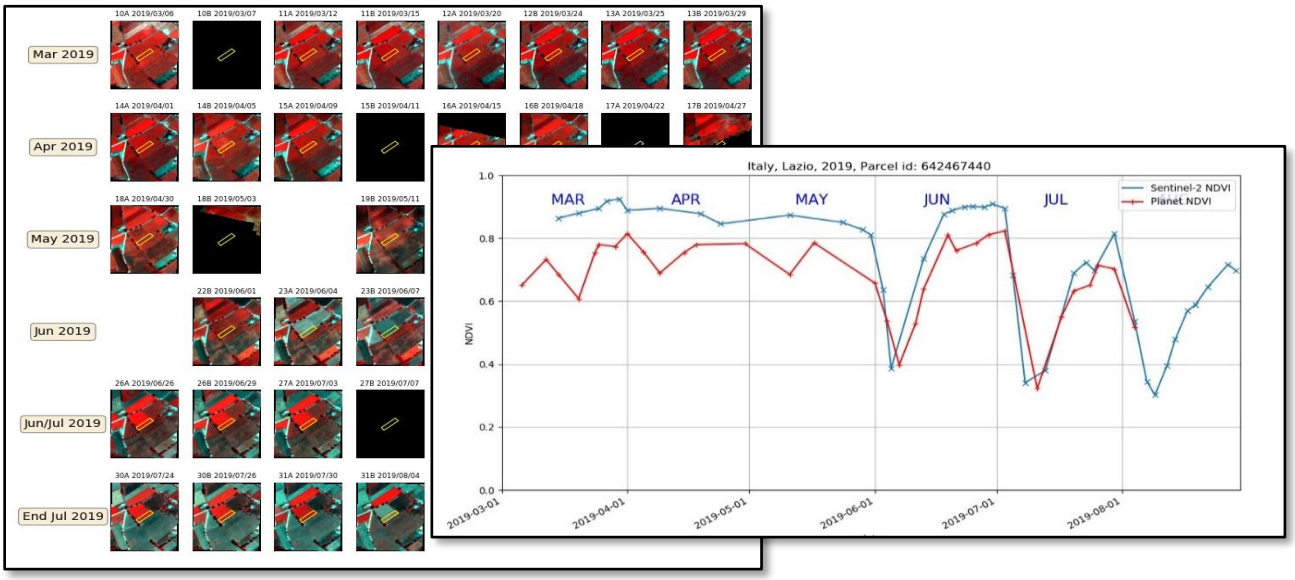
European Commission

JRC TECHNICAL REPORT

Planet HHR Time Stacks tests in the 2019 crop season

- *a synthesis*

Pär Johan Åstrand, Slavko Lemajic, Csaba Wirnhardt



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Executive Summary

The Common Agricultural Policy (CAP) Checks by Monitoring (CbM) replaces the on-the-spot-checks presently used to verify that area-based direct aid is granted correctly to EU farmers. This alternative control method is implemented through Article 40a of the implementing regulation (EU) 809/2014, and may be used since 2018. The CbM primarily relies on automatic methods to conclude on the CAP eligibility criteria, commitments and obligations from regular and systematic Copernicus Sentinel imagery. For some agricultural parcels, the spatial resolution of the Sentinel imagery could be insufficient to conclude on the support (eligibility, compliance). For this reason, the use of High High Resolution (HHR) image data has been considered to verify and possibly complement the results obtained using Sentinel data. This document summarizes the experiences of four MS Regions use of HHR data for their CbM in the crop season 2019, and compares them with the assessments made by the Joint Research Centre (JRC) either in collaboration or in parallel.

A consortium formed by Planet Labs Germany GmbH and GAF AG was awarded a contract to deliver the required HHR data consisting of archive Time Stacks (TSs) and raster representations (image chips) of selected parcels. The four MS Regions covered by HHR TSs were Denmark (delivery of 800 TS), Malta (250), Italy (7,997), and finally Spain (7,190) giving a total of 16,237 TSs.

As outcomes of the tests, there is a common agreement that S2 and Planet Normalized Difference Vegetation Index (NDVI) profiles are very comparable even for small parcels. However, the four MS Regions consider that the TSs, and especially the accompanying image chips, are useful in the CbM processing chain. The experiences reveal that certain parameters need to be further optimized to make the use more effective (i.e. producing the right result). First of all, it is essential to correctly determine the set of (small, narrow, etc.) parcels that should compose the HHR TS set i.e. to use the correct FOIs for input in the automatic CbM processing. A correctly extracted FOI may already solve many inconclusive parcels composing it. Then, other parameters to fine-tune are the optimization of ingest time, to ease the access to data, to increase the availability of image chips, and finally it is also suggested that MS Administrations should have a clear vision of where in their workflow the TS and image chips are needed.

In this context, it is also appropriate to mention the possible future need of HHR reference within the frame of the CbM process where the spatial, and heterogeneity components of the parcel (or correct FOI) may allow to extract more relevant information than the sole use of the temporal component. The document ends with some ideas on the way forwards.

Acknowledgements

The authors wish to acknowledge the Paying Agencies of Denmark, Italy, Malta and Spain, for providing their input, and to Planet/GAF for review.

Authors

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Acronyms	
AGEA	AGenzia per le Erogazioni in Agricoltura (PA Italy)
ARPA	Agriculture and Rural Payments Agency (PA Malta)
AL	Arable Land
AP	Agriculture Parcel
CAP	Common Agricultural Policy
CAPI	Computer Aided Photo-Interpretation
CbM	Checks by Monitoring
CESTEM	Cubesat-Enabled Spatio-Temporal Enhancement
COM	European Commission (EC)
CwRS	Control with Remote Sensing
CyL	Castilla y Leon
DOVE	Triple-CubeSat miniature satellites built by Planet
EOS	End Of Season
FEGA	Fondo Español de Garantía Agraria (i.e. Spanish Agrarian Guarantee Fund) (PA Spain)
FOI	Feature Of Interest
GSAA	Geo Spatial Aid Application
HHR	High High Resolution
JRC	Joint Research Centre of the EC
LC	Land Cover
MS	Member State
ML	Machine Learning
NDVI	Normalized Difference Vegetation Index
OTSC	On-The-Spot Checks
PC	Permanent Crop
PG	Permanent Grassland
QA	Quality Assurance
RFV	Rapid Field Visit
S1	Copernicus Sentinel-1
S2	Copernicus Sentinel-2
SNR	Signal to Noise Ratio
SOS	Start Of Season
TS	Time Stack
VC	Video Conference

1 Introduction

In the first phase of implementation of the CbM method, the spatial resolution of the Sentinel imagery (10m) was considered a priori insufficient to conclude on the support (eligibility, compliance) for some parcels. For this reason, the adoption of High High Resolution (HHR) image data has been set up to address that concern and test if such data could ensure reaching a decision on some or all parcels found as the inconclusive with Sentinel (yellow traffic light in the CbM workflow see Chapter 3.2 for further information on Traffic Lights).

A consortium formed by Planet Labs Germany GmbH and GAF AG was awarded the service contract (JRC no. 938.073 [ref i]) to deliver the requested time series of observations of the optical signal, hereinafter called 'Time Stacks' (TSs), plus their raster representations, hereinafter called "image chips", of all parcels[1] for all considered dates.

The MS Regions covered by HHR TSs in crop season 2019 were Denmark (DK) (#800 TSs); Malta (MT) (#250); Italy (IT) four Regions (#7,997); and Spain (ES) 4 Regions (#7,190). The amount of data requested and actually delivered is summarized in Table 1 below.

	REQUIRED			DELIVERED			
MS/ region	TS/parcels	1/2weeks	records in the TS table	records in the TS table	gaps	%	Image chips
DK	800	44	35200	35200	5585	15.87%	29615
MT	250	44	11000	11000	724	6.58%	10276
ITFVG	2804	44	123376	123376	25401	20.59%	95446
ITREL	1847	44	81268	81268	11489	14.14%	69779
ITPUG	979	44	43076	43076	5324	12.36%	37751
ITBEC	2367	44	104148	104148	13374	12.84%	90761
ESCYL	2619	45	117855	117855	7266	6.17%	110589
ESVAL	1839	45	82755	82755	5502	6.65%	77253
ESGAL	983	45	44235	44235	11341	25.64%	32894
ESARA	1749	45	78705	78705	5326	6.77%	73379
Total	**16 237**		**721 618**	**721 618**	**91 332**		**627 743**

Table 1 - Required versus delivered TSs in service contract 938.073

The requested TSs (16,237) correspond to 721,618 records and delivered records (721,618) where a total of 91,332 of gaps are present. Reasons for these gaps are due to:

- no ground lock (i.e. could not be georeferenced due to massive cloud cover),
- not used because not meeting Planet's QC standards,
- not used because no Surface Reflectance correction available,
- not used because data not being published for other reasons.

