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PROBA-V Vicarious Calibration :

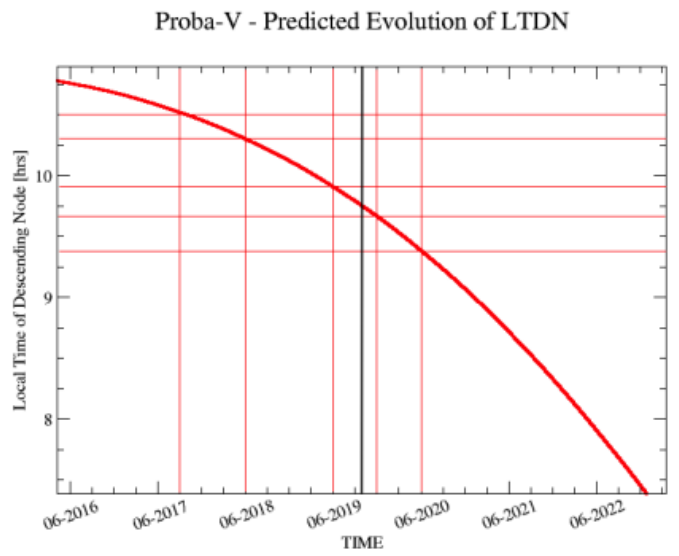
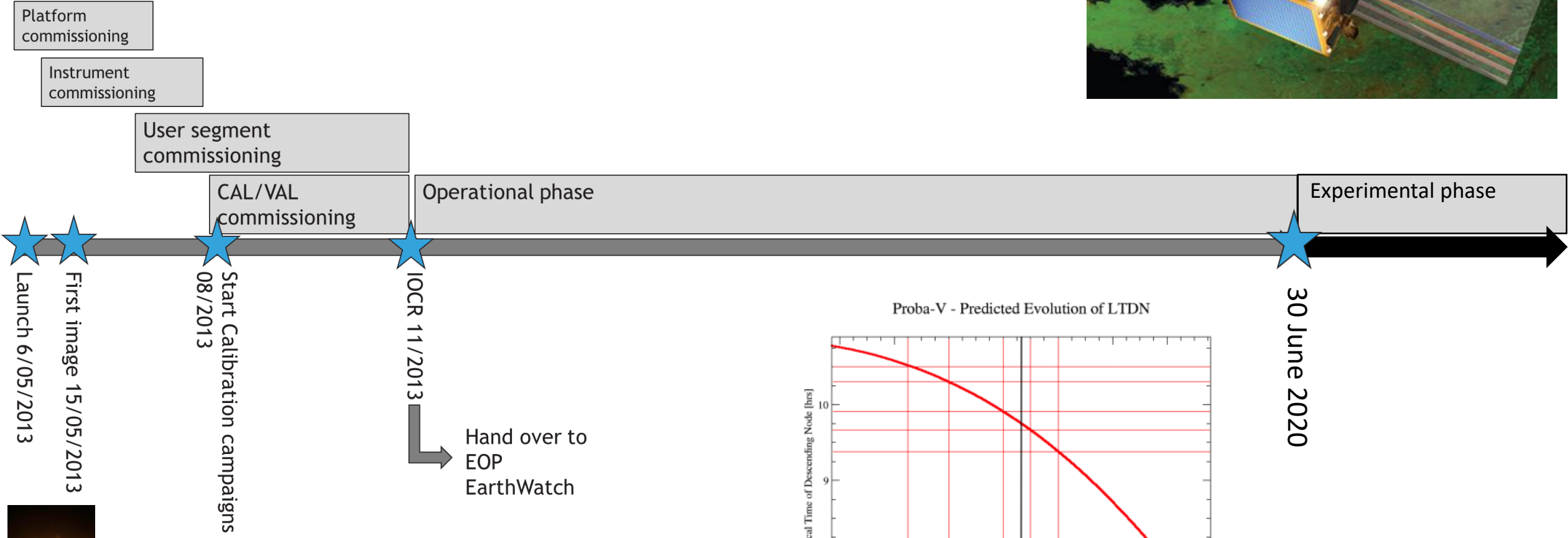
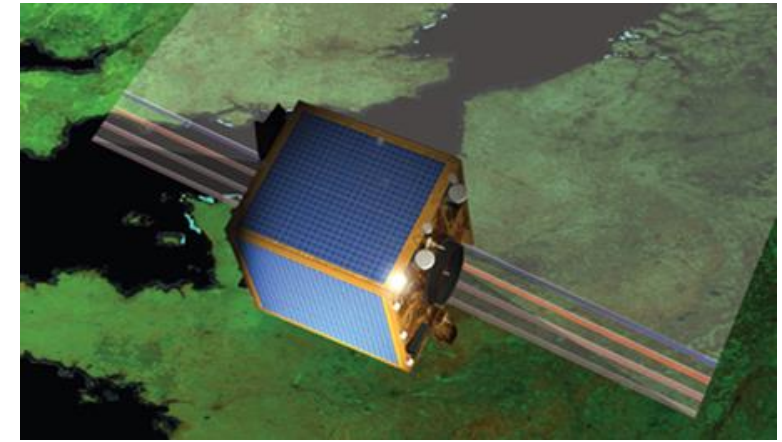
Investigation into the impact of in-orbit temperature variation

LIME (Lunar Irradiance Model ESA) model

Sindy Sterckx, Stefan Adriaensen (VITO)

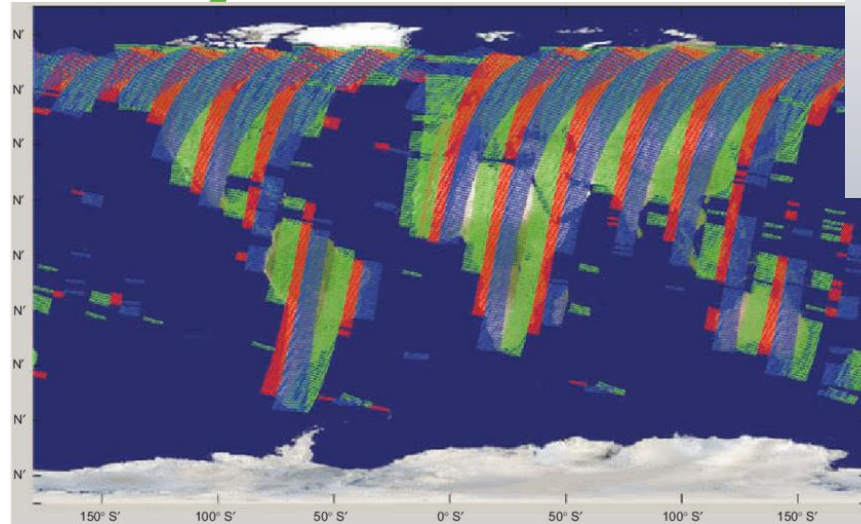
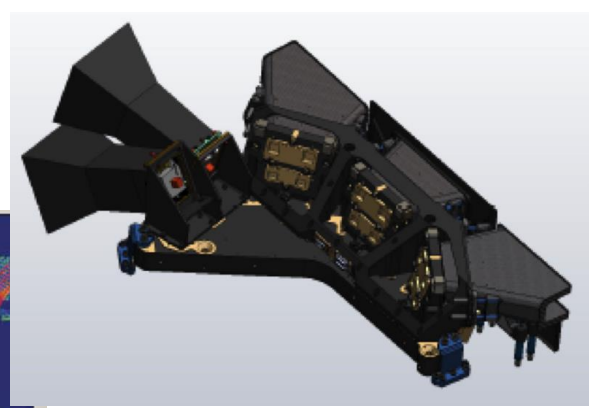


8 YEARS in orbit

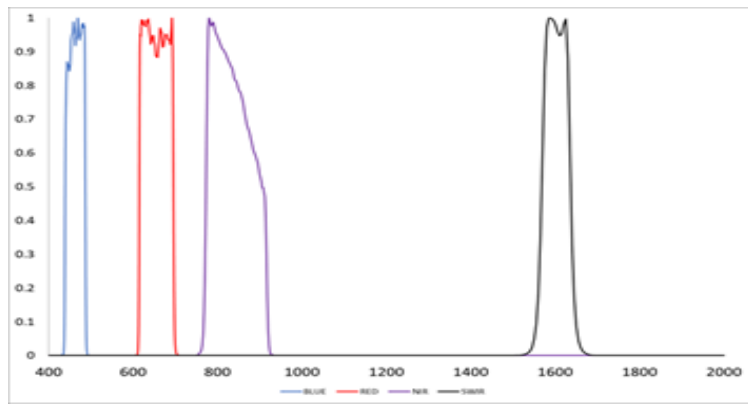
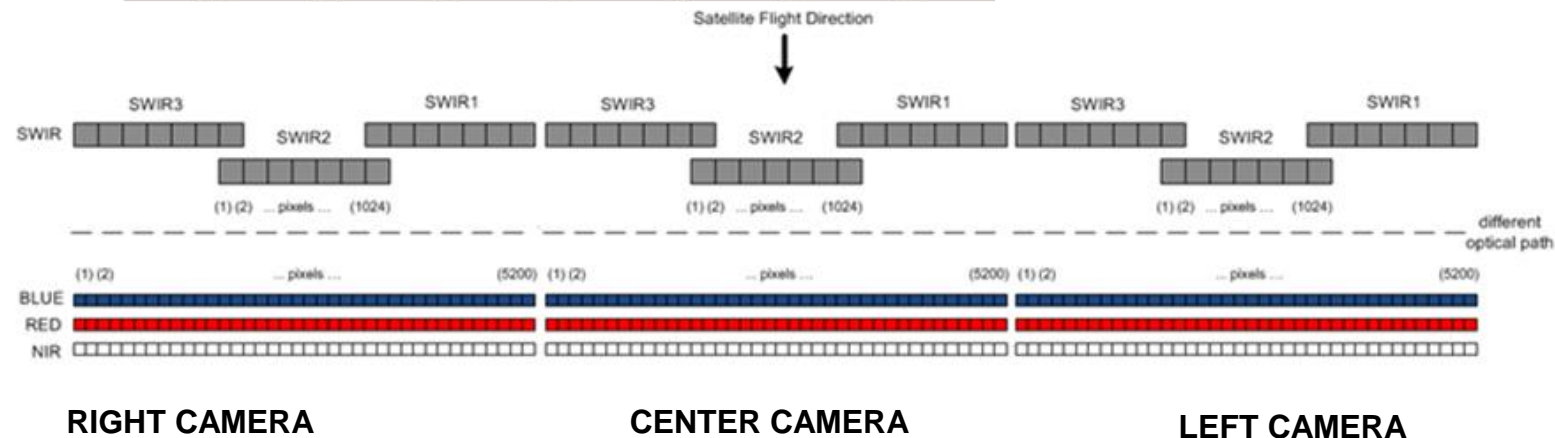




Design complexity



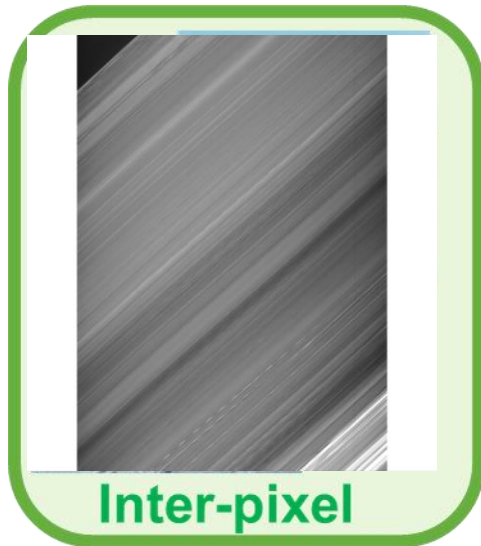
- No on-board calibration devices
- Design complexity
 - 3 Cameras
 - 2 focal planes:
 - VNIR with 3 bands
 - SWIR with 1 band but staggered strips





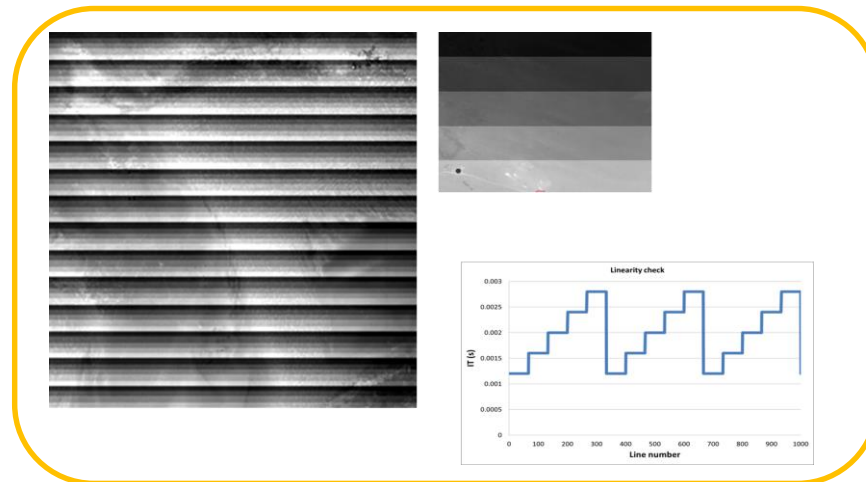
Vicarious Radiometric Calibration Approach

$$L_{TOA,i}^k = \frac{NL(DN_{i,acquired}^k) - dc_{im}^k}{A^k g_{im}^k}$$



OSCAR* (Optical Sensor Calibration with simulated Radiances)

- Absolute REQ. 5 %**
 - Oceans
 - DC Clouds
 - Interband REQ. 3%
- Deserts**
- Temporal (REQ. 3%)**





