

Geodetic Data Stewardship through Open Access, FAIR, TRUST and CARE

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South African Geodesy Workshop. 30 Sept. to 2 Oct. 2026



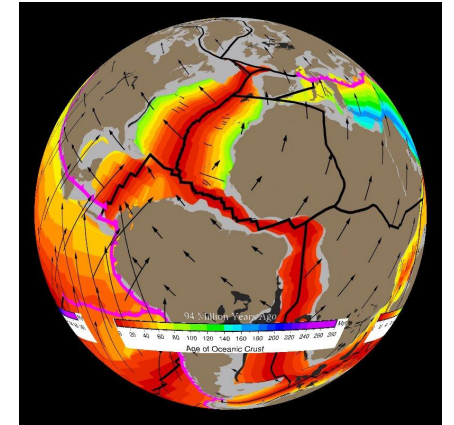


Credit: Vocal Media, 2026.

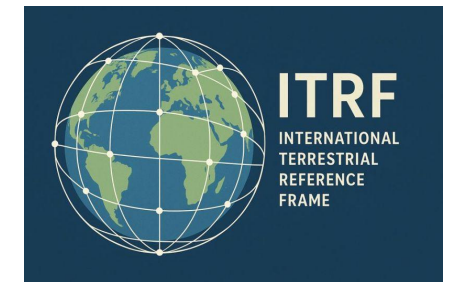
Geodesy data and products

- **Applications:** reference frames, sea-level rise, tectonics, hazards, land surveying and navigation
- **NB** – Data are only valuable if findable, accessible, interoperable, reusable and understandable.

How do we as data stewards handle data responsibly?



Source: NOAA, 2026.



Source: IERS, 2026.



Credit: GPS Navigation, 2025.



Credit: GIS Surveyors, 2025.



Credit: Britannica, 2026.



Credit: Fresh Vision, 2014.



The stewardship challenge

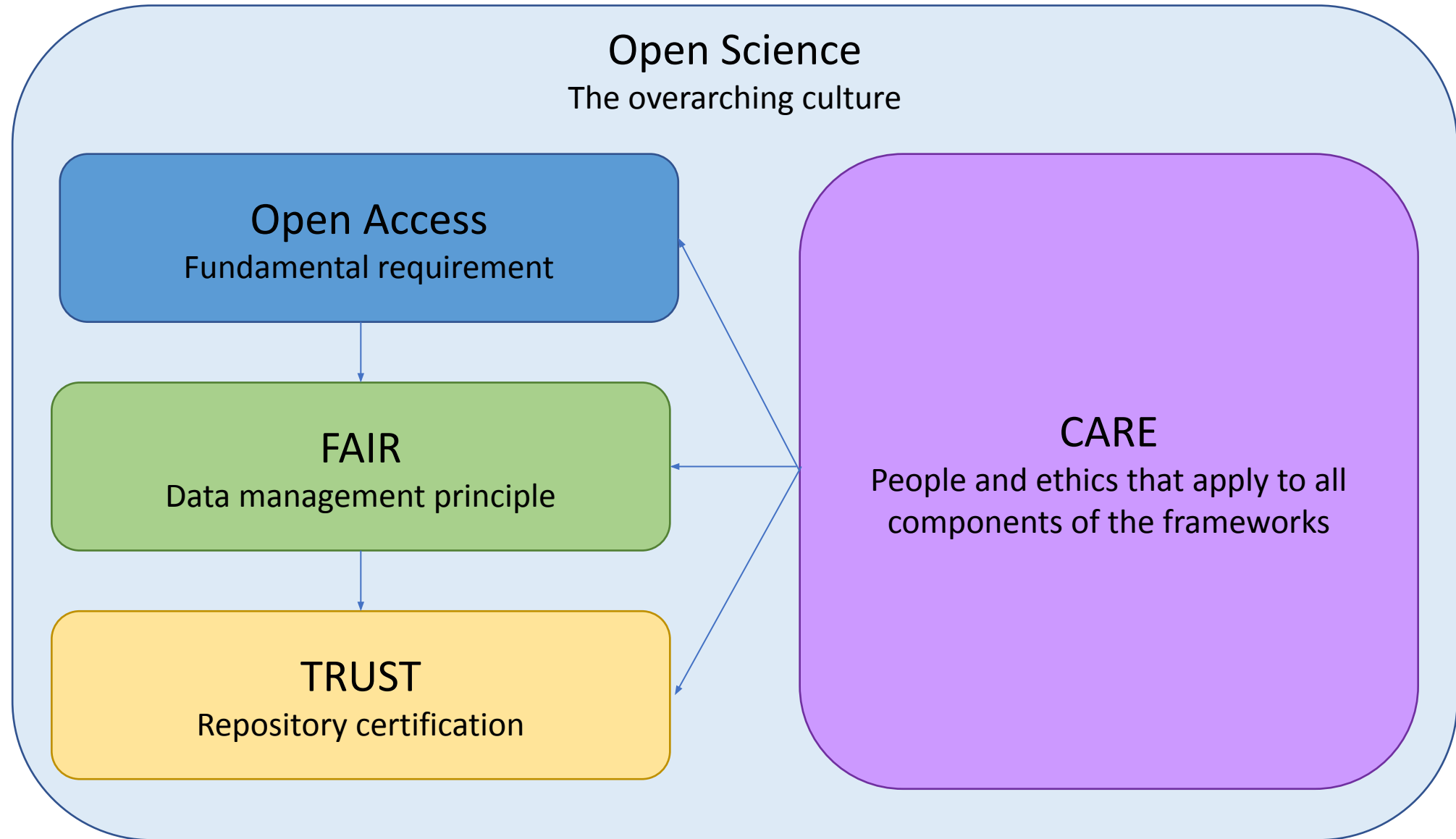
- Data are scattered across agencies, organisations and networks
- Data are managed inconsistently and lack policy
- Metadata standards exist, but applied inconsistently
- Use different licences, unclear reuse rights
- Inadequate citation



