GEO Knowledge Hub
Introduction and concepts

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GROUP ON EARTH OBSERVATIONS

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Open Data & Open Knowledge for Earth Intelligence
Visit the GKH
Standards Development
In-situ data strategy document
Data sharing and data management principles
Data and software licensing guidance
Strengthening National GEOs
Exchange
Reuse
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Youth Empowerment
Interaction space
Diverse environment
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GWPs
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GKH
DKWG
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Open Knowledge and Capacity Development
Activities and resources to support GEO Focus Areas
Abdul
Letwin
Felipe
Paola
Kalamkas

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Housekeeping

A few practical notes before we start

By and for the community

This training session was built with content created with the GEO Community, and it is here to serve it.

Ask at any time

There are dedicated slides for questions, but feel free to stop us whenever something needs clarifying.

Let's make it a conversation

We are here to interact and exchange. Your experiences and perspectives make the session richer.

Materials will be shared

All the materials presented today will be made available to you in the GEO Knowledge Hub.

GEO Knowledge Hub User Guides Development **Workshops** Events Metrics FAQ Search Light

User Guides Development

Overview

SA-GEO Knowledge Hub Training 2026

- **About**
- Agenda
- Resources
- Practice
- Feedback

About

Upcoming workshop

This training takes place on **27 July 2026** at the **CSIR International Convention Centre, Tshwane, South Africa**, as the opening day of the 2026 NEOSS Communities of Practice Integrated Workshop.

The **SA-GEO Knowledge Hub Training** introduces the South Africa GEO Knowledge Hub (SA-GKH), the GEO Knowledge Hub (GKH) and the Marketplace, covering their purpose, value proposition and role in improving access to Earth observation and space-related knowledge. Throughout the day, participants explore the concepts of open knowledge, community contribution, collaboration and knowledge sharing, and practice creating and publishing Knowledge Packages.

About the event

The training is the capacity-building day of the **2026 NEOSS Communities of Practice (CoP) Integrated Workshop and Capacity-Building Training**, hosted by the **National Earth Observations and Space Secretariat (NEOSS)** together with the **Council for Scientific and Industrial Research (CSIR)** and the **Department of Science, Technology and Innovation (DSTI)**.

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tinyurl.com/sa-gkh-docs

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Session 1 - agenda

1. The Group on Earth Observations
2. Open Knowledge: concept and principles
3. Reproducible science: concept and principles
4. GEO and South Africa Knowledge Hub

all about **Open Data** and **Open Knowledge**

GEO is a global partnership involving 116 governments and over 162 organizations from academia, business, United Nations and civil society.

GEO brings together Earth Observation providers and users to promote **free, open and equitable access** to EO data and Earth Intelligence solutions.

By sharing this wealth of information and research, we ensure that **decisions made for Earth's future are based on the best available knowledge.**

GEO is


INDIGENOUS COMMUNITIES


YOUNG PEOPLE


GOVERNMENTS


PRIVATE SECTOR


GLOBAL GENERAL PUBLIC

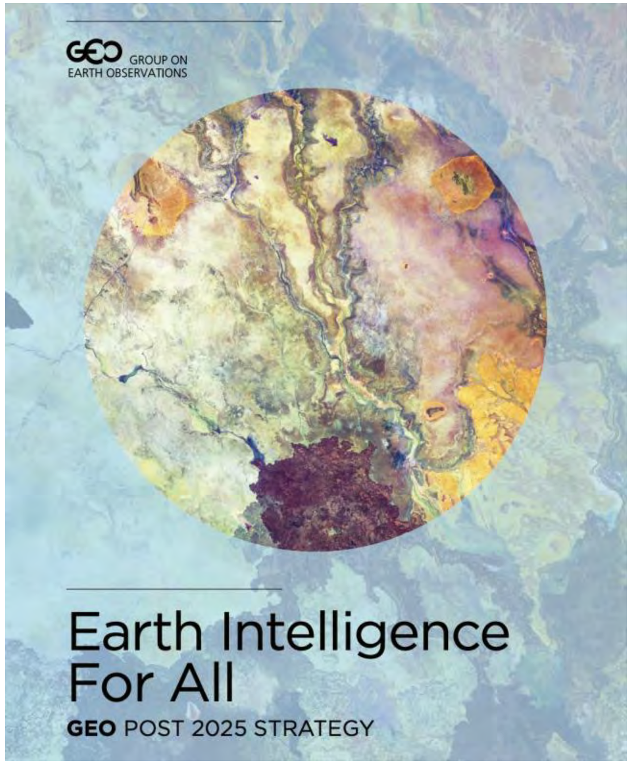

ACADEMIA AND RESEARCH


I/NGOS


UN

GEO Post 2025

“A world where trusted **Earth intelligence** is **universally accessible** and empowers society to achieve a **sustainable future**”



GEO Post 2025 Strategy

Group on Earth Observations · Strategic Plan

GEO Focus Areas

- AGRICULTURE & FOOD SECURITY
- WATER & LAND SUSTAINABILITY
- ECOSYSTEMS-BIODIVERSITY & CARBON MANAGEMENT
- WEATHER, HAZARD, & DISASTER RESILIENCE
- CLIMATE, ENERGY, & URBANIZATION
- ONE HEALTH
- EQUITY & INCLUSION
- OPEN DATA, KNOWLEDGE, & INFRASTRUCTURE

Satellite data and datacube

In situ

Tools

Services

A lot of scattered Earth Observation data and knowledge!

EO Derived

Methodology

Platforms

Coordinated
Earth Observation Data and Knowledge

Data

Satellite data and datacube

In situ

EO Derived

Software

Tools

Methodology

Services

Platforms

Base

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Motivation

Easy to explore

An ecosystem where anyone can discover the content and initiatives available across countries.

Coordinated, not scattered

Bringing today's fragmented data and knowledge into one connected, coherent space.

FAIR Principles

F

Findable

Easy to locate, with rich metadata and persistent IDs

A

Accessible

Retrievable via open, standard protocols

I

Interoperable

Works across systems, formats and vocabularies

R

Reusable

Clear licences and provenance for reuse

Source: GO FAIR Initiative, https://www.go-fair.org/

CARE Principles

C — **Collective benefit**
Data should benefit the communities it comes from

A — **Authority to control**
Indigenous peoples' right to govern their data

R — **Responsibility**
Accountable, respectful stewardship of data

E — **Ethics**
People's rights and wellbeing come first

Source: Global Indigenous Data Alliance, https://www.gida-global.org/care

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TRUST Principles

T — **Transparency**
Open processes, data and decisions

R — **Responsibility**
Accountable data stewardship

U — **User focus**
Built around user community needs

S — **Sustainability**
Durable, long-term preservation

T — **Technology**
Reliable, well-managed infrastructure

Source: TRUST Principles, Lin et al. (2020), Scientific Data

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GEO Data Sharing and Data Management Principles

 DOI: 10.60566/v56md-kqg97

GEO Data Management Principles

1 INTRODUCTION

In 2015, the GEO Data Management Principles Task Force was tasked with defining a common set GEO Data Management Principles[1]. These principles address the need for discovery, accessibility, usability, preservation, and curation of data and related resources that are shared. Such resources also should be shared as open data in accordance with the GEO Data Sharing Principles[2]. The GEO Data Management Principles complement the FAIR Principles and TRUST Principles, which also are being adopted across research communities. The GEO Data Management Principles can be applied to the entire data management lifecycle, while the FAIR principles (Wilkinson M.D. et al.) focus primarily on aspects of metadata, including persistent identifiers. The TRUST principles (Lin D. et al.) primarily focus on the curation and preservation of data and related resources. To support the implementation of the principles, the GEO Data Management Principles Guidelines have been developed so that data providers and other stakeholders can use them as a reference as they seek to implement the principles. These guidelines can also be used when assessing how well the principles are being followed in practice. This current version of the guidelines is the result of a revision process conducted by the GEO Data Working Group in 2022.

These guidelines are applicable to the management of all Earth Observation data products, both remote sensing and in-situ data, as well as other types of data products and services. These guidelines are intended to cover raw data and higher level products, including Analysis Ready Data (ARD) and data products that are produced on-demand by services. While the principles can be applied to services that generate data on-demand; this guidance focus primarily on data and related products. The Data Management Principles can be applied to Decision Ready Information (DRI) and other Knowledge assets, but these guidelines do not explicitly offer recommendations for them.

The GEO Data Branding website[3] offers a self-assessment opportunity for data providers to generate a GEO label that reflects the level of implementation of the DMPs. The GEOSS Yellow Pages[4] (https://www.geoportal.org/yellow-pages) provide information about the level of implementation of the DMPs as have been declared once by data providers and covering all their data. At this stage, the GEO has not defined any process for independent certification of a data provider against the DMPs.

Guidance for implementing the GEO Data Management Principles (DMP) is offered within each section of the guidelines. The following topics are covered in the guidelines for each of the DMP:

- Title and Category of the DMP,
- Explanation of the DMP,

[1] https://www.earthobservations.org/documents/dswg/201504_data_management_principles_long_final.pdf
[2] https://www.earthobservations.org/dswg.php
[3] https://geolabel.info/
[4] https://www.geoportal.org/yellow-pages

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GEO Data Management Principles (Revised: March 2024) DOI: 10.60566/v56md-kqg97

- Guidance on implementation, standards applicable and examples;
- Metrics to measure level of adherence to the principle;
- Resource Implications of Implementation

The Appendix contains a compilation of terms, an explanation about overarching interoperability levels, references, a summary of changes with respect to the original version and an acknowledgement of contributions.

Most of the guidelines reference community standards and practices that foster implementation of a principle in an interoperable manner by enabling one or more of the following levels of interoperability, which are further described in Appendix B: syntactic, semantic, schematic, and legal interoperability.

2 DMP-1: METADATA FOR DISCOVERY

DMP Category: Discovery.

DMP-1: Data and all associated metadata will be discoverable, through catalogues and search engines; moreover, data access and use conditions, including licenses, will be clearly indicated.

2.1 Explanation of the principle

A visitor to a library should be able to find a desired book without having to look at every book in the bookshelf. The library's catalogue allows the visitor to search information about the books (e.g. author, ISBN number, genre, keywords), to discover where to find the book and under what conditions or restrictions the book might be read or borrowed. This "information about the book" is its metadata. Likewise, a user looking for Earth Observation resources (data, web services, models, etc.) should be able to find what s/he wants by searching and retrieving the metadata associated with that digital resource, including information on how the resource can be accessed and whether there are any restrictions or conditions placed on its use. Consistent with the FAIR Data Principles, data should be Findable, Accessible, Interoperable, and Reusable (Wilkinson, et al., 2016). Currently, metadata is concentrated in metadata catalogues that are web services that can be interrogated to find the relevant datasets for an application. GEOSS maintains a catalogue of resource descriptions (metadata) and, like a library catalogue, does not keep copies of resources, but manages the metadata that facilitates discoverability, allowing users to locate and access the resources. Such resource descriptions may point to other catalogues - analogous to a library directing a visitor to other libraries' catalogues.

Not all users begin a search for resources by going to a specific catalogue. Some start by a study or a publication that cite artifacts like data and data fragments, or even software and methods to create new data. They use full citations and PIDs (see DMP-10) to find that dataset directly. Other users might be more inclined to use search engines instead of catalogues. For this reason catalogues may link to portals, such as a geoportal, for use by humans, as well as programmatic interfaces (Application Programming Interfaces - APIs) meant for access by search engines, metadata harvesters and the portals of other communities. The discovery of data is enabled by the syntactic interoperability provided by the combination of catalogue services and API and the metadata standard (commonly expressed in XML) that make use of XML schemas to improve schematic interoperability. However, in practice, true semantic interoperability is difficult to achieve, often requiring brokering and mediation to align with the preferred metadata standard

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GEO Data Management Principles (Revised: March 2024) DOI: 10.60566/v56md-kqg97

DMP-3: Data should be structured using encodings that are widely accepted in the target user community and aligned with organizational needs and observing methods, with preference given to non-proprietary international standards.

4.1 Explanation of the Principle

Usability of data, and especially automated use, depends strongly on the extent to which end users (both human and machine) can rely on standardized encoding as tools, applications, and algorithms are typically designed to work with such. Use of standardized encodings brings benefits to the end user and limits the amount of time spent on transforming data, and therefore is a key to ***interoperability***, as described under DMP-1.

4.2 Guidance on Implementation, with examples

The availability and acceptance of ***syntactic encoding standards*** are at a high level of maturity, and these standards cover the majority of data families that the GEO community uses routinely. Examples are sensor services defined by OGC SWE (2011), OPeNDAP service and NetCDF format (OGC Network Common Data Form 2015; Common Data Model 2015), and the work done by WMO in respect of globally available meteorological data (WMO Information System 2015). The extent to which the community has implemented these standards is, however, highly variable, with implementation of OGC Sensor Observation Services lagging seriously behind Web Mapping Services and the use of OPeNDAP and NetCDF (with or without the Climate and Forecast (CF) Metadata Conventions). The use of Python xarray and their related file formats (e.g, Zarr) is gaining traction in the image analysis community, stimulated by open code snippets that can be easily and remotely executed by Jupyter notebooks. Practitioners should select the open standards and implementations of these appropriate to their community, internal information technology platforms, and capabilities, as a preferred means of providing access to publicly available datasets.

Communities have also developed a portfolio of content standards in support of ***schematic interoperability*** (see Appendix B). For example, GML (OpenGIS® Geography Markup Language 2007) requires a GML application schema that ensures schematic interoperability, while GeoJSON (GeoJSON Format Specification 2016) is schemaless. Standards for raster data such as the GeoTIFF, NetCDF, HDF5, JPEG2000 rely on metadata to specify the schema and semantics. TimeSeriesML and O&M are examples of encodings of time series and sensor observations. Interoperability practices, for spatial datasets, whether vector datasets or raster datasets, are highly mature, and it is common for applications and web components to support a wide variety of data schema. Formats recognized by the GDAL/OGC libraries will facilitate exchange of data among many GIS products. Best practice and guidance should stress the application of these widely adopted standards whenever possible.

The most diverse landscape is found in respect of ***semantic interoperability***, as described under the Appendix B, Metadata for Discovery, and content standard encoding to support it. Some communities have access to mature content standards (for example the Biodiversity community through TDWG (TDWG Standards 2015), the Climate Modelling community through essential climate variables (GCOS Essential Climate Variable(s) 2015), and WaterML (OGC® WaterML 2015)), and there are significant efforts to establish ontologies, vocabulary services, federated vocabulary services, FAIR vocabularies, and naming services for a wide variety of disciplines [Cox, 2021]. A major concern is centered on this diversity, and it is often difficult

GEO Statement on Open Knowledge

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GEO-17 – 23-26 November 2021 GEO-17-4.1

GEO Statement on Open Knowledge

This document is submitted to the 17th Plenary for decision.

1 INTRODUCTION

This document presents the GEO Statement on Open Knowledge (Annex A). It proposes that the statement be reformulated to focus on "Open Knowledge". This concept, while inclusive of Open Science, is considered to be more closely aligned with the GEO Mission and Vision, which aim to support decision making and not only or primarily science.

As GEO moves further down the path towards providing its Members and Participating Organizations with the best evidence-based information from Earth observations possible, an Open Knowledge approach supports this ambition and the GEO Vision. The Statement provides a rationale and impetus for the open context of activities of the GEO Work Programme and the GEO community, the results of which will in turn be rendered accessible through the GEO Knowledge Hub.

2 DEVELOPMENT OF THE ORIGINAL STATEMENT

Impetus for the development of a statement on Open Science within GEO initially came from the GEO Secretariat as an outgrowth from the *Strategy for a Results-Oriented GEOSS* and the development of the GEO Knowledge Hub. Given the importance of Open Science to capacity building, particularly with respect to the capacity of GEO Members in developing countries to access and apply the solutions being developed through the GEO Work Programme, the Secretariat contacted the Capacity Development Working Group (CD-WG) to assist in the development of a statement. A drafting team was assembled, which included members of the CD-WG and others in the GEO community. Led by GEO Participating Organization ITC (Markus Konkol, ITC Open Science Officer), this team produced the statement which was presented to the Programme Board and the Executive Committee earlier this year.

3 FEEDBACK FROM THE GEO COMMUNITY

The presentation of the draft statement to the Programme Board at their 19th meeting met with a positive response. The Board endorsed the statement for presentation to the Executive Committee. It also requested that the CD-WG consider including references to the UNESCO statement, the TRUST principles and CARE principles, and to consider if changes were needed to address the relevance to models, methods, artificial intelligence, and machine learning. These changes were made to the statement prior to its presentation to the Executive Committee.

The Executive Committee, at its 54th meeting in March 2021, expressed support for the concept of Open Science, but recommended that further consultations with the GEO community be undertaken. These consultations were to include the Data Working Group, particularly with respect to the alignment with the GEOSS Data Sharing Principles and Data Management

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Annex A

GEO Statement on Open Knowledge

According to the Open Knowledge Foundation[1], knowledge that is free to use, reuse, and redistribute without legal, social, or technological restriction may be defined as "open knowledge." This definition clarifies the meaning of "open" with respect to knowledge, promoting a robust commons where collaborative community can thrive and interoperability is maximized.

Open Knowledge has proven to have played a pivotal role in tackling global challenges such as the COVID-19 pandemic. Open Knowledge is also beneficial for achieving the United Nation's Sustainable Development Goals, the Paris Agreement objectives, the Sendai Framework for Disaster Risk Reduction, and a reduction in the knowledge divide among countries.

The authoritative nature of Open Knowledge does not exist in a vacuum but is rather the product of a number of open components working in concert to establish credibility and increase trust, such as open data, open source, open science, open licensing, and open education. We, the Group on Earth Observations (GEO), advocate the adoption of Open Knowledge to create a commons environment that is transparent, diverse, collaborative, timely and sustainable with respect to addressing societal challenges through the application of Earth observations. In so doing, GEO aims at lowering the barriers for everyone who might benefit from and contribute to the derivation of authoritative knowledge.

To this end, based on UNESCO's Open Educational Resources and Recommendation on Open Science, we promote the following principles with respect to the generation, dissemination, sharing and uptake of Open Knowledge:

Open Science: Openness in science is a fundamental requirement to ensure the integrity of research, accelerate scientific progress, and disseminate knowledge among scientists, decision-makers, and the general public. In this context, Open Science is an umbrella term comprising a set of practices to share scientific knowledge by making all stages of the research processes findable, accessible, and reusable.

As Open Science becomes the new norm across disciplines, it creates a scientific landscape that opens up the research process and allows everyone to verify, understand, and adopt new research results. Furthermore, we endorse the ***San Francisco Declaration on Research Assessment*** (DORA) to evaluate a scholar's scientific outputs and impact.

Open Access: Everyone should be able to fully access and reuse all Open Knowledge contents and components, such as scholarly publications immediately after publication, free of charge, and without restrictions.

Citizen and Participatory Science: The active engagement and contribution of actors beyond the established research community can achieve a higher representation of the society and build up science literacy. Allowing citizens to contribute to science enables an evidence-based decision-making process by policy makers and the creation of a sustainable economy.

Open Data: The data needed to reproduce scientific results or support public decision making, including data stemming from publicly funded endeavors, should be released publicly under an open license and follow the GEO Data Sharing and Management Principles, the FAIR Principles

[1] https://opendefinition.org/od/2.1/en/

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(**F**indable, **A**ccessible, **I**nteroperable, and **R**eusable) using human- and machine-readable data formats, the TRUST Principles (**T**ransparency, **R**esponsibility, **U**ser focus, **S**ustainability, and **T**echnology), using trustworthy repositories, and the CARE Principles (**C**ollective benefit, **A**uthority to control, **R**esponsibility, and **E**thics). At the same time, the GEO Data Sharing Principles recognize the legitimate reasons to manage data access according to applicable international instruments, national policies and legislation, e.g., privacy, national security, and law enforcement.

Open Reproducible Research: The programming code or workflow needed to reproduce the analysis underlying the results (for example, figures, tables, and numbers) in scholarly publications should be released under an open license following the FAIR and TRUST Principles. The analysis should be executable and include any environment variables to facilitate understanding, verification, and reuse by others in new contexts.

Open Software: Any kind of software (including models and artificial intelligence) developed during the research process should be released under an open license and following the FAIR and TRUST Principles. Additionally, any reused software upon which the newly developed software is based or needed to execute the programming code or workflow should likewise be released under an open license as far as possible or made available according to the FAIR Principles.

Open Infrastructure: Any infrastructure needed to support Open Knowledge (for example, sharing platforms, data repositories, and computational infrastructures) should be non-proprietary and based on open standards, which are developed, approved, adopted and maintained via a collaborative and consensus driven open process to make data, information and services FAIR. Standards facilitate interoperability and data exchange among different systems, products, or services, prevent vendor lock-in, and provide long-term and unrestricted access to everyone.

Open Hardware: The design specifications of physical objects (hardware) should be released under an open license allowing others to study, modify, create, remix, and distribute.

Open Education: Teaching materials should be released under an open license (Creative Commons), allowing reuse and modification by others and following the FAIR and TRUST Principles. Open Education also involves teaching Open Science principles and using openly accessible materials (for example, data and software) as much as possible.

Open Evaluation: Scholarly articles should be evaluated in an Open Peer Review process resulting in publicly available reviews, at a minimum. To foster the transition to a new recognition and reward system, a researcher's reputation and output should be evaluated according to the Open Science principles, i.e., by focusing primarily on the content (see DORA) rather than the journal's impact factor and the h-index.

Diversity of Knowledge: The diversity of knowledge systems, holders, and producers should also be recognized in the production of Open Knowledge. This consideration requires acknowledging the rights of Indigenous People and the principles of non-discrimination based on income, gender, age, ethnicity, migratory status, disability, and geographic location. Weaving cultural knowledge bases together can maintain the validity and integrity of all methodologies and worldviews.

Overarching Goals of Open Knowledge

Openness in knowledge generation can help address society's local, regional, and global needs by creating an inclusive and interconnected environment. A thoughtfully designed open and

GEO advocates the adoption of **Open Knowledge** to create a commons environment that is transparent, diverse, collaborative, timely and sustainable

Principles of **Open Practices**

1

Transparency

Open methods

2

Accessibility

Knowledge for everyone

3

Reproducibility

Verifiable, repeatable results

4

Collaboration

Shared knowledge-building

5

Inclusivity

Equitable participation

Open **Knowledge**

is the concept of making knowledge (such as research findings, educational resources, or technical insights) freely accessible, usable, and shareable.

It emphasizes removing barriers to accessing information to foster widespread learning and collaboration.

Examples

Open Educational Resources

Free learning materials - e.g. OER Commons, MIT OpenCourseWare

Open Access Research

Freely available publications - e.g. arXiv, DOAJ

Source: Open Knowledge Foundation, https://opendefinition.org/od/2.1/en/

Open Data

refers to data that is freely available to everyone, with no restrictions on its use, modification, or distribution.

It promotes transparency and accessibility, enabling users to analyze, share, and collaborate on data for research or innovation.

Examples

Sentinel-2
Optical imagery - ESA Copernicus

Landsat
Optical imagery - NASA / USGS

ERA5
Climate reanalysis - ECMWF

SRTM
Elevation model - NASA

Source: Open Knowledge Foundation, https://opendefinition.org/od/2.1/en/

Open **Access**

refers to the practice of providing unrestricted access to scholarly publications, research articles, and academic papers, usually online.

It aims to eliminate paywalls and subscription barriers, allowing anyone to freely read, download, and share academic content.

Examples

Remote Sensing (MDPI)
Open-access research journal

GEO Knowledge Hub (GEO)
Open knowledge repository

Earth Data (NASA)
Free Earth science data

Source: Budapest Open Access Initiative, https://www.budapestopenaccessinitiative.org/read/

Open **Software**

refers to software whose source code is publicly available, enabling anyone to modify, use, and redistribute it.

It is fundamental for promoting collaboration and innovation in scientific research.

Examples

QGIS
Desktop GIS application

GRASS GIS
Geospatial analysis suite

GDAL
Geospatial data library

MapServer
Web mapping server

Source: Free Software Foundation, https://www.fsf.org/

Open **Hardware**

refers to physical devices and technologies whose designs are publicly available, allowing anyone to modify, replicate, or improve upon them.

In Earth observation, this could include sensors, drones, or satellite components.

Examples

OpenSense
Open environmental sensors

Arduino
Open hardware prototyping platform

SatNOGS
Open satellite ground stations

Source: Open Source Hardware Association, https://oshwa.org/resources/open-source-hardware-definition/

Open **Infrastructure**

refers to the systems, platforms, and tools that support the open sharing, storage, and analysis of data.

It groups digital platforms and repositories that facilitate the dissemination, preservation, and accessibility of research outputs like publications, data, software, hardware, and more.

