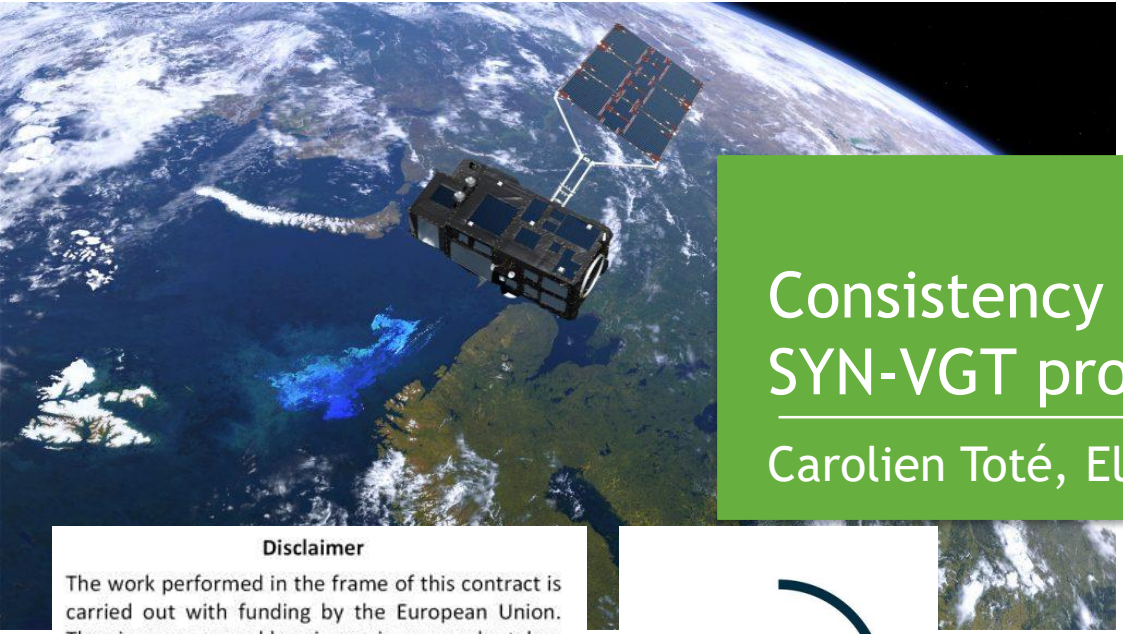


# Consistency between Sentinel-3 SYN-VGT products and PROBA-V

Carolien Toté, Else Swinnen (VITO)



PROBA-V QWG#12 | 27-28 Oct 2020

# Objective

- Analyze consistency between S3 SYN-VGT and PROBA-V products in view of time series continuity
- SYN VGT
    - Sentinel-3 A&B
    - SY_2_V10 (focus), SY_2_VG1, SY_2_VGP
    - Available on Sentinel-3 Open Access Hub (since October/2018), mirrored on Terrascope (since Jul/2020)
    - Latest PB S3A PB 2.56, S3B PB 1.28 from 15/Jan/2020

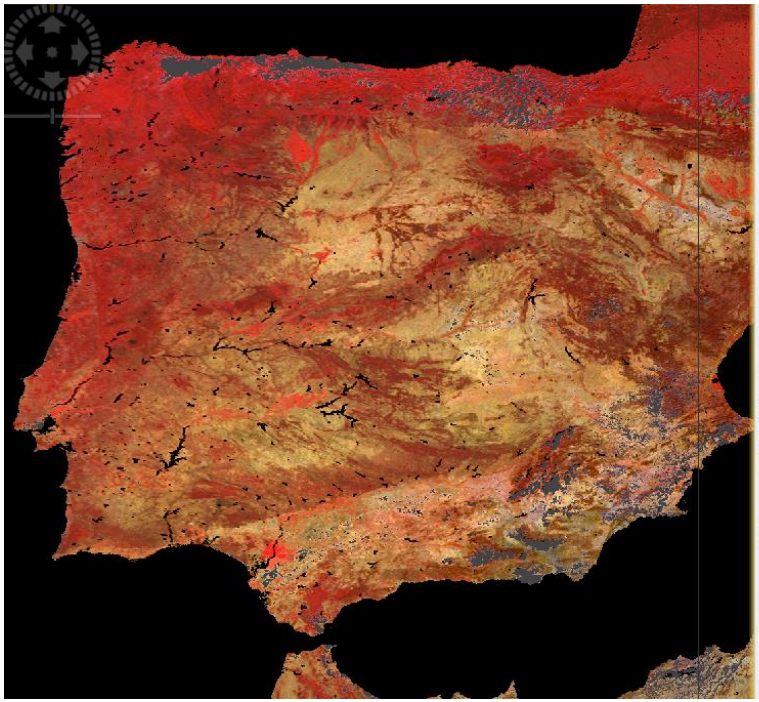
Note: fix temporal compositing SY_V10 since mid/May 2020

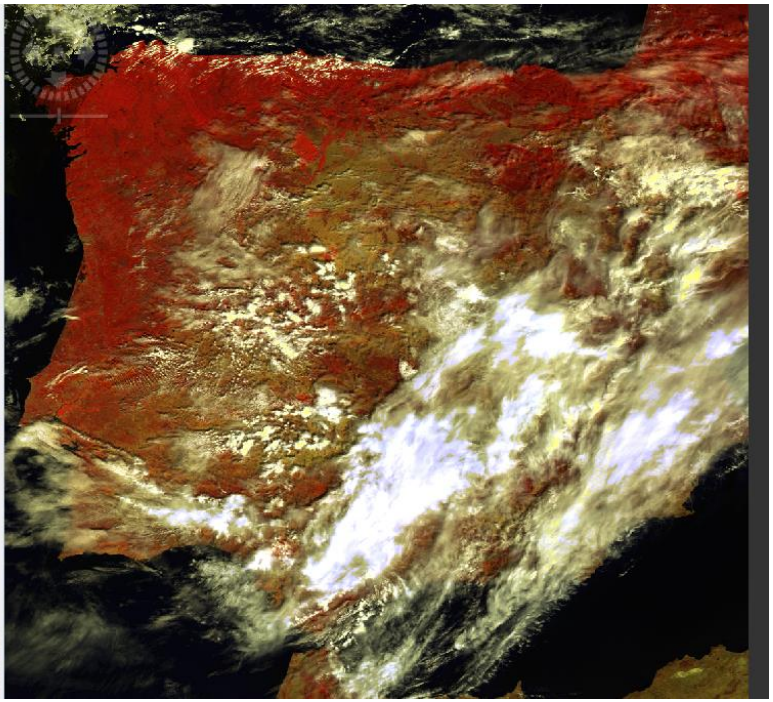
fix temporal compositing SY_VG1 since 24/09/2020

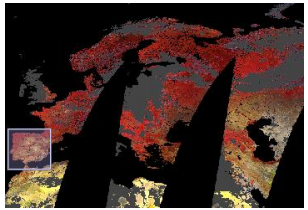
# Fixed temporal compositing SY_VG1 since 24/09/2020

S3B_SY_2_VG1 20200901

PROBAV_S1_TOC 20200901







S3B_SY_2_VG1____20200901T163347_20200902T163347_20200907T165311_EUROPE

start time end time

RGB: NIR-RED-BLUE

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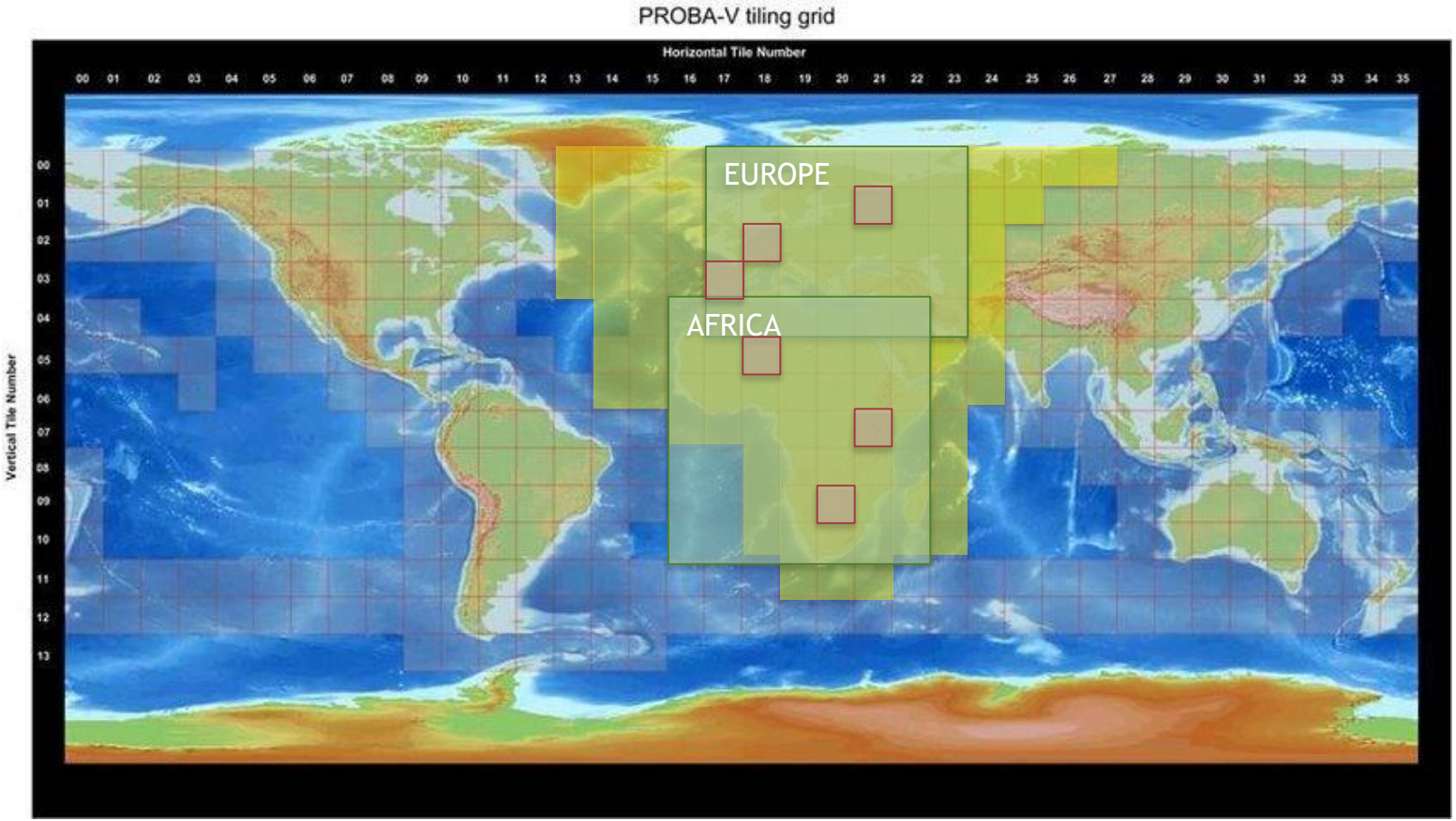
# Consistency analysis – data used

= PROBA-V coverage since July 2020

= S3 SYN VGT ‘TILE’

= 10°x10° PV ‘TILE’

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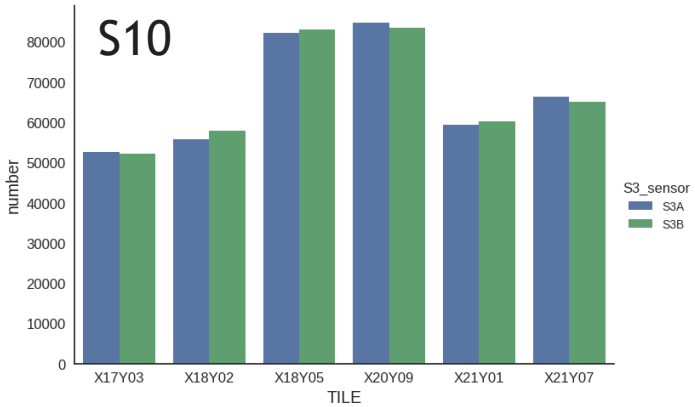
# Consistency analysis – data used

- SY_V10 + PV_S10 products 20200701 – 20200921 (=9 dekads)
- SY_VG1 + PV_S1 products 20201001 – 20201010 (=10 days)
- Spatial subsample
  - 6 10°x10° tiles in EUR and AFR
  - every 8th pixel in both x and y
  - SM == 248 in both products

