Radiometric harmonization of VGT-1, VGT-2 and PROBA-V data over Libya-4

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Yves Govaerts
Rayference

Advance Future Technology for Earth Observation Missions

Objectives

Secure the radiometric consistency between VGT-1 (1998-2012), -2 (2003-2014) and PROBA-V (2013-2021) for the generation of an AOT and surface reflectance climate data record.

Homogenisation

All radiometers are forced to look the same such that when looking at the same location at the same time they would (in theory) give the same signal.

Harmonisation

All the calibrations of the sensors have been made consistent with (a) reference dataset(s) which can be traced back to known reference sources, in an ideal case back to SI. Each sensor is calibrated to the reference in a way that maintains the characteristics of that individual sensor such that the calibration radiances represent the unique nature of each sensor.

Objectives

Secure … 012), -2 (2003-
2014) … OT and surface
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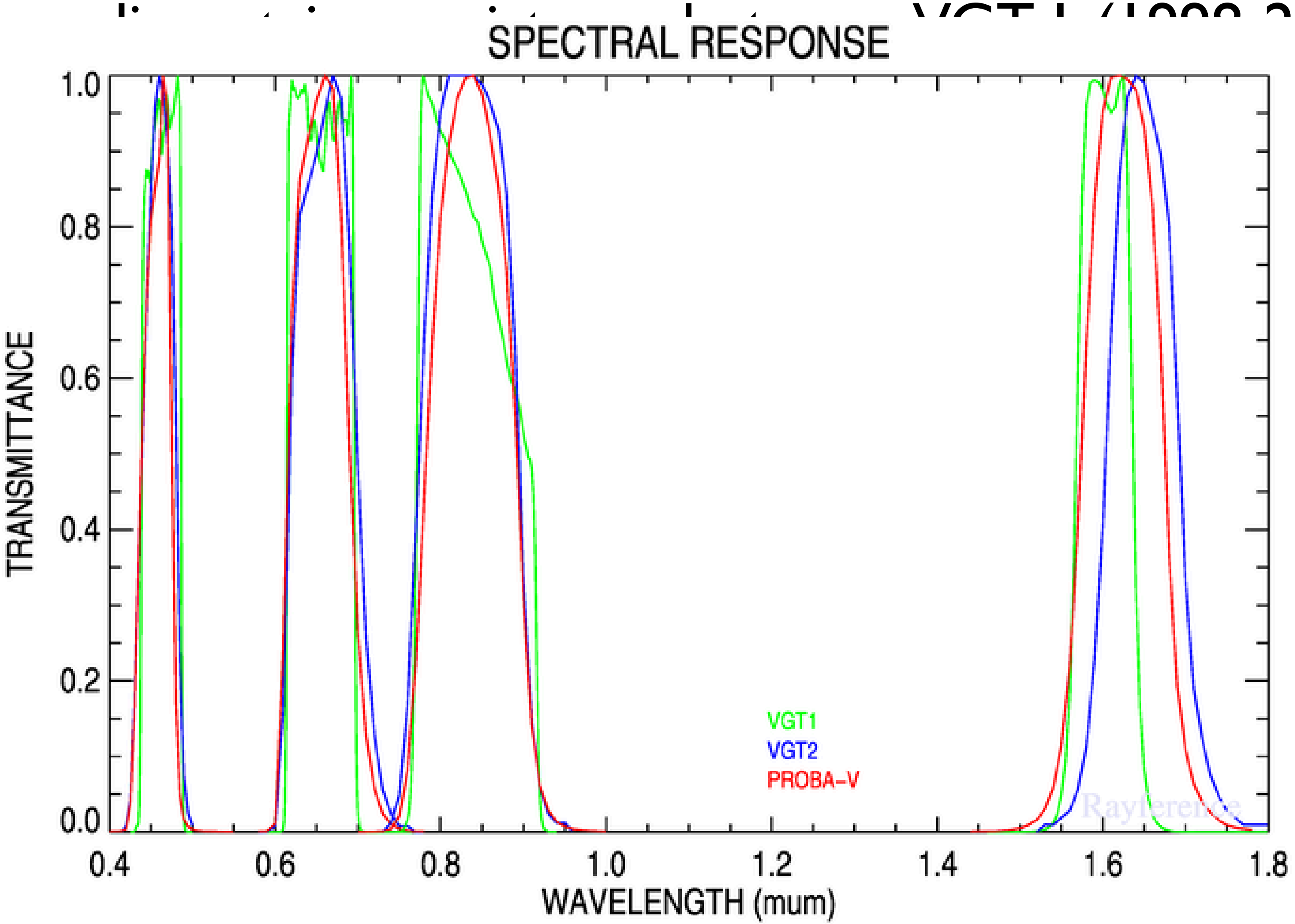

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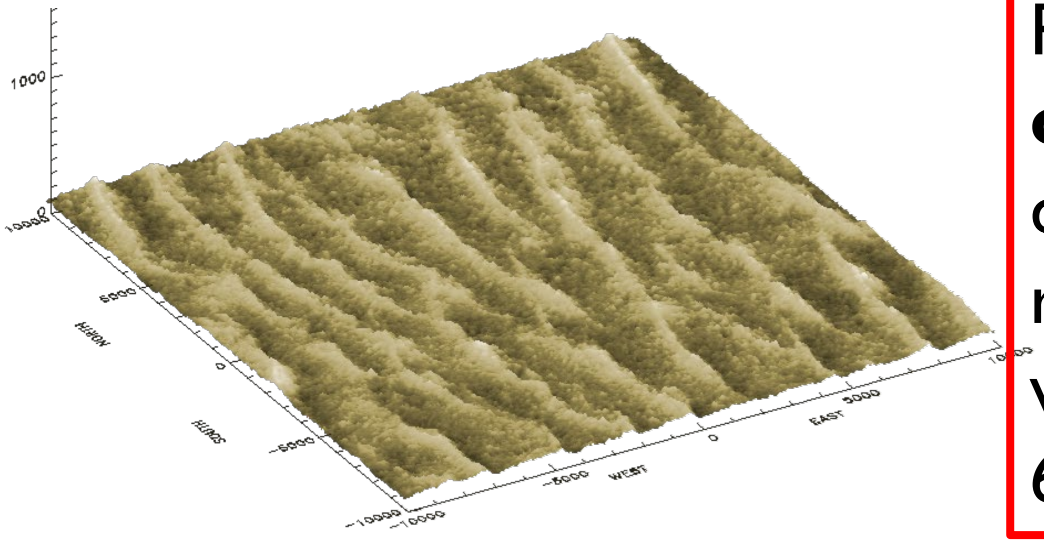
Libya-4 Rayference Calibration Reference (LRCR)

Use of Pseudo-Invariant Calibration Site (PICS) (Libya-4);



Rayference has developed an accurate **calibration reference** simulated with 4 different RTMs over Libya-4 with a spectral resolution of 1 nm and applicable to a viewing/illumination zenith angular range up to 65°. It is referred to as LRCR.

Govaerts, Y. M. 1999. "Correction of the Meteosat-5 and -6 VIS Band Relative Spectral Response with Meteosat-7 Characteristics." *International Journal of Remote Sensing* 20 (18): 3677–82.

Govaerts, Y. M., and M. Clerici. 2004. "Evaluation of Radiative Transfer Simulations over Bright Desert Calibration Sites." IEEE TGARS, 42 (1).

Govaerts, Yves, et al. 2013. "Use of Simulated Reflectances over Bright Desert Target as an Absolute Calibration Reference." RSE, 523-- 531.

Govaerts, Y. M. 2015. "Sand Dune Ridge Alignment Effects on Surface BRF over the Libya-4 CEOS Calibration Site." Sensors 15 (2): 3453–70;

Govaerts, Y. M., et al. 2018. "Climate Data Records from Meteosat First Generation Part I: Simulation of Accurate Top-of-Atmosphere Spectral Radiance over Pseudo-Invariant Calibration Sites for the Retrieval of the In-Flight Visible Spectral Response." Remote Sensing 10 (12): 1959.

Libya-4 Rayference Calibration Reference (LRCR)

RTM	0.46μm	0.65μm	0.83μm	1.60μm
MODIS, MERIS, OLI, MSI				
6SV	-0.60%±1.16%	-0.43%±0.72%	-0.39%±0.89%	-1.46%±0.51%
LibRadtran	+1.38%±1.19%	+0.50%±0.80%	+0.44%±1.00%	-0.42%±0.66%
RTMOM	+0.16%±1.13%	+0.95%±0.72%	+0.84%±0.89%	+0.75%±0.54%
ARTDECO	+0.20%±1.11%	+0.66%±0.76%	+0.88%±0.89%	+0.06%±0.49%
$\bar{B}_{\lambda_k}$	+0.26%±1.15%	+0.42%±0.75%	+0.43%±0.92%	-0.26%±0.55%

Mean relative bias between MODIS, MERIS, OLI and MSI observations over Libya-4 and LRCR simulated with each RTM.

