

Big Data from Space 2025, 1. Oct, Riga

OGC DGGS API AND ZARR: BUILDING BLOCKS FOR BIG DATA DIGITAL TWINS

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UNIVERSITY OF TARTU

Landscape Geoinformatics Lab



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FutureScapes

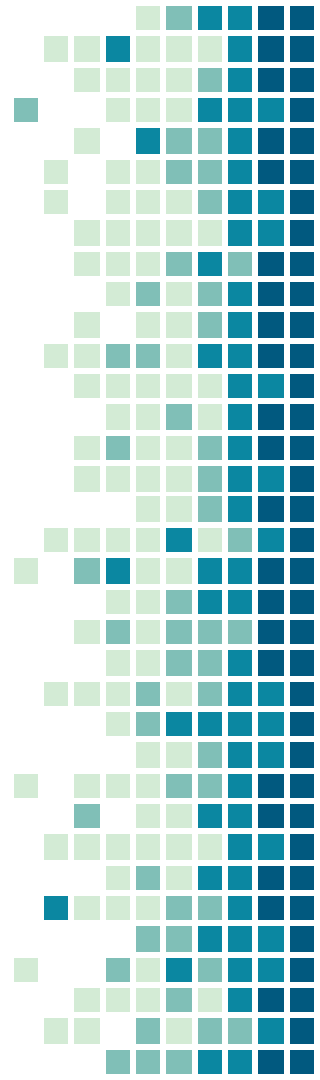


European Research Council
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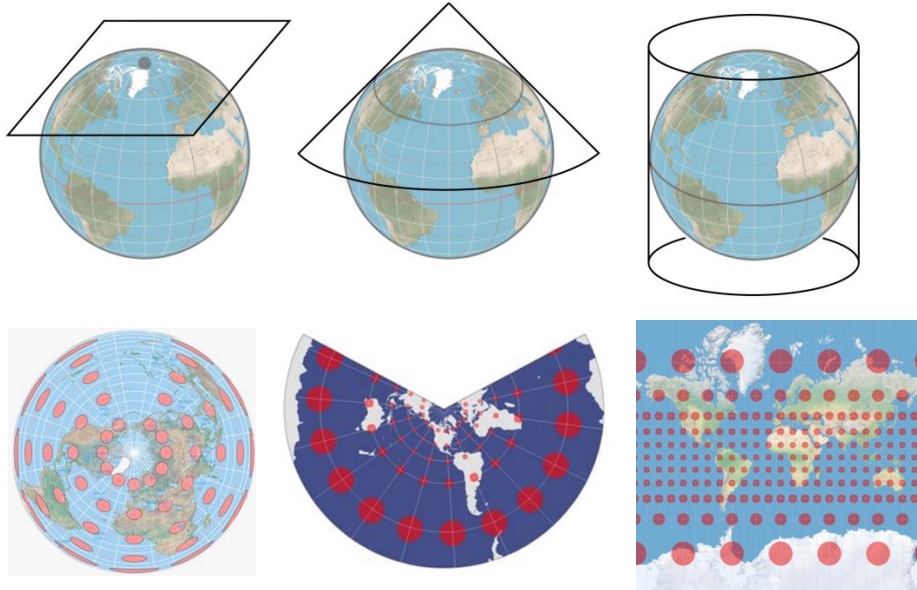
Why, in an era of unprecedented data collection, is it still so challenging to create vital intelligence?

How can digital twins can be realized on the vast amount and variety of data?

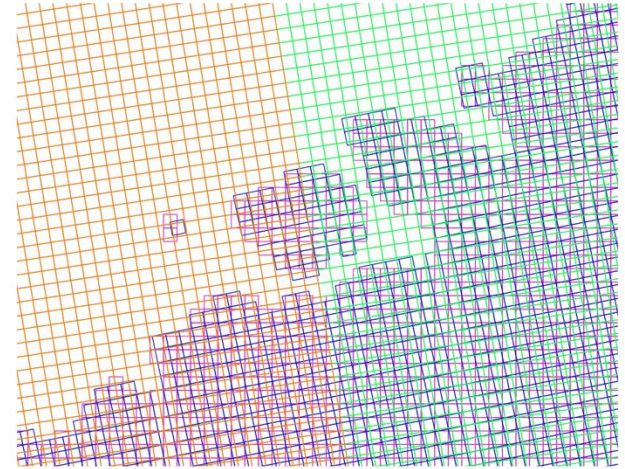
What are the struggles to unlock the full potential of Earth Observation data?



