Lunar Calibration Workshop Minutes

1-4 December 2014
EUMETSAT, Darmstadt, Germany

The GSICS Development Wiki will include all the presentations:
https://gsics.nesdis.noaa.gov/wiki/Development/LunarCalibrationWorkshop

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Minutes

Mon am	Day 1 - MORNING			
	Chair: Sebastien Wagner			

8:30	Sebastien Wagner	EUMETSAT	Introduction to the workshop	1a

No questions!
Change of minute takers.

8:50	Dieter Klaes	EUMETSAT	Welcome to EUMETSAT	1b

Tom expressed the group's appreciation for EUMETSAT hosting this workshop, which was supported by Jack Xiong, pointing out the amount of effort in preparing the GIRO and supporting tools on a timescale that would not have been possible for other organisations.

9:10	Tim Hewison	EUMETSAT	Beyond the Workshop: Developing inter-calibration products based on Lunar Observations	1c

Within the framework of inter-calibration, we are talking about double differences of irradiances from monitored and reference instrument. Sporadic data availability may be an issue due to instrument stability.
What could be a reference? Initially, Aqua/MODIS. But Tim raises the question whether or not other instruments such as VIIRS can be considered?
Key issues:

- Solar variability
- Phase angle dependence
- Spectral consistency

Tom commented on the notion of reference instrument as the reference has its own biases with respect to the ROLO. Trying to achieve absolute calibration with the lunar calibration is more the way to go. But for the moment, the use of inter-calibration is the alternative in short and medium term.

9:30	Tom Stone	USGS	The ROLO system: description and current status	1d

Tom described the basis dataset used to fit the ROLO model. Reminding us that the absolute scale is based on observations of the star, Vega, which is limited to 1.0-1.5% in the VIS/NIR and 3-4% in the SWIR, and that atmospheric corrections (including scattering) are needed, which also introduce some uncertainty - especially in the NIR.

Tom warns about using the moon reflectance data in the GIRO output as the effects of the solar irradiance spectrum are still there. Working in reflectance introduces a dependence on the solar spectrum used. Only the irradiance is “spectrum-effect” free (to a second order accuracy). Tom will reconsider the reference solar spectrum when deriving the next ROLO version and consider Thuillier (as recommended by CEOS IVOS: G. Thuillier; M. Hersé; D. Labs; T. Foujols; W. Peetermans; D.Gillotay; P.C. Simon; H. Mandel Solar Physics 214(1): 1-22 (2003)).

Tom is revising the ROLO model by applying constraints from other datasets (incl. Pleiades). Tom sees one of the aims of the workshop as coming to a consensus on the absolute scale of the ROLO model, but in the long-term he sees this as requiring new dedicated SI-traceable observations.

Q: Do you have a radiance model?
A: Yes - but it’s difficult to use, and needs to be scaled for distance. Tom is not going to pursue this further. Selene have developed a radiance model.

Q: About the spectral interpolation method?
A: In response to a question about the spectral interpolation method, Tom pointed out that a common smoothing function is applied to the ROLO (and GIRO) model for all phase angles.

9:50	Bartolomeo Viticchie	EUMETSAT	Description of the GIRO	1e

Bart stressed that having the imagettes available in the GIRO input is very useful for understanding the data and the results.

Q: Should we archive data that are outside the range of applicability of the ROLO?
A: Tom answered that yes it is useful as the only current limitation is in the model itself and it can be addressed in future developments.

Q: Can such data be used to adjust / extend the range of applicability of the ROLO?
A: Tom answered that data from Pleiades for instance could be extremely useful for future developments of the ROLO model.

10:40	Masaya Takahashi	JMA	I/O format description and first discussions	1f

Comment from Masaya on data compression (in case of imagettes): NetCDF4 has a compression function

Comment from Tom on the leap seconds: it should be a simple offset conversion between time representations in GIRO inputs and outputs, with no accounting for leap seconds needed.

11:00	B. Fougnie	CNES	Description of the shared dataset and status of the data preparation	1g

We have a common band to all instruments (in the red). More than 60% of the instruments have observations in the last two years.

Tom again stressed that one of the goals of the workshop could be to establish a dataset which could be used to improve the ROLO model. This requires a representative range of observations from each sensor.

Mon pm	Day 1 - AFTERNOON			
	Chair: Bertrand Fougnie			
13:20	Tae-Hyeong Oh (Webex)	KMA	Lunar observations data set preparation + results with the COMS satellite - GEO	1k

KMA has 69 images of the Moon.

The GIRO results are not consistent with the current IMPS method (degradation slope and standard deviation is more important for IMPS) with difference in the time series of about 4% sometimes. Tae-Hyeong showed some sensitivity analysis on the DC threshold when identifying the Moon pixels.

Q: what is the range of phase angle in the KMA data? It would be good to represent the results as a function of the phase angle, or to illustrate the phase in the time series.

Q: how do they correct for the dark current?
A: They use the fringe of the imagette to estimate the offset.

Q: why do they use a monthly average? The large variations need further investigation.

13:40	Lin Chen (Webex)	CMA	Lunar observations data set preparation + results with the FY-2 satellites - GEO	1l

Straylight is a problem for FY-2D (what about E-F ? To be checked).
Lunar images are only the one on the East side of the full disk image due to issues with stray light on the West part.
Data are under preparation for the various FY-2 missions.

14:00	Yogdeep Desai (Webex)	ISRO	Lunar observations data set preparation + results with the INSAT-3D satellite - GEO	1 m

Presentation was moved to Tuesday morning after Yogdeep request.

Yogdeep to revisit ISRO archive in order to extract more Moon observations. Yogdeep will be invited to present an update on the data archive at the next GSICS annual meeting.

Comment: many Moon images must have been captured; can these be found and processed?
- no need for limit to near-full moon
- perhaps provide Yogdeep with MSG IR Moon detection algorithm
- general times at which the Moon might be visible can be predicted

15:40	Bartolomeo Viticchie	EUMETSAT	Lunar observations data set preparation + results with the MFG and MSG satellites - GEO	1p

Biases in irradiance do integrate the calibration for MSG data as the calibration coefficients are updated from time to time. So irradiance biases time series integrate also the capability of the vicarious calibration to correct the degradation. For that reason, results are interpreted in terms of gain on a so-called ROLO scale.

EUMETSAT will pursue its work on 1) extracting lunar data from previous imagers (back to Meteosat 2) and 2) on looking into cross-comparisons and inter-calibration using for instance Aqua MODIS as a reference till ROLO is SI-traceable.

Q: What about the SRFs for the old Meteosat satellites?
A: Rob mentioned a project within the framework of climate activities where investigations will focus on the characterisation of the SRFs for past imagers.

Discussion:
Over-sampling: what is the confidence in our knowledge on the oversampling factor? How can we put an error bar on the oversampling factor?

