THE SPACEBORNE IMAGING SPECTROMETER DESIS: Mission summary and potential for scientific developments

EARSeL SIG Imaging Spectroscopy, June 22-24 2022, Potsdam

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[a] DLR, Germany
[b] TBE, USA
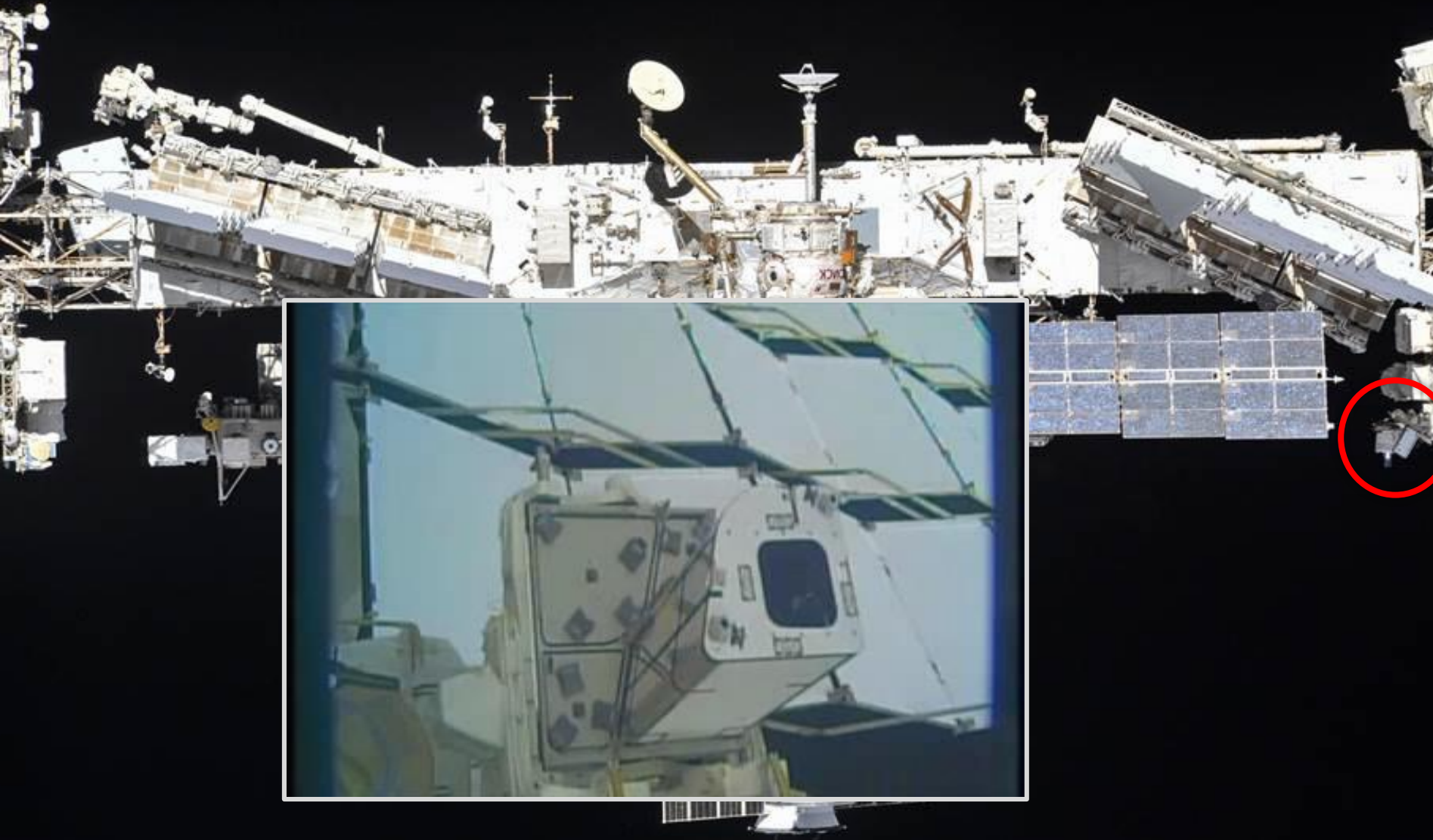[c] I2R, USA