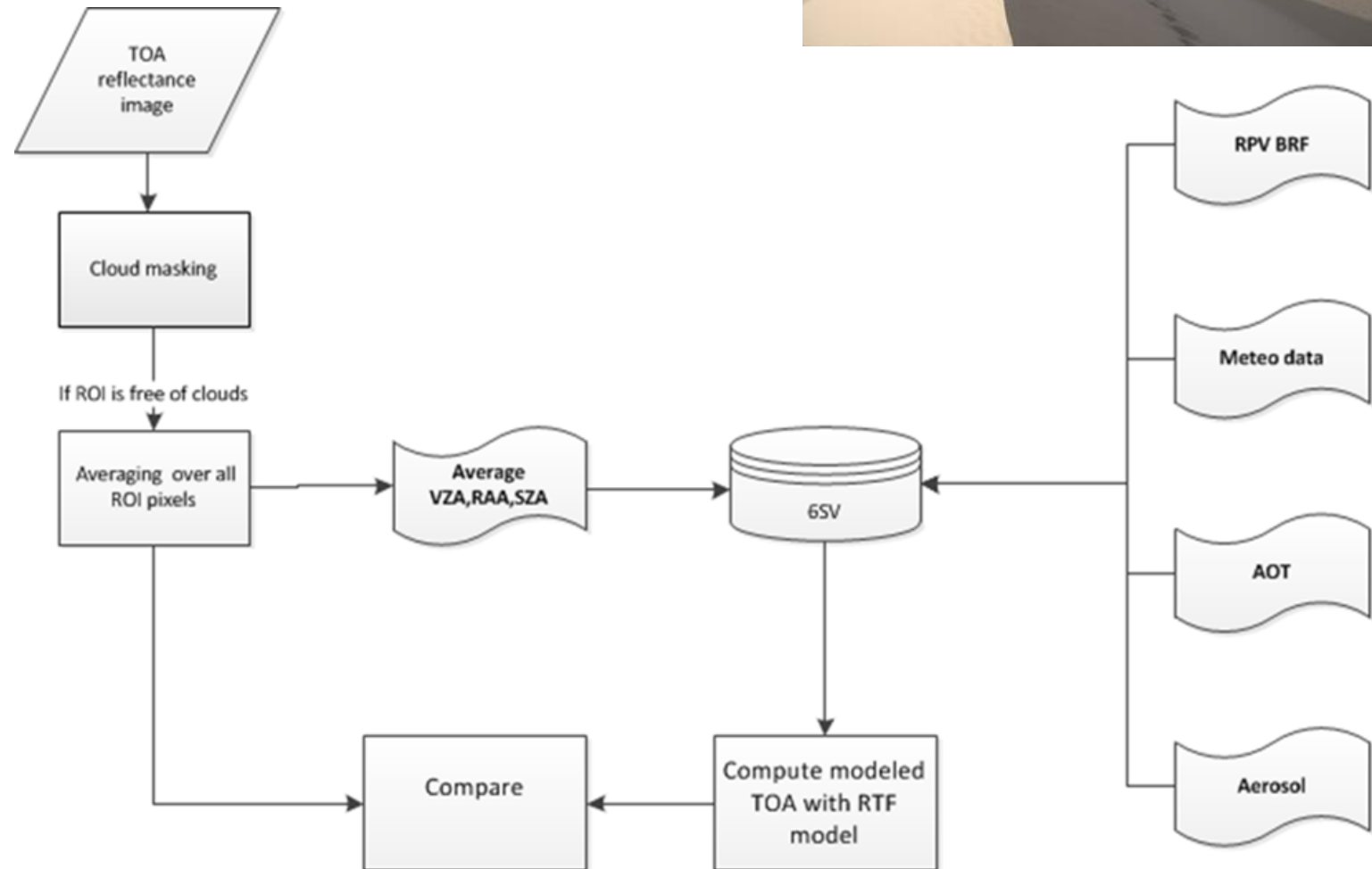
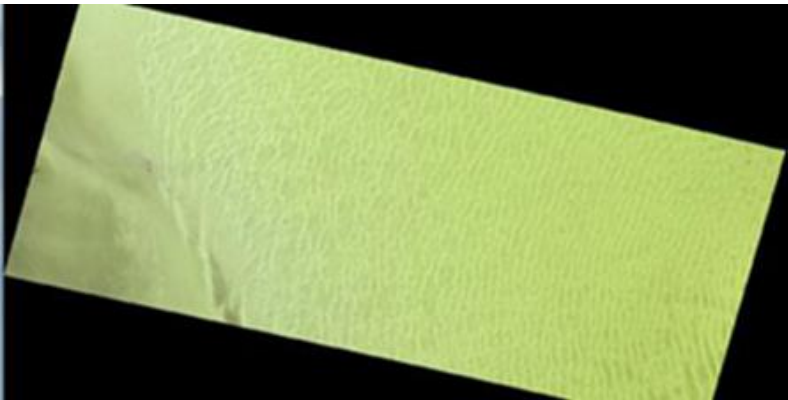
Long term trending VNIR BLUE, RED, NIR



OSCAR Desert Approach

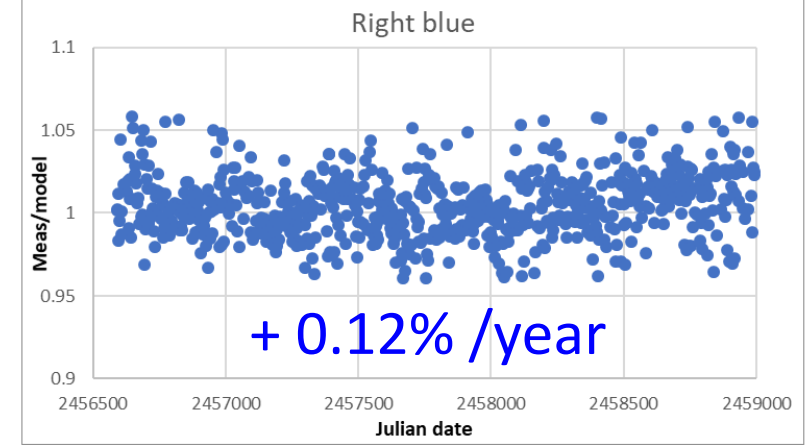
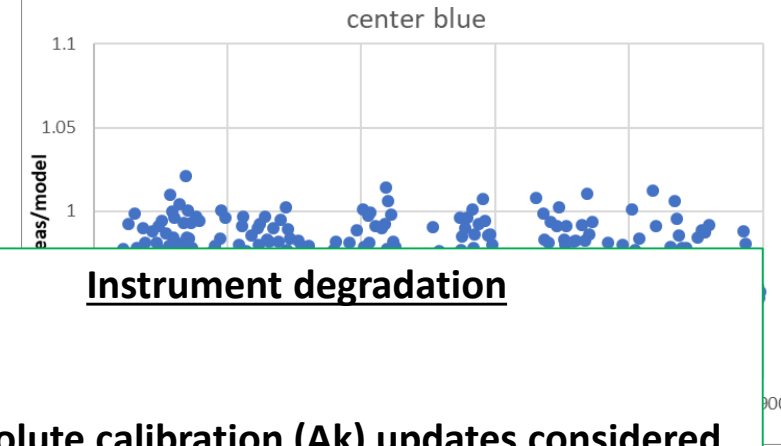
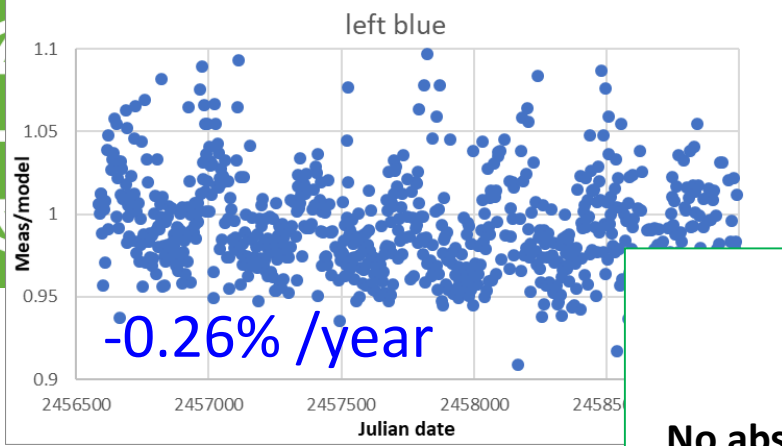


- 6SV simulations
- Surface RPV BRF
- ECMWF (P,O3,H2O)
- Desert aerosol
- AOT(month)



[Govaerts *et al.*, RSL, 2013]

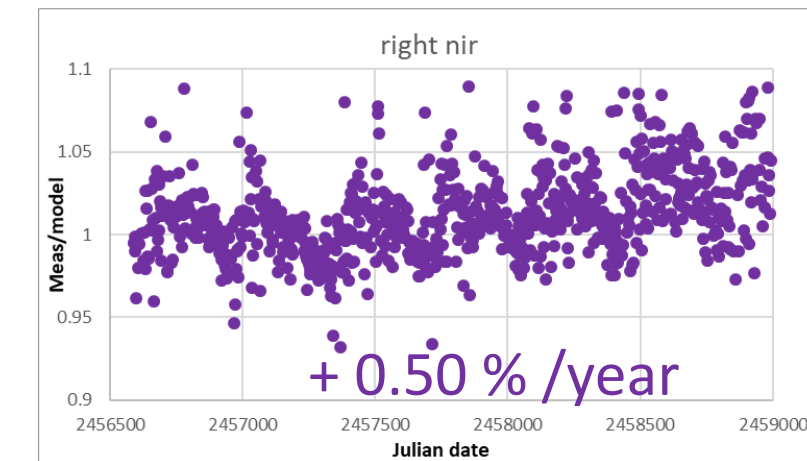
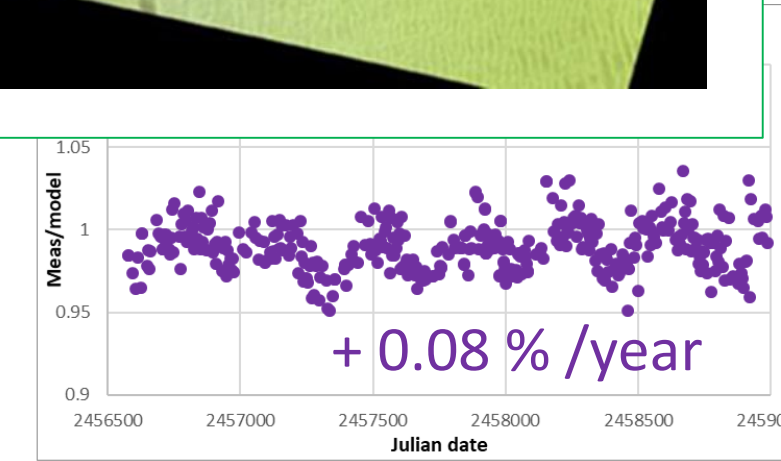
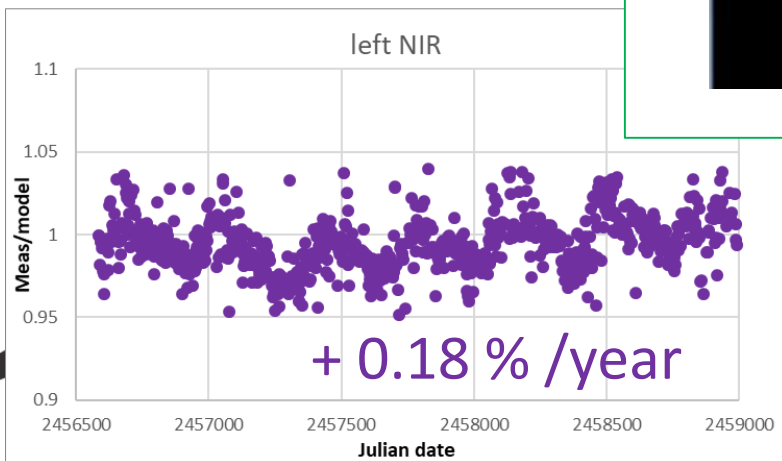
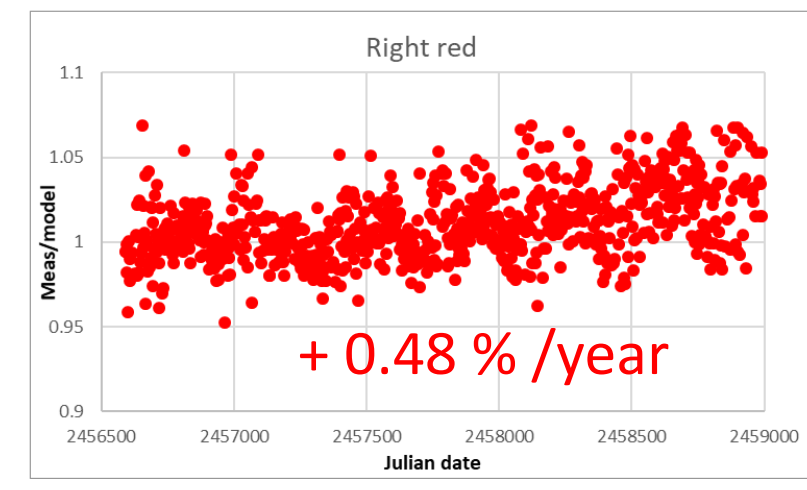
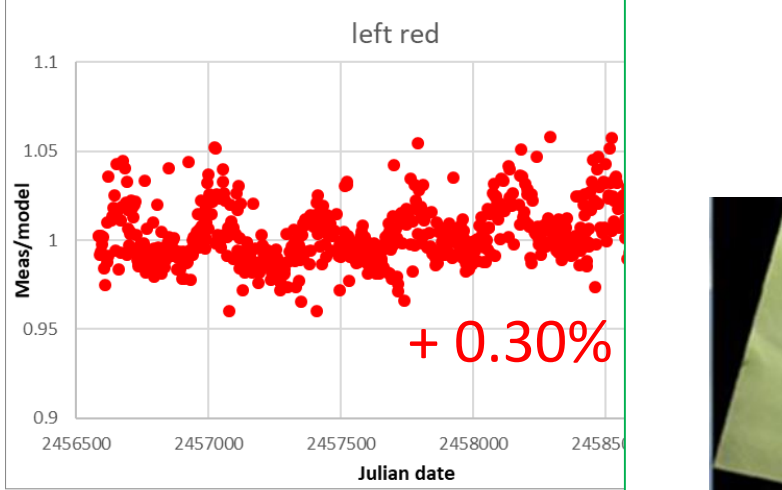
remotesensing.vito.be

