NWEM ERDDAP Tutorial Webinar

Seth Travis
setht1@uw.edu

October 26, 2023

With support from NANOOS

Schedule

- ERDDAP Tutorial
  - NWEM ORCA Moorings
  - ERDDAP – What is it?
  - Demonstrate NWEM ERDDAP to see data availability
  - Discuss NWEM Data Products
  - Discuss ERDDAP programming language interfaces

- NWEM Data Processing
  - Discuss NWEM Data Workflow
  - Discuss processing steps for each data product

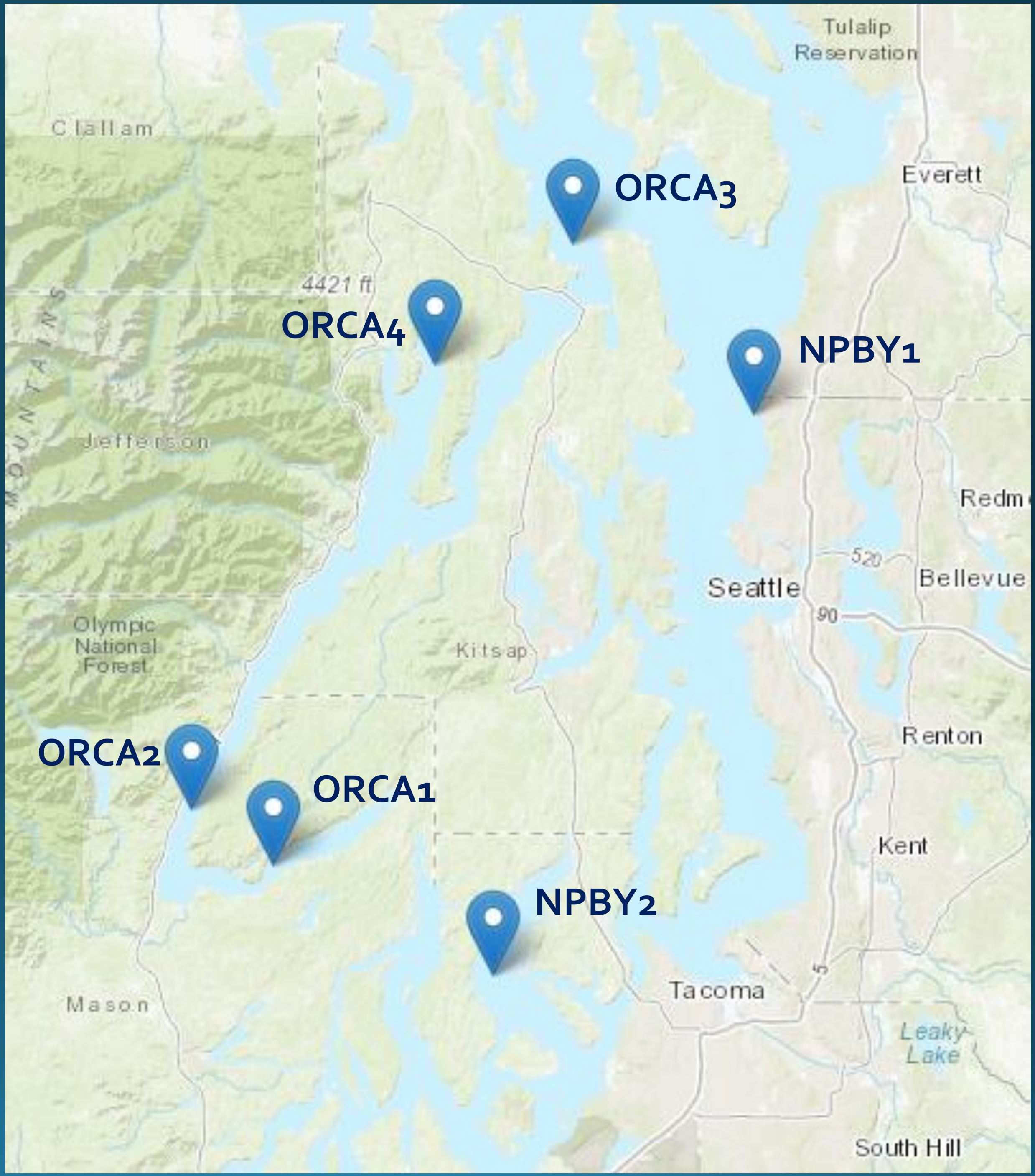
NWEM ORCA Moorings

- Northwest Environmental Moorings (NWEM) maintains a series of permanent moorings through Puget Sound, with the goal of providing real-time and long-term environmental monitoring

- We call these mooring ORCA buoys (Oceanic Remote Chemical Analyzer)
  - Consists of a winch-driven profiling system with a sensor package
  - Sensor package contains a CTD, as well as a variety of chemical and optical sensors

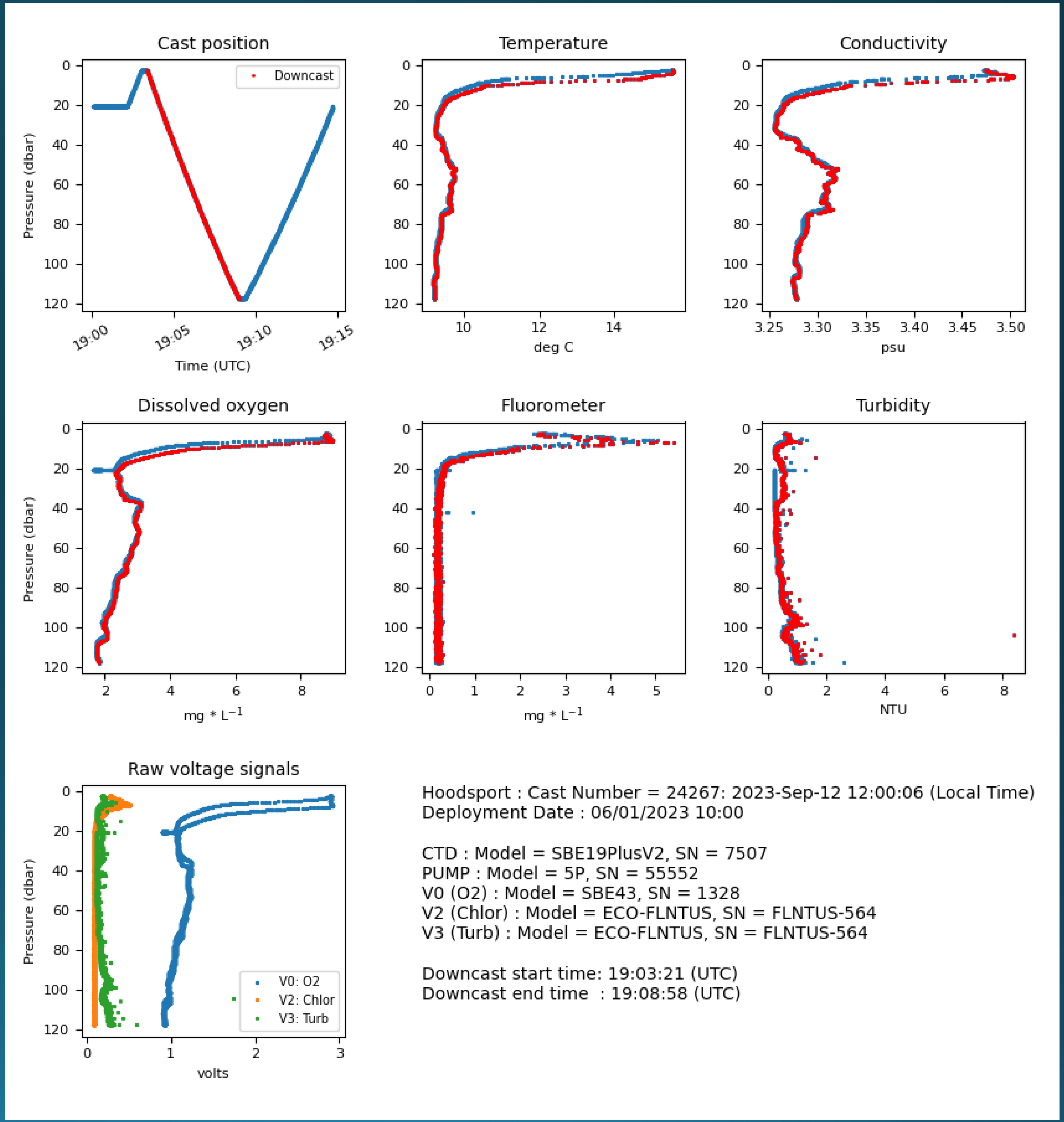
Buoy Locations

- ORCA1: Twanoh
- ORCA2: Hoodsport
- ORCA3: Hansville
- ORCA4: Dabob Bay
- NPBY1: Pt. Wells
- NPBY2: Carr Inlet



Typical Cast

- Each cast samples at 4 Hz, with the CTD package moving at a target speed of 25 cm/s
  - A sample is taken every ~6 cm when package is moving
  - For a 100 m cast, this results in ~1600 samples for just the downcast portion of each cast



Data Coverage

Buoy Name	Buoy Depth	Number of Individual Casts (as of 2023-09-12)	First Cast Date	Number of Years of Data Coverage
ORCA1: Twanoh	35 m	36,215	2005-Jan-19	18
ORCA2: Hoodsport	120 m	24,645	2005-Oct-19	18
ORCA3: Hansville	100 m	15,304	2005-Nov-18	18
ORCA4: Dabob Bay	105 m	7,161	2010-Jun-07	13
NPBY1: Pt. Wells	100 m	9,129	2010-Apr-10	13
NPBY2: Carr Inlet	47 m	24,950	2010-Oct-13	13
Total Casts		117,404		

- Target of at least 1 cast per day
  - This can be higher during the summer, when we have more time for solar to recharge the batteries
- Each cast can consist of 1200-4000 samples, depending on buoy depth

ERDDAP - What is it?

- ERDDAP is a data server platform to distribute & visualize data
  - Allows for temporal and spatial subsetting of data
  - Allows for multiple data file formats (ex. netCDF, csv, JSON, mat, etc.)
  - Visualization tools let you explore the data and save the resulting images in your preferred output (png, pdf, etc)
  - Server is “RESTful”, meaning that the URL used to access the data completely defines the output

- Overall, ERDDAP is a data platform that allows for direct user data exploration, and automated machine access

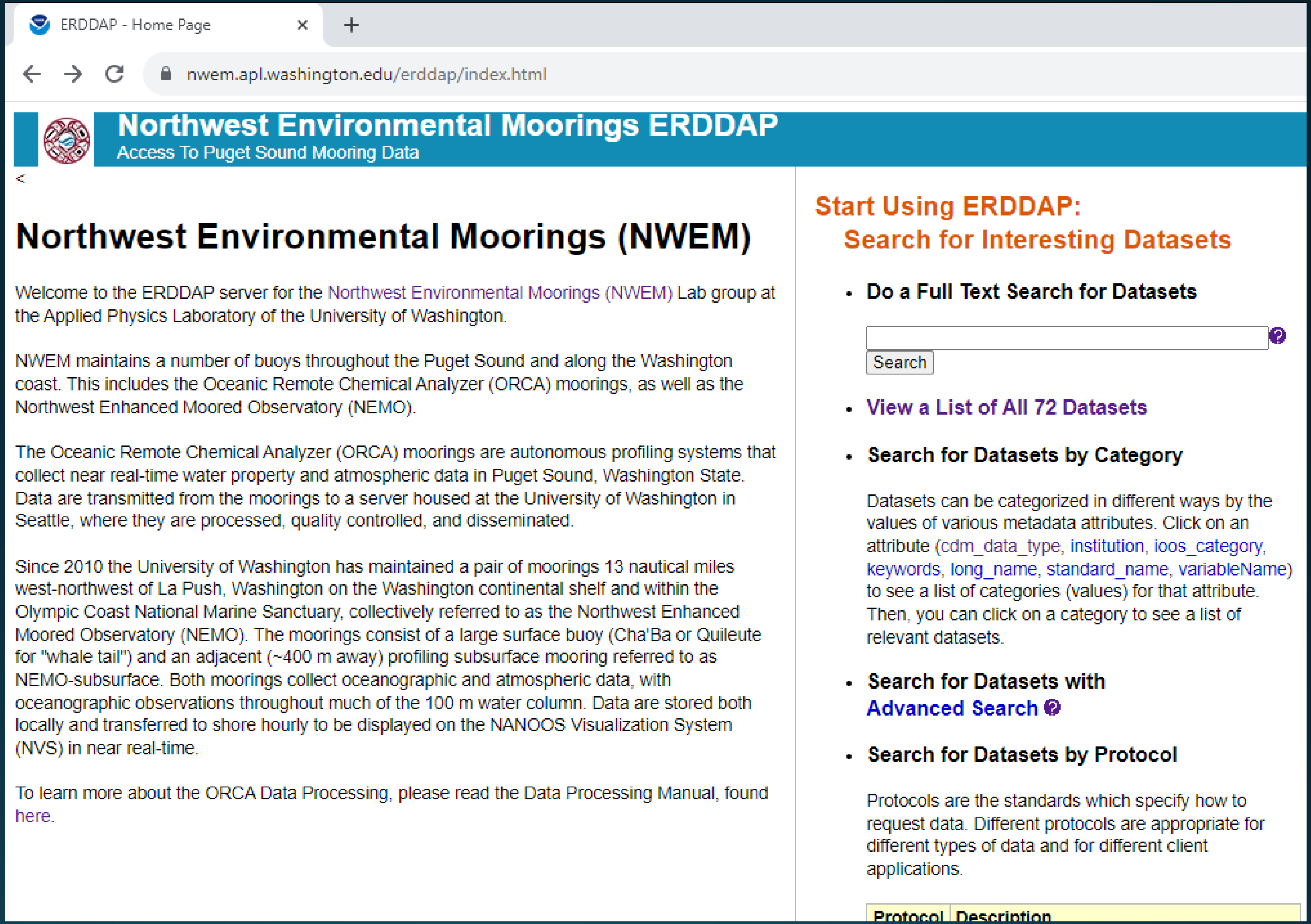
ERDDAP – Resources

- Coast Watch ERDDAP Tutorial – Best Resource: https://coastwatch.gitbook.io/satellite-course/tutorials/erddap-tutorial

ERDDAP – Web Interface

Front page of the NWEM ERDDAP lists:

- Description of the NWEM program
- Link to the data manual
- Access to the data sets

