Canada's PALSAR-2 L-band dual-polarized radar backscatter summer composite, circa 2020

This ''Readme" file is a more detailed text describing the dataset compared to the one found online at https://doi.org/10.23687/8ec4ee78-9240-4bd0-9c97-d3a27829e209, particularly for the methodology and the additional information on dataset.

This data publication contains the first ever Canada-wide gap-free, and radiometrically optimized mosaic of PALSAR-2 L-band dual-polarized radar backscatter summer composite for the year 2020. Its primary purpose is to offer the best possible analysis ready data (ARD) of L-band SAR summer-like composite mosaic mostly tailored for i) classifying natural treed or shrubby vegetation covers of boreal regions, particularly for upland forests and treed wetlands as reported by Pontone et al. 2024, and ii) estimating their structural attributes, such as height and biomass. It can be used for a range of terrestrial mapping applications beyond boreal regions and for different land cover types, although certain limitations are outlined below.

Methodology

The generation of this product involved the cloud-based post-processing of the freely available and open dataset of yearly JAXA Global PALSAR-2/PALSAR Mosaics ver. 1 (hereafter JAXA GPM v1) acquired over Canada. They were generated by the Japanese space agency (JAXA) using L-band SAR sensors aboard the Advanced Land Observing Satellite-2 (ALOS-2 PALSAR-2, 2015 to 2020) and the advanced Land Observing Satellite (ALOS PALSAR, 2007 to 2010). JAXA GPM v1 worldwide mosaics provide yearly orthorectified and slope-corrected L-band HH- and HV-polarized gamma naught (γ°) backscatter amplitude data as 1° x 1° tiles with 25-m resolution and scaled as 16-bit digital number (DN) values (Shimada et al. 2014). JAXA GPM v1 along with details are found at https://www.eorc.jaxa.jp/ALOS/en/dataset/fnf_e.htm and are accessible as a Google Earth Engine image collection at https://developers.google.com/earth-engine/datasets/catalog/JAXA_ALOS_PALSAR_YEARLY_SAR.

The yearly 2007 to 2020 JAXA GPM v1 dataset underwent a pixel-level post-processing methodology we implemented in Google Earth Engine combining in-house and published JavaScript codes (Mullissa et al. 2021) as detailed in Pontone et al. 2024. In summary, the method's three steps involved:

1. Post-processing of yearly 2007-to-2020 JAXA GPM v1 γ°HH and HV datasets: i) removing yearly data gap fillings applied by JAXA, ii) transforming 16-bit γ° amplitude data to 32-bit γ° intensity data, iii) applying spatial and temporal speckle filtering and iv) deriving two radar vegetation indices, the HV/HH γ° ratio (HVHH) and the Radar Forest Degradation Index (RFDI, Mitchell et al. 2012).

2. Temporal compositing of yearly 2015-to-2020 speckle filtered γ° HH, HV, HVHH, and RFDI backscatter data from PALSAR-2 aimed to i) address differently yearly data gaps and ii) mitigate detrimental backscatter fluctuations across ALOS-2 orbits resulting from numerous out-of-summer acquisitions particularly in northwestern Canada, due to the PALSAR-2 Basic Observation Scenario (BOS).We used temporal score-weighted averaging (*swave*) with yearly weights combining two quantitative scores dealing respectively with i) the temporal lag between PALSAR-2 acquisition and the preferred midst of the summer growing season (August 1st) and ii) the level of soil moisture, with drier soil moisture being

preferred. In cases where pixels were affected by fire or harvesting during the 2015-to-2020 period, as portrayed by the CanLaD yearly disturbance product of Guindon et al. (2017), only post-disturbance PALSAR-2 pixels were temporally composited. This compositing procedure ensures that the resulting circa 2020 temporal composite best reflects the land cover status of the summer of 2020.

3. Generating the final γ° L-band backscatter summer composite raster files: i) transforming 32-bit intensity data of HH, HV, HVHH and RFDI composites back to 16-bit amplitude data, ii) projecting into Lambert conformal conic projection using NAD 83 datum with a 30m pixel size using bilinear resampling and iii) masking out non-Canadian territories with a 100 km buffer.

Performance et limitations

The resulting Canada-wide (excluding the Arctic Archipelago), gap-free and radiometrically optimized mosaic of circa 2020 PALSAR-2 L-band backscatter summer composite was found significantly improved compared to utilizing the single-year 2020 JAXA GPM v1 mosaic, particularly in northern boreal Canada (Pontone et al. 2024). However, this composite is sub-optimal compared to the ideal but currently unavailable scenario of exclusive summer 2020 acquisitions within the JAXA GPM v1 dataset. Therefore, it should be considered as a summer-like composite and users should be mindful of the following known limitations:

- In northwestern Canada, there were often minimal to no summer PALSAR-2 acquisitions due to the PALSAR-2 BOS, resulting in unavoidable residual backscatter fluctuations across ALOS-2 orbits.

- The composite may exhibit patchy radiometric noise in areas that experienced disturbances between 2015 and 2020, owing to uncertainty in the CanLAD disturbance date relative to the PALSAR-2 acquisition date (particularly for 2020).

- Due to the temporal compositing optimized for natural treed or shrubby vegetation covers of boreal regions, this product is deemed less performant, or possibly not suitable, for i) characterizing other land cover types, particularly highly dynamic ones such as grasslands, croplands, and water bodies, or for ii) estimating soil and/or vegetation moisture content for the year 2020.

