IMAGE QUALITY ASSESSMENT OF VERY HIGH RESOLUTION OPTICAL DATA WITHIN ESA / EDAP PROJECT

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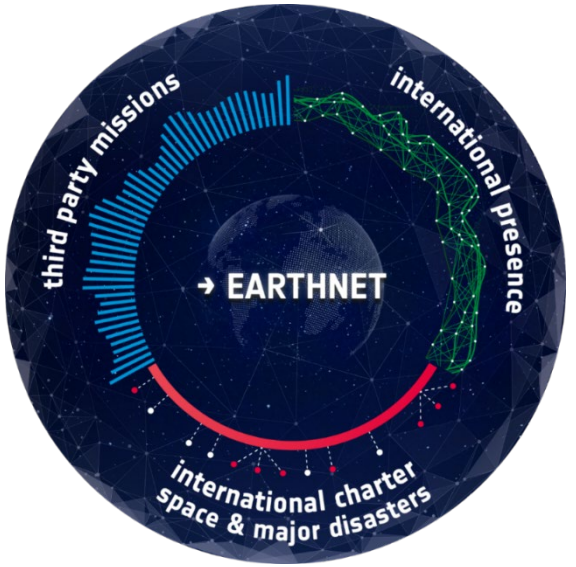

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(2) Hacettepe University
(3) ESA/ESRIN

B1.05 VHR Data Quality

Bonn, May, 24, 2022

Plan of the presentation

- What is EDAP ?
- Optical Mission: Quality Control and Cal / Val infrastructure
- Method examples
- Accuracy Results
- Way forward

A. What is EDAP?

- ✓ The main objective of EDAP activity is to perform **early data quality assessment of existing or future missions**, with specific focus on **New Space** and **multi-mission activities**

- ✓ It is achieved through provision of **clusters of expertise in various domains** *(Very High, High and Medium Resolution optical sensor, Low Resolution optical sensor, SAR sensor, Atmospheric Missions)*

- ✓ Specific focus is also be put on **capacity building** in the relevant data provider with the set up and evolution of documentations, tools and procedures to allow to efficiently perform data quality assessments in the domains of expertise defined within this activity

Summary of the missions addressed

VHR, HR, MR Optical
Planet Dove
Planet Dove-R
Proba-1
Skysat
Landsat 1-7
Landsat 8
Blacksky
Superview
Vision-1
Superdove
HySIS

VHR, HR, MR Optical
Maxar HD (15 cm)
Kompsat-3 / 3A
Vivid-X2
NEMO-HD
Jilin-1 SP03, GF02A, GXA, KF01, GF03A, GF03B, GP01 [TBC]
GaoFen-2, GaoFen-7 [TBC]
GaoFen-4 [TBC]

LR Optical	SAR	Atmospheric
OceanSat-2	ICEYE-X2	Spire
GOMX-4 (Hyperscout-1)	SAOCOM-1A	Tansat
OceanSat 3A	PAZ (SEOSAR)	GHGSat-D (Claire)
MOS	Capella	GCOM-C
FSSCat (Hyperscout-2)	ICEYE-X4, X6, X7	GOSAT
	SAOCOM-1B	GOSAT-2

Optical Mission: Quality Control and Cal / Val infrastructure

SCOPE

The ESA **Earthnet Data Assessment Pilot (EDAP)** is a project that is responsible for **assessing the quality and suitability** of candidate missions being considered for **Earthnet Third Party Missions**.

One major outcome of the mission quality assessment process is the Maturity Matrix

EDAP assess quality of optical, radar and atmospheric missions

Regarding **optical VHR data**, the geometry, radiometry and image quality of end user product are validated with **specific methodologies** and against well known **reference data**.

Geometric Equipment

Reference with in situ measurements (GCP test field campaign), uav flight campaing, and space based images.

Production of Planimetric and Elevation reference data of better resolution is required

Accuracy stability address with worlwide sites
Precision address with dense sites

Sites displays various contents more or less suitable depending on validation tem and processin methogs

Radiometric Equipment

Absolute calibration aspects covered with the support of in-situ measurement stations (RadCalNet, Aeronet).

Sentinel 2 mission is considered as a 'Gold Mission' and is a calibration reference monitored by agencies.

Pseudo Invariant Target (Desert) are essential to analyse calibration stabillity.

The processing (Simulation / Correction) of these reference data is not straightforward and should be under control in term of uncertainty budget.

RadCalNet

LIST OF METHODOLOGIES

Image Quality:
- Signal to Noise Ratio
- Modulation Transfer Function

Visual Inspection:
- Histogram Analysis
- Image Interpretability

Radiometry:
- Equalization
- Temporal Stability
- Absolute Calibration

Misc:
- Video Data Coherence
- Motion Tracking Capability

Geometry:
- Absolute Geolocation
- Geolocation Stability
- Band to Band Registration
- Stereoscopic Capability

Image Quality Target

Surrounding background

Natural and Artifical targets are used in the community

Targets are used to estimatie **Image Quality Parameters** (PSF, MTF, LSF, SNR) at product and system level.

Artificial targets (edge, pulse), fixed or as tarp, is generally well characterized and therefore more accurate

Natural targets are generally used for monitoring task
Specific test sites can be used to estimate Signal to noise ratio .

Methods are largely discussed in the community.

Visual Inspection

For many reasons, the recognition of object is an important point with VHR Data.

The introduction of **image interpretability technics** (NIRS rating scale) required design / definition of an object database.