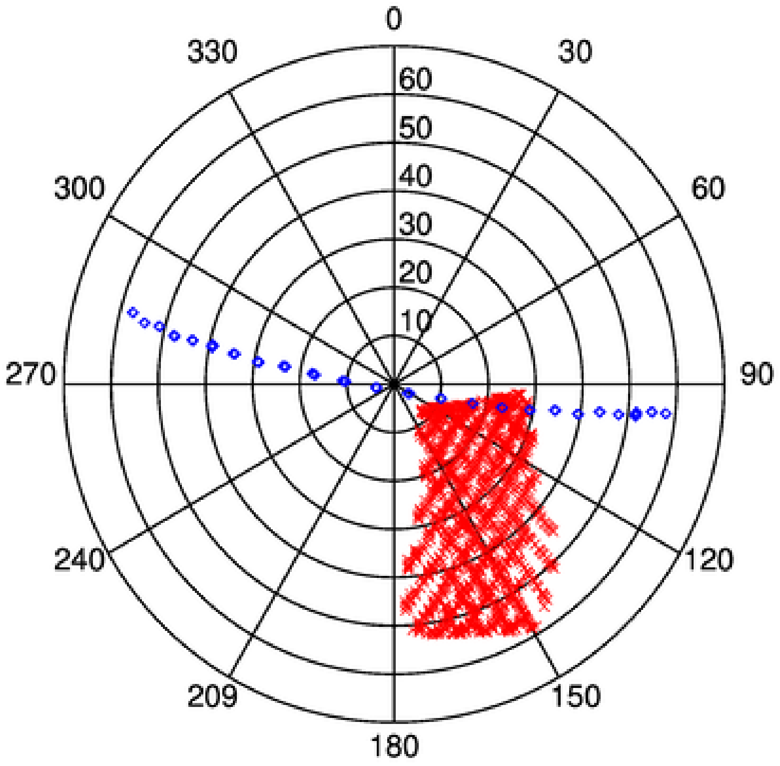
Libya-4 Rayference Calibration Reference (LRCR)

RTM	0.46μm	0.65μm	0.83μm	1.60μm
		u_{m,λ_k}		
6SV	1.30%	0.84%	0.97%	1.55%
LibRadtran	1.82%	0.94%	1.09%	0.78%
RTMOM	1.14%	1.19%	1.22%	0.92%
ARTDECO	1.13%	1.01%	1.26%	0.49%
		u_{λ_k}		
	1.18%	0.86%	1.02%	0.61%

Estimation of LRCR relative uncertainties u_{m,λ_k} against MODIS, MERIS, OLI, MSI radiometers for each RTM and $u(\lambda_k)$ for $\theta_s < 30^\circ$ and $\theta_v < 30^\circ$.

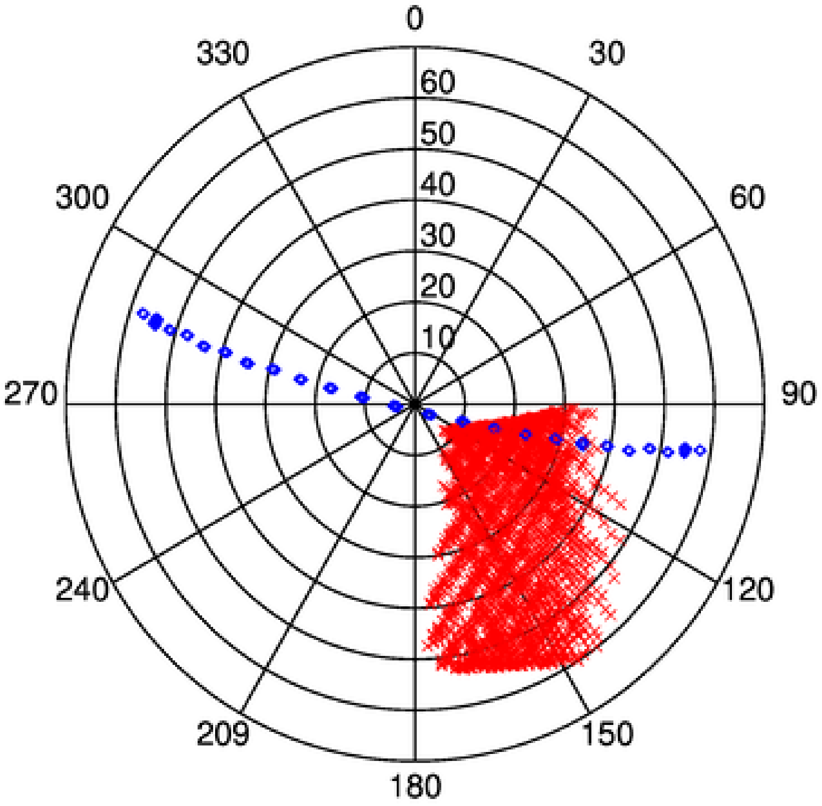
Viewing geometry over Libya-4

VGT-1



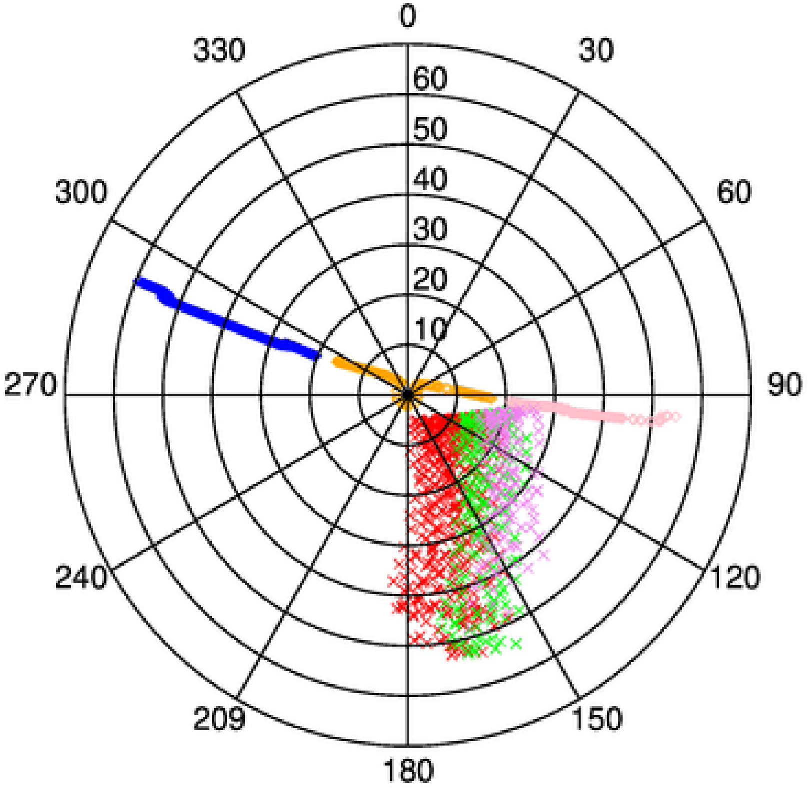
(04/1998 – 04/2012)

VGT-2



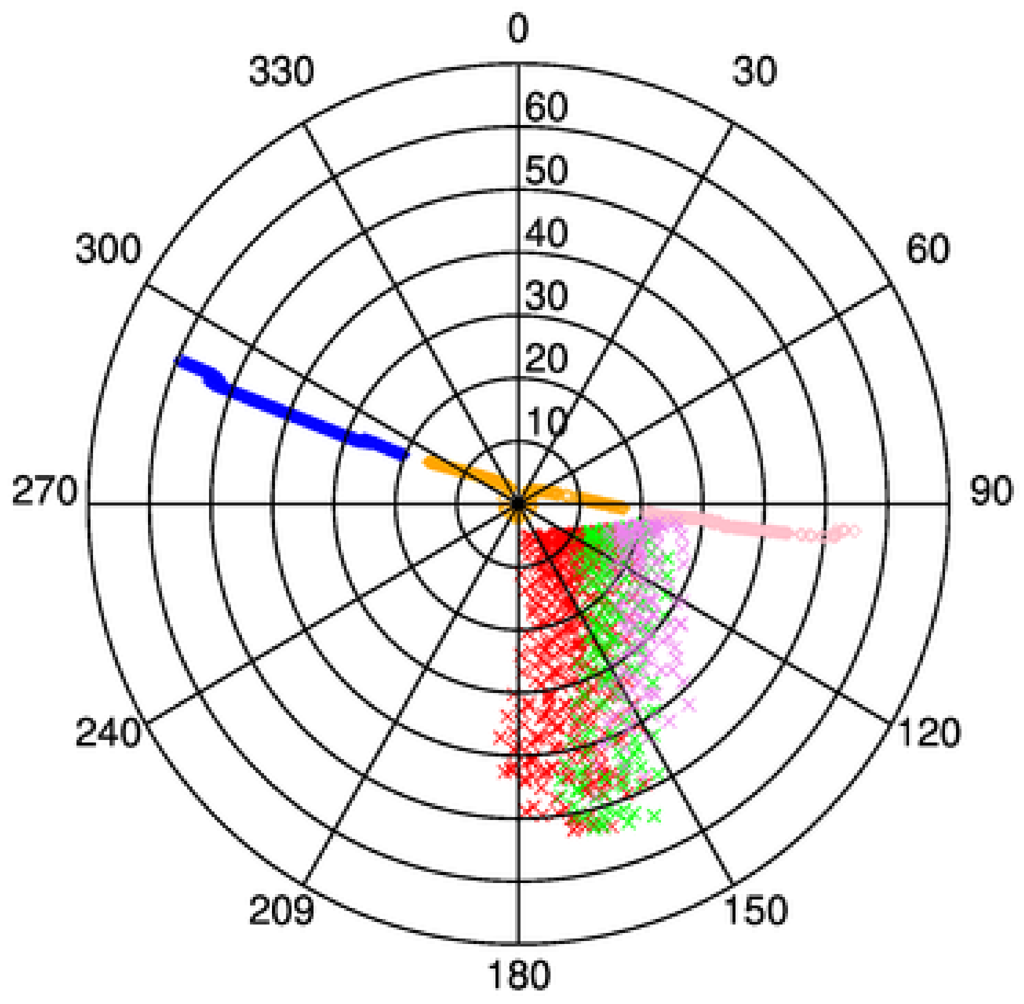
(01/2003 – 06/2014)