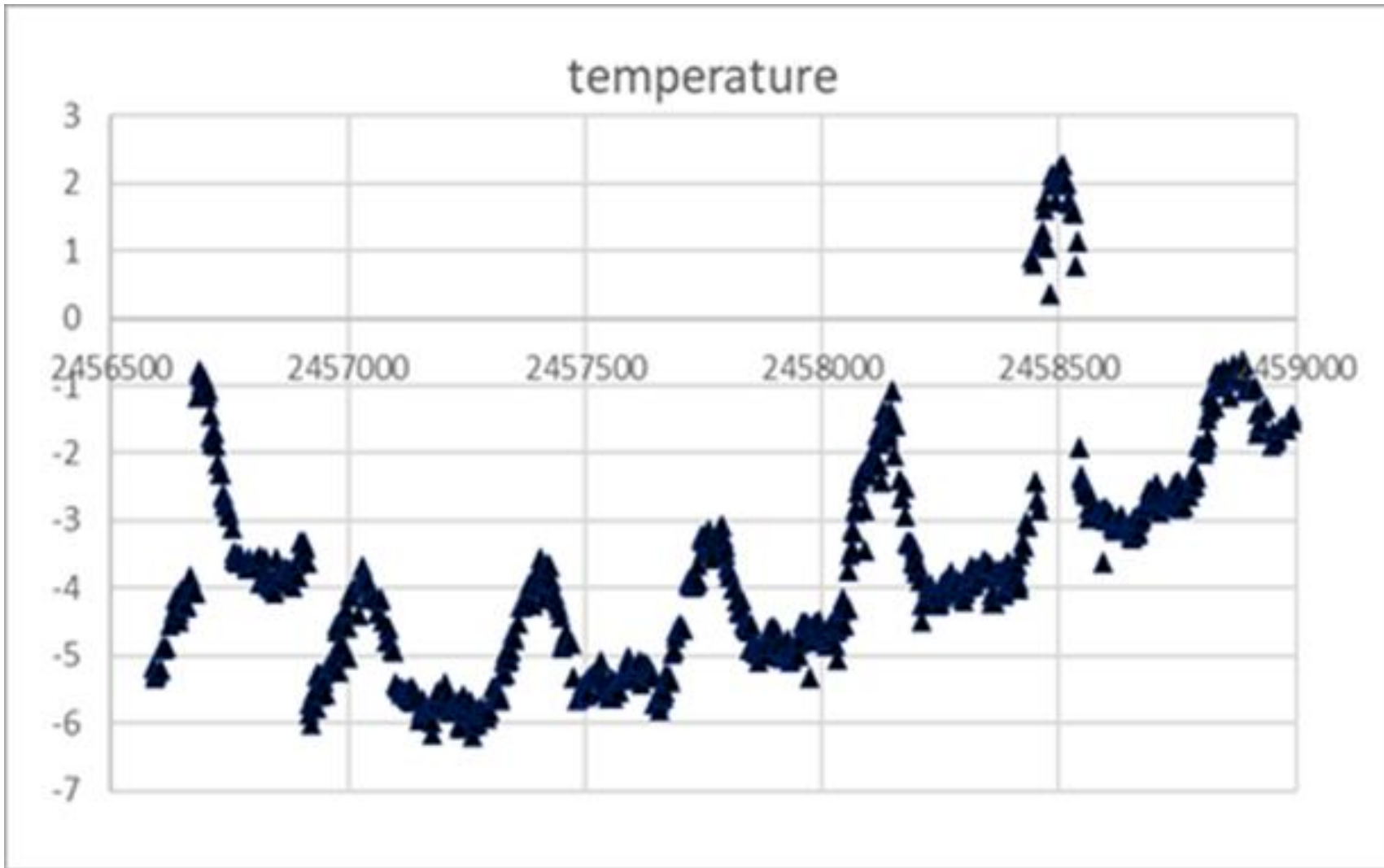


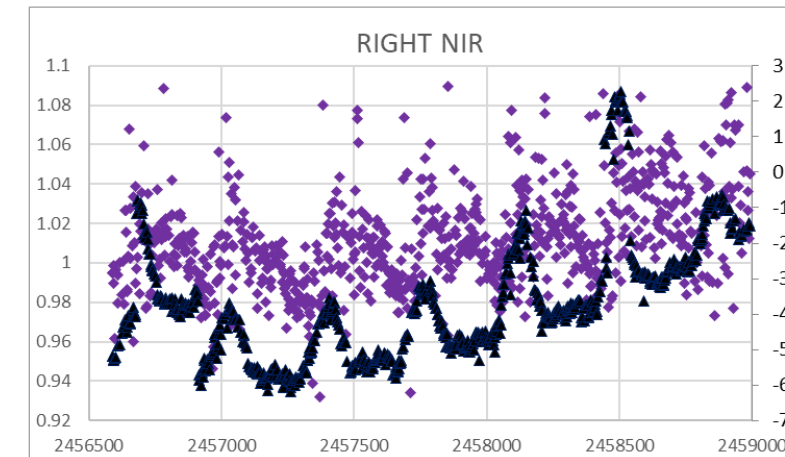
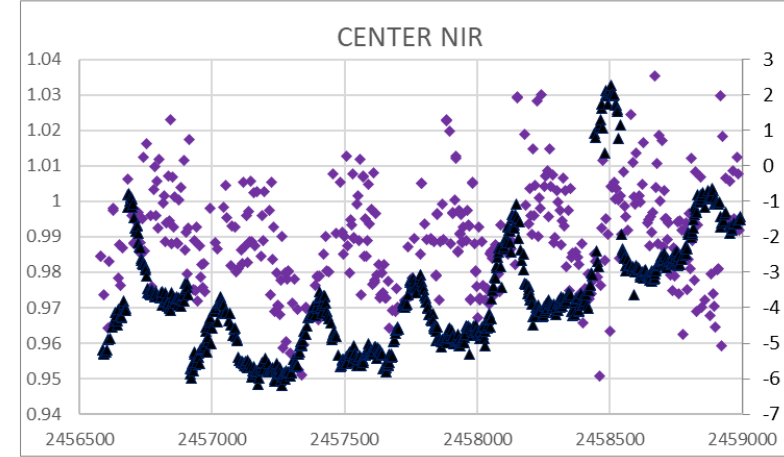
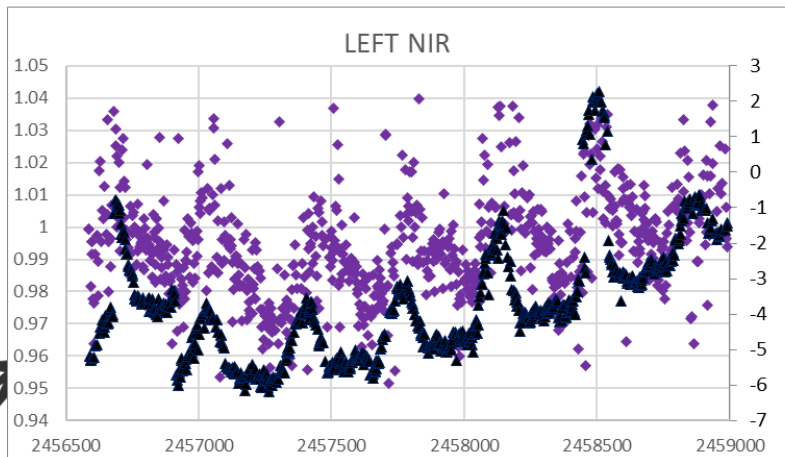
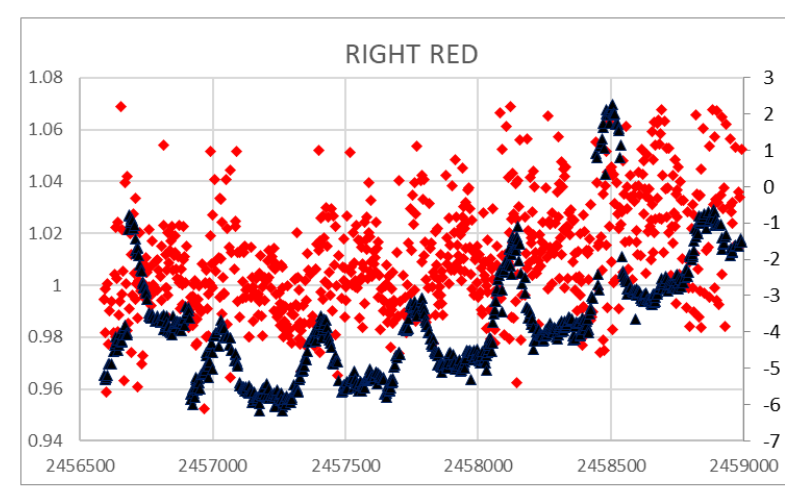
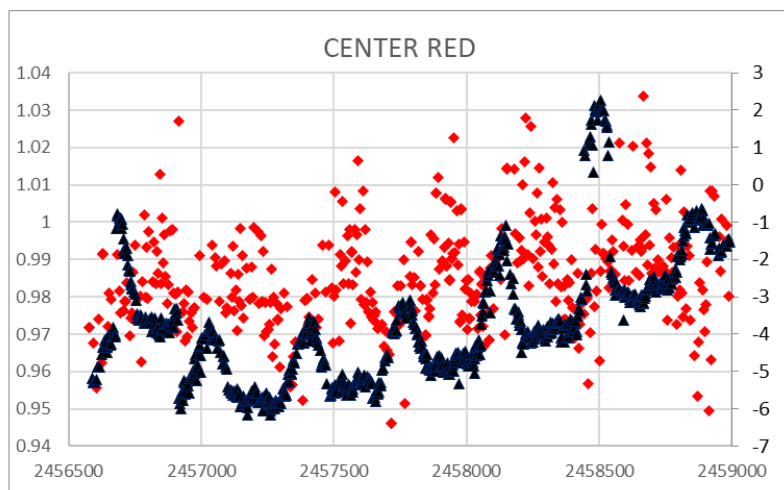
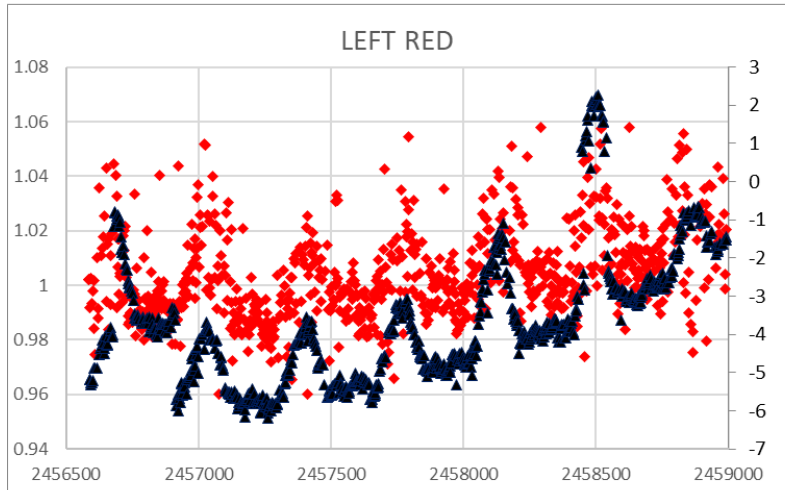
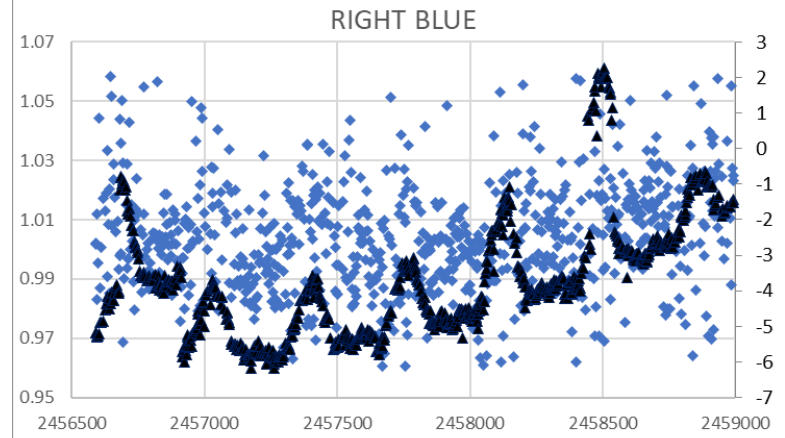
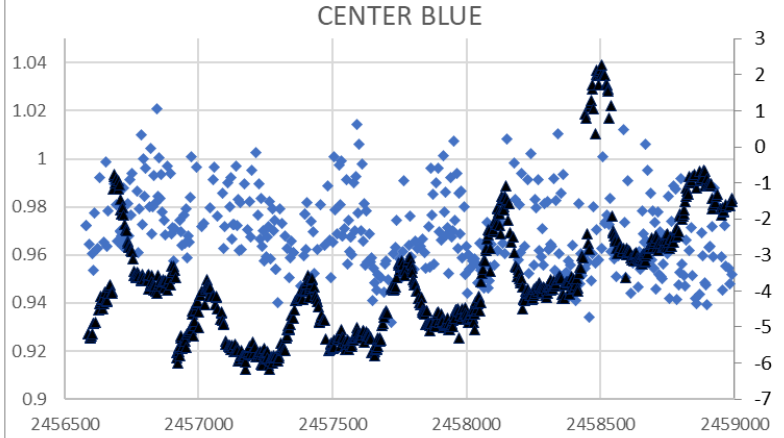
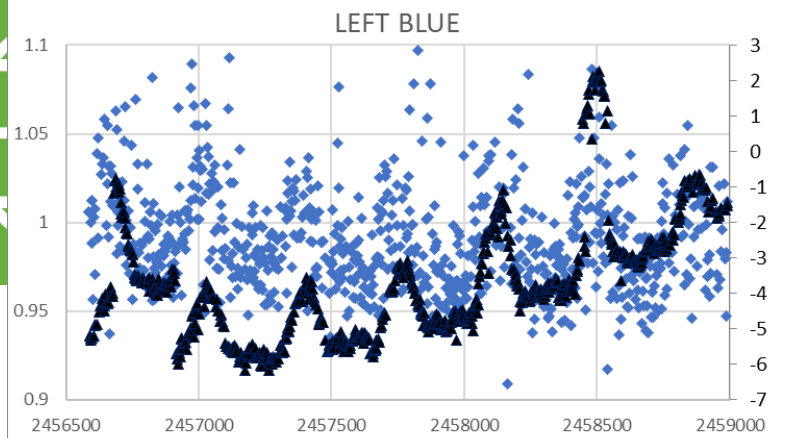
Instrument degradation

