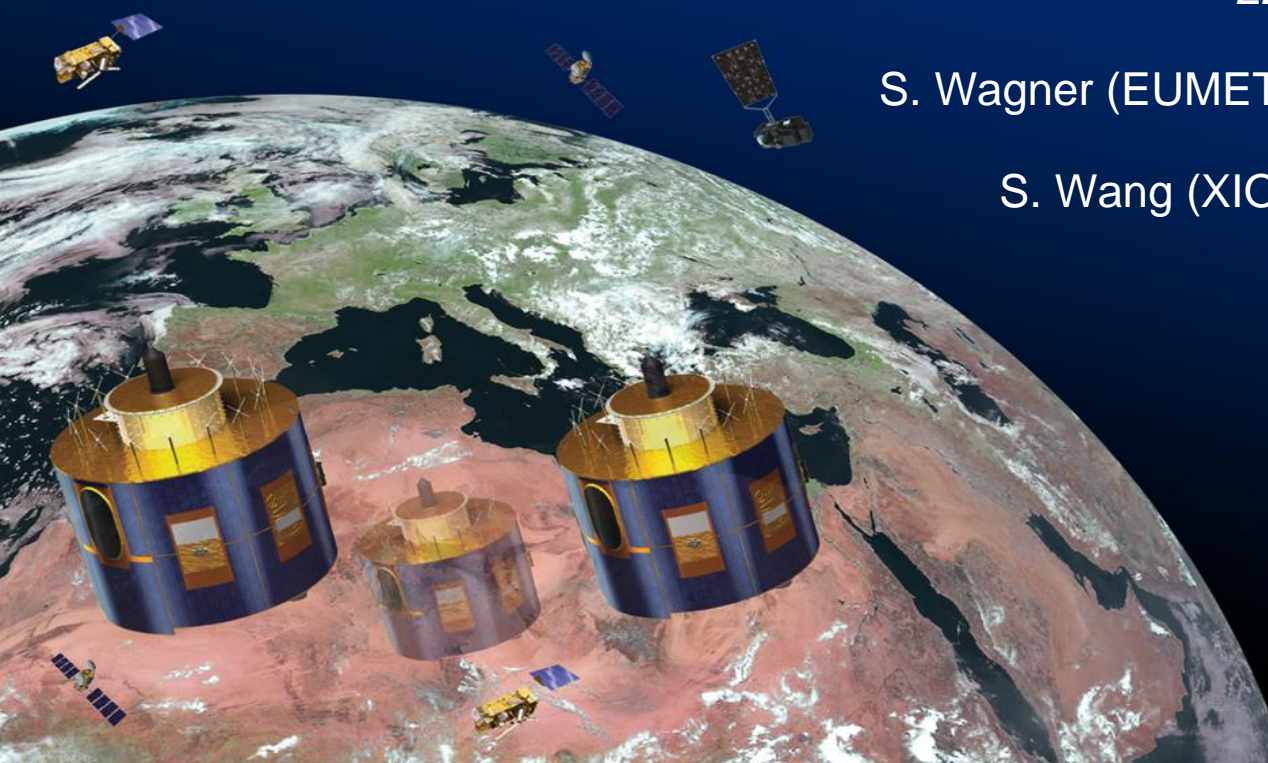


Outcome of the Second Joint GSICS/IVOS Lunar Calibration Workshop

22 March 2018, GSICS Annual Meeting,

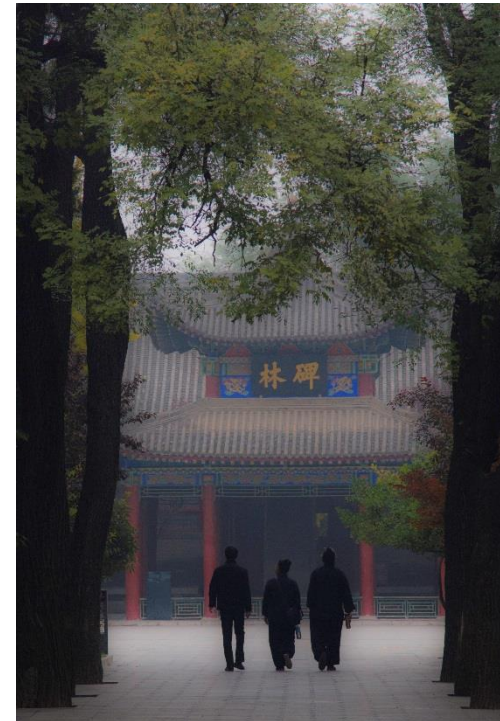
S. Wagner (EUMETSAT), T. Stone (USGS), X. Hu (CMA),

S. Wang (XIOPM), X. Wu (NOAA), X. Xiong (NASA)



2nd Joint GSICS/IVOS Lunar Calibration Workshop

- Second workshop after the meeting organised in 2014 at EUMETSAT
- Organisation: CMA and Xi'an Institute of Optics and Precision Mechanics, in partnership with EUMETSAT, USGS, NOAA and NASA
- Venue: Xi'an (China) 13-16 November 2017



