Cal / Val / DataQC Activities – DESIS, EnMAP, TIMELINE and CCVS

DLR – EOC Earth Observation Center

M. Bachmann, E. Carmona, K. Alonso, R. de los Reyes, R. Müller, T. Storch, P. Reiners and many others from the DESIS and EnMAP GS

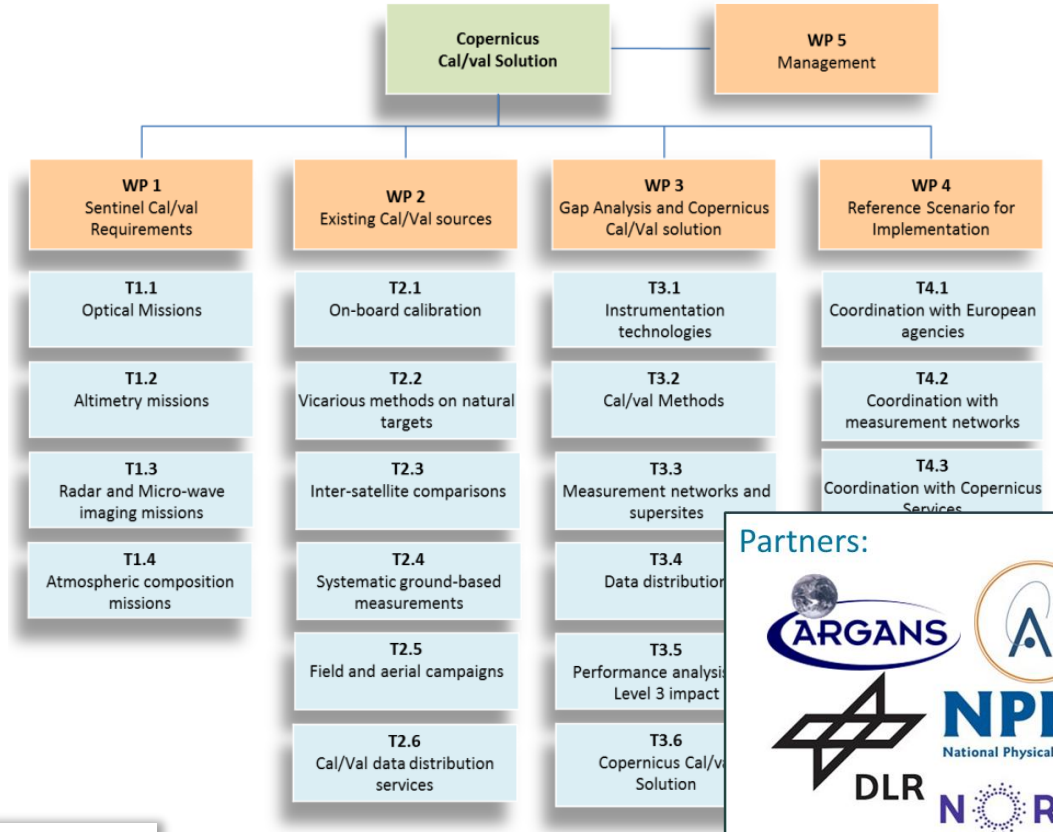
DLR activities within COPERNICUS Cal/Val

CCVS Toward a Copernicus CAL/VAL Solution

Objective:

To define a holistic solution for all Copernicus Sentinel missions (either operational or planned) to overcome current limitations of Calibration and Validation (Cal/Val) activities.

- Project duration Dec. 2020 - Nov. 2022
- 14 project partners
  (project coordination: ACRI-ST, France)



Advisory Board:

esa
EUMETSAT
European Environment Agency
Copernicus Europe's eyes on Earth

Partners:

ARGANS
BIRA-IASB
CLS COLLECTE LOCALISATION SATELLITES
cnes
DLR
NPL National Physical Laboratory
JRC EUROPEAN COMMISSION
NORCE
Koninklijk Nederlands Meteorologisch Instituut Ministerie van Infrastructuur en Waterstaat
rayference
UNIVERSITY OF TARTU Tartu Observatory
ThalesAlenia Space
Universiteit Antwerpen

Project website: https://ccvs.eu
Contact us: contact@ccvs.eu

DLR

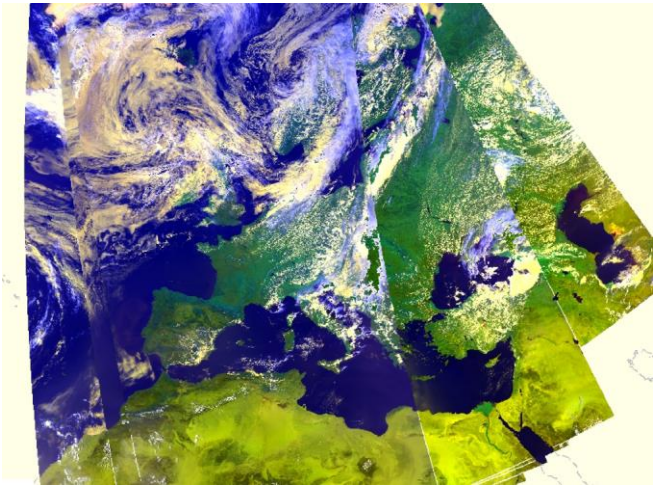
NOAA AHRR re-processing & harmonization DLR „TIMELINE“ project

TIMELINE – AVHRR Harmonization

Re-processing of >30 years of AVHRR HRPT data, from L0 to thematic products

Approach:

- Spectral Band Adjustment Factors (SBAFs) using Hyperion data & regression models
- Radiometric harmonization of AVHRR sensors (on top of NOAA OSPO cal)
  - Low gain: using Lybia 4, cross-check with Algeria 3
  - High gain: using dark coniferous forest areas
- Atm. & BRDF correction using climatology (cooperation with Brockmann consult)



Validation:

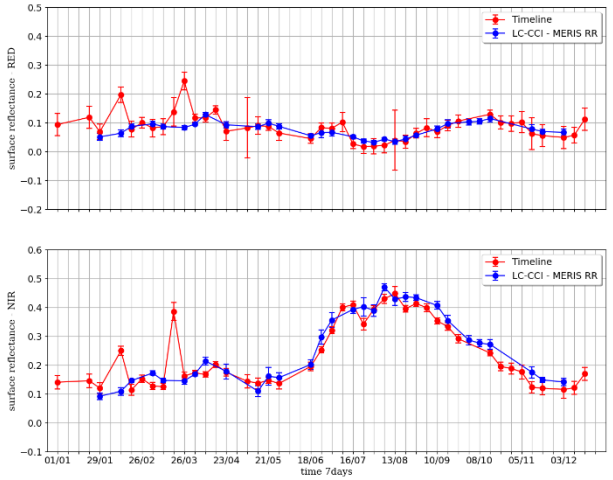
- Cross-check with other sensors:

Validation
@ BOA_ref:

CCI: ESA Climate Change Initiative

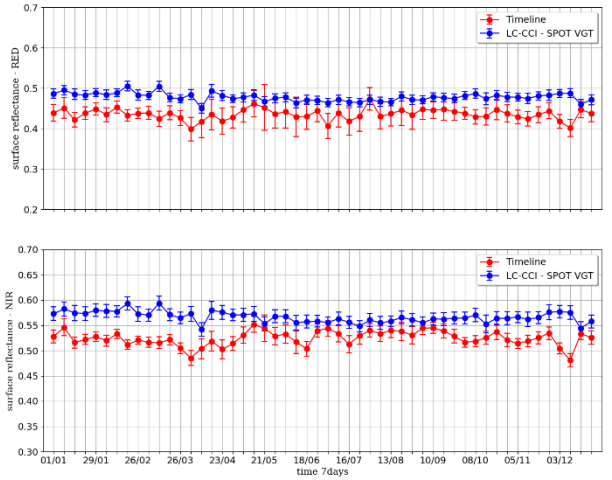
MERIS

Europe_Rice_Cultivation - year 2010



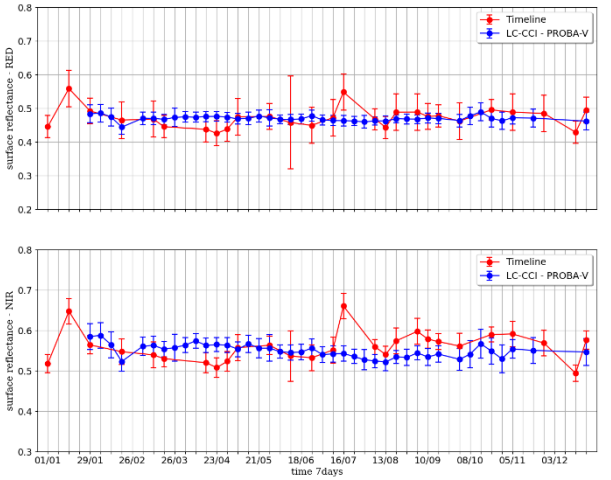
SPOT VGT

CEOS_Libya4 - year 2010

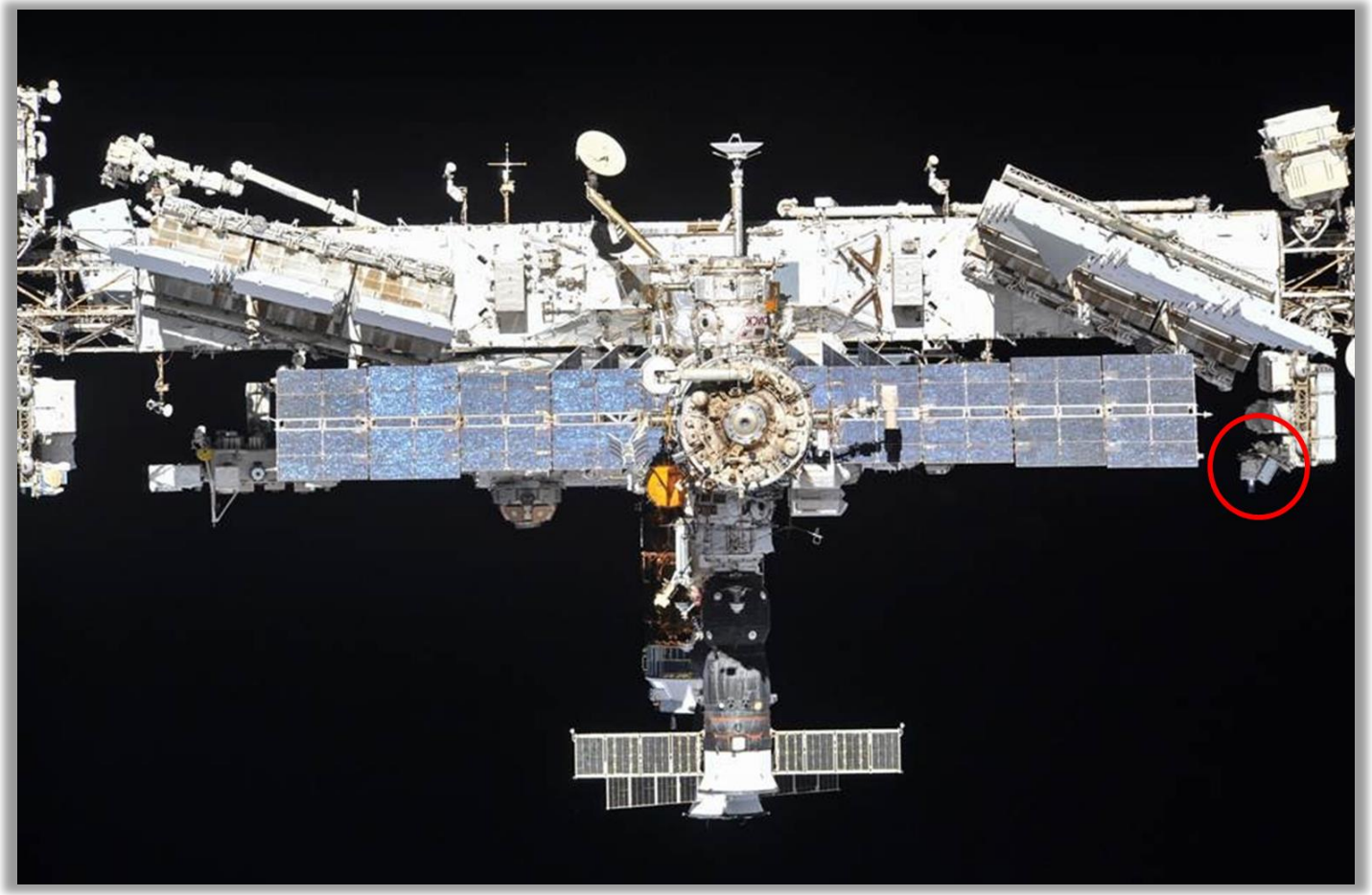


PROBA-V

CEOS_Libya4 - year 2015



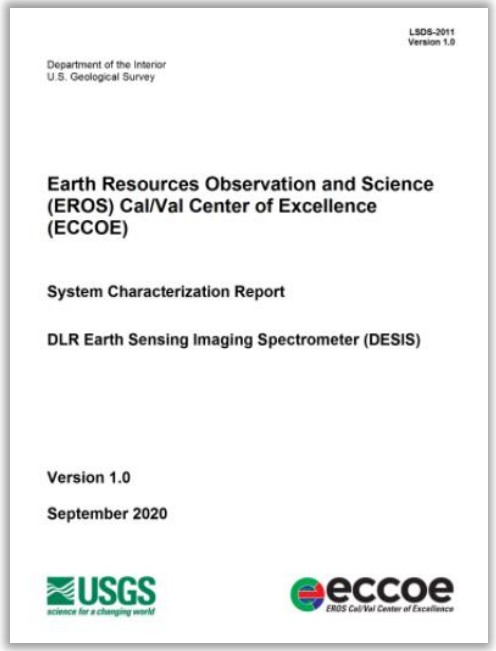
DESIS



DESIS – GS & Mission Update

- **DESIS Workshop** hosted by DLR-EOC (online), under ISPRS umbrella: **29.9 - 1.10.2021**
- Currently **~50 int. teams** are using DLR's science access to DESIS data (plus additional commercial customers of TBE)
- Highlights:

Successful **ECCOE** system characterization:


LSDS-2011
Version 1.0

Department of the Interior
U.S. Geological Survey

Earth Resources Observation and Science (EROS) Cal/Val Center of Excellence (ECCOE)

System Characterization Report

DLR Earth Sensing Imaging Spectrometer (DESIS)

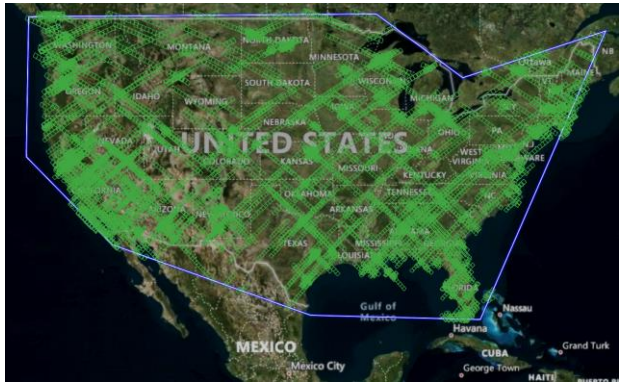
Version 1.0

September 2020

USGS science for a changing world

eccoe EROS Cal/Val Center of Excellence

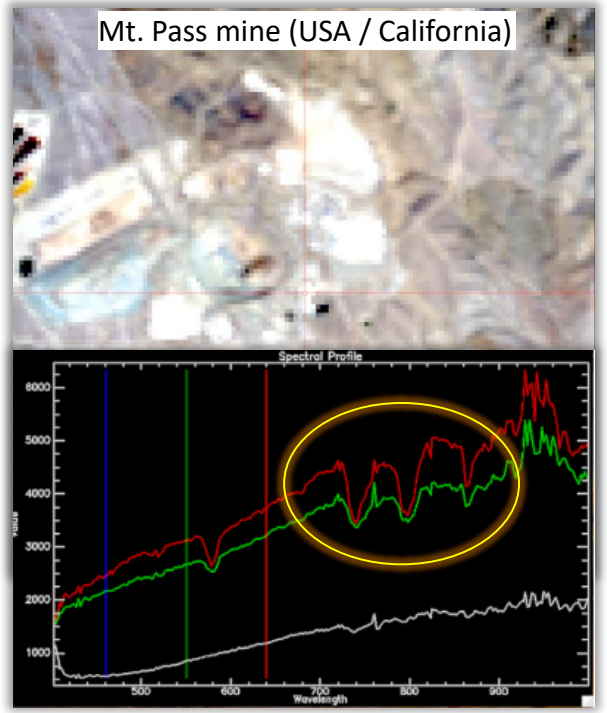
Since 2018 processing and archiving of **~55.000** scenes