Oversampling can vary with the mirror scan angle (this is the case for the GOES instruments, as illustrated by Fangfang).
Extensive discussions were made on how the lunar oversampling factor is defined and how it can be calculated. Tom Stone provided a general description of the oversampling factor and emphasized its computation might be payload/sensor dependent (e.g. GEO vs LEO and push-broom vs scanning sensors). If not corrected, other sensor-specific factors, such as scanning rate, detector integration time and IFOV, the movements of satellite and moon during each lunar calibration event, could also contribute to lunar calibration and inter-calibration error.

Q: what do we mean by over-sampling?
A: some elements: it does integrate a temporal aspect with the integration time, on the top of the geometrical aspect. For spin-stabilized imagers, the oversampling factor is constant. Not for 3-axis stabilized and push-brooms.

16:00	Masaya Takahashi	JMA	Lunar observations data set preparation + results with the GMS-5 and MTSAT satellites - GEO	1q

JMA uses a constant over-sampling factor. Some problems with the data were identified by visual inspection of the data. Because Digital Counts are not equalized, the threshold method for Moon extraction is done in radiance.
The phase dependence results on GMS-5 might be caused by problems in the irradiance calculation or straylight.

Comment on the oversampling factor: Knowledge on the over-sampling is necessary in order to cross compare instruments.

Comment on the Earth limb: Fangfang commented on the minimum distance to the Earth limb. NOAA uses 0.5 degrees. Bertrand raised the point of having a recommendation or not on the minimum distance to the Earth to avoid the atmospheric scattering. This does not consider straylight aspects that are instruments specific.

Q: It seems that GMS-5 does not degrade. Is it so?
A: In fact, it does (~0.5% per year, confirmed by the RTM method) after phase angle correction. However the phase angle dependence seems to be too large.

There is a very strong dependence with the non-linearity correction. Tom suggested to correct the DC for non linearities before processing. It could be done in the GIRO

Q: Should the GIRO be able to accommodate a pre-processing of the DC imagettes, such as Masaya needs?
A: No, it is a part of image processing and each user should be responsible for that.

16:20	Fangfang Yu	NOAA	Lunar observations data set preparation + results with the GOES satellites - GEO	1r

GOES-East frame configuration makes Moon availability very little for unscheduled Moon due to the acquisition time (every 3 hours): ~2-6 good Moon per year.
There is a scan angle dependence of the space count for the GOES. It means that this value needs to be adjusted from image to image.

The uncertainties with the Moon method is larger than the ones for DCCs and Ray matching.

The oversampling factor varies a lot as a function of the scan angle (from 1.75 up to 1.80). The variation is not linear.

Q: N-S oversampling is presumed=1.0, is this strictly valid?

Fangfang detailed her estimate of the oversampling factor. Two methods for extracting the Moon were also presented.

Q: is the IMC a major contributor to the over-sampling?
A: It looks like it but requires more investigation.

There was additional concern about detector recovery time for transition between bright and dark scene.

Comment from Lawrence: Lawrence mentions that they tried several methods to identified Moon boundaries (threshold, ellipse, classification) for EO1 (push broom instruments = Hyperion and ALI). At that time, results were not so different when integrating the irradiance. What does NOAA observe when testing that? Fangfang needs to look into that.

Comment from KMA: KMA does not use IMC. So the KMA data could be used to check NOAA results. For NOAA data, the IMC is used.

17:00	All	All	Discussion and recommendations for GEO	1t

Bertrand summarised the open Issues for application to GEO sensors:

- Dark signal corrections
    - related to straylight and size of the exclusion band around the Earth
    - Recommend all GEO sensors repeat Fangfang's analysis? (Straylight around Moon and Scan-angle dependency)
        - JMA are interested to to this.

        - EUMETSAT could be limited to a 20 pixel margin, which may be enough
- Oversampling factor
    - Recommend KMA repeat NOAA's analysis of over-sampling factor for GOES-15 with COM-1 results to establish impact of Image Motion Compensation system?
    - To be continued tomorrow!
- How to integrate the lunar irradiance: interaction with straylight from the Moon.
- Use of a threshold is good in the case of ghost effect (as observed in Meteosat-7 data). However, defining such a threshold is not straightforward and may require manual visual inspection.
- The above actions are prerequisites to addressing ROLO's phase angle dependence
    - KMA should repeat the analysis of the phase-angle dependence of the bias
- Phase dependence: a recommendation is to try to reach a consensus in the results from band to band in order to make the full use of the data set. This supposes that image processing is fine for each instrument in order to derive an accurate irradiance value.

Tues am	Day 2 - MORNING			
	Chair: Tim Hewison			
8:30	Ronghua Wu	CMA	Lunar observations data set preparation + results with the FY-3 satellites - LEO	2a

Selection of lunar disk by threshold of dark signal - does this capture the full disc?
How to deal with partial Moon images

For MERSI, the oversampling factor is calculated in real time and is not constant.
Tom commented on the fact that the integration for the irradiance can be done in 2 ways: only by considering the imagery where the complete Moon is available, or by taking the complete scan and determine the oversampling factor.

Q: can the pattern on the time series be due to oversampling calculations?
A: participants commented that the irradiance bias versus the oversampling factor can be plotted to check a possible correlation.

8:50	Sophie Lacherade	CNES	Lunar observations data set preparation + results with the Pleiades satellites - LEO	2b

The Pleiades calibration is based on reflectance and not on radiance.
CNES provides the operational Pleiades lunar observations (+/- 40 deg phase angle with a delta of +/- 0.5 deg).

Acquisitions are made at night time and special attention is paid to have no atmospheric effects. Different types of acquisition are performed, in particular to map the geometrical characteristics of the detector arrays.
No oversampling factor is needed as the Moon appears round in the images.
Integration by summing all pixels of image (after checking residual dark signal=0), weighted by IFOV variation factor.
PHR-1A shows a small jump in the official operational Moon dataset. Sophie needs to look closer at the those results. These acquisitions are done at +/- 40 deg phase angle with a delta of +/- 0.5 deg.
Comment: The variability in the comparison between Pleiades and MODIS might be due to differences in the libration as the comparisons are made regardless of the time (only the same phase angle is assured for the comparison).

Q: why taking 40 degrees and not 7 degrees?
A: The range 40-50 deg is the part of the phase angle interval that has the best accuracy for irradiance calculation.

Comment: CNES cannot use the GIRO operationally without access to the code.

Tom is concerned that CNES implementation of ROLO gives the same 32 A_k model outputs, but the irradiances are different - thus must be due to spectral handling of the outputs.

9:10	Yogdeep Desai (Webex)	ISRO	Lunar observations data set preparation + results with the OCM-2 instrument - LEO	2c

OCM-2 views Moon in pitch maneuver during 80s acquisition.
Oversampling factor = ratio of lunar image dimensions (crude estimate)

Q: where the color is coming from on the Moon image?
A: This image is a spectral composite image that is used for channel registration.

Phase angle is typically 8 degrees. The uncertainty on the oversampling factor is low for such a phase angle (calculated as the ratio of along scan pixel sample over the across scan pixel sample).

Comment: Participants commented that the irradiance bias versus the oversampling factor can be plotted to check a possible correlation.

