# EDAP Framework for the geometric validation of high resolution optical data

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**VH-RODA**

**Optical Sensors Sessions - Room 1**

# OUTLINE

- EDAP Presentation
- Geometric Assessment Methods
- Planet Results.
- Landsat / S2 Results

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# Earthnet Programme and Third Party Missions

- ESA's Earthnet Programme provides the framework for "integrating" non-ESA missions (Third Party Mission - TPM) into the overall ESA Earth Observation (EO) portfolio, allowing data access and supporting the development of new research and applications

- Earthnet support to TPMs can be divided in two types of activities:
  - Support to TPM cal/val and routine data quality monitoring,
  - TPM data supply for science and research purposes

- In the recent years, the EO capacity from space has grown with the multiplication of both institutional and commercial missions; in particular the domain of high-resolution optical sensors and SAR (Synthetic Aperture Radar) has dramatically increased.

- In this context, the ESA Earthnet Data Assessment Pilot (EDAP) project aims to perform an early data assessment for various missions, which may potentially become TPMs, covering specifically identified calibration and validation related tasks

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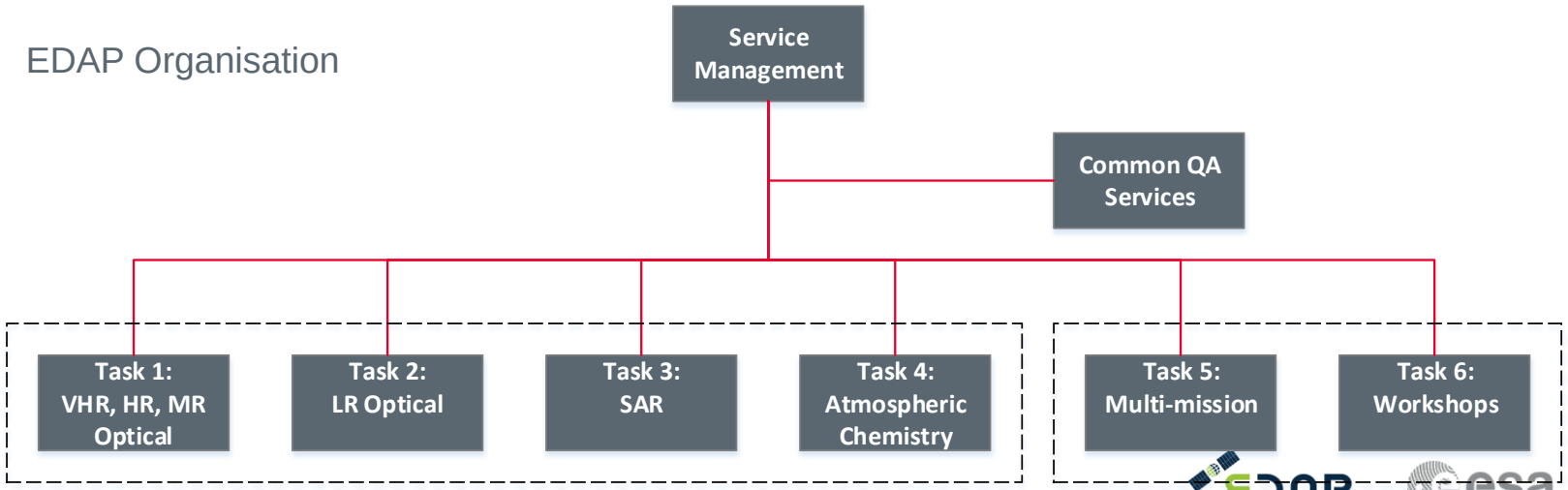
# What is EDAP?

- **ESA's Earthnet Data Assessment Pilot (EDAP**) is a project a 2-years project, started in November 2018.
- EDAP is designed to **perform early data quality assessments** on existing and future Earth Observation (EO) missions from national or commercial providers
- It is achieved through provision of **clusters of expertise in various domains**
- Specific focus will 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.
- EDAP Organisation

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# Service Domain Clusters & Input Missions

- The missions covered in each of the Domain Clusters:

| TASK | Domain | Missions |
|---|---|---|
| Task 1 | Very High, High and Moderate Resolution Optical | Planet – PlanetScope |
| | | Planet – Skysat |
| | | USGS Landsat |
| | | KARI Kompsat 3 |
| | | SSTL DMC/Triplesat |
| | | SSTL Superview |
| | | SSTL Vision-1 |
| | | Earth-i Vivid-i |
| | | BlackSky |
| | | Proba-1 CHRIS |
| Task 2 | Low Resolution Optical | ISRO OceanSat 2 |
| | | MOS |
| Task 3 | Synthetic Aperture Radar | SAOCOM 1A/B |
| | | ICEYE |
| | | PAZ |
| Task 4 | Atmospheric missions | GCOM-C1 |
| | | SPIRE |
| | | Tansat |
| | | Gosat-2 |
| | | GHGSat-D |
| Task 5 | Multimission | DEM study |
| Task 6 | Workshop organization | |

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# Geometric Methods

## Input products : Level 1C

*"This level of imagery is orthorectified, which implies the removal of the perspective distortion and the influence of elevation differences. The orthorectified imagery can be used a planimetric map since the scale is uniform. Accurate reference digital terrain or surface models are needed to generate Level-1C imagery."*

## Geometric Validation Items for L1C products

The Planimetric accuracy ,
The Band-to-band registration
The Multi temporal accuracy
The stereoscopic capability.

## Reference Data (With known uncertainties)

Ground Control Points set collected from testfield GPS survey,
Raster reference
Digital Elevation Data
Lidar Data

(WP210 - Geometry Sites), **http://calvalportal.ceos.org/calibration-test-sites**

## Tool

| | |
|---|---|
| Image Matching | Medicis (CNES) &OpenCV |
| Reprojection / Resampling | GDAL, Sickit |
| Data Visualization / GCP handling | QGIS |
| Accuracy / Statistical analysis | Numpy, Statsmodels |

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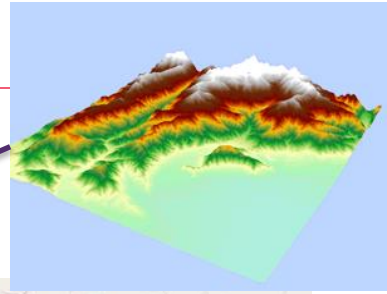
# Geometric Sites, global distribution



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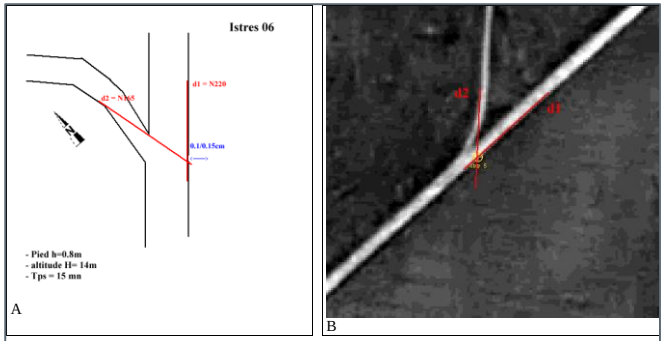
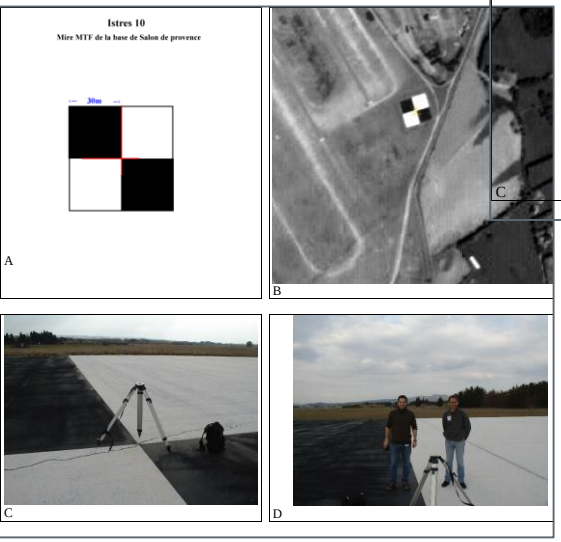
# Geometric Site (dense): La Crau



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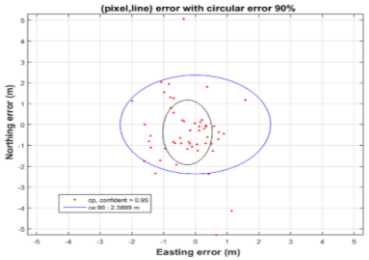
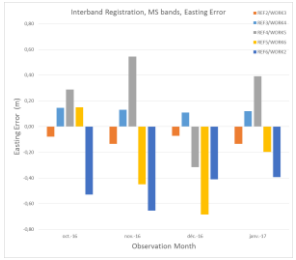
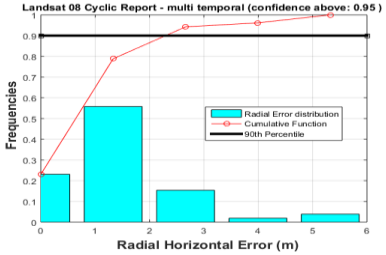
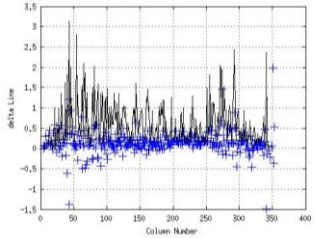
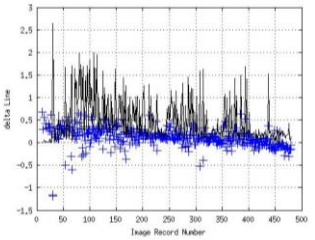
# Reporting on the geometric quality