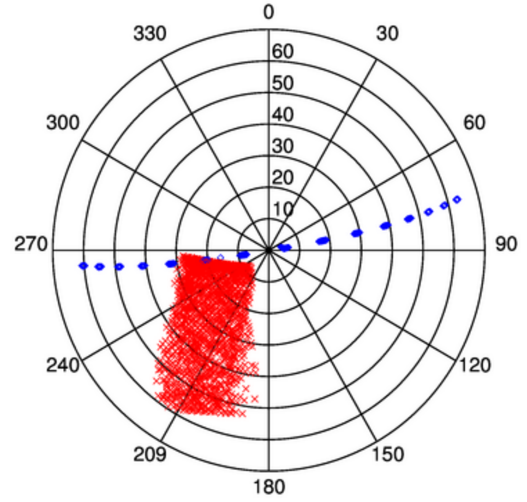
PROBA-V



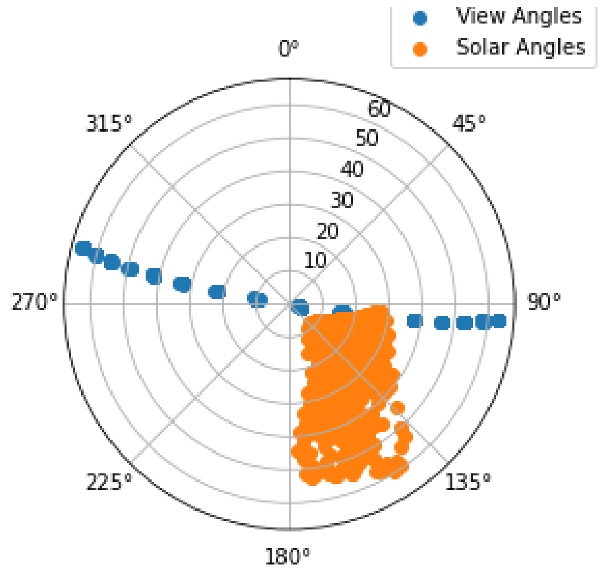
(04/2013 – 10/2021).