1.1 Planet issues

For this first crop season 2019, Planet made use of only the "classic Dove" constellation, and not the newer "Dove-R" and "SuperDove" [ref ii] since these were not within tender specifications [ref i]. Some Planet sensor issues were found during the experimentation and examples are shown in the figures below. The first two show Planet calibration issues, and the third a band co-registration problem for the 'Classic' Dove where RGB and IR bands had/has misalignment problems. The latter should be solved in the next generation Dove´s (Dove-R and SuperDove), which use a split-focal-frame where each part of the focal plane images one band [ref ii].

[1] Service contract 938.073 called for 5% of observed parcels to be delivered as image chips, while Planet delivered 100%.

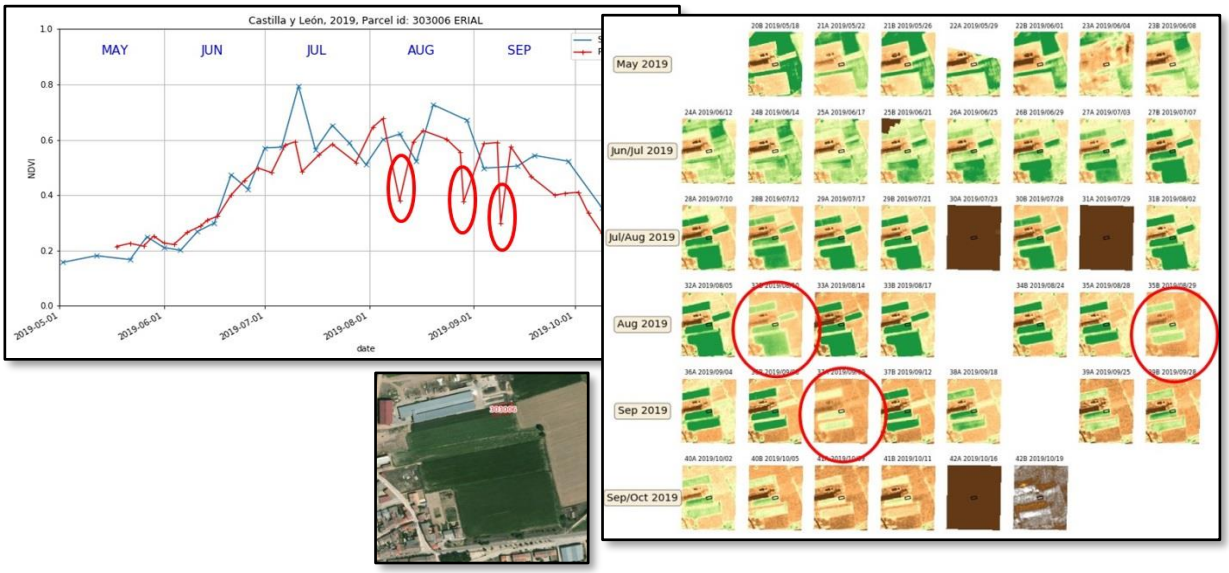


Figure 1 – Example of Planet sensors calibration issue; ES CyL; Parcel area 0.07 ha; Traditional fallow with vegetation cover

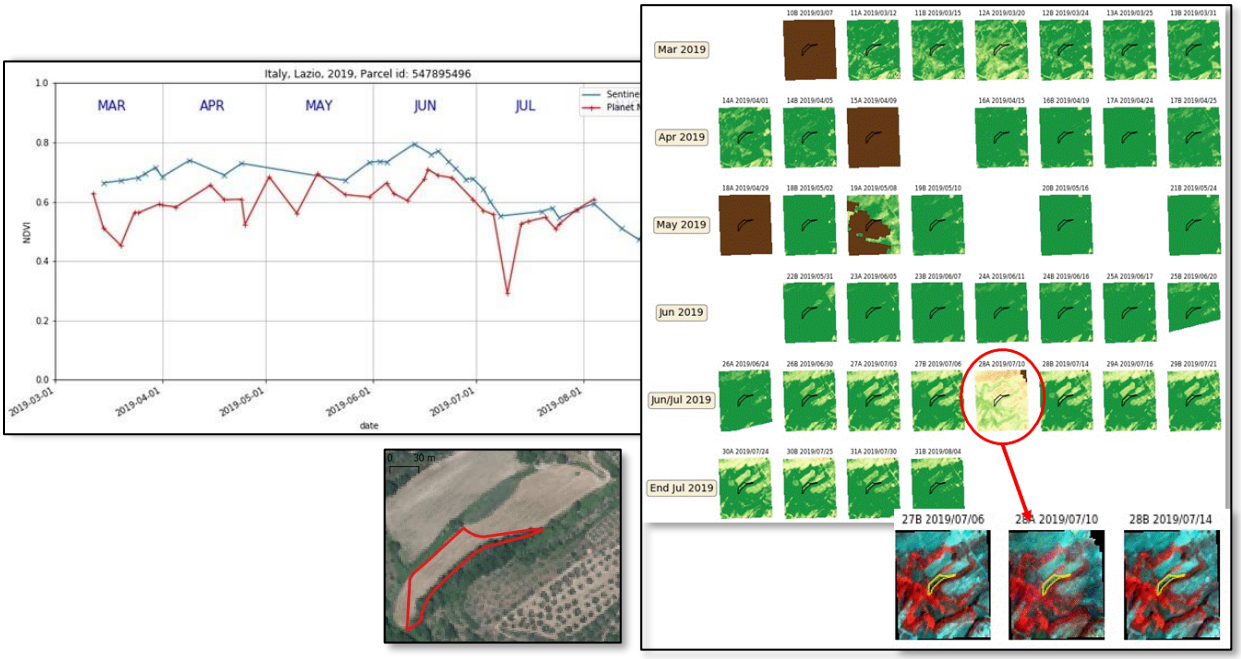


Figure 2 – Example of Planet sensors calibration issue (or haze effect); IT; Parcel d. 547895496; Parcel area 0.32 ha

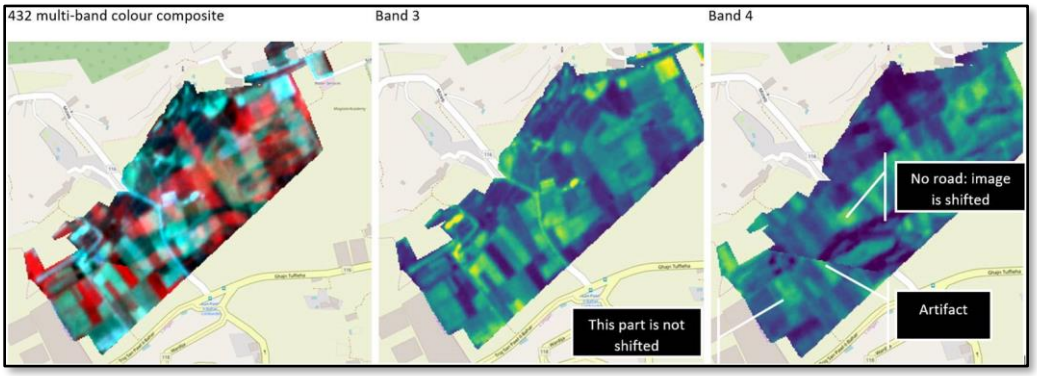


Figure 3 - Example of Planet (classic Dove) co-registration of band misalignment [ref ii].

2 MS and JRC Experiences

2.1 Denmark, DK

The JRC delivered 800 HHR TSs to DK. No introductory Video Conference (VC) has been held with the DK Administration. The parcels analysed in DK were larger (1-2 ha) than the sizes (lower than 0.2 ha) targeted by this Planet TS test. DK analysed a mix of yellow and red grassland/fallow parcels, and gave a probability score of non-compliance to split between these yellow and red. The aim was to assess whether the Planet TS could help in setting this non-compliance probability threshold. They started analysing trends of the NDVI for the crop categories (PG, Fallow). DK has not concluded this experiment. They however would like to further investigate if/how DK could potentially use TSs in the 2020 Campaign.

Tests were made by the JRC to compare Planet with S2 TSs in mowing detection over fallow land included in the DK parcel sample. Planet seems to give additional input, but results are varying. Some further remarks on this can be found in Chapter 2.5.