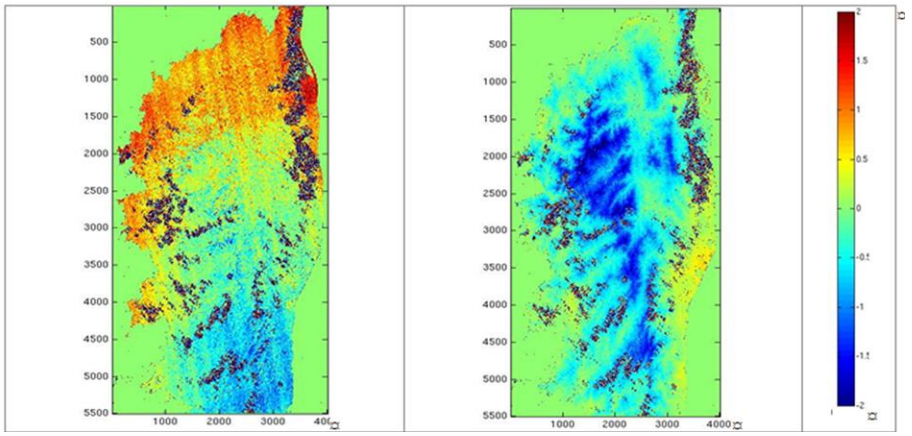


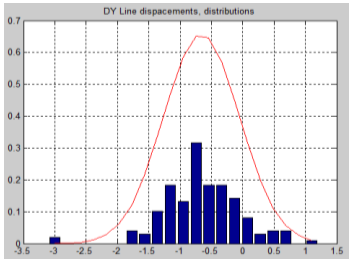



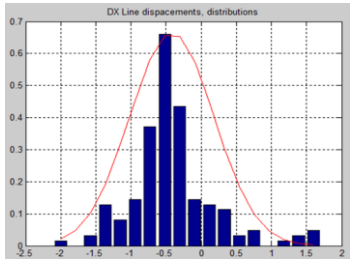



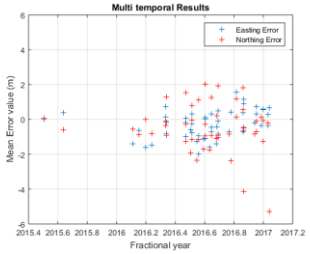



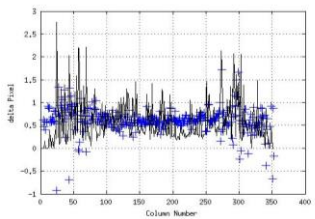



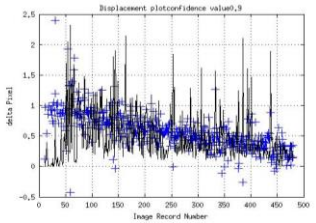


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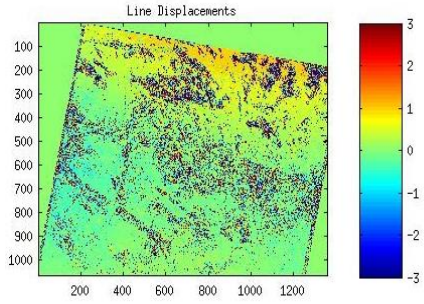
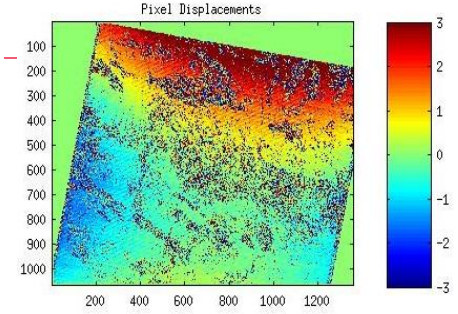
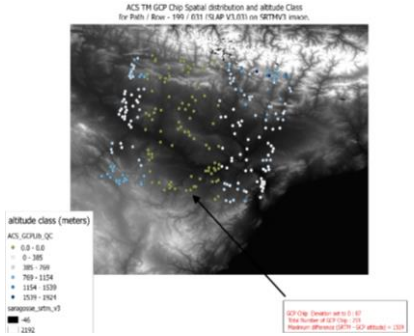
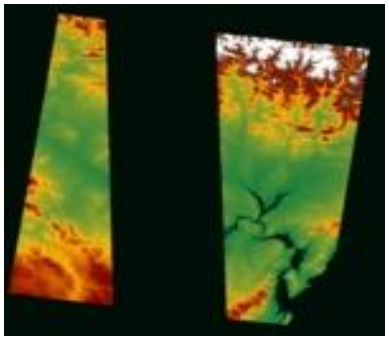
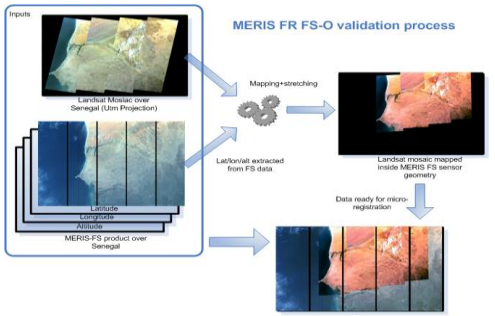
# MERIS FR Full Swath; Camera pointing Validation.





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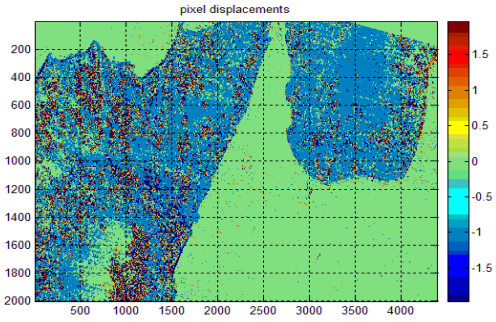
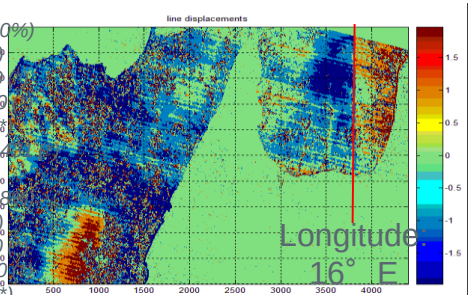
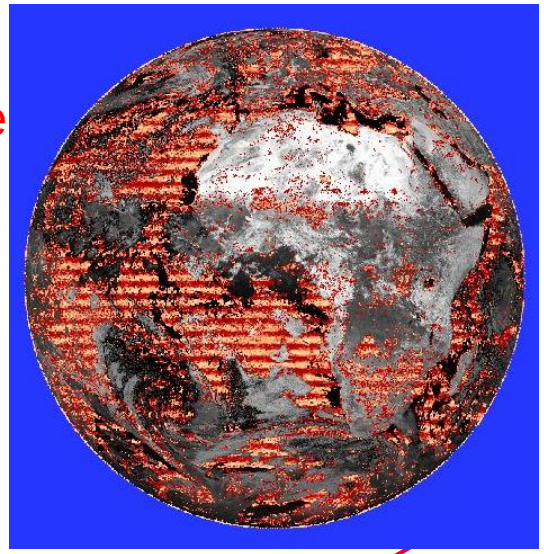



*X DISPLACEMENT:*
*ON LIMIT = 13626823 / 51612352 (26.40%)*
*RMS = 1.171082 vs. 0.919324 (*)*
*MINIMUM = -2.000000 vs. -1.000000*
*MAXIMUM = 2.000000 vs. 1.000000*
*MEAN = -0.156528 vs. -0.812092 (*)*
*STANDARD DEVIATION = 1.161 vs 0.*
*Y DISPLACEMENT:*
*ON LIMIT = 16142382 / 51612352 (31.28*
*RMS = 1.230662 vs. 0.886347 (*)*
*MINIMUM = -2.000000 vs. -1.000000*
*MAXIMUM = 2.000000 vs. 1.000000*
*MEAN = -0.186541 vs. -0.587803 (*)*
*STANDARD DEVIATION = 1.216 vs 0.663 (*)*

Longitude 16° E

Inter-channel registration errors on L1.5 image for MSG3
=> Mirror Step Time Table update (Nain 2019 )



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# Planet DOVE Assessment

- **Activities :**
  - Absolute geolocation accuracy by using GCP set for product observed over La Crau, Piemont & Wellington
  - Multi Temporal geolocation accuracy by using data from the constellation, whatever the patform
  - Interband registration accuracy by using data from all the sites, including (Libya 4 site).

- **Constraints :**
  - Early assessement (short time period),
  - Select representative products, (different plaforms / version launch dates) …

- **Missions Specification =>**

- **L1 Product Geometric Accuracy Specification (Public);**
  (10.0 m RMSE)

CONSTELLATION OVERVIEW: PLANETSCOPE

| Mission Characteristics | International Space Station Orbit | Sun-synchronous Orbit |
|---|---|---|
| Orbit Altitude (reference) | 400 km (51.6° inclination) | 475 km (~98° inclination) |
| Max/Min Latitude Coverage | ±52° (depending on season) | ±81.5° (depending on season) |
| Equator Crossing Time | Variable | 9:30 - 11:30 am (local solar time) |
| Sensor Type | Three-band frame Imager or four-band frame Imager with a split-frame NIR filter | Three-band frame Imager or four-band frame Imager with a split-frame NIR filter |
| Spectral Bands | Blue: 455 - 515 nm<br>Green: 500 - 590 nm<br>Red: 590 - 670 nm<br>NIR: 780 - 860 nm | Blue: 455 - 515 nm<br>Green: 500 - 590 nm<br>Red: 590 - 670 nm<br>NIR: 780 - 860 nm |
| Ground Sample Distance (nadir) | 3.0 m (approximate) | 3.7 m |
| Frame Size | 20 km x 12 km (approximate) | 24.6 km x 16.4 km (approximate) |
| Maximum Image Strip per orbit | 8,100 km² | 20,000 km² |
| Revisit Time | Variable | Daily at nadir (early 2017) |
| Image Capture Capacity | Variable | 200 million km²/day |

