

ECMWF – DESTINATION EARTH

POLYTOPE DEEP DIVE

Adam Warde, James Hawkes, Mathilde Leuridan, Peter Tsrunchev,
Chris Bradley, Alice Sartori Monteiro de Barros, Matt
Griffith, Tiago Quintino



Funded by
the European Union

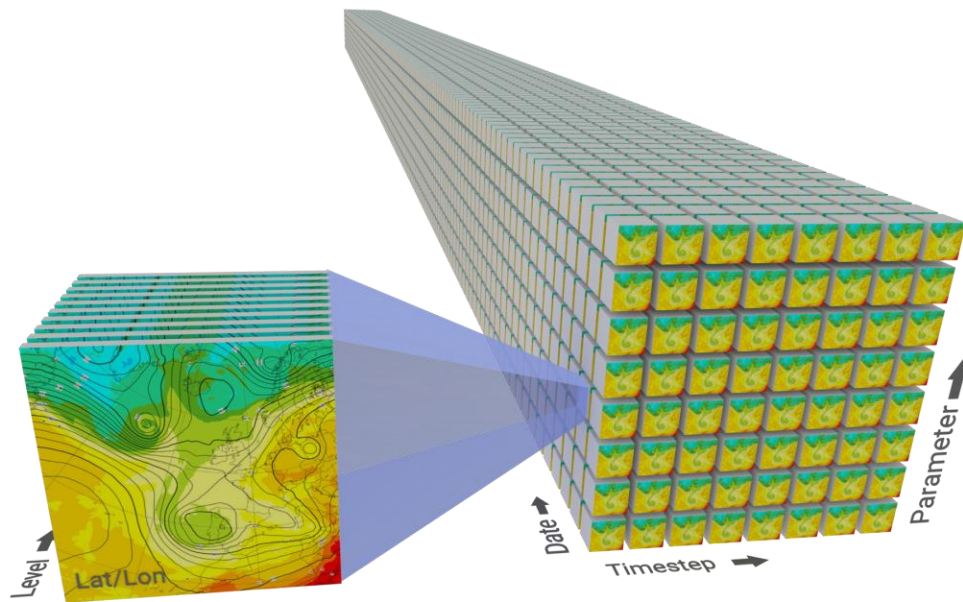
Destination Earth

implemented by

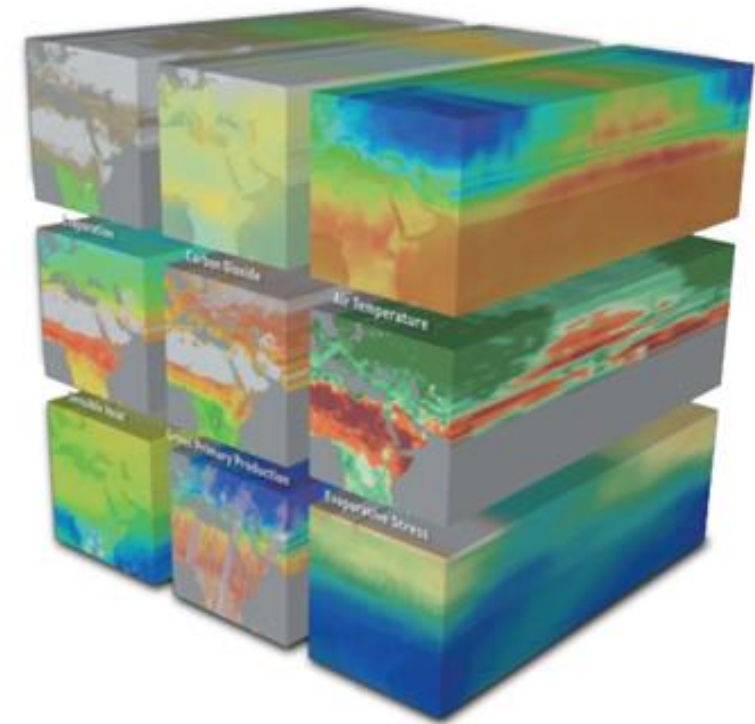


HOW IS DATA ORGANISED

- Digital Twin data is a high-dimensional datacube (~ 6D or 7D) stored on the databridge
- Multiple PiB in size (~20PiB)
- Too big to cache or transpose into different orientations
- Stored as global fields



ECMWF Numerical Weather Forecast

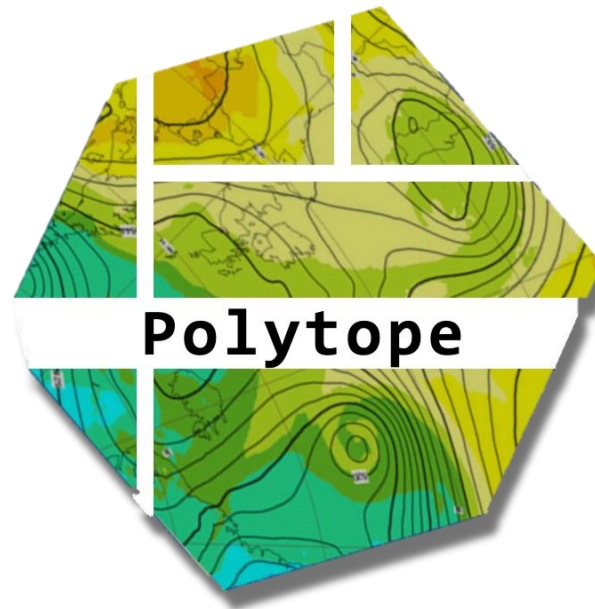


ESA's Earth System Data Cube.