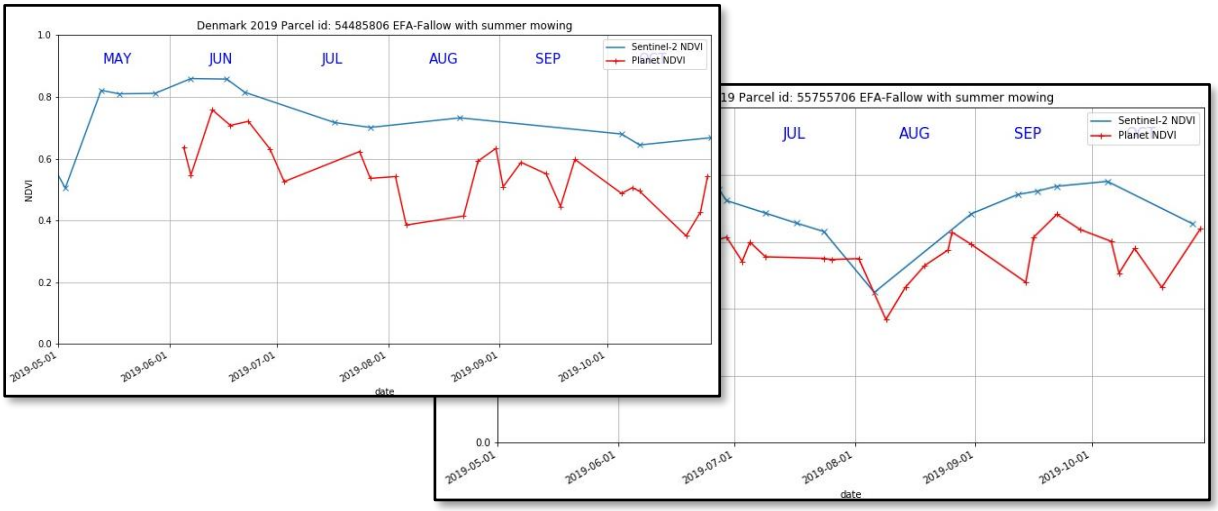


Figure 4 - Mowing detection in DK. Does Planet detect mowing in parcel 54485806, while S2 does not (left profile)?

2.2 Malta, MT

The JRC delivered 250 HHR TSs to ARPA, MT. A VC was held on 05/03/2020 to discuss the 2019 tests[2]. ARPA used also Planet data purchased by themselves in 2019 with an average of seven images per FOI/month. A total of 188 km2 of Planet data was ordered by ARPA. Multi-band Planet raster data is clipped with their GSAA polygons and used in the production of their processed NDVI polygons.

ARPA considered the (250) sample of TS delivered by JRC too small. In fact, they would like the delivered TSs not to be limited to "follow-up" (yellow) cases only. However, they found the data delivery from JRC easy to handle. They consider the sensing period of 5 months to be sufficient, adapted however with a batch delivery system (e.g. a first batch from SOS to end June with TSs at end June, and the rest of data from end of June until end August with weekly delivery). For the 2019 test, they were disappointed by the late delivery of TSs. For 2020, ARPA has in place financial commitments for their own orders to Planet.

ARPA reported cases of misalignment between bands for the Planet image data. This is not a new issue for 'classic Dove' (see Figure 3 above).

ARPA uses zonal statistics from the entire FOI to calculate the mean NDVI as opposed to the JRC approach (8 pixels mean NDVI within parcel applying no buffer. S2 NDVI seems to give similar values, but to consider for JRC is to apply an internal buffer. ARPA found some (3) cases having < 8 pixels inside their FOIs. They also suggest to include all pixel coordinates within parcel in order to be able to evaluate parcel homogeneity, and whether pixel is inside a reference parcel buffer. JRC had earlier analysed the representativeness of parcel

[2] For PPTs shown during this VC with ARPA, MT, and all VCs held with the other MS Regions pls. contact authors of this report.

statistics derived for the 8 points compared to the statistics calculated for the whole parcel. For completely cloud free, haze free and shadow free parcels, the NDVI values calculated from the two methods are completely comparable and regression analysis confirms this. Further analysis splitting into the three main agricultural land categories (AL, PC, and PG) could however be done.

It is referred to the presentations made at VC 09/03/2020. ARPA claims that S2 data is ineffective on 90% of their declared FOIs. They however say that Planet confirms the presence of tomato crop in 87% of the delivered 250 FOIs, the remaining 13% required follow up actions, which confirms the positive response of Planet for MT. At the end, no contradictory results compared to JRC analysis were found by ARPA who however focused mainly on comparing the HHR TS with the ARPA acquired Planet imagery, and not so much comparing with S2. JRC Planet and S2 values seem similar to the values of ARPA (see Figure 5 below)

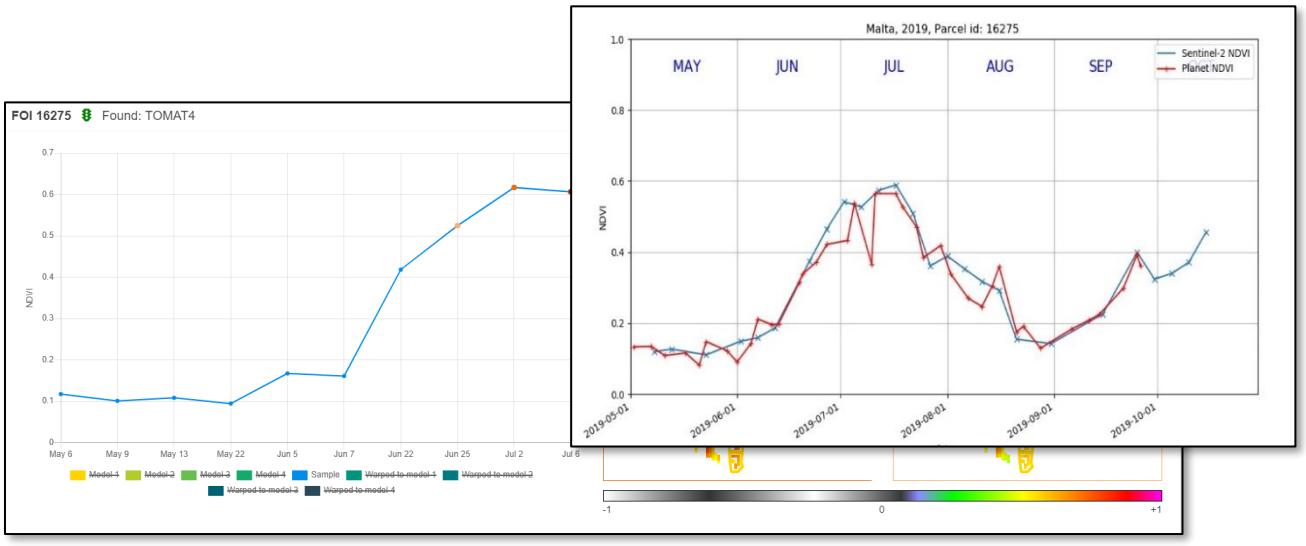


Figure 5 - Sample parcel (FOI) comparing ARPA and JRC NDVI values (16275)

In general, MT ARPA TSs do not include September (i.e. shorter sensing period, or calendar).

ARPA at the end considers that the method is effective and should allow to detect (yellow, red) parcels: detection of crop failure (diseases/heat stress), planting configuration (inter-row spacing), no-crop, small parcel (no internal pixels), and gradual cultivation. However, for 2020 they suggest, as mentioned above, that TSs should not be limited to follow-up cases only.

Another example where ARPA and JRC NDVI profiles show similar NDVI values is shown in Figure 6 below. ARPA asks whether further HHR TS would have helped reduce yellow instances as well as farmer input (e.g. geotagged photos, other evidence). It is however not very clear whether the higher frequency of the Planet TS provided by JRC, could have reduced the request for geotagged photos to farmers.

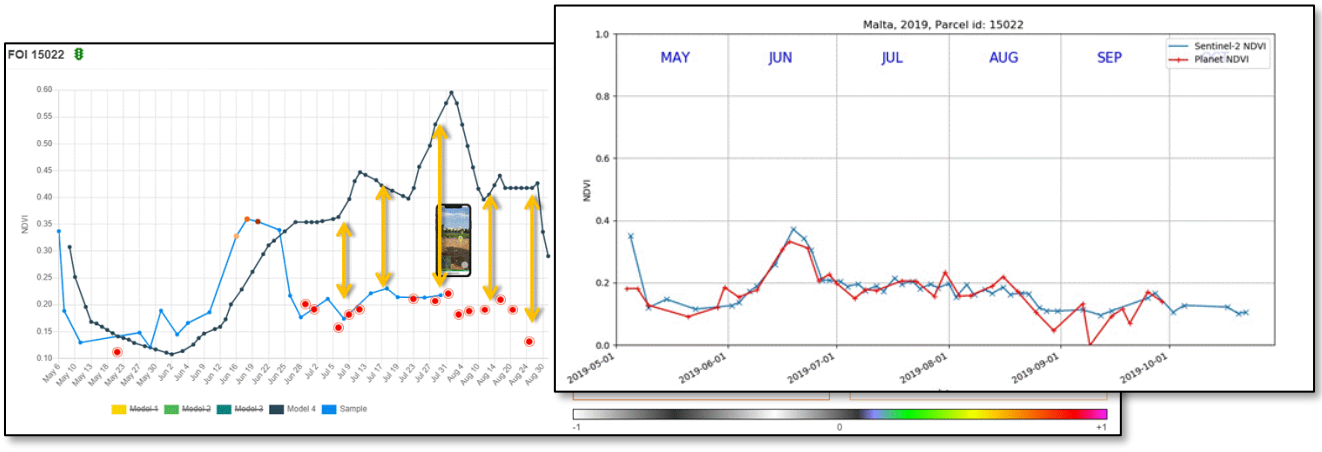


Figure 6 - Sample parcel (FOI) comparing ARPA and JRC TS NDVI values and ARPAs input from farmers

2.3 Italy, IT

The JRC delivered 7,997 HHR TSs to AGEA, IT, over four Regions. AGEA presented their results in a VC held on 05/03/2020. They showed a random selection of 50 parcels (ranging from 0.05 to 0.36 ha) displaying their multi-temporal phenological trends, their relative NDVI curves, and image chips of Planet compared to S2 (AGEA monitoring 2019). The selection covered the period March-August, from the four Regions (Puglia #979, Friuli Venezia Giulia #2.804, Lazio #1,847, and Calabria #2,367), more specifically in the six Provinces (Foggia, Bari, Pordenone, Viterbo, Cosenza, Crotone). The parcels contained various LC as follows; leguminous (vetch, chickpea), oats, pasture, fallow, durum wheat, annual grassland, permanent grassland, generic arable, alfalfa, maize, and sunflower.

