

Sentinel-2 Calibration and Validation : from the Instrument to Level 2 Products

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Outline

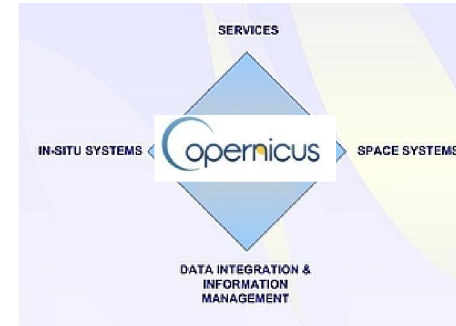
- Sentinel-2 mission, project status and products
- Radiometric calibration
 - Requirements
 - Sun diffuser calibration
 - Vicarious calibration
 - In-situ calibration
- Geometric calibration
- Level-2 validation

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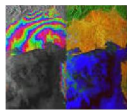
SENTINEL-2 mission

- Copernicus, ex “Global Monitoring for Environment and Security” (GMES) programme.



Sentinel family :

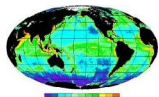
Information services to the European Union and its Member States



Sentinel-1 — radar-imaging mission for land and ocean services



Sentinel-2 — high-resolution and optical imaging mission for land services



Sentinel-3 — global ocean and land monitoring mission



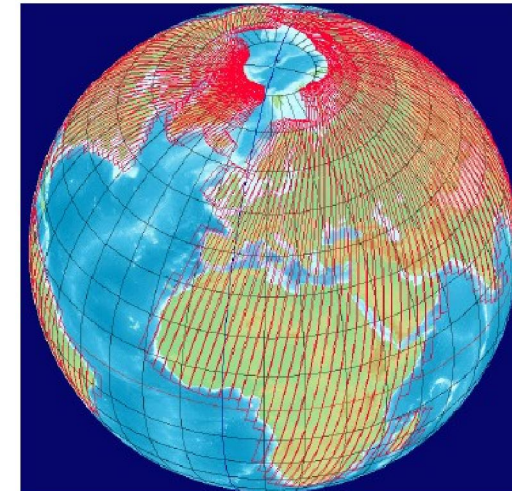
Sentinel-4 — geostationary atmospheric monitoring mission

Sentinel-5 — low-orbiting atmospheric monitoring mission

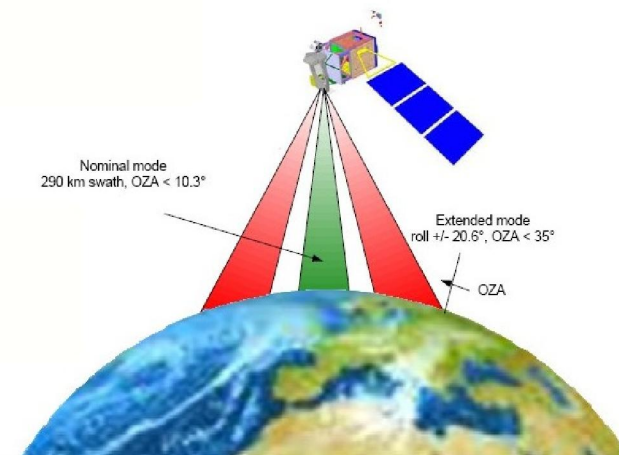


- Main features:
 - Spatial resolution: 10m, 20m, 60m
 - 13 spectral bands: VNIR & SWIR (443nm – 2190nm)
 - 5 days revisit with 2 satellites under the same viewing conditions
 - Global coverage of land surfaces (56°S to 84°N)
 - Swath: 290km

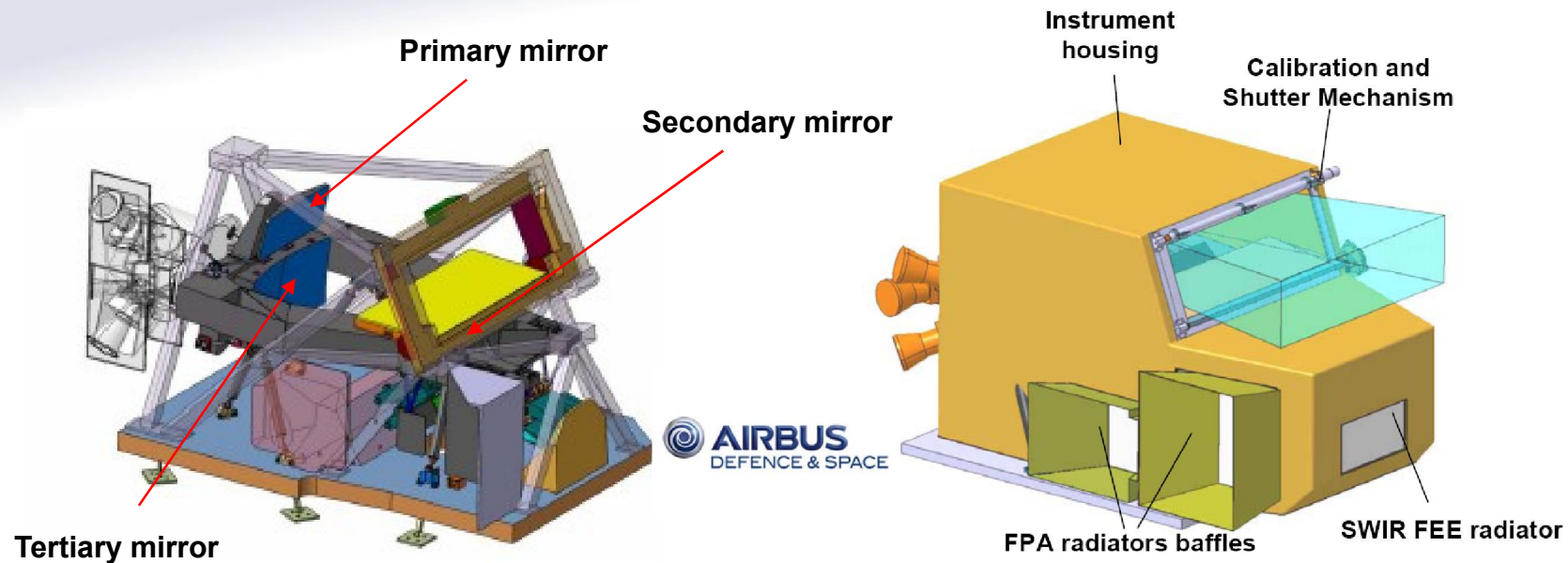
- Mission implementation:
 - Near polar sun synchronous orbit (inclination=98.5°)
 - Cycle: 14.3 orbits/day
 - Equator crossing time: 10.30 am
 - Altitude: 786km
 - Extended mode: roll $\pm 20.6^\circ$, OZA < 35°
 - Lifetime: 7 years (propellant sized for 12 years)



