



The Global Ocean Observing System



Global Ocean Observing System (GOOS) Observations Coordination Group (OCG) Data Activities

**Ocean Observatories Initiative Facility Board
(OOIFB) and Data Systems Committee (DSC)
Meetings Wednesday, and Thursday,
November 13-14, 2024**

**Kevin O'Brien
UW/CICOES, NOAA/PMEL
GOOS OCG Vice-chair for Data and
Information**

GOOS Observations Coordination Group (OCG)

The Observation Coordination Group (OCG) works to **efficiently operate, maintain, coordinate** and **integrate** a comprehensive *in-situ* global ocean observing system

Among the FOCI for the GOOS OCG are:

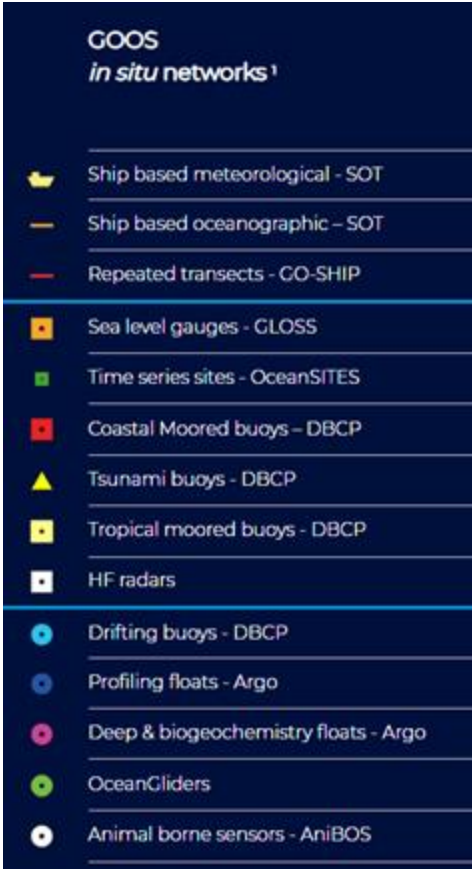
- Data Management
- Standards and Best Practices

Current Data Management Activities:














- Completed first attempt at mapping data/metadata flows for the Global Ocean Networks
- Released a Data Strategy Implementation Plan to support GOOS, WMO and IODE Data Policies/Services, FAIR data principles and improved interoperability of data
- Developing a cross-network Data Task Team
- Improve data links to Bio Eco communities

Observation Coordination Group Executive

Chair, Vice Chairs
WMO/Technical, Standards and Best Practice, OceanOPS, Data Management, Developing Community representative



A vertical list of GOOS in situ networks on a dark blue background. Each network is preceded by a small colored icon. The list is separated into two sections by a horizontal line. The first section includes Ship based meteorological (SOT), Ship based oceanographic (SOT), Repeated transects (CO-SHIP), Sea level gauges (GLOSS), Time series sites (OceanSITES), Coastal Moored buoys (DBCP), Tsunami buoys (DBCP), and Tropical moored buoys (DBCP). The second section includes HF radars, Drifting buoys (DBCP), Profiling floats (Argo), Deep & biogeochemistry floats (Argo), OceanGliders, and Animal borne sensors (AniBOS).

GOOS <i>in situ</i> networks ¹	
	Ship based meteorological - SOT
	Ship based oceanographic – SOT
	Repeated transects - CO-SHIP
	Sea level gauges - GLOSS
	Time series sites - OceanSITES
	Coastal Moored buoys – DBCP
	Tsunami buoys - DBCP
	Tropical moored buoys - DBCP
	HF radars
	Drifting buoys - DBCP
	Profiling floats - Argo
	Deep & biogeochemistry floats - Argo
	OceanGliders
	Animal borne sensors - AniBOS

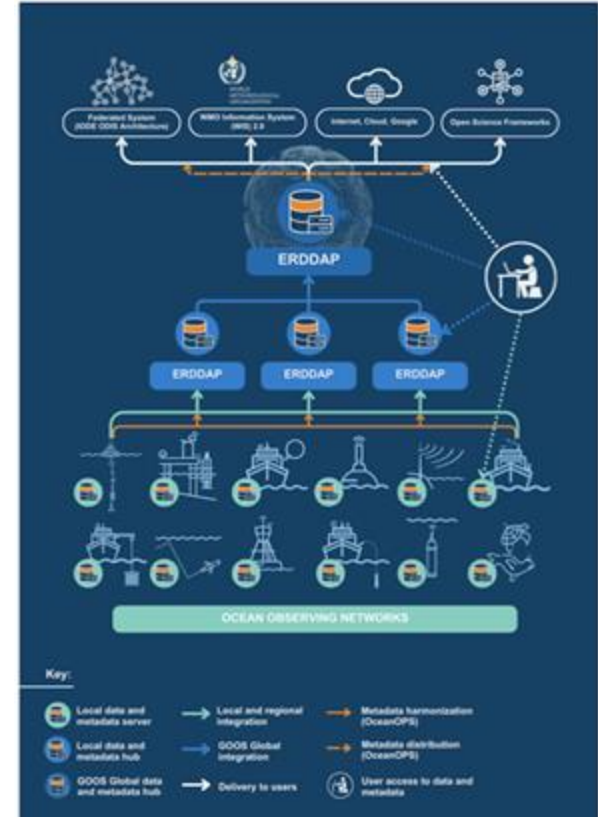
OCG Cross-Network Data Implementation Strategy Released