Traditional spatial data challenges



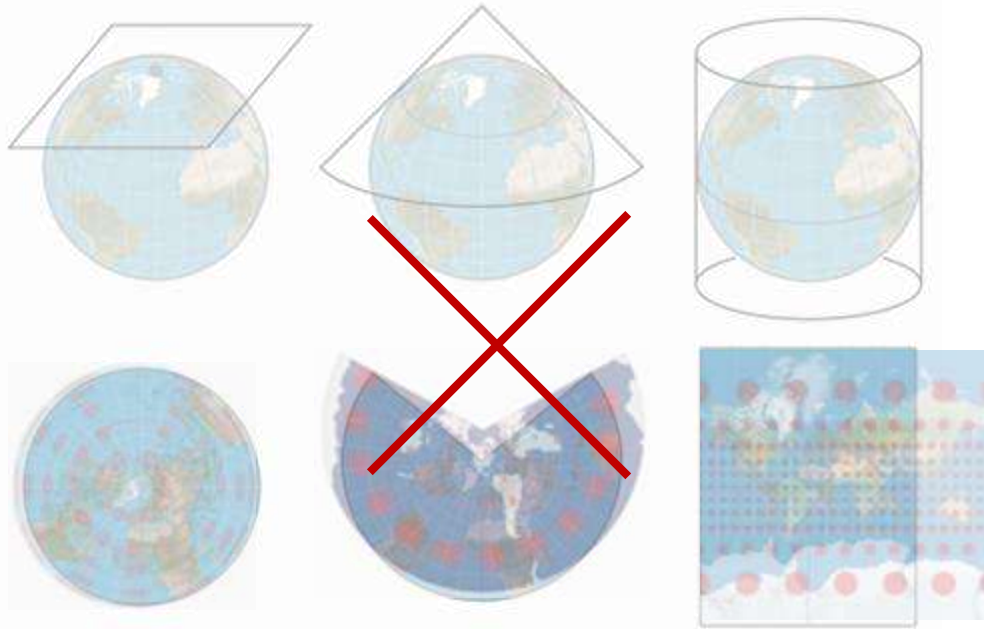
Areal distortions
resampling / reprojecting data



Different 1x1km grids(in EPSG:3035 / ETRS89-LAEA Europe)

- UTM 34N grid over Estonia
- UTM 35N grid over Estonia
- estonian statisticalgrid grid 3301 1x1km
- estonian statistical grid 3035 1x1km

What if ...

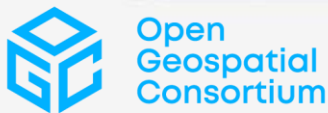


Globally same size pixels ?
alignment ? 

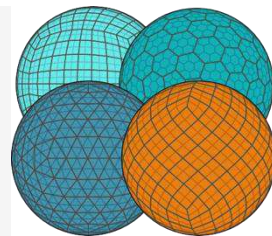


automatic data (grid)

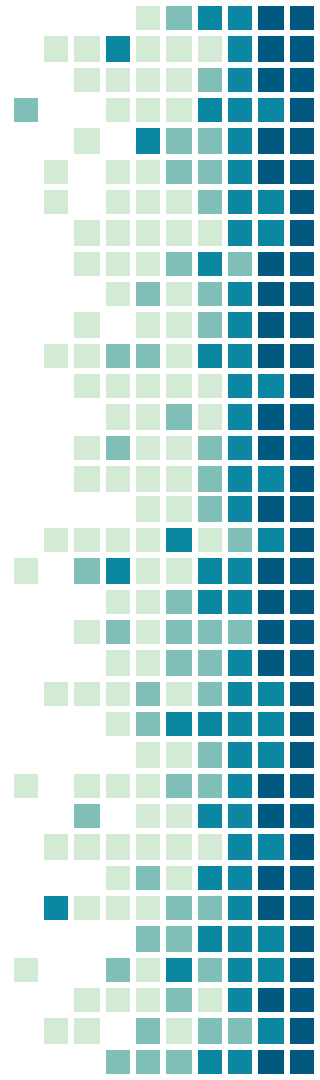

Building blocks



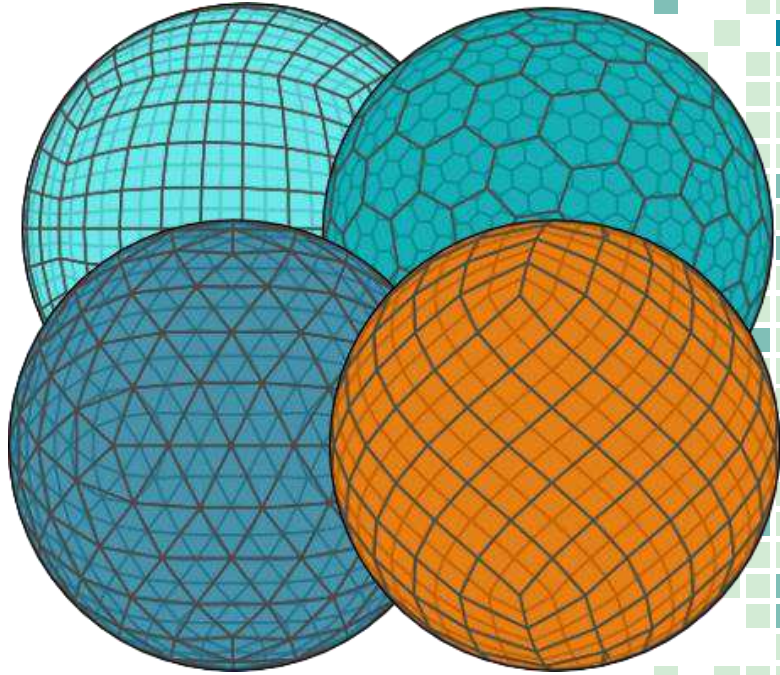
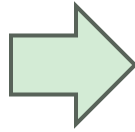
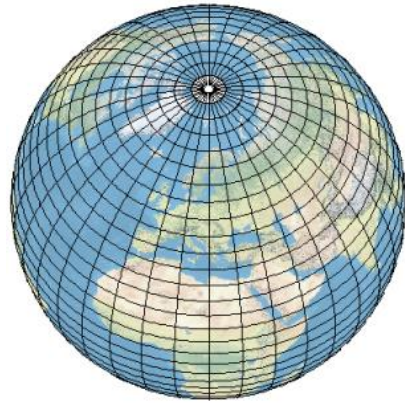
OGC Standards



Discrete Global Grid
Systems (DGGS)



What is a DGGS ?