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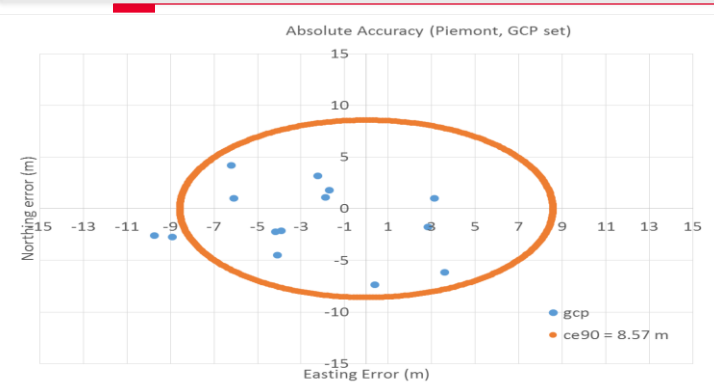
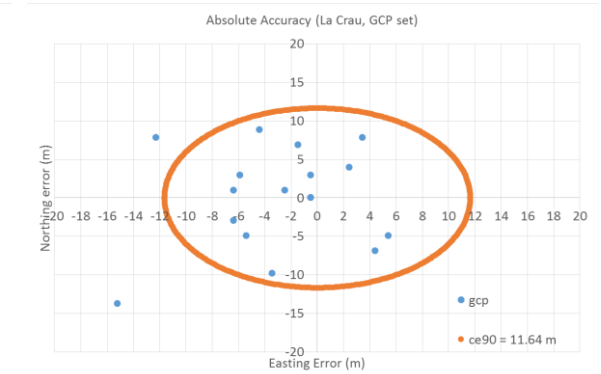
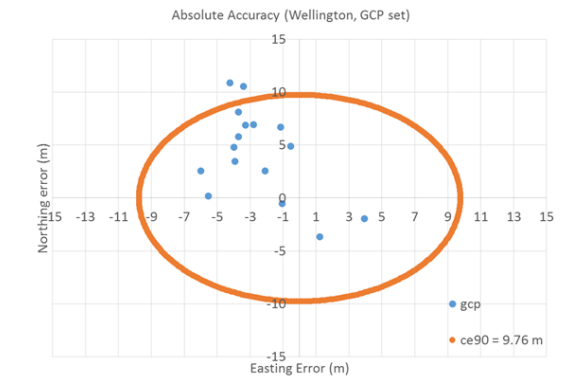
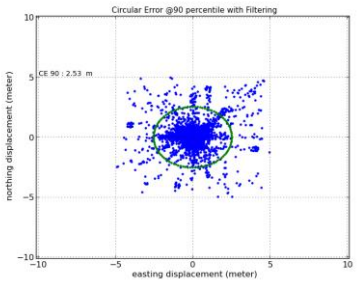
# Planet DOVE Absolute geolocation

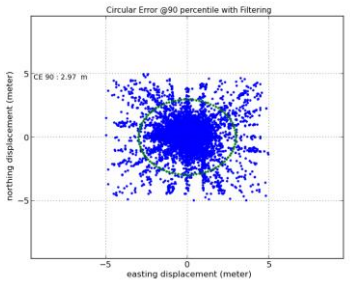


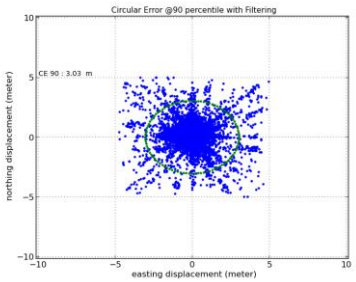



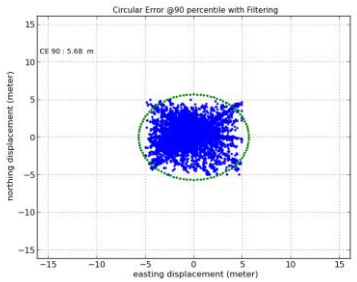




# Planet DOVE Multi Temporal geolocation

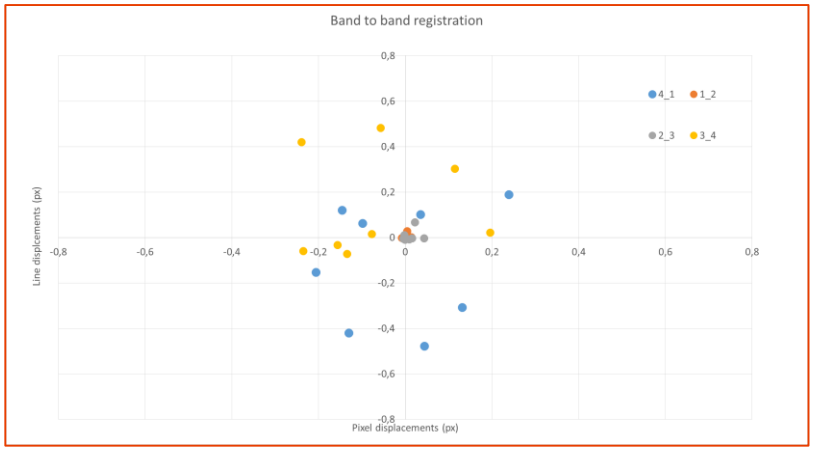


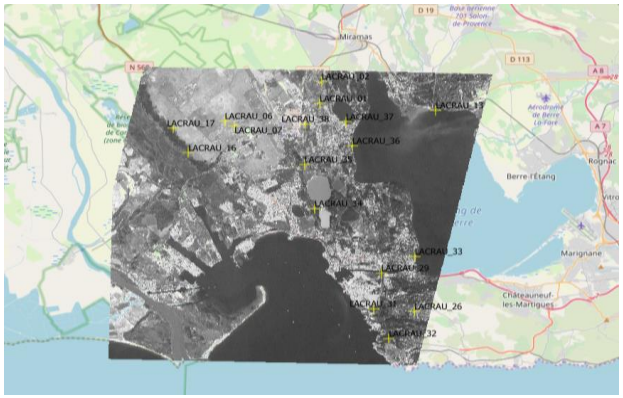




# Planet DOVE Interband Registration

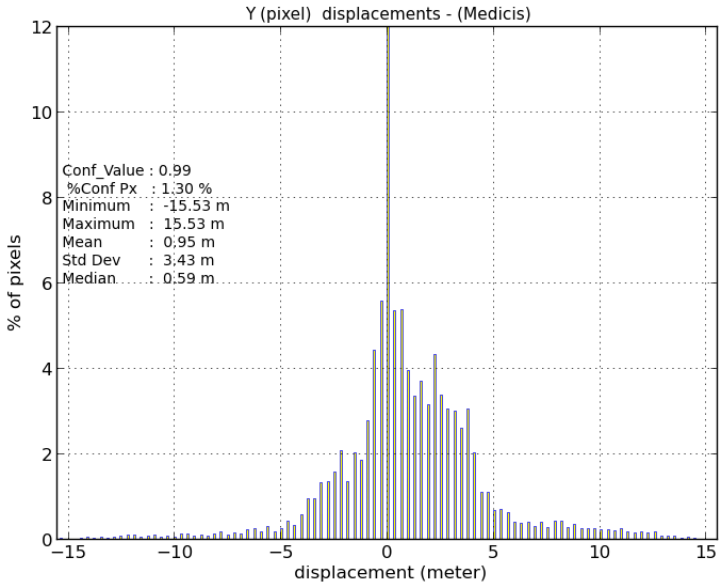


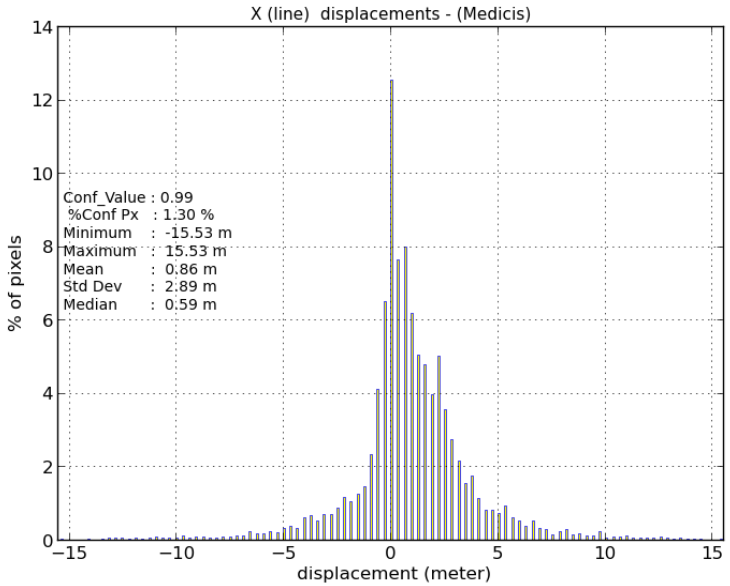



# Planet DOVE Assessment / Results (Level 1C)

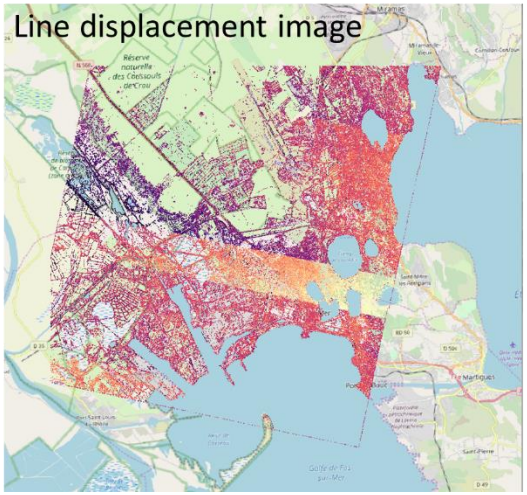
- Absolute geolocation accuracy
  Results fully in agreement with the product accuracy specifications (10.0 m RMSE).
- Multi Temporal geolocation accuracy
  Results are correct, somehow band dependant, exceeding 5.5 m CE90 for the NIR band.
- Interband registration accuracy
  The product RMSE accuracy is within 0.2 pixel for band twins (1,2) and (2,3) while it is above when band 4 is involved.

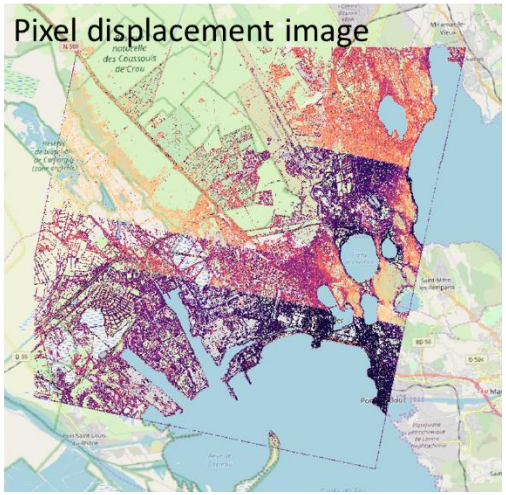
- Absolute geolocation accuracy
  We note that for Piemont and La Crau the CE@90 is high compared to RMSE
- Multi Temporal geolocation accuracy
  We note geometric distortions mosrly pronounced in the easting direction.
- Interband registration accuracy
  The interband registration is not stable, meaning variability in the internal image.