Number of valid observations in pairwise comparison



# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response

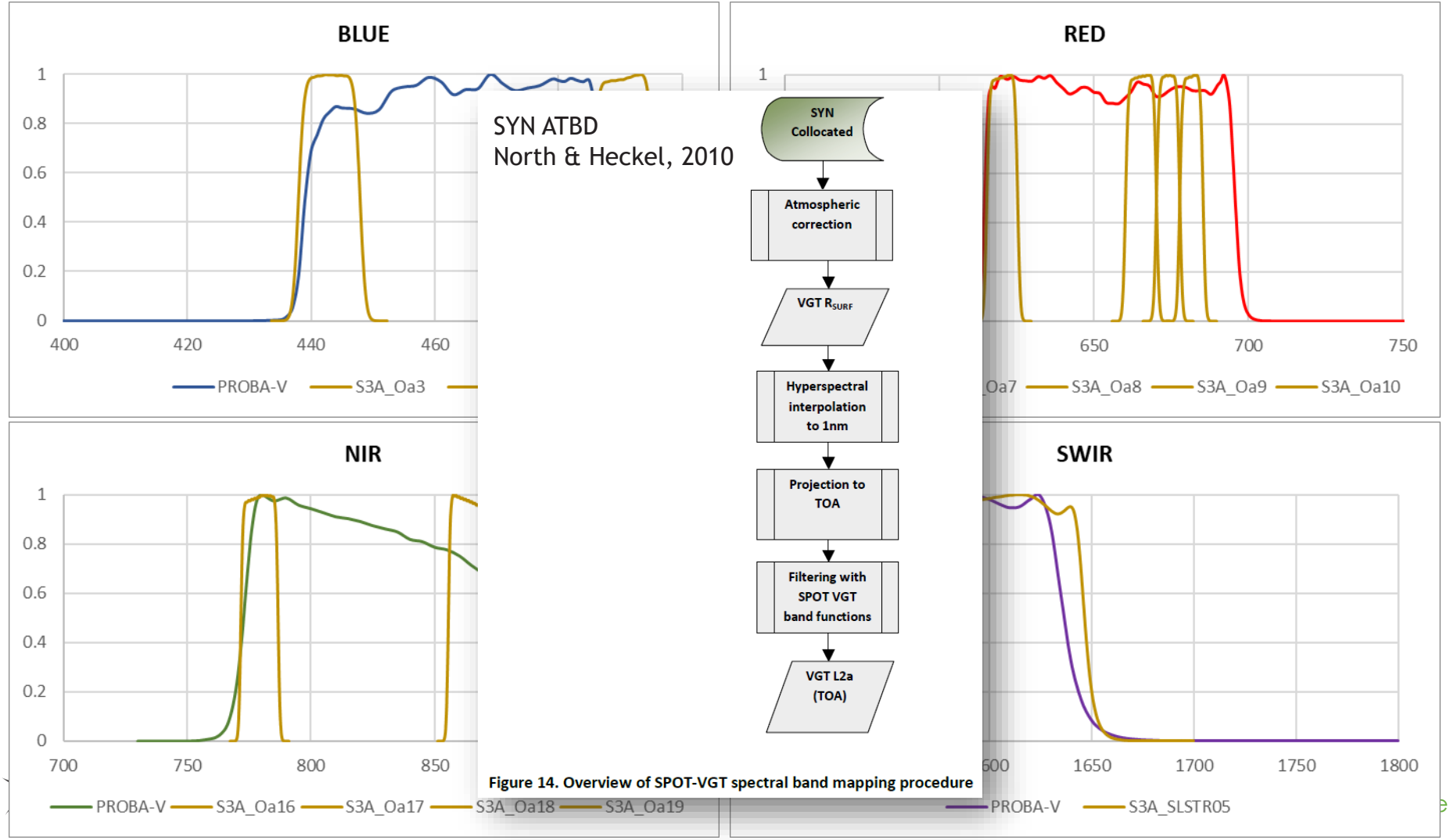


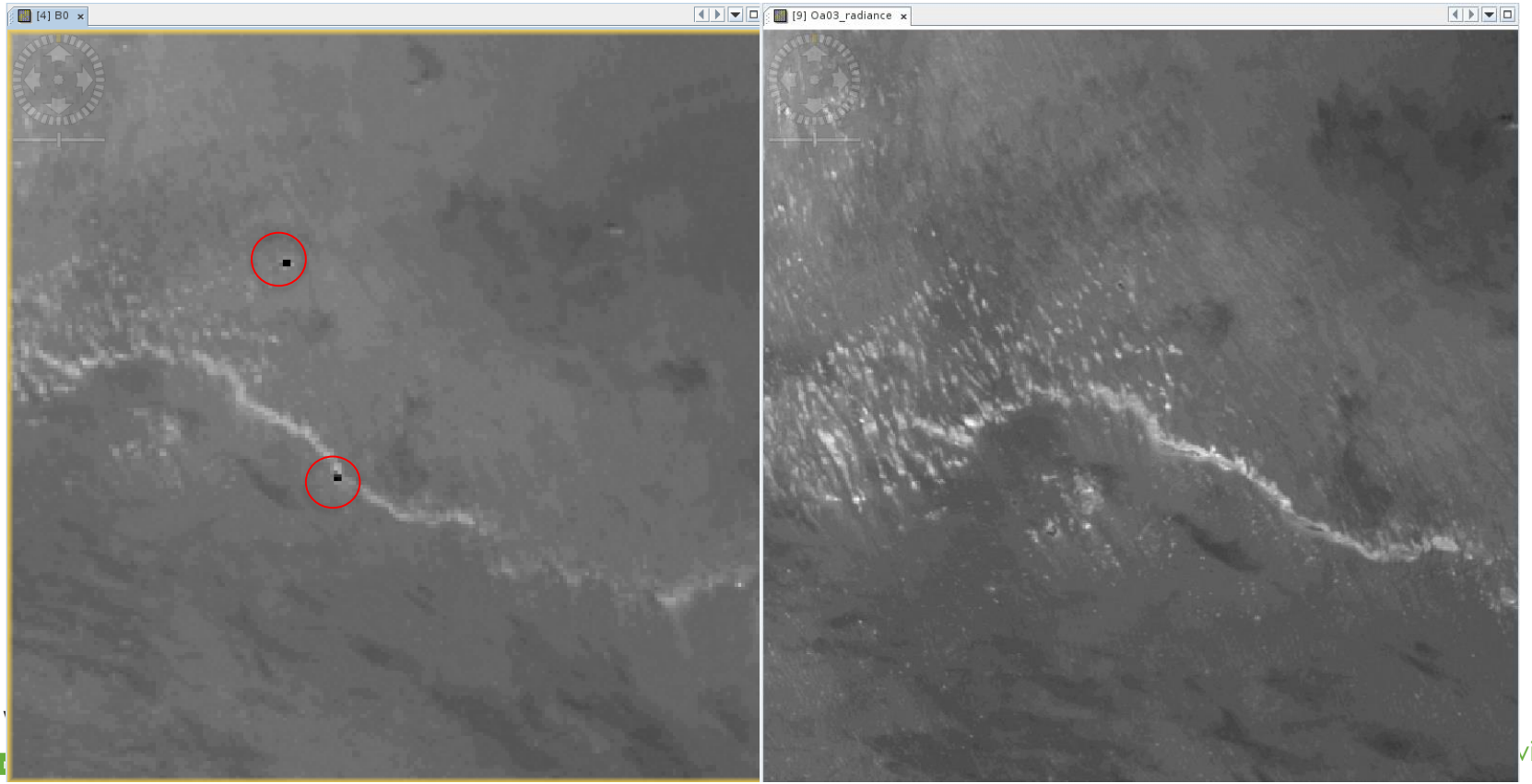

**Figure 14. Overview of SPOT-VGT spectral band mapping procedure**

# Introduction of artefacts?

S3A_SY_2_VGP____20200901T060934_20200901T065347

S3A_OL_1_EFR____20200901T062410_20200901T062710

B0

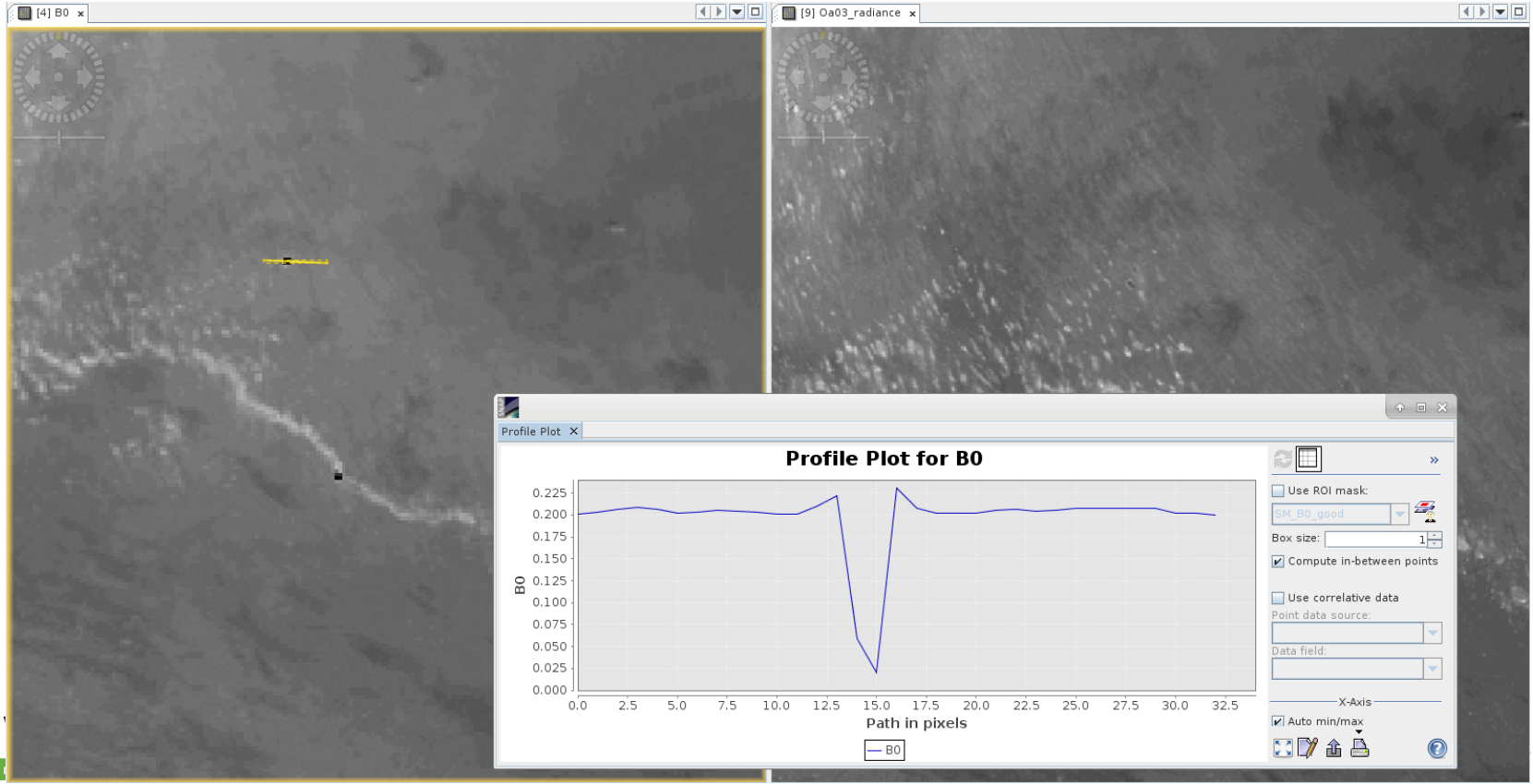


# Introduction of artefacts?

B0

S3A_SY_2_VGP____20200901T060934_20200901T065347

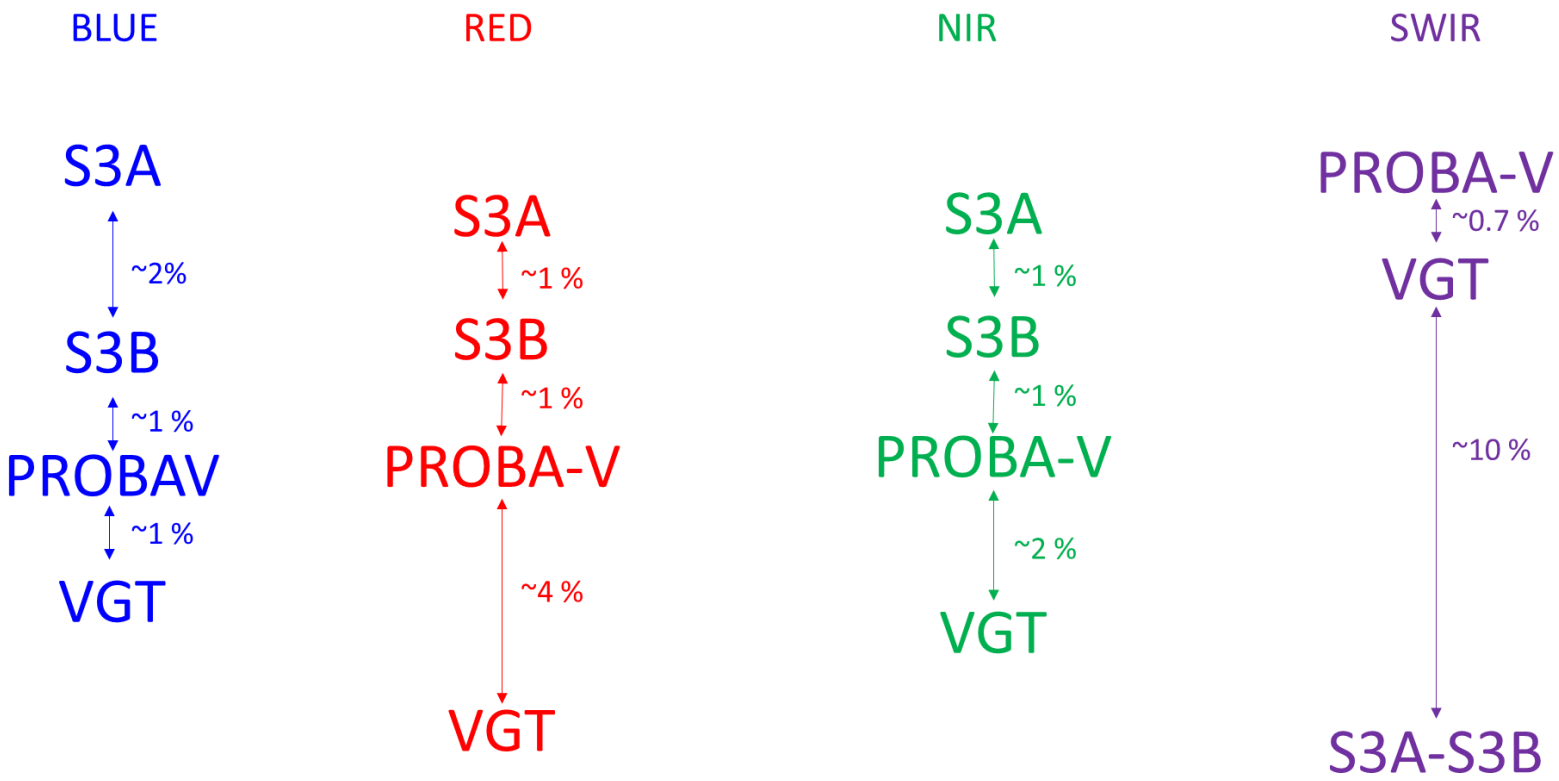
S3A_OL_1_EFR____20200901T062410_20200901T062710



# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
   - OLCI-A too bright (2.5%), same for OLCI-B but less (1%)
   - SLSTR-A&B S5 too dark (11%)

# Relative difference in absolute calibration between Sentinel-3, PROBA-V, VGT

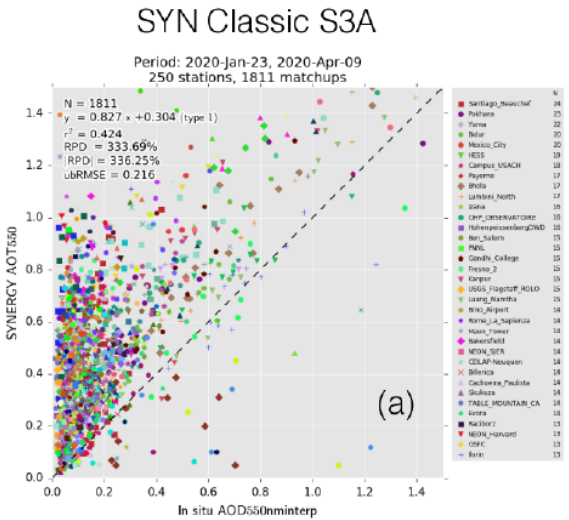


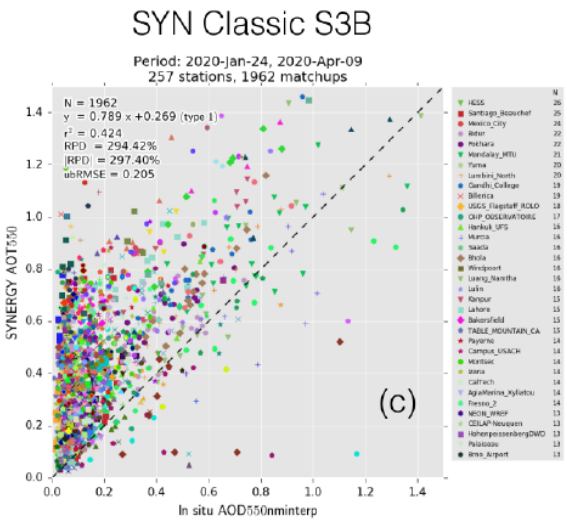

*S. Sterckx, Adapted from PROBA-V QWG#11 June 2020*

# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
   AOD is overestimated in SYN, underestimated in PROBA-V/C1