~11.200 scenes in USA

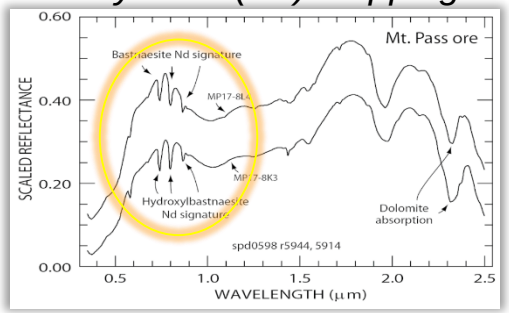
<10% of the land surface of the Earth
~27 TB data in the archive

Mapping Rare Earth Elements (REE) with DESIS:
Gregg Swayze, USGS SpecLab:



"So this may be the first demonstration of REE detection from space but may also have high enough resolution and SNR to allow differentiation of individual REE minerals"

=> Neodymium (Nd) mapping



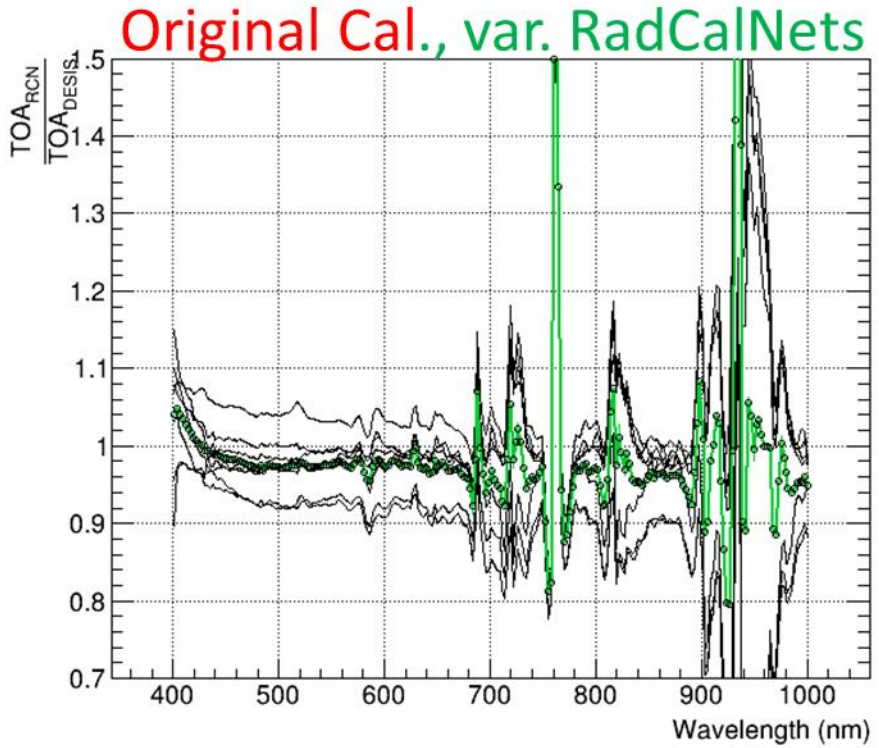
DESIS – Calibration Update

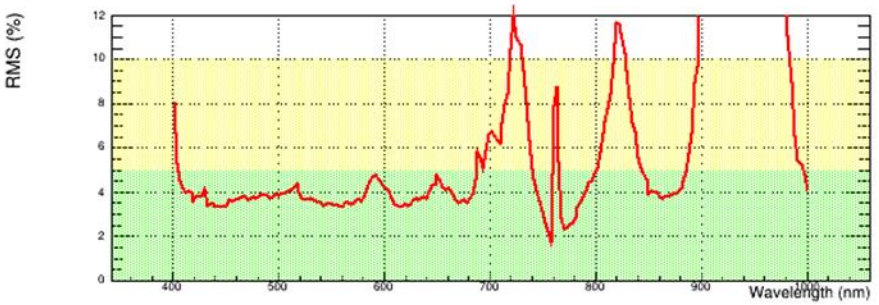
Instrument in orbit since 2018,
calibration stable, update every ~7 months

Issues:

- Etaloning > ~800 nm
- Aging esp. < ~420 nm

- Radiometric:
  - RadCalNet for absolute calibration
  - Relative (flat-fielding) using PICS-like





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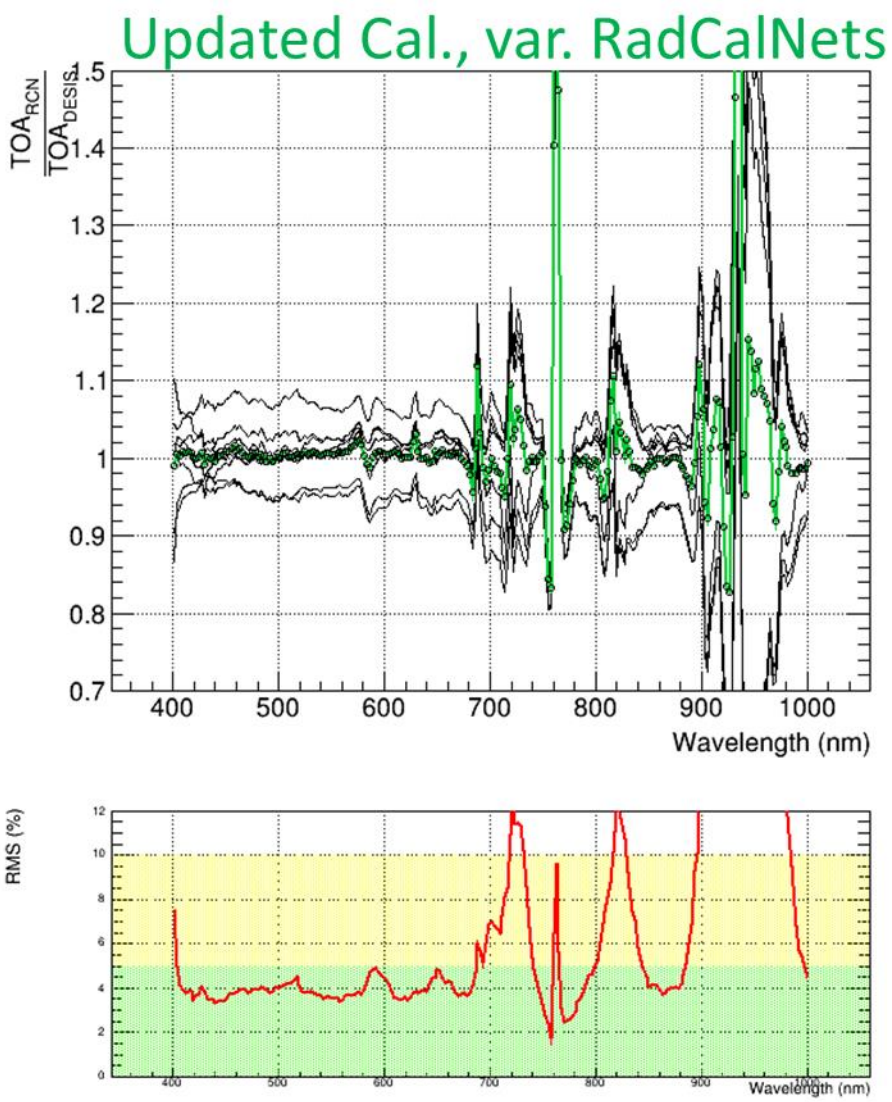

