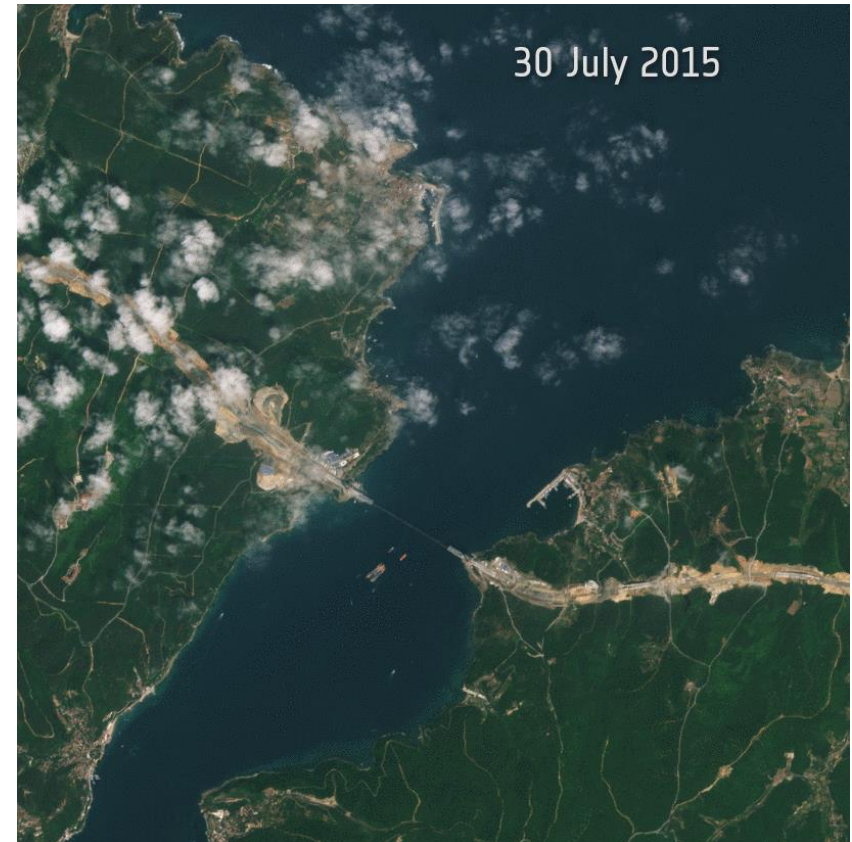


Sentinel-2 Products Data Quality

Ferran Gascon

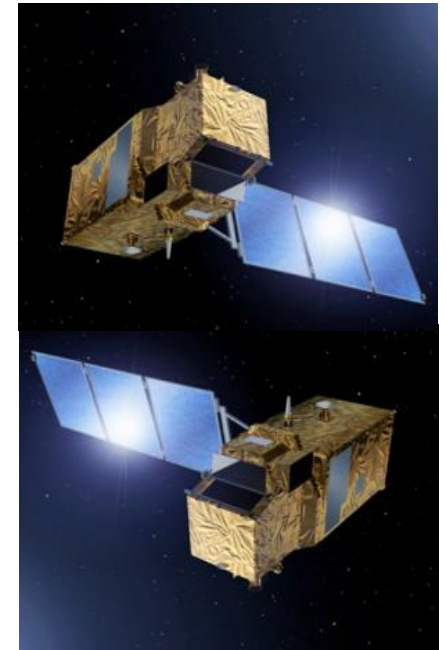
Sentinel-2 Data Quality Manager

Brugge, 08 November 2016



Mission Overview

- **Spacecrafts:** 2 operating in twin configuration
- **Orbit:** Sun-synchronous at 786 km (14+3/10 revs per day), with LTDN 10:30 AM
- **MultiSpectral Instrument (MSI):** operating in pushbroom principle, filter based optical system
- **Spectral bands:** 13 (VIS–NIR–SWIR domains)
- **Spatial resolution:** 10m / 20m / 60m
- **Swath:** 290 km



