

## Publishable summary



EarthServer ([www.earthserver.eu](http://www.earthserver.eu)) has established services and technology for **open, flexible, scalable, & user-friendly access to spatio-temporal Earth science data** (Fig. 1). Accessing such data ranges from simple navigation over extraction, download, filtering, and processing up to complex analytics. This is accomplished through versatile ad-hoc analytics suitable for extreme-size multi-dimensional Earth Science data, based on and extending leading-edge Array Database technology.

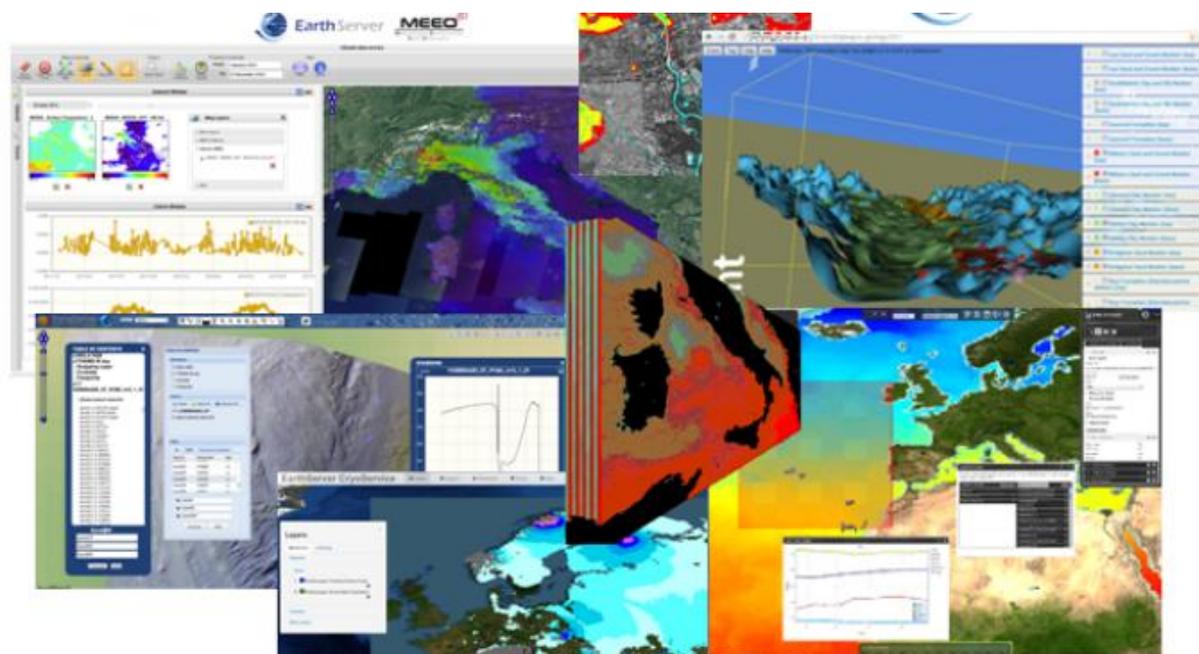


Fig. 1 EarthServer portal screenshots

The core idea is to use database query languages as client/server interface to achieve barrier-free "mix & match" access to multi-source, any-size, multi-dimensional spatio-temporal data - in short: "Big Earth Data Analytics" -- based on the open standards of OGC WCPS (aka "XQuery on raster data") and W3C XQuery. EarthServer combines both, thereby achieving tight data/metadata integration. Further, the rasdaman Array Database System is extended with further spatiotemporal coverage data types. On server side, highly effective optimizations -- such as parallel and distributed query processing -- ensure scalability to Exabyte volumes.

Several **Lighthouse Applications** (Fig. 2), spanning all Earth sciences, have been established with up to 132 TB databases covering: **atmosphere** (climate modelling), **hydrosphere** (oce-

anography), **lithosphere** (geology), and **cryosphere** (snow & ice mapping); in addition, a **airborne science** (drone) imagery database has been set up and a **Planetary science** use case with surface and subsurface data on Mars.