Conclusion

In situ data becomes more and more important to validate submetric GSD data
Cross Comparison with other reference sensor remains fundamental
The maintenance cost is an important paramter
Reference **data Sharing** strategy is to be promoted
Usefull Link :
CEOS Cal / Val Portail,
http://calvalportal.ceos.org/calibration-test-sites
Cal / Val Site Usgs
https://calval.cr.usgs.gov/apps/test_sites_catalog

Planet Dove/Dove-R
Planet Superdove
Planet Skysat
Airbus Vision-1

SuperView
Blacksky
MAXAR HD
Vivid - X2

Kompsat-3 / 3A
MEMO-HD

EDAP

https://earth.esa.int/eogateway/activities/edap

GEOAX

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NPL National Physical Laboratory

TELESPAZIO a LEONARDO and THALES company

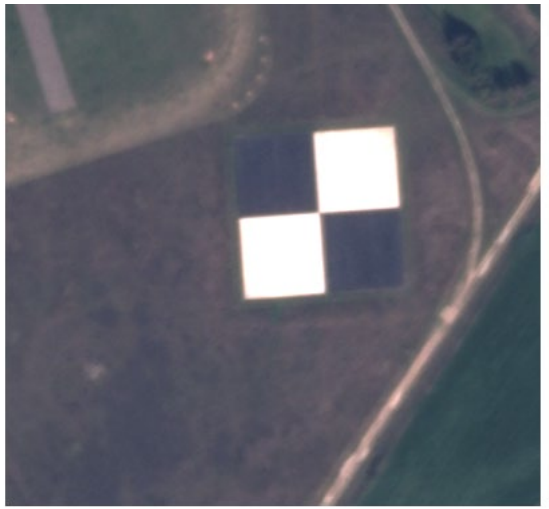
29/04/202

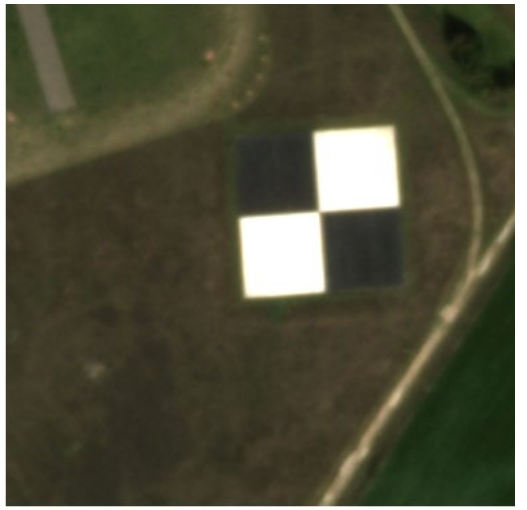
Mission provider and IQ Specifications …

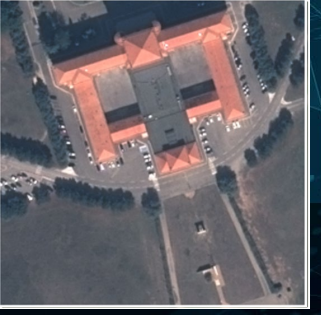
- ✓ The objective of our EDAP Image Quality activities is to assess sensor / products specifications with standardization in test procedure and to compare results against accuracy specification claimed by the mission provider.
- ✓ Unfortunately, the set of specifications given by the mission provider (GSD, SNR, MTF@Nyquist) is in general not sufficient to clearly state on data usability;.
- ✓ Further more, among mission providers, there is no standardized method to derive IQ parameters and comparison is not straightforward.
- ✓ Also, from end user perspective, results of the EDAP analysis (report) form a good basis to compare missions together and select mission/product accordingly.

Mission provider and IQ Specifications …

- ✓ Same GSD, different Missions,







Mission provider and IQ Specifications …






Mission provider and IQ Specifications …

- ✓ The curves A and B are for two optical systems, having different aberrations. Though at IGFOV both have the same MTF, for targets with dimension higher than IGFOV ‘A’ can discriminate lower contrast objects better than ‘B (Joseph, 2019)