Picture taken from <https://www.earthsystemdatalab.net>

WHAT IS POLYTOPE

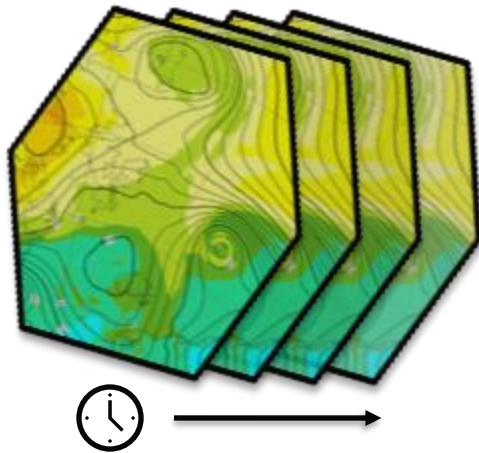
- **Polytope** is a data service specialized to efficiently serve datacube data



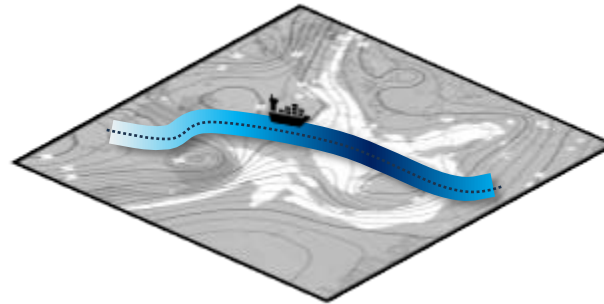
WHAT IS POLYTOPE?

- **Polytope** can serve global fields in the traditional way
- But its key feature is the ability to directly extract “**features**” from the datacube
- Server-side data reduction **massively reduces the amount of data transferred to the user**

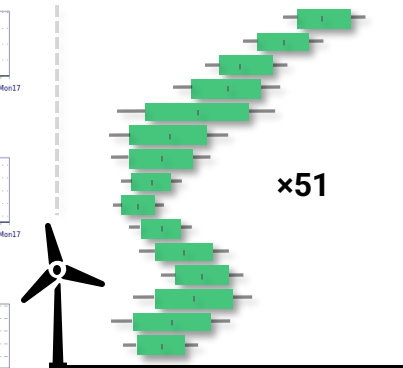
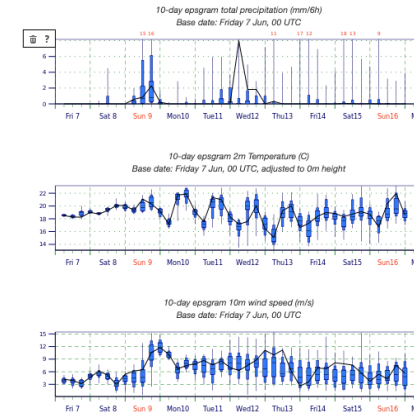
Regions and Series



Spatiotemporal
Trajectories



Point Data



and more...

