Thermal Data for Highly Dynamic Events (M. Seifert)

- **Presentation given by Marc Seifert.**

This presentation covered an overview of the satellite TIR imagers in development by OroraTech with the primary scientific objective of observing wildfires globally. The presentation included validation and calibration efforts and planned future constellations.

Marc Seifert clarified for Simon Hook that the saturation temperature of the instruments is around 800 K.

Jamie McMillan asked how the medium and long wave bands are measured. Marc said that the instrument has a thermal detector that is capable of measuring the full wavelength range of both of these bands.

Cody Anderson asked how the shutter was used for calibration, and if this included the mid-wave band. Marc said that this is not necessary for mid wave but is used for the long wave. Marc explained that as the shutter is in front of the camera optics, a model (using the shutter's well-known emissivity) is needed for how the sensitivity varies with camera optic temperature.

Nigel asked about the estimate for radiometric accuracy. Marc said that for LST the estimate is of the order of 3-5 K, and for TOA around 1 K.

Steffen asked about the uncertainty associated with the calibration using SLSTR as the reference, and Marc said that this is being actively worked on. Diogo commented that preliminary calibration coefficients evaluated using SLSTR as the reference matched well with those evaluated for VIIRS as the reference.

Nigel asked if OroraTech have been involved in the EDAP process. Marc said they were not but their quality will be assessed by the optical MPC. Nigel encouraged further engagement between OroraTech and CEOS IVOS and suggested they attend the VH RODA meeting later this year.

10 Cal/Val Services

Presentation	By	Filename
HYPERNETS Vicarious Calibration Feasibility Study	Pieter De Vis	39_DeVis_HYPERNETS.pdf
ERADIATE: A radiative transfer model for the Earth observation community	Vincent Leroy	40_Leroy_Eradiate.pdf
An SI-traceable protocol for the validation of radiative transfer model-based BRDF simulation	Vincent Leroy	41_Leroy_RTM_Validation.pdf

10.1 HYPERNETS Vicarious Calibration Feasibility Study (P. De Vis)

- **Presentation given by Pieter De Vis.**

This presentation covered a study to assess the suitability of the Hypernets Gobabeb (GHNA) and Antarctic (PEAN) sites for vicarious calibration.

Jeff asked who maintains Antarctic site. Pieter said that this site is run by RBINS and operates in summer campaigns.

Raquel asked why different RTMs were used between RadCalNet and Hypernets in the comparison. Pieter said the use is consistent within the networks – RadCalNet uses Modtran and they chose Libradtran for Hypernets, because that's what they have the most experience and confidence in.

Marc asked Pieter to clarify the comparisons shown between Hypernets and RadCalNet measurements at Gobabeb. Pieter explained he showed comparisons between RadCalNet and Hypernets products, and the Hypernets product and the Hypernets product processed by the RadCalNet processor.

Martin asked if they plan make measurements to characterise the BRDF of the Gobabeb site. Pieter said they plan to periodically take longer sequences with the Hypernets to cover more geometries for this reason.

Lingling asked how they evaluate the random uncertainty for the Hypernets products. Pieter said that at every geometry they take 10 measurements, with the random uncertainty the standard deviation of these measurements, after filtering for outliers.

10.2 ERADIATE: A radiative transfer model for the Earth observation community (V. Leroy)

- **Presentation given by Vincent Leroy.**

This presentation covered the motivations, development, current status and future planned developments for the radiative transfer model ERADIATE being developed by Rayference.

10.3 An SI-traceable protocol for the validation of radiative transfer model-based BRDF simulation (V. Leroy)

- **Presentation given by Vincent Leroy.**

This presentation described an SI-traceable protocol for the validation of radiative transfer model-based BRDF simulation, and presented results from the validation of Eradiate-simulated BRDF of an artificial target using SI-traceable lab measurements.

Pieter De Vis asked if the symmetry around 0 degrees seen in the biases between the simulated and lab-measured BRFs could result from the potential misalignment of the sample azimuth angle. Vincent said that they think this is more likely to be due to the measurement protocol or set up. The sample is systematically measured along different planes, with one side of the sample always measured to have lower BRF values. He said this could potentially be fixed by averaging the two sides and accounting for this in the uncertainty analysis.

Marc asked how SI-traceable lab measurements could be used to validate RT-simulations of molecular Rayleigh scattering. Vincent said that in his earlier presentation (10.2) he mentioned benchmarking for polarisation performed – as part of this effort the polarised Rayleigh scattering implemented was validated against reference data. In the future they are planned to validate this against more up-to-date data, however Vincent noted that these reference datasets are not SI-traceable. Vincent said this is planned to be addressed in future work.