This Implementation Plan is an effort to define specific and actionable ways OCG network/programs can move towards FAIR compliance

- Improve (meta)data discovery, exchange, accessibility and usability for all stakeholders
- Improve access to distributed (meta)data endpoints through federated, uniform data services

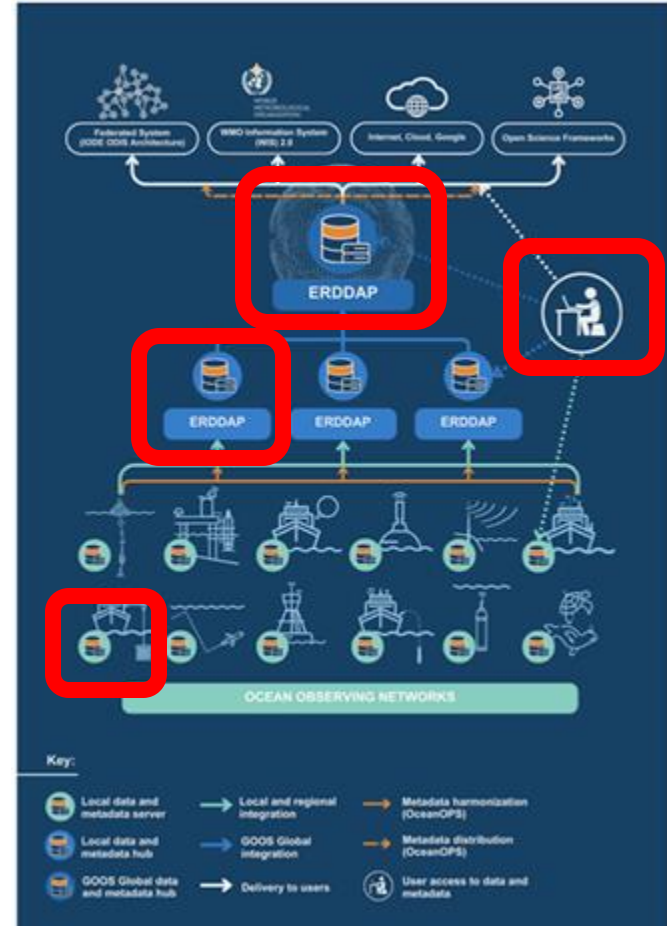


GOOS OCG Data Implementation Requirements	
Real Time Data	Metadata
OCG-R1 Data shall be exchanged in real time (with minimum delay) via the WIS/STS of the WMO in approved formats/templates.	OCG-R7 Networks shall have a defined uniform metadata content that includes at least the minimum OceanOPS requirements, thereby ensuring that they are compliant with the WIGOS metadata requirements. Note that OceanOPS is the authoritative source through which WIGOS metadata are submitted to OSCAR for all oceanographic and marine meteorological platforms.
OCG-R2 Data shall be available in real time or near-real time on the Internet through interoperable services (preferably ERDDAP) freely and without any restriction. Community agreed quality control procedures shall be applied in real-time and adjusted values made available when possible.	OCG-R8 Discovery and Use metadata shall be based upon a well-documented community standard, including a persistent and unique WMO/WIGOS identifier allocated by OceanOPS and use controlled vocabularies.
Delayed Mode Data	Best Practices
OCG-R3 Each network shall have at least one identified Global Data Repository. This Global Data Repository may be one or multiple (mirrored) repositories, or they may be data endpoints that can be federated into a virtual global repository.	OCG-B9 Platform and Discovery metadata shall be exchanged with OceanOPS utilizing machine-2-machine services.
OCG-R4 Data and data products shall be available through publicly accessible ERDDAP services. These distributed ERDDAP services will be federated under a single OCG ERDDAP focal point.	OCG-B10 Each network should have an active data team.
OCG-R5 NetCDF is the preferred data file format, though ERDDAP services can act as a data format translator if needed.	OCG-B11 Each network should have identified best practices on data infrastructure and workflows and data Q.C.
OCG-R6 Additional platform metadata should be available through the Global Data Repository and harvestable by machine-2-machine services.	OCG-B12 Raw/real-time data, delayed mode data and data products should be archived and have unique identifiers created [i.e., Digital Object Identifier (DOI)] for citation and reuse.

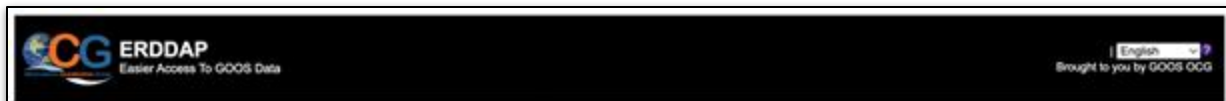


GOOS OCG Data Users and ERDDAP Federation

- Members of the GOOS Networks
 - World Meteorological Organization (WMO)
 - Ocean Data Information Service (ODIS)
 - UN Decade projects (DiTTO, etc)
- Cross-network projects
- Global stakeholders
 - World Meteorological Organization (WMO)
 - Ocean Data Information Service (ODIS)
 - UN Decade projects (DiTTO, etc)
- Who knows?



OCG Federated ERDDAP Node



ERDDAP

ERDDAP is a data server that gives you a simple, consistent way to download subsets of scientific datasets in common file formats and make graphs and maps. This particular ERDDAP instance has oceanographic data (for example, data from satellites and buoys).

Easier Access to Scientific Data

Our focus is on making it easier for you to get scientific data.

