General Characteristics of LIBYA-4

Patrice Henry, Sophie Lachérade,
Bertrand Fougnie, Bruno Lafrance

General presentation of Libya-4

- Located in t... nd Sea
- Bright sand
- Good unifo
- Very low cl

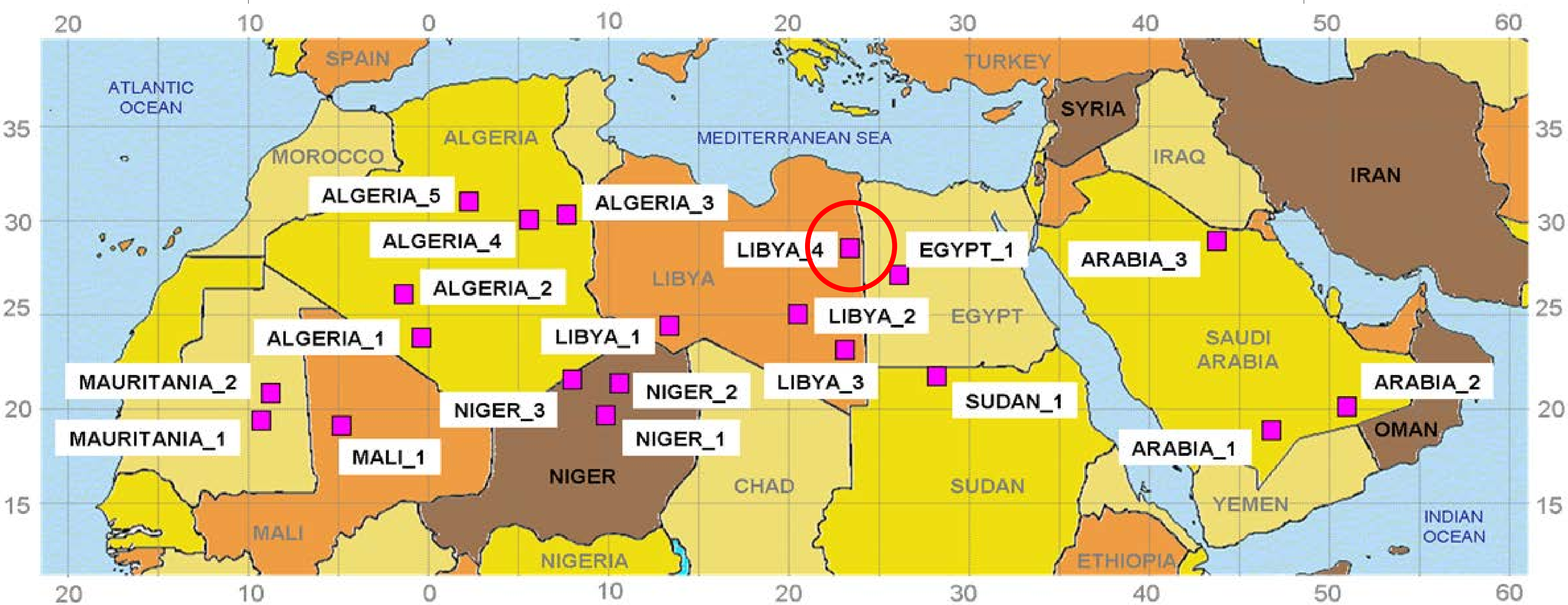
CONTENT

- Where is located Libya-4?
- Spatial and temporal uniformity
- Brightness and spectral behaviour
- Directional behaviour
- Short and long term stability
- Cloud coverage

Where is located the LIBYA-4 site?

Sophie Lachérade
CNES

Libya-4 site location



Latitude : 28.55 **Longitude : 23.39**

Comparison of the "LIBYA-4" sites

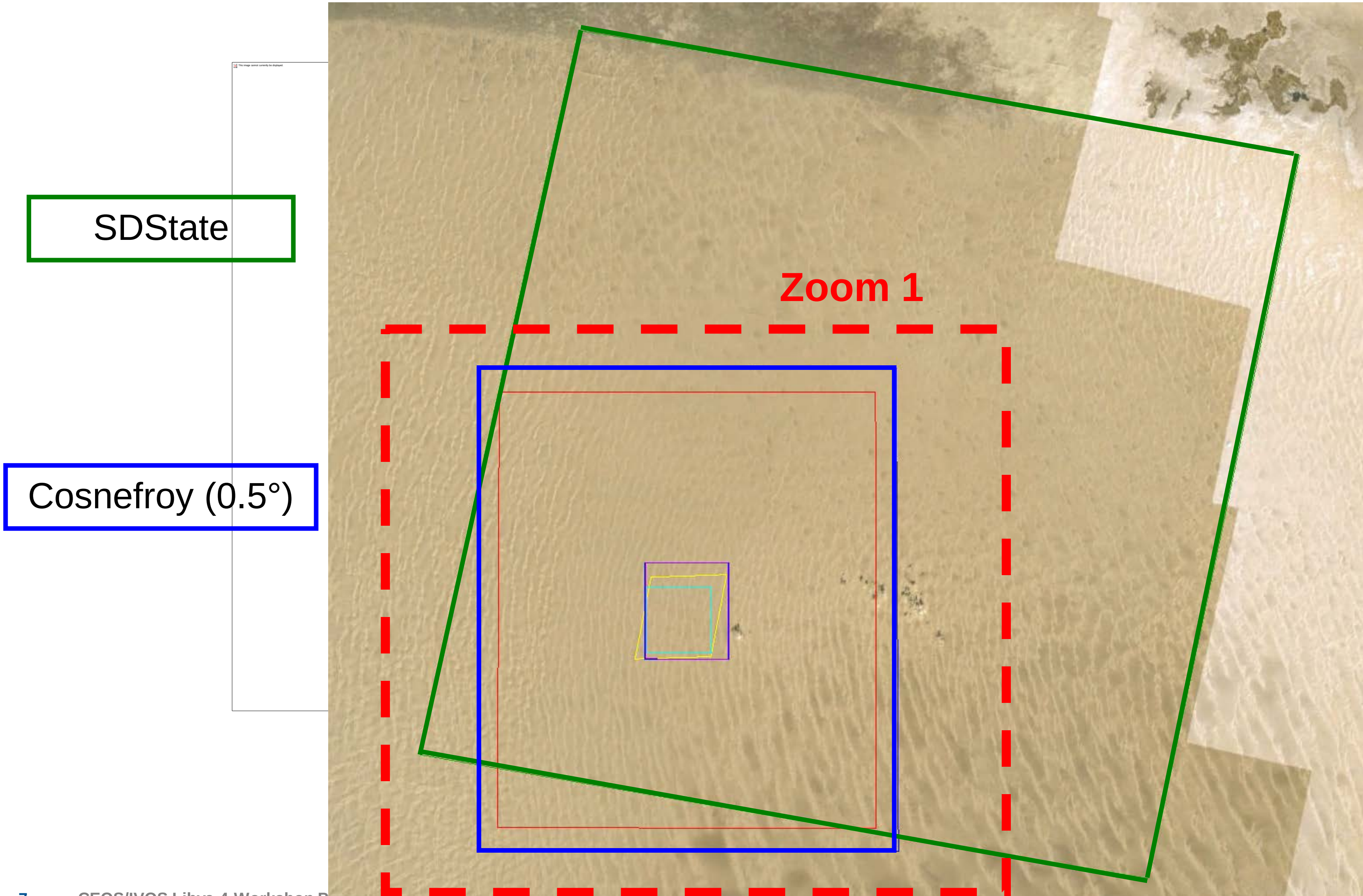
Definition of the LIBYA_4 site for the participants of the workshop:

STFC
DMCII
DIMITRI

	Lat min	Lat max	Lon min	Lon max
Cosnefroy et al (0.5°)	28.05	29.05	22.89	23.89
CNES Standard (0.45°)	28.10	29.00	22.94	23.84
CNES Small (0.1°)	28.45	28.65	23.29	23.49
LANDSAT/MODIS (NASA)	28.45	28.65	23.29	23.49
EUMETSAT	28.46	28.61	23.30	23.45
SDState	27.991	29.754	23.127	24.862
VITO	28.45	28.62	23.27	23.48

Useful but not very easy to compare!!!

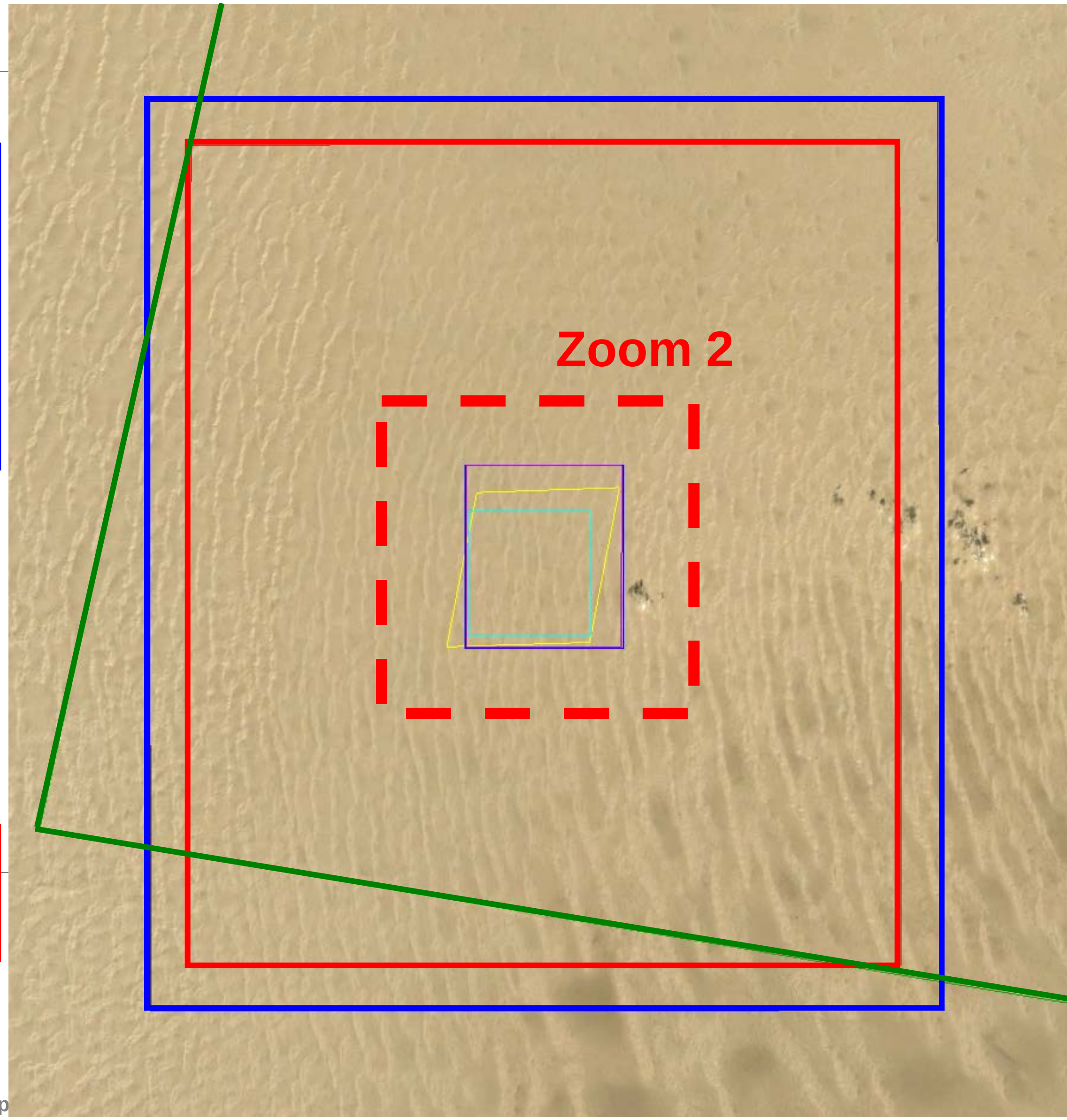
Comparison of the “LIBYA-4” sites



Comparison of the "LIBYA-4" sites

Cosnefroy (0.5°)
DIMITRI
STFC
DMCII

CNES std (0.45°)
METRIC

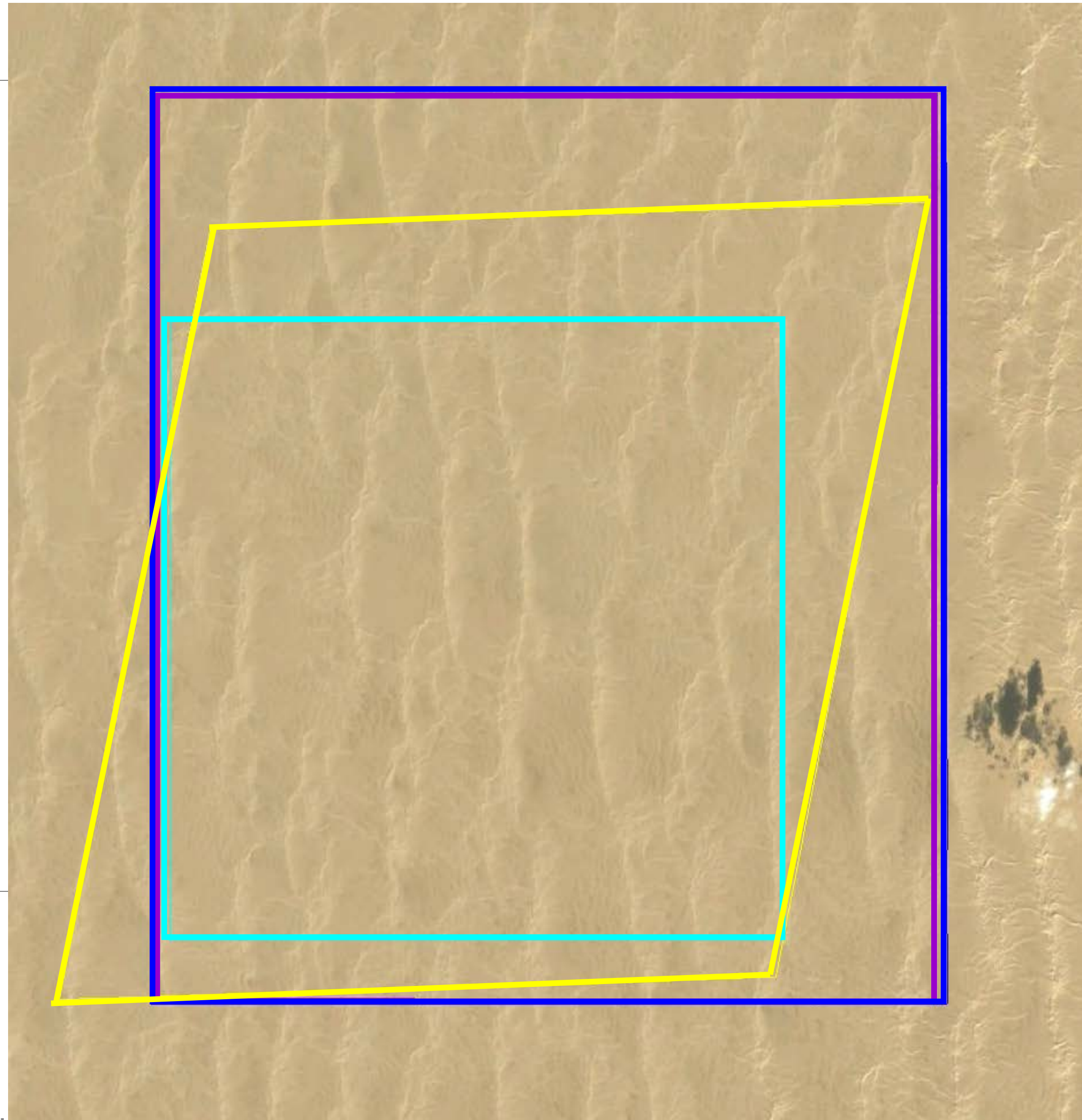


SDState

Comparison of the "LIBYA-4" sites

CNES small
(0.1°)

NASA
(LANDSAT/
MODIS)



VITO

EUMETSAT

Spatial & temporal uniformity

Bruno Lafrance, Patrice Henry
CS CNES

Rationale for a uniform site

- Calibration over desert sites requires a statistical approach over a large amount of measurements acquired at different dates

- Lowest is the spatial and temporal variability, best is the statistical validity

- A good spatial uniformity of the site is mandatory to cope with
  - Sensors location unaccuracy
  - Extraction method approximations
  - Difference of sensors footprint over the site
    - Pleiades → 20 km
    - SPOT → 60 km
    - VGT → 100 km (full site coverage)

- Spatial uniformity has to be analyzed over time series

Spatial uniformity

- Standard deviation computed over the whole image (TOA) of the site

Sensor	Blue	Green	Red	NIR	SWIR
VGT1	2.5%	NA	2.1%	2.0%	1.6%
VGT2	2.4%	NA	2.2%	1.9%	1.6%
MERIS	2.3%	2.7%	2.4%	2.2%	NA
MODIS	1.9%	2.3%	2.3%	2.0%	1.4%
SeaWiFS	1.9%	2.4%	2.2%	2.0%	NA
Parasol	2.2%	1.8%	1.6%	1.4%	NA

⇒ very good uniformity of the site

- Libya-4 is one of the most uniform desert site

Name	443 nm	665 nm	865 nm
Mali-1	2.3%	2.0%	1.7%
Sudan-1	2.7%	2.1%	2.0%
Arabia-1	2.6%	2.1%	2.3%
Arabia-2	3.5%	1.8%	1.7%
Egypt-1	4.0%	1.8%	1.6%
Libya-4	2.6%	2.6%	2.3%
Niger-2	2.2%	2.8%	2.8%
Algeria-1	3.0%	2.6%	2.7%
Algeria-5	2.9%	3.0%	2.7%
Mauritania-1	4.1%	2.4%	2.2%
Niger-1	3.6%	3.0%	2.7%
Algeria-3	4.8%	2.4%	2.6%
Mauritania-2	3.8%	3.3%	2.9%
Libya-1	3.5%	3.5%	3.6%
Algeria-2	4.5%	3.1%	3.1%
Niger-3	4.4%	3.8%	3.7%
Libya-3	4.7%	3.8%	3.8%
Algeria-4	5.9%	3.4%	3.7%
Libya-2	6.9%	3.1%	3.1%
Arabia-3	8.8%	3.7%	4.3%

Relative standard deviation on the TOA reflectance over the site for a 4-years MERIS archive (in %)

