Lunar Calibration Workshop Summary

1-4 December 2014
EUMETSAT, Darmstadt, Germany

Almost 30 people from 14 different agencies and departments attended the meeting either physically in Darmstadt or remotely through WebEx sessions. Such group of attendees represents potentially more than 25 instruments with lunar observations capabilities. The workshop lasted four days with the following agenda:

- Monday : Introduction to the ROLO/GIRO systems, participant reports and discussion on GEO instruments and on lunar calibration applied to GEO VIS/NIR instruments.

- Tuesday : follow up of the reports and discussion on LEO instruments and on lunar calibration applied to LEO VIS/NIR instruments.

- Wednesday : Sensitivity analysis.

- Thursday : Reporting outcomes and discussing the way forward

The detailed agenda and all presentations are available at:
https://gsics.nesdis.noaa.gov/wiki/Development/LunarCalibrationWorkshop

These presentations generated a lot of discussions and interactions to better understand and improve the preparation of the data for lunar calibration. In particular the critical point of how to estimate accurately the oversampling factor was largely addressed and led to a series of recommendations.

Most of the groups managed to prepare data for their various instruments with lunar observation capabilities and to process them with the GIRO application as provided by EUMETSAT. The results were presented together with some comparisons with results obtained using the USGS ROLO model. It revealed a limited series of issues such as a discrepancy in the 2.2 micron spectral range that require further investigations as captured in the List of Actions. However, it was agreed by all participants that the GIRO is accurate and consistent enough with the latest USGS ROLO model to be considered from now onwards as the publicly available international reference for lunar calibration.

Additionally, one full day was spent on performing sensitivity analysis using the GIRO, the GIRO PERT tool (also provided by EUMETSAT) and the current available lunar calibration dataset. Participants acknowledged that the GIRO PERT tool could constitute the starting point for a more advanced open tool to be shared with the international community to perform in a uniform manner the sensitivity analysis as required by the GSICS procedure when establishing inter-calibration products. The development of such a tool is foreseen to be continued through collaborative efforts.

It was also agreed by all participants that a policy for the usage of the lunar calibration data and the GIRO should be officially established. For the time being, all participants agreed that

access to the dataset is restricted to the Lunar Calibration Workshop participants (including groups working on future missions). Once the data and GIRO usage policy is formalized, a suitable access will be defined on the GSICS Wiki webpage. Requests from new participants will be first forwarded to the Lunar Calibration Workshop community for prior agreement. Regarding the GIRO, access to the application and the source code will be provided following a similar process. When using the source code, users are allowed to refer to the GIRO in their reporting/publications if and only if no modification or re-coding was involved. In the eventuality of modifications to the code, users will be asked to explicitly mention it; in case of comparisons with results from other groups, traceability to the GIRO should be ensured and described, following the data and GIRO usage policy (still to be drafted and discussed).

The current Moon observation dataset is expected to grow with the availability of new lunar observations from past, current and future missions. All participants agreed on EUMETSAT pursuing its efforts in developing and maintaining the GIRO in collaboration with USGS to ensure traceability to the reference USGS ROLO model.

Finally, all participants agreed on the need to continue the present effort and to organize at a suitable date a new Lunar Calibration Workshop (see List of Decisions).

The detailed minutes of the meeting are available on:
https://gsics.nesdis.noaa.gov/wiki/Development/LunarCalibrationWorkshop

The detailed lists of decisions, actions and recommendations are provided hereafter.