2nd Joint GSICS/IVOS Lunar Calibration Workshop

Objectives

1. To share knowledge and expertise on the latest dedicated ground-based lunar observation campaigns, and space-based lunar datasets
2. To share knowledge and expertise in the preparation of lunar irradiance measurements from observations by the instruments to be monitored
3. To work jointly on algorithms to compare and inter-calibrate instruments with lunar observation capabilities
4. To explore further alternative applications of lunar observations for calibration purposes or post-launch assessments, such as geometric and MTF characterization

2nd Joint GSICS/IVOS Lunar Calibration Workshop

Objectives

1. To share knowledge and expertise on the latest dedicated ground-based lunar observation campaigns, and space-based lunar datasets → **NEW**
2. To share knowledge and expertise in the preparation of lunar irradiance measurements from observations by the instruments to be monitored → **Initiated at LCWS#1**
3. To work jointly on algorithms to compare and inter-calibrate instruments with lunar observation capabilities → **NEW**
4. To explore further alternative applications of lunar observations for calibration purposes or post-launch assessments, such as geometric and MTF characterization → **NEW**

Increasing interest... 2014 EUMETSAT HQ

First Lunar Calibration Workshop (2014):

- 14 agencies + departments
- 26 people (including remote attendees)

Second Lunar Calibration Workshop (2017):

- 22 agencies + departments
- More than 60 scientists (including remote attendees)



Increasing interest... 2017 Xi'an



Agenda

- **Four-day meeting**
- **Monday: Measurements and Moon Observations (chaired by X. Hu - CMA)**
- **Tuesday: Using the ROLO and the GIRO + Lunar Model Developments (chaired by T. Stone - USGS)**
- **Wednesday:**
 - **Inter-calibration and Inter-band Calibration (chaired by S. Wagner - EUMETSAT)**
 - **Alternative uses of lunar measurements (MTF post-launch characterisation, chaired by F. Yu - NOAA)**
- **Thursday:**
 - **Alternative uses of lunar measurements (ghost, cross-talk, infrared, microwave, etc. – chaired by X. Xiong - NASA)**
 - **Discussions, Review of actions/recommendation/way forward + Conclusions of the workshop (chaired by S. Wagner - EUMETSAT).**

Measurements and Moon observations

- Great effort made by CMA and collaborating Chinese institutes from CAS to:
 - Develop new instruments dedicated to lunar observations from ground
 - Lead measurement campaigns
- ➔ Goal = achieve SI traceability and develop new models for lunar calibration



Lunar imager



AOTF imager



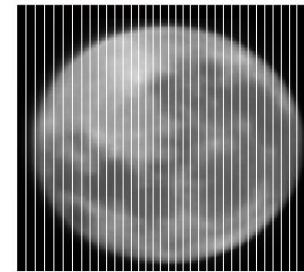
high-spectral lunar photometer



CE318U Lunar-photometer



HSFTS



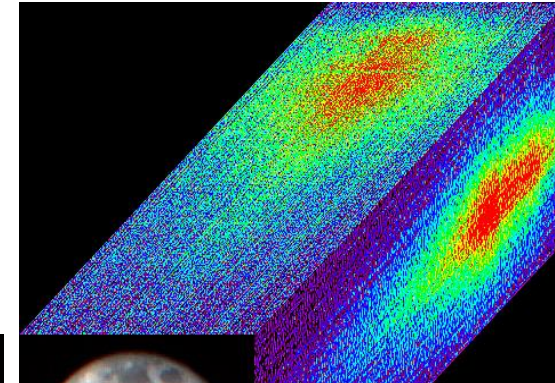
Sweep Scanning



Split Joint



CCD



Lunar Spectral Imager,
Y. Wang & al, 2017
Zhang & al.
LCWS2017
#1d

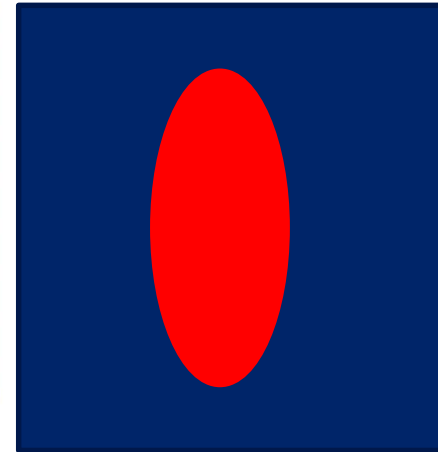
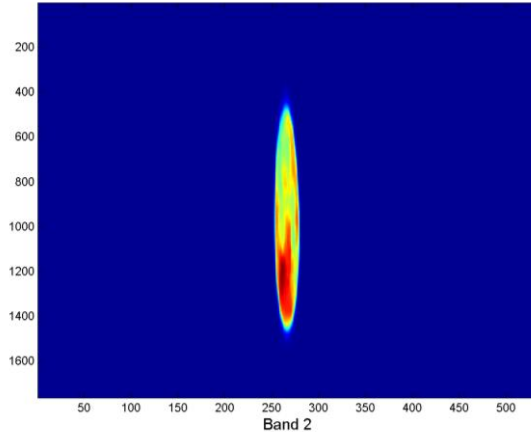
Measurements and Moon observations