2015

2020

2030

Sentinel-2 A/B/C/D

Sentinel-2 Second Generation



Sentinel-2 Products

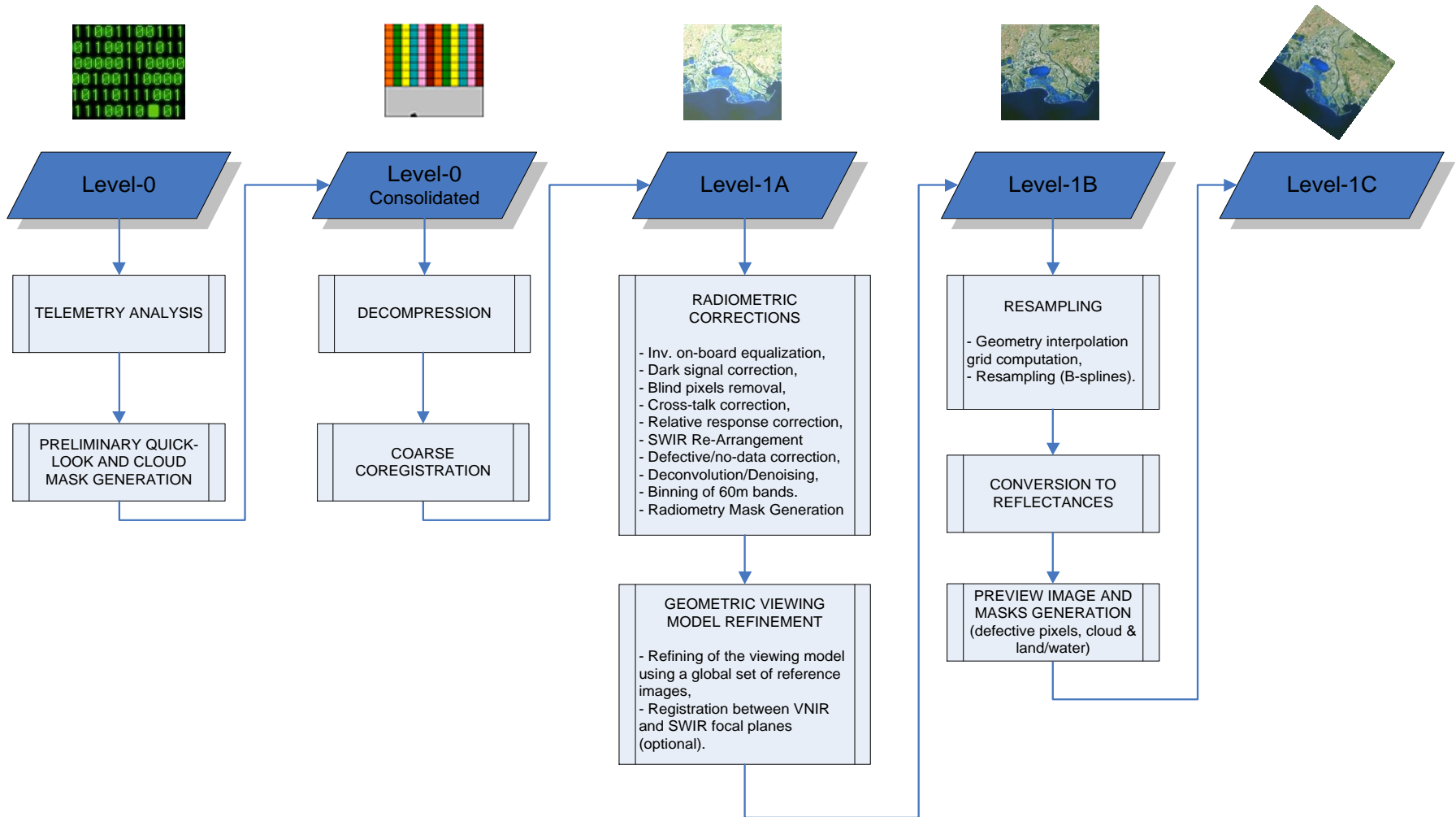


Name	High-level Description	Production	Preservation Strategy	Volume
Level-1B	Top-of-atmosphere radiances in sensor geometry	Systematic	Long-term	~27 MB (each 25x23km ²)
Level-1C	Top-of-atmosphere reflectances in cartographic geometry	Systematic	Long-term	~500 MB (each 100x100km ²)
Level-2A	Bottom-of-atmosphere reflectances in cartographic geometry	On user side* (using Sen2Cor on Sentinel-2 Toolbox**)	N/A	~600 MB (each 100x100km ²)

*: Systematic production of L2A is currently being prepared.

** : <https://sentinels.copernicus.eu/web/sentinel/toolboxes/sentinel-2>

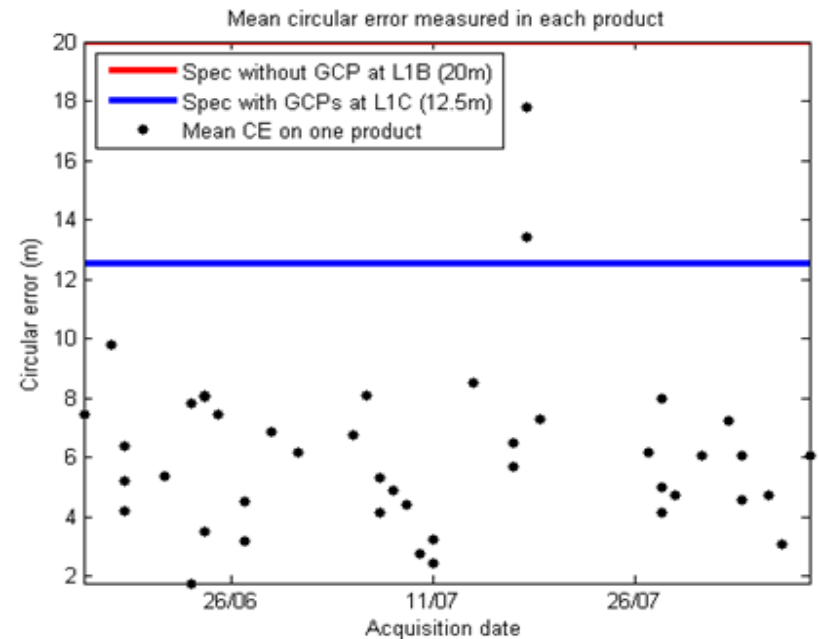
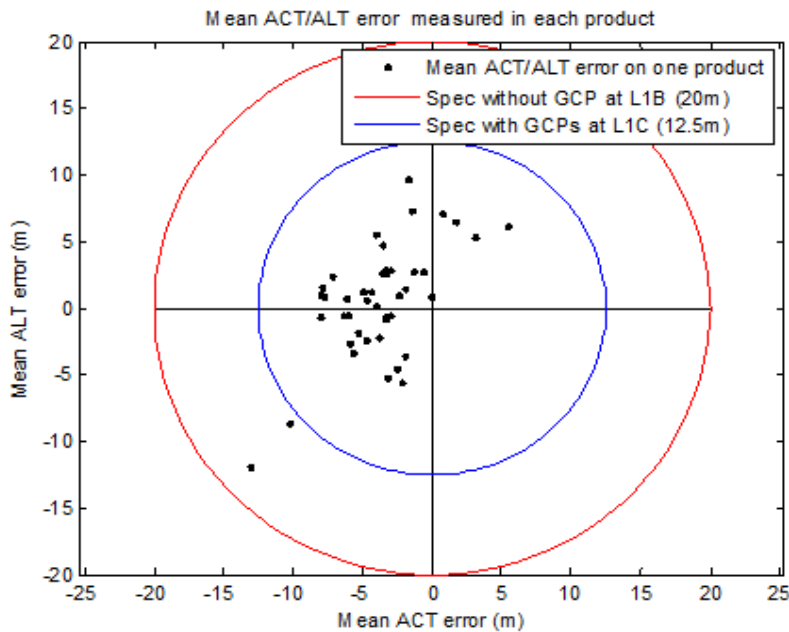
L1 Algorithm



Geolocation

- **Method:** Matching L1 images with perfectly geolocalized reference images (GCPs).
- **Results:** Performance analysed on 43 products including 430 GCPs.

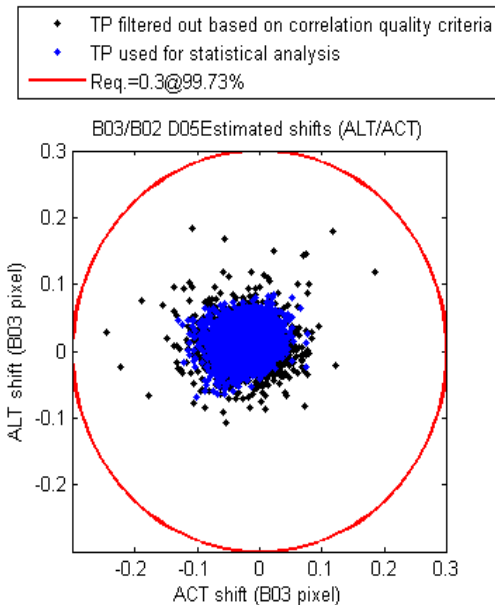
Parameter	Value
Circular error @95.4% over all GCPs	9.2 m



Multi-spectral Registration

- **Method:** Correlation of a large number of tie points between spectral bands couples.
- **Results:**