Risks: data that is siloed, difficult to find and access, unused, lost and researcher apathy

How can we address these challenges?

The frameworks at a glance



Open Access and Open Science

- **Open Access** means free, timely access with clear licences (*e.g.*, CC BY, CC0)
- **Open Science** covers open data, software, methods, publications and collaboration

(UNESCO Recommendation on Open Science, 2021)

- Geodetic precedent of collaborative sharing:
 - Example: **IGS** and **IVS** of the **IAG services** have shared **GNSS data** and **products** openly for decades



FAIR (goal-oriented) principles for data



Findable

- PIDs (DOIs), rich metadata, catalogue and metadata repository, interface



A ccessible

- Through agreed protocols (HTTPS, FTP, APIs)



nteroperable

- Standard formats (RINEX, SINEX, SP3, NetCDF), controlled vocabularies, metadata schemes (DataCite, Dublin Core, ISO) and GeodesyML



Reusable

- Clear licence framework, provenance to be trusted, comply with ethics



TRUST certification for repositories

- **Transparency:** clear policies, scope and holdings
- **Responsibility:** data integrity, authenticity, community accountability
- **User focus:** meets the needs of data communities
- **Sustainability:** long-term funding, preservation, succession planning
- **Technology:** secure, reliable infrastructure and standards



Link: [FAIR](#) describes the data and [TRUST](#) describes the place where data is stored

Certification options:

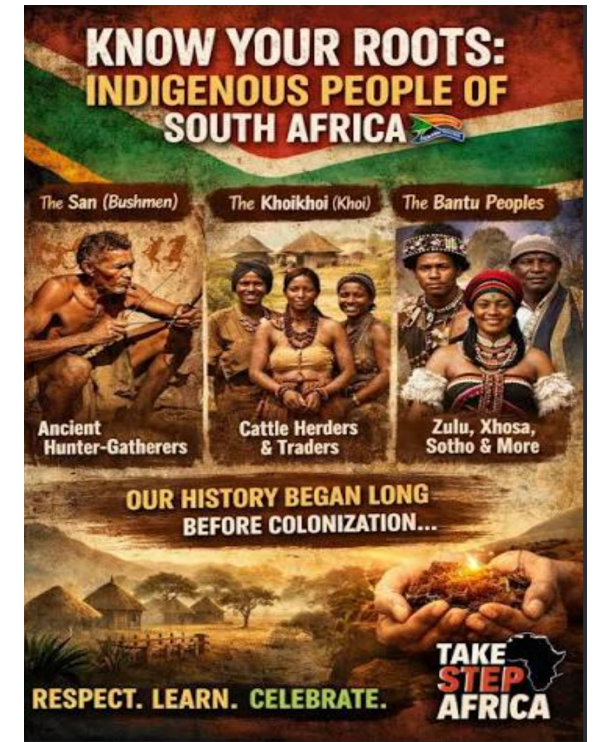
- CoreTrustSeal (<https://www.coretrustseal.org>)
- WDS-aligned repositories (<https://worlddatasystem.org>)

CARE principles for indigenous data governance

- **Collective benefit:** data ecosystems should benefit communities
- **Authority to control:** community consultation and access agreements
- **Responsibility:** transparency and positive relationships
- **Ethics:** minimise harm and maximise benefit of data for society

Link: FAIR is data-centric and CARE is people- and purpose-centric

Geodetic relevance: stations and campaigns on indigenous or community land, requires co-designed monitoring, capacity building, respect for sensitive locations



Credit: Take Step Africa, 2026.

NB - Respect for indigenous knowledge and providing credit and acknowledgement is vital!

Credit and acknowledgement: data citation and policies



Data and software policy

AGU requires that the **underlying data** and/or **software or code** needed to understand, evaluate, and build upon the reported research **be available at the time of peer review and publication**. [...]. This entails:

1. Depositing the data and software in a **community accepted, trusted repository**, as appropriate, and **preferably with a DOI**
2. Including an **Availability Statement** as a separate paragraph in the Open Research section explaining to the reader where and how to access the data and software
3. And including **citation(s)** to the deposited data and software, **in the Reference Section**.

<https://www.agu.org/Publish-with-AGU/Publish/Author-Resources/Data-and-Software-for-Authors> (last access 2 Sep 2024)

SPRINGER NATURE

Citing data sources

You should cite any publicly available data on which the conclusions of the paper rely. This includes novel data shared alongside the publication and any secondary data sources.

Data citations should include a persistent identifier (such as a DOI), should be included in the reference list using the minimum information recommended by DataCite (Dataset Creator, Dataset Title, Publisher [repository], Publication Year, Identifier [e.g. DOI, Handle or ARK]) and follow journal style.

<https://www.springernature.com/de/authors/research-data-policy/data-availability-statements> (last access 11 Oct 2024)

Credit through citation

Hydrology and Earth System Sciences
An interactive open-access journal of the European Geosciences Union

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Landscape-scale water balance monitoring with an iGrav superconducting gravimeter in a field enclosure

Andreas Güntner^{1,4}, Marvin Reich¹, Michal Mikolaj¹, Benjamin Creutzfeldt², Stephan Schroeder¹, and Hartmut Wziontek^{1,3}

„Data availability: [...] Güntner et al. (2017) provided the data of iGrav006, both raw 1 s gravity records and [...] Wziontek et al. (2017) provided the raw gravity data of the two superconducting gravimeters [...] in Wettzell.”

References

Güntner, A., Reich, M., Mikolaj, M., Creutzfeldt, B., Schroeder, S., Thoss, H., Klügel, T., and Wziontek, H.: Superconducting gravimeter data of iGrav006 and auxiliary hydro-meteorological data from Wettzell – Supplement to: Landscape-scale water balance monitoring with an iGrav superconducting gravimeter in a field enclosure, <https://doi.org/10.5880/igets.wc.gfz.ll.001>, 2017. DOI

Wziontek, H., Wolf, P., Nowak, I., Richter, B., Rülke, A., and Wilmes, H.: Superconducting gravimeter data from Wettzell – Level 1, <https://doi.org/10.5880/igets.wc.ll.001>, 2017. DOI

data citations in papers

Cite as: ...