Different scientific communities have developed different types of data servers.

For example, OPeNDAP, WCS, SOS, OBIS, and countless custom web pages with forms. Each is great on its own. But without ERDDAP, it is difficult to get data from different types of servers.

- Different data servers make you format your data request in different ways.
- Different data servers return data in different formats, usually not the common file format that you want.
- Different datasets use different formats for time data, so the results are hard to compare.

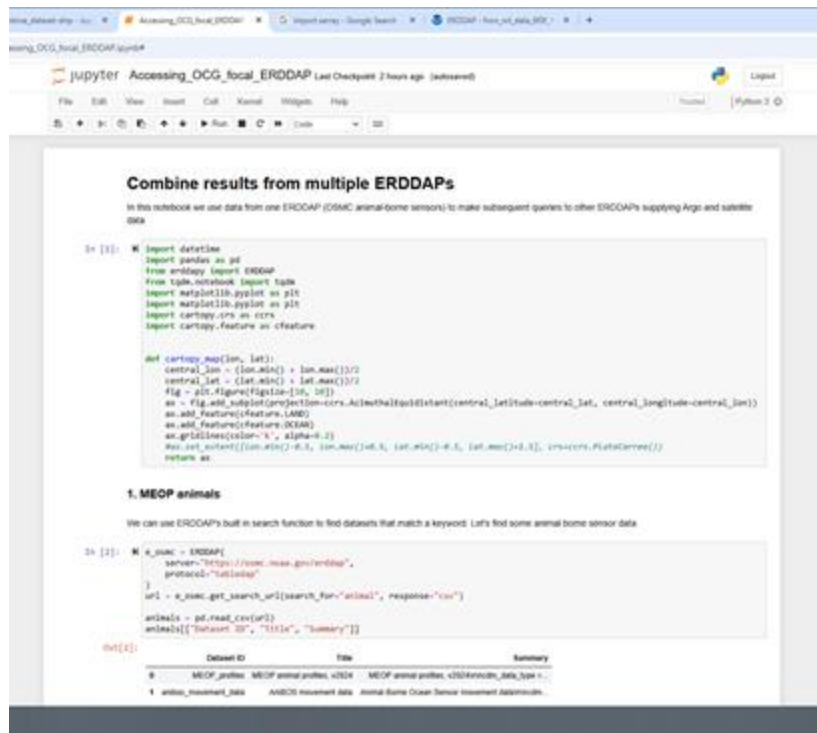
ERDDAP unifies the different types of data servers so you have a consistent way to get data you want, in the format you want.

- ERDDAP acts as a middleman between you and various remote data servers. When you request data from ERDDAP, ERDDAP reformats the request into the format required by the remote server, sends the request to the remote server, gets the data, reformats the data into the format that you requested, and sends the data to you. You no longer have to go to different data servers to get data from different datasets.

- ERDDAP offers an easy-to-use, consistent way to request data: via the OPeNDAP standard. Many datasets can also be accessed via ERDDAP's [Screenshot](#) (or WMS).

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title	Summary	FGDC, ISO, Metadata	Back-ground Info	RSS	E-mail	Institution	Data
	set	data	graph			* The List of All Active Datasets in this ERDDAP *		M	background			OSMC	allDatasets
	set	data	graph			AniBOS Platform Metadata		M	background			AniBOS	anibos_metadata
	set	data	graph			CCHDO GO SHIP bottle data		F I M	background			CCHDO	cchdo_bottle
	set	data	graph			CCHDO GO SHIP ctd data		F I M	background			CCHDO	cchdo_ctd
	set	data	graph			Global Drifter Program - 1 Hour Interpolated QC Drifter Data		F I M	background			NOAAAtlantic Oce...	drifter_hourly_qc
	set	data	graph			Global Drifter Program - 6 Hour Interpolated QC Drifter Data		F I M	background			NOAAAtlantic Oce...	drifter_6hour_qc
	set	data	graph	files		IOOS GTS counts		M	background			IOOS, NDBC	ioos_obs_counts
	set	data	graph			JASLUHSLC Research Quality Tide Gauge Data (daily)		F I M	background			University of Haw...	global_daily_rqds
	set	data	graph			JASLUHSLC Research Quality Tide Gauge Data (hourly)		F I M	background			University of Haw...	global_hourly_rqds
	set	data	graph			JCOMMPS Active WMO ID LIST		M	background			OSMC JCOMMOPS	wmo_list
	set	data	graph			MEOP animal profiles, v2024		F I M	background			OSMC	MEOP_profiles
	set	data	graph			OSMC 90 day RT data		F I M	background			OSMC	OSMC_30day
	set	data	graph			OSMC Argo Profile data		F I M	background			OSMC	OSMC_PROFILERS
	set	data	graph			OSMC flattened observations from GTS		F I M	background			OSMC	OSMC_flattened
	set	data	graph			OSMC normalized observations from GTS		F I M	background			OSMC	OSMC_Points
	set	data	graph			OSMC Profiles		F I M	background			OSMC	OSMCV4_DUO_PRO
	set	data	graph			OSMC surface trajectory data		F I M	background			OSMC	OSMCV4_DUO_SUR
	set	data	graph			OSMC TimeSeries		F I M	background			OSMC	OSMCV4_DUO_TIME
	set	data	graph			TAO/TRITON, R... Buoy's, Daily, 1977-present, Air Temperature		F I M	background			NOAA PMEL, TAO/TR...	prf1TaoDyAirt