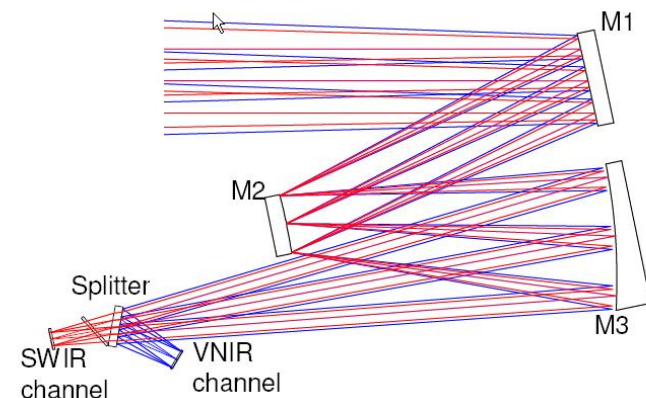
Sentinel-2 ground tracks



Multi Spectral Instrument (MSI)



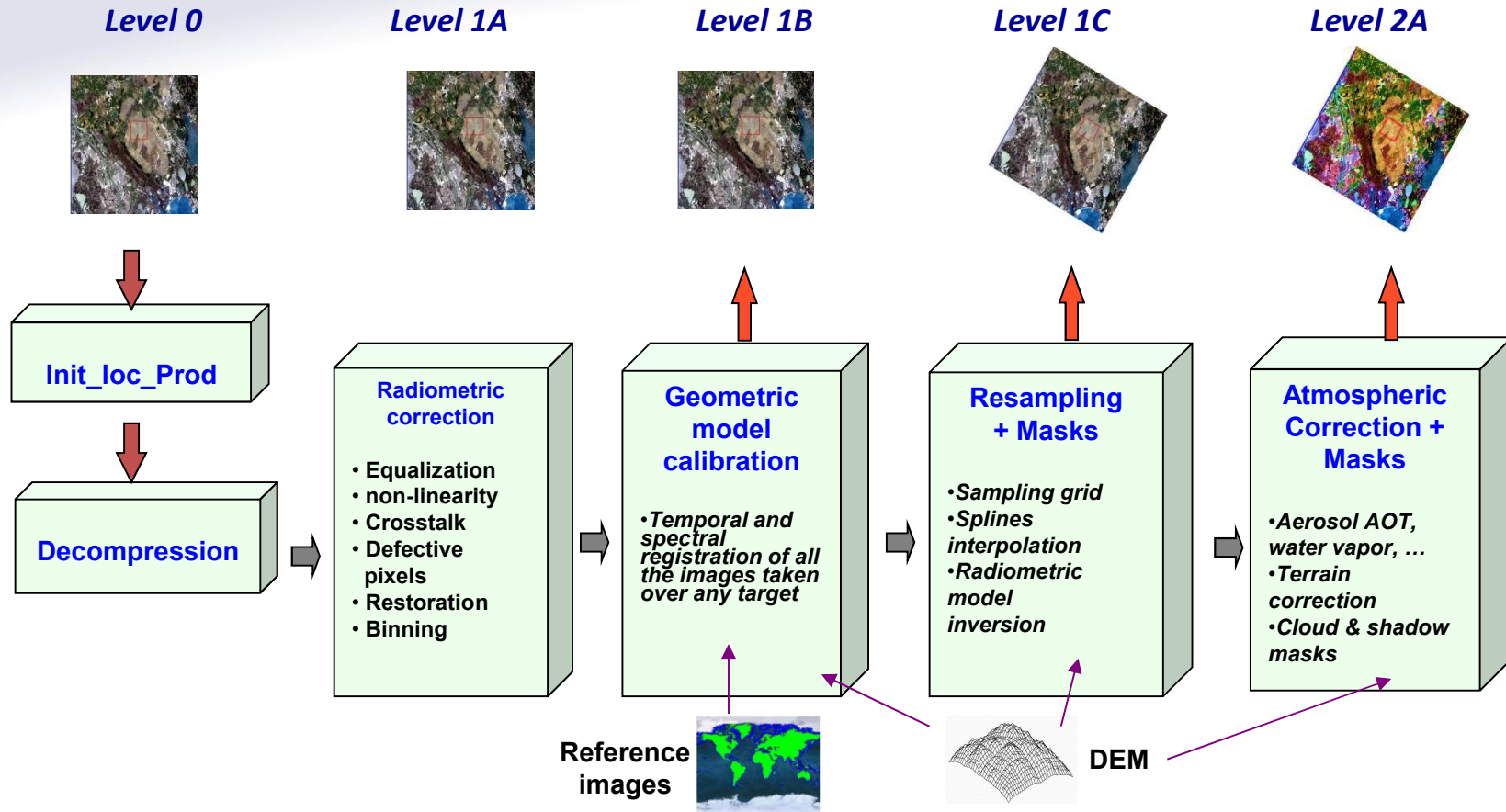
- ❑ Telescope: TMA (Tri Mirror Anastigmat)
- ❑ Push-broom imager
- ❑ Pupil: 150mm
- ❑ Focal length: 0.598m
- ❑ FOV: 20.6°
- ❑ Focal plane array:
 - ❑ Si CMOS VNIR detectors
 - ❑ HgCdTe SWIR detectors (passively cooled)
- ❑ Radiometric resolution: 12 bits