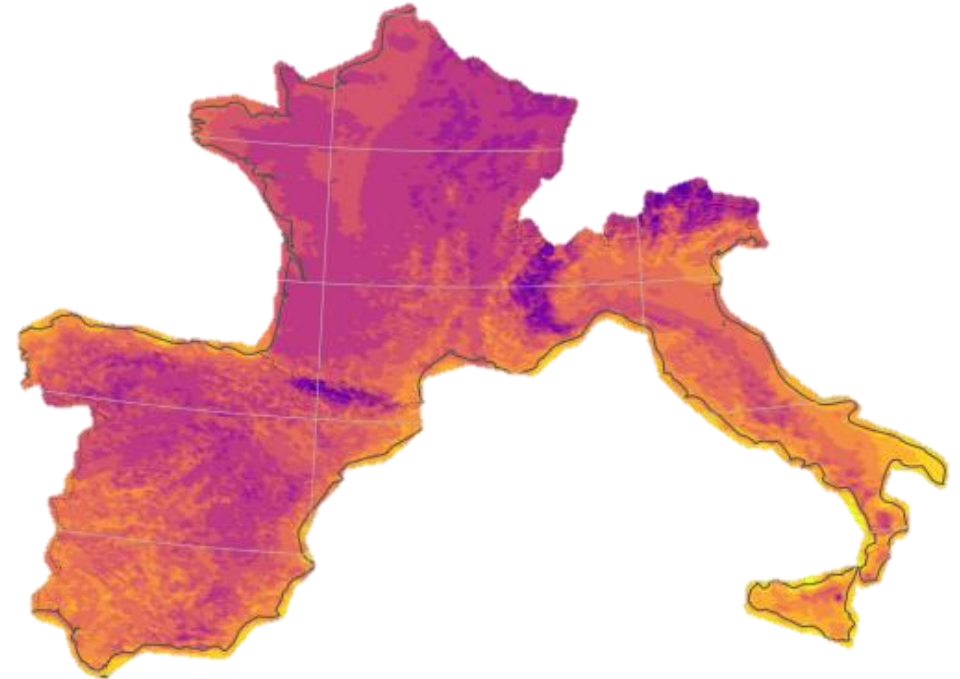
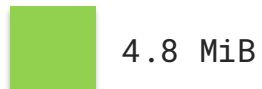
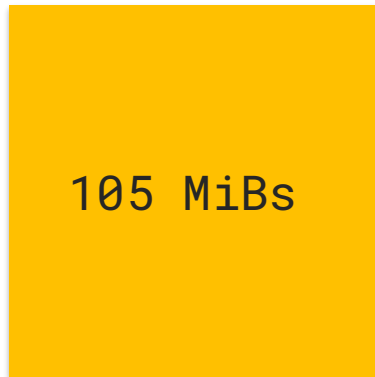
DATA REDUCTION EXAMPLE

Polygon extraction of Spain, France and Italy

vs.

Extracting the entire global field

Percentage Reduction: **~95%**



DATA REDUCTION EXAMPLE

Climate DT 20-year time-series of one parameter

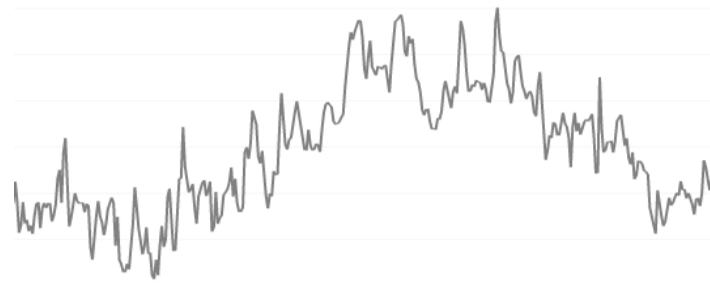
Global fields: ~770 GiB

vs.

A single point: 5.5 MiB

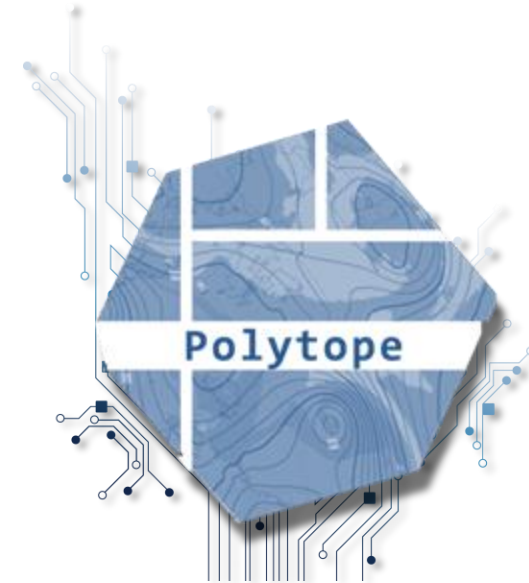
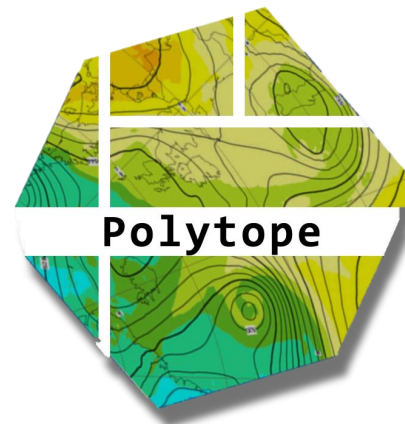
Percentage Reduction: ~99.999%
(1:140000)

*We don't even read the
excess data from disk!*



WHAT IS POLYTOPE?

- **Polytope** consists of a four main components:
 - **Polytope** (service), the web service which delivers the data externally
 - **Polytope** (library), the algorithm for translating N-dimensional features to grid indexes
 - **GribJump**, responsible for “jumping” to indexes within individual GRIBs in FDB
 - **Covjsonkit**, which translates the data to OGC CoverageJSON.