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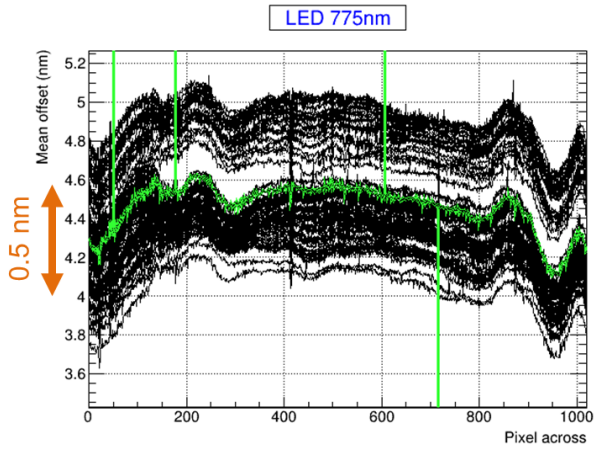
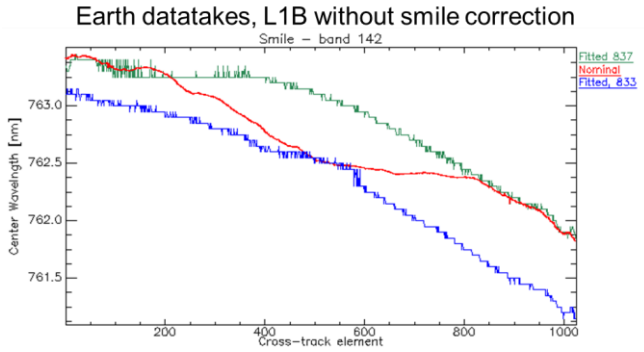
  - Relative (flat-fielding) using PICS-like

- Spectral:
  - On-board LEDs & atm. absorption features

Slight spectral shifting due to temperature gradient





Fit for 2 datatakes with different ΔT

Corrected in L1B processor, remaining RMS ~0.1 nm (@ ~ 2.55 nm SSI)

DESIS – Calibration Update

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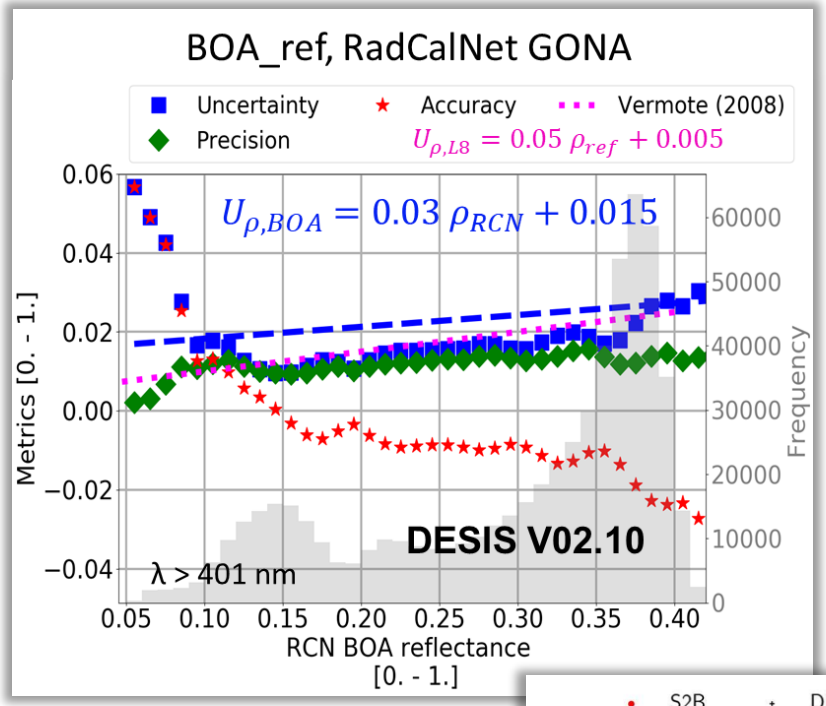
- Radiometric:
  - RadCalNet for absolute calibration
  - Relative (flat-fielding) using PICS-like

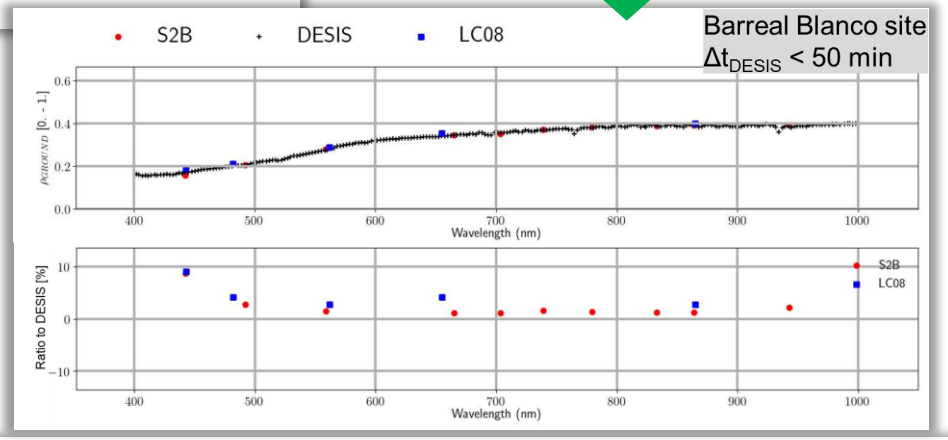
- Spectral:
  - On-board LEDs & atm. absorption features

- Validation @ TOA & BOA:
  - Using additional RadCalNet scenes
  - Cross-Check with S2 and L8 on BOA_ref level (using PACO)

