

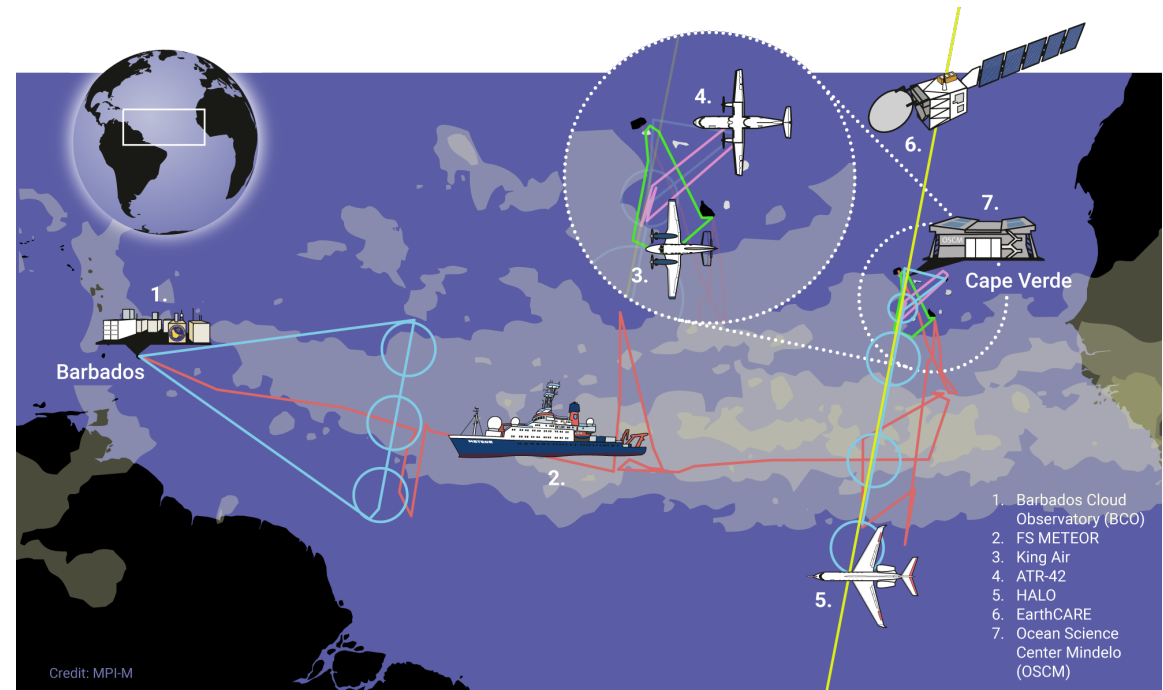


Providing Analysis-Ready Campaign Data via the InterPlanetary File System

Lukas Kluft and Tobias Kölling

Observational data during field campaigns

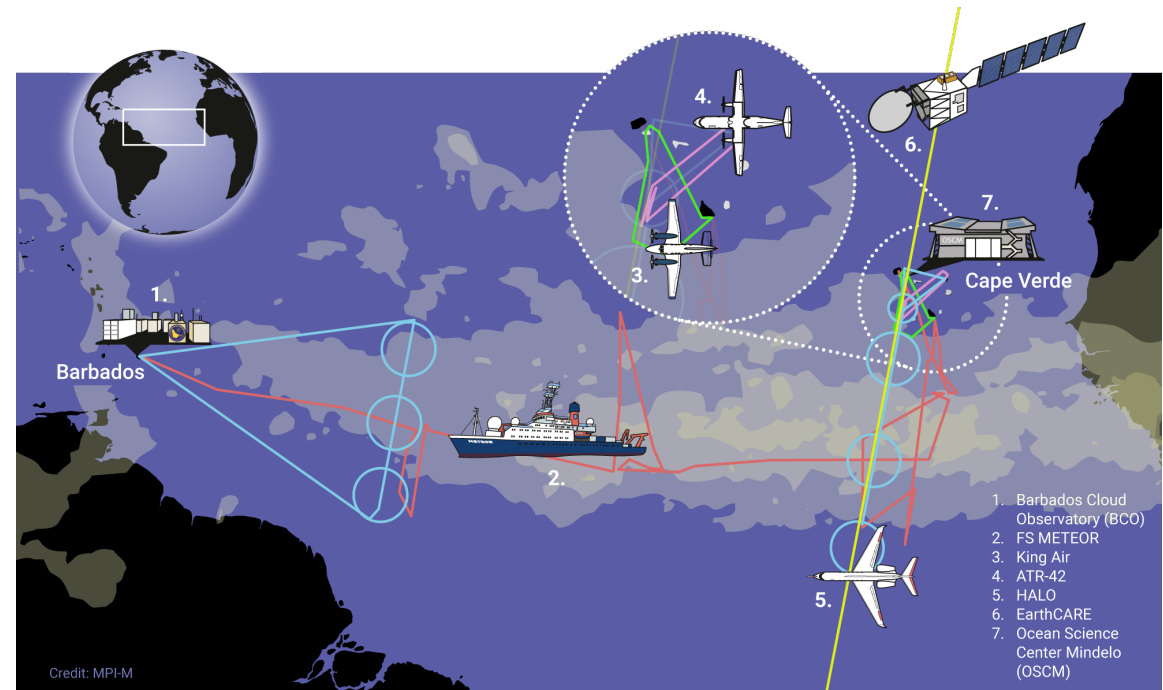
- ORCESTRA field campaign (Aug.–Sep. 2024)
 - 8 subcampaigns
 - 3 aircrafts, 2 stations, 1 ship, 1 satellite