No absolute calibration (Ak) updates considered

Libya-4 VNIR



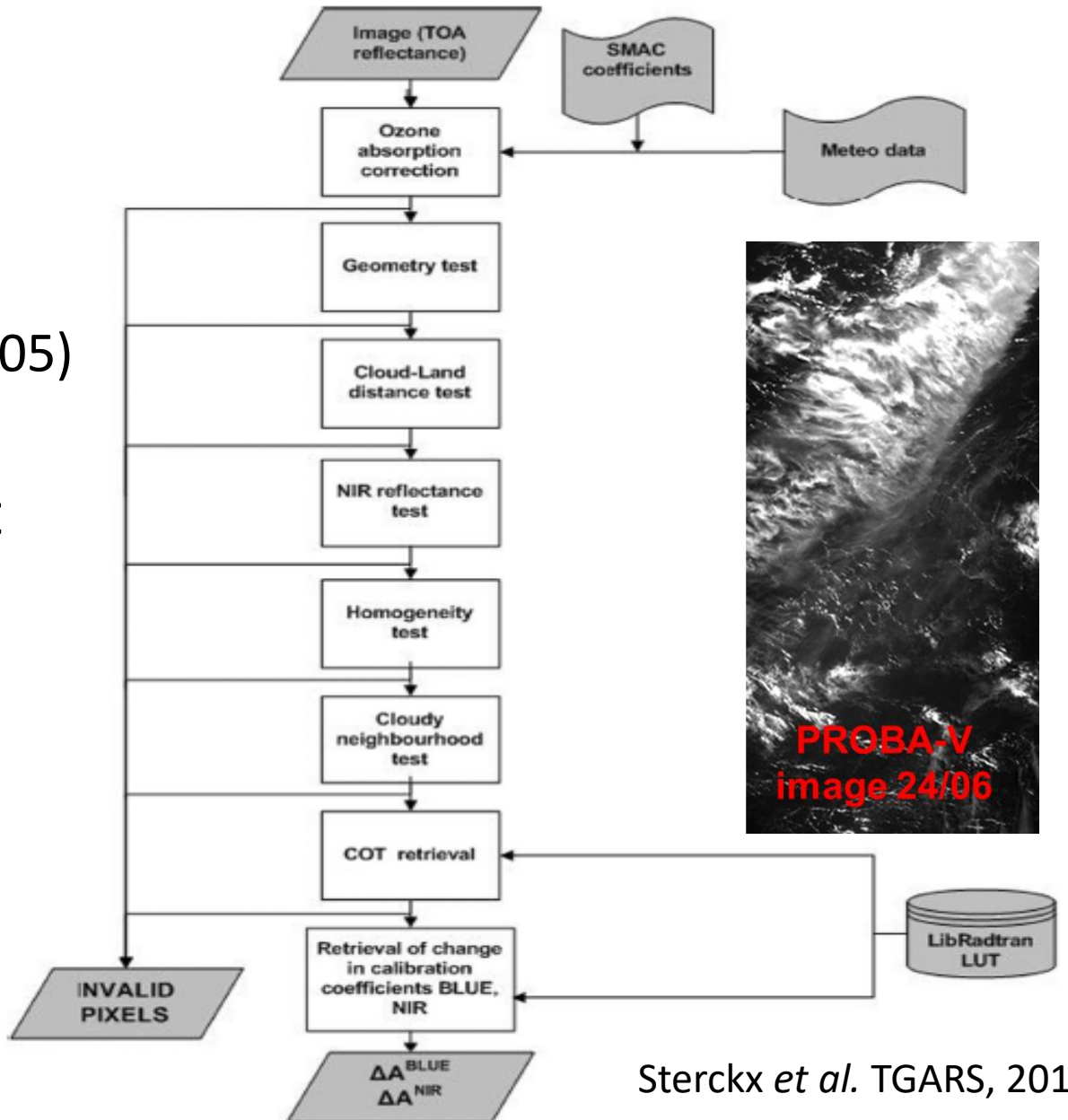
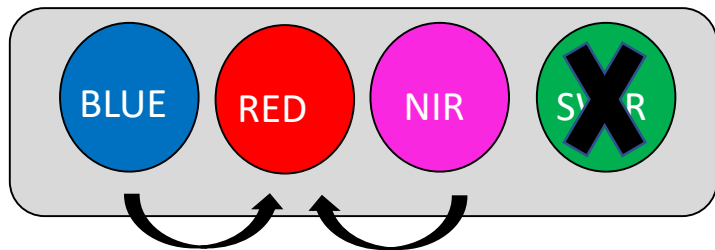




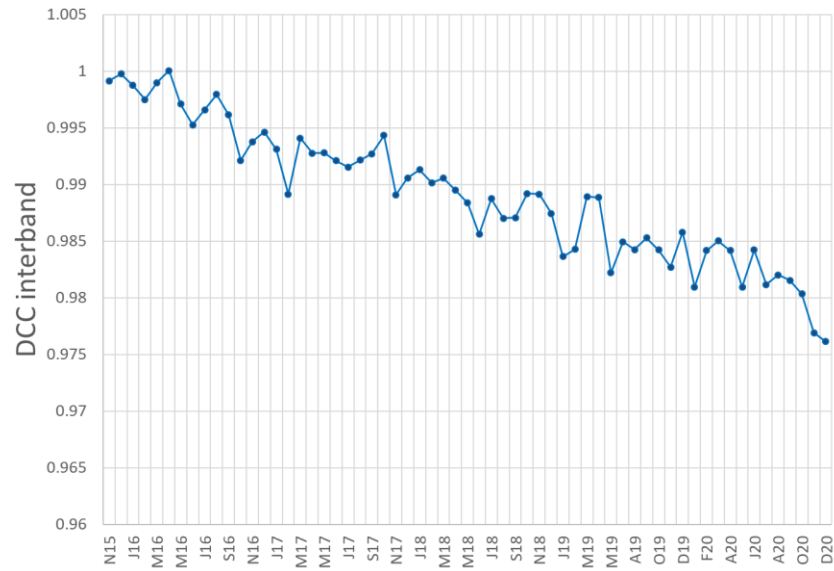


OSCAR Deep convective clouds calibration

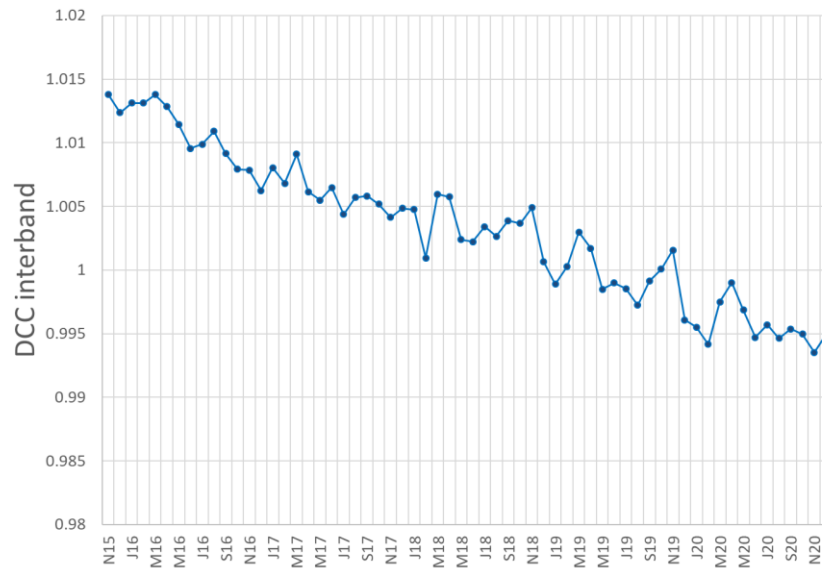
- LibRadtran LUT
- Ice clouds optical properties (Baum et al. 2005)
- Fixed effective ice cloud radius
- Strict procedure to automatically select DCC
- Not for SWIR band
- INTER-BAND CAL. APPROACH