OCG Federated ERDDAP Node - Example



The screenshot shows a Jupyter Notebook interface with the following content:

Combine results from multiple ERDDAPs

In this notebook we use data from one ERDDAP (OSMC animal-bone sensor) to make subsequent queries to other ERDDAPs supplying Argo and satellite OCG.

```
In [1]: # Import datetimes
import pandas as pd
from erddapy import ERDDAP
from ipynb.notebook import Table
import matplotlib.pyplot as plt
import matplotlib.pyplot as plt
import cartopy.crs as ccrs
import cartopy.feature as cfeature

def cartopy_map(lon, lat):
    central_lon = (lon.min() + lon.max())/2
    central_lat = (lat.min() + lat.max())/2
    fig = plt.figure(figsize=(10, 10))
    ax = fig.add_subplot(projection=ccrs.AcipolarEqualEarth(central_lat), central_longitude=central_lon)
    ax.add_feature(cfeature.LAND)
    ax.add_feature(cfeature.OCEAN)
    ax.gridlines(color='k', alpha=0.2)
    ax.set_extent([lon.min()-0.5, lon.max()+0.5, lat.min()-0.5, lat.max()+0.5], crs=ccrs.PlateCarree())
    return ax
```

1. MEOP animals

We can use ERDDAP's built in search function to find datasets that match a keyword. Let's find some animal bone sensor data.

```
In [2]: # a_func = ERDDAP
server="https://ocg.noaa.gov/erddap",
product="subdaily"
}
url = a_func.get_search_url(search_key="animal", response="csv")
animals = pd.read_csv(url)
animals[["Dataset ID", "Title", "Summary"]]

Out[2]:
```

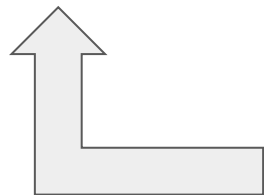
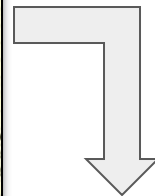
Dataset ID	Title	Summary
MEOP_profile	MEOP animal profile, v2024	MEOP animal profile, v2024/animal_data_type + ...
animal_instrument_data	AMOC instrument data	Animal Bone Ocean Sensor Instrument Address...

Integration with IODE* Ocean Data and Information System (ODIS)*

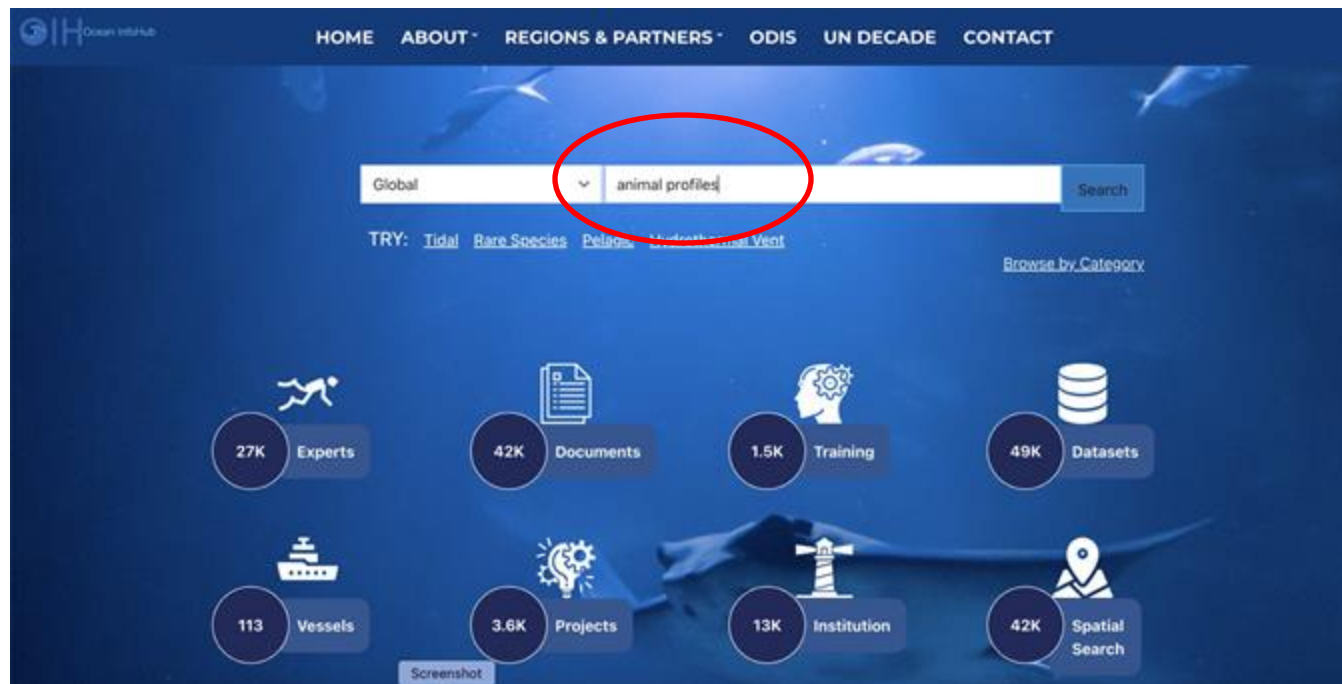
**International Oceanographic Data and Information Exchange*