- New campaigns planned with increased capabilities (automation, spectral coverage and resolution, time series, etc.)
- Lunar observations from space are also part of CMA future developments
- ESA + partners : project on Lunar irradiance measurement and modelling for absolute radiometric calibration of EO sensors (K-O in Sept. 2017) using CIMEL CE318 instruments → will also use the GIRO + GLOD
- AIOFM (Anhui Institute of Optics and Fine Mechanics, CAS) presented a very good approach for ensuring SI traceability → shall be pursued
- New instruments datasets available (F. Yu presentation on data cataloging: 1s): not only in the VNIR, multispectral to hyperspectral, also ground-based, “new” applications (MTF, inter-band, co-registration ,radiance model, etc.) → beyond the original scope of the GLOD...
 - Evolution of the GLOD discussed and will need to be addressed by the Lunar Calibration Community

ROLO/GIRO and Lunar Model Developments

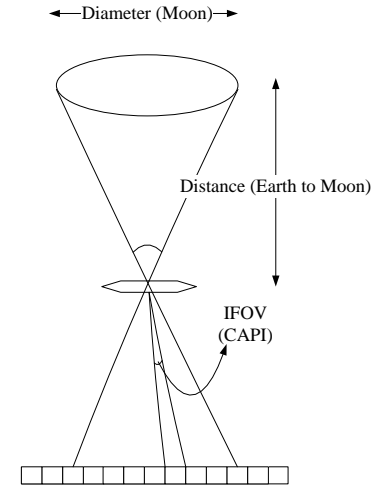
- Further iteration after 1st LCWS on how to estimate the oversampling factor

R. Wu, LCWS2017: 2f



lines

samples



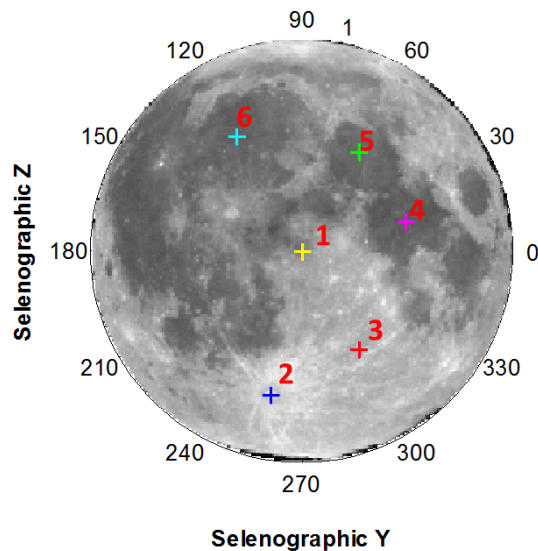
$$f_{os} = \frac{lines_{moon}}{samples_{moon}} = \frac{lines_{moon}}{\frac{diameter_{moon}}{distance_{earth_{moon}}} / IFOV_{CAPI}}$$

➔ Recommendation = do not use geometrical ratio if possible...

- New datasets presented (i.e. SCIAMACHY + GOME-2)
 - ➔ inclusion in the GLOD still to be discussed between EUMETSAT and ESA for SCIAMACHY
- USGS (T. Stone) funded to work on the original ROLO telescope data ➔ data will become publicly available
- Traceability of GIRO to ROLO: creation of a benchmark. First comparisons to be shown at this GSICS WG meeting