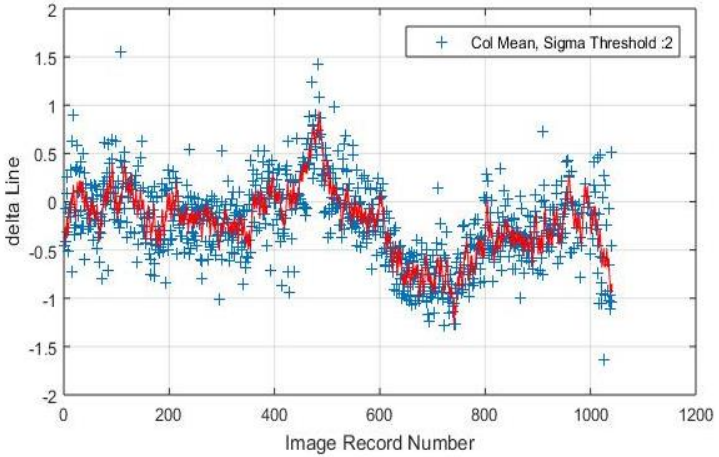


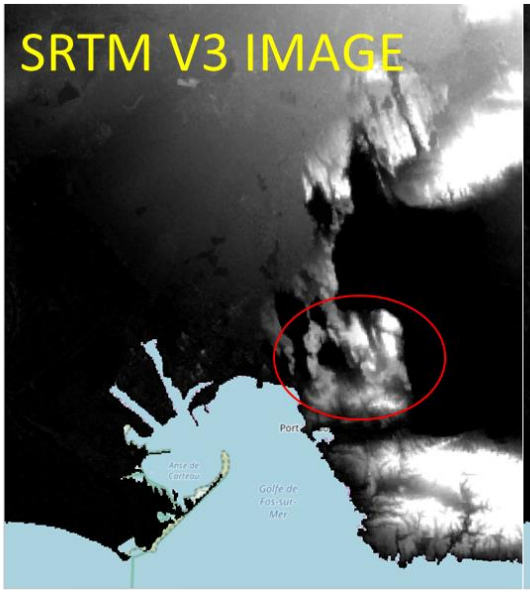



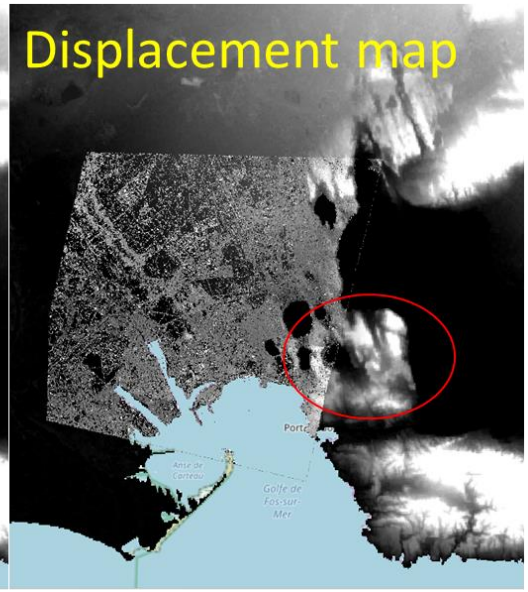
# Planet DOVE Assessment / Results (Level 1C)

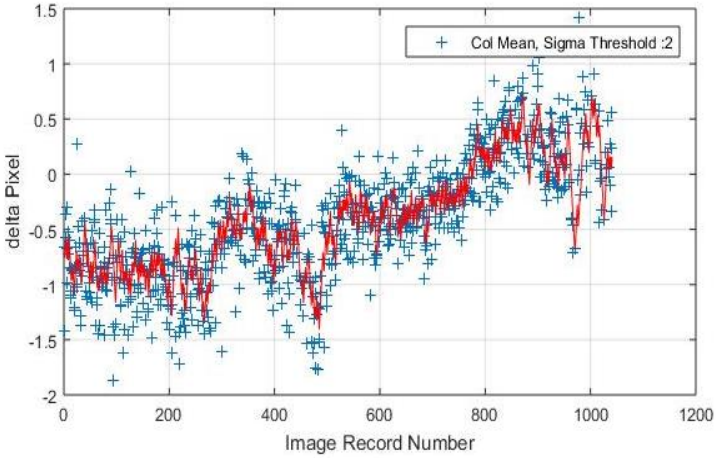
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# Planet DOVE Assessment 2/3

- Wellington Geometric Test Field (South Africa),
- Image comparison, at the GCP location for a same cartographic scale 1:8000).
- The image quality of input RS image influences the GCP Pointing accuracy

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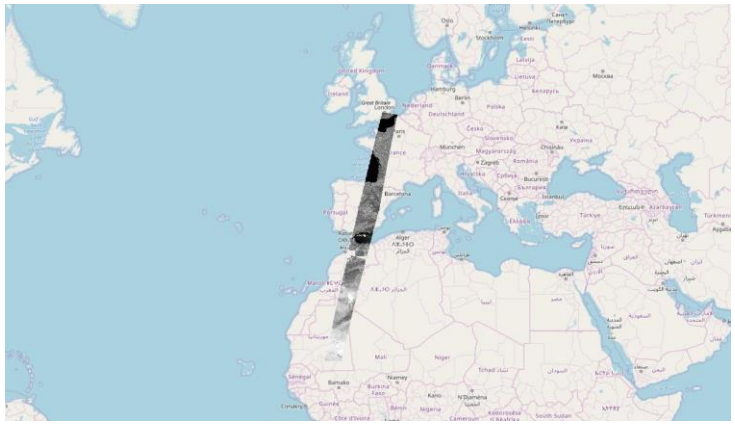
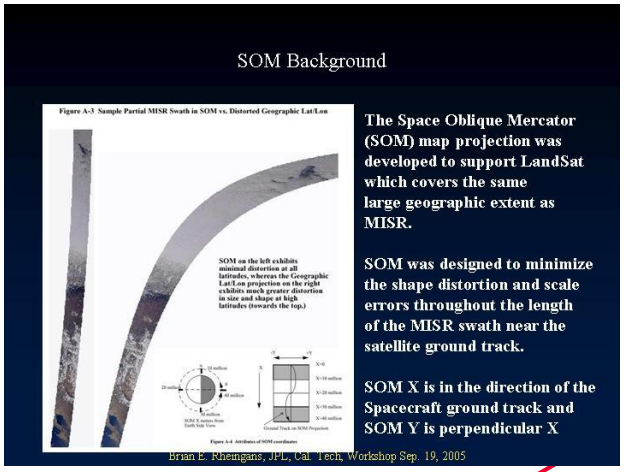
# Constellation Assessment / «Orbit» Analysis

- Motivation 1 : Discern systematic / Non systematic effects in the Level 1C geometry, an analysis as close as possible to the sensor geometry.
- Motivation 2 : Evaluate interoperability between Missions
- Input Mission : All Landsat MSS / TM / EMT+ / OLI data, Sentinel 2 data, **GLS**
- History : First results presented @SPIE 2019 & Questions (for me)
- Current Method : Collect L1C data and performed Image matching in the Space Oblique Mercator between full orbits.
- Reference 1 : Evaluation of the geometric accuracy across the European Space Agency (ESA) Landsat historical archive. (Saunier & Al, 2019) , https://doi.org/10.1117/12.2533198 (previous method)
- Reference 2 : JOHN P. SNYDER Space Oblique Mercator Projection, Mathematical development, Geological Survey Bulletin 1518. https://pubs.usgs.gov/bul/1518/report.pdf





# Constellation Assessment / «Orbit» Analysis - L1C input data

- [ S2 data ] : No Georeferencing Model refinement with a GCP set (GRI)
  PlanetDem 90.0 m (2015)
- [ Landsat TPM data ] : Refinement with GCP set from the GLS product (ESA Processing)
  SRTM V3.0
- [ Landsat 8 data ] : Refinement with GCP set from GLS product, Collection-1 products.
  (INFO : LS8 L1C data processing with GCP adjusted to the GRI foreseen for Collection-2 (1st Quarter 2020))

| S2A (R094) | S2B (R094) | GLS (WRS P 201) | LT5 (WRS P 201) | LS8 (WRS P 201) | LT7 (WRS P 201) | LM5 (WRS P 201) |
|---|---|---|---|---|---|---|
| 2018/08/02 (193 Tiles), 2019/10/06 (157 Tiles) | 2019/10/01 (125 Tiles), 2019/10/11 (141 Tiles) | p201r024_7dt20000619<br>p201r025_7dt20020913<br>p201r026_7dt20000721<br>p201r027_7dt20010521<br>p201r028_7dt20010521<br>p201r030_7dt20000619<br>p201r031_7dt20000619<br>p201r032_7dt20020422<br>p201r033_7dt20020422<br>p201r034_7dt20020321<br>p201r035_7dt19990820<br>p201r036_7dt20010606<br>p201r037_7dt20000502<br>p201r038_7dt20000502<br>p201r039_7dt20000331<br>p201r040_7dt20010214<br>p201r041_7dt20010129<br>p201r042_7dt20010129<br>p201r043_7dt20010129<br>p201r044_7dt20010129<br>p201r045_7dt20010521<br>p201r046_7dt20010214<br>p201r047_7dt20010214<br>p201r048_7dt20011231 | 1998/03/02 | 2014/10/24 | 2000/04/16 | 1986/11/28 |