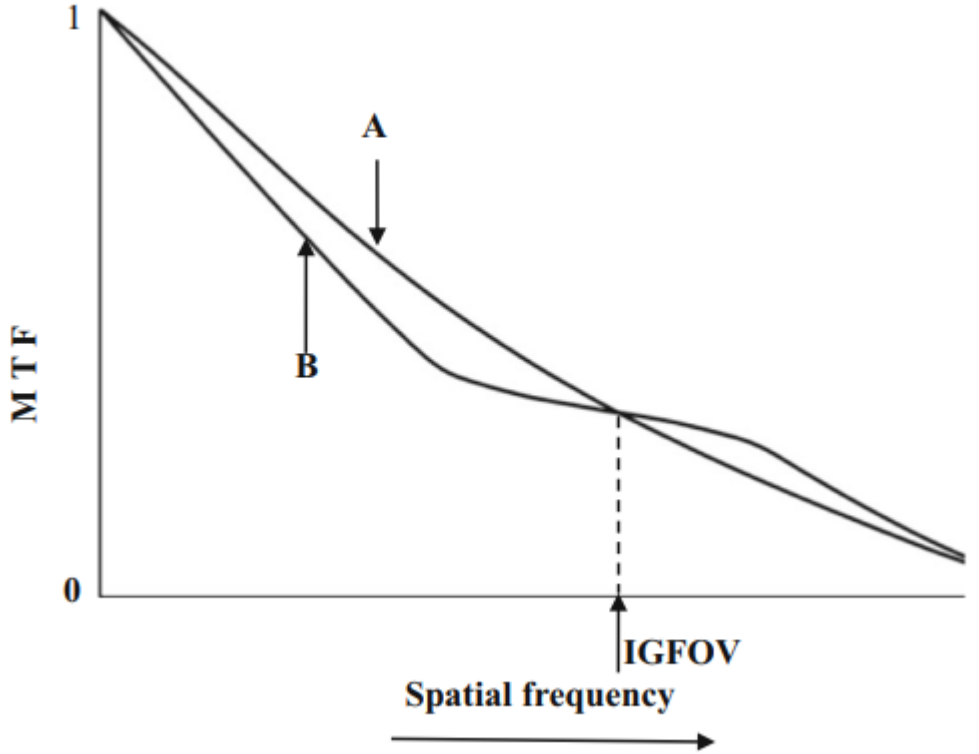


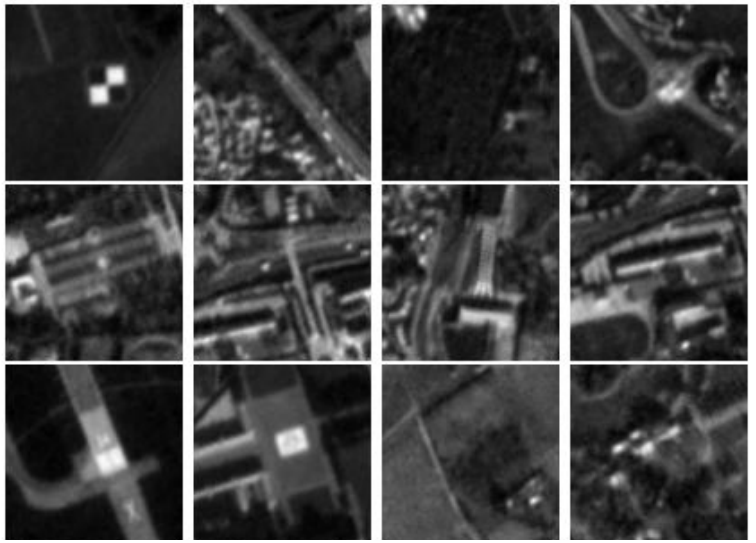
Image Intrepretability Activity

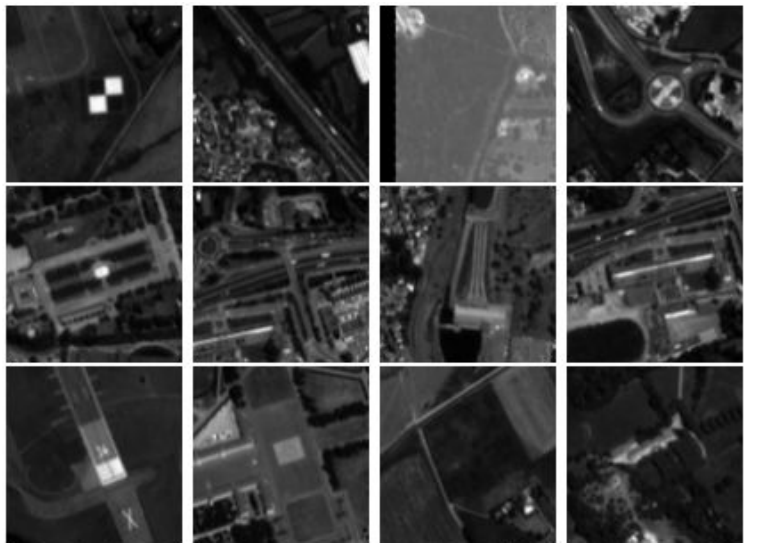
- ✓ The aerial imaging community utilizes the National Imagery Interpretability Rating Scale (NIIRS) to define and measure the quality of images and performance of imaging systems. Through a process referred to as "rating" an image, the NIIRS is used by imagery analysts to assign a number, which indicates the interpretability of a given image.