A few comments by AGEA when viewing the extracts:

1.) Friuli Venezia Giulia, FVG (Pordenone)

- Permanent grassland - negative spike visible in Planet HHR (parcel 572940814)
- Alfalfa - negative spike visible in Planet HHR (for haze?) (parcel 601914345)

2.) Calabria, BEC (Cosenza, Crotone)

- Leguminous vetch: non homogeneous cultivation visible in image chip (parcel 585579971)
- Oats, Arable: only for a smaller part; visible in image chip (parcel 634694136)
- Incorrect declaration of barley; the signals does not help evaluation (parcel 644168049)

Results:

- HHR, even for very small parcels, does not give additional information of relevance; no relevant difference in point/curve trend (a systematic lower NDVI value for Planet vs S2 is detected due to the lower SNR of Planet).
- Some improvement can be achieved for the detection of agronomic practices that induce a sudden change in the parcel such as a mowing event. This is due to higher frequency of imaging rather than resolution. However, there is no need to receive two TSs / week. Indeed, in their trial they interpolated data to a 15-day window.
- For yellow light parcels processed as back office work; there is a benefit with image chips provision, which provide additional input for diagnosis. The provided image chips allow a better understanding of the parcels real land use elements (presence of trees, hedge rows, small portions not worked, etc.) which are not visible in S2 products.
- The provision of image chips is suggested to substitute field visit / geotagged imagery. This could speed up the CbM cycle and decision on "inconclusive" applications, and also reduce costs for MS Admin. It is suggested to deliver one or two full cloud free coverages (e.g. best monthly coverage) or at least May/June coverages per crop season of the "inconclusive" yellow parcels of size < 0.2 ha. IT considers that this would decrease number of parcels sent to "flashing blue" traffic light and at the end therefore less (Rapid) Field Visits (RFV/FV).
- For a systematic processing of all provided Planet (HHR) data, a specific SW must be developed for their ingestion and usage in the same workflow as the IT one developed on Sentinel data, including the link to the back office application i.e. there is a need to facilitate data ingestion. A suggestion is a subscription to Planet portal/API to share between MS.

JRC comments:

- The 15 days interpolation of Planet and S2 data is not properly investigated. See example in Figure 7 below of alfalfa (Italian: erba medica) where mowing is to be detected (Lazio Parcel id = 642467440). AGEA answers that the best balance between detection window and success of detection is a 15-day window for all markers they address. This particular mowing marker needs just to detect one instance which is indeed picked up. They use an algorithm which works with the NDVI maximum level over a 15-days window to overcome false alarms due to cloud cover that is not properly filtered out by the ESA mask.

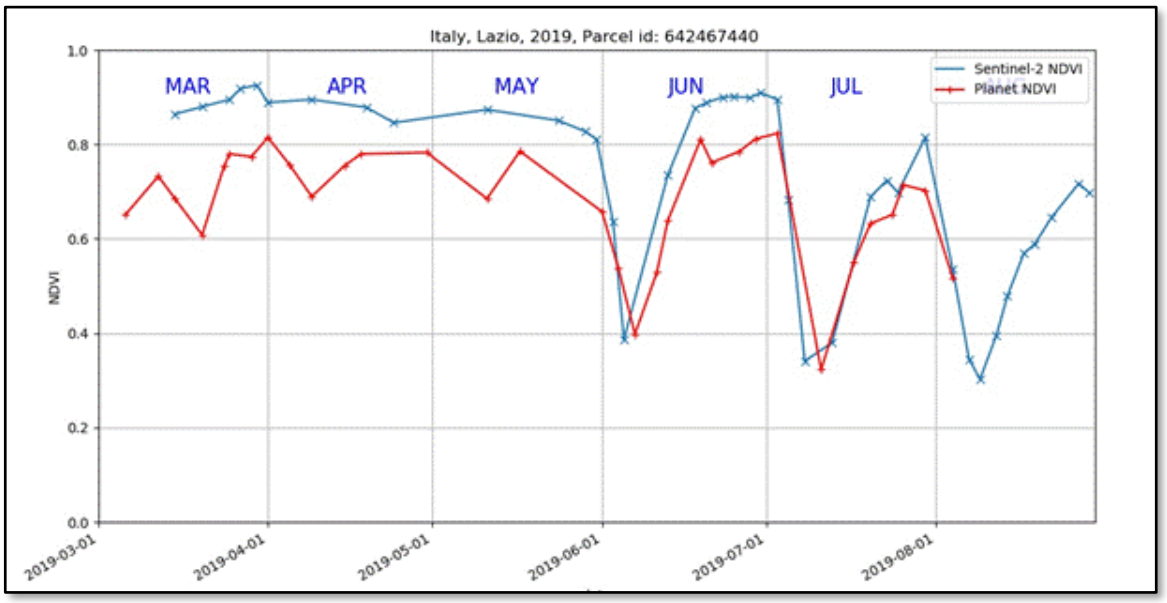


Figure 7 - NDVI profile detecting mowing in sample parcel from Lazio, IT

- Dealing with yellow light inconclusive parcels does not seem to be the primary reason for HHR usage for IT. The primary reason remains unclear: is it to measure area on image chips? to substitute a Rapid Field Visit? to make CAPI? This added value in the CbM chain needs to be known to assess any future actions by the EC.
- Preferred SOS, EOS, frequency, of HHR data if provided? Important seems to be data in May June August, image chips, and interval 2 weeks.

2.4 Spain, ES

The JRC delivered 7190 HHR TSs to FEGA, ES over four Regions (ESCYL 2,619, ESVAL 1,839, ESGAL 983, and ESARA 1,749). FEGA Spain, held a two-day meeting (3-4/03/2020) to discuss the Spanish CbM implementation status. The second day involved presentations and some assessment on their HHR TSs summarized here below (VC was held on 04/03/2020).

Tragsatec (the contractor) in their analysis of HHR TS potential contribution to their automatic phase of CbM including ML to identify crops, presented data over Galicia and Valencia where crops (herbaceous, grassland, permanent crop) were assessed. In Galicia, yellow light numbers basically increase by 6% (i.e. green decrease), and in Valencia decrease by 2% (i.e. green increase), with the inclusion of HHR NDVI signals in addition to S1/S2 input. Hence, improvements were not as high as expected. They claimed that they need data delivery 1-2 weeks after acquisition to ingest continuously into the automatic phase of CbM. They also claim they have no time to implement HHR TS analysis in their 2020 monitoring.

Castilla y Leon (CyL) and their Instituto Technologico Agrario analysed the reason for yellow (or red) light in 2.619 FOIs of average size 0.079 ha, # of crops 39. Some examples were given; e.g. for wheat (parcel 427462) shows the need of data in the period March-May to describe crop behaviour. CyL further claimed that there is more information to extract in the case of permanent crop (nuts) (parcel 536896, Figure 8 below). This result was not confirmed by the JRC for same parcel. All in all, CyL concluded that the Planet TSs should be included to characterize the small parcels and included in the automatic monitoring part, but complained that the capture period was not long enough, and there was a lack of data in the beginning of season. They even would prefer to extend the sensing period to the autumn before the crop season. They say (as also Tragsatec above) that delivery date should be max 15 days after acquisition. No need to increase frequency. Image chips for parcels not concluded after the automatic processing should be available to make further judgement or trigger "follow up" action.