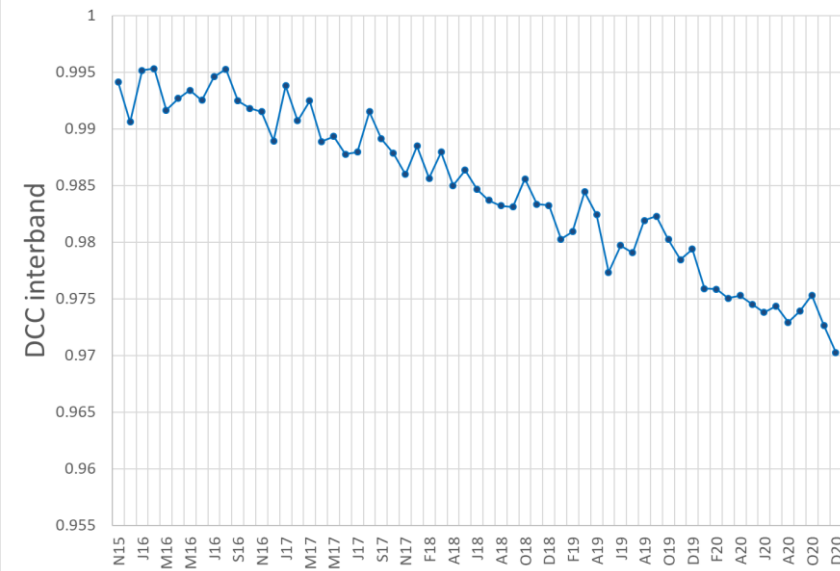
DCC LEFT BLUE



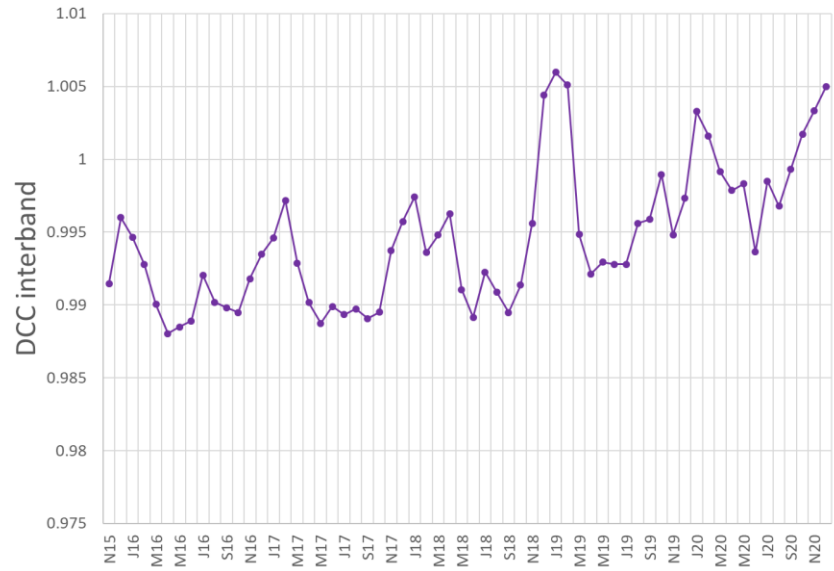
DCC CENTER BLUE



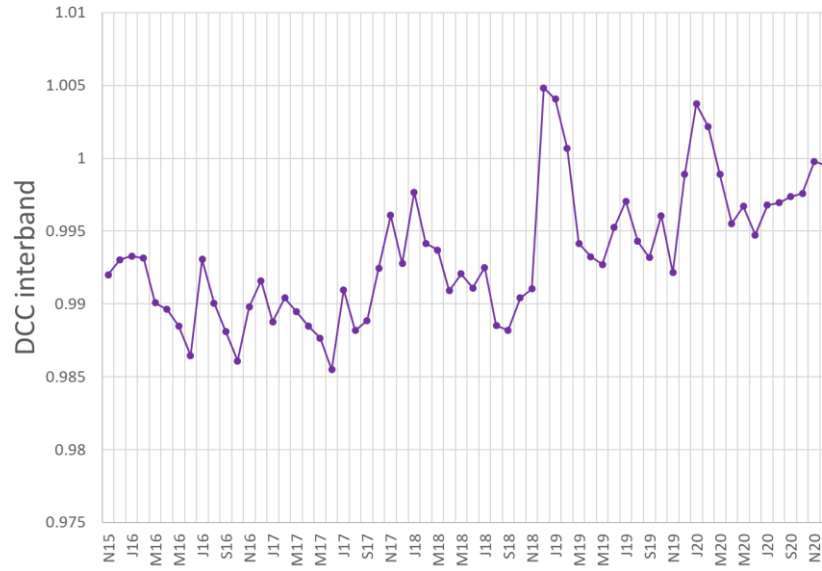
DCC RIGHT BLUE



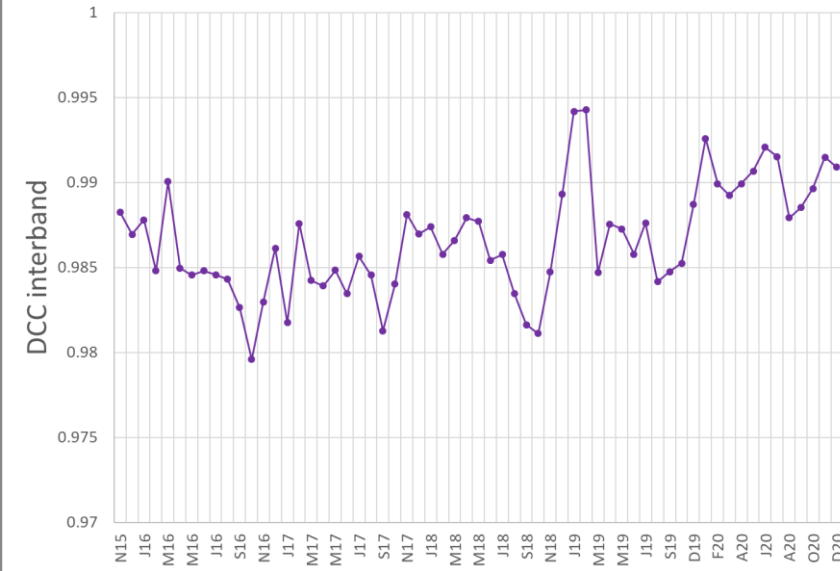
DCC NIR LEFT



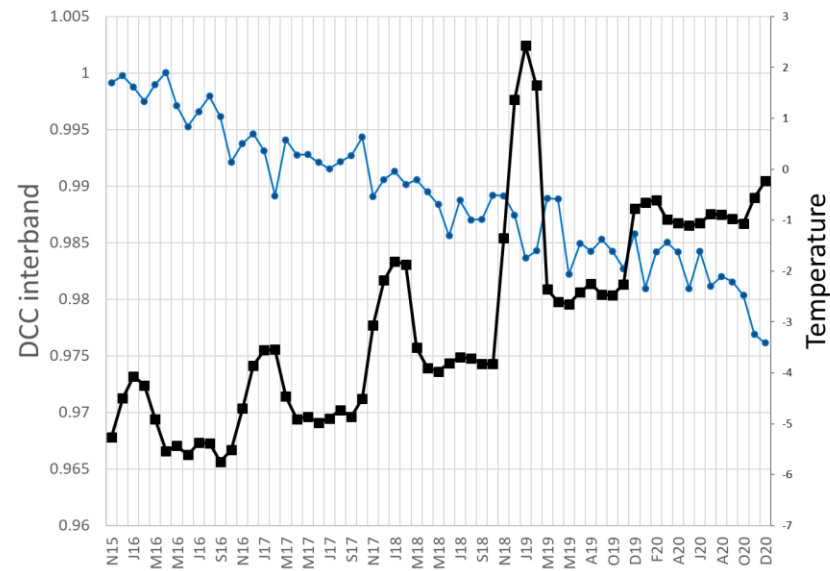
DCC NIR CENTER



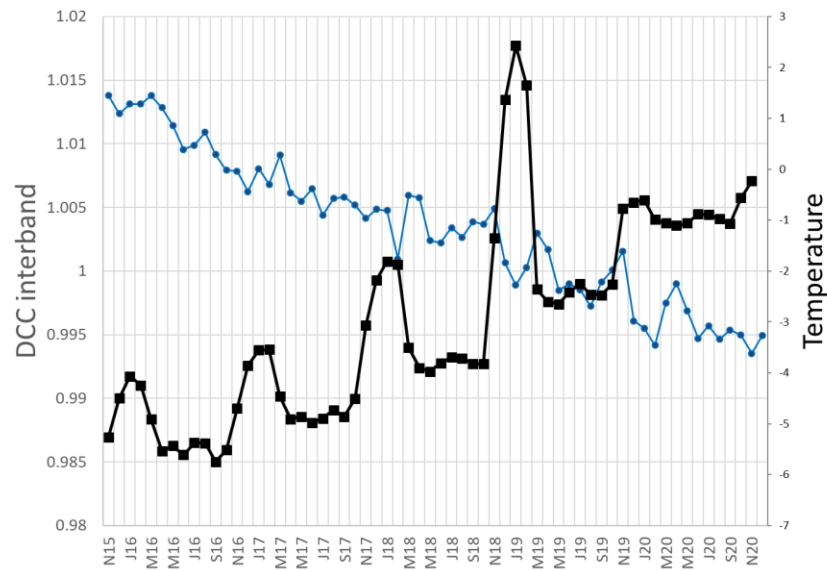
DCC RIGHT NIR



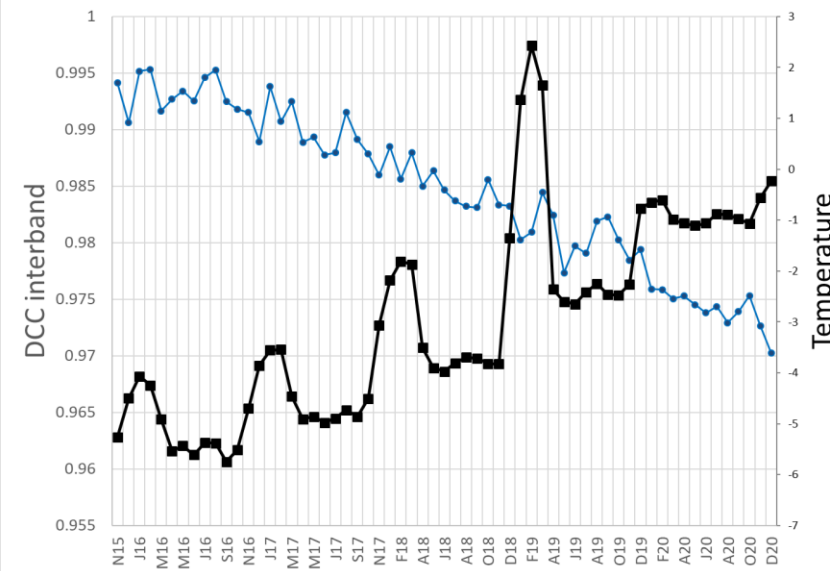
DCC LEFT BLUE



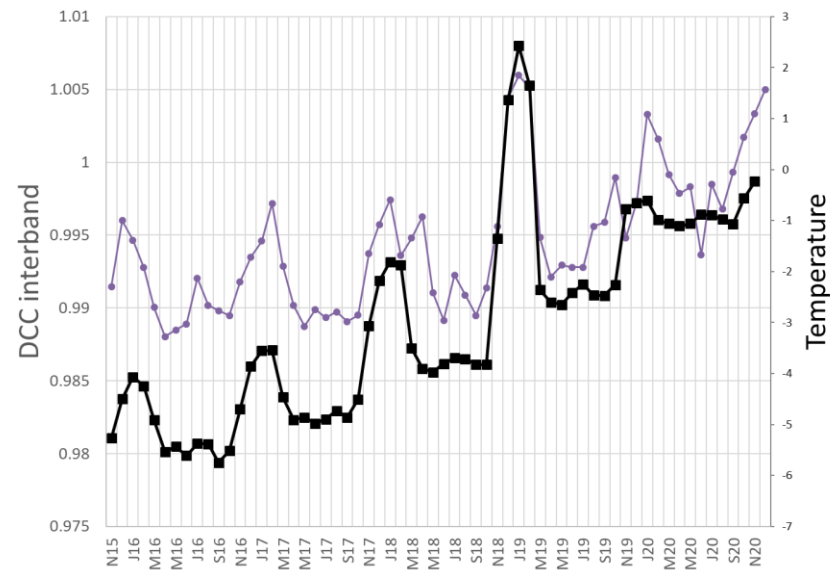
DCC CENTER BLUE



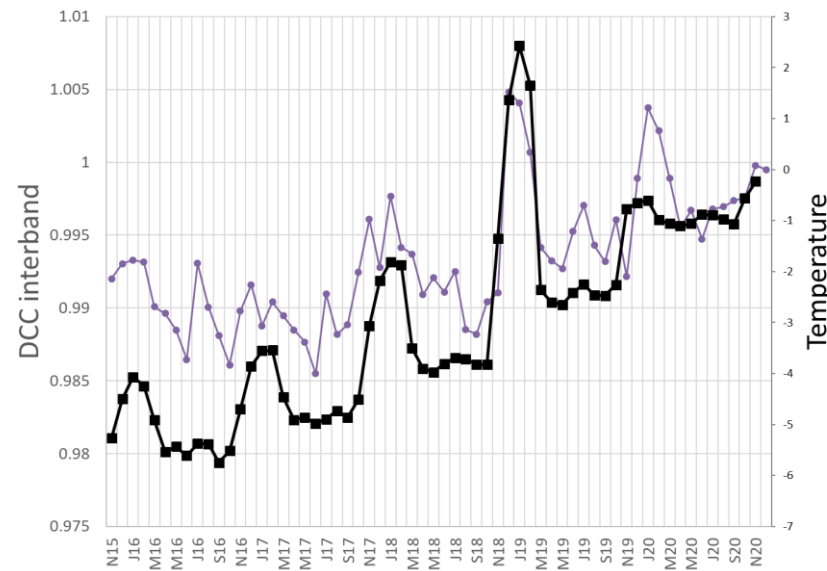
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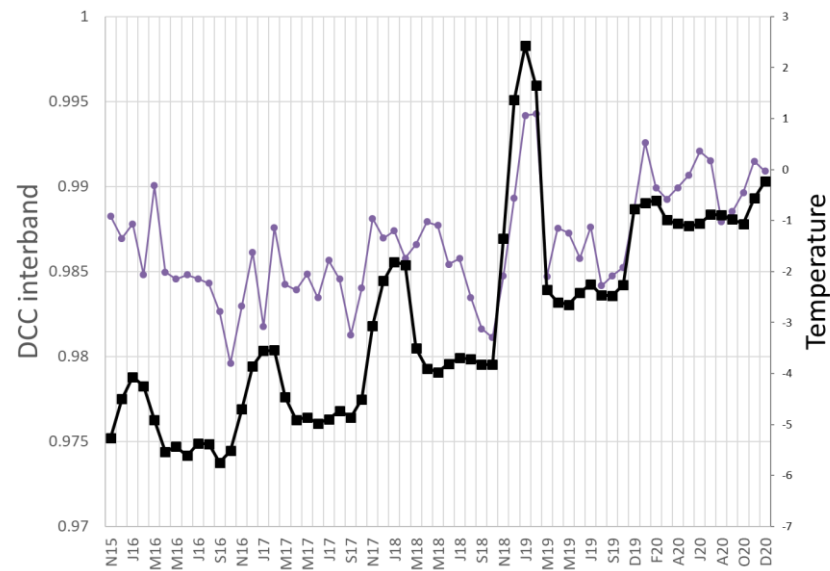
DCC NIR LEFT



DCC NIR CENTER

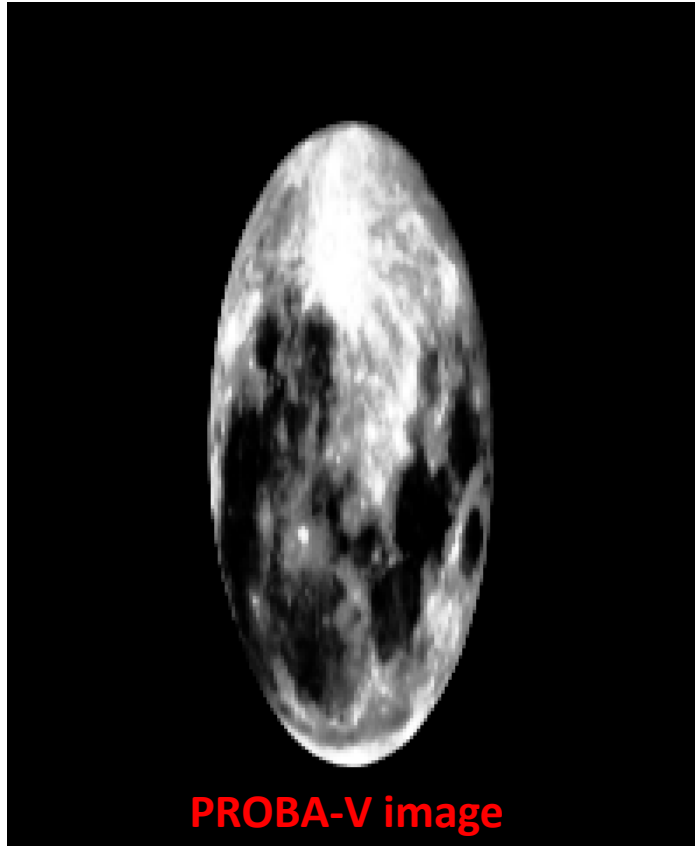


DCC RIGHT NIR



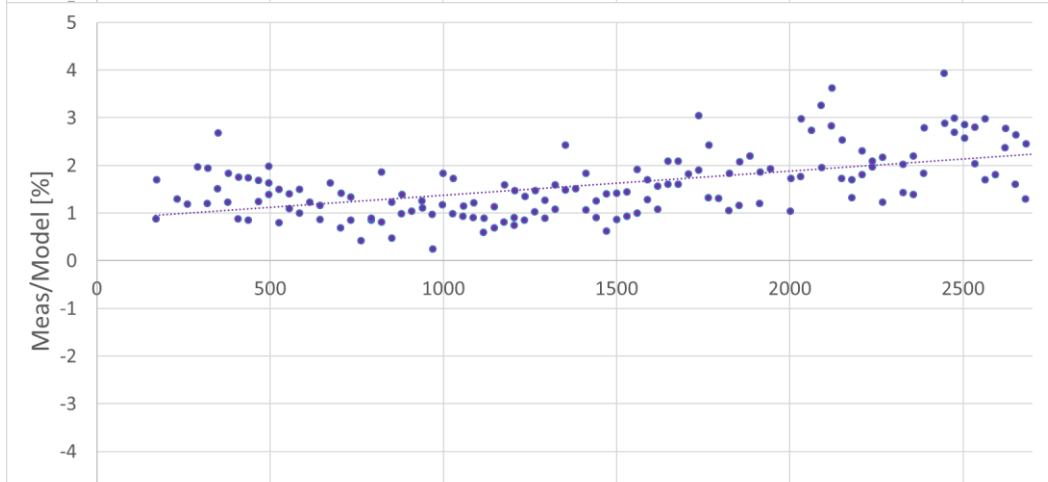
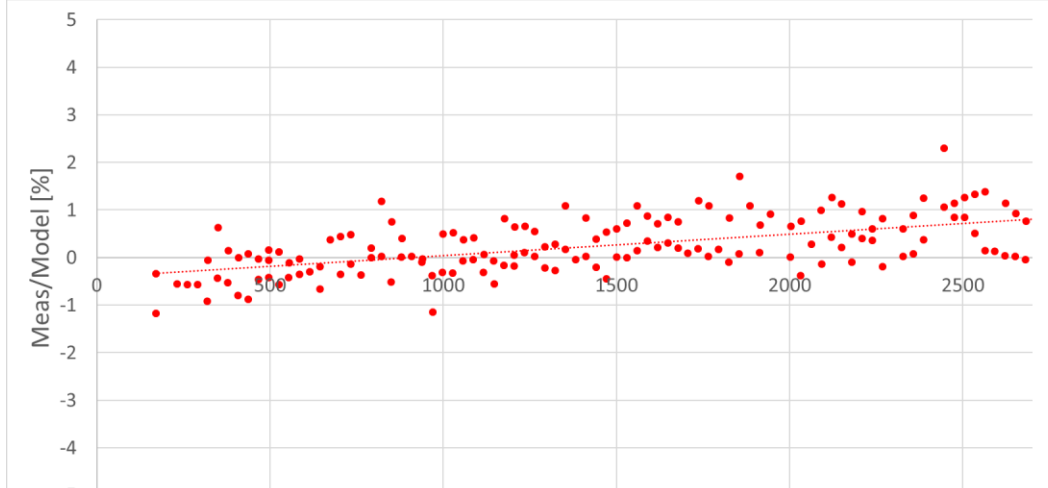
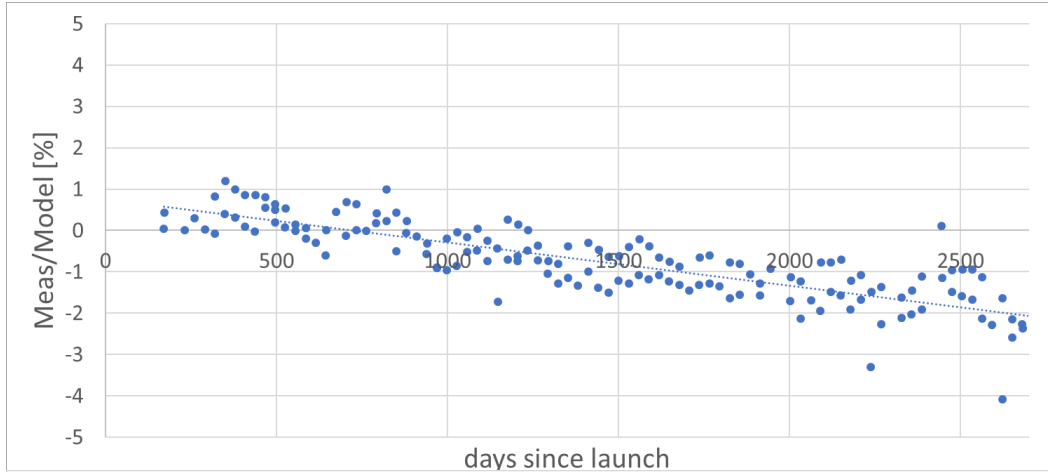