https://fas.org/irp/imint/niirs.htm

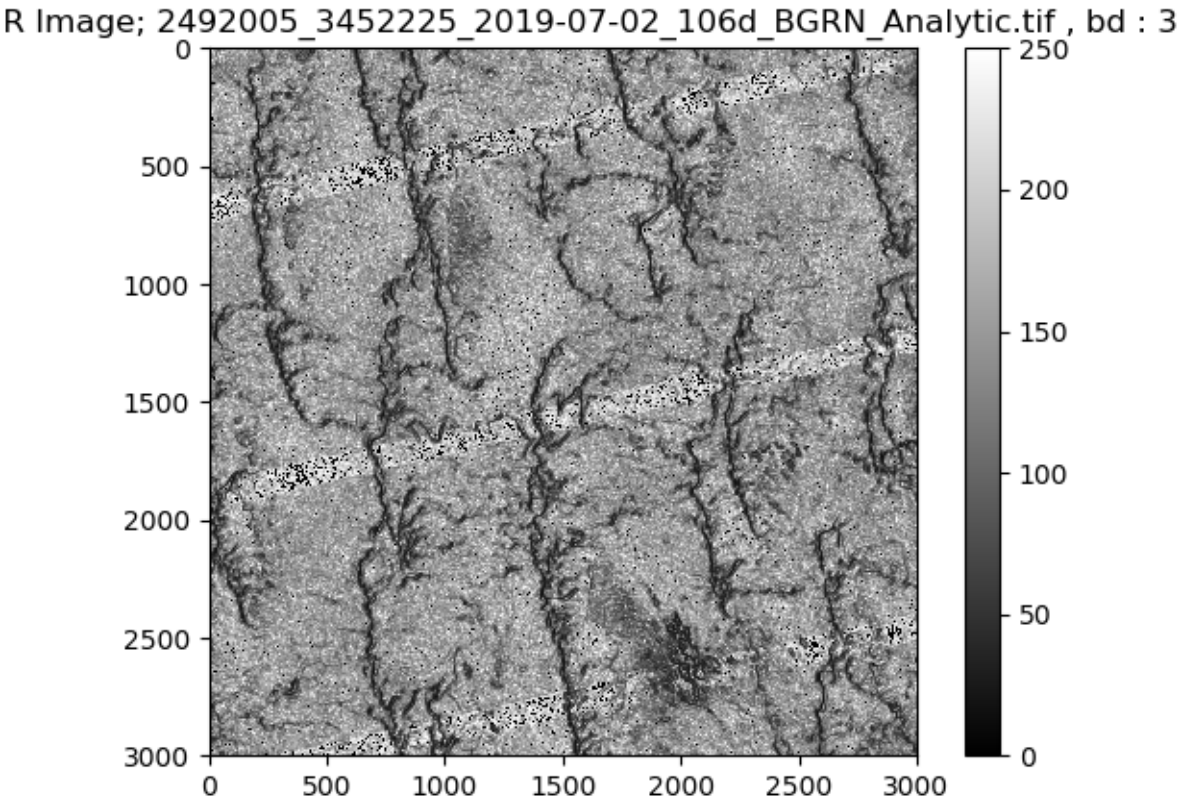
Image Intrepretability Activity

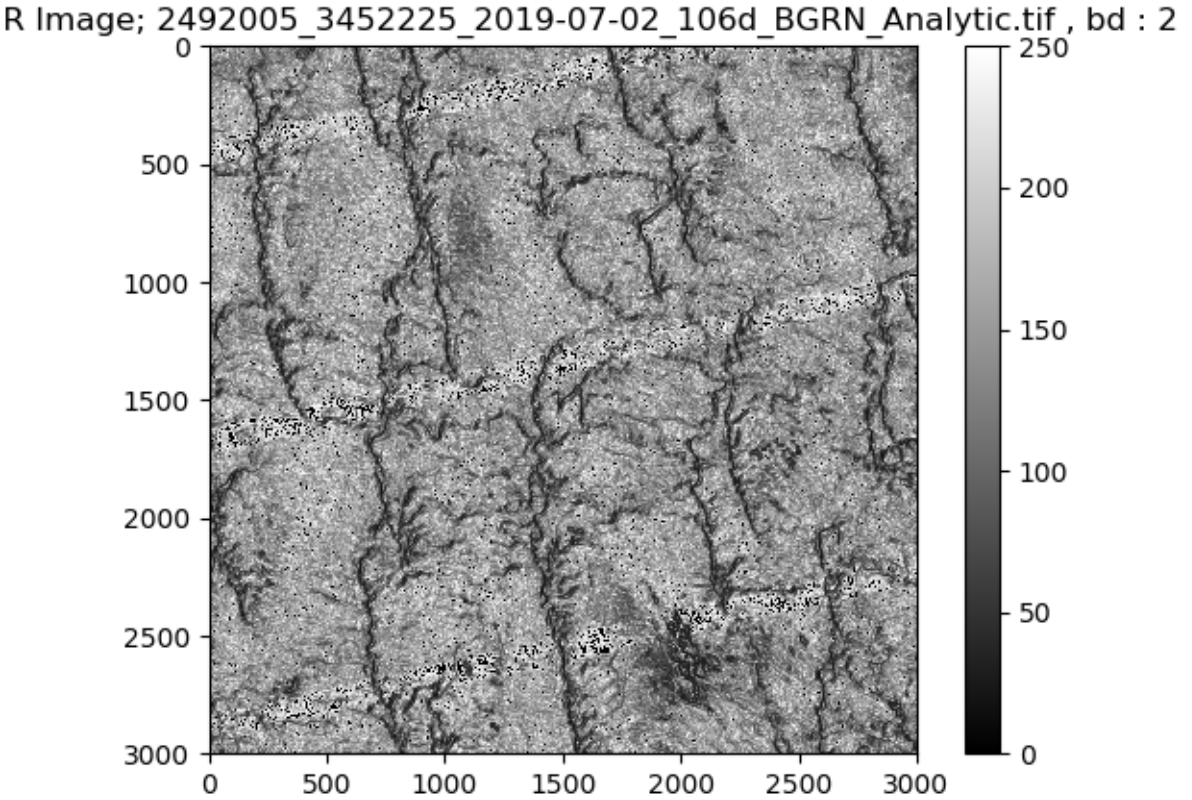
- ✓ Data provider Images (left) / Reference Objects from Image Database (right)



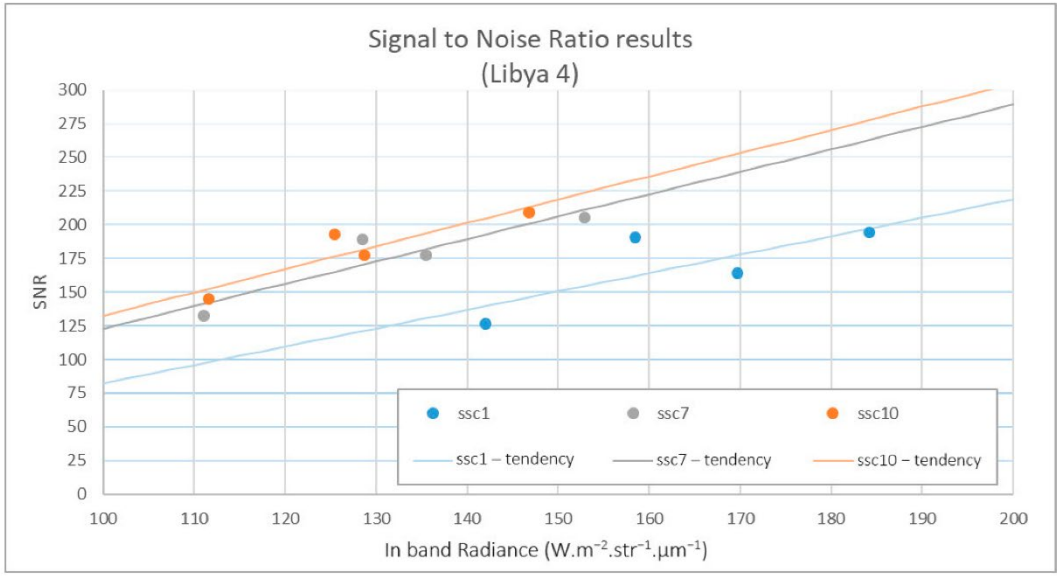


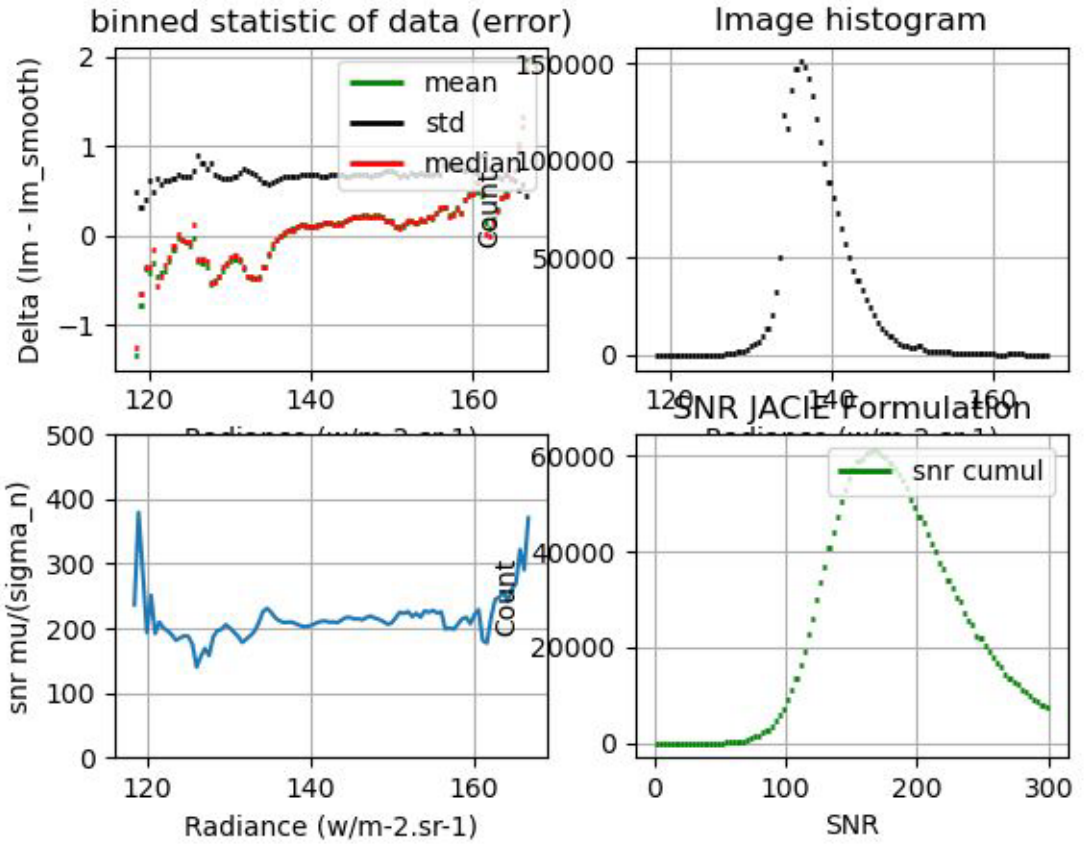
SNR Activity (1/2)