“A **Discrete Global Grid System** is a spatial reference system that uses a **hierarchical** tessellation of cells to **partition** and **address** the globe.”

Terminology

- **discrete global grid (DGG)**

set of zones at the same refinement level, that uniquely and completely cover a globe

- **discrete global grid hierarchy (DGGH)**

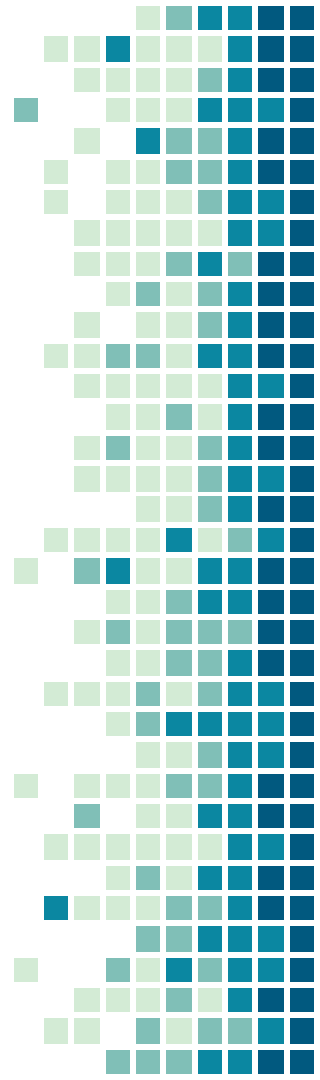
series of discrete global grids organized in a hierarchy of successive levels of zone refinement, using a specific set of parameters fully establishing the geometry of all zones

- **discrete global grid reference system (DGGRS)**

integrated system comprised of a specific discrete global grid hierarchy, spatio-temporal referencing by zone identifiers and deterministic sub-zone ordering

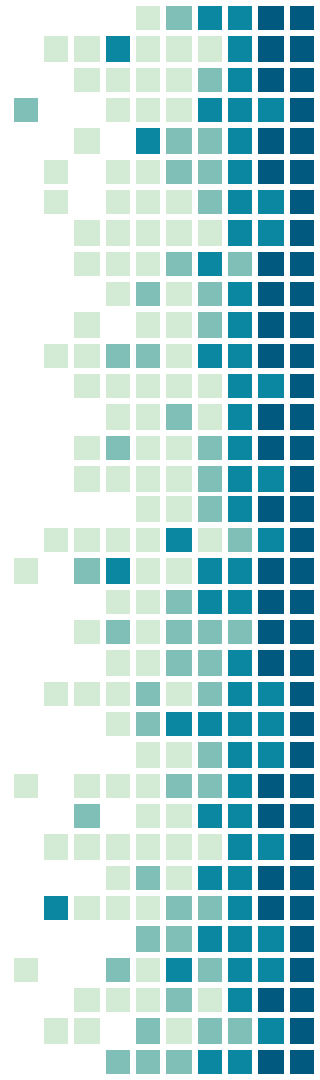
- **discrete global grid system (DGGS)**

integrated system comprising a hierarchy of discrete global grids, spatio-temporal referencing by zonal identifiers and functions for quantization, zonal query, and interoperability

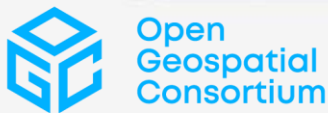


Terminology (*continued*)

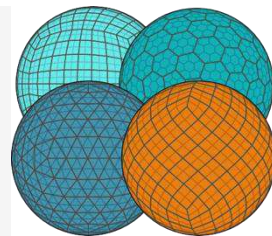
- **zone** (aka “cell”)
particular region of space or space-time
- **zone identifier** (aka “cell_id”)
spatio-temporal reference in the form of a label or code that uniquely identifies a zone
- **child zone**
immediate descendant of a parent zone
- **parent zone**
zone in a lower refinement level of a discrete global grid with immediate descendants
- **refinement level** (formerly called “resolution”)
numerical order of a discrete global grid in the tessellation sequence
- **refinement ratio** (formerly called “aperture”)
numerical order of a discrete global grid in the tessellation sequence