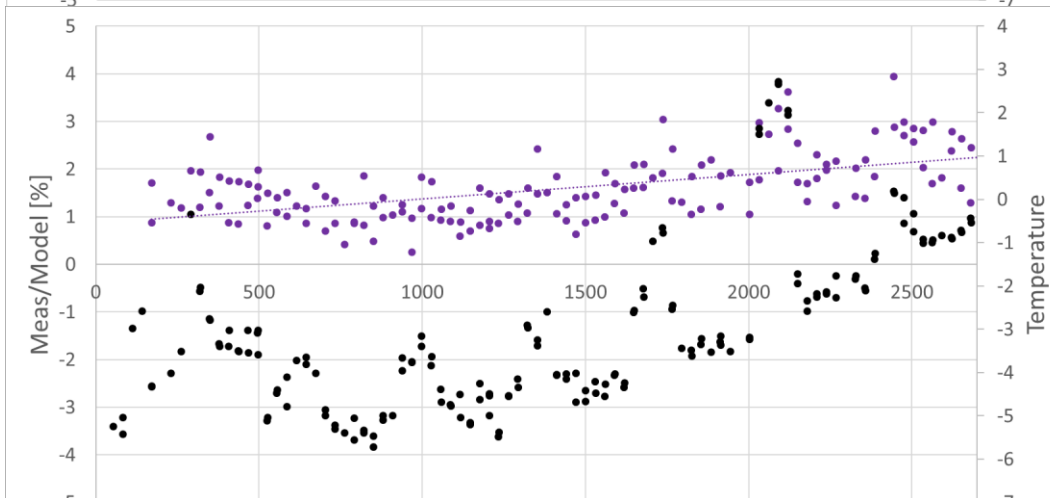
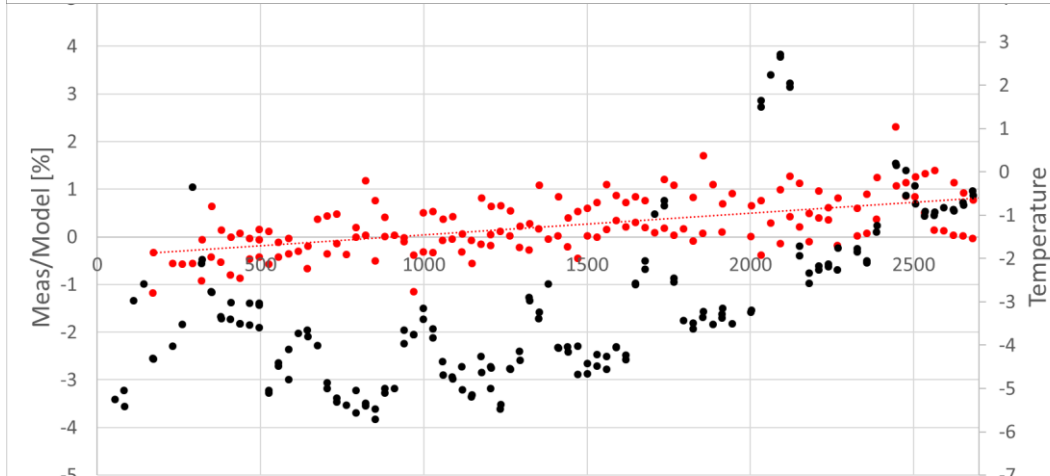
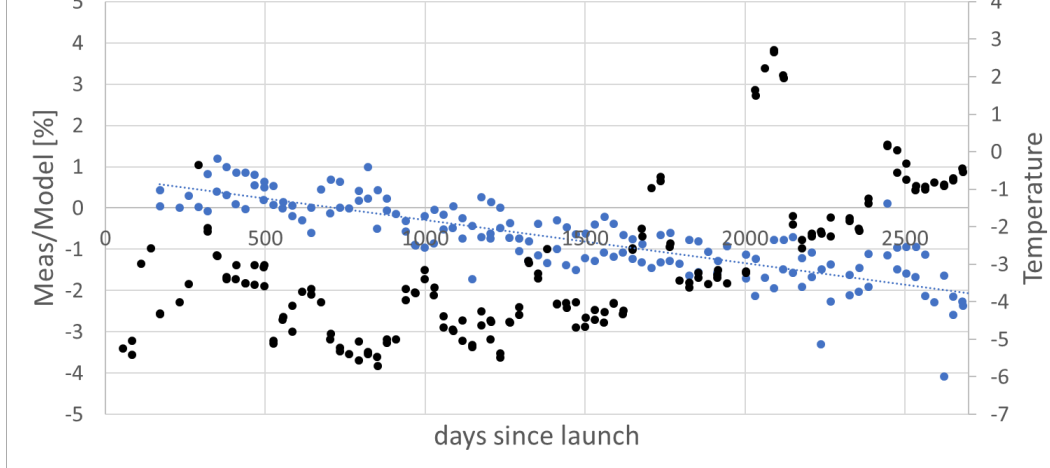
Lunar Calibration



PROBA-V image

- Observation of the moon :
 - Twice a month at phase angle $\pm 7^\circ$
- LIME (Lunar Irradiance Model ESA) model
- ONLY CENTER CAMERA

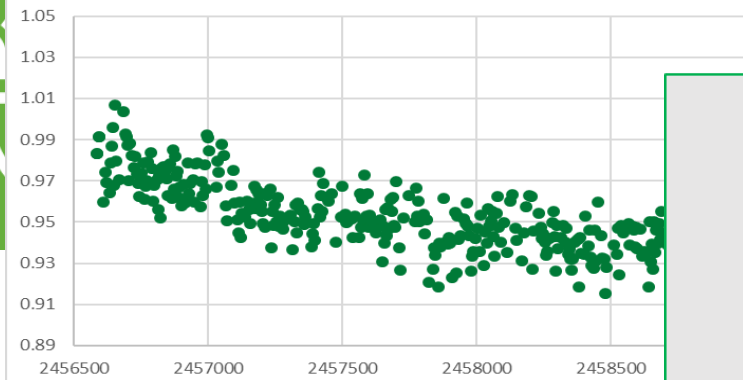




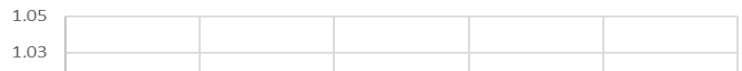


Long term trending SWIR

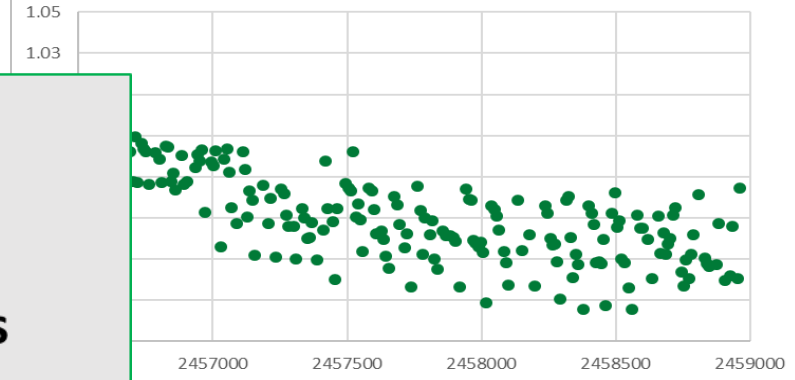
left SWIR1



Left SWIR2



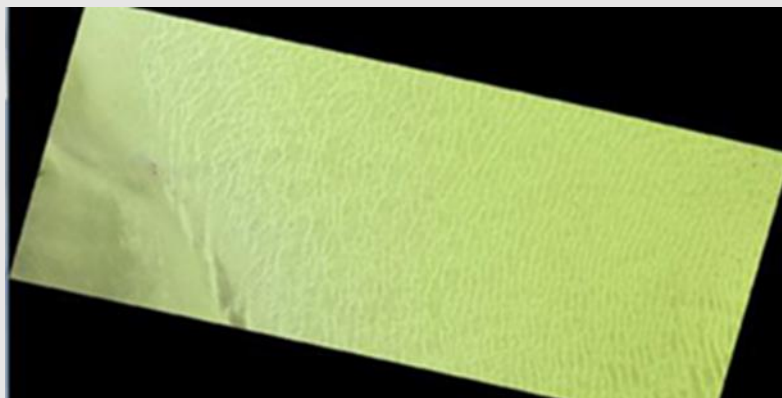
Left swir3



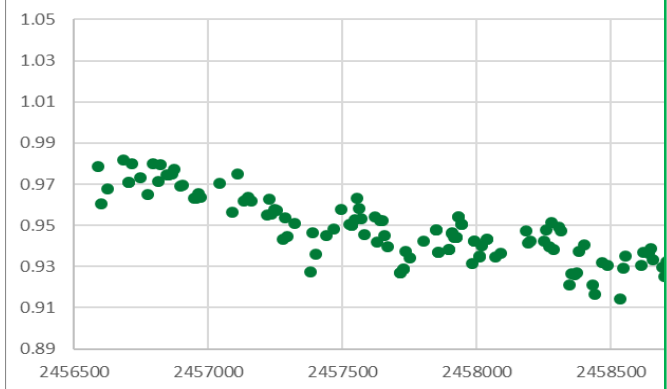
Instrument degradation

No absolute calibration (Ak) updates considered

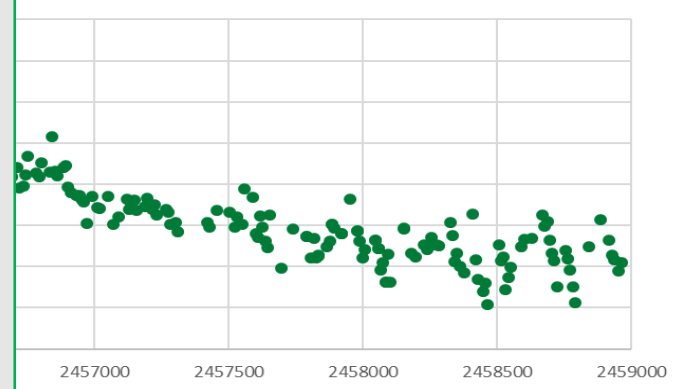
Libya-4 SWIR



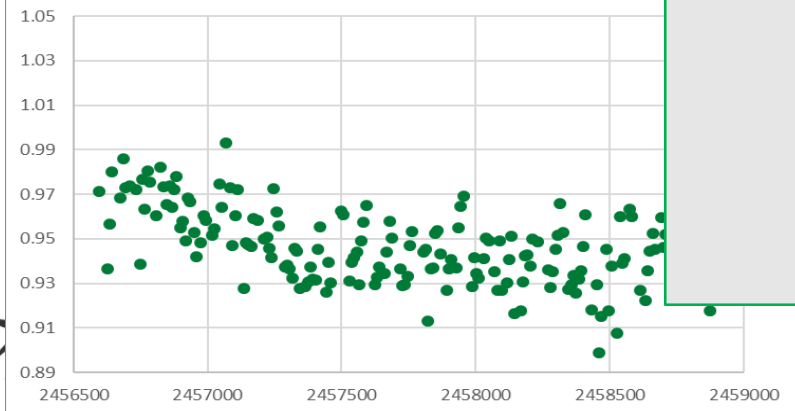
center swir1



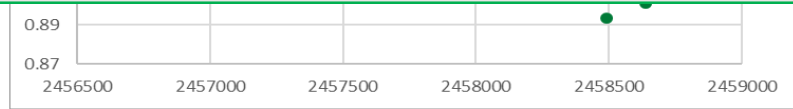
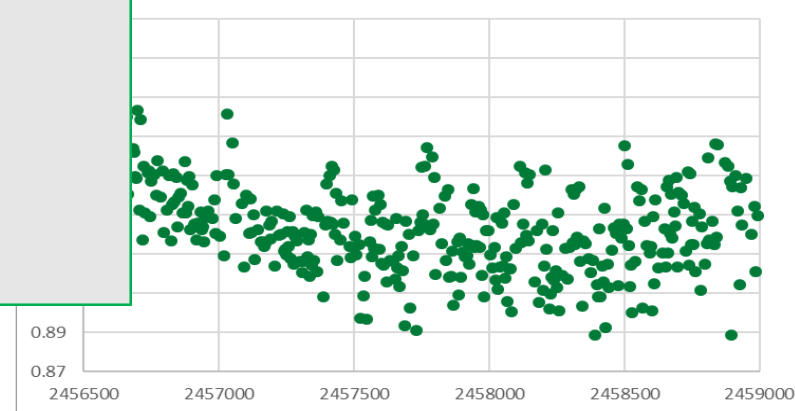
Center SWIR3