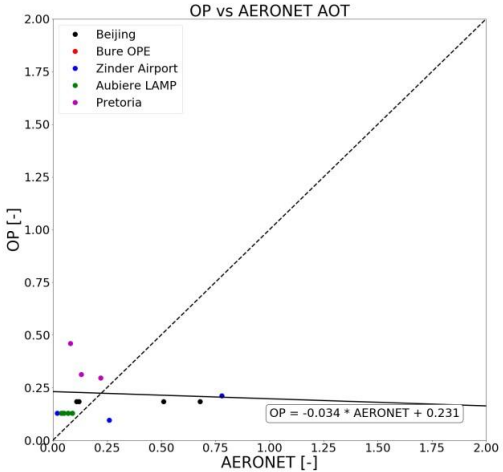
## $AOD_{SYN}$ >> $AOD_{AERONET}$




*C. Henocq, PROBA-V QWG#11 June 2020*

## $AOD_{PV-C1}$ << $AOD_{AERONET}$



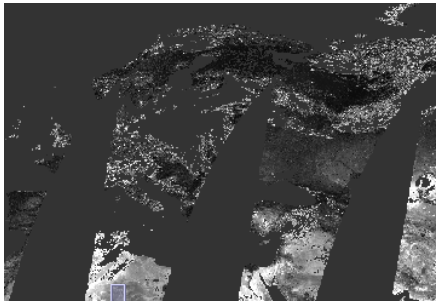

*E. Wolters, PROBA-V QWG#6 Nov 2017*

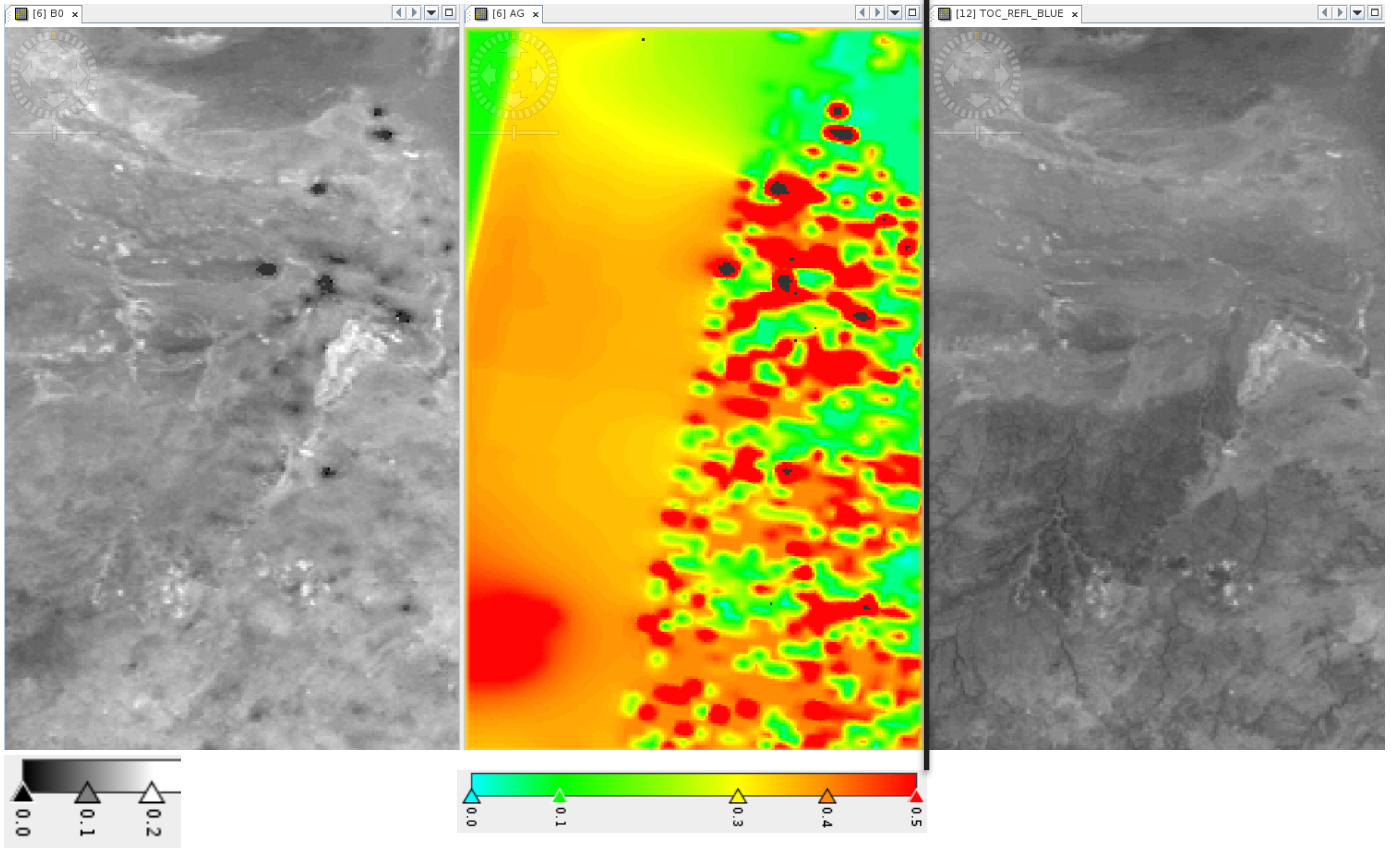
# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
   - AOD is overestimated in SYN, underestimated in PROBA-V/C1
   - Interface SLSTR single/dual view; artefacts in AOD; largest effect in B0

S3A_SY_2_VG1 B0 AOT PROBA-V S1-TOC B0

20200701



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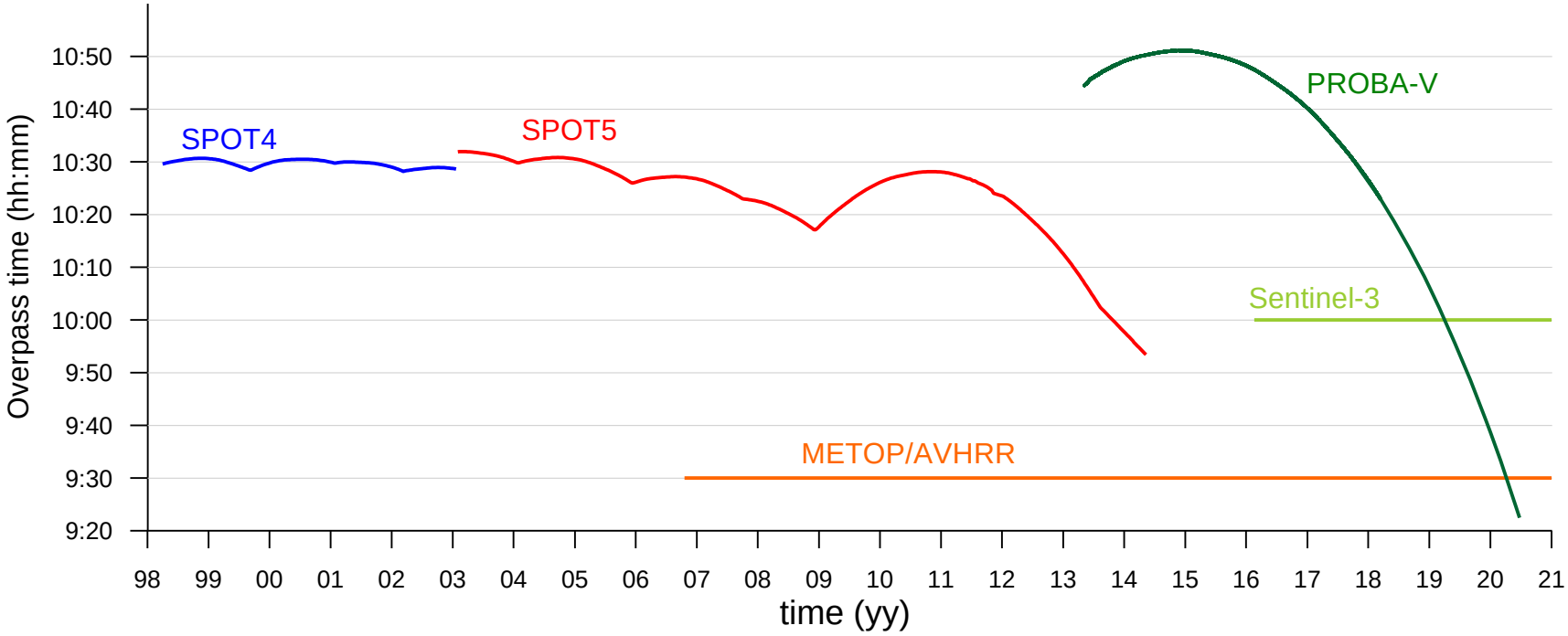
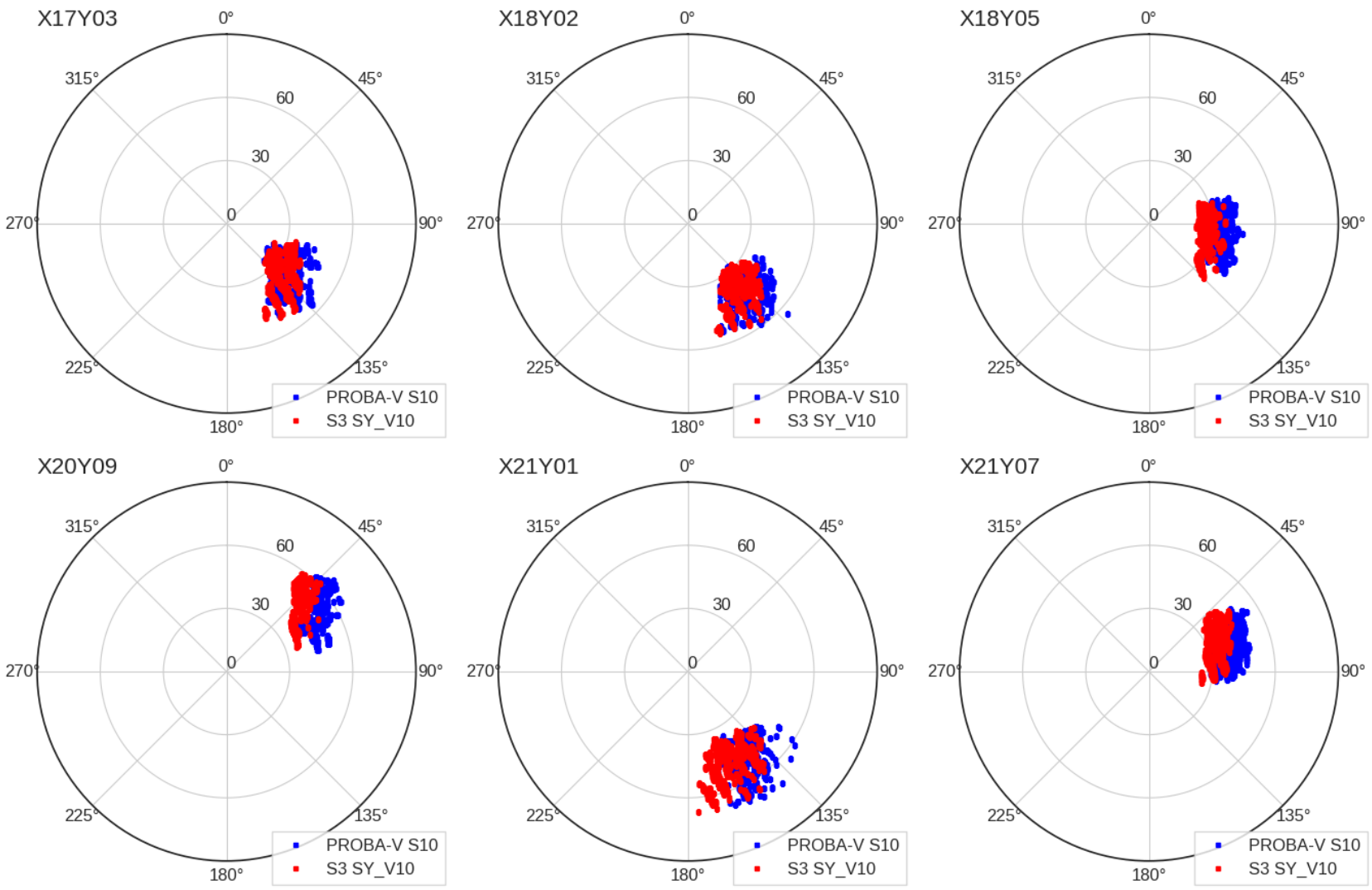
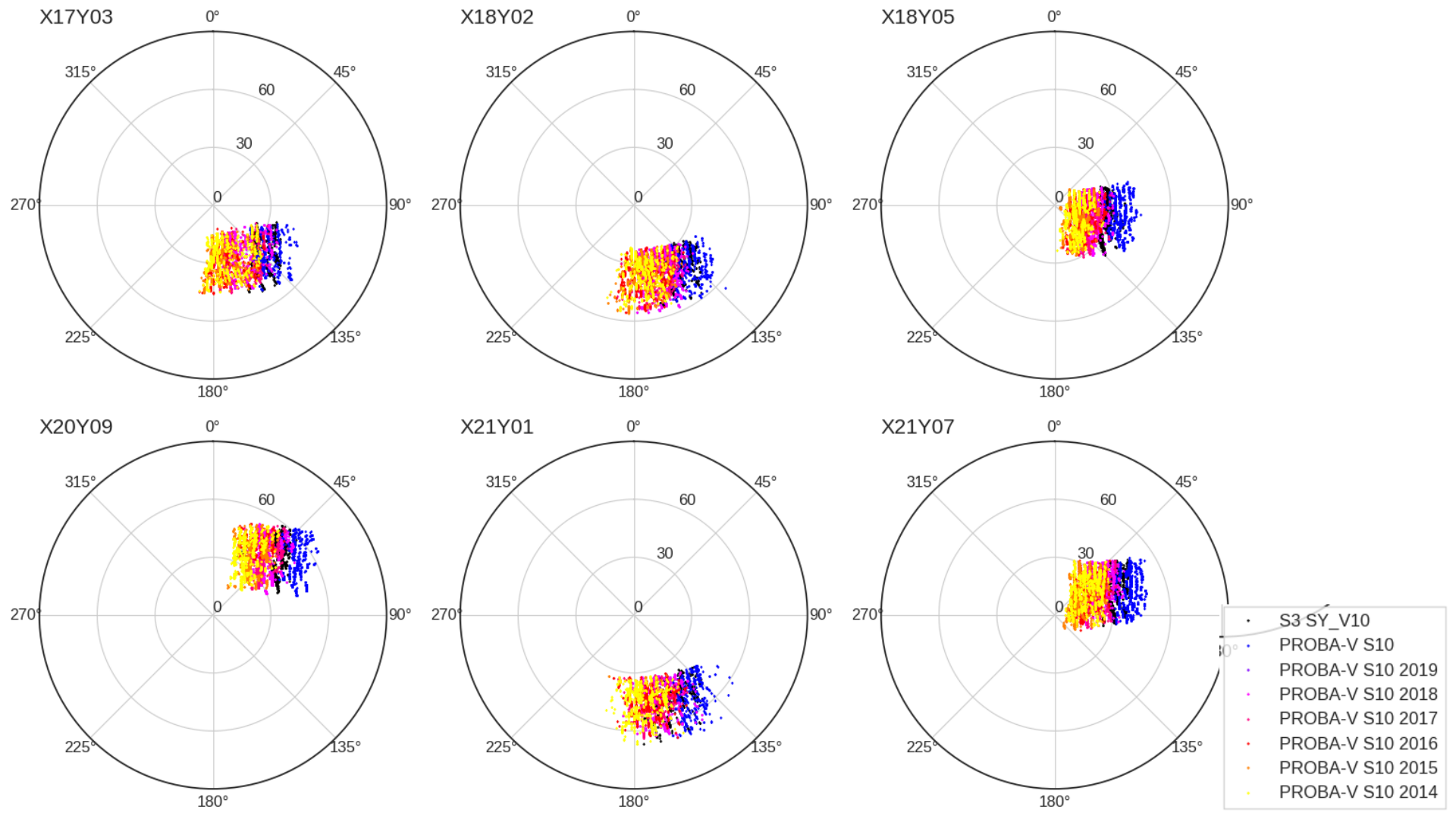
# Sources of inconsistency between SY_VGT and PROBA-V