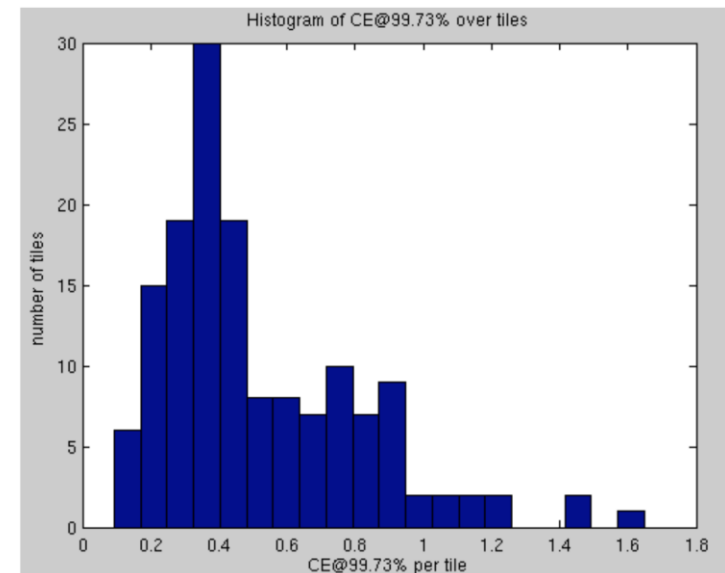
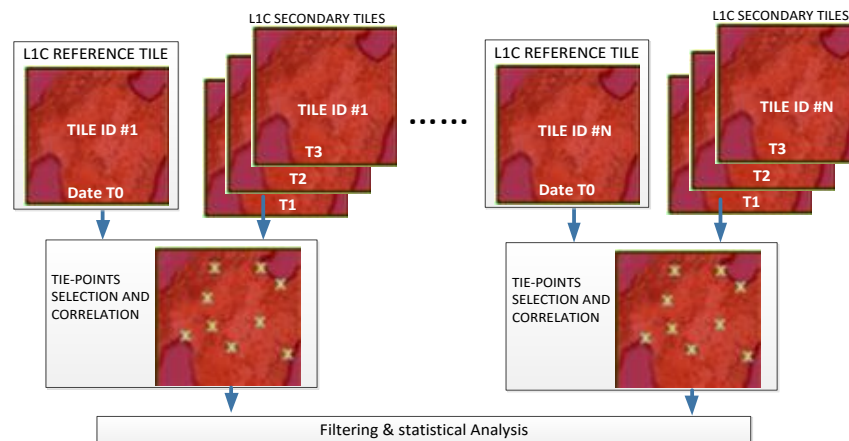
Bref/Bsec - Det	CE@99.73%	Bref/Bsec - Det	CE@99.73%
B04/B03-D01	0.237	B05/B11-D01	0.189
B04/B03-D02	0.214	B05/B11-D02	0.222
B04/B03-D03	0.202	B05/B11-D03	0.181
B04/B03-D04	0.165	B05/B11-D04	0.15
B04/B03-D05	0.182	B05/B11-D05	0.16
B04/B03-D06	0.168	B05/B11-D06	0.147
B04/B03-D07	0.203	B05/B11-D07	0.151
B04/B03-D08	0.162	B05/B11-D08	0.143
B04/B03-D09	0.146	B05/B11-D09	0.127
B04/B03-D10	0.145	B05/B11-D10	0.111
B04/B03-D11	0.135	B05/B11-D11	0.125
B04/B03-D12	0.122	B05/B11-D12	0.113
B11/B12-D01	0.259	B05/B12-D01	0.212
B11/B12-D02	0.292	B05/B12-D02	0.221
B11/B12-D03	0.218	B05/B12-D03	0.178
B11/B12-D04	0.155	B05/B12-D04	0.151
B11/B12-D05	0.182	B05/B12-D05	0.141
B11/B12-D06	0.133	B05/B12-D06	0.121
B11/B12-D07	0.109	B05/B12-D07	0.115
B11/B12-D08	0.121	B05/B12-D08	0.117
B11/B12-D09	0.107	B05/B12-D09	0.113
B11/B12-D10	0.084	B05/B12-D10	0.107
B11/B12-D11	0.114	B05/B12-D11	0.114
B11/B12-D12	0.091	B05/B12-D12	0.096



- ✓ Spatial Registration error is lower than the requirement (0.3 pixel CE @ 99.73% conf. Level) for all measured band couples

Multi-temporal Registration

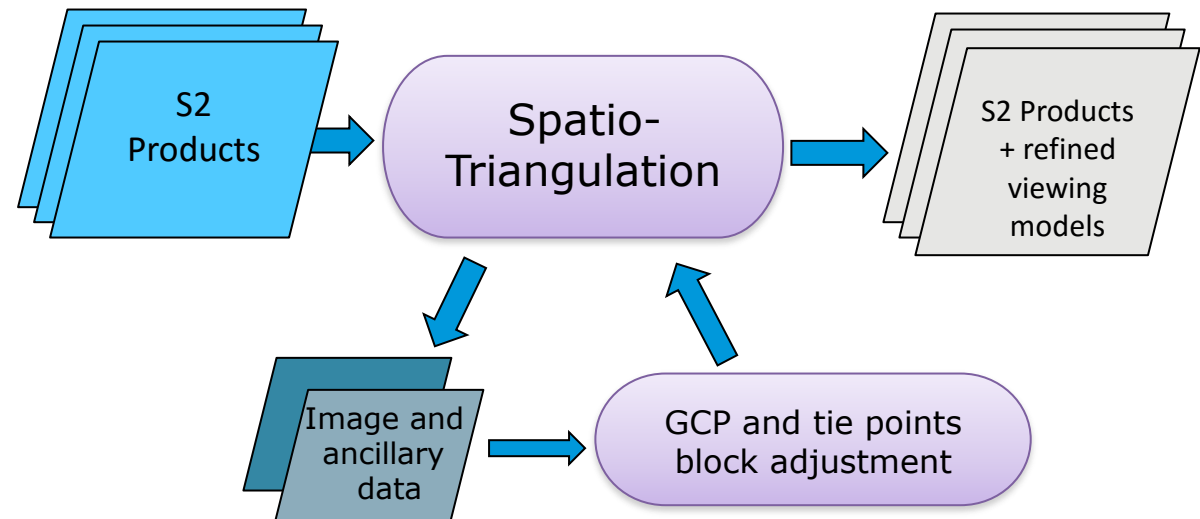
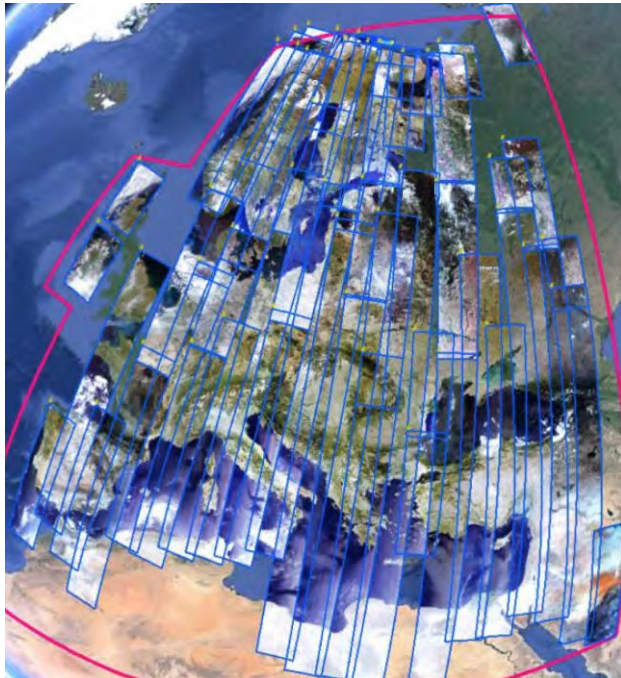
- **Method:** Correlation of L1C tiles acquired with same relative orbits at various dates.
- **Results:** 105 L1C tiles (covering 53 geographic tiles) analyzed over the world without geometric refinement.