Wissen für Morgen

Teledyne Brown Engineering (USA) and **DLR** have partnered to build and operate the DLR Earth Sensing Imaging Spectrometer (**DESIS**) from the Teledyne-owned Multi-User System for Earth Sensing (**MUSES**) Platform on the ISS

DESIS, the hyperspectral sensor has been developed by DLR, which is currently the first payload of MUSES.

DLR also established the Ground Segment and licensed the SW processors to Teledyne running in an Amazon Cloud

DESIS – Introduction / Timeline

2014 / 2015

MUSES / DESIS
Start Mission

7. June 2017

MUSES installation
on ISS

29. June 2018

DESIS launch from
Cape Canaveral to ISS
via SpaceX Dragon

27.-28.08 2018

Installation of DESIS
in MUSES. Start
Commissioning Phase

23. October 2019

@ IAC Washington
Start operational
Phase (official
announcement)

29.09.–01.10.2021

1st DESIS User
Workshop (online)

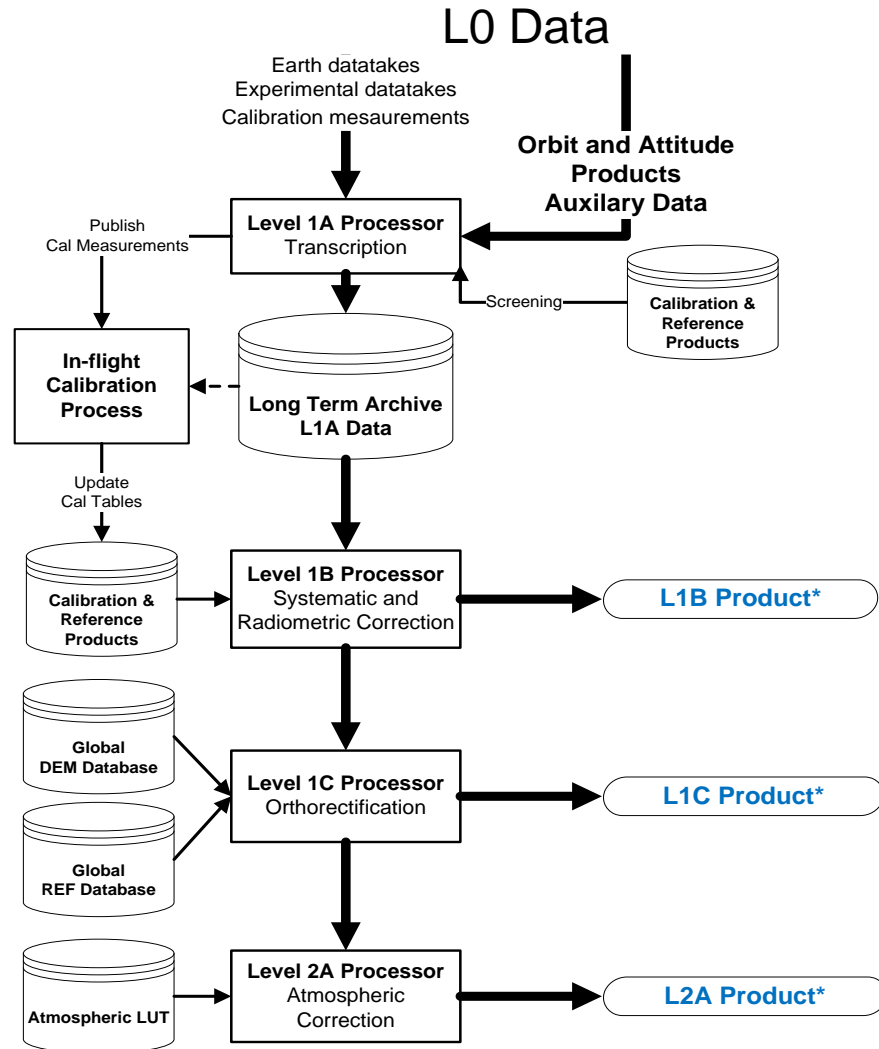| Design, Implementation, Test		Commissioning	Operations	