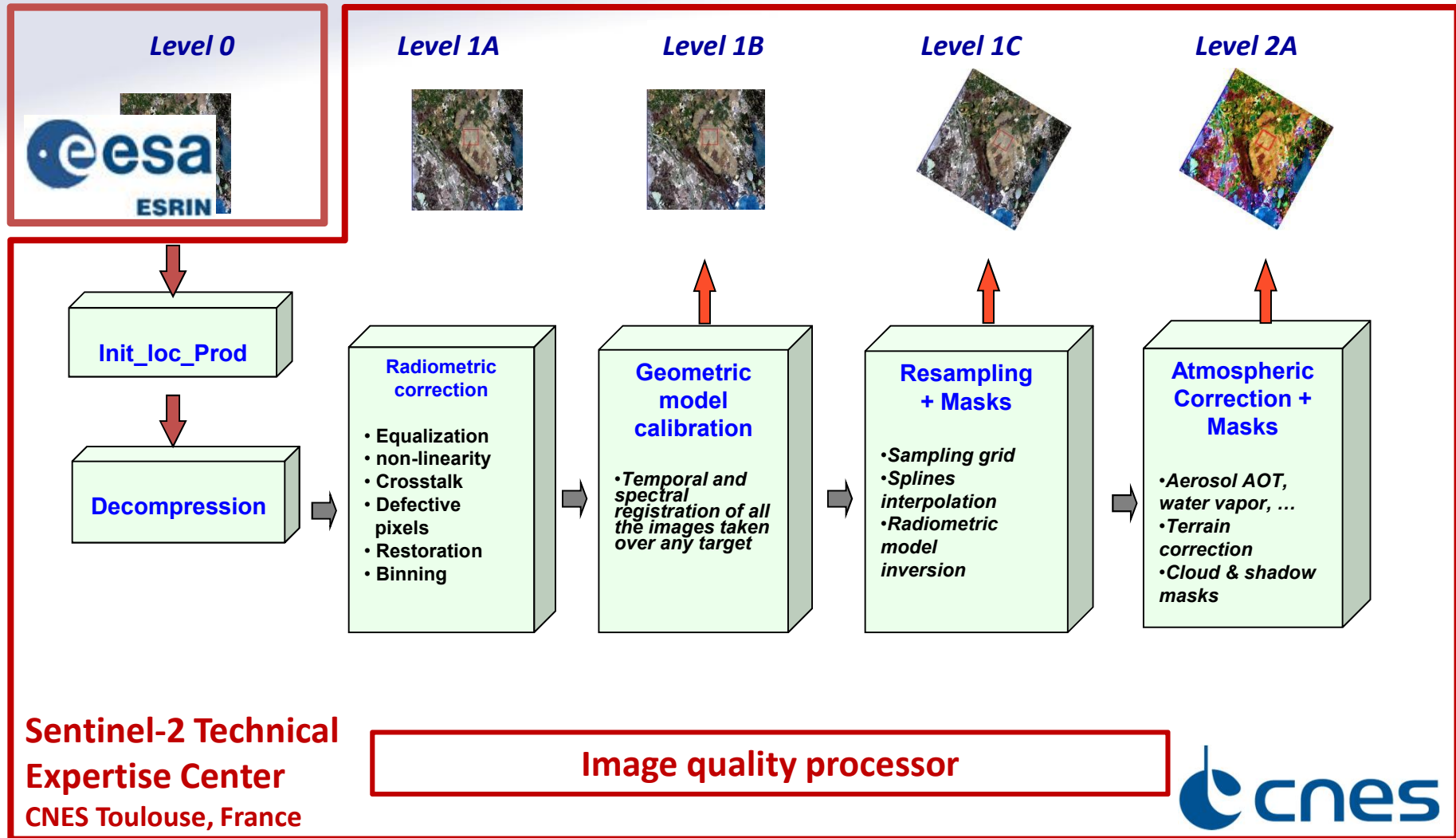


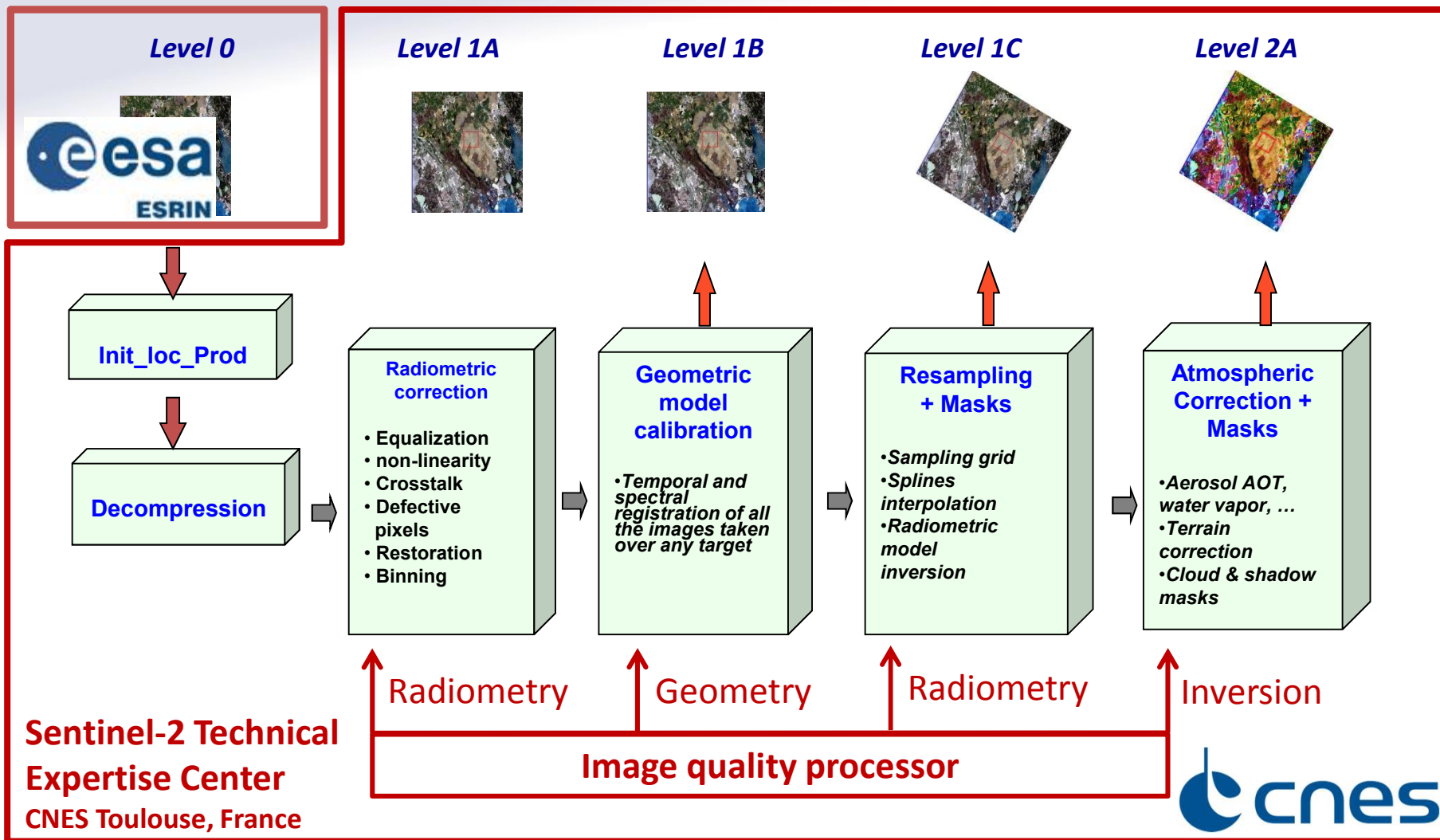
SENTINEL-2 Project

- Project organisation
 - European commission Copernicus programme
 - ESA/ESTEC : space segment
 - Prime contractor : Airbus Defense and Space 
 - ESA/ESRIN : ground segment & data distribution
 - CNES supports ESA on mission performances through the development of :
 - Image Simulation and Analysis Tool
 - Ground Processing Prototype
 - Sentinel-2 Technical Expertise Center (calibration + level-2)

