A Global Sentinel-1 Datacube for Soil Moisture and Vegetation Applications

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Earth Observation Data Centre for Water Resources Monitoring

Copernicus Sentinel-1

https://www.esa.int/Applications/Observing_the_Earth/Copernicus/Sentinel-1/Instrument

Sentinel-1 (MENSIG38_VV)
Sentinel-1 (MENSIG38_VV)
Sentinel-1 (MENSIG38_VH)
OpenStreetMap

https://s1map.eodc.eu/

Two Years (2016-2017) 500 000 Sentinel-1 Images 1.1 PB total disk space



Bauer-Marschallinger et al. (2021) The normalised Sentinel-1 Global Backscatter Model – mapping Earth's land surface with C-band microwaves, Scientific Data, 8, 277.

Geophysical Data Retrieval



Datacube Processing Architecture

• From offline scientific analysis to online operations



Wagner et al. (2021) A Sentinel-1 Backscatter Datacube for Global Land Monitoring Applications, *Remote Sensing*, 13, 4622.



Datacube System based upon the Equi7Grid



Sentinel-1 ARD datacube: Concept of Equi7Grid data structure & time series access | Example for T3-tile over the USA

Bauer-Marschallinger et al. (2014) Optimisation of global grids for high-resolution remote sensing data, Computers & Geosciences, 72, 84-93. Figure from Wagner et al. (2021) A Sentinel-1 Backscatter Datacube for Global Land Monitoring Applications, *Remote Sensing*, 13, 4622.



Sentinel-1 Preprocessing



Data Volume in TB

Level-1 Sentinel-1 IW GRD data											
Year	Africa	Asia	Europe	NA	Oceania	SA	Total				
2015	12.7	15.1	22.0	6.2	4.9	5.3	66.2				
2016	20.6	19.2	31.9	11.5	6.6	9.0	98.8				
2017	45.0	53.9	71.8	31.4	18.4	23.1	243.6				
2018	48.0	58.1	70.3	35.3	20.2	24.7	256.6				
2019	94.4	61.1	119.9	38.5	21.1	26.9	361.9				
2020	97.3	63.3	130.7	41.4	21.3	28.6	382.6				
Total	318.0	270.7	446.6	164.3	92.5	117.6	1409.7				

20 m Sentinel-1 datacube										
Year	Africa	Asia	Europe	NA	Oceania	SA	Total			
2015	2.5	2.9	4.3	1.2	1.1	1.0	13.0			
2016	4.4	4.0	6.4	2.5	1.5	1.9	20.7			
2017	9.8	11.9	14.6	6.9	4.3	4.9	52.4			
2018	10.3	12.8	12.8	7.6	4.7	5.2	53.4			
2019	16.9	19.4	23.5	13.4	7.6	8.6	89.4			
2020	17.3	20.1	25.0	14.6	7.7	9.4	94.1			
Total	61.2	71.1	86.6	46.1	26.9	31.0	323.0			



Vegetation Dynamics from Sentinel-1



False colour composite of Sentinel-1 VH images acquired in 2015 over Vienna and surrounding areas

Red – June Green – July Blue – August





Lower Austria



Sentinel-1 Crop Classification with Machine Learning

Comparison of a Long-Short Term Memory (LSTM) network and Random Forest (RF) for crop classification in 3 countries and 5 crop seasons





Reuß et al. (2021) Comparison of Long-Short Term Memory Networks and Random Forest for Sentinel-1 time series based large scale crop classification, submitted.



C-Band Backscatter from Forests



Land Cover Classification



Dostálová, A., M. Lang, J. Ivanovs, L.T. Waser, W. Wagner (2021) European wide forest classification based on Sentinel-1 data, Remote Sensing, 13, 337, 26p.



1 km Sentinel-1 Surface Soil Moisture

a) Drought: Italy Summer 2017 Sentinel-1 SSM Monthly Mean 2017 July



b) Rainfall Event: Po Valley 2017 July 11**Observed Cumulative Rainfall**Sentine2017 July 10 | 0-24h2017 July



2017 July 11 | 0-24h



Precipitation [mm] 0 40 100 200 Sentinel-1 SSM (single observations) 2017 July 10 | 05:18



2017 July 11 | 17:04



Surface Soil Moisture [%]0255075100



Bauer-Marschallinger et al. (2019) Towards global soil moisture monitoring with Sentinel-1: Harnessing assets and overcoming obstacles, IEEE Transactions on Geoscience and Remote Sensing, 57(1), 520-539.



Scattering of Microwaves by Vegetation and Soil

- Radiative transfer model for bi- and monostatic scattering
- Generalised phase functions for modelling surface-volume interactions
- Available on GitHub: https://github.com/TUW-GEO/rt1



Quast et al. (2019) A generic first-order Radiative Transfer modelling approach for the inversion of soil- and vegetation parameters from scatterometer observations, Remote Sensing, 11, 285, 24p.



Sentinel-1 Soil Moisture Retrieval using a Radiative Transfer Model



Sentinel-1 Soil Moisture Retrieval using Machine Learning



Greifeneder et al. (2021) A machine learning-based approach for surface soil moisture estimations with Google Earth Engine, Remote Sensing, 13, 2099, 21p.



Earth Observation Data Centre Collaboration for Earth Observation



Petabyte Storage Supercomputing Cloud Platform

https://eodc.eu/

- Building a federated multi-owner IT infrastructure for
 - Scientists
 - Public services
 - Innovators
- Users are partners who participate in decision making
- Development of collaborative services
 - From data to model predictions



end

Scientific ICT Infrastructure

Technical Infrastructure for Sentinel-1 ARD datacube





Wagner et al. (2021) A Sentinel-1 Backscatter Datacube for Global Land Monitoring Applications, *Remote Sensing*, 13, 4622.

Accessing the Global Sentinel-1 Data Cube

- Via Virtual Machines run on the EODC Cloud and user accounts on the VSC
- Data stored as GeoTIFF files and organized in folders according to the Equi7Grid tiling system



yeoda toolbox

 "your earth observation data access"



- provides lower and higher-level data cube classes to work with welldefined and structured earth observation data.
- https://github.com/TUW-GEO/yeoda
- Upcoming: openEO



openEO – connecting EO back-ends and front-end applications



Schramm et al. (2021) The openEO API - Harmonising use of Earth Observation cloud services using virtual Data Cube functionalities, Remote Sensing, 13, 1125, 21p.



RGB composites over Vienna generated from Sentinel-1 datacube via the **openEO API**



openEO Use Case

- Sentinel-1 polarisation composite of Vienna (March 2017) created at the Google Earth Engine (top) and EODC back-end (bottom) using the openEO API
 - R=Mean of VV
 - G=Mean of VH
 - B=VH/VV

Wagner et al. (2021) A Sentinel-1 Backscatter Datacube for Global Land Monitoring Applications, *Remote Sensing*, 13, 4622.



Outlook

- The Sentinel-1 backscatter datacube is already available to interested users via the EODC (on the basis of individual agreements)
- Besides R&D projects it serves Copernicus Services
 - Land Monitoring Services: soil moisture
 - Emergency Management Service: flood monitoring
- We aim to
 - improve access and usability of Sentinel-1 datacube
 - federate with European infrastructures



EUROPEAN OPEN SCIENCE CLOUD Interested in using the Sentinel-1 Data Cube? Contact info@eodc.eu

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