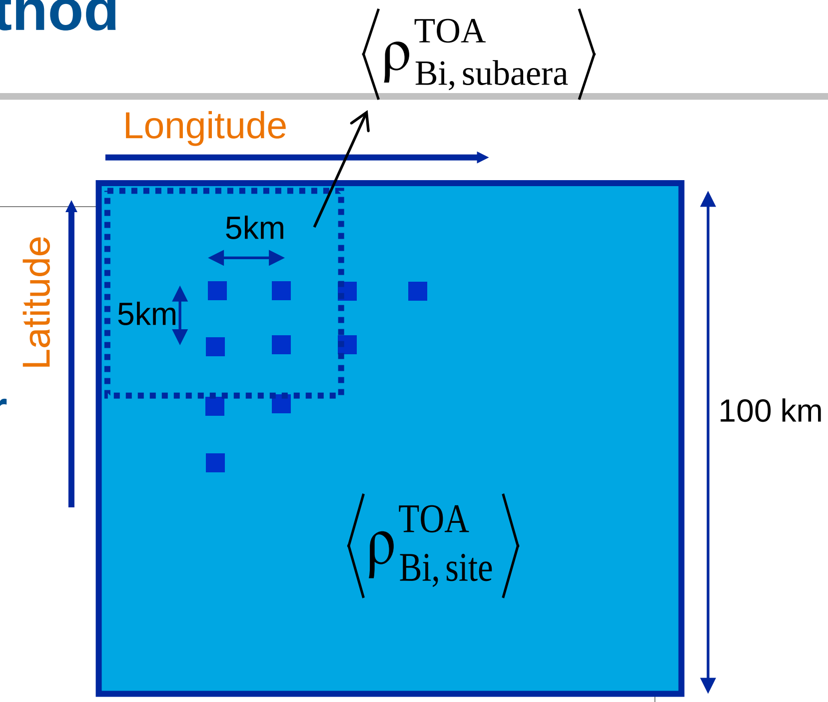
Data used for homogeneity analysis

- **AQUA / MODIS images**
  - **1 km resolution**
  - **Use of 4 spectral bands**
    - » **Blue** band 3 470 nm
    - » **Green** band 4 555 nm
    - » **Red** band 1 650 nm
    - » **NIR** band 2 865 nm
  - **59 acquisitions in 2009 (January to October)**
  - **Cloud filtering by using the MODIS cloud mask→ 25 acquisitions used (cloud free)**

- **Some THEOS images (15 m) used to check the uniformity at high resolution range**

Method

- **Subaera definition**
  - **15 x 15 subarea of 20km side**
  - **Shift of 5 km between two subareas**



- **Calculation of mean reflectance for**
  - **The site**
  - **Each 225 subareas**

- **Spectral and temporal parameters**
  - **Spectral parameter**

$$\mathrm{RMS}(\mathrm{d},\mathrm{sub}) = \sqrt{\frac{1}{4} \times \sum_{i=1}^{4} \left(\frac{\left\langle \rho^{TOA}_{Bi,\,subaera} \right\rangle - \left\langle \rho^{TOA}_{Bi,\,site} \right\rangle}{\left\langle \rho^{TOA}_{Bi,\,site} \right\rangle} \right)^2}$$

Relative Root Mean Square between reflectance of the site and reflectance of the subarea
→ combines the spectral information (by date of acquisition, by subarea)

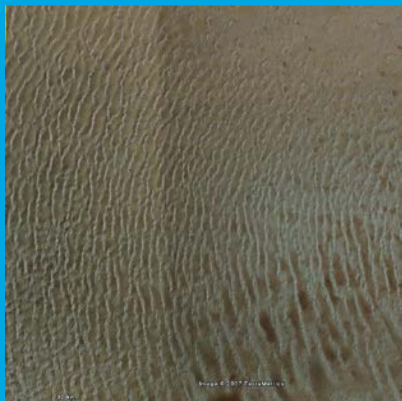
  - **Temporal parameter**

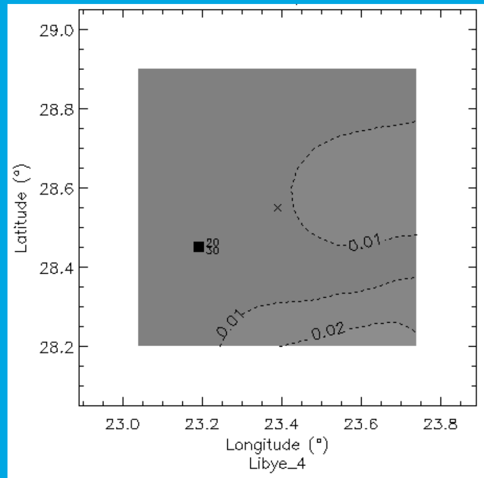
$$\mathrm{TRMS}(\mathrm{sub}) = \sqrt{\frac{1}{N} \times \sum_{d=1}^{N} \mathrm{RMS}^2(\mathrm{d},\mathrm{sub})}$$

Temporal Relative Root Mean Square
→ adds the temporal information (by subarea)

Results

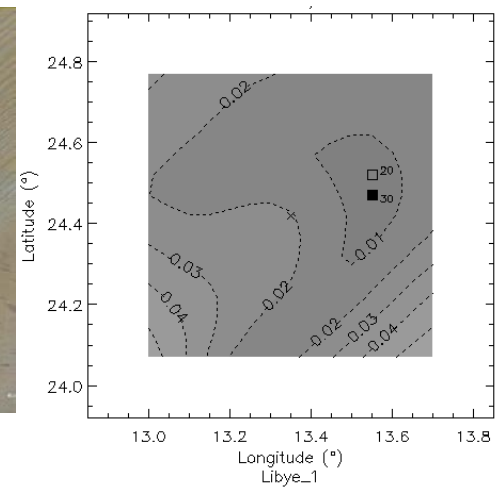
Libya 4



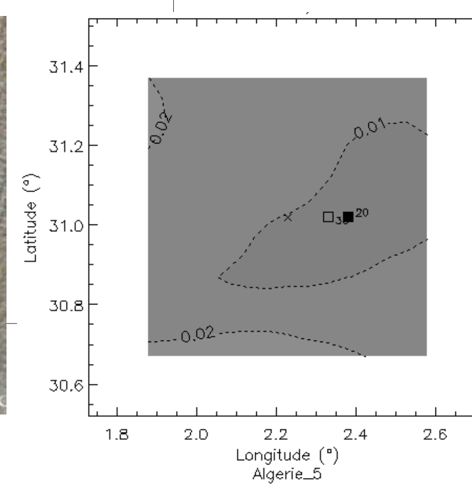


TRMS value : Root Mean Square over the temporal set

Libya 1



Algeria 5



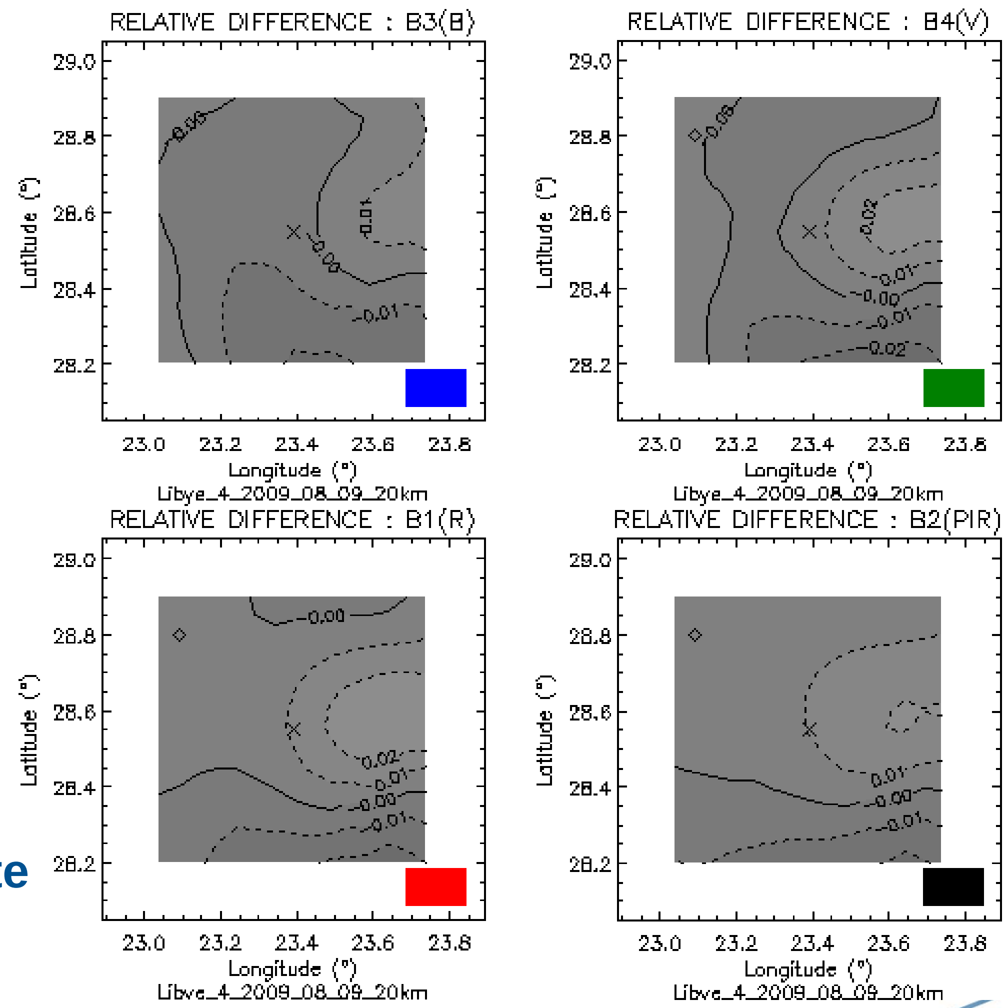
- **A site with a good homogeneity**
- **Very similar results with the subarea size of 20 km and 30 km**

Uniformity in the spectral range

- **Similar uniformity signature for the different spectral bands**
  - Slight evolution from PIR to blue
  - Subareas and whole image mean reflectance difference < 0.025

Name	σ_{20km}
Mali 1	0.40%
Algeria 5	0.45%
Niger 2	0.50%
Libya 4	0.53%
Sudan 1	0.56%
Niger 3	0.57%
Egypt 1	0.72%
Algeria 1	0.76%
Algeria 2	0.78%
Arabia 2	0.85%
Arabia 1	0.90%
Libya 3	0.91%
Niger 1	0.96%
Mauritania 1	0.97%
Libya 1	1.05%
Mauritania 2	1.16%
Algeria 3	1.20%
Libya 2	1.52%
Algeria 4	1.56%
Arabia 3	2.32%

- **From spatial, temporal and spectral point of views, Libya-4 is classified as an homogeneous site**



Site homogeneity: comparison between Libya_4 and Niger_2

LIBYA_4

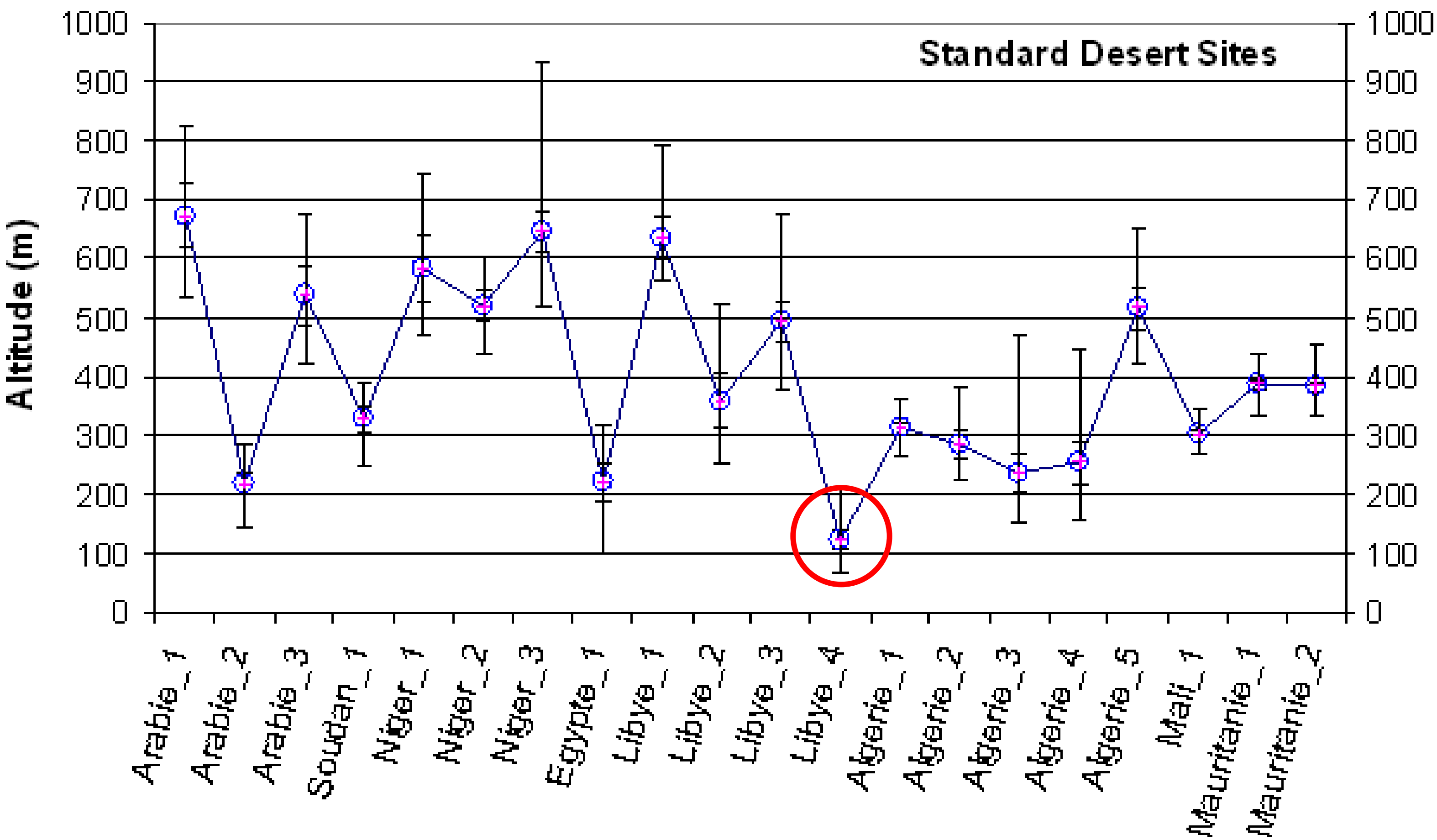
NIGER_2

Pleiades_1A images

Structure and DTM

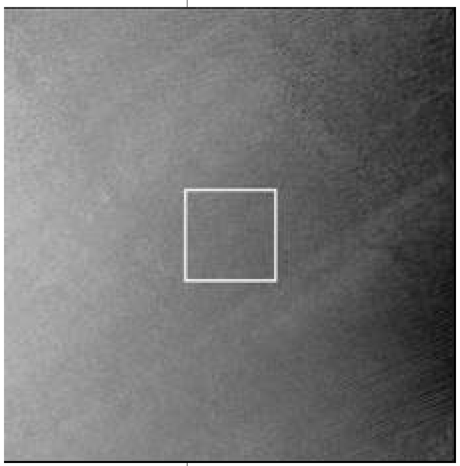
Patrice Henry
CNES

Site altitude: Libya-4 vs other desert sites



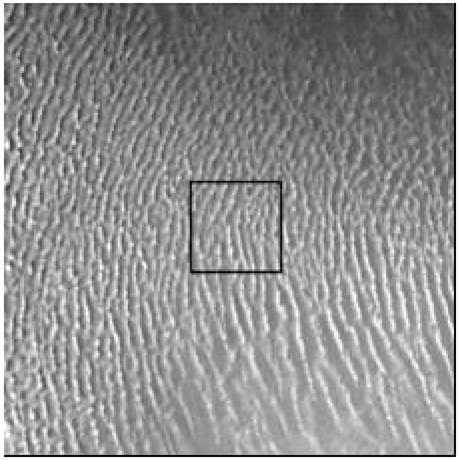
Libya-4 has the lowest altitude among all desert sites and small altitude variation

Site DTM: Libya-4 vs other desert sites



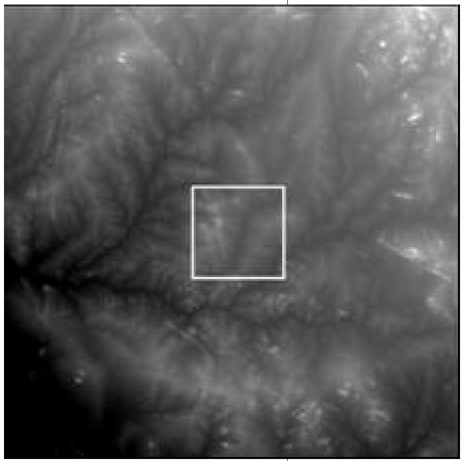
Mali-1 DTM (SRTM)

Altmoy.	stdev	min.	max.
304.0	6.9	271	342



Libya-4 DTM (SRTM)

Altmoy.	stdev	min.	max.
123.4	17.9	66	215



Niger-3 DTM (SRTM)

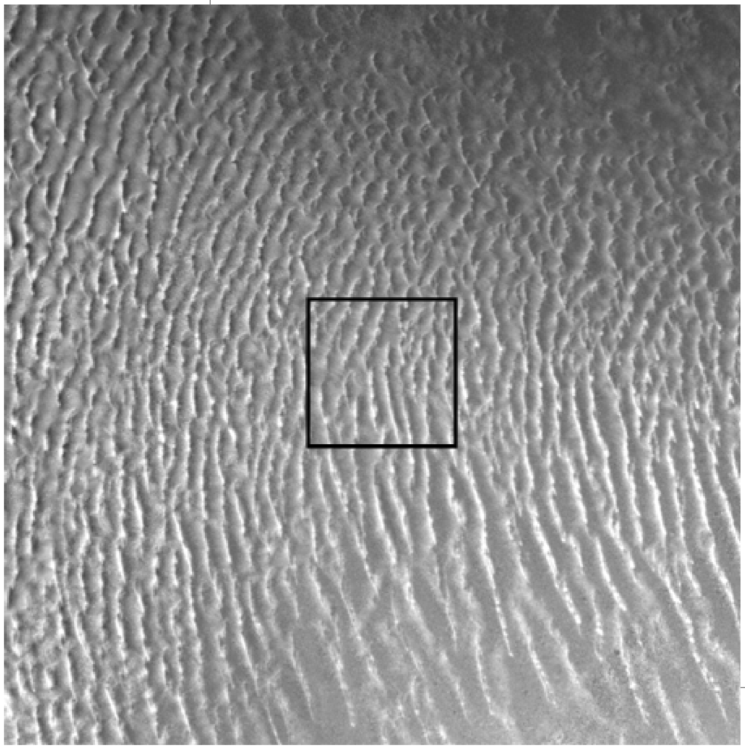
Altmoy.	stdev	min.	max.
645.2	33.2	518	932

Libya-4 is not the most flat but much better than some other sites…

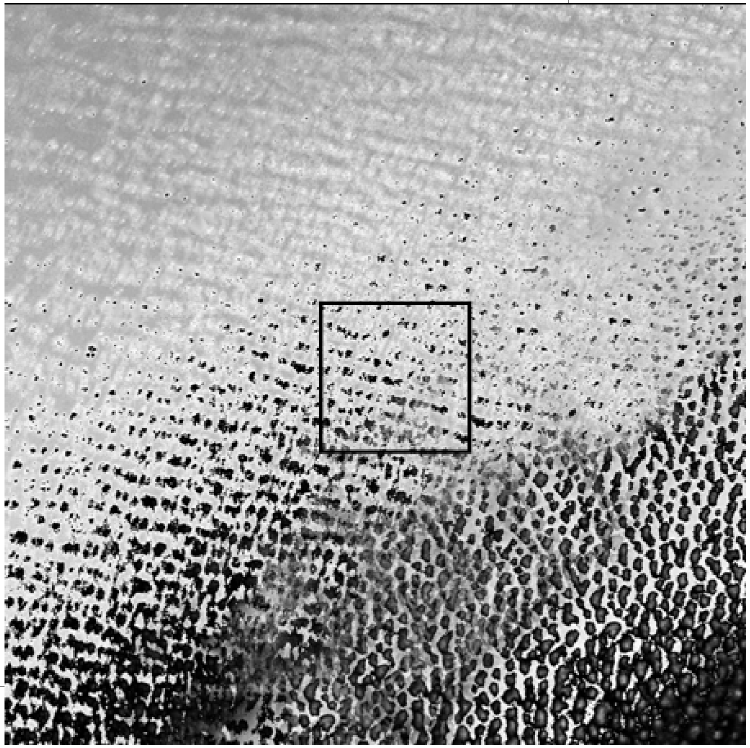
Elevation: comparison between Libya-4 and Algeria-3