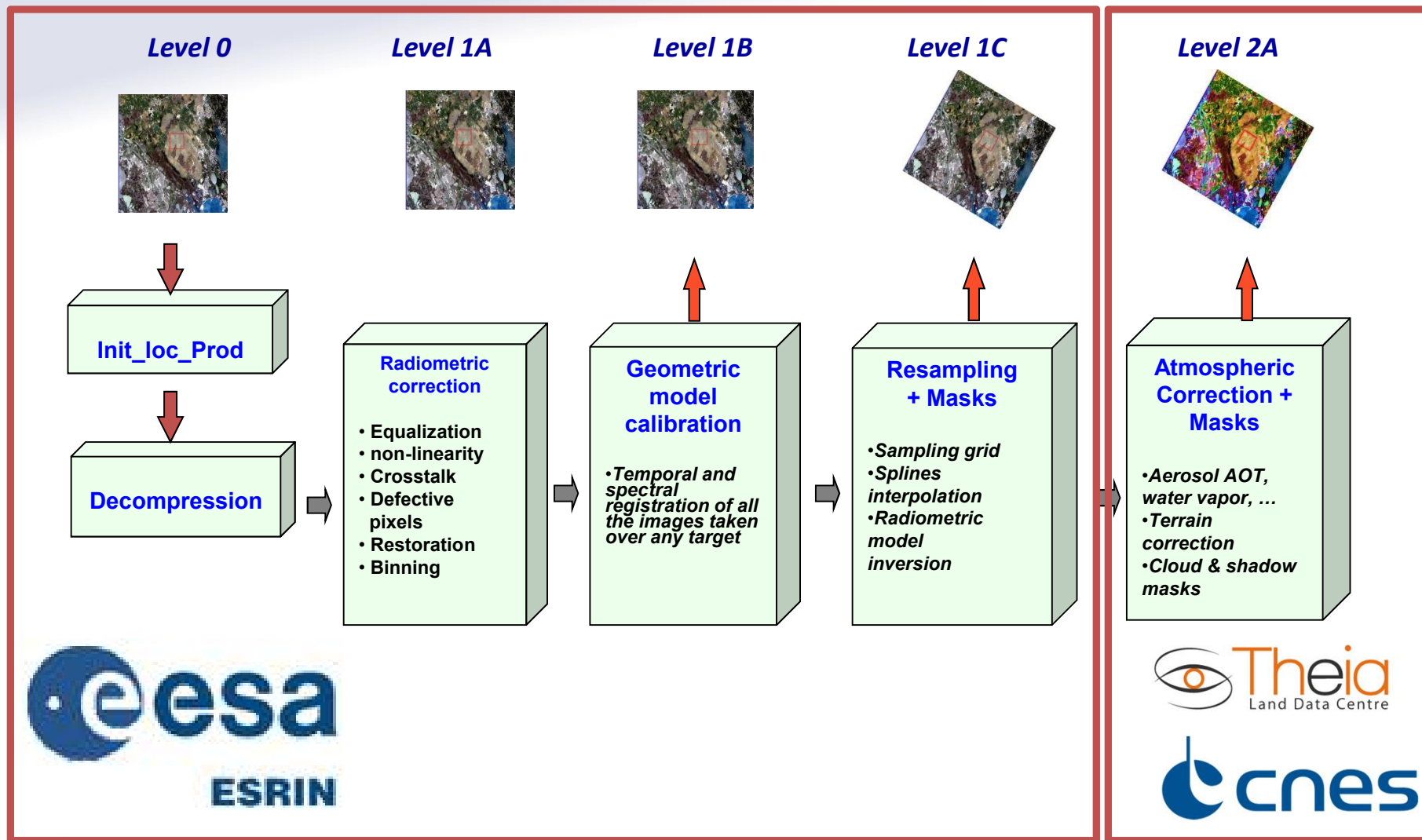
- Project status
 - All MSI performance & qualification tests were successfully completed in April 2014 by AirbusDS France
 - Instrument under integration on platform
 - Launch readiness : 30/04/2015







COMMISSIONNING



ROUTINE

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- Sentinel-2 mission, project status and products
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 - **Requirements**
 - Sun diffuser calibration
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Radiometric requirements

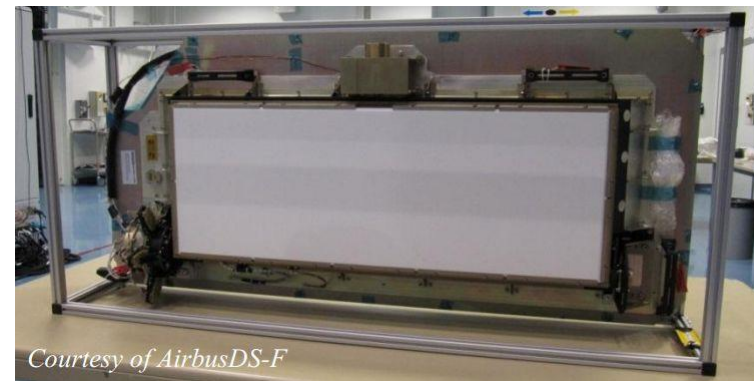
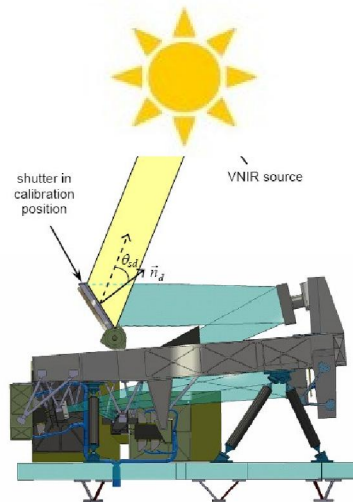
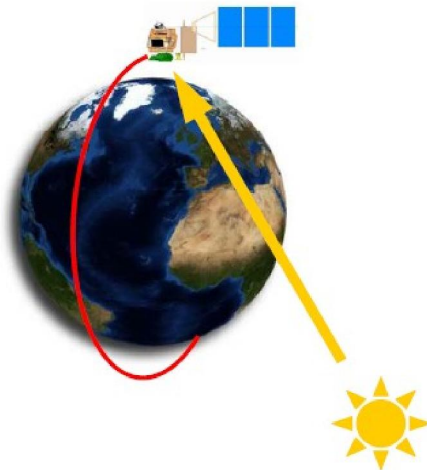
□ Radiometry