Files: ...

Dataset: ...



GFZ DATA SERVICES
GEOSCIENCES DATA PUBLISHER

Superconducting Gravimeter Data from Wettzell - Level 1

Released

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Cite as:
Wziontek, Hartmut; Wolf, Peter; Nowak, Irena; Richter, Bernd; Rülke, Axel; Wilmes, Herbert (2017): Superconducting Gravimeter Data from Wettzell - Level 1. GFZ Data Services. <https://doi.org/10.5880/igets.wc.ll.001>

Files:
IGETS Data Base Website
Data download via ftp (registration and FTP client required)
License: CC BY 4.0

Dataset Description:
Documented by
Voigt, C., Förste, C., Wziontek, H., Crossley, D., Meurers, B., Piliński, V., ... Sun, H. (2016). Report in the Data Base of the International Geodynamics and Earth Tide Service (IGETS). GFZ German Research Centre for Geosciences. <https://doi.org/10.5880/igets.wc.ll.001>

Abstract:
The International Geodynamics and Earth Tide Service (IGETS) was established in 2015 by the International Association of Geodesy (IAGG). IGETS continues the activities of the Global Geodynamics Project (GGP, 1997-2015) to provide support to geodetic and geophysical research activities using superconducting gravimeter (SG) data within the context of an international network.

The Geodetic Observatory Wettzell (Germany) is operated jointly by the Federal Agency for Cartography and Geodesy (BKG) and the Technical University of Munich (TUM) and was established in 1972. Continuous temporal gravity and atmospheric pressure time series from the different SGs is made available to the IGETS data base hosted by ISDC (Information System and Data Center) at GFZ.

The Geodetic Observatory Wettzell is located on a mountain ridge of the Bavarian Forest (longitude: 12.88 E, latitude: 49.10 N, height above MSL: 611 m). The crystalline basement of metamorphic rocks (Gneiss) in Wettzell is covered from bottom to top by weathering zones of fractured gneiss, saprolite, periglacial weathering layers and soil, with Cambisols making up the predominant soil type. The climate is temperate with mean annual precipitation of 995 mm and mean annual temperature of 7°C. Land cover in the surroundings of the observatory is dominated by a mosaic of grassland and forest, while gravel, gravel and sealed surfaces of roads and buildings alternate the grounds of the observatory. Because of the remote, rural location the station is characterized by low environmental noise.

Since 1989, an almost uninterrupted time series of gravity and barometric pressure variations was acquired with different SGs. In 1993, a series of repeated measurements with different absolute gravimeters (AG) was started.

There are two gravity laboratories at station Wettzell: L1 and L2. L1 was built in 1988. It is an isolated solid building with 2 concrete pillars in separate rooms for SG and AG observations. Now each room is thermally stabilized by air-conditioning system. The new laboratory L2 is a well isolated solid building constructed in 2009. It provides 2 concrete pillars in separate rooms for SG observations and 4 concrete pillars for AG observations and comparisons in a third room. All rooms are thermally stabilized by air-conditioning systems.

From November 1999 to October 2010 the dual sphere SG CD029 was operated in L1 and since June 2010 the dual sphere SG030 (after upgrade) is recording in L2. Since March 2011 the dual sphere SG029 (after upgrade) is recording data in L1 again. These data are available at the IGETS database. Earlier, TT60 (1989/09-1995/06) and SG101 (1996/04-1997/07) were installed at L1.

Due to the excellent stability of the station and the facilities to inter-compare different AGs, the Geodetic Observatory Wettzell was developed as a regional comparison site which serves as a reference for the national German gravity reference system.