PROBA-V viewing geometry over Libya-4



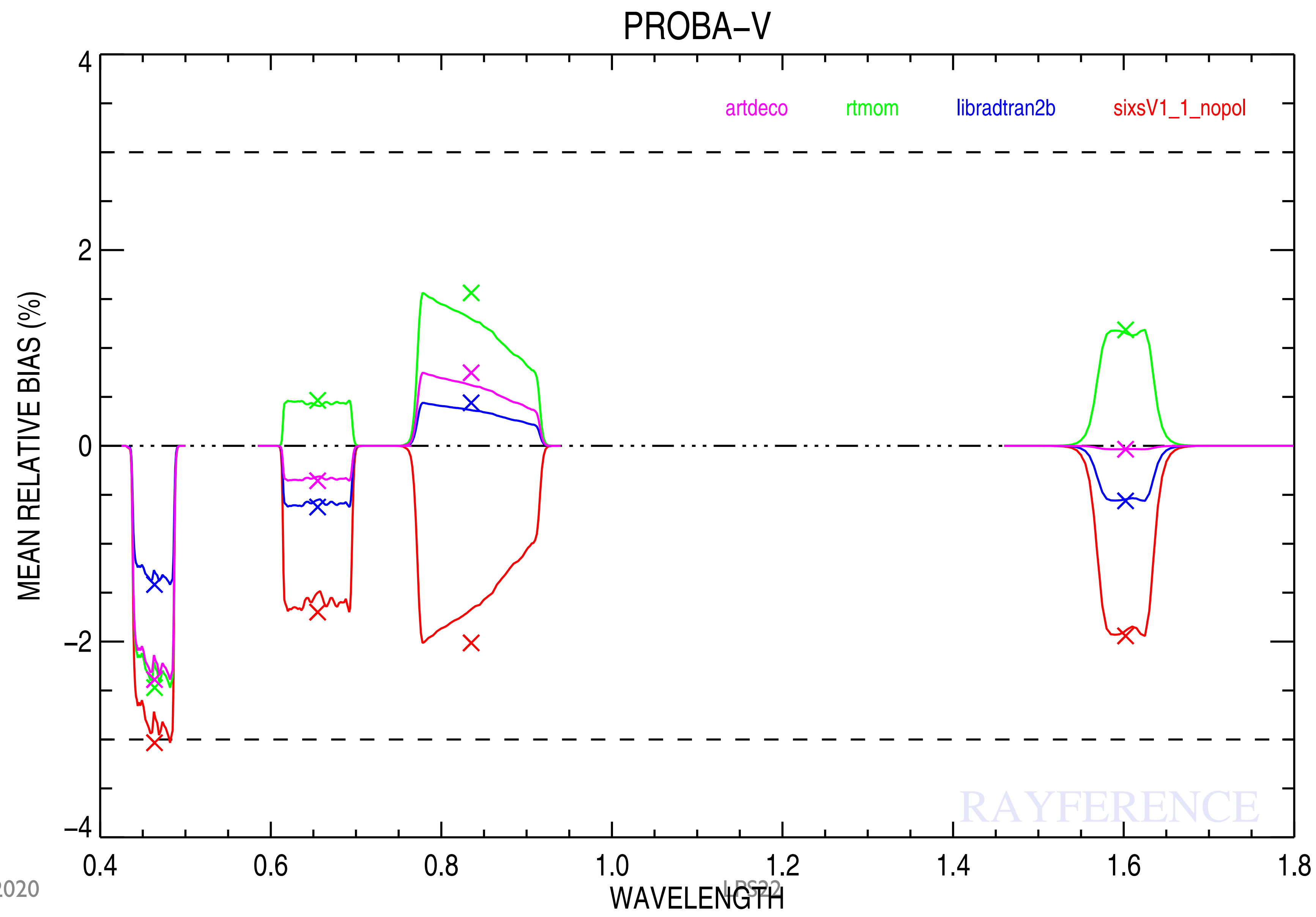


AQUA-MODIS



TERRA-MODIS

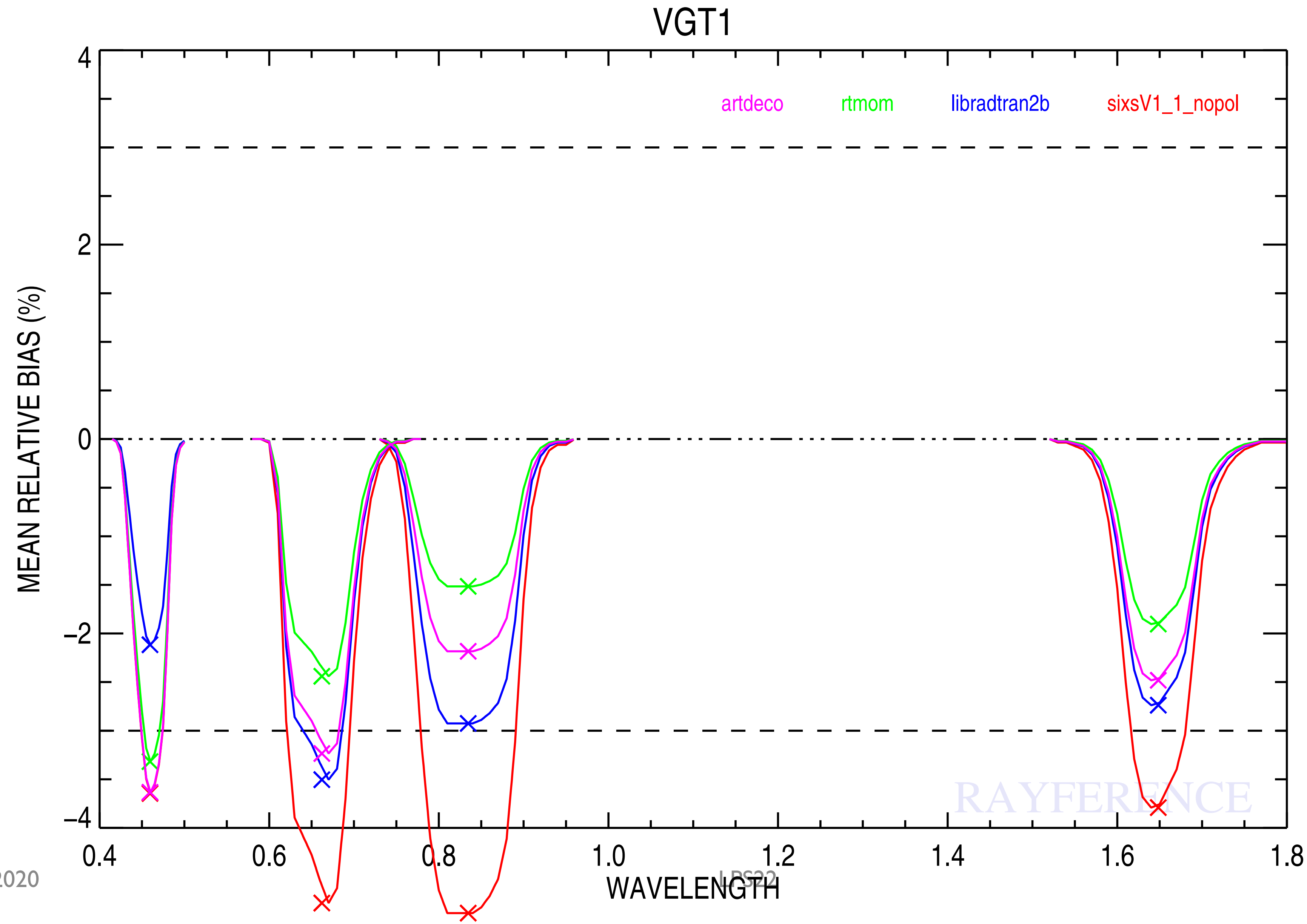
Results



All cameras

$10^\circ < \theta_s < 30^\circ$

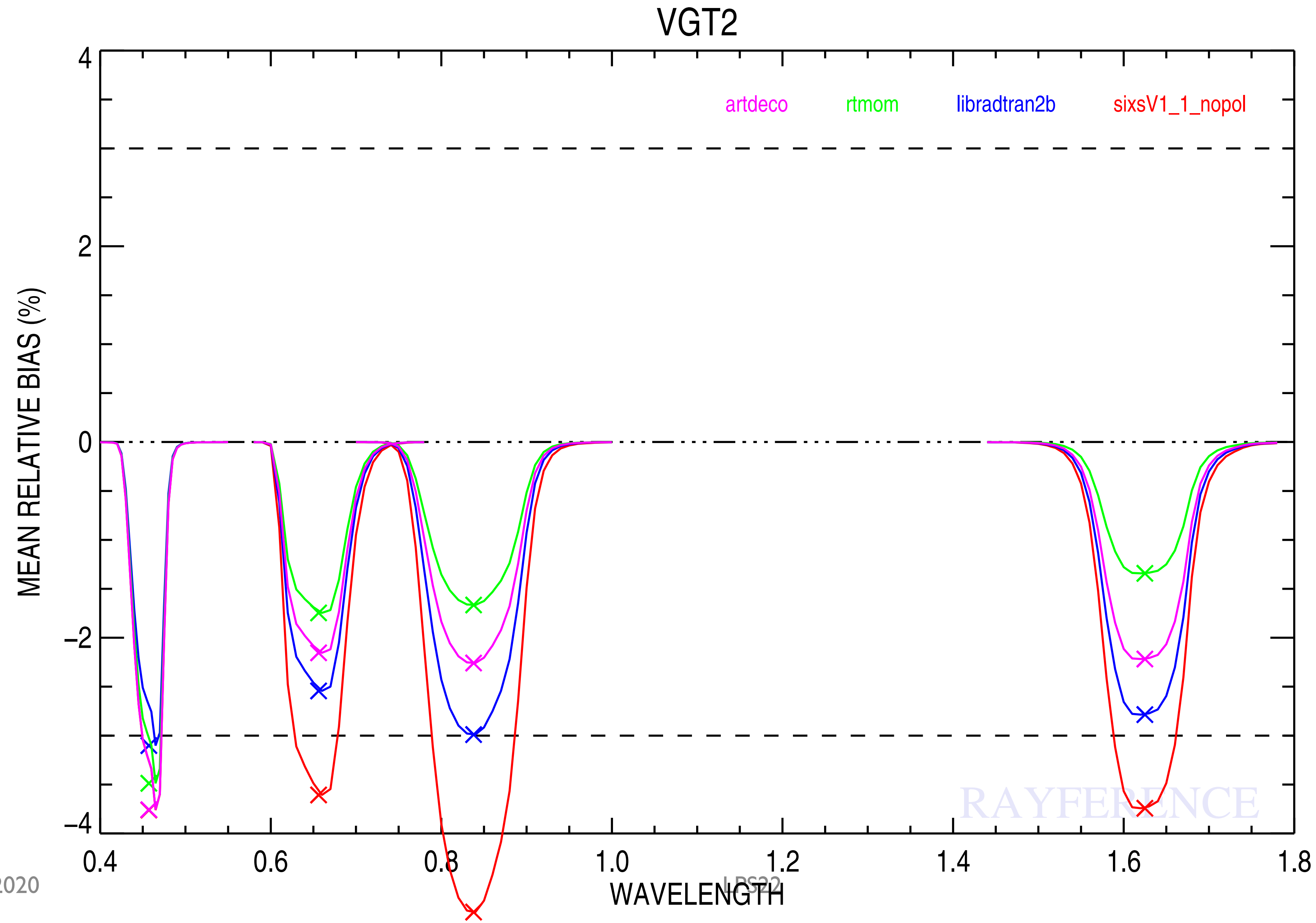
Results



All cameras

$10^{\circ} < \theta_s < 30^{\circ}$

Results



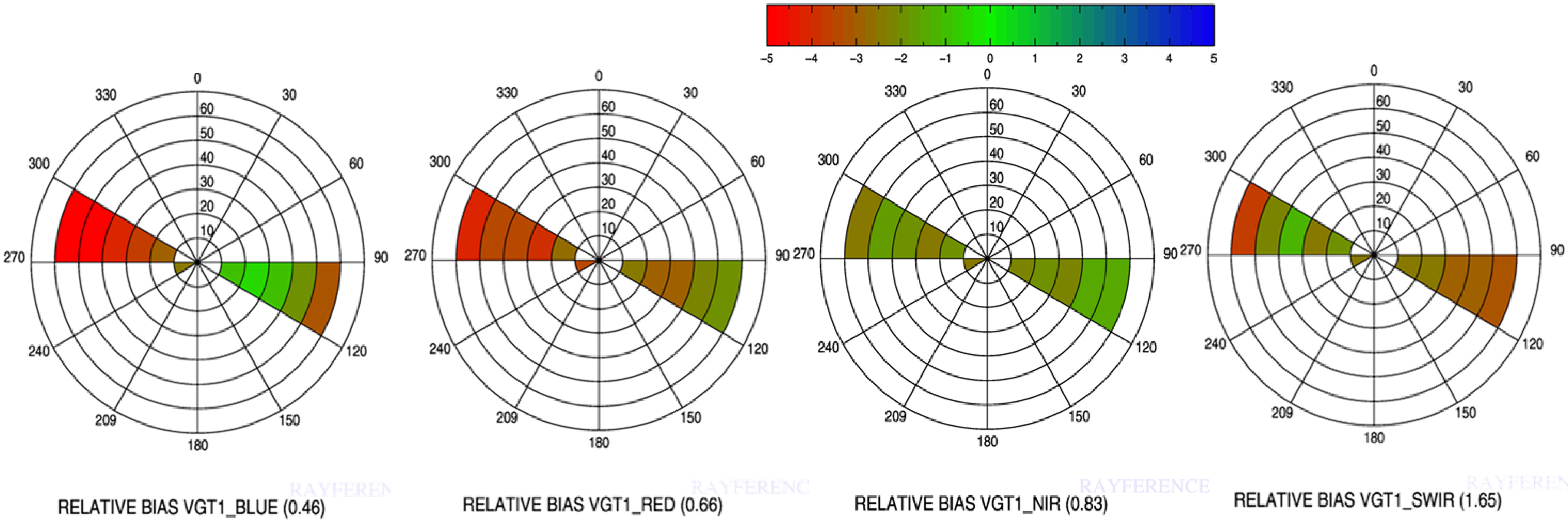
All cameras
$10^{\circ} < \theta_s < 30^{\circ}$

Harmonisation

	BLUE	RED	NIR	SWIR
SPOT-VGT1				
	1.042	1.028	1.020	1.026
SPOT-VGT2				
	1.036	1.024	1.013	1.019
PROBA-V				
ALL	1.024	1.005	0.997	1.004
LEFT	1.040	1.005	0.997	1.001
CENTRAL	1.011	1.012	1.001	1.003
RIGHT	1.010	0.999	0.993	1.014

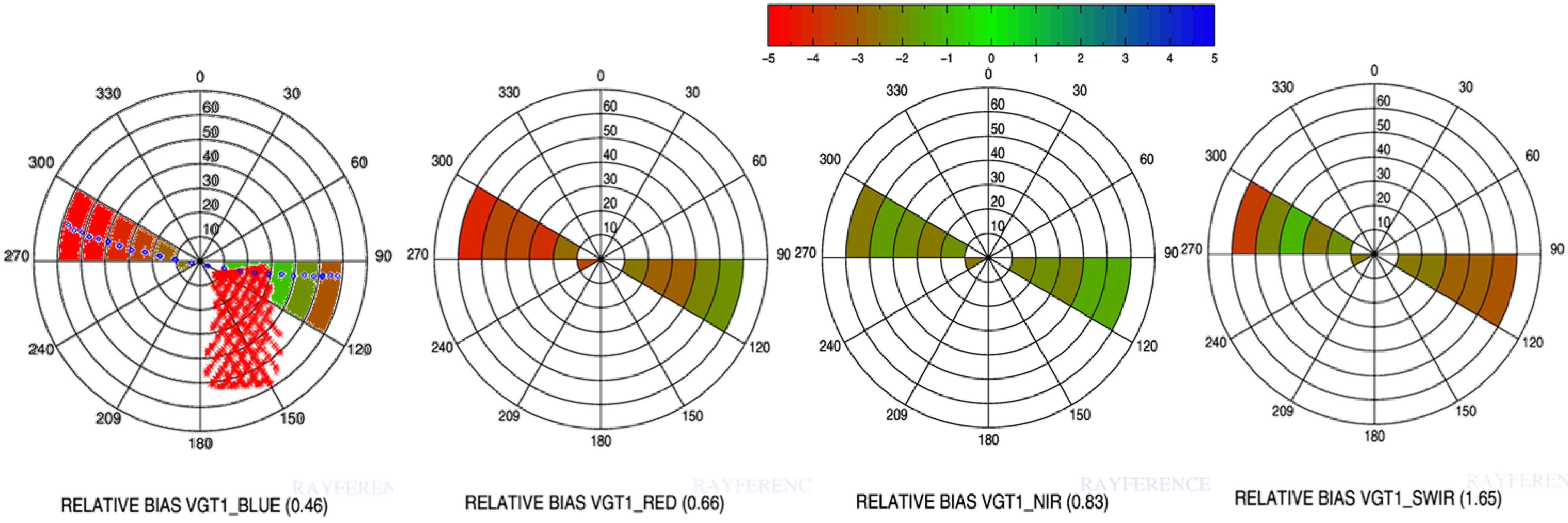
For PROBA-V, it is suggested to apply a correction per camera