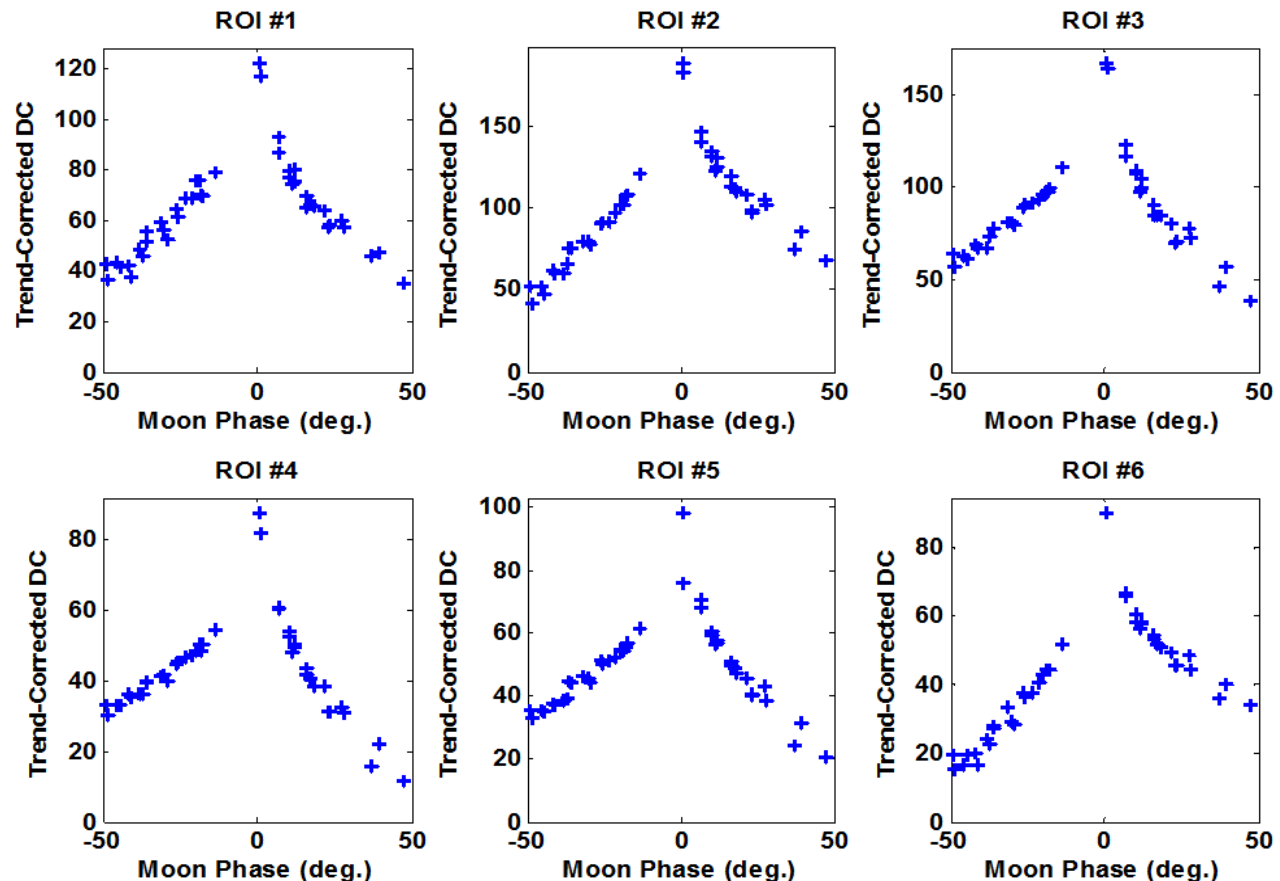
ROLO/GIRO and Lunar Model Developments

- Development of new models by NOAA, CMA and JMA , in particular radiance models.



Shao et al. 2015, SPIE 9639, doi:10.1117/12.2193914

F. Yu, LCWS2017: 3i



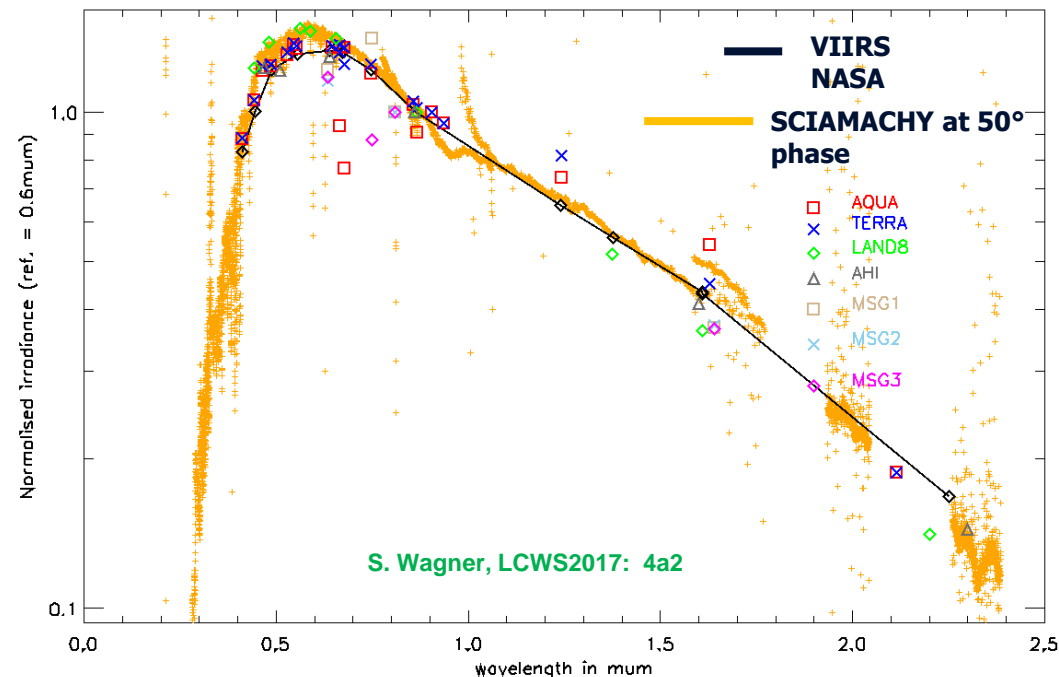
- Interest of the Lunar Calibration community in developing a model accounting for the Moon light polarisation