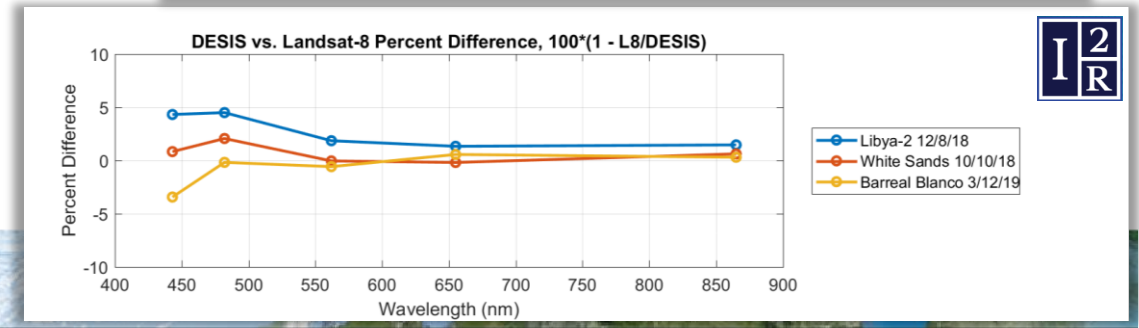


RadCalNet @ BOA_ref

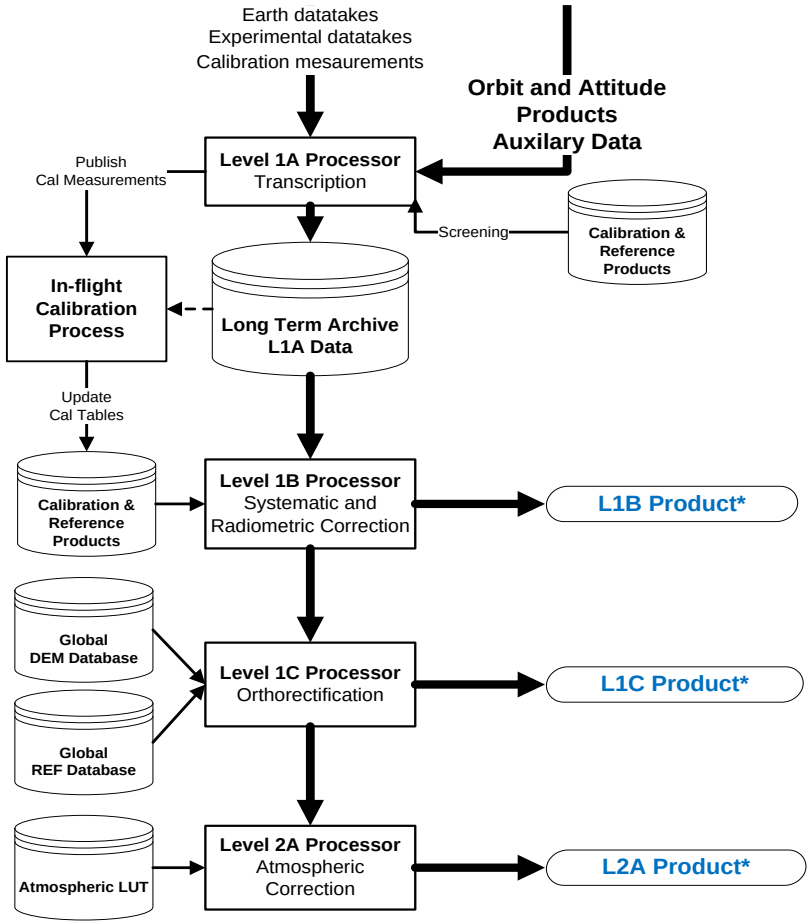
DESIS Matchups to L8 & S2 @ BOA_ref, using PACO



PICS, Matchups to L8 @ TOA_rad



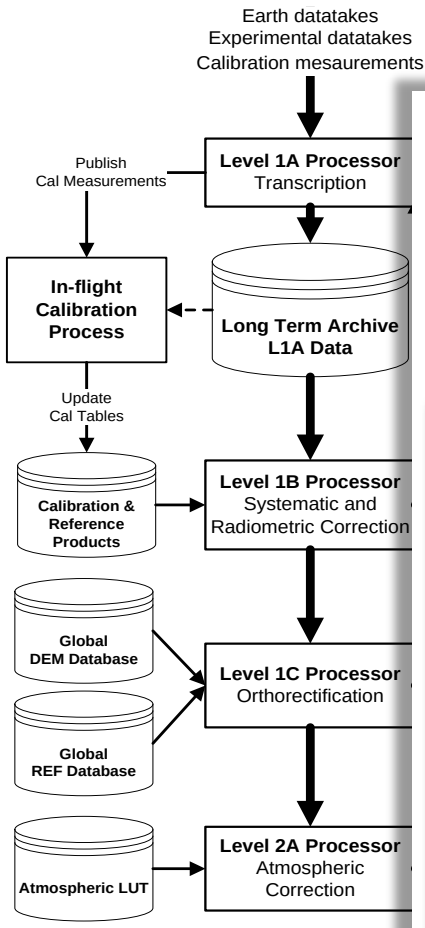
DESIS – Processor Update



Products:

- **Level 0 (L0)**
  - Raw data (Datatakes up 100 tiles 30x30 km², trajectory files, DC)
- **Level 1A (L1A)**
  - Tiled images, browse image, metadata, quality flags <= archived
- **Level 1B (L1B)***
  - Top of Atmosphere (TOA) radiance ($W \cdot m^{-2} \cdot sr^{-1} \cdot \mu m^{-1}$)
  - Systematic and radiometric correction (rolling shutter, smile, …)
  - All metadata attached for further processing
- **Level 1C (L1C)***
  - Level 1B data ortho-rectified, re-sampled to a specified grid
  - Global DEM (SRTM, 1arcsec), sensor model refinement using global reference image (Landsat-8 PAN with acc. 18m CE90)
- **Level 2A (L2A)***
  - Ground surface reflectance (i.e. after atmospheric corrections)
  - With and w/o terrain correction

DESIS – Processor Update



Products:

- **Level 0 (L0)**

s, DC)

hived

, …)

ing global

ns)

Recent changes:

L2A allows for negative reflectances

=> request by water community

650 nm

Negative reflectances in yellow

DLR

DESIS – Summary & Candidate Work Plan Activities

- In-orbit calibration
  - RadCalNet for absolute radiometric calibration
  - Established PICS for relative radiometric calibration

- L1B/C TOA-rad validation
  - Matchups with S-2 and L-8 established & ongoing
  - PRISMA (work in progress), HISUI (@ ISS) of interest

- L2 BOA-ref validation
  - Validation using DLR‘s airborne hyperspectral sensors (see next presentation)
  - Approaches to address uncertainity @ BOA level

- L3 Thematic Products
  - Application development in land & soil degradation, forestry, … ongoing (see next session)
  - Supported by lab & field spectroscopy

DESIS – Summary & Candidate Work Plan Activities

- In-orbit calibration
  - RadCalNet for absolute radiometric calibration
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  - Approaches to address uncertianity @ BOA level
- L3 Thematic Products
  - Application development in land & soil degradation, forestry, … ongoing (see next session)
  - Supported by lab & field spectroscopy

Proposed joint activities (I)

(1) Application of EPCIS approach to non-mapping mission

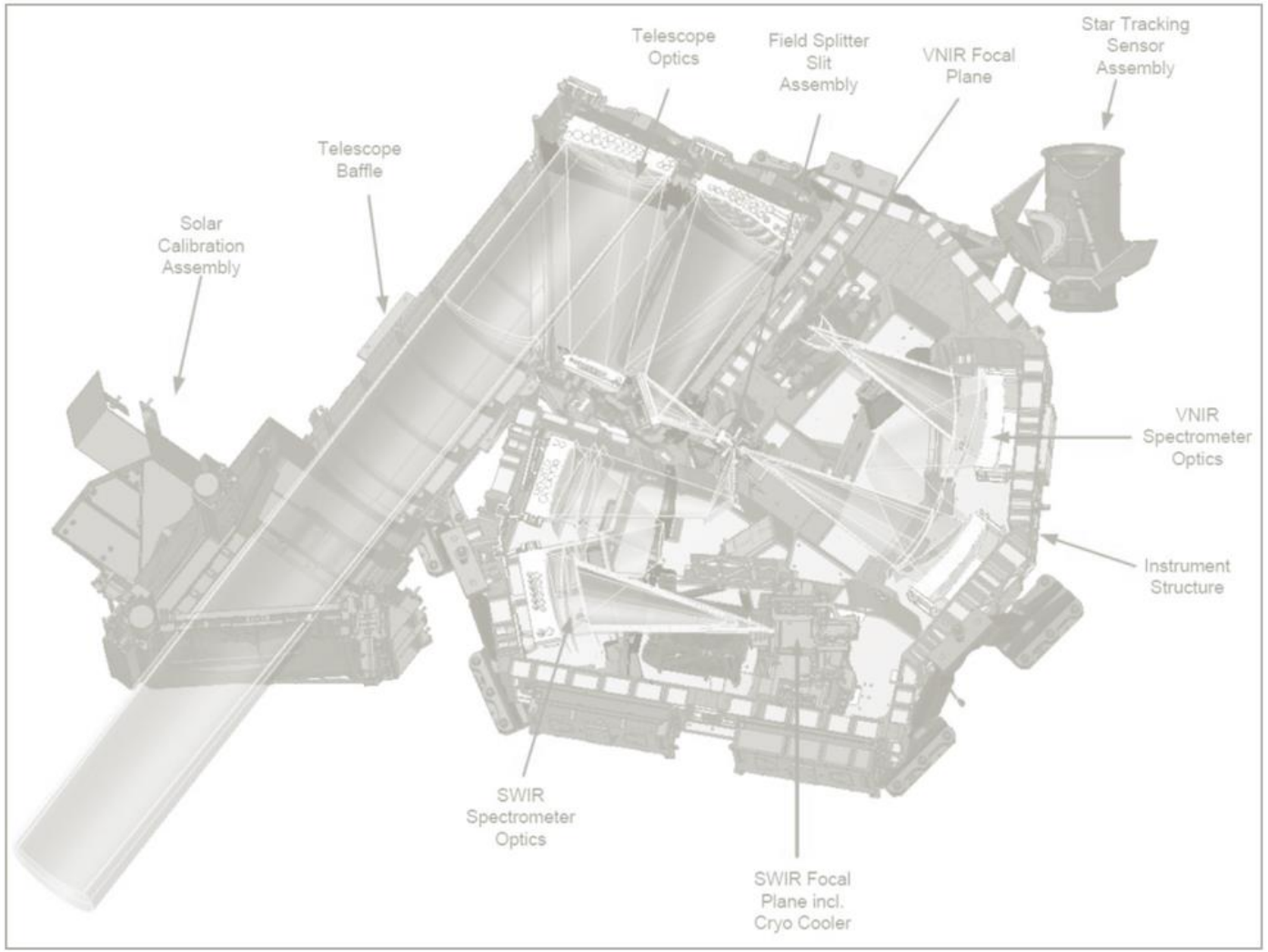
(2) Preparation towards CLARREO Pathfinder @ ISS