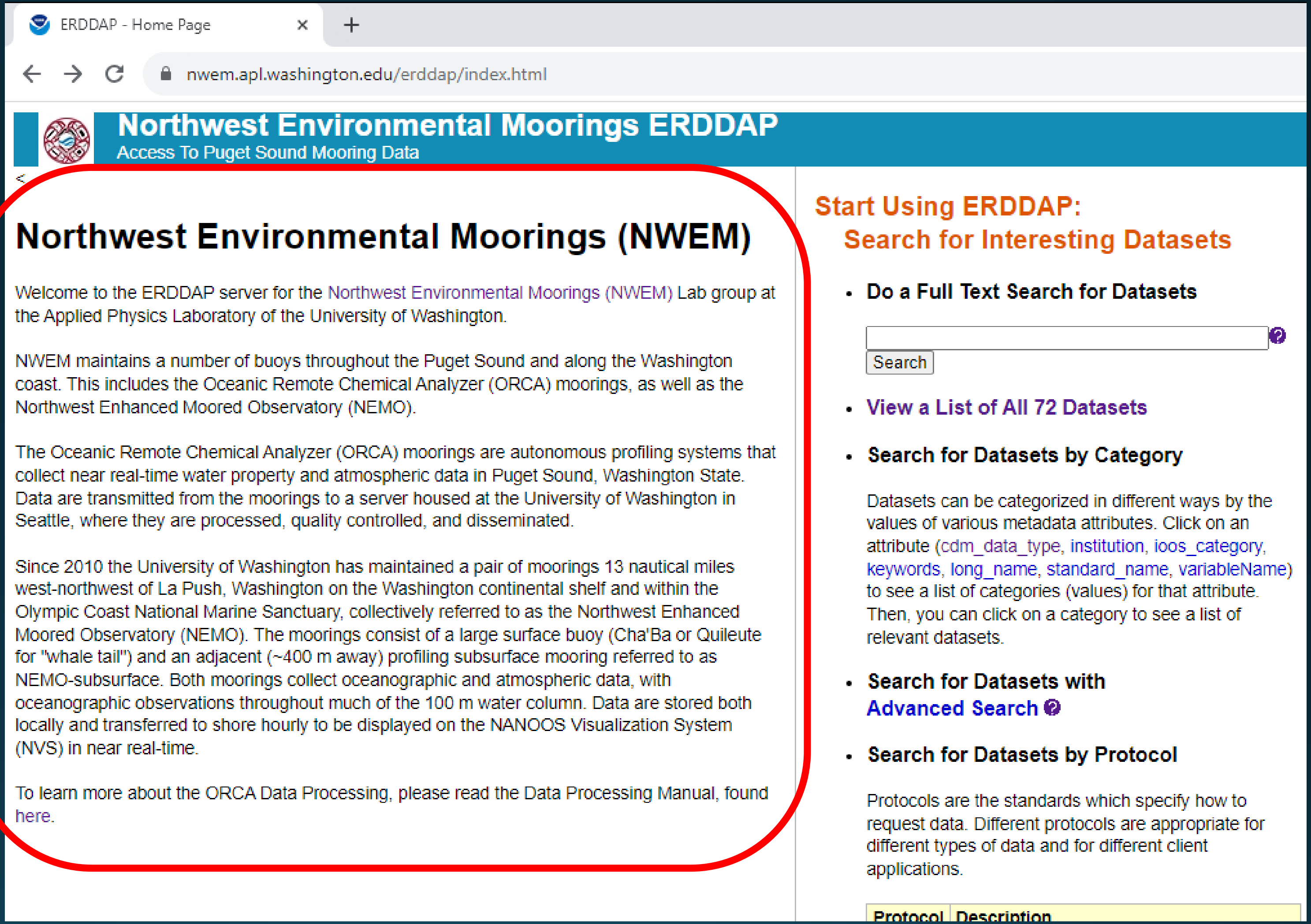


NWEM ERDDAP:
https://nwem.apl.washington.edu/erddap/index.html

ERDDAP – Web Interface

Front page of the NWEM ERDDAP lists:

- Description of the NWEM program
- Link to the data manual
- Access to the data sets

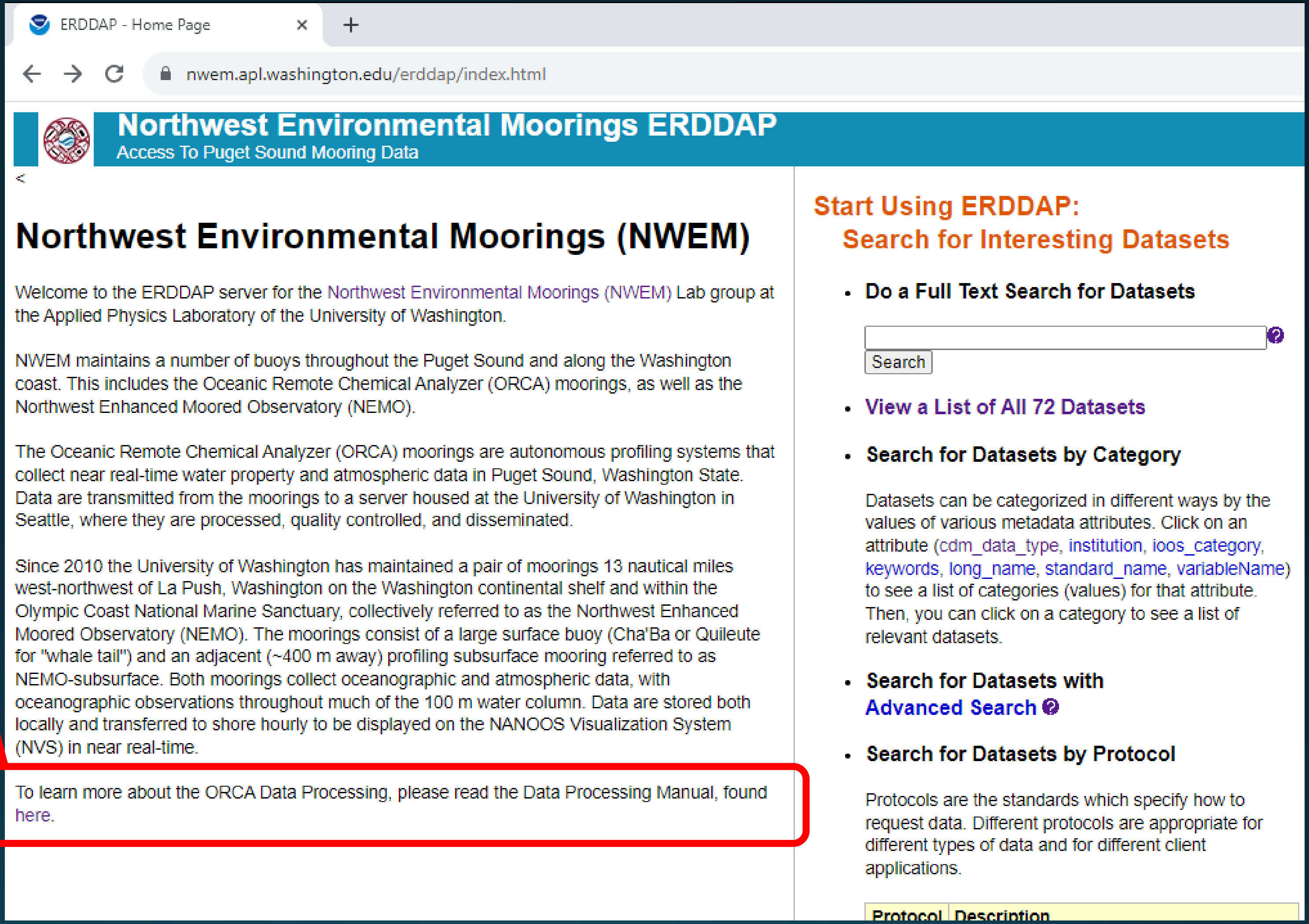


NWEM ERDDAP:
https://nwem.apl.washington.edu/erddap/index.html

ERDDAP – Web Interface

Front page of the NWEM ERDDAP lists:

- Description of the NWEM program
- Link to the data manual
- Access to the data sets



ERDDAP - Home Page

nwem.apl.washington.edu/erddap/index.html

Northwest Environmental Moorings ERDDAP
Access To Puget Sound Mooring Data

Northwest Environmental Moorings (NWEM)

Welcome to the ERDDAP server for the Northwest Environmental Moorings (NWEM) Lab group at the Applied Physics Laboratory of the University of Washington.

NWEM maintains a number of buoys throughout the Puget Sound and along the Washington coast. This includes the Oceanic Remote Chemical Analyzer (ORCA) moorings, as well as the Northwest Enhanced Moored Observatory (NEMO).

The Oceanic Remote Chemical Analyzer (ORCA) moorings are autonomous profiling systems that collect near real-time water property and atmospheric data in Puget Sound, Washington State. Data are transmitted from the moorings to a server housed at the University of Washington in Seattle, where they are processed, quality controlled, and disseminated.

Since 2010 the University of Washington has maintained a pair of moorings 13 nautical miles west-northwest of La Push, Washington on the Washington continental shelf and within the Olympic Coast National Marine Sanctuary, collectively referred to as the Northwest Enhanced Moored Observatory (NEMO). The moorings consist of a large surface buoy (Cha'Ba or Quileute for "whale tail") and an adjacent (~400 m away) profiling subsurface mooring referred to as NEMO-subsurface. Both moorings collect oceanographic and atmospheric data, with oceanographic observations throughout much of the 100 m water column. Data are stored both locally and transferred to shore hourly to be displayed on the NANOOS Visualization System (NVS) in near real-time.

To learn more about the ORCA Data Processing, please read the Data Processing Manual, found here.

Start Using ERDDAP:
Search for Interesting Datasets

- **Do a Full Text Search for Datasets**

  Search

- **View a List of All 72 Datasets**
- **Search for Datasets by Category**

  Datasets can be categorized in different ways by the values of various metadata attributes. Click on an attribute (cdm_data_type, institution, ioos_category, keywords, long_name, standard_name, variableName) to see a list of categories (values) for that attribute. Then, you can click on a category to see a list of relevant datasets.

- **Search for Datasets with Advanced Search**
- **Search for Datasets by Protocol**

  Protocols are the standards which specify how to request data. Different protocols are appropriate for different types of data and for different client applications.

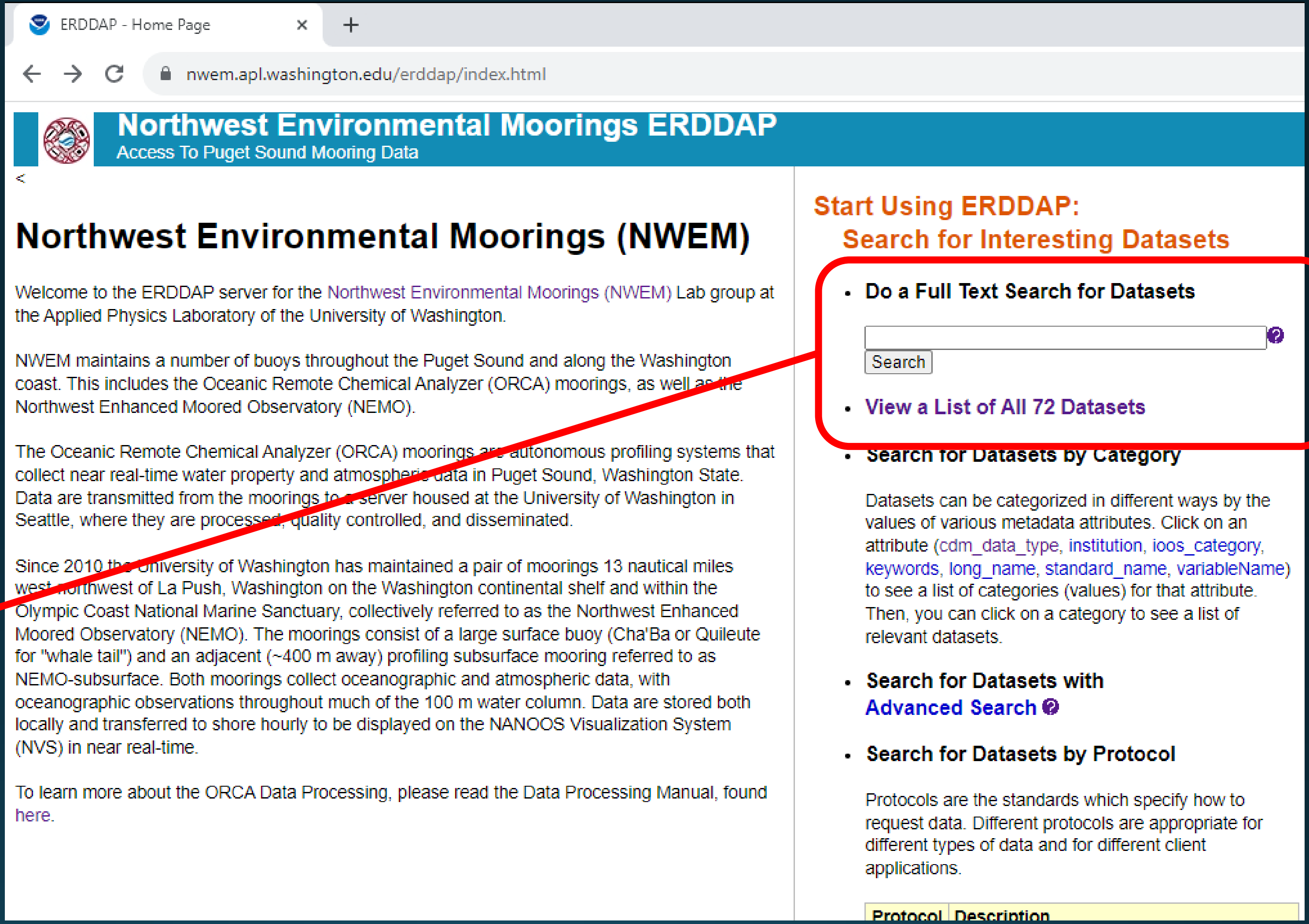
Protocol	Description

NWEM ERDDAP:
https://nwem.apl.washington.edu/erddap/index.html

ERDDAP – Web Interface

Front page of the NWEM ERDDAP lists:

- Description of the NWEM program
- Link to the data manual
- Access to the data sets

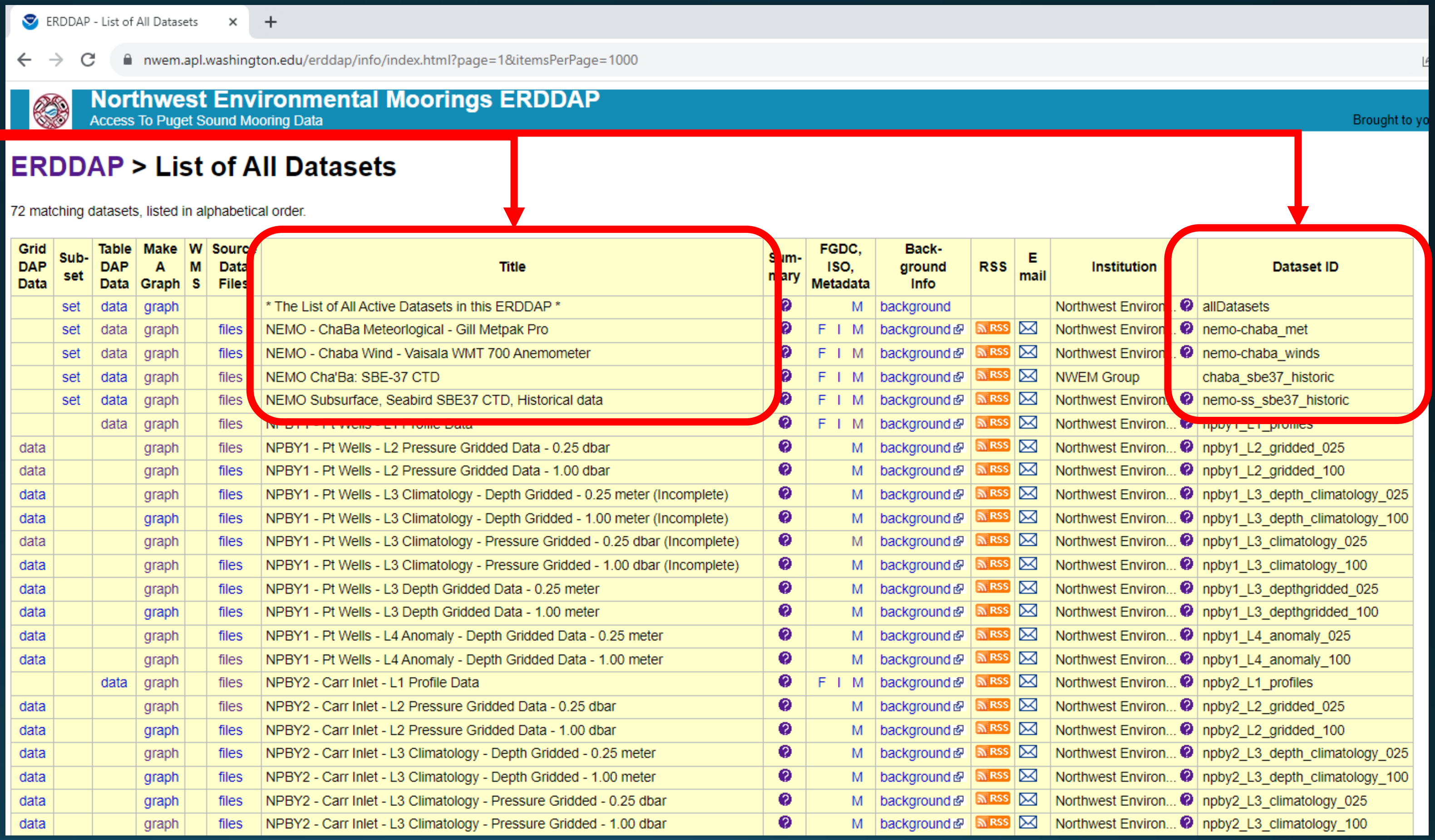


NWEM ERDDAP:
https://nwem.apl.washington.edu/erddap/index.html

ERDDAP – Web Interface

List of all Data Products:

- Title & Dataset ID

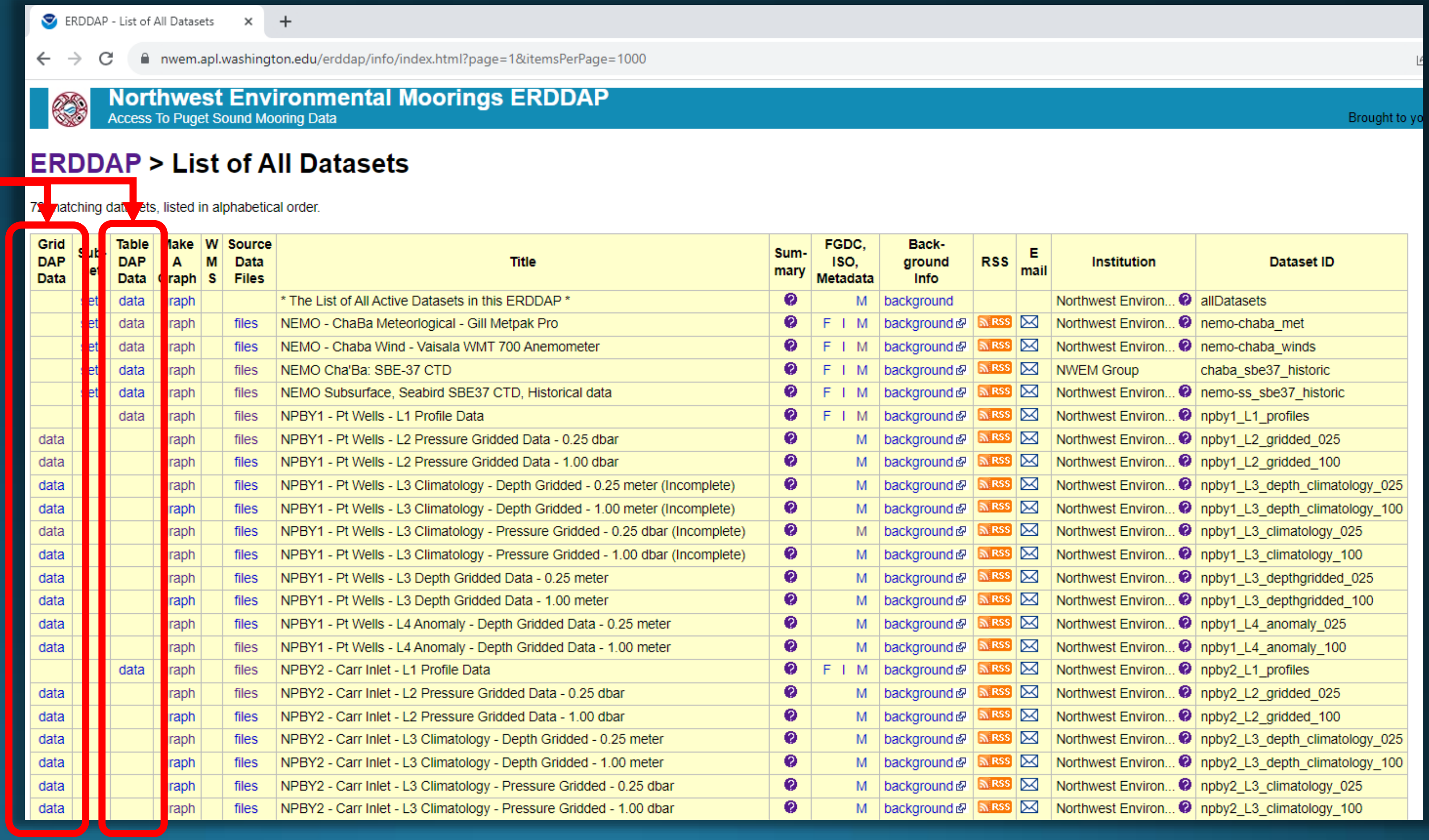


Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution		Dataset ID
	set	data	graph			* The List of All Active Datasets in this ERDDAP *	?	M	background			Northwest Environ...	?	allDatasets
	set	data	graph		files	NEMO - ChaBa Meteorlogical - Gill Metpak Pro	?	F I M	background	RSS		Northwest Environ...	?	nemo-chaba_met
	set	data	graph		files	NEMO - Chaba Wind - Vaisala WMT 700 Anemometer	?	F I M	background	RSS		Northwest Environ...	?	nemo-chaba_winds
	set	data	graph		files	NEMO Cha'Ba: SBE-37 CTD	?	F I M	background	RSS		NWEM Group		chaba_sbe37_historic
	set	data	graph		files	NEMO Subsurface, Seabird SBE37 CTD, Historical data	?	F I M	background	RSS		Northwest Environ...	?	nemo-ss_sbe37_historic
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data	?	F I M	background	RSS		Northwest Environ...	?	npby1_L1_profiles
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar	?	M	background	RSS		Northwest Environ...	?	npby1_L2_gridded_025
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar	?	M	background	RSS		Northwest Environ...	?	npby1_L2_gridded_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)	?	M	background	RSS		Northwest Environ...	?	npby1_L3_depth_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)	?	M	background	RSS		Northwest Environ...	?	npby1_L3_depth_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)	?	M	background	RSS		Northwest Environ...	?	npby1_L3_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)	?	M	background	RSS		Northwest Environ...	?	npby1_L3_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter	?	M	background	RSS		Northwest Environ...	?	npby1_L3_depthgridded_025
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter	?	M	background	RSS		Northwest Environ...	?	npby1_L3_depthgridded_100
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter	?	M	background	RSS		Northwest Environ...	?	npby1_L4_anomaly_025
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter	?	M	background	RSS		Northwest Environ...	?	npby1_L4_anomaly_100
		data	graph		files	NPBY2 - Carr Inlet - L1 Profile Data	?	F I M	background	RSS		Northwest Environ...	?	npby2_L1_profiles
data			graph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 0.25 dbar	?	M	background	RSS		Northwest Environ...	?	npby2_L2_gridded_025
data			graph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 1.00 dbar	?	M	background	RSS		Northwest Environ...	?	npby2_L2_gridded_100
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 0.25 meter	?	M	background	RSS		Northwest Environ...	?	npby2_L3_depth_climatology_025
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 1.00 meter	?	M	background	RSS		Northwest Environ...	?	npby2_L3_depth_climatology_100
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 0.25 dbar	?	M	background	RSS		Northwest Environ...	?	npby2_L3_climatology_025
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 1.00 dbar	?	M	background	RSS		Northwest Environ...	?	npby2_L3_climatology_100

ERDDAP – Web Interface

List of all Data Products:

- Title & Dataset ID
- Data Access Form
  - TableDAP or GridDAP options
  - TableDAP:
    A list of points with values associated with each
    Example: Excel Tables
  - GridDAP:
    Variables on a fixed data grid (with axis variables)
    Example: Maps of sea surface temperature

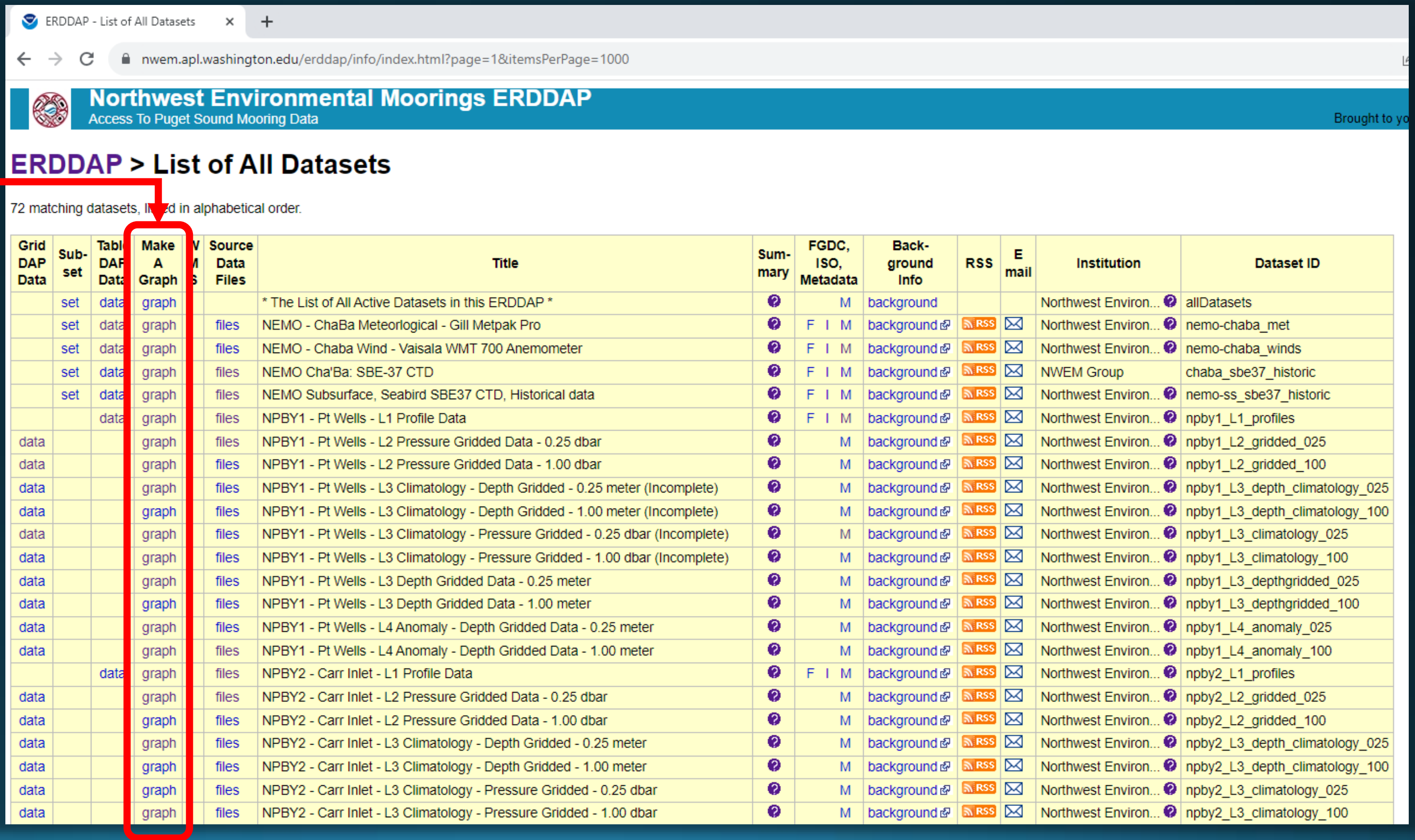


Grid DAP Data	Sub et	Table DAP Data	ake A raph	W M S	Source Data Files	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution	Dataset ID
	et	data	raph			* The List of All Active Datasets in this ERDDAP *		M	background			Northwest Environ...	allDatasets
	et	data	raph		files	NEMO - ChaBa Meteorological - Gill Metpak Pro		F I M	background	RSS		Northwest Environ...	nemo-chaba_met
	et	data	raph		files	NEMO - Chaba Wind - Vaisala WMT 700 Anemometer		F I M	background	RSS		Northwest Environ...	nemo-chaba_winds
	et	data	raph		files	NEMO Cha'Ba: SBE-37 CTD		F I M	background	RSS		NWEM Group	chaba_sbe37_historic
	et	data	raph		files	NEMO Subsurface, Seabird SBE37 CTD, Historical data		F I M	background	RSS		Northwest Environ...	nemo-ss_sbe37_historic
		data	raph		files	NPBY1 - Pt Wells - L1 Profile Data		F I M	background	RSS		Northwest Environ...	npby1_L1_profiles
data			raph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_025
data			raph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_100
data			raph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_025
data			raph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_100
data			raph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_025
data			raph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_100
data			raph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_025
data			raph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_100
data			raph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_025
data			raph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_100
		data	raph		files	NPBY2 - Carr Inlet - L1 Profile Data		F I M	background	RSS		Northwest Environ...	npby2_L1_profiles
data			raph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 0.25 dbar		M	background	RSS		Northwest Environ...	npby2_L2_gridded_025
data			raph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 1.00 dbar		M	background	RSS		Northwest Environ...	npby2_L2_gridded_100
data			raph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 0.25 meter		M	background	RSS		Northwest Environ...	npby2_L3_depth_climatology_025
data			raph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 1.00 meter		M	background	RSS		Northwest Environ...	npby2_L3_depth_climatology_100
data			raph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 0.25 dbar		M	background	RSS		Northwest Environ...	npby2_L3_climatology_025
data			raph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 1.00 dbar		M	background	RSS		Northwest Environ...	npby2_L3_climatology_100

ERDDAP – Web Interface

List of all Data Products:

- Title & Dataset ID
- Data Access Form
  - TableDAP or GridDAP options
- Data Visualization



Grid DAP Data	Sub-set	Tabl DAF Data	Make A Graph	V M S	Source Data Files	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution	Dataset ID
	set	data	graph			* The List of All Active Datasets in this ERDDAP *		M	background			Northwest Environ...	allDatasets
	set	data	graph		files	NEMO - ChaBa Meteorlogical - Gill Metpak Pro		F I M	background	RSS		Northwest Environ...	nemo-chaba_met
	set	data	graph		files	NEMO - Chaba Wind - Vaisala WMT 700 Anemometer		F I M	background	RSS		Northwest Environ...	nemo-chaba_winds
	set	data	graph		files	NEMO Cha'Ba: SBE-37 CTD		F I M	background	RSS		NWEM Group	chaba_sbe37_historic
	set	data	graph		files	NEMO Subsurface, Seabird SBE37 CTD, Historical data		F I M	background	RSS		Northwest Environ...	nemo-ss_sbe37_historic
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data		F I M	background	RSS		Northwest Environ...	npby1_L1_profiles
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_025
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_025
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_100
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_025
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_100
		data	graph		files	NPBY2 - Carr Inlet - L1 Profile Data		F I M	background	RSS		Northwest Environ...	npby2_L1_profiles
data			graph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 0.25 dbar		M	background	RSS		Northwest Environ...	npby2_L2_gridded_025
data			graph		files	NPBY2 - Carr Inlet - L2 Pressure Gridded Data - 1.00 dbar		M	background	RSS		Northwest Environ...	npby2_L2_gridded_100
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 0.25 meter		M	background	RSS		Northwest Environ...	npby2_L3_depth_climatology_025
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Depth Gridded - 1.00 meter		M	background	RSS		Northwest Environ...	npby2_L3_depth_climatology_100
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 0.25 dbar		M	background	RSS		Northwest Environ...	npby2_L3_climatology_025
data			graph		files	NPBY2 - Carr Inlet - L3 Climatology - Pressure Gridded - 1.00 dbar		M	background	RSS		Northwest Environ...	npby2_L3_climatology_100