9:30	Yogdeep Desai (Webex)	ISRO	Lunar observations data set preparation + results with the INSAT-3D satellite - GEO	1m

Presentation was moved from Monday afternoon after Yogdeep request.

Only VIS channel for now (0.52-0.77µm), but will look at SWIR (1.55-1.70µm) soon.

The group encouraged ISRO to review the whole archive of lunar images, adopting EUMETSAT's Moon detection algorithm, based on saturation of off-Earth IR pixels. This would allow a dataset to be built up over the range of phase angles from +/-(5-95) degrees - and especially for the SWIR channel. The results of this analysis could then be presented at the next GSICS Working Group meeting in Delhi in March.

10:40	Zhipeng (Ben) Wang	NASA	Lunar observations data set preparation + results with the MODIS instruments - LEO	2f

Scheduled lunar observations in phase angle range [54°,56°] for Terra, [-56°,-54°] for Aqua in roll maneuver, but also unscheduled observations in space view.
To date, there are 139/119 scheduled Moon observations for Terra/Aqua (respectively). For the moment the unscheduled observations are not used for the operational calibration.

MODIS acquisition process allows for images where the Moon is close to the image borders (comment made after a question on the feasibility of using such images).

K_{inst} accounts temperature variations of the instrument. If we change the instrument temperature by 1K, the level of uncertainty on the response is about 0.3%.

To obtain the total lunar irradiance, one can integrate over detectors, then take average, or integrate over scans for each detector (used nominally, as it is detector independent??).
The oversampling factor is determined by angular speed of lunar image, which varies with time. This has been validated by comparing with the other method to calculate the total lunar irradiance - it agrees within 0.2% - See SPIE paper. The individual detectors in the 250m resolution bands actually under-sample the Moon, so need to be co-averaged.

Many Aqua bands show a dip around the end of 2012, but seem to have recovered.
Variations ~2% p-p. MODIS cal LUTs are updated roughly every 2-4wks, based on when observations from solar diffuser goes out of limits (~0.2%).

Comment: Ben should compare the observed lunar irradiances he calculated with previous results. But USGS processing of MODIS data used a different "driver", which handles the spectral interpolation of the ROLO wavelengths.

Some bands are affected by cross-talk. The cross-talk was not corrected. The level of cross-talk is 2 to 3 times higher for Terra MODIS than for Aqua MODIS.

Q: what is the best interpolation method (or driver in USGS terminology) to use?
A: Tom answered that the best method is the one implemented in the GIRO.

Q: can MODIS lunar measurements be used to improve or set the absolute scale for the GIRO?

11:00	Jon Fulbright	NASA	Lunar observations data set preparation + results with the VIIRS instrument - LEO	2g

Image processing for VIIRS has commonalities with MODIS processing.
Day-Night Band not included in this presentation, but Jon has started processing.
Integration time for the Space View = 2.6s. So oversampling is not relevant.
SRF ("RSRs") plotted on log scales show significant Out Of Band sensitivity in M1 band.
Started doing scheduled observations around 56° phase angle. But now using 51° as it generates more availability.
Interesting Moon edge & centre detection from Sobel filtering and circle fitting.
Jon has scripts to handle changing SRFs as GIRO inputs.
In comparison of ROLO & GIRO results M1 is an outlier.
VIIRS data have been processed using the latest driver (supposedly being similar to the one in GIRO!). So it means that, once we removed any potential mistake when displaying results, we have an issue with the GIRO.
Jon has also checked the impact of Tom's change of ROLO "drivers".
Tom commented on the VIIRS dataset value for looking into residual dependencies in the libration parameter.

Discussion: are there any other parameters needed in the GIRO output to analyse the differences? e.g. Libration Angle - no that is already in the output as the selenographic coordinates.

Later during the meeting, the source of the difference between NASA-ROLO and GIRO results was found, results now agree for all bands except M11; Jon is investigating this.

11:20	Taeyoung Choi	NOAA	Lunar observations data set preparation + results with the VIIRS instrument - LEO	2h

Space view , scheduled -50° (includes maneuver) + free moons
Irradiance calculation : bilinear including RVS + resampling factor/IFOV (supposed to be constant) so a mean value is used. Effective pixel averaging method.

M7/I2 and M10/I3 have very similar SRFs. Spatial resolution is different.
M1 to M5 have an oversampling factor 3 times larger than for M6.
In the VIIRS calibration, the DN is bias corrected. Temperature effects are also removed.

2 Band average SRF considered : original RSR set from NG and modified SRF (after contamination): impact about 0.2% effect for moon.

To avoid need for oversampling factor:
Irr(Obs)=Averaged_Radiance_Moon*Moon_Solid_Angle
(This is a simplistic approximation - and may be very sensitive to the threshold used to count the number of Moon pixels). However, doing that way excludes the dark Moon pixels from the calculation of the Moon_Solid_Angle factor.

Results :
GIRO V4 successfully implemented. 1-2% difference between GIRO and observed in general, but some of them reach a few percents : M2, M6, M8.
Time series: seasonal oscillation shape
Future plan : calculate F-factor and compare to operational

Discussion:
An action was set on NOAA to compare their results with the NASA team. Various items to be checked were discussed: satellite coordinates used by VCST (is the reference frame J2000 or not), estimate of the deep space count, oversampling factor variability, estimate of the solid angle, etc. Tom commented that the calculation does not consider the darkest side of the moon and that it would be useful to compare with the other method (NASA).

Due to contamination of the Rotating Telescope Assembly, new modulated SRFs had to be implemented.
It looks like the impact of the SRFs change is very small on average (with extremely small standard deviation).

9:30	Bertrand Fougnie	CNES	Over-sampling factors	2d

This presentation was finally given on Thursday afternoon, as part of the discussion on developing inter-calibration products.

Tues pm	Day 2 - AFTERNOON			
	Chair: Jack Xiong			
13:20	Tom Stone	USGS	Lunar observations data set preparation + results with the OLI instrument - LEO	2k

Tom computes oversampling factor from the slew rate of the line of sight vector over time, accounting for satellite motion during scan.
The Moon is acquired in about 8 seconds with OLI. It affects the irradiance by about 0.04%.
Radiance imagettes are provided but not the DC imagettes as the process to move from the DC image to the radiance one is not straightforward (quadratic calibration among other)

Some numbers and characteristics:

- 14 focal planes
- Phase angle: ~8°
- Lunar observation rate: once a month. Even + Odd patterns.
- Similar band to Landsat 7 and ALI (EO-1)
- Raw image: about 230x1860 pixels.
- Oversampling: 8.25 (computed from ancillary data: Line Of Sight versus moon scan accounting for satellite motion [slew rate])
- Integration : threshold above space background.
- IFOV taken from calibration

3 OLI moon in 2014.

13:20	Lawrence Ong	NASA	Lunar observations data set preparation + results with the OLI instrument + Hyperion - LEO	2k 2

Two instruments are available on EO-1 : Hyperion and ALI
Hyperion lunar database can be very useful/informative.

