INTERFACE

Kurzfassung

Seit 2014 hat das europäische Copernicus-Programm eine große Reihe von Erdbeobachtungs (EO) - Satelliten namens Sentinels gestartet. Die Sentinel-Mission soll mindestens für die nächsten 15 bis 20 Jahre Daten liefern, um den Zustand der Umwelt an Land, im Meer und in der Atmosphäre zu überwachen und vorherzusagen. Zu den Zielen von Copernicus gehören die Unterstützung von Klimaschutz- und Anpassungsstrategien, der effiziente Umgang mit natürlichen Ressourcen sowie Notsituationen und die Erhöhung der Sicherheit aller Bürgerinnen und Bürger weltweit. Die ständig wachsende Menge an erfassten Daten macht Copernicus zum größten EODatenanbieter und zum drittgrößten Datenanbieter der Welt. Das Potenzial dieser Daten wurde bereits in mehreren neuen oder verbesserten Anwendungen oder Produkten gezeigt. Dennoch besteht eine große Herausforderung darin die Endnutzer mit diesen Anwendungen/Produkten zu erreichen. Unter der Führung der Österreichischen Forschungsförderungsgesellschaft (FFG) wurden im Rahmen des Austrian Space Applications Programme (ASAP) erhebliche Mittel für die Entwicklung innovativer Anwendungen unter Nutzung großer Copernicus-Daten bereitgestellt. Obwohl diese Projekte bei der Entwicklung und Demonstration innovativer Ideen erfolgreich waren, sind noch signifikante weitere Maßnahmen erforderlich, um die praktische Nutzung und Auffassung solcher neuen Dienste im öffentlichen, aber auch im privaten Bereich zu fördern.
Um die Nutzung von Copernicus-Daten- und -Informationsdiensten für die öffentliche Verwaltung zu etablieren, haben wir die folgenden essentiellen Bereiche für zusätzliche Entwicklungen identifiziert: (1) nutzerzentrierte Schnittstellen und Standards für Daten und höherwertige Produkte, die direkt in die bestehenden lokalen und regionalen Entscheidungsfindungsabläufe des öffentlichen Sektors integriert werden können; (2) das Schließen der Lücke zwischen den vorhandenen hochauflösenden Geodaten und Copernicus-Informationen durch höher auflösende Satellitenmissionen wie die Plejaden-Mission; (3) Die Copernicus-Daten mit anderen Geodatensätzen wie bestehenden luftgestützten und In-situ-Datensätzen zu verknüpfen; (4) die Notwendigkeit, systematisch spezifische höherwertige Produkte zu generieren, die den tatsächlichen Bedarf der öffentlichen Einrichtungen mit ihren speziellen regionalen Anforderungen berücksichtigen, z.B. für die Alpen oder Österreich im Allgemeinen; (5) die Möglichkeit individuelle Datenanalysen durchzuführen, um bestimmte statistische Werte abzuleiten und die Berechnungsabläufe an lokale Bedürfnisse anzupassen, und (6) um Datensätze basierend auf einer semantischen Beschreibung abzufragen und zugänglich zu machen. Das vorgeschlagene Projekt „INformaTion accEss seRvice For Austrian CopErnicus and contributing missions data“ (INTERFACE) adressiert alle oben genannten Herausforderungen systematisch durch eine agile und kontinuierliche Einbindung des öffentlichen Sektors entlang der Implementierung des Serviceprototyps. Neben den oben erwähnten erforderlichen benutzerzentrierten Schnittstellen und Datenstandards wird ein besonderer Fokus auf die Integration der verschiedenen Datensätze sowie den Aufbau eines Prototypenystems gelegt, das die systematische Generierung von höherwertigen Informationsprodukten ermöglicht. Im Zuge der Vorbereitung von INTERFACE haben wir folgende erste konkrete Produkte in Abstimmung mit den öffentlichen Bedarfsträgern identifiziert:

(1) Eine Sentinel-2-basierte Anzeige und Überwachung versiegelter Oberflächen und Zugang zu höchauflösenden Pleiades-Daten zur Validierung

(2) Ein Sentinel-1-basierter Feuchtgebietskartierungsdienst

(3) Ein auf Sentinel-1 und Sentinel-2 basierender Service bezüglich Schneedetektion und der Bestimmung von Schneeeigenschaften

(4) Eine semantische inhaltsbasierte Bildersuche zum automatischen Finden und Bereitstellen von wolkenlosen Sentinel-2-Daten vor und nach einem Ereignis basierend auf einem individuell einstellbaren Datum

