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PROBA-V lunar calibration

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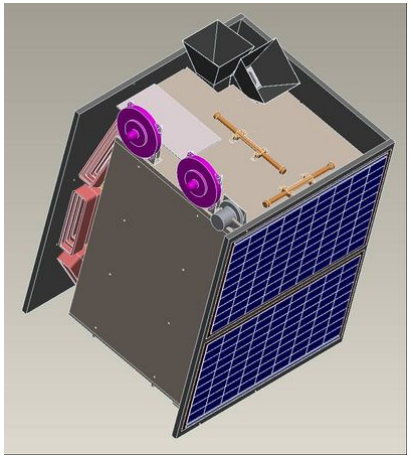
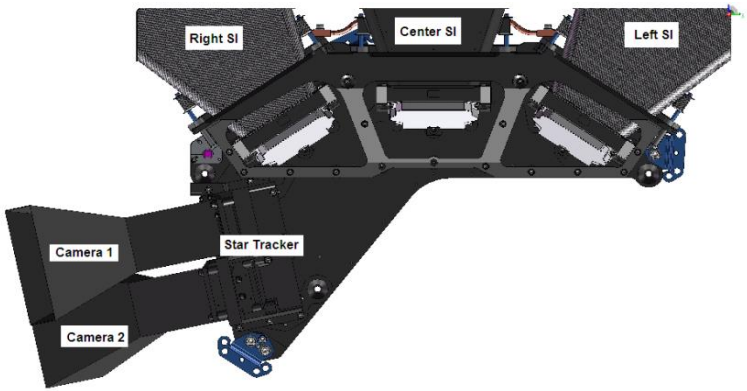
Presentation outline

- Mission
- SRF
- Sensor model
- Vicarious calibration
- Observation moon
- Images
- Masking
- Results
  - Moon
  - Other methods

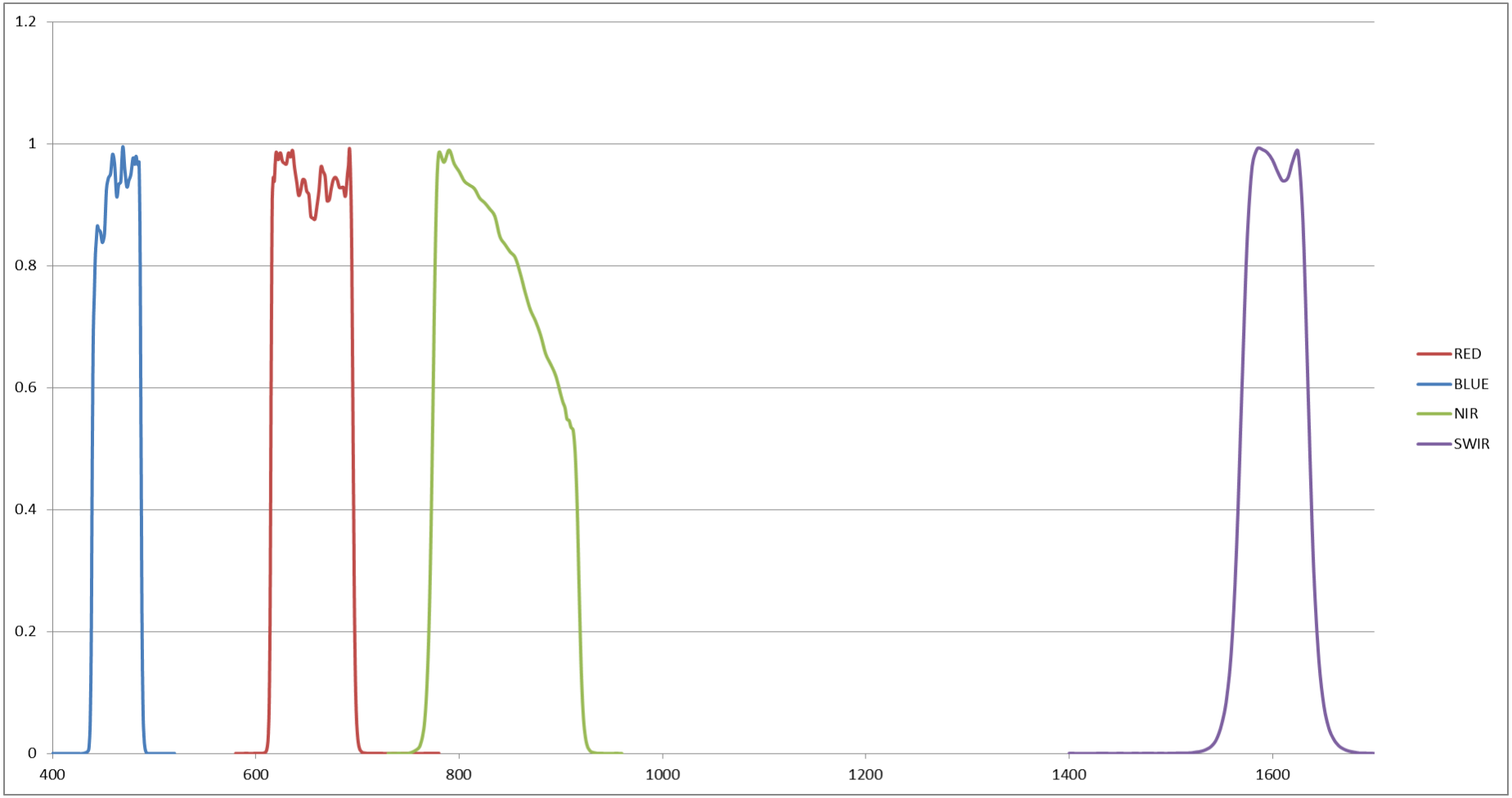
Mission



- Small satellite : 140kg
- Sun-synchronous polar orbit@820km
- Swath approx. 2000km
- 1 sensor - 3 cameras
- 1 VNIR and 3 SWIR detectors per camera
- Minimal GSD 100m
- Different geometry per band
- 4 spectral bands : blue, red, nir and swir
- No calibration device onboard.
- 5% absolute 3% interband accuracy
- DELIVER DAILY GLOBAL NDVI COMPOSITES



SRF



Sensor model : DN to Radiance (ESA/OIP)

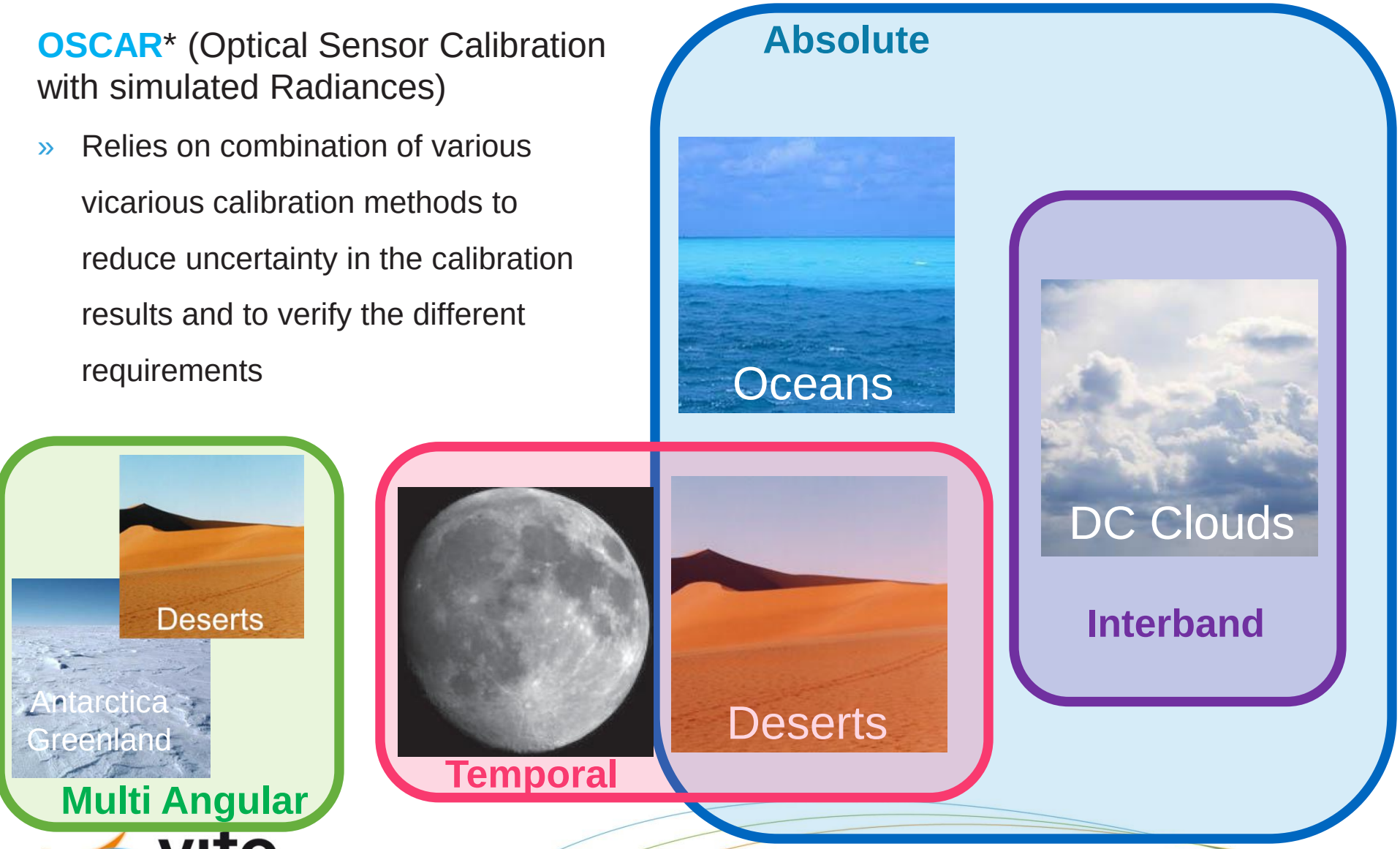
$$L = \frac{DN_{i,k,g,T} - NL_{k,g} - (dc_{i,k,g,T} IT + off_{i,k,g})}{A_{k,T} g_{i,k,g} (IT + dIT_k)}$$

