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SenSARP: A pipeline to pre-process Sentinel-1 SLC data by using ESA SNAP Sentinel-1 Toolbox

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Summary

The Sentinel-1 mission consists of two polar-orbiting satellites acquiring Synthetic Aperture Radar data (SAR) at C-band (frequency of 5.405 GHz) with a revisit time of 6 days. The SAR data is distributed free of charge via the Copernicus Open Access Hub (https://scihub.copernicus.eu/) by European Space Agency (ESA) and the European Commission. Large archives are also provided by Data and Information Access Services (DIAS) which serve the purpose to facilitate the access and use of Sentinel Data. Due to the specific imaging geometry of the radar system the acquired radar data contains different radiometric and geometric distortions. The radiometric quality is affected by spreading loss effect, the non-uniform antenna pattern, possible gain changes, saturation, and speckle noise. Geometric distortions such as foreshortening, layover or shadowing effects are based on the side looking radar acquisition system. To account for these radiometric and geometric distortions the Sentinel-1 Level 1 data has to be corrected radiometrically and geometrically before the data can be used for further analysis or within third party applications. Therefore, either an automatic or manual pre-processing of Sentinel-1 images is needed.

Statement of need

Sentinel-1 satellites will provide continuous free available microwave remote sensing data of the entire globe at least until the end of 2030. Furthermore, ESA is not only providing Sentinel satellite images (e.g. Sentinel-1, Sentinel-2, Sentinel-3) but they also developed free open source toolboxes (Sentinel-1, 2, 3 toolboxes) for scientific exploitation. The toolboxes can be accessed and used via the Sentinel Application Platform (SNAP). SNAP offers a graphical interface were expert users can develop different processing schemes and apply them on the satellite images. Although, Sentinel-1 satellite data and a processing software are freely available, the usage of the data is mainly limited to expert users in the field of microwave remote sensing as different pre-processing steps need to be applied before using Sentinel-1 images.

SenSARP was developed to provide a push-button option to easily apply a rigid pre-processing pipeline with sensible defaults to a Sentinel-1 Level 1 SLC time series data as well as single Sentinel-1 Level 1 SLC images. Thus, non-expert users in the field of pre-processing microwave data are able to use radiometric and geometric corrected sigma nought backscatter data for their specific applications. Beside a rigid pre-processing pipeline SenSARP provides filter options to retrieve only images of a specific year or images that contain a specific area of interest from a stack of downloaded Sentinel-1 data. Furthermore, the default processing scheme of SenSARP can handle if an area of interest is contained in two tiles of the same swath (due to storage reasons data of one Sentinel-1 satellite swath is provided by ESA within

different tiles). Additionally, SenSARP checks if within a stack of Sentinel-1 images one specific image was multiple processed by ESA and uses the newest.

For expert users SenSARP provides the possibility to automate their pre-processing on a large scale by either modifying the default pre-processing scheme (modification of xml graph pre_processing_step1.xml) or create their own pre-processing scheme (create a new xml graph) with the graph builder of the SNAP software. They can benefit from the filter options, the default pre-processing step 2 (co-registration of images) and the SenSARP functions to stack all processed and co-registered images within a netCDF file with additional image information e.g. satellite name, relative orbit and orbitdirection.

Method

This python package generates a file list of to be processed Sentinel-1 images (already downloaded and stored in a specific folder) based on different user defined criteria (specific year, area of interest). Additionally, specific cases of repeatedly processed data are handled, as sometimes Sentinel-1 data were initially processed multiple times and stored under similar names on the Copernicus Open Access Hub. Also, cases where Sentinel-1 data within the user-defined area of interest might be stored in consecutive tiles are considered.

Based on the generated file list the default processing pipeline of the python package applies a pre-processing chain to Sentinel-1 Single Look Complex (SLC) time series or single images to generate radiometrically and geometrically corrected Sigma nought backscatter values. Furthermore, if a time series is processed the images are co-registered and additional output files of multi-temporal speckle filtered data are generated. In addition, a single speckle filter instead of a multi-temporal one is applied as well and the output will be stored as a separate layer. To pre-process the images, the python package uses the GPF (Graph Processing Framework) of SNAP and the operators provided by the Sentinel-1 Toolbox. The Sentinel Toolbox is available for download at step.esa.int, its source code is available in the senbox-org organization on Github. Each of these operators performs a pre-processing step. The operators can be chained together to form a graph, which is used by the python package to run on the Sentinel-1 data using the GPF. The graphs are stored in xml-files. Users may change the graphs by modifying the files directly or via the Sentinel Toolbox. User Guides to show how the GPF can be used are provided here: https://senbox.atlassian.net/wiki/spaces/SNAP/pages/70503053/Processing.

After the pre-processing the resulting radiometrically and geometrically corrected images are stored for further usage within a NetCDF4 stack file. Among other applications the processed images can be used e.g. for flood risk analysis, monitoring land cover changes, monitoring global food security or estimation of land surface parameters. In the future many more new products and operational third party services based on consistent Sentinel-1 time series might be developed.

Applications

This python package was developed within the Horizon 2020 project called MULTIscale SENTINEL land surface information retrieval Platform (MULTIPLY) (http://www.multiply-h2020.eu/, https://cordis.europa.eu/project/id/687320, https://multiply.obs-website.eu-de.otc.t-systems.com). Furthermore, data processed by this package is used within Sentinel-Synergy-Study S3 project (https://www.researchgate.net/project/Sentinel-Synergy-Study-S3). In addition, the python code was used to process Sentinel-1 time series images for the detection and analysis of temporary flooded vegetation (Tsyganskaya et al., 2018, 2019) and for the evaluation of different radiative transfer models for microwave backscatter estimation of wheat fields (Weiß et al., 2020).

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References

Tsyganskaya, V., Martinis, S., & Marzahn, P. (2019). Flood Monitoring in Vegetated Areas Using Multitemporal Sentinel-1 Data: Impact of Time Series Features. *Water*, *11*(9), 1938. https://doi.org/10.3390/w11091938

Tsyganskaya, V., Martinis, S., Marzahn, P., & Ludwig, R. (2018). Detection of Temporary Flooded Vegetation Using Sentinel-1 Time Series Data. *Remote Sensing*, *10*(8), 1286. https://doi.org/10.3390/rs10081286

Weiß, T., Ramsauer, T., Löw, A., & Marzahn, P. (2020). Evaluation of Different Radiative Transfer Models for Microwave Backscatter Estimation of Wheat Fields. *Remote Sensing*, *12*(18), 3037. https://doi.org/10.3390/rs12183037