Summary of decisions

- **Establishment of a Moon observation dataset repository**: it was agreed by the Lunar Calibration Workshop participants to build a centralised repository for the dataset.
- **Access to the lunar datasets** : it was agreed to limit dataset access to Lunar Calibration Workshop participants, who agree with data sharing policy.
- **GIRO development**: it was agreed that EUMETSAT will continue to have the responsibility of implementing in the GIRO the future enhancements to the ROLO model.
- **GIRO distribution**: it was agreed that the GIRO source code should be made accessible to the workshop participants, under a usage policy. Only this version should be referred to as the GIRO reference and all users are expected to provide feedback on its performance. Furthermore, anyone modifying the source code is required to review any modifications and to make this written review available to the Lunar Calibration Workshop community, and to validate their modified version using the checking procedure (see Inter-Calibration Actions) and the test dataset (see Traceability Recommendations) to be provided by GSICS.
- **Organization of another Lunar Calibration Workshop**: all participants encouraged the organization of another Lunar Calibration workshop either when a new observation dataset is available (in about 12 months) or following a new major release of the GIRO (after the implementation of the foreseen published enhancements to the ROLO by

USGS, probably in about 15-18 months). EUMETSAT offered to organize it again, upon approval of EUMETSAT management, unless other co-organizing agencies wish to host the event. In the mean time, other communications channels are available (regular web meetings through GSICS, e.g. bi-monthly).

Summary of Actions

Data processing:
- NASA and USGS to interact to process the MODIS data with the latest driver to check the agreement with the GIRO. Two methods are tested for the irradiance integration (original MODIS data as provided to USGS initially, and the processing as done for the GIRO). USGS and NASA are invited to report at the next GSICS annual meeting.
- NASA and NOAA to interact on the VIIRS lunar data to check the result consistency and to compare their oversampling factor estimates.
- EUMETSAT, NASA (VIIRS + Landsat teams) and USGS to interact and investigate the discrepancies observed in the 2.2 microns band.
- CNES had the possibility to do dedicated Moon acquisitions with PARASOL. CNES is invited to present the results of the analysis at a further meeting (web meeting or GSICS annual meeting).
- All participants to provide lunar irradiances from the missing instruments to the common lunar calibration data set.

Data sharing:
- Sébastien Wagner (EUMETSAT) to circulate a draft for a data sharing and GIRO usage policy to the workshop participants. This should include the requirements for newcomers to join the community and get access to the data and the GIRO.
- Masaya Takahashi (JMA) to identify a suitable mechanism for sharing the dataset through the GSICS Data Working Group.
- All participants to report any restrictions on the use of their datasets in relation to the proposed data sharing policy.

Inter-Calibration:
- Establish a proposal for the way forward on a comparison of instruments with similar SRFs and phase angles. EUMETSAT will circulate a proposal to the Lunar Calibration Workshop participants by mid January.
- The GSICS Data Working Group is asked to develop a procedure for verifying users' implementation of GIRO.

Sensitivity analysis:
- EUMETSAT should implement a systematic bias on the irradiance in the GIRO PERT.
- EUMETSAT should implement the proposed formulation for the calculation of the effective wavelength (see Minutes).
- EUMETSAT to revisit the change of the SRF shape in order to be more realistic.

Summary of Recommendations:

Data acquisition:
- All satellite operators are encouraged to use decommissioning to acquire lunar observations. The current identified missions coming to end-of-life are Terra/ASTER, Meteosat-7, MTSAT-1R, EO-1 ALI, EO-1 Hyperion.
- ISRO is encouraged to extract all Moon images from the INSAT archives, possibly with help from EUMETSAT. An update on data availability could be presented at the next GSICS annual meeting.
- NASA is encouraged to extend EO-1 mission and to push further the analysis of Hyperion lunar data

Data representation:
In order to make comparisons between instruments easier and to push further the analysis, the following recommendations were made:
- Plot the number of pixels versus phase angle. Tom Stone offered to provide support to the various groups for determining the phase angle.
- Each GEO instrument should represent the Mean Space Count as a function of the ring distance to the Moon edge (see NOAA presentation on the GEO instruments by Fangfang Yu).
- Similarly, each GEO instrument should represent the Mean Space Count as a function of the scan angle.
- Plot the evolution in time of the oversampling factor. The idea is to have more understanding on the evolution of this parameter in order to see if there are some correlations with the irradiance time-series.
- Plot the normalised lunar irradiance with respect to the GIRO as a function of the equivalent wavelength for similar phase angles.

