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CLIMATE IMPACT EXPLORER

DIGITAL TWIN EARTH PRECURSOR

ESA Living Planet Symposium, 26 May 2022

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ESA Digital Twin Earth Precursor: Climate Use Case

- Help decision makers to generate and visualise information relating to regionalised impacts of **climate change** in real-time
- Land surface and drought risk (utilising JULES model) as focus
- Rapid prototyping and explorative
- Aggressive time scales

TELESPAZIO a LEONARDO and THALES company

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UNIVERSITY OF LEICESTER

University of Reading

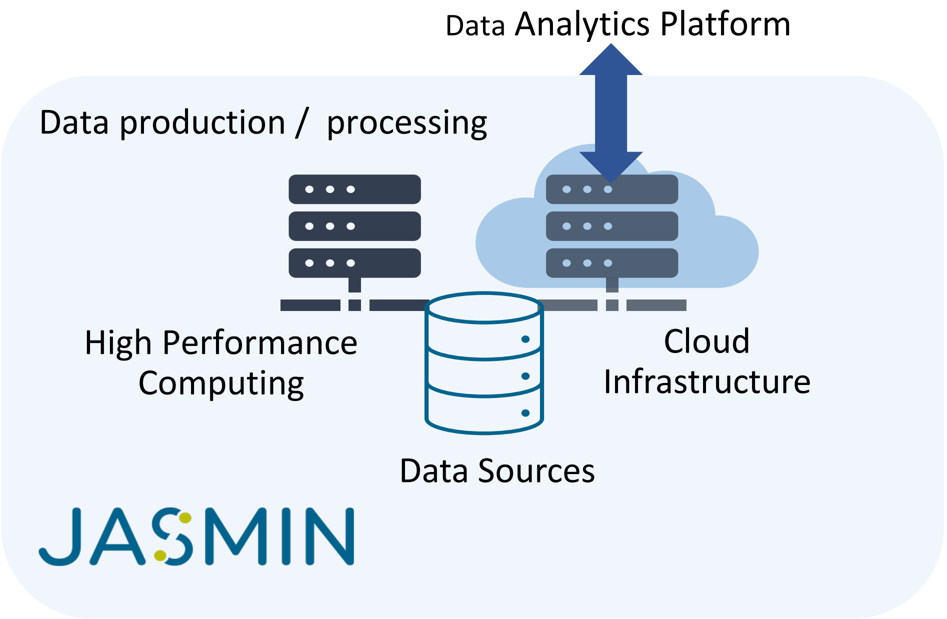
Summary – what did we achieve?

- Challenge: complex modelling required and access to specialised High-Performance Computing

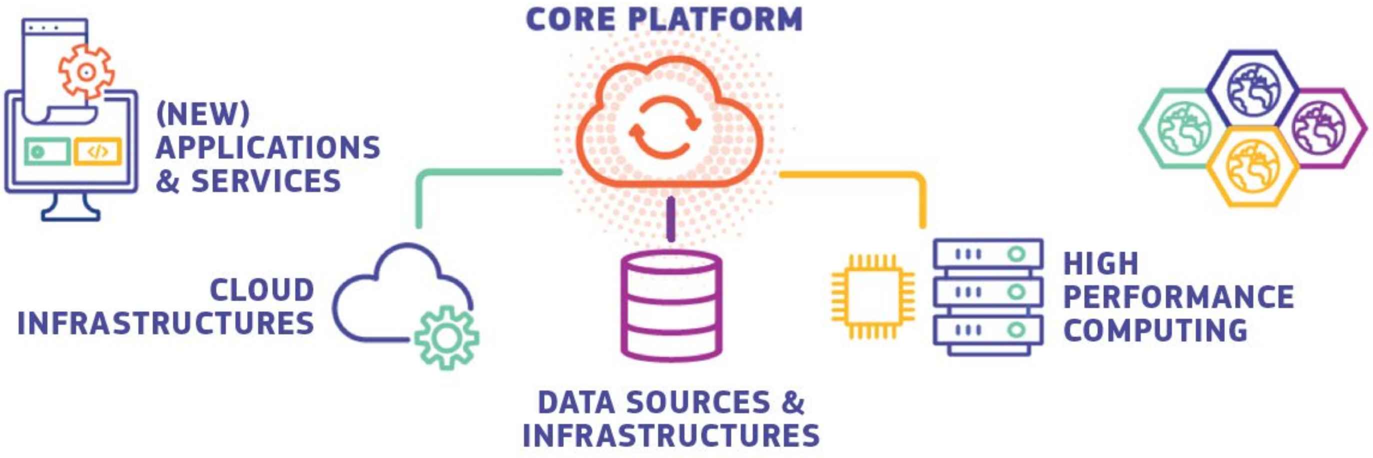
- Applied machine learning to develop an emulator
  - suitable for deployment on a commodity cloud computing environment
  - accessible on-demand when required by end-users