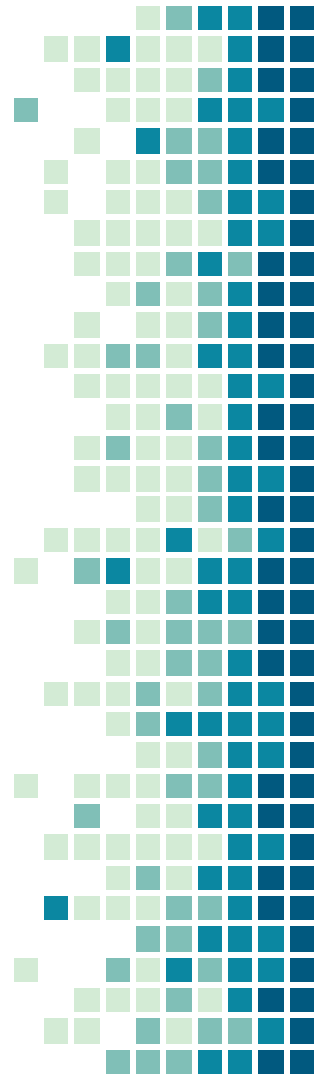
Building blocks



OGC Standards



Discrete Global Grid
Systems (DGGS)



OGC Standards (excerpt)

<https://www.ogc.org/standards/>

Services

Standards that implement XML Remote Procedure Calls using the HyperText Transfer Protocol (HTTP).

- 3D Portrayal Service
- Table Joining Service
- Web Feature Service
- Web Map Tile Service
- Web Services Security
- Coordinate Transformation Service
- Web Coverage Processing Service (WCPS)
- Web Map Context
- Web Processing Service
- Location Service (OpenLS)
- Web Coverage Service
- Web Map Service
- Web Service Common

OGC APIs

Standards that build upon the legacy of the OGC Web Service Standards but define resource-centric APIs that take advantage of modern web development practices.

- GeoAPI Implementation Specification
- OGC API – Features
- OGC API – Processes
- OGC SensorThings API
- OGC API – Common
- OGC API – Maps
- OGC API – Records
- OGC API – Environmental Data Retrieval
- OGC API – Moving Features
- OGC API – Tiles

OGC API DGGS - draft

For developers: OGC API DGGs specification

<https://ogcapi.ogc.org/dggs/>



DGGRS Description

GET /dggs Retrieve the list of available DGGRSs

GET /dggs/{dggsId} Retrieve the description of the specified Discrete Global Grid Reference System

GET /dggs/{dggsId}/zones/{zoneId} Retrieve information about a DGGRS Zone, such as geometry and data availability.

GET /collections/{collectionId}/dggs Retrieve the list of available DGGRS for the specified collection

GET /collections/{collectionId}/dggs/{dggsId} Retrieve the description of the specified Discrete Global Grid Reference System in the context of a specified collection

GET /collections/{collectionId}/dggs/{dggsId}/zones/{zoneId} Retrieve information about a DGGRS Zone, such as geometry and data availability, in the context of a specific collection.

DGGS Data Retrieval

GET /dggs/{dggsId}/zones/{zoneId}/data Retrieve data from a DGGRS Zone. For a DGGRS defining a sub-zone order, optimized zone data packets such as DGGS-(UB)JSON for raster data, or DGGS-(UB)JSON-FG for vector data can be used.

GET /collections/{collectionId}/dggs/{dggsId}/zones/{zoneId}/data Retrieve data from a DGGRS Zone for a specific collection. For a DGGRS defining a sub-zone order, optimized zone data packets such as DGGS-(UB)JSON for raster data, or DGGS-(UB)JSON-FG for vector data can be used.

DGGS Zone Query

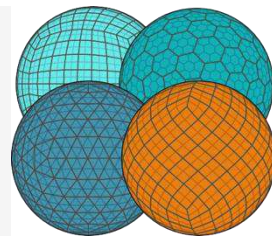
GET /dggs/{dggsId}/zones Retrieve the list of zones with data for this dataset, or for a particular query

GET /collections/{collectionId}/dggs/{dggsId}/zones Retrieve the list of zones with data for a specific collection, or for a particular query