	Acronym	Units
Dark current at reference temp	$dc_{i,k,g}$	LSB s^{-1}
Dark current - activation energy	$\Delta E_{i,k}$	J
Offset	$off_{i,k,g}$	LSB
Absolute radiometric coefficient	$A_{k,T}$	LSB $W^{-1}m^2$ Sr s^{-1}
Average gain setting	$AVG_{k,g}$	No units
Equalisation coefficient	$g_{i,k,g}$	No units
Integration time offset	dIT_k	s
Non-linearity	$NL_{k,g}$	LSB

RC – IQC: Vicarious Calibration Concept

OSCAR* (Optical Sensor Calibration with simulated Radiances)

» Relies on combination of various vicarious calibration methods to reduce uncertainty in the calibration results and to verify the different requirements



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*Sterckx *et al.* IJRS, 2014; Sterckx *et al.* , TGARS, 2013; Govaerts *et al.*, RSL, 2013

Rayleigh calibration

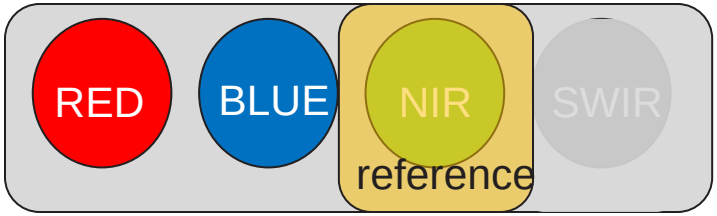
Target: stable, homogenous oceans

Method: compare TOA radiances to **simulated** values,

using NIR band to retrieve aerosol optical depth

Usage : Operational absolute calibration, for RED and BLUE

combine with inter-band to transfer results to NIR, SWIR



Implementation:

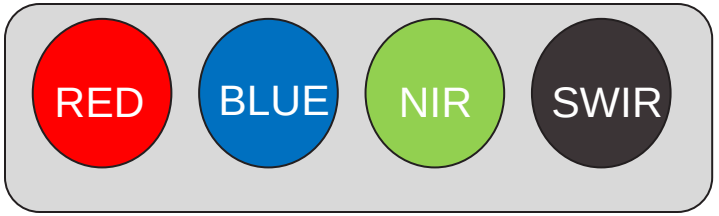
- M98 aerosol
- ECMWF (Wind speed, P,O3,H2O)
- 6SV LUT *(takes into account coupling effect between ocean and atmosphere (including Cox Munk model), polarization and multiple-scattering)*
- Chl(month) to account for seasonal variation
- Strict automatic pixel selection procedure

Desert calibration over Libya-4

Target: stable, homogenous desert sites

Method: compare TOA radiances to **simulated** values

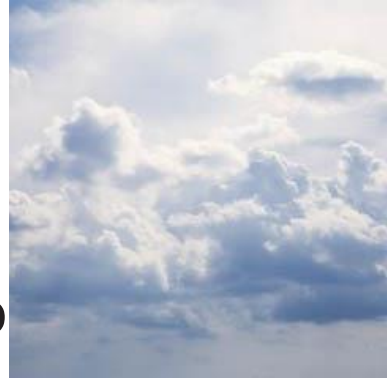
Usage : Operational absolute calibration for all bands , cross mission calibration, multi-temporal



Implementation:

- 6SV simulations
- Surface BRDF reflectance chacteristics
- ECMWF (P,O3,H2O)
- Dedicated desert aerosol model

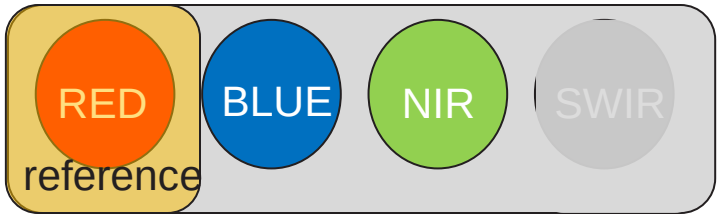
Deep Convective Clouds calibration



Target: reflection of deep convective clouds over oceans

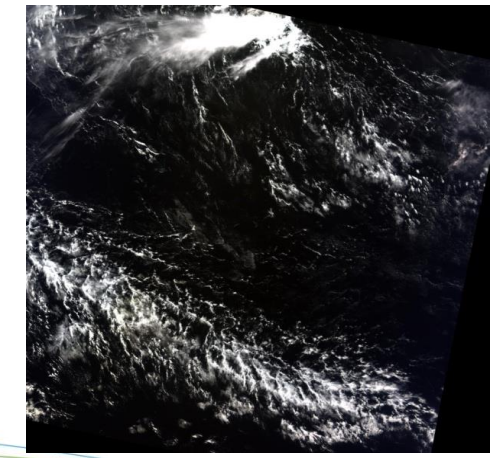
Method: Compare PROBA-V TOA data to **simulated** data using RED reference band to retrieve cloud optical thickness"

Usage: inter-band (absolute if combined)



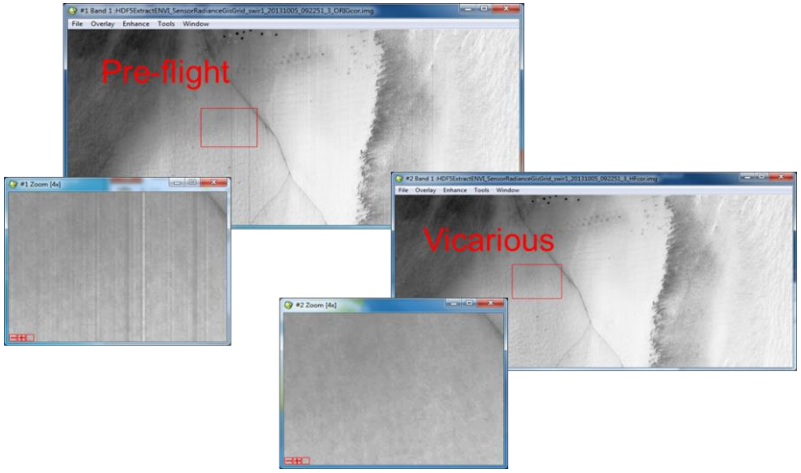
Implementation:

- LibRadtran LUT
- Ice clouds optical properties (Baum et al. 2005)
- Fixed effective ice cloud radius
- ECMWF (O3)
- Strict procedure to automatically select DCC pixels
- Not for SWIR band



Equalisation

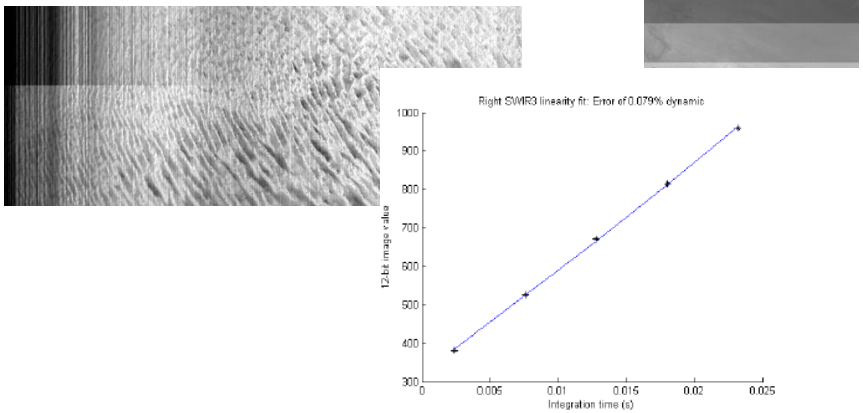
- Reduction of SWIR stripes



- A few bad SWIR pixels identified + some marked as suspect

Non-linearity

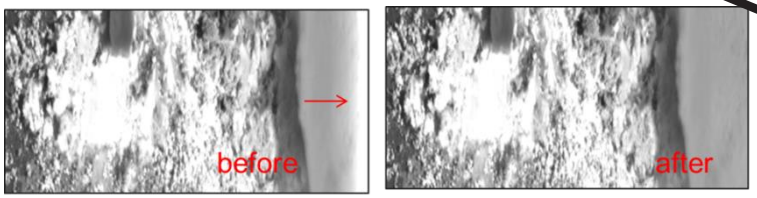
- SWIR detector non linearity for DN > 3300 => IT reduced
- Observed linearity VNIR below 1 %
- Observed linearity SWIR below 0.4 %



Dark current

- Monitoring of stability
- Identification bad & suspect pixels

Vignetting



List of bad pixels

List of 10 SWIR bad pixels

CAMERA	STRIP	BAD (commis)
LEFT	SWIR1	352
LEFT	SWIR2	711,863
LEFT	SWIR3	438,759
CENTER	SWIR1	1021
CENTER	SWIR2	769
CENTER	SWIR3	890
RIGHT	SWIR1	
RIGHT	SWIR2	14,438
RIGHT	SWIR3	