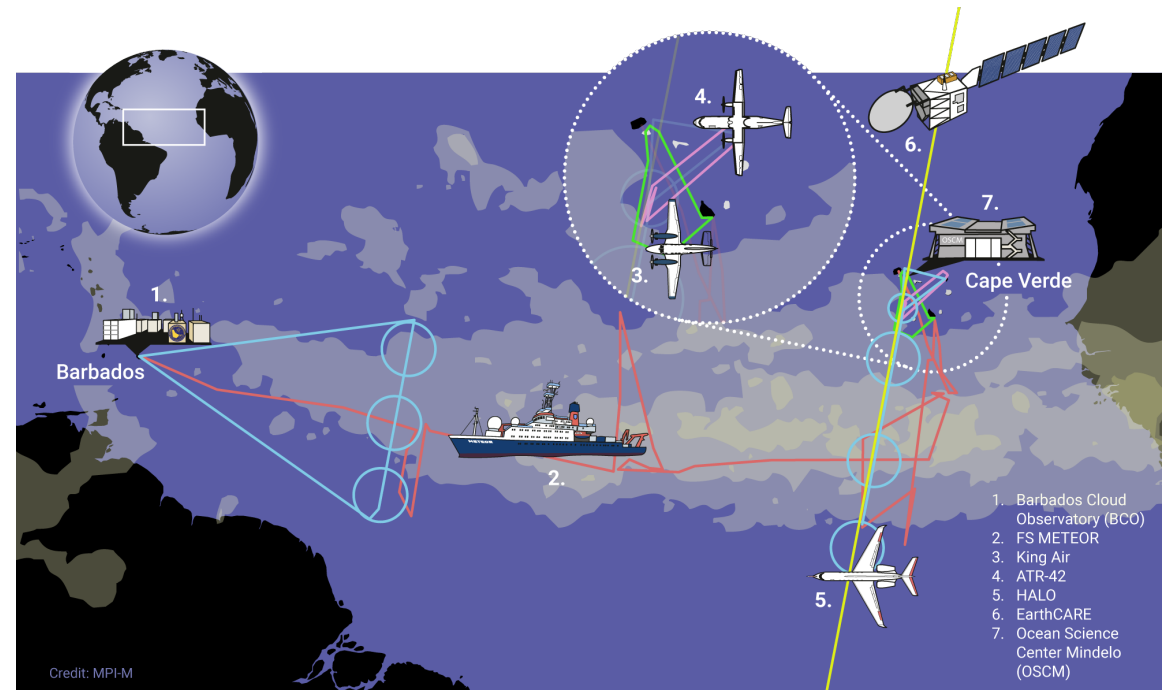
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- ORCESTRA field campaign (Aug.–Sep. 2024)
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- Various different file formats
- Sharing preliminary data immediately



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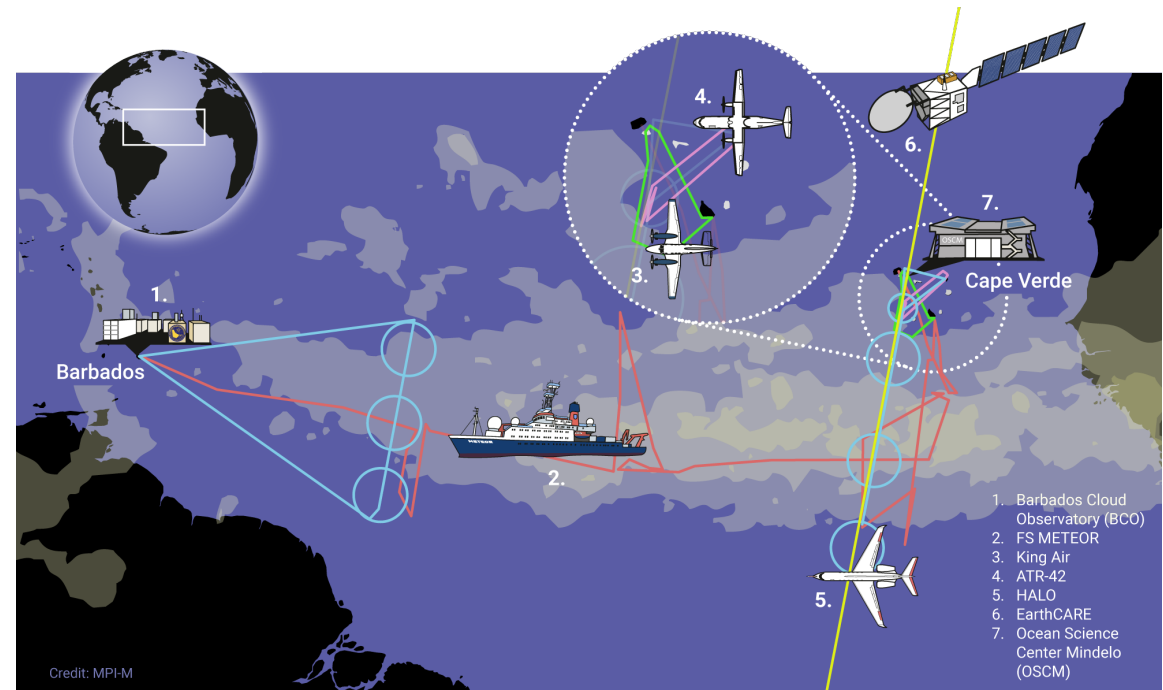
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How to make the use of observational data fun?