RIGHT SWIR1

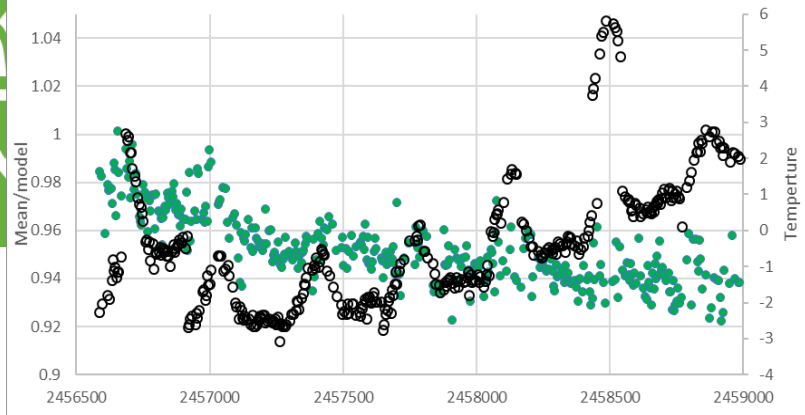


RIGHT SWIR3

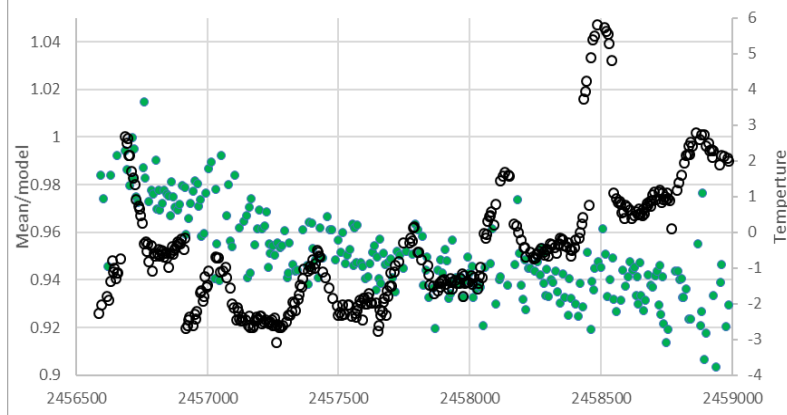




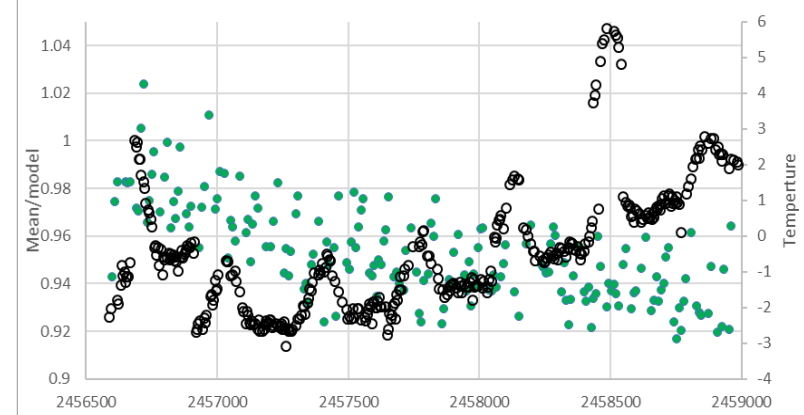
LEFT SWIR1



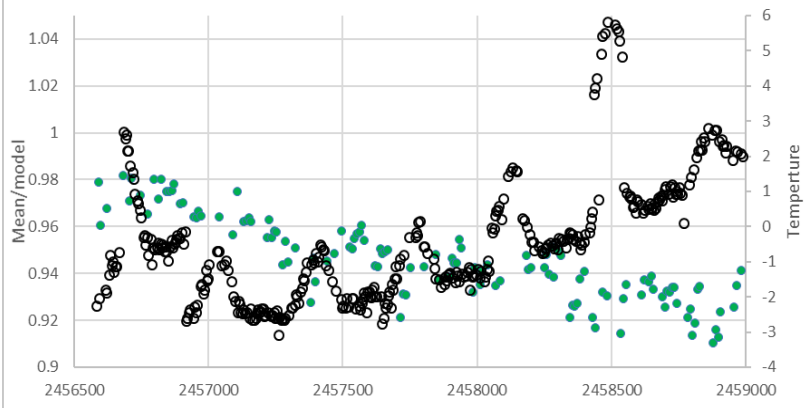
LEFT SWIR2



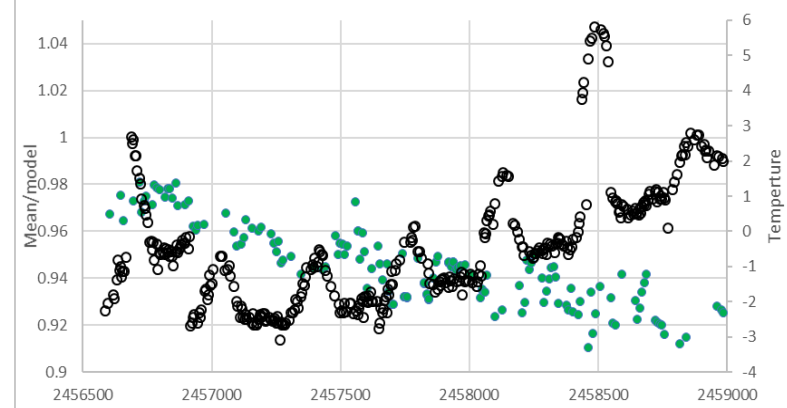
LEFT SWIR3



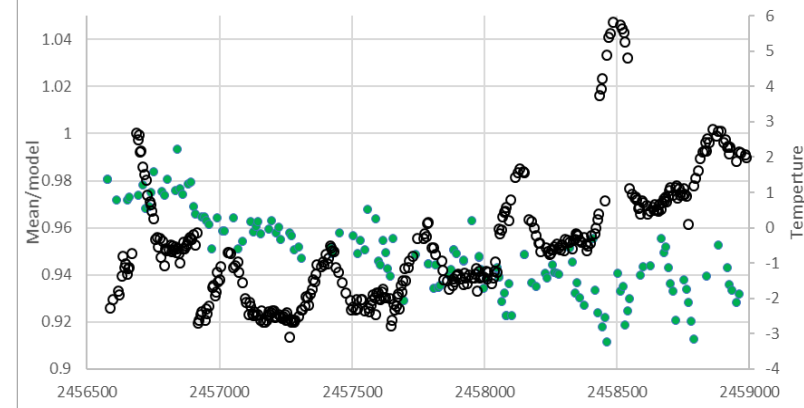
CENTER SWIR1



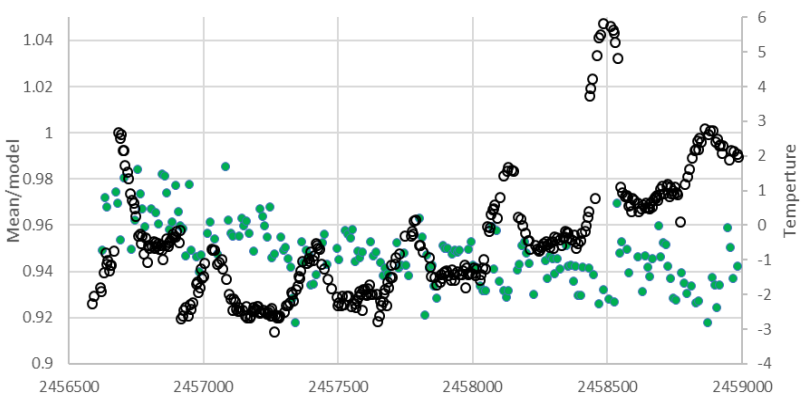
CENTER SWIR2



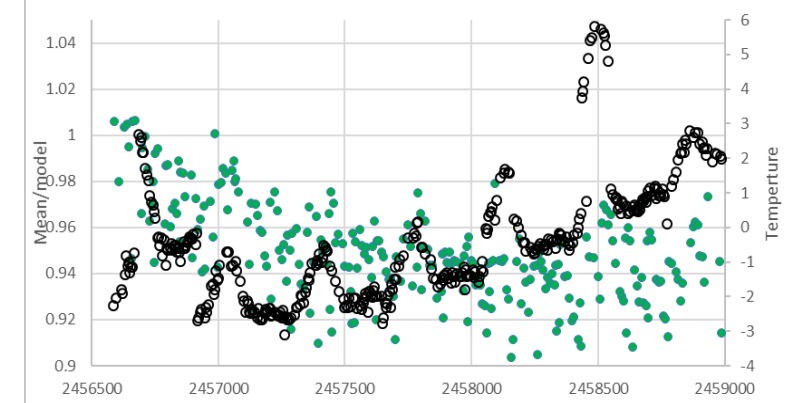
CENTER SWIR3



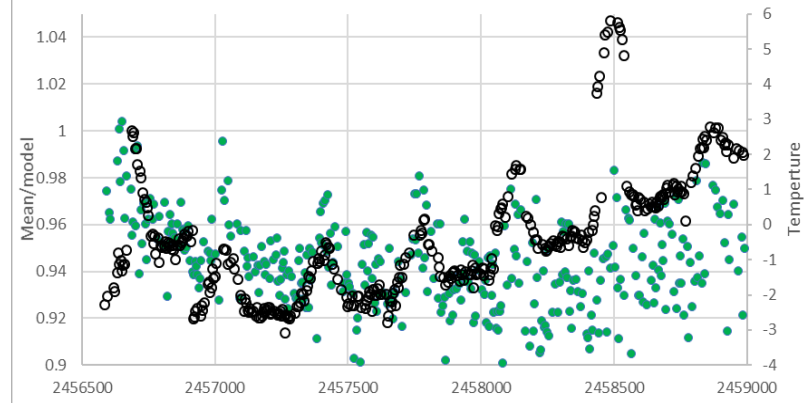
RIGHT SWIR1



RIGHT SWIR2

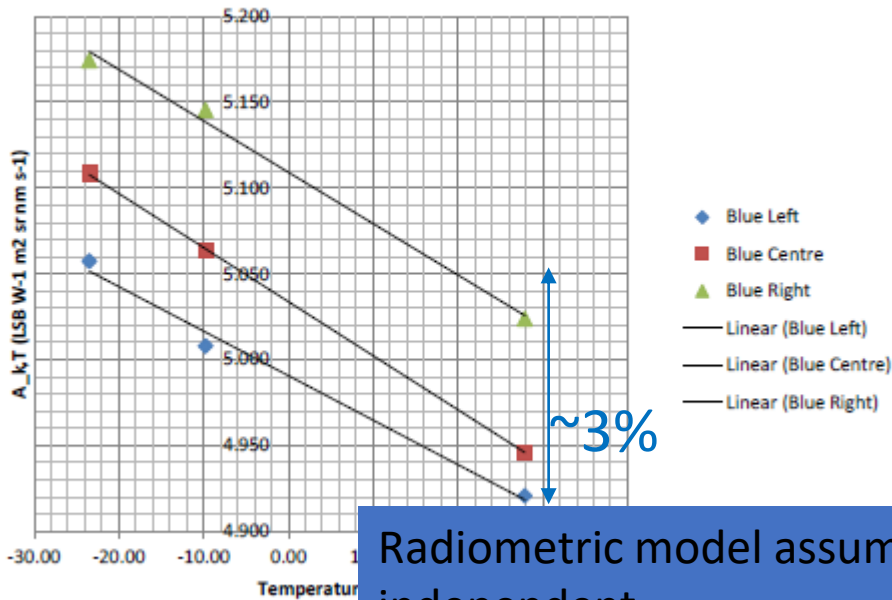


RIGHT SWIR3

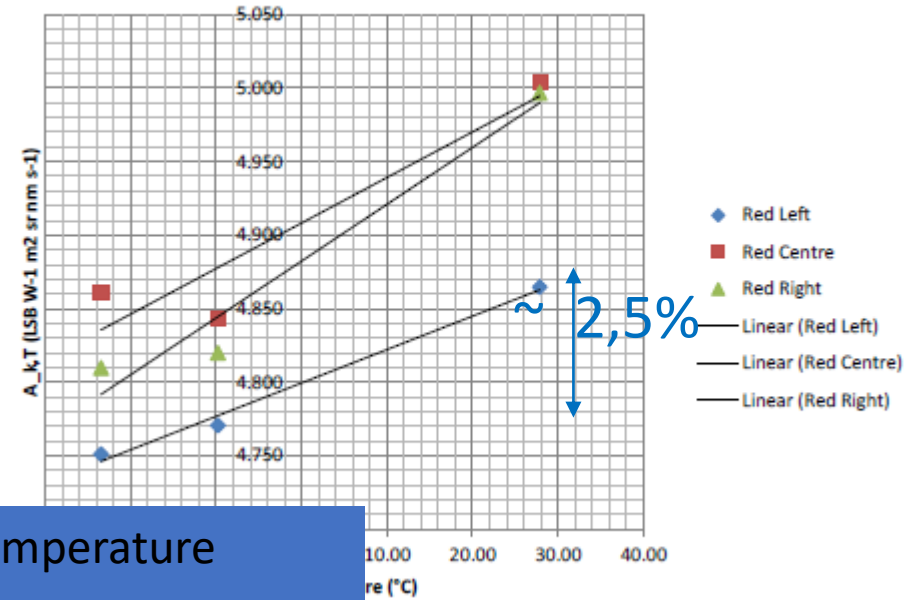




A_{k,T} versus T- Blue



A_{k,T} versus T- Red

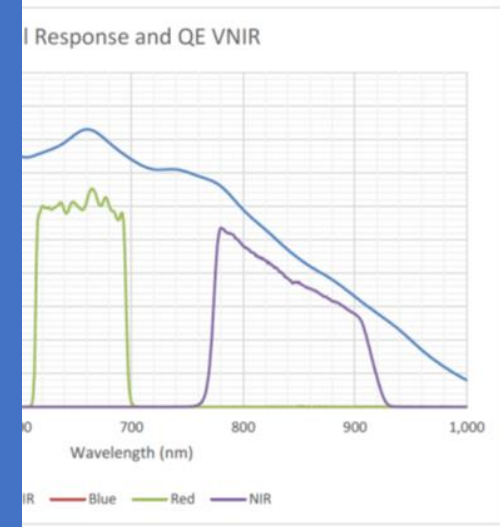


Pre-flight
A_k
(absolute
cal coef.)
-24°C
-10°C
+28°C

Radiometric model assumes A_k temperature independent

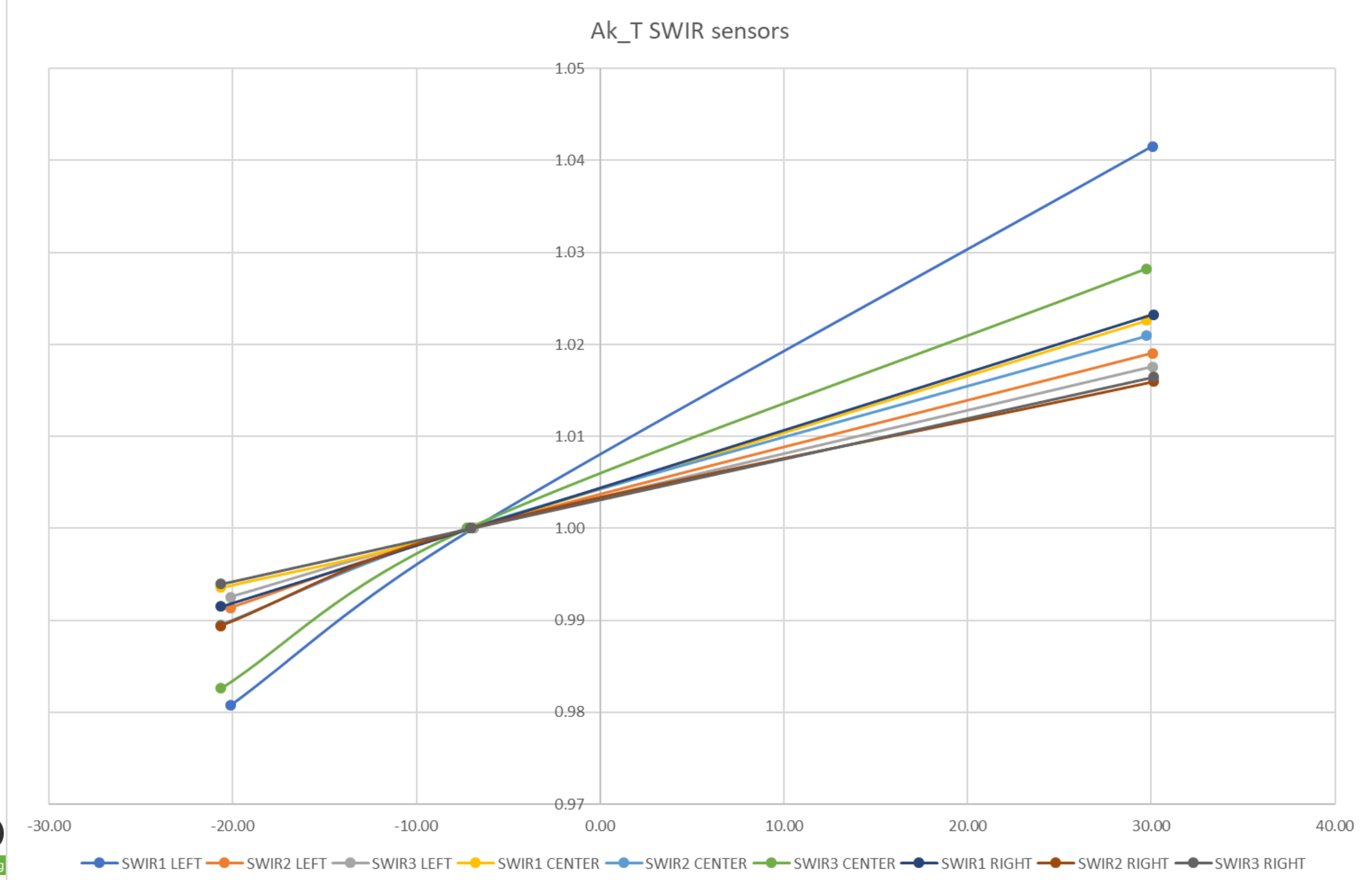
$$L_{TOA,i}^k = \frac{DN_{i,acquired}^k}{A^k g_{im}^k} - dc_{im}^k$$

=> temperature increase that not considered in A_k results in L increase for NIR & RED bands (opposite for BLUE)