Moon is observed on a monthly basis with a 5 - 9 degrees phase angle.

Results :

- Comparison of spectra between Hyperion, ROLO, ALI.
- Scan along the lunar terminator. Ensure easier detection of the bright edge for oversampling consideration.
- Comparison in absolute calibration between OLI and ROLO : +6% except for 1.6 micron.
- Moon trending agrees well with trending based on lamps except for Band 1 (443nm). But Moon results are much more scattered. Some of the outliers are due to changes in phase angle conditions, image clamping, etc.
- Libration effect observed on time series.
- Hyperion trend on the blue (-4%).
- GIRO V4 tested. Data converted. Comparison with GSFC in progress.
- GIRO shows bias compare to operational calibration
- ROLO-GSFC versus GIRO

- Comparison Hyperion and GIRO in progress. Good in SWIR not in VIS.

Differences between GIRO and the ROLO/GSFC still need to be investigated - the latter seems to be based on the old “driver” for spectral interpolation. Differences with OLI raise up to 5%. Using Hyperion, the difference are much larger for short wavelengths, which Tom suggested would be explained by the difference between his old and new “drivers”.

Q: can the GIRO be modified to use Moon disk down-track size (Y-size) as an input (this would serve in place of the oversampling factor)?
A: Probably not a problem.

Comments:

- Seb : discrepancy at 2.2 microns. Also on John’s talk (updated figure from VIIRS using Tom’s update). For VIIRS, mystery is solved except for 2.2 microns with a 3% bias.
- Seb : could we do the same thing with OCO?
- Tom : OCO is very high spectral resolution. Hesitation to use GIRO on OCO data, except by smoothing the spectrum.
- Seb : can we aggregate OCO channels to reach Hyperion spectral resolution to help the comparison? It might be useful.

Regarding outliers, it was recommended to look at the images to identify detection issues (EO-1 stray light, ghost for ALI, echo effect for Hyperion). The straylight negligible for OLI.

13:40	Stefan Adriaensen	VITO	Lunar observations data set preparation + results with the PROBA-V instrument - LEO	2l

Some facts:

- 4 bands: blue, red, nir, swir,
- all bands independent in 3 cameras, so each Moon view cover ~24s
- equalised over snow/desert
- No on-board device on sensor, so uses multi-scene vicarious calibration (similar to Pleiades)
- Views Moon in 360° pitch-over maneuver (twice a month) before/after full Moon (7° phase)
- Integration uses mask, based on a threshold of 5% of maximum
- 24sec between SWIR and VISNIR bands.
- Dark current estimated using nightly views over ocean.

Results:

- Compared PROBA-V observations with GIRO and own version of ROLO.
- Validated Inter-band calibration over DCC, based on RTM-simulations.
- GIRO : small bias for VISNIR and large bias for SWIR.

- Stability (not from GIRO): seasonal variation up to 2%. It is confirmed by the vicarious calibration over the Libya-4 calibration site.

The fact that the libration potential effect is less with PROBA-V w.r.t to VIIRS could be explained by the difference in the illumination conditions when observing the Moon. Tom suggested to look at the results as a function of the libration (general recommendation).

14:00	Toru Kouyama	AIST	Lunar observations data set preparation + results with the ASTER instrument - LEO	2m

The Moon cannot be viewed easily as the swath is only 60km at Earth ground (narrow FOV). In order to view the Moon with Terra/ASTER, special 360° maneuver is required. As it implies a risk on the mission, it was only allowed once in 2003. The phase angle for that dedicated observation is about -27°.

Some facts:
- Oversampling = 4.57 based on image analysis.
- Acquisition duration = 5sec.
- Two views (nadir/back)
- Dark current through night side observations
- On-board calibration using lamp.
- Integration step : Threshold +5 on DC from dark.
-

Results from the GIRO :
- +9% for bands 1 & 3B, -5/6% for bands 2 & 3N. A small discrepancy from Stone et al. 2003.
- Anomaly on dark current : line pattern. Preliminary correction that seems to improve the comparison.

Second lunar observation proposed with the same phase angle during decommissioning.

Q: Are dark artifacts due to systematic or electronic?
A: Probably electronic.

Comments:
Tom and Jack : more thing could be done on Terra due to decommissioning.
There are some issues on the dark current calculation and correction.

15:40	Gene Eplee (Webex)	NASA	Lunar observations data set preparation + results with the SeaWiFS instrument - LEO	2p

SeaWiFS used back-flip maneuvers to acquire 1 image per band, which generates a different oversampling factor, which was estimated by comparing the apparent size of the Moon in the image with its geometric size. This causes an uncertainty in the observed irradiance, which appears as a noise in the time series, which varies with time, but is highly correlated between the bands.

Some facts for SeaWiFS:

- 13 years of moon : 145 low phase < 10° and 59 between 27-66°
- variation in time of the oversampling term
- Dark current not evolving the same way for all bands
- Oversampling factor : from 3.5 (in general) to 4.5 at the end-of-life due to orbital drift because moon is leaving the nadir plane.
- Uncertainty on oversampling factor is limiting and produce noise on time series. Correlation between bands. Called noise correction. Computation of a correction on the ROLO output.
- Detrended lunar calibration results : after removal of the mean trend = anomaly
- Mean bias versus ROLO = 2-3%
- Data not ready for the GIRO application

Results were shown also for VIIRS (3 years, 24 scheduled moon + some others).
VIIRS time series shows a periodical effect (seen a little bite for some seawifs bands).
Bias VIIRS vs ROLO : 4 to 10% (in yellow)

Gene has not yet put SeaWiFS data into GIRO format, but this is next on his list, and he hopes to have it ready by mid-January.

Discussion:
Seb : When able to prepare data for GIRO ? R= January 2015. Contact Massaya for SRF (send @mail to GSFC).
Tom : fit to correct libration is a convincing case <- this is for Gene's analysis of VIIRS data.
Recommendation: to be considered on the future improvement of the model (Thursday discussion)
Lawrence : Is the same ROLO model as for OLI. Yes !
Seb & Fred : specificity of ocean color calibration : Use of buoy. Yes, for absolute, but not for trending (moon is used).

16:00	Lars Chapski	NASA	Lunar observations data set preparation with the OCO-2 instrument - LEO	2q

Did not attend the meeting.

16:40	All	All	Discussion	2s

17:00	All	All	Discussion and recommendations for LEO	2t

Wed am	Day 3 - MORNING			
	Chair: Tom Stone			
8:30	Bertrand Fougnie	CNES	Uncertainty budgets with the goal of combining methods	3a

An implementation of several calibration methods is very important to cover the full radiometric range of the instrument. Analysis of the uncertainty should be performed for each channel. Uncertainty derived from an instrument such as stray light and nonlinearity provides information to evaluate the uncertainty of calibration methods. Then, instrument trend, absolute calibration, inter-band feature, etc. are characterized. This characterization is also used for the instrument uncertainty evaluation.

