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Geophysical Research Abstracts
Vol. 20, EGU2018-15538, 2018
EGU General Assembly 2018

Level 3 wide-area backscatter time-series for wet-snow mapping and forest classification

David Small (1), Christoph Rohner (1), Nuno Miranda (2), Marius Rüetschi (3), Lars Waser (3), Marius Vögtli (1), and Michael Schaepman (1)

(1) University of Zurich, Remote Sensing Laboratories, Zurich, Switzerland (david.small@geo.uzh.ch), (2) European Space Agency, Frascati, Italy (nuno.miranda@esa.int), (3) Swiss Federal Institute for Forest, Snow and Landscape Research WSL (marius.rueetschi@wsl.ch)

Standard level 1 (L1) radar backscatter products are currently the basic unit of data access for most scientists to data from radar satellites such as Sentinel-1A (S-1A), Sentinel-1B (S-1B), Radarsat-2 (RS2). L1 data are typically delivered in either slant or ground range geometry (e.g. SLC: single-look-complex, or GRD: ground range detected in the case of Sentinel-1 data).

CEOS defines level 3 products as "data or retrieved environmental variables that have been spatially and/or temporally re-sampled (i.e. derived from level 1 or 2 products). Such re-sampling may include averaging and compositing". We apply terrain geocoding to transform L1 products into our L3 reference map geometry. Both the *geometry* and *radiometry* of the L1 backscatter values are corrected for terrain distortions, ensuring that the backscatter estimates can be compared on a "level playing field". These radiometrically-terrain-corrected (RTC) products are then input into a compositing stage, whereby all observations available from within a given time-window are combined into a composite backscatter map representing the time-span. When multiple observations are available within the time window, then weighting is applied based on the reciprocal of the local area (i.e. the local resolution) of each RTC value. This enables the generation of seamless wide-area backscatter composites.

We demonstrate such products generated over the Alps, Arctic Canada, Iceland, and forested regions within Switzerland. We then show examples of applications that can use such products as input, e.g. wet-snow mapping, storm damage assessment, classifying mixed temperate forest through comparison of summer vs. winter composite maps, and monitoring forest phenology through time series analysis in spring and autumn. Were standardized L3 products to be made available to users, then many applications could be developed in relatively simple 2D image geometry, and users would be freed from the necessity of grappling with multiple (and relatively complex) individual L1 slant or ground range geometries. In addition, data quality is enhanced by mitigating unwanted properties of single-acquisition data such as variable local resolution, noise, speckle and short-term environmental variations.

Building reliable L3 products requires the availability of a sufficiently accurate DEM, and that the L1 products used as input meet strict quality standards, esp. concerning their (a) geolocation accuracy, and (b) radiometric calibration. We demonstrate wide area backscatter time-series derived from single-sensor composites as well as S-1A/S-1B combinations and finally S-1/RS2. The latter demonstration helps indicate the types of opportunities that will become possible after the launch of the Radarsat-Constellation-Mission (RCM) composed of three C-band Radar satellites due for launch later this year. We illustrate how, by ensuring high standards of geometric and radiometric calibration, wide-area coverage could be obtainable with unprecedented near-daily temporal resolution, even at temperate latitudes.