NWEM Data Products

ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt+Wells

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

Brought t

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells | Search

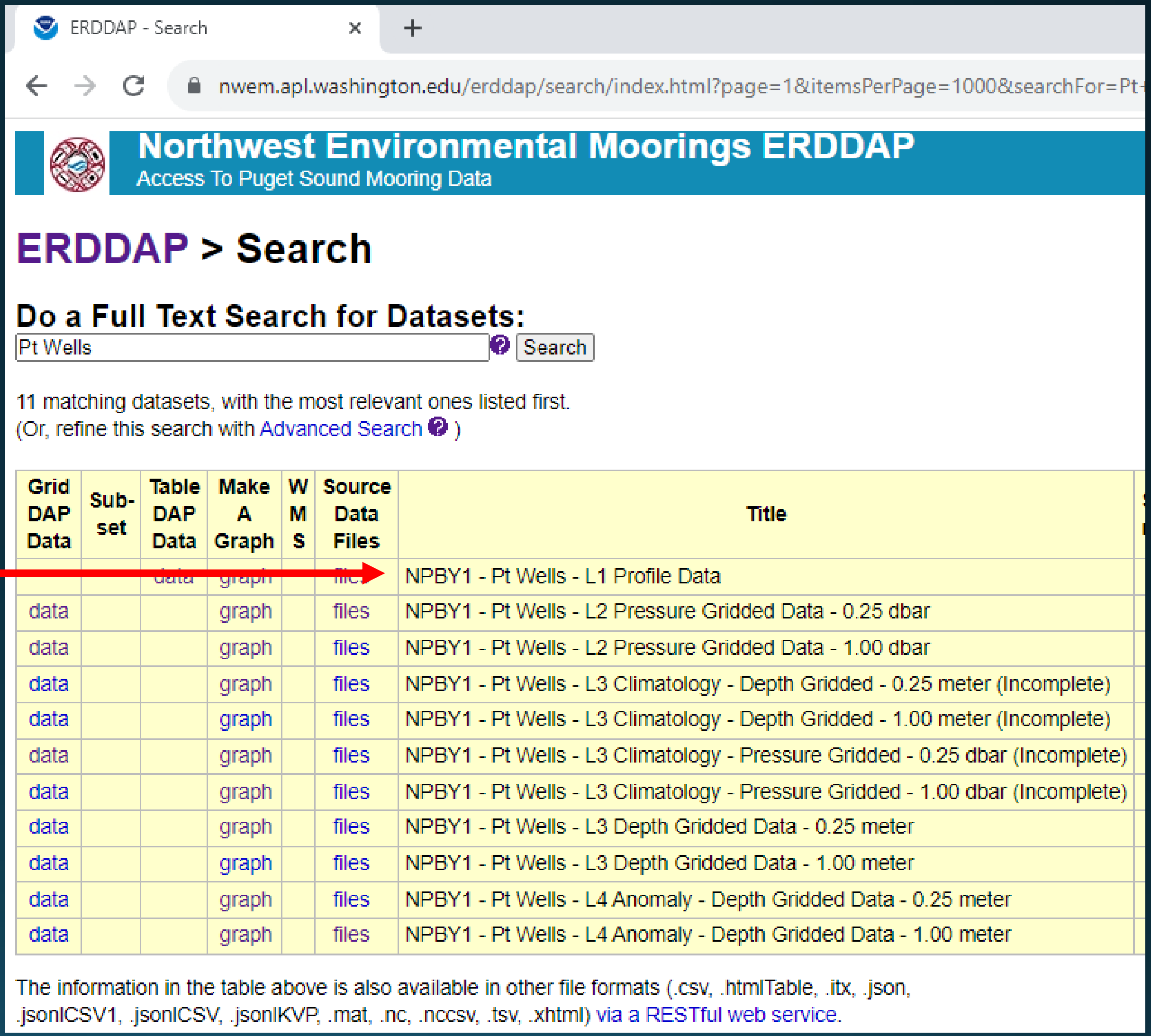
11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title	Sum-mary	FGDC, ISO, Metadata	Back-ground Info	RSS	E mail	Institution	Dataset ID
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data		F I M	background	RSS		Northwest Environ...	npby1_L1_profiles
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_025
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar		M	background	RSS		Northwest Environ...	npby1_L2_gridded_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_depth_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_025
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)		M	background	RSS		Northwest Environ...	npby1_L3_climatology_100
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_025
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L3_depthgridded_100
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_025
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter		M	background	RSS		Northwest Environ...	npby1_L4_anomaly_100

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

NWEM Data Products

- L1: Profile Data
  - Contains every point taken by the CTD package during a cast
  - Contains all the IOOS QARTOD quality control tests performed for every point
- L2: Pressure-Gridded Data
  - The downcast portion of each cast is interpolated onto a uniform pressure grid
  - Gridding is done at 1.00 dbar and 0.25 dbar resolution
- L3: Depth-Gridded Data
  - Pressure-gridded casts are converted into hydrostatic depths, and re-gridded to uniform depth grids
  - Gridding is done at 1.00 m and 0.25 m resolution



ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells | Search

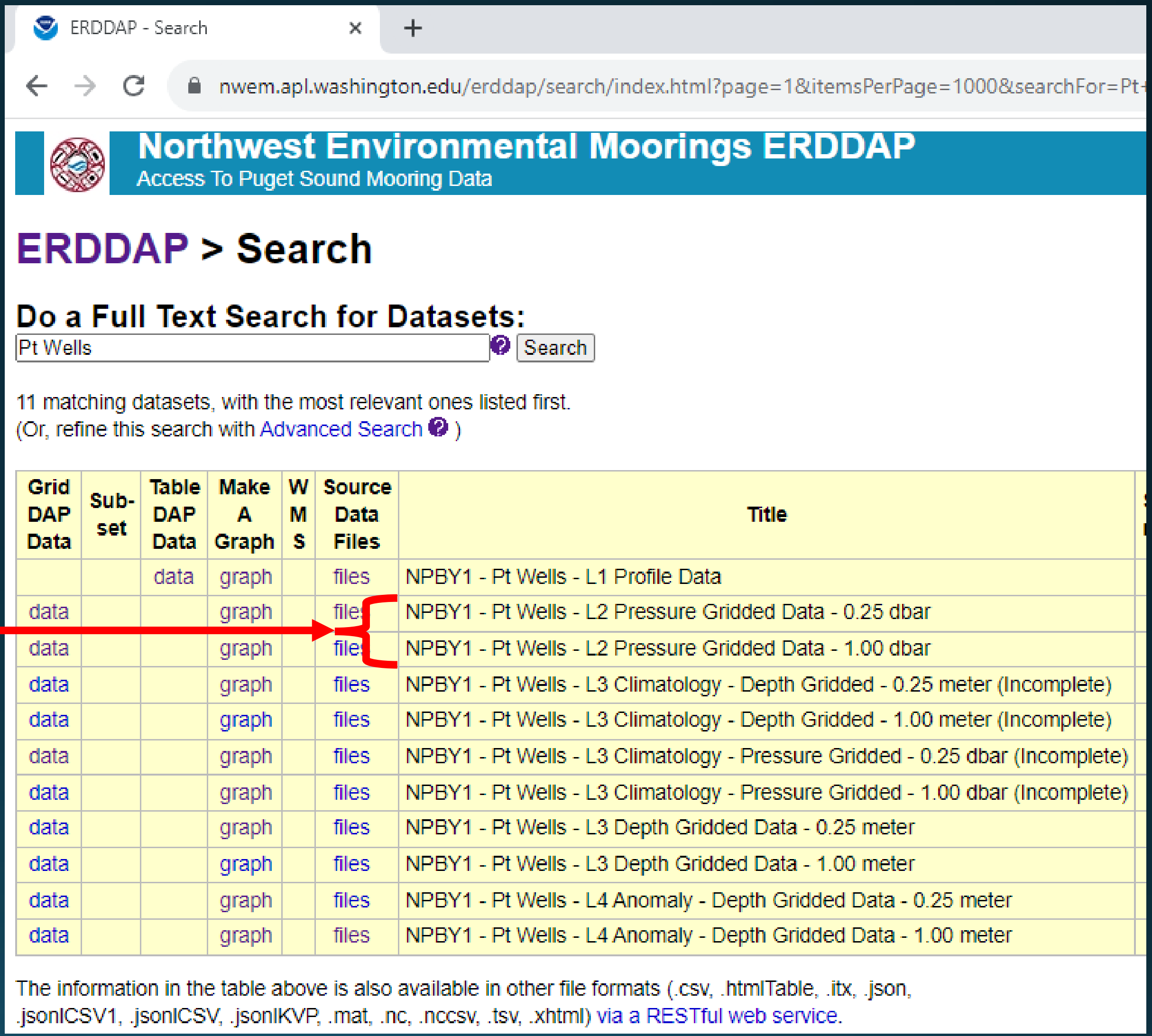
11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

NWEM Data Products

- L1: Profile Data
  - Contains every point taken by the CTD package during a cast
  - Contains all the IOOS QARTOD quality control tests performed for every point
- L2: Pressure-Gridded Data
  - The downcast portion of each cast is interpolated onto a uniform pressure grid
  - Gridding is done at 1.00 dbar and 0.25 dbar resolution
- L3: Depth-Gridded Data
  - Pressure-gridded casts are converted into hydrostatic depths, and re-gridded to uniform depth grids
  - Gridding is done at 1.00 m and 0.25 m resolution



ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells Search

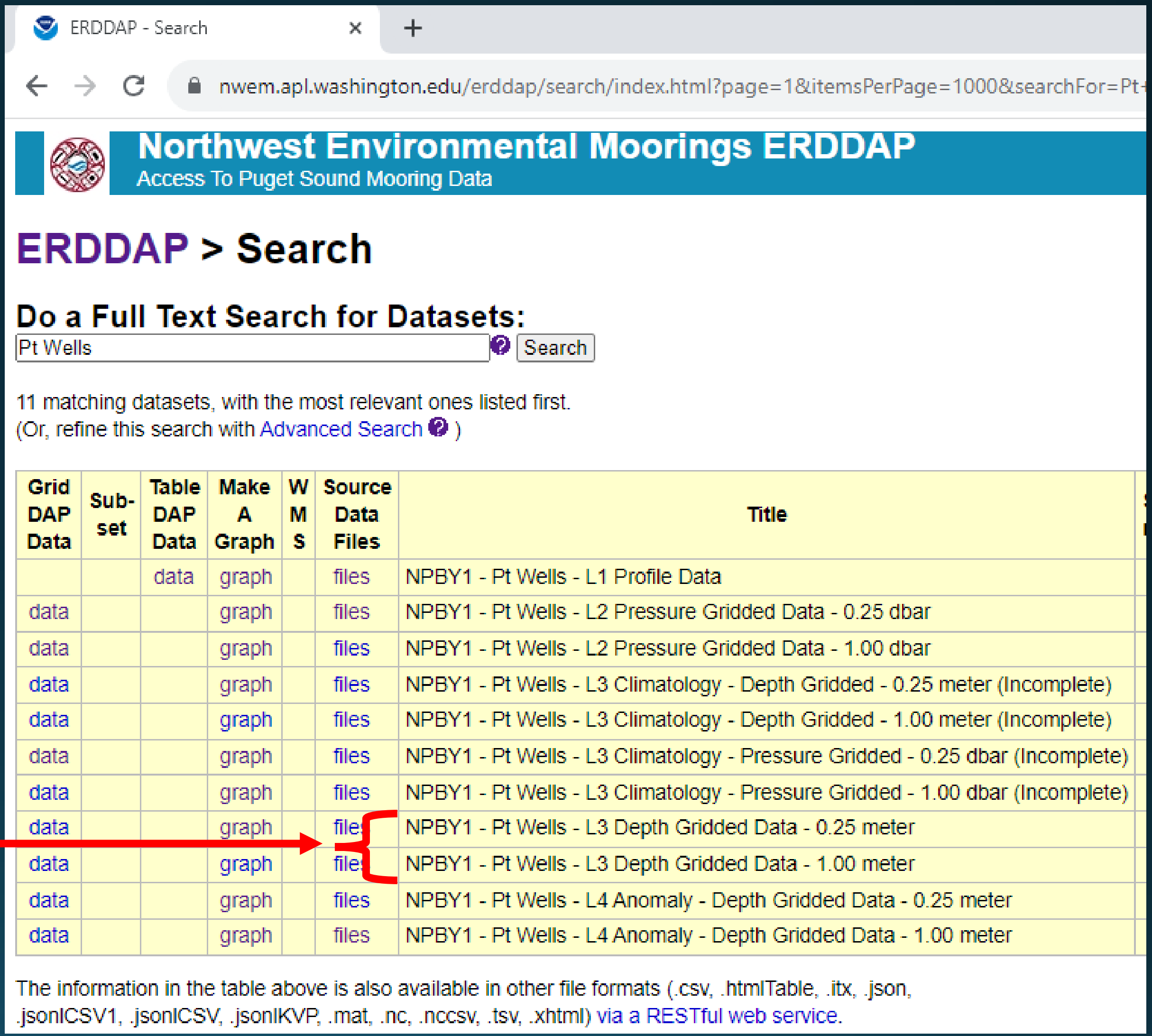
11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	WMS	Source Data Files	Title
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

NWEM Data Products

- L1: Profile Data
  - Contains every point taken by the CTD package during a cast
  - Contains all the IOOS QARTOD quality control tests performed for every point
- L2: Pressure-Gridded Data
  - The downcast portion of each cast is interpolated onto a uniform pressure grid
  - Gridding is done at 1.00 dbar and 0.25 dbar resolution
- L3: Depth-Gridded Data
  - Pressure-gridded casts are converted into hydrostatic depths, and re-gridded to uniform depth grids
  - Gridding is done at 1.00 m and 0.25 m resolution



ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt+

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells Search

11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

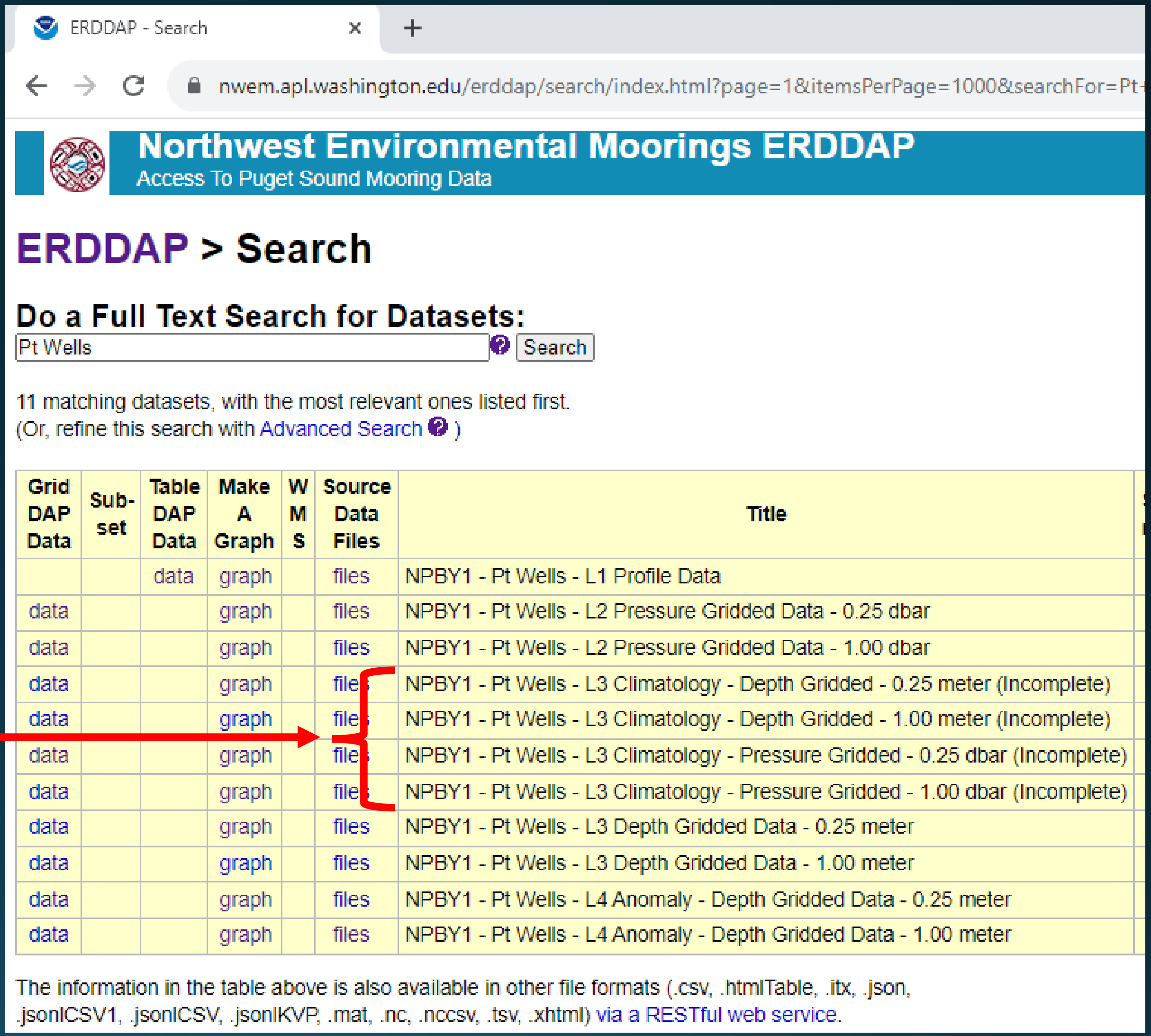
Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

NWEM Data Products

- L3: Climatology
  - Climatological means and standard deviations for each sensor variable are created
  - Climatologies are only considered “complete” if we have at least 6 full years of data over the time period used (2010-2022)
  - Only 3 buoys have “complete” climatologies: ORCA1 – Twanoh, ORCA2 – Hoodsport, and NPBY2 – Carr Inlet
  - Climatologies are made for pressure- and depth-gridded data, at all resolutions: 1.00 dbar and 0.25 dbar for pressure-gridded; 1.00 m and 0.25 m for depth-gridded

- L4: Anomaly
  - Depth-gridded data with the climatological mean for the cast day-of-year removed
  - At 1.00 m and 0.25 m resolution



ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt+

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells Search

11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

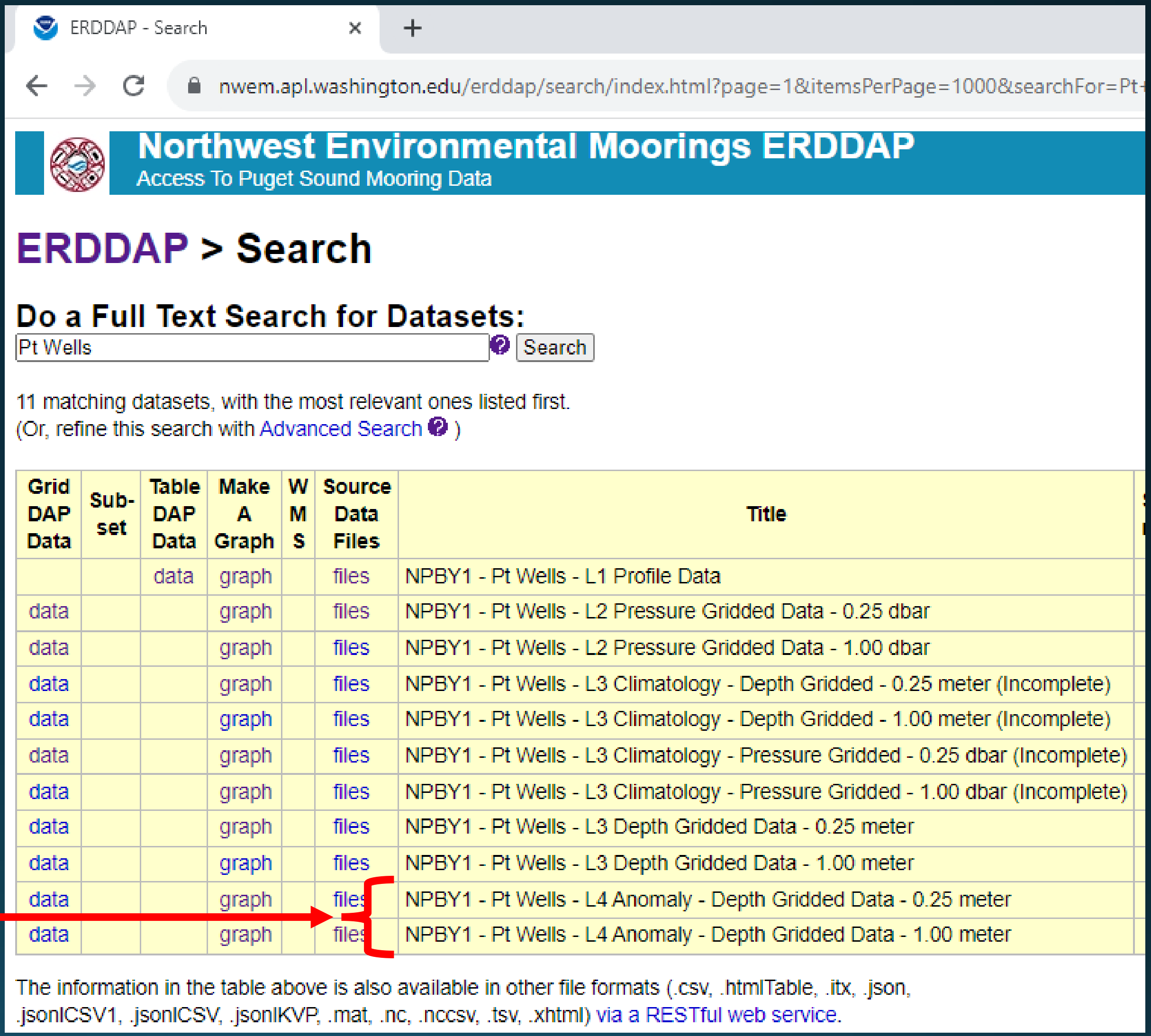
Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	WMS	Source Data Files	Title
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

NWEM Data Products

- L3: Climatology
  - Climatological means and standard deviations for each sensor variable are created
  - Climatologies are only considered "complete" if we have at least 6 full years of data over the time period used (2010-2022)
  - Only 3 buoys have "complete" climatologies: ORCA1 – Twanoh, ORCA2 – Hoodsport, and NPBY2 – Carr Inlet
  - Climatologies are made for pressure- and depth-gridded data, at all resolutions: 1.00 dbar and 0.25 dbar for pressure-gridded; 1.00 m and 0.25 m for depth-gridded

- L4: Anomaly
  - Depth-gridded data with the climatological mean for the cast day-of-year removed
  - At 1.00 m and 0.25 m resolution



ERDDAP - Search

nwem.apl.washington.edu/erddap/search/index.html?page=1&itemsPerPage=1000&searchFor=Pt

Northwest Environmental Moorings ERDDAP

Access To Puget Sound Mooring Data

ERDDAP > Search

Do a Full Text Search for Datasets:

Pt Wells Search

11 matching datasets, with the most relevant ones listed first.
(Or, refine this search with Advanced Search)

Grid DAP Data	Sub-set	Table DAP Data	Make A Graph	W M S	Source Data Files	Title
		data	graph		files	NPBY1 - Pt Wells - L1 Profile Data
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 0.25 dbar
data			graph		files	NPBY1 - Pt Wells - L2 Pressure Gridded Data - 1.00 dbar
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 0.25 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Depth Gridded - 1.00 meter (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 0.25 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Climatology - Pressure Gridded - 1.00 dbar (Incomplete)
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L3 Depth Gridded Data - 1.00 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 0.25 meter
data			graph		files	NPBY1 - Pt Wells - L4 Anomaly - Depth Gridded Data - 1.00 meter

The information in the table above is also available in other file formats (.csv, .htmlTable, .itx, .json, .jsonlCSV1, .jsonlCSV, .jsonlKVP, .mat, .nc, .nccsv, .tsv, .xhtml) via a RESTful web service.

ERDDAP – NWEM Demonstration

Let’s walk through some examples of downloading data from the NWEM ERDDAP server:

https://nwem.apl.washington.edu/erddap/index.html

ERDDAP – Download via Data URL

- ERDDAP creates data URLs which can be used to download data

- By understanding the format of these URLs, they can be manipulated to download the data of your choosing

- Example Download From TableDap:
  https://nwem.apl.washington.edu/erddap/tabledap/orca2_L1_profiles.csv?cast_number%2Ctime%2Csample_time%2Csea_water_pressure%2Csea_water_temperature&time%3E=2023-10-24T19%3A00%3A08Z&sea_water_temperature_qc_agg%3C=3

ERDDAP – Download via Data URL

- TableDAP: Deconstruct the Example:

  https://nwem.apl.washington.edu/erddap/tabledap/orca2_L1_profiles.csv?cast_number%2Csample_time%2Csea_water_pressure%2Csea_water_temperature&time%3E=2023-10-24T19%3A00%3A08Z&sea_water_temperature_qc_agg%3C=3

- Base url: https://nwem.apl.washington.edu/erddap
- ERDDAP Data Type: tabledap
- dataset_id: orca2_L1_profiles
- Desired file format: csv
- Selected Variables: {cast_number, sample_time, sea_water_pressure, sea_water_temperature}
- Constraints: {time%3E=2023-10-24T19%3A00%3A08Z, sea_water_temperature_qc_agg%3C=3}

ERDDAP – Additional Resources

- Coast Watch ERDDAP Tutorial – Best Resource: https://coastwatch.gitbook.io/satellite-course/tutorials/erddap-tutorial

- Python – Direct Interface Client:
  - erddapy: https://ioos.github.io/erddapy/
- R – Direct Interface Client:
  - rerddap: https://cran.r-project.org/web/packages/rerddap/index.html
- Matlab – It may be possible if you have the Mapping Toolbox

NWEM ERDDAP

Any questions?

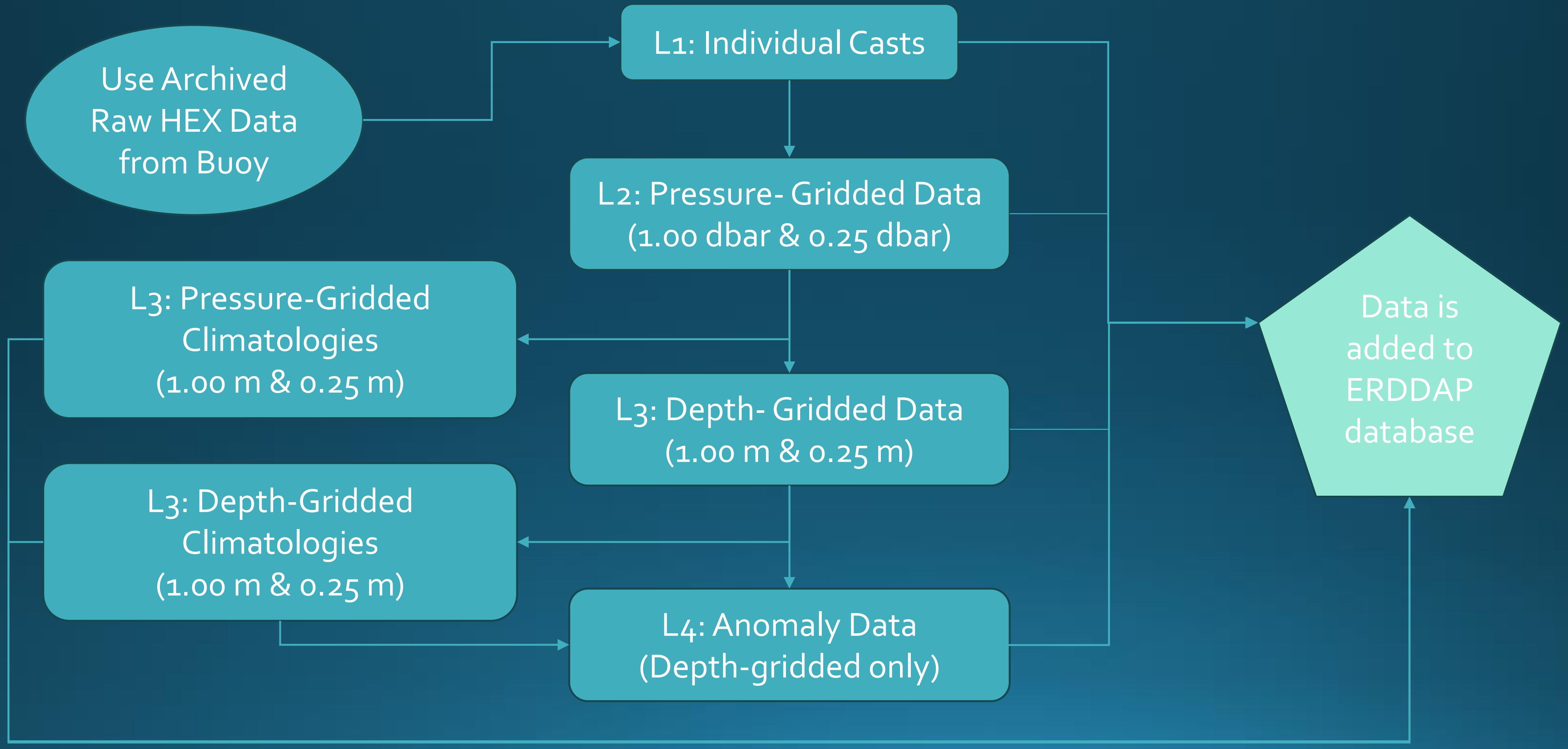
Seth Travis: setht1@uw.edu

NWEM – ORCA Data Processing

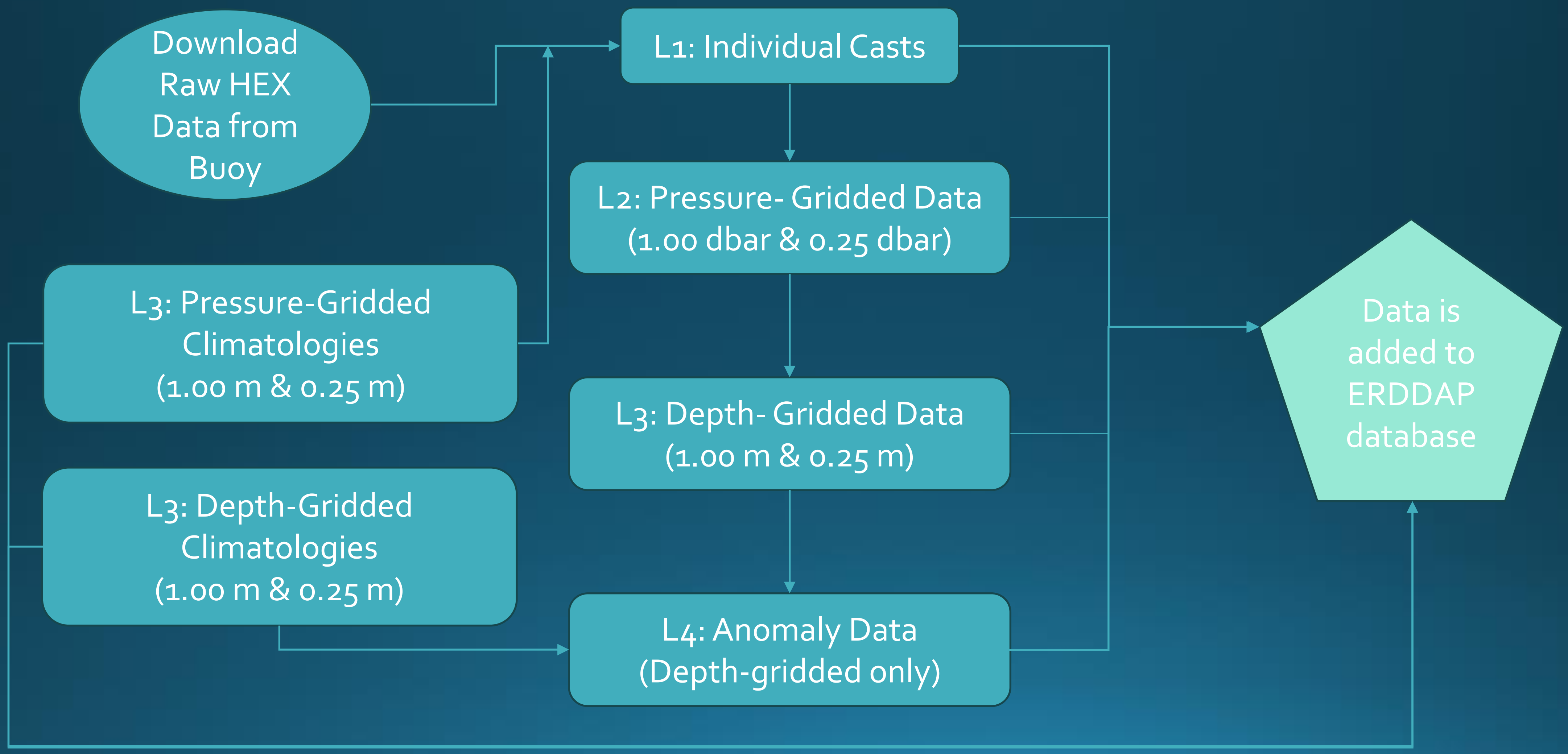
Data Manual Can Be Found Here:
https://nwem.apl.washington.edu/orca_datamanuals/ORCA_DataProcessing_Manual.pdf