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# Constellation Assessment / «Orbit» Analysis - statistical results

| Image Matching Results, orbit configuration , (confidence : 0.95), unit : meter, AL :Along Track, AC : ACross Track | | | | | | | |
|---|---|---|---|---|---|---|---|
| Twin | total valid pixel | median AL | mean AL | std AL | median AC | mean AC | std AC |
| GLS_LM5 | 927 | -7,97 | -7,04 | 31,32 | 4,22 | 4,22 | 77,72 |
| GLS_LT5 | 7455 | -0,70 | -0,70 | 14,00 | -1,17 | -0,73 | 17,11 |
| GLS_LS7 | 6080 | -1,41 | -1,41 | 10,41 | -2,58 | -2,14 | 12,51 |
| GLS_LS8 (20141024) | 22966 | 0,47 | 0,61 | 6,71 | -1,88 | -1,81 | 7,76 |
| | | | | | | | |
| GLS_S2B (20191001) | 5759 | 8,67 | 8,44 | 11,63 | -13,83 | -14,27 | 13,18 |
| LS8-S2A (20191006) | 24241 | 0,94 | 0,62 | 9,69 | -9,14 | -12,31 | 14,94 |
| LS8-S2A (20180802) | 6011 | 18,52 | 12,26 | 30,08 | -4,69 | -6,90 | 18,01 |
| LS8-S2B (20191001) | 15031 | 5,63 | 4,98 | 11,05 | -9,14 | -10,30 | 11,32 |
| LS8-S2B (20191011) | 7562 | 7,03 | 8,47 | 11,86 | -19,69 | -22,50 | 17,45 |
| S2A (20191006)<br>S2B (20191001) | 61232 | 4,22 | 4,00 | 2,34 | -2,11 | -1,61 | 3,06 |

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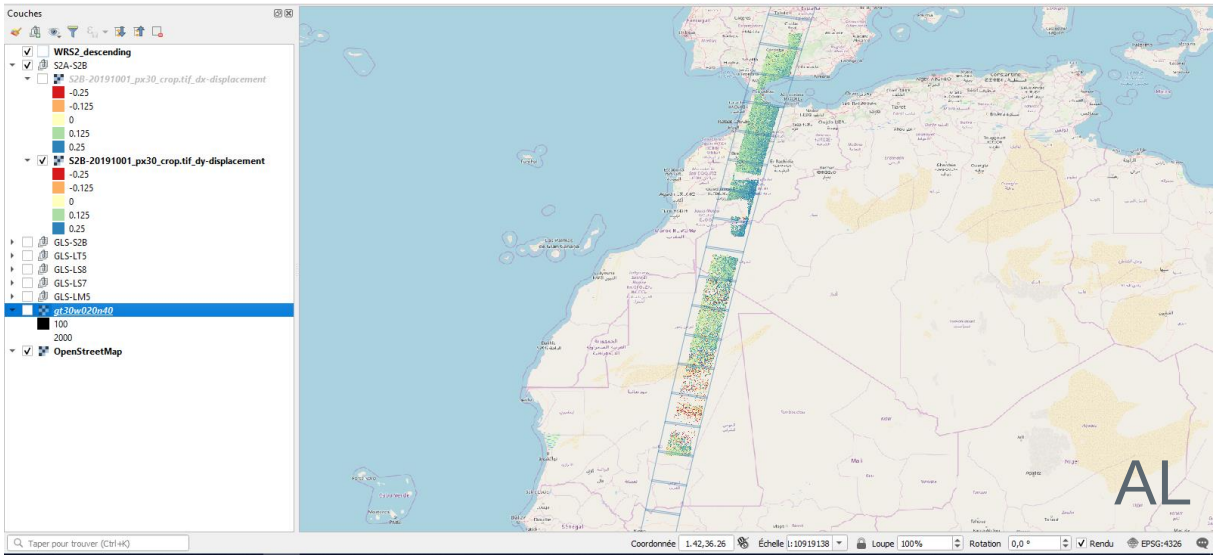
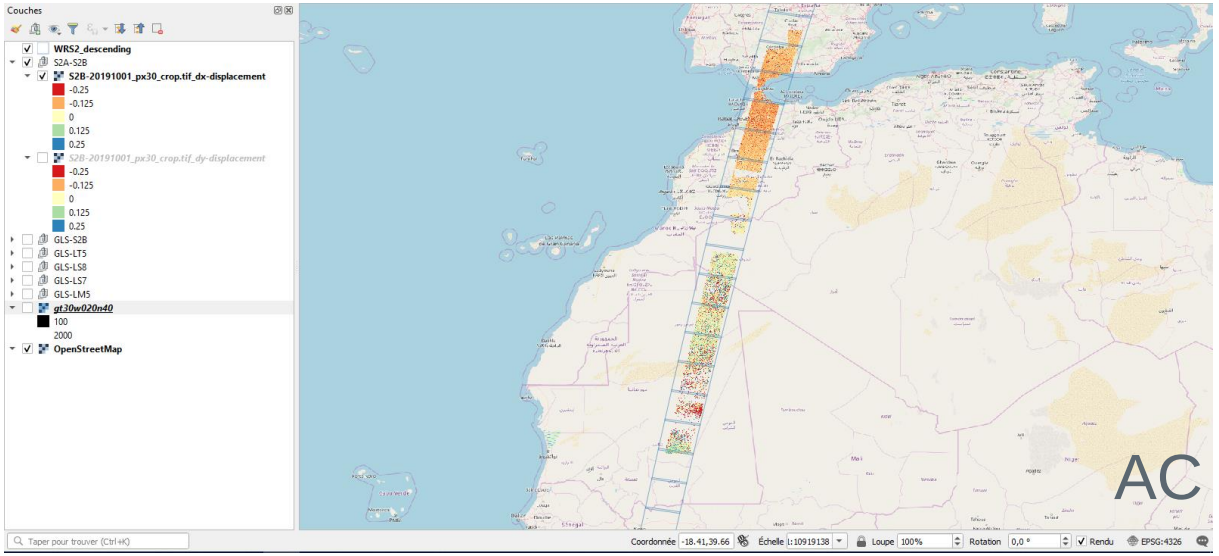
# Constellation Assessment / «Orbit» Analysis - matching results S2A / S2B

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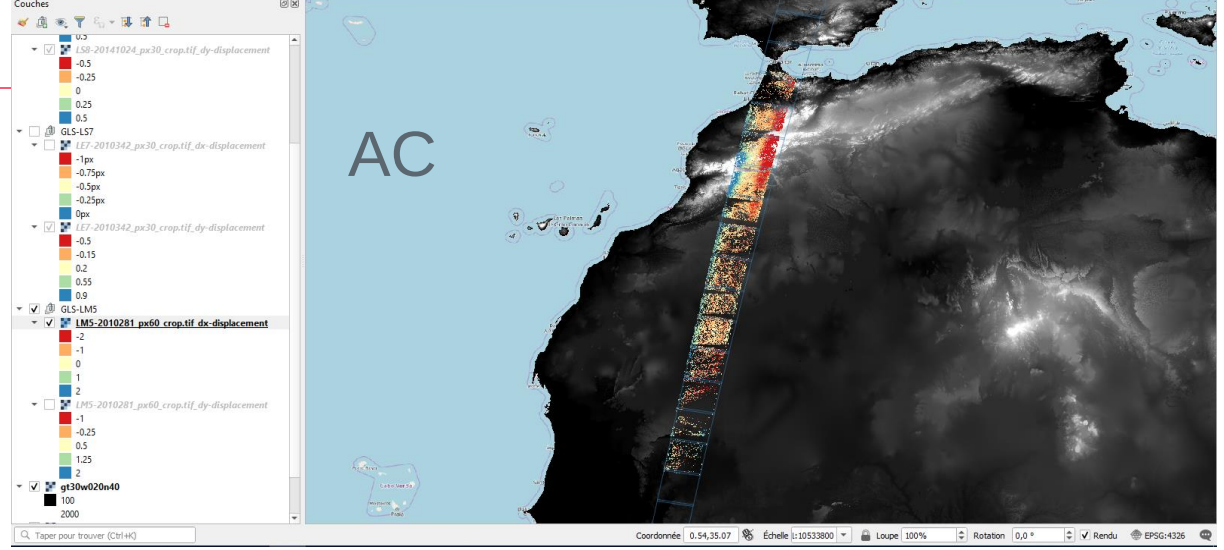
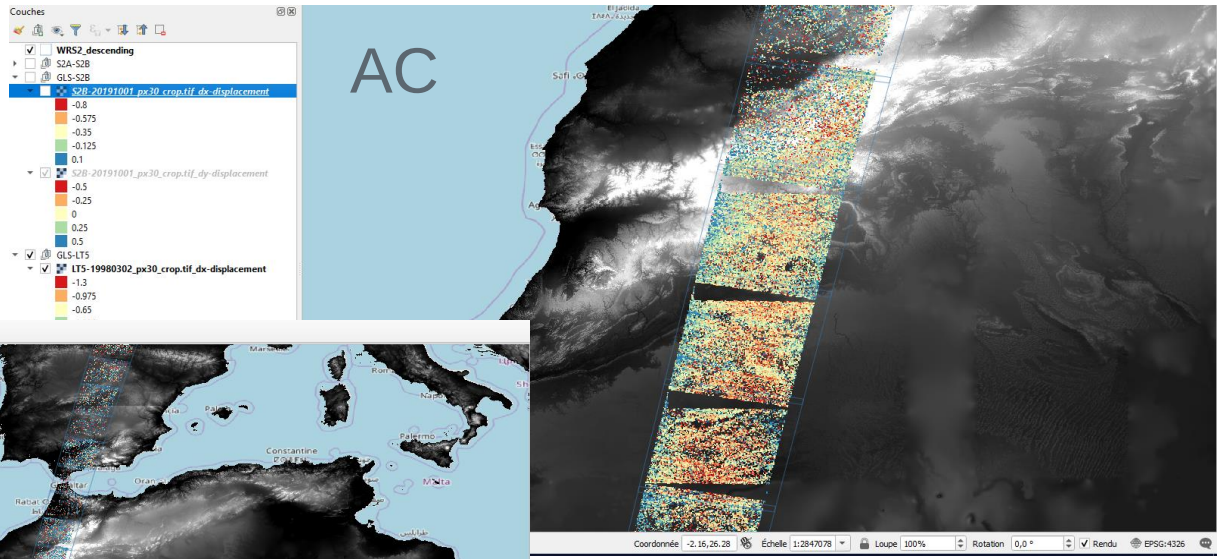
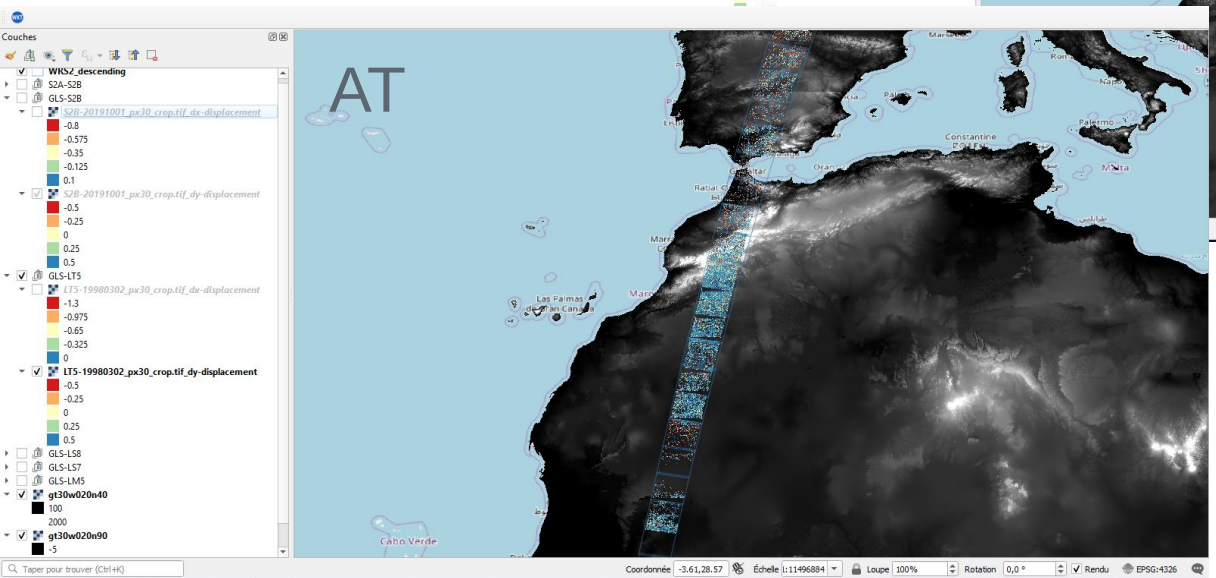
# Constellation Assessment / «Orbit» Analysis - matching results