Nigel emphasised the potential impact of the biases of ~2 % shown between different radiative transfer models.

Vincent recommended Pieter repeat the analysis presented in his presentation (see 10.1) using the same radiative transfer model for both the RadCalNet and Hypernets networks to provide an estimate for the uncertainty associated with this choice of RTM.

11 Miscellaneous: RadCalNet, STAR-cc-OGSE, and Lunar Activities

Presentation	By	Filename
The Radiometric Calibration Network: RadCalNet	Marc Bouvet	42_Bouvet_RadCalNet.pdf
STAR-cc-OGSE for the Calibration of TRUTHS	Paul Green	43_Green_STAR.pdf
Lunar Activities at VITO	Stefan Adriaensen	44_Adriaensen_lunar.pdf

11.1 The Radiometric Calibration Network: RadCalNet (M. Bouvet)

- **Presentation given by Marc Bouvet.**

This presentation provided a summary of the presentations and discussions that occurred in the RadCalNet WG meeting that was held at the beginning of this week.

Nigel Fox thanked Marc Bouvet and the team for their efforts in running this network that is of great value to the community. Marc commented that it is a highly collaborative effort.

11.2 STAR-cc-OGSE for the Calibration of TRUTHS (P. Green)

- **Presentation given by Paul Green.**

This presentation covered an overview of the STAR-cc-OGSE pre-flight characterisation and calibration system developed and built by NPL. The presentation described updates currently in development to

meet the low uncertainty requirements for the pre-flight radiometric calibration of the TRUTHS mission.

Stefan clarified that the presentation should have referred to NPL's historical calibration of PROBA-I CHRIS not PROBA-V.

Jamie McMillan asked what efforts are being made to extend the spectral range of the characterisation to the mid- or far-infrared. Paul said that this would involve blackbody-based calibration systems rather than the laser-based STAR system – between NPL and RAL there are facilities for these wavelengths that NPL provides the SI-traceability for.

Jamie asked how STAR could demonstrate traceability to the Kelvin and ITS90 for satellite measurements of LST. Jamie pointed out that in the comparison between LST measurements from satellites and ground measurements by thermometers, the measurements are traceable to these different standards. Paul said that the traceability of the STAR system is to the Watt, but there have been on-going efforts by NPL to ensure SI and ITS90 standards are interoperable. Paul noted the value of the research suggested by Jamie but clarified that the intended purpose of the STAR system is for practical calibration purposes. Nigel commented that this issue is not relevant to the solar reflectance domain that STAR operates in. Jamie said his concern was if EO and ground reference measurement were traceable to different standards. Nigel said are the uncertainty level of LST this is unlikely to be an issue.

Andreas Baumgartner asked if standardised evaluation tools for the measurement data output by STAR-type systems are in development. Paul said that tools to report the data are part of the system ensuring standardisation of data reporting. However, work on tools for the standardisation of evaluating the data are not yet in development. Nigel emphasised the importance of this for the case of the pre-flight calibration of the TRUTHS mission, for which a huge amount of data processing will be required (e.g. stray light kernels & ISRF of every pixel). Nigel, Paul and Andreas encouraged collaboration on these efforts between the TRUTHS team and DLR in an effort to build on DLR's existing expertise.

11.3 Lunar Activities at VITO (S. Adriaensen)
- **Presentation given by Stefan Adriaensen.**

This presentation covered an overview of the radiometric lunar calibration, presenting the case study of the calibration of PROBA-V.

Martin Bachmann asked if the LIME lunar model is based mostly on measurements or models. Stefan said that measurements provide inputs for the derivation of the model.

Cody Anderson asked if the dataset from PROBA-V is open – Stefan confirmed that it will be shared.

Marc Bouvet commented that interpolation between ASD measurements for each phase angle is performed, and that currently the ASD measurements cover four lunar cycles. Marc said that a corresponding lunar toolbox will be made available in the coming months. He said this will provide functionality for a user to input an SRF and perform the comparison between measurement data (in GSICS WG defined format) to simulated observations. Miguel Pato expressed interest to discuss this further with Marc.

Steffen Dransfeld asked about the relative bias between the results for S3 A/B 2020 data shown in the presentation. Stefan said that the bias is noticeable and confirmed that there is ongoing work to establish the reason for this.

Sam Hunt asked why more stray light is seen on the left of the enhanced stray light image of the Moon shown in the presentation. Stefan said this is likely to be because this is the sharpest edge of the image and the other edge is smoother.