Examples

OpenStreetMap
Open collaborative map

GeoServer
Open geospatial server

Zenodo
Open research repository

GEO Knowledge Hub
Open EO knowledge platform

Source: CERN, https://openscience.cern/infrastructure

Open **Education**

refers to the use of openly available educational resources, tools, and materials to improve access to knowledge and learning.

Open Education seeks to scale educational opportunities by taking advantage of the power of the internet, allowing rapid and essentially free dissemination, and enabling people around the world to access knowledge, connect and collaborate.

Examples

OpenCourseWare (MIT)
Free MIT course materials

Coursera
Open online courses

edX
University-level MOOCs

Khan Academy
Free lessons for all

Source: Open Education Consortium, https://www.oeconsortium.org/about-oec/

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GEO Data Licensing Guidance

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Data Licensing Guidance
Law and Policy Subgroup of the GEO Data Working Gorup

This document submitted by the Data Working Group was approved in the 25th Programme Board meeting

1 INTRODUCTION

The Programme Board directed the Data Working Group (DWG) to prepare guidelines regarding open data licensing (Action PB-24.05). This document responds to that action, providing data licensing guidance for GEO members and Participating Organizations and GEO Work Programme Activities, consistent with the GEO Data Sharing Principles and other existing GEO policy. This living document was developed by the Law and Policy Subgroup (LP-SG) and approved by the Data Working Group.[1]

2 BACKGROUND

Data users need to understand their legal rights and obligations when using data. The Earth observation (EO) community has often used phrases such as "full and open" to convey this information. With expanded use of EO data, however, this phrase no longer provides sufficient legal certainty. This uncertainty discourages the use of EO data.

Additionally, some GEO members and the private EO community use custom, lengthy "End User License Agreements" (EULAs) to describe allowable use. Accepting EULAs requires legal review, and EULAs often include substantive restrictions on use (such as restricting to non-commercial use).

Frequently these custom EULAs include terms that national governments are unwilling to accept (such as being subject to foreign law, and indemnification requirements), requiring lengthy negotiation of those terms. Small and medium-size enterprises are at a further disadvantage, lacking the clout to request that data providers negotiate EULA terms and requiring investment in legal counsel to understand the implications of accepting those terms. Furthermore, the lack of uniformity in definitions, treatment of value-added products, and other important terms causes uncertainty, and could create legal risks for users.

This issue has been well known and explored for at least a decade, both within GEO and in other international groups. In 2011, for example, the GEO Legal Interoperability Sub-Group of the Data Sharing Task Force first developed a White Paper for the GEO-VIII Plenary that recommended that "GEO Members and Participating Organizations should consider adopting one of the following

[1] The primary authors of this document were Derek Hanson and Jordi Sandalinas. The Law and Policy Subgroup (LP-SG) would like to express its gratitude to its members for their thoughtful review and comments: Suchith Anand, Mariel Borowitz, Gilberto Camara, Robert Chen, Estelle Chou, Paola De Salvo, Robert Downs, Joanne Gabrynowicz, Chuang Liu, Thomas McInerney, Lea Shanley, and Fraser Taylor. The views expressed here are those of the authors and not necessarily those of their employing institutions.

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existing private-law waivers or standard common-use licenses," listing five options from Creative Commons and Open Data Commons. However, wide adoption of these recommendations stalled.

With the recent push to combine open datasets to leverage artificial intelligence, machine learning, and other cloud storage and computing techniques, however, attempting to combine datasets that are subject to different license terms has only further compounded these legal issues (sometimes referred to as "legal interoperability"). Put simply, the legal treatment of data has not kept up with the rapid advancement of data processing techniques and interoperability standards.

In response, the GEO community and other groups have renewed calls for the use of standard open data licenses. Within the past year, the GEO Statement on Open Knowledge and the Revised GEO Data Sharing and Data Management Principles have specifically called for the use of open data licenses. Just a few of the groups or principles outside of GEO that have called for the use of open data licenses include:

- The FAIR Principles and other Open Science initiatives (including UNESCO's)
- The Research Data Alliance and CODATA
- International Hydrographic Organisation
- United Nations Statistical Commission
- European Commission

To note, there has also been increasing focus in the broader data community (beyond EO data) on individual data privacy, data ethics, indigenous data rights (CARE Principles for Indigenous Data Governance), and other concerns.

Recognizing indigenous interests in datasets can occur through inclusion of indigenous metadata alongside open data licenses. Disclosure of indigenous interests may occur through acknowledgement, attribution, authorship, and/or tools like the Traditional Knowledge/Biocultural (TK/BC) Notices & Labels that recognize cultural authority and can sit alongside rights statements and open licenses.

These are important issues for the GEO community, but this guidance document is not intended to address these issues. Instead, this guidance is designed for use by data providers when sharing EO data that they have determined to be appropriate for sharing openly and without restrictions.

3 PRIOR GEO ANALYSIS

GEO has considered this issue for over a decade. Following publication of the 2011 White Paper described earlier, in 2014, the Legal Interoperability Sub-Group of the GEO Data Sharing Working Group presented its "Legal Mechanisms to Share Data as Part of GEOSS Data-CORE" to GEO-XI Plenary. This comprehensive analysis was the result of years of work and identified and addressed all of the issues described above. It recommended "the use of only standard instruments to help assure legal interoperability of data."

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The Law and Policy Subgroup of the GEO Data Working Group reviewed this 2014 analysis and confirmed its continued validity. Therefore, rather than reproduce this report, the Law and Policy Subgroup decided to summarize its recommendations and focus on barriers to implementation.

This guidance document is the first work product of the Law and Policy Subgroup, designed to summarize the recommendations of the 2014 report and to provide general guidance on all data shared within GEO. Furthermore, it is designed to be used in specific existing GEO efforts, including:

- To inform an existing license drop-down menu for submissions of data to the GEO Knowledge Hub;
- As part of guidance for implementing the GEO Open Knowledge Statement; and
- As part of follow-on guidance to the GEO Data Management Principles Implementation Guidelines.

4 DATA LICENSING GUIDANCE

The following data licenses[2] are consistent with the GEO Data Sharing Principles:

- Creative Commons Zero 1.0 Universal Public Domain Dedication (CC0) (https://creativecommons.org/publicdomain/zero/1.0/)
- Open Data Commons Public Domain Dedication and License (PDDL) v1.0 (https://opendatacommons.org/licenses/pddl/1-0/)
- Creative Commons Attribution 4.0 International (CC BY 4.0) (https://creativecommons.org/licenses/by/4.0/)

GEO Members, Participating Organizations, and other entities that share open, unrestricted data should clearly license such data using only one of these licenses. Custom license agreements should not be used, and these standard licenses should not be modified or augmented with additional text.

Additional summary information regarding these three data licenses:[3]

- Creative Commons Zero 1.0 Universal Public Domain Dedication (CC0 1.0)
  - Summary Description: Waives copyright and related rights in the data, to the extent permitted by law. Permits users to use, copy, modify, and redistribute the data for any purpose.
  - Copyright Retained? No.
  - Attribution Legally Required? No.

[2] While some of the legal instruments listed can be characterized as public domain dedications or waivers of rights rather than a license, this guidance document refers to all such instruments as "licenses."
[3] Nothing in this guidance should be construed as legal advice. Data providers and data users should consult with their own legal counsel if they have additional questions or concerns about these licenses.

Licences in Open Practices

it determines the terms under which data, software, or research can be used, modified, and distributed.

Examples

CC0 1.0

Public-domain dedication (Creative Commons)

ODC PDDL v1.0

Public-domain dedication (Open Data Commons)

CC BY 4.0

Attribution required (Creative Commons)

Licences: CC0 & CC BY 4.0 (creativecommons.org) · PDDL (opendatacommons.org)

GEO GROUP ON EARTH OBSERVATIONS

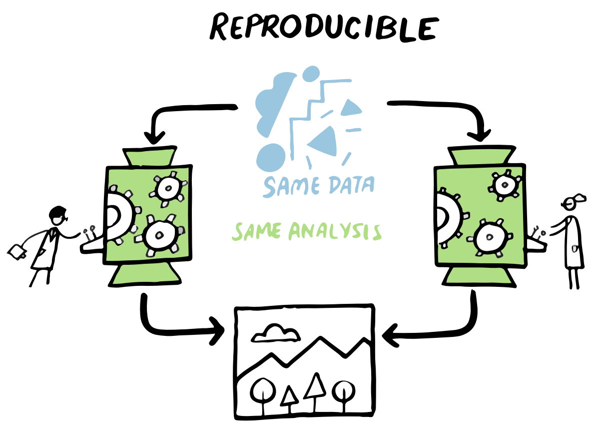
Reproducible research

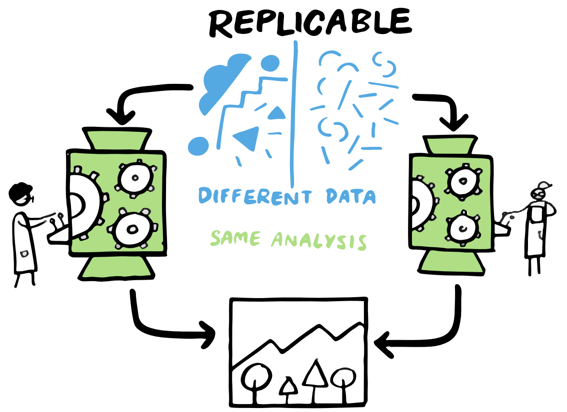
Reproducible

Authors provide all the necessary data and the computer codes to run the analysis again, re-creating the results.

Replicable

A study that arrives at the same scientific findings as another study, collecting new data (possibly with different methods) and completing new analyses.





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GEO In-situ Data Strategy

GROUP ON EARTH OBSERVATIONS

GEO-21 – 28 May 2026 GEO-21-4.2.2(Rev1)

GEO In-Situ Data Strategy

This document is submitted to Plenary for decision, following a decision by the Executive Committee at its 69th session on 25 May 2026 and its endorsement by the Executive Committee at its 67th session on 29 October 2025. It is presented for Plenary's consideration and final approval.

Executive Summary

GEO's Member governments, Participating Organizations and Associates work together to develop and implement Earth observation (EO) projects and initiatives that address global environmental and societal challenges and help decision-makers understand and act on global environmental challenges. EO data, both in-situ and satellite-based observations / measurements, are fundamental components of these actions and essential for GEO to achieve its mission of Earth Intelligence for All.

This document responds to the need for an In-Situ Data Strategy that has been acknowledged within successive GEO Ministerial Declarations e.g. Canberra Declaration (2019). Building on a significant body of work by GEO Members spanning several years, the In-situ Data Strategy aims to provide a framework for GEO that addresses the specific challenges associated with the acquisition and use of in-situ measurements and observations. It also provides a set of objectives, and potential roles that will enhance integration of all forms of EO data to support GEO's ongoing mission.

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GEO-21 – 28 May 2026 GEO-21-4.2.2(Rev1)

INTRODUCTION

Background

In-situ data refers to Earth observations and measurements collected directly at or near the Earth's surface, as opposed to remote sensing (RS) data that is gathered from space-based systems, e.g., satellites. In-Situ data encompasses, but is not limited to, observations and measurements obtained from ground-based monitoring systems, maritime platforms, airborne sensors (excluding satellites), field surveys, and citizen science (Strobl, 2024).

In contrast to satellite-based observations, in-situ data are usually direct measurements of selected variables, often in specific and fixed locations, which are likely to be more precise and therefore considered as the "ground truth". Satellite-based observations and measurements tend to be more indirect but systematically cover the Earth's surface.

Together, in-situ and RS data are complementary, providing a comprehensive suite of observations and measurements of the planet. For this reason, both satellite and in-situ Earth observations are equally important in order for GEO to deliver its stated mission, especially with respect to data, knowledge and Earth Intelligence for all.

The significant value of in-situ data is demonstrated through various applications, including the GEO Work Programme activities, because it:

- is essential for realizing GEO's key global priorities as defined in the GEO Post-2025 Strategy;
- enables evidence-based policy and governance-based processes. It helps assess the effectiveness of regulations, identify areas of concern, and guide investments in infrastructure and conservation;
- is essential for the calibration and validation of remote sensing products and Earth system models (including training Artificial Intelligence and as input for Machine Learning modules);
- provides measurements in difficult to access locations, e.g., within the global oceans, in areas affected by clouds, smoke or aerosols, or other areas that are not accessible to space-based observing systems;
- often measure significant variables in the Earth system that are directly impacted by human activities;
- has a temporal and spatial distribution that allows more accurate and frequent measurements. In-Situ measurements tend to be tied to a specific location and taken at a greater frequency, which provides higher resolution data than can be achieved by space-based systems;
- potentially provides long time series based on repeated historical measurements that can, in some cases, be over a period of more than 100 years;
- is the only legally admissible form of Earth observation data that can be used to prove illegal activities in some Member States e.g. destruction of protected natural habitats.

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GEO-21 – 28 May 2026 GEO-21-4.2.2(Rev1)

Due to the diversity and nature of the various in-situ data acquisition activities spread across a wide range of different disciplines, e.g., hydrology, climatology, oceanography, biodiversity, etc., the current associated data landscape is highly heterogeneous. Despite some limited efforts to standardize monitoring protocols and aggregate in-situ datasets to generate more general coverage, the landscape remains fragmented in many sectors with significant gaps in some areas. A situation that is further exacerbated by inconsistent data policies at the national and local level, including those related to data archiving, preservation, and reuse, which leads to loss of critical data and knowledge. Actually, the diverse nature of in-situ data necessitates significant investment of resources in its curation and archiving to ensure its usability and accuracy for specific user applications. Significant data management efforts in terms of standardization, harmonization, and interoperability are also critical to effectively consolidating different datasets to fulfil the needs of users.

In addition to the already existing efforts by observational research infrastructures, some of which are included in the GEO Work Programme), achieving the necessary level of in-situ data integration requires new and existing in-situ data systems and networks to implement common data frameworks, metadata standards, and quality control processes to ensure consistency and reliability across different sources. This should include encouraging wider adoption of recognised data management practices, the GEO Data Sharing and Management principles, the Data Licensing principles as well as other relevant best practices, e.g., the FAIR, CARE, and TRUST Principles.

Challenges associated with in-situ data

The specific challenges associated with the in-situ data landscape, such as its heterogeneity, lack of coordination, geographical variations, large and diverse range of stakeholders, and barriers to data access, have been recognized in successive Declarations from GEO Ministerial Summits (Cape Town 2007, Beijing 2010, Geneva 2014, Mexico City 2015). Reinforcing this message, the Canberra Declaration (November 2019) states that the Ministers:

- Recognise the critical role that data collected from the atmosphere, land, and water (in-situ data) plays in achieving GEO's mission;
- Note that the sharing of such data is limited, and significant gaps remain for a global observing system;
- Note that such data has specificities in its nature, governance, technical management, financing,
- Call upon the GEO community to develop a strategy to address the challenges in this area and to demonstrate progress in implementation.

GEO Members, Participating Organizations and Associates work together to develop and implement Earth observations projects and initiatives that address global environmental and societal challenges and help decision-makers understand and act on the global

In **Practice**

You might...

- download Sentinel imagery **(open data)**
- use QGIS **(open software)**
- publish your workflow on GitHub **(open knowledge)**
- and cite it in a paper shared on arXiv **(open access)**

GEO Community

GEO Community

EO Applications

Digital Earth

GEO LAND DEGRADATION NEUTRALITY

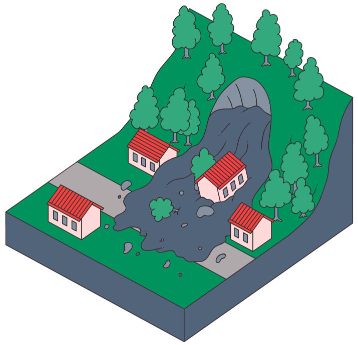
GEOGLOWS

AfriGEO Earth Observations for Africa

AmeriGEO Earth Observations for the Americas

AOGEO Earth Observations for Asia-Oceania

EuroGEO



Disasters

Climate and Energy

Food security

GEO GROUP ON EARTH OBSERVATIONS

GEO Community

EO Applications

Digital Earth

LAND DEGRADATION NEUTRALITY

GEOGLOWS

AfriGEO Earth Observations for Africa

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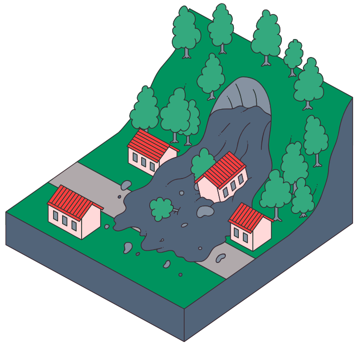


Disasters

Climate and Energy

Food security

GEO GROUP ON EARTH OBSERVATIONS

GEO Community

Knowledge

EO Applications

Digital Earth

GEO LAND DEGRADATION NEUTRALITY

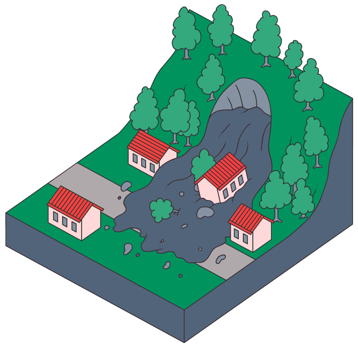
GEOGLOWS

AfriGEO

AmeriGEO

AOGEO

EuroGEO



Disasters

Climate and Energy

Food security

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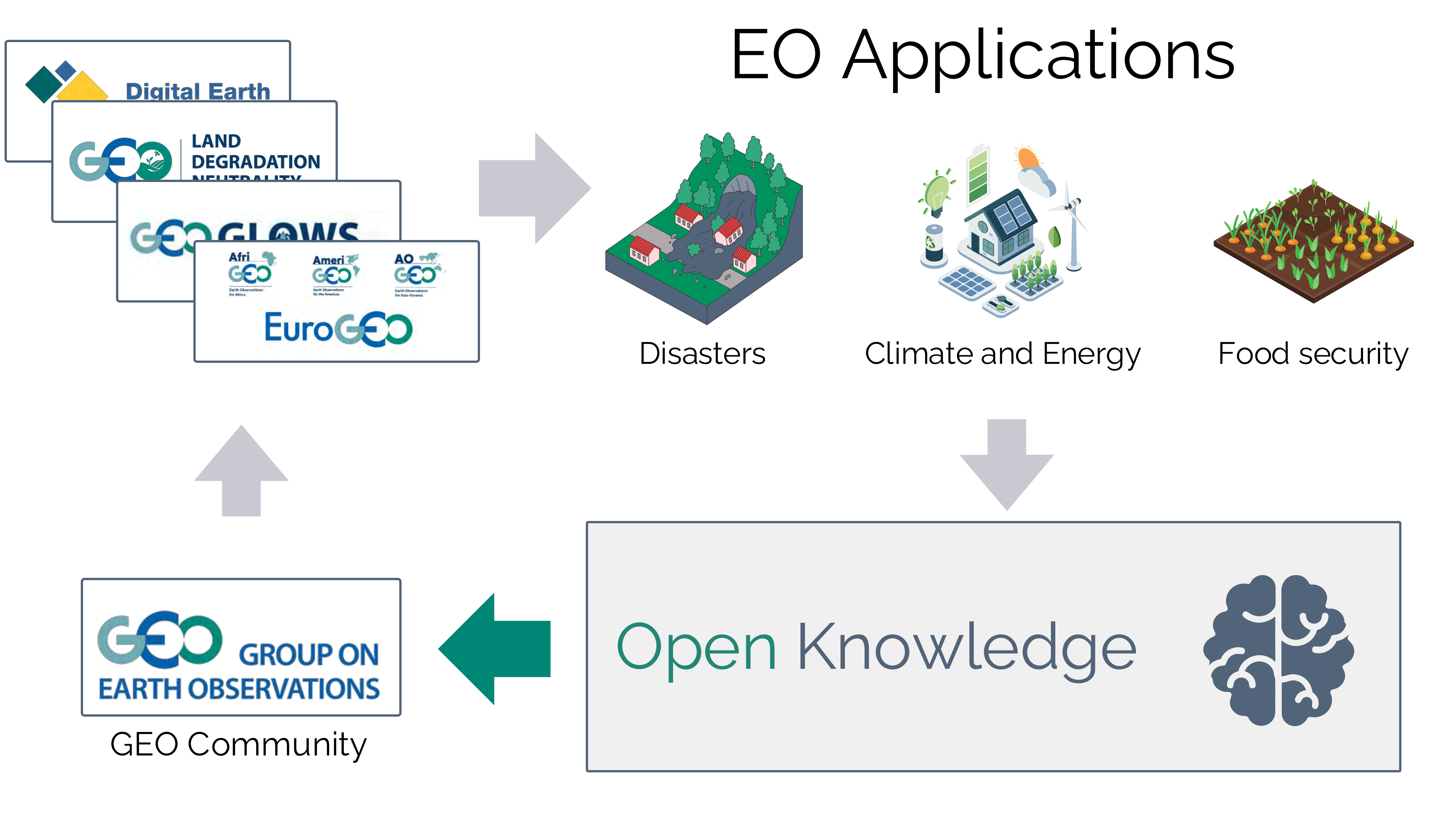
GEO Community

Open Knowledge


EO Applications
Digital Earth
LAND
DEGRADATION
Afri
Ameri
AO
EuroGEO
Disasters
Climate and Energy
Food security
Open Knowledge
GROUP ON
EARTH OBSERVATIONS
GEO Community

Satellite data and datacube

In situ

Tools

Services

A lot of scattered Earth Observation data and knowledge!

