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A Holistic Perspective on the Calibration and Validation of Sentinel-2 L2A products: Contribution From the CCVS Project

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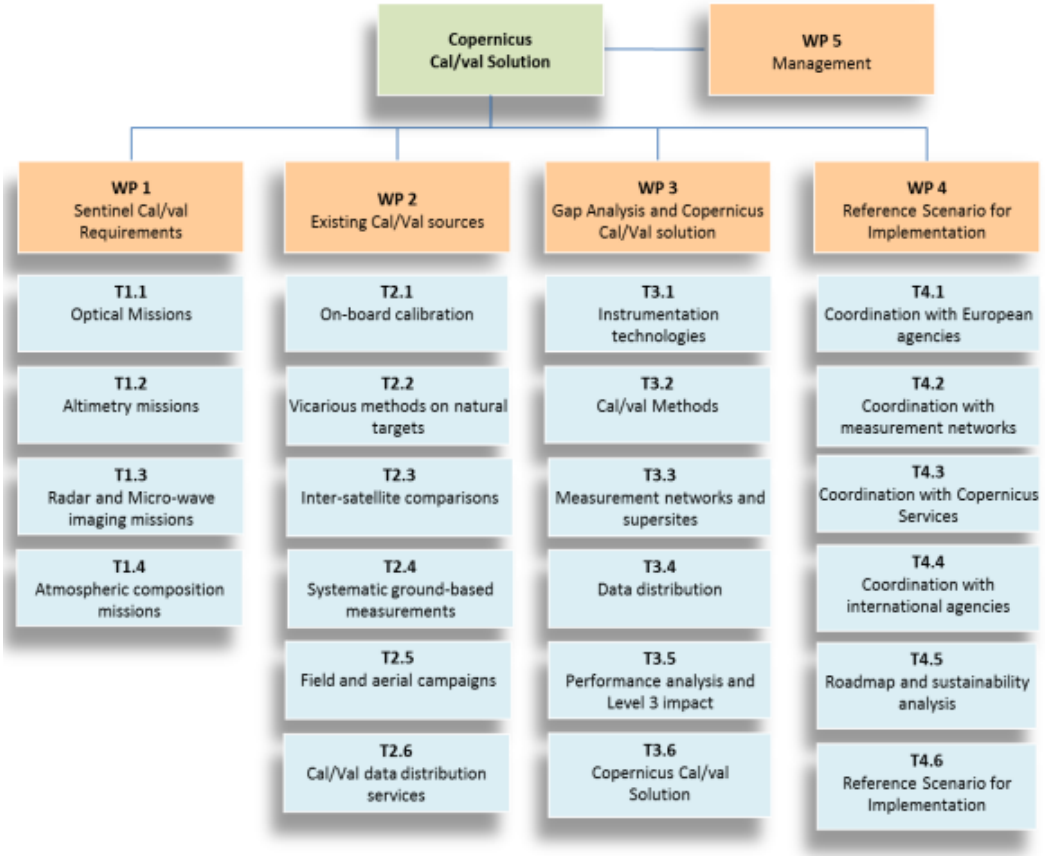
- H2020 Coordination and Support Action
- Objective: *"To define a holistic solution for all Copernicus Sentinel missions (either operational or planned) to overcome current limitations of Calibration and Validation (Cal/Val) activities."*
- Kick-Off 02/12/2020
- 2-year project
  - Phase 1 06/2021: Analysis and state of the art
  - Phase 2 : Elaboration of a new Cal/Val Solution
- Today's presentation is focused on S2 L2A validation sources, but CCVS will also address L1C validation



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CCVS partners

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Parameters to be validated

- SCL: accuracy assessment, with specific focus on cloud mask
- AOD
- WV
- Directional Surface Reflectance VIS/SWIR

Performance requirements

- Mission requirement S2-MP-200: 5% relative accuracy for SDR (goal)
- Performance targets set by MPC team:
  - ✓ Uncertainty(SDR) < 0.05 * SDR + 0.005
  - ✓ Uncertainty(WV) < 0.1 * WV + 0.2 [$kg.m^{-2}$]
  - ✓ Uncertainty(AOD) < 0.1*AOD + 0.03
- Classification accuracy: no performance target defined yet

Preliminary considerations on Sentinel-2 Level 2A validation

Validation scope and influence factors

- Surfaces with various biomes and land cover types
- Temporal sampling
  - ✓ Compatible with phenology for vegetated sites
  - ✓ Dense and long time series to assess surface reflectance smoothness
- In-land waters
- Various atmospheric conditions and cloud cover
- Various altitudes and topography
- Sensibility to adjacency effects and inhomogeneity to be investigated
- Various latitudes (but with SZA < 70°)