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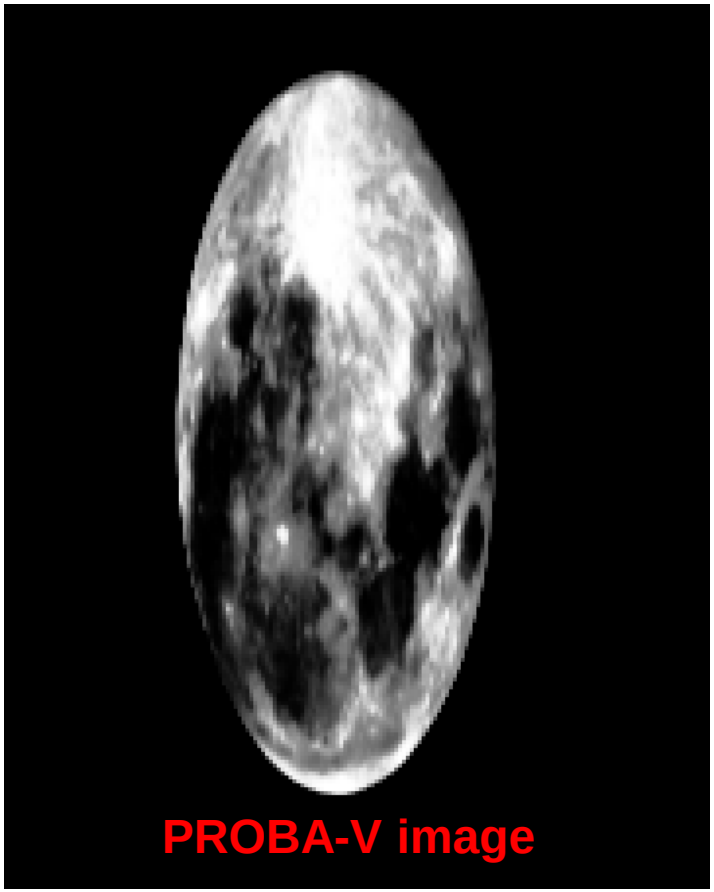
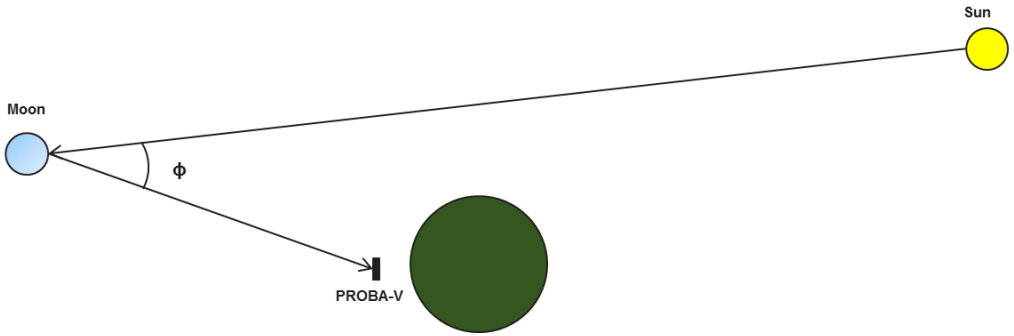
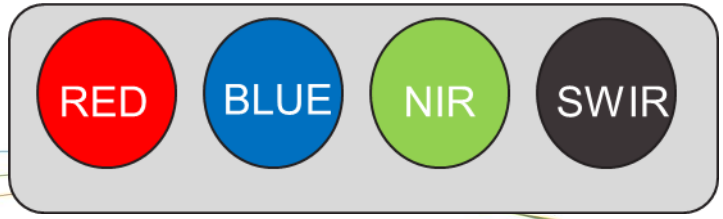
Observation of the moon



- Phase angle 7° +/- 0.5 degrees (moon - observer - sun angle)
- 2 observtions a month
- Pitch maneuver : 360 degrees rotation at approx. 0.2 °/s
- Oversampling of +/-4.0





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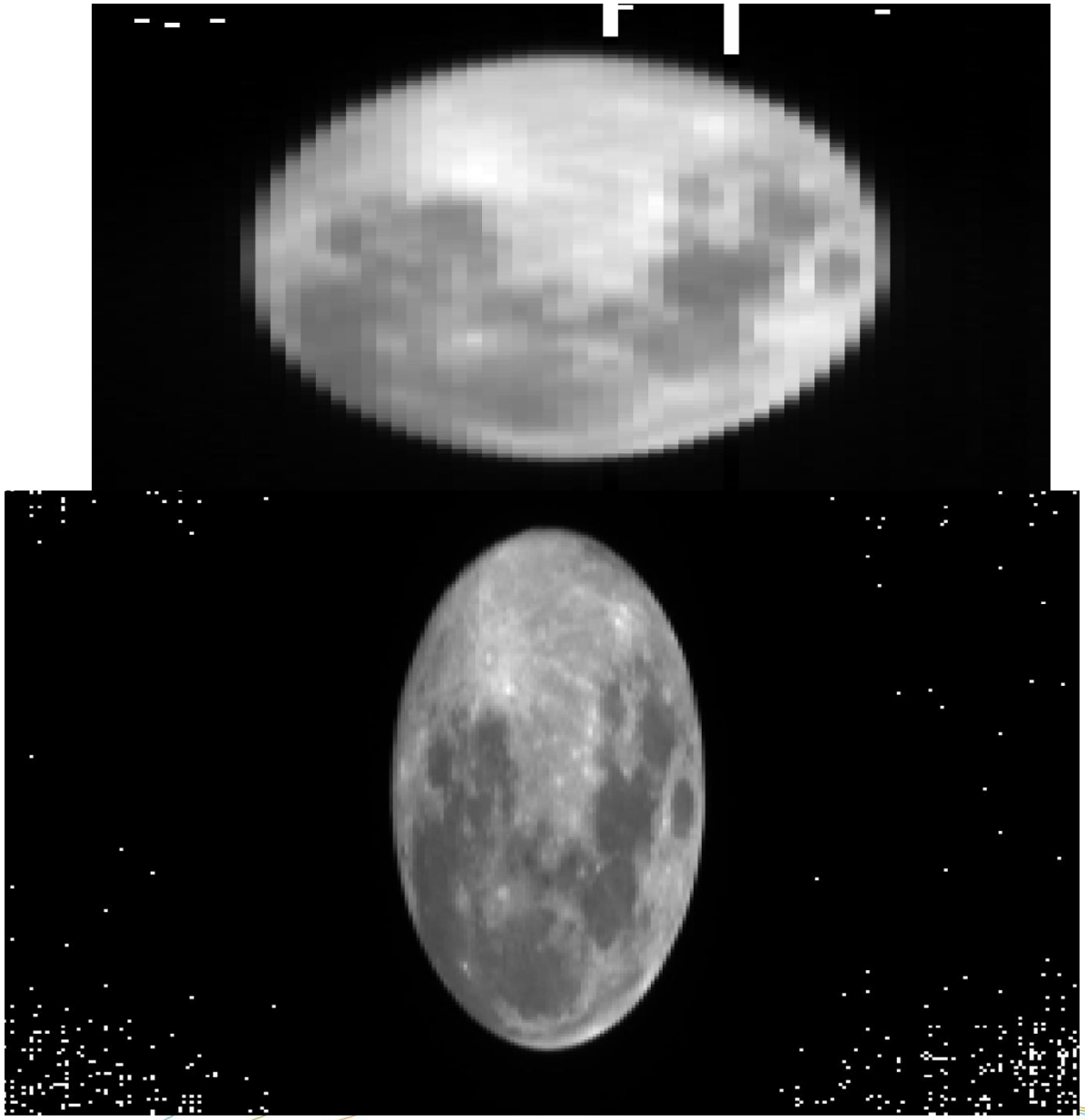
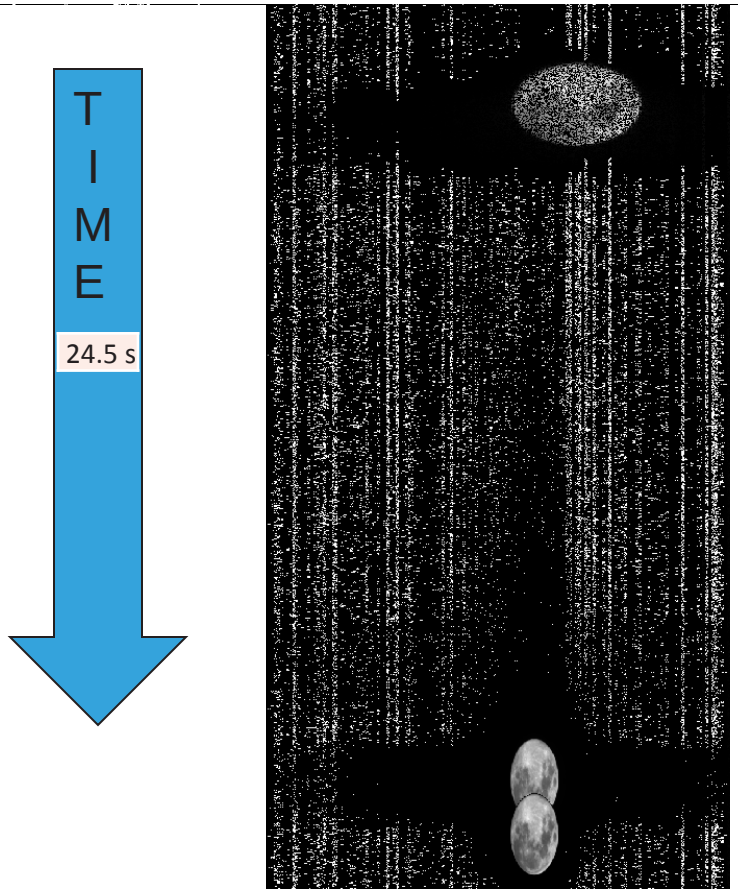
Images