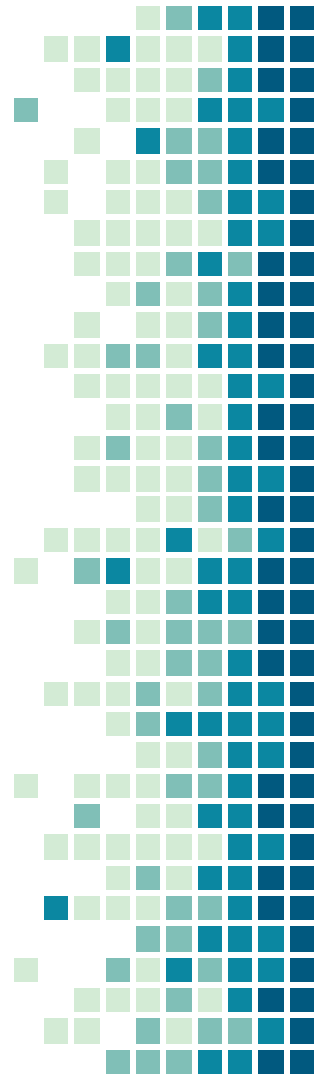
Building blocks



OGC Standards



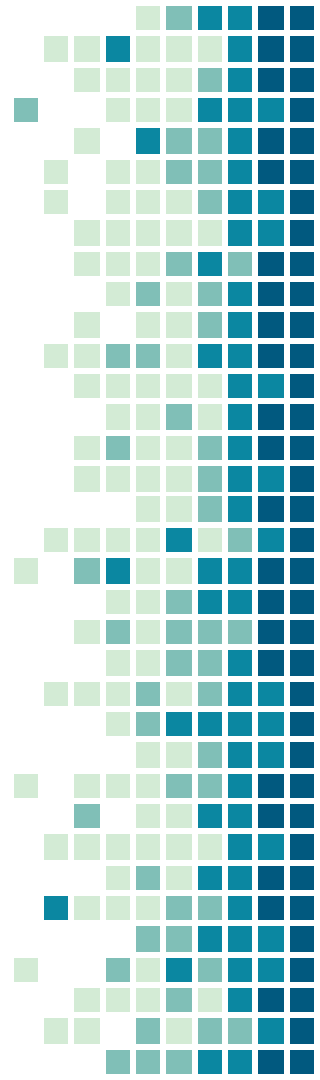
Discrete Global Grid
Systems (DGGS)



xdggs

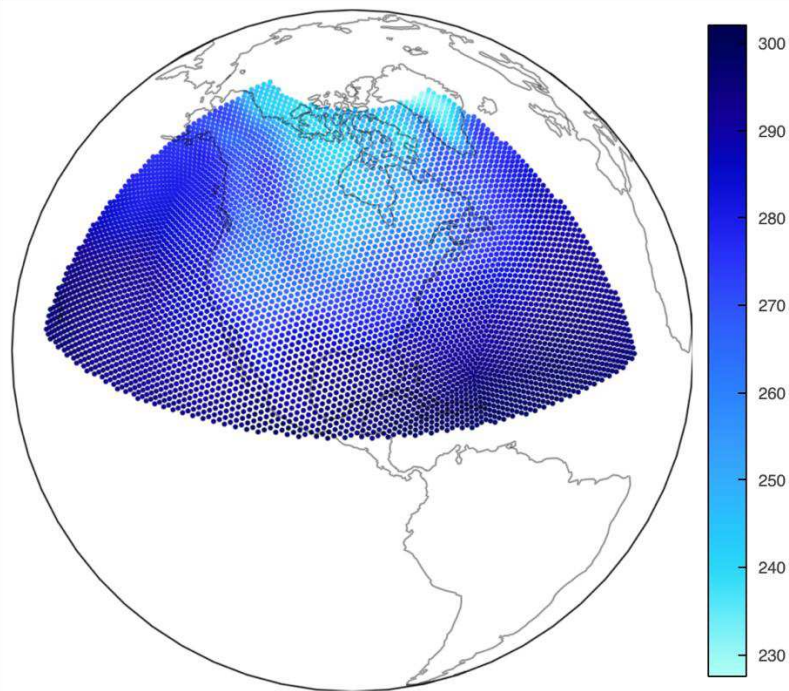
- Common API for using DGGS with xarray
- Features:
 - Metadata encoding scheme (creates a pandas index)
 - Derivation of cell centers / cell boundaries from cell ids
 - Selection based on cell centers
 - Built-in support for HEALPix (via cdshealpix) and H3 (via h3ronpy), more via extension packages (e.g. xdggs-dggrid4py)
 - Exploratory visualization using lonboard

<https://isprs-archives.copernicus.org/articles/XLVIII-4-W12-2024/75/2024/>





created during the joint
Pangeo-OSGEO code sprint at
the *Big data from Space 2023*
conference