Related Work

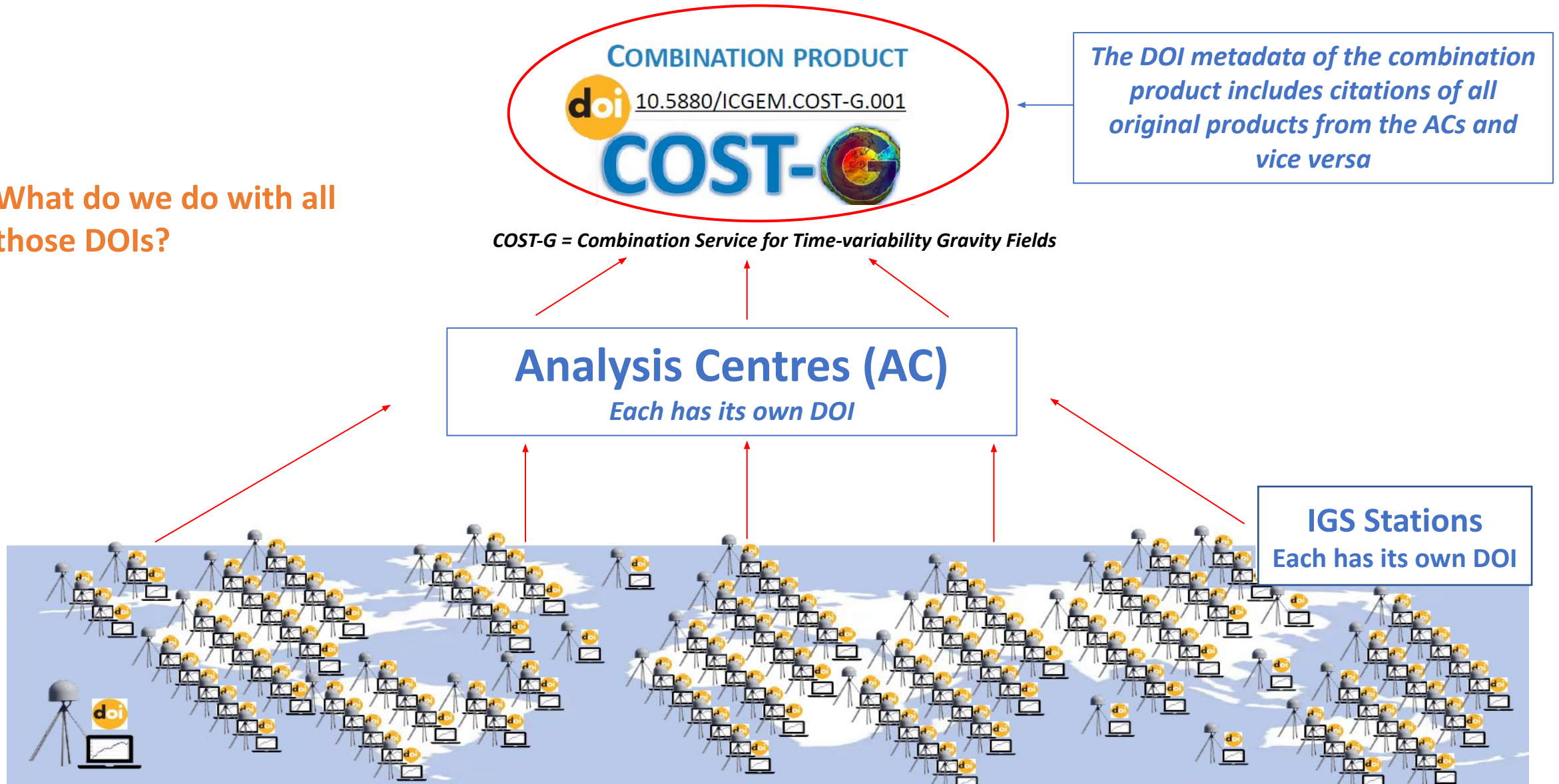
Cited by

Güntner, A., Reich, M., Mikolaj, M., Creutzfeldt, B., Schroeder, S., & Wziontek, H. (2017). Landscape-scale water balance monitoring with an iGrav superconducting gravimeter in a field enclosure. *Hydrology and Earth System Sciences*, 21(6), 3167–3182. doi:10.5194/hess-21-3167-2017 DOI

paper citations in data publications

How to cite derived products?