Inter-Calibration and Inter-Band Calibration

- Two major issues with inter-calibration:
 1. Residual phase dependence in the GIRO as in the ROLO
 2. To move from Aqua MODIS to (Suomi NPP) VIIRS as GSICS reference instrument for VNIR
- However, several potential activities are identified:
 - GEO-GEO inter-calibration using the Moon
 - Implementation of the GEO-LEO concept with matching phase angle range

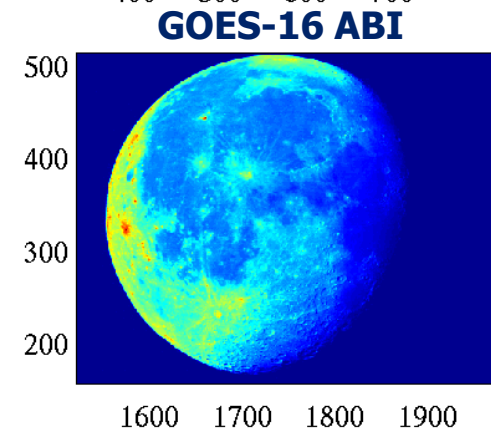
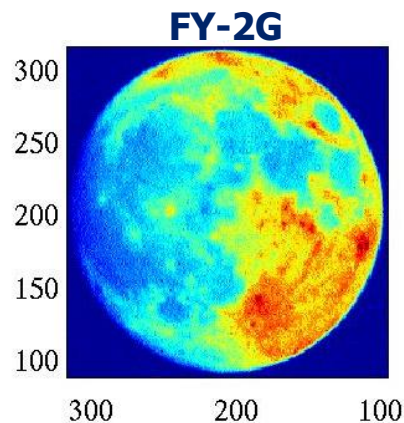
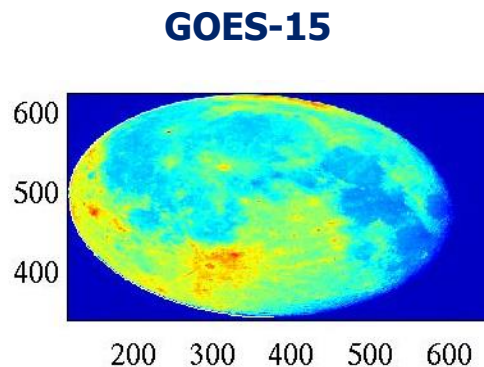
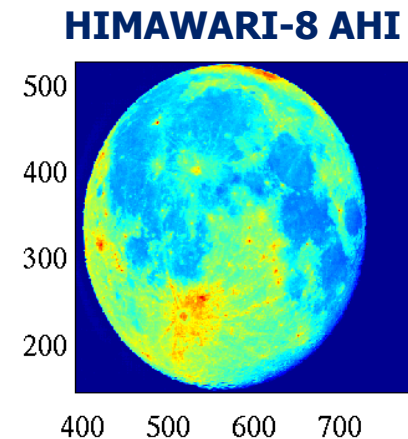
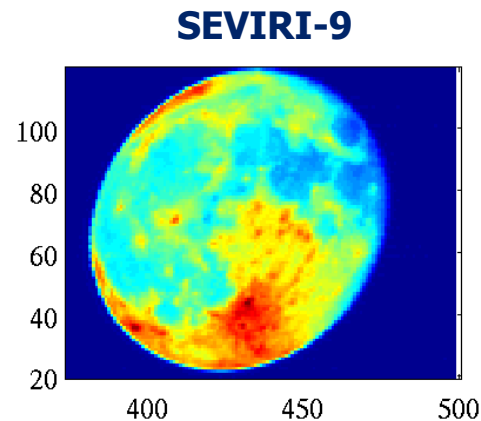
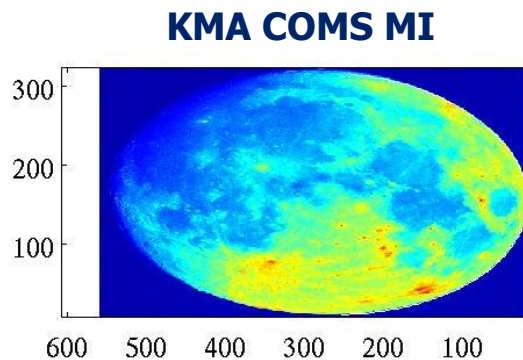
- **New topic: inter-band calibration**

- A way to validate/monitor the relative radiometric consistency between bands of a same instrument
- A way to transfer absolute calibration from a reference band to others (in particular for the calibration of absorption bands)