- L1: Profile Data
  - Contains every point taken by the CTD package during a cast
  - Contains all the QARTOD tests performed for every point
- L2: Pressure-Gridded Data
  - The downcast portion of each cast is interpolated onto a uniform pressure grid
  - Gridding is done at 1.00 dbar and 0.25 dbar resolution
- L3: Depth-Gridded Data
  - Pressure-gridded casts are converted into hydrostatic depths, and re-gridded to uniform depth grids
  - Gridding is done at 1.00 m and 0.25 m resolution
- L3: Climatology
  - Climatological means and standard deviations for each sensor variable are created
  - Climatologies are only considered "complete" if we have at least 6 full years of data over the time period used (2010-2022)
  - Only 3 buoys have "complete" climatologies: ORCA1 – Twanoh, ORCA2 – Hoodsport, and NPBY2 – Carr Inlet
  - Climatologies are made for pressure- and depth-gridded data, at all resolutions: 1.00 dbar and 0.25 dbar for pressure-gridded; 1.00 m and 0.25 m for depth-gridded
- L4: Anomaly
  - Depth-gridded data with the climatological mean for the cast day-of-year removed
  - At 1.00 m and 0.25 m resolution

Data Initial Workflow

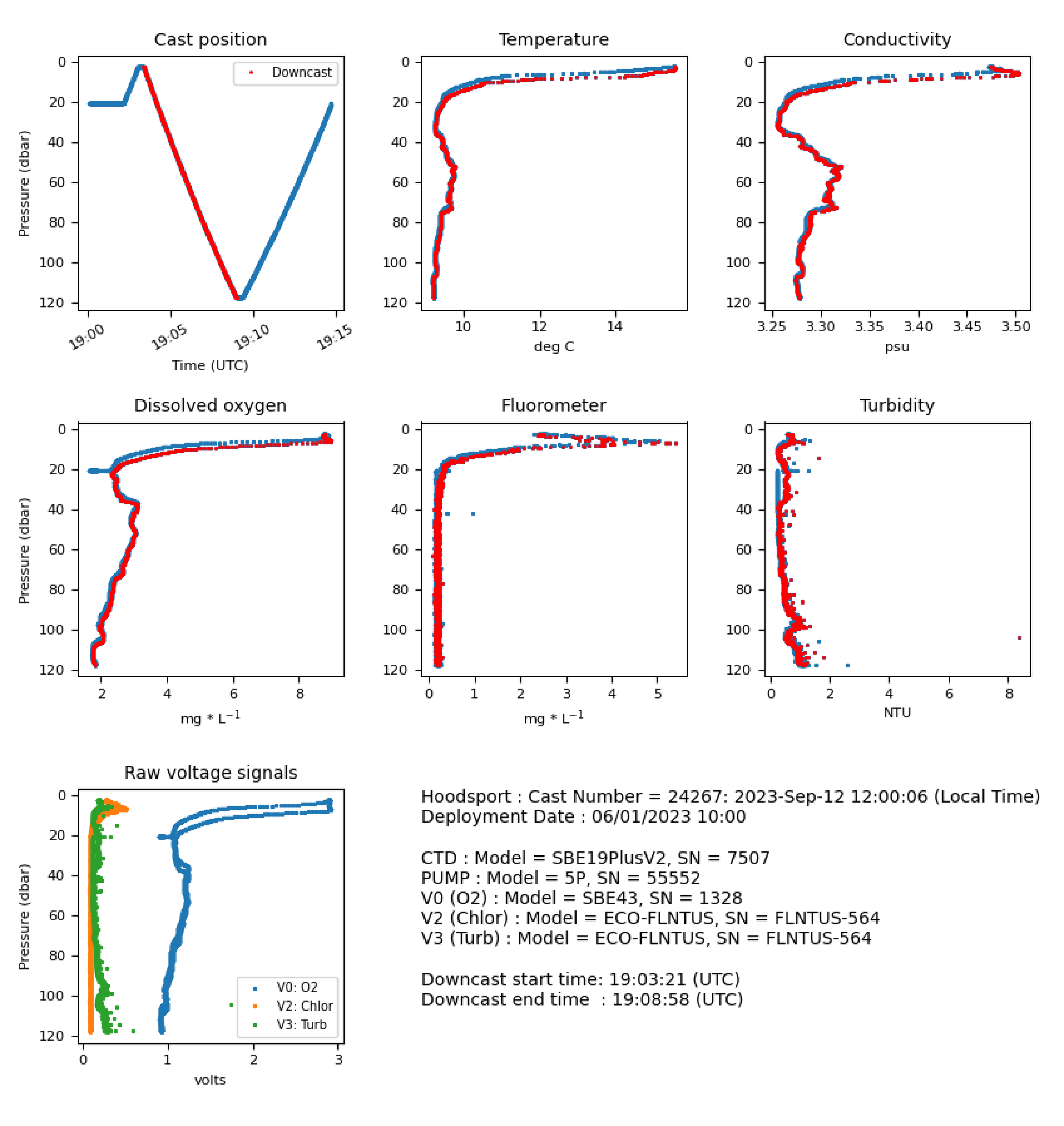


Data Ingestion Workflow



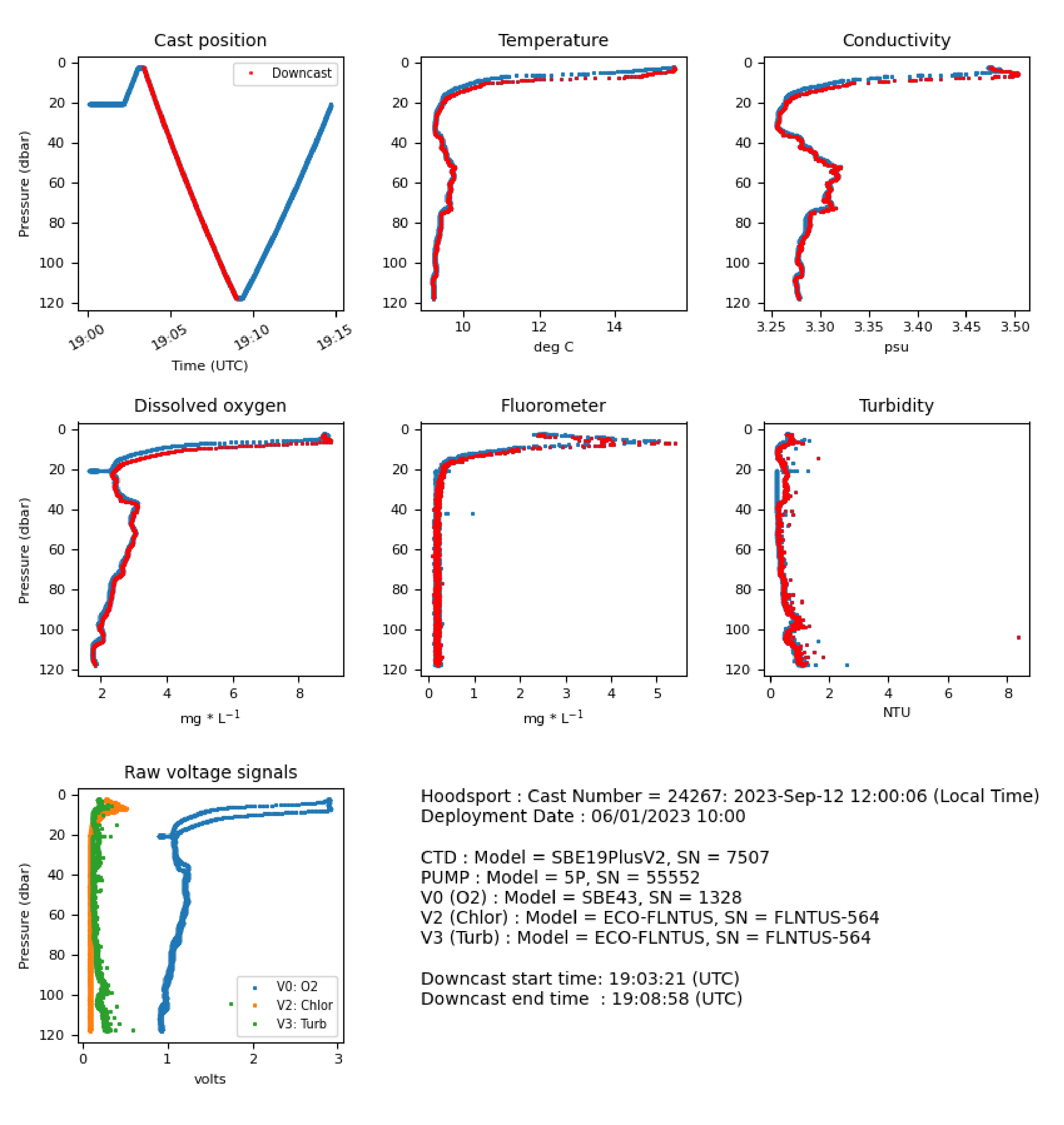
Typical Cast

- Each cast samples at 4 Hz, with the CTD package moving at a target speed of 25 cm/s
  - A sample is taken every ~6 cm when package is moving
  - For a 100 m cast, this results in ~1600 samples for just the downcast portion of each cast



Typical Cast

- Sensor calibrations applied to each cast
- Sensor alignment performed on every cast
  - Needed to ensure sensor measurement corresponds to correct water parcel (ex. Salinity spiking)
- All these parameters are stored in the individual netCDF files for each cast



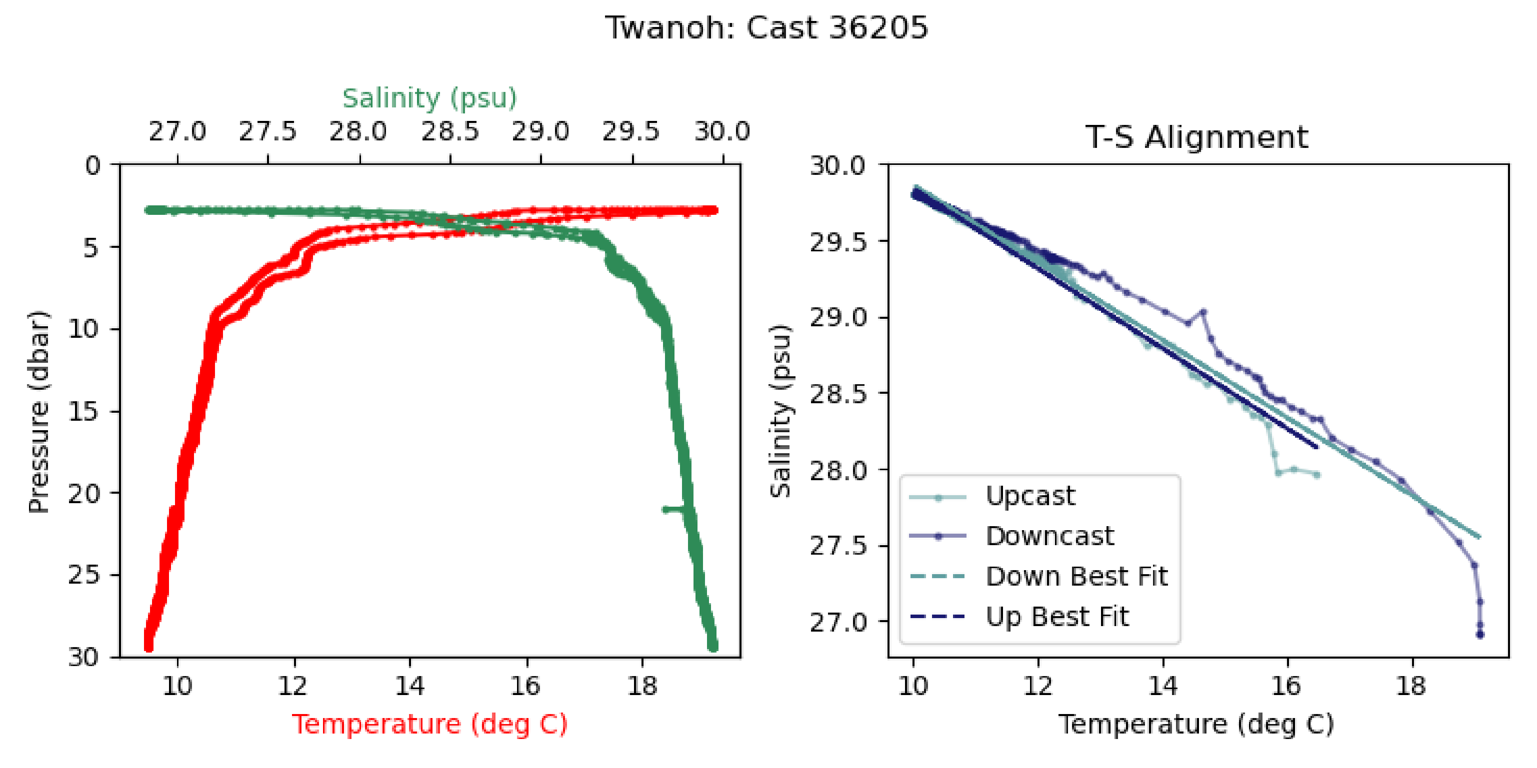
Data QA/QC

- For every cast, IOOS-standard QARTOD tests are performed, assigning a QC flag value to every point
  - 1 = good, 3 = questionable, 4 = bad, 9 = untested
  - QARTOD tests performed:
    - Spike test, flat-line test, gross-range test, climatology test
    - Check NWEM ORCA Data manual for the thresholds we use
- We perform a few additional tests that we've developed in-house. If any of these fail, the whole cast "fails"
  - Ensure that CTD port is not clogged by making sure T-S space on downcast is same as on upcast
  - Ensure that non-CTD based sensors aligned on up- and downcasts
  - Check for density inversions in the dataset
  - Make sure that pressure data is good