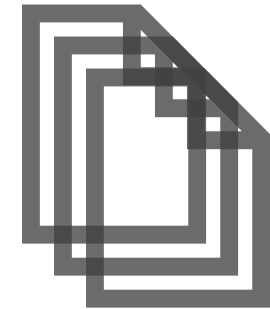
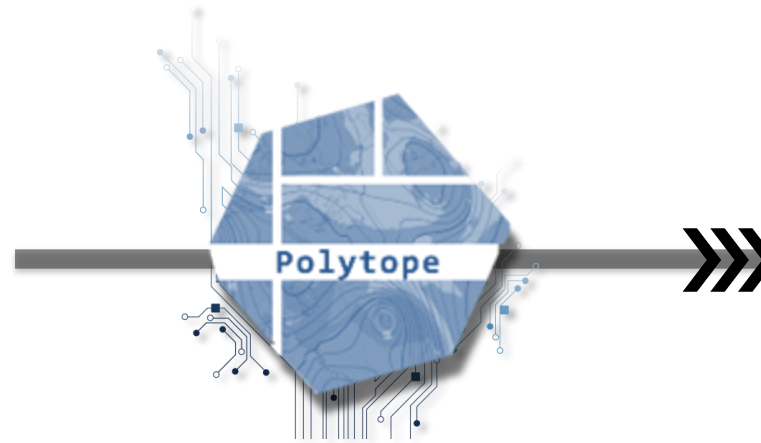


+ covjsonkit
+ polytope-mars

EXAMPLE

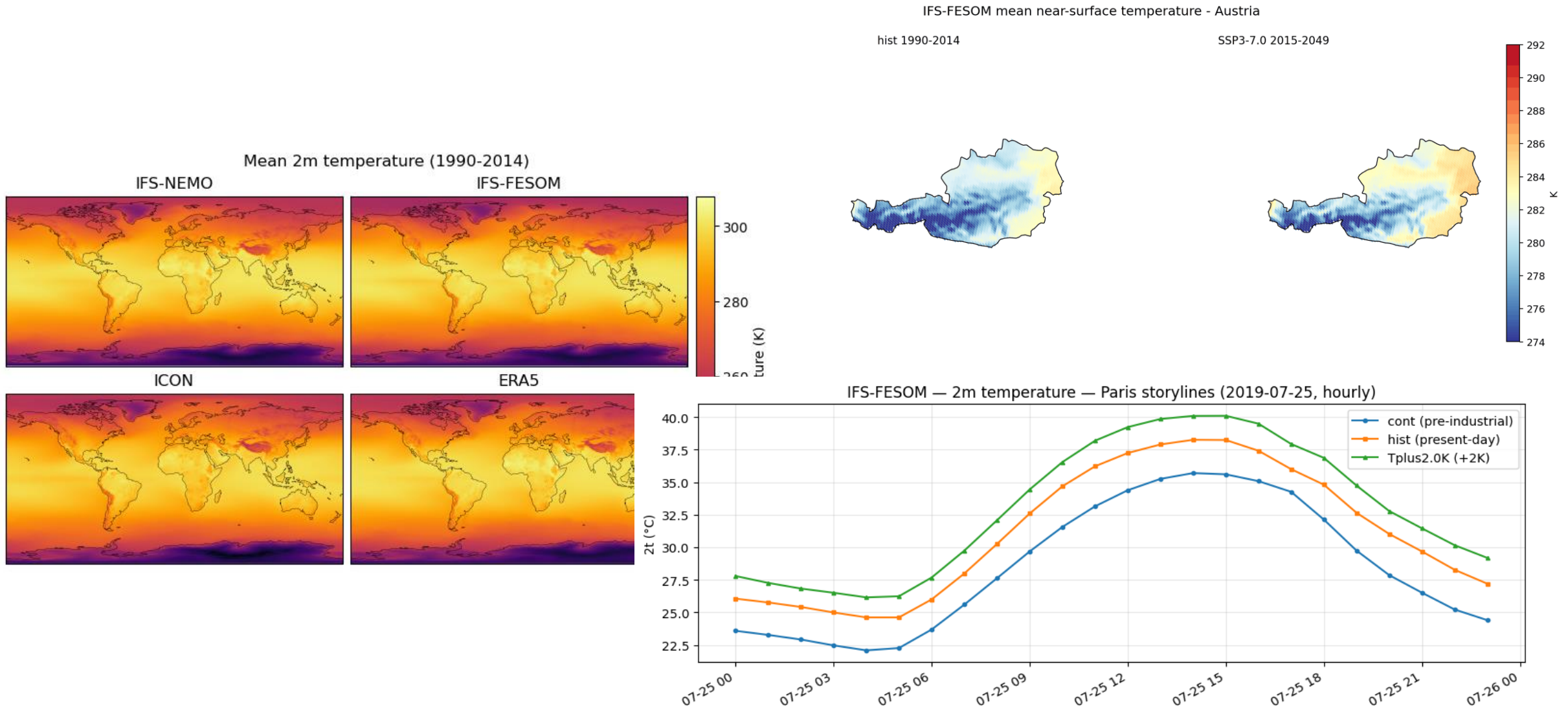
- Users can submit a Polytope request for a global fields
- And receive a grib file containing the data they requested

```
{  
  "class": "od",  
  "stream": "enfo",  
  "type": "pf",  
  "date": "20231205",  
  "time": "0000",  
  "levtype": "sfc",  
  "expver": "0001",  
  "param": "228/49/164/165/166/167",  
  "number": "1/to/50",  
}
```