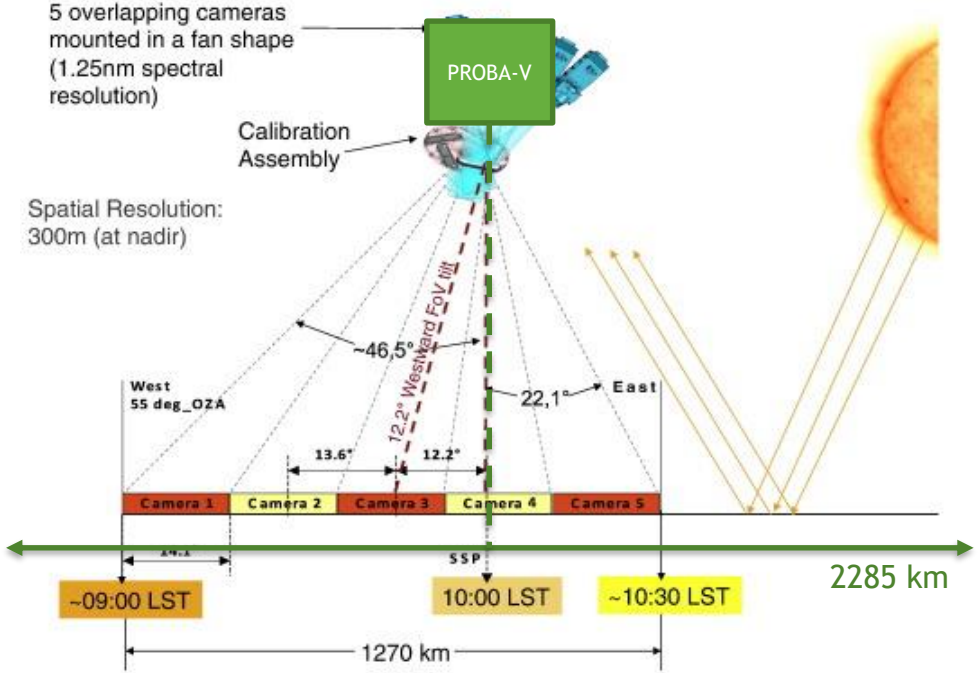
1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
4. Overpass time ~illumination angles
5. Observation angles


Overpass time (hh:mm)
10:50
10:40
10:30
10:20
10:10
10:00
9:50
9:40
9:30
9:20
SPOT4
SPOT5
PROBA-V
Sentinel-3
METOP/AVHRR
98
99
00
01
02
03
04
05
06
07
08
09
10
11
12
13
14
15
16
17
18
19
20
21
time (yy)

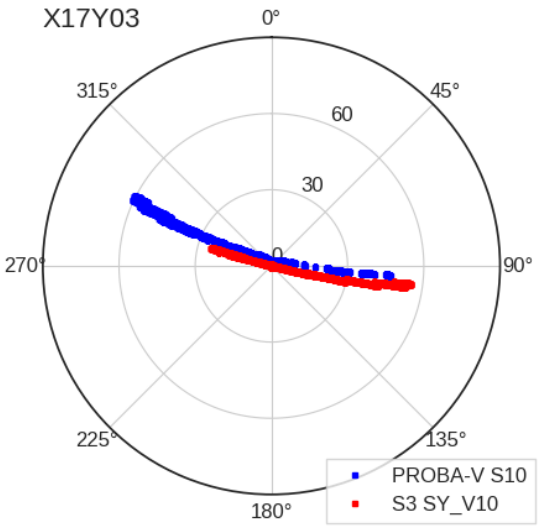

X17Y03
X18Y02
X18Y05
X20Y09
X21Y01
X21Y07
0°
45°
90°
135°
180°
225°
270°
315°
30
60
PROBA-V S10
S3 SY_V10

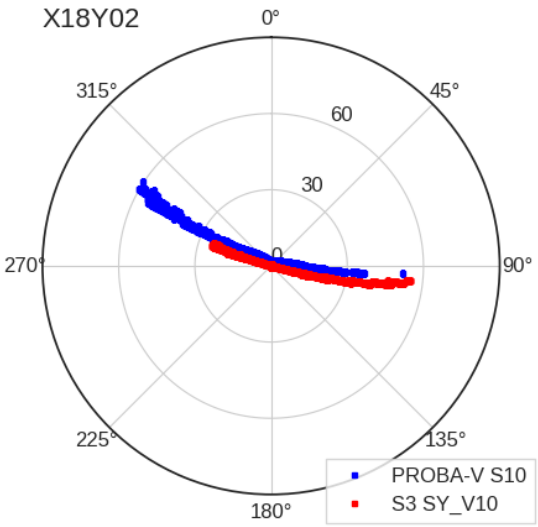

X17Y03
X18Y02
X18Y05
X20Y09
X21Y01
X21Y07
0°
45°
90°
135°
180°
225°
270°
315°
0
30
60
S3 SY_V10
PROBA-V S10
PROBA-V S10 2019
PROBA-V S10 2018
PROBA-V S10 2017
PROBA-V S10 2016
PROBA-V S10 2015
PROBA-V S10 2014

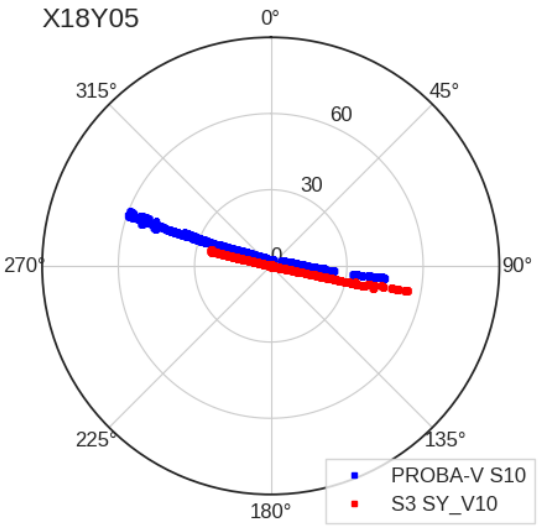
# Sentinel-3 OLCI

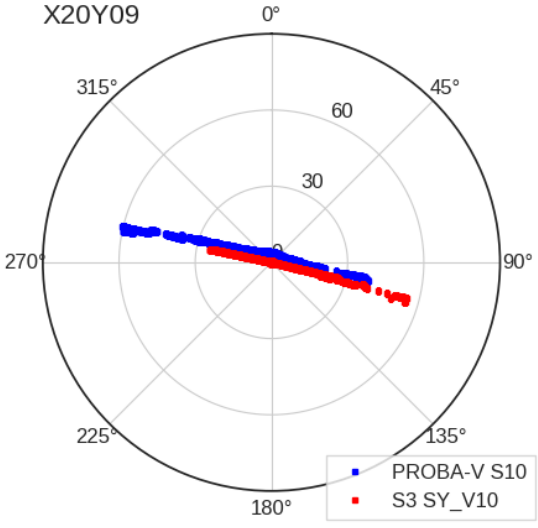


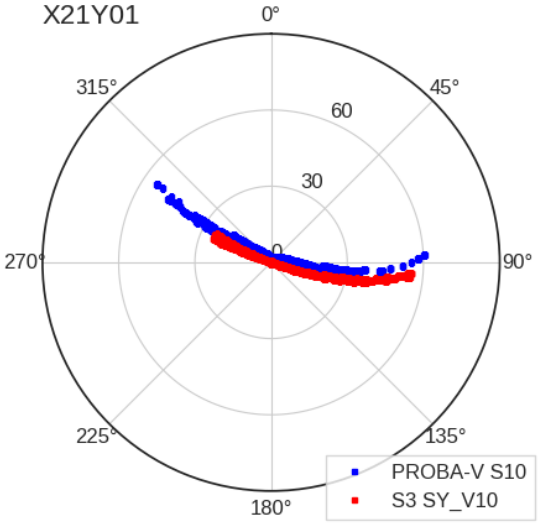

*S3 OLCI User Guide*

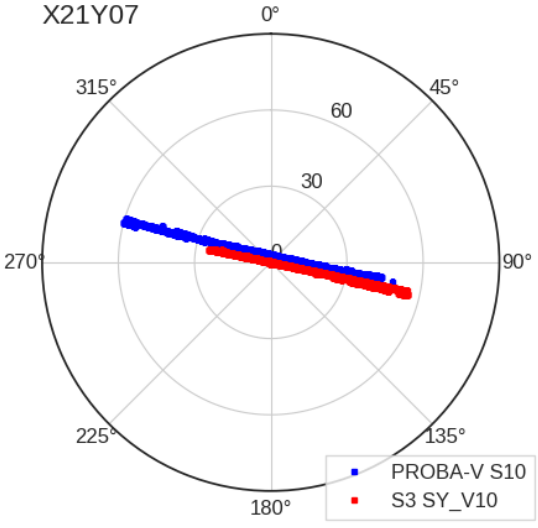

X17Y03
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10


X18Y02
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10


X18Y05
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10


X20Y09
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10


X21Y01
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10


X21Y07
0°
45°
90°
135°
180°
225°
270°
315°
60
30
0
PROBA-V S10
S3 SY_V10

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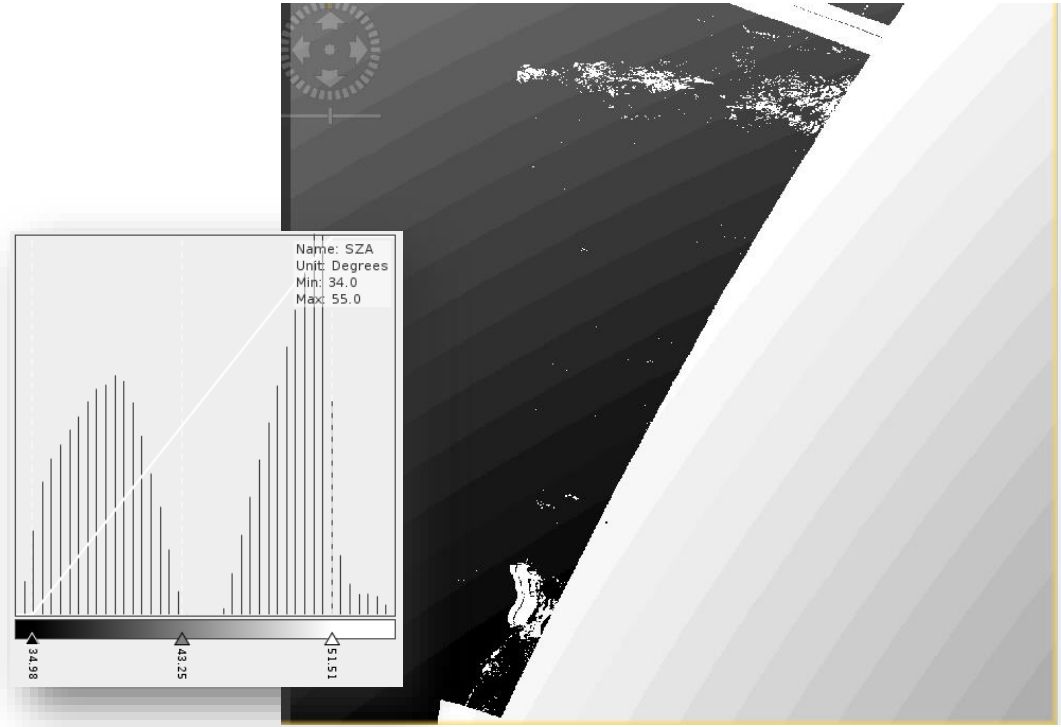
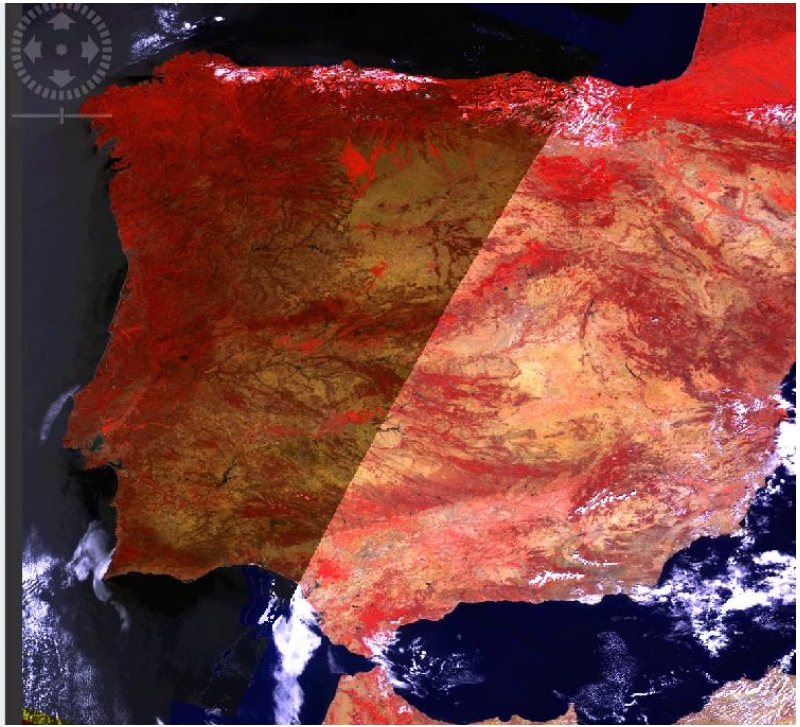
SZA




PROBAV_S1_TOC 20200902



RGB: NIR-RED-BLUE

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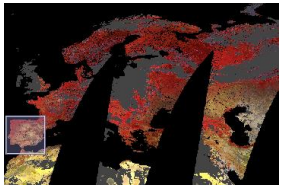
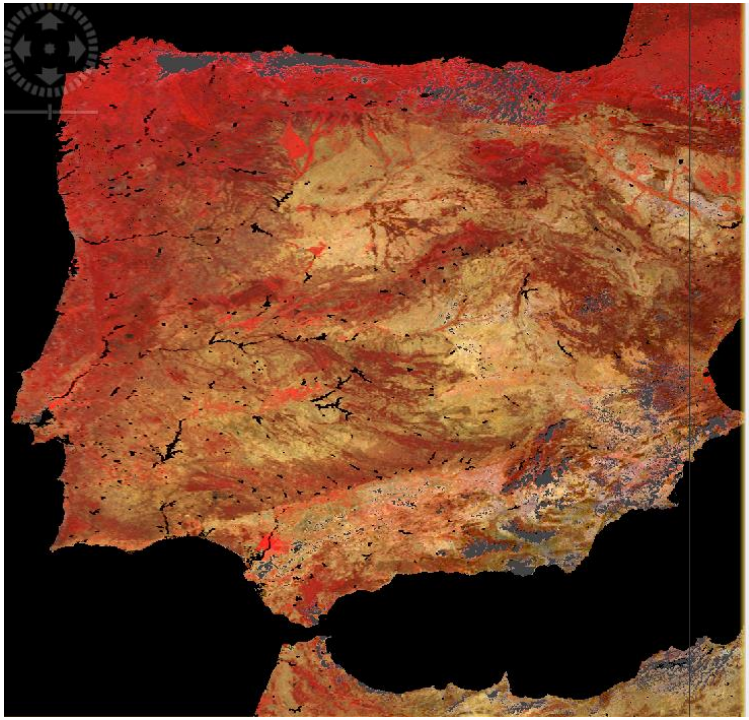
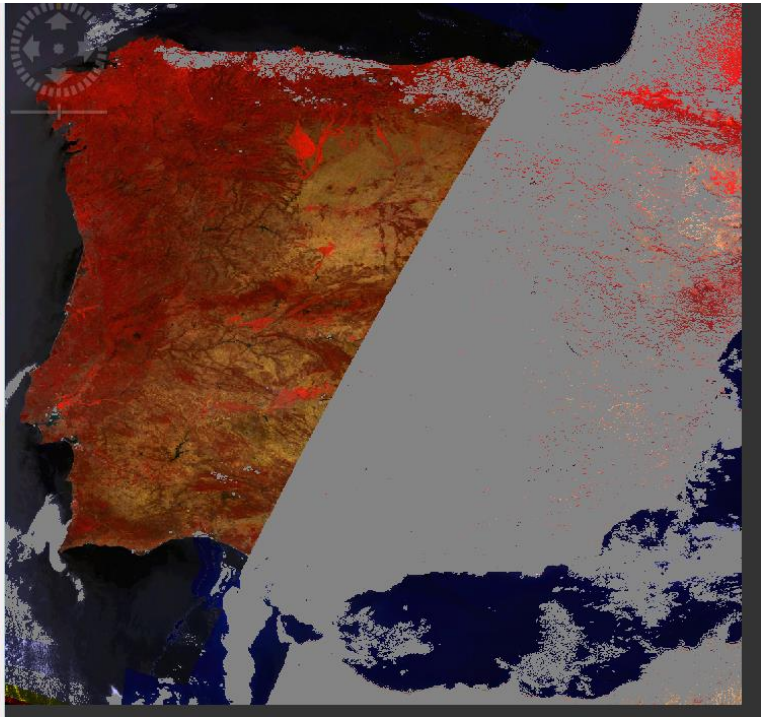
S3B_SY_2_VG1 20200901