VGT-1 bias vs viewing geometry



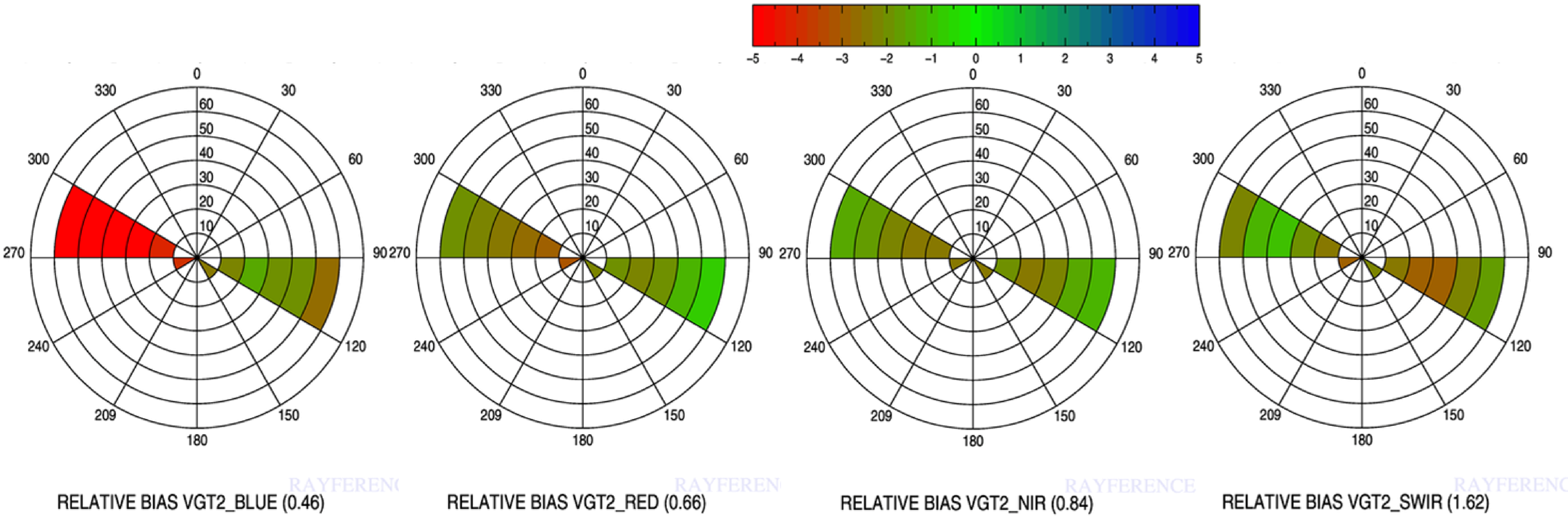
REFERENCE MODEL : ARTDECO

VGT-1 bias vs viewing geometry



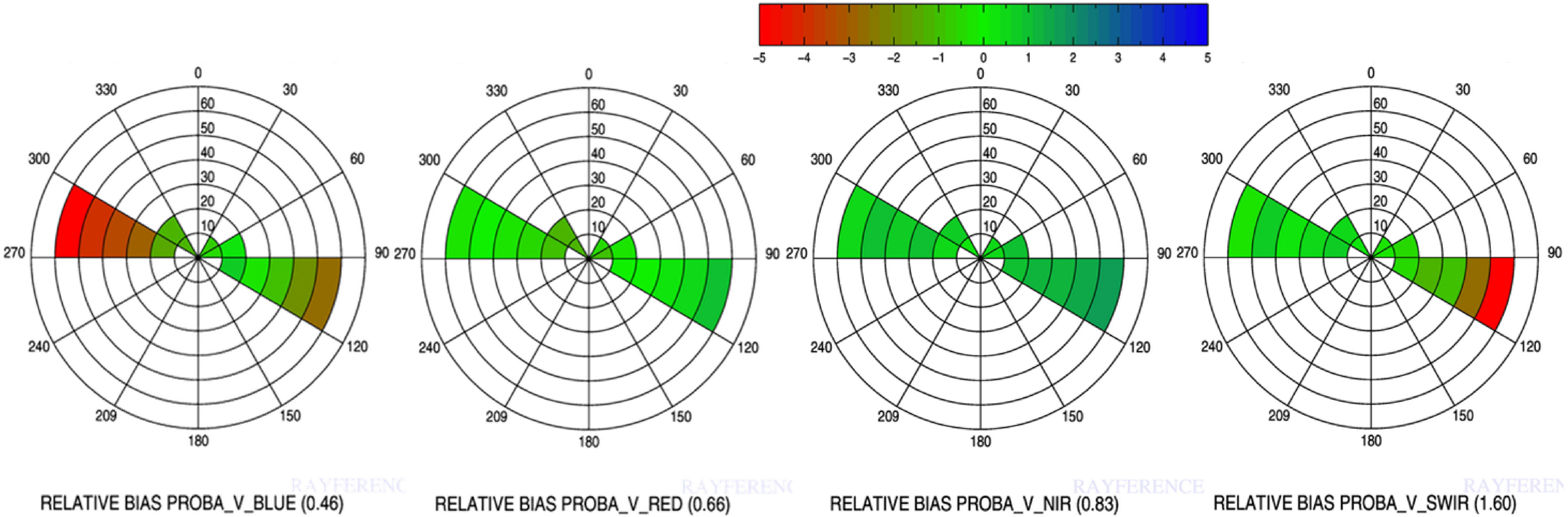
REFERENCE MODEL : ARTDECO

VGT-2 bias vs viewing geometry



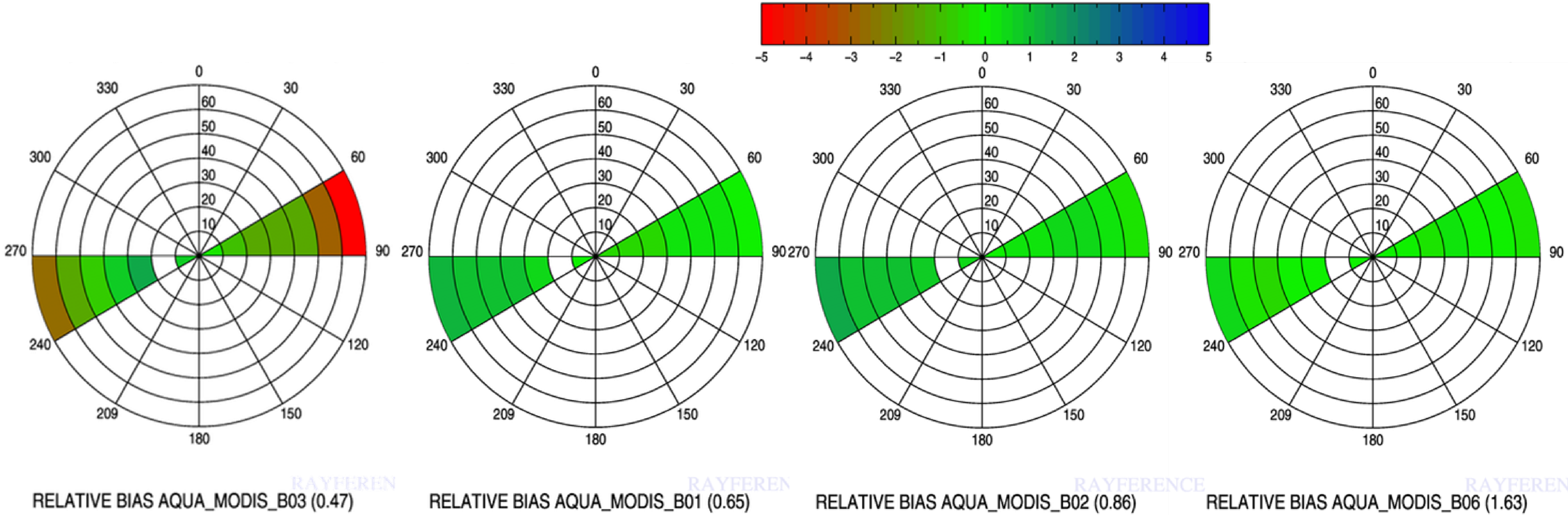
REFERENCE MODEL : ARTDECO

PROBA-V bias vs viewing geometry



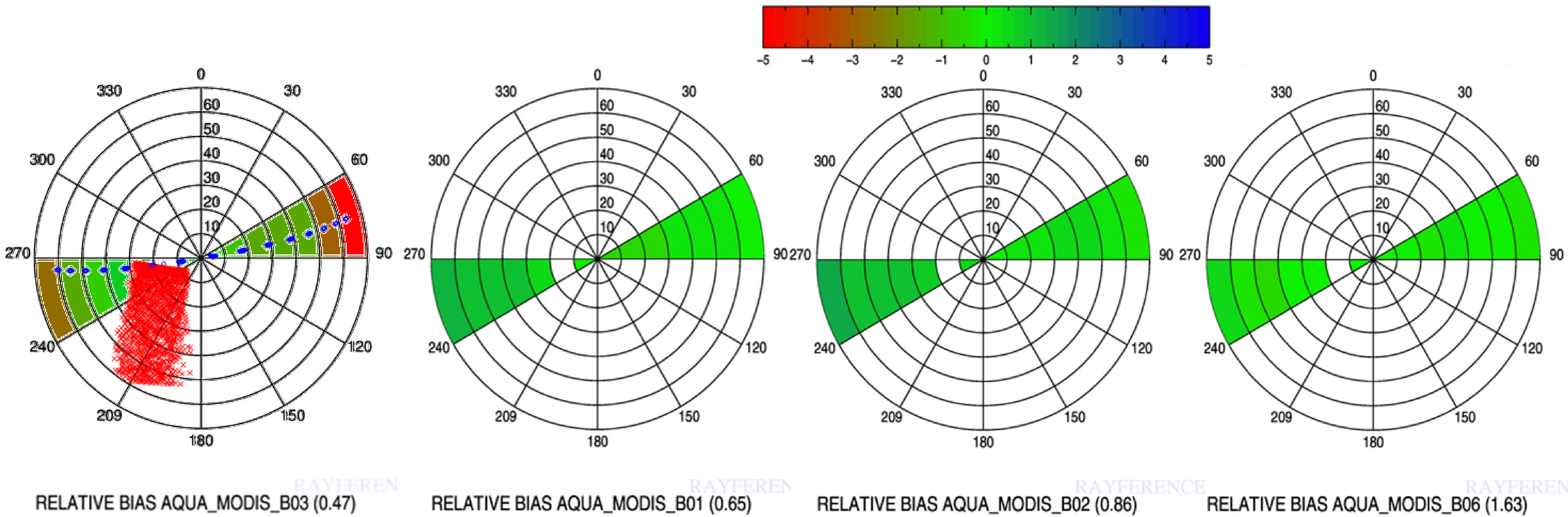