Surface Reflectance Validation sources

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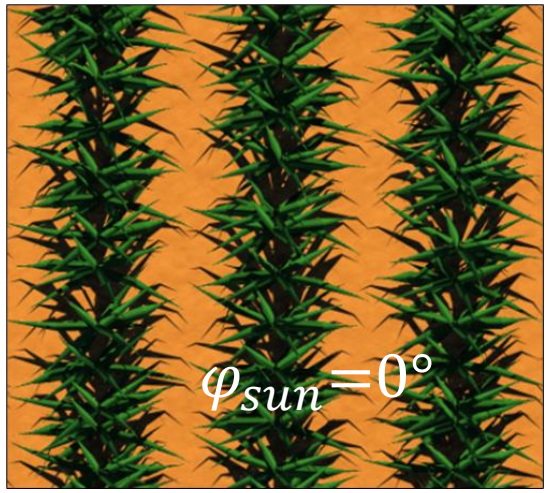
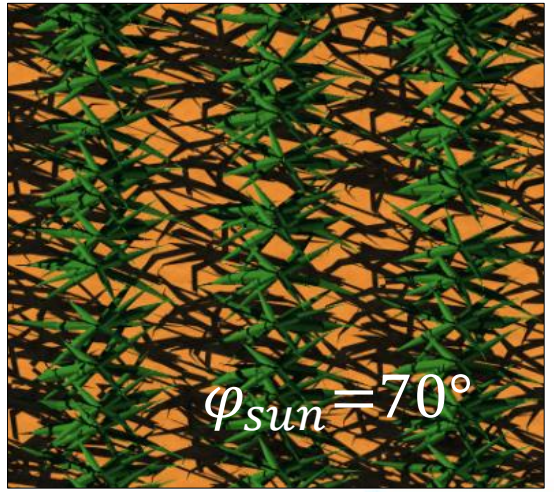
- **Inter-satellite validation**
  - Comparisons with LANDSAT, MODIS, Sentinel-3 SYN L2
    - ✓ Require Simultaneous Nadir Observations and/or correction with BRDF models
    - ✓ Spectral Band adjustment
- **Algorithm comparisons**
  - ACIX exercise
- **Models / Natural sites**
  - Comparison with PICS models is possible but probably not very useful
  - 3D modelling of validation sites (DART, E-Radiate…) could be useful for BRDF assessment



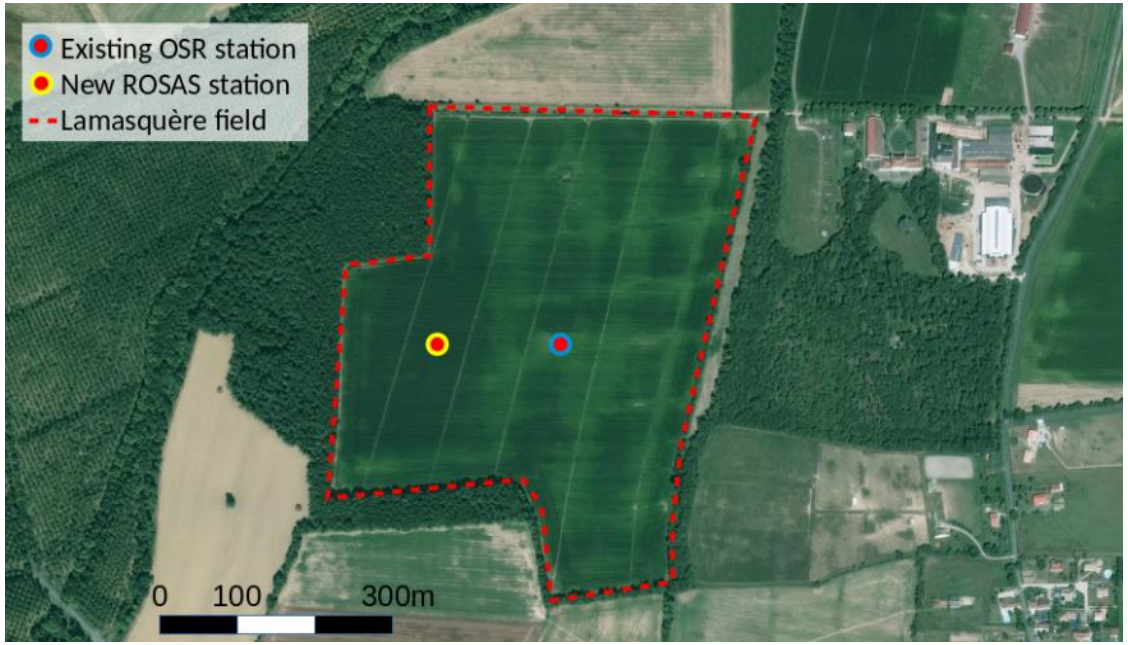


DART simulation
Courtesy CESBIO

Surface Reflectance Validation sources

In-situ: radiometers

- **RadCalNet sites**
  - ✓ Not ideally suited for L2 validation (bright soil and clear atmosphere)
- **New ROSAS site**
  - ✓ Planned site at Lamasquère (CESBIO)
  - ✓ 24-hectare field, rotating cereal crops
  - ✓ Homogeneity of the surface around measurement point is critical