PROBAV_S1_TOC 20200902

20200901







RGB: NIR-RED-BLUE

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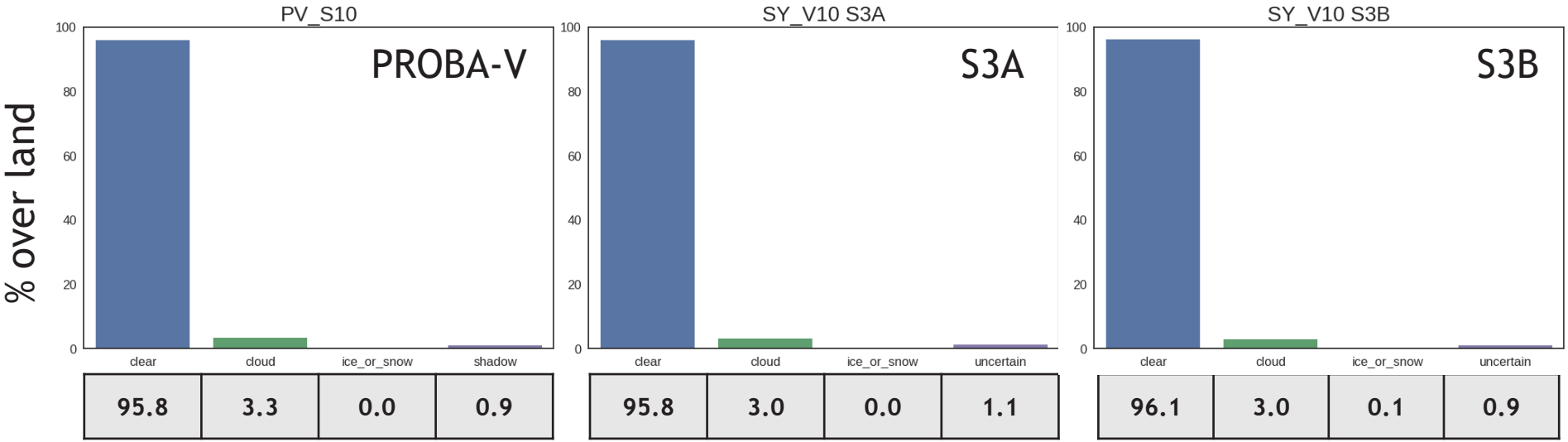
# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
4. Overpass time ~illumination angles
5. Observation angles
6. SY_VG1 and SY_V10 are produced based on S3A and S3B separately

# Product completeness

Averaged over 6 tiles, 9 dekads




| PROBA-V | | | |
|---|---|---|---|
| clear | cloud | ice_or_snow | shadow |
| 95.8 | 3.3 | 0.0 | 0.9 |

| S3A | | | |
|---|---|---|---|
| clear | cloud | ice_or_snow | uncertain |
| 95.8 | 3.0 | 0.0 | 1.1 |

| S3B | | | |
|---|---|---|---|
| clear | cloud | ice_or_snow | uncertain |
| 96.1 | 3.0 | 0.1 | 0.9 |

S10

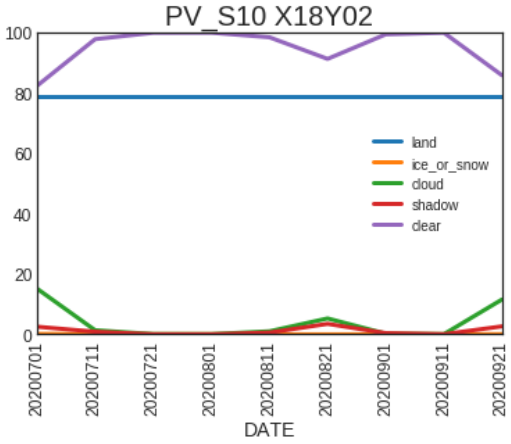
X18Y02

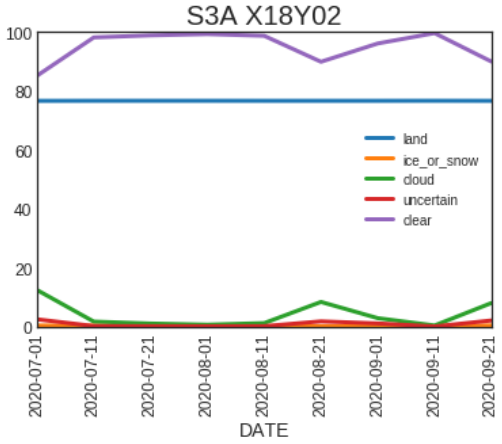
X21Y07

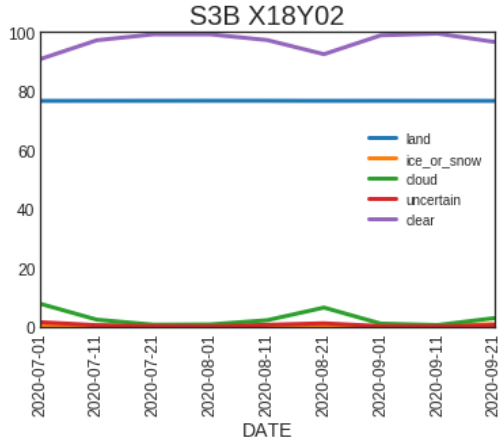
PROBA-V

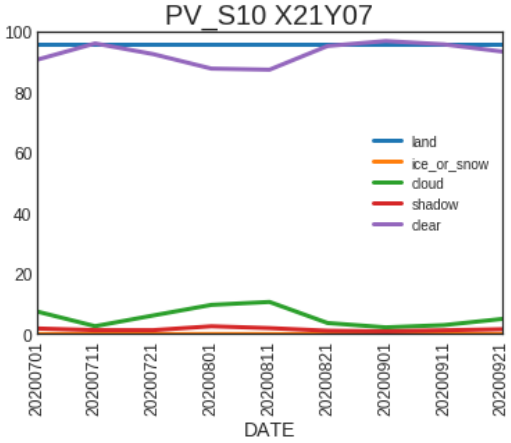
S3A

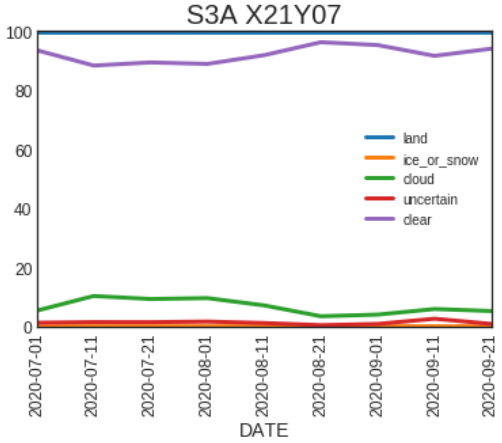
S3B

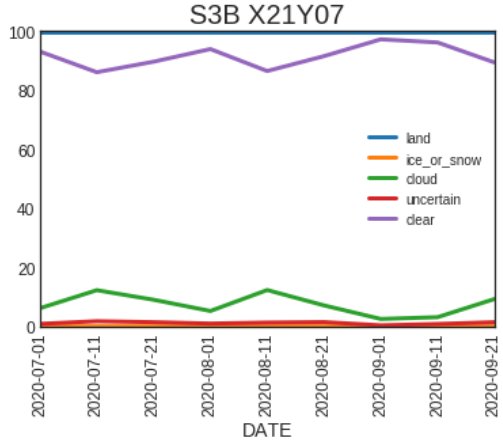
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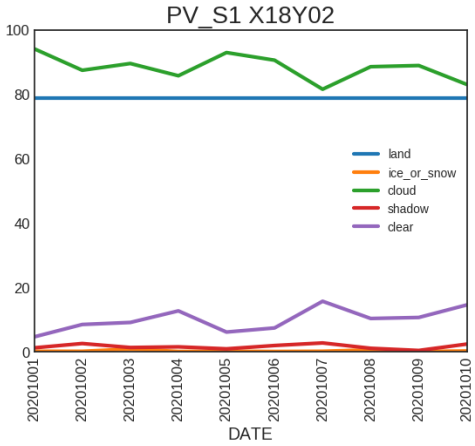
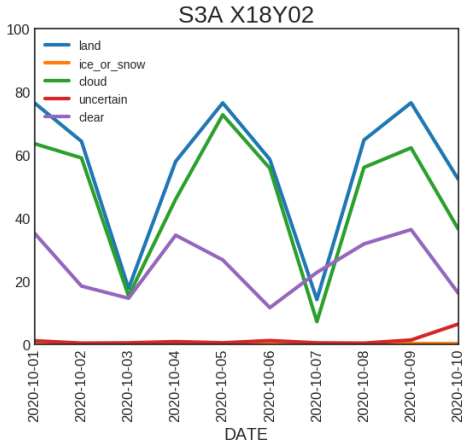
# S1

## X18Y02

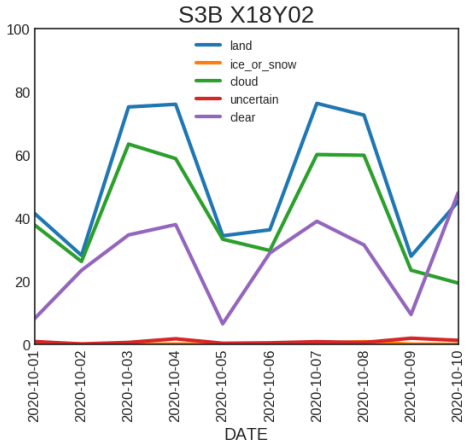
### PROBA-V



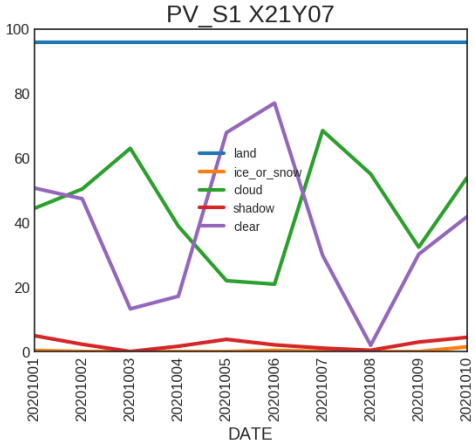

### S3A

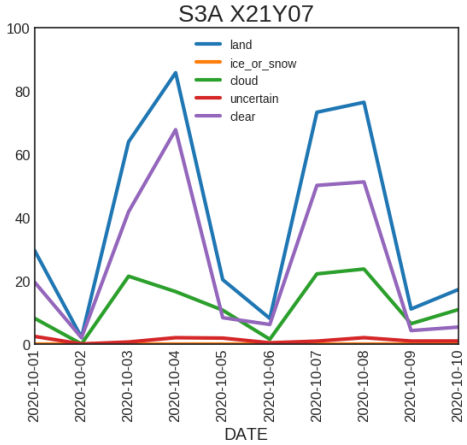


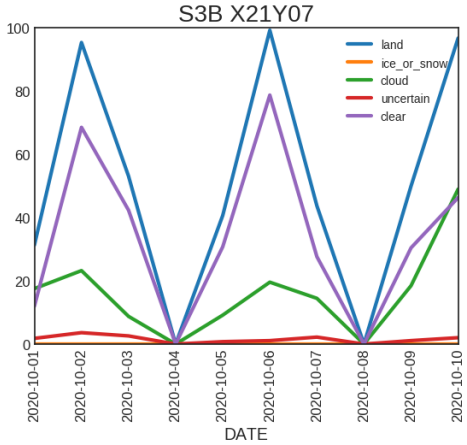

### S3B




## X21Y07

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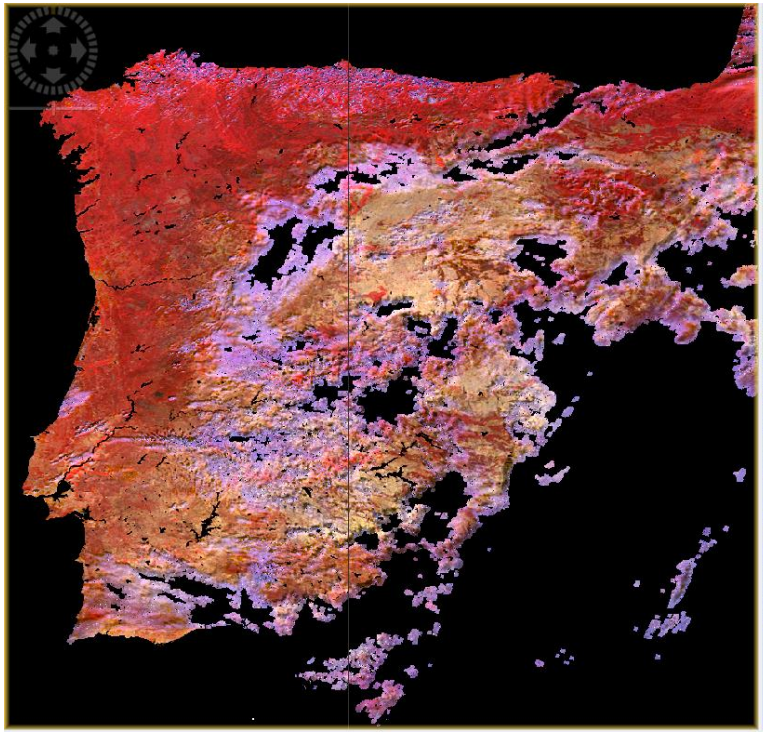
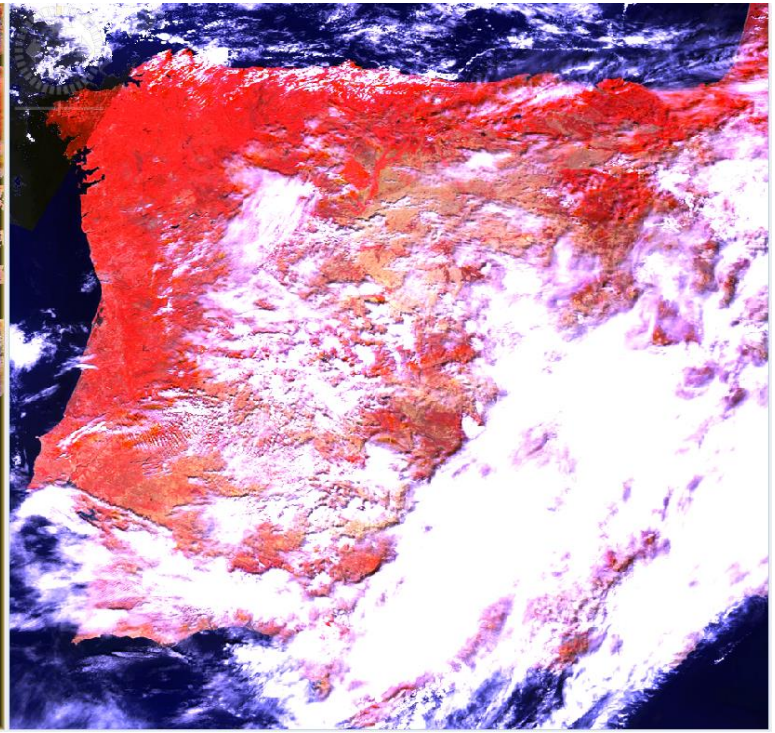
# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
4. Overpass time ~illumination angles
5. Observation angles
6. SY_VG1 and SY_V10 are produced based on S3A and S3B separately
7. Undetected clouds, no cloud shadow detection in SYN
8. Land/sea mask