What do we do with all those DOIs?



Citing 100+ DOIs in data publications

- Citations must be included in the DataCite Metadata (XML, JSON) as „related identifier“
- Not easy with general repositories, like Zenodo
- Technically possible for DataCite

>1000 citations

GFZ DATA SERVICES
GEOSCIENCES DATA PUBLISHER

The Global Heat Flow Database: Update 2023

Released

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Cite as:
Global Heat Flow Data Assessment Group; Fuchs, Sven; Neumann, Florian; Norden, Ben; Beardsmore, Graeme; Chiozzi, Paolo; Colgan, William; Anguiano Domínguez, Ana Pauline; Duque, María Rosa Alves; Ojeda Espinoza, Orlando Miguel; Förster, Florian; Förster, Andrea; Fröhder, Robert; Fuentes, Karina; Hajto, Marek; Harris, Robert; Jösel, Argo; Liebing, Helene; Liu, Shaowen; Lüdtke, Gwendolin; Madon, Mazlan; Negrete-Aranda, Raquel; Poort, Jeffrey; Reznik, Itay J.; Riedel, Michael; Rolandone, Frédérique; Stål, Tobias; Verdoya, Massimo; Wu, Jyun-Nai (2023): The Global Heat Flow Database: Update 2023. V. 1. GFZ Data Services. <https://doi.org/10.5880/lfgeo.2023.008>

Files
Download data and description
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Dataset Description
Documented by
Fuchs, S., Beardsmore, G., Chiozzi, P., Espinoza-Ojeda, O. M., Gola, G., Gosnold, W., Harris, R., Jennings, S., Liu, S., Negrete-Aranda, R., Neumann, F., Norden, B., Poort, J., Rajver, D., Ray, L., Richards, M., Smith, J. D., Tanaka, A., & Verdoya, M. (2021). A new database structure for the IHFC Global Heat Flow Database. *International Journal of Terrestrial Heat Flow and Applications*, 4(1), 1–14. <https://doi.org/10.31214/ijthfa.v4i1.62>

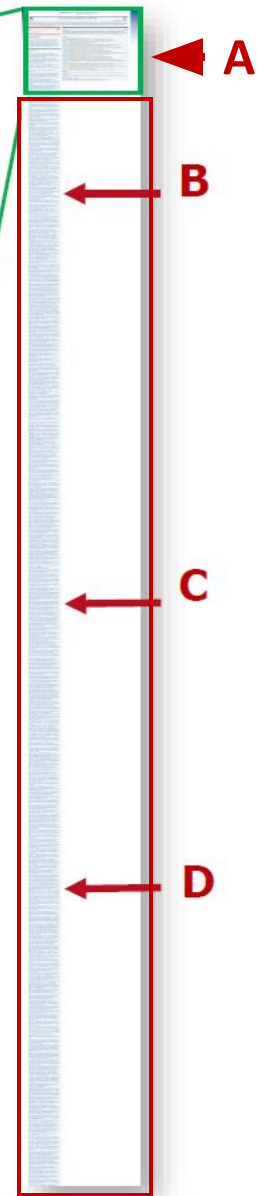
Related Work
Cites
Fuchs, S.; Förster, A.; Norden, B. (2022): Evaluation of the terrestrial heat flow in Germany: A case study for the reassessment of global continental heat-flow data. *Earth-Science Reviews*. 10.1016/j.earscirev.2022.104231
Global Heat Flow Compilation Group. (2013). Component parts of the World Heat Flow Data Collection [Data set]. PANGAEA – Data Publisher for Earth & Environmental Science. <https://doi.org/10.1594/PANGAEA.810104>
<https://doi.org/10013/epic.40176.d002>
Lucas, F. (2019). Analysis and Mapping of an Updated Terrestrial Heat Flow Data Set. *Geochimistry, Geophysics, Geosystems*, 20(8), 4001–4024. <https://doi.org/10.1029/2019gc008089>
<https://doi.org/110.1029/2020jg006608>
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Abbott, D., Menko, W., Hobert, M., Anderson, R. N., & Embrey, R. W. (1984). Correlated sediment thickness, temperature gradient and excess pore pressure in a marine fault block basin. *Geophysical Research Letters*, 11(5), 485–488. <https://doi.org/10.1029/g011i005p00485>
Abbott, D. H., Morton, J. L., & Holmes, M. L. (1986). Heat flow measurements on a
Escanaba Trough. *Geophysical Research Letters*, 13(7), 678–680. <https://doi.org/10.1029/g013i007p00678>
Afendi, Akhmad; Lusi, Nuraini; Catrawedarma, IGMB; Badarus Zaman, M.; Subeno; (2021):