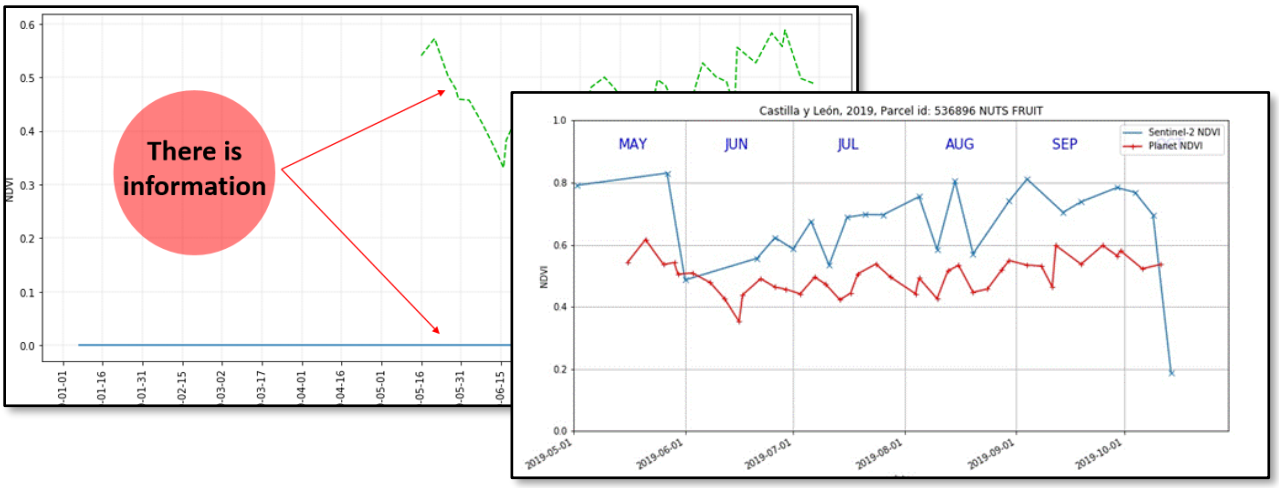


Figure 8 - Nut fruit profile parcel 536896 (CyL cf. JRC)

The last region to present was Aragon (PPT not made available). Their opinion was to integrate Planet TSs from April onwards at a frequency of twice per month. They maintain the opinion that detail in HHR should allow the resolution of "yellow" light inconclusive cases for parcels of small size.

2.5 JRC tests

2.5.1 Planet added value (yes / no) - some examples

In the DK sample, a comparison of Planet and S2 temporal NDVI profiles showed that in some cases the Planet TS may allow to pick up a mowing event while it is not possible with S2 data (see red circle in Figure 9 below)

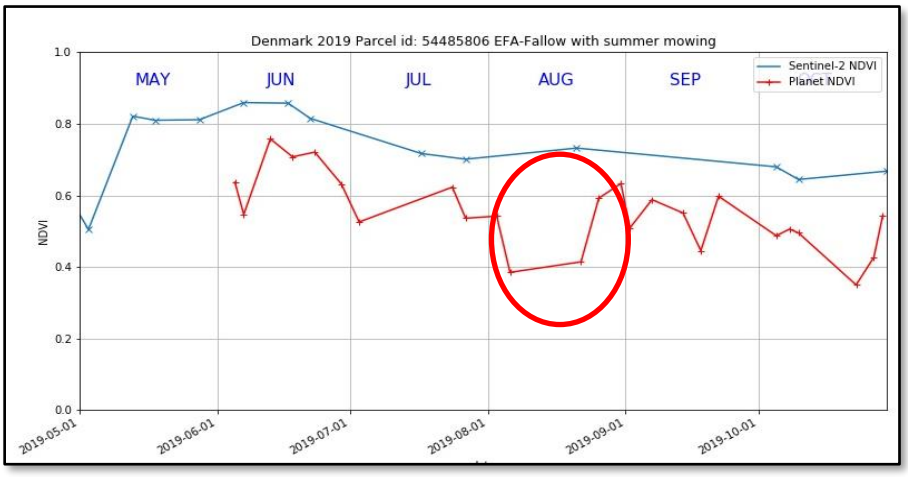


Figure 9 - Mowing detection in DK. Does Planet detect mowing in parcel 54485806, while S2 does not?

Analysing the calendar view of the Planet image chips also indicated that at the beginning of August there is indeed a loss of vegetation over the parcel (see red circle below; Figure 10). The corresponding S2 image chip indicated no mowing event in that period.

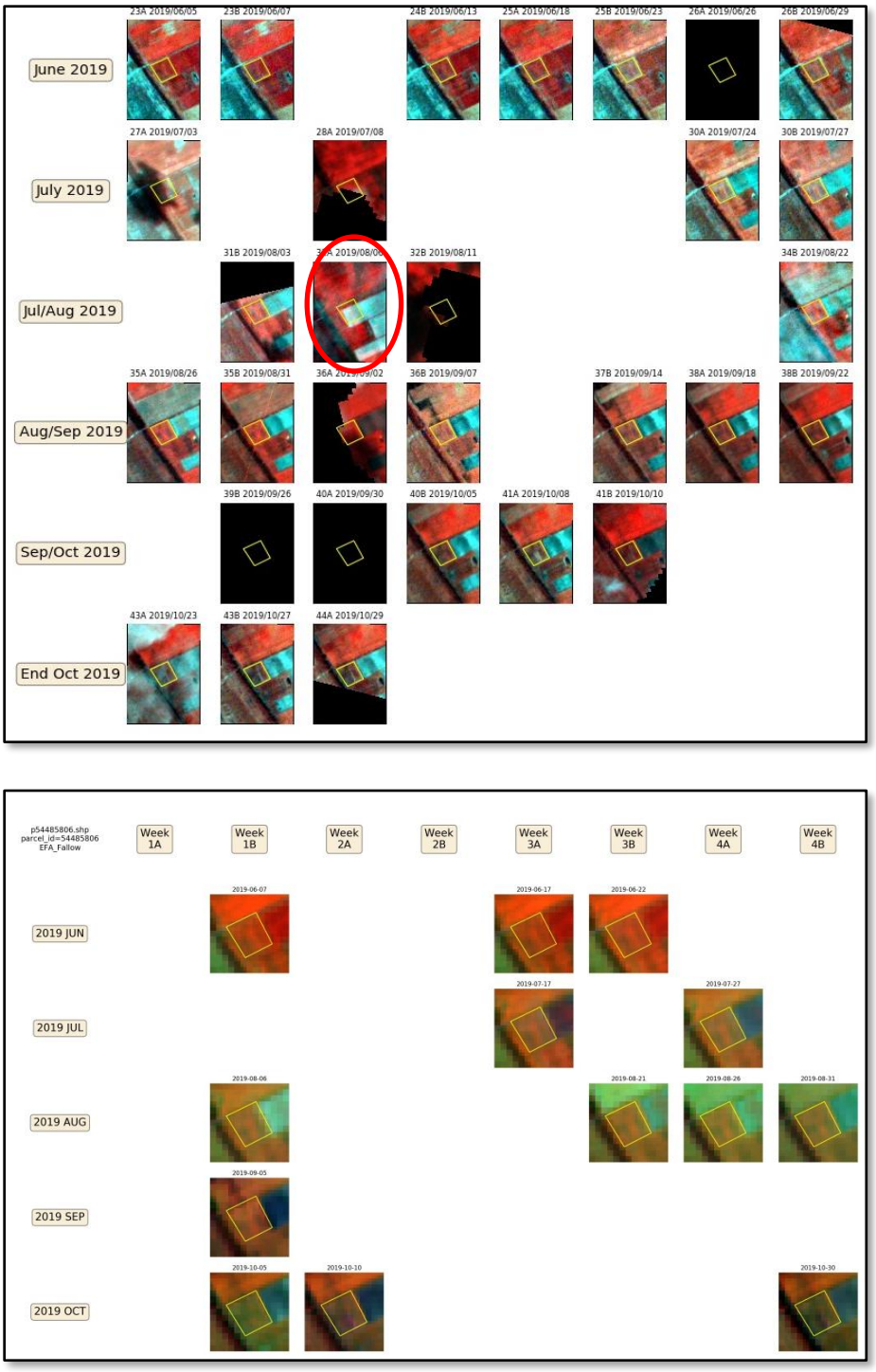


Figure 10 - Planet and S2 image chips of the parcel 54485806 (EFA fallow with summer mowing)

Detailed analysis of the Planet image acquired on 6 August, 2019 showed that there is a significant geometry shift of that image that showed up as a mowing event, so in reality the signal comes from a neighbouring bare soil parcel (Figure 11). This figure indeed also shows the co-registration issue between the visible and IR channels of the Planet "classic" Dove (kind of "hologram" effect in middle image below). Therefore it is concluded that it is not a mowing event detected by Planet and it cannot be considered an added value.

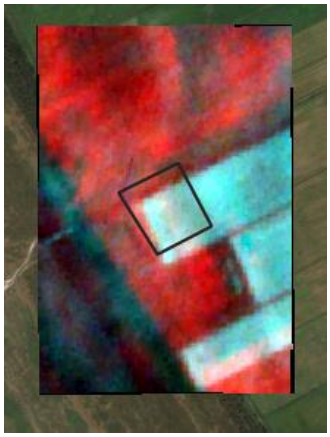
Bing image with parcel	Planet image of week 32A (2019/08/06) with parcel	Planet image of week 35A (2019/08/26) with parcel
		

Figure 11 - Geometry shift between Planet (2019/08/06) and Bing aerial photography.

Moving from mowing detection to other items of interest in the comparison of PlanetScope and Sentinel-2 rendering, below example from CyL, ES, Figure 12 shows how the S2 NDVI profile often appears with more variability than the more frequently acquired Planet. Planet still does not give additional information. Moreover the parcel is actually part of a bigger parcel on one side bordered with forest and cannot be considered as a correct FOI (see Chapter 2.5.2).