- ✓ CE at 95.45% is 1.12 pixel
- ✓ Not yet compliant with requirement (0.3 pixel)
- ✓ Expected to become compliant with the geometric refinement using a Global Reference Image (GRI).

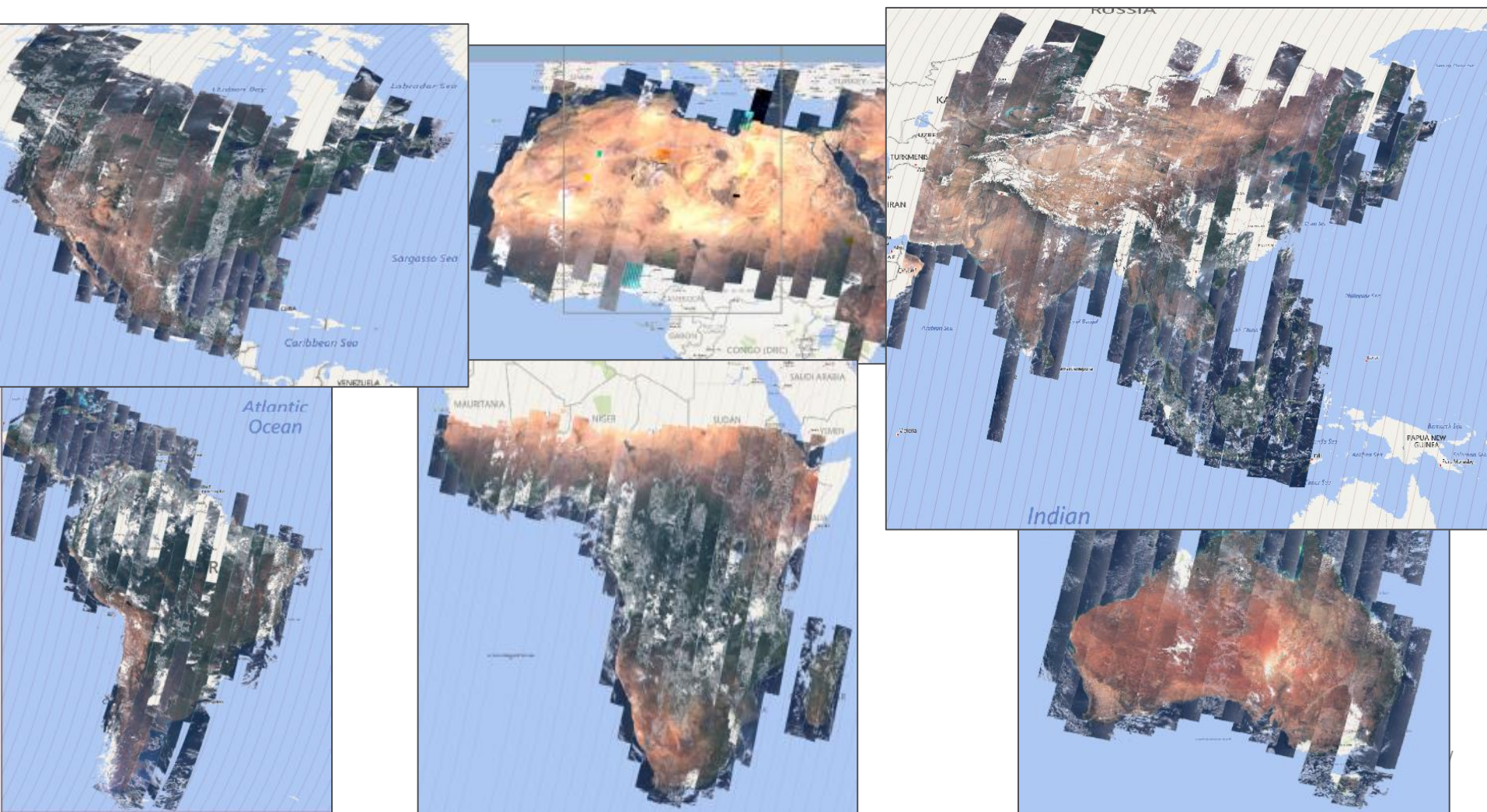
GRI (Global Reference Image)

- **Objective:** To obtain a full repeat cycle dataset of well-localized mono-spectral Level-1B images (band 4) which will be used as reference images in the processing to improve geolocation and multi-temporal registration.
- **Methodology:** Massive spatio-triangulation on large blocks.



GRI Construction Status

- ✓ Worldwide GRI will be completed (including validation) by Q4 2017.