**Federation of distributed metadata catalogs to further discovery and access of ocean data*

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title	Summary	FGDC ISO, Metadata	Background Info	RSS	E mail	Institution	Data
set	data	graph				* The List of All Active Datasets in this ERDDAP *		M	background			OSAC	allDatasets
set	data	graph				AnBOS Platform Metadata		M	background			AnBOS	anbos_metadata
set	data	graph				COHOO GO SHIP bottle data		F I M	background			COHOO	cochoo_bottle
set	data	graph				COHOO GO SHIP rtd data		F I M	background			COHOO	cochoo_rtd
set	data	graph				Global Drifter Program - 1 Hour Interpolated QC Drifter Data		F I M	background			NOAA Atlantic Oce...	drifter_hourly_gc
set	data	graph				Global Drifter Program - 6 Hour Interpolated QC Drifter Data		F I M	background			NOAA Atlantic Oce...	drifter_6hour_gc
set	data	graph			files	IODS GTS counts		M	background			IODS, NDBC	iods_obs_counts
set	data	graph				JASL/USLRC Research Quality Tide Gauge Data (daily)		F I M	background			University of Mass...	global_daily_rpts
set	data	graph				JASL/USLRC Research Quality Tide Gauge Data (hourly)		F I M	background			University of Mass...	global_hourly_rpts
set	data	graph				JCOMMPS Active WMO ID LIST		M	background			OSAC JCOMMPS	wmo_list
set	data	graph				MEOP animal profiles, v2024		F I M	background			MEOP	MEOP_profiles
set	data	graph				OSAC 90 day RT data		F I M	background			OSAC	OSAC_90day
set	data	graph				OSAC Argo Profile data		F I M	background			OSAC	OSAC_PROFILES
set	data	graph				OSAC flattened observations from GTS		F I M	background			OSAC	OSAC_flattened
set	data	graph				OSAC normalized observations from GTS		F I M	background			OSAC	OSAC_points
set	data	graph				OSAC Profiles		F I M	background			OSAC	OSACV4_DUO_PRO
set	data	graph				OSAC surface trajectory data		F I M	background			OSAC	OSACV4_DUO_SUR
set	data	graph				OSAC TimeSeries		F I M	background			OSAC	OSACV4_DUO_TME
set	data	graph				TAO/TRITON, R... Screenshot... A Buoys, Daily, 1977-present, Air Temperature		F I M	background			NOAA PMEL, TAO/TR...	pmelTaoAirT



Integration with IODE Ocean Data and Information System (ODIS)



Integration with IODE Ocean Data and Information System (ODIS)

The screenshot displays the IODE Ocean Data and Information System (ODIS) Spatial Search interface. The top navigation bar includes links for HOME, ABOUT, REGIONS & PARTNERS, ODIS, UN DECADE, and CONTACT. Below this, a secondary navigation bar features buttons for Documents, Experts, Institutions, Datasets (highlighted with a '74' badge), Training, Vessels, and Projects. The main search area is titled 'Spatial Search' and contains several dropdown menus for Provider, Variable, Keyword, Starting, and Ending, along with a CLEAR button. Below the search filters, it indicates 'Total results found 80'. The search results section displays the following information:

- Name:** MEOP animal profiles, v2024
- License:** Follow MEOP data policy standards, cf. <http://www.meop.net/the-dataset/data-access.html>. Data available free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data.
- Keywords:** A list of metadata fields including CYCLE_NUMBER, DATA_CENTRE, DATA_MODE, DATA_STATE_INDI..., DATA_TYPE, DATE_CREATION, DATE_UPDATE, DC_REFERENCE, FORMAT_VERSION, HANDBOOK_VERSI..., INST_REFERENCE, JULD_LOCATION, JULD_QC, PI_NAME, PLATFORM_NUMBER, POSITIONING_SYS..., POSITION_QC, PROFILE_PRES_QC, PROFILE_PSAI_QC, and PROFILE_TEMP_QC. A 'Show More' button is located below the list.
- Temporal Coverage:** 2004-01-27T11:49:00Z/2024-02-22T12:45:00Z
- Region:** Southern Ocean, Africa, Arctic Ocean, Caribbean Sea, Atlantic Ocean, Indian Ocean, Mediterranean Sea, Latin America and the Caribbean, Pacific Small Islands, Pacific Ocean

Integration with IODE Ocean Data and Information System (ODIS)

The screenshot shows the ODIS website interface. At the top, there is a navigation bar with links for HOME, ABOUT, REGIONS & PARTNERS, ODIS, UN DECADE, and CONTACT. Below this is a secondary navigation bar with buttons for Documents, Experts, Institutions, Datasets (highlighted with a '74' badge), Training, Vessels, and Projects. The main content area is titled 'Spatial Search' and contains a search filter section with dropdown menus for Provider, Variable, Keyword, Starting, and Ending, along with a CLEAR button. Below the filters, it states 'Total results found 80'. The search results list 'MEOP animal profiles, v2024', which is circled in red. The details for this result include: Name: MEOP animal profiles, v2024; License: Follow MEOP data policy standards, cf. http://www.meop.net/the-dataset/data-access.html. Data available free of charge. User assumes all risk for use of data. User must display citation in any publication or product using data. User must contact PI prior to any commercial use of data; Keywords: CYCLE_NUMBER, DATA_CENTRE, DATA_MODE, DATA_STATE_INDI..., DATA_TYPE, DATE_CREATION, DATE_UPDATE, DC_REFERENCE, FORMAT_VERSION, HANDBOOK_VERSI..., INST_REFERENCE, JULD_LOCATION, JULD_QC, PI_NAME, PLATFORM_NUMBER, POSITIONING_SYS..., POSITION_QC, PROFILE_PRES_QC, PROFILE_PSAI_QC, PROFILE_TEMP_QC; Temporal Coverage: 2004-01-27T11:49:00Z/2024-02-22T12:45:00Z; Region: Southern Ocean, Africa, Arctic Ocean, Caribbean Sea, Atlantic Ocean, Indian Ocean, Mediterranean Sea, Latin America and the Caribbean, Pacific Small Islands, Pacific Ocean. A 'Screenshot' button is visible at the bottom of the result card.