Data processing:
When processing lunar observations it is recommended to pay extra attention to:
- The minimum distance to the Earth limb that is required to avoid the scattering from the atmosphere: this aspect does not address specific issues with straylight.
- Check that the full spectral response function (including Out Of Band sensitivity) is considered in the processing and the analysis.
- Check the images to ensure there are no artifacts.

- Recommendation by T. Stone for JMA to apply the detector equalisation and re-run their analysis.
- All participants should agree on a common approach for the computation of the observation time expressed as seconds elapsed from 19790101T00:00:00. Shall leap

seconds be included in this computation? Tom suggested not to include them (see Workshop's minutes).

In particular a set of recommendations addressed the question of the oversampling:
- EUMETSAT to study the oversampling factor for SEVIRI. The method proposed for VIIRS by NOAA (Taeyoung Choi) could be tested for estimating the SEVIRI oversampling factor.
- CMA to plot the irradiance comparisons versus the oversampling factor and look for a potential correlation.
- Similarly, ISRO to plot the irradiance comparison versus the oversampling factors and look for a potential correlation.
- Each data provider to review the questions raised by Bertrand Fougnie (CNES) on the oversampling factor: what is the instrument Field Of View? How to estimate its dimensions? Does it vary? Is there oversampling or undersampling in the Moon image? How to estimate it? How accurate should the estimate be? (see B. Fougnie's presentation).

Sensitivity analysis:
- Each data provider to assess the error budget for each band of each instrument.
- Each data provider to use specific perturbation values for each instrument and each channel (e.g., SRF shift).
- Each data provider to consider performing the sensitivity analysis using rotated images in order to investigate issues related to the oversampling factor.

Data sharing:
One objective of the workshop was to initiate a dataset of Moon observations and to make it available to the lunar calibration community. The following recommendations were made:
- KMA to provide COMS data for comparisons with GOES and similar instruments.
- All participants to report any restrictions on the use of their datasets in relation to the proposed data sharing policy (see list of actions for the data sharing policy).

Traceability:
In order to ensure traceability, in particular between the GIRO and the ROLO model, the following recommendations were made:
- Tom Stone (USGS) to add a version number to the current "driver" for ROLO.
- EUMETSAT and USGS to generate a validation test dataset (instrument-independent) and perform comparison runs of the current versions of ROLO and GIRO to provide traceability.

Lunar Irradiance Model developments:
In order to develop further the lunar irradiance model, the following recommendations were made:

- To consider in the future improvement discussion the libration effect based on the VIIRS time series.
- Repeated recommendation to all satellite operators, who are encouraged to use decommissioning to acquire lunar observations (see also the section for Data Acquisition).
- Develop a proposal for the development of a new instrument and infrastructure to provide a new basis dataset to develop a new lunar irradiance model, tied to SI. The idea of a Lunar Traceable Irradiance Calibration Spectrometer (LunarTICS) was mentioned.
- Workshop participants to investigate possibility of their agency participating in funding the establishment of a new lunar observation facility and report by next GSICS Research Working Group meeting.

Inter-Calibration:
- GSICS Research Working Group to investigate further the possibility to use the lunar spectrum to derive Spectral Band Adjustment Factors.
- GSICS Research Working Group to investigate the potential use of hyperspectral lunar observations to validate Spectral Band Adjustment Factors derived from the ROLO/GIRO.
- Investigate the possibility to aggregate OCO channels to Hyperion-like channels in order to see further potential use of OCO data.
- Repeated recommendation to all dataset providers to review the oversampling factor, and associated uncertainty for their observing system, following [the presentation by Bertrand Fougnie (CNES)](#).
- All dataset providers to review the list of key issues related to inter-calibration.
- All dataset providers to perform analysis of sensitivity to the space count levels.

Attendees

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