- Absolute 3 (5) %
- Cross-band 3 (5) %
- Multi-temporal 1%
- Cross satellite 3%
- Stability 0.5% over the day part of the orbit

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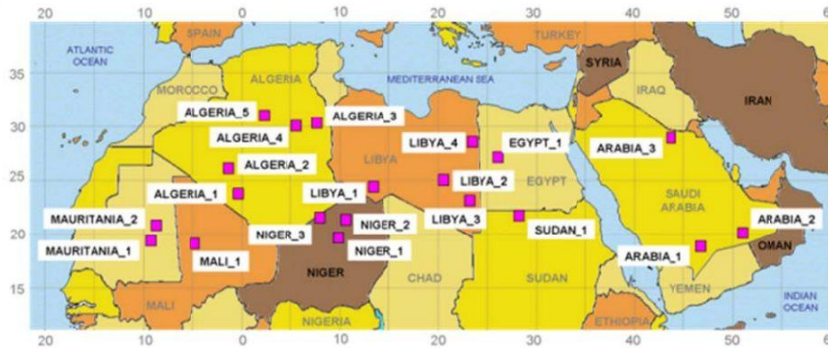
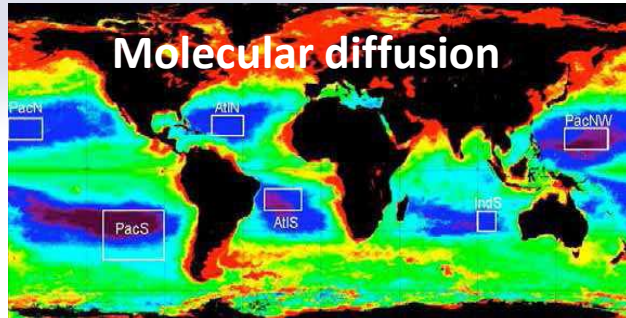
- Diffuser lighting the complete FOV
 - > 700 x 250 mm² ensuring calibration of each pixel into the FoV
 - Non uniformity calibration (non-linearity)
 - Absolute calibration over the sun
 - all bands
 - ~ weekly



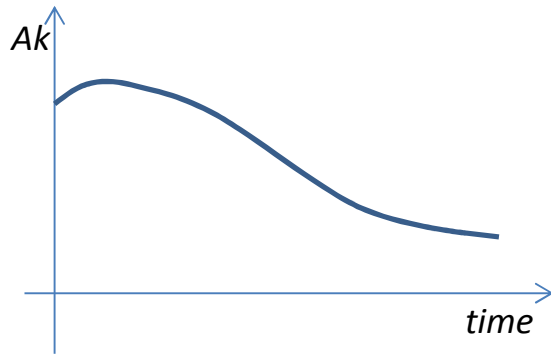
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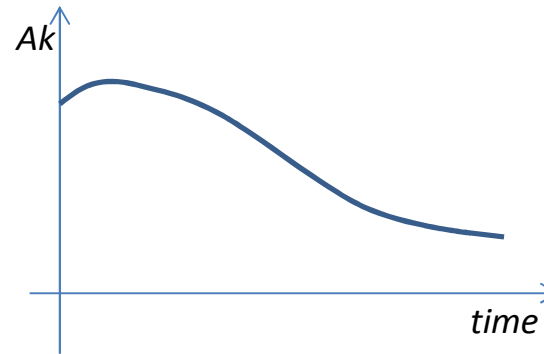
Radiometric calibration : Vicarious



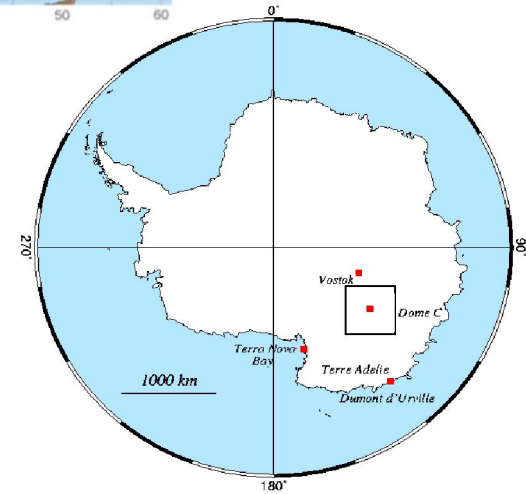
PICS :
Deserts
& Dome



Absolute calibration (for short wavelengths B1–B4)