S3B_SY_2_VG1 20200831

PROBAV_S1_TOC 20200901





RGB: NIR-RED-BLUE

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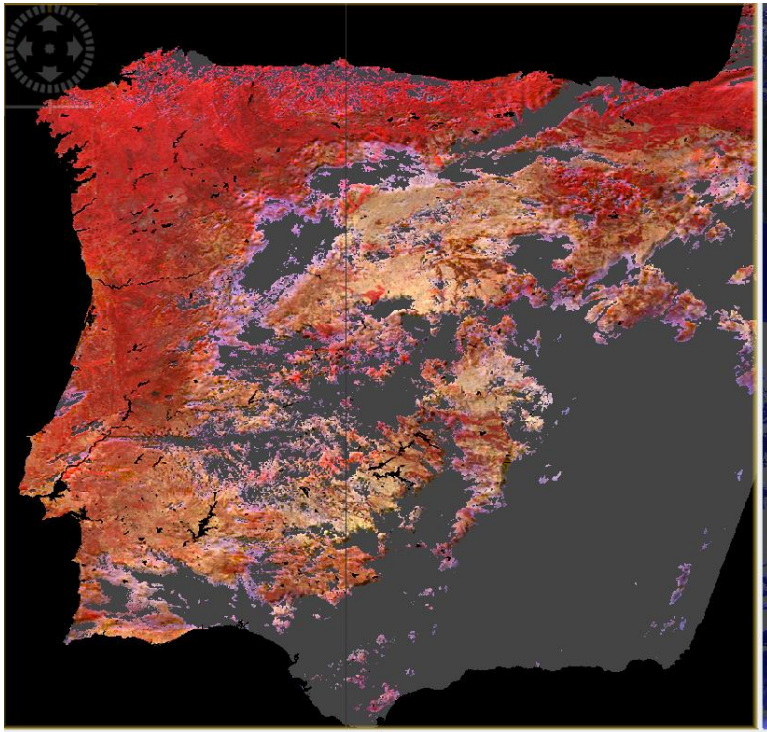
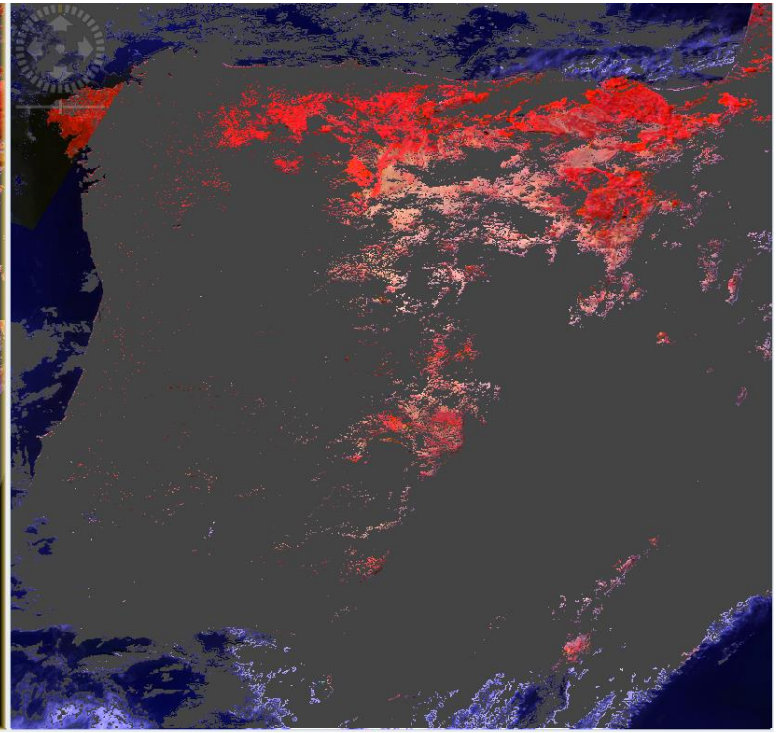
S3B_SY_2_VG1 20200831

PROBAV_S1_TOC 20200901





RGB: NIR-RED-BLUE

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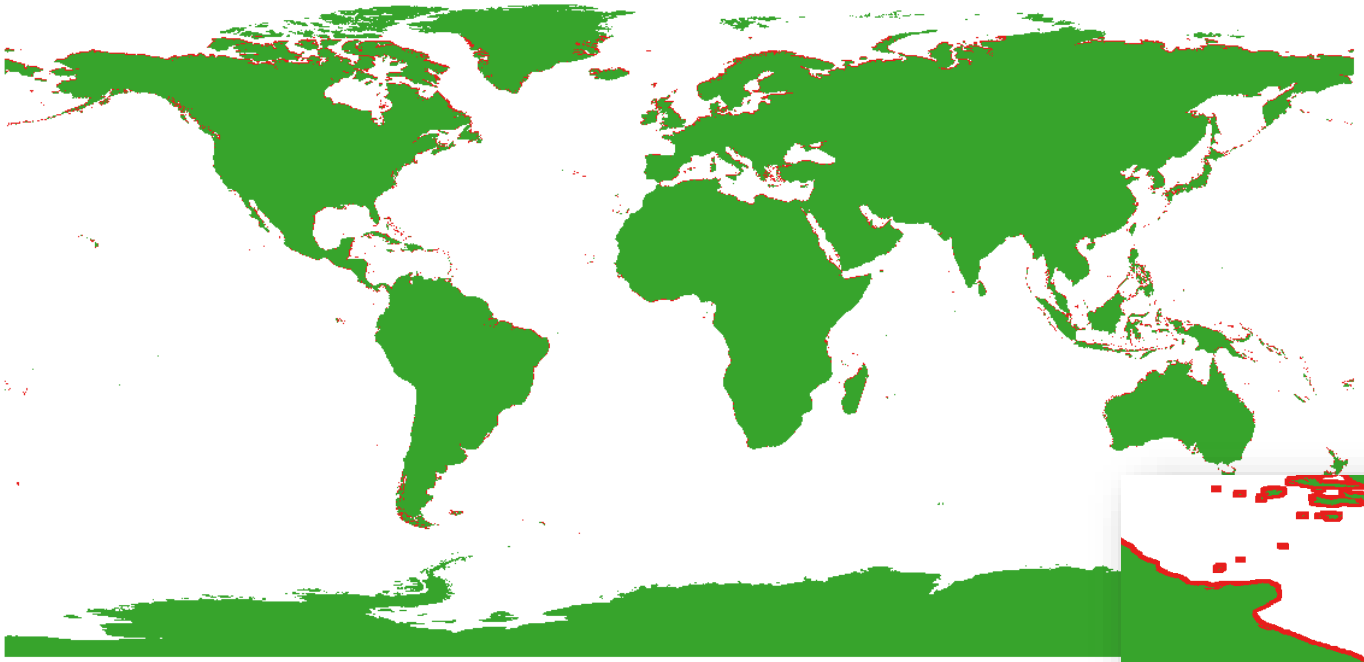

OLCI Open Ocean Mask
PROBA-V Land/Sea Mask

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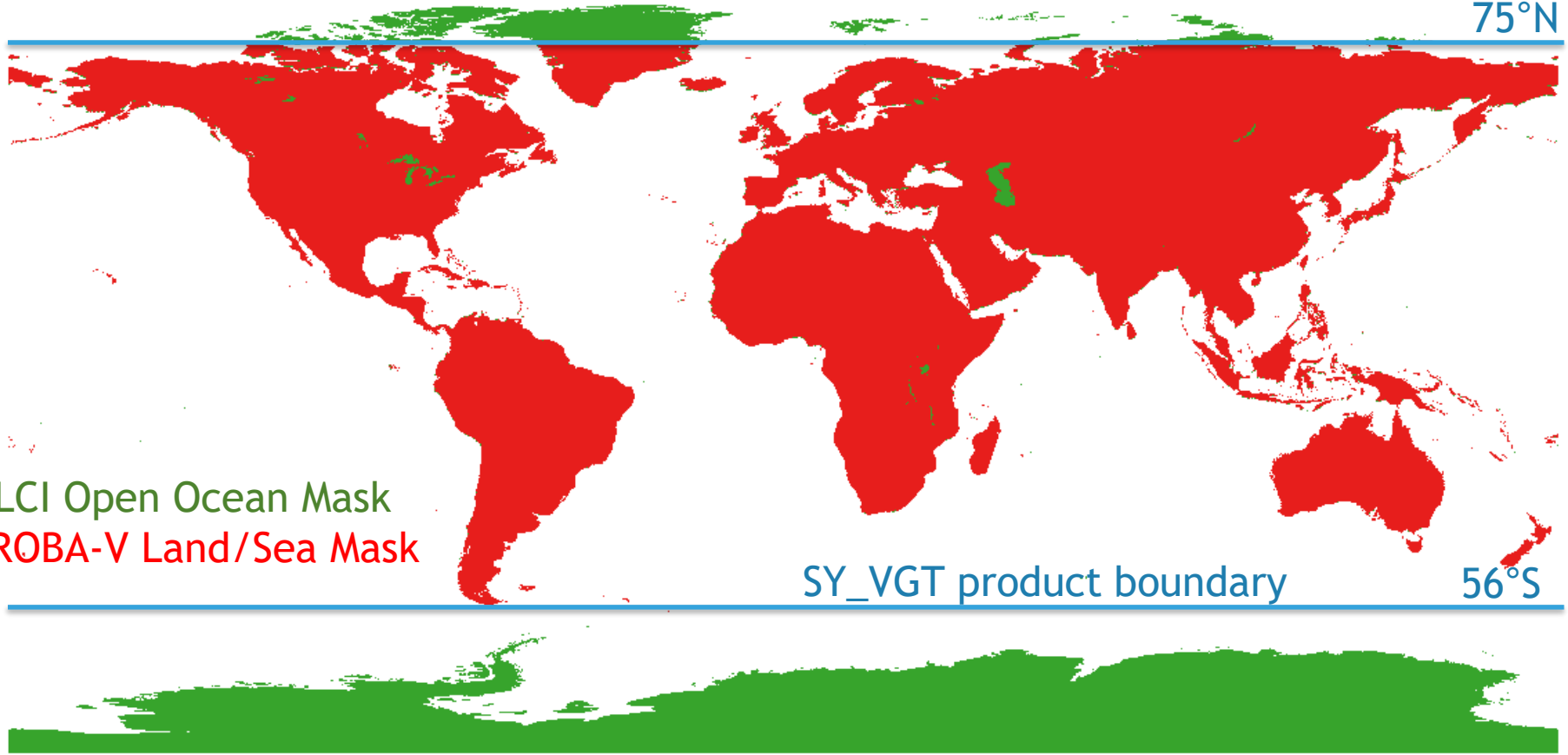
remote sensing

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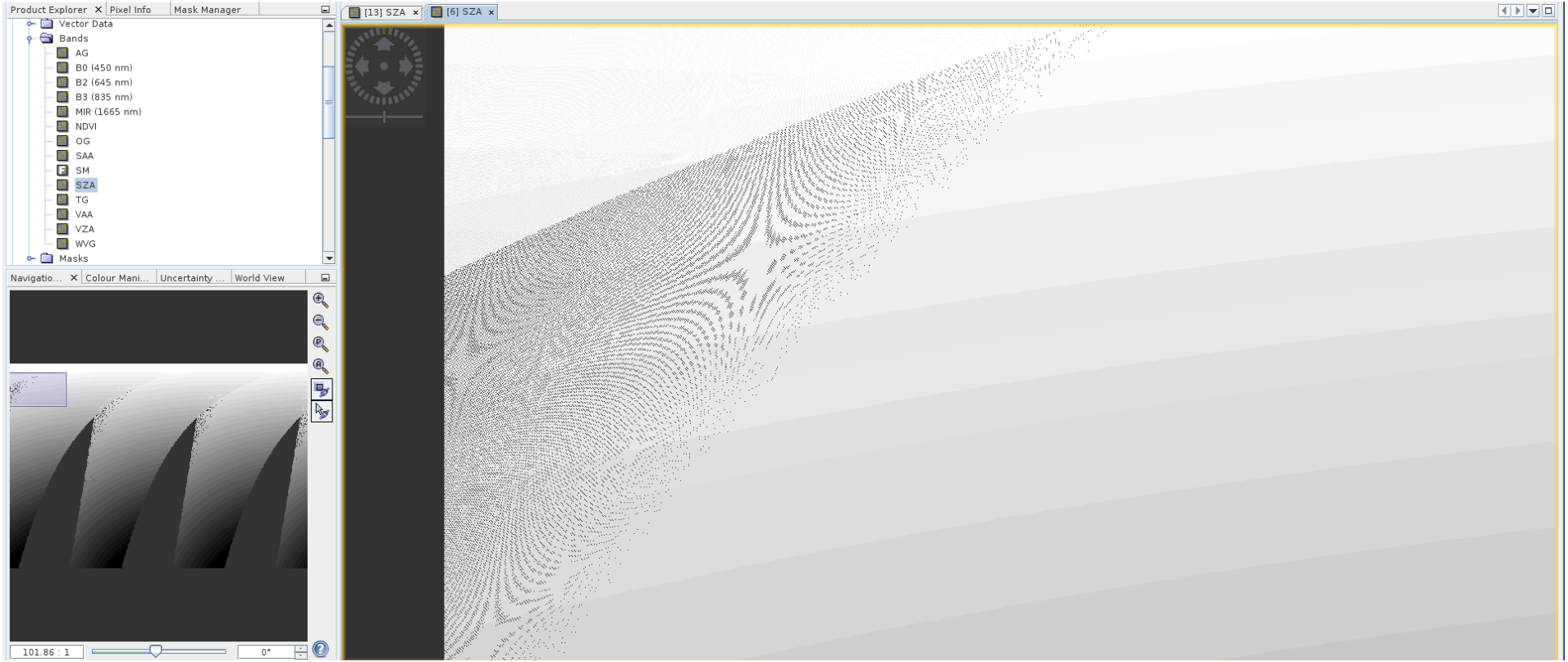
S3A_SY_2_VG1____20200901T120000_20200902T120000_20200907T122216_EUROPE_____LN2_O_NT_002.SEN3