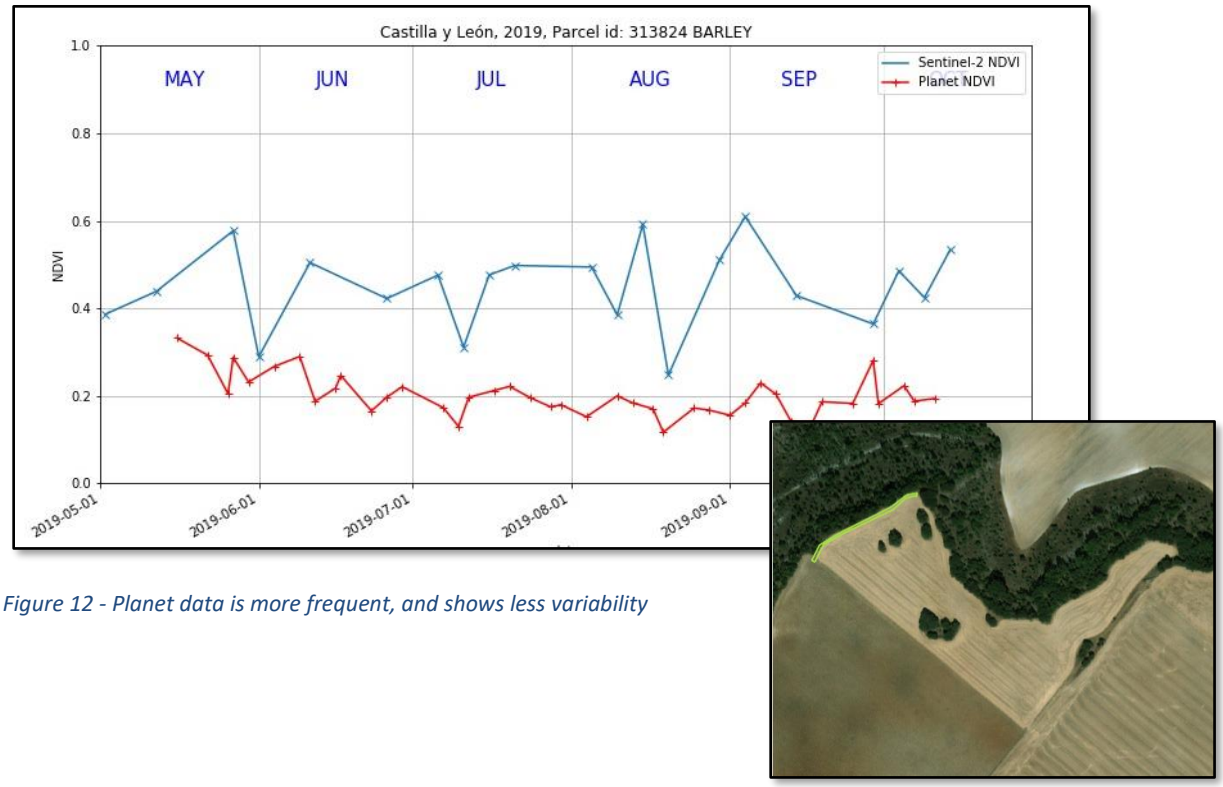


Figure 12 - Planet data is more frequent, and shows less variability

The more homogeneous values of PlanetScope is also shown in below Figure 13 from MT, for crop type tomato.

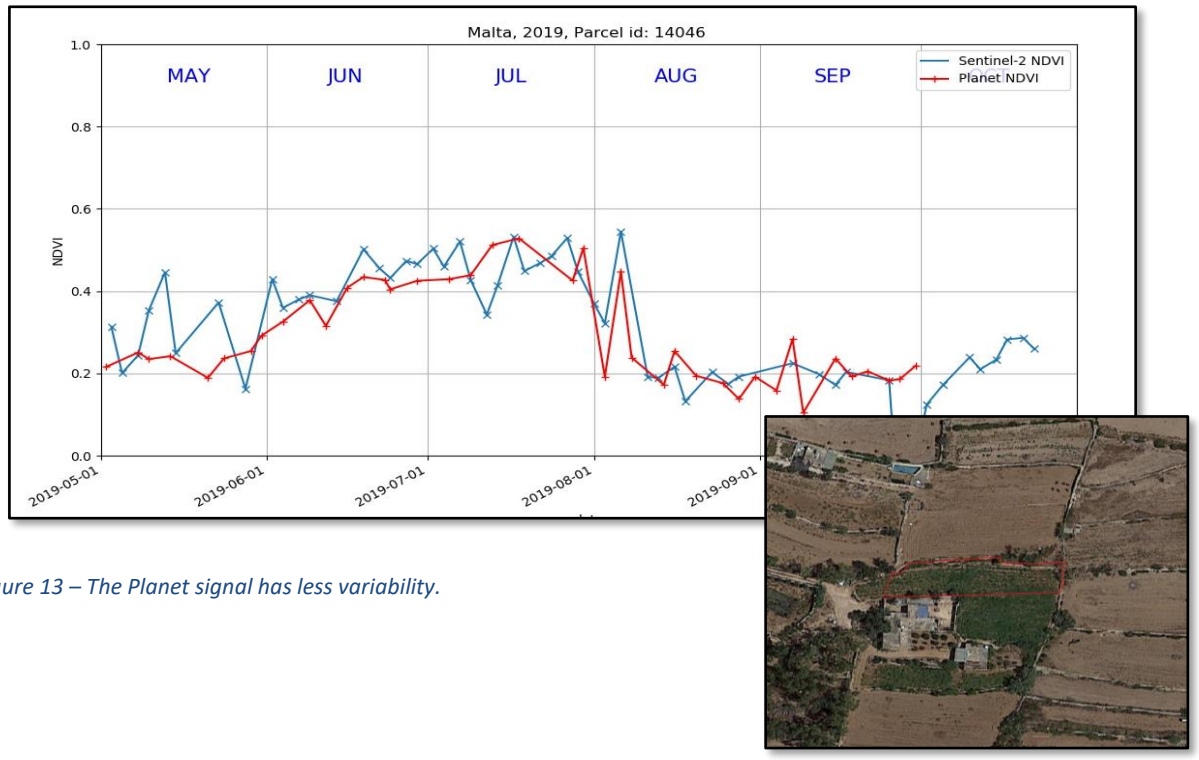


Figure 13 – The Planet signal has less variability.

Also the Figure 14 below from CyL, ES, shows a S2 NDVI profile with more variability than PlanetScope, and that Planet has higher acquisition frequency, and is more homogeneous. Here, however, the added value is the fact that Planet also includes acquisitions in May and September where S2 data is missing, so Planet indeed complements S2.

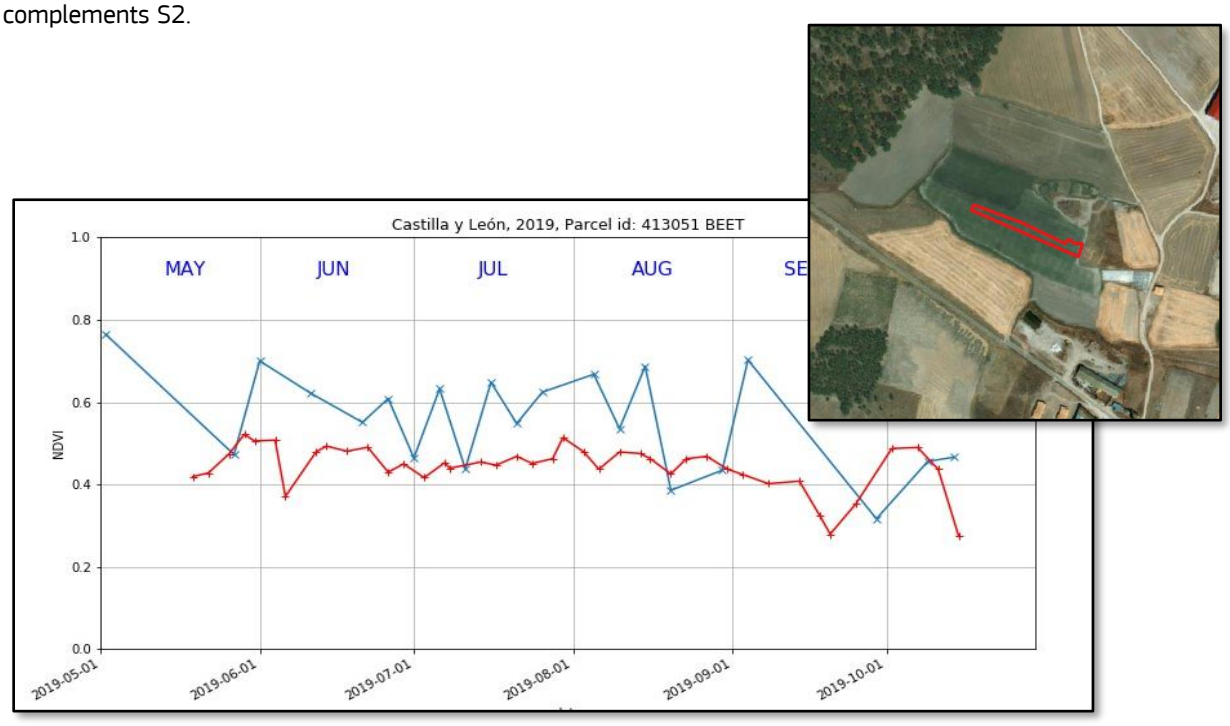


Figure 14 - PlanetScope acquisitions are present in periods where S2 is missing (I).