Mission Instrument	ISS/MUSES DESIS
Off-nadir tilting (across-track, along-track)	-45° (backboard) to +5° (starboard), -40° to +40° (by MUSES and DESIS)
Spectral range	400 nm to 1000 nm
Spectral (res., acc.)	2.55 nm, (*)
Radiometry (res., acc.)	13 bits, (*)
Spatial (res., swath)	30 m, 30 km (@ 400 km)

Mission Instrument	ISS/MUSES DESIS
Target lifetime	2018-2023
Satellite (mass, dimension, usage)	455 t, 109.0×97.9×27.5 m³ (multi-purpose)
Orbit (type, local time at equator, inclination, height, repeat cycle)	not Sun-synchronous, various, 51.6°, 320 km to 430 km, no repeat cycle
Coverage	55° N to 52° S
Revisit frequency	3 to 5 days (average)

DESIS – Operational processors (DLR + Amazon Cloud)

Products:

- **Level 0 (L0)**
  - Raw data (Datatakes up to 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

* Delivery Product

DESIS – Data products + Data quality

DESIS L2A

Archive

L1A Raw Data
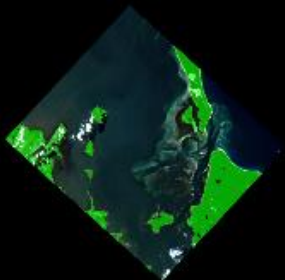(prepared for selection & ordering & processing)

Analysis Ready Data

L1B Top-Of-Atmosphere (TOA) Radiance

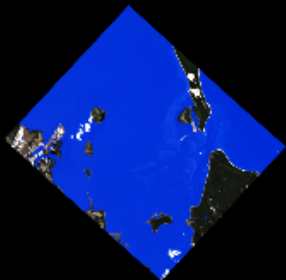L1C Geocoded & Orthorectified

L2A Bottom-of-Atmosphere (BOA) Reflectance

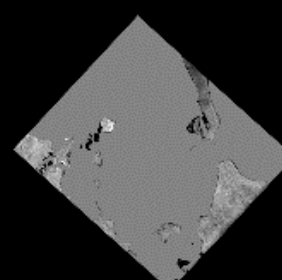| Land Mask | Water Mask | Cloud Mask | Cloud Shadow over land | Haze over land | Haze over water | AOT Map | WV Map |

DESIS – Data products + Data quality

Absolute radiometric calibration is well within ~5% at the Top-of-Atmosphere (TOA) radiance and TOA reflectance level when validated against RadCalNet

Geometric accuracy with respect to Landsat-8 reference is ~20 m (< 1 pixel) linear RMSE

Agreement of Bottom-of-Atmosphere (BOA) reflectance within ~5% to RadCalNet, Sentinel-2 and field campaign data from Pinnacles site (Australia)

Spectral calibration after smile correction is typically better than ~0.5 nm.

Archive

L1A Raw Data
(prepared for selection & ordering & processing)