12 Communications

Presentation	By	Filename
CEOS Cal/Val Portal Status and Updates	Paolo Castracane	45_Castracane_CalVal_Portal.pdf

12.1 CEOS Cal/Val Portal Status and Updates (P. Castracane)

- **Presentation given by Paolo Castracane.**

This presentation covered updates made to the CEOS Cal/Val Portal since the last IVOS meeting, including the status of WGCV-51 and WCGV-52 actions, and highlighted hyperspectral Cal/Val resources available.

Nigel asked for suggestions from anyone as to how the Cal/Val portal could be made more dynamic in demonstrating the value of the extensive Cal/Val activities being done. Nigel encouraged greater use of providing reference links to our work on the Cal/Val portal. He suggested a "Support for New Space" section/tab on the website containing consolidated information or providing links to relevant resources.

Sam Hunt asked about the intended scope for activities published to the portal as news stories. During the following discussion Nigel said that he thinks any Cal/Val activity related to an IVOS sensor or application is within the scope. Cody said that many of the Cal/Val activities undertaken by IVOS are part of separate projects with marketing independent to the IVOS Cal/Val portal. He suggested resharing of these other resources to the IVOS website. Simon recommended adding a sentence highlighting the Cal/Val aspect of work being reshared, giving the example of an airborne campaign over a Cal/Val site. Nigel agreed, pointing out the opportunity this could provide for greater synergy between activities. Nigel suggested there could be a specific section for campaigns.

Cody suggested sharing references to related literature, with agreement from Nigel.

Paolo said the idea was to collect as much as possible, so welcomed any further content.
Cody suggested added an announcement about VH-RODA on the portal.

Action number	Activity	Date
AP.2023-15	**All** to send Paolo news stores for the Cal/Val portal	On-going

13 Final points/AOB

Jamie McMillan asked if the ESA Cal/Val park initiative has a connection to CEOS-WGCV. Nigel confirmed that this is an ESA project as a contribution to the CEOS community. Steffen Dransfeld said he saw its place within CEOS-WGCV more aligned to the LPV subgroup.

Nigel raised the question about hosting more regular meetings and/or discussions, perhaps as sub-groups. Steffen Dransfeld commented that discussions occur more regularly within some other subgroups, and suggested that further meetings are arranged ad-hoc as required. Nigel offered to

hold these ad-hoc meetings, and pointed out that two intermediate activities are already planned to be organised (see actions).

The meeting was closed with thanks to Martin Bachmann and all the DLR team for all the work they have done in hosting the meeting. Also with thanks to all who travelled for enabling the benefit of an in-person meeting, and those who joined online.

14 The next meeting

It is still expected that the next IVOS will be a 5-day event including workshops and then the IVOS meeting in mid-September 2024. The location has not yet been defined and invitations are requested. Typically we have been rotating between "Americas", "Europe" and "Rest of World", and therefore the next meeting is due to be in the "Rest of World", however other areas may be possible.

Since the IVOS meeting Hirokazu Yamamoto of AIST Japan has volunteered to host the next IVOS meeting either in Tokyo or Tsukuba and will confirm the date (around mid September) and exact location early in 2024.

AP.2023-16	**Anyone** wishing to propose a location for the next meeting should contact **Nigel Fox**	DONE
AP.2023-17	**Maddie Stedman** to complete the minutes. **Nigel Fox** to share draft to all attendees of the IVOS 2023 meeting for review, followed by sharing of minutes to wider community via the Cal/Val Portal.	By end of year
AP.2023-18	**Nigel Fox** to organise dates and practicalities for the next IVOS meeting.	By end of year
AP.2023-19	**All presenters** to send presentations to Nigel Fox and/or Maddie Stedman (nigel.fox@npl.co.uk, maddie.stedman@npl.co.uk).	By November

Appendix A   Complete list of Recommendations

Decision number	Decision
R.2023-1	Define a subset of test sites to encourage New Space to task over.