SWIR
- 23 cols
- 93 lines

VNIR :
- 41 cols
- 170 lines

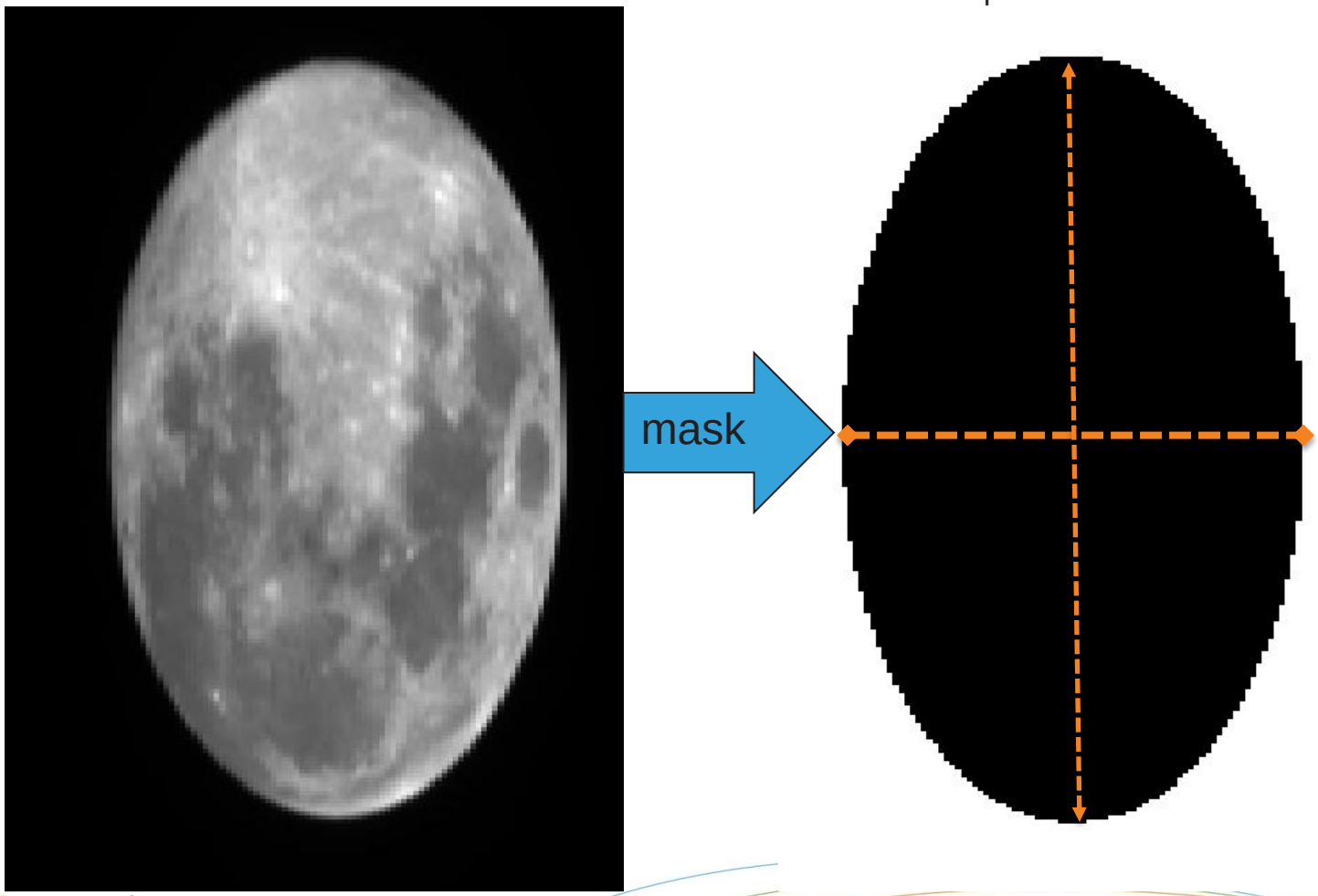


Images

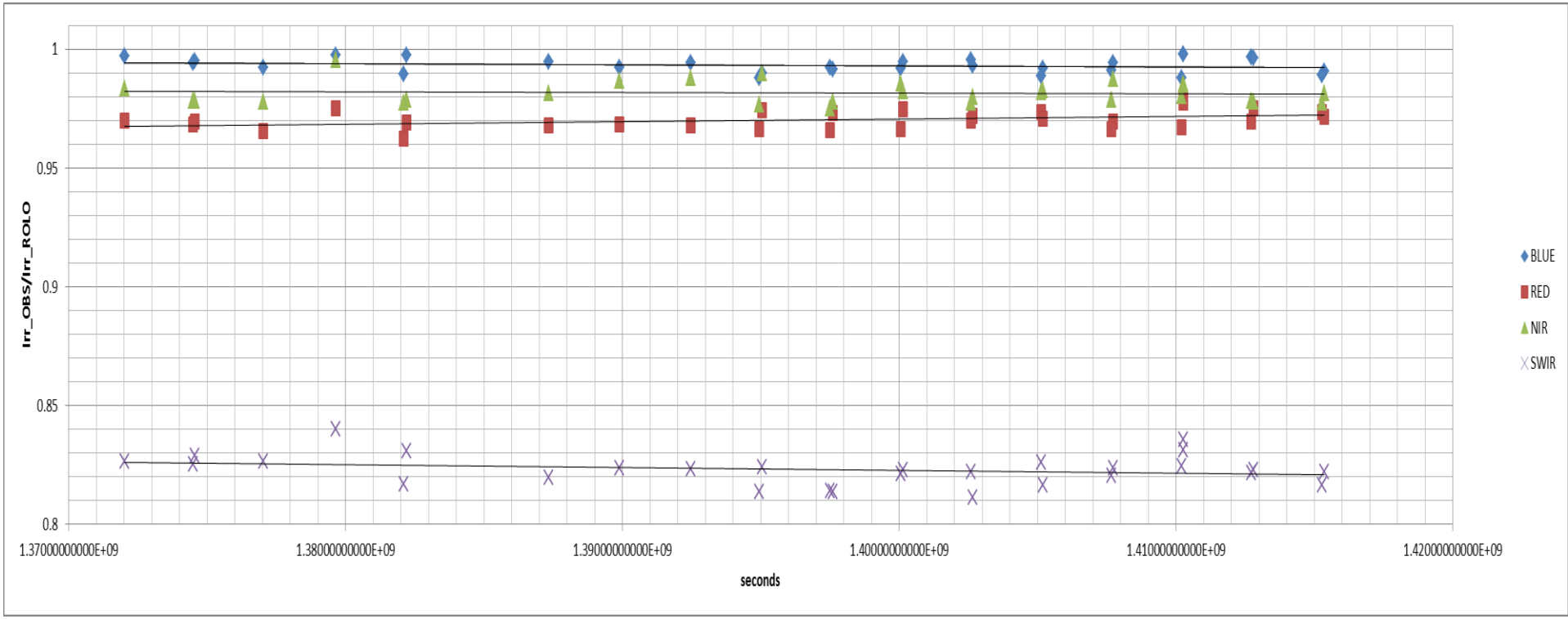


Masking

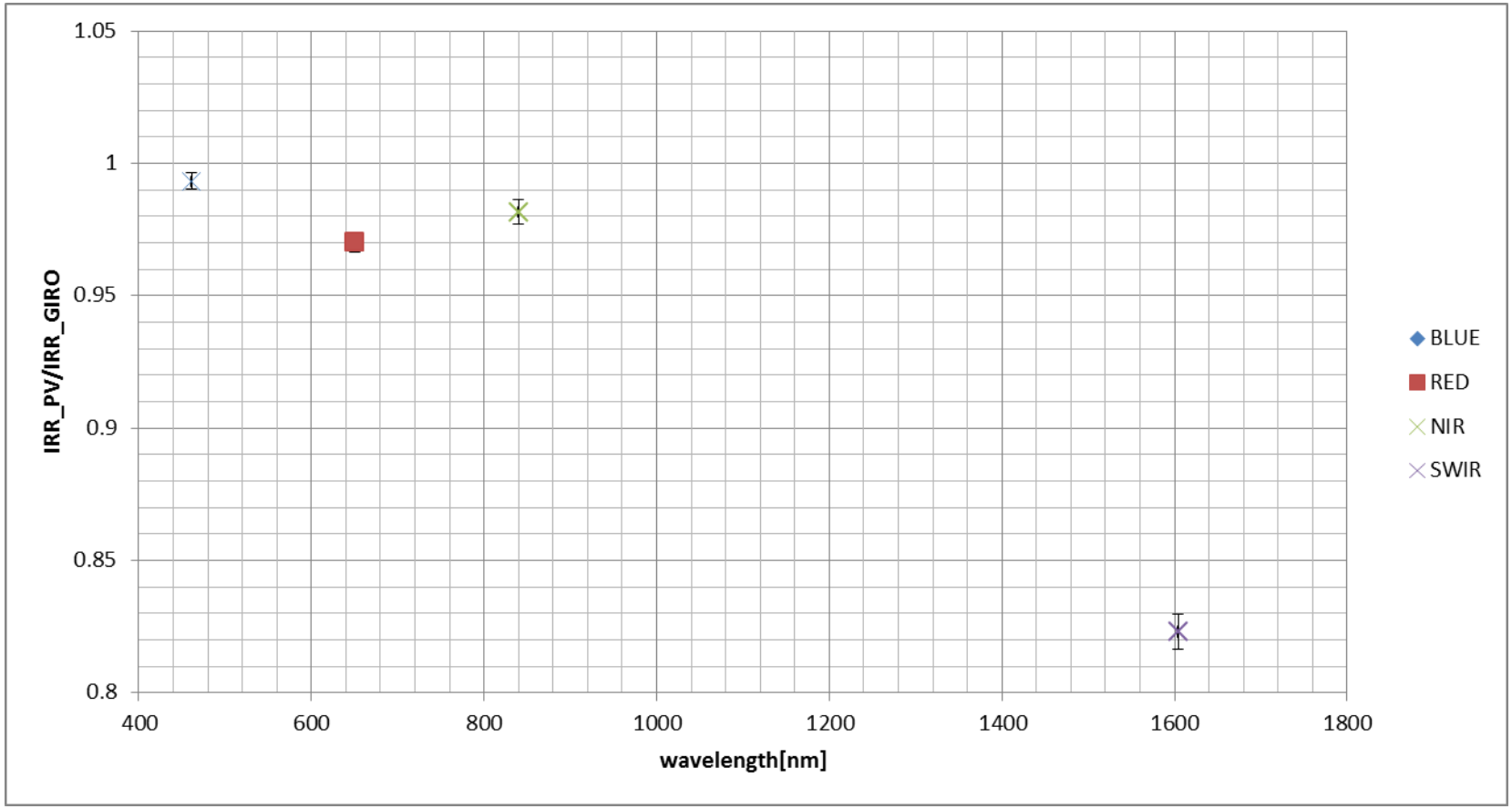
- Threshold based with neighbour checks
- Pixel solid angle
- Center of observation timestamp
- Platform position



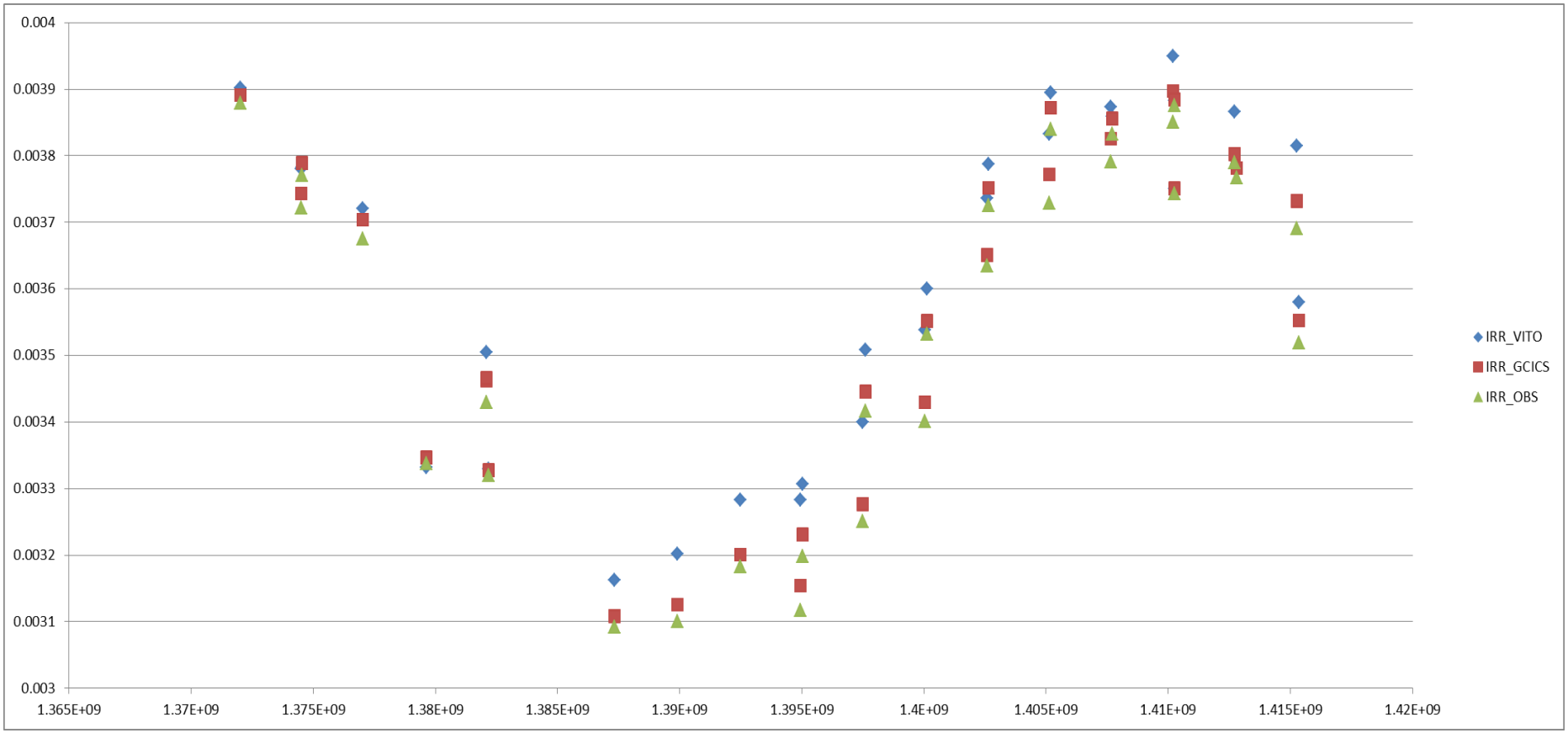