Analysis Ready Data

L1B Top-Of-Atmosphere (TOA) Radiance

L1C Geocoded & Orthorectified

L2A Bottom-of-Atmosphere (BOA) Reflectance
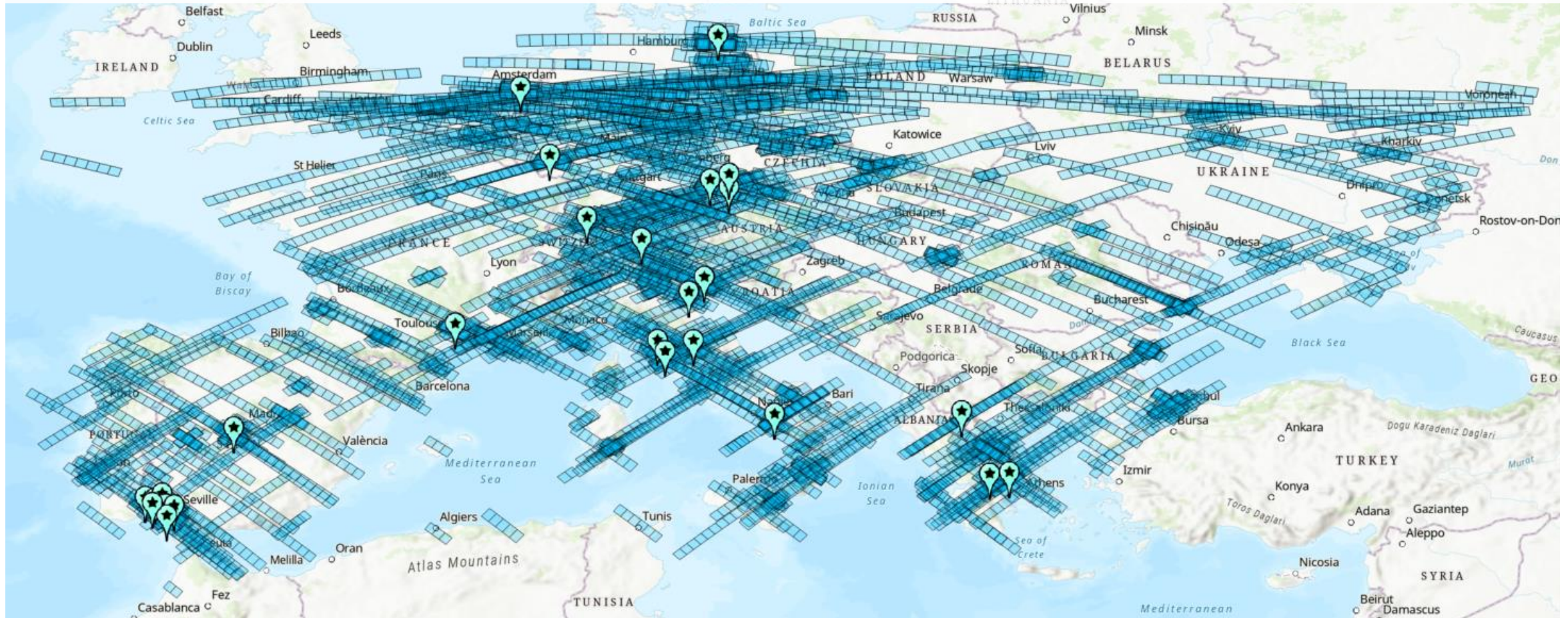
Poster (Thursday):
- de los Reyes, R. et al. (DLR): Validation of Atmospheric Correction of DESIS L2A Products: comparison of hyperspectral and Sentinel-2-like multispectral sensors
- Pflug, B. et al. (DLR): DESIS And Copernicus Sentinel-2 Surface Reflectance, AOT and WV Products Compared To Measurements On Ground
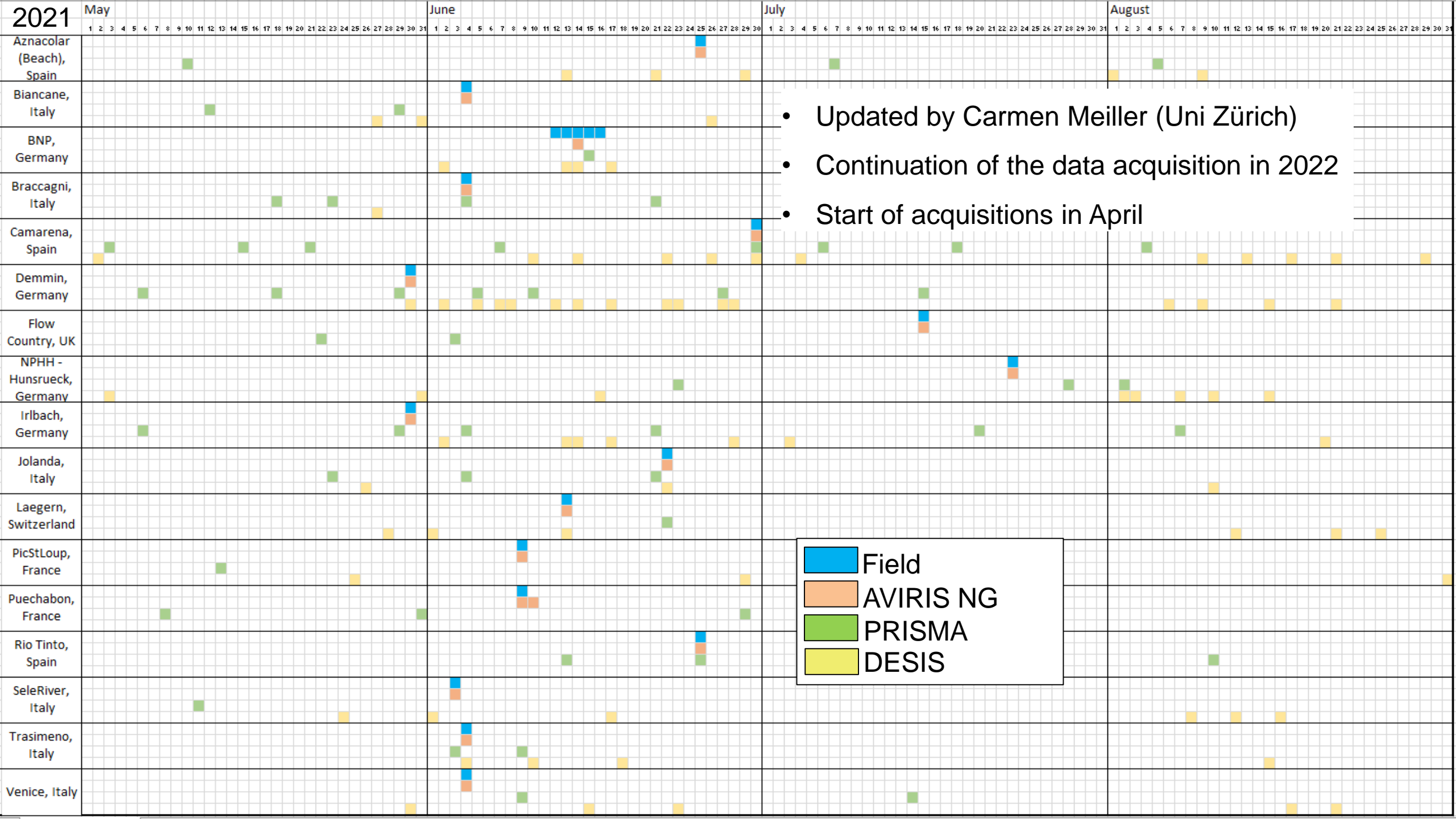
DESIS - Science Coordination