Alternative Uses of Lunar Measurements

- Largely dedicated to MTF post-launch estimation using lunar imagery
 - Inter-comparison exercise (lead = NOAA) → Goal: come up with recommended approach
 - Current participants: CMA, EUMETSAT, JMA, KMA, NOAA, VITO (presented the method developed with ESA)
 - → **Coordination with IVOS**



X. Shao,
LCWS2017: 5b

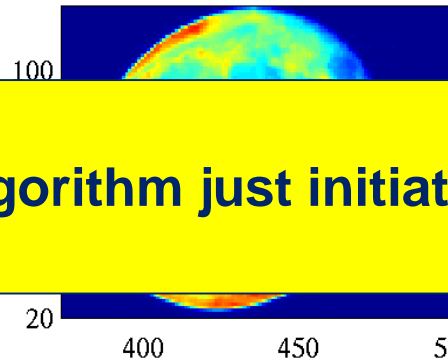
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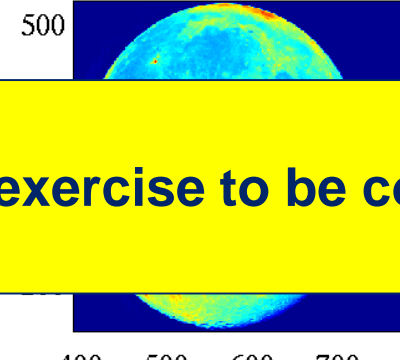
KMA COMS MI