Results with GIRO



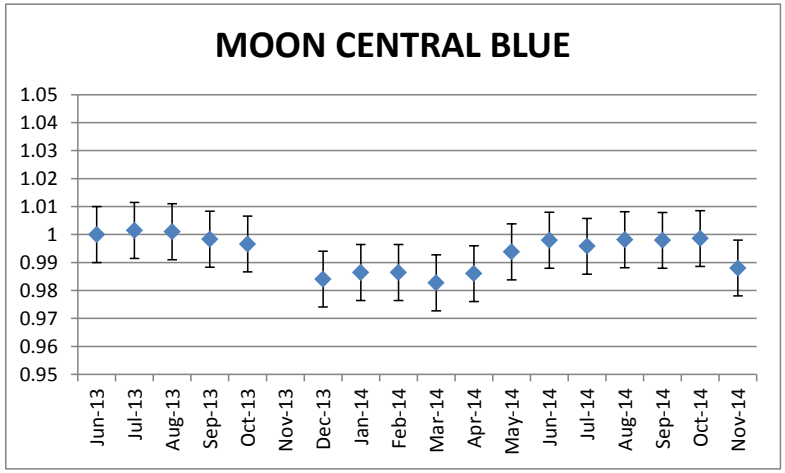
Results with GIRO

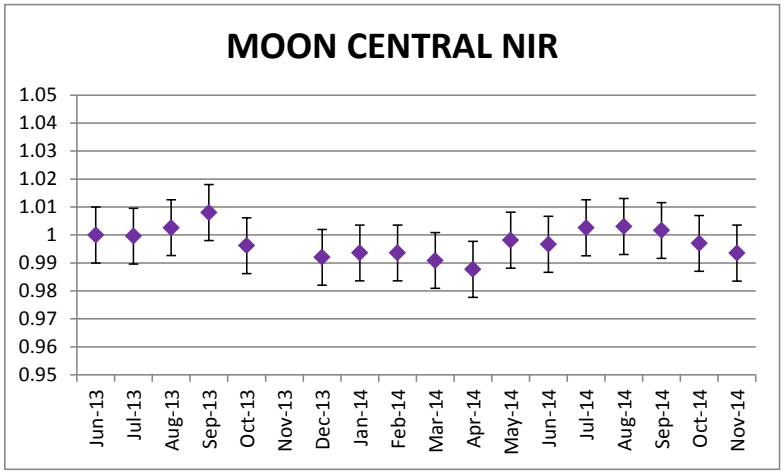


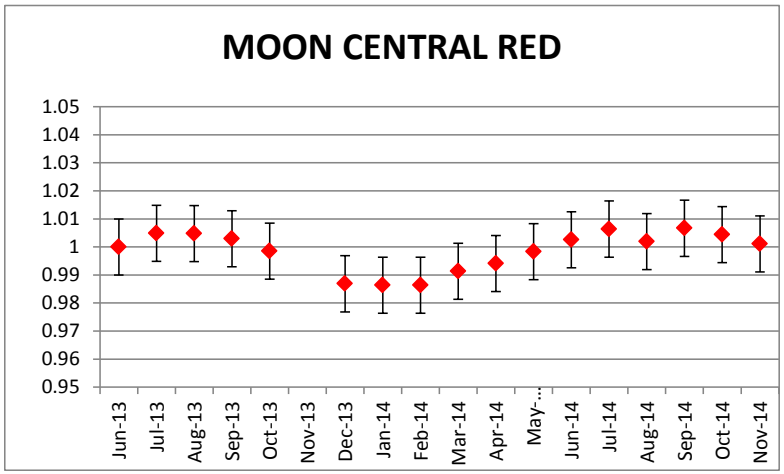
Irradiances : comparison

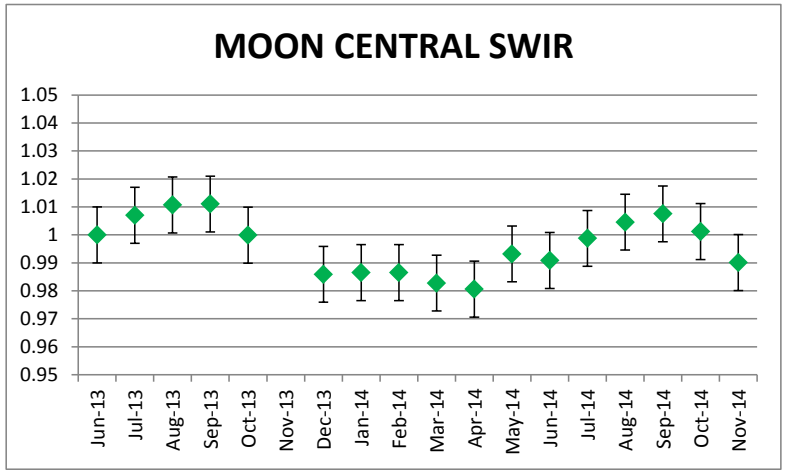


Stability: ROLO_VITO









Plots relative to June-2013 observations; on the basis of a constant absolute calibration parameter