~ 10.000 scenes for Europe – 40 permanent test sites for CHIME preparatory activities

- Updated by Carmen Meiller (Uni Zürich)
- Continuation of the data acquisition in 2022
- Start of acquisitions in April

DESIS acquisition variabilities - Agricultural sites: Camarena, Spain

100 scenes

* Standing acquisition request of 40 CHIME sites across Europe
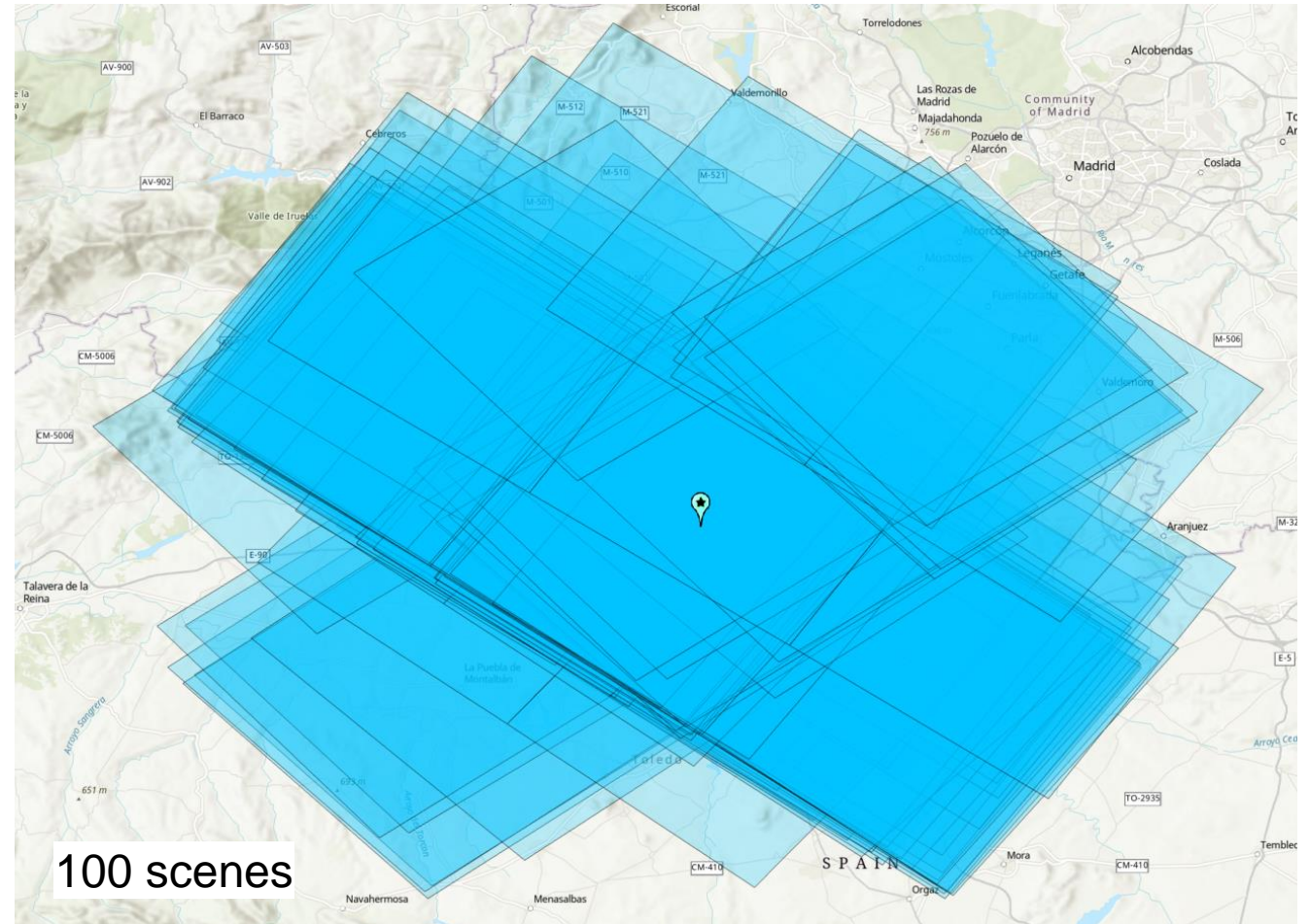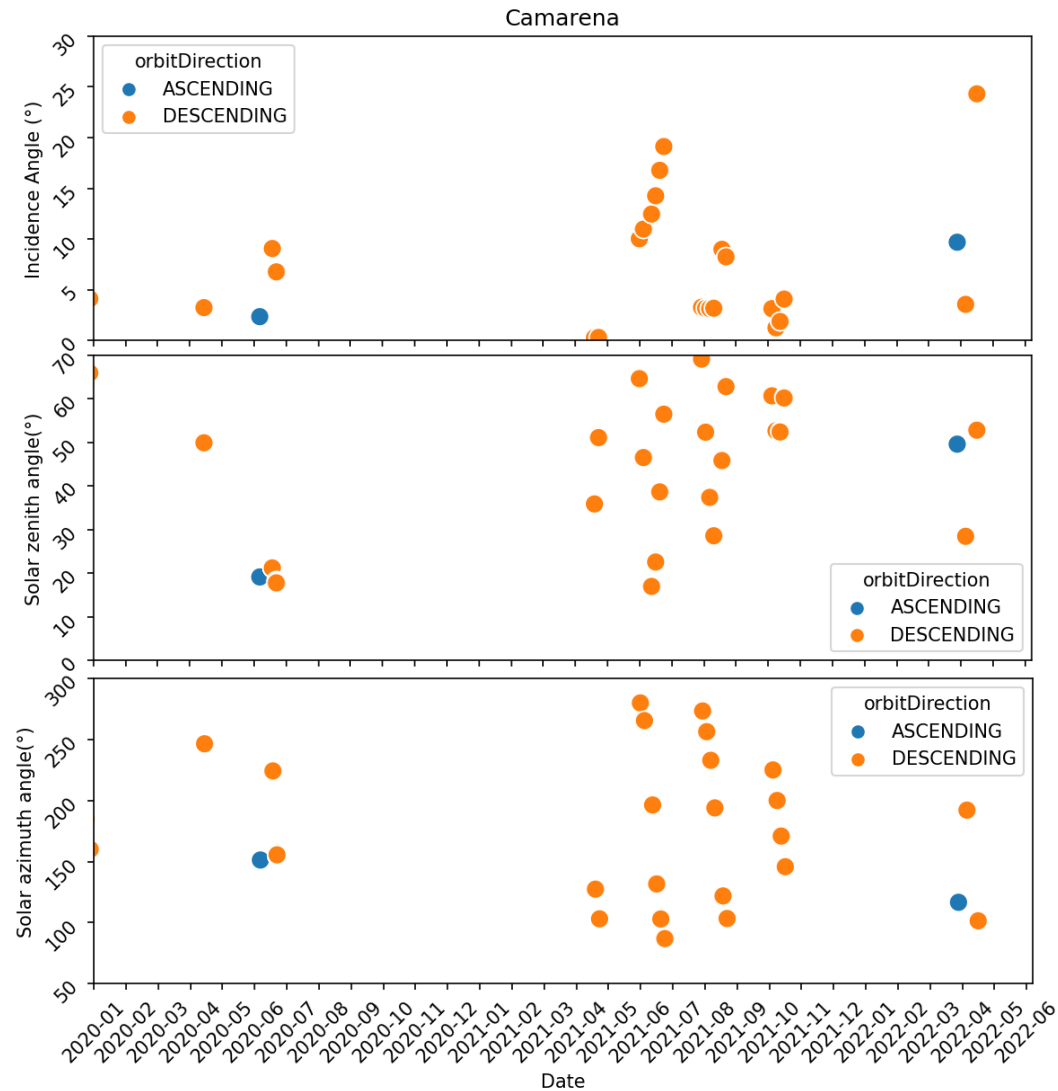
DESIS – News + Mission highlights