Abstract
The data publication contains the compilation of global heat-flow data by the International Heat Flow Commission (IHFC; www.ihfc-ugg.org) of the International Association of Seismology and Physics of the Earth's Interior (IASPEI). The presented data update 2023 contains data generated between 1939 and 2022 and constitutes the first intermediate update benefiting from the global collaborative assessment and quality control of the Global Heat Flow Database running since May 2021 (<http://assessment.ihfc-ugg.org>).

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Keywords
heat flow density, Global Heat Flow Database, International Heat Flow Commission, physical property > temperature
GCMD Science Keywords
EARTH SCIENCE > OCEANS > MARINE VOLCANISM > BENTHIC HEAT FLOW
EARTH SCIENCE > OCEANS > OCEAN HEAT BUDGET > HEAT FLUX

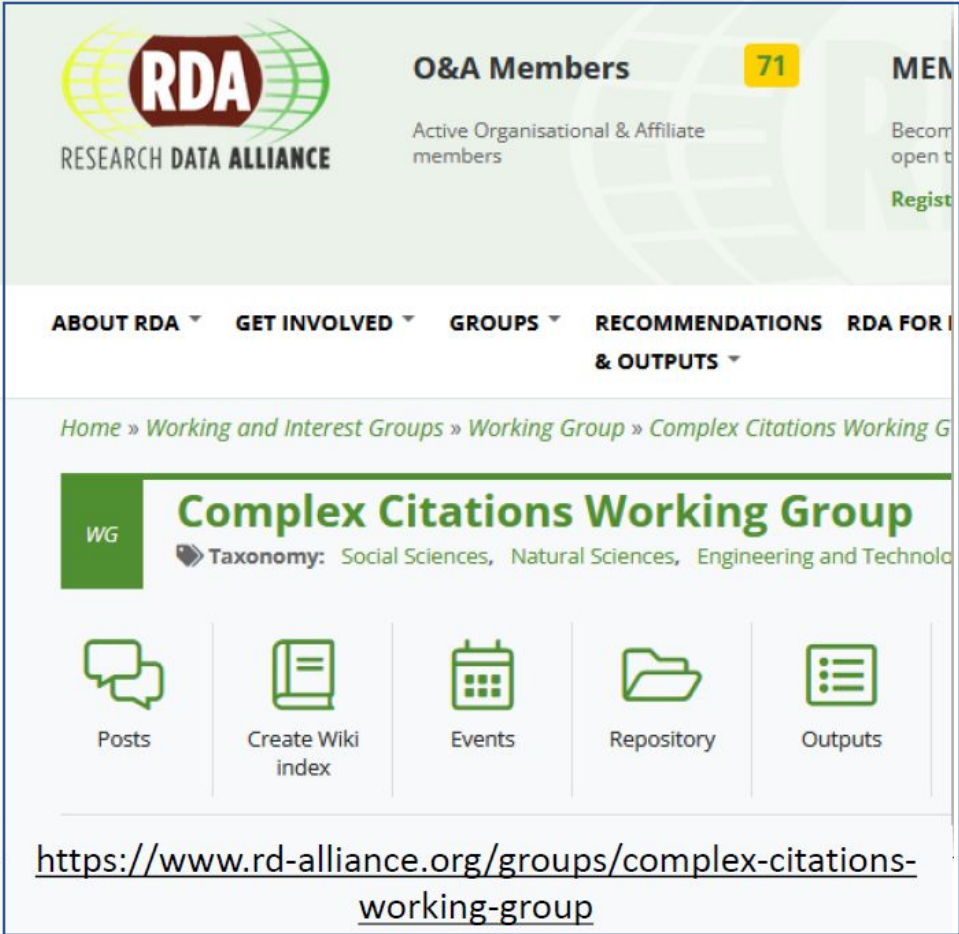


Citing >100 DOIs in journal articles

- **Problem:** Journals often limit the number of citations in articles - but each data provider must get credit

RDA Complex Citation Working Group (2023+):

- Create a „container“ that includes, e.g. DOIs of 500 GNSS stations used in an article
- Cite the „container“ in the article
- Develop a workflow for journals to „unpack“ the „container“ and include all individual citations in the DOI metadata



The screenshot shows the RDA (Research Data Alliance) website. At the top, the RDA logo is on the left, and 'O&A Members 71' is on the right. Below the logo, it says 'RESEARCH DATA ALLIANCE'. The main navigation bar includes 'ABOUT RDA', 'GET INVOLVED', 'GROUPS', 'RECOMMENDATIONS', and 'RDA FOR I & OUTPUTS'. The breadcrumb trail reads 'Home » Working and Interest Groups » Working Group » Complex Citations Working Group'. The page title is 'Complex Citations Working Group' with a 'WG' icon. Below the title, the taxonomy is listed as 'Social Sciences, Natural Sciences, Engineering and Technology'. There are five icons with labels: 'Posts', 'Create Wiki index', 'Events', 'Repository', and 'Outputs'. At the bottom, the URL is displayed: <https://www.rd-alliance.org/groups/complex-citations-working-group>