(5) Ein Boden- und Massenbewegungserkennungsdienst basierend auf Sentinel-1 InSAR-Daten

(6) Ein Service zur Ableitung von hochauflösenden 3D - Produkten (DSM und DTM) aus Pleiades (Tri) – Stereodaten

Abstract

Since 2014, the European Copernicus programme has launched a wide range of Earth Observation (EO) satellites, named Sentinels. The Sentinel mission is designed to deliver data for at least the next 15 to 20 years to monitor and forecast the state of the environment on land, sea and in the atmosphere. Copernicus' objectives include the support of climate change mitigation and adaptation strategies, efficient management of natural resources as well as emergency situations, and improvement of the security for every citizen of the world. The ever-increasing amount of acquired data makes Copernicus the largest EO data provider and the third biggest data provider in the world. The data's potential has already been shown by experts in several new or improved applications and products. Still, challenges exist to reach end users with these applications/products, i.e. challenges associated with distributing, managing, and using them in users' respective operational contexts. Under the leadership of the Austrian Research and Promotion Agency (FFG), substantial funding through the Austrian Space Applications Programme (ASAP) has been made available to develop innovative applications making use of big Copernicus data. ASAP provides crucial funding for R&D projects sparking scientific advances or commercial applications and cementing Austria's position in the space sector. Although these projects were successful in developing and demonstrating innovative ideas, significant further actions are required to stimulate the practical use and uptake of such new services in both public and private domains.

In order to mainstream the use of Copernicus data and information services for public administration, we have identified the following main areas that require special attention: (1) designing user centric interfaces and standards to data and higher level products that can be directly integrated into existing local and regional decision making workflows and consider tools and services currently used by the public sector; (2) bridging the gap between existing high resolution geo-data and Copernicus information with data from higher resolution contributing missions like Pleiades; (3) linking with other existing geo datasets like airborne, VHR spaceborne and in-situ datasets; (4) systematically generating specific higher level products that consider the needs of public entities and their specific regional requirements, e.g. for the alps or Austria in general; (5) supporting individual on-demand analysis of data to derive certain statistics and adapt workflows to local needs; and (6) querying and obtaining datasets based on a semantic description.

The proposed "INformaTion accEss seRvice For Austrian CopErnicus and contribution missions data" (INTERFACE) addresses all of the previously mentioned challenges in a systematic manner via agile and continuous involvement of the public sector to implement service prototypes. The focus will be on user-centric interfaces and data standards with special attention to integrating different data sets and setting up a prototype system that allows the systematic generation of higher level information products. During a consultation phase while preparing for INTERFACE, we have identified the following initial specific products:
(1) Indicating and monitoring sealed surfaces based on Sentinel-2 and on-demand VHR Pleiades access for verification
(2) Wetland monitoring service using Sentinel-1
(3) Snow characteristics service using Copernicus Sentinel data and information
(4) Semantic content based image retrieval system for automated provision of cloudfree Sentinel-2 data before and after an event based on a user-defined date
(5) Ground motion and mass movement detection service based on Sentinel 1 InSAR data
(6) Service for deriving on-demand high resolution 3D products (DSM and DTM) from Pleiades (Tri) - stereo data