REFERENCE MODEL : ARTDECO

AQUA-MODIS bias vs viewing geometry



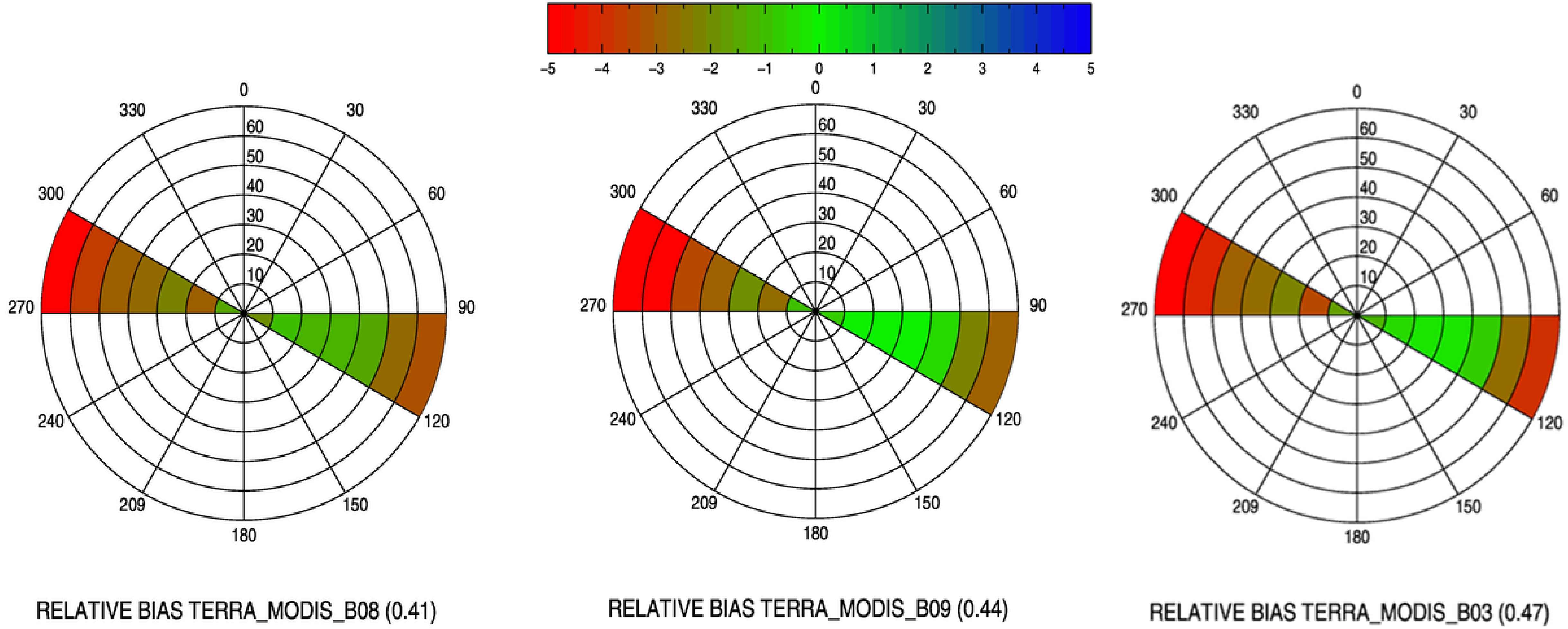
REFERENCE MODEL : ARTDECO

AQUA-MODIS bias vs viewing geometry



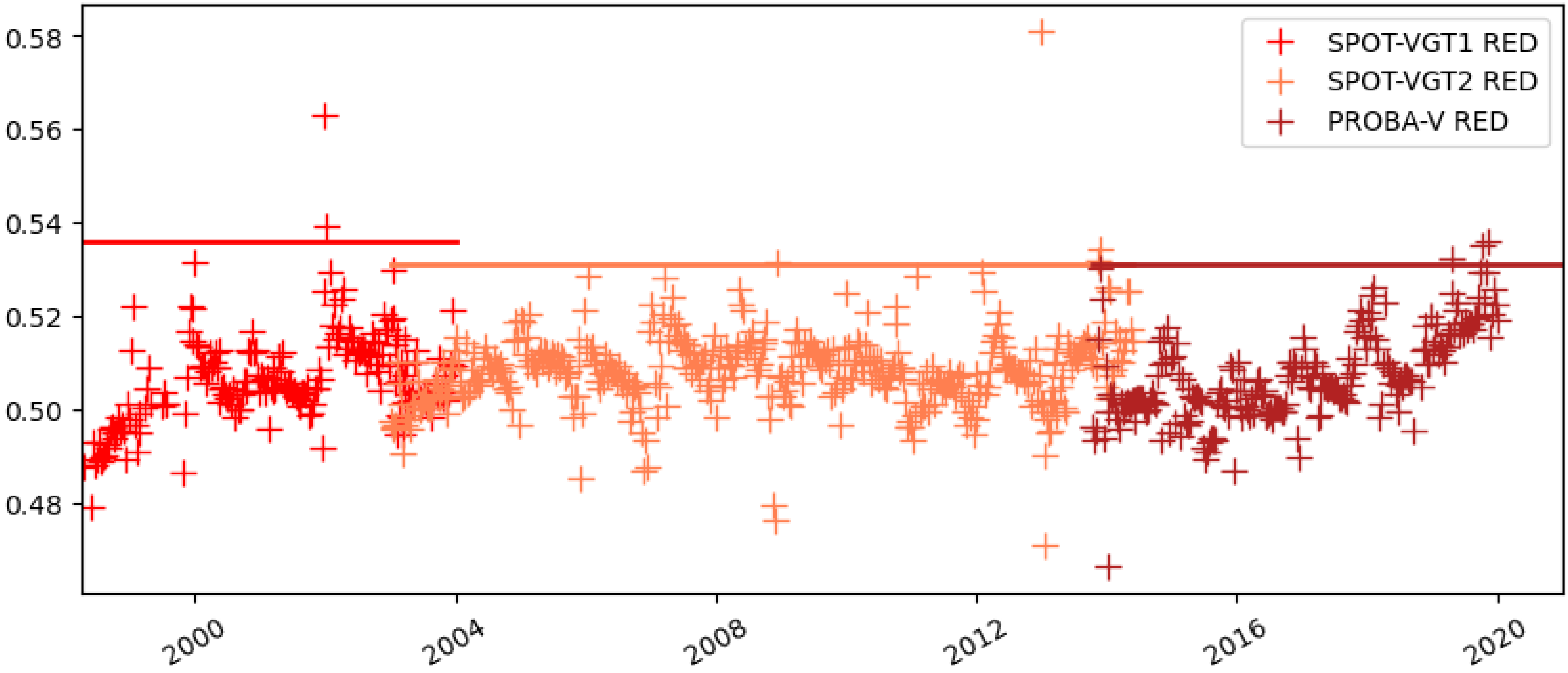
REFERENCE MODEL : ARTDECO

TERRA-MODIS bias vs viewing geometry



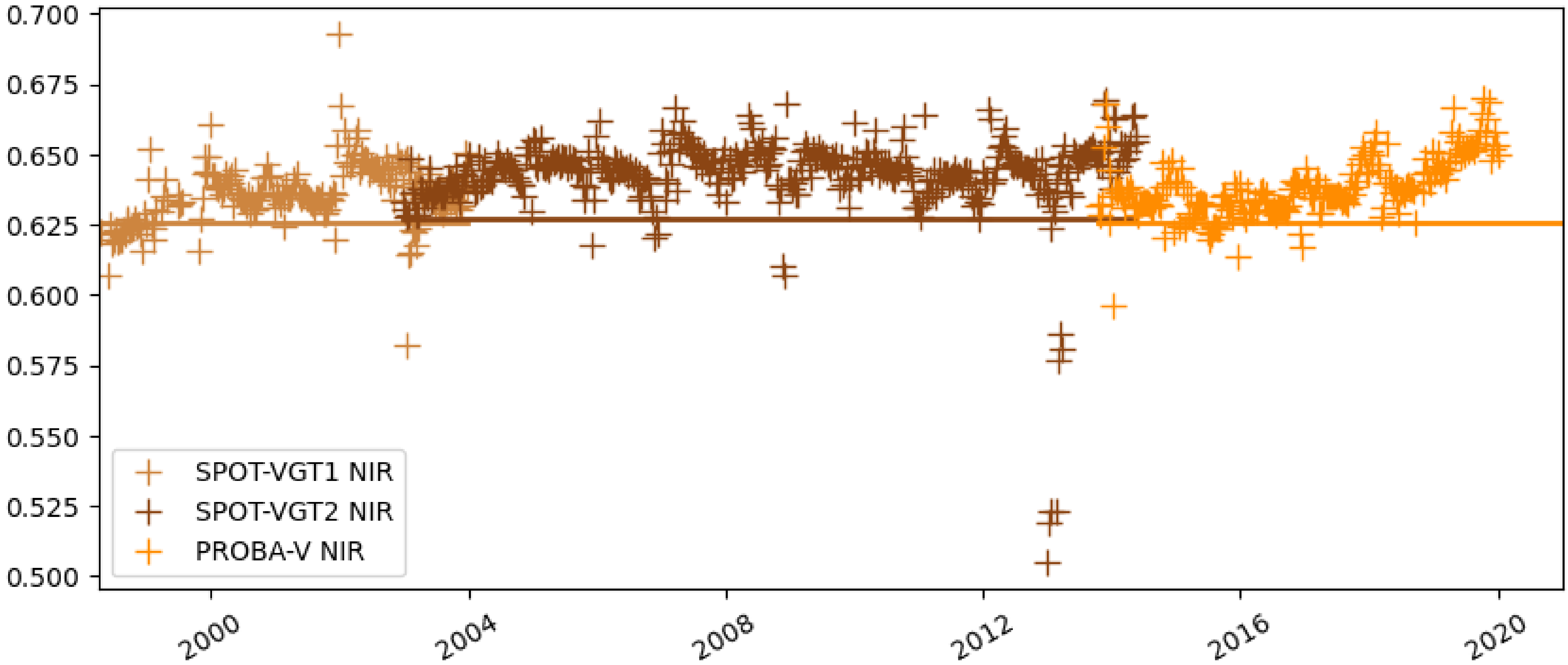
REFERENCE MODEL : RTMOM

Impact on surface albedo retrieval (BHR)