- Currently **~70 int. teams** are using DLR's science access to DESIS data + ~ 20 int. CHIME teams
- Continuation of the DESIS data acquisition for the CHIME sites in 2022
- Meet the DESIS team at IGARSS 2022 (mission + cal/val presentation)
- Highlights:
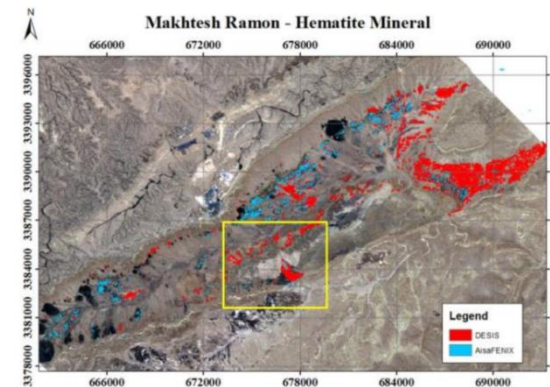
Successful **ECCOE** system characterization:
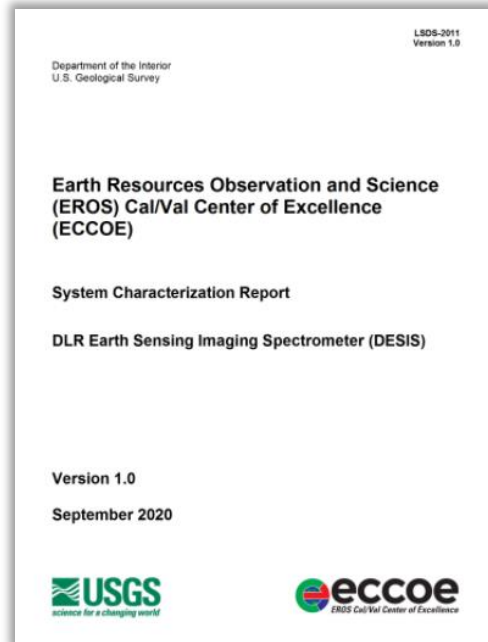
Since 2018 processing and archiving of **~130.400** scenes