SEVIRI-9

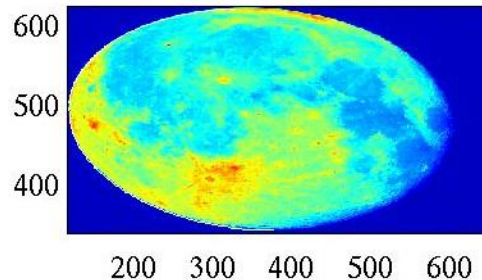


HIMAWARI-8 AHI

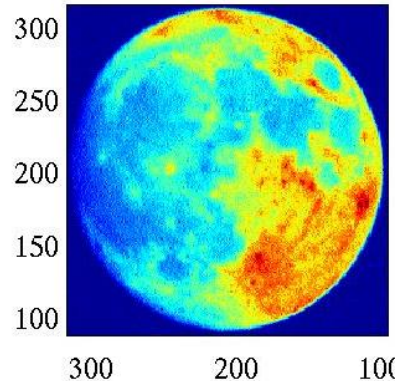


MTF: discussion on the algorithm just initiated → exercise to be continued

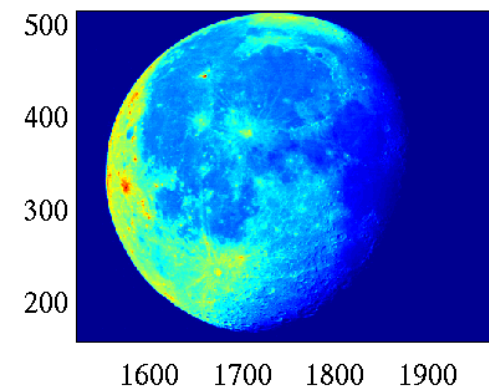
GOES-15



FY-2G



GOES-16 ABI

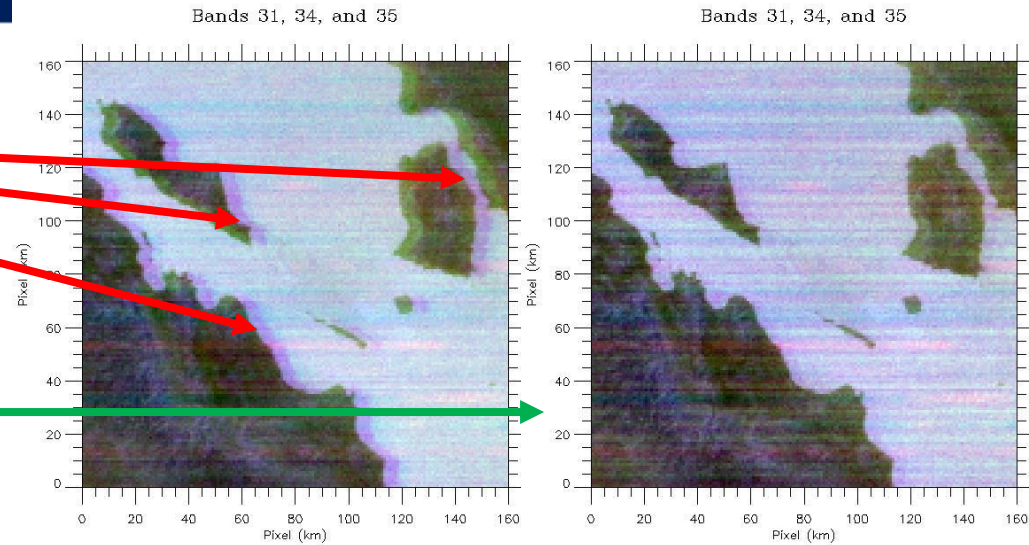


X. Shao,
LCWS2017: 5b

Alternative Uses of Lunar Measurements

- Cross talk → Terra MODIS experience
 - Optical cross-talk
 - → Correction

X. Xiong & V. Chiang, LCWS2017: 5k

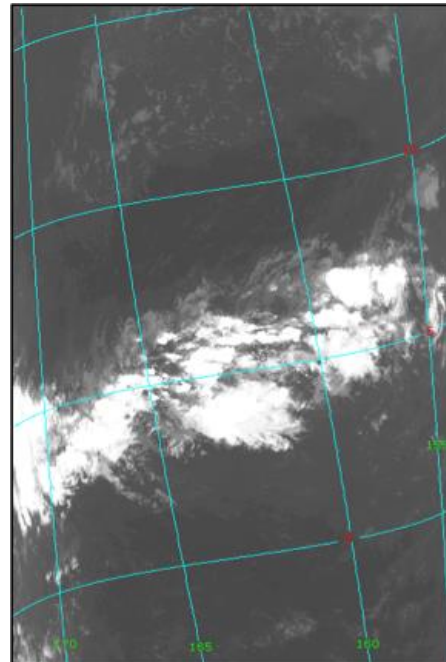


- Electronic cross-talk: lunar imagery to identify the sending anomalies and correct

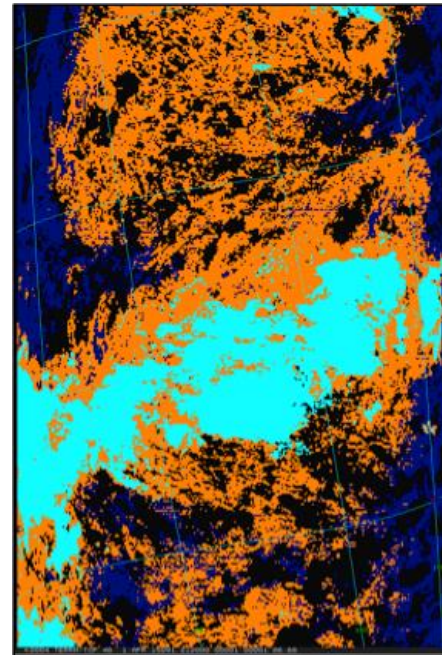
Impact on MODIS Science Products: Cloud Particle Phase Retrieval → reduced uncertainty