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 - 8 subcampaigns
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How to make the use of observational data less annoying?



Standard solutions

On site

- Network-attached storage (NAS)
- USB sticks/E-Mail attachments
- Subsampled data (not the real data)
- Quick looks (no data)



Standard solutions

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Back home

- Hard drives
- “Log in to our system”
- Data repositories



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PANGAEA.
Data Publisher for Earth & Environmental Science

Not logged in

SEARCH SUBMIT HELP ABOUT CONTACT

Citation: **Klocke, Daniel (2025):** Master tracks in different resolutions of METEOR cruise M203, Mindelo - Bridgetown, 2024-08-16 - 2024-09-24 [dataset]. Max Planck Institute for Meteorology, PANGAEA, <https://doi.org/10.1594/PANGAEA.974752>

Always quote citation above when using data! You can download the citation in several formats below.

Published: 2025-01-22 • DOI registered: 2025-02-20

BIB Citation BibTeX Citation Copy Citation C Share Show Map Google Earth

28 2 1

Abstract: Raw data acquired by position sensors on board RV METEOR during expedition M203 were processed to receive a validated master track which can be used as reference of further expedition data. During M203 the motion reference unit Kongsberg SeaTex AS MRU-5 combined with Kongsberg SeaTex AS Seapath 320 and two C and C Technologies GPS receivers C-NAV3050 were used as navigation sensors. Data were downloaded from DAVIS SHIP data base (<http://dship.bsh.de/>) with a resolution of 1 sec. Processing and evaluation of the data is outlined in the data processing report. Processed data are provided as a master track with 1 sec resolution derived from the position sensors' data selected by priority and a generalized track with a reduced set of the most significant positions of the master track.

Other version: [Generalized master track of METEOR cruise M203](#)

Klocke, Daniel (2025): Master track of METEOR cruise M203 in 1 sec resolution (zipped, 144 MB) [dataset]. Max Planck Institute for



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The screenshot shows the PANGAEA website interface. At the top, there is a logo and the text 'PANGAEA. Data Publisher for Earth & Environmental Sciences'. Below this, a citation is displayed: 'Klocke, Daniel (2025): Master tracks in different resolution METEOR cruise M203, Mindelo - Bridgetown, 2024-08-11 09-24 [dataset]. Max Planck Institute for Meteorology, PANGAEA. https://doi.org/10.1594/PANGAEA.974752'. There are buttons for 'BIB Citation', 'BIB/TX Citation', 'Copy Citation', 'Share', 'Show Map', and 'Google Earth'. An abstract is visible below the citation, and a link for 'Generalized master track of METEOR cruise M203' is provided.

The screenshot shows the HALO database website. The header includes the DLR logo and 'Deutsches Zentrum für Luft- und Raumfahrt German Aerospace Center'. The page title is 'HALO database'. There are navigation links for 'About', 'Contact', 'FAQ', 'Glossary', 'Conventions', and 'News'. A search bar contains 'Data Detective'. The main content area is titled 'MISSION: PERCUSION' and includes a description: 'PERCUSION is a German initiative that uses the German research aircraft HALO and ESA's EarthCARE satellite aiming to test factors hypothesized to influence the organization of deep maritime convection in the tropics...'. Below the description is a 'MAP OF THE MEASURING AREA' showing a map of the tropical Atlantic with flight tracks. On the right side, there is a 'MISSION INFO' section with details like 'Start: 2024-07-03', 'Stop: 2024-11-19', and 'Region: North America > Barbados'. There is also a 'DATA ORIGIN' and 'INSTRUMENTS' section listing various instruments used during the mission.



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The image displays three overlapping screenshots of data portals. The top screenshot is the PANGAEA website, showing a citation for Daniel Klocke (2025) about METEOR cruise M203. The middle screenshot is the ORCESTRa catalog page for a dataset titled 'MAESTRO-2024_SAFIRE-ATR42_SAFIRE_CORE_NAV Navigation and platform characteristics 1hz'. It includes a map showing the spatial extent of the data and a list of instruments. The right screenshot shows the 'MISSION INFO' section for the PERCUSSION mission, detailing the start and stop dates, region (Barbados), and data access information.



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How to make the use of observational data less annoying?



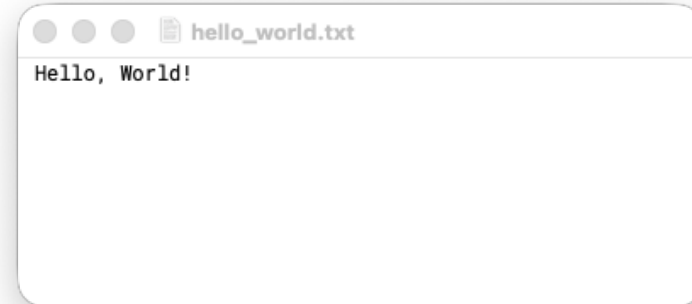
InterPlanetary File System (IPFS)

- Peer-to-peer network for file sharing
- Content-addressable storage (data integrity)