Lamasquère site, CESBIO

Surface Reflectance Validation sources

In-situ: radiometers

- **Hypernets**
  - ✓ HYPSTAR sensor: hyperspectral radiometer
  - ✓ Multi-sensor validation
  - ✓ Tests planned at Whytham woods site, PI NPL
  - ✓ Homogeneity is again a critical point
- **Synergies with existing networks (e.g. BSRN, ICOS…) to be investigated**

Whytham woods site

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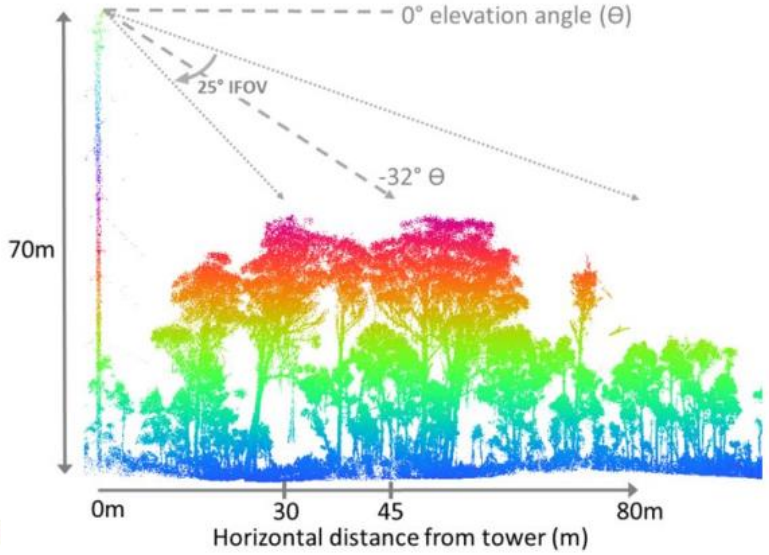
In-situ: hyperspectral camera

- **Hyperspectral camera on pan/tilt mechanism**
  - ✓ Example: THEMS instrument (Woodgate et al. 2020)
  - ✓ Provides information about homogeneity and BRDF effects
  - ✓ But methodology for comparison with satellite data needs to be defined

Woodgate et al., 2020



Surface Reflectance Validation sources

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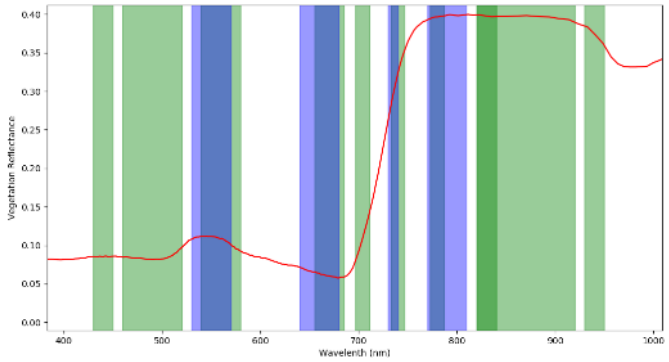
Aerial campaigns

- UAV:
  - ✓ Example: off-the-shelf BlueGrass drone
  - ✓ 4 bands in the red-edge – good match with S2 bands, less good with S3
- Manned aerial campaigns:
  - ✓ e.g. DLR, ONERA, NEON
- Homogeneity and BRDF effects can be assessed
- Operation cost is higher
- Potential for cross-mission campaigns ? e.g. LANDSAT, FLEX ?