Alt aver.	Alt stdev	Alt min.	Alt max.
122.7	18.7	64	222

Alt aver.	Alt stdev	Alt min.	Alt max;
235.4	35.8	142	484



LIBYA-4 DTM (SRTM)



ALGERIA-3 DTM (SRTM)

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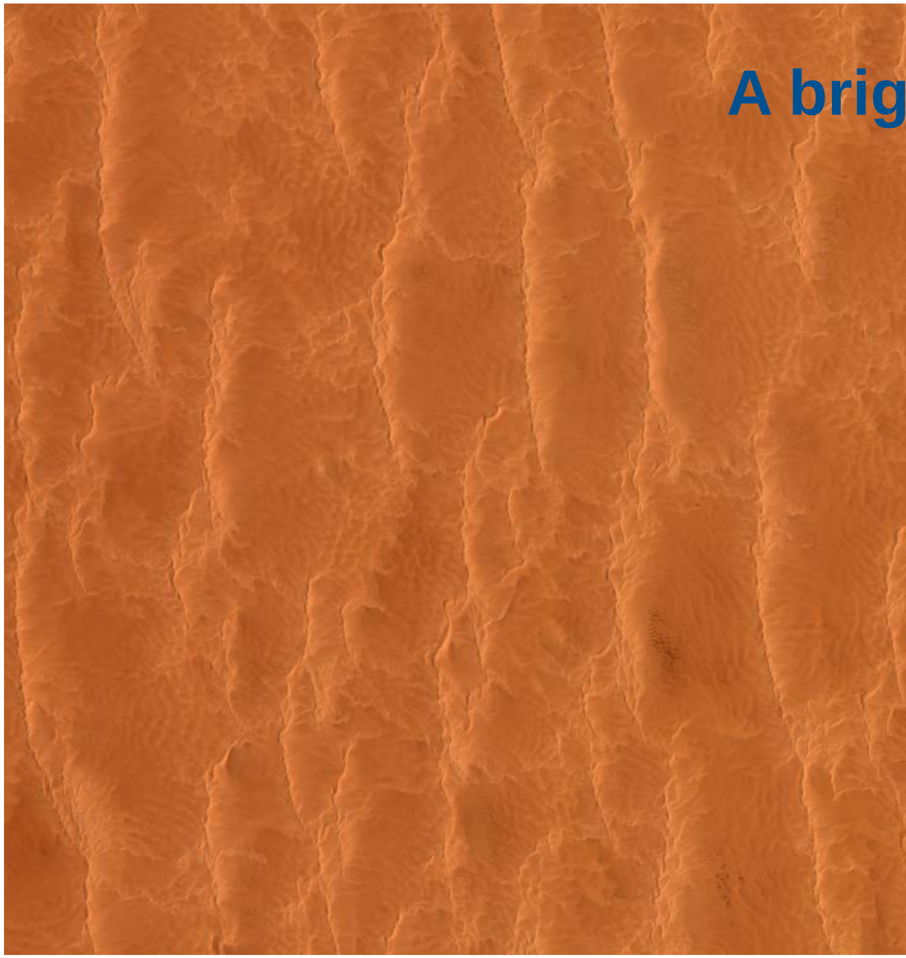
Brightness and spectral behaviour

Bertrand Fougnie, Patrice Henry
CNES

Site brightness: comparison between Libya_4 and Niger_2

A bright site!



LIBYA-4

NIGER-2

Pleiades-1A images

Mean reflectance

Name		443 nm	665 nm	865 nm
Libya-1		0.141	0.556	0.649
Libya-2		0.187	0.539	0.632
Algeria-5		0.110	0.526	0.625
Libya-4		0.190	0.530	0.624
Mali-1		0.181	0.538	0.619
Niger-1		0.163	0.531	0.618
Egypt-1		0.185	0.518	0.617
Mauritania-1		0.147	0.515	0.606
Algeria-4		0.130	0.495	0.591
Mauritania-2		0.119	0.484	0.578
Libya-3		0.123	0.496	0.577
Algeria-3		0.106	0.485	0.576
Sudan-1		0.163	0.482	0.565
Algeria-2		0.140	0.479	0.563
Arabia-1		0.141	0.467	0.556
Arabia-2		0.161	0.463	0.539
Niger-2		0.150	0.449	0.529
Algeria-1		0.144	0.430	0.515
Niger-3		0.140	0.435	0.513
Arabia-3		0.135	0.417	0.498

Sites listed from the brighter to the darker in band 865 nm

Name		443 nm	665 nm	865 nm
Libya-4		0.190	0.530	0.624
Libya-2		0.187	0.539	0.632
Egypt-1		0.185	0.518	0.617
Mali-1		0.181	0.538	0.619
Niger-1		0.163	0.531	0.618
Sudan-1		0.163	0.482	0.565
Arabia-2		0.161	0.463	0.539
Niger-2		0.150	0.449	0.529
Mauritania-1		0.147	0.515	0.606
Algeria-1		0.144	0.430	0.515
Libya-1		0.141	0.556	0.649
Arabia-1		0.141	0.467	0.556
Algeria-2		0.140	0.479	0.563
Niger-3		0.140	0.435	0.513
Arabia-3		0.135	0.417	0.498
Algeria-4		0.130	0.495	0.591
Libya-3		0.123	0.496	0.577
Mauritania-2		0.119	0.484	0.578
Algeria-5		0.110	0.526	0.625
Algeria-3		0.106	0.485	0.576

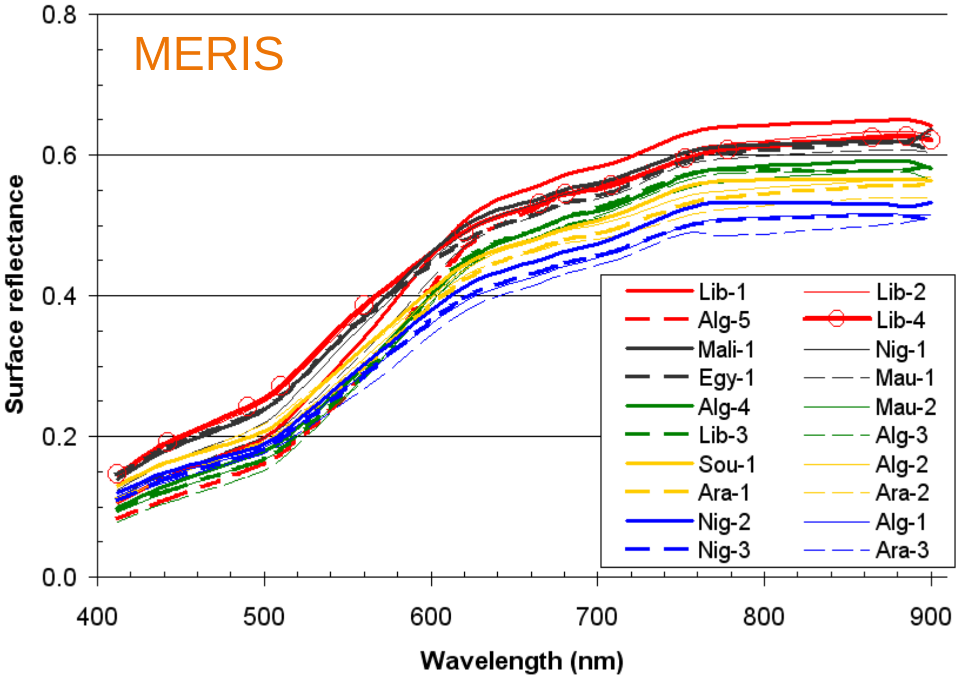
Sites listed from the brighter to the darker in band 443 nm

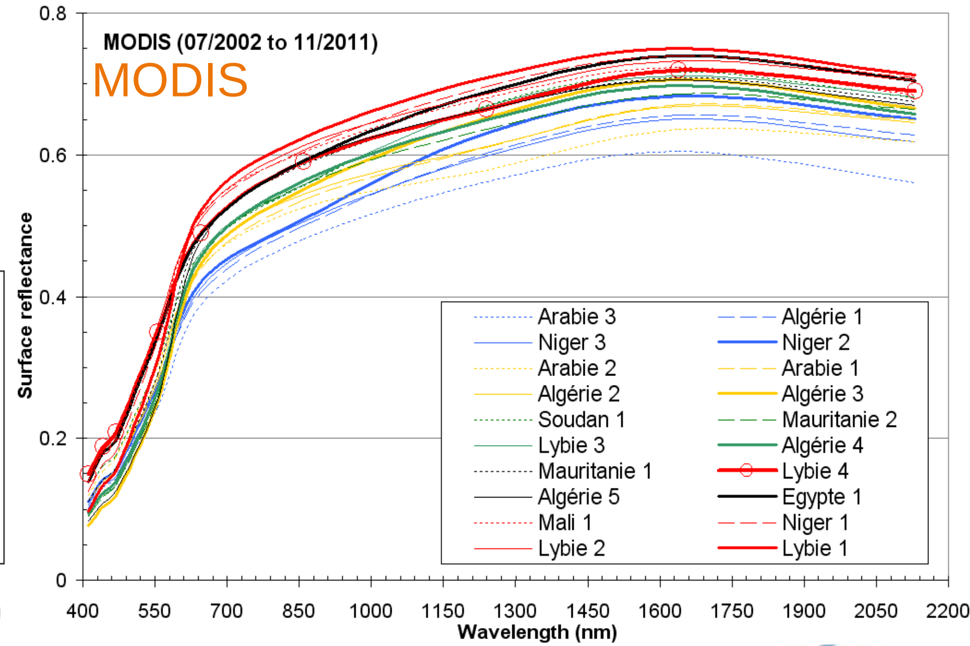
Mean reflectance computed over a 4-year time series of MERIS data

cnes

Magnitude and spectral behaviour

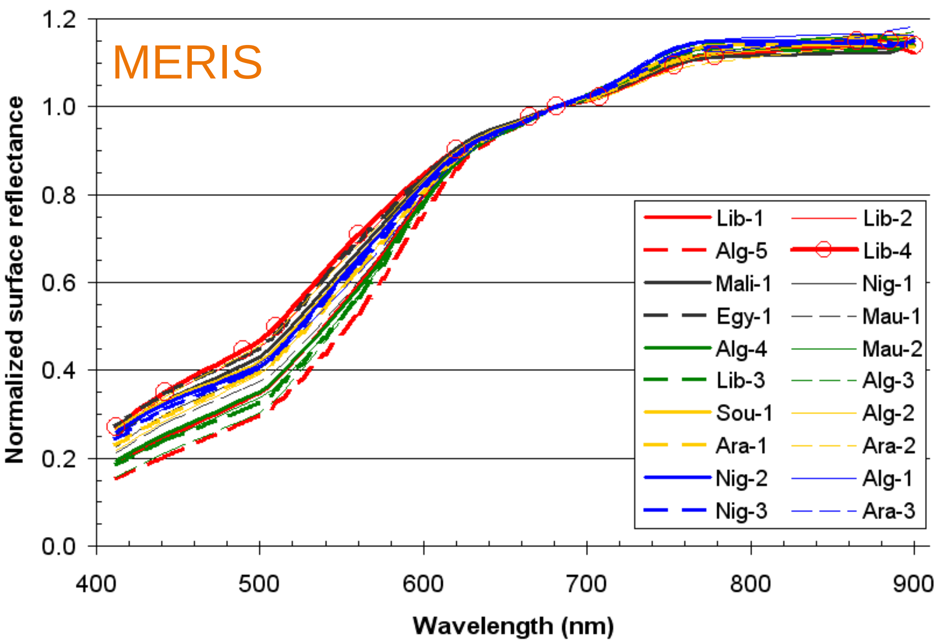
- Magnitude :
  - BOA mean values derived from MERIS (2006-2009) and MODIS (2002-2011)
  - compared to other desert sites :
    - the brighter site in blue - R(443)=0.2
    - one of the brighter sites in NIR - R(865)=0.625
    - relatively common in SWIR – R(1640)=0.72

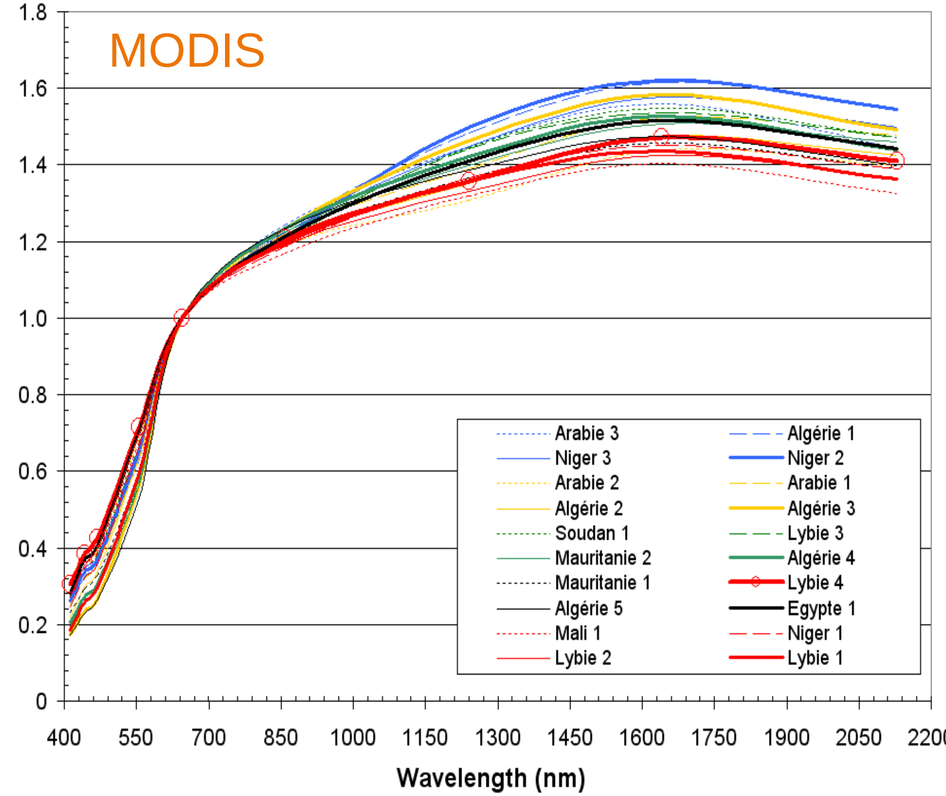




Magnitude and spectral behaviour

- Spectral ratio – normalized by 670nm
  - BOA mean values derived from MERIS (2006-2009) and MODIS (2002-2011)





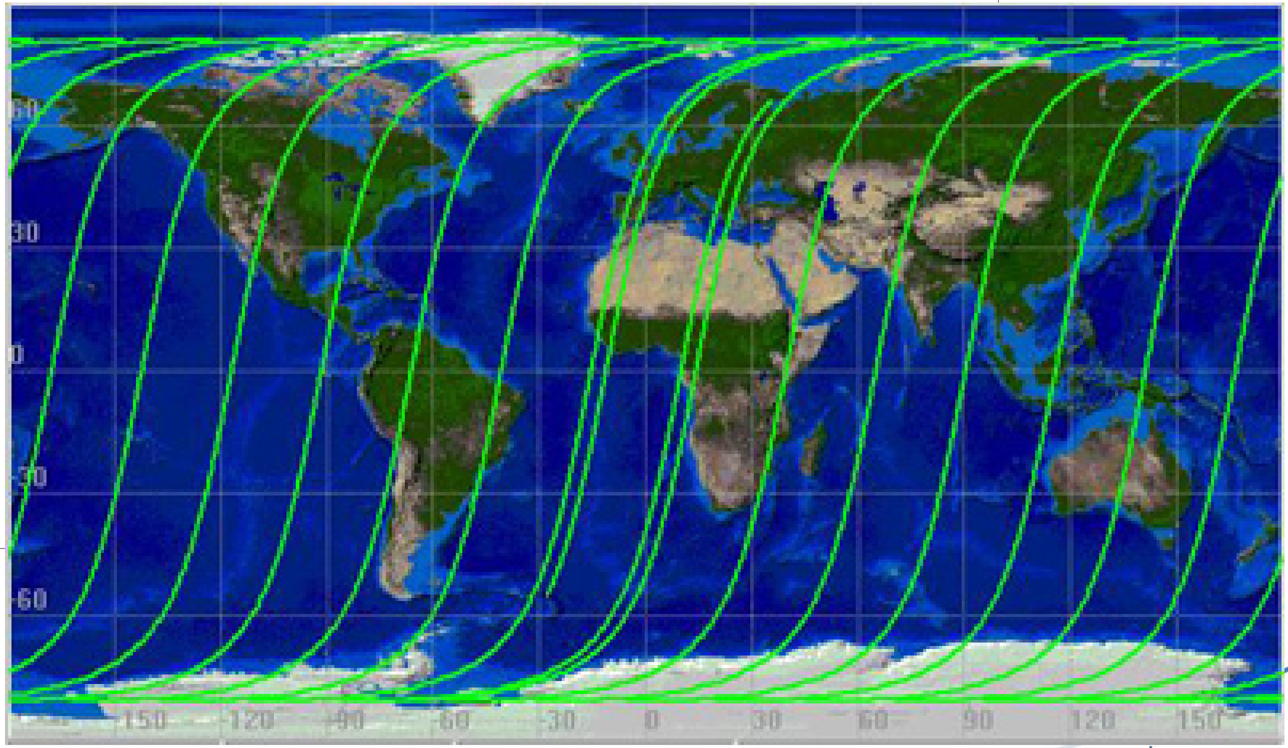
Directional behaviour

Patrice Henry
CNES

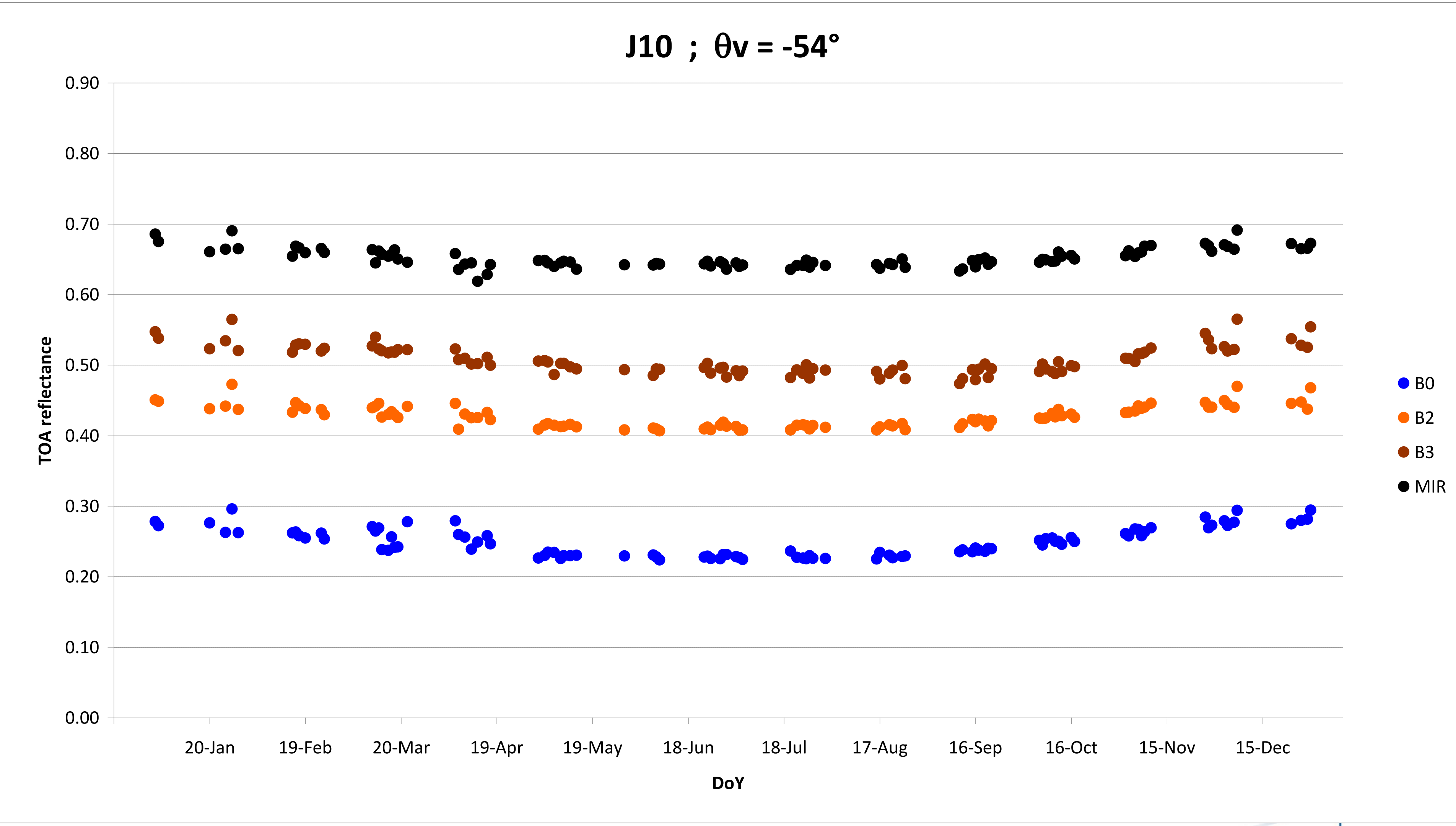
How to illustrate directional effects?