Integration with IODE Ocean Data and Information System (ODIS)

ERDDAP > tabledap > Data Access Form

Dataset Title: **MEOP animal profiles, v2024**

Information: MEOP (Dataset ID: MEOP_profiles)

Information: Summary | License | FQDC | ISO 19115 | Metadata | Background | Submit | Make a graph

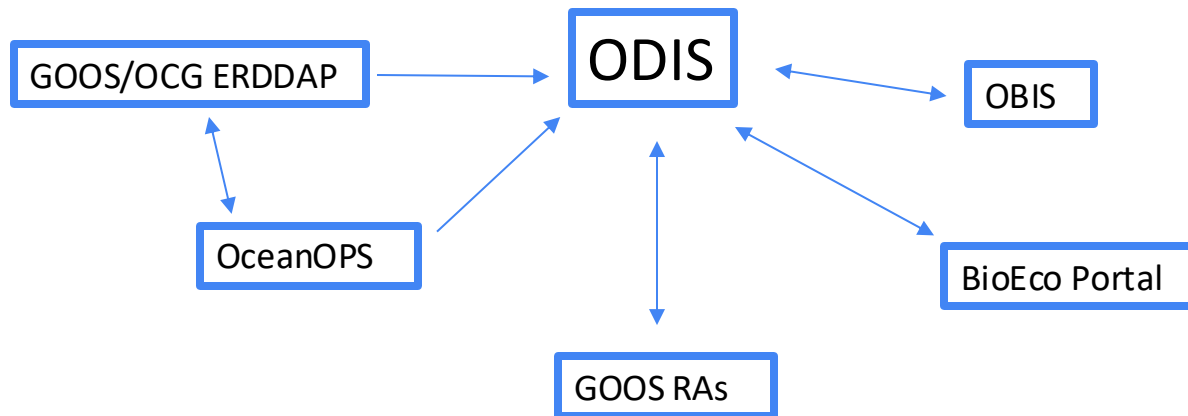
Variable: Check All Uncheck All

Variable	Optional Constraint #1	Optional Constraint #2	Minimum of a List of Values	Maximum
<input type="checkbox"/> deployment_code				
<input type="checkbox"/> ship_platform_code				
<input type="checkbox"/> ship_platform_code				
<input type="checkbox"/> species (Species type)				
<input type="checkbox"/> DATA_TYPE				
<input type="checkbox"/> FORMAT_VERSION				
<input type="checkbox"/> HANDBOOK_VERSION				
<input type="checkbox"/> REFERENCE_DATE_Time				
<input type="checkbox"/> DATE_CREATION				
<input type="checkbox"/> DATE_UPDATE (Date of update of this file)				
<input type="checkbox"/> PLATFORM_NUMBER (Four unique identifier)				
<input type="checkbox"/> PROJECT_NAME				
<input type="checkbox"/> PI_NAME				
<input type="checkbox"/> CYCLE_NUMBER (First cycle number, 1)				
<input type="checkbox"/> DIRECTION			1	2693
<input type="checkbox"/> DATA_CENTRE			A	A
<input type="checkbox"/> QC_REFERENCE				
<input type="checkbox"/> DATA_SITING_INDICATOR			D	D
<input type="checkbox"/> DATA_MODE				
<input type="checkbox"/> INST_REFERENCE (Instrument type)				
<input type="checkbox"/> INST_INST_TYPE (Coded instrument type)				
<input type="checkbox"/> site (UTC)				
<input type="checkbox"/> AUL2_QC (Quality on Date and Time)			1	1
<input type="checkbox"/> AUL2_LOCATION (UTC)			2004-01-27T11:49:00Z	2004-02-22T12:45:00Z
<input type="checkbox"/> latitude (degrees_north)			-78.56	87.7764
<input type="checkbox"/> longitude (degrees_west)			-175.3996	175.3984
<input type="checkbox"/> POSITION_QC			1	1
<input type="checkbox"/> POSITIONING_SYSTEM				
<input type="checkbox"/> PROFILE_PRES_QC			A	A
<input type="checkbox"/> PROFILE_PRES_QC			A	A
<input type="checkbox"/> PROFILE_TEMP_QC			A	A
<input type="checkbox"/> PRES (SEA PRESSURE, decibar)			0.0	2502.0
<input type="checkbox"/> PRES_QC (quality flag)			1	9
<input type="checkbox"/> PRES_ADJUSTED (SEA PRESSURE, decibar)			0.0	2502.0
<input type="checkbox"/> PRES_ADJUSTED_QC (quality flag)			1	9
<input type="checkbox"/> PRES_ADJUSTED_ERROR (SEA PRESSURE, decibar)				
<input type="checkbox"/> TEMP (degree_Celsius)			-7.801476	932.5018
<input type="checkbox"/> TEMP_QC (quality flag)			1	9
<input type="checkbox"/> TEMP_ADJUSTED (degree_Celsius)			-4.915466	31.96509
<input type="checkbox"/> TEMP_ADJUSTED_QC (quality flag)			1	9
<input type="checkbox"/> TEMP_ADJUSTED_ERROR (degree_Celsius)			0.03	0.4
<input type="checkbox"/> PSAL (PRACTICAL SALINITY, PSU)			-0.006794212	22614.26
<input type="checkbox"/> PSAL_QC (quality flag)			1	9
<input type="checkbox"/> PSAL_ADJUSTED (PSU)			4.065279	35.05772
<input type="checkbox"/> PSAL_ADJUSTED_QC (quality flag)			1	9
<input type="checkbox"/> PSAL_ADJUSTED_ERROR (PRACTICAL SALINITY ERROR, psu)			0.05	0.4
<input type="checkbox"/> data_center				
<input type="checkbox"/> reference_file_name (Name of reference file)				
<input type="checkbox"/> nation (Name of nation)				
<input type="checkbox"/> meop_platform_code				