Sensitivity of calibration coefficients on the View Zenith Angle using multiple calibration methods (DCC, Desert, and Rayleigh) for MERIS and PARASOL indicates the stray light effect in PARASOL in the 443 nm band. Multiple calibration methods for the PARASOL shows consistent instrument drift. To merge multiple calibration methods for one blended calibration result, instrument bias (type-B uncertainty) should be evaluated whether that satisfies its uncertainty criteria.

It is important to understand how the uncertainties coming from the sensor will impact the method and the end result. It is actually not possible to derive a general uncertainty budget. It has to be addressed for each band of each instrument.

Comments:
Tim commented that in case of incorrect SRF, it introduces the biases, and it is difficult to separate from the SRF shape change. GSICS approach is to blend all the uncertainties and compare with the reference.

8:50	Sebastien Wagner	EUMETSAT	Sensitivity analysis tests	3b

To understand typical uncertainty on the system (i.e., GIRO) is a purpose of this workshop. Two out of three input elements to the GIRO, SRF and satellite position, are used in the GIRO perturbation tool established at EUMETSAT (also called GIRO PERT). In detail, random perturbation of the satellite position and SRF shape, rigid shift of the SRF, and change in the wavelength sampling of the SRF are supported. The other input, observed irradiance, also contains potential parameters such as dark signal correction, oversampling and radiometric calibration. However, they are parts of the image processing to derive the irradiance and not available to all the participants. Perturbation values should be equivalent to the instrument accuracy.

Issues to be discussed are 1) the sensitivity perturbation value for each instruments, 2) difference of the sensitivity among similar SRFs, and 3) listing parameters to be used in the future sensitivity analysis.

Discussion:

Q: Fangfang asked why is the absolute calibration listed as one of the sensitivity elements.
A: Because of the conversion from digital counts to radiance. The calibration method does not matter.

Comment: Tim commented that out-of-band response in random noise on the SRF might provide interesting results.

Q: Lawrence asked if the GIRO executable does resample the SRF.
A: No, a well sampled SRF is assumed. The sensitivity regarding SRF highly depends on its sampling resolution.

Q: Fangfang asked if the sensitivity analysis on the random noise is useful.
A: This time is just for the practice. After the analysis and the discussion, elements to be used and sensitivity analysis itself could be revisited.

Fangfang showed her interests to share the lunar observation data to perform the sensitivity analysis of MTSAT-2 for the comparison with that of GOES/Imager. To be discussed on Thursday.

Bertrand recommended to use perturbation values (e.g., SRF shift) individual to each instrument, each channel.

9:10	Sophie Lacherade	CNES	Example of sensitivity analysis on the observed irradiance	3c

Three parameters for the sensitivity analysis were presented.

1) Oversampling factor: Impact of the orientation of the Moon image on the disk-integrated lunar irradiance is not small because that is related to the oversampling factor. Recommendation: To perform the sensitivity analysis on the image rotation.

2) Dark signal correction: Even if the dark signal correction value is constant, the impact on the irradiance difference between observation and the ROLO varies with the phase angle (e.g., small impact ~0.4% for phase angle=3deg, ~5% for phase angle=90deg). Methods to estimate the correction value highly depend on the instruments.

3) ROLO inputs: Sophie stressed that librations components such as satellite selenographic latitude and longitude, and the Sun longitude should be separately assessed. Bart commented that the impact of satellite positions on the delta irradiance is very small if reasonable perturbation values are used. Changing the selenographic coordinates needs to be done with a consistent typical change in the satellite position that led to the corresponding change in the selenographic coordinates.

Impacts of phase angle (plus/minus 1 degree perturbation) on the ROLO irradiance difference (perturbed vs original) could be useful for the analysis.1 degree is a good representation for cross calibration such as Pleiades vs OLI.

A small error in the dark signal estimate could translate in much larger error in the bias, in particular for high phase angles.

The GIRO_PERT tool could include the delta in irradiance (a fixed bias assuming a constant uncertainty on the dark signal). The typical delta in irradiance needs to be estimated for each and instrument and band.

9:30	Bartolomeo Viticchie	EUMETSAT	Introduction to the sensitivity analysis tool	3d

The GIRO perturbation tool is not a different version of the GIRO executable but prepares the data to perform a perturbed run. The GIRO executable is used for the analysis. At present, perturbations of SRF and satellite positions are supported. The purpose is to test the sensitivity of the ROLO reference irradiance. Bart instructed how to use the GIRO perturbation tool.

10:40	All	All	Sensitivity analysis practical work - on laptops	3f

Firstly, each participant was asked what he/she wants to do during the practical work session. Many of them showed the interests in the sensitivity on the oversampling factor and phase angle, whereas these parameters are not supported at present by the GIRO PERT tool as it should be part of the image processing.

The next step will be to analyse the results of the perturbations to define the sensitivity of the irradiances to typical perturbations, (e.g. 2% change per nm shift) where the response is sufficiently linear to do so. Then to identify typical uncertainties on each of the inputs - (e.g. 1nm), and to include both these in an error budget.

Wed pm	Day 3 - AFTERNOON			
	Chair: Tom Stone			
13:20	All	All	Sensitivity analysis practical work - Presentations of results	3k

Sensitivity analysis practical work - Presentations of various results - Viticchie	3f
Sensitivity analysis practical work - Presentations of VIIRS results - Fulbright	3g
Sensitivity analysis practical work - Presentations of Pleiades results - Lacherade	3h
Sensitivity analysis practical work - Presentations of Aqua/MODIS results - Fulbright/Wang	3i
Sensitivity analysis practical work - Presentations of Terra/MODIS results - Fulbright/Wang	3j

Sophie commented that the GIRO_PERT tool is very valuable for establishing specifications for SRFs characterisation, in particular when looking at the spectral sampling of the SRFs.

15:40	All	All	Discussion on the sensitivity analysis: Was it conclusive? What else do we need?	3p

When working on the SRFs, we should have a parameter to characterize the change in the SRF shape. The effective wavelength can be such a parameter. Two ways were proposed to estimate it (with and without the ROLO reflectance). The method with the ROLO reflectance is preferred as closer to the ROLO calibration:

$$\frac{\int \cdot Srf(\lambda)\cdot I(\lambda)\cdot A(\lambda)\cdot d\lambda}{\int Srf(\lambda)\cdot I(\lambda)\cdot A(\lambda)\cdot d\lambda}$$

Srf = Spectral response function
I = solar irradiance spectrum
A = ROLO albedo

For the shape of the SRFs we need to adjust the calculation in the GIRO PERT. The systematic bias on the irradiance should also be implemented in the GIRO PERT.

Such a useful perturbation tool allows users to evaluate the sensitivity of the GIRO to their perturbations, but these are instrument-specific.

SAT_POS options should allow (x,y,z) coordinates to be perturbed independently, by converting these from along-, across- track and height perturbations.

Q: Should we make the GIRO_PERT tool open source?
A: Seb mentioned that EUMETSAT cannot commit to the development and maintenance of the perturbation tool. However, as it is recognised as a valuable starting point for performing the sensitivity analysis, a process allowing collaborative effort (development and maintenance) can be put in place to allow multiple developers. That would be greatly beneficial for the Lunar Calibration Community.