- In time series, directional effect are induced both by the variety of sun angles and viewing angles ⇒ difficult to display in a 2D illustration
- Directional effect due to the sun can be showed through a plot of the reflectance along the year for a given viewing direction
- In a second step the different selected viewing directions can be compared

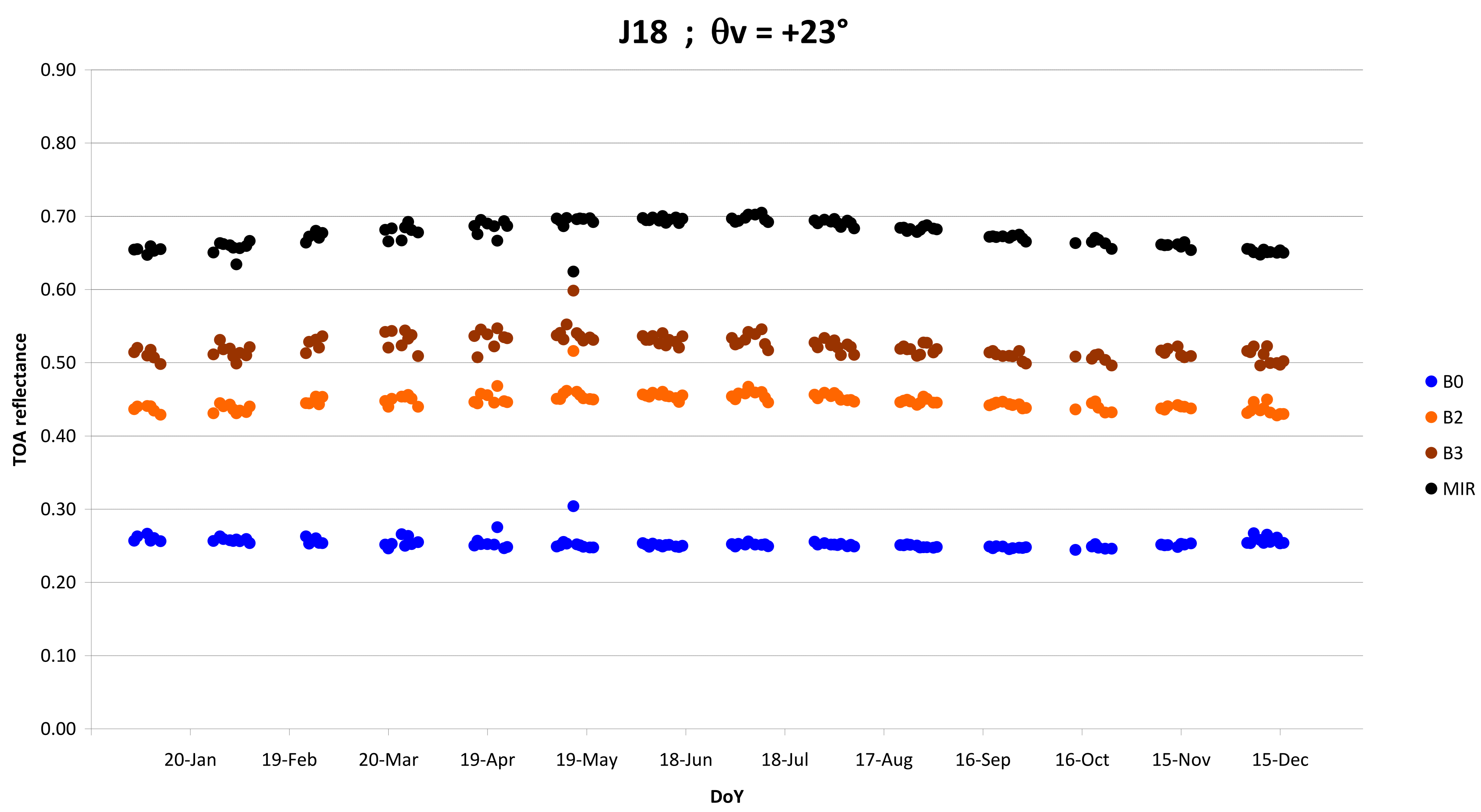
- For practical reason, most of the satellites have a cycling orbit: identical overpass after 'N' days
- The idea is to put together all the data acquired for a given day of this orbit cycle (Jn)
- Example: SPOT cycle duration = 26 days



VGT2 TOA Reflectance vs Day of Year



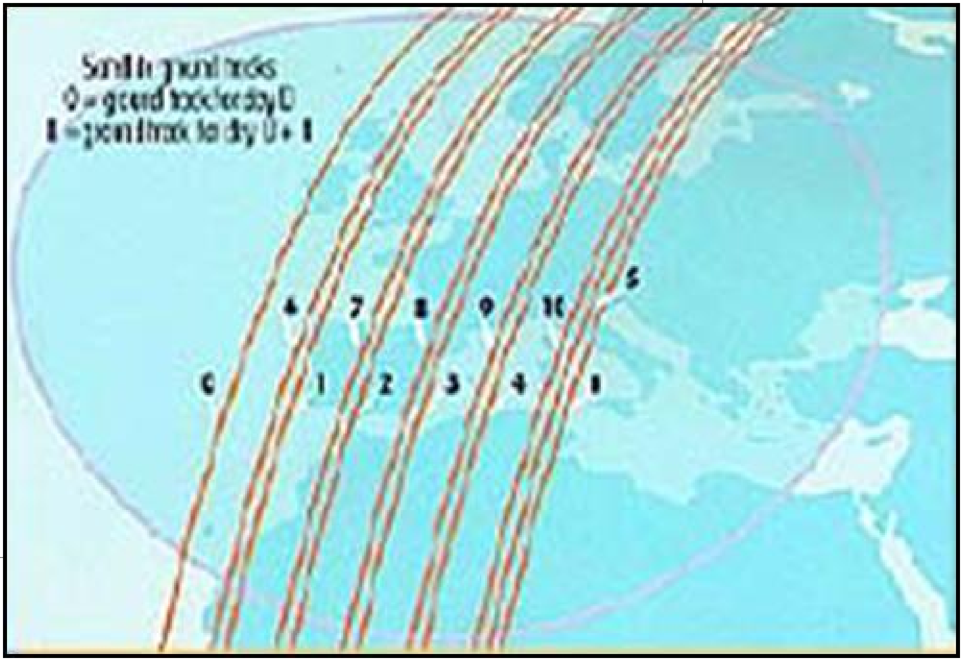
VGT2 TOA Reflectance vs Day of Year



How to illustrate directional effects?

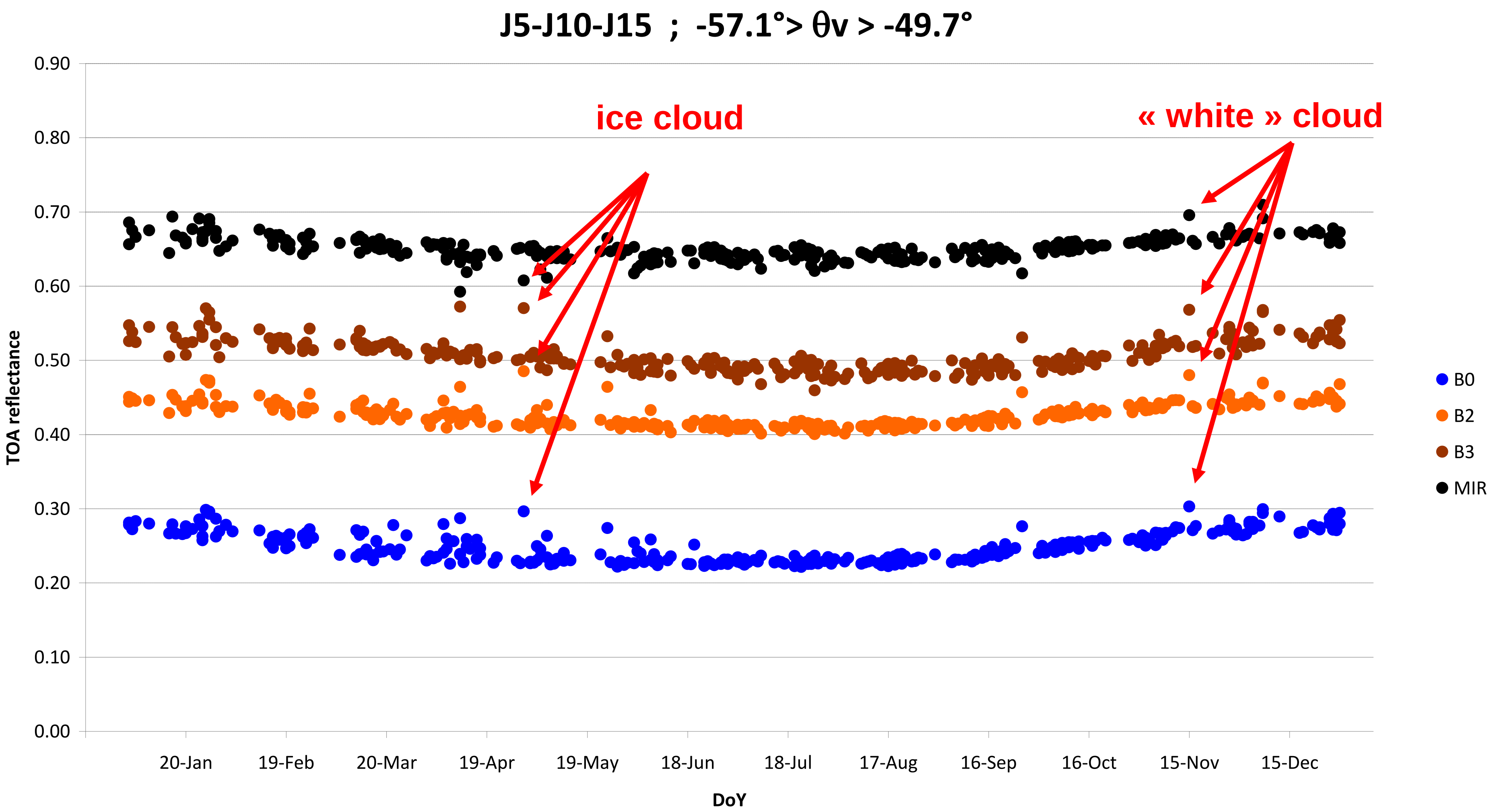
- Because the length of the SPOT satellite cycle
  - Poor temporal coverage over the year (even with 10 years of data)
  - Directional effect due to viewing conditions difficult to appreciate
  - Very poor coverage when plotting over 10 years

  - After 5 days SPOT overpass the site with near similar viewing conditions
  - The idea is to gather data acquired for 1day of the orbit cycle with data acquired during the same day of the previous and the next subcycles: Jn-5/Jn/Jn+5

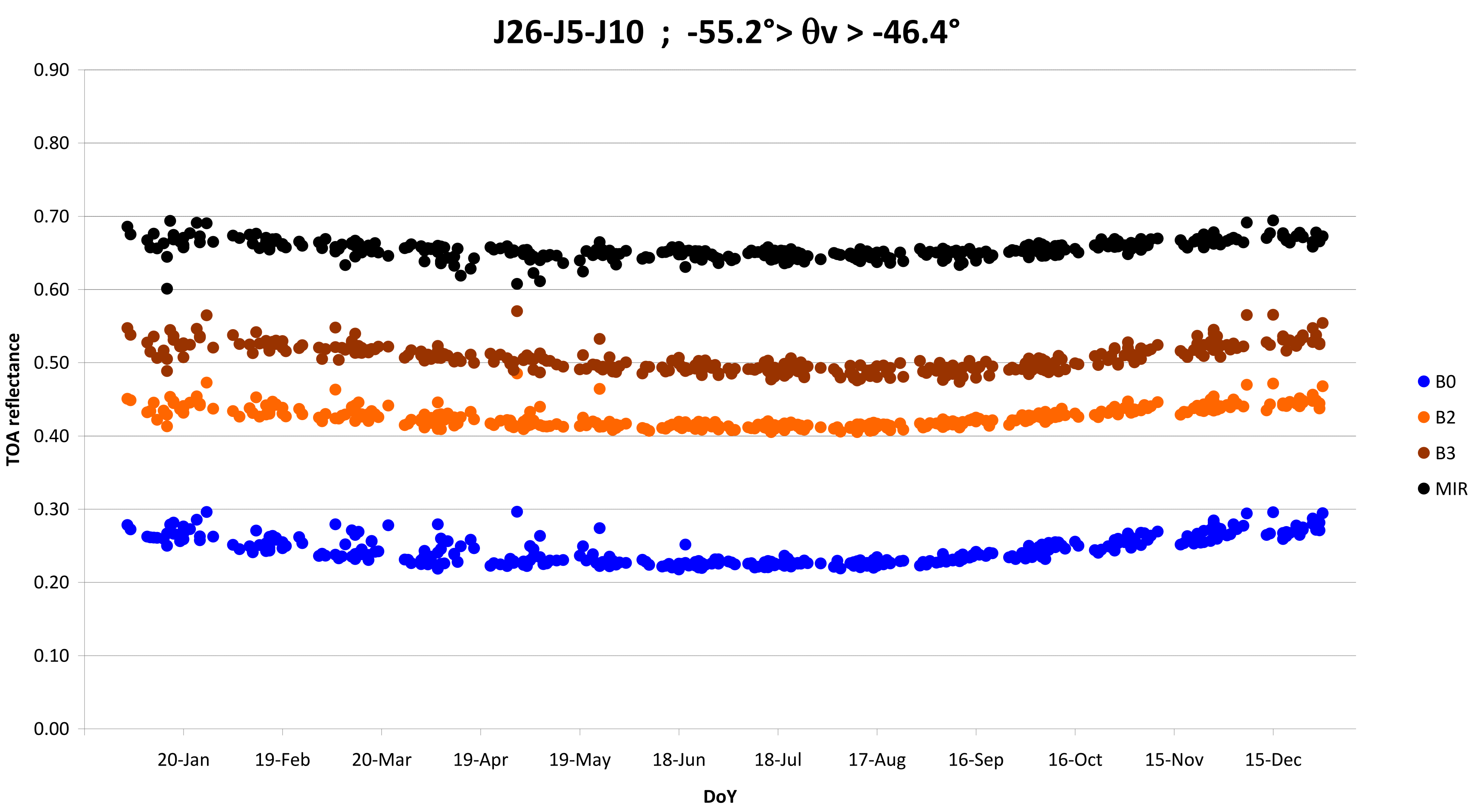


same day of 3 successive subcycles

VGT2 TOA Reflectance vs Day of Year



VGT2 TOA Reflectance vs Day of Year



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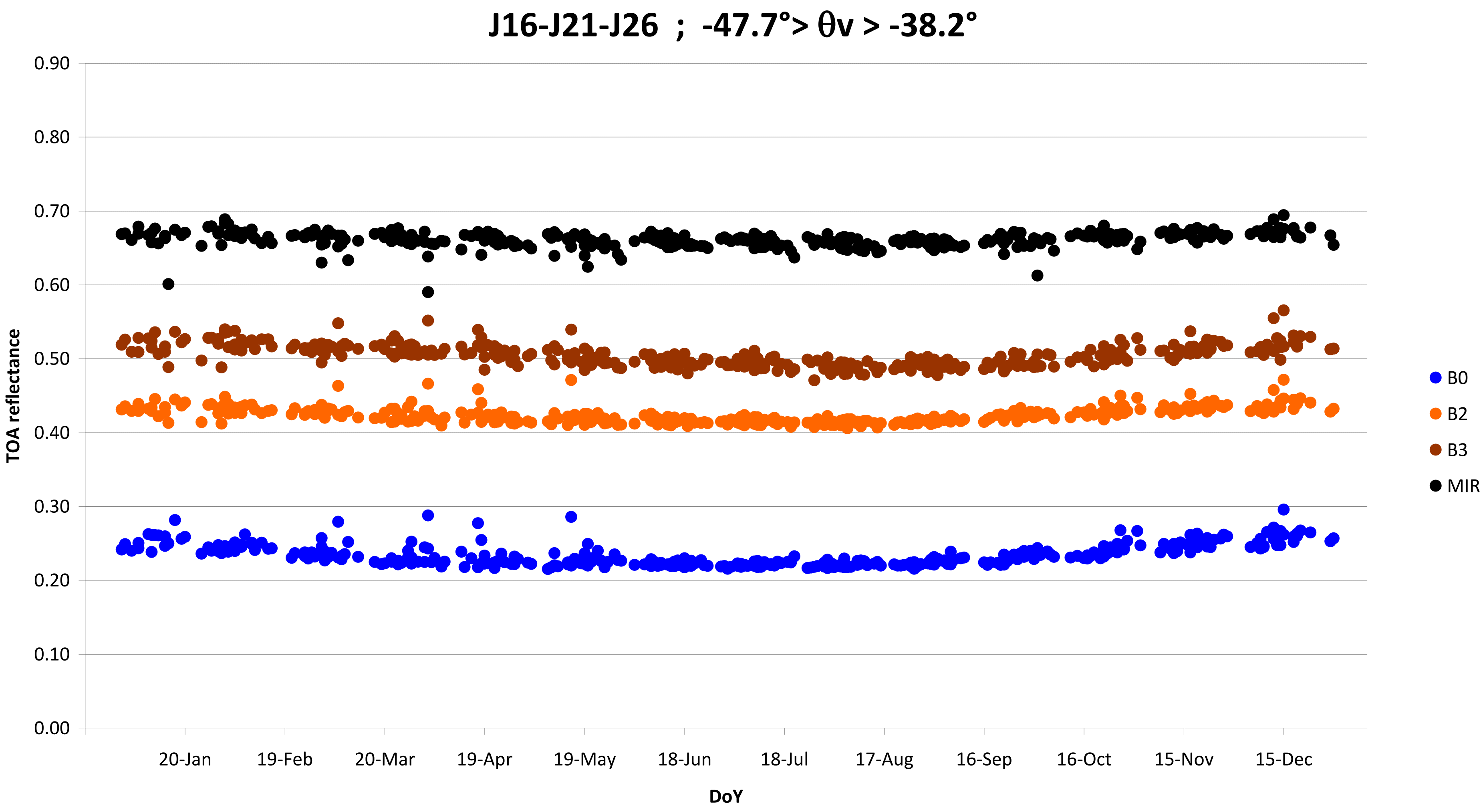