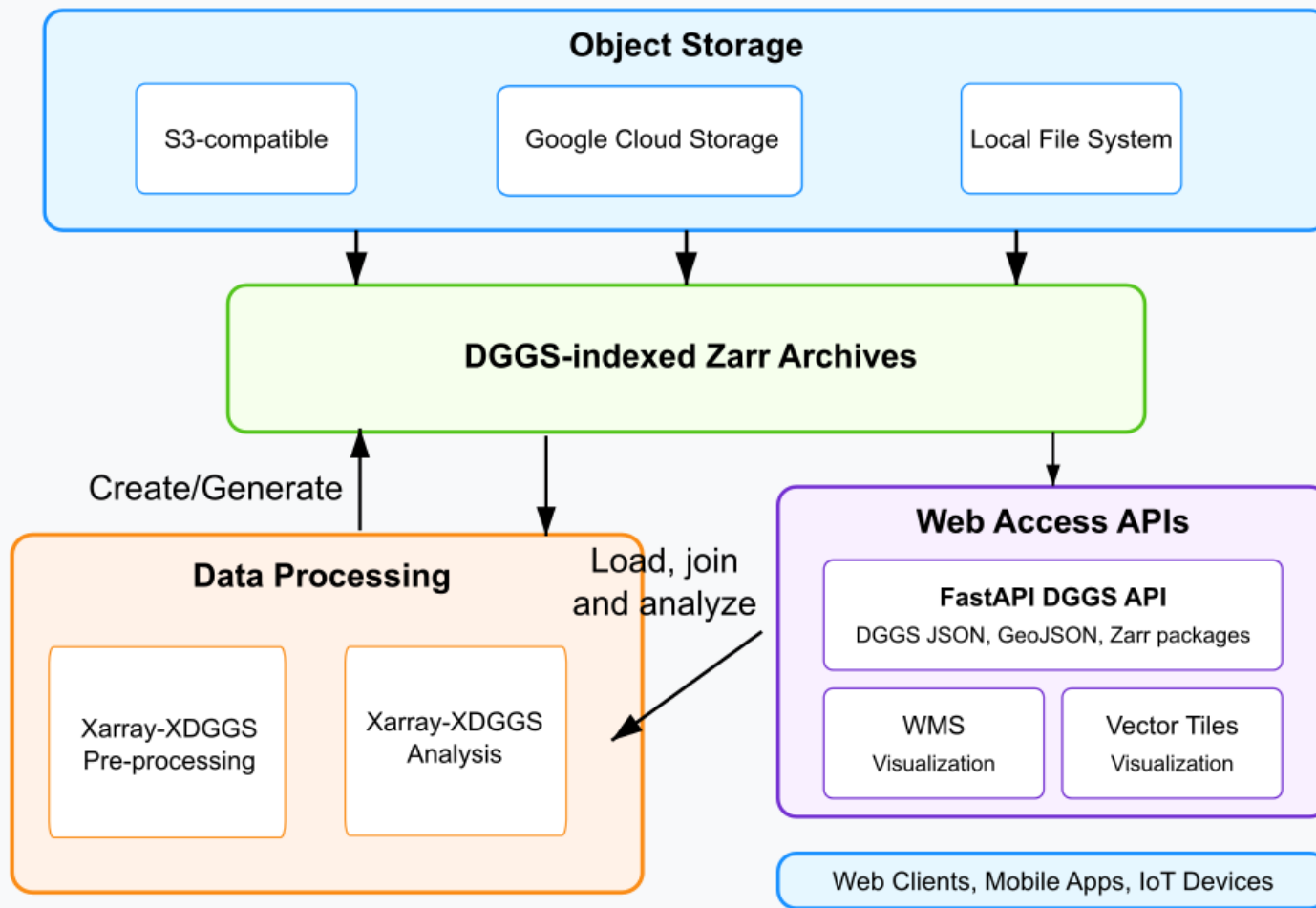
 [xarray-contrib/xdggs](https://github.com/xarray-contrib/xdggs)

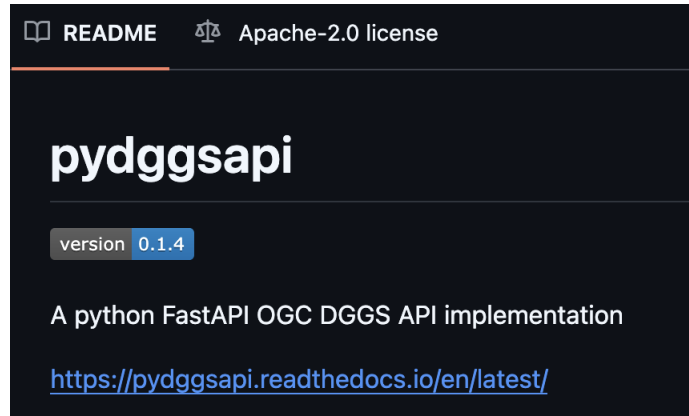
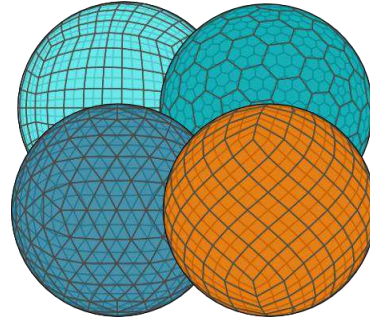
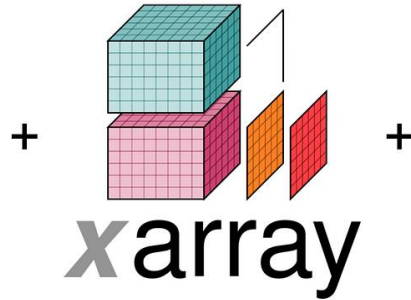
PyPI: `xdggs`