- The above made possible through key elements provided by underlying JASMIN infrastructure

JASMIN – a platform with the essential elements to build a Digital Twin Earth Precursor

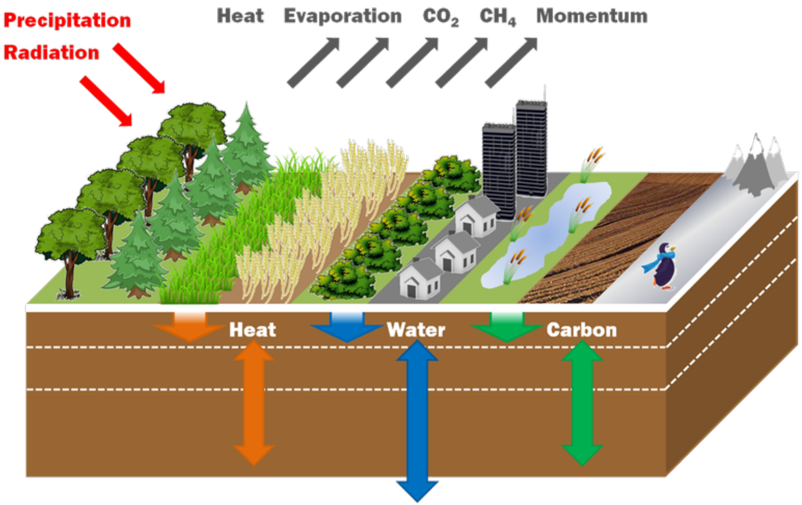


DestinE and Blueprint Architecture



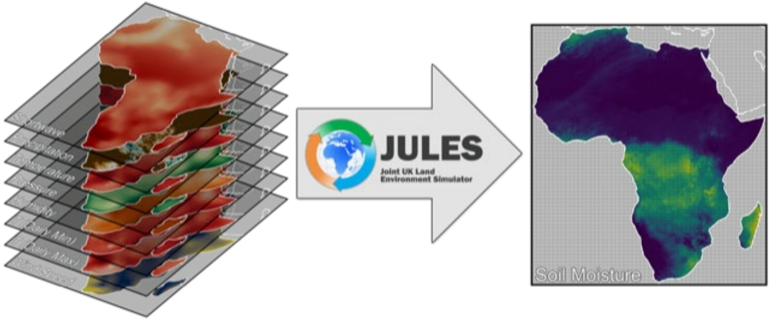
https://digital-strategy.ec.europa.eu/en/library/destination-earth

Climate Explorer focus on land surface modelling use case



- Using JULES (Joint UK Land Environment Simulator)
  - the land surface component in the Met Office Unified Model
- Improvements with LAVENDAR data assimilation system (Reading University)
  - Feed in satellite observations – SIF and SMAP data

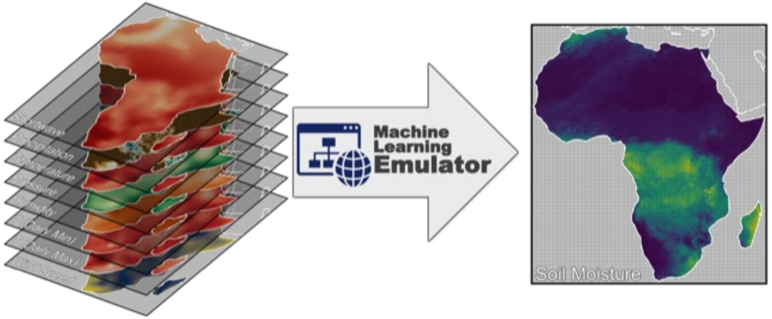
What could be the future impact of climate change on the soil moisture?