GLS / LM5 (MSS)
GLS / LT5 (TM)

(systematic effects)



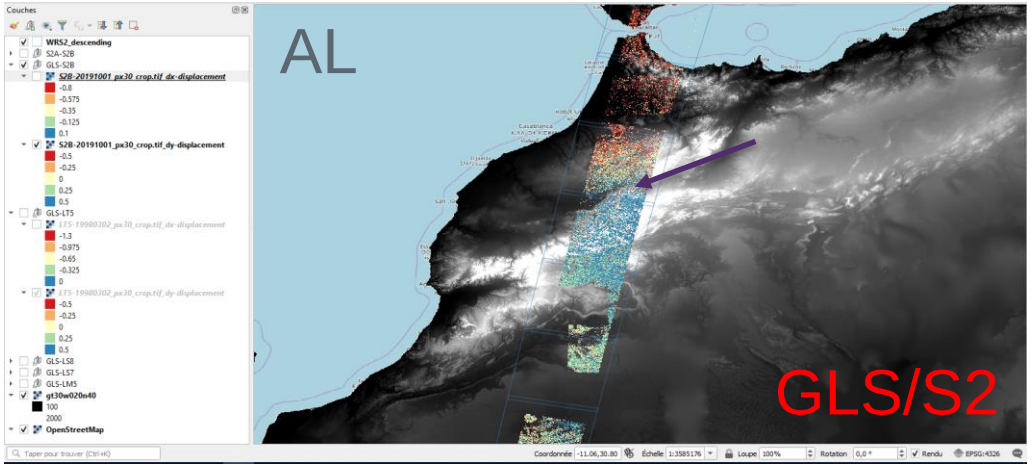



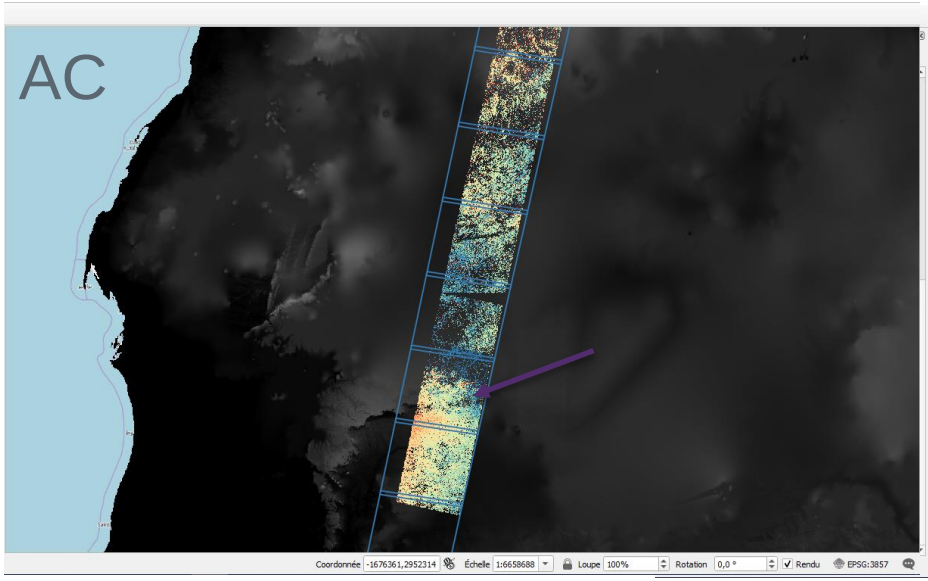



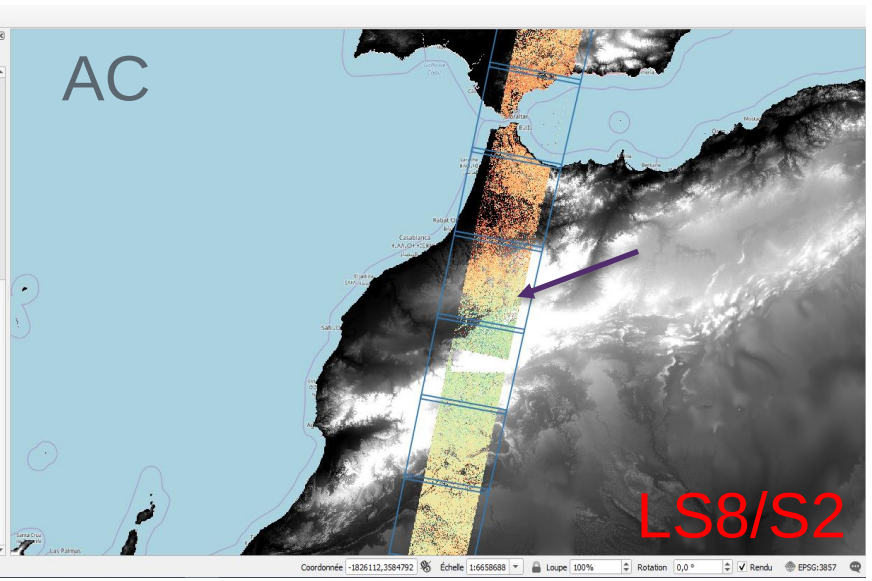
# Constellation Assessment / «Orbit» Analysis matching results

## GLS/ S2, LS8 / S2

## (non systematic)

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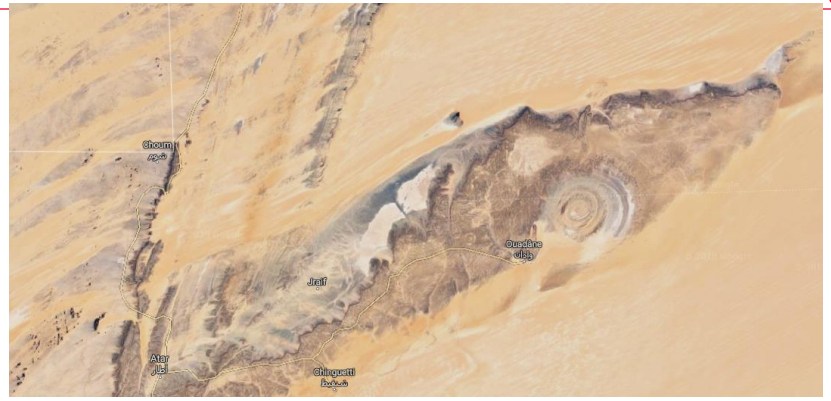
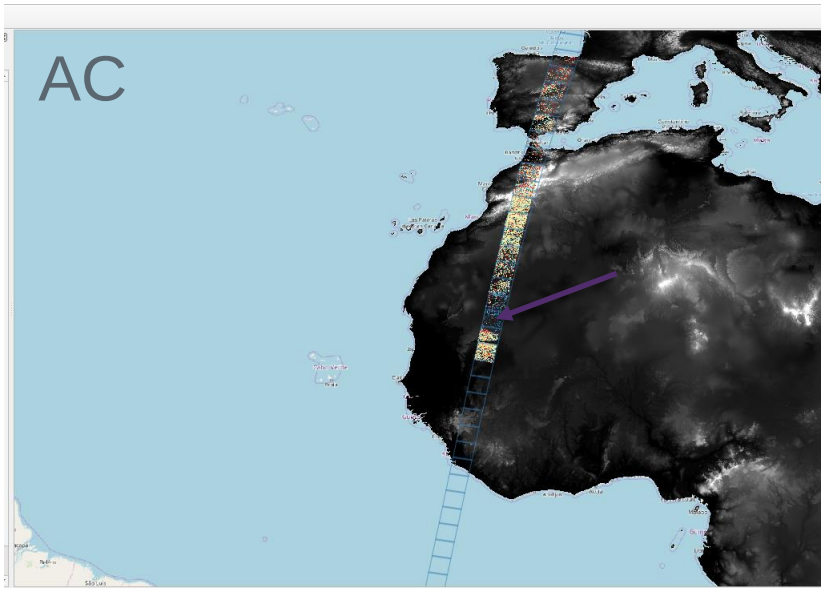
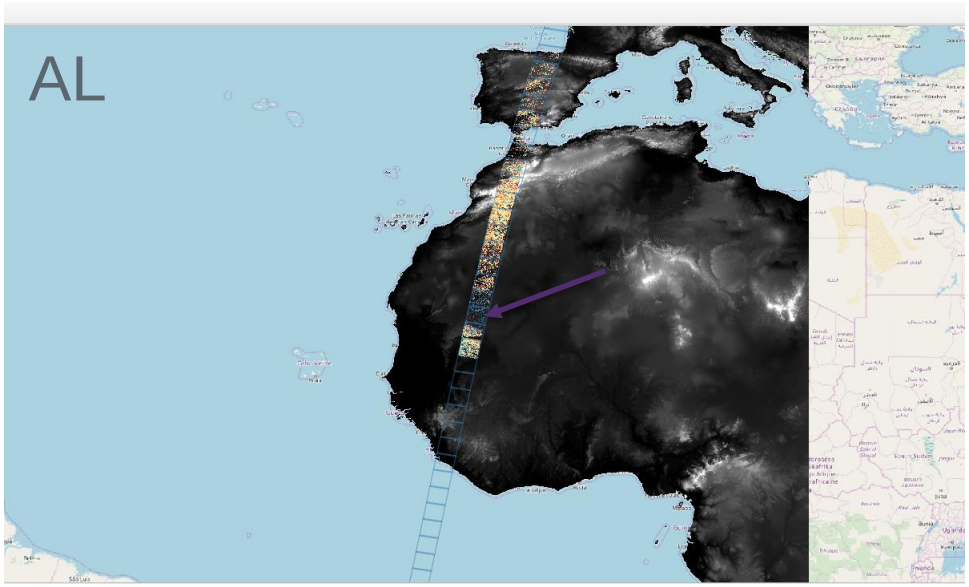
# Constellation Assessment / «Orbit» Analysis matching results