What could a cross-GOOS infrastructure look like?

Within GOOS, we will harness the power of ERDDAP to provide easy federation of distributed data nodes

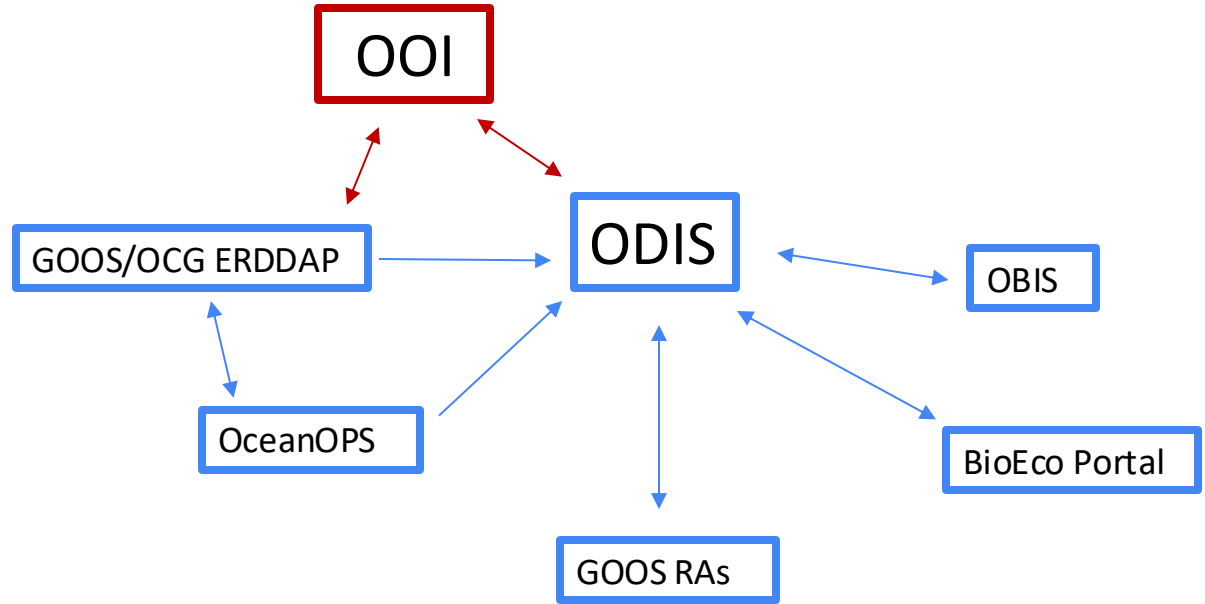
ODIS seems well placed to act as the glue between disparate systems



What could a cross-GOOS infrastructure look like?

Within GOOS, we will harness the power of ERDDAP to provide easy federation of distributed data nodes

ODIS seems well placed to act as the glue between disparate systems



ERDDAP - integration with WIS 2.0

1963 World Weather Watch

1970s Global Telecommunication System (GTS)

2007 WMO Information System (WIS)

2019 WMO Reform (Earth System Approach)

2021 WMO Unified Data Policy (Core,

Recommended)