16:00	All	All	Recommendations on input/output uncertainties	3q

Thurs am	Day 4 - MORNING			
	Chair: Sophie Lachérade			
8:30	Sebastien Wagner	EUMETSAT	Future EUMETSAT Missions: MTG-FCI and EPS-SG	4a

Q: Fangfang had a question on the stability requirements for FCI.
A: Same requirements than for SEVIRI even though we know we can do better than the specs.

Q: Lawrence asked about quantization of data.
A: It should be 12 bits.

Q:Lawrence asked about the signal to noise improvements and about EUM expectations on this aspect.
A: Need to get back to the instrument engineers to get an answer to that question.

Q: Lawrence asked about dark measurements in UVN.
A: Need to get back to the instrument engineers to get an answer to that question.

Q: How do you acquire Moon observations with UVN?
A: It will be challenging to define the acquisition mode (active scan or drifting Moon are two possibilities). Tom suggested to let the Moon move across the slit while acquiring. He also commented and confirmed that the use of the UVN data will be easy since he has had experience with Hyperion.

Fangfang commented that for limited Fields of Regard it is very important to avoid the atmosphere when being close to the Earth disk.

Q: Jason asked about the band-to-band registration for the observation of the Moon with EPS-SG MetImage.
A: Tom commented that the space view should be large enough so that all the channels can observe the Moon.

Q: Lawrence commented on the monitoring of the thermal bands by using the Moon.
A: By performing Moon observations with a reduced gain we may not be able to use the outcome of the calibration when the gain is set back to the standard value.

Q: Fangfang asked what is the use of star observations in future missions?
A: For navigation purposes on FCI.

Seb recalled the open issue of the phase angle dependence and its impact on the calibration of future GEOs. Tom answered that in the future this issue will be solved. Besides, it is also important to figure out the role of the image processing (as shown by Sophie in the presentation on the sensitivity). The effects must be separated: ROLO model/imagette processing.

Q: Will FCI have scheduled Moon observations?
A: No dedicated observations.

Q: Masaya asked if one can reduce the uncertainty on the drift measurement via Moon calibration by using more observations of the Moon to evaluate the instrument drift over short periods (e.g. one year)?
A: In principle yes, but one must also consider what is the expected amplitude of the drift that is to be measured.

8:50	Seongick Cho	KIOST	Future GOCI-2 mission and use of lunar calibration	4b

Q: Tom asked about the origin for the filter/band shift?
A: Different acquisitions on different bands at different times due to a rotating filter. Jack added that it has to see with an off-axis effect. Seongick commented that it brings again the issue of the use of the absolute SRF (not normalized).

Seongick discussed the role of lunar calibration for the KIOST future missions. He will be in charge of implementing the calibration model and he has no previous experience on this topic.
It emphasizes the value of the workshop for the use of the lunar calibration for future missions. This will help new users to learn from more experienced ones.

Q: Is KIOST collaborating with KMA?
A: No. The two institutions do not work together.

9:10	Yoshihiko Okamura	JAXA	Future GCOM-C mission and use of lunar calibration	4c 1

360° pitch-over maneuver to view Moon - once a month (like SeaWiFS, but better)

Q: Where is the space view window?
A: Plus 90 deg with respect to the nadir.

They plan to have 3 types of manoeuvre for calibration: lunar, solar and yaw 90deg calibration manoeuvre.

Yoshihiko mentioned JAXA's availability to share GCOM-C data within GSICS for Lunar calibration purposes.

Seb commented on the potential use of the GIRO for future missions together with the policy on data sharing. Key issues to be discussed in the workshop.

9:20	Yoshihiko Okamura	JAXA	Future GOSAT mission and use of lunar calibration	4c 2

On GOSAT:
Fourier Transform Spectrometer (FTS) includes 3 channels in VNIR. IR bands have been compared with AIRS (could be included in IASI traceability report?).
FTS and CAI perform lunar calibration with JAXA implementation of the ROLO model. FTS spectral bands are similar to OCO.

Description of the lunar calibration results on CAI based on the ROLO implementation of JAXA.

Plans for GOSAT-2: 2 follow-on sensors (FTS-2 + CAI-2). They will have additional manoeuvre to sense the Moon and monitor their instruments.

Yoshihiko stressed again JAXA interest in using the GIRO for future applications.

Q: Is this instrument similar to OCO?
A: FTS bands are similar to OCO (the instruments are very different: Fourier Transform Spectrometer vs. grating dispersive spectrometer for OCO). There is a close collaboration between the GOSAT and OCO teams. Suggestion to use GIRO for the recalibration of the

Moon observation dataset already acquired. Tom commented that FTS cannot be calibrated using the ROLO/GIRO. There is currently activity to have the possibility to analyse these data.

Q: Seb asked if the results of this activity will be a completely new tool or an extension of the ROLO/GIRO?
A: Tom said that possibly it will be part of the ROLO.

Tim commented on the general interest for high resolution capabilities, and encourages the JAXA team to take part in further discussions on developing inter-calibration products within GSICS Research Working Group meetings and web meetings.

Tim also commented on the observations of the Moon with very small phase angle values. These might be the outliers of Lunar calibration results already obtained by JAXA.

Q: Ronghua asked about the other calibration methods for CAI.
A: Combination of vicarious and lunar.

Q: Ronghua asked if there are observations of the Moon done with the FTS and if the shape of the spectra is publicly available.
A: Yoshihiko will ask to the staff of JAXA (they seem available to share the spectra).

9:30	Masaya Takahashi	JMA	Himawari 8	4d

Private communication: potential for observing about 100 (30 sec repeat cycle) of observations of the Moon even though the plan is to use the dedicated observation mode mainly for image navigation purposes.

Moon acquired in one swath.

Moon observations will be shared and will be prepared on NetCDF format.

Q: Could JMA maximise the number of Moon observations over short time?
A: Initially there will be problems since the dedicated observations will be used for image navigation. Later there will be more flexibility.

9:50	Toru Kouyama	AIST	Update on the SELENE/SP project	4e

SP = Spectral Profiler, details: http://www.kaguya.jaxa.jp/index_e.htm

SELENE data are free, and available from http://l2db.selene.darts.isas.jaxa.jp/

There is a lunar reflectance model developed using SELENE data. Investigators: Tsuneo Matsunaga, Yoshihiro Yokota (main developer of the reflectance model, Icarus 2011 published)
Lunar reflectance maps with dependencies on obs angles and phase angles.

Two reflectance maps of the Moon have been built: one at 1x1 deg (publically available) and one at 0.5x0.5 deg resolution (availability to be discussed).

Model provides reflectance for specific observation conditions. and then these info are used to derive the reflectance for a generic observation.

Possibility to simulate any moon observations! This means also illumination conditions! There are check comparisons between observations and simulations pixel by pixel. Band 1 is brighter for the observed ASTER image than the model. Band 2 has a very good agreement and Band 3 as a small bias for “high” reflectances.