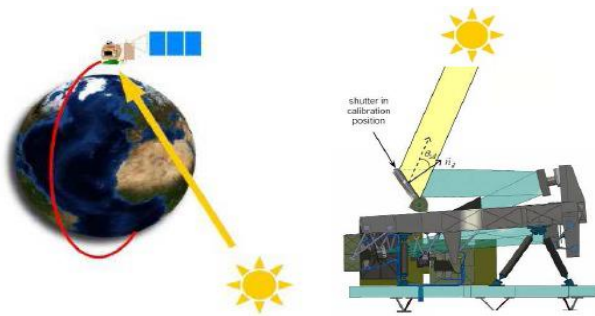
First GRI validation results



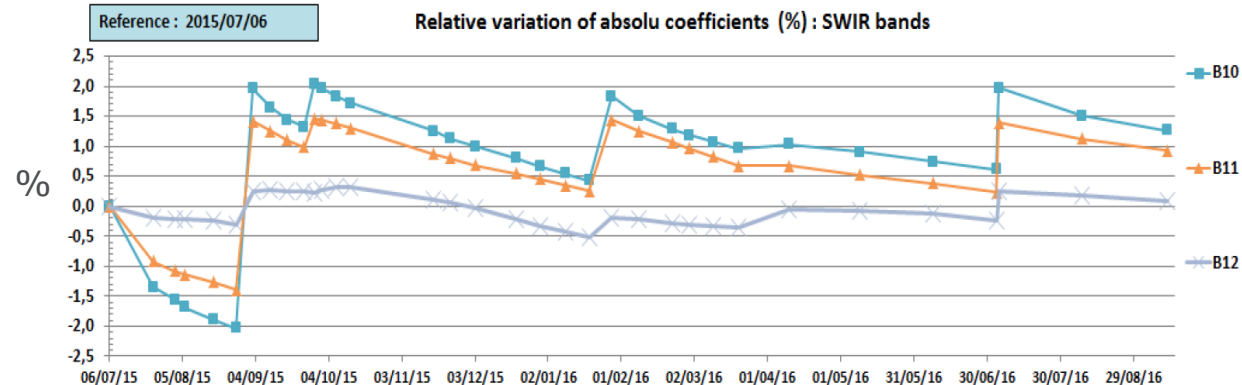
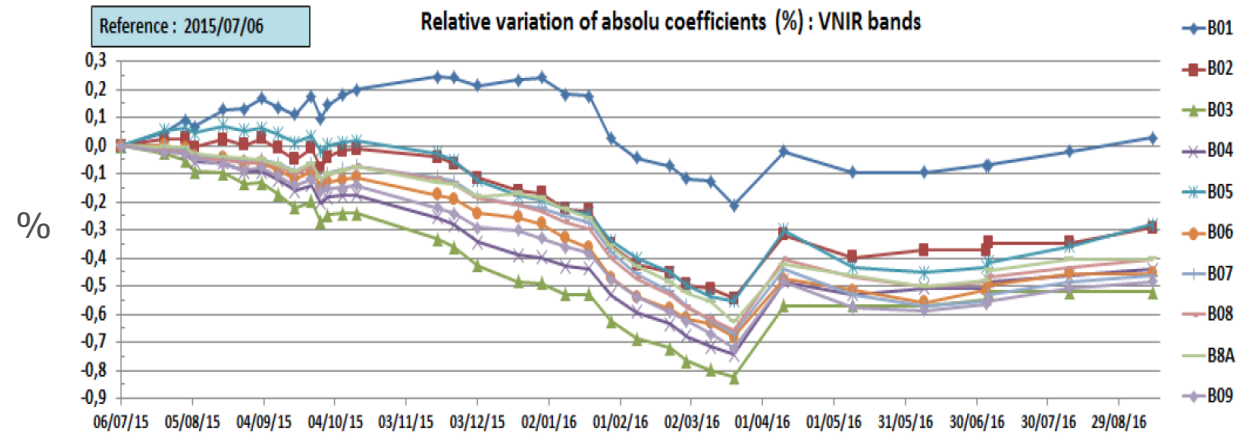
Green <7m **Orange** <10m **Red** >10m

Pre-validation made internally.
Geolocation estimated to 9m CE95

Absolute Radiometry / Calibration Approach

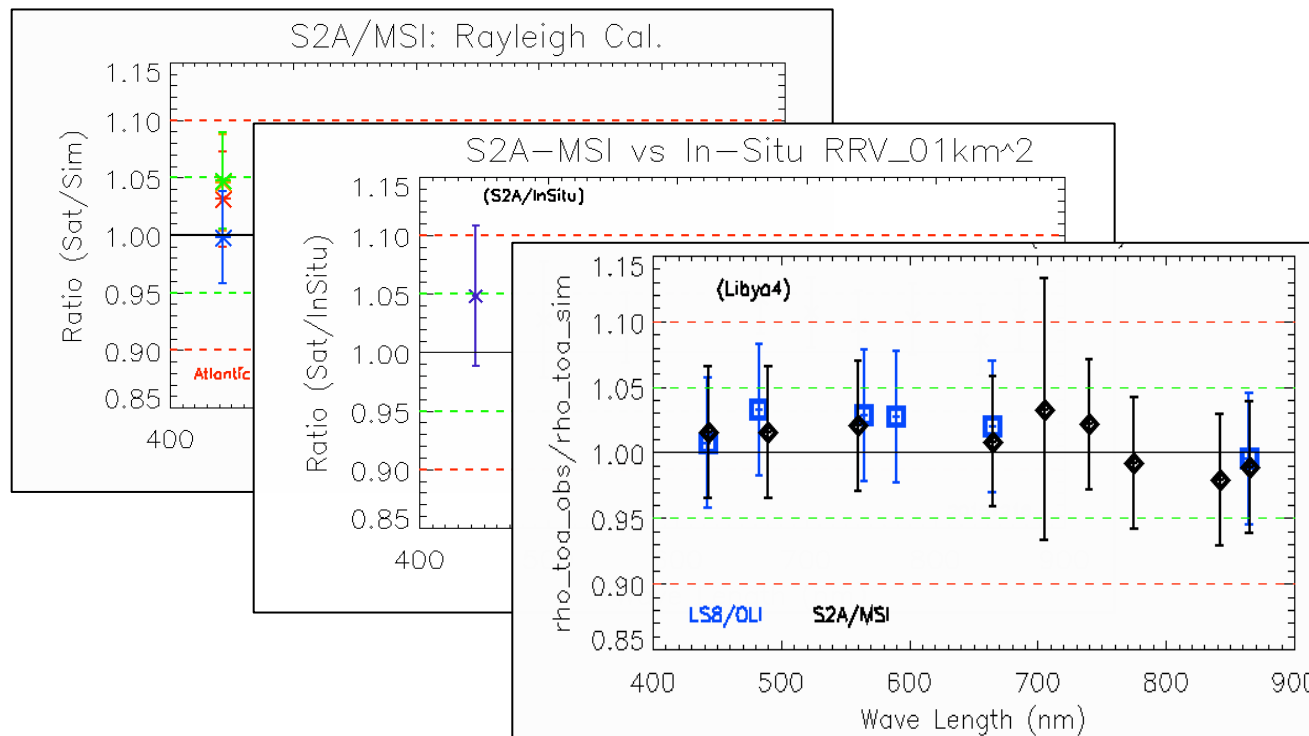


On-board sun diffuser



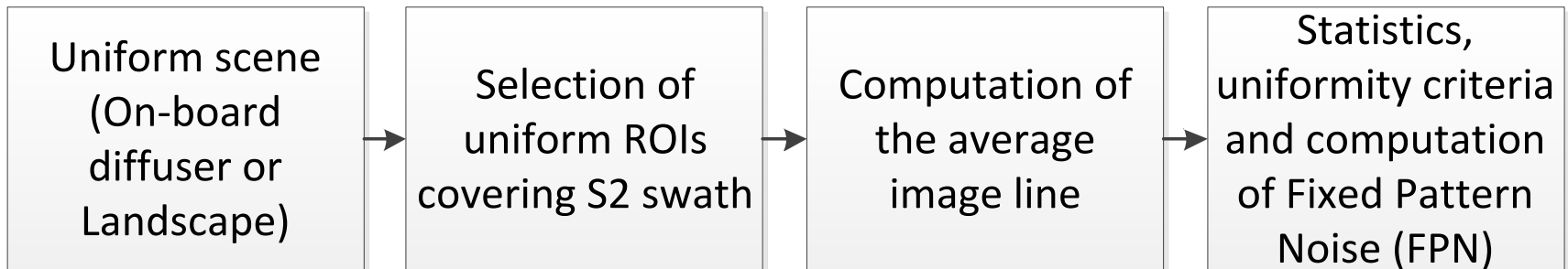
Absolute Radiometry

- Method:** Rayleigh scattering using ocean targets, using ground measurements over RadCalNet sites, and inter-comparison with Landsat-8.
- Results:**



Equalisation

- **Method:** With on-board diffuser after calibration, and vicarious on uniform scenes.