Tailored services

Short description

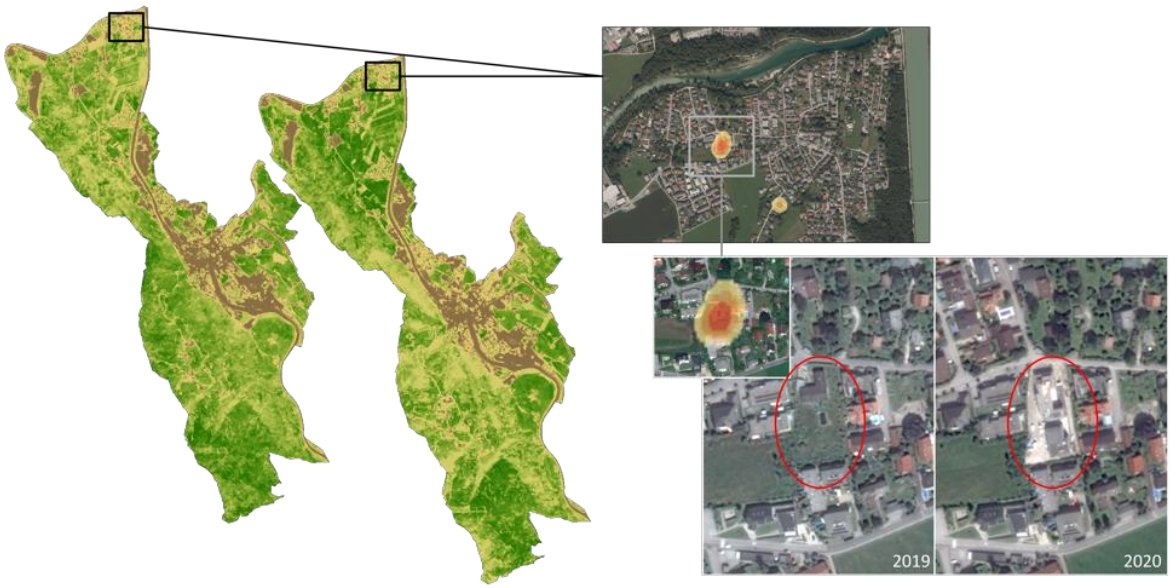
Each of the INTERFACE tailored services will be described in short

Snow Characteristics:

Due to the impact of climate change, the expected change in snow cover dynamics and the associated change in groundwater recharge will have an impact on the water management use of groundwater as a resource. A comprehensive assessment of the development of snow cover and melt extent is an essential basis for identifying any future changes in the amount and intensity of snowmelt water (Bender et al., 2020, Wagner et al., 2021). The proposed NRT snow service makes use of the georeferenced and collocated data of the Sentinel satellite family available in the ACUBE and applies retrieval algorithms for mapping fractional snow from optical data and snow conditions (wet/dry) from SAR. The optical snow products include cloud screening, and detection of fractional snow applying a multispectral retrieval algorithm. The snow conditions, (wet/dry) are detected from dual polarized S1 SAR data applying change detection technique following the algorithm of Nagler et al., 2016. The combined optical and SAR based snow cover and melt extent product is of great importance for future water management plans.

Soil Sealing Identification:

Soil continues to be sealed, thus there are international mandates (e.g. UN SDG 15.3) to reliably and continuously monitor and report land degradation. Science-based methods for detecting such surface changes can leverage high-frequent Earth observations (e.g. from Sentinel-2) to identify soil sealing hotspots inter- and intra-annually. These methods are only effective if they are capable of generating meaningful disaggregated, provincial and national level information and are provided to and in close collaboration with institutions that have provincial and national level interests. Within a currently conducted ASAP 17 project (SIMS - Soil sealing identification and monitoring system, Strasser et al., 2022) a prototypical service to improve analyses of human-induced soil sealing processes and support monitoring, decision-making and reporting activities in Austria is implemented. This prototypical service will be further developed within INTERFACE into a demonstrator up to TRL7. Users should be enabled to conduct custom queries and analyses using graphical semantic models, which are stored and shared in a knowledge base and can be applied to all Sentinel-2 images available in Austria using the sen2cube.at backbone implementation. All semantic models can be reused, e.g. for different AOIs or regular executions and without the need of specific software or programming skills.