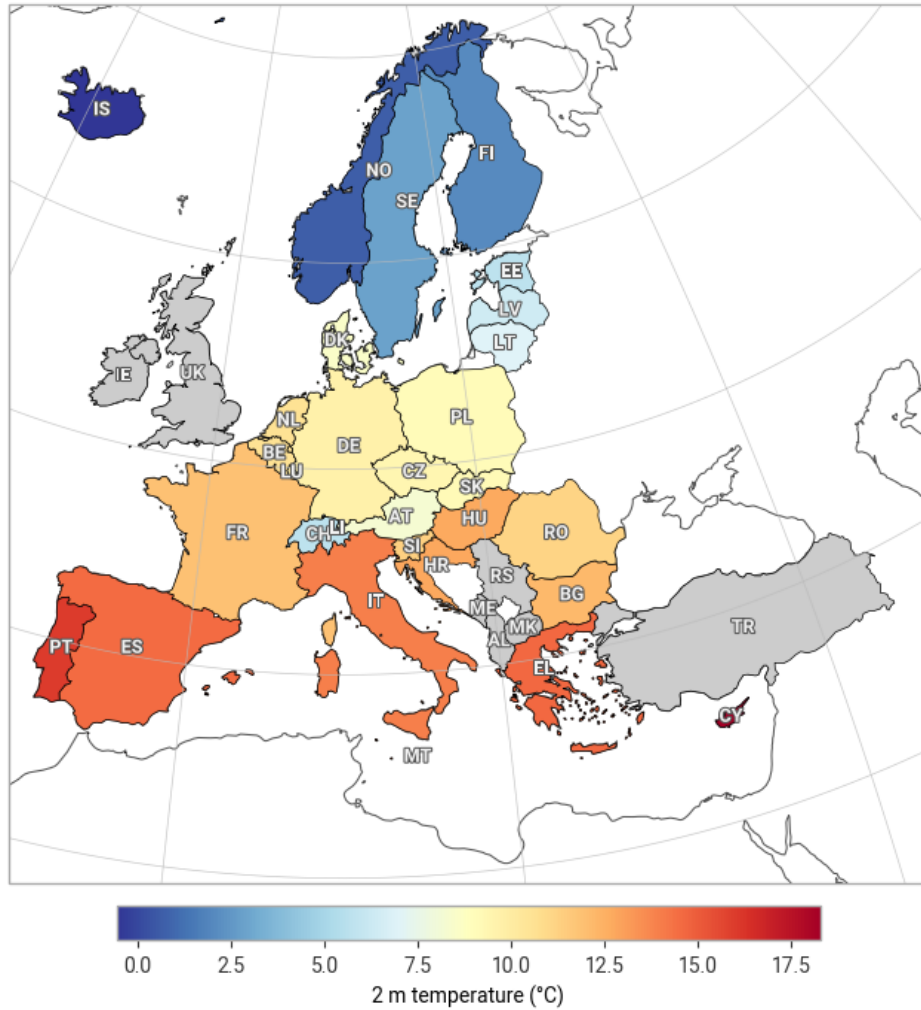
Data.grib

EXAMPLE USE CASE

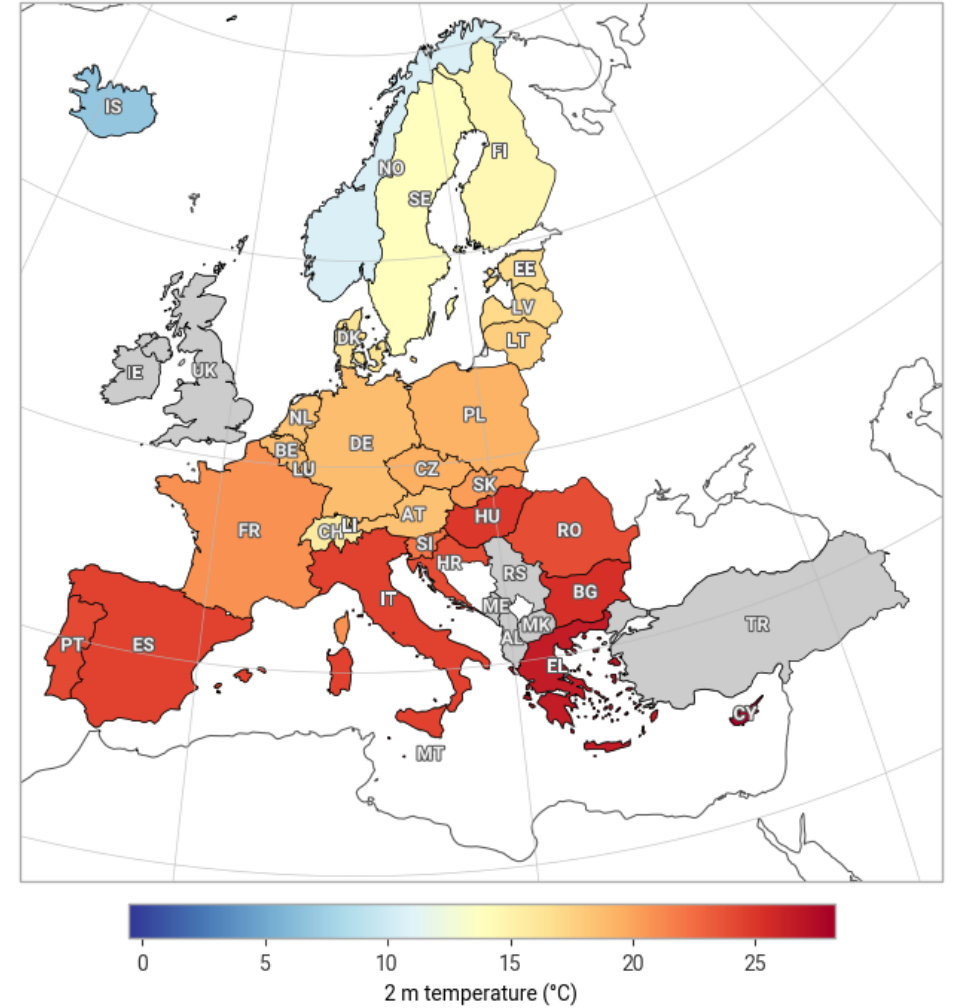


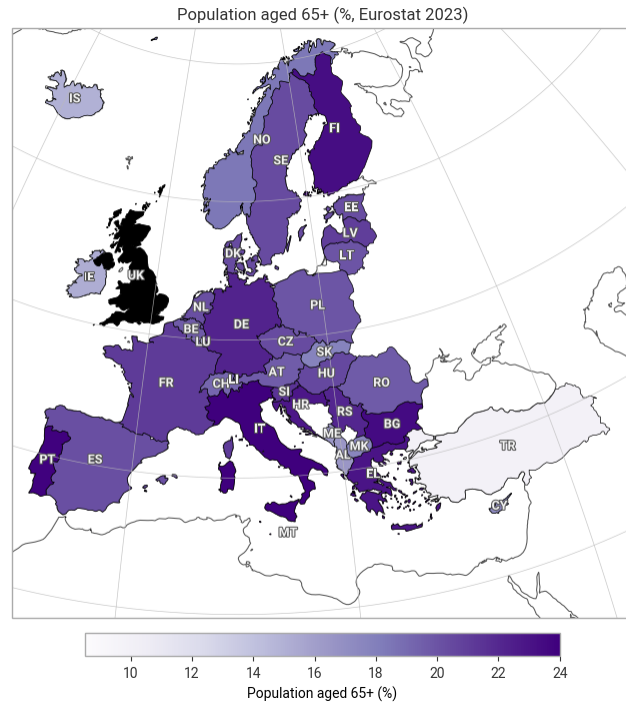
INTEROPERABLE WITH OTHER DATASETS