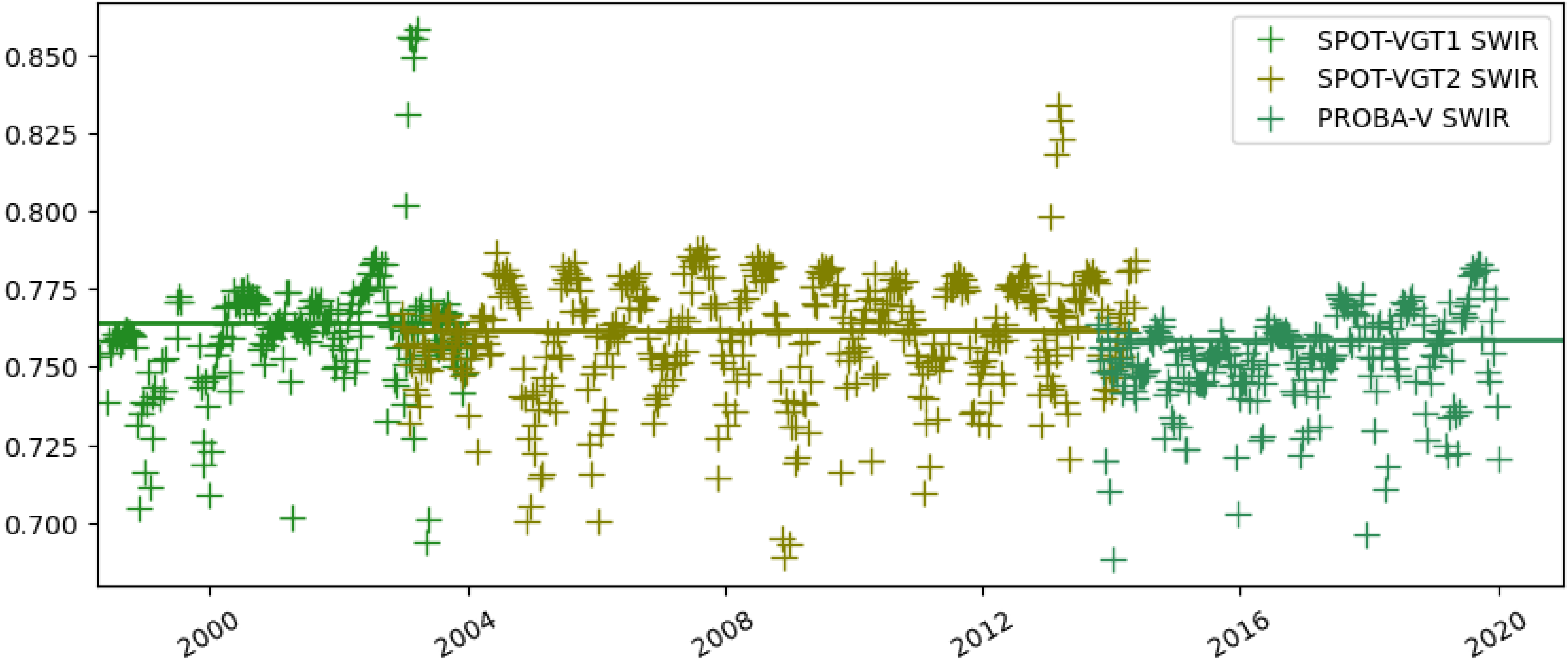
Surface albedo (BHR) retrieval over Libya-4 in the RED band

Impact on surface albedo retrieval (BHR)



Surface albedo (BHR) retrieval over Libya-4 in the NIR band

Impact on surface albedo retrieval (BHR)



Surface albedo (BHR) retrieval over Libya-4 in the SWIR band

Conclusions

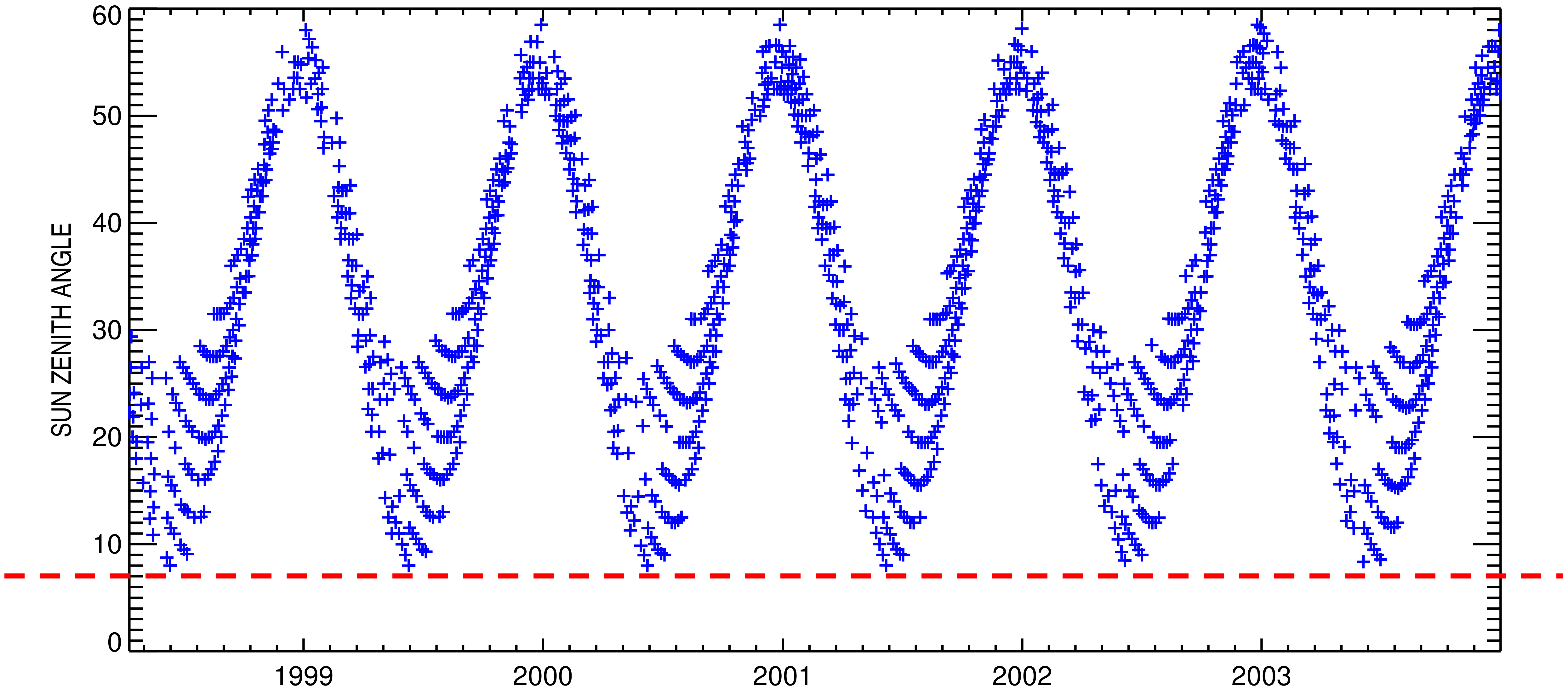
- PROBA-V radiometric calibration seems very reliable;
- VGT-1 and VGT-2 radiometric calibration of the blue still requires additional analysis concerning the Eastward acquisition (polarization?);
- The retrieved surface albedo is very consistent in the red, NIR and SWIR bands;
- Additional work is needed in the blue band that might affect surface albedo retrieval;
- VGT-1, VGT-2 and PROBA-V represent a more than 20 year long (1998 – 2021) data set which is very promising for the generation of climate data records.