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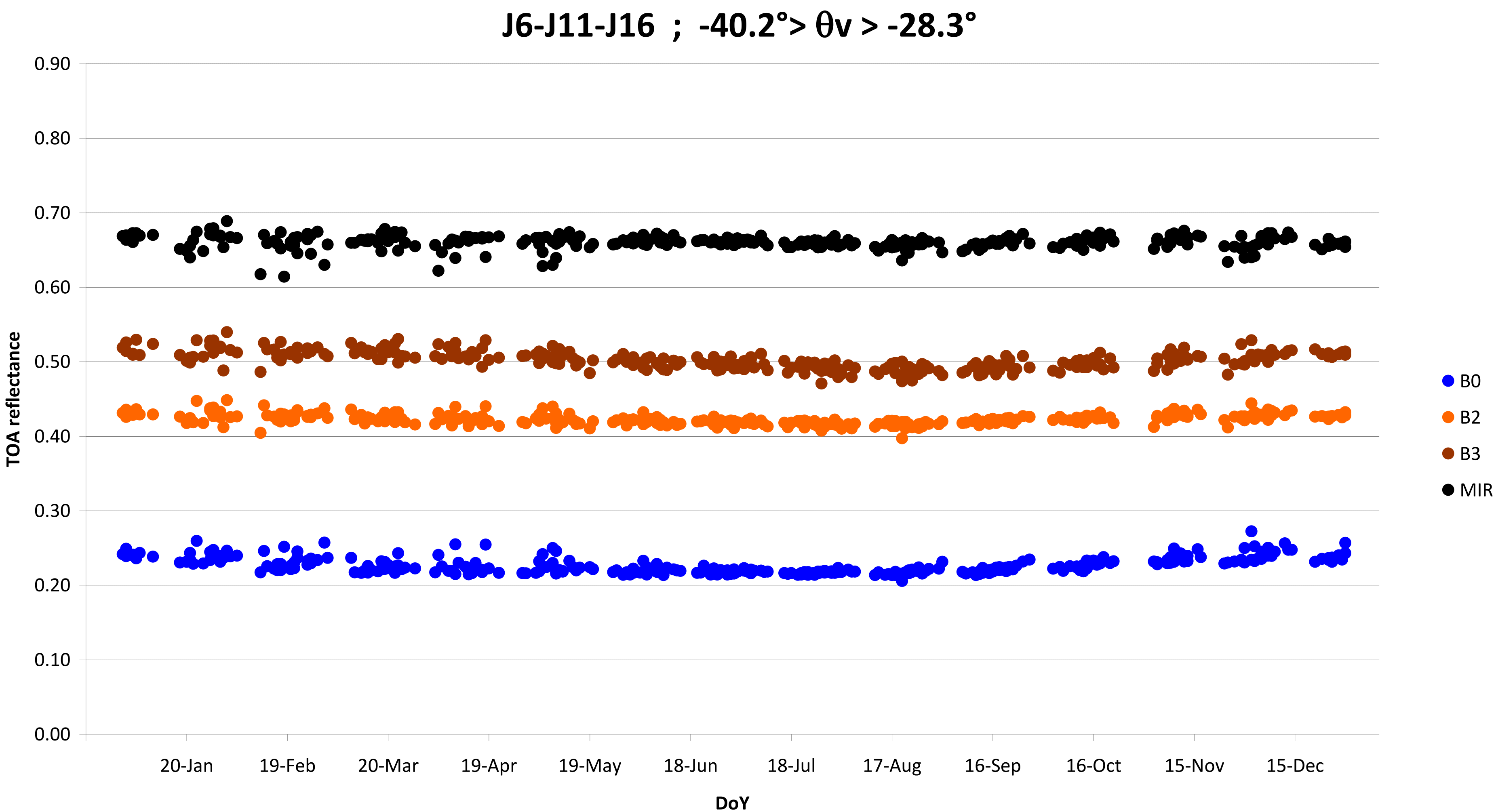

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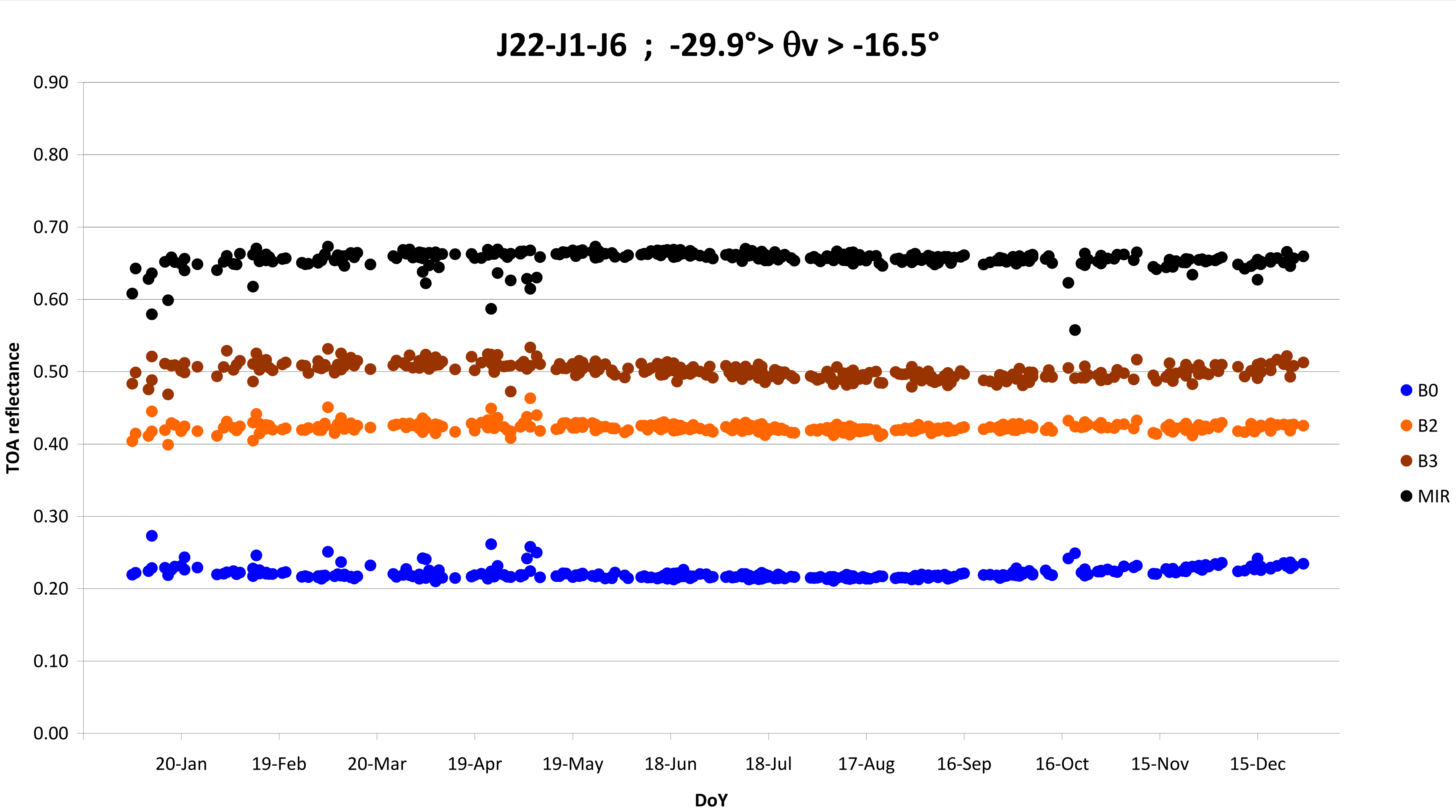

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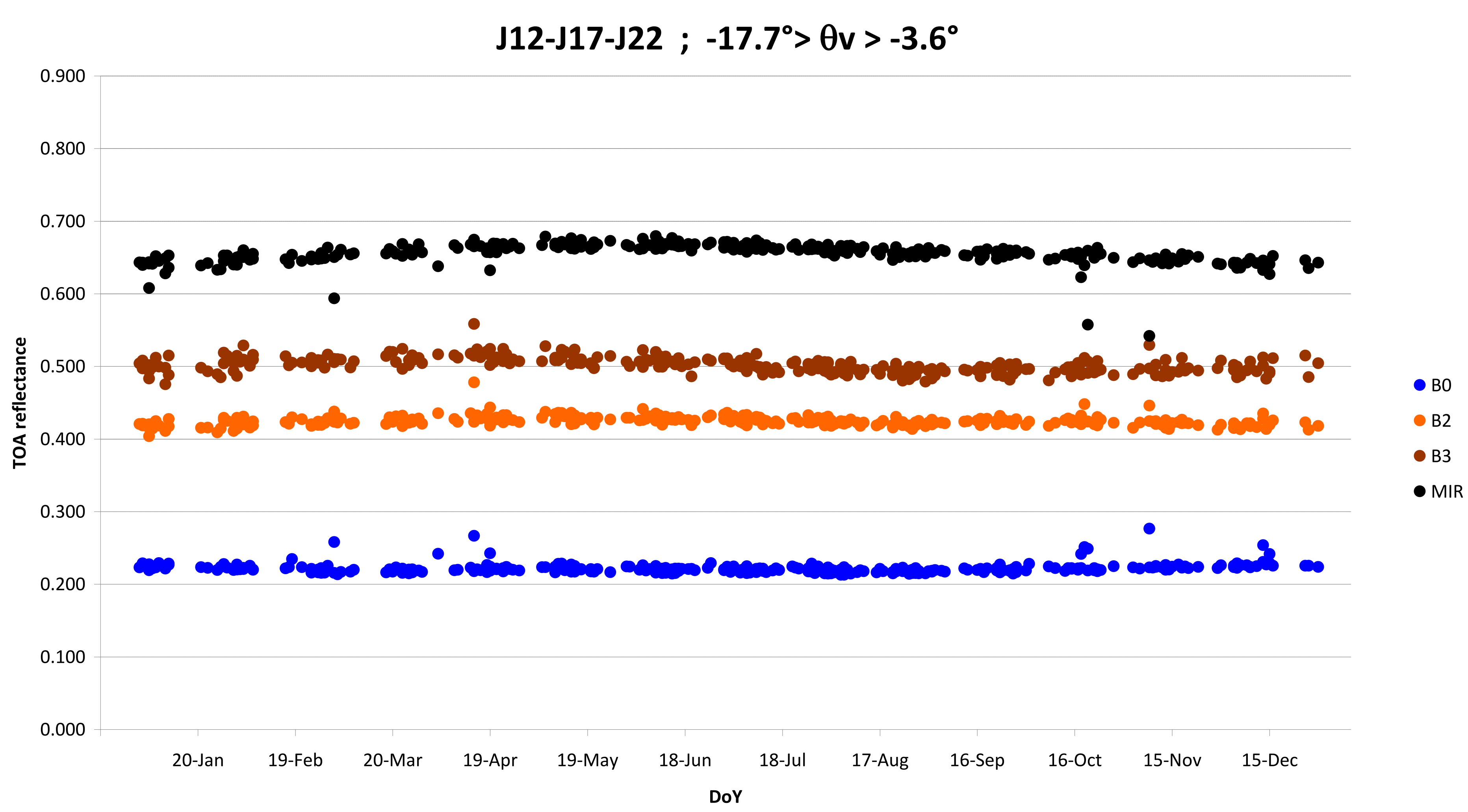

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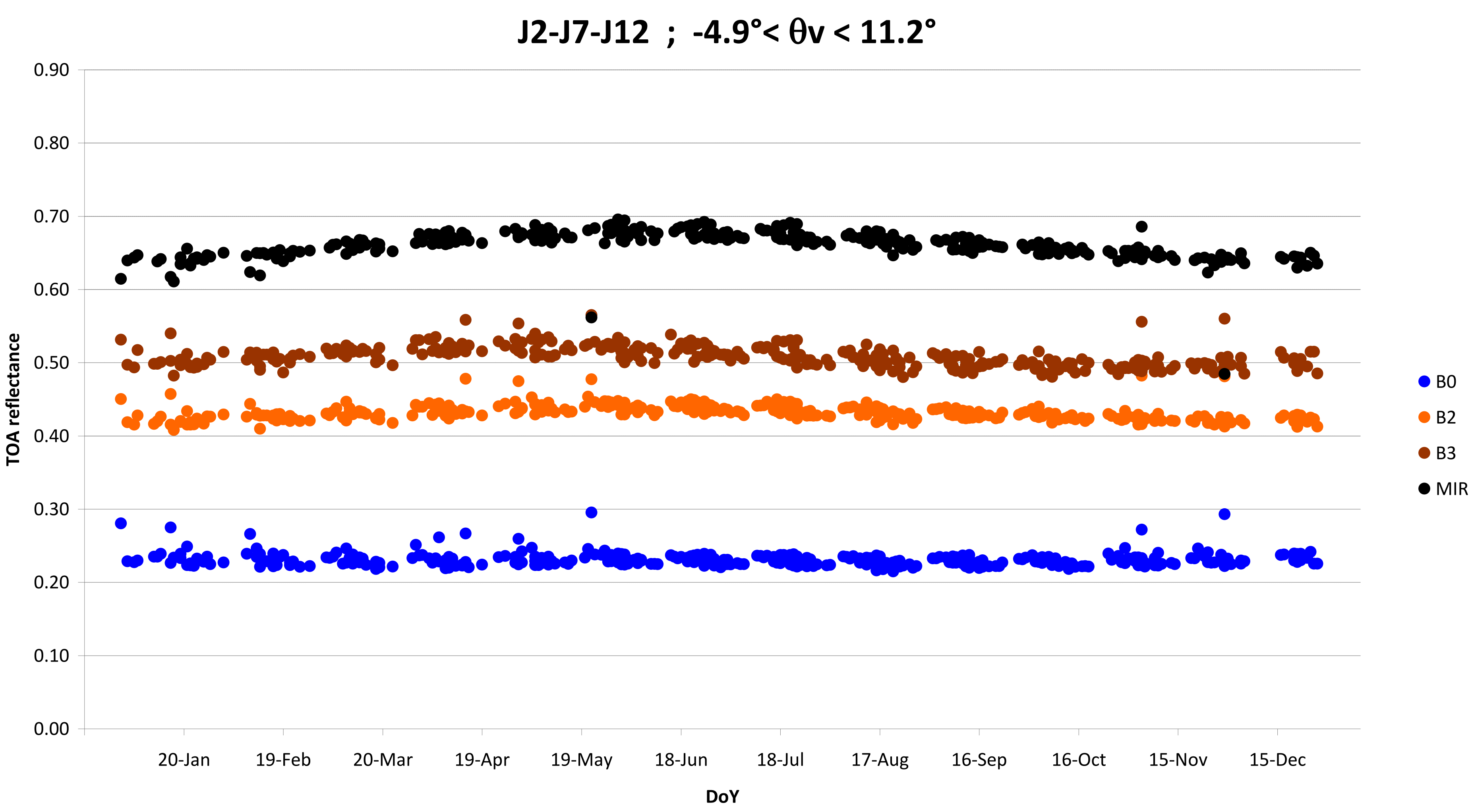

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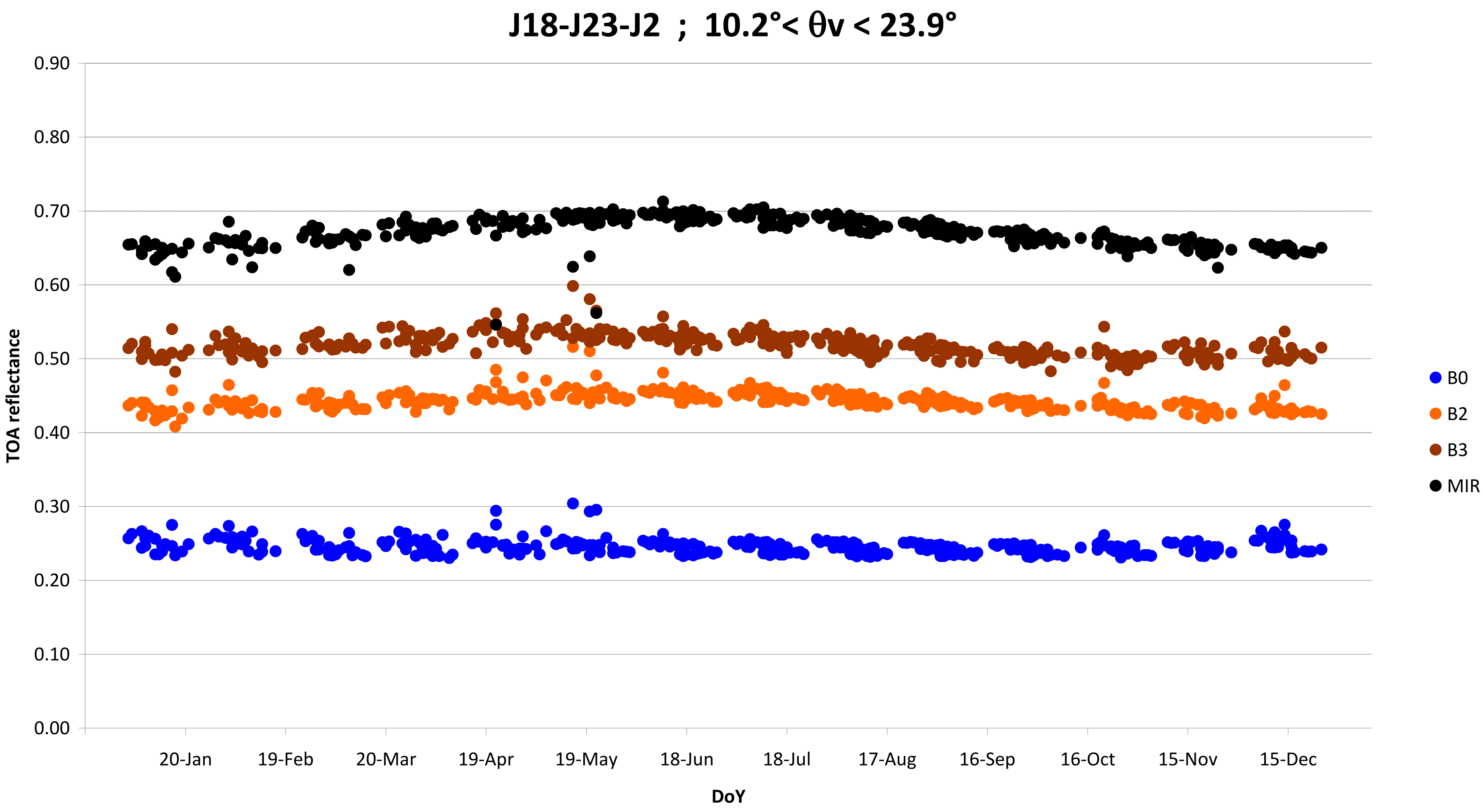