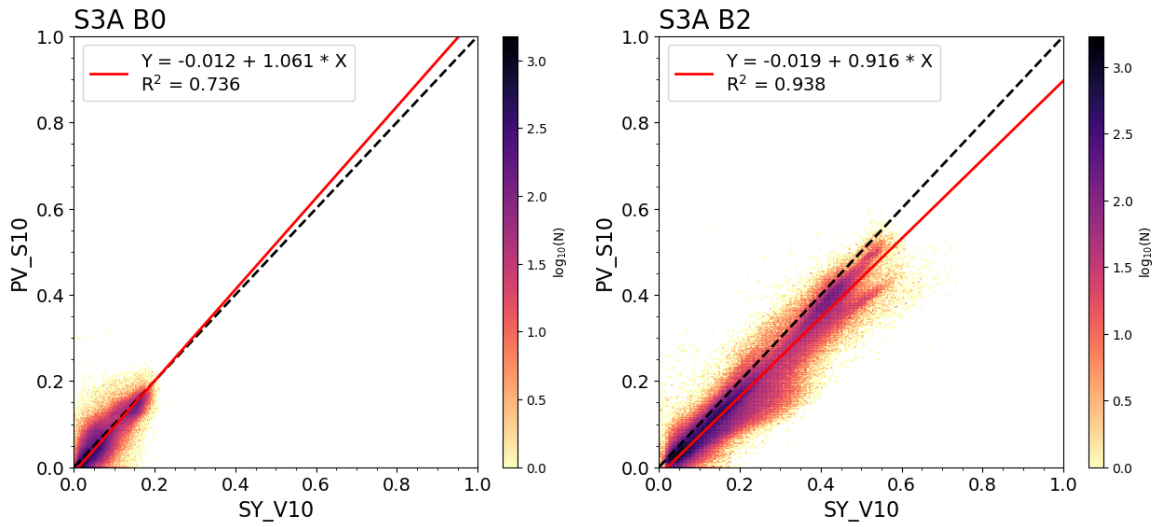


# Sources of inconsistency between SY_VGT and PROBA-V

1. Differences in spectral response
2. Differences in absolute calibration
3. Differences in atmospheric correction
4. Overpass time ~illumination angles
5. Observation angles
6. SY_VG1 and SY_V10 are produced based on S3A and S3B separately
7. Undetected clouds, no cloud shadow detection in SYN
8. Land/sea mask

# Statistical consistency analysis on S10

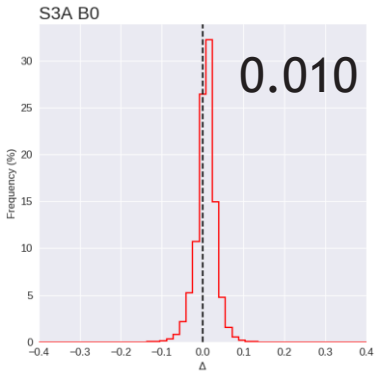
- Over 6 tiles, per sensor, per band

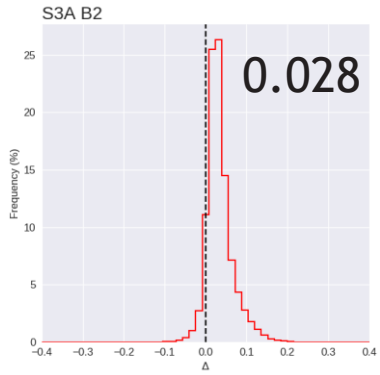


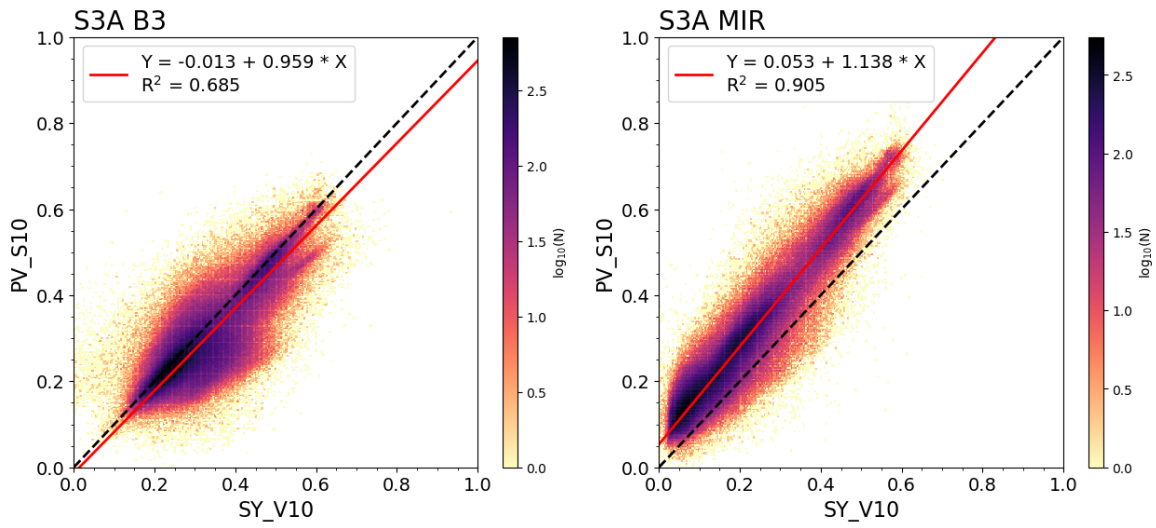




# Bias SY_V10 – PV_S10

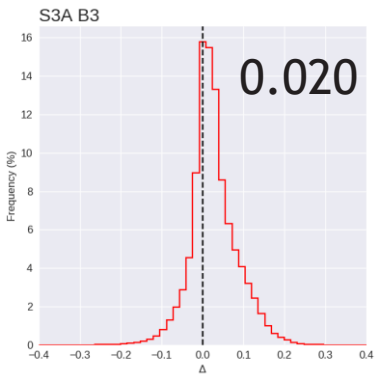


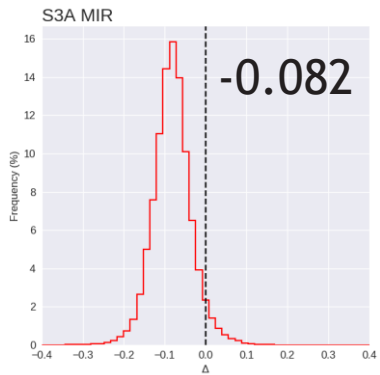







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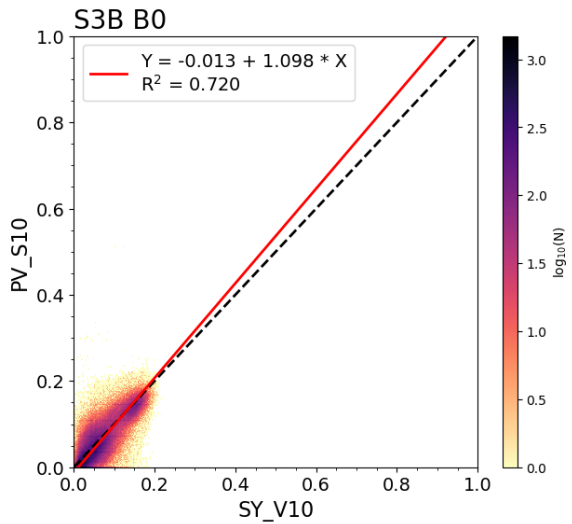
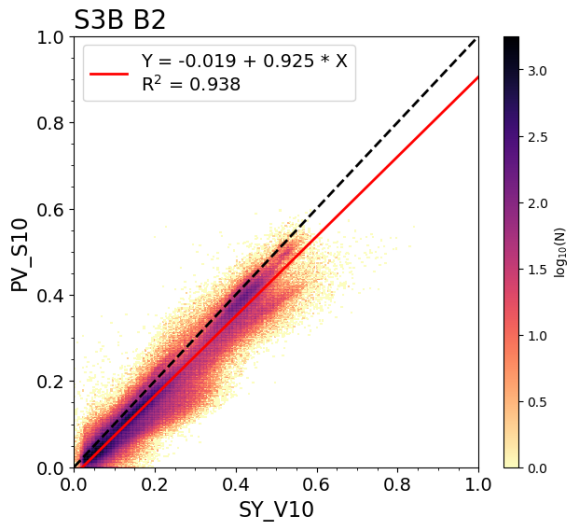
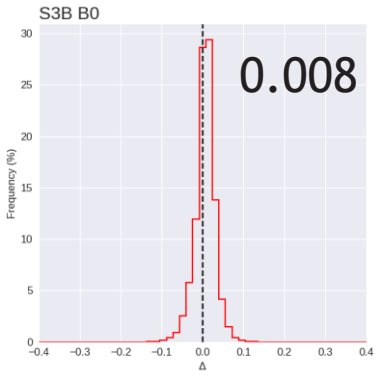
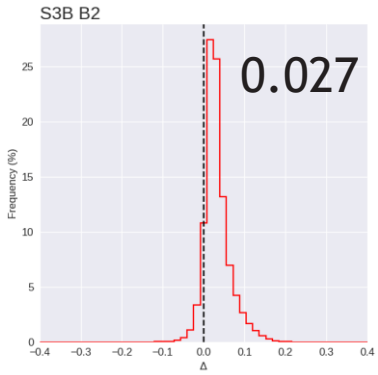
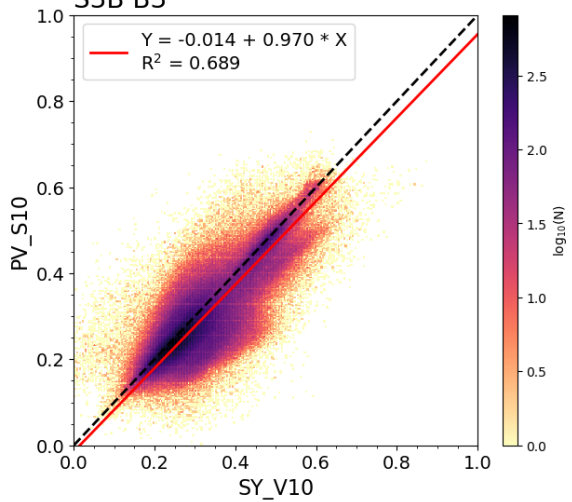


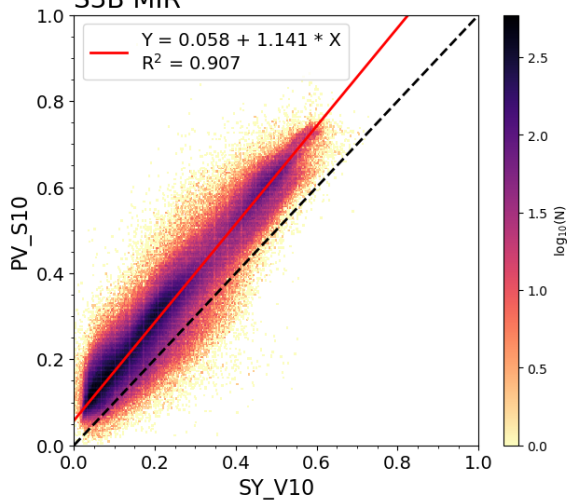



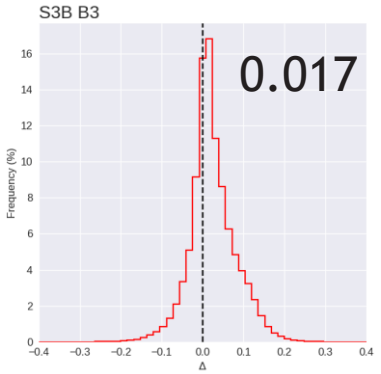

# Bias SY_V10 – PV_S10

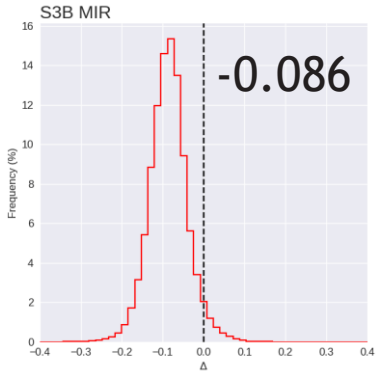
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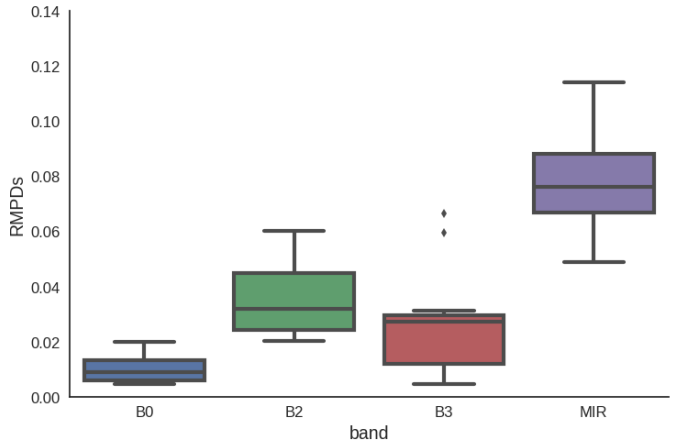
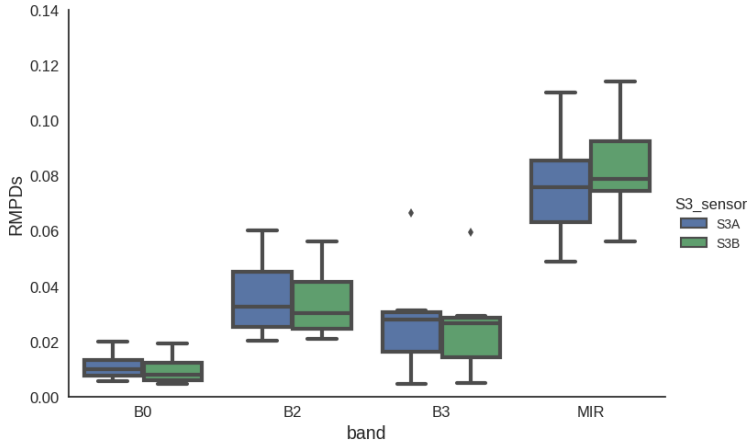
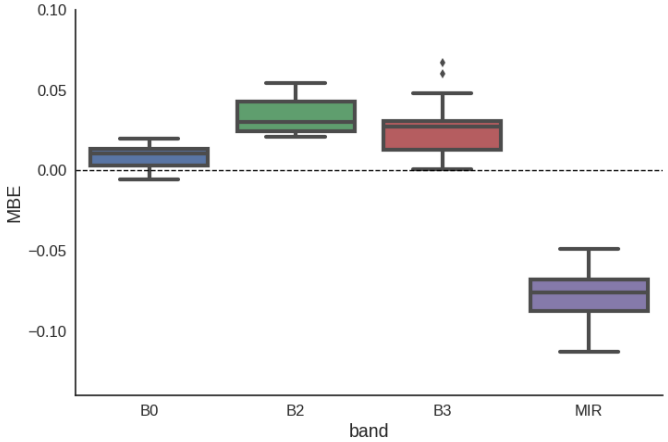
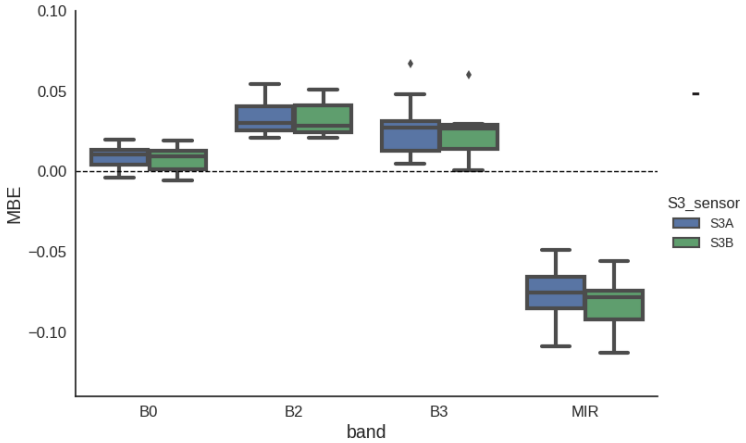
# Systematic difference