THANKS

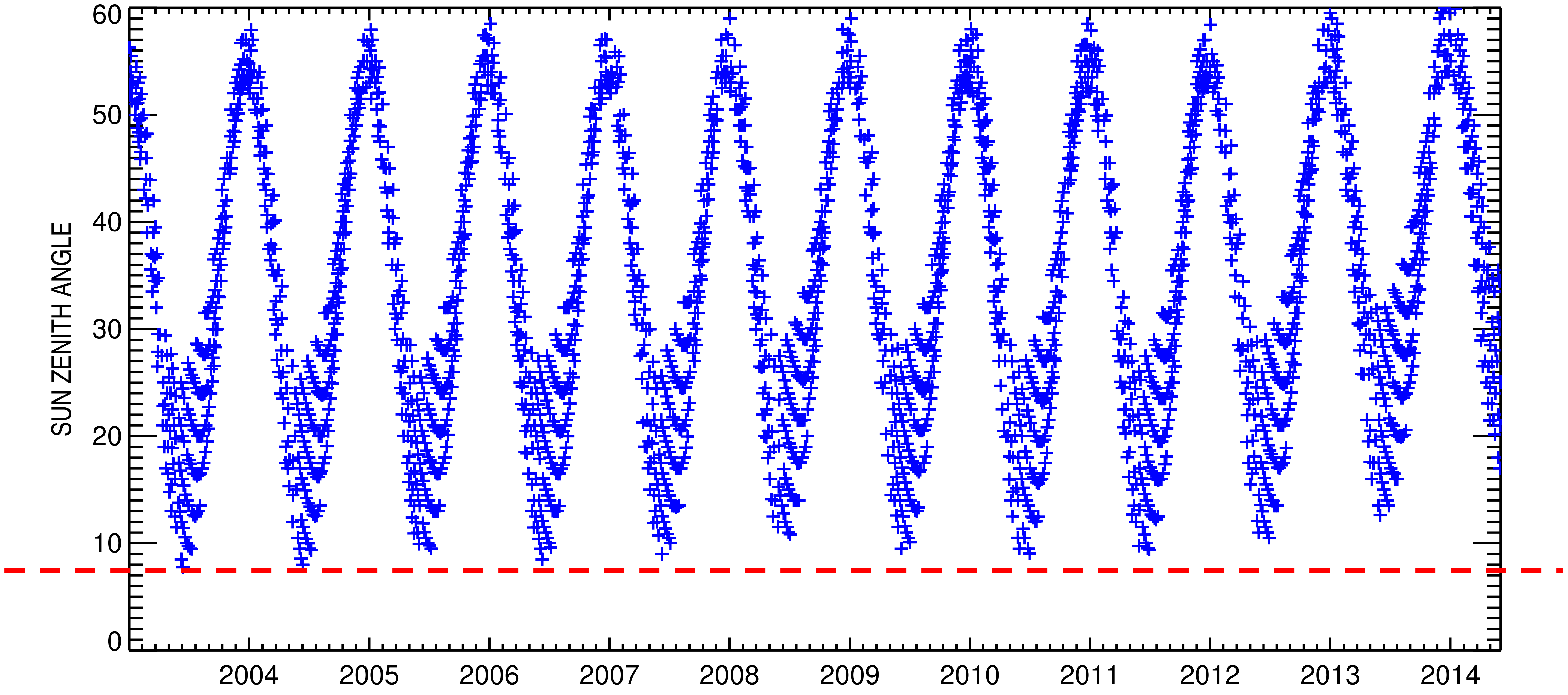
Libya-4 Rayference Calibration Reference (LRCR)

- Characterisation of surface BRF from 300nm to 2800nm with a 1nm spectral resolution (assuming a flat surface for an area >100km^2);
- Characterization of the atmospheric vertical profile and gas concentrations (H2O, O3, CO2, CH4, …);
- Characterization of aerosol type and concentration;
- Simulation of spectral TOA BRF with 4 different models implementing:
  - Different methods to solve the radiative transfer equation;
  - Different assumptions for molecular absorption and its coupling with scattering;
- Can be used from 300nm to 2800nm at about 1 nm spectral resolution for sun and viewing zenith angles up to 65°.

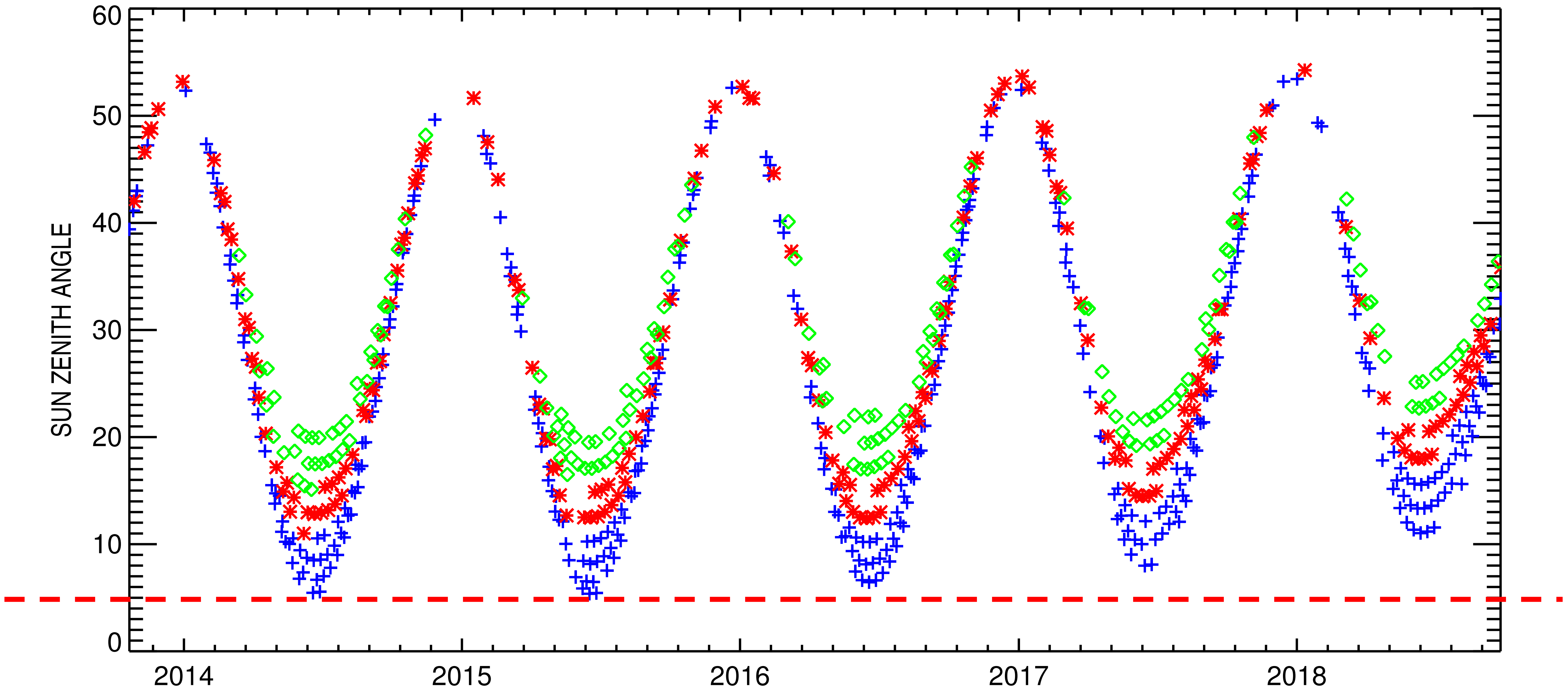
VGT-1 Sun Zenith Angle over Libya-4



VGT-2 Sun Zenith Angle over Libya-4

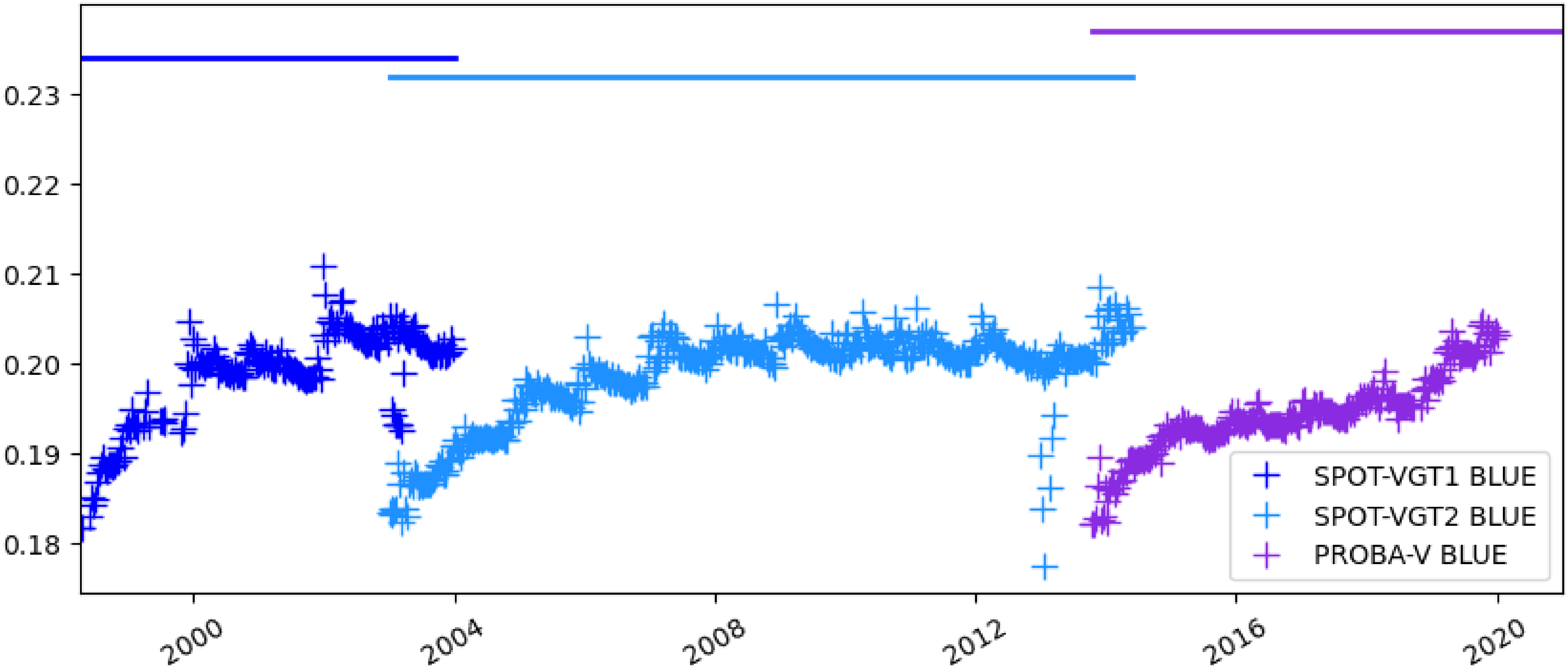


PROBA-V Sun Zenith Angle over Libya-4



LEFT CENTRE RIGHT

Impact on surface albedo retrieval (BHR)



Impact on surface albedo retrieval (BHR)