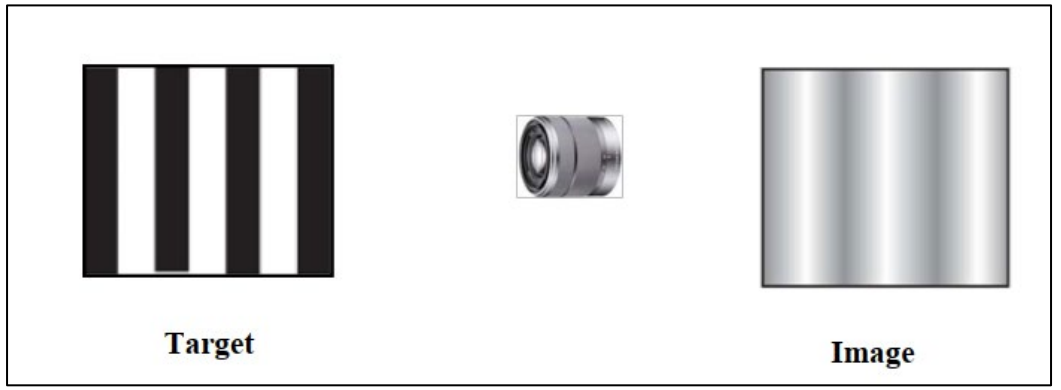
SNR Activity (2/2)

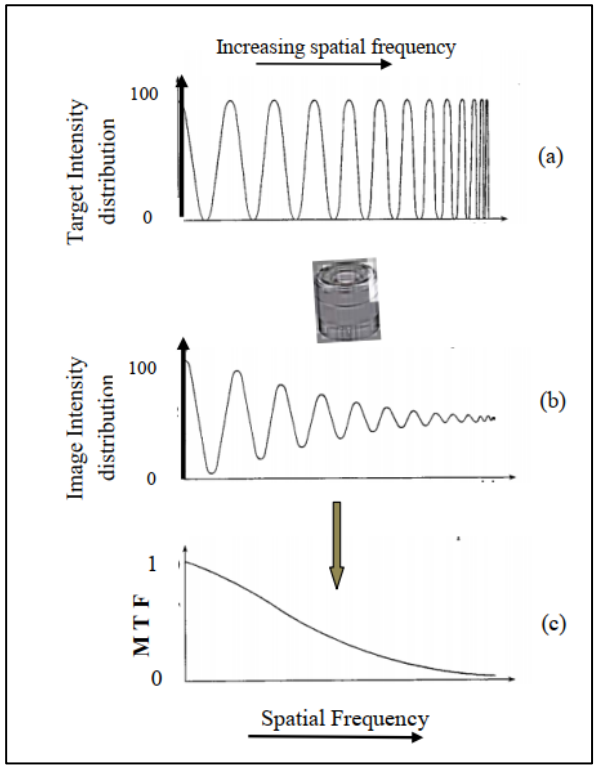




Saunier, S.; Karakas, G.; Yalcin, I.; Done, F.; Mannan, R.; Albinet, C.; Goryl, P.; Kocaman, S. SkySat Data Quality Assessment within the EDAP Framework. Remote Sens. 2022, 14, 1646. https://doi.org/10.3390/rs14071646

MTF Activity: Principles





$$MTF = \frac{Contrast\ modulation\ in\ image\ space}{Contrast\ modulation\ in\ object\ space}$$

(Joseph, 2020)