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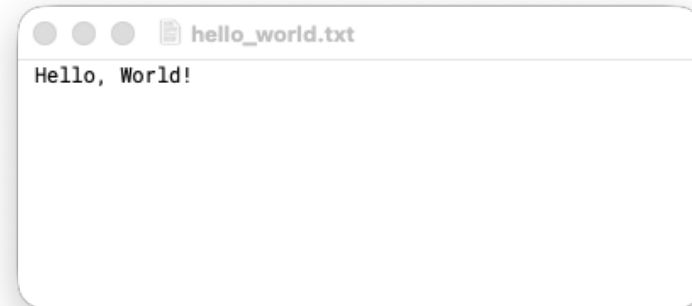


```
$ ipfs add hello_world.txt  
bafkreigjrqlm57p6regbl7kn5etxoxmloy4js5sbhdpk53i73g74vnge
```



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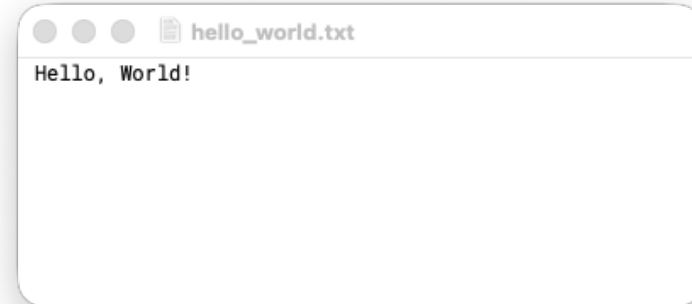
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Hello, World!
```



InterPlanetary File System (IPFS)

- Peer-to-peer network for file sharing
- Content-addressable storage (data integrity)
- On-site sharing (local network)
- Local caching (offline access)
- Trustless mirroring (no central authority)
- Consistent data access
(remote and on-site use)



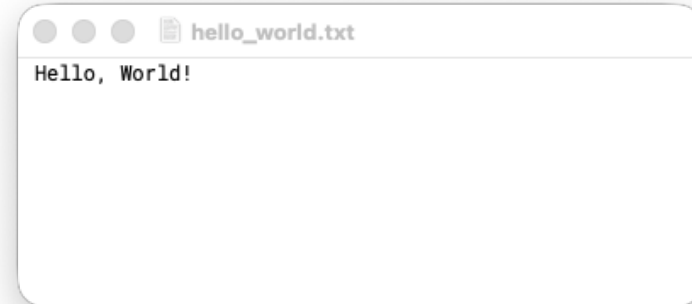
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Verifiable data access via content identifiers (CIDs)



Analysis-ready datasets

- **Zarr** format (chunked and compressed)
- Single analysis-ready datasets
- Following a subset of CF Conventions and Attribute Convention for Data Discovery (ACDD)
- Directly accessible via Python (`ipfsspec`)
(*and other languages*)



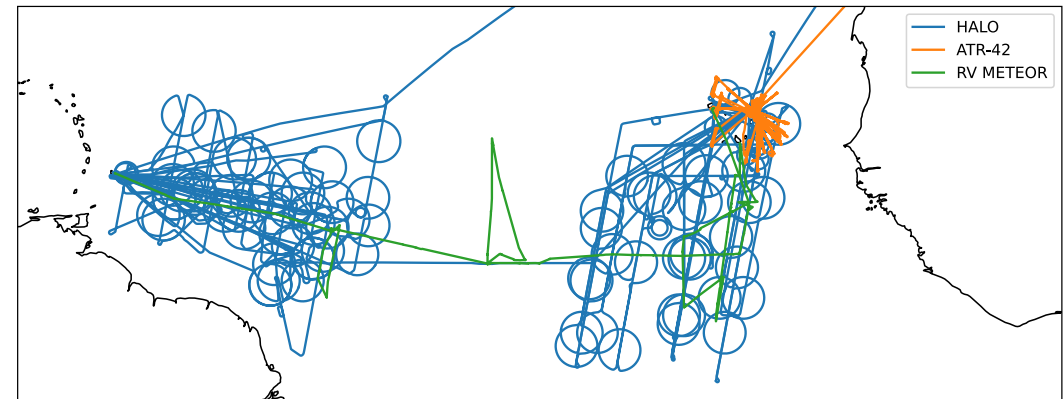
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```
import cartopy.crs as ccrs
import matplotlib.pyplot as plt
import xarray as xr
```

```
halo = xr.open_dataset("ipfs://bafybeif52irmuorpb27cuwpqhtbg5w6maw4d7zppg21qgpew25gs5eczm", engine="zarr")
atr = xr.open_dataset("ipfs://bafybeifhj7cdxa5edqhg2fvfa3ticiy6pz2f46jxye7r4hnhawzbxjra", engine="zarr")
meteor = xr.open_dataset("ipfs://bafybeib5awa3le6nxi4rgepn2mwxj733aazpkmgtpa3uc2744gxv7op44", engine="zarr")
```

```
fig, ax = plt.subplots(figsize=(12, 4.8), subplot_kw={"projection": ccrs.PlateCarree()})
ax.set_extent([-65, -5, 0, 20])
ax.coastlines()
ax.plot(halo.IRS_LON, halo.IRS_LAT, label=halo.platform)
ax.plot(atr.LONGITUDE, atr.LATITUDE, label=atr.platform)
ax.plot(meteor.lon, meteor.lat, label=meteor.platform)
ax.legend()
```