EO Derived

Methodology

Platforms

Coordinated

Earth Observation Data and Knowledge

Data

Satellite data and datacube

In situ

EO Derived

Software

Tools

Methodology

Services

Platforms

Base

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GEO
Knowledge Hub

The **GEO Knowledge Hub** is a central cloud-based digital library created to **preserve**, **disseminate**, and **support** the reuse of EO Applications developed by the **GEO Community**

Since 2021, the GEO Knowledge Hub is **serving** the GEO Community as the **central repository** to **share** and **preserve** **Open EO Data** and **Open EO Knowledge**

GEO Knowledge Hub

Open

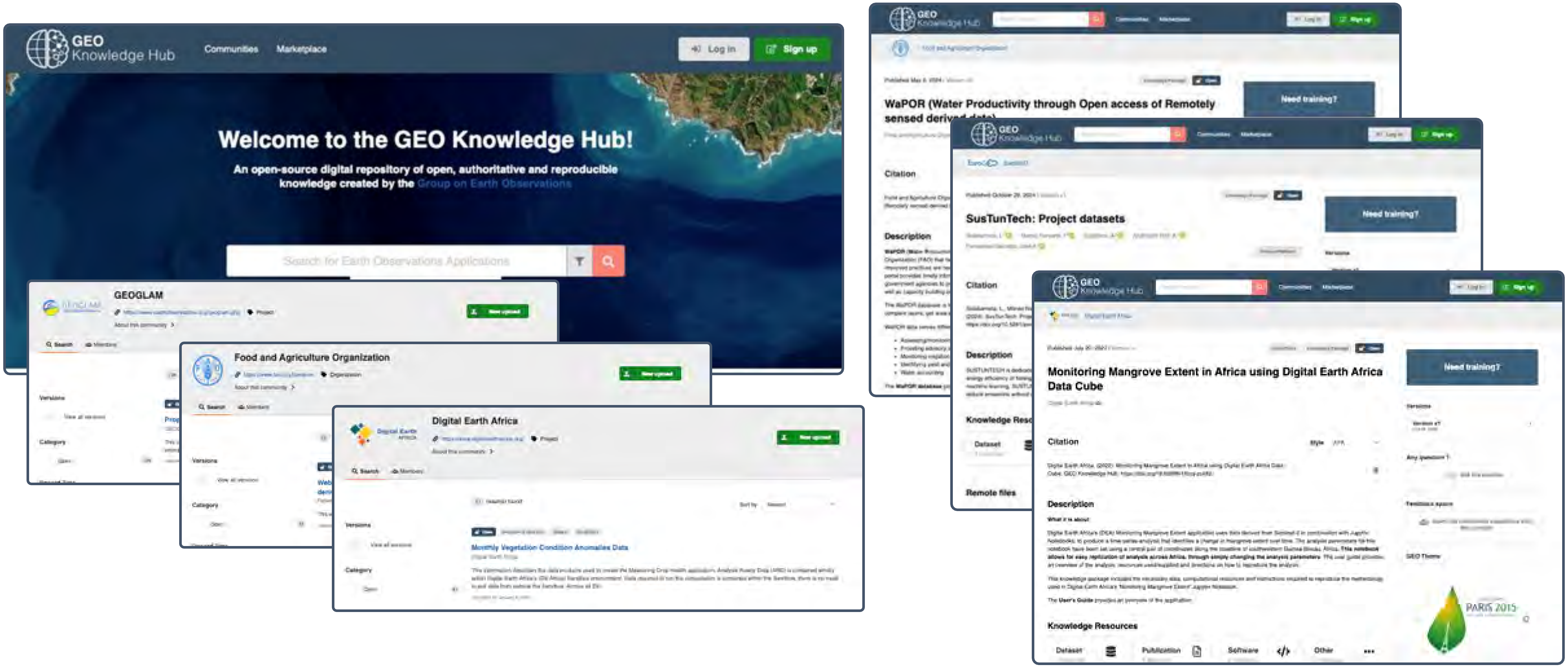
Centralize

Preserve

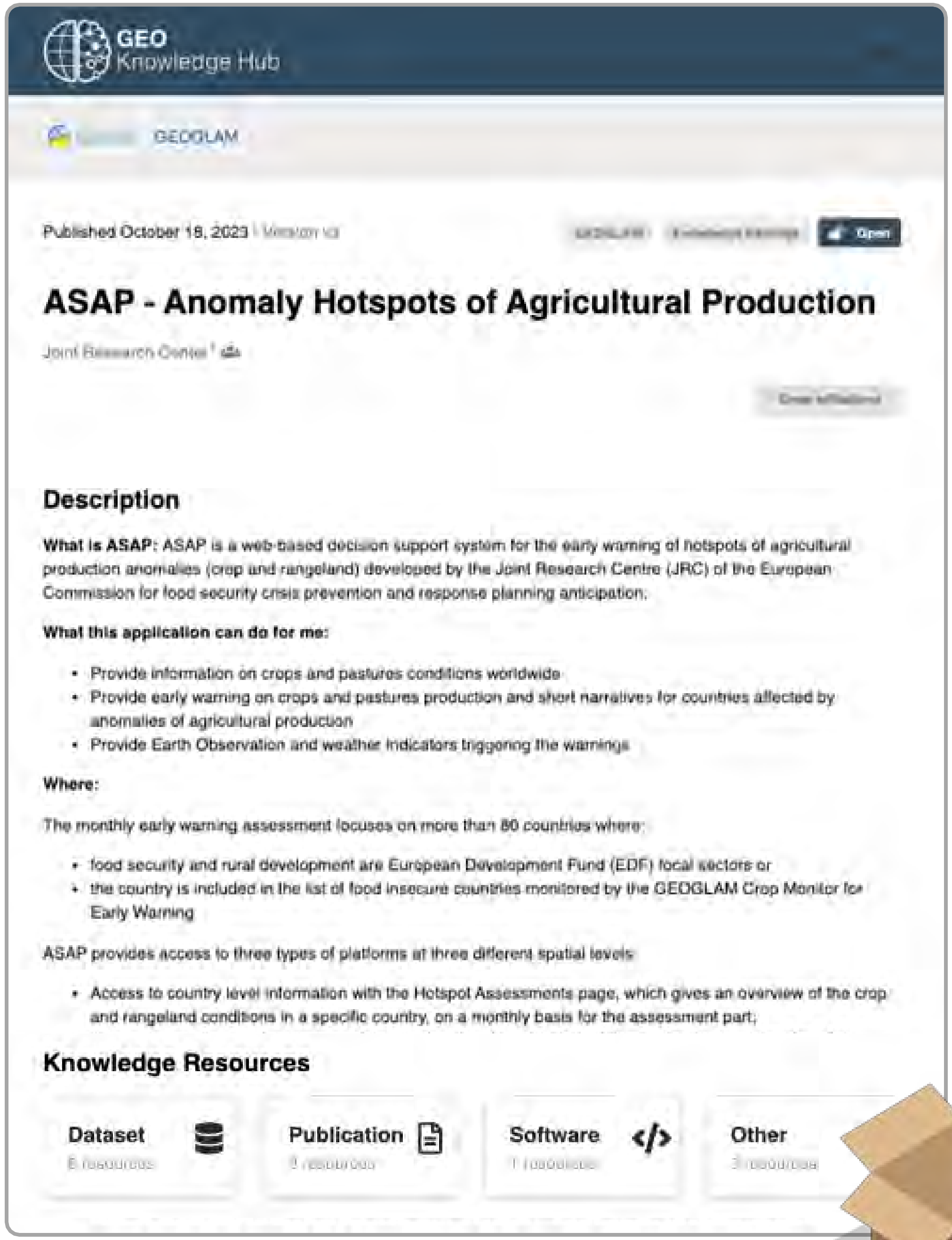
Curate

Engage

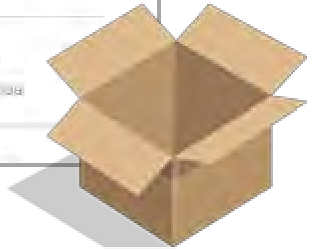
GEO Knowledge Hub

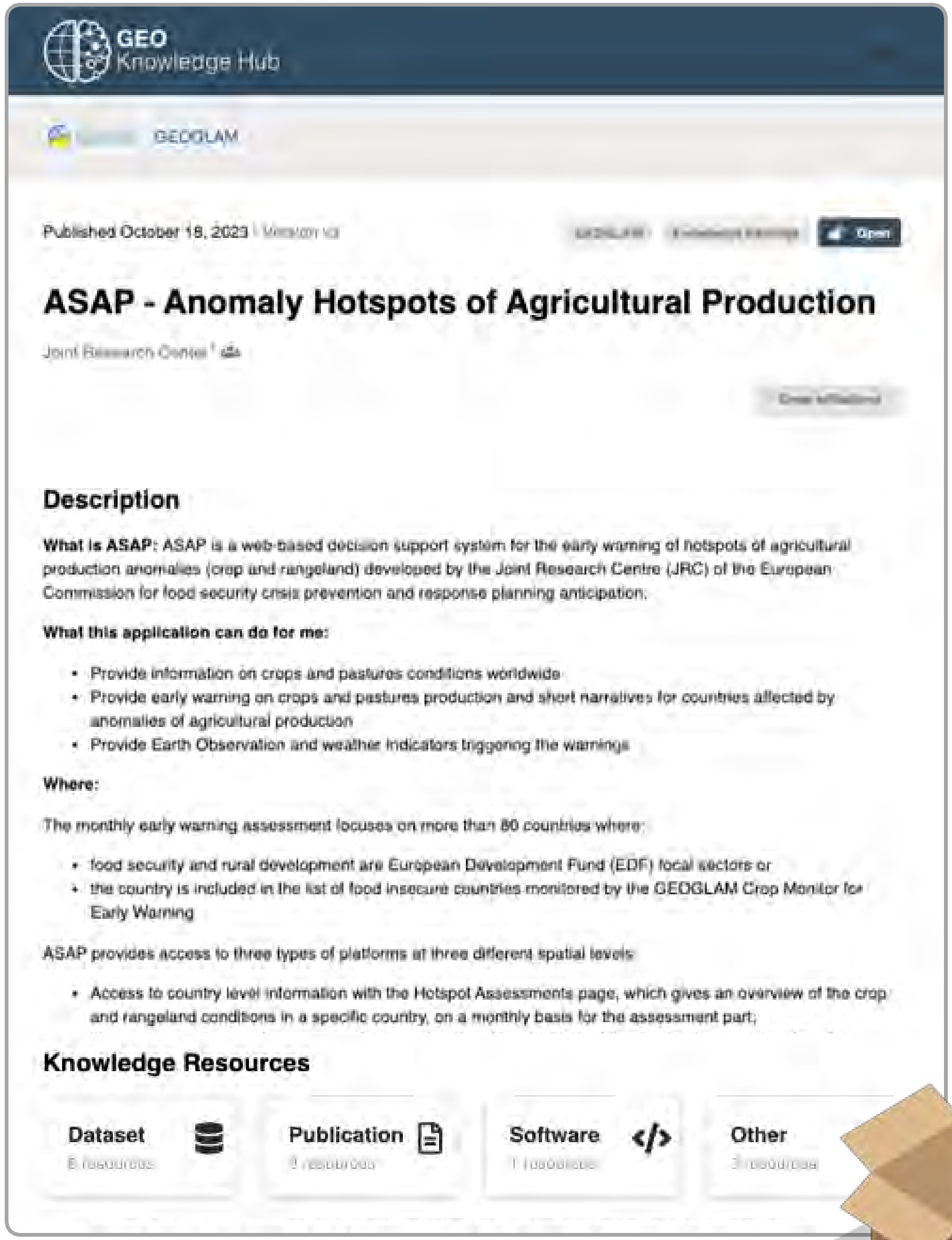


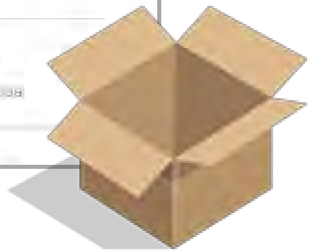
gkhub.earthobservations.org



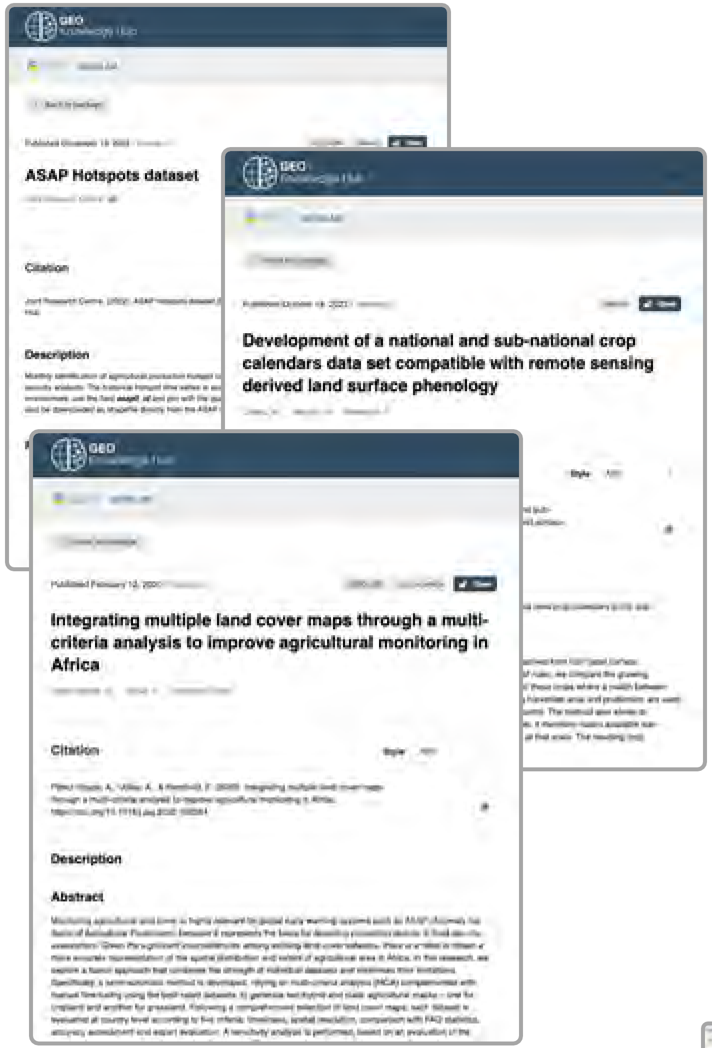
GEO
Knowledge Hub
GEOGLAM
Published October 18, 2023
Open
ASAP - Anomaly Hotspots of Agricultural Production
Joint Research Centre
Description
What is ASAP: ASAP is a web-based decision support system for the early warning of hotspots of agricultural production anomalies (crop and rangeland) developed by the Joint Research Centre (JRC) of the European Commission for food security crisis prevention and response planning anticipation.
What this application can do for me:
• Provide information on crops and pastures conditions worldwide
• Provide early warning on crops and pastures production and short narratives for countries affected by anomalies of agricultural production
• Provide Earth Observation and weather indicators triggering the warnings
Where:
The monthly early warning assessment focuses on more than 80 countries where:
• food security and rural development are European Development Fund (EDF) focal sectors or
• the country is included in the list of food insecure countries monitored by the GEOGLAM Crop Monitor for Early Warning
ASAP provides access to three types of platforms at three different spatial levels:
• Access to country level information with the Hotspot Assessments page, which gives an overview of the crop and rangeland conditions in a specific country, on a monthly basis for the assessment part;
Knowledge Resources
Dataset
Publication
Software
Other







Knowledge Resources

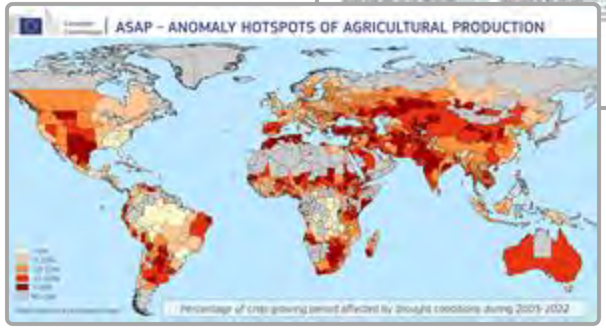


Content

Reports

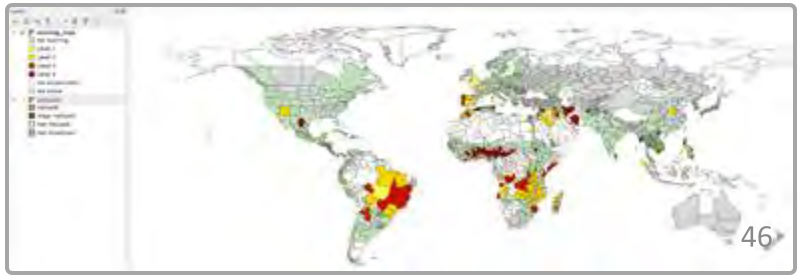
Articles

Maps



(Frequency of crop warnings)

OGC Services



Think **global**, act **local**

Global

Local

National GEO Knowledge Hub

Contextualize

Issues | **Communities** | **Activities**

National GKH

National GEOs can have their own customizable space

Countries are sovereign to manage their spaces

Based on the content and features of the global GKH

Benefits for countries

Shared challenges

Countries face the same environmental problems and solutions can be shared.

National ownership

Each country deploys and manages its own platform on the GKH infrastructure.

Impact beyond borders

Benefits the country and adds knowledge that other nations can reuse.

Our trajectory

Milestones in the journey of the National GKH.

2024

ODOK China

The starting point — where the idea first took shape.

Our trajectory

Milestones in the journey of the National GKH.

2024

ODOK China

The starting point — where the idea first took shape.

2025

ODOK Italy

First functional version presented to the community.

South Africa was the **first country** to adopt the National GKH and contribute actively to its development.

GROUP ON EARTH OBSERVATIONS

Our trajectory

Milestones in the journey of the National GKH.

2024

ODOK China

The starting point — where the idea first took shape.

2025

ODOK Italy

First functional version presented to the community.

2026

ODOK Switzerland

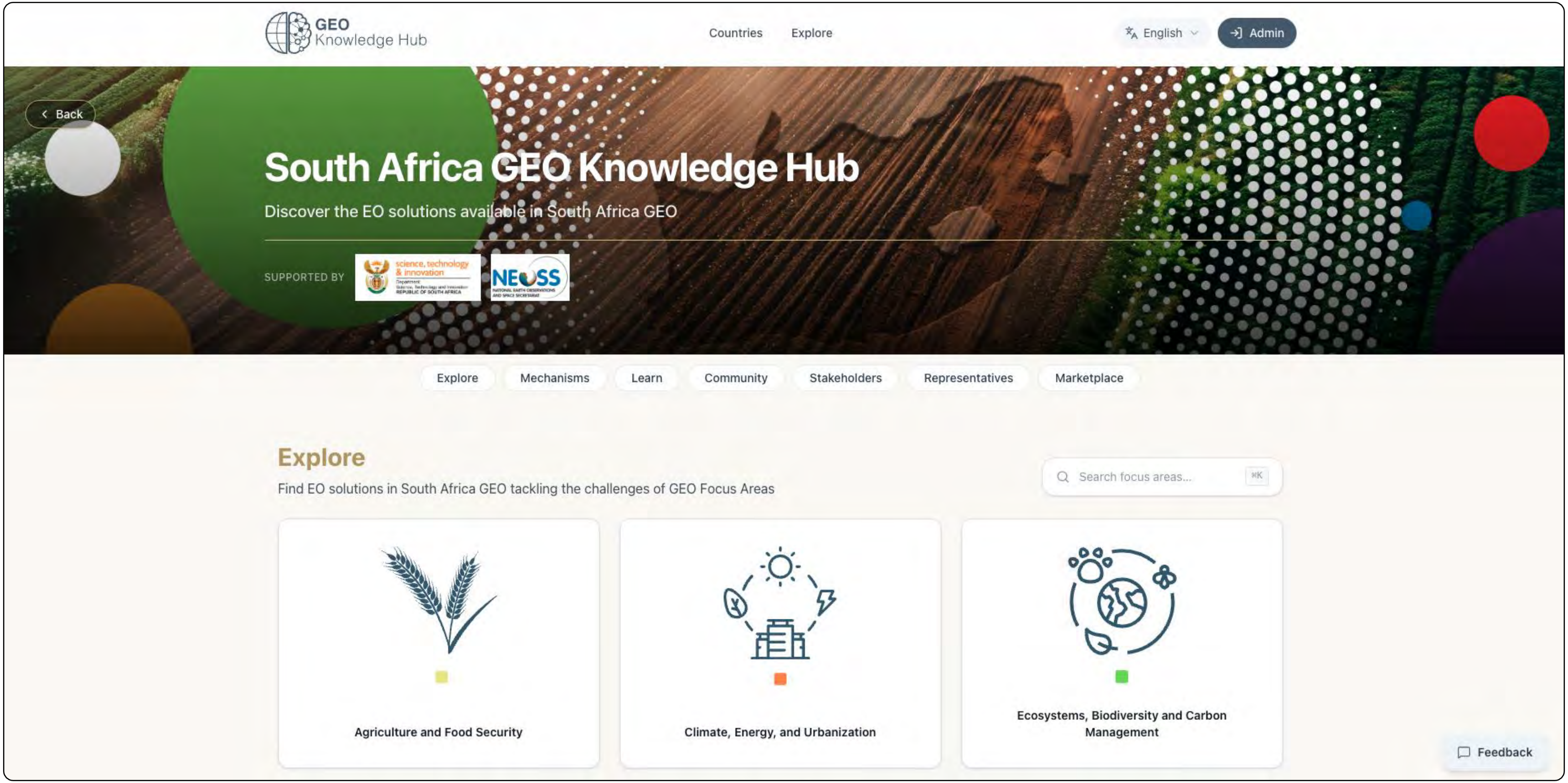
Dedicated session on the National GKH to share experiences.

2026

NEOSS Workshop

Workshop introducing the hub to the wider community.

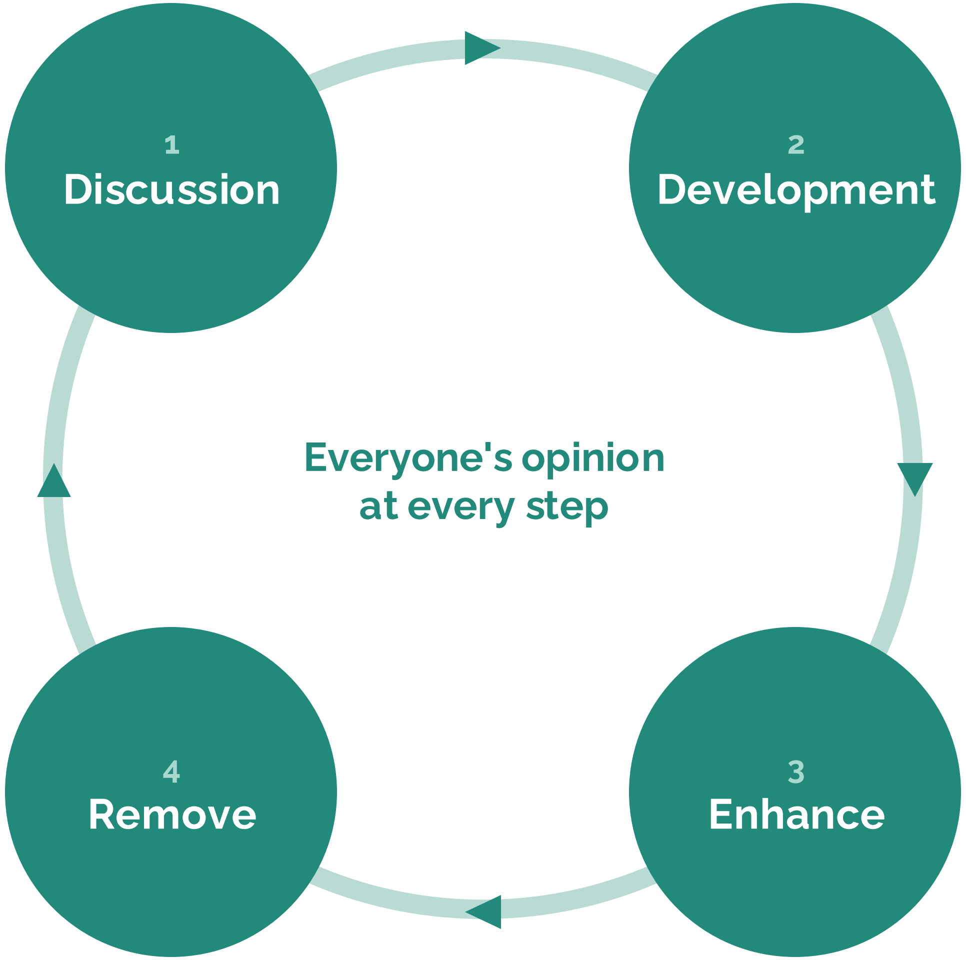
South Africa GKH



Co-development process

The idea is raised, discussed and shaped together.

The agreed idea is implemented in the National GKH.



We review what is in place and adjust what needs changing.

When the team agrees, we take out what is no longer useful.

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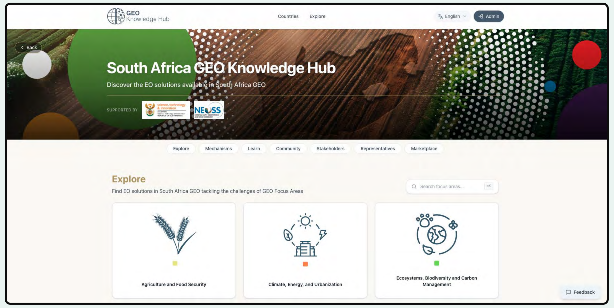
South Africa GKH



South Africa

First National GKH in operation, **the pioneer**

Ownership

Full control over governance, configuration and published content.

Sovereignty

The country decides what it publishes or shares.

Trusted infrastructure

GKH-grade preservation and global discoverability.

Key representatives

Lulu Makapela

Bolelang Sibolla

Kwanele Ngongoma

Elhadi Adam

Tshisikhawe Mphaphuli

GROUP ON EARTH OBSERVATIONS

National GEO Knowledge Hub Implementation guidelines

This document provides step-by-step guidance on establishing a **National GEO Knowledge Hub**, which serves as a centralized system for managing Earth Observation (EO) data, knowledge, and collaboration in National GEOs.

The GEO Knowledge Hub

GEO Knowledge Hub

The **GEO Earth Observations (GEO) Knowledge Hub** is an open source centralized digital library which serves as a platform to facilitate data, knowledge sharing, collaboration, and capacity building on a global scale. Aligned to GEO initiative's objectives, such as improving access to Earth observation data and knowledge, enabling informed decision-making, and supporting sustainable development.

The world is facing a variety of socio-environmental problems; many of those benefit from EO data and knowledge.

Researchers, organizations in countries are developing applications using EO data, code, algorithms to mitigate and respond those challenges, in order to accelerate the impact that EO can have, The GEO Knowledge Hub has been developed to enhance the sharing across people, and countries on existing solutions. Countries can learn from countries and enhance existing applications for their own area.

The National GEO Knowledge Hub

Example: South Africa National GEO Knowledge Hub

The GEO Knowledge Hub is the localized version of the global GEO Knowledge Hub, designed to support the specific needs of a country's Earth observation community.

The National GKH functions within the country and its role in supporting national priorities, such as environmental monitoring, disaster management, and climate adaptation. It may also explain how the National GEO Knowledge Hub integrates with global initiatives and national stakeholders.

Authorities, researchers responders within the country need to have quicker access to data and knowledge that respond to the specific country problems and the scope of the National GKH is to facilitate this as well learn from other countries, how they are facing specific challenges with EO data and existing open applications.