Problems:

1. Biases
2. Extra features in simulated images (artifacts). This is related to the original observation conditions.
3. Model limitations known by the developers.
4. LOS simulation.

Q: Tim asked how would it be possible to calculate a lunar disc irradiance for comparison with ROLO model? How do you use it for integrated irradiance?
A: There will be the need to develop ad-hoc methods.

Tom commented that the reflectance spectrum of SP is normalized to the standard geometry. This implies a photometric correction needs to be applied. This can contribute to the deviations.

Q: Tom asked how do AIST see the collaboration between the SELENE team and the GIRO team?
A: AIST would provide the results and data. Use of the data for computing disk integrated irradiances. There will be the chance of simulating more data.

Q: Seb asked about the possibility of comparing PLEIADES and simulated images.
A: Tom and Sophie answered that it will be a difficult task for matching the spatial resolution.

Toru emphasized the big interest that AIST has to join the GIRO activity.

Q: What is the full resolution?
A: Spatial dimension of 500 m on the Moon surface per spectrum.

Q: when will the 0.5 deg maps published?
A: PI is not sure yet, even though the data have been already used by Toru.

Q: Fred asked about the correction applied to the model to produce the ASTER image.
A: Tom commented on the need to have a photometric correction, plus observed incident-observation angle correction.

Q: What does 1 deg mean?
A: It is lunar longitude and latitude.

Q: What about collaborations between the SELENE team and JAXA?
A: Tom commented on the idea to put images all together as done in astrogeology, however there are problems to define the collaboration because of USGS.

10:50	Tom Stone	USGS	Future developments on the ROLO	4g

How to provide Tom with a summary database - e.g. https://docs.google.com/spreadsheets/d/1tAGuKGztZWX342pIap6nhGICRnAocEYR-il6QI9dA7I/edit?usp=sharing

We need to isolate the model in order to check if a possible dependence is introduced by the ROLO data processing to derive the model and not by the other instruments image processing. Sophie has showed during the sensitivity analysis day that a bias in the irradiance can have drastic effect on the irradiance bias and “create” a phase dependence. However, consistency across instruments is a key indicator to identify such a dependency.

Q: Fred raised the question about the known deficiencies of GIRO and priorities. The 2005 paper mentioned potential issues at 950 nm, 1900 nm, 2130 nm, and 440 – 700 nm. This week we heard potential issues of phase angle, libration, and 2250 nm. Are there more? Which ones matter more and/or easier to resolve?

The image processing of the ROLO database could have introduced the phase angle (or in general geometry dependence) dependence in the model.

CNES has provided the full-month acquisition campaign (done in 2013) to Tom in order to work on the phase dependency issue.

Tom already started the reprocessing of the ROLO dataset.
Refinement on the computation of the atmospheric extinction.

There may be the need of reformulating the ROLO formula.

What is needed is a new set of measurements of the Moon. One of the biggest problems is that there is no SI traceability.

Having a new dataset means waiting for a long time, minimum of 3 years.

NIST plans: acquiring a new dataset, planning of the observations, full spectral coverage, possibility of performing irradiance observations (no image processing).

CALCON presentation on LUSI project to acquire Moon irradiances (http://digitalcommons.usu.edu/calcon/CALCON2013/All2013Content/56/).

Q: Seb asked about the amount of money needed for a program to define a new Moon observation archive?
A: Tom answered it would be about a single-digit million dollars

Refinement to the ROLO model using the PLEIADES data is expected before the end of 2015. Refinement of the ROLO model using the ROLO data is expected within the next 2 years.

Q: Seb mentioned the administrative issues for funding projects with USGS. Even though many people would like to work with Tom. Is there a way to move forward?
A: Two main difficulties:

1. Small amount of money, USGS is not interested as just the cost of the overhead work would represent the budget for the project .
2. Export of the licence (transfer of knowledge), but not within small projects.

Seb commented that international partners would probably be ready to collaborate if the outcome of the study can be shared with no constraints among the contributors and Tom is confident that it can be done. So, the first thing to know is if USGS is available to collaborate before people start looking for fundings in their own agencies.

So the question was raised to know if the agencies represented at the workshop are interested in collaborating to have a new dataset. A problem might be the long term of the mission (maybe too long). This may be overcome if the task could be split into two parts. International partners could fund the development of the infrastructure and instrumentation to deliver short time series of datasets to allow the current state-of-the-art ROLO model to be tied to an absolute standard. For their contribution, the US agencies (at least USGS) would then be expected to commit to the long-term maintenance of the system over an extended period (>7yrs) to provide a full new dataset and to develop a new irradiance reference model from that.

Q: Lawrence commented on reducing absolute uncertainties and on the data fitting. Is the ROLO data available for performing an alternative fitting of the data?

A: One problem is to handle the linear and the non linear part of the fitting. Besides, the dataset could be made available, but it has important limits related to the evaluation of the atmospheric extinction.

11:10	Jack Xiong	NASA	Traceability to the GIRO and traceability to the ROLO	4h

Comment on the GIRO uncertainty to be evaluated since the implementation is not the same.

Calibration accuracy requirements should always be defined with respect to a typical scene radiance.

When showing the Eplee results, one has to keep in mind that SeaWiFS has large uncertainties. MODIS does not need to use over-sampling whereas SeaWiFS needs. So, a problem with the oversampling might explain (part of) the differences.

Jack also warned that viewing the Moon in pitch maneuvers can cause rapid changes in instrument temperatures, which may alter the instruments' calibration.

During the previous days discussions, it came clear that there are two "modules" in the ROLO system: the ROLO system itself and the driver. Whereas the ROLO has not changed, the driver has changed. So versioning traceability should be ensured.

Possibility to use PLEIADES to set an absolute scale for ROLO and GIRO.

Tom reminded that traceability requires error and uncertainty budget. Building this can reveal some of the main problems in the measurements performed by a specific satellite.

Q: In order to have the GIRO traceable to the ROLO should we do additional work or not?
A: Tom mentioned that it has been already done. But Tim added that what must be evaluated are the uncertainties of the ROLO.

Q:Seb mentioned that the test has been run only on SEVIRI data. Shall we use all the satellites?
A:Tom said the key point is to use only one, considered as a reference. Tim added that the traceability of GIRO to the ROLO can be achieved also using synthetic datasets.

Jack commented on the fact that one can define traceability with respect to a specific implementation.

The workshop organizers stressed again the goal of the GIRO effort that is to provide a international publically available reference for lunar calibration, traceable to the USGS ROLO model.

11:30	Sebastien Wagner	EUMETSAT	Data policy, use of the lunar calibration data set and update of the dataset	4i

Sebastien explained the proposed policy for sharing the dataset of GIRO inputs (including SRFs) among workshop participants (including remote attendees). It was said again that no lunar imagettes are required. The irradiance data provided to the common dataset should cover the representative range of conditions viewed by each instrument.