The next example is from Lazio, IT, Figure 15 below, and shows S2 missing useful acquisitions from beginning of April until mid of May, showing again the complementarity of PlanetScope data.

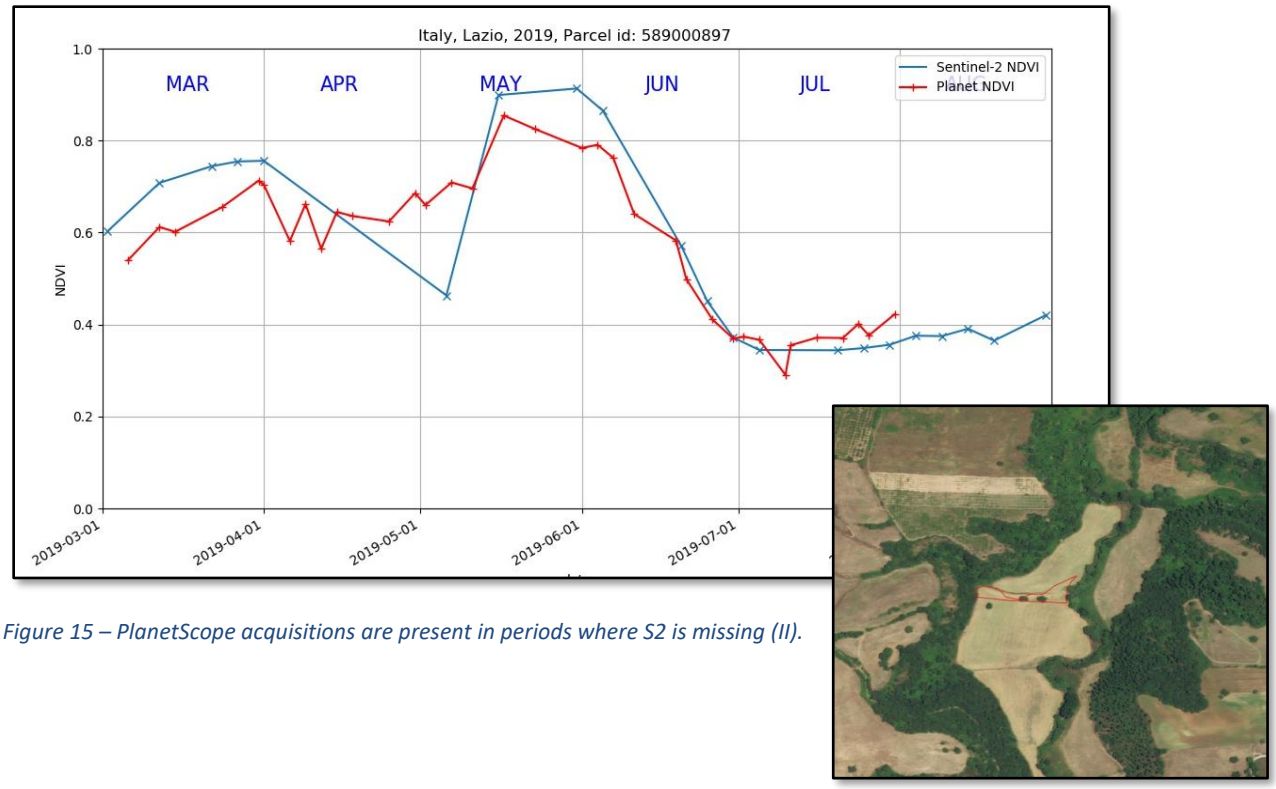


Figure 15 – PlanetScope acquisitions are present in periods where S2 is missing (II).

From above examples, a few conclusions can be drawn:

- Less variability in Planet data. For small parcels, since Planet data have a smaller GSD, they are less impacted than the larger S2 pixels by the neighbouring parcels;
- Planet has a higher acquisition frequency,
- Complementarity, where one is missing the other one has acquired. This is suitable when S2 acquisitions are missing for some period during the crop season and Planet can substitute the reading.

S2 appears, however, to give all temporal information needed for the selected small yellow traffic light inconclusive parcels analysed (81% of the parcels in our study were < 0.3 ha, 38% < 0.2 ha).

2.5.2 Importance of a proper selection of the "real" sample of inconclusive yellow parcels

Yellow traffic lights are first assigned to parcels where the automatic process did not allow to conclude on compliance or non-compliance. Filtering to obtain the "real" set of (small, narrow, etc.) parcels must be done regardless of the LPIS/GSAA system implemented in the MS. Moreover the physical land cover must be considered. If the set of inconclusive parcels are aggregated to proper FOIs, S2 monitoring might conclude on compliance or non-compliance, and HHR TS are indeed not required. Only after such checks the "real" sample of inconclusive parcels is obtained, and a correct assessment can be made on whether the HHR TS are necessary. The following examples try to illustrate this.

Figure 16 - the parcel is actually part of a bigger parcel on one side bordered with forest and cannot be considered as a correct FOI (see Fig 12 above CyL, ES).

Figure 17 - the parcel is in the middle of a bigger parcel and cannot be considered as a correct FOI (Galicia, ES).

Figure 18 - Small narrow but not completely isolated standalone parcel (left) (CyL, ES, parcel is smaller than 0.1ha); and (right), the parcel could have been merged with adjacent parcel and then would have constituted a real FOI

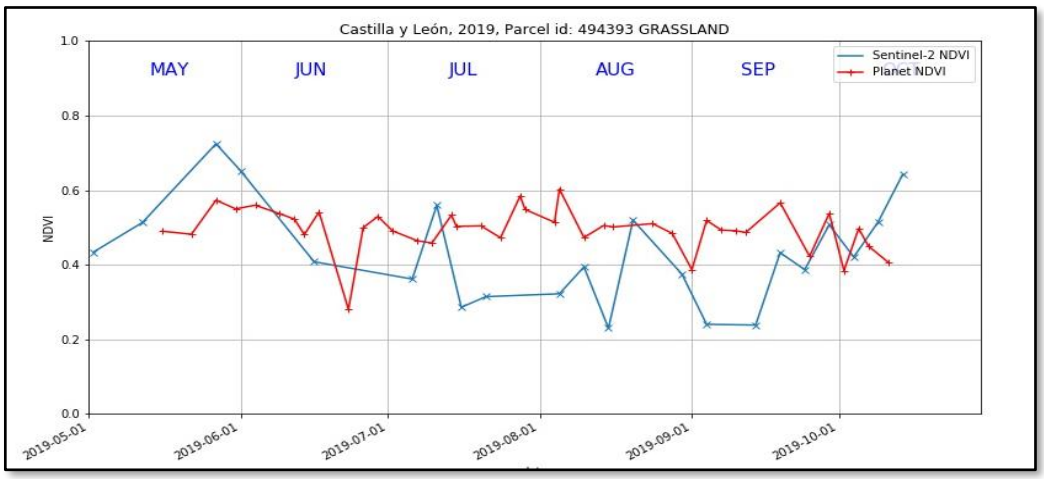


Figure 19 - But still, does Planet give added value?

Figure 20 -Small narrow and isolated standalone parcel (Malta, parcel size is 0.29ha). This is a typical example where for S2 pixels at the border cause noise (see the Figure 21 below)

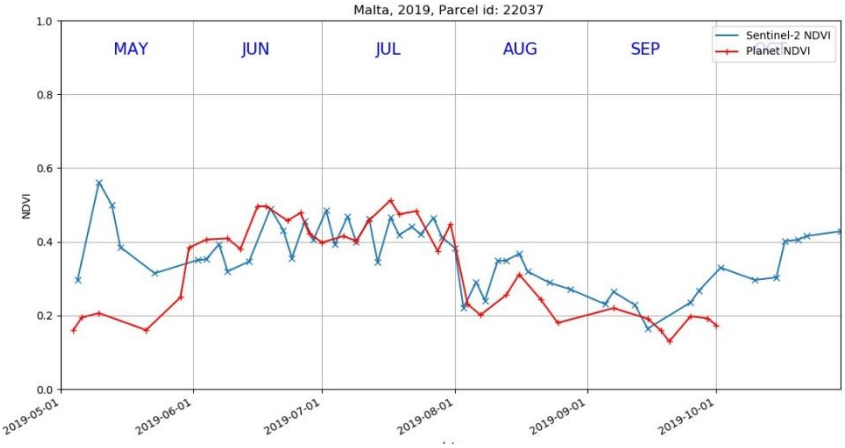


Figure 21 - S2 shows higher variability (noise) because of the border pixels

All the examples shown above clearly illustrate the importance of proper determination of the so-called "yellow" traffic light inconclusive parcels. In many cases, based on the requirements of the individual MSs (e.g. IT and ES), there is a visible inconsistency in the definition of the FOI. This means, as illustrated above, that the small parcel that does not represent a so-called FOI should be merged to the neighbouring larger crop (land cover) before processing with S2 to most probably become "conclusive".