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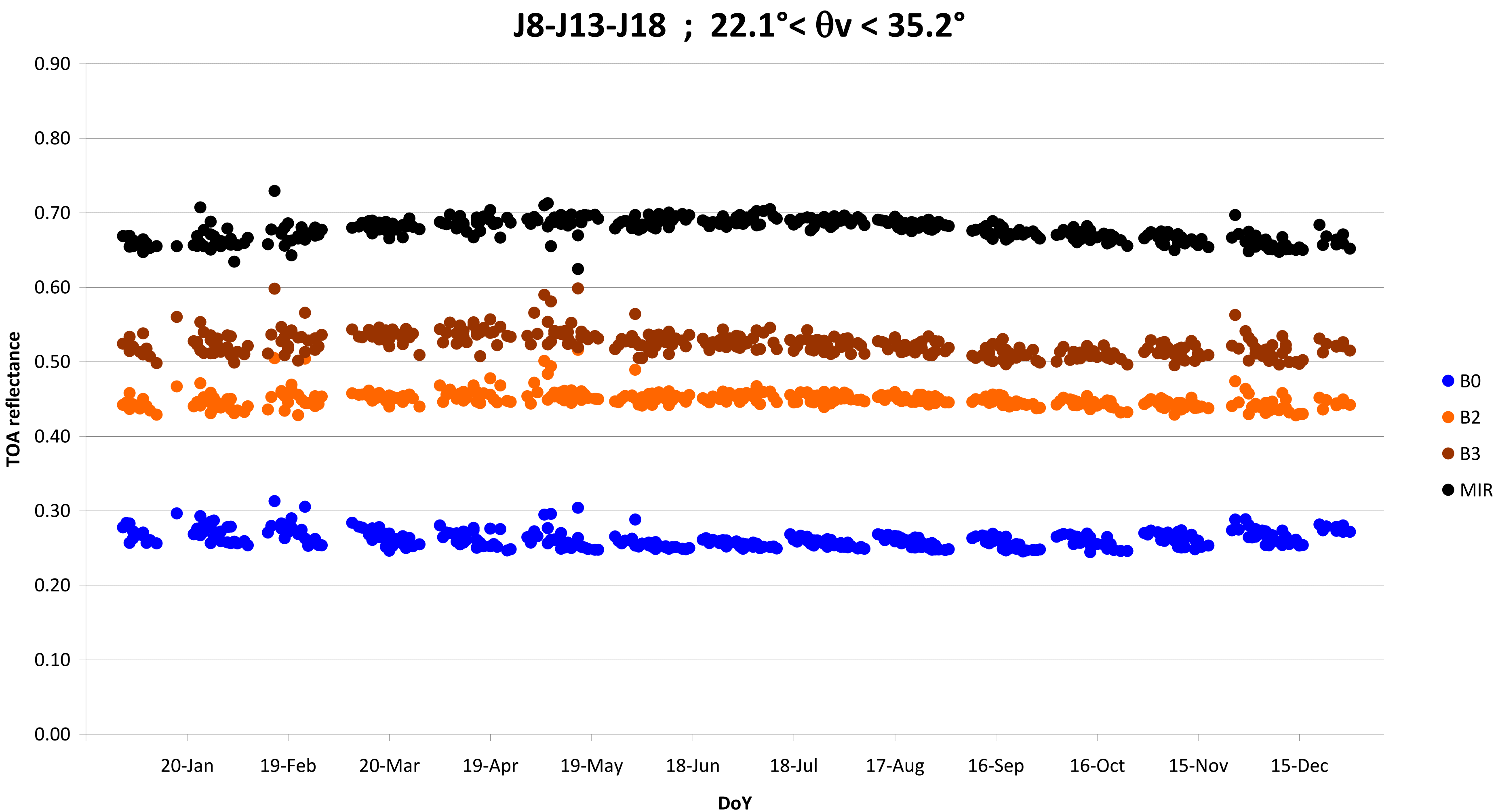

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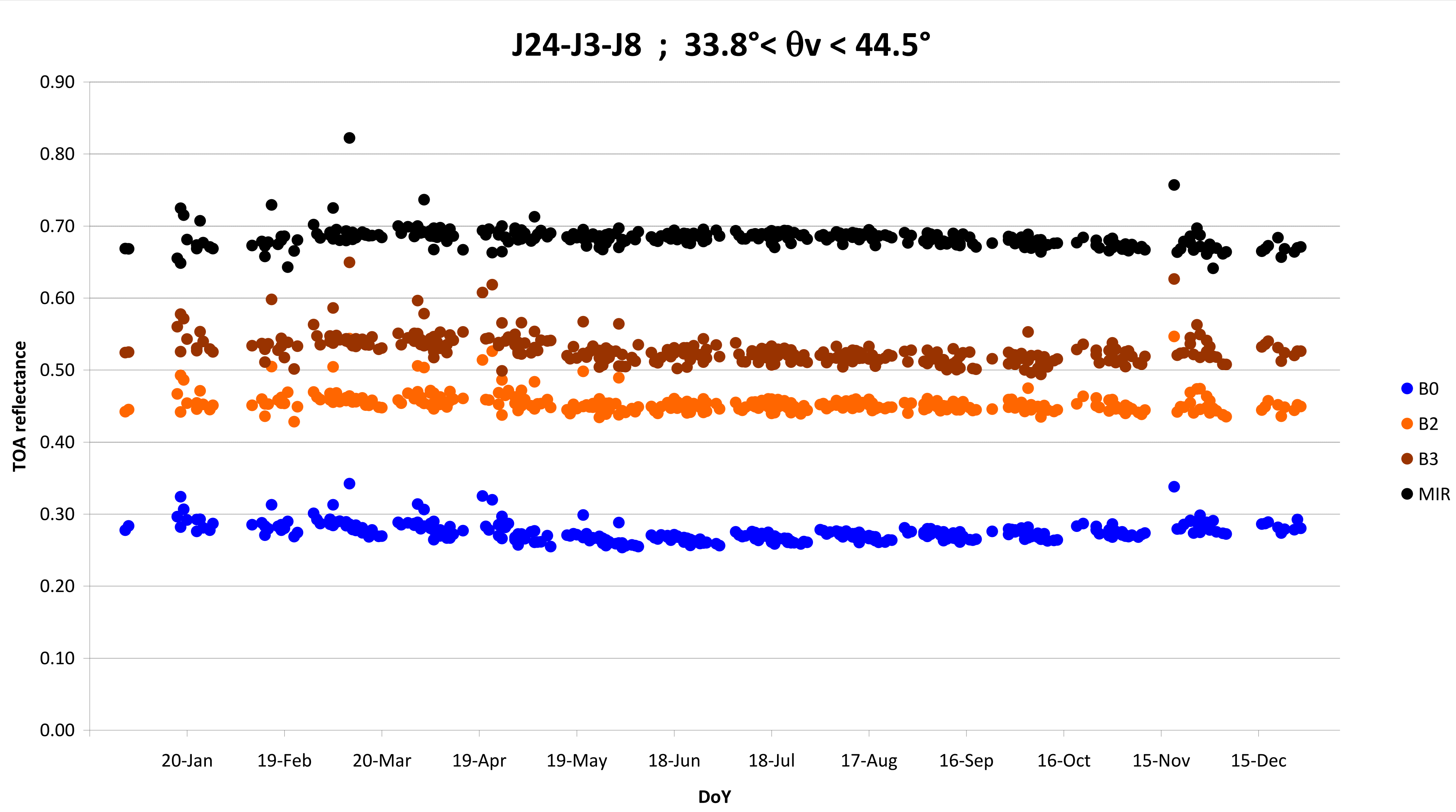

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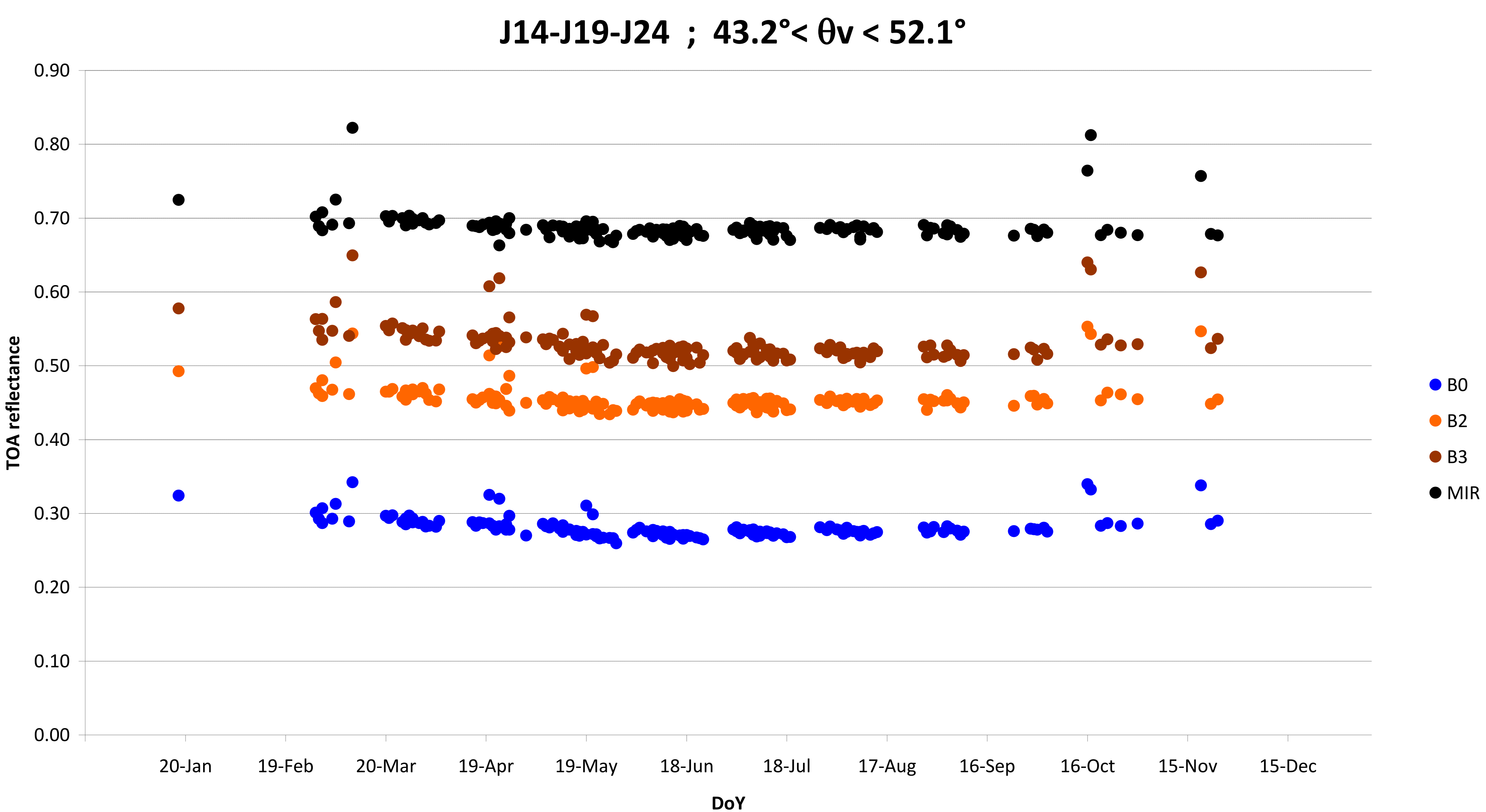
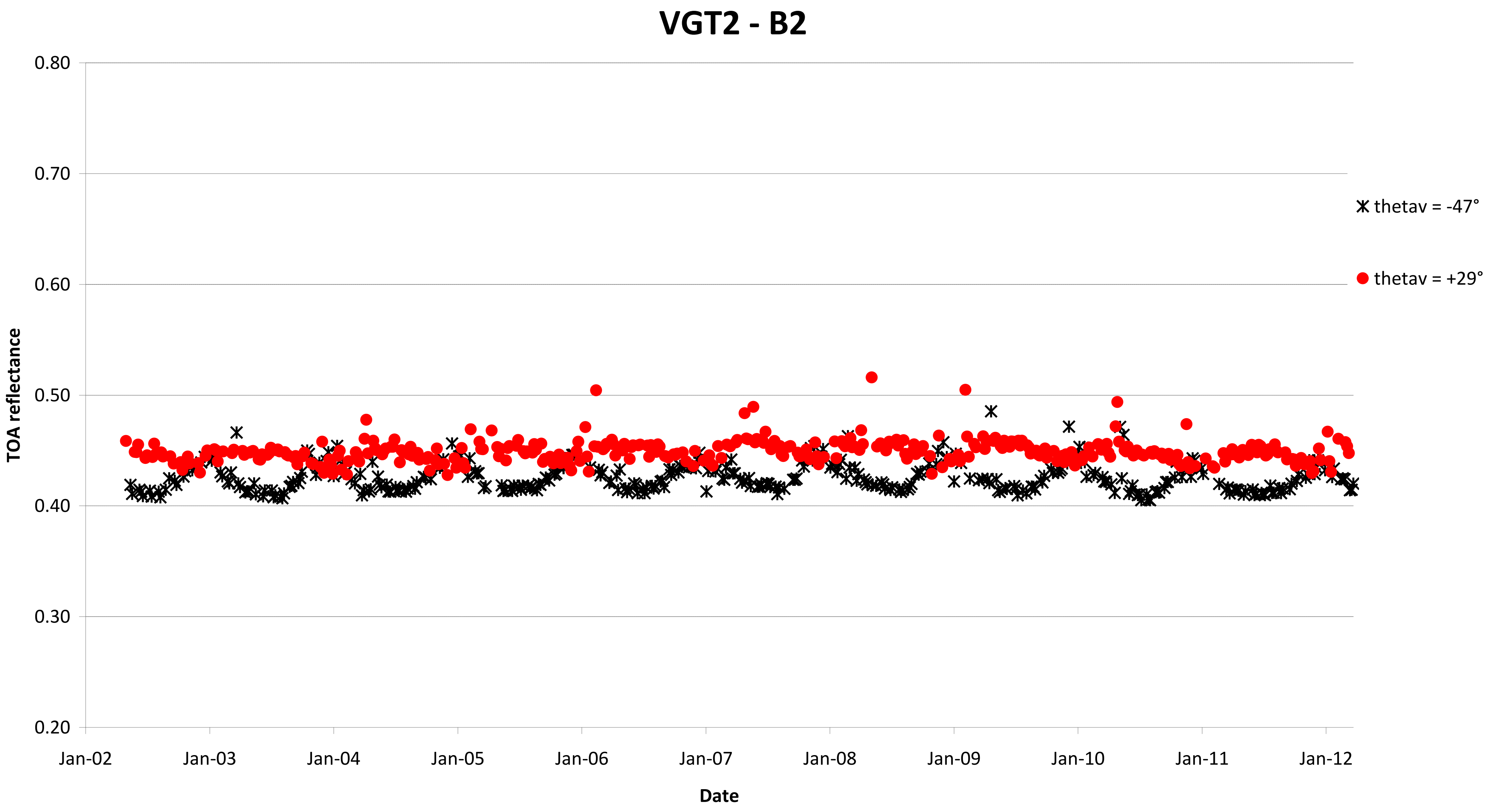
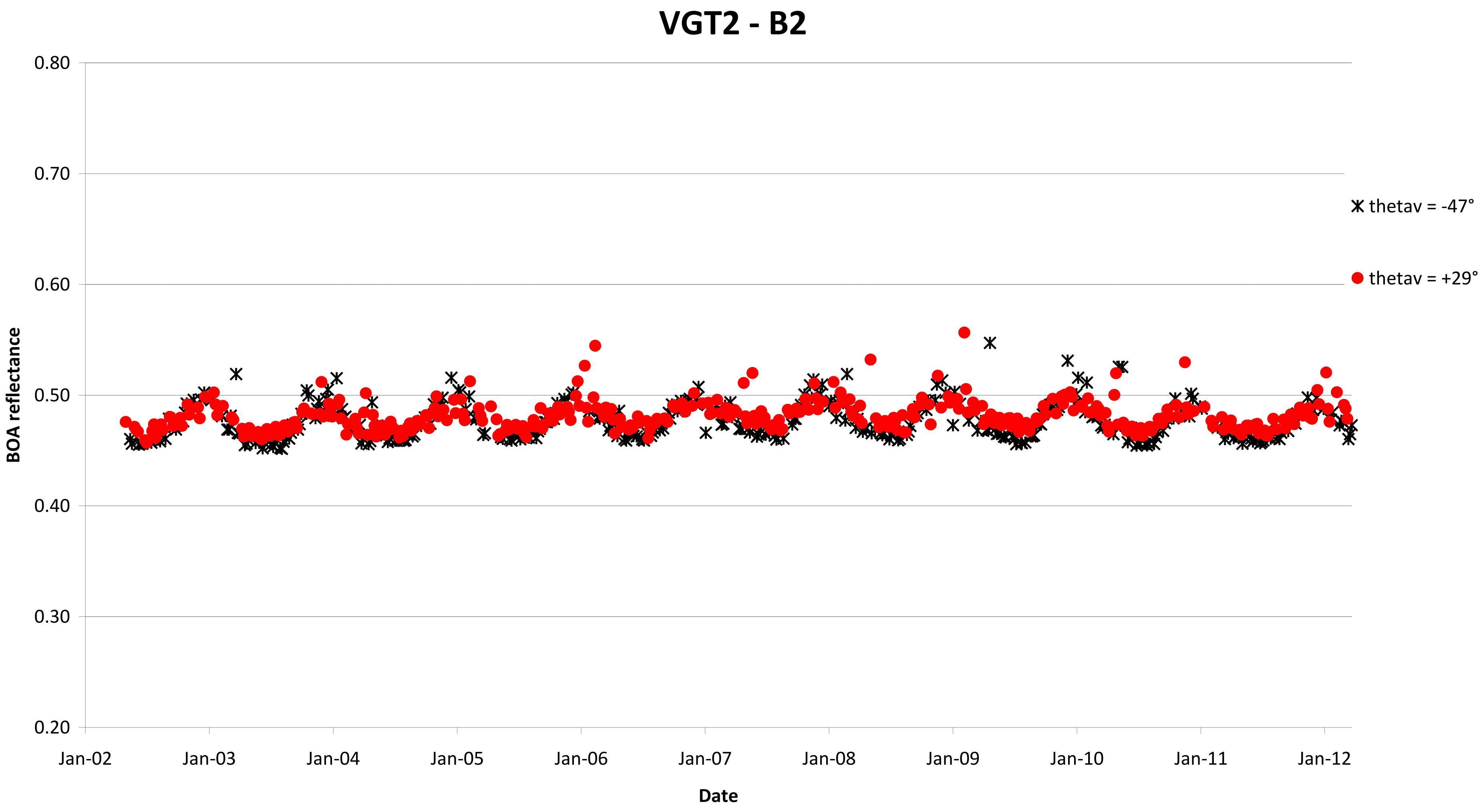