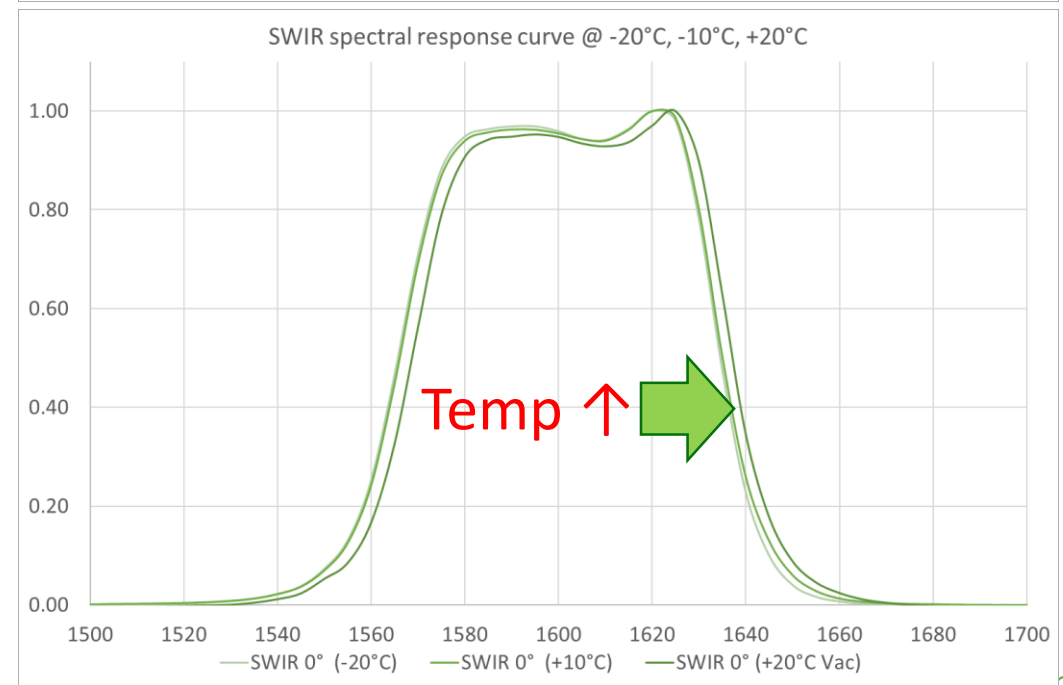
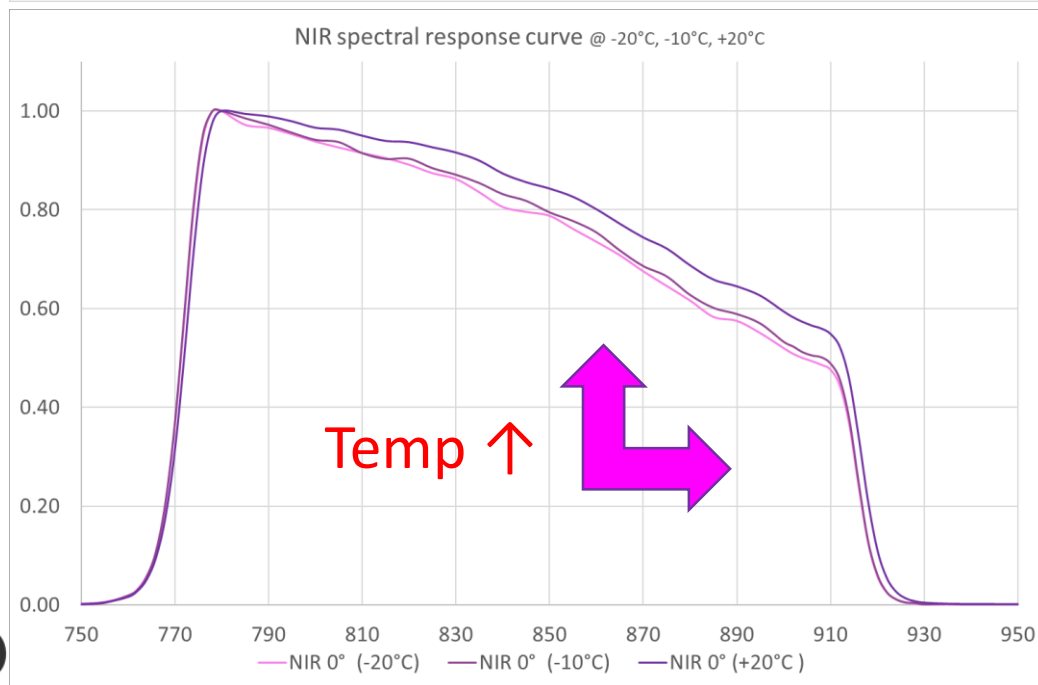
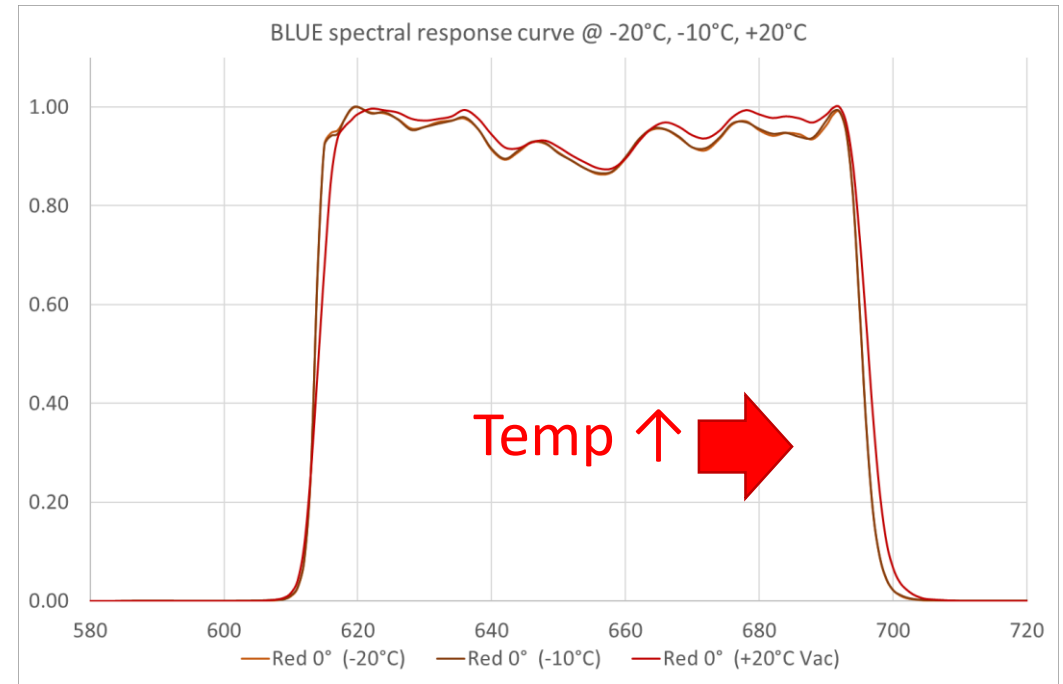
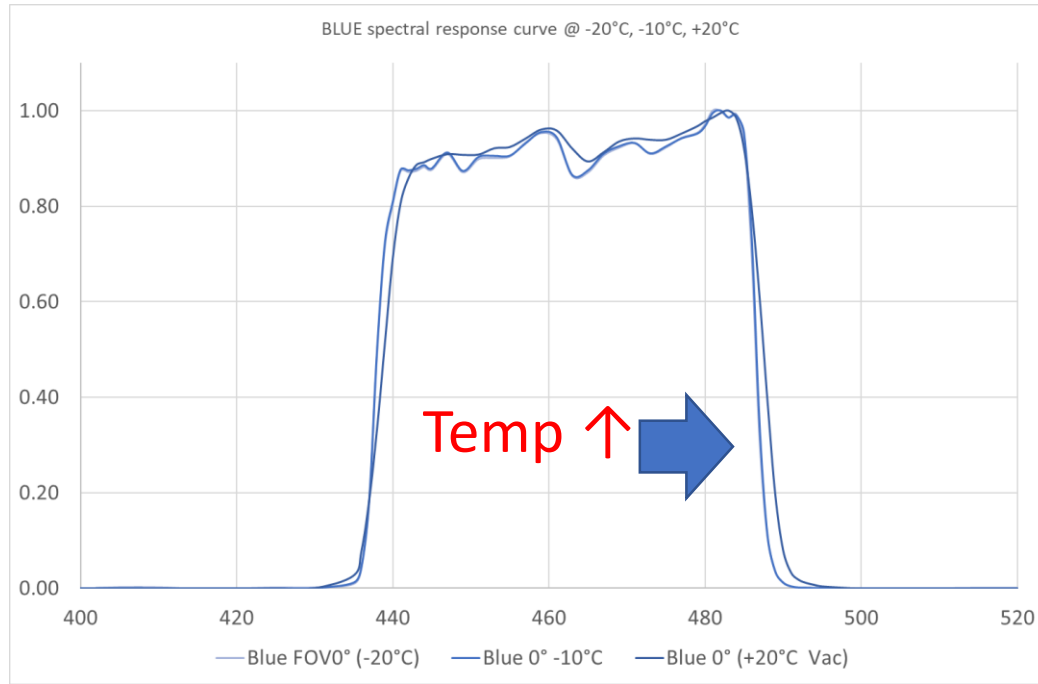


Pre-flight
Ak
(absolute
cal coef.)
-20°C
-7°C
+30°C
SWIR





Pre-flight Spectral Response curves
-20°C
-10°C
+20°C
(measured on the spare SI)





Conclusions

- PROBA-V instruments relatively stable over time
- Vicarious calibration results show impact of temperature change over the mission, but impact temperature CAMERA and BAND dependent
 - For VNIR:
Largest impact for NIR band:
Temperature increase correlates with observed increase in calibration results. Pre-flight calibration data “confirms” this behavior.
 - For SWIR: degrading trend counterbalanced by temperature increase



Conclusions

- Calibration updates PROBA-V Collection 2:
 - 2nd degree polynomial model in function of date for each camera/band to correct for long term temperature change (but not abrupt temperature changes)