Climate DT annual mean 2 m temperature – IFS-NEMO historical 2010 (°C)



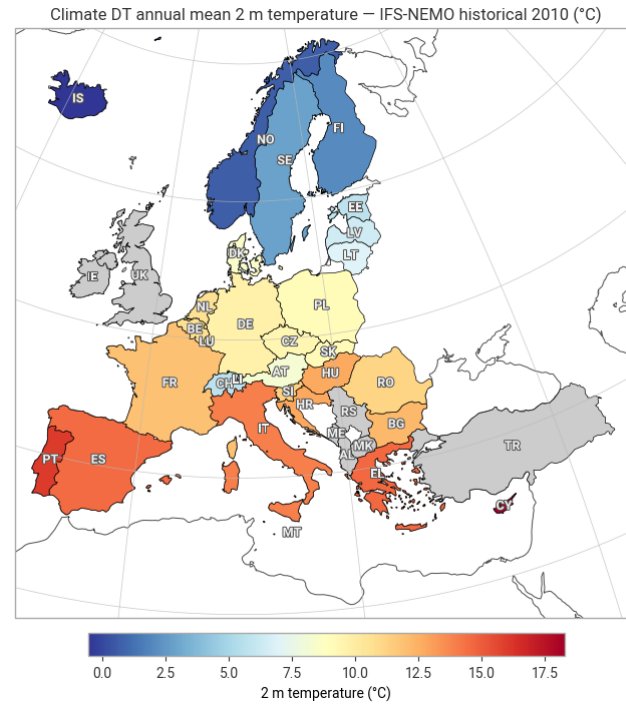
Climate DT JJA mean 2 m temperature – IFS-NEMO SSP3-7.0 2040–2049 (°C)