(3) Product inter-operability and product standards
=> Exchange on val. procedures & standards (e.g., solar irradiance) – extending CEOS IVOS
=> CEOS CARD4L, see EnMAP part

(4) Ground reference data, „RadCalNet-like“ infrastructure on vegetated non-desert sites

(5) Improved approaches to address uncertianity @ BOA level

EnMAP



Federal Ministry for Economic Affairs and Energy

Supported by the DLR Space Administration with funds of the German Federal Ministry of Economic Affairs and Energy on the basis of a decision by the German Bundestag (50 EE 0850).

DLR

EnMAP – Teaming for Calibration, DataQC and Validation

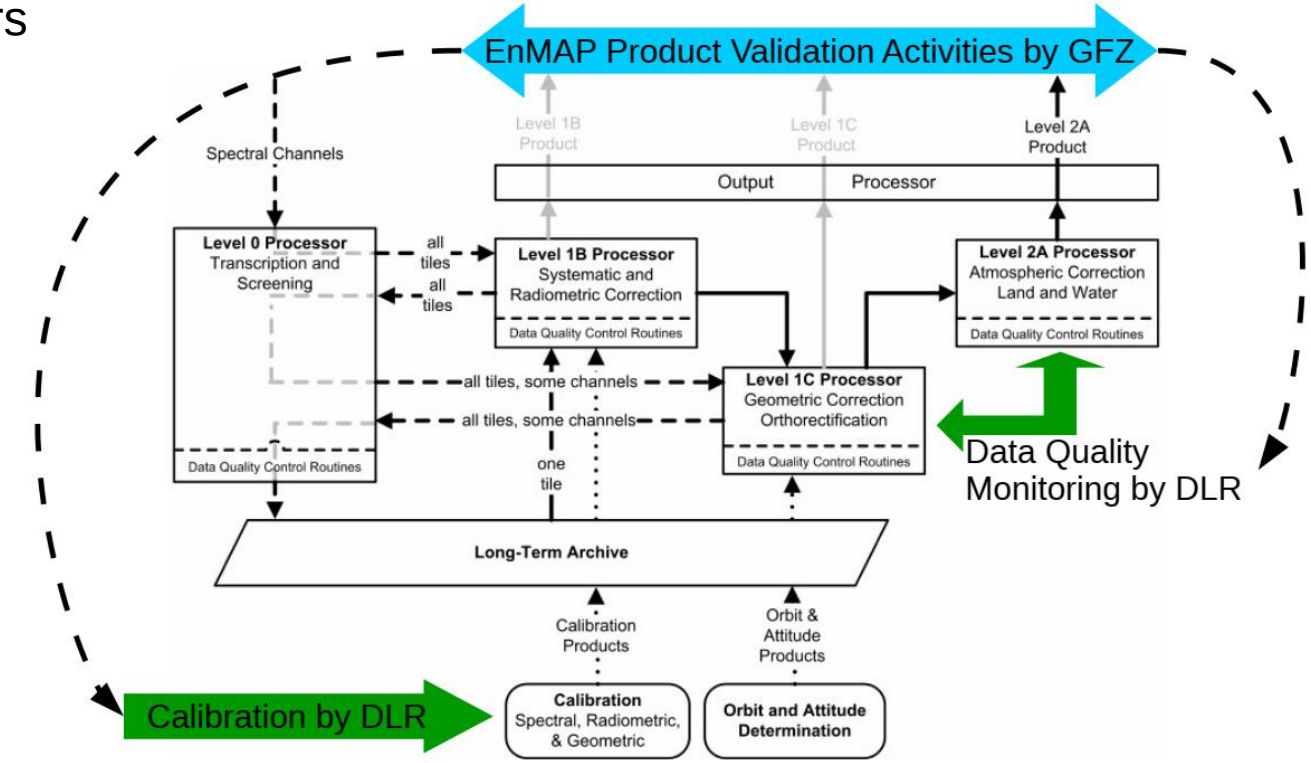
EnMAP Hyperspectral Imager

EnMAP Ground Segment (DLR):

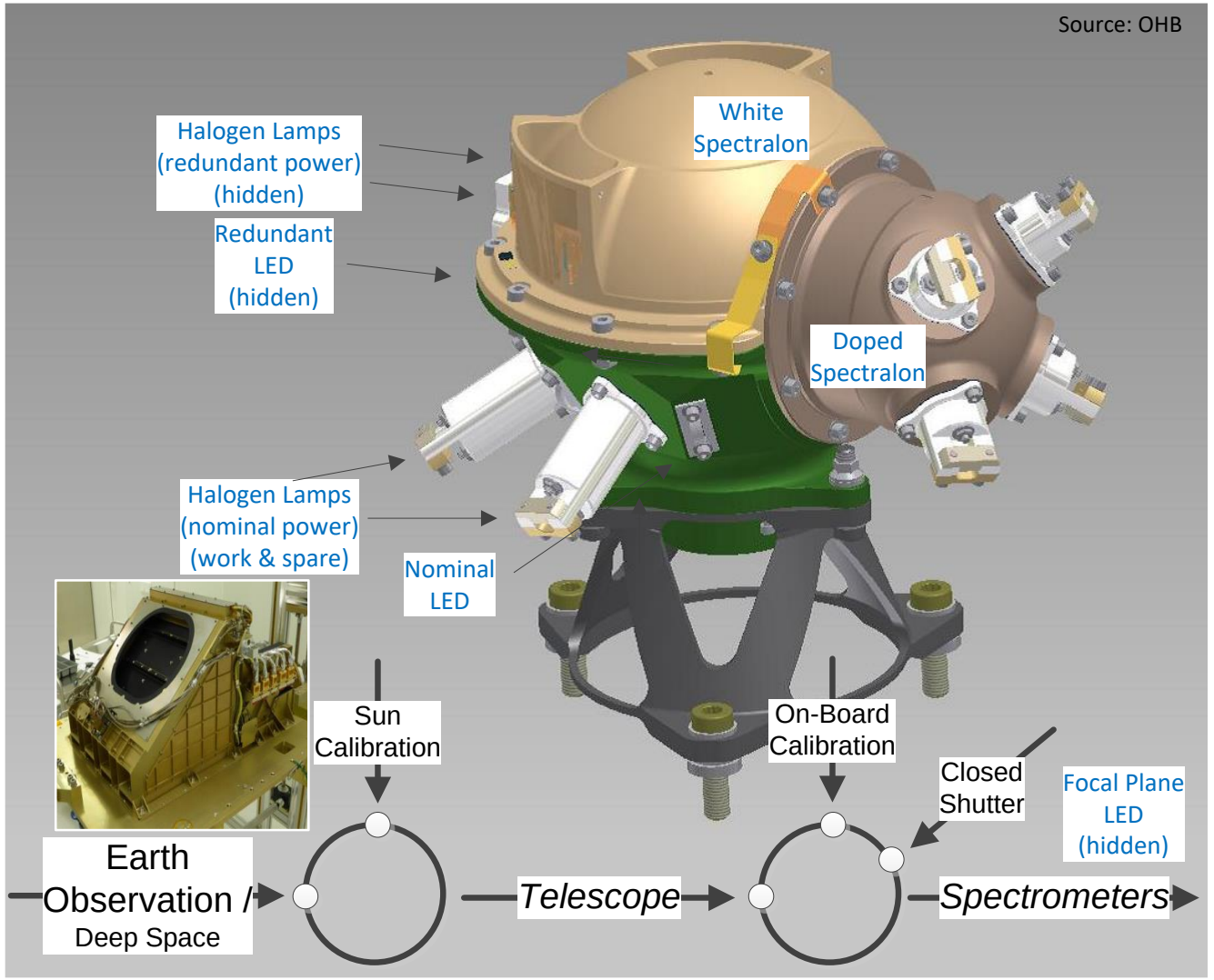
- Generates & delivers user products (L1B, L1C, L2A) to end-users using latest calibration
- Monitors and updates calibration parameters using in-flight calibration
- Performs Quality Control activities on user products
- Performs Monitoring of Instrument parameters
- Point of Contact:
  Tobias.Storch@dlr.de (GS manager)
  Emiliano.Carmona@dlr.de (PCV System Eng.)