JULES driven with climate projections from ISIMIP data

(Inter-Sectoral Impact Model Intercomparison Project)

Make a surrogate AI model to JULES



- Experimented with different Machine Learning (ML) techniques
- Goal: a general-purpose algorithm -

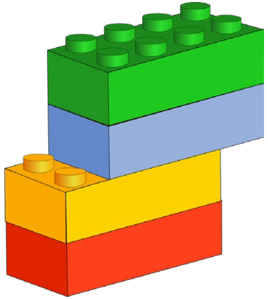
  `time series of daily weather data ➔ time series of soil moisture data`

- Successfully applied XGBoost (eXtreme Gradient Boosting) algorithm.
- Trained on up to 1000 grid cells, representative of the various biomes in continental Africa
- Demonstrated to accurately emulate JULES output at other locations in Africa
- The credibility of the model is enhanced by its transparency and explainability

JASMIN Cluster-as-a-Service to build data analysis environments from pre-configured building blocks

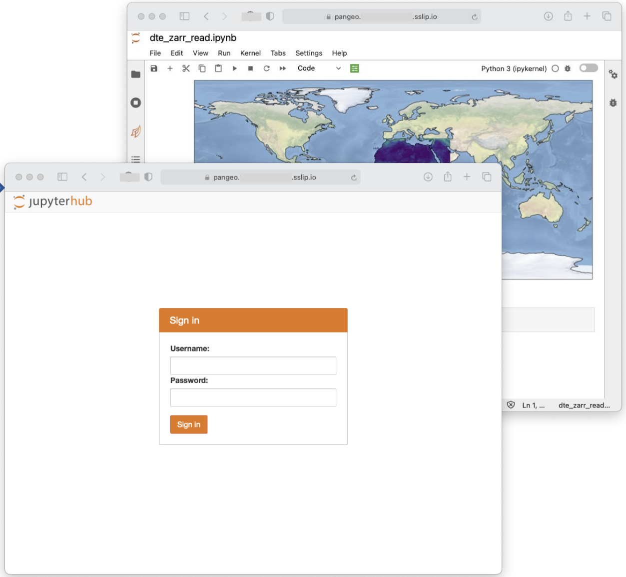
1) Cloud Portal – Cluster-as-a-Service

2) Select required building blocks and deploy

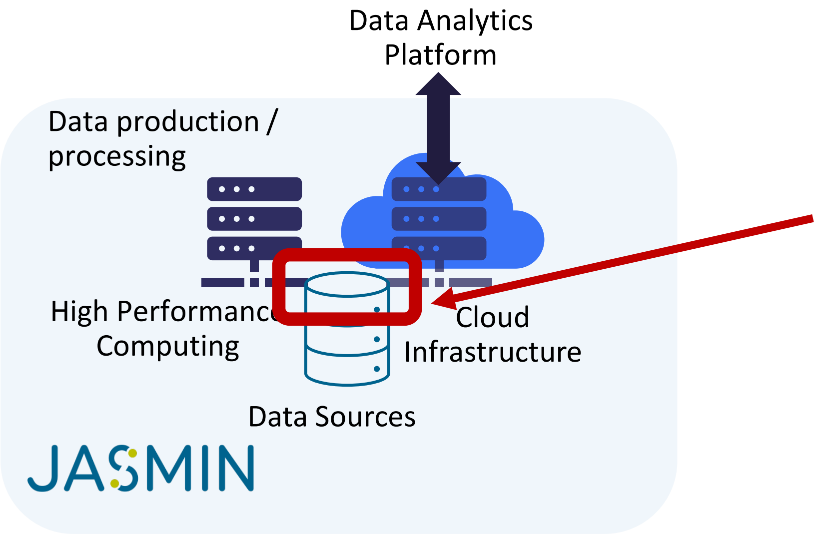


https://www.goodfreephotos.com/

3) Use deployed components



HPC and Cloud data access mismatch



- HPC – POSIX file systems
- Cloud – object store
- Access and format translation needed to map from one to another

