Vicarious calibration of PROBA-V: One year in orbit

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CALCON, August 11 - 15 2014, Utah, USA
PROBA-V In-flight calibration

- Variations in the characteristics of the instrument are likely to occur in orbit due to:
  - outgassing phenomena during launch
  - aging of the optical parts
  - cosmic ray damage
  - ...

- **NO** on-board calibration devices such as lamps, solar diffuser panels, LEDs,..

- Vicarious calibration techniques to meet requirements
  - 5% absolute accuracy
  - 3% relative accuracy
    - inter-band
    - multi-temporal
**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

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

Assessment absolute calibration

Assessment interband calibration

Pre-flight cal. coef

Vicarious cal.

Pre-flight

Vicarious

DCC INTERBAND - OLD A PARAMETERS

DCC INTERBAND - NEW A PARAMETERS
RAYLEIGH

Rayleigh - RIGHT camera

ΔA^k

0.9
0.95
1
1.05
1.1
1-Jan 1-Feb 1-Mar 1-Apr 1-May

Rayleigh - LEFT camera

ΔA^k

0.9
0.95
1
1.05
1.1
1-Jan 1-Feb 1-Mar 1-Apr 1-May

Rayleigh - RIGHT camera

ΔA^k

0.9
0.95
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1.05
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Rayleigh - LEFT camera

ΔA^k

0.9
0.95
1
1.05
1.1
1-Jan 1-Feb 1-Mar 1-Apr 1-May
DCC Inter-band

DCC LEFT CAMERA

BLUE relative to RED

NIR relative to RED
Oscar Libya-4 calibration - LEFT

Ak
DATE

 BLUE

 RED

 NIR

SWIR1

SWIR2

SWIR3
ProbaV L1C vs. MERIS model – Band: BLUE – TMA: LEFT

Libya-4 - LEFT

PROBA-V vs MERIS 3rd repr.
Bouvet M., RSE, 140, 2014.
Libya-4 - CENTER

PROBA-V vs MERIS 3rd repr.

BOUVET M., RSE, 140, 2014.
ProbaV L1C vs. MERIS model – Band: BLUE – TMA: RIGHT

STATISTICAL ANALYSIS OF (\(\rho_{\text{TOA, PV}}/\rho_{\text{TOA, SIM}}\))/\(\rho_{\text{TOA, SIM}}\) in %
- Nb of ProbaV L1C products simulated: 64 (3-sigma filtered = 3)
- Mean value in %: -2.40 % (95% CI = +/- 0.21 % assuming norm. distrib.)
- Standard deviation in %: 0.84 %
- Temporal linear trend: 0.39 %/year (95% CI = +/- 1.05 %/year assuming norm. distrib.)
- 2-sigma uncertainty associated to TOA reflectance simulations: 3.00 %

BLUE

Analysis performed on: Thu Aug 7 08:48:42 2014

ProbaV L1C vs. MERIS model – Band: RED – TMA: RIGHT

STATISTICAL ANALYSIS OF (\(\rho_{\text{TOA, PV}}/\rho_{\text{TOA, SIM}}\))/\(\rho_{\text{TOA, SIM}}\) in %
- Nb of ProbaV L1C products simulated: 62 (3-sigma filtered = 5)
- Mean value in %: -0.57 % (95% CI = +/- 0.23 % assuming norm. distrib.)
- Standard deviation in %: 0.36 %
- Temporal linear trend: -2.53 %/year (95% CI = +/- 0.91 %/year assuming norm. distrib.)
- 2-sigma uncertainty associated to TOA reflectance simulations: 3.00 %

RED

Analysis performed on: Thu Aug 7 08:48:43 2014

ProbaV L1C vs. MERIS model – Band: NIR – TMA: RIGHT

STATISTICAL ANALYSIS OF (\(\rho_{\text{TOA, PV}}/\rho_{\text{TOA, SIM}}\))/\(\rho_{\text{TOA, SIM}}\) in %
- Nb of ProbaV L1C products simulated: 63 (3-sigma filtered = 4)
- Mean value in %: -0.35 % (95% CI = +/- 0.48 % assuming norm. distrib.)
- Standard deviation in %: 1.91 %
- Temporal linear trend: -5.48 %/year (95% CI = +/- 1.39 %/year assuming norm. distrib.)
- 2-sigma uncertainty associated to TOA reflectance simulations: 3.00 %

NIR

Analysis performed on: Thu Aug 7 08:48:43 2014

Libya-4 - RIGHT

PROBA-V vs MERIS 3rd repr.

BOUVET M., RSE,140, 2014.
Lunar Calibration

Moon = stable over thousands of years

Usage: stability monitoring

Implementation:
- Compute integrated irradiance
- Convert integrated irradiance to full disc reflectance and compare with a lunar reflectance model
- Monthly acquisition at same phase angle to reduce uncertainty

Other usage:
- MTF
- Dark current validation
- Straylight assessment
Observations

» Observation of the moon:
   » Phase angle 7° +/- 0.5 degrees (moon - observer - sun angle)
   » Waxing and waning
   » Pitch maneuver: 360 degrees rotation at approx. 0.2 degrees/s
   » Oversampling of +/-1.8
   » Only center camera
Lunar reflectance model

» USGS ROLO model implemented (311g)
  » Kiefer and Stone, 2005
  » Based on thousands of automated lunar observations

» Main model Input parameters :
  » Phase angle
  » Sun selenographic longitude
  » Observer selenographic lat and Ion
  » Response curve

» Model returns ‘disc equivalent reflectance’
  » Smoothed to Apollo sand reflectance
  » Corrected for distance observer – moon and sun – moon
Workflow

Unpack → Apply Radiomodel → Masking → Calculate Geometry

Moon Irradiance → Moon Reflectance

Model Reflectance

Ak [meas/model]
Masking

[Diagram showing a moon image with a mask applied to it, indicating the center of observation and pixel solid angle.]

Probablility

Pixel solid angle

Center of observation timestamp
Masking

» Result strongly depend on correct masking
» Geometry :
  » Timestamp center line of the moon
  » Position of the moon, sun, earth and platform
  » Distances and angles between them
» Define pixel solid angle along track :
  » Conversion from radiance to disk eq reflectance :
    » pixel solid angle
    » integrate over disc
Stability monitoring lunar observations
Comparison with desert
Comparison with desert
Conclusions

» PROBA-V behaves well!
» Lunar reflectance model is implemented and applied successfully
» It can be used for temporal stability monitoring
» Results for absolute calibration moon are in line with desert method.
» Verification/validation of the implementation still necessary
  » Participate Lunar Calibration Workshop organized by GSICS later this year.
» SWIR results

» Acknowledge:
  » T. Stone (USGS)