## GLS / LS8

**For some regions, the image information to be matched is poor.**
**(The Level 1 processing might failed to find and accurate GCP set for georeferencing?)**



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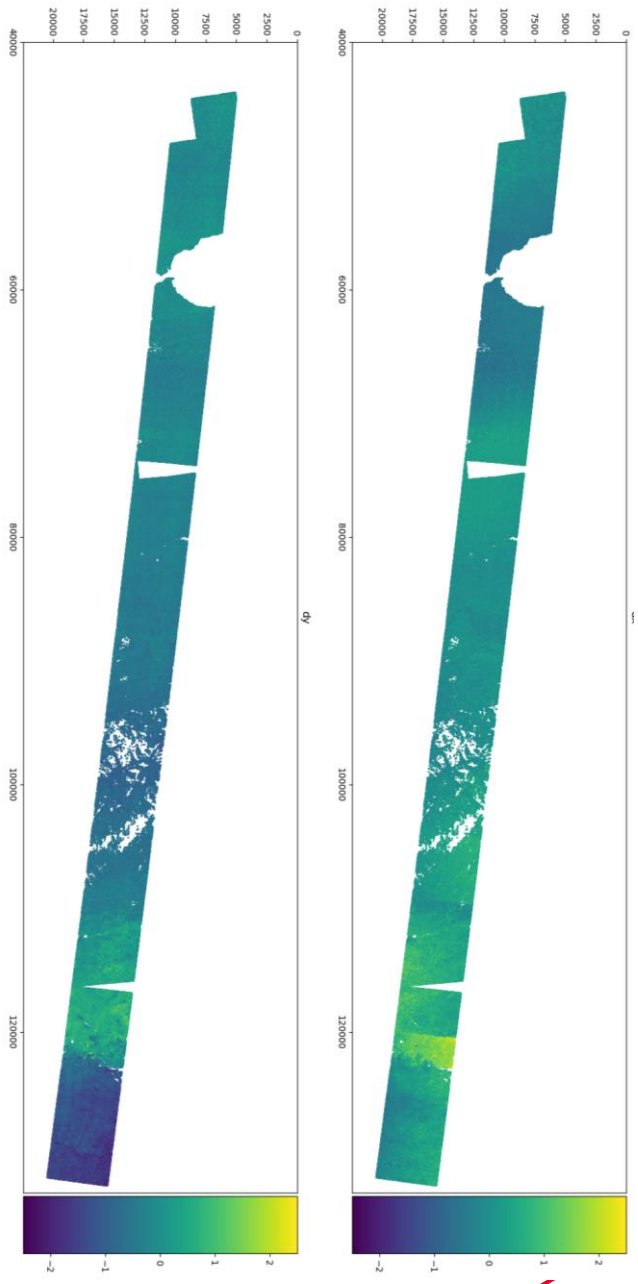
# Constellation Assessment / «Orbit» Analysis

- Assessing with an Alternative methods for matching (LS8/S2)
- Promising results !!!
- Deviation confirms

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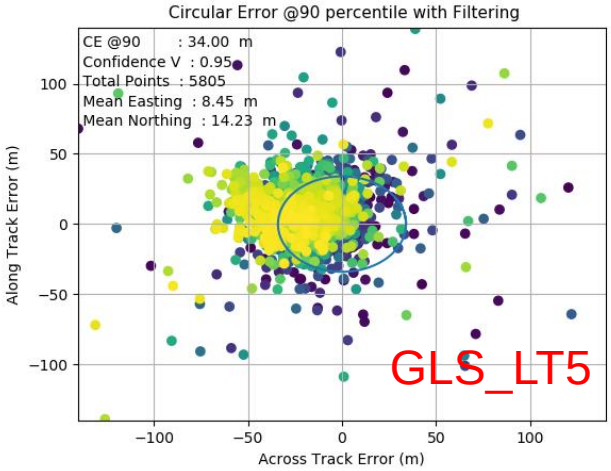
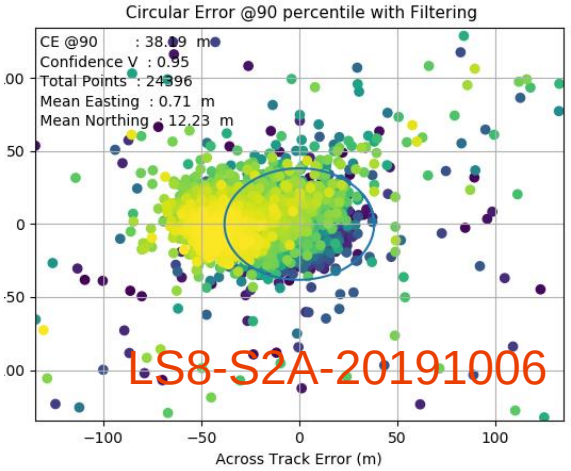
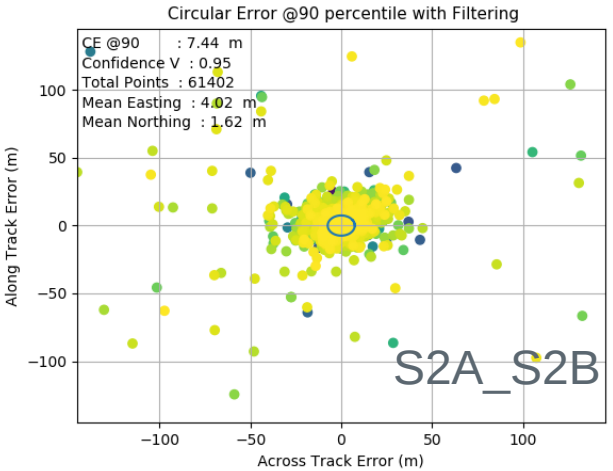
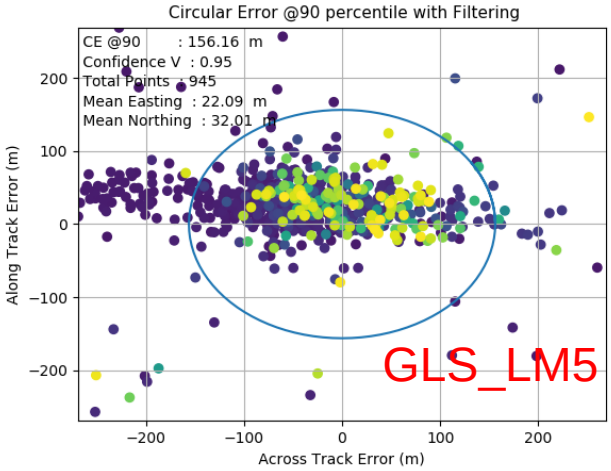
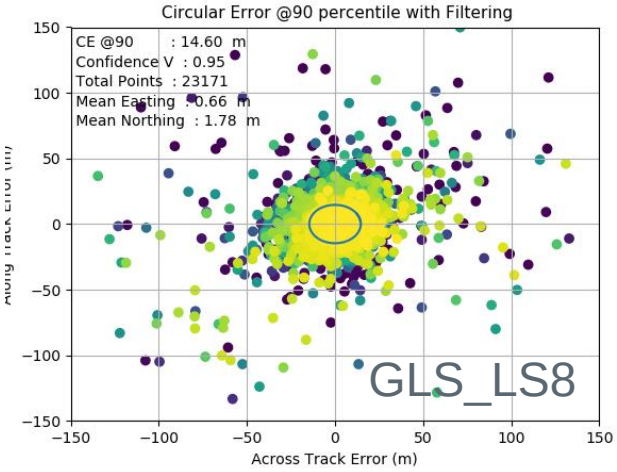
# Hello world