# Mean bias



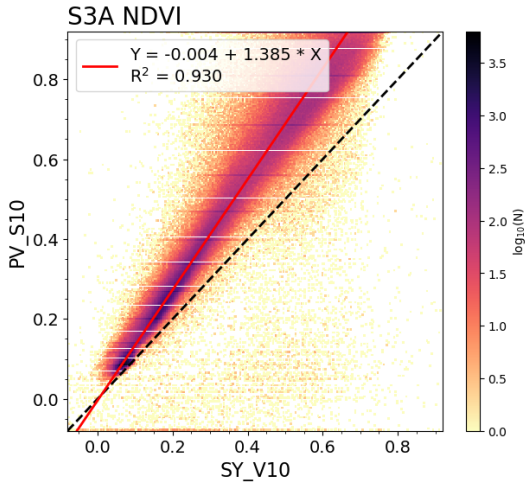



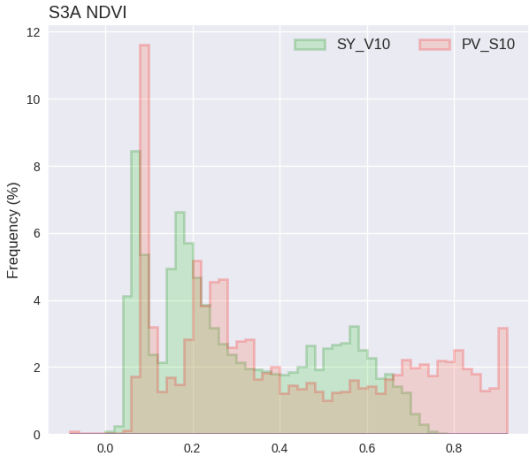

- MIR bias around -8%
  ~ SLSTR calibration issue
- Large bias for B2, B3 and B0 (S3 > PV)
  ~ radiometric calibration
  ~ atmospheric correction
- Bias is slightly smaller for S3B (except MIR)

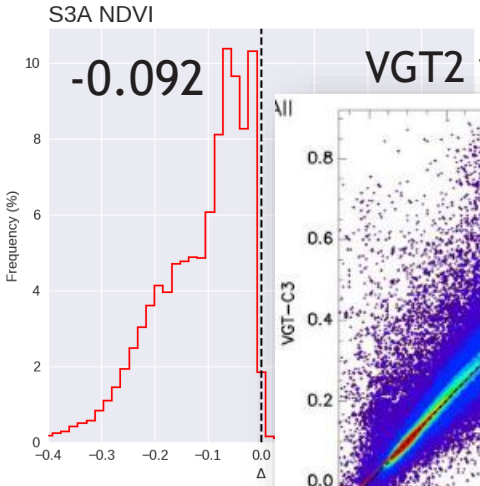
# Statistical consistency analysis on S10

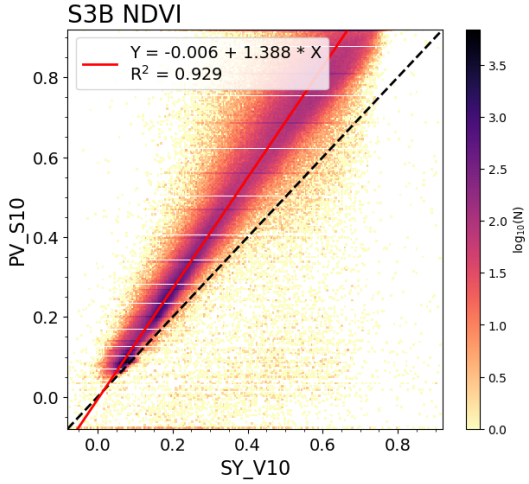
- Impact on NDVI ?

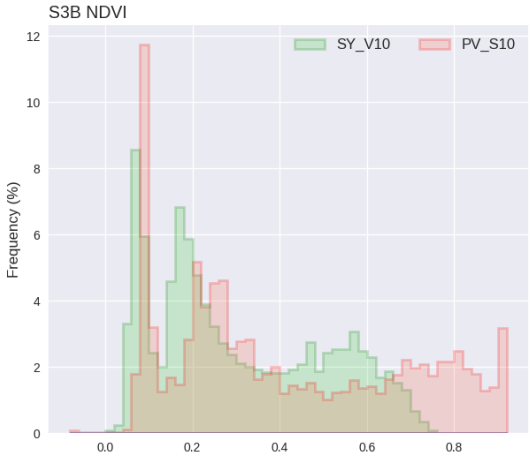
# Bias SY_V10 – PV_S10

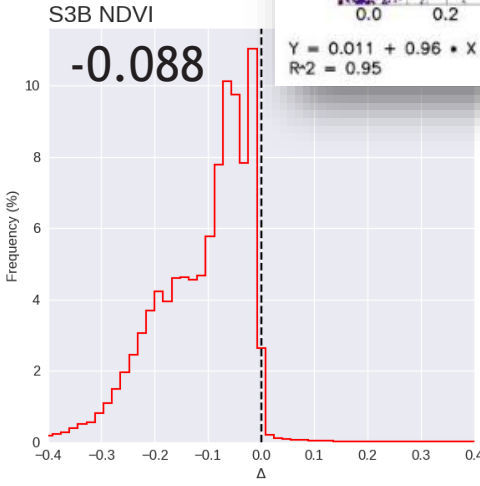


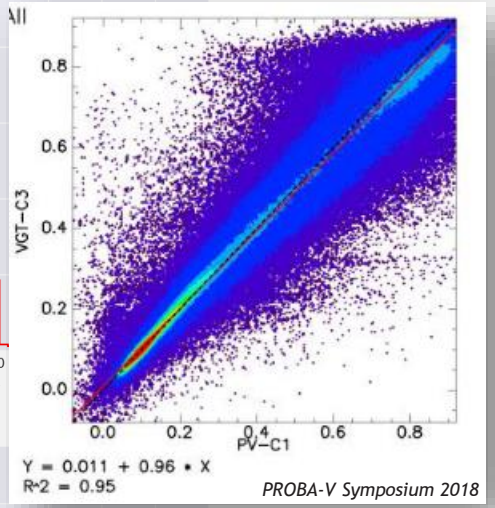



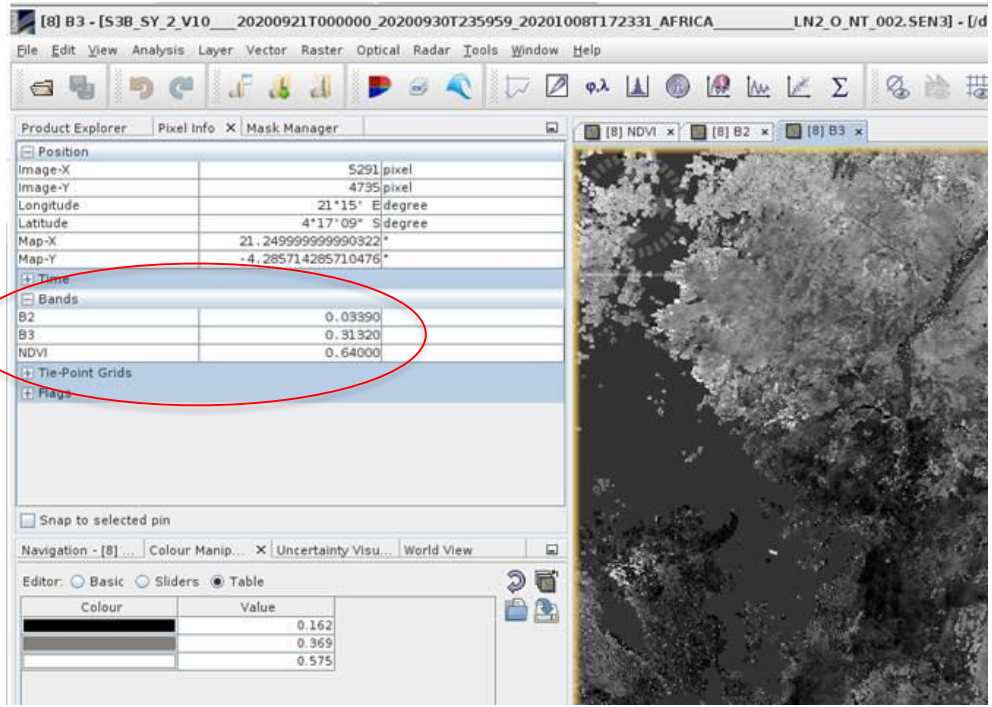




## VGT2 vs. PROBA-V





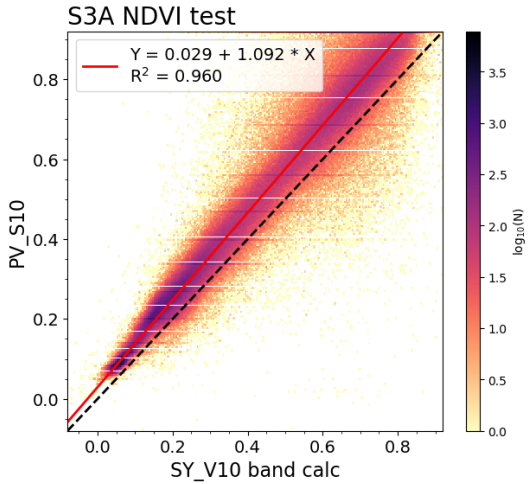

~~Bug in NDVI calculation?~~

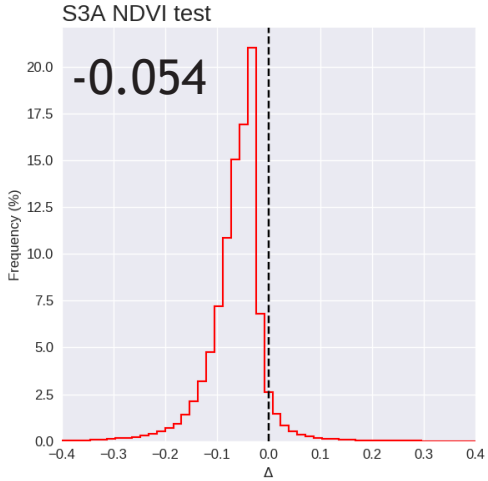
NDVI in VG1 and V10 is **TOA** not TOC !

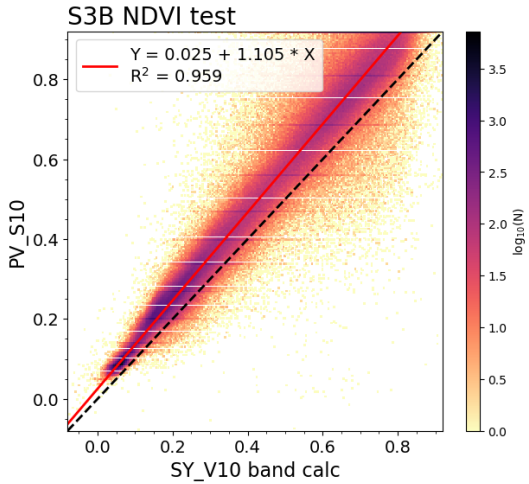
(0.3132 - 0.0339) / (0.3132 + 0.0339) = 0.804667

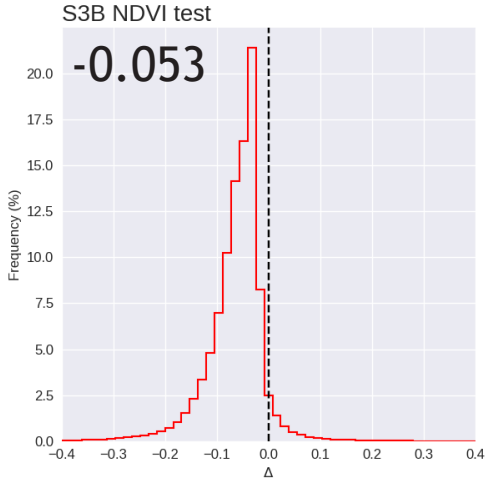
!= 0.640 in NDVI band

# Bias SY_V10 - PV_S10

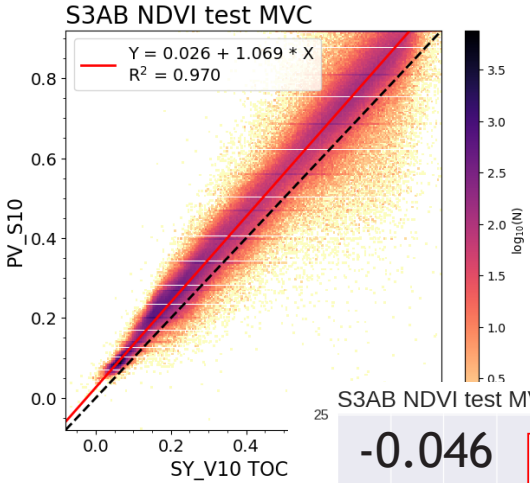


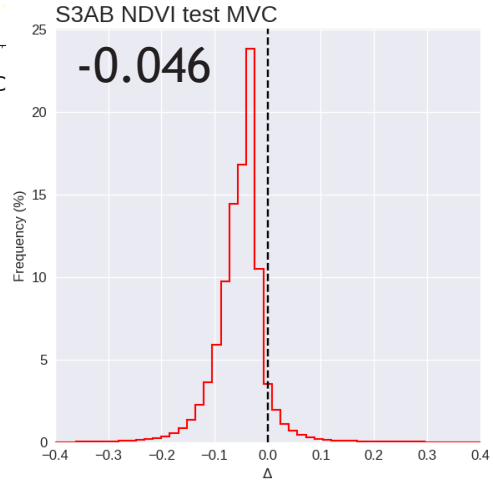




If the error is fixed, we still will still observe a systematic bias



# Conclusions

- Statistical consistency analysis on S10 shows
  - Large systematic differences for RED and NIR (not observed at TOA → TBC)
  - Slightly better consistency for S3B than for S3A
  - Large systematic difference for SWIR (~ calibration SLSTR) → apply factors
  - Very large systematic differences for NDVI (~ no A/C) → needs fix
- Sentinel-3 SYN VGT products currently do not provide continuity to the user
  - Serious inconsistencies, especially for S10 NDVI product → gap in series
  - Inadequate compositing strategy, not combining sensors
  - Issues related to AOT (striping, artefacts) → use CAMS/MERRA-2/SYN AOD?
  - Issues in status map (clouds, cloud shadows)
- We need reprocessed SYN VGT data for temporal consistency analysis over an overlapping period with *nominal* PROBA-V (e.g. from Jul/2018)
- Planned user communication on Terrascope documentation platform

**Disclaimer**

The work performed in the frame of this contract is carried out with funding by the European Union. The views expressed herein can in no way be taken to reflect the official opinion of either the European Union or the European Space Agency.

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# THANK YOU

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