Preliminary steps

The initial steps needed to establish the National GEO Knowledge Hub. Key actions might include:

- Setting goals and objectives for the hub
- Mapping of the Entities Working with Earth Observations in the Country by Thematic Focus Area and Identifying stakeholders and actors in the Earth Observation space
- Establishing the legal, technical, and institutional frameworks
- Conducting a needs assessment to identify gaps in data and infrastructure

1. Benefits

Outline of the benefits for the Country to Have One Single Entry Point for All Earth Observations Actors and Data and Knowledge.

This section elaborates on the **advantages** of establishing a single, centralized **National GEO Knowledge Hub** to manage all Earth Observation activities in the country. Key benefits may include:

Collaboration

A centralized platform would foster collaboration between:

- Government agencies
- Research institutions
- NGOs
- Private sector companies (GEO Knowledge Hub Marketplace)

By streamlining data access and promoting shared efforts, the hub can help coordinate and amplify national efforts to address socio-environmental challenges.

Long-Term Preservation

A national EO hub would help ensure that valuable Earth Observation data and knowledge are preserved for future generations. This could involve:

- Archiving EO datasets
- Establishing data governance frameworks
- Ensuring that datasets are not lost due to technological obsolescence

Enhanced Capacity Building

The hub could serve as a platform for:

- **Training and education** in Earth observation, GIS, and data analysis
- **Capacity-building programs** for professionals working with EO data
- Facilitating knowledge transfer and technical assistance from other countries or global institutions

Learning from Other Countries on Similar Socio-Environmental Problems

A GEO Knowledge Hub provides an opportunity for:

- **Cross-country knowledge exchange**: Countries facing similar environmental or socio-economic challenges could collaborate and share lessons learned.
- **Adapting global best practices** to local contexts: By understanding how other nations are addressing their challenges with EO data, a country could apply these lessons in their own efforts.
- Allow the country to make visible ongoing EO efforts in the commercial sector, by leveraging the GEO Knowledge Hub Marketplace (examples from South Africa)

2. Team in the Country

To ensure a secure and sustainable development of the National GEO Knowledge Hub, it is important to have at least 2 personals assigned for the activity, including:

- **GEO Knowledge Hub Coordinator**: An EO knowledgeable coordinator for the activity. This MUST be a person that is connected to the community, knows the landscape, institutions and activities running in the country dealing with Earth Observations (satellite and in-situ)
- **GEO Knowledge Hub Technical Focal Point**: An EO practitioner able to engage with Knowledge providers and support the registration of the content for the GEO Knowledge Hub by respecting the quality standards adopted by the GEO Knowledge Hub, to ensure full comprehension of the available knowledge packages, applications, knowledge resources and their reproducibility

3. Mapping of the Entities Working with Earth Observations in the Country by Thematic Focus Area

Create an inventory or map of the key actors by thematic areas (GEO focus areas) in the country's Earth Observation landscape. This could include:

- **Government agencies** responsible for environmental monitoring or natural resource management
- **Academic and research institutions** conducting studies related to Earth science or EO data
- **Private sector entities** developing EO technology or services
- **NGOs and international organizations** working on socio-environmental issues
- **Industry sectors** like agriculture, forestry, or water management utilizing EO data

This mapping would likely categorize these actors based on thematic areas like climate change, land use, agriculture, disaster management, water resources, etc.

Mapping example:

doi.org/10.60566/bxtza-34p90

A growing network

From the first hub to a growing community of National GKHs.

South Africa

Live

First National GKH in operation.

Ghana

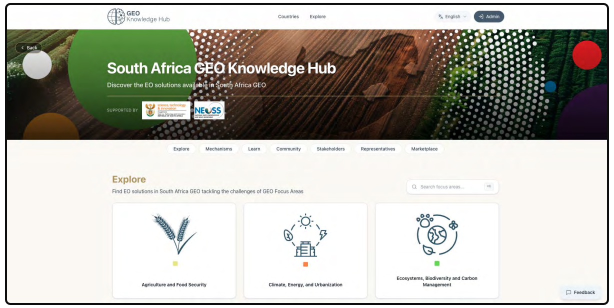
Building

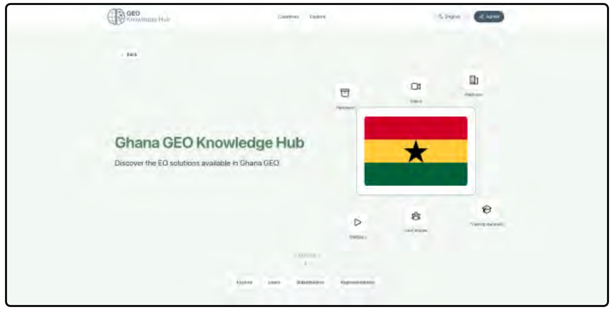
National GKH under construction

Kenya

In discussion

Conversations under way





GEO Data Sharing and Data Management Principles

DOI: 10.60566/v56md-kqg97

GEO Data Management Principles

1 INTRODUCTION

In 2015, the GEO Data Management Principles Task Force was tasked with defining a common set GEO Data Management Principles[1]. These principles address the need for discovery, accessibility, usability, preservation, and curation of data and related resources that are shared. Such resources also should be shared as open data in accordance with the GEO Data Sharing Principles[2]. The GEO Data Management Principles complement the FAIR Principles and TRUST Principles, which also are being adopted across research communities. The GEO Data Management Principles can be applied to the entire data management lifecycle, while the FAIR principles (Wilkinson M.D. et al.) focus primarily on aspects of metadata, including persistent identifiers. The TRUST principles (Lin D. et al.) primarily focus on the curation and preservation of data and related resources. To support the implementation of the principles, the GEO Data Management Principles Guidelines have been developed so that data providers and other stakeholders can use them as a reference as they seek to implement the principles. These guidelines can also be used when assessing how well the principles are being followed in practice. This current version of the guidelines is the result of a revision process conducted by the GEO Data Working Group in 2022.

These guidelines are applicable to the management of all Earth Observation data products, both remote sensing and in-situ data, as well as other types of data products and services. These guidelines are intended to cover raw data and higher level products, including Analysis Ready Data (ARD) and data products that are produced on-demand by services. While the principles can be applied to services that generate data on-demand; this guidance focus primarily on data and related products. The Data Management Principles can be applied to Decision Ready Information (DRI) and other Knowledge assets, but these guidelines do not explicitly offer recommendations for them.

The GEO Data Branding website[3] offers a self-assessment opportunity for data providers to generate a GEO label that reflects the level of implementation of the DMPs. The GEOSS Yellow Pages[4] (https://www.geoportal.org/yellow-pages) provide information about the level of implementation of the DMPs as have been declared once by data providers and covering all their data. At this stage, the GEO has not defined any process for independent certification of a data provider against the DMPs.

Guidance for implementing the GEO Data Management Principles (DMP) is offered within each section of the guidelines. The following topics are covered in the guidelines for each of the DMP:

- Title and Category of the DMP,
- Explanation of the DMP,

[1] https://www.earthobservations.org/documents/dswg/201504_data_management_principles_long_final.pdf
[2] https://www.earthobservations.org/dswg.php
[3] https://geolabel.info/
[4] https://www.geoportal.org/yellow-pages

GEO Data Management Principles (Revised: March 2024) DOI: 10.60566/v56md-kqg97

- Guidance on implementation, standards applicable and examples;
- Metrics to measure level of adherence to the principle;
- Resource Implications of Implementation

The Appendix contains a compilation of terms, an explanation about overarching interoperability levels, references, a summary of changes with respect to the original version and an acknowledgement of contributions.

Most of the guidelines reference community standards and practices that foster implementation of a principle in an interoperable manner by enabling one or more of the following levels of interoperability, which are further described in Appendix B: syntactic, semantic, schematic, and legal interoperability.

2 DMP-1: METADATA FOR DISCOVERY

DMP Category: Discovery.

DMP-1: Data and all associated metadata will be discoverable, through catalogues and search engines; moreover, data access and use conditions, including licenses, will be clearly indicated.

2.1 Explanation of the principle

A visitor to a library should be able to find a desired book without having to look at every book in the bookshelf. The library's catalogue allows the visitor to search information about the books (e.g. author, ISBN number, genre, keywords), to discover where to find the book and under what conditions or restrictions the book might be read or borrowed. This "information about the book" is its metadata. Likewise, a user looking for Earth Observation resources (data, web services, models, etc.) should be able to find what s/he wants by searching and retrieving the metadata associated with that digital resource, including information on how the resource can be accessed and whether there are any restrictions or conditions placed on its use. Consistent with the FAIR Data Principles, data should be Findable, Accessible, Interoperable, and Reusable (Wilkinson, et al., 2016). Currently, metadata is concentrated in metadata catalogues that are web services that can be interrogated to find the relevant datasets for an application. GEOSS maintains a catalogue of resource descriptions (metadata) and, like a library catalogue, does not keep copies of resources, but manages the metadata that facilitates discoverability, allowing users to locate and access the resources. Such resource descriptions may point to other catalogues - analogous to a library directing a visitor to other libraries' catalogues.

Not all users begin a search for resources by going to a specific catalogue. Some start by a study or a publication that cite artifacts like data and data fragments, or even software and methods to create new data. They use full citations and PIDs (see DMP-10) to find that dataset directly. Other users might be more inclined to use search engines instead of catalogues. For this reason catalogues may link to portals, such as a geoportal, for use by humans, as well as programmatic interfaces (Application Programming Interfaces - APIs) meant for access by search engines, metadata harvesters and the portals of other communities. The discovery of data is enabled by the syntactic interoperability provided by the combination of catalogue services and API and the metadata standard (commonly expressed in XML) that make use of XML schemas to improve schematic interoperability. However, in practice, true semantic interoperability is difficult to achieve, often requiring brokering and mediation to align with the preferred metadata standard

Editor: Data Sharing and Data Management Subgroup of the GEO Data and Knowledge Working group

GEO Data Management Principles (Revised: March 2024) DOI: 10.60566/v56md-kqg97

DMP-3: Data should be structured using encodings that are widely accepted in the target user community and aligned with organizational needs and observing methods, with preference given to non-proprietary international standards.

4.1 Explanation of the Principle

Usability of data, and especially automated use, depends strongly on the extent to which end users (both human and machine) can rely on standardized encoding as tools, applications, and algorithms are typically designed to work with such. Use of standardized encodings brings benefits to the end user and limits the amount of time spent on transforming data, and therefore is a key to ***interoperability***, as described under DMP-1.

4.2 Guidance on Implementation, with examples

The availability and acceptance of ***syntactic encoding standards*** are at a high level of maturity, and these standards cover the majority of data families that the GEO community uses routinely. Examples are sensor services defined by OGC SWE (2011), OPeNDAP service and NetCDF format (OGC Network Common Data Form 2015; Common Data Model 2015), and the work done by WMO in respect of globally available meteorological data (WMO Information System 2015). The extent to which the community has implemented these standards is, however, highly variable, with implementation of OGC Sensor Observation Services lagging seriously behind Web Mapping Services and the use of OPeNDAP and NetCDF (with or without the Climate and Forecast (CF) Metadata Conventions). The use of Python xarray and their related file formats (e.g, Zarr) is gaining traction in the image analysis community, stimulated by open code snippets that can be easily and remotely executed by Jupyter notebooks. Practitioners should select the open standards and implementations of these appropriate to their community, internal information technology platforms, and capabilities, as a preferred means of providing access to publicly available datasets.

Communities have also developed a portfolio of content standards in support of ***schematic interoperability*** (see Appendix B). For example, GML (OpenGIS® Geography Markup Language 2007) requires a GML application schema that ensures schematic interoperability, while GeoJSON (GeoJSON Format Specification 2016) is schemaless. Standards for raster data such as the GeoTIFF, NetCDF, HDF5, JPEG2000 rely on metadata to specify the schema and semantics. TimeSeriesML and O&M are examples of encodings of time series and sensor observations. Interoperability practices, for spatial datasets, whether vector datasets or raster datasets, are highly mature, and it is common for applications and web components to support a wide variety of data schema. Formats recognized by the GDAL/OGC libraries will facilitate exchange of data among many GIS products. Best practice and guidance should stress the application of these widely adopted standards whenever possible.

The most diverse landscape is found in respect of ***semantic interoperability***, as described under the Appendix B, Metadata for Discovery, and content standard encoding to support it. Some communities have access to mature content standards (for example the Biodiversity community through TDWG (TDWG Standards 2015), the Climate Modelling community through essential climate variables (GCOS Essential Climate Variable(s) 2015), and WaterML (OGC® WaterML 2015)), and there are significant efforts to establish ontologies, vocabulary services, federated vocabulary services, FAIR vocabularies, and naming services for a wide variety of disciplines [Cox, 2021]. A major concern is centered on this diversity, and it is often difficult

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GROUP ON EARTH OBSERVATIONS

Questions

Session 2 - agenda

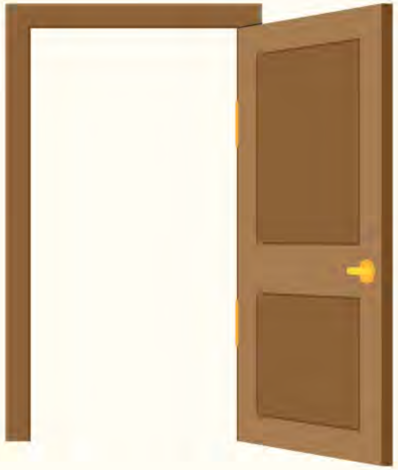
1. GEO Knowledge Hub to preserve and share content
2. Importing content to the National GEO Knowledge Hub

Session 2 - agenda

1. GEO Knowledge Hub to preserve and share content
2. Importing content to the National GEO Knowledge Hub

GEO
Knowledge Hub

Open



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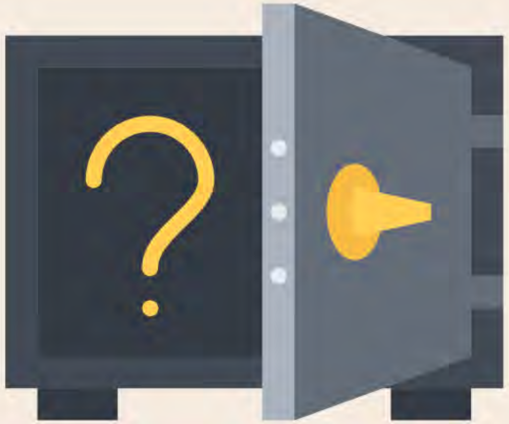
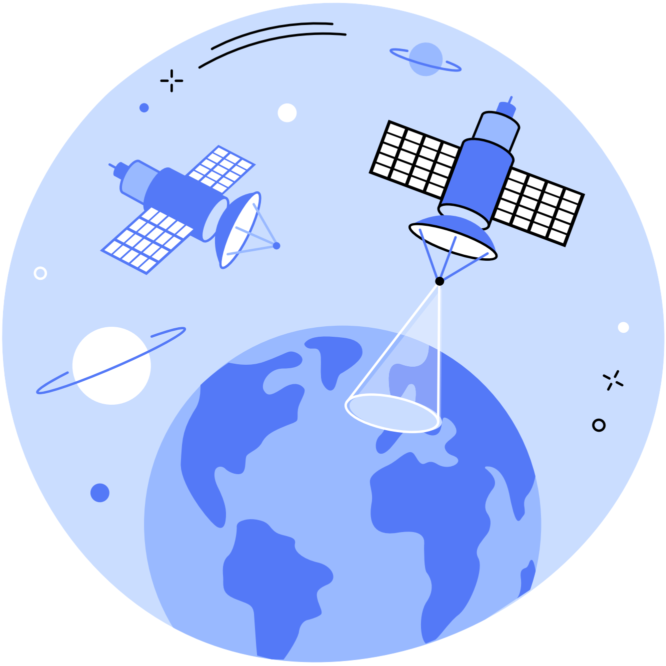


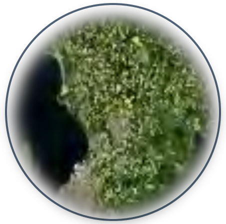
Use

Making EO Applications

EO Application

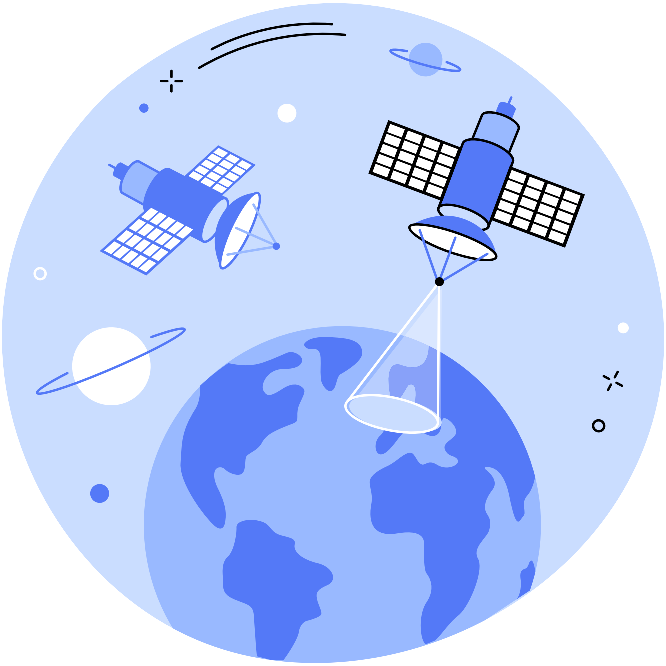


Making EO Applications



Satellite imagery

EO Application



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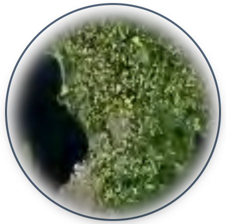

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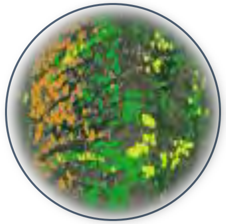
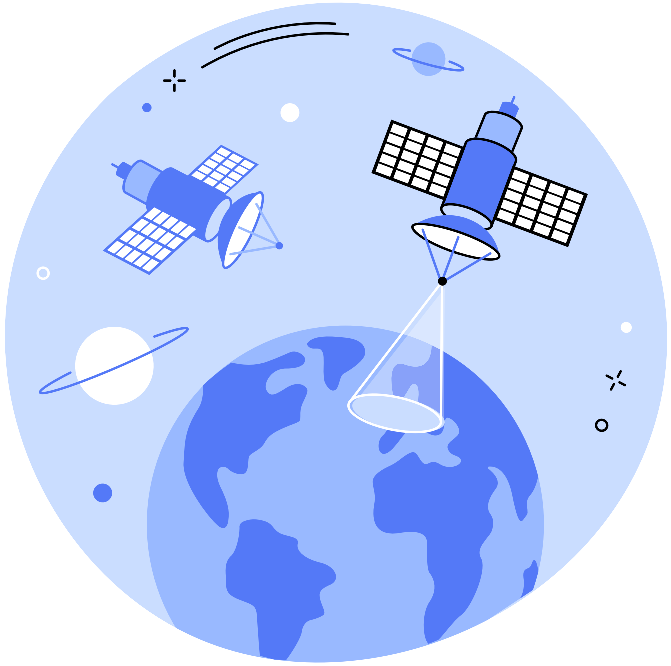
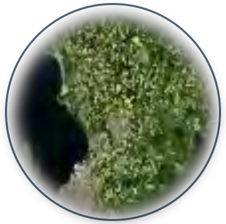


In-situ data

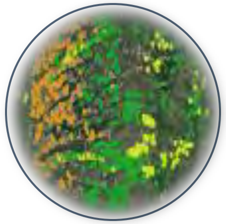
EO Application



Making EO Applications



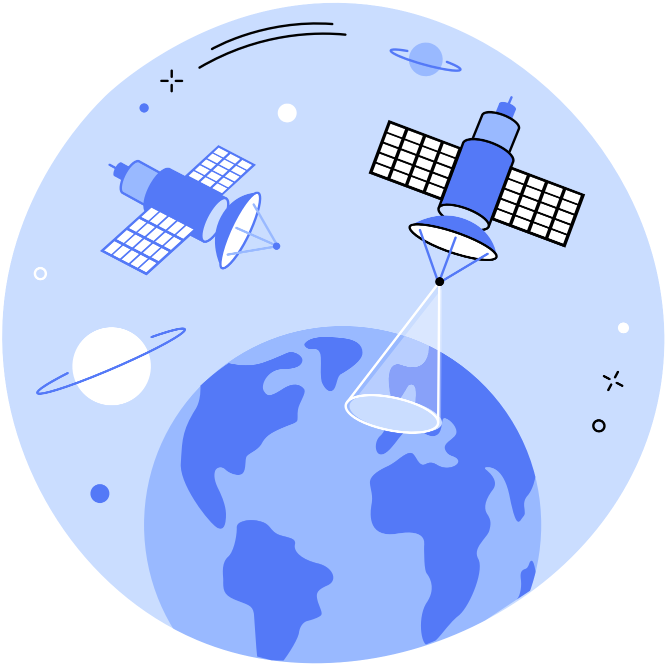
Satellite imagery



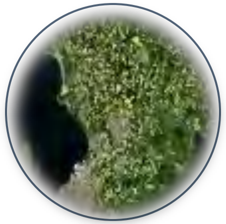
In-situ data

Processing scripts

EO Application



Making EO Applications



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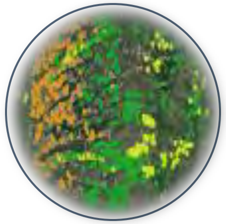
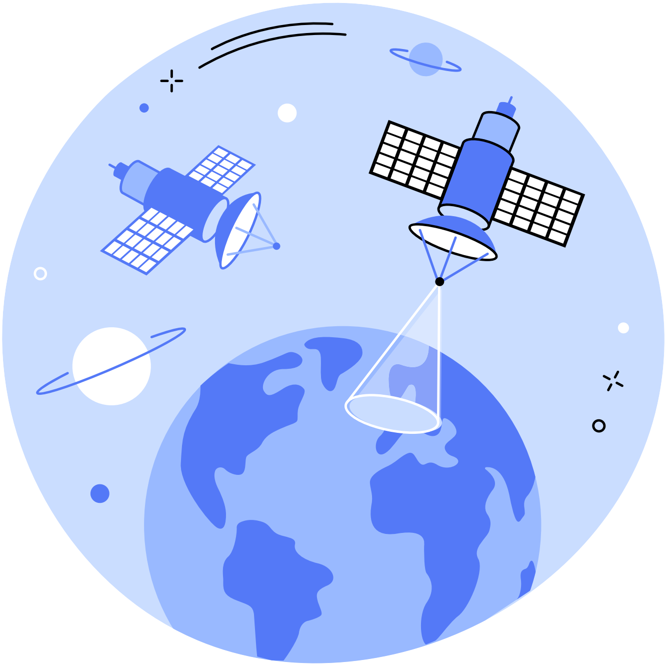
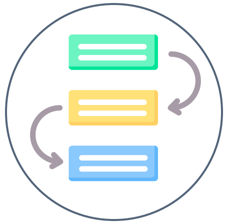


In-situ data

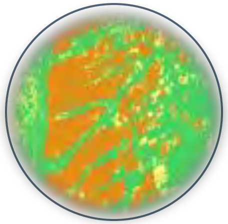
Processing scripts

EO Application





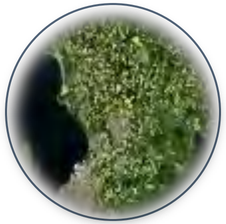
Workflow



Data results

Articles & notes

Sharing EO Applications



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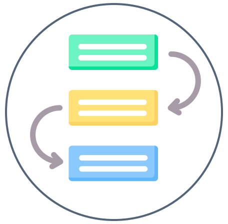
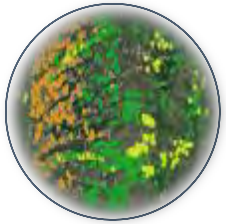
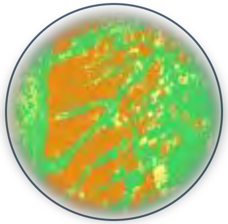


Workflow



In-situ data

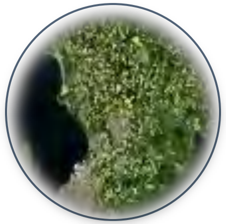


Data results

Processing scripts

Articles & notes

Sharing EO Applications



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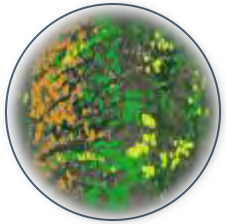
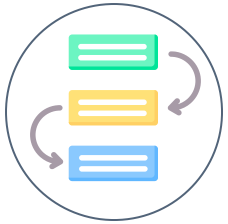


In-situ data

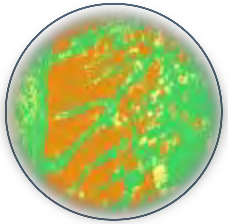
Processing scripts

Metadata

(title, description, license, and others)



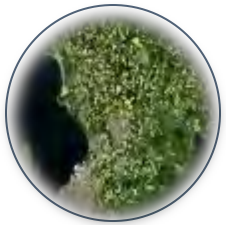
Workflow



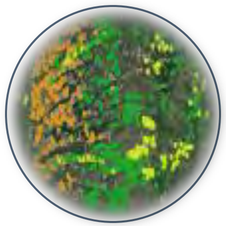
Data results

Articles & notes

Sharing EO Applications



Satellite imagery



In-situ data

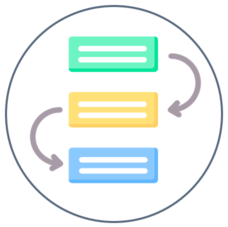
Processing scripts

Metadata

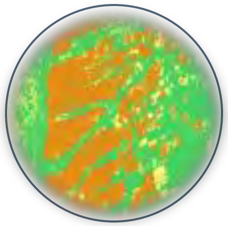
(title, description, license, and others)

Files

(Resource file itself or auxiliary ones)



Workflow



Data results

Articles & notes

Sharing EO Applications

Sharing EO Applications

Knowledge Package and resources

Knowledge Package and resources

Knowledge Package and resources

Metadata

Provides critical information about the dataset's origin, purpose, structure, and context.