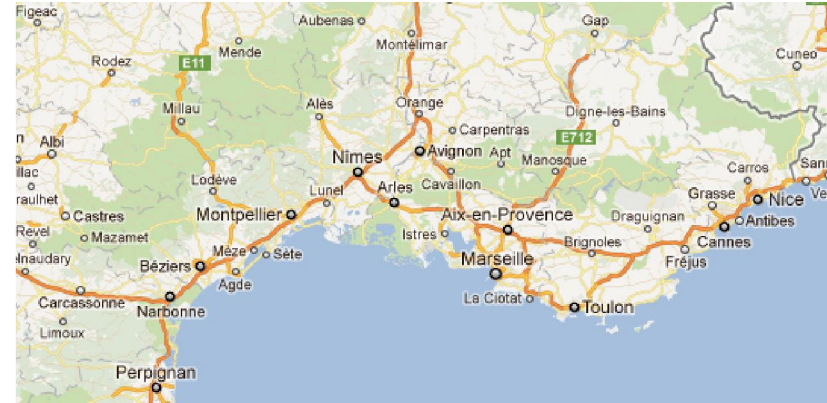
Temporal evolution + intercalibration (all bands)



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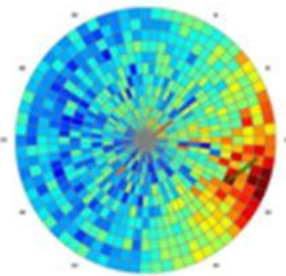
Radiometric calibration : in –situ calibration using LACRAU robotic station (ROSAS)



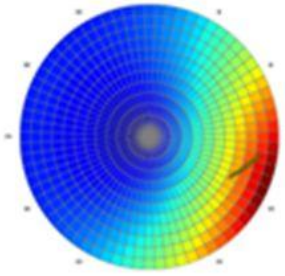
- 380 - 1650nm (9=>12 bands)
- Ground + atmosphere characterisation

Proc. SPIE 8153, Earth Observing Systems XVI, 815311, 2011

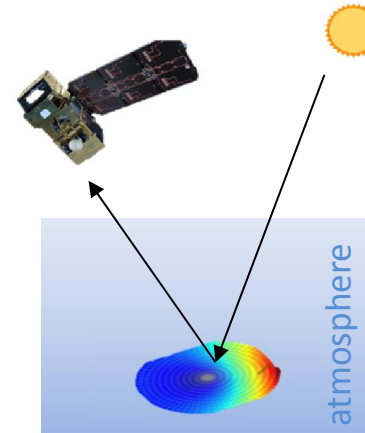
Measured ground reflectance



Modelled ground reflectance



Simulated TOA reflectance

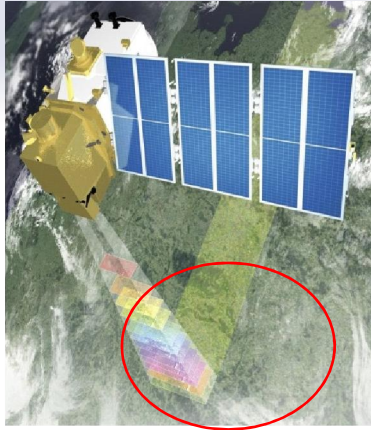


- Simulated TOA reflectance ↔ Sensor TOA reflectance
- **Absolute calibration (all bands except B9, B10 & B12)**
- 10 days revisit
- RadCalNet (ESA-CNES site under selection)

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GEOMETRIC Calibration



□ Geometric performances

- Pointing accuracy: 2km (3σ)
- Geo-location
 - 20m (2σ) without GCP
 - **12.5m (2σ) with GCP**
- Multi-spectral registration 0.3 pixels (3σ)
- Multi-temporal registration **0.3 pixels (2σ)**

□ Geometric calibrations during IOT

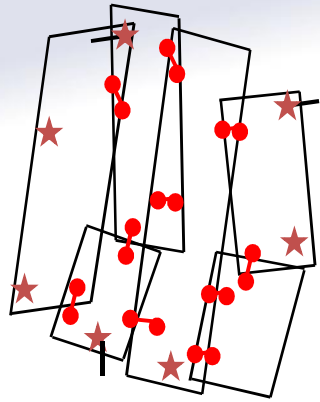
- Geometric biases computation using ground control points



□ Focal plane cartography :

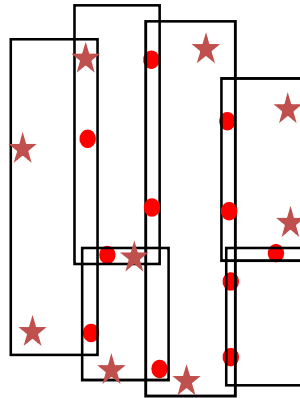
- Absolute lines of sight calibration using supersites
- Relative lines of sight calibration