Appendix B   Complete list of Actions

Action number	Activity	Date
AP.2023-1	Interested IVOS members to review the proposed CEOS-FRM standard.	Next WGCV meeting
AP.2023-2	**Nigel Fox** to contact groups running FRM-type measurements to ask them to complete the proposed CEOS-FRM standard self-assessment as case studies	Next IVOS

AP.2023-3	**Nigel Fox** to draft first announcement for the upcoming planned CEOS/GSICS Pre-Flight Workshop presented at IVOS 2023 on Tuesday and share with IVOS members.	Next IVOS
AP.2023-4	**Anyone** to contact **Nigel Fox** to express interest or recommendations of people to join the scientific committee for the upcoming planned CEOS/GSICS Pre-flight workshop presented at IVOS 2023 on Tuesday.	Jan 2024
AP.2023-5	**Anyone (agency representatives only)** to contact Nigel if interested in being involved in the CEOS-WGCV SITSat Task Group.	On-going
AP.2023-6	**Nigel Fox, Sam Hunt, Cody Anderson and Steffen Dransfeld** to set up a task group & organise a longer meeting(s)/workshop (~1 day) on the curation and dissemination of uncertainty data information (volume / formats). Meeting(s) to be held before/after another meeting(s), JACIE and perhaps IGAARS. This could include representatives from the user community, New Space and CARD4L, depending on scope of meeting(s) - first meeting at JACIE with smaller group, more open meeting to follow (potentially at IGAARS).	In next 6 months – Mar/July
AP.2023-7	**Nigel Fox** and **Jack Xiong** to decide if thermal infra-red domain should be included in discussions at CEOS/GSICS pre-flight workshop on requirements for pre-flight calibration & characterisation to facilitate creation of robust uncertainty budgets. One option is to add an additional day to the workshop for discussion of TIR.	Done
AP.2023-8	**Nigel Fox** to confirm whether an international protocol has been defined in FRM4VEG to provide guidance for assessing uncertainty for surface reflectance field measurements. If so, Nigel Fox to consider how to increase visibility and transparency of this guidance.	Next IVOS
AP.2023-9	**Pieter De Vis,** with **Martin Bachmann,** to submit an abstract to VH-RODA 2023 on the change of CEOS-recommended solar irradiance spectrum with the authorship of CEOS WGCV IVOS.	Done
AP.2023-10	**Nigel Fox** to update CEOS Cal/val portal website to add some examples of difference between solar irradiance spectra and make clear the difference between TSIS1-v1 and TSIS1-v2, and links to the spectra.	End of this year

AP.2023-11	**Nigel Fox** to plan a discussion on whether L1 products calibrated in reflectance should still be provided in radiance.	Next IVOS
AP.2023-12	**Nigel Fox** to contact Cody Anderson for further discussions on the proposed CEOS-reviewed method database.	Done
AP.2023-13	**Anyone** to contact Cindy Ong if interested in being involved in the SRIX4VEG-II activity scheduled in Australia in March 2024.	ASAP – by end of October
AP.2023-14	**Marc Bouvet** to send an email to anyone interested about site samples available for emissivity measurements.	Done
AP.2023-15	**All** to send Paolo Castracane news stories for the Cal/Val portal.	On-going
AP.2023-16	**Anyone** wishing to propose a location for the next meeting should contact Nigel Fox	Done
AP.2023-17	**Maddie Stedman** to complete the minutes. **Nigel Fo**x to share draft to all attendees of the IVOS 2023 meeting for review, followed by sharing of minutes to wider community via the Cal/Val Portal.	By end of year
AP.2023-18	**Nigel Fox** to organise dates and practicalities for the next IVOS meeting.	By end of year
AP.2023-19	**All presenters** to send presentations to Nigel Fox and/or Maddie Stedman (nigel.fox@npl.co.uk, maddie.stedman@npl.co.uk).	By November

Appendix C   Attendee list and email contacts

This includes only those who attended the meeting in person and who agreed we could publish their email addresses in the minutes

Name	Organisation	Email
Nigel Fox	NPL	nigel.fox@npl.co.uk
Sam Hunt	NPL	sam.hunt@npl.co.uk
Dave Smith	RAL	dave.smith@stfc.ac.uk
Steffen Dransfeld	ESA	steffen.dransfeld@esa.int
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Cindy Ong	CSIRO	cindy.ong@csiro.au
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Jack Xiong	NASA	xiaoxiong.xiong-1@nasa.gov

Pieter De Vis	NPL	pieter.de.vis@npl.co.uk
Stefan Adriaensen	VITO	stefan.adriaensen@vito.be
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Andreas Baumgartner	DLR	andreas.baumgartner@dlr.de
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Marc Seifert	OroraTech	marc.seifert@ororatech.com
Paul Green	NPL	paul.green@npl.co.uk