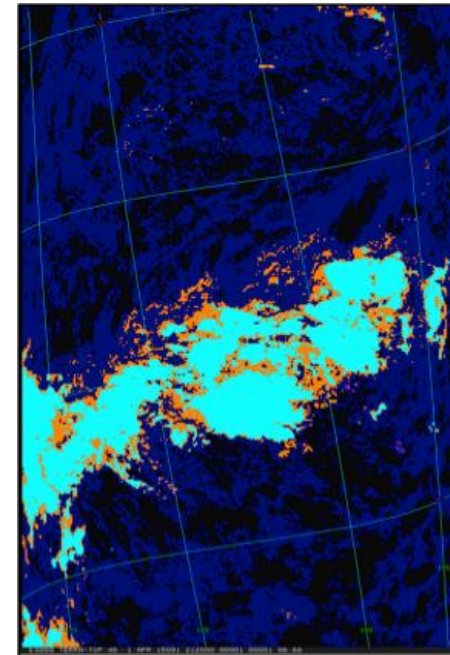
Band 31 Image



CPP Before Correction



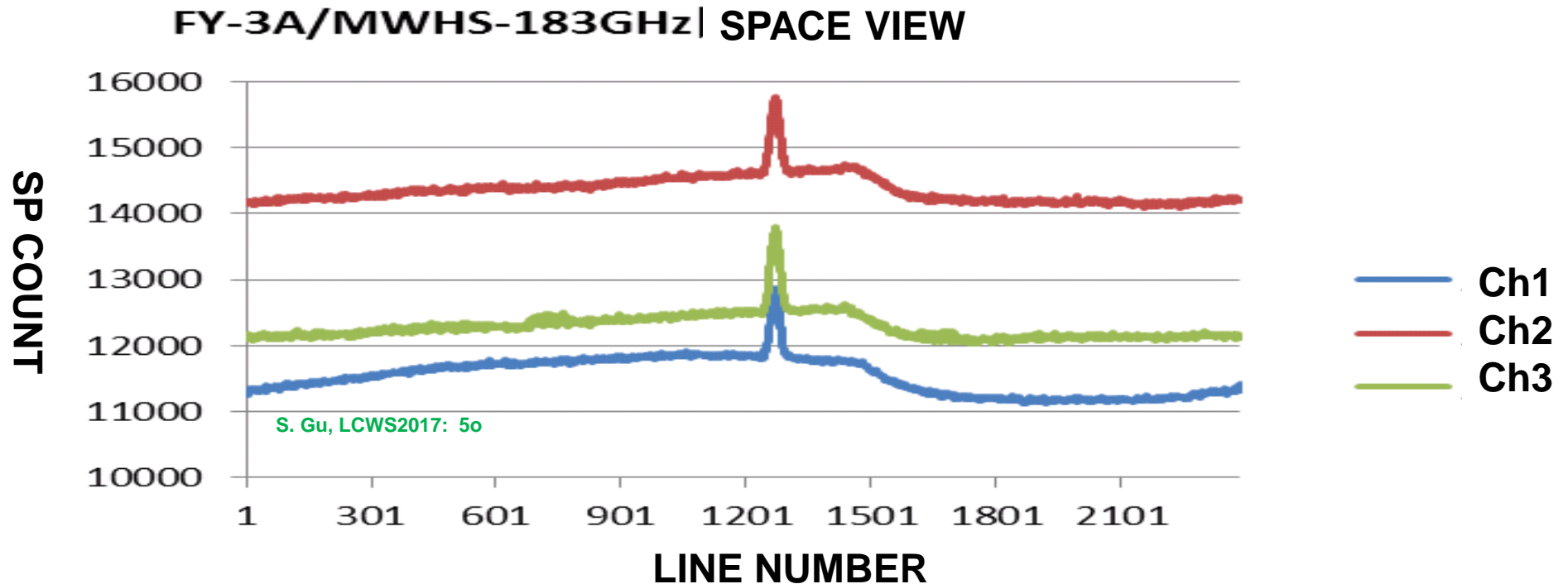
CPP After Correction



T. Wilson, LCWS2017: 5I
 T. Wilson et. al., Remote Sens. 9 (6), 569 (2017)

Alternative Uses of Lunar Measurements

- Lunar observation and microwave measurements → CMA presented their activities and plans for FY-3 MWHS



Main actions (total = 8)

- LCWS.2017.1t.1: EUMETSAT to contact the participants to get updates on the lunar data for the GLOD → The GIRO is being now distributed but GLOD will be first consolidated...
- LCWS.2017.1t.3: CMA to consider a similar plan to ESA to schedule ground measurements in the future (e.g. instruments, calibration, sites, measurement strategy) → new measurements in coordination with partners from the Lunar Calibration Community
- LCWS.2017.2p.1: EUMETSAT/USGS to report at the next GSICS annual meeting on the traceability of the GIRO to the ROLO using the benchmark
- LCWS.2017.5h.1: MTF post-launch estimation using lunar imagery. Points of Contact to coordinate and provide details about the algorithm implemented in their agency as listed in EUMETSAT's presentation on MTF (slide 30, point 4) → new activity. Topic for discussion within GSICS, in coordination with IVOS?

Main recommendations (total = 22)

- LCWS.2017.2k.1: Agencies operating geostationary instruments to work together to investigate the possible **non-linearity impact** on the phase angle dependence of the ratio between measured irradiance and the modeled irradiance.
- LCWS.2017.2o.1: agencies to investigate further their calculation of the **oversampling factors** and to make use of the operational scan rate and corresponding time when available.
- LCWS.2017.4d.1: NOAA/NASA to interact on calibration dataset (VIIRS) and report back at the next GSICS annual meeting to provide advice on what to use for inter-calibration
→ **impact not only lunar calibration but GSICS VNIR products in general**
- LCWS.2017.6a.2: the Lunar Calibration Community is invited to contribute to the development of a polarisation model for the Moon light. This model would complement the ROLO/GIRO and could be a separate model.
- LCWS.2017.6d.3: NOAA to liaise with IVOS regarding MTF estimation (contacts: Françoise Viallefont - Françoise.Viallefont - AT - onera.fr , or Dennis Helder - Dennis.Helder - AT - sdstate.edu) → **GSICS can benefit from IVOS experience**

Conclusion and future activities

- Very successful meeting: very large audience, plenty of very nice achievements presented, good discussions and very nice venue!
- ROLO/GIRO development to be continued
- New models will also be developed (i.e. radiance models) to complement ROLO/GIRO
- New measurement campaigns to improve lunar calibration + achieve SI traceability
- New areas for activities: MTF, inter-band, cross-talk characterisation, etc.

Conclusion and future activities

- Workshop Format:
 - 2014 : workshop with home work preparation + activities during the WS → focus was ROLO/GIRO
 - 2017 : some coordinated home work preparation (MTF), but more topics covered by the workshop
 - All participants agreed on the need to organize another Lunar Calibration Workshop within the next two years

谢谢

Thank you

<http://gsics.wmo.int>

<http://gsics.atmos.umd.edu/bin/view/Development/MeetingsAndConferences>

2017 Lunar Calibration WS

<http://gsics.atmos.umd.edu/bin/view/Development/20171106>