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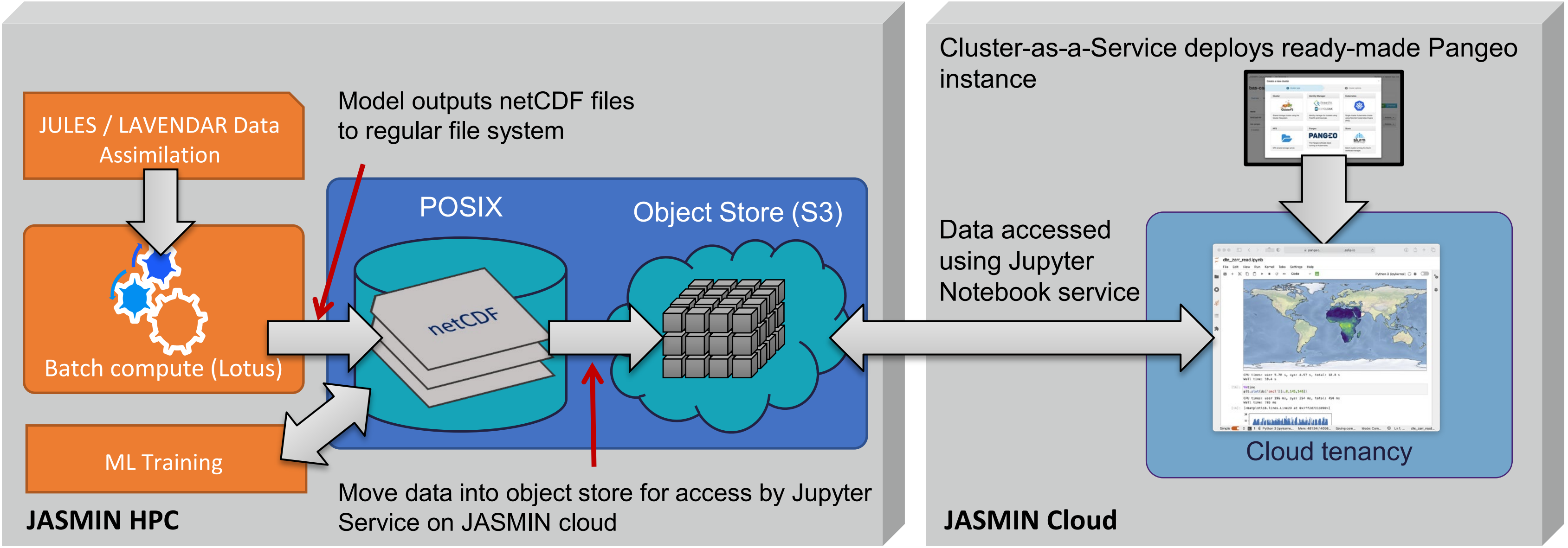
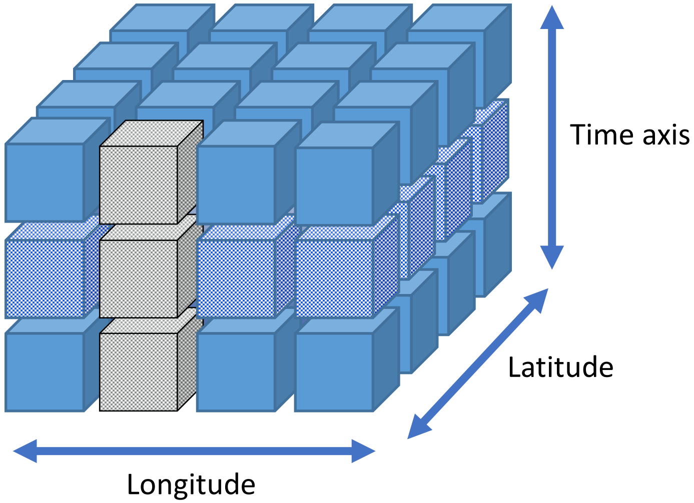
Bringing together HPC and Cloud-Friendly Storage