As a final note, JAXA released an improved GPM ver. 2 up to year 2022 (JAXA GPM v2) available as a Google Earth Earth collection at https://developers.google.com/earth-engine/datasets/catalog/JAXA_ALOS_PALSAR_YEARLY_SAR_EPOCH that was not available at the time of our study. A preliminary analysis shows that our circa 2020 PALSAR-2 composite still seems to outperform the 2020 JAXA GPM v2 in northern Canada. However, the use of yearly JAXA GPM v2 datasets in our methodology is expected to provide a further improved and more up to date PALSAR-2 L-band dual-pol summer backscatter composite across Canada.

Dataset Citation:

Beaudoin, A., Villemaire, P., Gignac, C., Tolszczuk, S., Guindon, L., Pontone, N., Millard, C. (2024). Canada's PALSAR-2 dual-polarized L-band radar summer backscatter composite, circa 2020. Natural Resources Canada, Canadian Forest Service, Laurentian Forestry Centre, Quebec, Canada. https://doi.org/10.23687/8ec4ee78-9240-4bd0-9c97-d3a27829e209

In addition, please provide credits to the Japanese space agency JAXA with the mention "Original Global PALSAR-2/PALSAR Mosaics v1 provided by JAXA (©JAXA)"

Publication Reference for Product Development and Use in Wetland Mapping:

Pontone, N., Millard, K., Thompson, D., Guindon, L., Beaudoin, A. (2024). A hierarchical, Multi-Sensor Framework for Peatland Sub-Class and Vegetation Mapping Throughout the Canadian Boreal Forest. *Remote Sensing for Ecology and Conservation* (accepted for publication).

Cited references:

Guindon, L., Villemaire, P., St-Amant, R., Bernier, P.Y., Beaudoin, A., Caron, F., Bonucelli, M., Dorion, H. (2017). Canada Landsat Disturbance (CanLaD): a Canada-wide Landsat-based 30-m resolution product of fire and harvest detection and attribution since 1984. https://doi.org/10.23687/add1346b-f632-4eb9-a83d-a662b38655ad

Mitchard, E. T. A., Saatchi, S. S., White, L. J. T., Abernethy, K. A., Jeffery, K. J., Lewis, S. L., Collins, M., Lefsky, M. A., Leal, M. E., Woodhouse, I. H., & Meir, P. (2012). Mapping tropical forest biomass with radar and spaceborne LiDAR in Lopé National Park, Gabon: Overcoming problems of high biomass and persistent cloud. Biogeosciences, 9(1), 179–191. https://doi.org/10.5194/bg-9-179-2012

Mullissa, A., Vollrath, A., Odongo-Braun, C., Slagter, B., Balling, J., Gou, Y., Gorelick, N., Reiche, J. (2021). Sentinel-1 SAR Backscatter Analysis Ready Data Preparation in Google Earth Engine. Remote Sensing, 13(10), 1954. https://doi.org/10.3390/rs13101954

Shimada, M., Itoh, T., Motooka, T., Watanabe, M., Tomohiro, S., Thapa, T., Lucas, R. (2014). New Global Forest/Non-Forest Maps from ALOS PALSAR Data (2007-2010). Remote Sensing of Environment, 155, pp. 13-31. https://doi.org/ 10.1016/j.rse.2014.04.014

Additional Information on Dataset:

This dataset comprises four raster geotiff files of circa 2020 L-band PALSAR-2 summer-like temporal composites as four wall-to-wall mosaics of orthorectified and slope corrected dual-polarized HH and HV gamma naught (γ°) backscatter amplitude along with two radar vegetation indices (HVHH, RFDI), all scaled as 16-bit Digital Number (DN) values. A fifth 8-bit RGB quick-view raster file is also provided. Data are provided in Lambert conformal conic projection using NAD 83 datum (http://www.spatialreference.org/ref/sr-org/8787/) and with 30m pixel size. The following list provides the five raster file names along with short content descriptions and equations to transform DN values into absolute γ° intensity values in decibels (dB).

- Circa2020_Canada_PALSAR-2_Summer_Composite_HH.tif:
  HH-polarized backscatter amplitude
  $\gamma°_{HH}$ (dB) = $10\log_{10}(DN_{HH}^2) - 83$

- Circa2020_Canada_PALSAR-2_Summer_Composite_HV.tif:
  HV-polarized backscatter amplitude
  $\gamma°_{HV}$ (dB) = $10\log_{10}(DN_{HV}^2) - 83$

- Circa2020_Canada_PALSAR-2_Summer_Composite_HVHH.tif*:
  Amplitude of HV over HH backscatter ratio, $\gamma°_{HVHH} = (\gamma°_{HV} / \gamma°_{HH})$
  $\gamma°_{HVHH}$ (dB) = $10\log_{10} (DN_{HVHH}/10^4)^2$

- Circa2020_Canada_PALSAR-2_Summer_Composite_RFDI.tif*:
  Amplitude of the Radar Forest Degradation Index, $\gamma°_{RFDI} = (\gamma°_{HH} - \gamma°_{HV})/ (\gamma°_{HH} + \gamma°_{HV})$
  $\gamma°_{RFDI}$ (dB) = $10*\log_{10}(DN_{RFDI}/10^4)^2$

- Circa2020_Canada_PALSAR-2_Summer_Composite_RGB_Quick_View.tif:
  8-bit RGB quick-view rendering of HH, HV and HVHH backscatter amplitude
  (for data visualisation purposes only; no stretch required)

* Notice that the HVHH and RFDI indices are highly correlated as being quasi-linearly related; nevertheless, we provide both indices as one index may perform a bit better than the other one depending on the targeted use. Furthermore, these indices were composited the same way as the HH and HV backscatter data. Therefore, re-calculating them from the provided HH and HV backscatter composites will result in slightly different values than those provided.