Example ~23.000 scenes in USA
~10.000 scenes in EU

<79% of the land surface
of the Earth
~64 TB data in the archive

**DESIS Workshop publication
The International Archives of the ISPRS**

Heller Pearlshtien, D. and Ben-Dor, E.:
CALVAL EVALUATION OF DESIS PRODUCTS IN AMIAZ PLAIN AND MAKHTESH RAMON TEST SITES, SOUTHERN ISRAEL, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVI-1/W1-2021, 13–21, https://doi.org/10.5194/isprs-archives-XLVI-1-W1-2021-13-2022, 2022
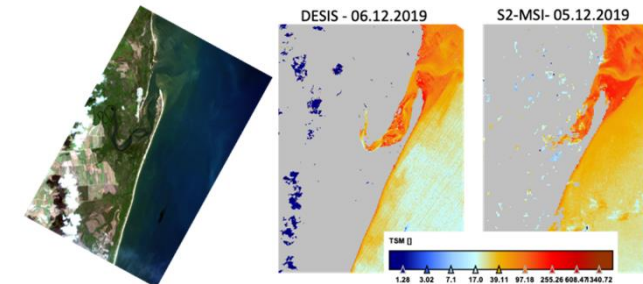
Soppa, M. A., Dinh, D. A., Silva, B., Steinmetz, F., Alvarado, L., and Bracher, A.:
INTERCOMPARISON OF DESIS, SENTINEL-2 (MSI) AND SENTINEL-3 (OLCI) DATA FOR WATER COLOUR APPLICATIONS, Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci., XLVI-1/W1-2021, 69–72, https://doi.org/10.5194/isprs-archives-XLVI-1-W1-2021-69-2022, 2022.

Thank you for your attention!

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DESIS Science Coordinator

Poster:
- **Thursday:** de los Reyes, R. et al. (DLR): Validation of Atmospheric Correction of DESIS L2A Products: comparison of hyperspectral and Sentinel-2-like multispectral sensors
- **Thursday:** Pflug, B. et al. (DLR): DESIS And Copernicus Sentinel-2 Surface Reflectance, AOT and WV Products Compared To Measurements On Ground
- **Friday:** Asam, S. et al. (DLR): Detection of Grassland Degradation in Azerbaijan by Combining Multi-decadal NDVI Time Series and Fractional Cover Estimates Based on DESIS Data