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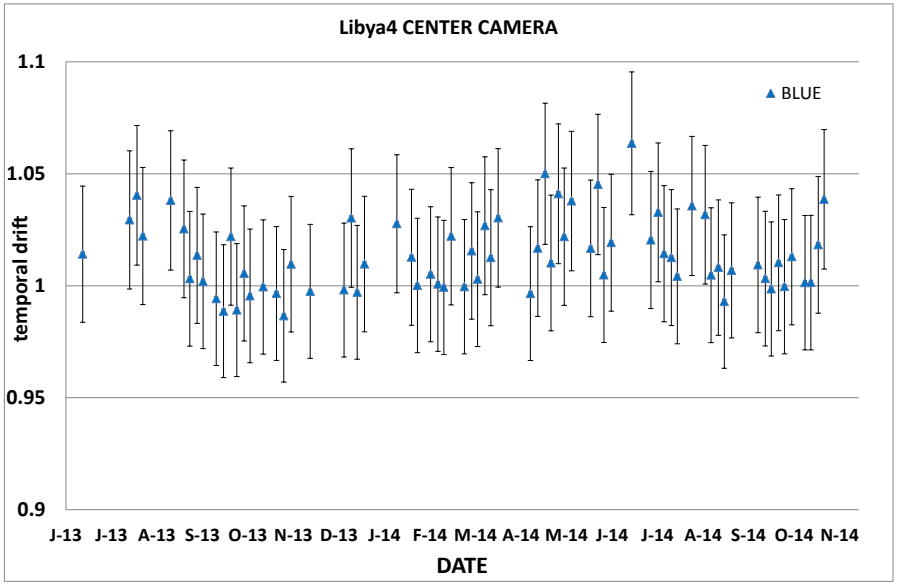
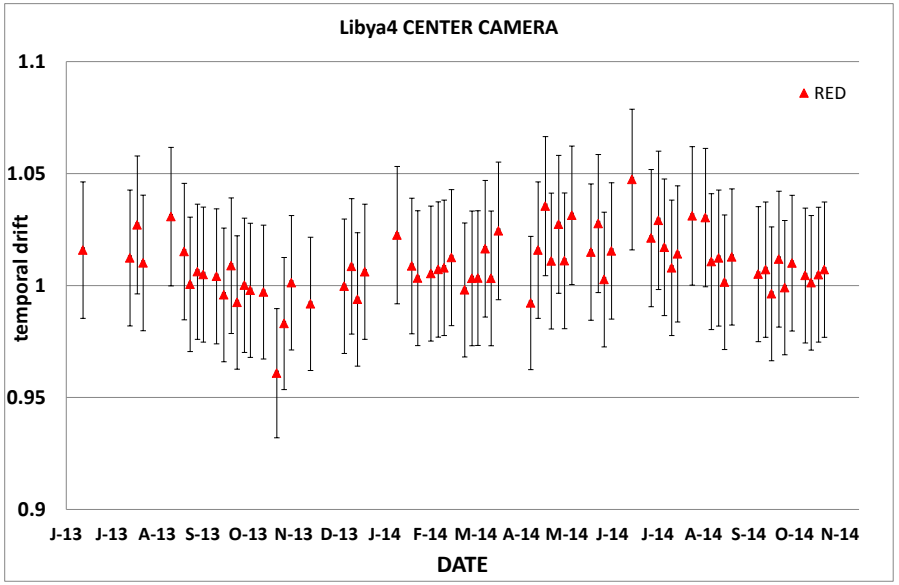
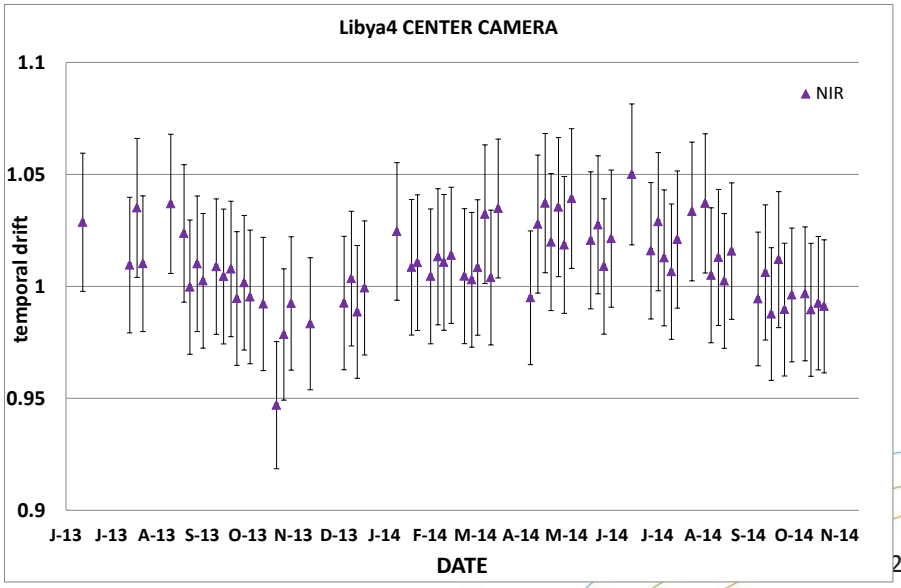
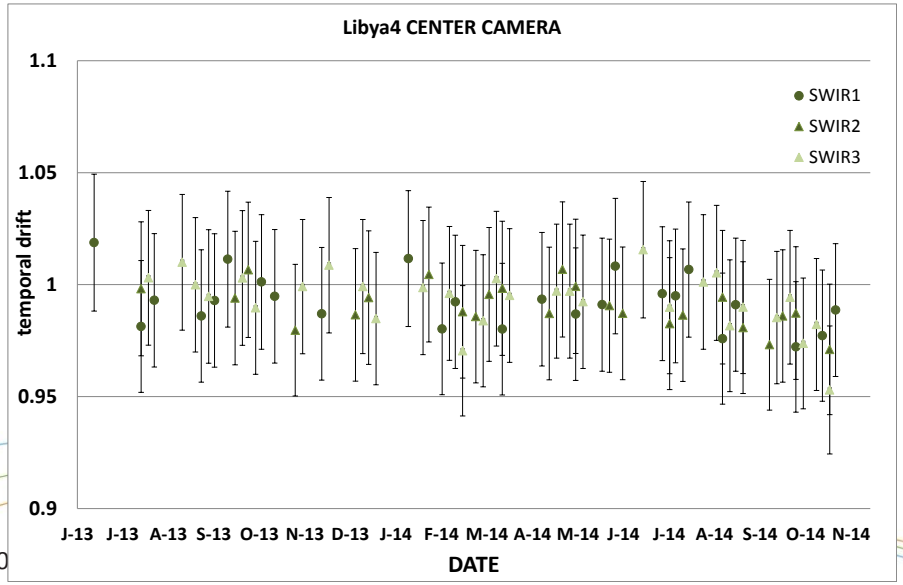
Radiometric response stability - CENTER camera desert