Appendix D   Full list of presentations

All presentations will be available at: http://calvalportal.ceos.org/ivos-35

Presentation	By	Filename
Welcome	DLR	01_DLR_Intro.pdf
Welcome	Nigel Fox	02_Fox_Intro.pdf
CEOS-WGCV Initiatives/Activities	Cody Anderson	03_Anderson_WGCV.pdf
Roadmap Towards an Assessment Framework for CEOS Fiducial Reference Measurements (FRM)	Nigel Fox	04_Fox_FRM.pdf
CEOS/GSICS Preflight workshop	Nigel Fox	05_Fox_CEOS_GSICS_Workshop.pdf
JACIE/VH RHODA Quality Initiatives	Cody Anderson	06_Anderson_JACIE_VH-RODA.pdf
SITSat task group	Nigel Fox	07_Fox_SITSat.pdf
Landsat 8 OLI & TIRS L1T Radiometric Pixel Uncertainty Estimation Update	Mary Pagnutti	08_Pagnutti_Landsat.pdf
Uncertainty Assessment and Delivery	Sam Hunt	09_Hunt_Uncertainty.pdf
Lunar calibration/comparison of NOAA NPP 20 & 21 (VIIRS)	Jack Xiong	10_Xiong_VIIRS.pdf
Sentinel-3 Status	Steffen Dransfeld	11_Dransfeld_S3.pdf
Copernicus optical sensors L1 validation	Bahjat Alhammoud	12_Alhammoud_S2_S3.pdf
Cal/Val methodology for the SatVu HotSat-1 MWIR thermal imager	Jamie McMillan	13_McMillan_SatVu.pdf
Recalibration of HJ-1B thermal infrared historical image using ERA5 reanalysis data	Ning Wang	14_Wang_HJ-1B.pdf
DESIS Spaceborne Hyperspectral Instrument Calibration	Emiliano Carmona	15_DLR_DESIS.pdf
EnMAP Mission Overview: status, calibration and quality control	Miguel Pato, David Marshall, Raquel de los Reyes, and Martin Bachmann	16_DLR_EnMAP.pdf
TIMELINE: ~40 years of NOAA/MetOp AVHRR reprocessing and harmonisation	Martin Bachmann	17_Bachmann_AVHRR.pdf
Sensor Development & Cal/val Activities	Christian Fischer	18_Fischer_FIREBIRD.pdf
Image transformation between imaging spectrometers	Andreas Baumgartner	19_Baumgartner_HySpex.pdf
ENMAP Data Product Validation	Maximilian Brell	20_Brell_EnVAL.pdf

Hyperspectral Cal/Val Resources	Cindy Ong	21_Ong_CEOS_Hyperspectal.pdf
CNES Activities for Hyperspectral	Aimé Meygret	22_Meygret_CNES_Hyperspectral.pdf
Solar Irradiance Spectrum: Discussion	Nigel Fox	23_Fox_TSIS.pdf
DIMITRI-Database for Imaging Multispectral Instrument and Tools for Radiometric Intercomparison: QA4EO DIMITRI-Evolution Project Outcomes	Bahjat Alhammoud	24_Alhammoud_Dimitri.pdf
Sensor performance assessment	Sam Hunt	25_Hunt_CEOS_Cal_Monitoring.pdf
Site selection for newspace	Cody Anderson	26_Anderson_Newspace_Cal_Sites.pdf
L1 Calibration Method Capability Database	Nigel Fox	27_Fox_Cal_Method_Database.pdf
Modelling of TOA reflectance for stable field in NW China & calibration approach	Lingling Ma	28_Ma_China_PICS.pdf
Israel	Eyal Ben-Dor	29_BenDor_Israel.pdf
CSIRO Pinnacles (PIAU) update 2023 & SRIX4Veg-II	Cindy Ong/Ian Lau	30_CSIRO_Australia.pdf
TIRCalNet Update	Steffen Dransfeld	31_Dransfeld_TIRCalNet.pdf
Instrumented Site to TIR Cal/Val	Morgane Chapelier	32_Chapelier_TIRCalVal.pdf
TIR Cal/Val at La Crau	Sebastien Marcq	33_Marcq_La_Crau.pdf
Validation of Thermal Infrared Satellite Measurements Using Automated Validations Sites	Simon Hook	34_Hook_JPL_TIRVal.pdf
Monitoring the Health of the Earth (Pixxel)	Awais Ahmed	35_Ahmed_Pixxel.pdf
ASTeRN – Advanced Surface Temperature Radiometer Network	Dave Smith	36_Smith_ASTeRN.pdf
CEOS IR Radiometer Comparison	Yoshiro Yamada	37_Yamada_IR_comparison.pdf
Realtime Thermal Data for Highly Dynamic Events	Marc Seifert	38_Seifert_TIR.pdf
HYPERNETS Vicarious Calibration Feasibility Study	Pieter De Vis	39_DeVis_HYPERNETS.pdf
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