GKH uses DataCite schema

Examples

ISO 19115
Geographic metadata standard

DataCite
Metadata for research data & DOIs

Dublin Core
Simple cross-domain metadata

EML
Ecological Metadata Language

Knowledge Package and resources

Open
Data Formats

File structures that store data. Formats define how the data is stored, accessed, and shared.

Examples

GeoTIFF
Georeferenced raster imagery

CSV
Comma-separated tabular data

JSON
Text-based data interchange

XML
Structured markup data

NetCDF
Array-oriented scientific data

GeoPackage
SQLite geospatial container

Open
Data Conventions

are the guidelines for how data is organized and formatted within a specific data format.

Examples

CF Conventions
Climate & Forecast metadata standard

GeoJSON
Geospatial data encoded in JSON

OGC Standards
Open Geospatial Consortium specs

INSPIRE
EU spatial data infrastructure

Knowledge Package and resources

Knowledge Package and resources

Knowledge Package and resources

GROUP ON EARTH OBSERVATIONS

Persistent **Identifiers**

A persistent identifier (PID) is a permanent, unique reference to a digital resource. It keeps providing access to that resource even if its web location changes.

PIDs make content citable, findable, and reliably linkable over time.

GKH provides DOI and uses ORCID and ROR

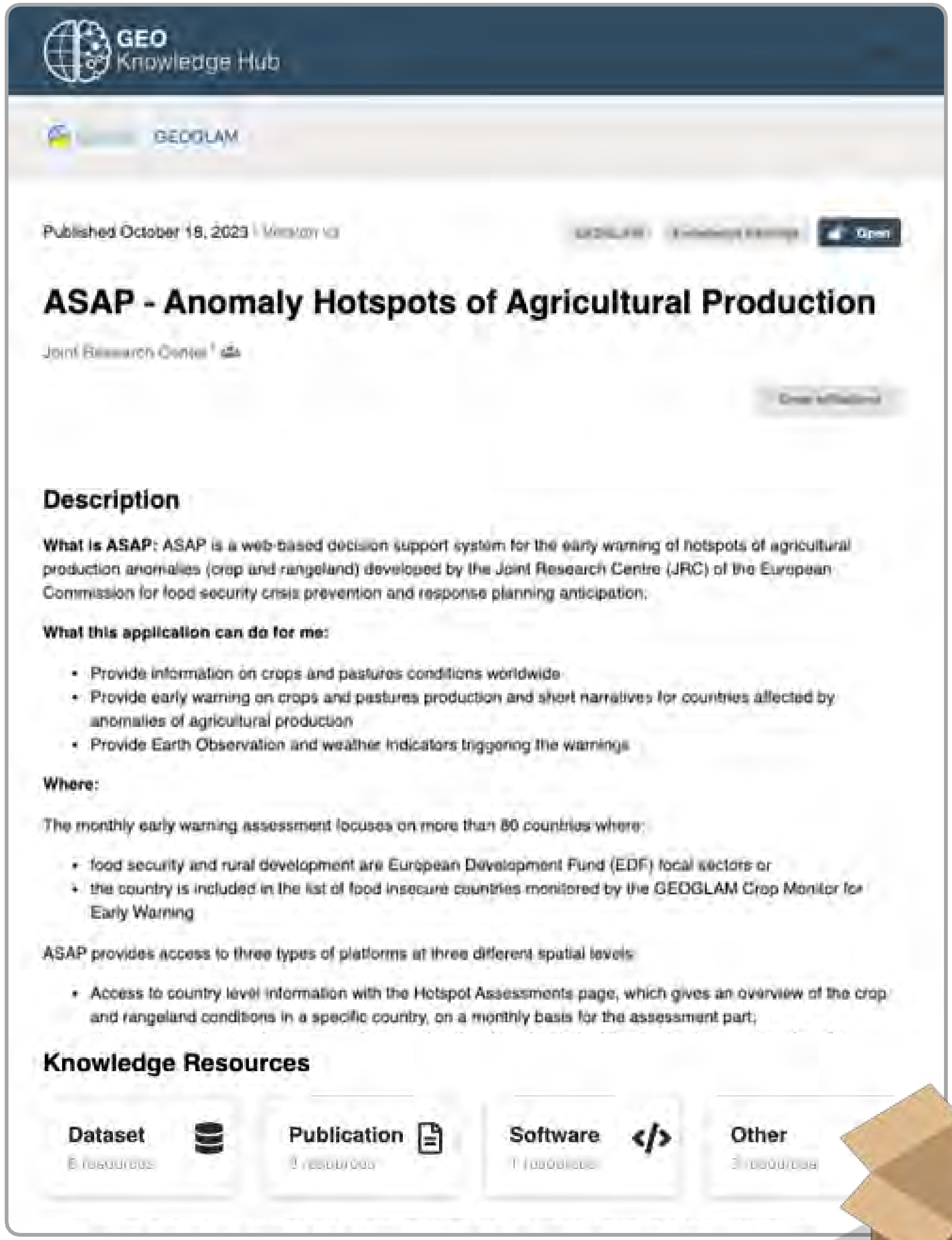
Examples

DOI
Datasets, papers and publications

ORCID
Researchers and authors

Handle
General persistent ID system

ROR
Research organizations


GEO Knowledge Hub

GEOGLAM

Published October 18, 2023

Open

ASAP - Anomaly Hotspots of Agricultural Production

Joint Research Centre

Description

What is ASAP: ASAP is a web-based decision support system for the early warning of hotspots of agricultural production anomalies (crop and rangeland) developed by the Joint Research Centre (JRC) of the European Commission for food security crisis prevention and response planning anticipation.

What this application can do for me:

- Provide information on crops and pastures conditions worldwide
- Provide early warning on crops and pastures production and short narratives for countries affected by anomalies of agricultural production
- Provide Earth Observation and weather indicators triggering the warnings

Where:

The monthly early warning assessment focuses on more than 80 countries where:

- food security and rural development are European Development Fund (EDF) focal sectors or
- the country is included in the list of food insecure countries monitored by the GEOGLAM Crop Monitor for Early Warning

ASAP provides access to three types of platforms at three different spatial levels:

- Access to country level information with the Hotspot Assessments page, which gives an overview of the crop and rangeland conditions in a specific country, on a monthly basis for the assessment part;

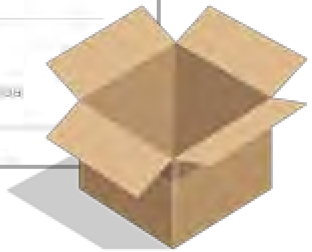
Knowledge Resources

Dataset

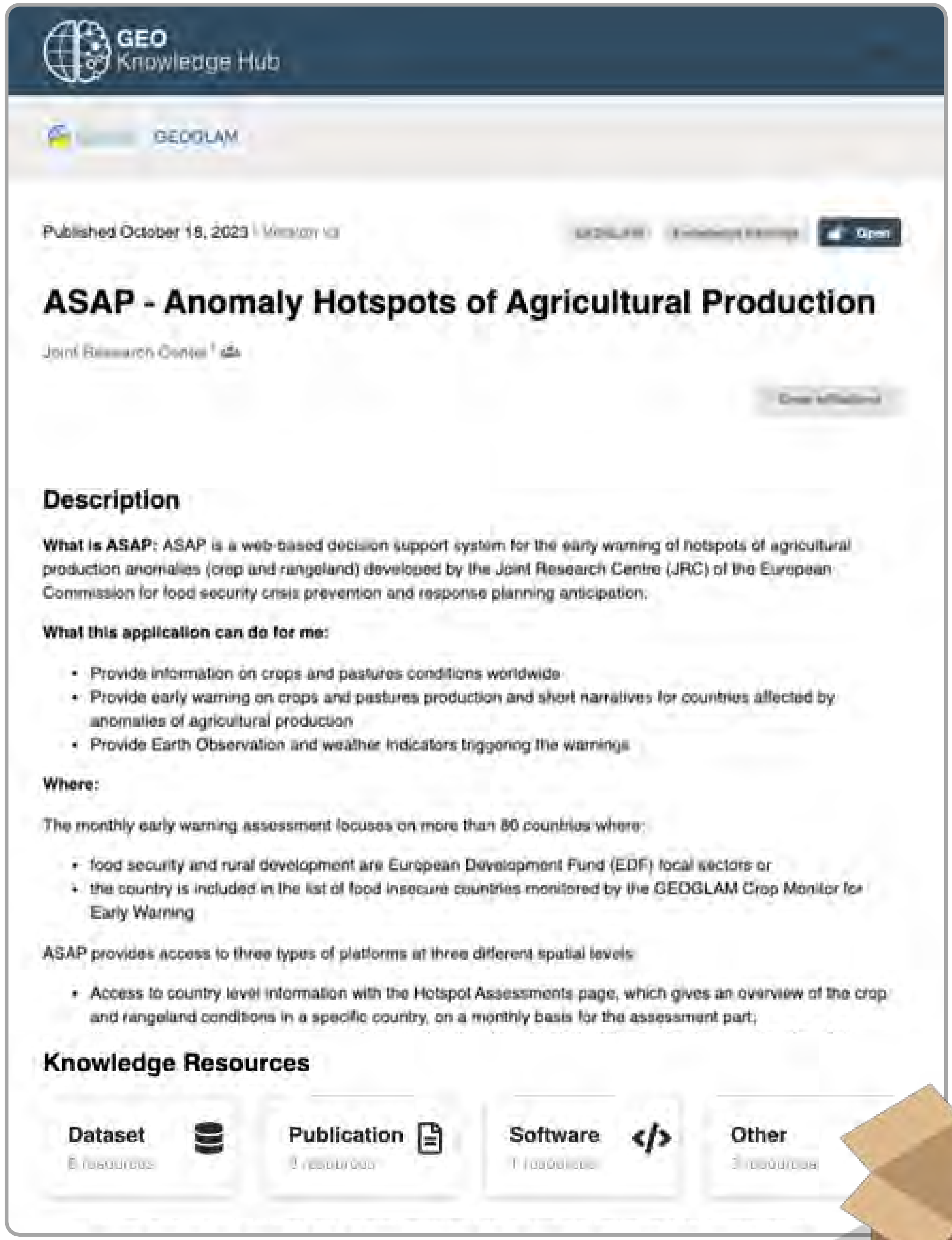
Publication

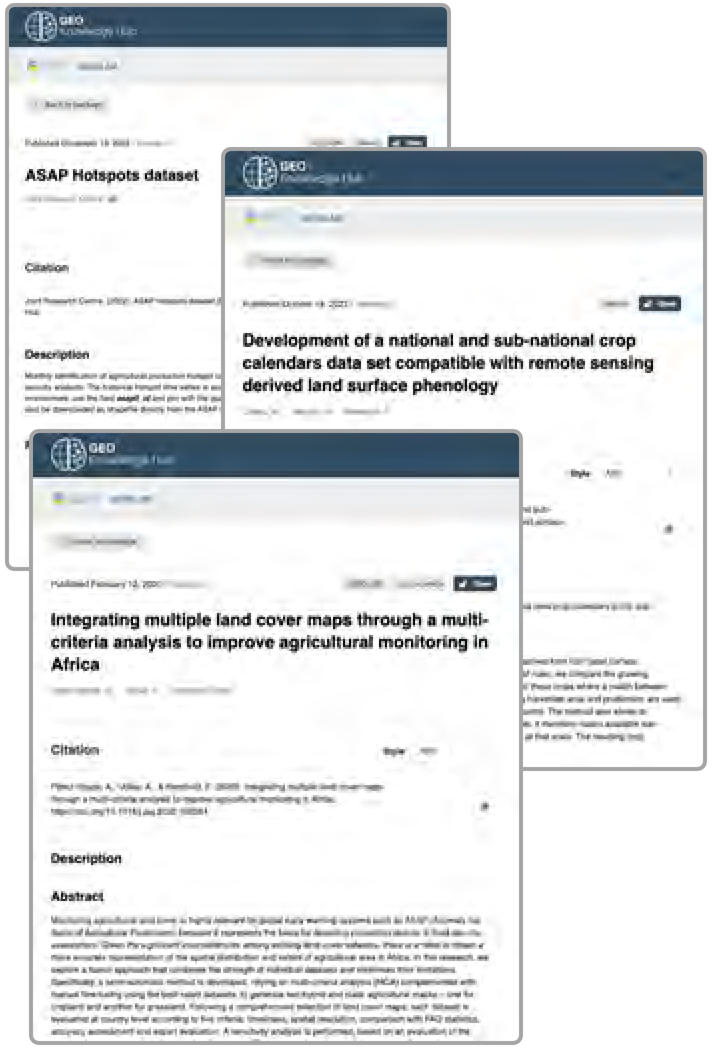
Software

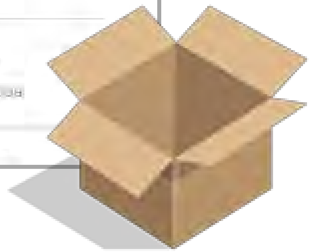
Other

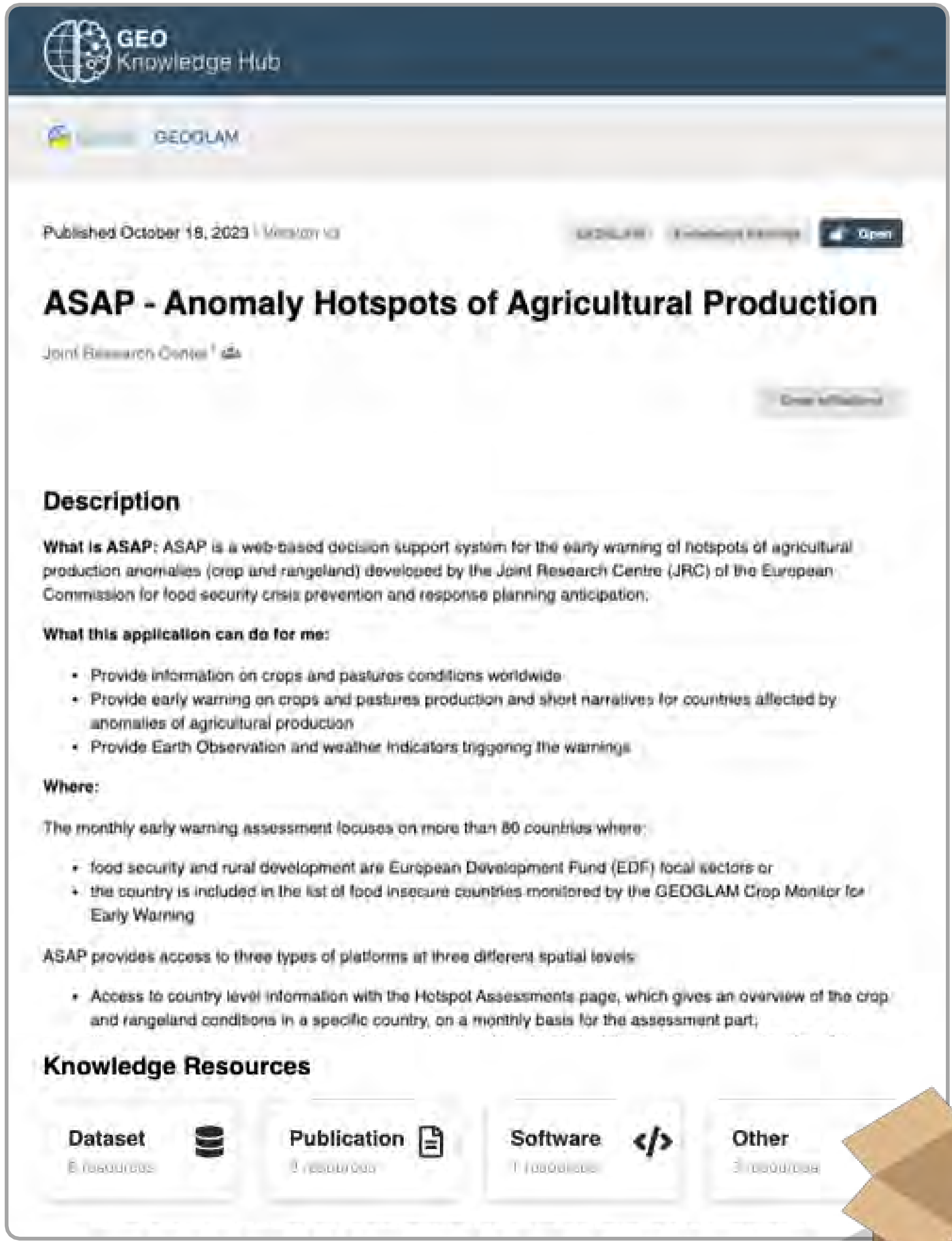


Knowledge Resources

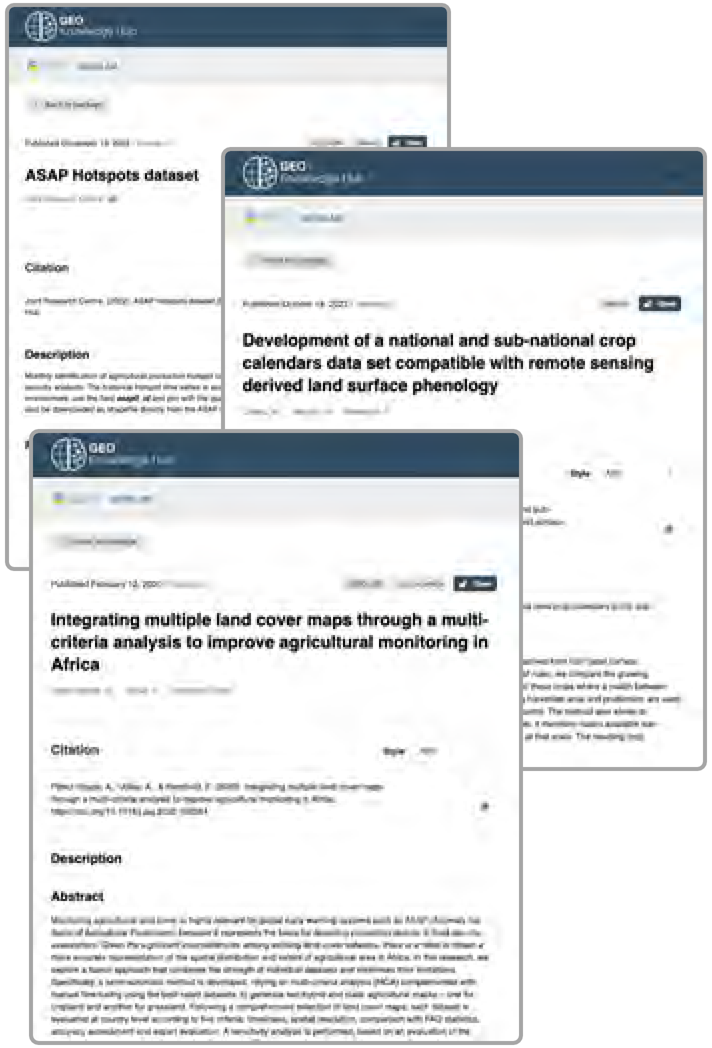








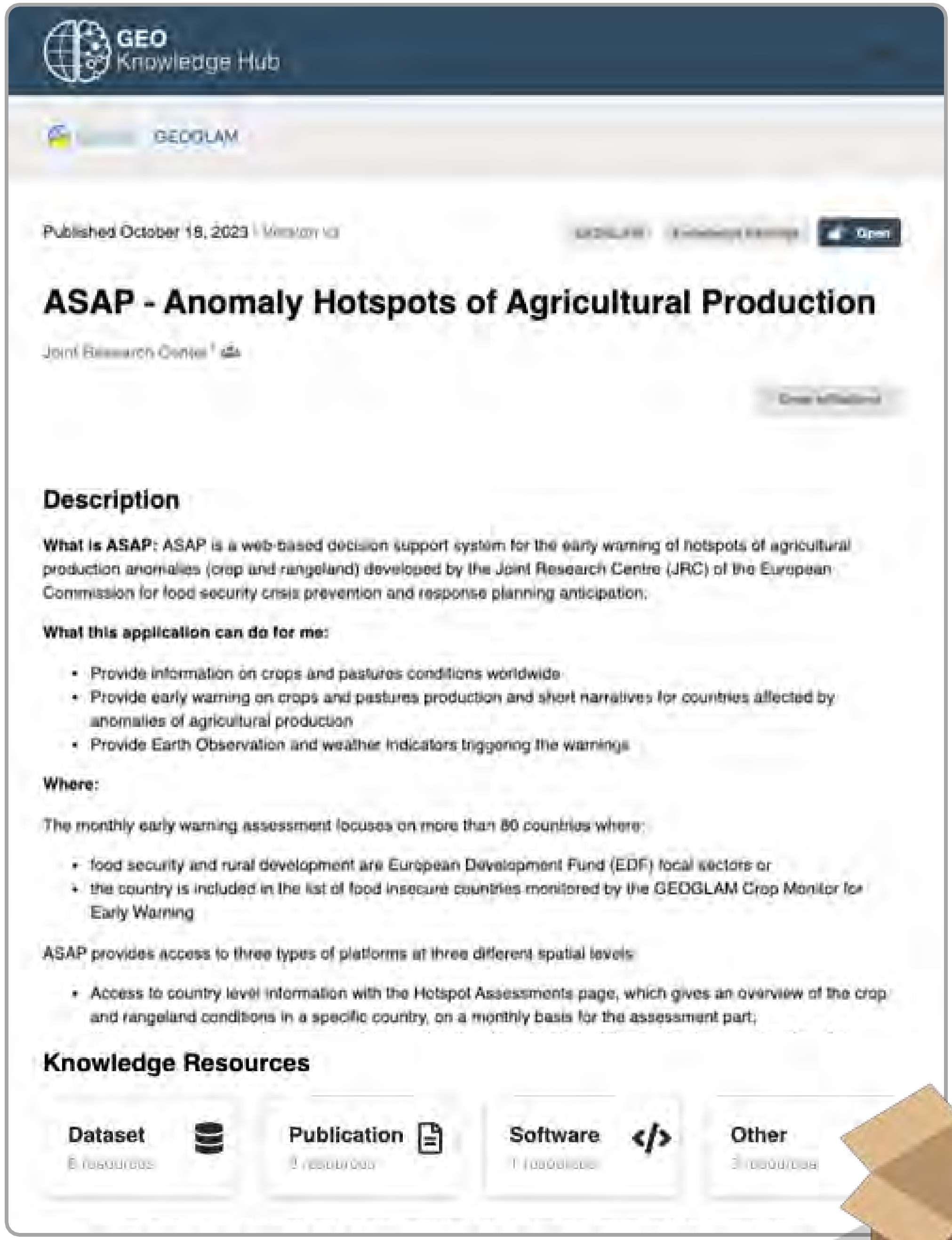
Knowledge Resources



Content

Reports

Articles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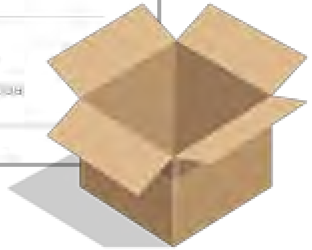
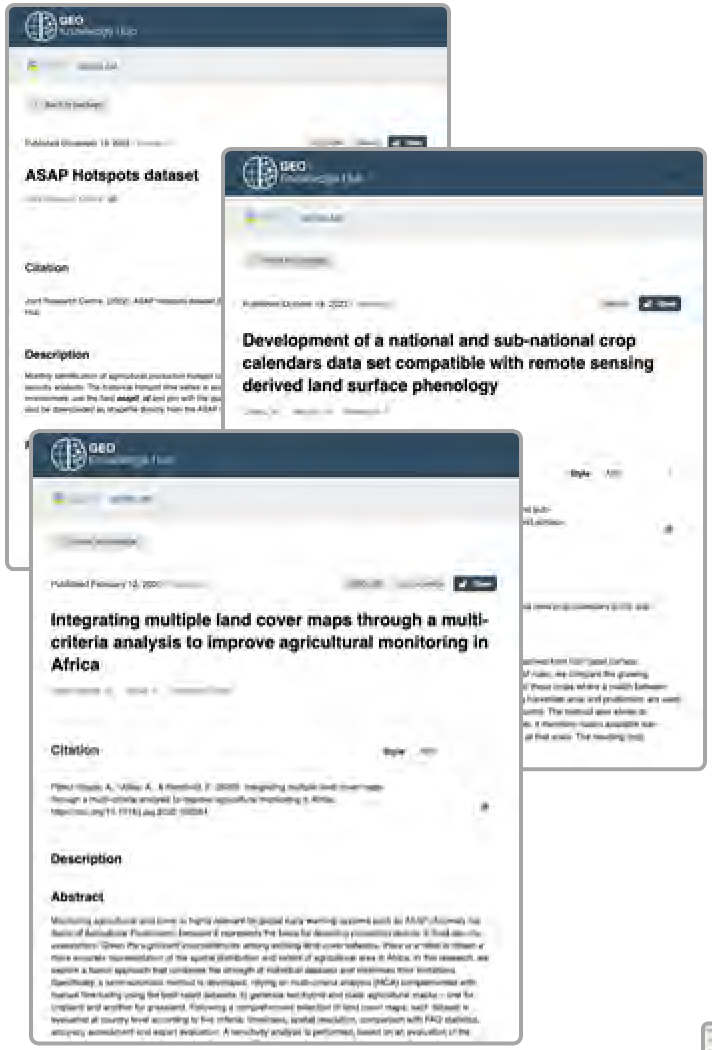
Knowledge Resources