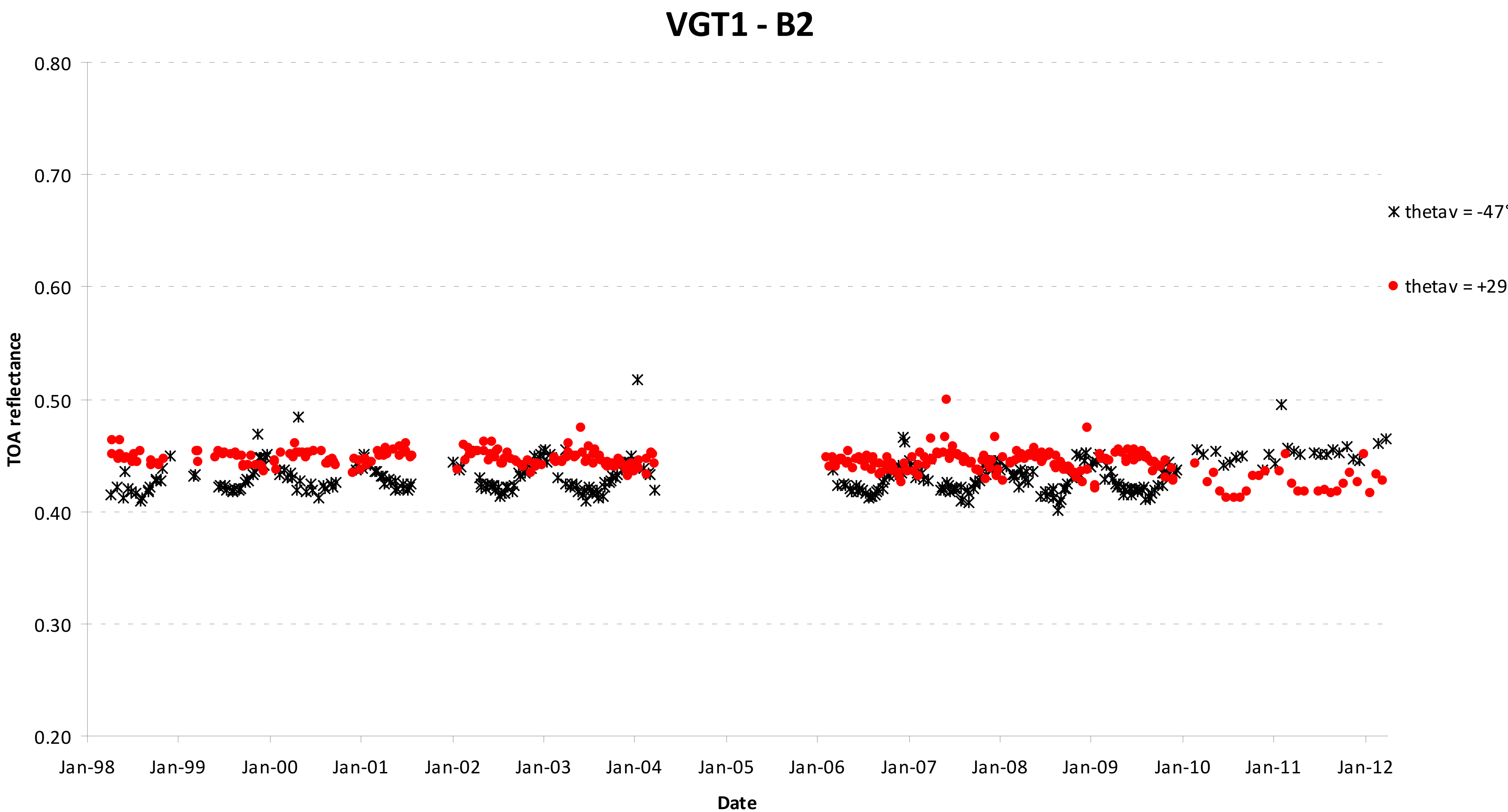
VGT2 TOA Reflectance vs Date



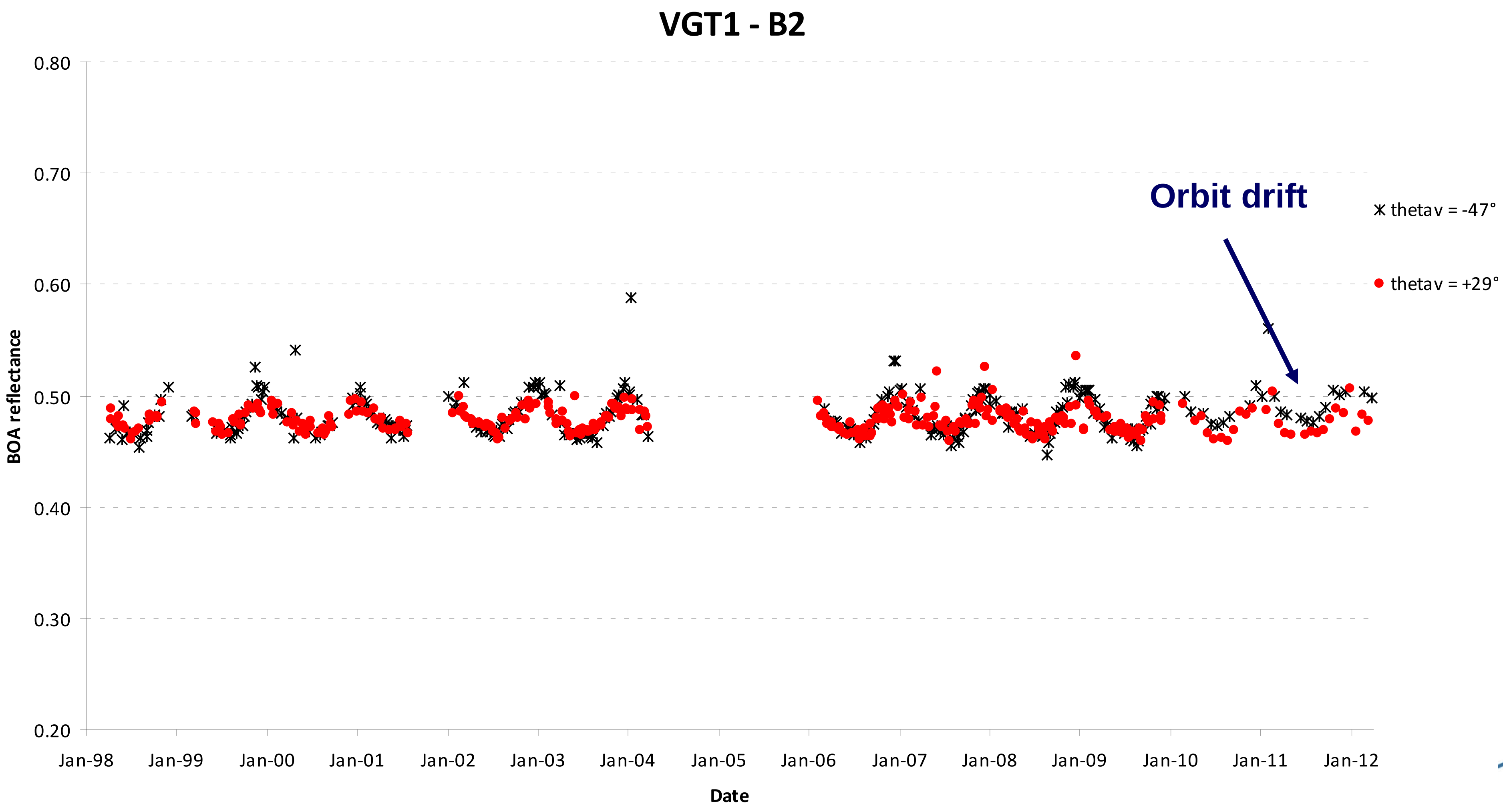
VGT2 BOA Reflectance vs Date



VGT1 TOA Reflectance vs Date



VGT1 BOA Reflectance vs Date



Short and long term stability

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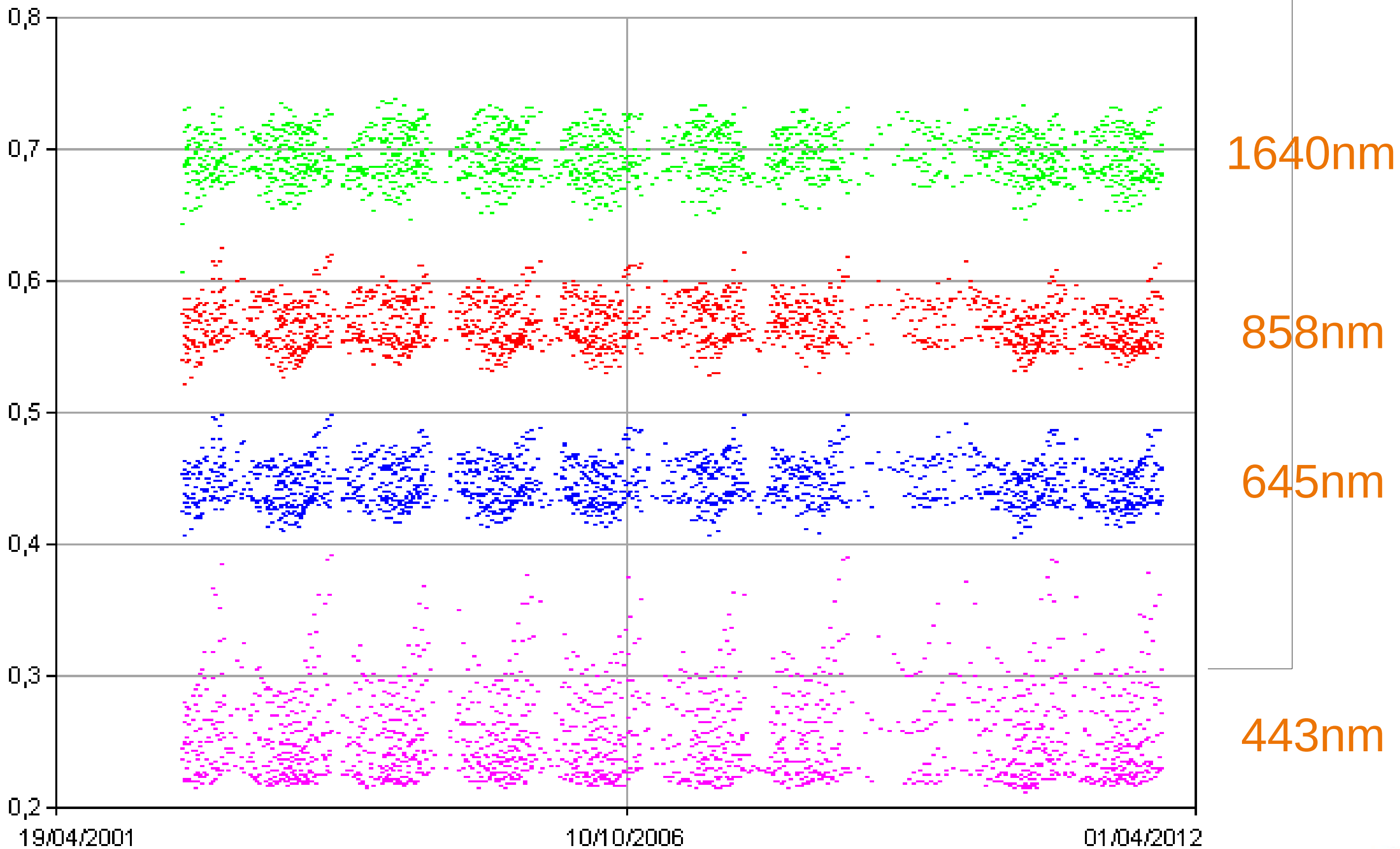
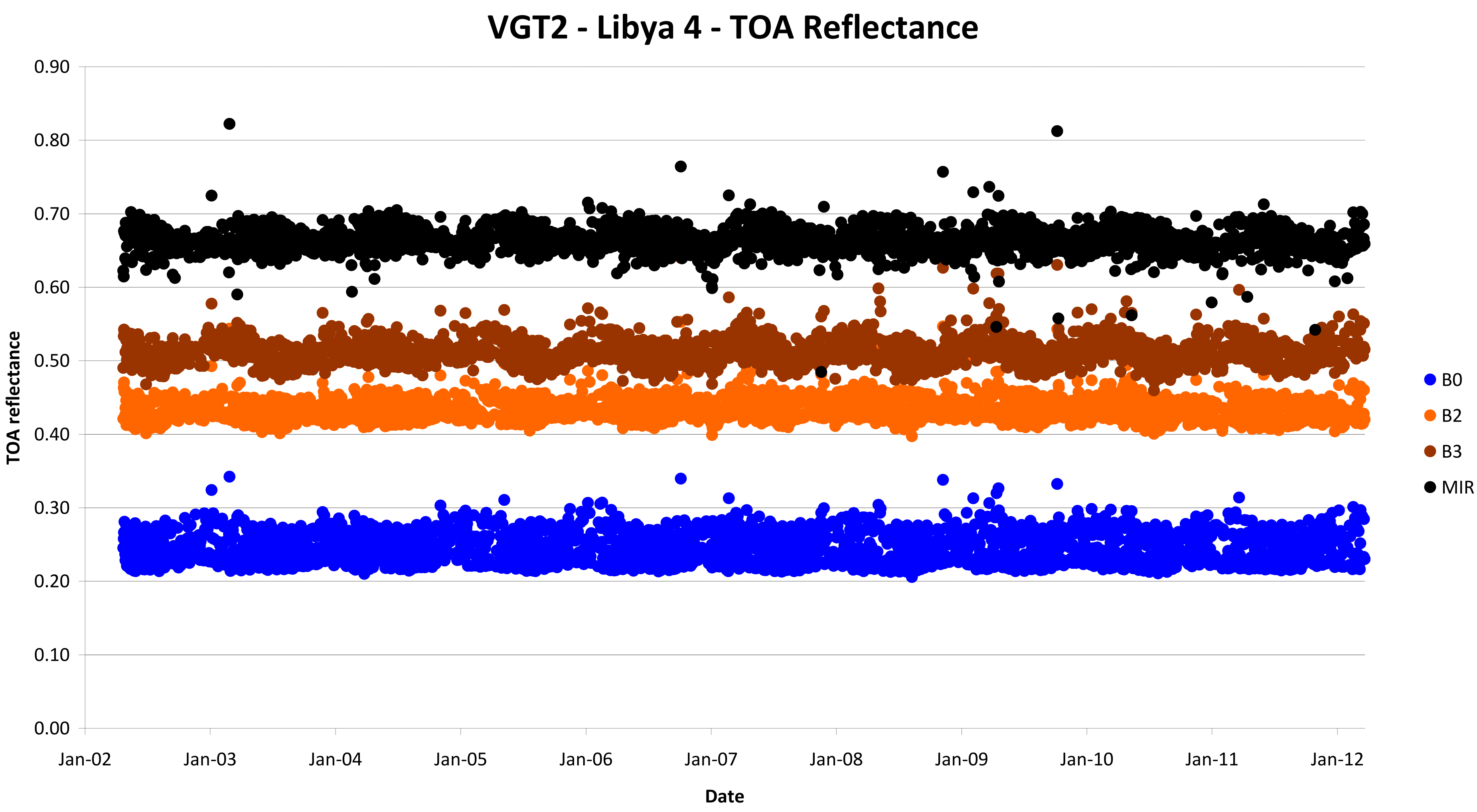
MODIS time series over Libya-4

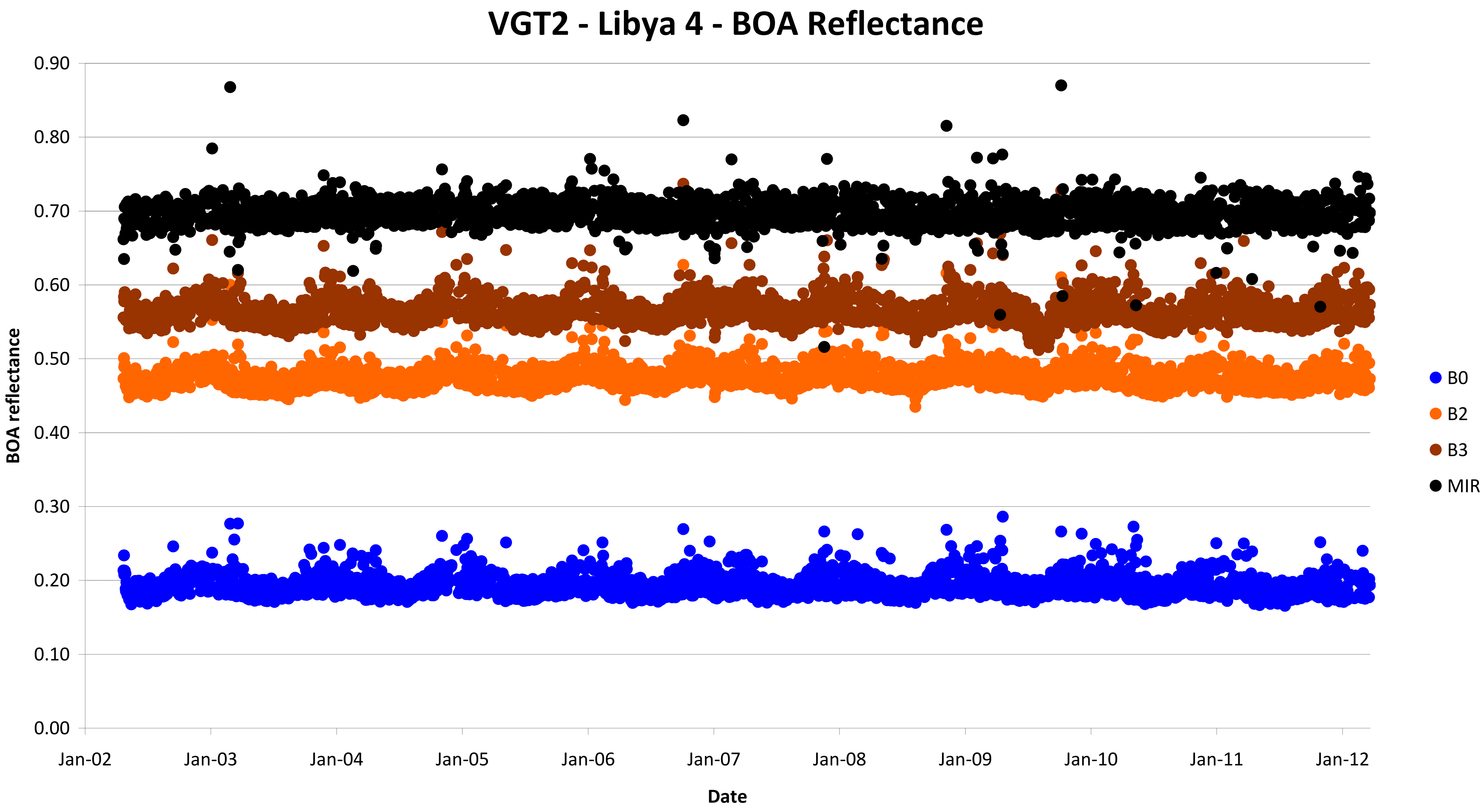
- Time series of MODIS TOA reflectances over the archive 2002-2011
  - Seasonality
  - Long-term trend