GEOMETRIC Calibration



★ GCPS
● Tie points

Raw geolocation
before
spatiotriangulation

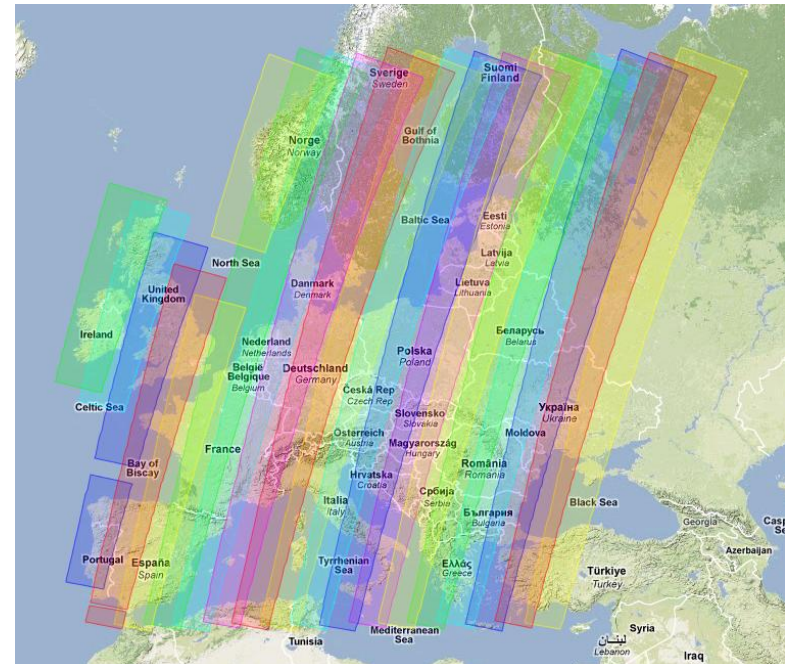


Adjustment of
geolocation

□ Geometric Reference Image

Sentinel2 segments,
adjusted by spatiotriangulation

- Any L1 production includes a geometric refining over this reference
- Ensures the multi-temporal registration of S2 products



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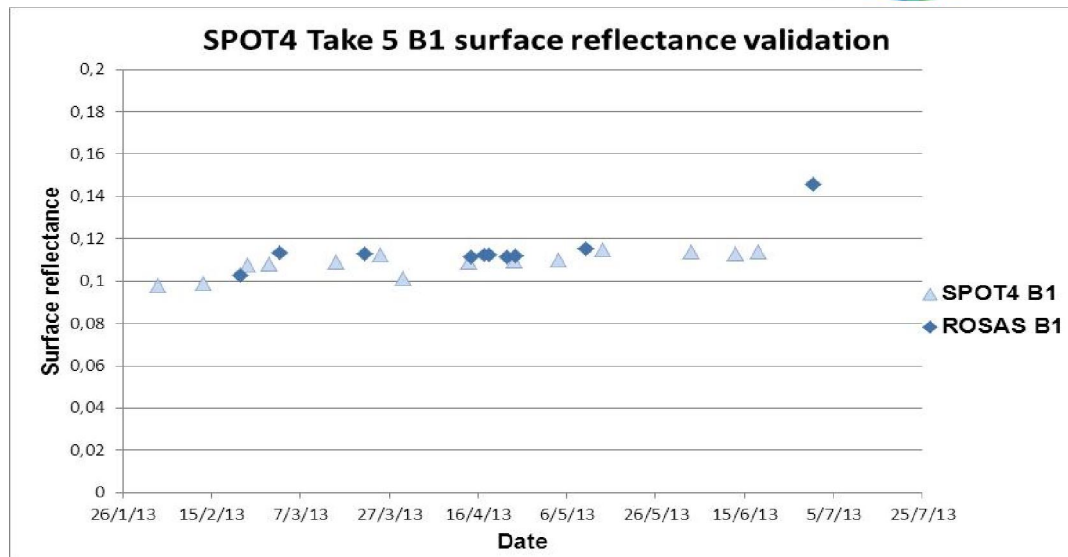
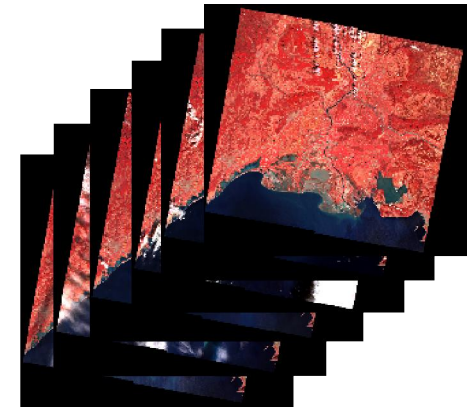
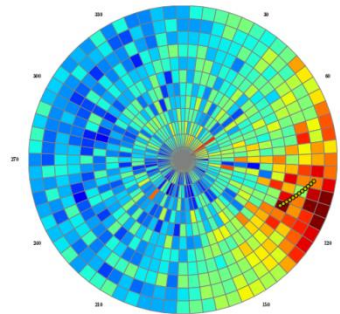
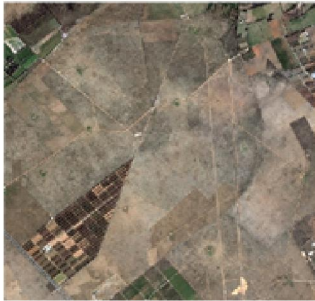
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L2 validation

Level 2 = Level 1 + inversion
=> « Level 2 validation » is a combined validation of the level-1 product and the atmospheric correction

- **Field campaign**
 - 1 campaign planned during commissioning
 - Reflectance
 - AOT
- **Point station**
 - AOT with AERONET (many)
 - Reflectance (few)
 - ROSAS (SPOT4 / Take5)
 - RadCalNet
- **Product intercomparison**
 - BDRF / timing effects to be taken into account
 - Under study

Exemple de BOA reflectance validation using LACRAU robotic station ROSAS on SPOT4/Take5 data



~ 5% en B1, B2, B4
~ 7-8% en B3

Conclusion

- Complete radiometric calibration scheme
 - On-board diffuser
 - Vicarious calibration
 - In-situ (TOA – BOA)
- L1 & L2 validation synergy
- Hopefully, Sentinel-2 first light before next CALCON