Data QA/QC

Correctly aligned

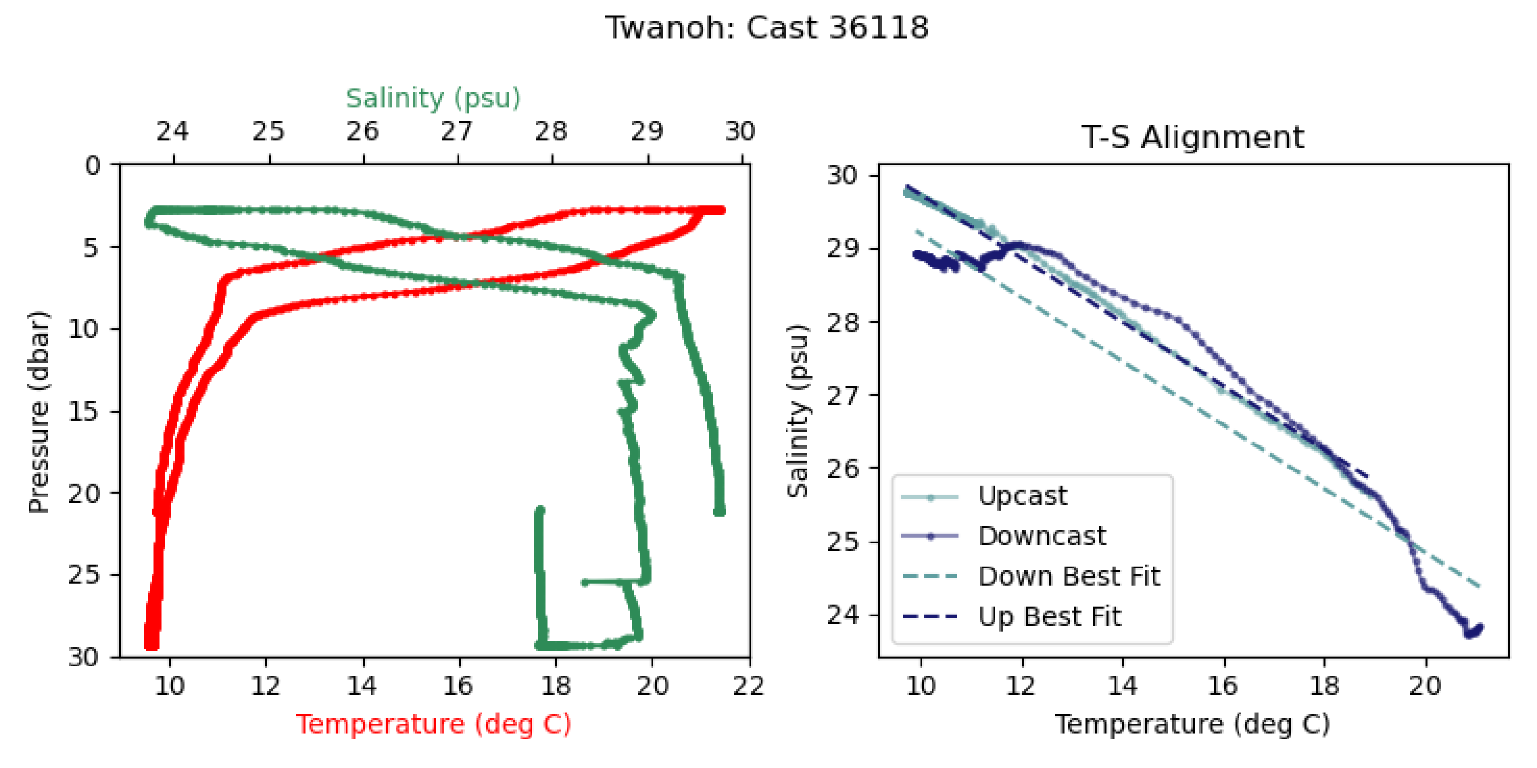
- T-S Alignment Test:
  - This test checks to ensure that the temperature-salinity signature on the up- and downcast are the same



Data QA/QC

Incorrectly aligned

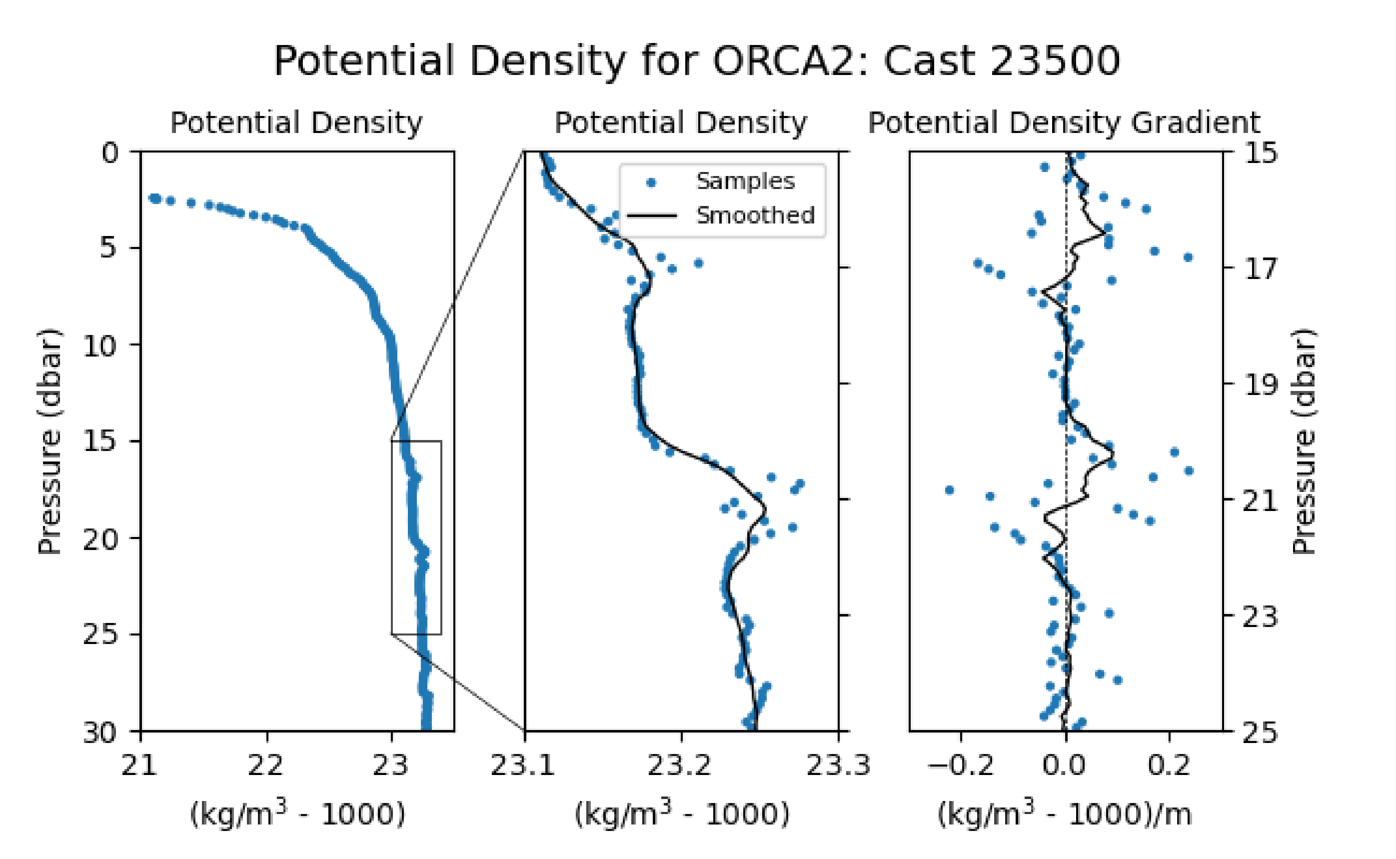
- T-S Alignment Test:
  - Pump port for CTD sampling can get clogged
  - When this happens, the values that the CTD samples look realistic, but seem odd



  - By testing if the up- and downcast have the approximately the same temperature-salinity (T-S) signal, we can check to see if the CTD is functioning correctly

Data QA/QC

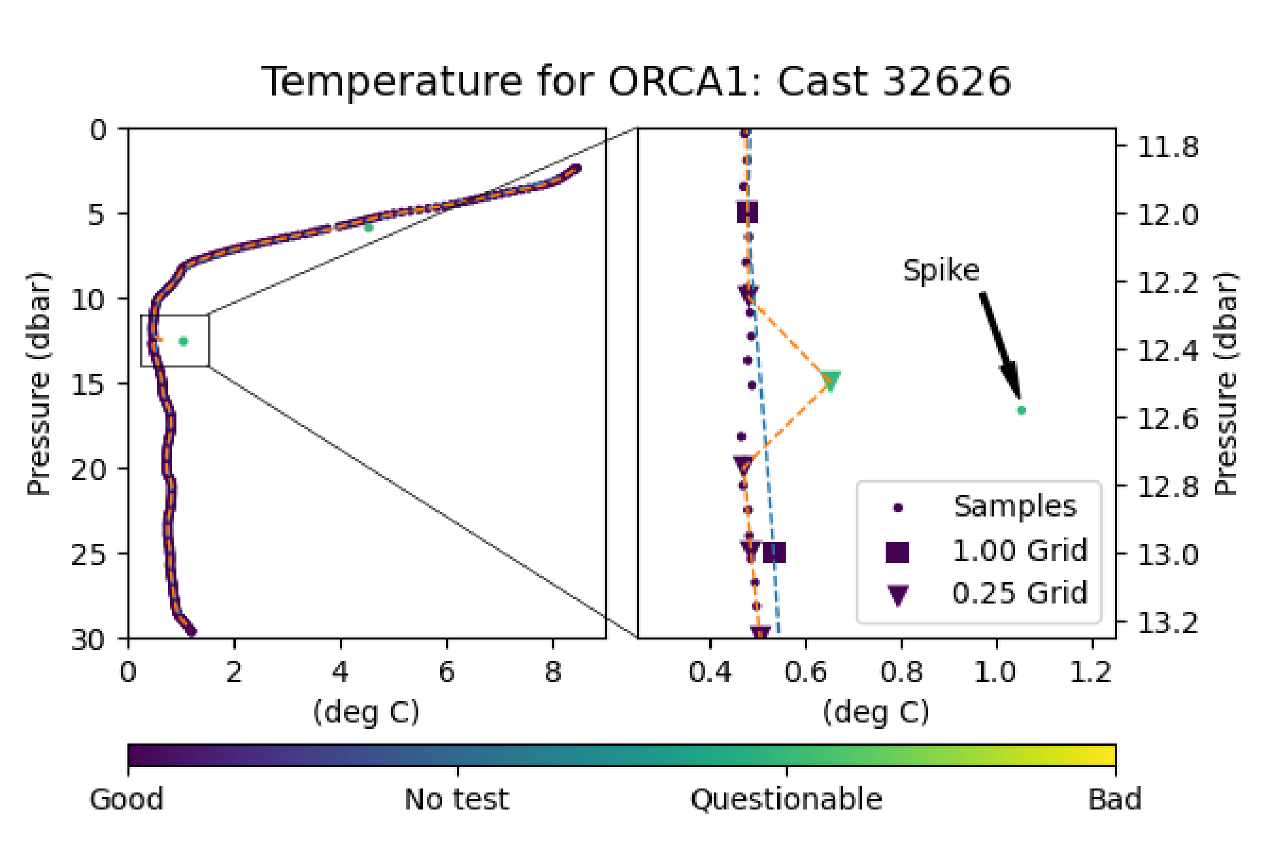
- Density Inversion Test:
  - We check for any density inversions that occur in a profile
  - Small density inversions could be detected, and shouldn't be discounted



- We look for large density inversions, or inversions that occur over a significant portion of the water column
- If inversions are detected, we assume the whole profile is suspect, and flag as bad

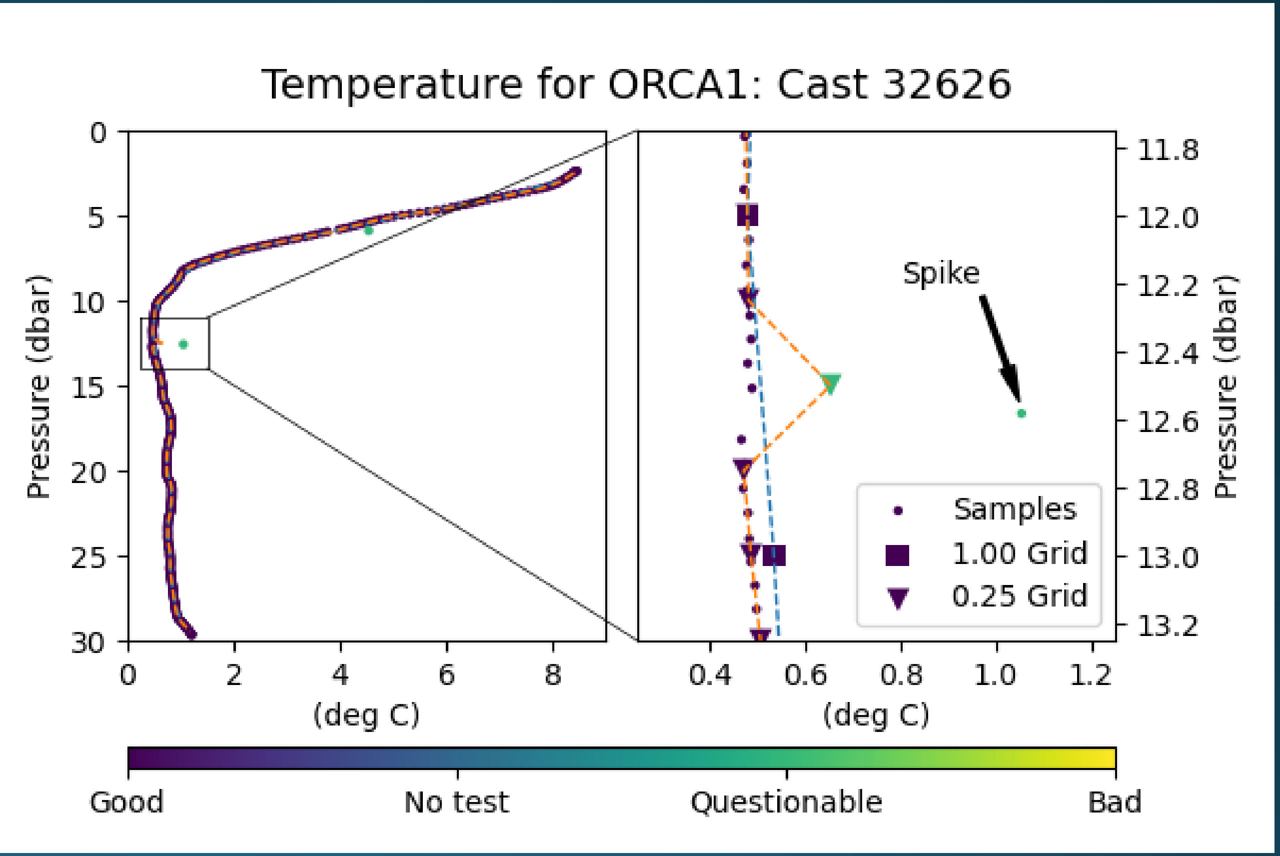
Pressure-Gridding

- When gridding the data, we first smooth the data with a rolling centered mean with a window width of 1-grid size
    - Ex. 0.25 dbar smoothing window for 0.25 gridded-data
- Bad data (QC_flag = 4) is excluded from the smoothing
- The smoothed data is then interpolated onto the fixed pressure grid

