CEOS-ARD FOR SYNTHETIC APERTURE RADAR – 2023 STATUS UPDATE

Ake Rosenqvist[1,2], Clément Albinet[3], Bruce Chapman[4], François Charbonneau[5], Danilo Dadamia[6], Guillaume Hajduch[7], Josef Kellndorfer[8], Marco Lavalle[3], Thomas Logan[9], Franz Meyer[9], Nuno Miranda[4], Paolo Pasquali[10]; Marko Repse[11], HariPriya Sakethapuram[12] Andreia Siqueira[13]; David Small[14], Takeo Tadono[1], Medhavy Thankappan[13], John Truckenbrodt[15], Anna Wendleder[15], Fang Yuan[16], Howard Zebker[17], Zheng-Shu Zhou[18]

[1]Japan Aerospace Exploration Agency (JAXA); [2]solo Earth Observation (soloEO); [3]European Space Agency (ESA); [4]Jet Propulsion Laboratory, Caltech (JPL); [5]Canada Centre of Remote Sensing, NRCan; [6]Argentina Space Commission (CONAE); [7]Collecte Localisation Satellites (CLS); [8]Earth Big Data; [9]Alaska Satellite Facility (ASF); [10]sarmap; [11]Sinergise; [12]Indian Space Research Organisation (ISRO); [13]Geoscience Australia; [14]Univ. of Zürich (UNZ); [15]German Aerospace Center (DLR); [16]FrontierSI; [17]Stanford Univ.; [18]Commonwealth Scientific and Industrial Research Organisation (CSIRO)

CEOS Analysis-Ready Data (CEOS-ARD) – previously referred to as CARD4L – is a joint effort by the Committee on Earth Observation Satellites (CEOS) agencies to streamline data flows and enable interoperable products between sensors and data providers, and, specifically, to broaden the Earth Observation user community by provision of data products that do not require expert knowledge to ingest and analyse. This last point is perhaps particularly relevant for Synthetic Aperture Radar (SAR), where the potential to contribute to today's great environmental challenges with unique information is significant, but with the SAR user community remaining small and expert-oriented even after 30+ years of operational SAR missions. CEOS ARD for SAR is an opportunity to bridge that gap.

In a coordinated effort by the CEOS Land Surface Imaging Virtual Constellation (LSI-VC) and the CEOS Working Group on Calibration and Validation (WGCV) SAR Subgroup, three SAR-specific CARD4L Product Family Specifications (PFS) have been developed and two more are under development:

- **Normalised Radar Backscatter (NRB)**. The NRB product has been subject to Radiometric Terrain Correction (RTC) and is provided in the gamma-nought (γ^0) backscatter convention. It is the most common SAR product and expected to be useful for, in particular, non-expert users.

- **Polarimetric Radar (POL).** The POL product format is an extension of the NRB format, required in order to better support Level-1 SLC polarimetric data, including full-polarimetric modes (RADARSAT-2, ALOS-2, SAOCOM and future missions), and hybrid or linear dual-polarimetric modes (i.e., Compact Polarimetric mode available on RCM, SAOCOM and the upcoming NISAR mission). The POL product can be defined in two processing levels:
    - The normalised covariance matrix (CovMat) representation which preserves the inter-channel polarimetric phase(s) and maximizes the available information for users.
    - Polarimetric Radar Decomposition (PRD) products, derived from coherent or incoherent polarimetric decomposition techniques. The selection of composition product(s) to be offered (e.g., Freeman-Durden, van Zyl, Cloude-Pottier, Yamaguchi-based) are at the discretion of each data provider.

- **Ocean Radar Backscatter (ORB).** The ORB product is a simplified version of the NRB. The main differences are the geometric correction with respect to a geoid and the provision of measurements in sigma-nought (σ^0) backscatter convention, which is recommended for most ocean applications

- **Geocoded Single-Look Complex (GSLC).** The CARD4L GSLC product describes the complex radar reflectivity on the surface with all propagational phases removed, so that the amplitude and phase values represent properties of the surface and not the instrument. GSLC data are presented in a common, often user-defined, ground based coordinate system (e.g. UTM, geographical coordinates, etc.), rather than in radar slant range coordinates, to facilitate use by non-radar-specialists.

- **Interferometric Radar (INSAR).** The CARD4L INSAR product specification covers a suite of three products generated by InSAR processing of (at least) two images captured of the same geographic area at different times:
    - Wrapped interferogram: Image of differential phase signals between two SLC images.
    - Unwrapped interferogram: Image of differential phase signals where the wrapped fringes are summed ("unwrapped") to give a continuous phase signal across the image.
    - Interferometric coherence: Image of phase coherence between the two images.

The NRB, POL and ORB specifications have been endorsed by CEOS LSI-VC and can be accessed on the CEOS ARD website [1]. The GSLC and INSAR product specifications are under development.

CEOS ARD Normalised Radar Backscatter products are currently produced operationally by the SentinelHub through Digital Earth Africa (Sentinel-1 data) [2], and by JAXA's Earth Observation Research Center (JERS-1, ALOS PALSAR, ALOS-2 PALSAR-2 global mosaic data) [3]. CEOS-ARD SAR products are also being considered by, amongst others, the Alaska Satellite Facility, CSIRO, CONAE, ESA and ISRO.

REFERENCES

[1] CEOS Analysis Ready Data website; https://ceos.org/ard

[2] Yuan F., Repse M., Leith A., Rosenqvist A., Milcinski G., Moghaddam N.F., Tishampati D., Burton C., Hall L., Jorand C., Lewis A., "An Operational Analysis Ready Radar Backscatter Dataset for the African Continent", *Remote Sens.* **2022**, *14*(2), 351; https://doi.org/10.3390/rs14020351

[3] Japan Aerospace Exploration Agency, Earth Observation Research Center (JAXA EORC), Global PALSAR-2/PALSAR/JERS-1 SAR Mosaic homepage: https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf_e.htm