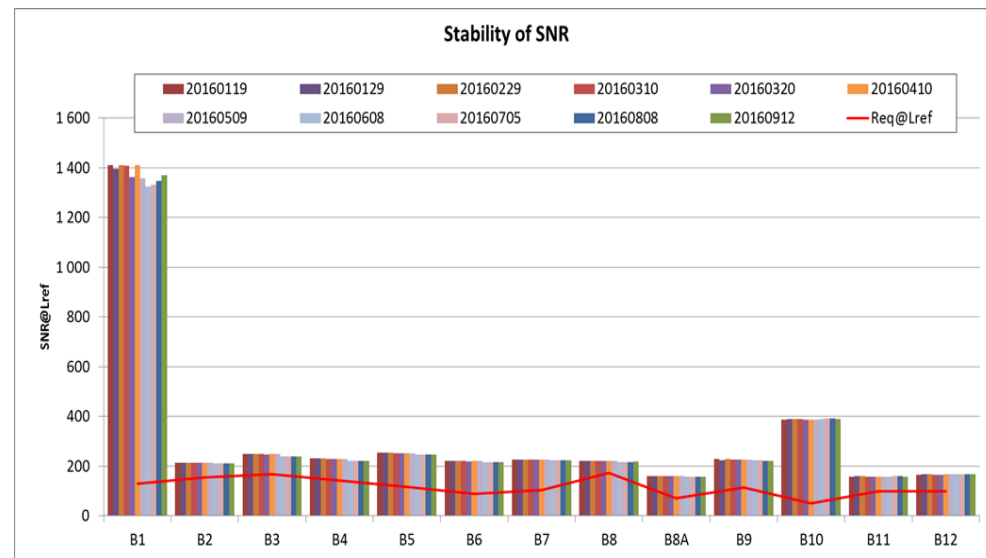


- **Results:** FPN < 0.2 %

SNR (Signal-to-Noise Ratio)

- Method:** Calculation from on-board diffuser, and vicarious approach based on a re-estimation of noise model from a dark image and absolute calibration coefficient measured by vicarious validation activity.
- Results:** SNR performance is well better than requirements for all bands and very stable in time.

Spectral Band	Lref	SNR SPEC @Lref	SNR@Lref	SNR/spec relative diff
B1	129	129	1410.3	993.2%
B2	128	154	214.3	39.2%
B3	128	168	249.0	48.2%
B4	108	142	230.2	62.1%
B5	74.5	117	253.3	116.5%
B6	68	89	220.6	147.9%
B7	67	105	227.1	116.3%
B8	103	174	220.8	26.9%
B8A	52.5	72	160.8	123.3%
B9	9	114	228.9	100.8%
B10	6	50	389.9	679.8%
B11	4	100	159.2	59.2%
B12	1.5	100	217.4	117.4%

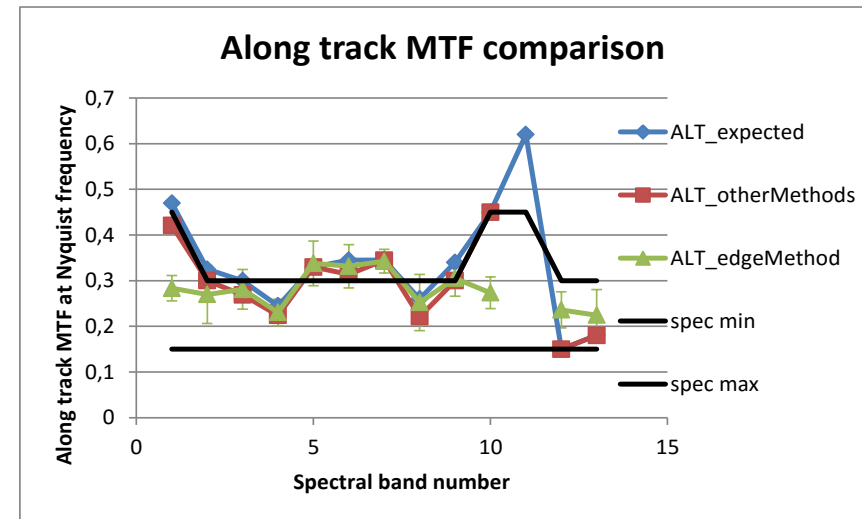
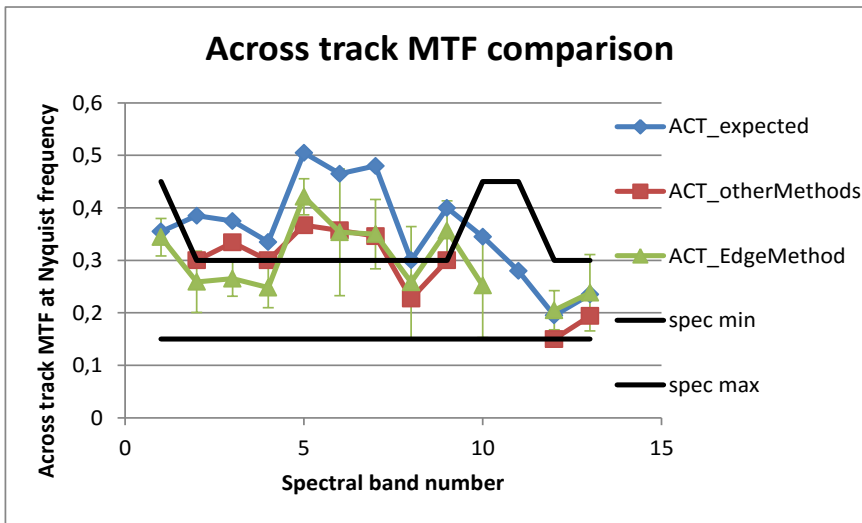


MTF (Modulation Transfer Function)