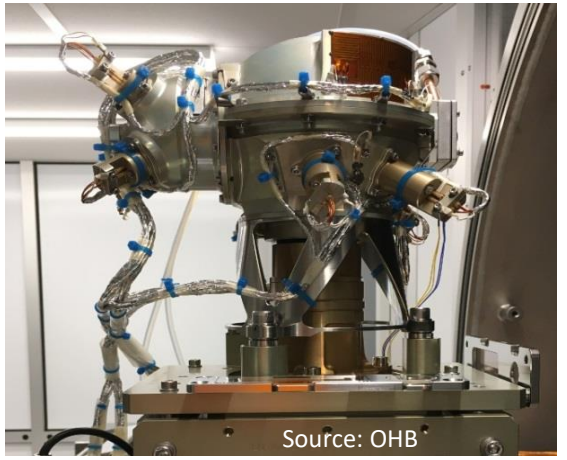
EnMAP Validation Entity (GFZ):

- Validation of user products to absolute references at selected reference sites
  - Aeronet, RadCalNet, PICS, campaigns
- Activities considered ‘scientific’ rather than ‘operational’
- Point of contact:
  Sabine.Chabrillat@gfz-potsdam.de (PI)
  Maximilian.Brell@gfz-potsdam.de (Val)

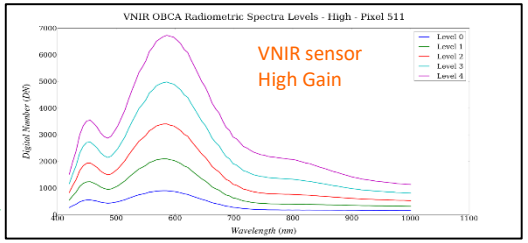


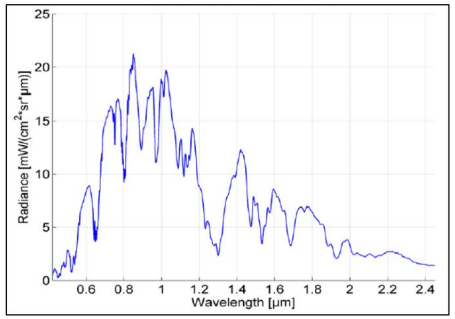
EnMAP – On-Board Calibration Assembly





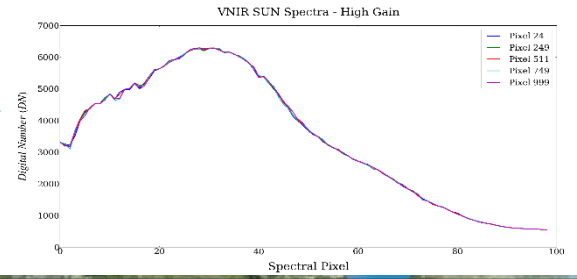
- White Spectralon Sphere [relative radiometric]
- Doped Spectralon Sphere [absolute spectral]
- Focal Plane LED [linearity]





M. Mücke et al. Proc. SPIE 11180 (2019)

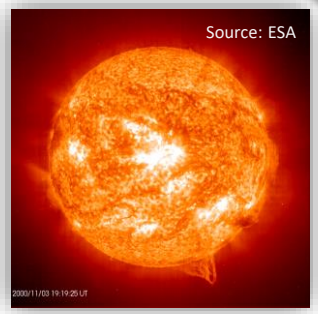
- Solar diffuser [absolute radiometric]



EnMAP – Calibration Procedures

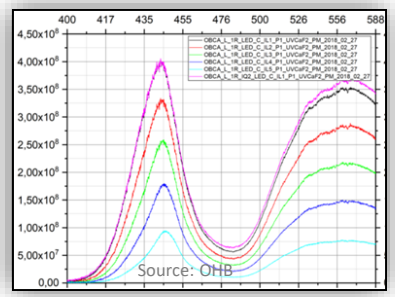
← Closed Shutter [**dark**]

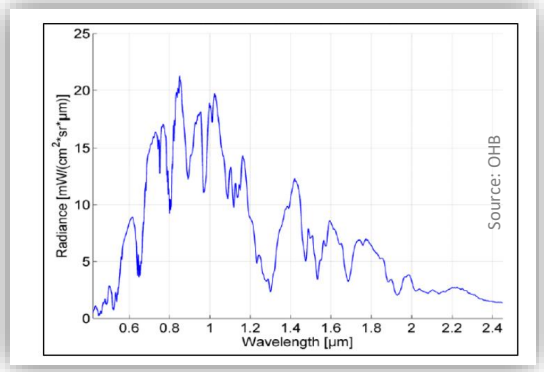
Deep Space [**dark**] →



← Sun Calibration [**absolute radiometric**]

White Spectralon Sphere [**relative radiometric**] →





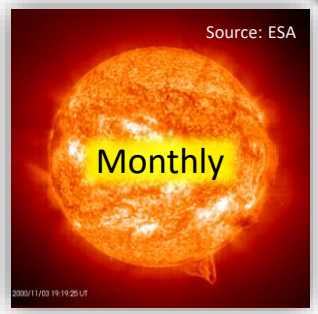
← Doped Spectralon Sphere [**absolute spectral**]

Focal Plane LED [**linearity**] →

EnMAP – Calibration Procedures

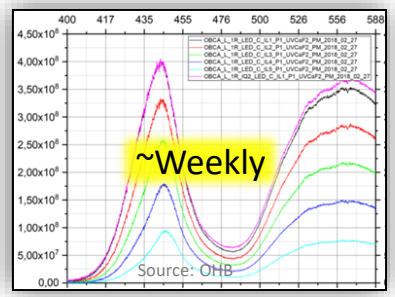
← Closed Shutter [**dark**]

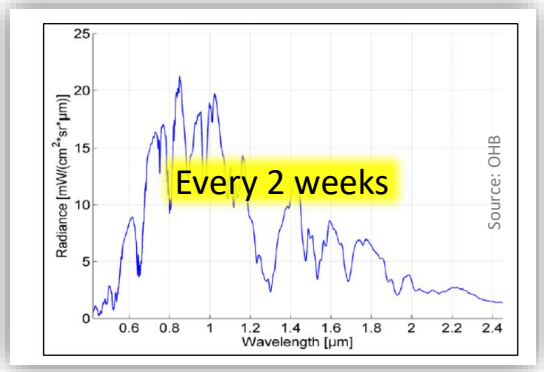
Deep Space [**dark**] →



← Sun Calibration [**absolute radiometric**]