Dataset	Publication	Software	Other



Knowledge Resources

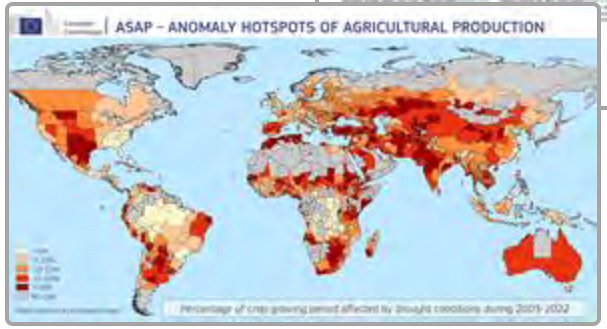


Content

Reports

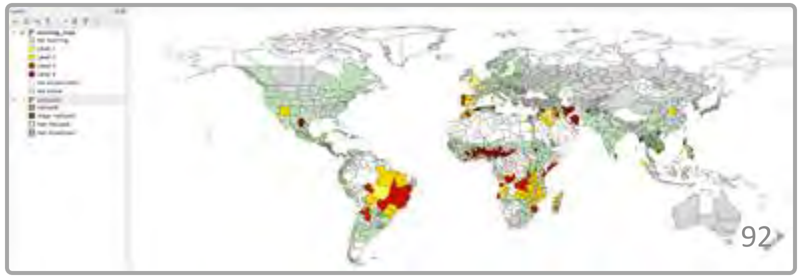
Articles

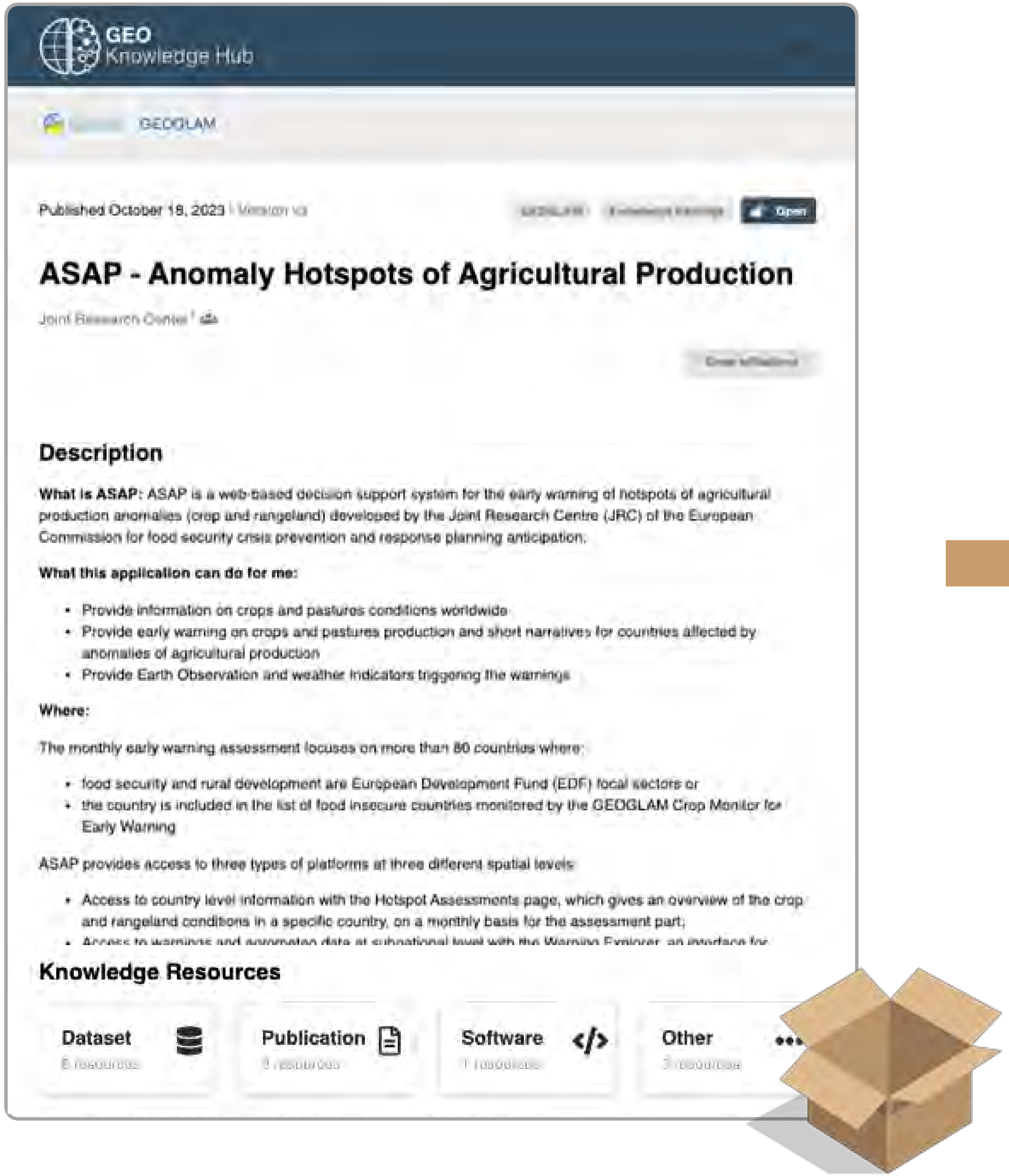
Maps



(Frequency of crop warnings)

OGC Services

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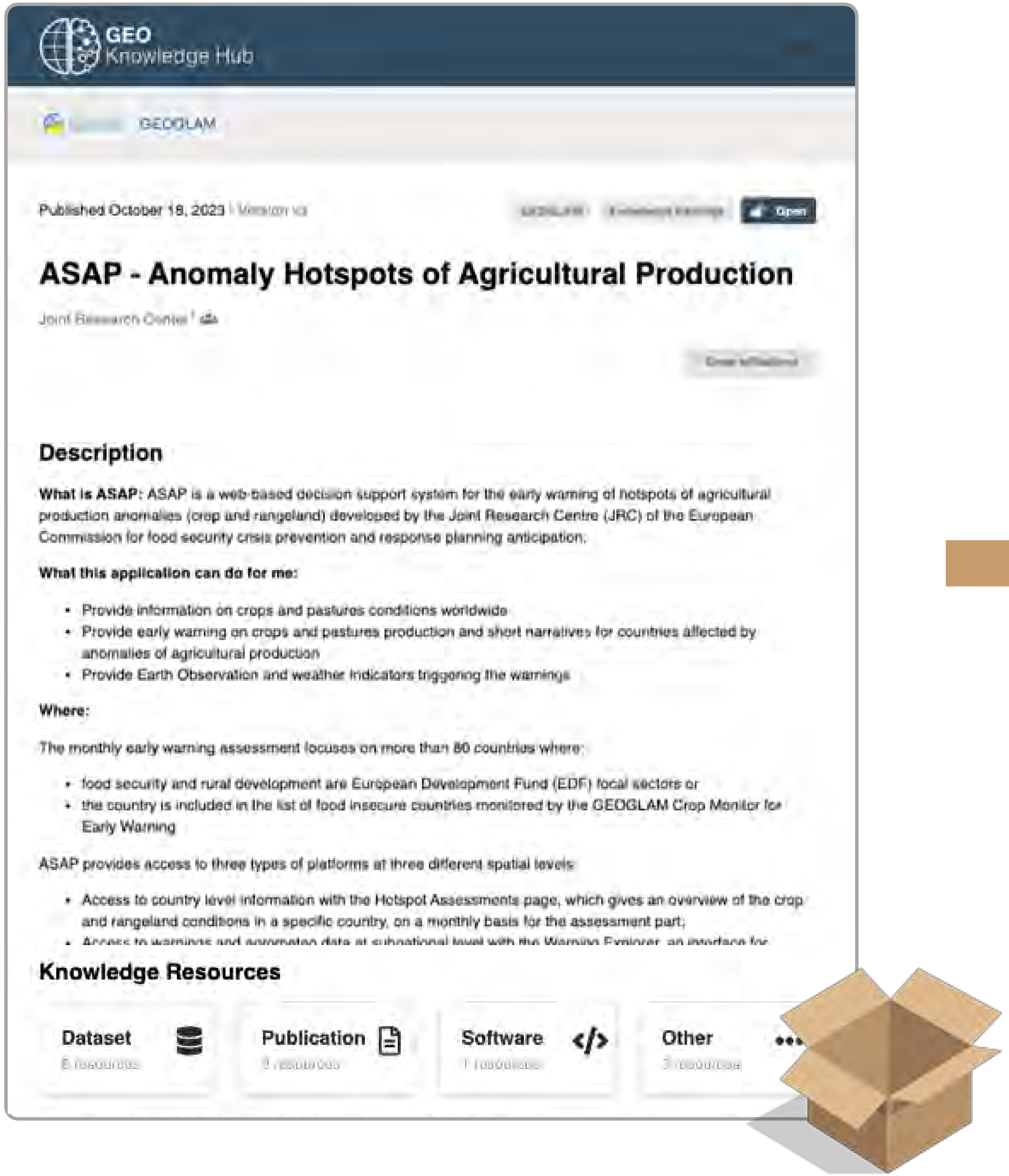
Knowledge Resources
Dataset
Publication
Software
Other


GEO Knowledge Hub
Published November 21, 2023 | Version v1
GEOGLAM
Open
Webinar - Focus on GEOGLAM ASAP (November / 2023)
Kerdiles, Herve; Veiga, Manolo; Gilliams, Sven
Producers: de Salvo, Paola; Carlos, Felipe; Yessimkhanova, Kalamkas
Citation
Style APA
Kerdiles, H., Veiga, M., & Gilliams, S. (2023, November 21). Webinar - Focus on GEOGLAM ASAP (November / 2023). GEO Knowledge Hub. https://doi.org/10.60566/fsmec-45513
Description
The second webinar in the series, held on November 16 from 14:00 to 16:00 (Central European Time - CET), introduces the GEOGLAM Anomaly hotSpots of Agricultural Production (ASAP).
Files
File view
Page 1 of 54
Automatic Zoom
Anomaly hotSpots of Agricultural Production
ASAP - overview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GEOGLAM
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Knowledge Resources
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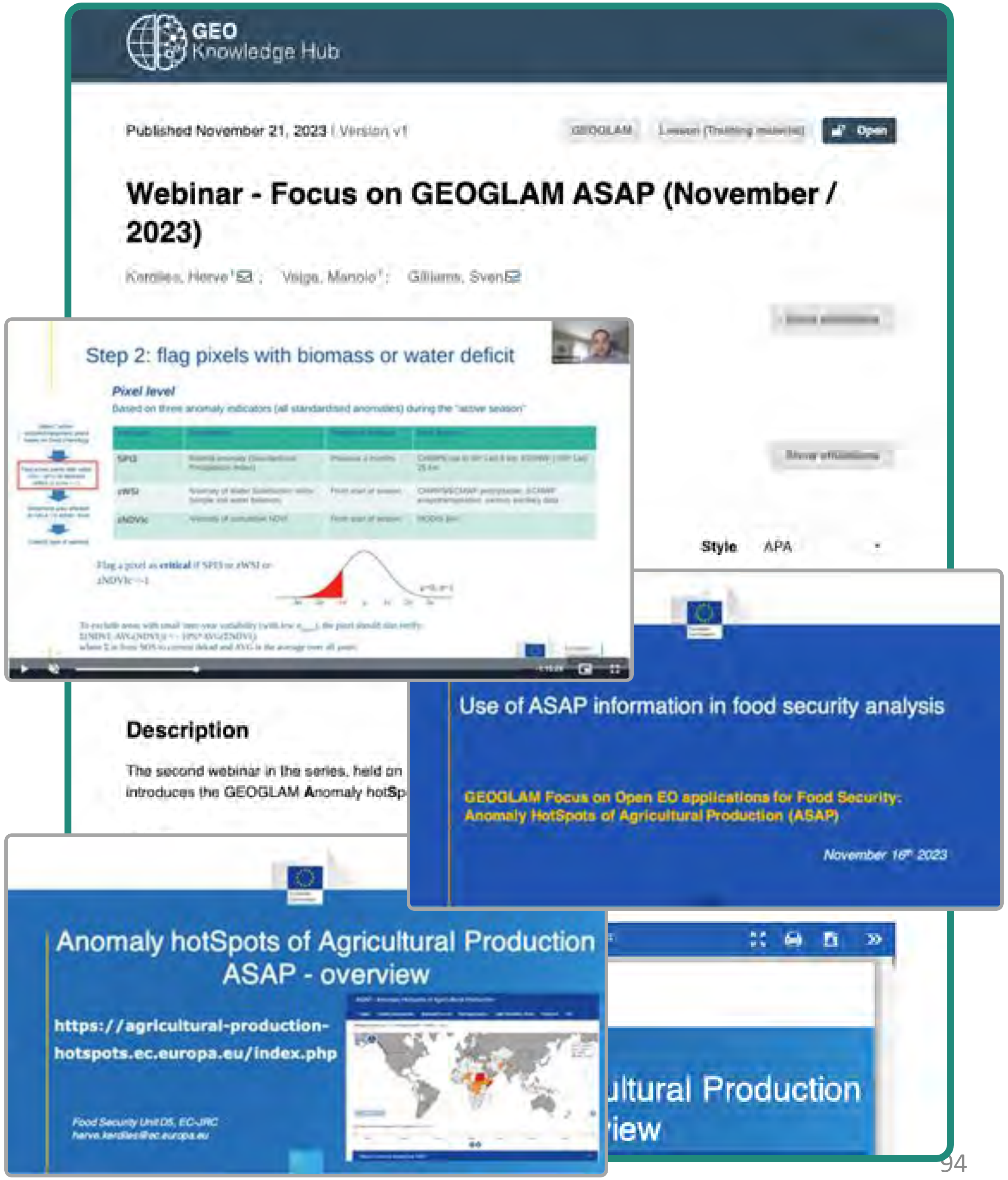
GEO Knowledge Hub
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GEOGLAM
Open
Webinar - Focus on GEOGLAM ASAP (November / 2023)
Step 2: flag pixels with biomass or water deficit
Pixel level
Description
The second webinar in the series, held on
introduces the GEOGLAM Anomaly hotSp
Style
APA
Use of ASAP information in food security analysis
GEOGLAM Focus on Open EO applications for Food Security:
Anomaly HotSpots of Agricultural Production (ASAP)
November 16th 2023
Anomaly hotSpots of Agricultural Production
ASAP - overview
https://agricultural-production-hotspots.ec.europa.eu/index.php

Open
Protocols and APIs

allow data and software to communicate and work together seamlessly.

GKH provides a REST API

Examples

OGC WMS

Serve map images over the web

OGC WFS

Serve vector feature data

REST APIs (STAC)

Web APIs for geospatial assets

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User

Knowledge Package

A **User** is someone who goes into the digital library to discover and learn from EO Applications.

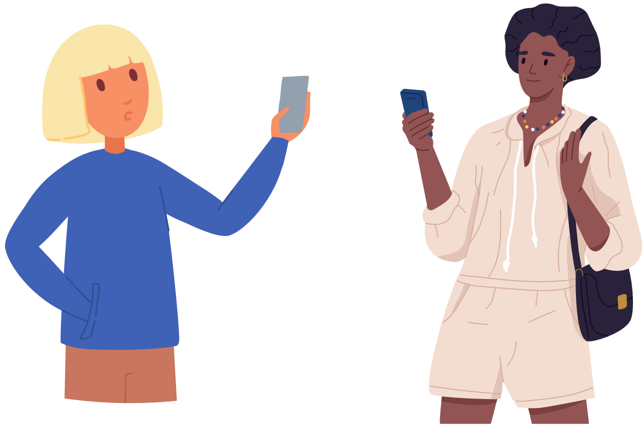
Search and access content

Interact with the community

Help in the content improvement

Knowledge Provider

Knowledge Package



A **Knowledge Provider** is a special kind of User that can share content in the GEO Knowledge Hub

Same possibilities as a User

Create and manage Packages and resources

Questions

Example of a Knowledge Package

GROUP ON EARTH OBSERVATIONS

Title: Monitoring climate zone change in Kazakhstan: Köppen-Geiger climate maps

DATA MANAGEMENT PLAN

PDF kalamkas-dmp.pdf

INPUT DATA

CSV station-1.csv

OUTPUT DATA

CSV model-biases-temperature.csv
trend-results-location.csv

SOFTWARE

JS koppen-modal-ssp585-2071-2100.js

PUBLICATION

DOI https://doi.org/10.3390/ijgi15020057

PRESENTATION

PDF presentation-2025.pdf

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Resources

- GEO Statement on Open Knowledge
- The Value of Open Data Sharing
- GEO Data Sharing and Data Management Principles
- GEO Data Licensing Guidance
- GEO Dialogue Series (2023)
- GEO Dialogue Series (2024)
- GEO Data and Knowledge Dialogue Series (2026)

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Session 3 - agenda

1. Sustainability of shared knowledge
2. On-boarding with the GEO Self Assessment Dashboard
3. Creating Knowledge Packages using AI and curation
4. GEO Knowledge Hub documentation

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Tools we will look at

Everything is open and available online

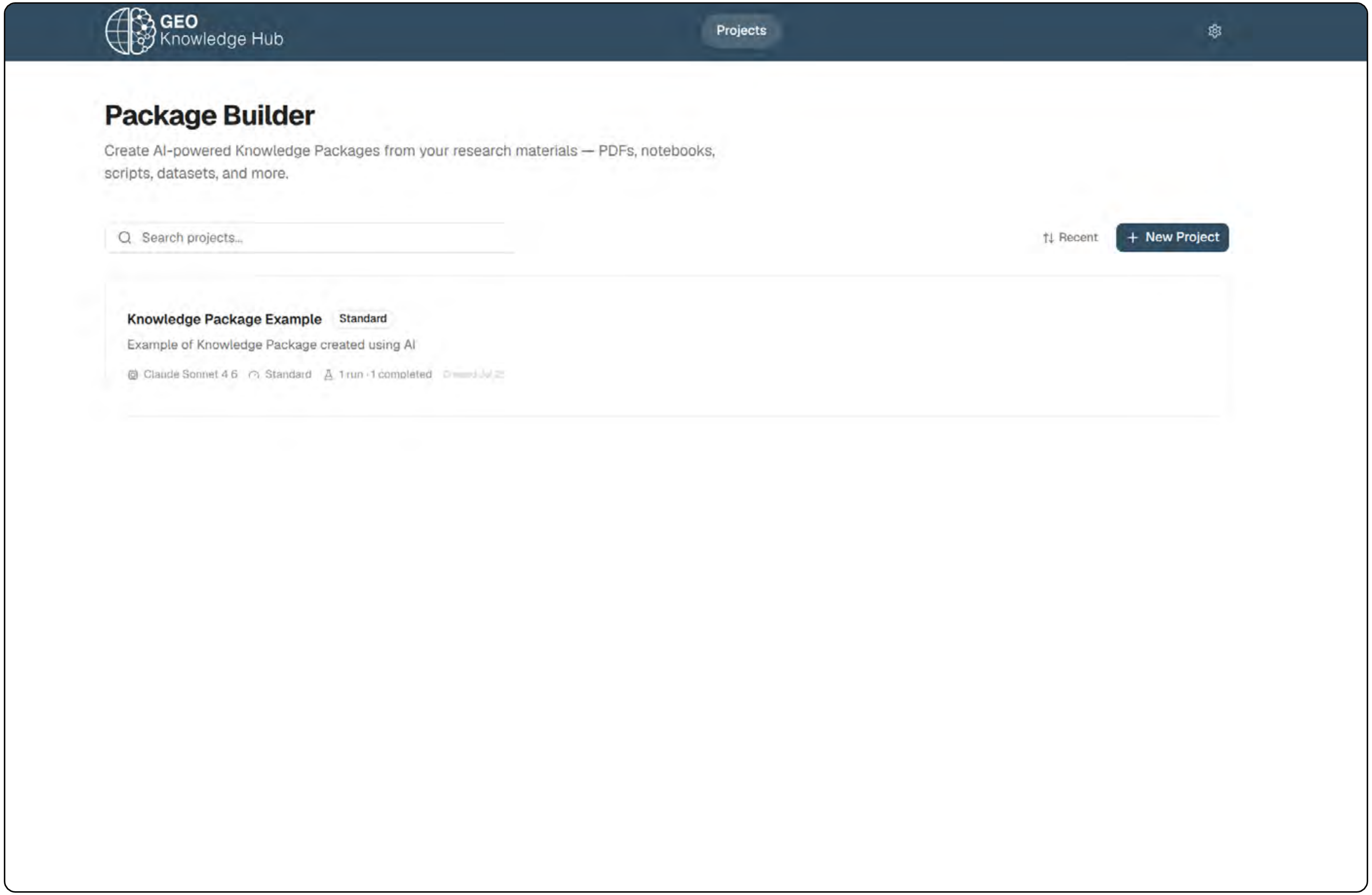
1. **Knowledge Package Checker**
   https://gkhub.earthobservations.org/tools/checker

2. **GEO Self-Assessment Dashboard**
   https://gkhub.earthobservations.org/tools/self-assessment