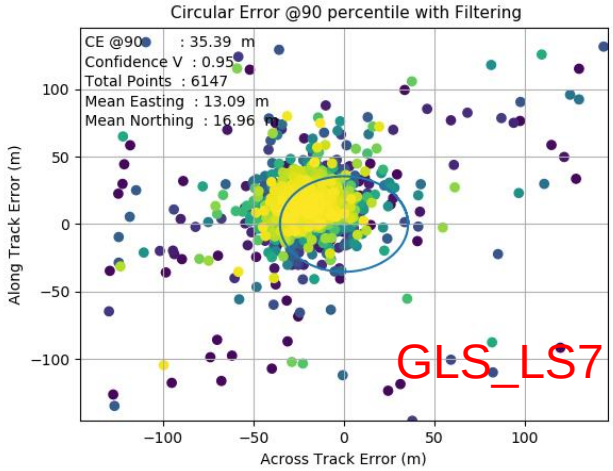
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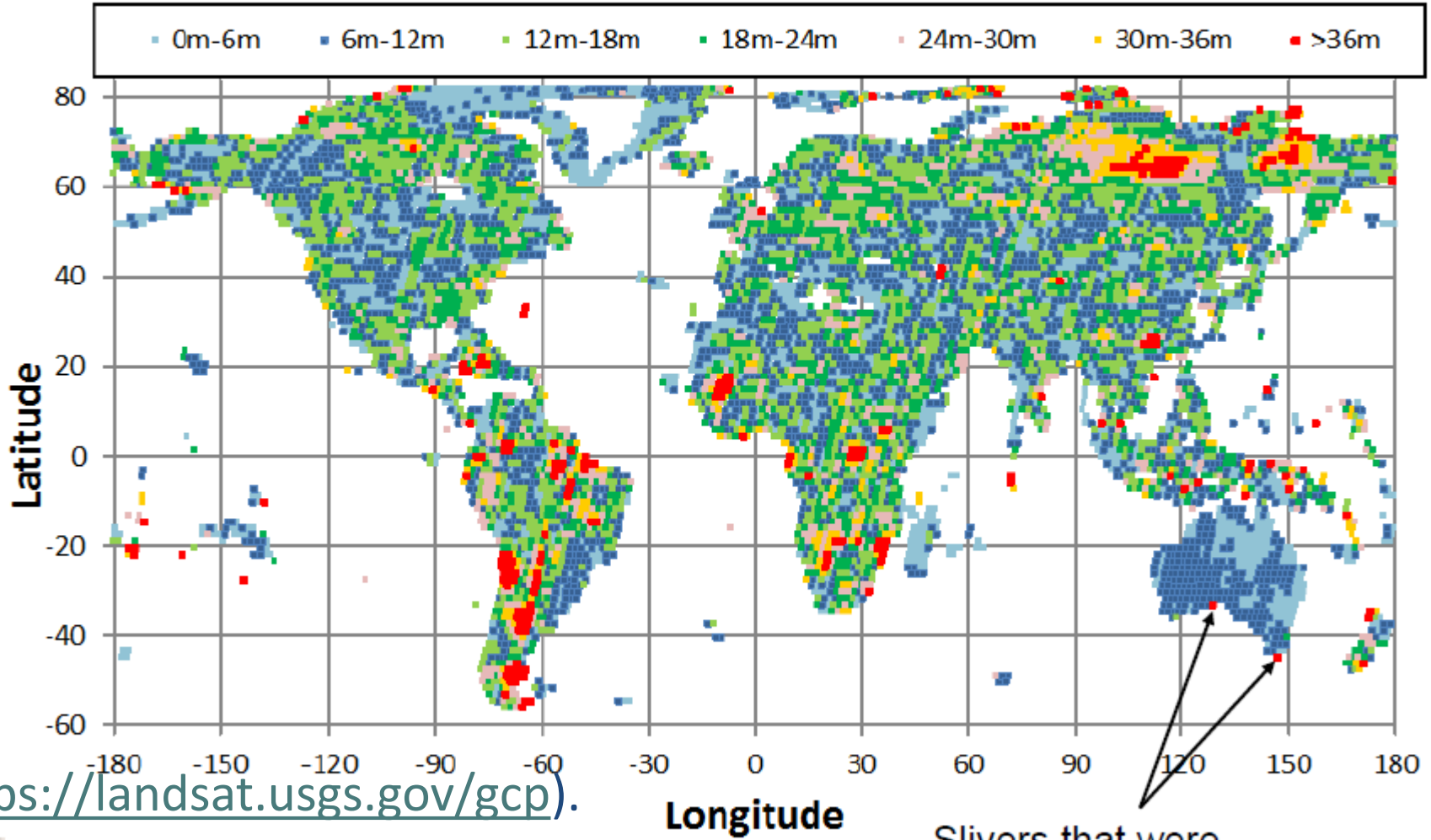
# L8 Estimate of GLS Horizontal Error




https://landsat.usgs.gov/gcp).

USGS

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# Conclusions

- Task 1 EDAP framework for geometric analysis is set up and used in an operational way to assess input missions.
- The reference data are essential
- The proposed QC / Validation methodologies provides consistent accuracy measured,
- It has been shown that the analysis of products for a long term orbit period is usefull.

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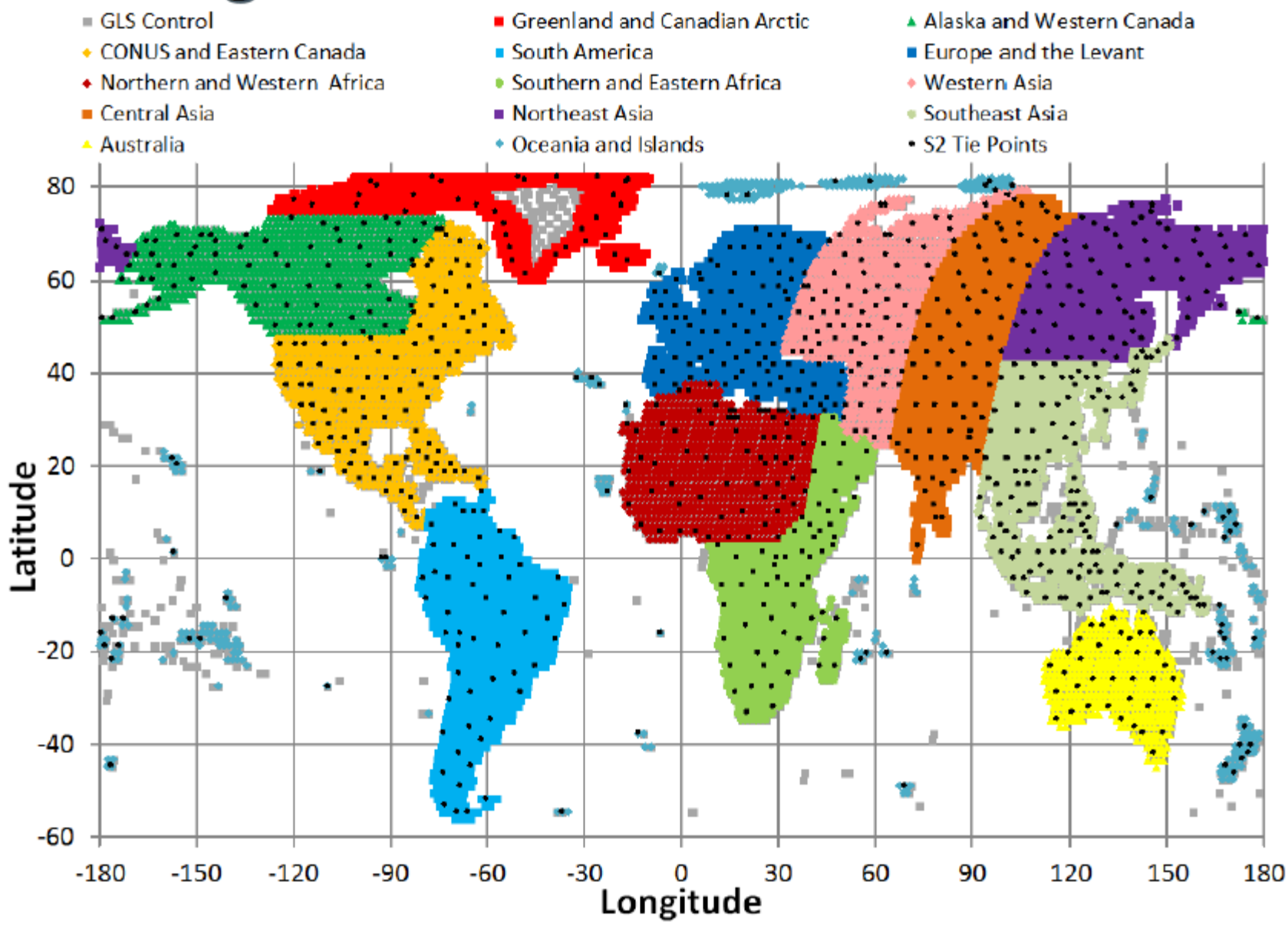
# Triangulation Blocks & S2 Tie Sites



# sured Landsat 8 / Sentinel 2 registration

registration accuracy was measured at 255 sites.

l results before and after L8-only triangulation:

| lock | # Scenes or Blocks | Net RMSEr | 2σ Difference | # Scenes or Blocks Completed | L8 Trig RMSEr | L8 Trig 2σ |
|---|---|---|---|---|---|---|
| tern Canada | 13 | 13.272 | 18.769 | 13 | 10.953 | 15.490 |
| | 10 | 9.900 | 14.000 | 10 | 9.900 | 14.000 |
| | 19 | 19.653 | 27.794 | | | |
| | 16 | 13.787 | 19.498 | 16 | 6.618 | 9.359 |
| Levant | 93 | 15.135 | 21.404 | 93 | 8.682 | 12.279 |
| Canadian Arctic | 8 | 18.692 | 26.435 | 8 | 13.670 | 19.333 |
| | 29 | 16.945 | 23.964 | | | |
| Western Africa | 11 | 14.789 | 20.915 | 11 | 7.361 | 10.411 |
| | 12 | 18.593 | 26.295 | 12 | 7.662 | 10.836 |
| | 8 | 16.080 | 22.741 | | | |
| stern Africa | 15 | 16.369 | 23.150 | 15 | 9.634 | 13.624 |
| | 21 | 12.936 | 18.294 | 21 | 9.102 | 12.872 |
| | **255** | **15.622** | **22.093** | **199** | **9.017** | **12.751** |
| | **12** | **15.744** | **22.265** | **9** | **9.502** | **13.438** |

Outils de recherch

Commentai

Remplir et s

Autres outil

# THANK **YOU**
# FOR YOUR ATTENTION

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