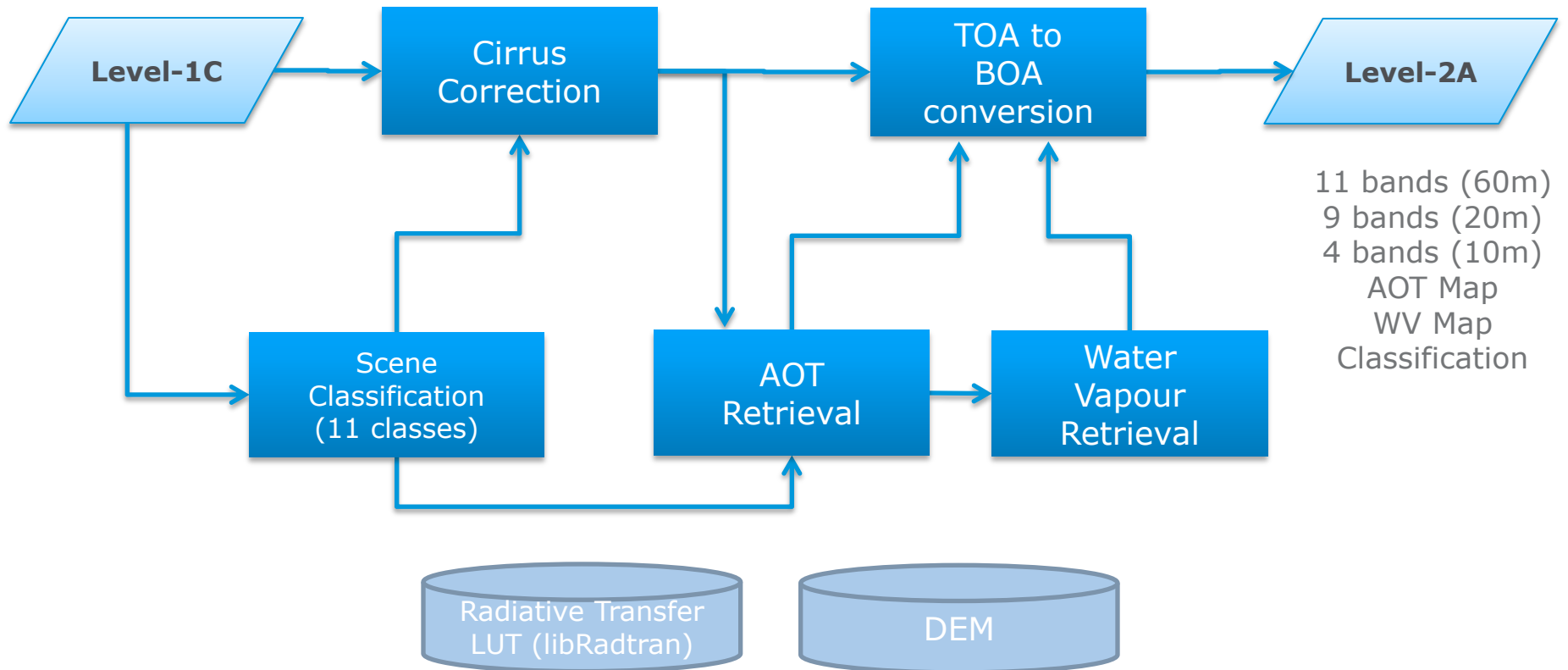
- Method:** Slanted edge (on fields and bridges) and reference image methods.



- Results:**

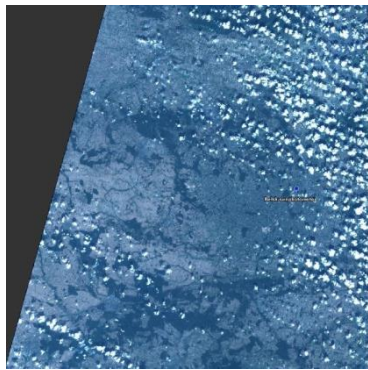


L2A Algorithm

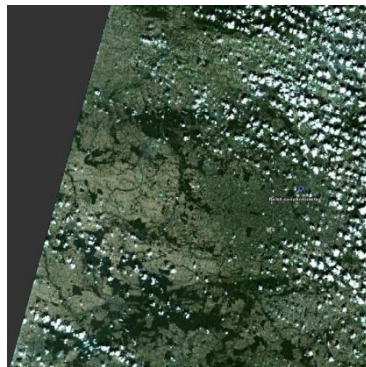


- Level-2A algorithm is implemented in Sen2Cor processor.

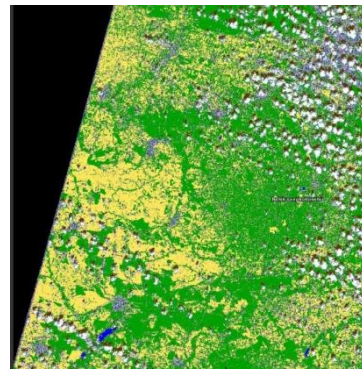
Surface Reflectance



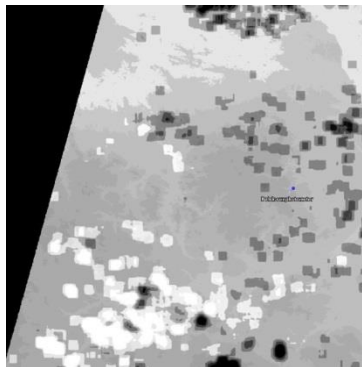
TOA-RGB (L1C-input)



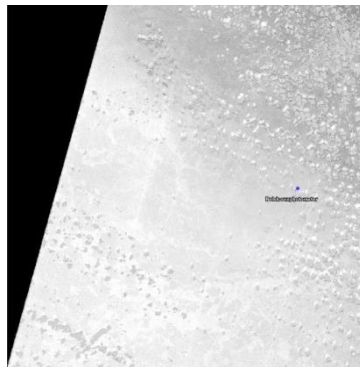
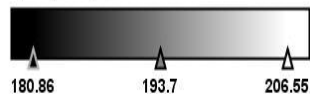
BOA-RGB (L2A-output)



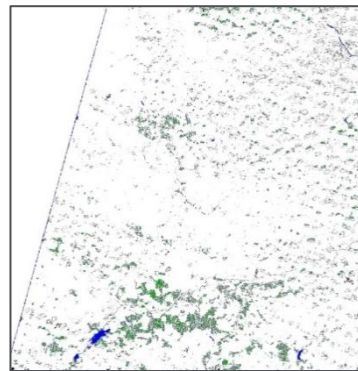
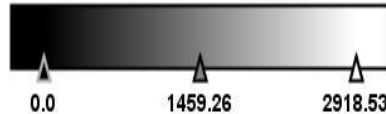
Scene classification