Dahra orthoimage
courtesy CIRAD/IRD



S2 bands
BlueGrass Bands

Surface Reflectance Validation sources

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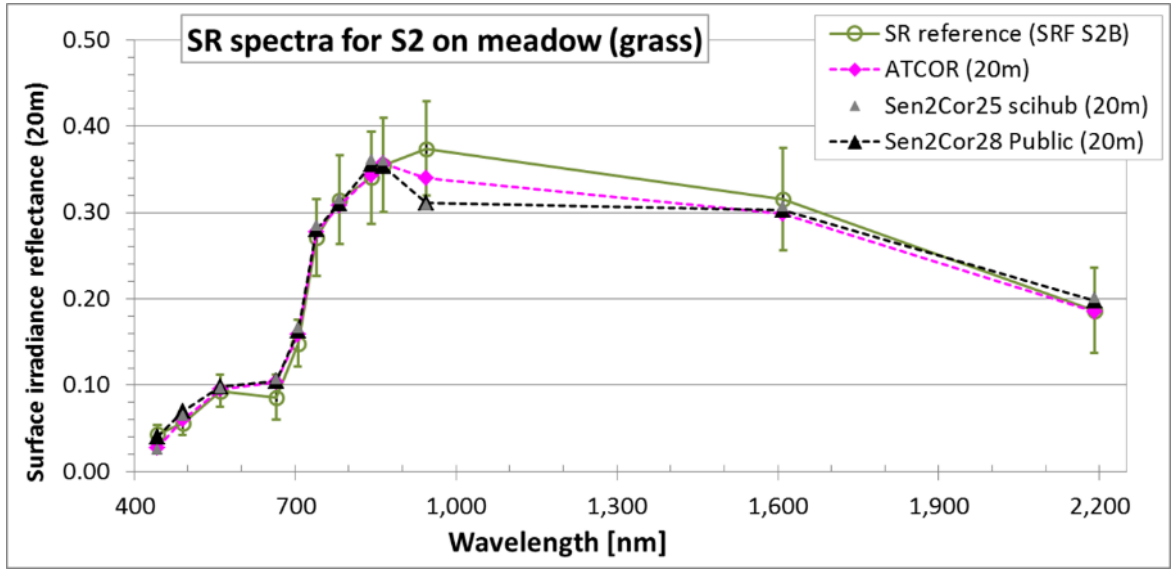
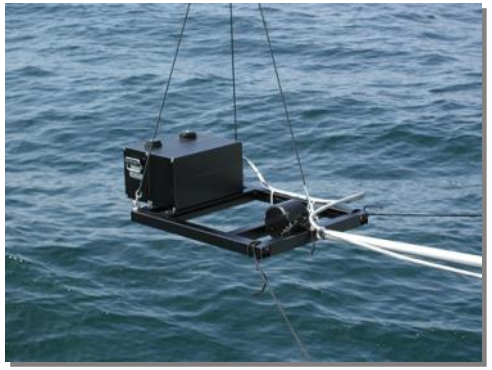
- **In-situ: field campaigns**
  - Example: DLR Lake Stechlin campaigns
  - Very valuable source of reference measurements
  - Assessment of inhomogeneity / adjacency effects
  - Various surfaces (grass, water)





AOD / WV Validation sources

Well-established in-situ data sources

- Various networks: TCCON, AERONET, GRUAN….
- Methodology is mature
- Goal: establish synergies with other Copernicus missions
  - ✓ Data collection and processing: e.g. LAW project for S3
  - ✓ Triple Collocations ?

Scene Classification Validation sources

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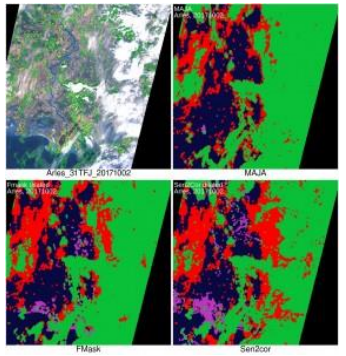
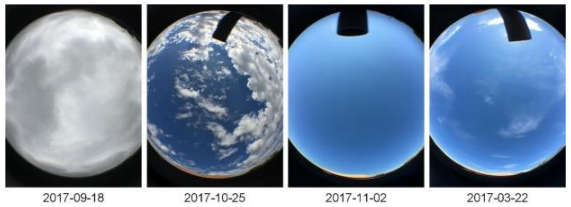
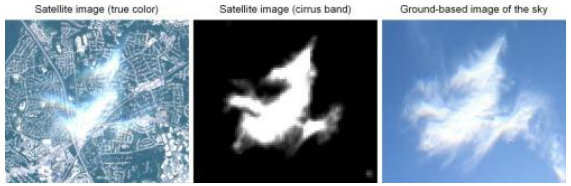
- **Manual photo-interpretation**
  - "State-of-the-art" method
  - Human resource-intensive – classification validation tools help (e.g. Active Learning for Cloud Detection)
- **In-situ**
  - Zenith-looking DHP camera: e.g. Skakun et al. 2021
  - Cloud altitude from stereo or ceilometer
- **Other approaches**
  - Algorithm inter-comparisons (CMIX)
  - Statistical (e.g. % of unclassified pixels)



Baetens et al. 2019





Skakun et al. 2021

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Perspectives for the validation of S2 L2A products

- Combination of high-quality “FRM”-type measurements and more systematic “low quality” measurements
- Efforts on methodology and instrumentation are needed (e.g. surface reflectance, cloud masks)

Getting involved

- CCVS is looking for contributions to build the future Copernicus Cal/Val Solution
  - ✓ New ideas (methods, technologies, approaches…)
  - ✓ Contributions and available facilities (sites, networks, infrastructures…)
- Public virtual Workshop planned for October 2021 (TBC)
- Check the CCVS website for news ccvs.eu
- Contact us at contact@ccvs.org

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