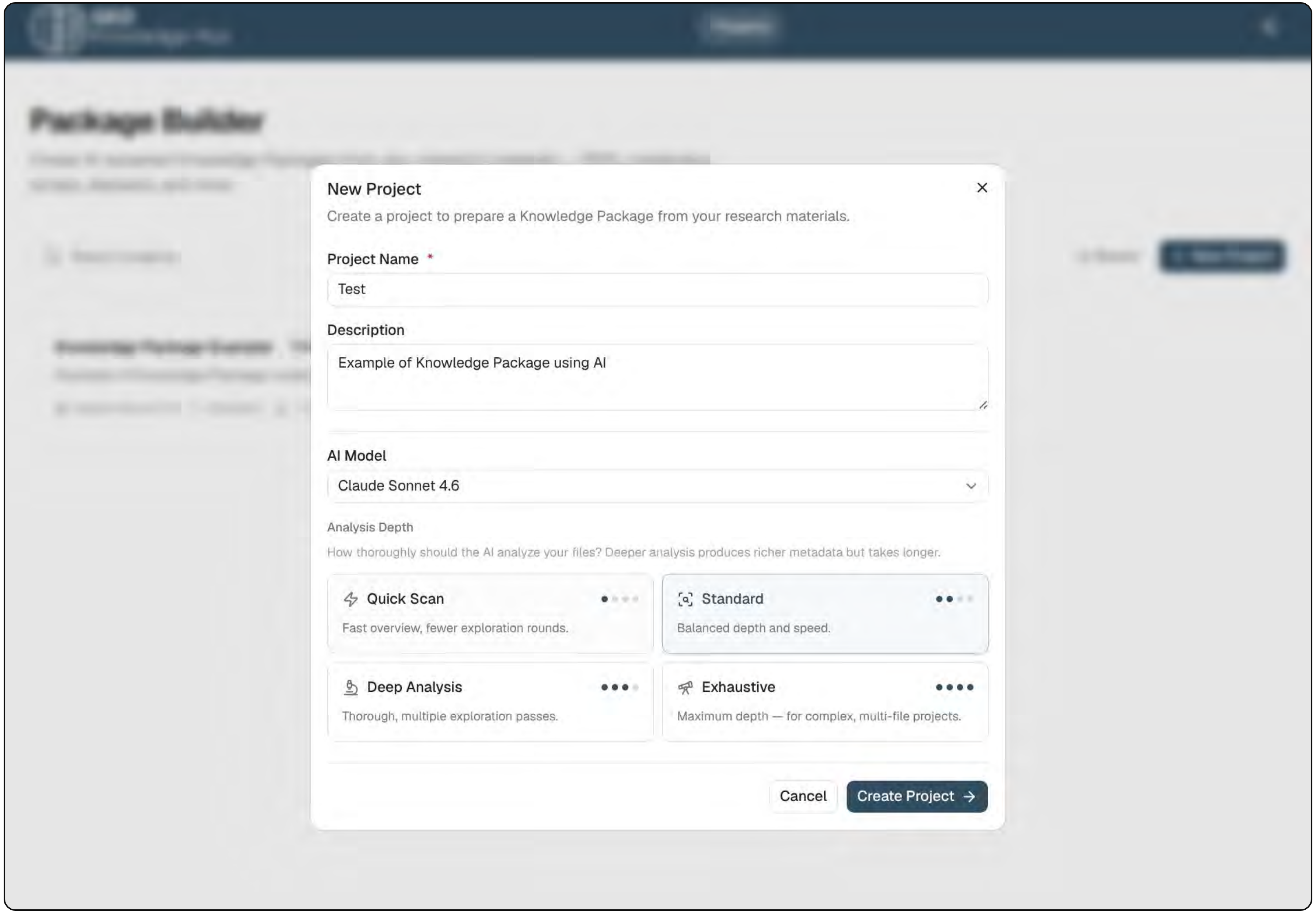
3. **AI-assisted Knowledge Package creation**
   Not available yet — coming soon

4. **GEO Knowledge Hub Documentation**
   https://gkhub.earthobservations.org/documentation

