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
Preliminary considerations on Sentinel-2 Level 2A validation

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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

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- 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**

- **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

\[ \varphi_{sun} = 0^\circ \]
\[ \varphi_{sun} = 70^\circ \]
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

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- **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**

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Whytham woods site
**Surface Reflectance Validation sources**

**In-situ: hyperspectral camera**

- **Hyperspectral camera on pan/tilt mechanism**
  - Example: THEMIS 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

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?

S2 bands
BlueGrass Bands

Dahra orthoimage courtesy CIRAD/IRD
Surface Reflectance Validation sources

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

**AOD / WV Validation sources**
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)
(Preliminary) Conclusions and Perspectives

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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

Project Funded by the European Union under GA 101004242