It was agreed that any analysis should be sent to the owners of the datasets used. For publications, data owners should be acknowledged and co-authorship might be offered. Bertrand and Sophie agreed about the review and acknowledgements in relation to any publication and presentation using the dataset from a group. So did the other participants. Jack mentioned that acknowledged would be enough.

Any other uses? No

What restrictions are necessary? participants only - see below
Open access? No

A series of decisions were taken and are listed in the Summary of the workshop.

NASA have an issue with sharing processed data, which would limit access to data for some participants. This restriction could be bypassed by NASA sending data to USGS to process, who then request that the dataset is entered into the database.

Does the data sharing policy apply to updates?

1. Additional observations
2. New image processing
3. New instruments

Updates will be provided on a best efforts basis, but participants without data should be willing to provide when available.

Versioning - proposed follow GSICS conventions

What about the GIRO? - covered in later discussion

Bertrand commented on the fact that the first version of the dataset was aimed at allowing the workshop. We should move now towards the (inter)cross-calibration analyses. Tim added that we should work on the absolute scale of the ROLO/GIRO tool.

Tom reminded that understanding the lunar calibration can mean:

1. Everyone learns how to use it - best practice for calculating lunar irradiance from observations
2. To develop inter-calibration products
3. For USGS (Tom), to improve the model itself.

Seb commented on the fact that for some instruments (MODIS and PLEIADES for instance) there are operational lunar observations (officially used for the monitoring) and extra data (from dedicated acquisition campaigns or by chance).
Q: the related question is: what is the data that should go into the shared dataset?
A: Bertrand: said that cross calibration can be done via double difference, ergo, few data are enough.

Q: are we happy to share the data or not? Are there restrictions?
A: Bertrand mentioned there might be cases in which there is a lack of control on the data can bring to problems. The use should be restricted to the calibration community, for example within the calibration community.

Q: Besides, there are three different groups CEOS, GSICS, and external users. How do we solve the issue?
A: Seb proposed to have a board or similar to examine requests of participation to the project.

Tom proposed to host the dataset in a centralized way. The proposal was supported as separate repositories lead to more issues such as accessibility for instance.

Q: Bertrand asked how to update the dataset.
A: Updating the dataset is up to the user.
Bertrand raised his concerns about the maintenance and update of the datasets.

Seb mentioned we cannot put this activity completely in GSICS since many people are not part of GSICS.

Jack asked what we want to do with the data. The important thing is to share the results more than the data.

Thurs pm	Day 4 - AFTERNOON			
	Chair: Bertrand Fougnie			
13:00	Tim Hewison	EUMETSAT	Using the Moon in the context of inter-calibration and GSICS activities	4j

The way to go is to perform double differencing. The oversampling has to be correct in order to be able to address inter-calibration. There could be a list of recommendations to follow when evaluating the oversampling factor.

Q: How to derive the lunar Spectral Band Adjustment Factors? Is the lunar spectrum smooth enough to derive such SBAFs (using Hyperion)?
A: Tom and Lawrence commented that Hyperion has some deficiencies in the calibration of its channels. Some of them must be avoided. Additionally, the handling of the Moon spectrum is not the same of handling the Solar Spectrum (the differences should be studied). Bertrand proposed to use SCIAMACHY data to check the smoothness of the Moon spectrum. Tim added that we are looking for good interchannel calibration for performing this check.

Q: who is going to evaluate the error budgets and how?
A: This budget has two parts: the method and the sensor. With respect to the sensor there should be a list of recommendations to follow to evaluate the sensor error budget.

Bertrand presented some slides about the oversampling to have a common understanding of what it is.

13:40	All	All	Discussion - Users' Expectations and needs	4l

Already discussed

14:40	All	All	Discussion - Establishing new requirements on the ROLO/GIRO Input/Output formats	4p

Seb reviewed open questions related to the further development of the GIRO and perturbation tool (the GIRO PERT).

Including the full impact of time perturbations in the GIRO PERT tool would require orbital propagation through SPICE - this would require the addition of the velocity vector at observation time. Bart suggested that this would be best handled by the users, in defining the satellite position position perturbations.

The participants agreed to consider GIRO as the publicly available implementation of the ROLO and a common reference.

Furthermore, it was agreed that the source code should be distributed to workshop participants. However, any modification must not be referred to as the reference implementation of the ROLO.

It was discussed whether this could be regarded in the same way as software licensing, We agreed that we cannot control what people do with the code, or how they refer to it. Seb expressed his concern that EUMETSAT cannot provide support to everyone if they modify the code.

It was agreed that GIRO development needs to be version controlled and under configuration managements, such that any modifications are reviewed by the developers. This will be done as a matter of course within EUMETSAT.

A purpose of GIRO is to provide a validation tool for new versions of observation datasets.

Round table about using the GIRO:

- Jon: would use executable version for calibration trending, but would like source code for development purposes.
- Fred: need public reference lunar model. GIRO as version of ROLO is secondary.
- Jack: for MODIS/VIIRS will continue to work with USGS, but plan to use GIRO for comparison with others groups.
- Yoshihiko: maybe will use the executable.
- Seongick: KIOST needs source code to understand the algorithm. He would also like to include example input and output datasets for verification. Seb clarified that such datasets would be available.
- Sophie: very important for the international community to have a common lunar calibration tool be made available as a common reference, which should not be a black box. So source code should be made available. Although CNES have their own implementation of ROLO, they would be happy to use GIRO for comparison with other agencies' results.
- Bertrand added his appreciation of the effort from EUMETSAT in developing GIRO.
- VITO have their own implementation, but would expect to have the GIRO source code available.
- Ronghua: CMA will share FY data and feedback results of GIRO, and would like to know the details of the GIRO through access to the source code.
- Lawrence: agrees with CNES and shares sentiment about sharing source code, as useful for developers of source code to customise inputs and outputs for operational implementation.
- Jason: as a reference, it should have source code accessible.
- Toru: the ATBD is more important than source code - although the source code would be important for comparisons with SELENE model. He would be happy to contribute to the efforts made by the Lunar Calibration Community.
- Fangfang: Agrees with GIRO as a reference, and as such everything should be open and accessible to the public including access to source code
- Tom: the purposes of developing GIRO was to have one single common reference for all instruments. Afraid that once the source code is released, it destroys the reference. Overcome this by insisting on versioning, so any modifications get submitted for

review - or ask any modifications to be reviewed by those doing so and this review be made available to the Lunar Calibration Workshop community.

- Bart: would like to continue the collaboration once the source code is shared.
- Masaya: JMA needs source code for operational purposes. GSICS products should use GIRO. GDWG could develop checker for implementation. (Recommendation)
- Seb: code and data should be shared but it is a key point that a consensus is reached on the data and code access policy.
- Tim: working on common datasets is highly beneficial.

EUMETSAT plan to implement the next published version of the ROLO model.
A second Lunar Calibration Workshop will be held after this version is released.

16:40	Sebastien Wagner	EUMETSAT	Wrap-up / next steps / list of actions	4s

Went through summary of actions/recommendations (see joint document “Summary of the Lunar Calibration Workshop”)