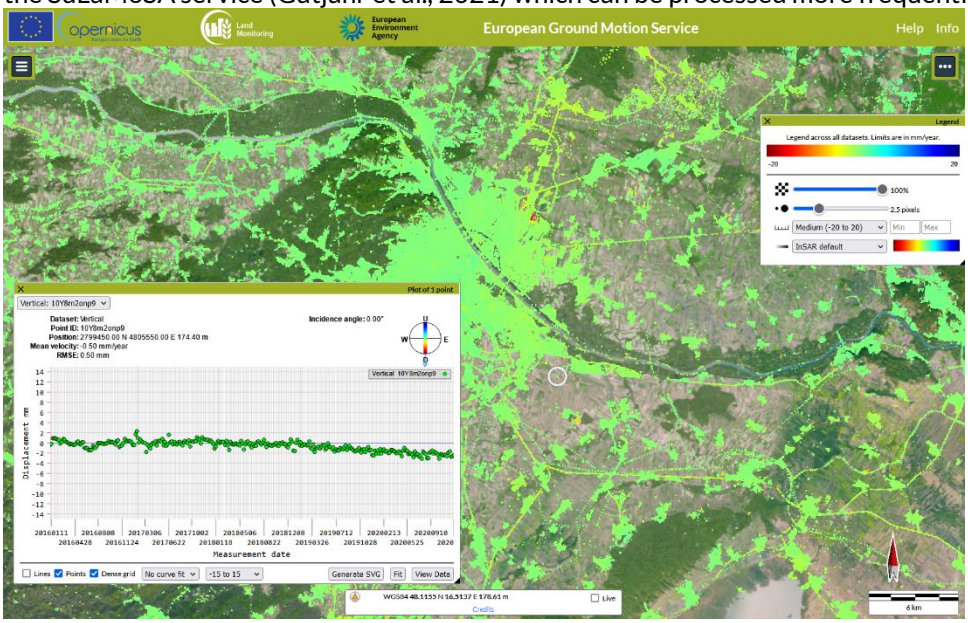


Wetland Monitoring:

Wetlands are wet patches of land, with a water table at or near the land surface for a long enough period each year to support aquatic plants. They perform many important ecosystem functions, from being a carbon sink and regional climate regulator to flood retention and other hydrological functions. Therefore, there are national and international policies (e.g. the Ramsar Convention) in place that aim to protect remaining wetlands. However, such policies may be helpless in the face of prolonged drought conditions that lower the water table within the wetland area, causing open water surface areas to shrink and the topsoil layers to dry out. In Austria, this is a particular concern for wetlands situated in the eastern parts of Austria, where low annual rainfall levels in combination with increased drought risks threaten these important ecosystems. As the main technical innovation of INTERFACE, we exploit the frequent, high-resolution Sentinel-1 coverage to monitor the wetland areas around Neusiedler See, which have witnessed worrying drying events in the past years. The attractiveness of Sentinel-1 lies in its sensitivity to the presence of open water (Zhao et al. 2021), soil moisture, and vegetation conditions irrespective of weather conditions. These are key properties of wetlands, but nonetheless, even the mapping of open water and water with emergent vegetation is not straightforward. Fortunately, as long as the vegetation does not become too dense and high, the interaction of the radar pulses with both the plant and the water surface leads to so-called double bounce effects, leading to very strong signals (Nguyen et al. 2016). Therefore, it will also be possible to map water below emergent vegetation, e.g. over the reed belt of Neusiedler See, for at least part of the year when the vegetation is low or dry. However, when the vegetation is high and fully developed, Sentinel-1 just captures the signals from the vegetation canopy. Therefore, in addition to providing maps of 'open water' and 'water with low emergent vegetation', we will investigate methods to provide uncertainty information and masking layers.

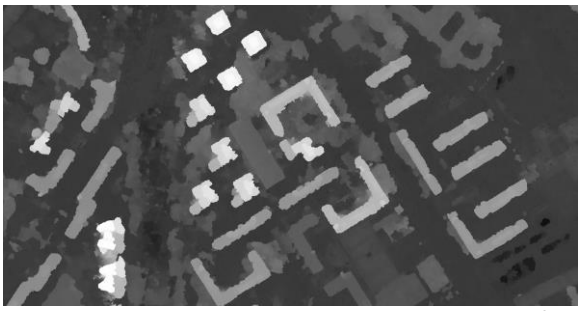
Ground Motion and Mass Movement Detection:

Until now, no standard method to continuously monitor landslides and subsidence is implemented, but a diversity of approaches based on inhomogeneous data has been rather used in isolated applications. Advanced differential SAR interferometry (DInSAR) techniques are increasingly accepted to be a well-suited method to provide continuous, homogenous and large-area monitoring services with respect to subsidence and landslide. This is not only confirmed by many scientific publications but also by various present as well as future national and supra-national initiatives to set up ground motion services based on these techniques. The main innovation from the user point of view is the availability of a provincewide service with short update intervals. In the European Ground Motion Service (EGMS), the main products are level 2a, 2b and 3, but currently only level 2b products are provided (Larsen et al., 2020). Level 2b data is produced at the highest possible spatial resolution and contains the full line-of-sight deformation history of each measurement point and therefore no assumptions are made about the true direction of the ground motion. This can be seen as an advantage for expert InSAR users, but it is very demanding for users who do not have knowledge about InSAR technologies to interpret these products as the comparison to other deformation measurements is not straightforward. In order to make the data easier to use, INTERFACE will combine level 2b data from corresponding ascending and descending orbits (Yin et al., 2018) and provide up/down and east/west deformation components on a regular basis. Secondly, as the EGMS product update cycle is planned for one year, INTERFACE will also provide access to products of the SuLaMoSA service (Gutjahr et al., 2021) which can be processed more frequently.