Arrangement of data and efficient access



- Data output from models as netCDF format
- Data in files arranged in spatial dimensions one per time step
- But predominate access pattern for analysis of climate data in the project is time series query (grey blocks)

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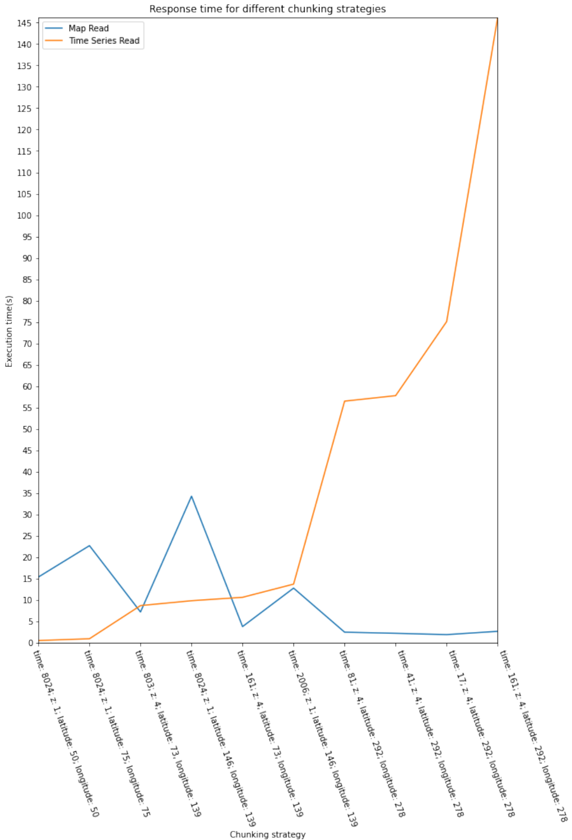
Object Store: Different storage strategies showed radically different performance



- We experimented with different storage chunking arrangements
- 20-year dataset of soil moisture

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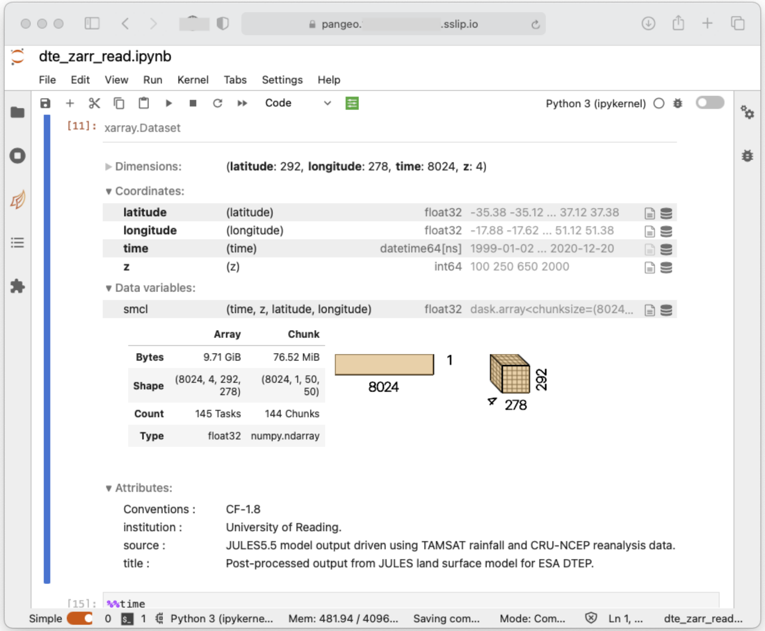
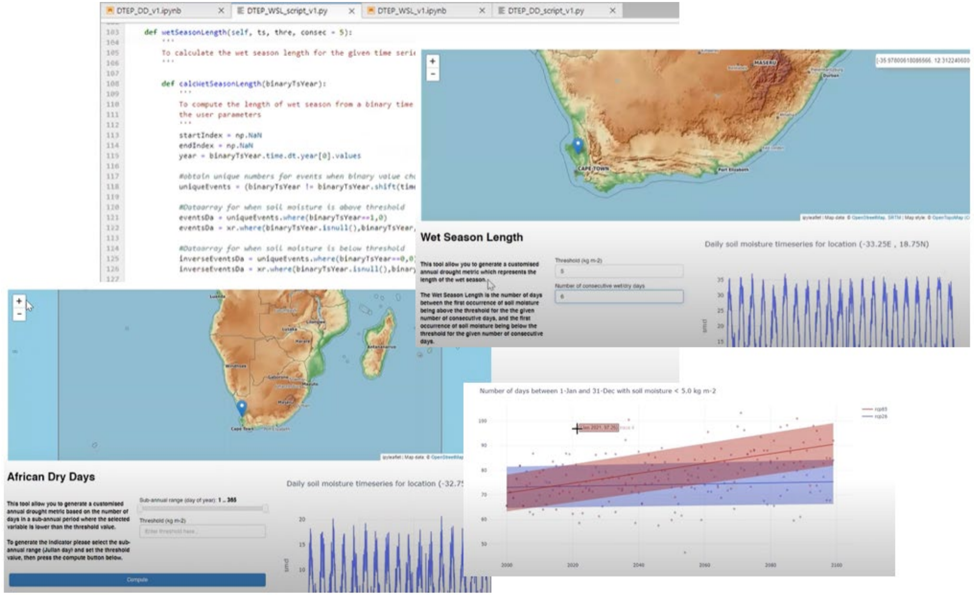
Using Object Store for re-arrangement of data to suite our access patterns