A more ethical question

What happens when, e.g. a data product with assigned DOI is distributed through another data center? Do they need a new DOI?

Arguments for “yes”

You need an identifier to download the data – independent of the data center.

→ Does this identifier need to be a DOI??

“however”

GRACE L2 data: produced by GFZ and distributed via PO.DAAC (JPL) – With original DOI minted by GFZ Data Services (DOI prefix 10.5880/)



Home » Dataset Discovery

GRACE NON-TIDAL ATMOSPHERE GEOPOTENTIAL COEFFICIENTS GFZ RELEASE 6.0 GAA
(GRACE_GAA_L2_GRAV_GFZ_RL06)



Citation is critically important for dataset documentation and discovery. Please cite the data as follows, and cite the reference papers when it is appropriate.

Citation GRACE. 2018. GRACE_GAA_L2_GRAV_GFZ_RL06. Ver. 6.0. PO.DAAC, CA, USA.
Dataset accessed [YYYY-MM-DD] at https://doi.org/10.5880/GFZ.GRACE_06_GAA

DOIs provide the credit for the data originators and should not change when the data are distributed through other data centers. For direct access, other persistent identifiers (e.g. Handles) could be used. New versions for changes citing the original!

Summary

- Data is only valuable if it is **FAIR** and **open** and remains so over time.
- Data stewards experience challenges caused by **dispersed** data, **poor** data management and **lack of adoption** of metadata standards.
- A **lack of credit** through citations causes apathy among researchers and data providers.

□ What can we do?

- Adopt data policies to align with FAIR, TRUST and CARE
- Register and certify repositories
- Give credit where it is due.
- Adopt best practices for metadata management.
- Be part of collaborative initiatives such as *the GGOS Committee on DOIs for Geodesy Datasets and the RDA Complex Citation WG.*

Thank you

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