3D Products (DTM/ DSM):

Digital surface models (DSM) and terrain models (DTM) are used for example for landscape visualization, disaster management, navigation, vegetation and forest monitoring. They are derived from laser scanning campaigns at irregular and, above all, at long intervals due to the very high costs involved. DSMs and DTMs can also be derived from aerial photographs, which are usually taken every three years, but calculations of DSMs only take place sporadically and for limited areas. Due to the continuous availability of Pleiades data, 3D information can be derived on demand at any time and for any area of interest, which canfacilitate many planning processes from the user's point of view. The main technical innovations of the proposed 3D reconstruction service are twofold. (1) Sensor block adjustment will be performed globally, which also allows epipolar rectification of the whole images based on the optimized rational polynomial coefficients (in contrast to local methods like proposed in (De Franchis et al., 2014)). In this step in addition to ground control points, also tie-points can be utilized allowing highly stable and accurate adjustment results. (2) Image matching will be custom tailored for the very high-resolution multispectral Pleiades image data with 0.5m GSD and 4 bands. In this respect, the design and implementation of appropriate cost functions employed within the stereo matching are crucial. For cost aggregation, a variant of the semiglobal matching will be used that is based on belief propagation and approximates the energy minimization of a 2D Markov random field with a first order smoothness constraint in a truncated manner to decrease the overall computational effort and memory consumption. To preserve 3D breaklines an adaptive penalty will be employed within the matching that uses the input gray values as guidance.

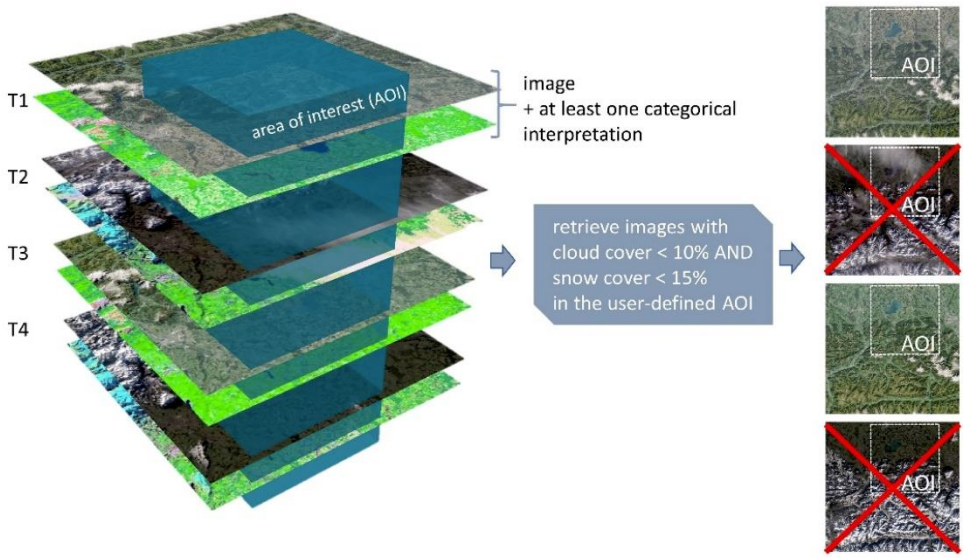


digital surface model @ 0.5m GSD (750x400 m²)

true RGB ortho @ 0.5m GSD (750x400 m²)

Semantic Content-Based Image Retrieval:

Semantic Content-Based Image Retrieval (SCBIR) is a method to filter images based on criteria derived from content descriptions. For example, it is possible to search for images which are cloud-free in a specific part (area of interest). Cloud statistics are usually calculated for the entire image and may not reflect the cloud occurrence in the area-of-interests. In such cases, users may miss useful images because the statistics do not correspond to the user's area of interest. The SCBIR method applies content-based filters only for areas that users select for any custom topic. Such topics can include clouds, floods, or vegetation loss. The SCBIR service can be applied to all Sentinel-2 images in Austria.



Schematic illustration of a SCBIR query. Here, a query searches for images with low cloud and low snow cover within a user-defined area of interest (AOI)-based on the associated semantic information. It retrieves images that match the semantic content-based criteria for the AOI instead of the entire image's extent. In a classic image wide query such AOI specific semantic queries are not possible (Augustin et al., 2019).