White Spectralon Sphere [**relative radiometric**] →



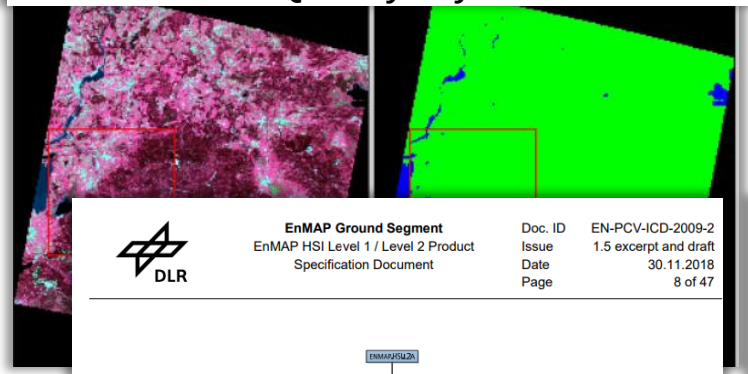


← Doped Spectralon Sphere [**absolute spectral**]

Focal Plane LED [**linearity**] →

EnMAP – ARD / CARD4L Metadata and Quality Layers

Datacube + 8 QualityLayers + XML Metadata



CEOS Committee on Earth Observation Satellites

Analysis Ready Data *For Land*

Product Family Specification
Surface Reflectance (CARD4L-SR)

DLR

EnMAP Ground Segment
EnMAP HSI Level 1 / Level 2 Product Specification Document

Doc. ID EN-PCV-ICD-2009-2
Issue 1.5 excerpt and draft
Date 30.11.2018
Page 8 of 47

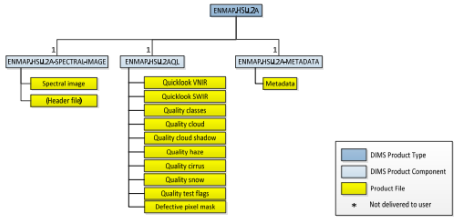


Figure 3-3 L2A product files.

Name	Description	File	Format	Estimated Size
ENMAP.HSI.L2A-METADATA	Provided metadata	ENMAP01-____L2A-DTnnnnnnnnn_yyyymmddThhmmssZ_nnn_Vnnnnnn_yyyymmddThhmmssZ-METADATA.XML	xml	10 MB
ENMAP.HSI.L2A-SPECTRAL_IMAGE	Earth image measurement data covering 1 tile (30x30km) in orthorectified geometry	ENMAP01-____L2A-DTnnnnnnnnn_yyyymmddThhmmssZ_nnn_Vnnnnnn_yyyymmddThhmmssZ-SPECTRAL_IMAGE.{TIF,BSQ,BIP,BIL,JPEG2000}	tif, bsq, bip, bil, jpeg2000 (selectable by user)	<639 MB
		ENMAP01-____L2A-DTnnnnnnnnn_yyyymmddThhmmssZ_nnn_Vnnnnnn_yyyymmddThhmmssZ	Envi header file (only for	10 KB

#	Item	Threshold (Minimum) Requirements	Target (Desired) Requirements	Threshold Self-Assessment	Target Self-Assessment	Self-Assessment Explanation/ Justification	Recommended Requirement Modification
2.4	Saturation	Metadata indicates where one or more spectral bands are saturated.	Metadata indicates which pixels are saturated for each spectral band.	ok	Partially. Aggregate informatic (if numbe of saturat bands for spatial pix exceeds threshold	Within	
2.5	Cloud	Metadata indicates whether a pixel is assessed as being cloud.	As threshold, information on cloud detection should be available in the metadata as a single DOI landing page.	ok	ok (also link t ATBDs or enmap.or		
2.6	Cloud Shadow	Metadata indicates whether a pixel is assessed as being cloud shadow.	As threshold, but information on cloud shadow detection should be available in the metadata as a single DOI landing page.	ok	ok (also link t ATBDs or enmap.or		
2.7	Land/Water Mask	Not required.	The metadata indicates whether a pixel is assessed as being land or water. Information on land/water mask should be available in the metadata as a single DOI landing page	n.a.	ok (also link t ATBDs or enmap.or		

Summary Self-Assessment Table

	Threshold	Target
1. General Metadata		
1.1 Traceability	n.a.	no
1.2 Metadata Machine Readability	ok	ok
1.3 Data Collection Time	ok	no
1.4 Geographical Area	ok	ok
1.5 Coordinate Reference System	ok	ok
1.6 Map Projection	ok	ok
1.7 Geometric Correction Methods	n.a.	ok
1.8 Geometric Accuracy of the Data	n.a.	ok
1.9 Instrument	ok	ok
1.10 Spectral Bands		
1.11 Sensor Calibration		
1.12 Radiometric Accuracy		
1.13 Algorithms		
1.14 Auxiliary Data		
1.15 Processing Chain Provenance		
1.16 Data Access		
1.17 Overall Data Quality		
2. Per-Pixel Metadata		
2.1 Metadata Machine Readability		
2.2 No Data		
2.3 Incomplete Testing		
2.4 Saturation		
2.5 Cloud		ok
2.6 Cloud Shadow		ok
2.7 Land/Water Mask		ok
		ok
ometr		
orrection	n.a.	no
2.13 Aerosol Optical Depth Parameters	n.a.	tbd
3. Radiometric and Atmospheric Corrections		
3.1 Measurement	ok	no
3.2 Measurement Uncertainty	n.a.	partially
3.3 Measurement Normalisation	n.a.	no
3.4 Directional Atmospheric Scattering	ok	ok
3.5 Water Vapour Corrections	ok	ok
3.6 Ozone Corrections	n.a.	ok
4. Geometric Corrections		

Review started in October

CEOS Analysis Ready Data

Overview Framework Specifications FAQ Resources Data

CARD4L SAR Webinar – February 1 & 2, 2021: Register Here >>

Under Develo

Product	CARD4L Type	PFS Version	Agency
Landsat Collection 2	Surface Reflectance	v5.0	USGS
Landsat Collection 2	Surface Temperature	v5.0	USGS
Sent			ESA
Sent (E84)	Reflectance		Element 84
EnMAP	Surface Reflectance	v5.0	DLR

EnMAP Product Specification & demo products

Self-Assessment ✓

Threshold fulfilled
Target mostly fulfilled

CEOS Review

Approval by CEOS (pending)

DLR

EnMAP – Summary & Candidate Work Plan Activities

Proposed joint activities (II)

(6) Benefit of additional Lunar cal., interlinking with USGS ROLO activities

(7) Inter-operability and product standards
- Radiometric consistency, L1B TOA_rad
  Procedures esp. towards
  - Cal. missions like CLARREO / ESA TRUTHS
  - L9, SBG, EMITS
- Product level, esp. L2A BOA_ref
  - L9, SBG, EMITS

(8) Thematic product development (land & soil degradation, bathymetry, forestry, …),
=> see next session

Proposed joint activities (I)

(1) Application of EPCIS approach to non-mapping missions

(2) Preparation towards CLARREO Pathfinder @ ISS

(3) Product inter-operability and product standards
=> Exchange on val. procedures & standards (e.g., solar irradiance) – extending CEOS IVOS
=> CEOS CARD4L, see EnMAP part

(4) Ground reference data, „RadCalNet-like“ infrastructure on vegetated non-desert sites

(5) Improved approaches to address uncertianity @ BOA level

Online Resources

- DESIS:
  - https://www.dlr.de/eoc/desktopdefault.aspx/tabid-13614/
  - Full presentation on DESIS – Cal/Val: Bachmann et al., 2020, NASA SBG Webinar: https://elib.dlr.de/135646/1/SBG_CalVal_DESIS_Bachmann_NoMovie.pdf
- EnMAP:
  - www.enmap.org
  - Full presentation on EnMAP – Cal/Val: Alonso et al., 2020, NASA SBG Webinar: https://elib.dlr.de/135647/1/SBG_CALVAL__EnMAP_Alonso_Carmona.pdf
- TIMELINE
  - https://www.dlr.de/eoc/en/desktopdefault.aspx/tabid-9035/15754_read-38904/
- CCVS:
  - https://ccvs.eu