Analysis-ready datasets

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(*and other languages*)

Direct access to analysis-ready datasets

Rowan Orlijan-Rhyne

Fri, 08 May, 16:15–18:00
Hall X4 | **X4.94**



Automated workflows for ever-growing,
analysis-ready datasets at the
Barbados Cloud Observatory

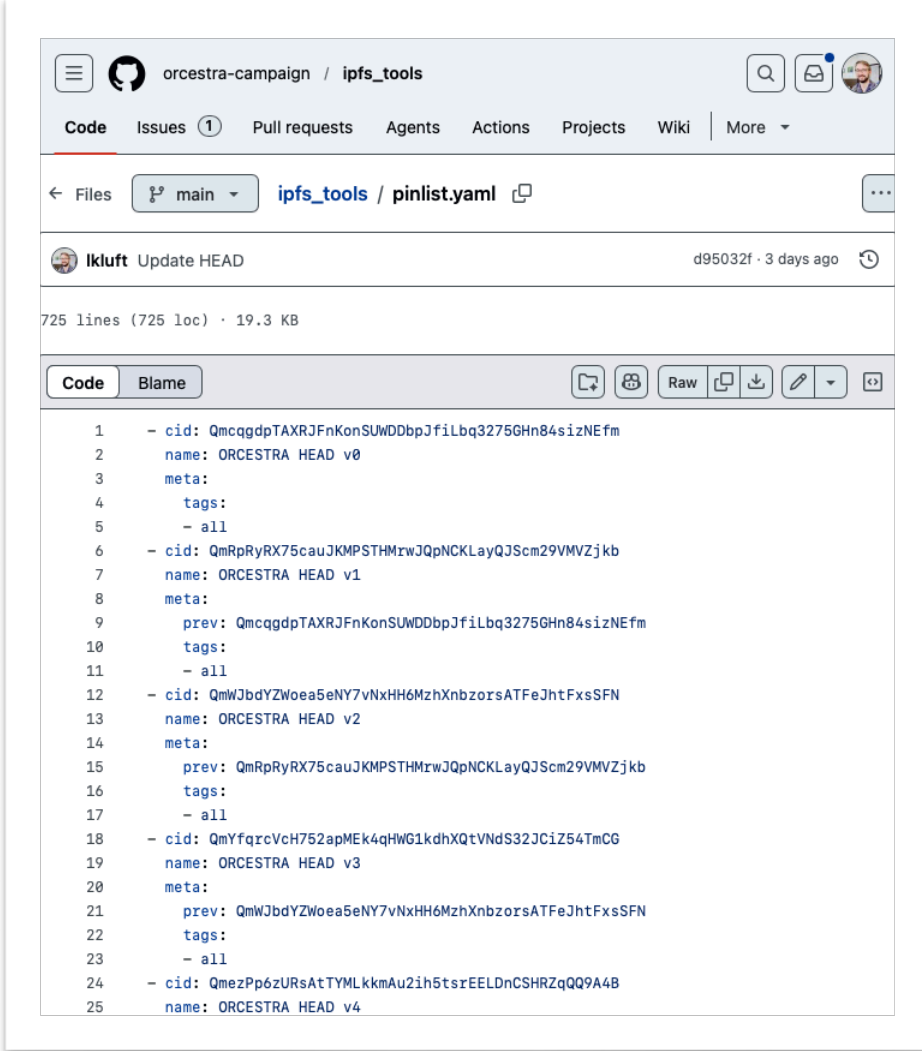
Our IPFS ecosystem



Our IPFS ecosystem

Our IPFS ecosystem

- Tracking of relevant CIDs via GitHub repo
- Automated sync between various IPFS nodes (DKRZ, Florida State, Raspberry Pis, Laptops)
 - Redundancy in case of hardware corruption
 - Resilience in case of political corruption
 - Faster access for local users
- Operating our own HTTP Gateway
<https://latest.orchestra-campaign.org>