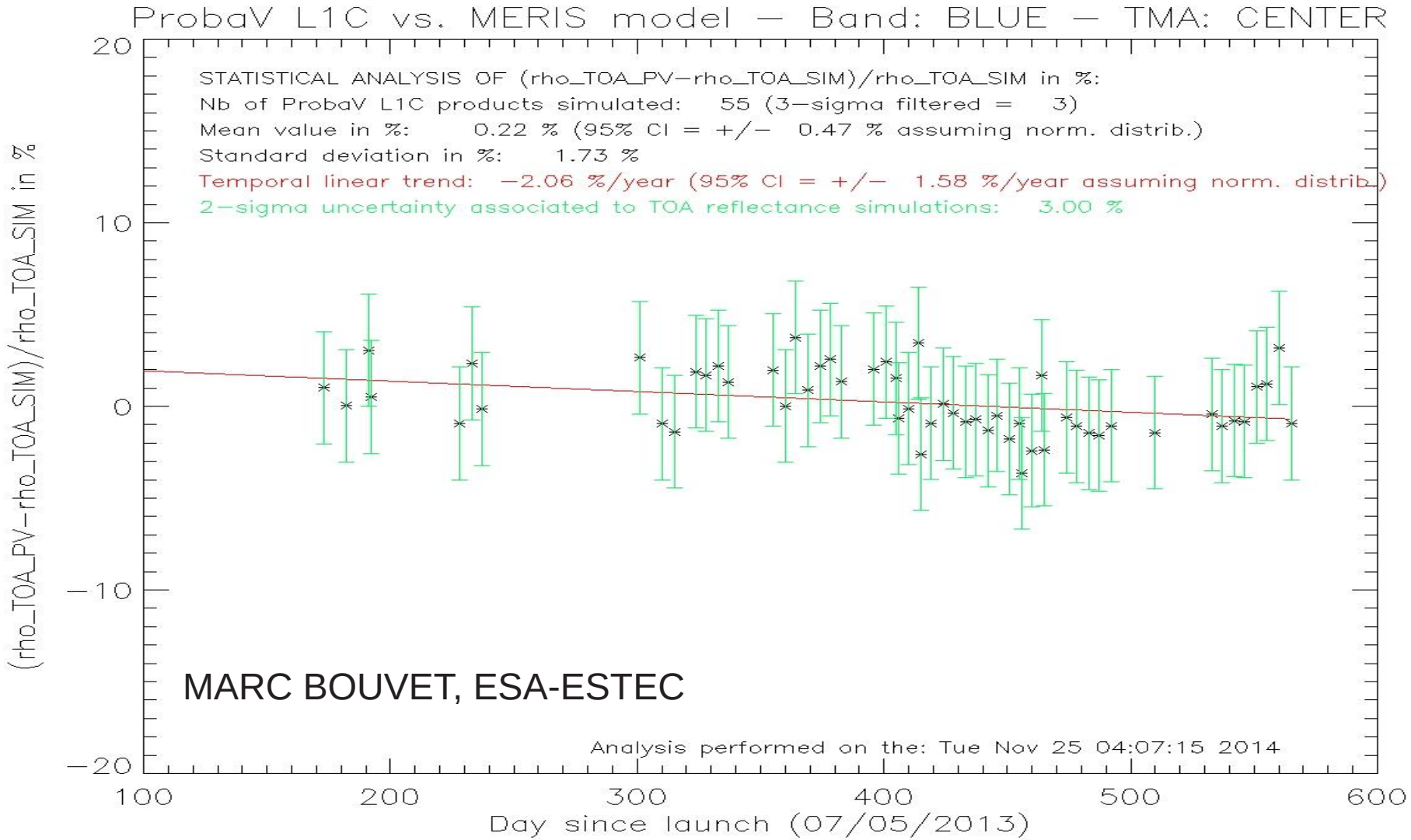




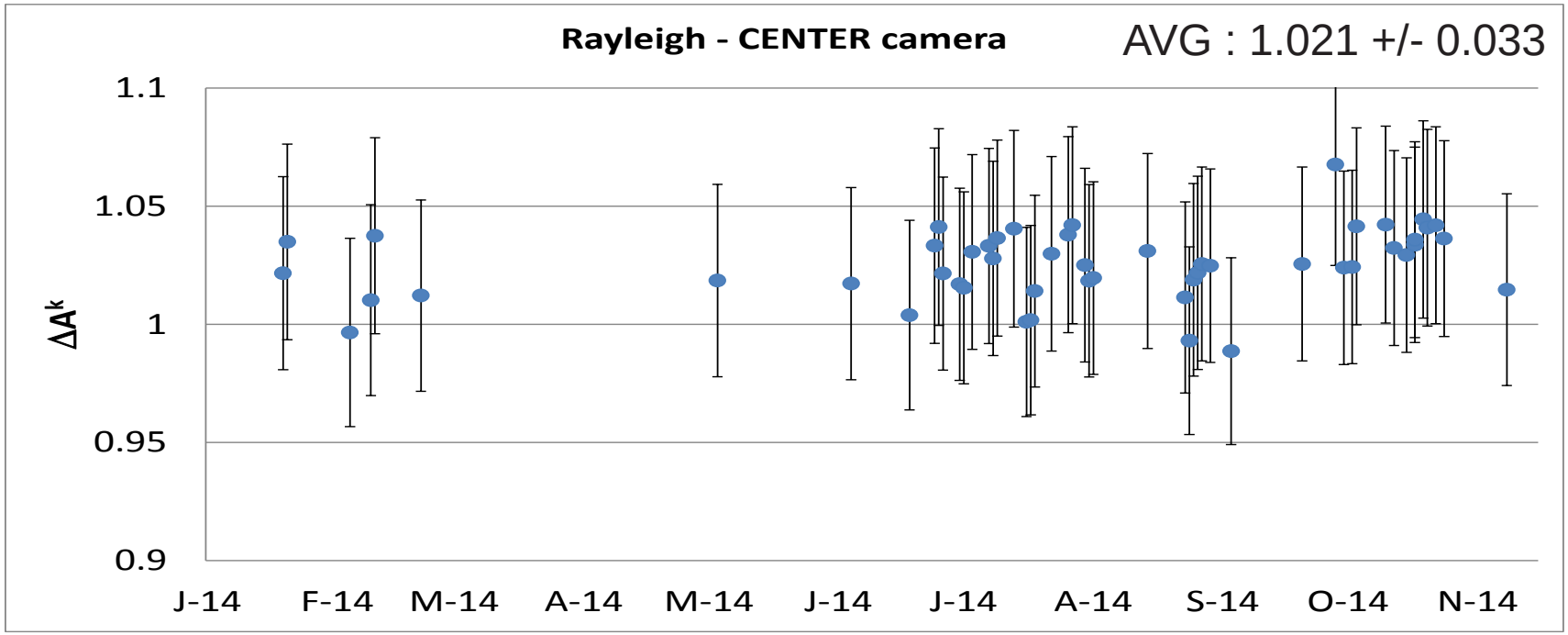


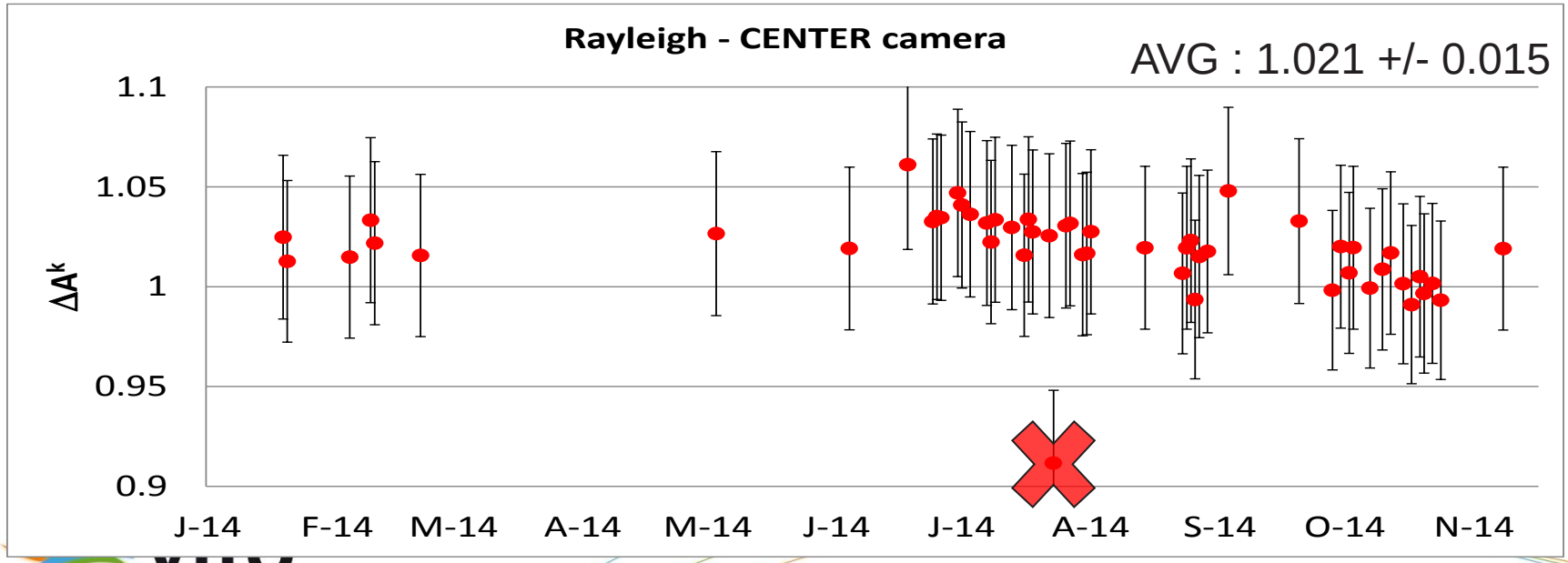


PROBA-V LIBYA4 : MERIS

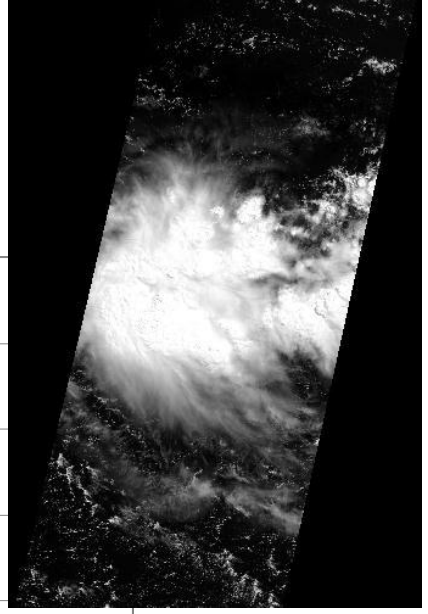


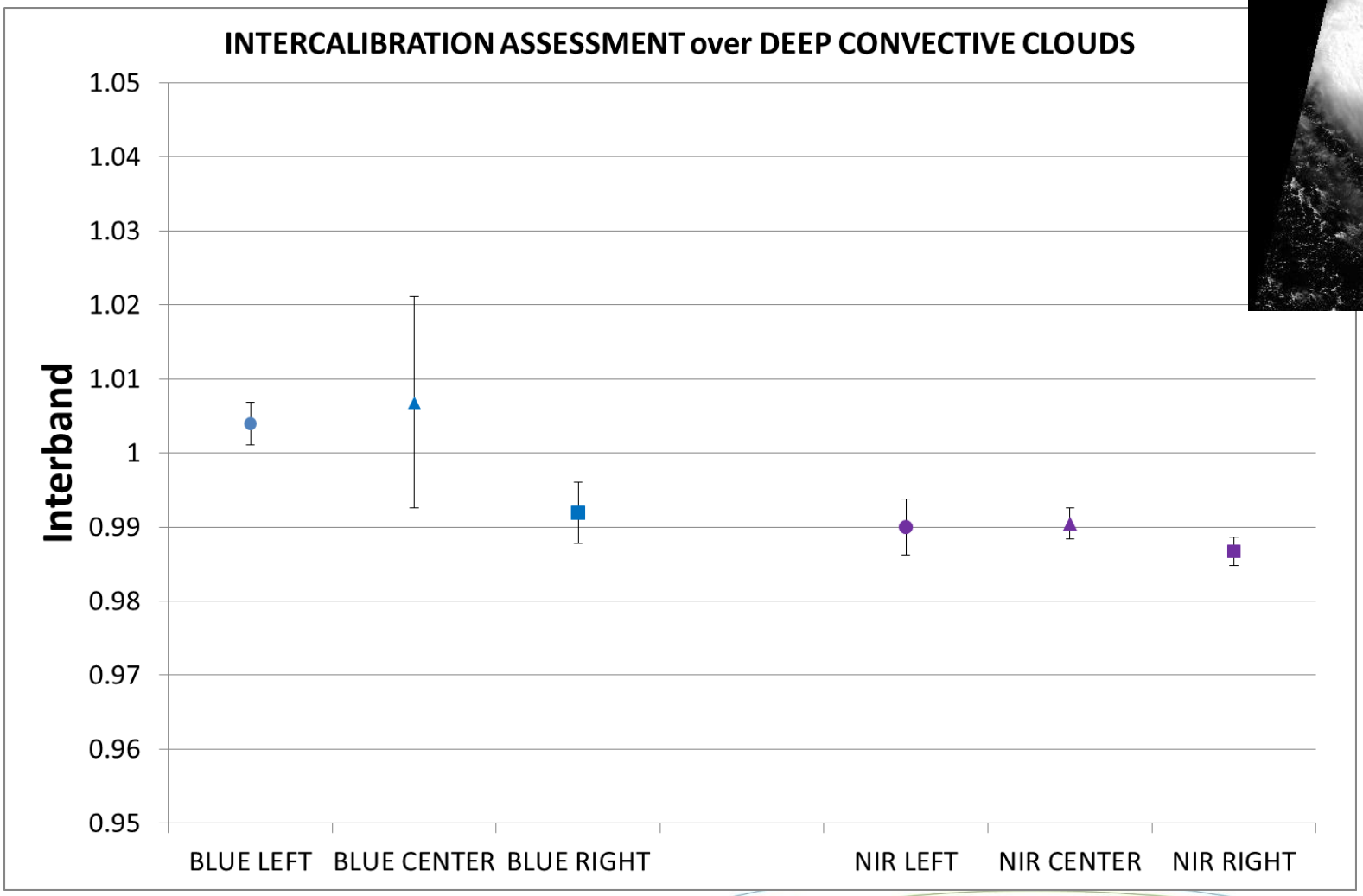
		% degradation since June	
CAMERA	**STRIP**	**Libya-4**	**Moon**
LEFT	BLUE	-1.83%	
LEFT	NIR	-0.66%	
LEFT	RED	-0.22%	
LEFT	SWIR1	-1.70%	
LEFT	SWIR2	-2.07%	
LEFT	SWIR3	-1.30%	
CENTER	BLUE	0.60%	-0.40%
CENTER	NIR	0.37%	-0.28%
CENTER	RED	0.99%	0.38%
CENTER	SWIR1	-1.40%	
CENTER	SWIR2	-1.70%	-0.72%
CENTER	SWIR3	-1.83%	
RIGHT	BLUE	-1.49%	
RIGHT	NIR	-0.95%	
RIGHT	RED	-0.28%	
RIGHT	SWIR1	-1.90%	
RIGHT	SWIR2	-2.69%	