MTF Activity: Targets

- ✓ Artifical Target
- ✓ Natural Target

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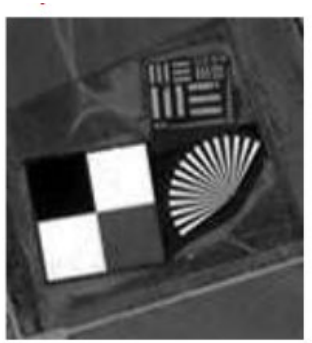
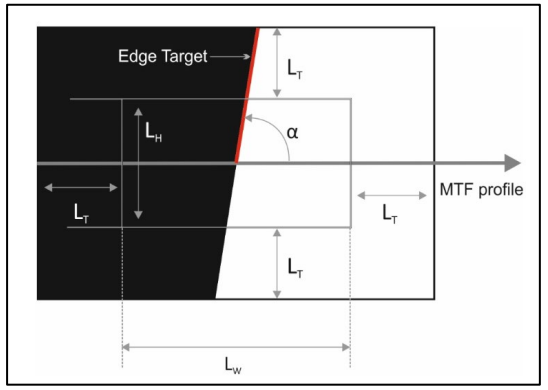
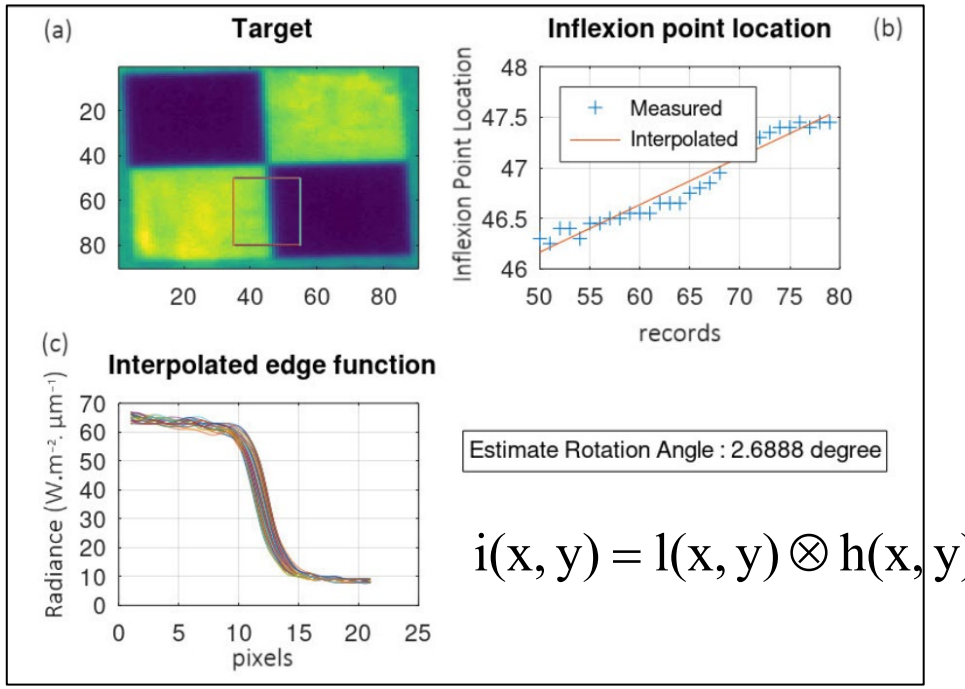
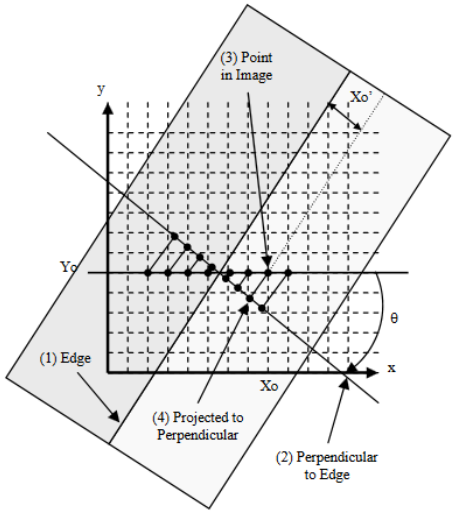