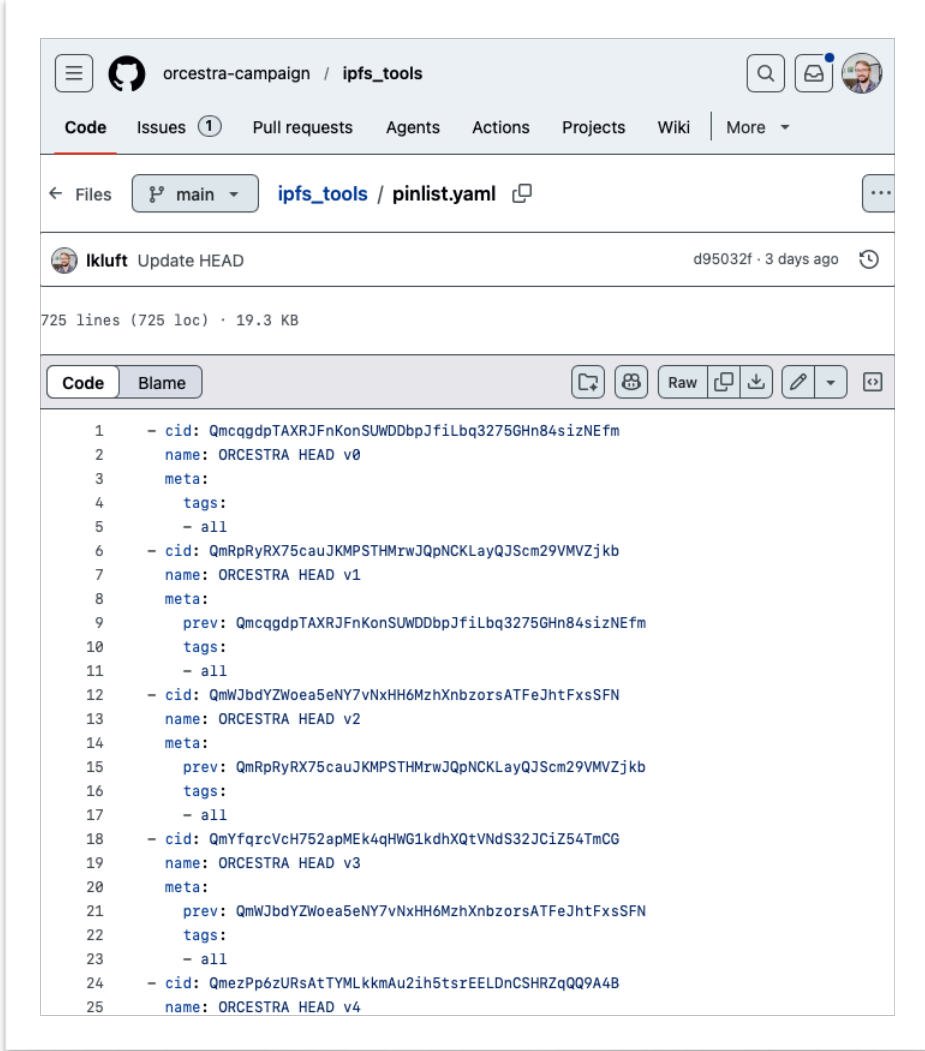


```
1 - cid: QmcqgdpTAXRJFnKonSUWDDbpJfiLbq3275GHn84sizNEfm
2   name: ORCESTRA HEAD v0
3   meta:
4     tags:
5     - all
6 - cid: QmRpRyRX75cauJKMPSTHMrwJQpNCKLayQJScm29VMVZjkb
7   name: ORCESTRA HEAD v1
8   meta:
9     prev: QmcqgdpTAXRJFnKonSUWDDbpJfiLbq3275GHn84sizNEfm
10    tags:
11    - all
12 - cid: QmWJbdYZWoea5eNY7vNxHH6MzhXnbzorsATFeJhtFxsSfN
13   name: ORCESTRA HEAD v2
14   meta:
15     prev: QmRpRyRX75cauJKMPSTHMrwJQpNCKLayQJScm29VMVZjkb
16    tags:
17    - all
18 - cid: QmYfqrVcH752apMEk4qHWG1kdhXQtVndS32JCiZ54TmCG
19   name: ORCESTRA HEAD v3
20   meta:
21     prev: QmWJbdYZWoea5eNY7vNxHH6MzhXnbzorsATFeJhtFxsSfN
22    tags:
23    - all
24 - cid: QmezPp6zURsAtTYMLkkmAu2ih5tsrEELDnCSHRZqQQ9A4B
25   name: ORCESTRA HEAD v4
```

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Still work in progress, but surprisingly performant



```
1 - cid: QmcqgdpTAXRJFnKonSUWDDbpJfiLbq3275GHn84sizNEfm
2   name: ORCESTRA HEAD v0
3   meta:
4     tags:
5     - all
6 - cid: QmRpRyRX75cauJKMPSTHMzrwJQpNCKLayQJScm29VMVZjkb
7   name: ORCESTRA HEAD v1
8   meta:
9     prev: QmcqgdpTAXRJFnKonSUWDDbpJfiLbq3275GHn84sizNEfm
10    tags:
11    - all
12 - cid: QmWJbdYZWoea5eNY7vNxHH6MzhXnbzorsATFeJhtFxsSfN
13   name: ORCESTRA HEAD v2
14   meta:
15     prev: QmRpRyRX75cauJKMPSTHMzrwJQpNCKLayQJScm29VMVZjkb
16    tags:
17    - all
18 - cid: QmYfqrVcH752apMEk4qHWG1kdhXQtVndS32JCiZ54TmCG
19   name: ORCESTRA HEAD v3
20   meta:
21     prev: QmWJbdYZWoea5eNY7vNxHH6MzhXnbzorsATFeJhtFxsSfN
22    tags:
23    - all
24 - cid: QmezPp6zURsAtTYMLkkmAu2ih5tsrEELDnCSHRZqQQ9A4B
25   name: ORCESTRA HEAD v4
```



ORCESTR A Browser



<https://browser.orcestra-campaign.org>

- Memorising CIDs is annoying
- Metadata-rich browser lists all datasets

The screenshot displays the ORCESTR A Data Browser interface. At the top, there is a search bar with the placeholder text "Search...". Below the search bar, a list of datasets is shown, each with a title and the names of the researchers involved. The datasets listed are:

- Basic Halo Measurement and Sensor System (BAHAMAS) data**
Christian Mallaun, Dominika Pasternak and Lisa Eirenschmalz
- Basic Halo Measurement and Sensor System (BAHAMAS) quick look (QL) data**
Christian Mallaun, Dominika Pasternak and Lisa Eirenschmalz
- BEACH dropsonde dataset (Level 3)**
Helene Gloeckner, Theresa Mieslinger and Nina Robbins
- BEACH dropsonde dataset (Level 3) QC**
Helene Gloeckner, Theresa Mieslinger and Nina Robbins
- BEACH dropsonde dataset (Level 4)**
Helene Gloeckner, Theresa Mieslinger and Nina Robbins
- Broadband solar and terrestrial, upward and downward irradiance measured by BACARDI on HALO during the PERCUSSION field campaign**
A. Giez, M. Zoeger, Ch. Mallaun, V. Nenakhov, L. Eirenschmalz and D. Pasternak
- Calibrated SMART upward irradiance at selected wavelength bands**
Kevin Wolf
- Calibrated SMART upward radiance at selected wavelength bands**
Kevin Wolf
- Cellometer (CHM15k Nimbus) measurements during METEOR cruise M203**
Friedhelm Jansen
- Clear-air vertical velocity during ORCESTR A retrieved from Meteosat water vapor brightness temperatures**
Basile Poujot
- Cloud radar and Cloudnet on RV Meteor during BOWTIE**
Andreas Foth
- Continuous subskin sea surface temperature data along RV METEOR M203 cruise track**
Marcus Dengler
- Continuous thermosalinograph salinity and temperature data along RV METEOR M203 cruise track**
Michael Schlundt
- GEOMAR PO-processed CTD data of cruise Meteor 203/1 CTD station number 1**
Marcus Dengler
- HALO position and attitude data during the PERCUSSION campaign**
Lukas Kluff
- HATPRO observation on RV Meteor during BOWTIE MWR multiple-pointing from RV Meteor**
Andreas Foth
- HATPRO observation on RV Meteor during BOWTIE MWR single-pointing from RV Meteor**
Andreas Foth
- Horizontal wind profiles from shipborne scanning wind lidar**
Louise Nuijens
- Integrated Water Vapor Retrieval from the K-Band and W-Band Microwave Radiometers**
Jakob Deutloff, Lukas Kluff and Clara Bayley



ORCESTR A Browser



<https://browser.orcestra-campaign.org>

- Memorising CIDs is annoying
- Metadata-rich browser lists all datasets
- Dataset landing page is build on-the-fly
- Attributes and coordinates are read from the dataset directly

The screenshot shows the ORCESTR A Data Browser interface. At the top, the title "ORCESTR A Data Browser" is displayed. Below it, the URL "ipfs://bafybeiczbv7mycr2jois6t4dq3zwltycomwo5xxvjqcjz2ot3newzar6q" is shown. The main heading is "BEACH dropsonde dataset (Level 3)". Below the heading, the names of the researchers "Helene Gloeckner, Theresa Mieslinger, Nina Robbins" are listed. There are several tabs: "ORCESTR A", "BEACH", "Sounding", "Dropsondes", "Tropics", "Atmospheric Profiles", and "Common Altitude". A description of the dataset is provided, stating it is the Level 3 BEACH dataset with quality controlled dropsonde data. To the right, there is a map showing the flight path of the dropsonde over the Atlantic Ocean, with labels for "BRASSO SEA", "MAURITIUS", "SIERRA LEO", "BRASIL", "SURINAM", and "IBIA". Below the map, there are access options: "Python", "IPFS", and "HTTP Gateway". A code block shows the Python code to open the dataset:

```
import xarray as xr
ds = xr.open_dataset("ipfs://bafybeiczbv7mycr2jois6t4dq3zwltycomwo5xxvjqcjz2ot3newzar6q", engine="zarr")
```

 Below the code block, there is a "Parameter(s)" section with a table of parameters.

NAME	UNIT	DESCRIPTION
altitude	m	altitude (altitude) Best estimate from either GPS or pressure measurements. See details for each sonde in respective Level 2 dataset.
flight_id (sonde)		flight identifier unique flight ID
interpolated_time (sonde, altitude)	microseconds since 2024-08-09T14:26:37.333386+00:00	time of recorded measurement (time)
iwv (sonde)	kg m-2	integrated water vapor (atmosphere_mass_content_of_water_vapor) vertically integrated water vapor up to aircraft altitude
lat (sonde, altitude)	degrees_north	latitude (latitude)
launch_altitude (sonde)	m	aircraft altitude at launch
launch_lat (sonde)	degrees_north	aircraft latitude at launch (deployment_latitude)
launch_lon (sonde)	degrees_east	aircraft longitude at launch (deployment_longitude)
launch_time (sonde)	microseconds since 2024-08-09T14:27:28+00:00	dropsonde launch time



ORCESTRA Browser



<https://browser.orcestra-campaign.org>

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Rendering of actual attributes (and data)

ORCESTRA Data Browser

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bafybeiczbv7mycr2jois6t4dq3zwltycomwo5xxvjqcjz2ot3newzar6q

BEACH dropsonde dataset (Level 3)

Helene Gloeckner Theresa Mieslinger Nina Robbins

ORCESTRA BEACH Sounding Dropsondes Tropics Atmospheric Profiles Common Altitude

This dataset is the Level 3 BEACH dataset. It contains quality controlled dropsonde data from the ORCESTRA field campaign with a common altitude dimension. All thermodynamic and dynamic variables are (re-)calculated consistently within the dataset and integrated quantities such as integrated water vapour are added. As such, the Level 3 dataset is the core dataset of BEACH and should be the default for any analysis. It is based on BEACH Level 2 datasets of single sonde profiles. Aggregated OC information can be found in the `sonde_qc` variables and further details are stored in the separate `Level_3_QC` dataset or respective Level 2 datasets. For analyses using the time, refer to the BEACH Level 2. Circle products, like mesoscale divergence and vertical velocity can be found in BEACH Level 4.