conda-forge: `xdggs`

Discord: discord.gg/M4WPSwDF6S

OGC DGGs API + Zarr Architecture





Co-funded by
the European Union



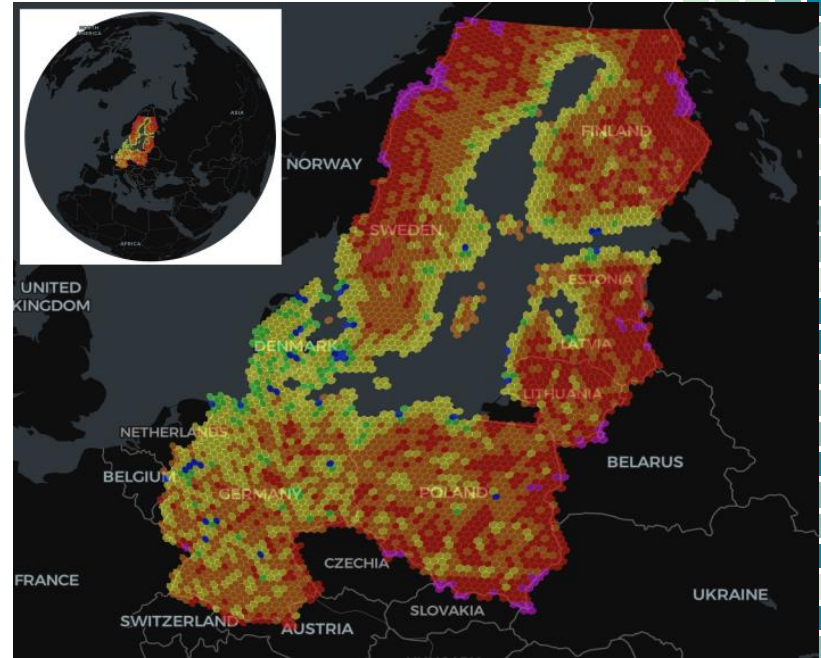
SMART GREEN MOBILITY

HyTruck



European Research Council
Established by the European Commission

Interactive clients



Results and outlook

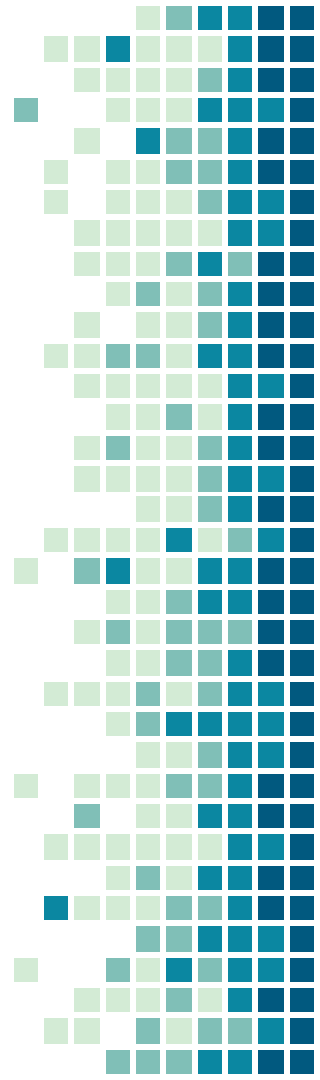
DGGS Zarr data lake vs OGC API DGGS requirements:

- unique indexing across refinement levels
- Zarr data organisation considerations – chunking, sharding – regarding query performance

The GRID4EARTH project (EOPF DGGS) has made massive progress in advancing tools and capabilities to test HEALPIX and Zarr on large Sentinel collections.

PyDGGSAPI is currently tested in the OGC AI DGGS pilot program, with large scale RCM and geomorphological data (flood mapping in Canada).

We will also test PyDGGSAPI and DGGS Zarr backends in our ERC consolidator project (WaterSmaterLand) at European scale (100m).





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GRID4EARTH

ESA Digital Twin Earth (DTE) Framework: Common
DGGS for DestinE and Copernicus Sentinels Data

Project Overview

Within the ESA Digital Twin Earth (DTE) Framework, the **GRID4EARTH** project focuses on creating a unified, standardized data infrastructure based on **Discrete Global Grid Systems (DGGS)**. This framework supports seamless integration, visualization, and analysis of diverse Earth Observation (EO) datasets. By addressing the increasing complexity and volume of EO data—especially from Copernicus missions and the Destination Earth (DestinE) program—this project promotes interoperability, scalability, and efficient data usage.

Consortium

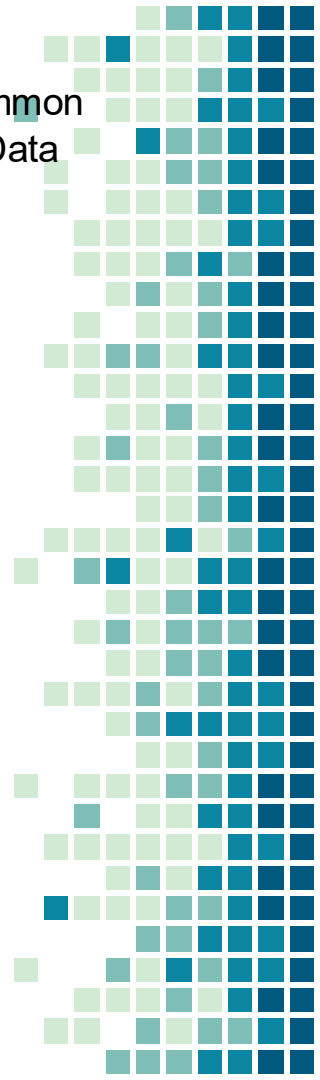
Funded by:

The European Space Agency

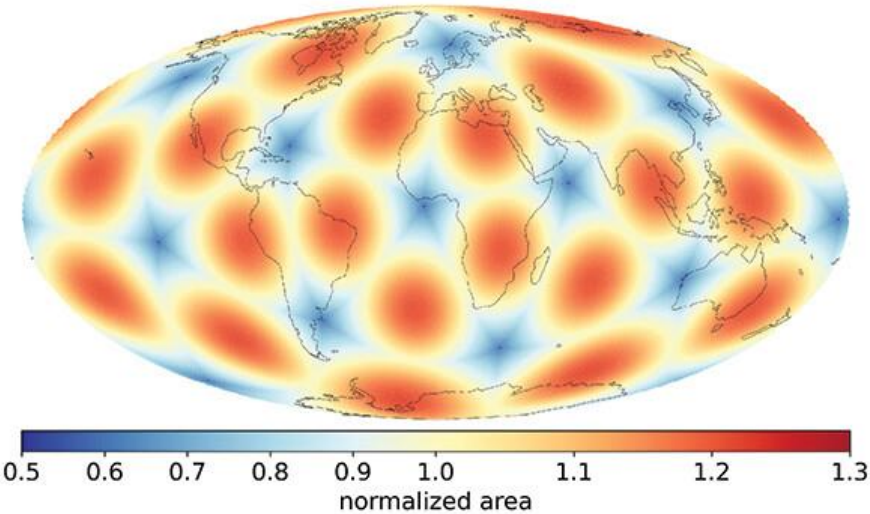
Consortium Members:

- IFREMER
- CNRS
- Simula
- The University of Tartu
- GEORODE

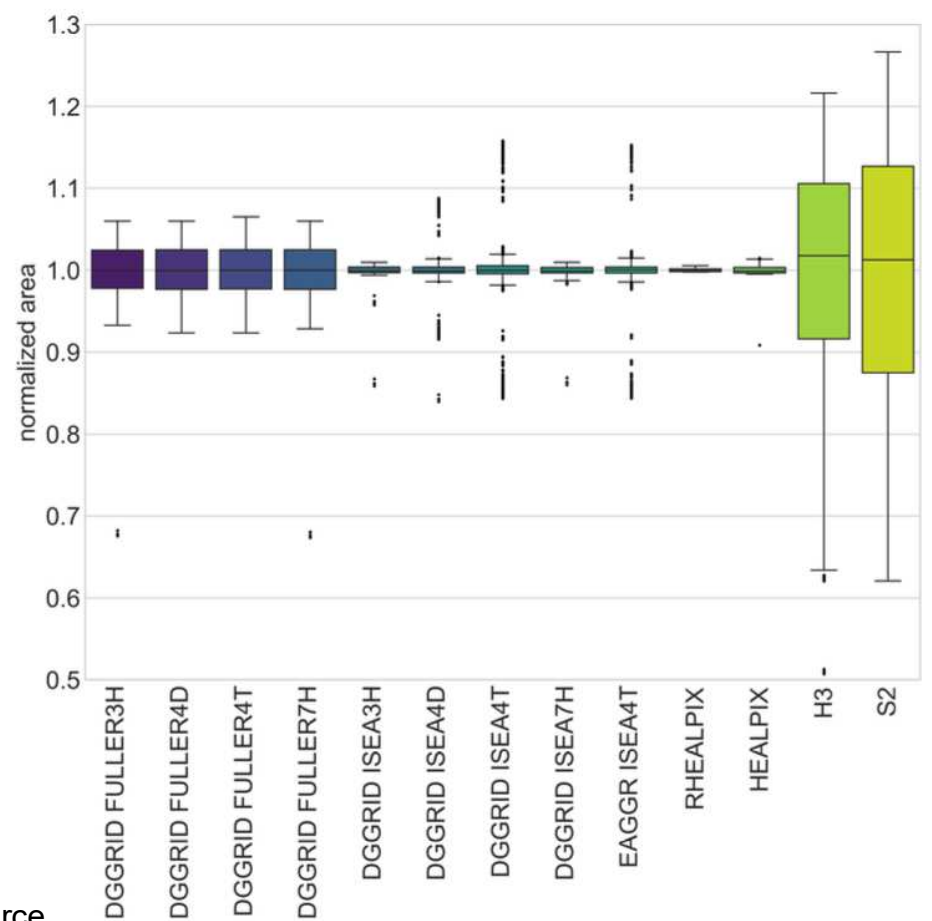
<https://eopf-dggs.github.io/>



H3 – big success, but...



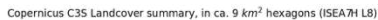
(a) Distribution of H3 area distortions.



Kmoch, A. et al (2022). Area and shape distortions in open-source discrete global grid systems. *Big Earth Data*, 6(3), 256–275. doi: 10.1080/20964471.2022.2094926

[10.5194/isprs-archives-XLVIII-4-W12-2024-75-2024](https://doi.org/10.5194/isprs-archives-XLVIII-4-W12-2024-75-2024)

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How can I use it today?

- <https://dggrid.readthedocs.io/latest/>
- <https://dggrid4py.readthedocs.io/en/latest/>
- H3 equal-area alternative
- Tabular geodata workflows “without” geometry columns

Anaconda.org 8.3

Installers

linux-64 v8.3
osx-64 v8.3
win-64 v8.3
osx-arm64 v8.3

conda install ?

To install this package run one of the following:

```
conda install conda-forge::dggrid
```

pip install dggrid4py

pypi package 0.4.1

Awesome Discrete Global Grid Systems



<https://github.com/LandscapeGeoinformatics/awesome-discrete-global-grid-systems>



"DGGs as a Common Geography will ensure that all statistical data is consistently geospatially enabled and that users can discover, access, integrate, analyse and visualise statistical information seamlessly for geographies of interest."

United Nations Committee of Experts on Global Geospatial Information Management - [The Global Statistical Geospatial Framework](#)