MTF Activity: Convention / Method





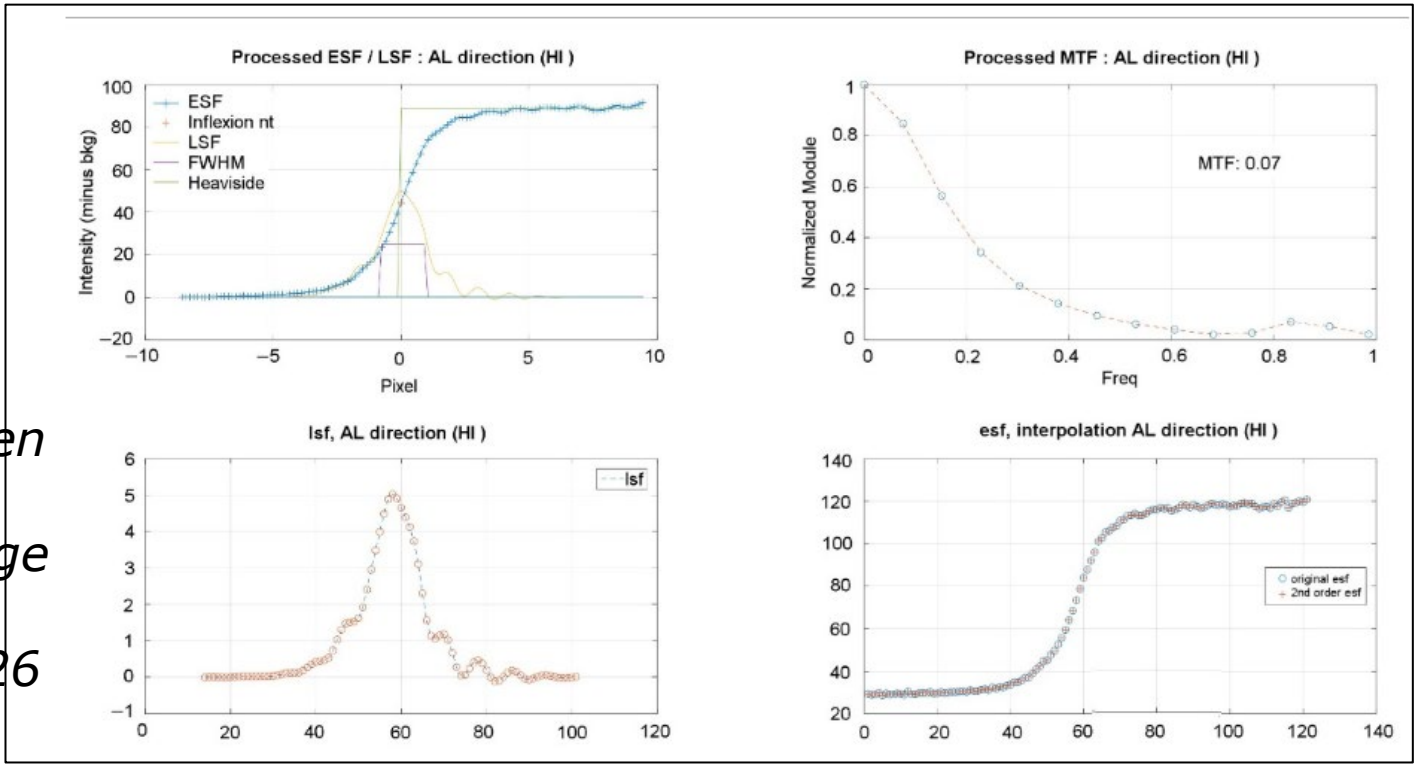
$$i(x, y) = l(x, y) \otimes h(x, y)$$



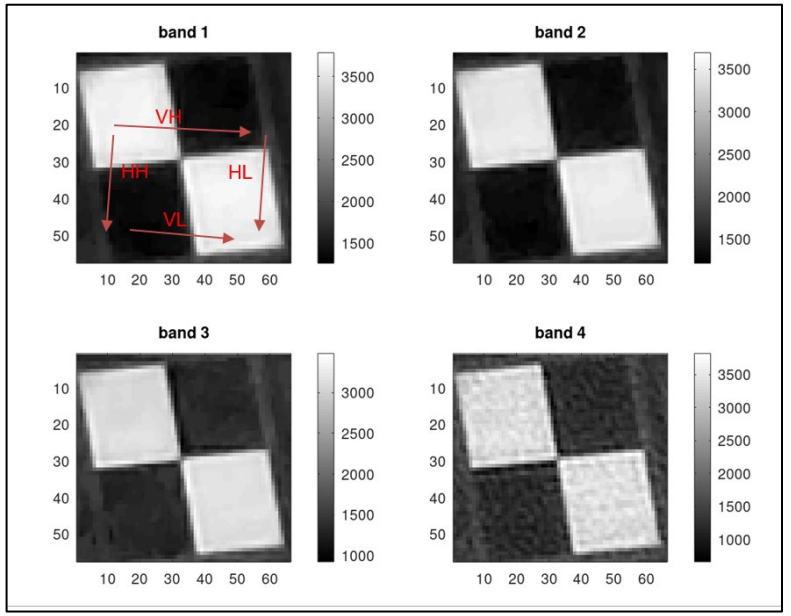
MTF Activity: Method

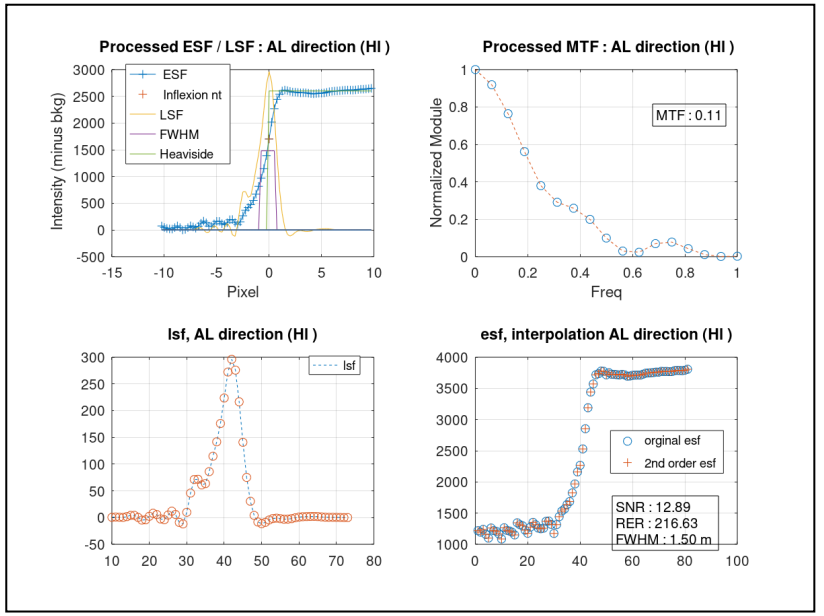
Slant edge Method widely used in the community but implementation differ

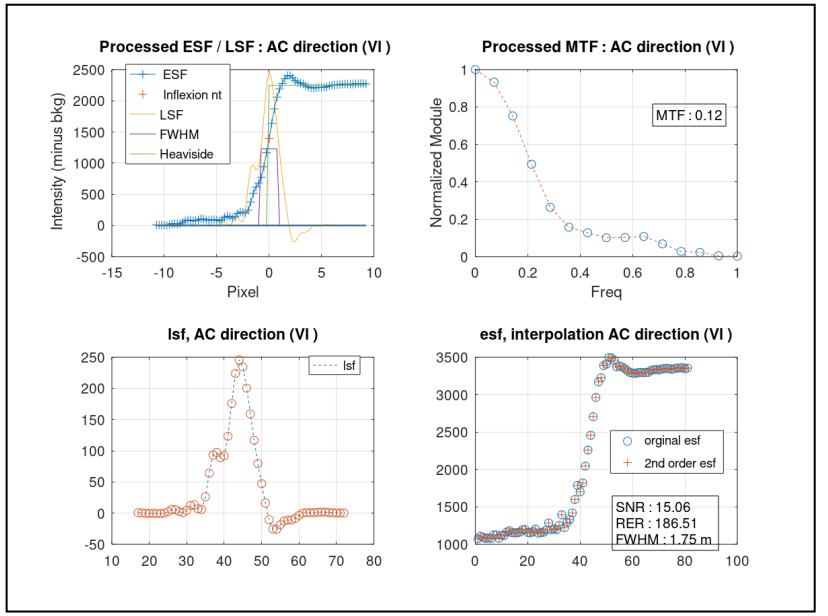
Françoise Viallefont-Robinet, Dennis Helder, Renaud Fraisse, Amy Newbury, Frans van den Bergh, Donghan Lee, Sébastien Saunier.. Comparison of MTF measurements using edge method: towards reference data set. Optics Express, Optical Society of America, 2018, 26 (26), pp.33625-33648. ⟨hal-02055611⟩