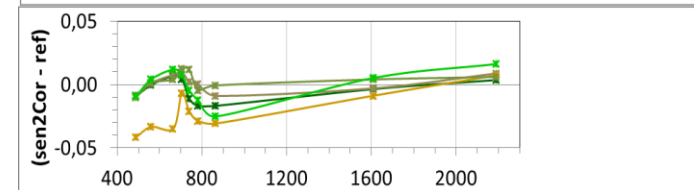
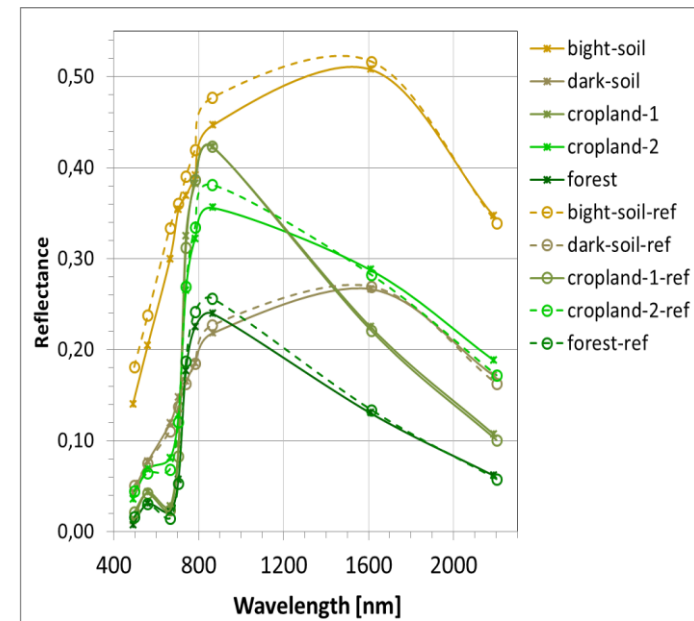
quality_aot [dl]



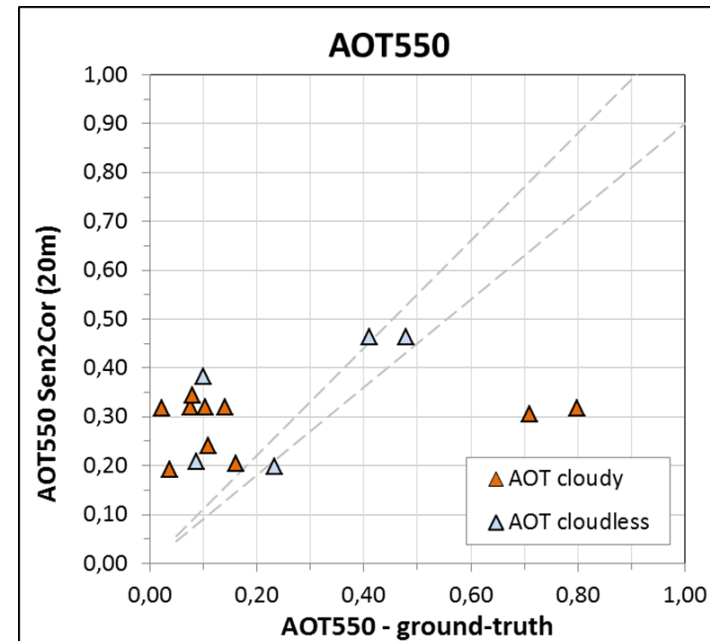
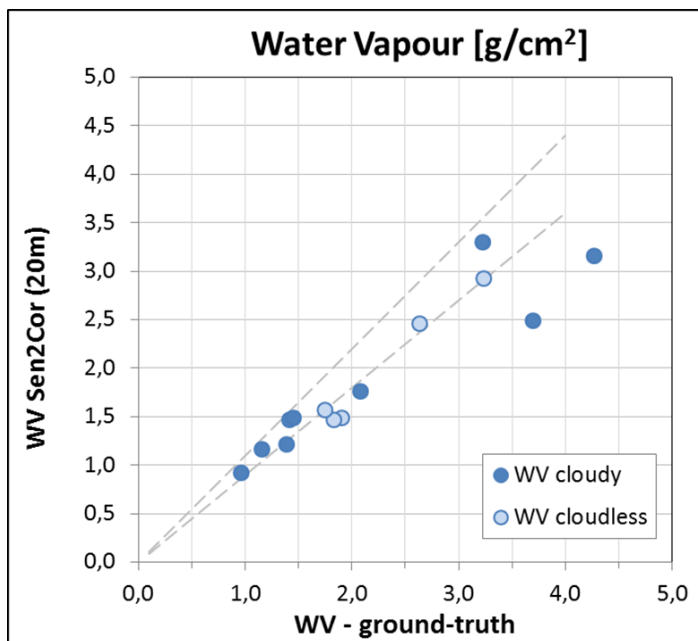
quality_wvp [dl]



DDV (Dense Dark Vegetation)



Surface Reflectance



Processing Baselines and Anomalies



✓ <https://sentinels.copernicus.eu/web/sentinel/missions/sentinel-2/data-quality-report>

Anomaly ID	Baseline number	02.01		02.02	02.03	02.04		
	Deployment date	27/01/2016	31/03/2016	03/05/2016	09/06/2016	15/06/2016	03/08/2016	
	Anomaly title							
4	Instrument Measurement Time MTD		yes					
5	Minimum Reflectance "0"	yes						
6	Detector Footprint at Equator	yes						
7	Missing Physical Gains MTD	yes						
11	Missing Viewing Angles MTD	yes, not systematic						
12	Anomalous Pixels	yes, few products impacted						
15	Strong Misregistration				yes			
16	Stretched 60 m bands	A few orbits impacted						

Not an anomaly!



- Mission Performance Centre (MPC)
 - ✓ Calibration of the MSI sensor and L1/L2A processors
 - ✓ Validation of L1/L2A products
 - ✓ L1 Production Quality Control
 - ✓ L1/L2A processors prototyping/maintenance
- Centre National d'Études Spatiales (CNES)
 - ✓ Support for L1 products validation
 - ✓ Support for GRI validation
- Quality Working Group (QWG)
- Sentinel-2 Validation Team (S2VT)



Data Quality Entities



- Val Support
- ESL L2A
- ESL L1 Val
- ESL L1 Cal
- Operators
- MPC Prime



- ✓ QWG (Quality Working Group) is a forum providing recommendations to ESA on products data quality aspects.

- ✓ Participants include Copernicus Services, EC and ESA representatives:
 - ✧ **Land Monitoring:** Dufourmont (EEA), Wijesingha (EEA), Strobl (JRC), Soille (JRC), Cherlet (JRC), Szantoi (JRC), Lacaze (Hygeos)
 - ✧ **Emergency Management:** Kucera (JRC), Wania (JRC), Spruyt (JRC), Broglia (JRC)
 - ✧ **Marine Environment Monitoring:** Bahurel (Mercator Ocean)
 - ✧ **Security:** Joyanes (Satcen)
 - ✧ **EC DG Grow:** Bamps, Bydekerke

- ✓ S2VT is an open forum to gather feed-back on S2 products, algorithms and cal/val activities.

- ✓ First S2VT (Sentinel-2 Validation Team) on 28-29 November 2016
 - ✓ <http://esaconferencebureau.com/2016-events/16c20/home>