- Using zarr and xarray Python libraries to store and access the data
- Chunked data into a series of strips along the time axis

Rechunking of data made possible interactive maps with long time series



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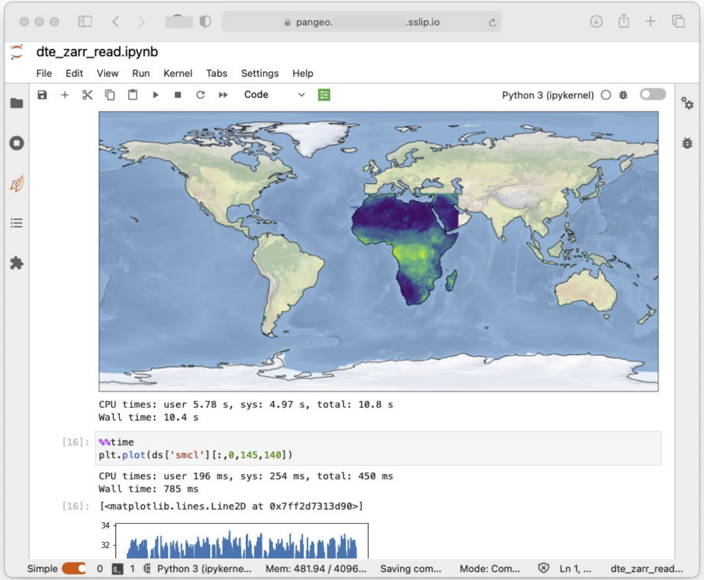
Use of object store for analysis-ready cache specific to project needs

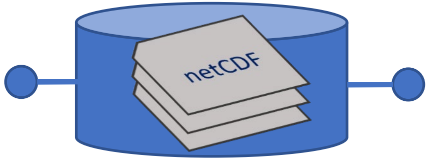


- Object store efficient for access on JASMIN Cloud
- Essential to orient data storage to suit predominant access patterns

Summary

- Emulator: suitable for commodity cloud instead of HPC needed for JULES
- JASMIN: provided HPC, Cloud and storage (object store + POSIX) essential high-level infrastructure constituents needed for the demonstrator
- Cluster-as-a-Service: Rapid prototyping environment possible from day one
- Analysis-ready caches of data on object store
  - Pattern emerging where we make copies of data on the fly arranged to support specific analysis use cases
  - Future: storage for simultaneous POSIX and S3 Interfaces – experiment with *Kerchunk*

POSIX



S3 ⇔ Kerchunk ⇔ zarr ⇔ xarray

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Further Information

- Climate Explorer web-site: https://climate-impact-explorer.org
- JULES: https://jules.jchmr.org
- JASMIN: https://jasmin.ac.uk

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