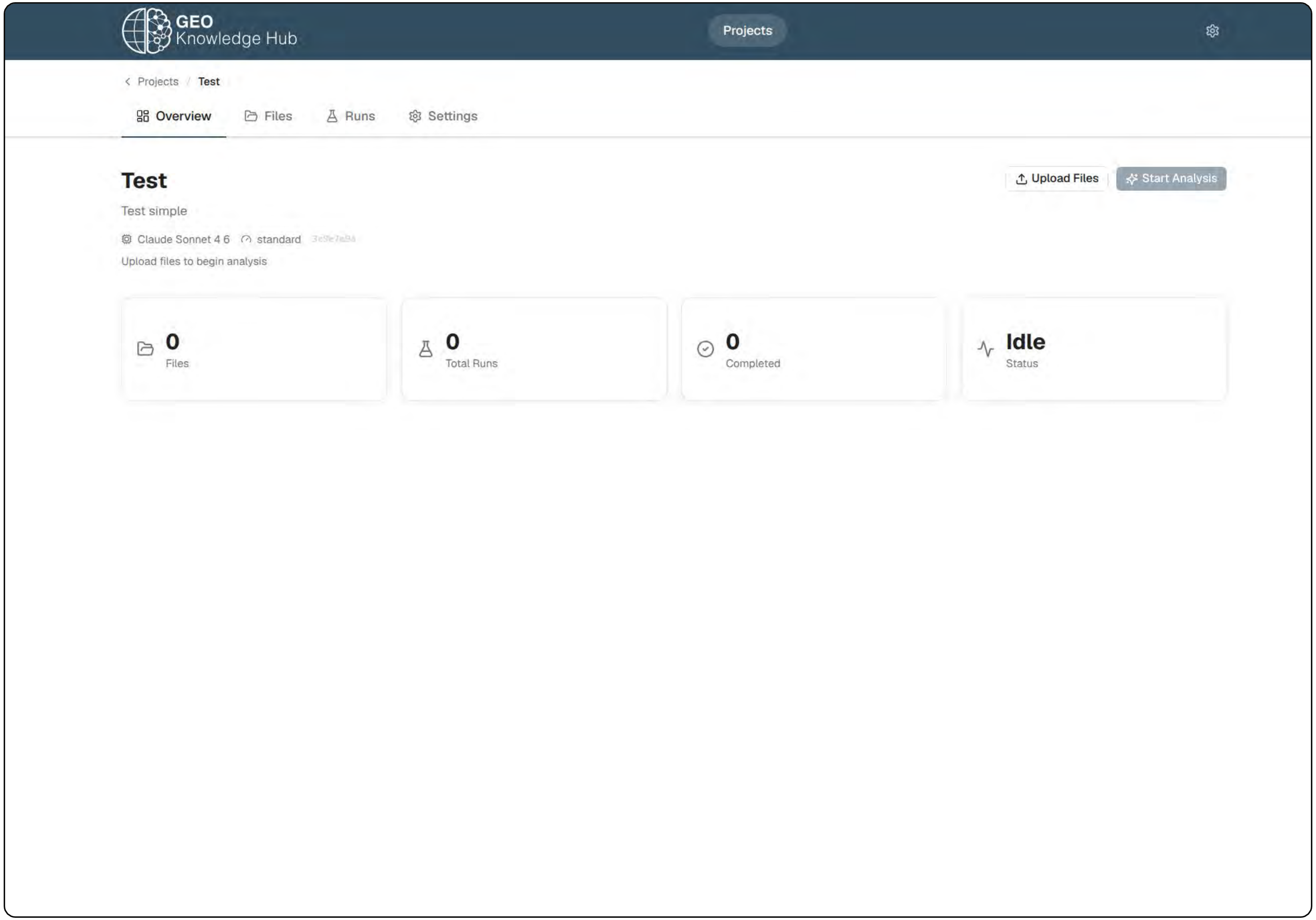
Creating Knowledge Packages using AI



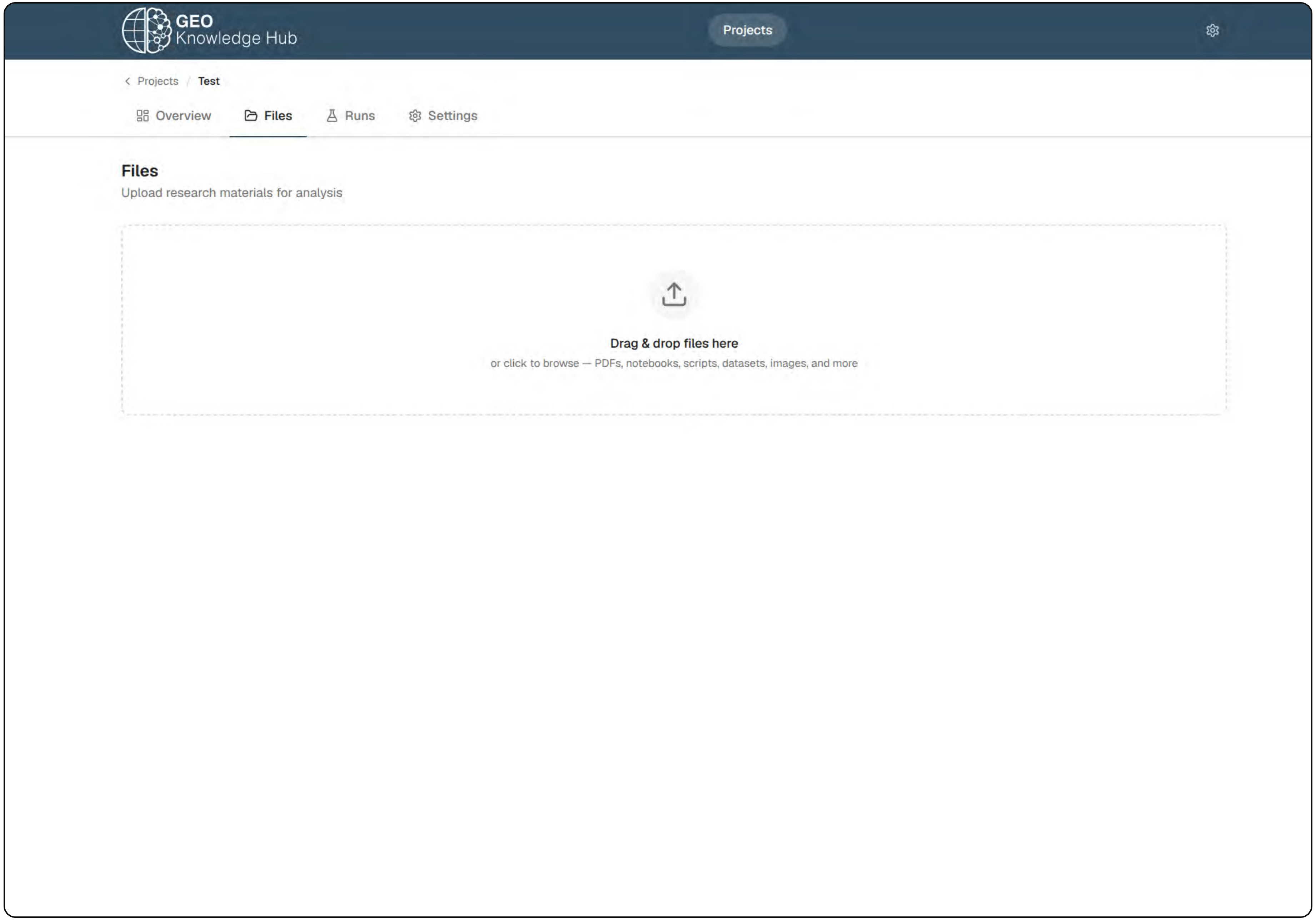
Creating Knowledge Packages using AI



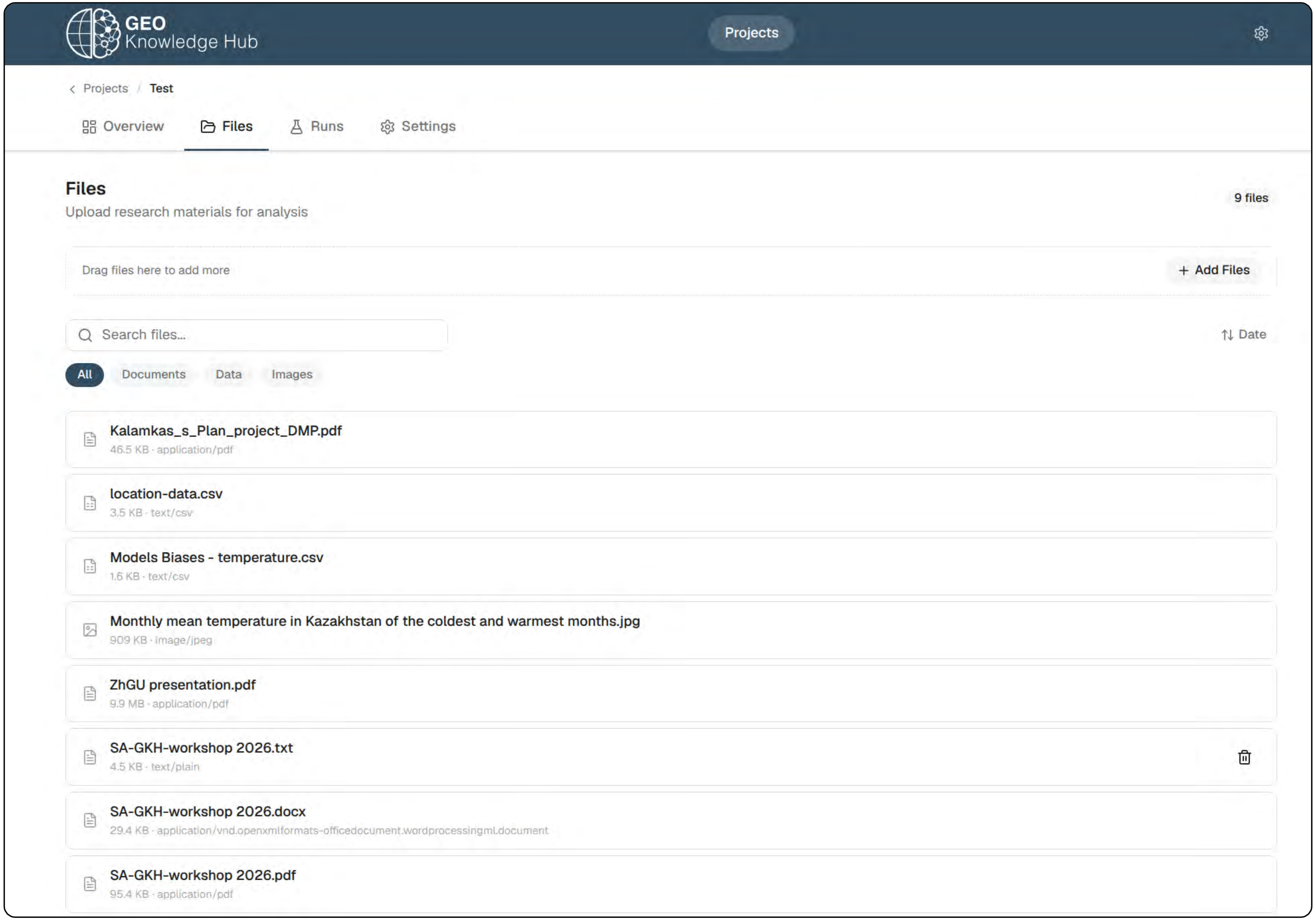
Creating Knowledge Packages using AI



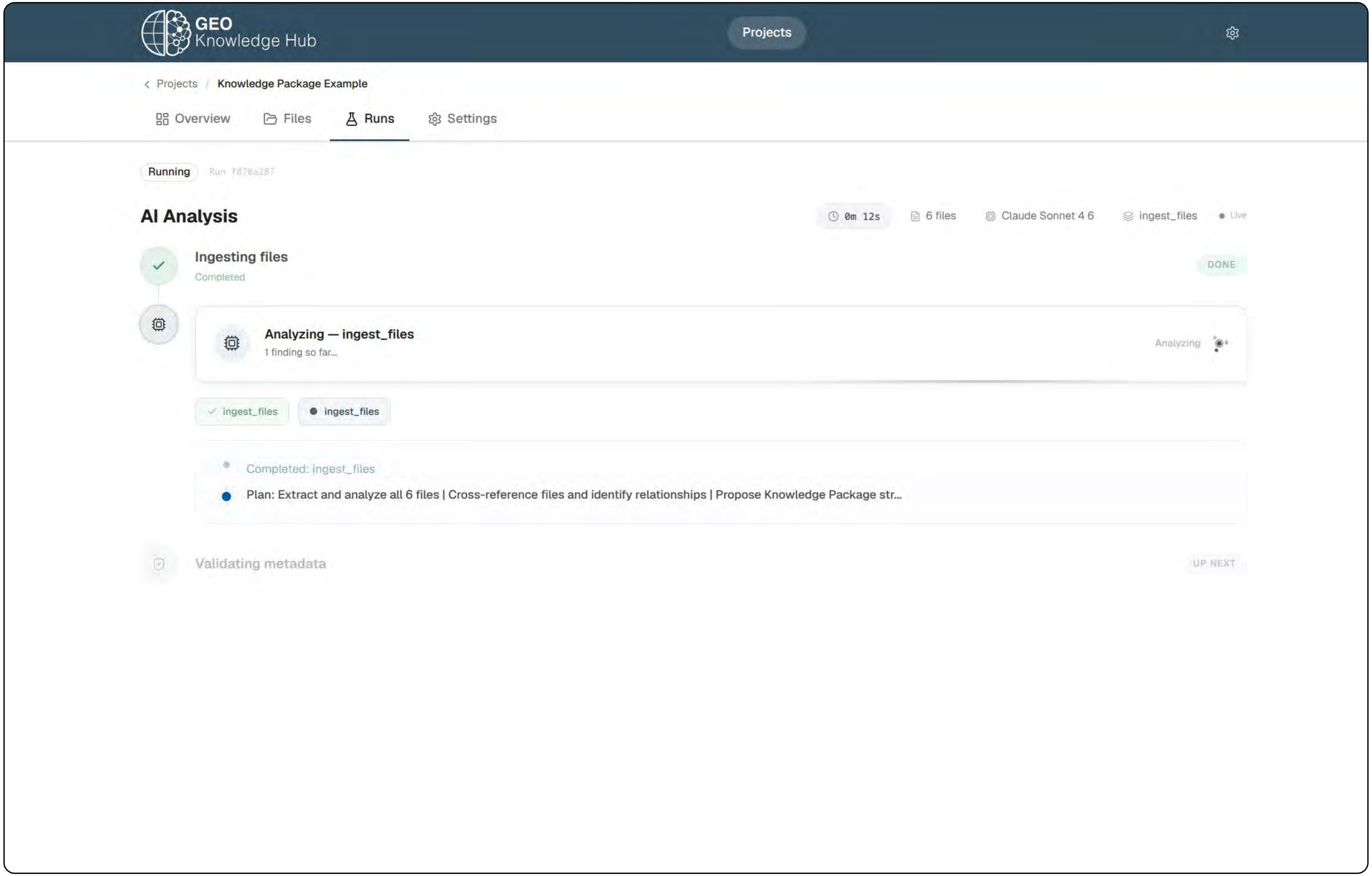
Creating Knowledge Packages using AI



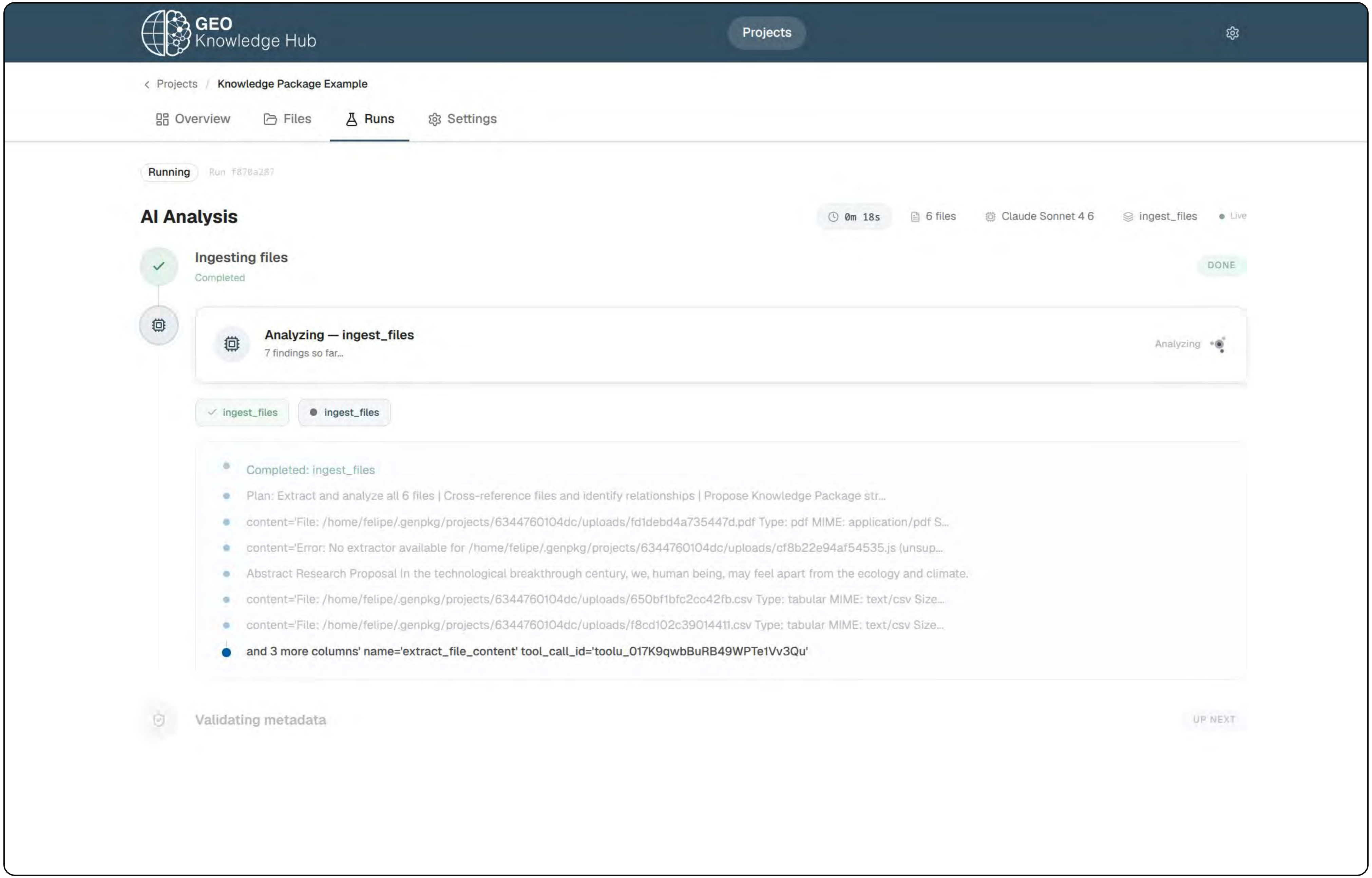
Creating Knowledge Packages using AI



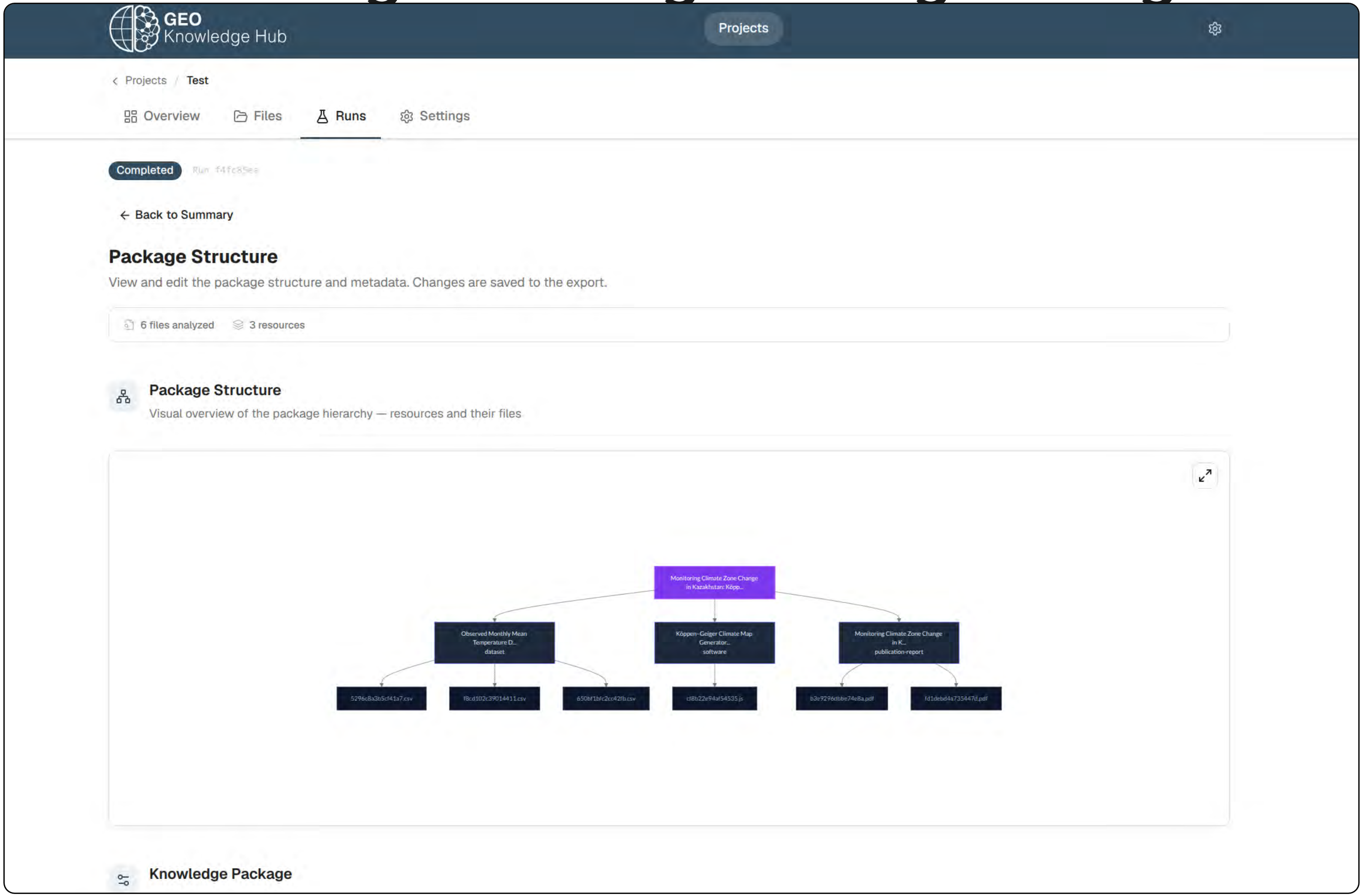
Creating Knowledge Packages using AI



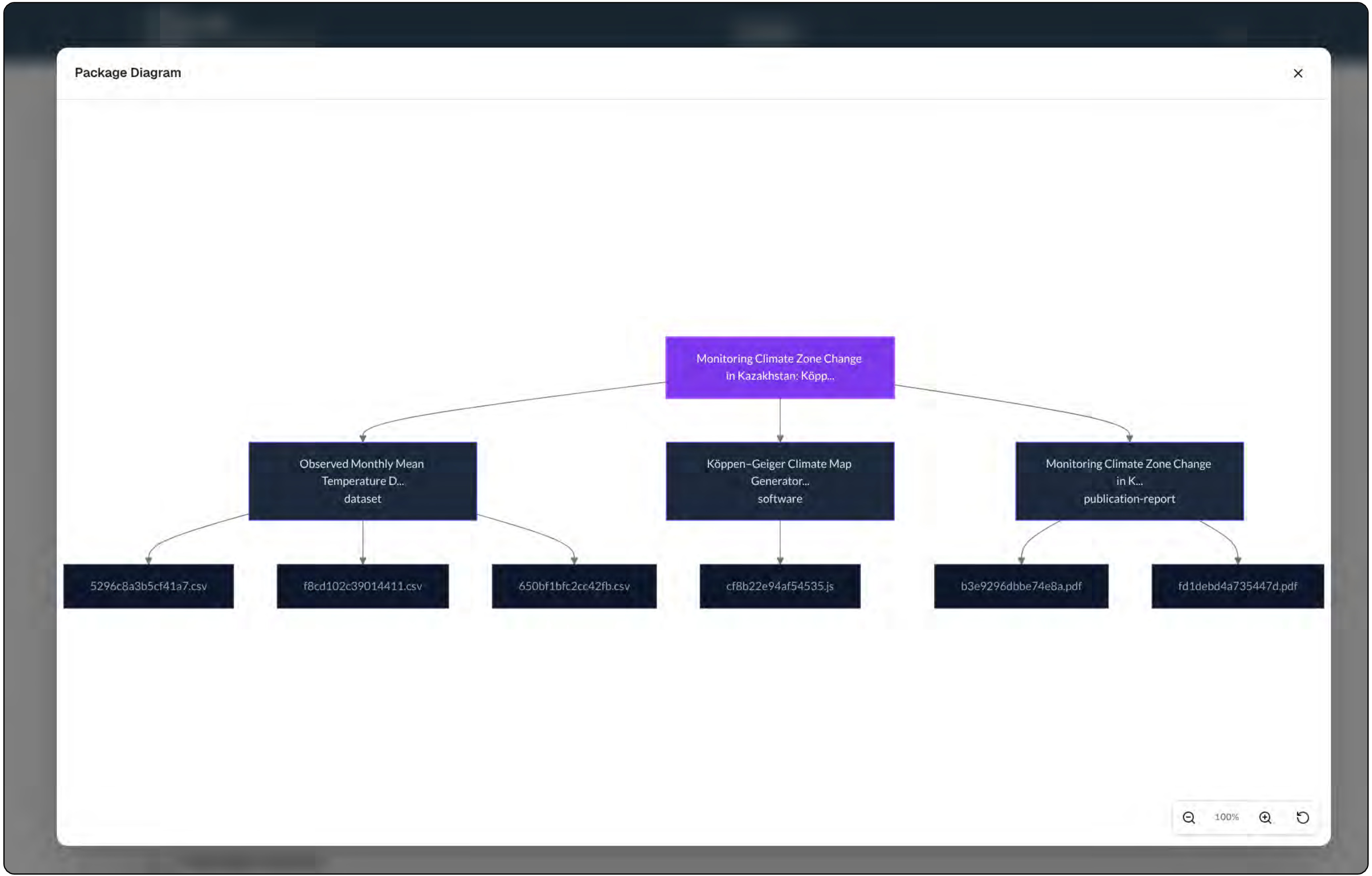
Creating Knowledge Packages using AI



Creating Knowledge Packages using AI



Creating Knowledge Packages using AI



Creating Knowledge Packages using AI

GEO Knowledge Hub

Projects

Knowledge Package

Title, description, and summary of the proposed package

Monitoring Climate Zone Change in Kazakhstan: Köppen–Geiger Climate Maps

This Knowledge Package bundles all materials produced for the research project "Kalamkas's Plan", which investigates the effects of climate change in Kazakhstan over the past 50 years and models future tendencies. The project applies the Köppen–Geiger climate classification system to map historical climate zone shifts and project future changes using CMIP6 general circulation models, satellite remote sensing (Sentinel-2, Sentinel-3, Landsat), and meteorological station records from RSE Kazhydromet. An interactive web application built on Google Earth Engine allows users to visualise Köppen–Geiger climate maps for Kazakhstan.

3 resources

Y Yessimkhanova, K.

Climate change | Kazakhstan | Köppen–Geiger climate classification | CMIP6 | Google Earth Engine | Sentinel-2 | Sentinel-3 | Landsat | +5 more

Knowledge Resources

3

Each resource represents a distinct component of the package. Click to view and edit metadata.

Observed Monthly Mean Temperature Data for Kazakhstan (1961–2014) R1

dataset | 3 files

This dataset contains observed monthly mean air temperature records for a meteorological station in Kazakhstan, covering the period 1961 to 2014 (54 years). The data are organised as a tabular CSV file with columns for Year and 12 monthly mean temperatures (°C). A companion CSV file provides Mann-Kendall trend test results and Sen's slope estimates, confirming a statistically...

Köppen–Geiger Climate Map Generator — Google Earth Engine Web Application R2

software | 1 file

Edit

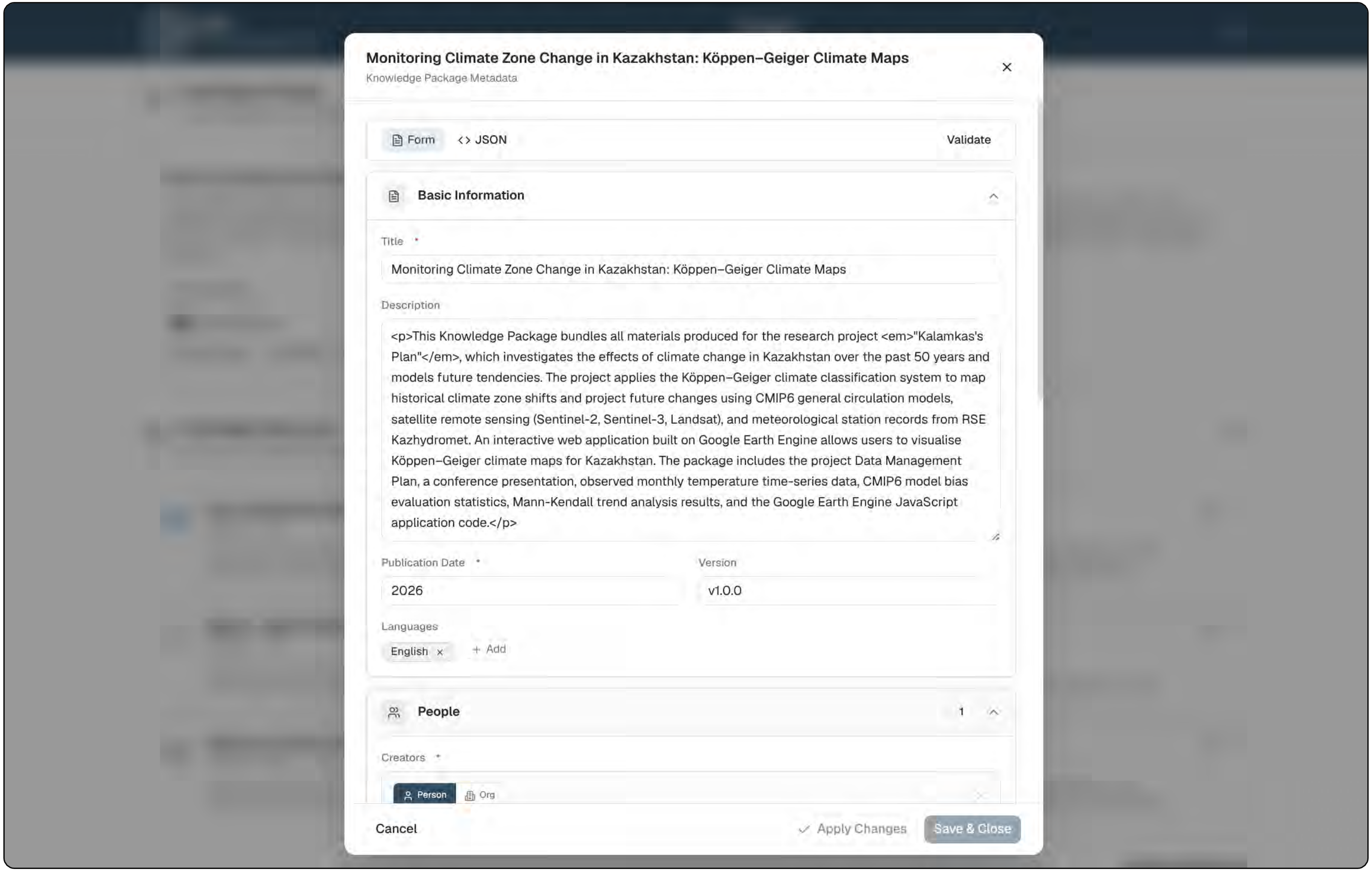
JavaScript source code for the Köppen–Geiger Climate Map Generator, an interactive web application deployed on Google Earth Engine (GEE) and accessible at https://kalamkas.users.earthengine.app. The application enables users to visualise Köppen–Geiger climate classification maps for Kazakhstan, supporting analysis of historical climate zone shif...

Monitoring Climate Zone Change in Kazakhstan: Project Documentation R3

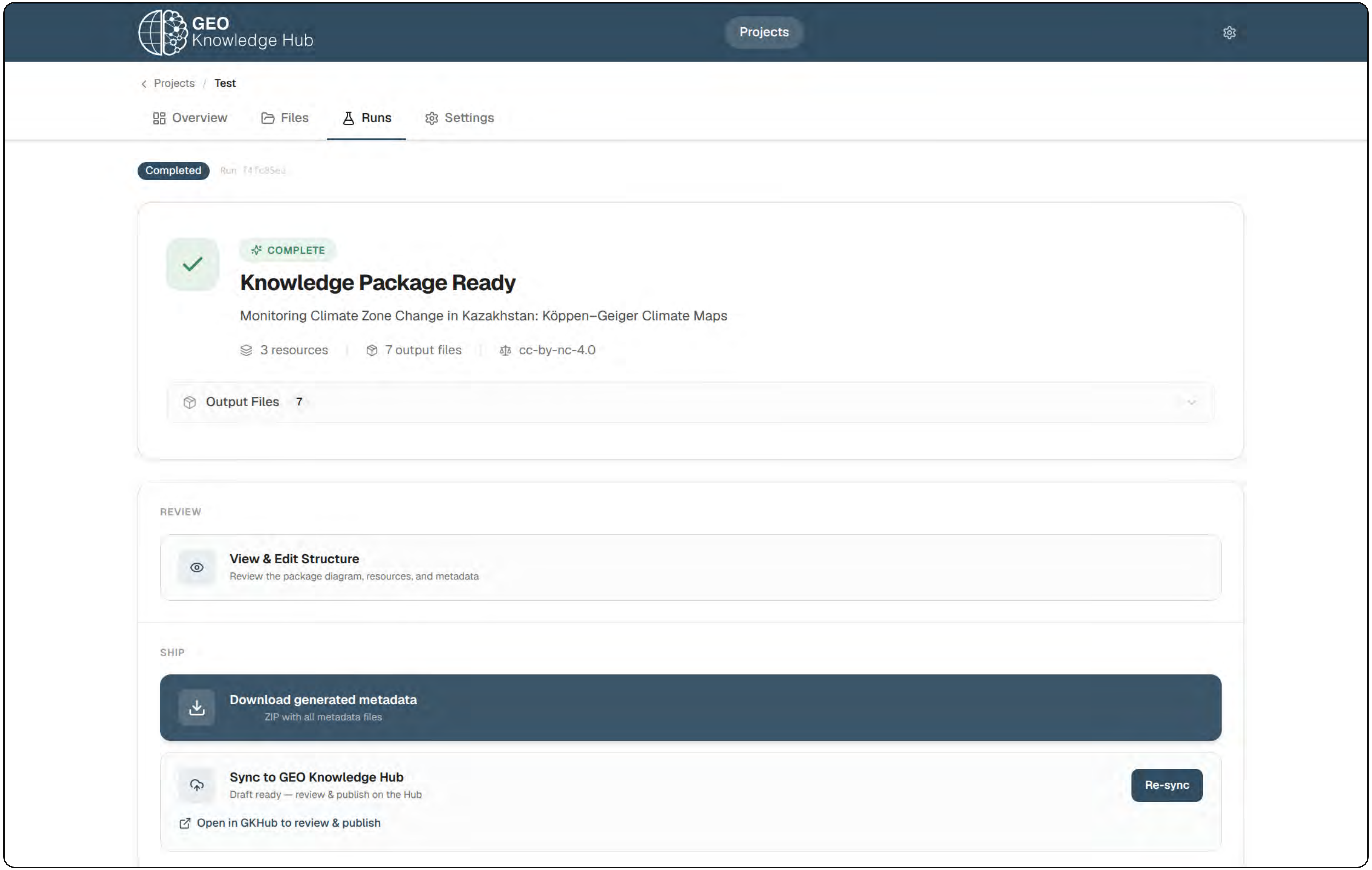
publication-report | 2 files

Project documentation for the "Kalamkas's Plan" research initiative on mapping climate change effects in Kazakhstan. This resource includes two documents: (1) the Data Management Plan (DMP) created using DMP OPIDoR following the Science Europe structured template, describing data collection strategies (Sentinel-2, Sentinel-3, Landsat imagery; Kazhydromet meteorological...

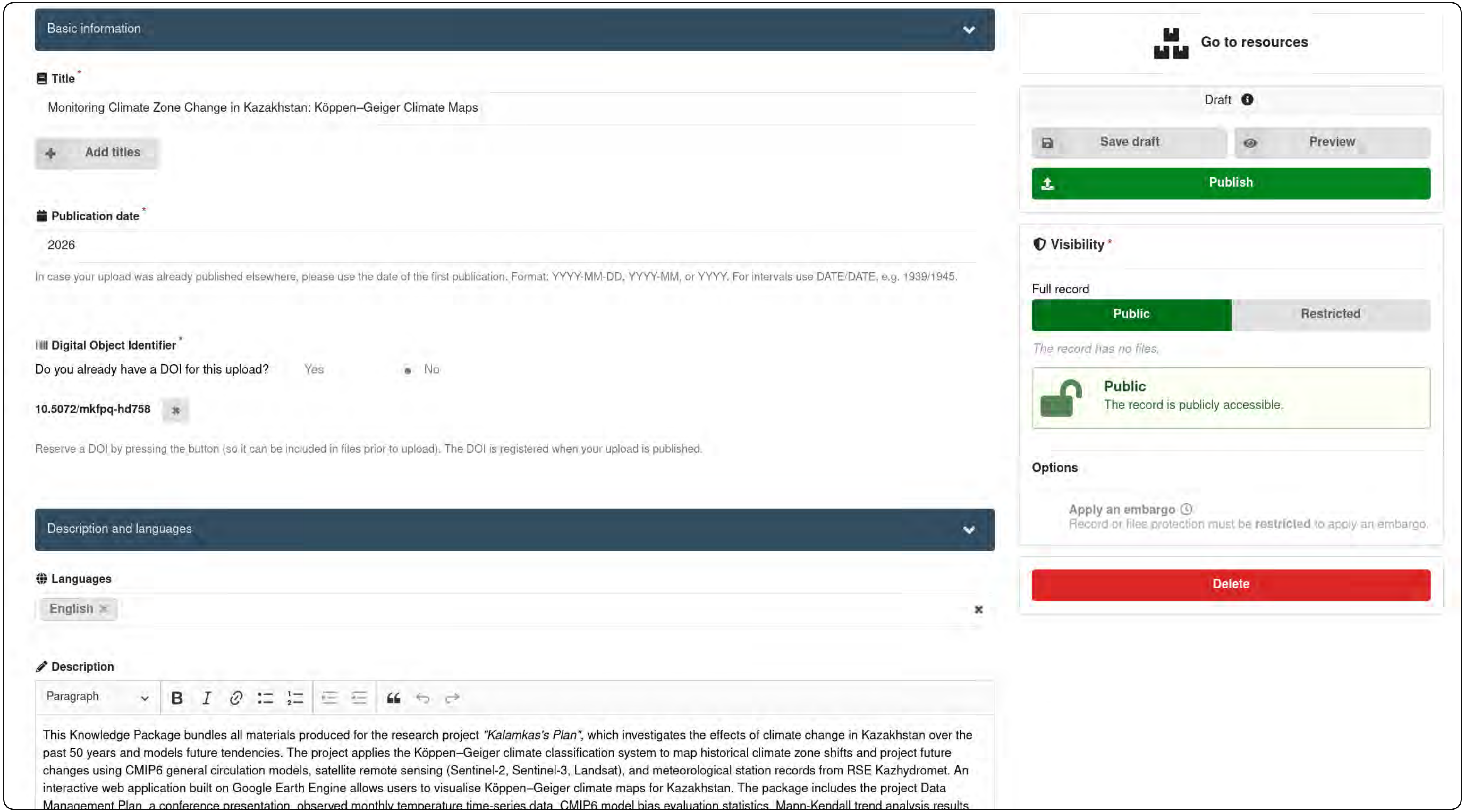
Creating Knowledge Packages using AI



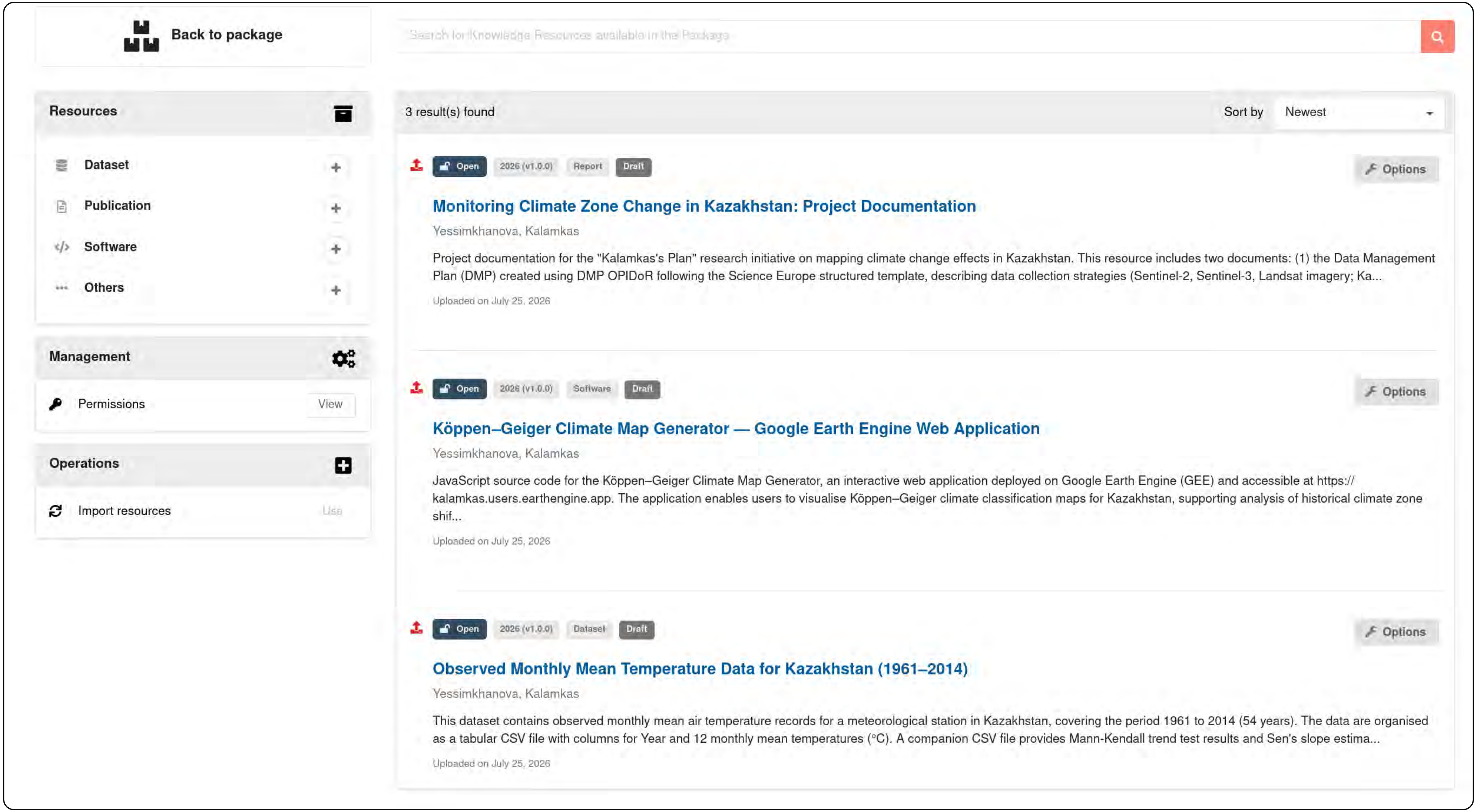
Creating Knowledge Packages using AI



Creating Knowledge Packages using AI



Creating Knowledge Packages using AI



Creating Knowledge Packages using AI

‹ Back to edit

Published 2026 | Version v1.0.0

Knowledge Package | Open

Monitoring Climate Zone Change in Kazakhstan: Köppen–Geiger Climate Maps

Yessimkhanova, Kalamkas

Citation

Style: APA

Yessimkhanova, K. (2026). Monitoring Climate Zone Change in Kazakhstan: Köppen–Geiger Climate Maps (v1.0.0). GEO Knowledge Hub. https://doi.org/10.5072/mkfpq-hd758

Description

This Knowledge Package bundles all materials produced for the research project *"Kalamkas's Plan"*, which investigates the effects of climate change in Kazakhstan over the past 50 years and models future tendencies. The project applies the Köppen–Geiger climate classification system to map historical climate zone shifts and project future changes using CMIP6 general circulation models, satellite remote sensing (Sentinel-2, Sentinel-3, Landsat), and meteorological station records from RSE Kazhydromet. An interactive web application built on Google Earth Engine allows users to visualise Köppen–Geiger climate maps for Kazakhstan. The package includes the project Data Management Plan, a conference presentation, observed monthly temperature time-series data, CMIP6 model bias evaluation statistics, Mann-Kendall trend analysis results, and the Google Earth Engine JavaScript application code.

Knowledge Resources

Dataset	Publication	Software	Other
1 resources	1 resources	1 resources	0 resources

Monitoring Climate Zone Change in Kazakhstan: Project Documentation
Yessimkhanova, Kalamkas;
Open | 2026 (v1.0.0) | Report

Versions

Preview
Preview mode does not display versions.

Geographic Locations

Details

DOI
DOI 10.5072/mkfpq-hd758

Resource type
Knowledge Package

Publisher
GEO Knowledge Hub

Languages
English

Keywords
Climate change | Kazakhstan

How we apply AI

Three steps, and the human review is what makes it trustworthy.

1

Upload

The author uploads the resources of the knowledge package.

2

Generate

AI drafts metadata and documentation from that material.

3

Review

The author checks, corrects and approves every generated item.

Review is the step that matters most

AI only proposes, nothing becomes part of a knowledge package without the author's review and approval.

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Session 4 - agenda

1. Participant feedback
2. Discussions on lessons learned
3. Next steps for the SA-GEO Knowledge Hub community

forms.gle/JMr9BNVqqFJdKsoaA

Thank you!

Group on Earth Observations

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EARTH OBSERVATIONS