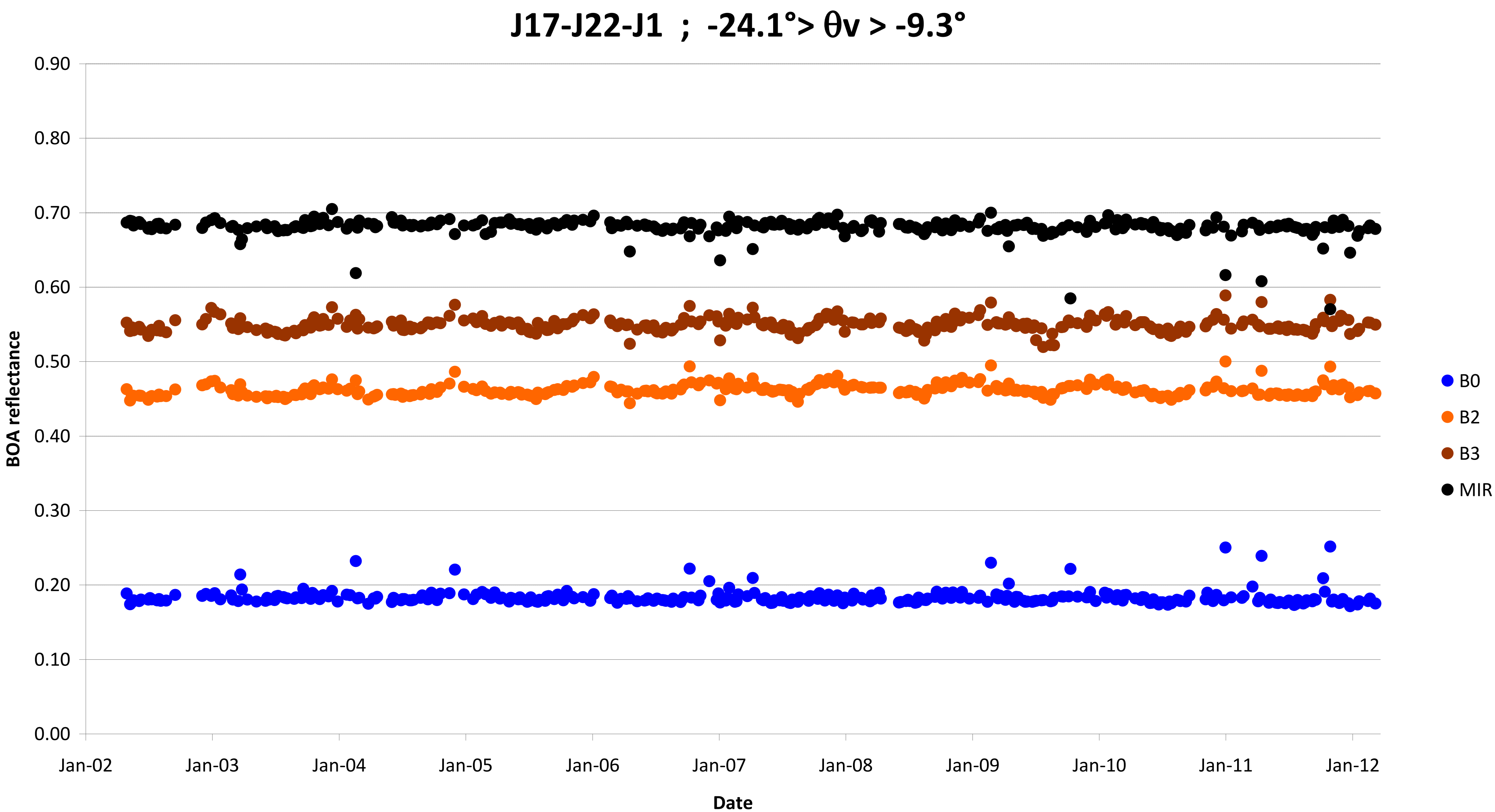
VGT2 TOA Reflectance vs Date



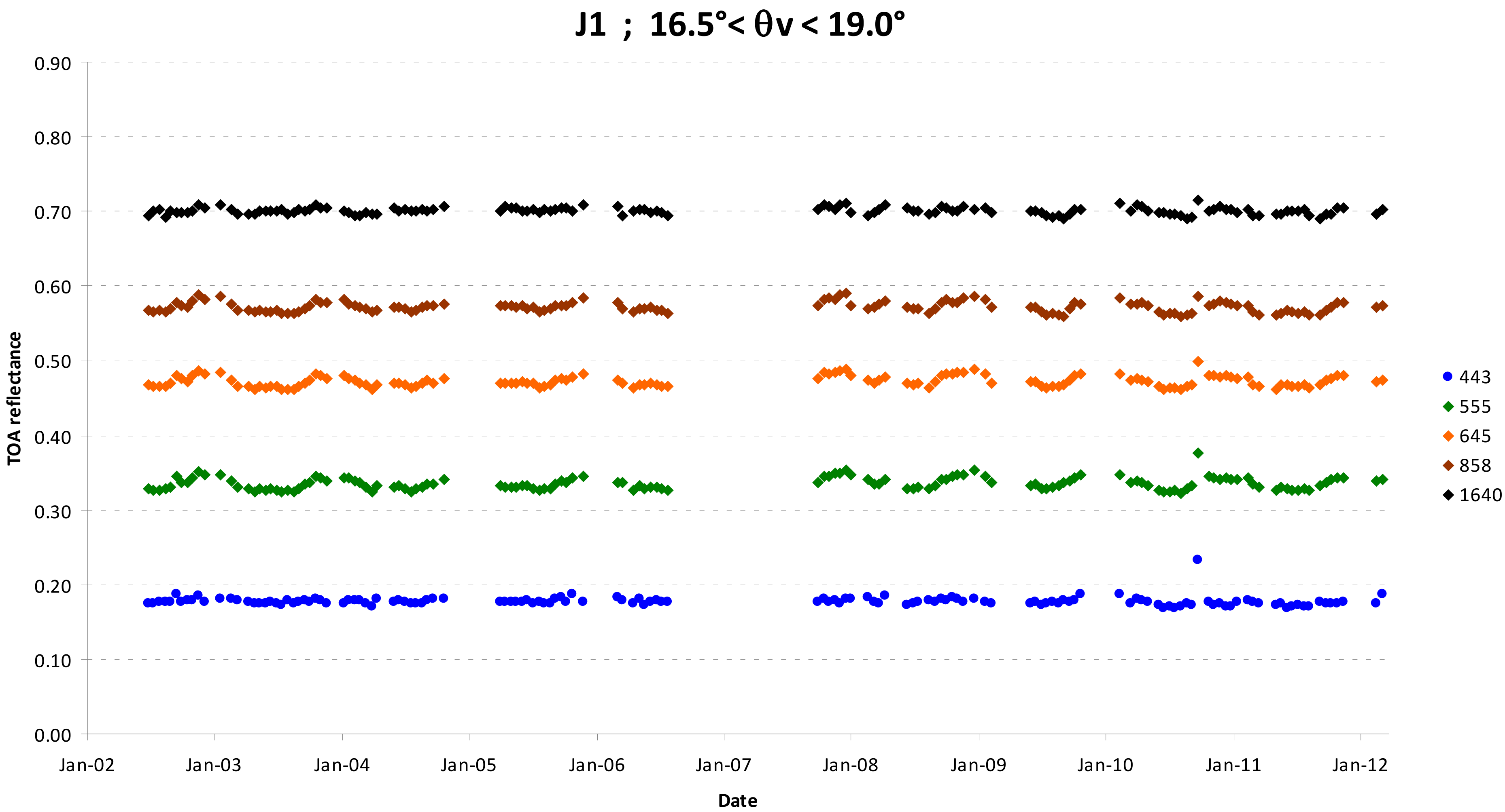
VGT2 BOA Reflectance vs Date



VGT2 BOA Reflectance vs Date (sub-cycles)

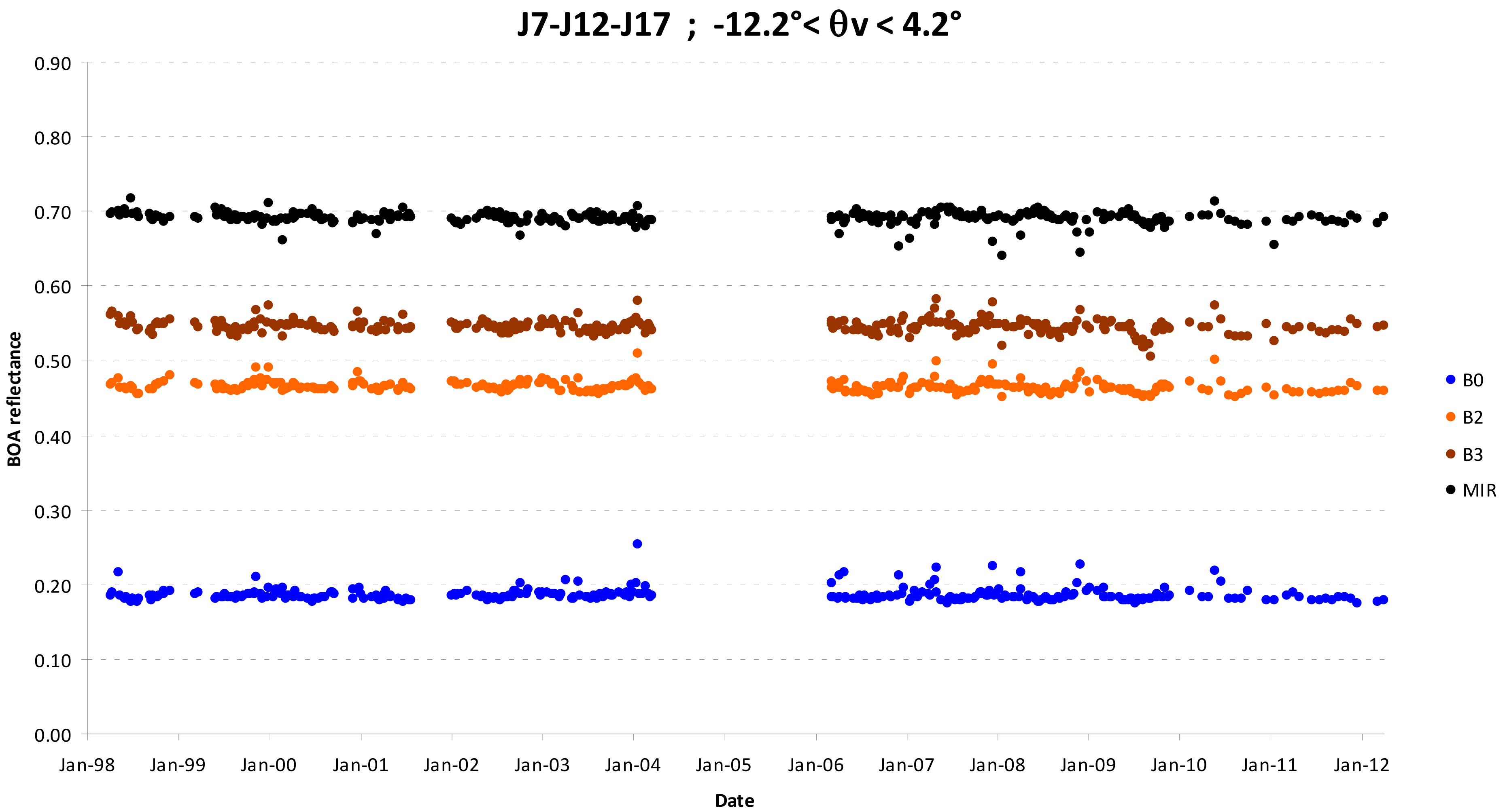


MODIS BOA Reflectance vs Date (1 day of the cycle)



cnes

VGT1 BOA Reflectance vs Date (sub-cycles)



Cloud coverage

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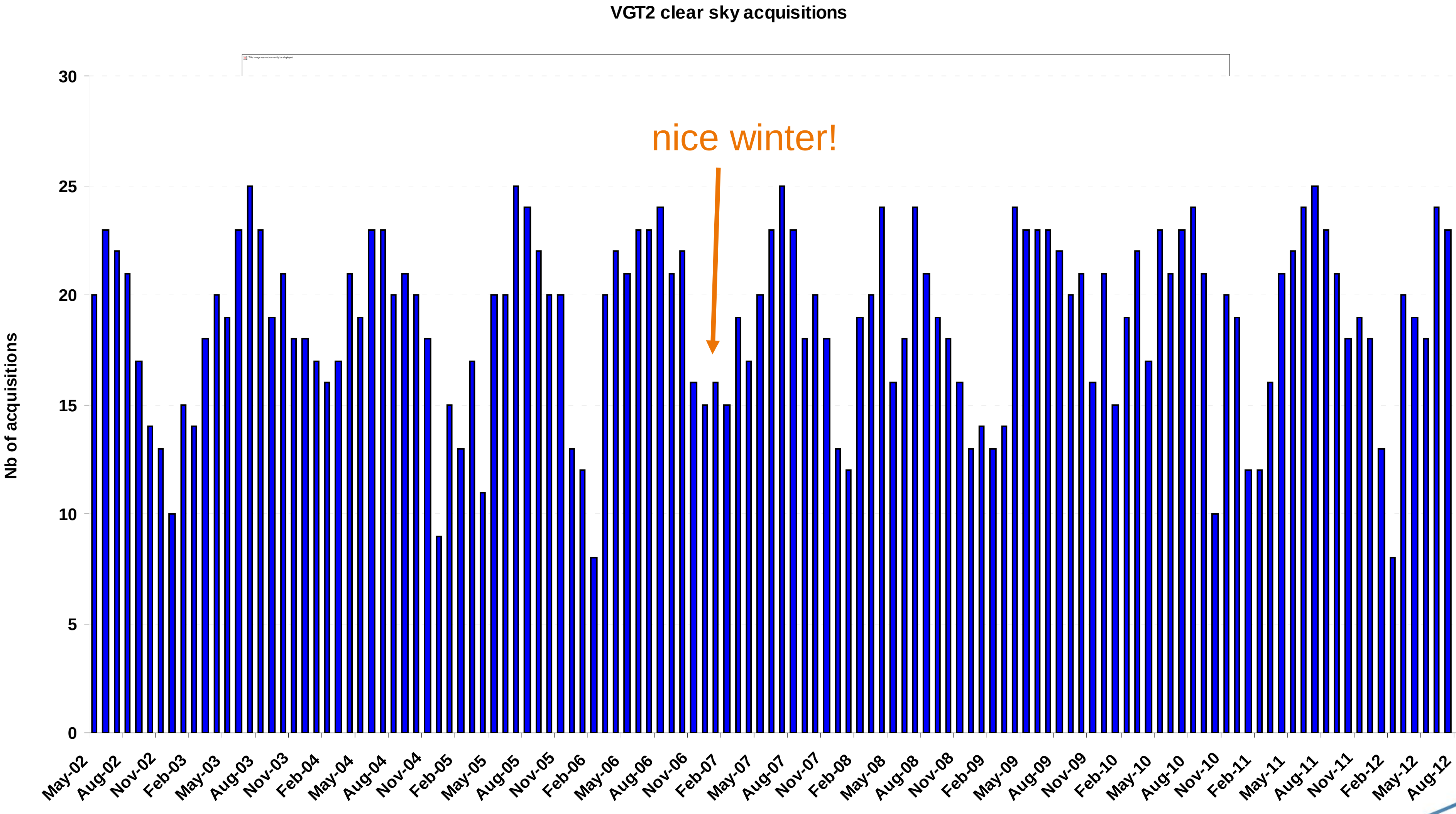
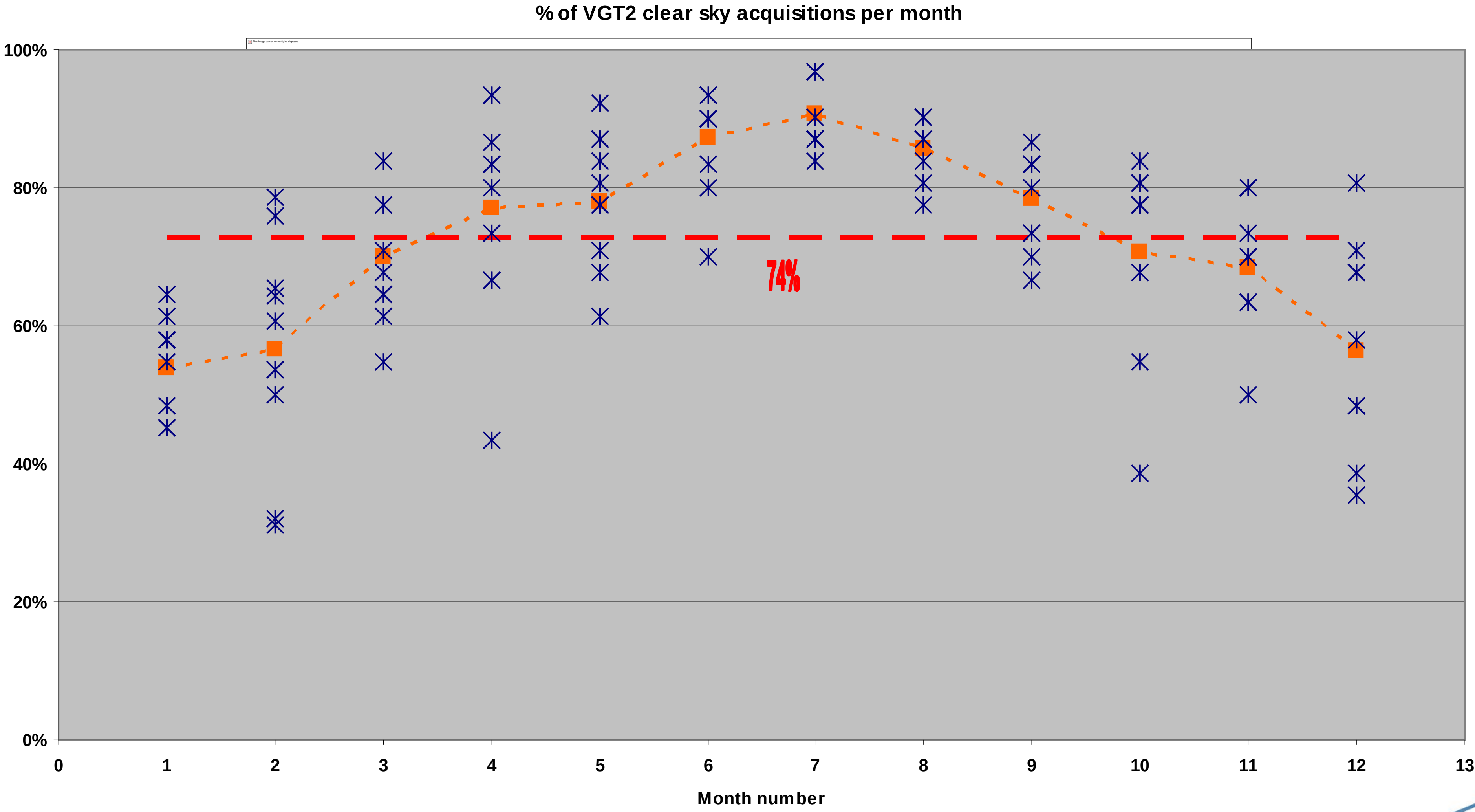
CNES

VGT2 acquisitions per month



A clear seasonal signature with some year particularities

Cloud coverage estimation



⁎ percentage per month ■ month average — — total average