MTF Activity: Results





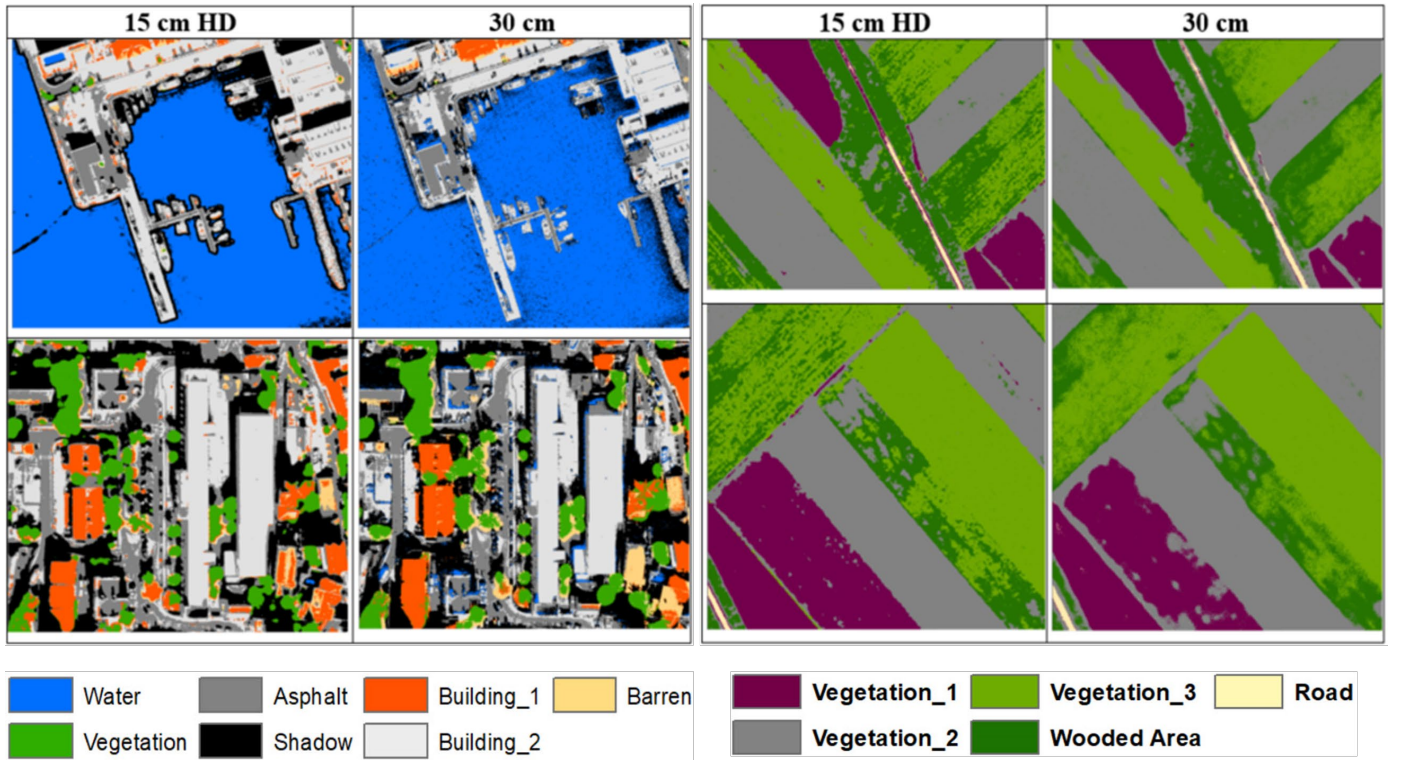


Ressources / Blog

1. https://medium.com/sentinel-hub/the-most-misunderstood-words-in-earth-observation-d0106adbe4b0
2. https://www.i2rcorp.com/main-business-lines/sensor-hardware-design-support-services/spatial-resolution-digital-imagery-guideline
3. Joseph, G., How to Specify an Electro-optical Earth Observation Camera? A Review of the Terminologies Used and its Interpretation. Journal of the Indian Society of Remote Sensing, (2020) 48: 171"
4. A User's Perspective on Optical Earth Observation Sensors-Understanding Spatial Resolution, published in GIM International Magazine ,ISSUE 4 • VOLUME 34 • SEPTEMBER/OCTOBER 2020.
5. Joseph G, 2021, Does imaging system MTF affects classification accuracy?, DOI: 10.13140/RG.2.2.13746.32965

Image Quality / Image usability

- We compared the image classification accuracy of 30 cm pan-sharpened and 15 cm HD products.
- Image quality improvement of the HD products were mainly observable in urban areas with strong edges. Thus, they provide a clear advantage for LULC classification in urban areas.
- In agricultural fields, classification noise was observed with HD data.
- The results in both areas confirm the findings of a previous publication that are edge improvement and color noise with HD.



I. Yalcin[1, 2], G. Karakas [2, 3], S. Kocaman [3, 4, *], S. Saunier [5], C. Albinet, INVESTIGATIONS ON THE EFFECT OF MAXAR HD PROCESSING IN LAND COVER CLASSIFICATION, In ISPRS Congress 2022.

Yalcin, I., Kocaman, S., Saunier, S., and Albinet, C.: RADIOMETRIC QUALITY ASSESSMENT FOR MAXAR HD IMAGERY, ISPRS Congress 2021. https://doi.org/10.5194/isprs-archives-XLIII-B3-2021-797-2021, 2021.

Conclusions / Perspectives

Conclusions

- ✓ EDAP Image Quality Methods for HR data has been presented.
- ✓ All HR missions processed with similar approach
- ✓ Constraint due to data quantity.
- ✓ Difficult to assess sensor parameter, rather assess user product parameter.
- ✓ Global / Automatic Method under testing

THANKS YOU

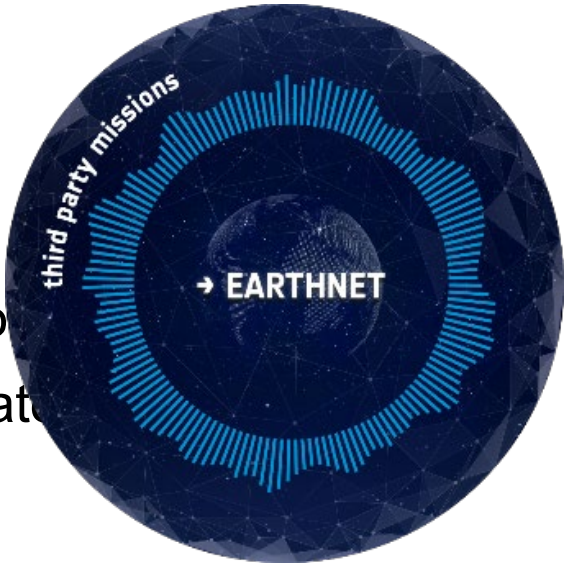
→ *https://earth.esa.int/eogateway/activities/edap*

ESA Third Party Missions (TPM) → *https://earth.esa.int*

SPARE SLIDES

A. TPM integration within Earthnet programme

Possible integration steps:



1- Before integration as formal ESA TPM:

→ ***Data evaluation***:

Earthnet Data Assessment Pilot (EDAP) on data quality and documentatio

Preliminary user feedbacks on data usability (selected users and/or dedicat projects).

2- Integration as formal ESA TPM:

→***Candidate TPM report*** approval by ESA Member States

3- The above process paves the way towards the utilization of the data for **operational** services in Copernicus context (***EU Copernicus Contributing Mission***)