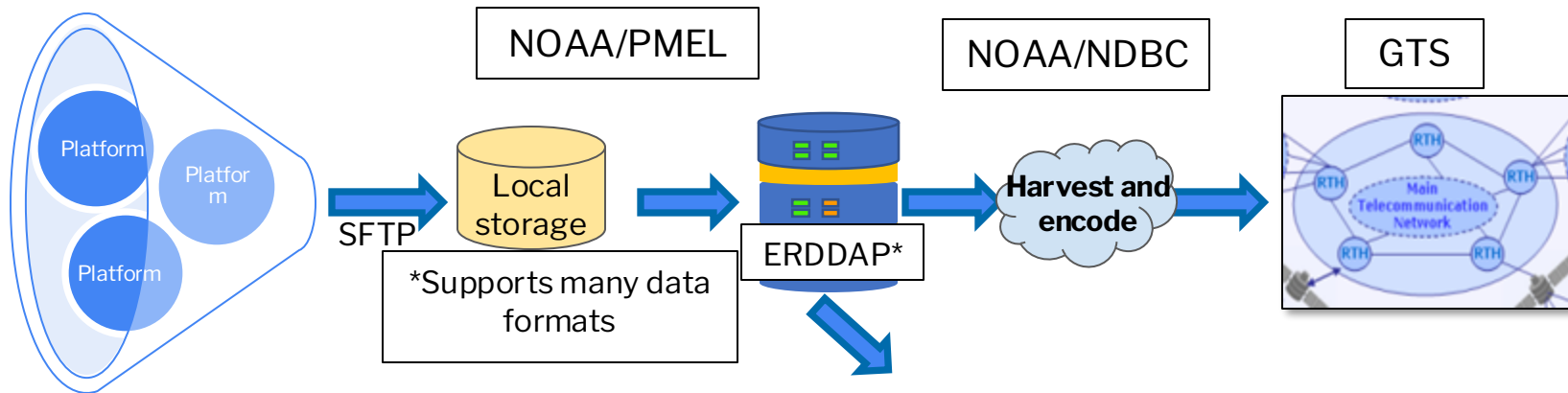
WIS 2.0

... collaborative system of systems using Web-architecture and open standards to provide simple, timely and seamless sharing of trusted data and information ...

- Open Standards (OGC, W3C, IETF, ...)
- Free and Open Source tooling
- Data sharing through Web and real-time notifications with publication/subscription (Pub/Sub) protocols
- Cloud ready (turn-key solutions)
- Web APIs (Application Programming Interface)

GOOS Open Access to the GTS Data Exchange Workflow

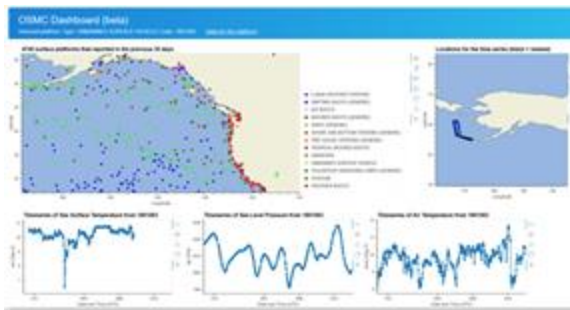
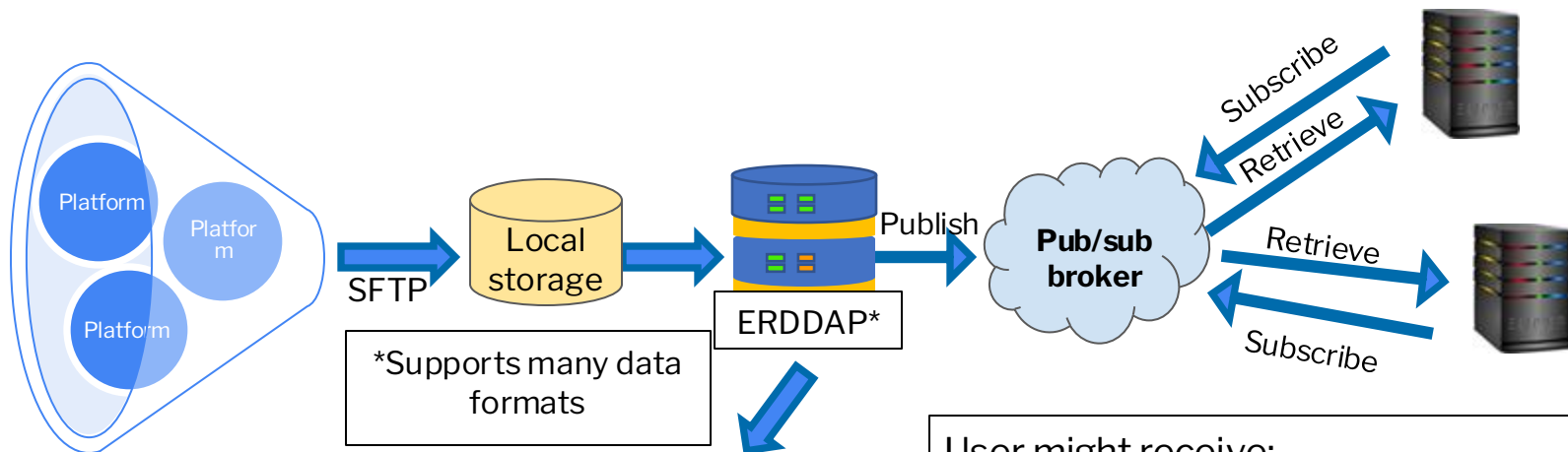
The Open-GTS currently uses the GTS for exchanging data in near real-time



However, the ERDDAP data/metadata endpoints are available to the public.



Open-GTS, WMO and WIS 2.0



User might receive:

- CSV/NCCSV file
- NetCDF file
- Service URL to access the data

Current Open-GTS contributions

USV data exchange

- Data from 80+ missions to the GTS
- Most recently 12 USVs involved in 2024 hurricane season

Non-traditional ship data exchange

- Working with OceanSync to pilot exchange of weather data from commercial ships
- 1 vessel at this time
- Non-VOS ships only

Science RoCS data exchange

- Science Research on Commercial Ships
- Data from Xaymaca going to GTS

Fishing Vessel Observing Network (FVON)

- New GOOS OCG emerging network
- Place data from 45 fishing vessels onto the GTS
- Temperature profile data from fishing tows and traps



The Global Ocean Observing System



Global Ocean Observing System (GOOS) Observations Coordination Group (OCG) Data Activities

**Ocean Observatories Initiative Facility Board
(OOIFB) and Data Systems Committee (DSC)
Meetings Wednesday, and Thursday,
November 13-14, 2024**

**Thank You
Kevin.M.O'Brien@noaa.gov**