3 Summary, discussion and conclusions

3.1 Summarizing the experiences from above

Comparing profiles:

- Contrary to the a priori initial assertion, Planet and S2 NDVI profiles proved to be very comparable even for small parcels (All, nearly all agree).
- In the parcels analysed, S2 appears to give all temporal information needed to conclude on the small parcels retained as inconclusive (yellow traffic light) with automated processes (81% of the parcels in our study were < 0.3 ha, 38% < 0.2 ha) (JRC).
- There is less variability in Planet data. Planet with a smaller GSD does not, like S2, pick up neighbouring parcels, and is therefore more homogeneous (JRC).
- Planet has a higher acquisition frequency. This is suitable when S2 acquisitions are missing for some period during the crop season and Planet can substitute the reading. There is therefore a complementarity between S2 and Planet (JRC).

Need of image chips:

- Image chips for parcels not concluded after the automatic processing should be made available to make further judgement or trigger "follow up" action (ES).
- Importance of image chips: frequency more important than resolution (IT).
- Need of one or two complete coverages of inconclusive yellow light parcels (May/June, August; best monthly coverage) (IT).

Comparing calendar, duration and capture frequency:

- Sensing period of 5 month sufficient (MT).
- A lack of data in the beginning of season, even extend to the autumn before the crop season (ES).
- Planet TSs from April onwards at a frequency of twice per month (ES).
- No need to increase frequency (ES).
- Important is data in May, June, August, image chips, and interval 2 weeks (IT)

Comparing delivery schedule:

- Weekly delivery of TS (MT).
- Data delivery 1-2 weeks after acquisition (ES) to ingest continuously in the automatic phase of the CbM.
- Earlier delivery in batches (1st batch March/end June delivered at end June, and then weekly delivery until end August (MT))

Technical specifications:

- Buffer on TS sample coordinates. All coordinates necessary to be within parcel (MT).
- ARPA uses zonal stats from the entire FOI to calculate the NDVI cf. to JRC approach (8 pixels mean NDVI within parcel applying no buffer). A JRC study shows however that NDVI values calculated from the two methods are completely comparable. Further analysis splitting into the three main agricultural land categories (AL, PC, and PG) could however be done.
- Data delivery from JRC easy to handle (MT);
- IT suggest to have interface to a provider portal in future.

Open issues:

- Necessary not only to deal with "follow up" or "yellow parcels". It remains to be explained whether IT wants to measure area in the image chips, whether they want to make CAPI, whether they want to help back office and reduce (Rapid) Field Visits. (IT)
- Somewhat larger grassland/fallow parcels (1-2 ha) were analysed in DK. Analysis not complete where goal was to conclude whether Planet TSs can help in setting a non-compliance probability threshold between yellow light and red light parcels?
- Planet TSs should be included to characterize the small plots and included in the automatic monitoring (ES).
- Correct determination (filtering, sifting) to obtain the (small, narrow, etc.) parcels is extremely important before processing with S2 in order to use correct FOI, and correct input for the CbM automatic processing. This may very well allow to reach "conclusion" on that parcel.

3.2 Added value for assigning traffic lights

There needs to be a constraint (limitation) that is solved in the CbM processing chain i.e. what do the HHR TSs or image chips solve in dealing with any of the different diagnosis codes (traffic lights states, or actions) before taking a decision on the future need of these HHR TSs. Before drawing any conclusions, a recap of these codes is appropriate

YELLOW lights are assigned to inconclusive parcels where there is absence of sufficient information to conclude on compliance or non-compliance. Action is needed when it matters for the payment. This is for example when Sentinels cannot detect markers (cloud, small parcels, irregular parcels…). There is here insufficient evidence for a (confirm GREEN or a (reject) RED, but parcel is considered OK for processing of the holding at that time. In these cases follow actions should be taken at holding (dossier) level, and a solution making use of geotagged photo, (R)FV, or the HHR TS could be used.

- Impact on payment is < € 50 set to GREEN
- € 50 < Impact on payment < € 250

✓ 5% sampling set to FLASHING BLUE which means expert judgement required. Additional information from non-monitoring sources is needed, and must lead to RED or GREEN. It triggers PA to try to detect any non-compliance marker. It triggers an expected "follow up" e.g. use of geotagged image in next farmer declaration, look for administrative/alternative evidence, use an explicit check in next LPIS update, set to YELLOW, or FLASHING YELLOW in Y+1, and if no measure of these are appropriate launch (R)FV).

✓ If not in sample, keep YELLOW for Y+1, but set to GREEN

- Impact on payment > € 250; flashing BLUE which must lead to GREEN or RED

… and to continue:

- FLASHING YELLOW is a warning when there is an absence of compliance marker before a specific deadline (1), or an inconsistency in the declaration (e.g. location of secondary crop, false area values) (2). Follow up is expected on (1) if no feedback received on message sent to farmer start Y+1 in YELLOW; on (2) include parcel in field visit pool?
- FLASHING BLUE, FLASHING YELLOW are both ACTION states
- (R)FV is a targeted observation on the AP. It is done on a monthly basis, via zoning of APs like CwRS legacy, and aims to collect what is needed for conclusion;

3.3 Conclusions

From the exercise performed by the four MS in 2019, there is little to no evidence that there is a wealth of "extra" processing-ready information inside the Planet HHR TSs compared to those of the S2, even for small narrow parcels. This is an unexpected outcome.

This places some doubt on the need for a regular provision of HHR stacks for the CbM workflows. Nevertheless, there is a common opinion by the MS Regions participating that the TSs, and especially the accompanying image chips, are useful.

However, the correct analysis of HHR TSs has been jeopardized by some incorrect provision of small parcels, resulting from the declarative LPIS/GSAA system, and not representing the actual small FOIs. It is essential to correctly determine the set of (small, narrow, etc.) parcels that should compose the correct HHR TS to be used (see below Chapter 4.1). In addition to this, the following items were identified of importance to make the use of the HHR TS more effective (i.e. producing right result), and should lie as basis for further follow-up:

- Adjust the parameters (SOS, EOS, capture frequency, delivery schedule); having right data in right time would allow optimization of ingest time in automatic workflows;
- Ease the access to data;
- Increase the number of image chips (even with best monthly coverages of inconclusive parcels) to help the back-office expert judgement to reduce the number of (R)FVs;

4 Future outlook

4.1 Follow-up

MS Administrations should be asked to specify more clearly where TSs and image chips are needed in their workflow to optimize their use in their:

- Expert judgement;
- Follow-up to obtain alternative evidence;
- Follow-up an inconsistency in the declaration;
- Substitution of any agricultural parcels in the final (R)FV pool when all follow-up fails.

for the purpose of completing assessment, and to assure financial interest.

MS Administrations should use appropriate mechanisms (filtering, sifting) to extract correct FOIs for input in their automatic CbM processing. The JRC suggests that a correctly extracted FOI may already solve many inconclusive parcels composing it.

In this context, it is also appropriate to mention that the superior spatial resolution of the HHR comparing to the one of the Sentinels, is expected to enhance the capabilities of the CbM system to extract the "spatial" types of information, related to cardinality[3] between FOI representations and intra-FOI variability. So, what is of interest is the possible added value brought in intra-parcel homogeneity/heterogeneity brought by a better GSD than the Sentinel data. The higher information content could be able to reduce the "noise" from the pixels on the border of the FOI geometry and provide better insight of the spatial pattern within. Since such approach would require a more systematic use of HHR in the frame of CbM (in real time and on-demand), the modality of provision of such HHR TS needs yet to be defined, but the JRC could support the research and methodological aspects.

4.2 Planet technical developments

The use of the newer Dove constellations ("Dove-R" and "SuperDove", [ref. ii]) can lead to the following enhancements:

- A better initial data processing which can decrease the number of images rejected due to quality filter settings;
- Satellite resource increase - i.e. an improvement of data availability by benchmark of the new sensors "Dove-R" and "SuperDove";
- Improved image quality (clearly separated spectral band information which gives a better Signal-to-Noise Ratio (SNR), a more stable and repeatable signal, and a better matching of spectral bands cf. S2). The new sensors will also allow a better RGB NIR band registration;
- An additional data intercalibration will also align spectral properties of all available Planet Sensors, and the Cubesat-Enabled Spatio-Temporal Enhancement Method (CESTEM), will stabilize radiometry across the sensors (CESTEM Q3 2020).

In addition, Planet is also proposing an efficient platform based delivery of TSs and imagery chips as a self-service for the interested MS Administrations/contractors to access HHR TSs more efficiently.

[3] In the case of CbM QA G1 cardinality checks that there is a 1-1 cardinality between the FOI derived from GSAA and the FOI representation derived from automated processing of Sentinel time stacks.

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