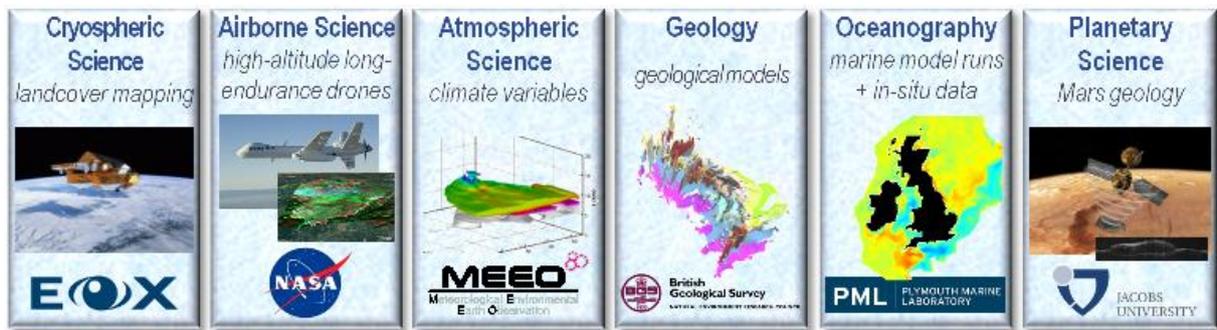


Fig. 2 Comprehensive Earth & Planetary science support through Big Data Analytics

The **main innovations** of EarthServer are:

- Substantial simplification of use of any-size, any-dimension Big Earth Data, through flexible, scalable, integrated, standards-based access interfaces;
- Integrating data and metadata in Big Earth Data queries,
- Uniform access across space and time, in particular: massive image and weather timeseries;
- Web service support for across all OGC coverage types: multi-dimensional grids, point clouds, and meshes;
- Transparent queries across heterogeneous file archives and databases;
- Paving the way for Petabyte Copernicus and climate services through parallel & distributed processing of queries.
- Strict reliance on the open OGC standards for Big Earth Data access, Web Coverage Service (WCS) and Web Coverage Processing Service (WCPS), including advancing these standards themselves.

Nucleus for this development is the pre-existing rasdaman system which has coined a new research field, Array Databases. During EarthServer, rasdaman has strengthened its position as the world's leading Array Database over recent competitors such as SciDB.

This substantial technological advance has resulted in several **innovation awards** for Jacobs Uni and rasdaman GmbH: German SME Award ("Mittelstandspreis") 2012, category: innovation); Geospatial World Forum Innovation Award 2013; Copernicus Master Challenge / Big Data, 2014; OGC Kenneth Gardel Award 2014 for sustained and extraordinary contribution to geo service standardization.

The outcome includes **open-source server & client packages** which will be used, maintained, and advanced beyond the project by several partners.

Simultaneously, OGC **standardization** has been advanced. About ten specifications extending the "Big Geo Data" suite, OGC WCS, have been submitted to OGC, many of them

adopted as standards now; more than half of them meantime have been adopted as official standard. Conformance tests have been established so that both rasdaman and any other tool can be validated, down to single pixels in the results. As a major breakthrough, the project succeeded in convincing ISO about the need to extend the SQL query language with multi-dimensional arrays. This new standard, ISO 9075 SQL Part 15: MDA, is being established with an EarthServer partner as national delegate to the SQL working group and co-editor of the specification.

A wide range of outreach activities has accompanied technology development and service deployment. Trainings, best practices, and auxiliary software tools have been provided at events and on the Web. A multitude of communication channels have been used to position the EarthServer technology worldwide (such as GEO Plenaries, Copernicus workshops, climate data workshops, standardization meetings). A particular highlight is a 1h TV documentary titled “Big Earth Data – the digitized planet” (Fig. 3) done by Jacobs and rasdaman GmbH one in collaboration with German ZDF and ARTE, to be broadcast soon after the project.



Fig. 3 Big Earth Data TV documentary screenshot

While focusing on Earth sciences, this project **transcends Earth and Planetary data**; rather, Array Databases comprise horizontal platform technology equally game-changing Life sciences, but also industry (such as oil & gas exploration) and eGovernment. In the latter context, during EarthServer INSPIRE has agree to base its Download Services for coverages on the OGC Web Coverage Service (WCS); work will commence in October 2014. To foster such uptake, industry and authorities have been involved in EarthServer.

**Consortium partners:**

- Jacobs University, Bremen (Germany; project coordination)

- ATHENA Research and Innovation Center in Information, Communication and Knowledge Technologies (Greece)
- British Geological Survey (UK)
- Consiglio Nazionale delle Ricerche (Italy)
- Consorzio Multi Ente per la Promozione e l' Adozione di Tecnologie di Calcolo Avanzato (Italy)
- EOX IT Services GmbH (SME, Austria)
- Fraunhofer Institute for Computer Graphics (Germany)
- Meteorological Environmental Earth Observation S.R.L. (SME, Italy)
- Plymouth Marine Laboratory (UK)
- rasdaman GmbH (SME, Germany)