Access: Python IPFS HTTP Gateway

```
import xarray as xr
ds = xr.open_dataset("ipfs://bafybeiczbv7mycr2jois6t4dq3zwltycomwo5xxvjqcjz2ot3newzar6q", engine="zarr")
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Parameter(s)

NAME	UNIT	DESCRIPTION
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<code>flight_id (sonde)</code>		flight identifier unique flight ID
<code>interpolated_time (sonde, altitude)</code>	microseconds since 2024-08-09T14:26:37.333386+00:00	time of recorded measurement (time)
<code>iwv (sonde)</code>	kg m-2	integrated water vapor (atmosphere_mass_content_of_water_vapor) vertically integrated water vapor up to aircraft altitude
<code>lat (sonde, altitude)</code>	degrees_north	latitude (latitude)
<code>launch_altitude (sonde)</code>	m	aircraft altitude at launch
<code>launch_lat (sonde)</code>	degrees_north	aircraft latitude at launch (deployment_latitude)
<code>launch_lon (sonde)</code>	degrees_east	aircraft longitude at launch (deployment_longitude)
<code>launch_time (sonde)</code>	microseconds since 2024-08-09T14:27:28+00:00	dropsonde launch time



Generating DOIs

- People (and journals) still like DOIs
- Creating DOIs usually involves filling out web forms with metadata
- Metadata may not fit the data



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- Metadata may not fit the data
- Create DOIs from CIDs directly

DataCite
Fabrica

About Support BMLM.MPIMET -

Max Planck Institute for Meteorology / DOIs

10.82246/bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q

Update DOI (Form)
Update DOI (File Upload)

Findable

Metadata Export
DataCite XML
DataCite JSON
Schema.org JSON-LD
BibTeX

DOI created
April 21, 2026 at 12:30:28 UTC

DOI registered
April 21, 2026 at 14:32:21 UTC

DOI last updated
April 21, 2026 at 14:32:21 UTC

Schema
DataCite Metadata Schema 4

URL

<https://browser.orcestra-campaign.org/#/ds/ipfs://bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q>

Metadata Summary View

BEACH dropsonde dataset (Level 3) Dataset

Helene Gloeckner, Theresa Mieslinger, Nina Robbins,
Dataset published 2026 via Max Planck Institute for Meteorology

This dataset is the Level 3 BEACH dataset. It contains quality controlled dropsonde data from the ORCESTR field campaign with a common altitude dimension. All thermodynamic and dynamic variables are (re-)calculated consistently within the dataset and integrated quantities such as integrated water vapour are added. As such, the Level 3 dataset is the core dataset of BEACH and should be the default for any analysis. It is based on BEACH Level 2 datasets of single sonde profiles. Aggregated QC information can be found in the `sonde_qc` variables and further details are stored in the separate Level_3_QC dataset or respective Level 2 datasets. For analyses using the time, refer to the BEACH Level 2. Circle products, like mesoscale divergence and vertical velocity can be found in BEACH Level 4.

<https://doi.org/10.82246/bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q>

Citation APA

Helene Gloeckner, Theresa Mieslinger, & Nina Robbins. (2026). *BEACH dropsonde dataset (Level 3)* [Data set]. Max Planck Institute for Meteorology.
<https://doi.org/10.82246/BAFYBEICZBV7MYCR2JOIS6T4DQ3ZWILTYCOMWO5XXVJQCJZ2OT3NEWZAR6Q>

FEEDBACK

```
$ dito doi register --publicationYear 2026 --cid=bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q
```

```
$ dito doi publish --cid=bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q
```



Generating DOIs

- People (and journals) still like DOIs
- Creating DOIs usually involves filling out web forms with metadata
- Metadata may not fit the data
- Create DOIs from CIDs directly

The screenshot shows the DataCite Fabrica interface for a DOI registration. The DOI is [10.82246/bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q](https://doi.org/10.82246/bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q). The page includes options to update the DOI via a form or file upload, and a 'Findable' section with metadata export options (DataCite XML, DataCite JSON, Schema.org JSON-LD, BibTeX). The metadata section is titled 'BEACH dropsonde dataset (Level 3) Dataset' and provides a detailed description of the data, including its origin from the ORCESTRA field campaign and its use as the core dataset for BEACH Level 3 analysis. A citation section is also visible, showing the dataset's citation in APA format.

```
$ dito doi register --publicationYear 2026 --cid=bafybeiczbv7mycr2jois6t4dq3zwiltycomwo5xxvjqcjz2ot3newzar6q
```

```
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```

Creating DOIs for data that is actually used, with metadata that is actually attached to the data



TL;DR

- **The InterPlanetary File Systems (IPFS) enables the distributed sharing of scientific data**
- **Content identifiers (CID) give access to the data and not only metadata (DOI)**
- **We provide access to 50+ analysis-ready datasets**
- **Datasets can be searched using a content-based data browser**
- **Creating a dataset just once enables data usage, landing page rendering and DOI registration**