RIGHT	SWIR3	-3.81%	


Rayleigh - CENTER camera
AVG : 1.021 +/- 0.033
1.1
1.05
1
0.95
0.9
ΔA^k
J-14
F-14
M-14
A-14
M-14
J-14
J-14
A-14
S-14
O-14
N-14

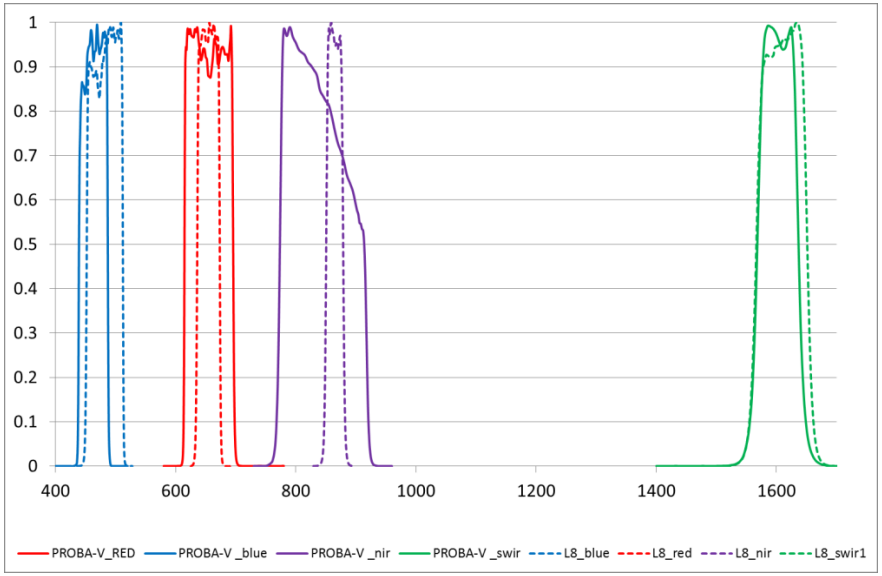

Rayleigh - CENTER camera
AVG : 1.021 +/- 0.015
1.1
1.05
1
0.95
0.9
ΔA^k
J-14
F-14
M-14
A-14
M-14
J-14
J-14
A-14
S-14
O-14
N-14

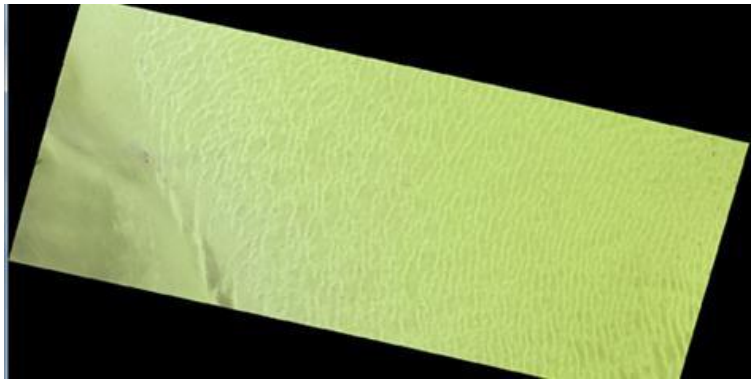
DCC interband

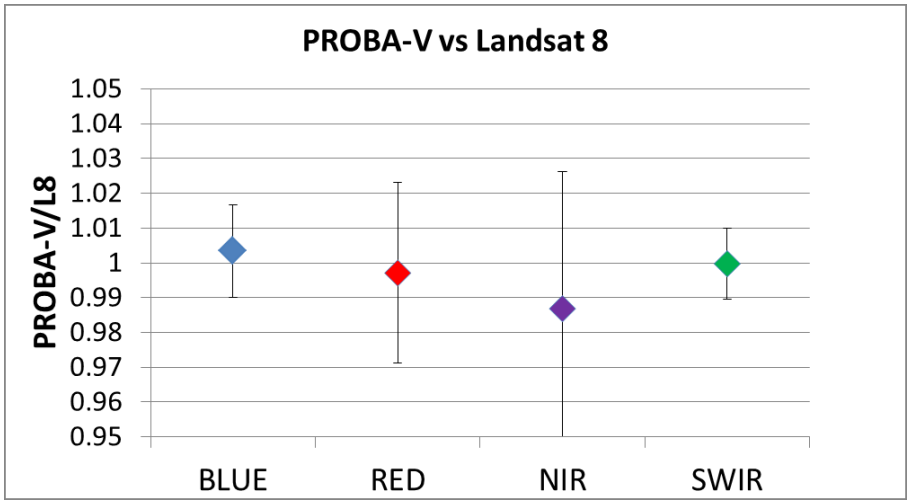




PROBA-V VERSUS LANDSAT8







Landsat 8 Libya-4 data Dennis Helder & Nischal Mishra, South Dakota State University

Results generated June 2014 using data from July 2013 till Feb. 2014

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THANK YOU !