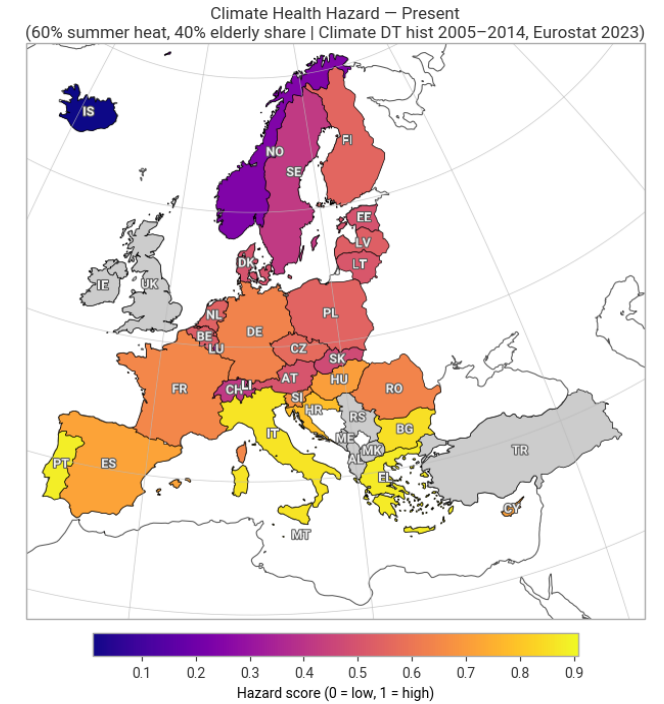
% over 65

+

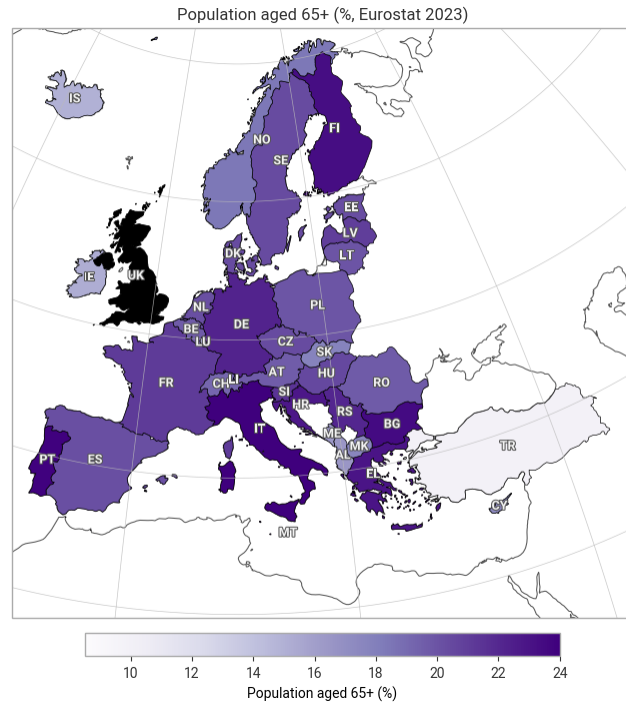


Present temperatures

=

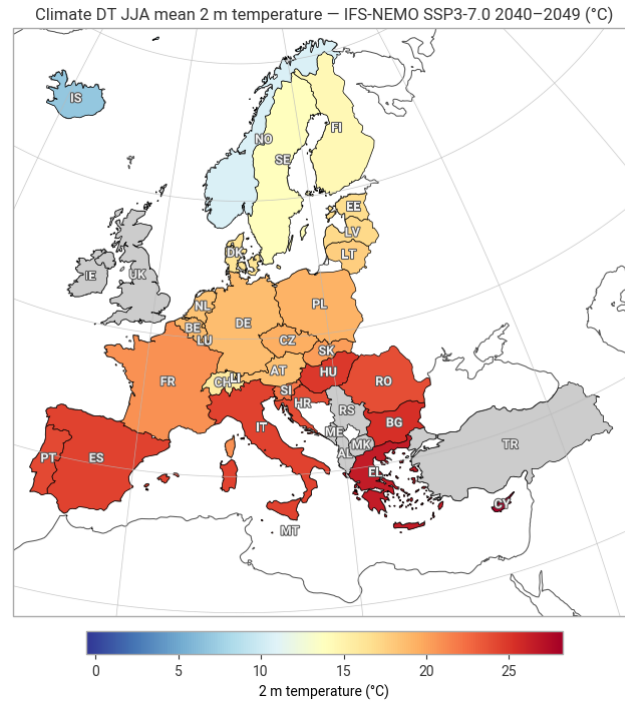


Climate heat hazard



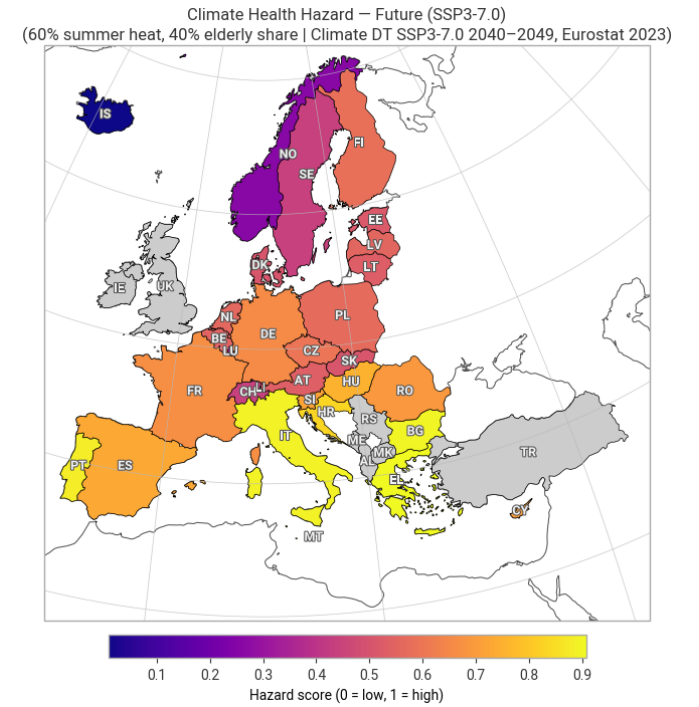
% over 65

+

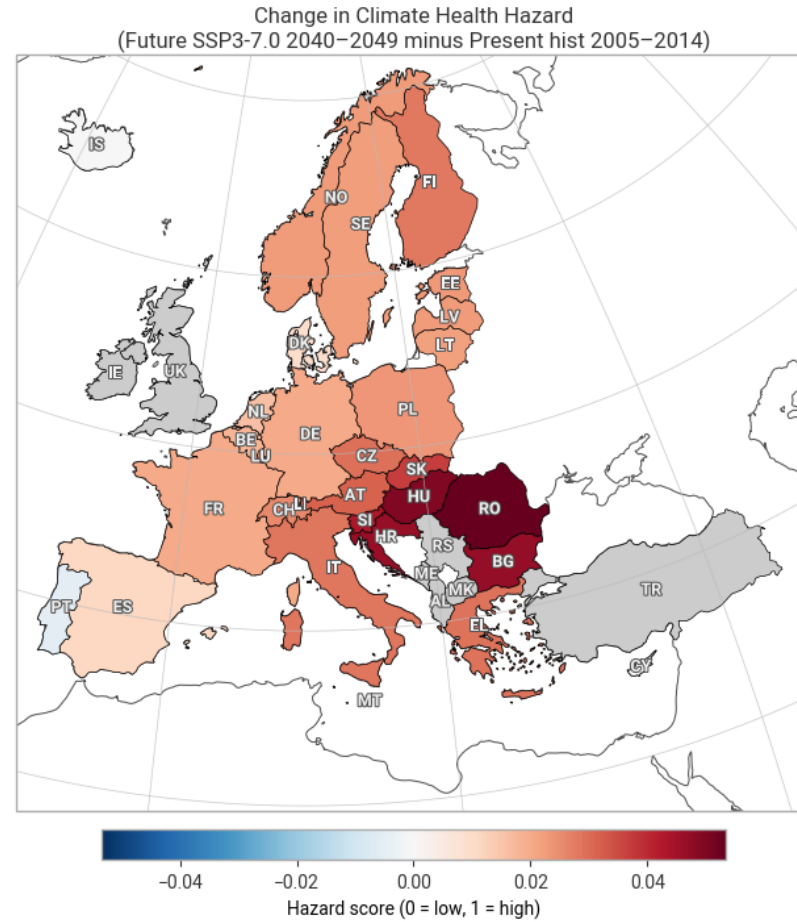


Future temperature

=



Climate heat hazard



Climate Heat Hazard Change

POLYTOPE FUNCTIONALITY

- Feature Extraction
 - TimeSeries
 - Bounding Box
 - Polygon
 - Trajectory
 - Vertical Profile
- Full Field Extraction
 - Grib
 - All Digital Twin Data
- Post Processing
 - Regridding
 - Area Subset
 - Different Interpolation Methods
- Format Conversions
 - Grib
 - CoverageJSON
 - GeoJSON
 - GeoTIFF

- Polytope Examples Repo <https://github.com/destination-earth-digital-twins/polytope-examples>
- Aviso Examples Repo <https://github.com/destination-earth-digital-twins/aviso-examples>



Destination Earth

Polytope Examples for DT Data Access

- [Polytope Examples for DT Data Access](#)
 - [Access using your Destination Earth Service Platform credentials](#)
 - [Installation](#)
 - [Option 1: Conda Instructions](#)
 - [Option 2: Python Virtual Environment \(venv\)](#)
 - [Data Locations](#)
 - [Climate-DT Examples](#)
 - [Full Field](#)
 - [Full Field Post-Processing](#)
 - [Feature Extraction](#)
 - [Climate DT Explorer](#)
 - [Extremes-DT Examples](#)
 - [On-Demand Extremes-DT Examples](#)
 - [NextGEMS Examples](#)
 - [Polytope Quota Limits for DestinE](#)