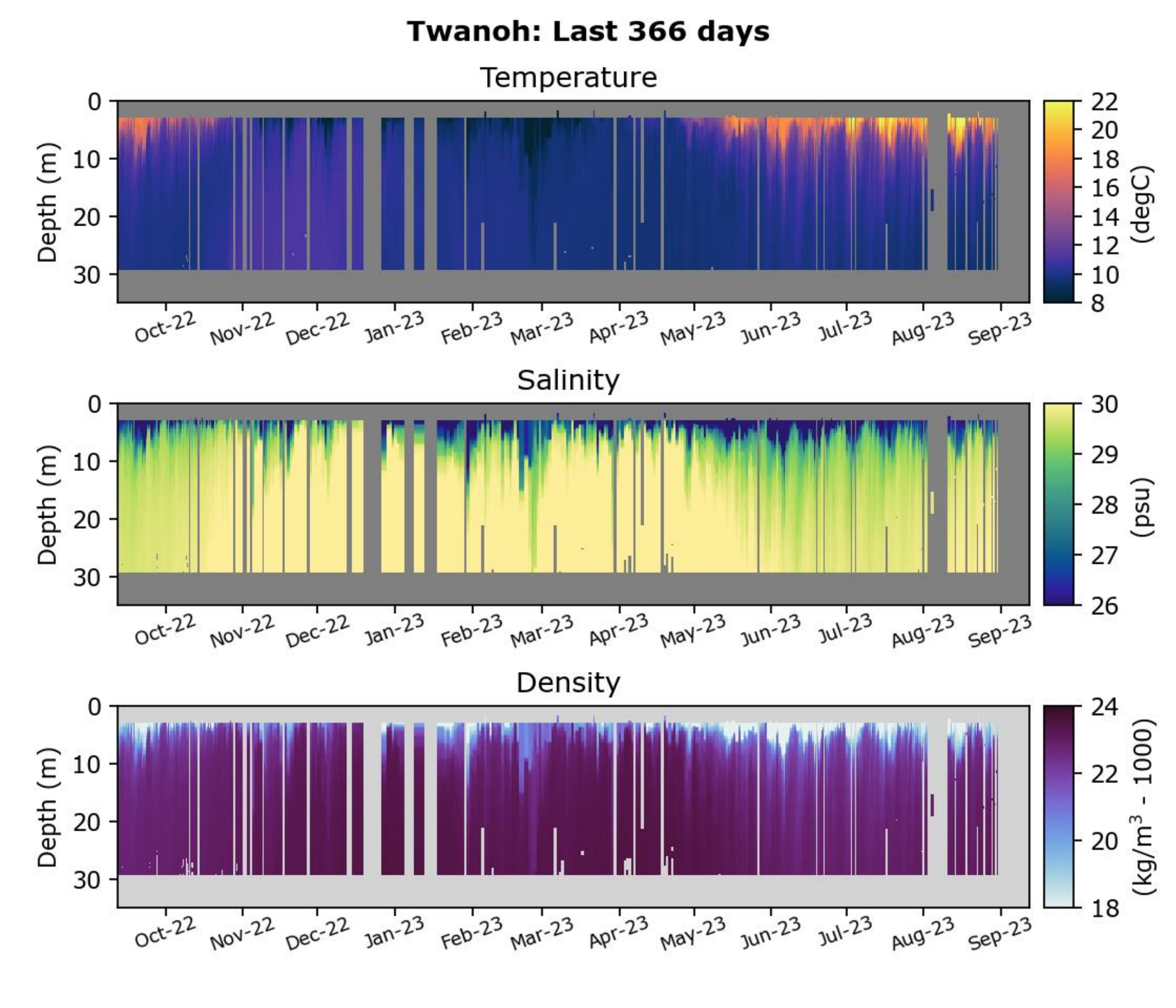


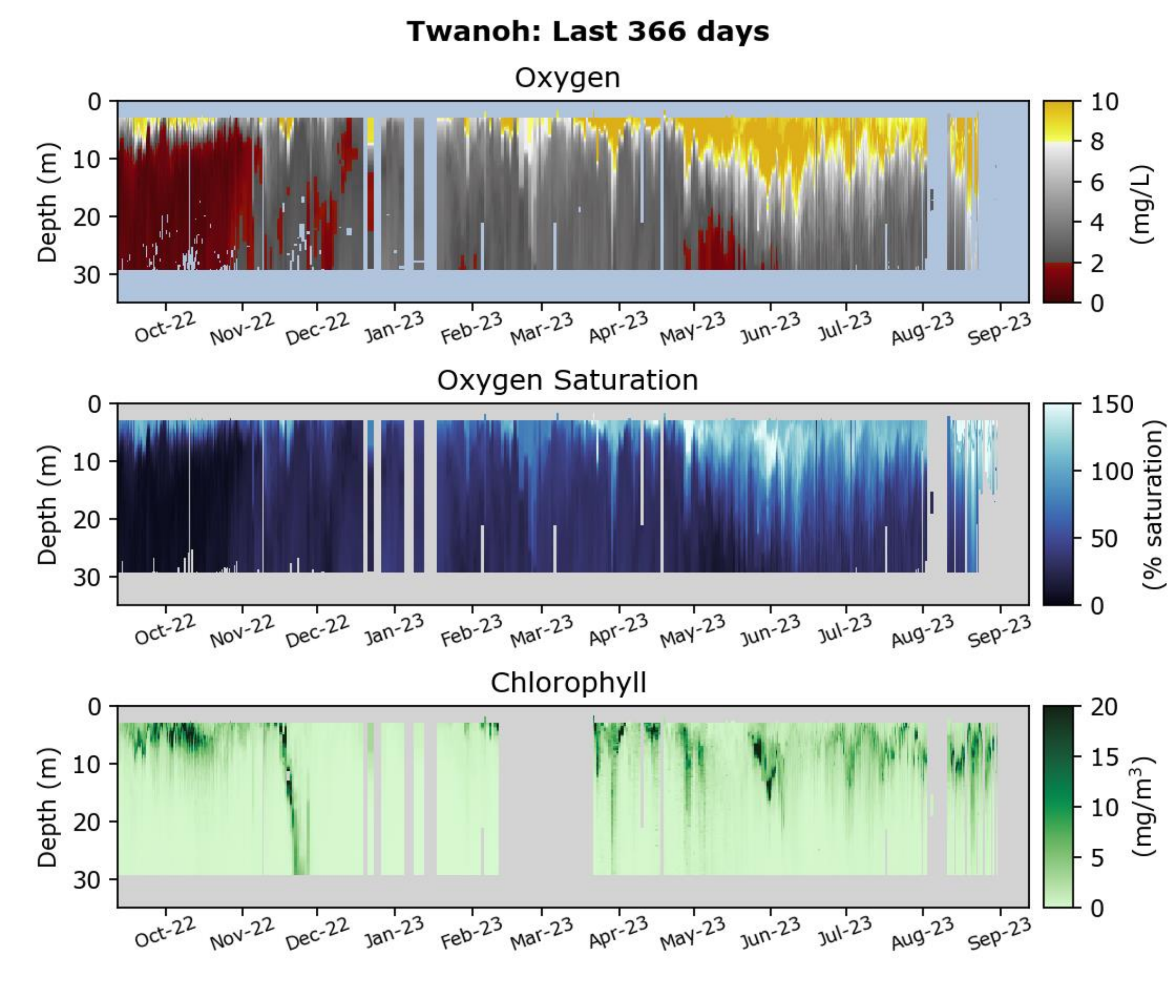
Pressure-Gridding

- QC flags are propagated through by checking all QC flags with +/-0.5 grid-size
  - Ex. For 1.00 dbar gridding, the point at 10.0 dbar uses data between 9.5-10.5 dbar
- If all QC flags within the window = 4, then the new QC flag = 4
- If there is no data within the window, the new QC flag = 3
- If the QC flag for >25% of points in the window = 3, then the new QC flag = 3
- For all other cases, assume the data is good, and the new QC flag = 1



Gridded Data





Depth-Gridding

- Pressure is roughly equivalent to depth, but not exactly
- Depth is a more natural coordinate for many users
- To convert our pressure-gridded data to depth-gridded data, we:
  - Calculate a hydrostatic depth from our pressure-gridded for every cast: $d(p) = \int \delta p/(\rho(p)g)$
  - Interpolate the hydrostatic depth onto a fixed depth grid

Climatologies

- Climatological means and standard deviations for each sensor variable are created
- Time period used is 2010 – 2022; Only consistent time period across all buoys
- Climatologies are only considered "complete" if we have at least 6 full years of data
- Only 3 buoys have "complete" climatologies:
  ORCA1 – Twanoh, ORCA2 – Hoodsport, and NPBY2 – Carr Inlet
- Climatologies are made for pressure- and depth-gridded data, at all resolutions:
  Pressure: 1.00 dbar and 0.25 dbar; Depth: 1.00 m and 0.25 m

Climatologies

1. First, we average all gridded casts taken on any given day
   - Prevents biasing against days with higher sampling, such as during the summer

2. Find the day-of-year for every cast

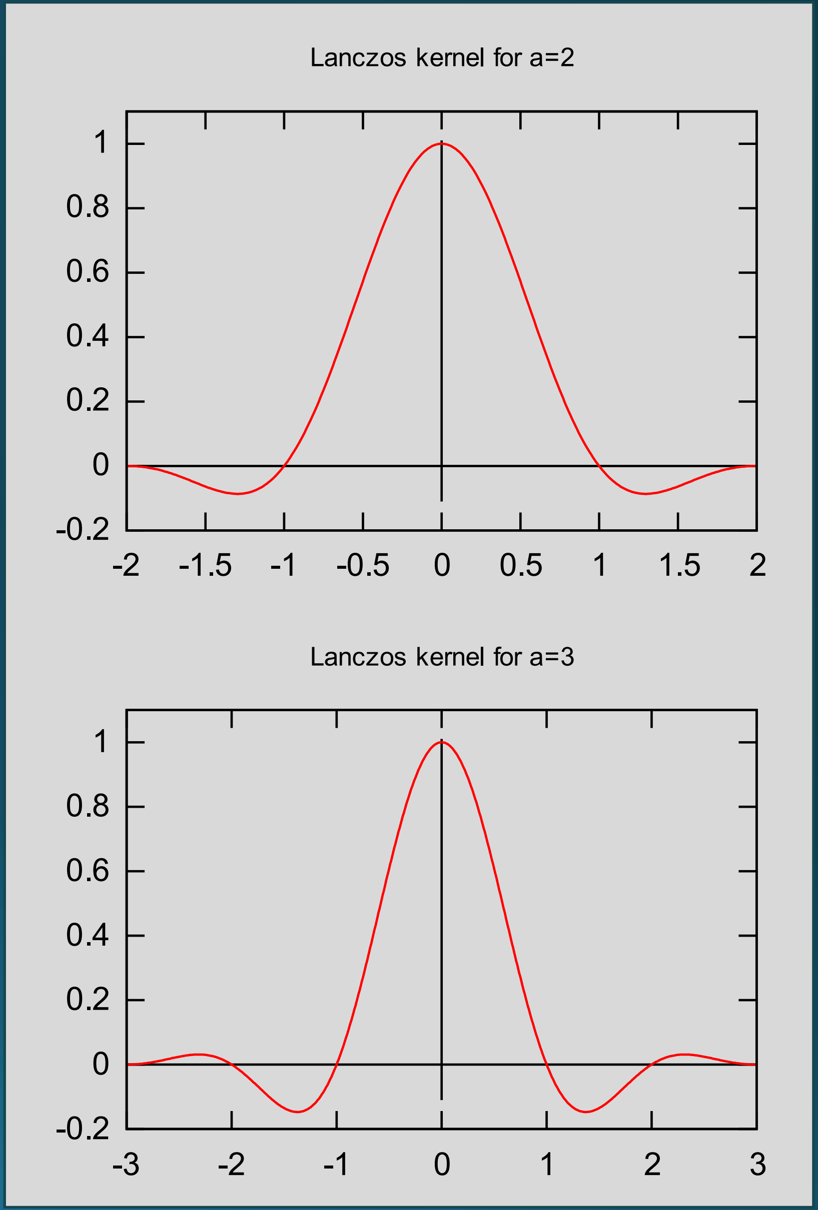
3. Average the all data by z-level (pressure or depth) and day-of-year

Climatologies

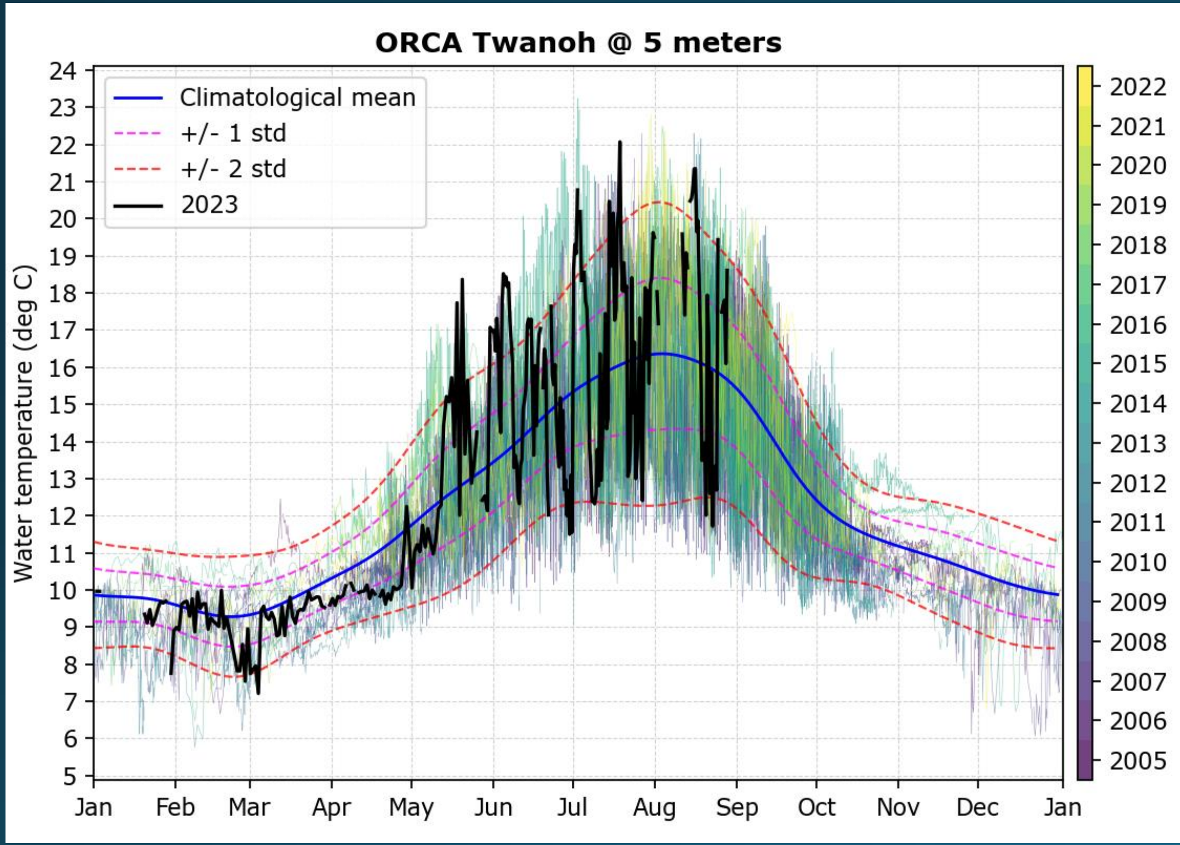
4. Perform a 2-D convolution smoother

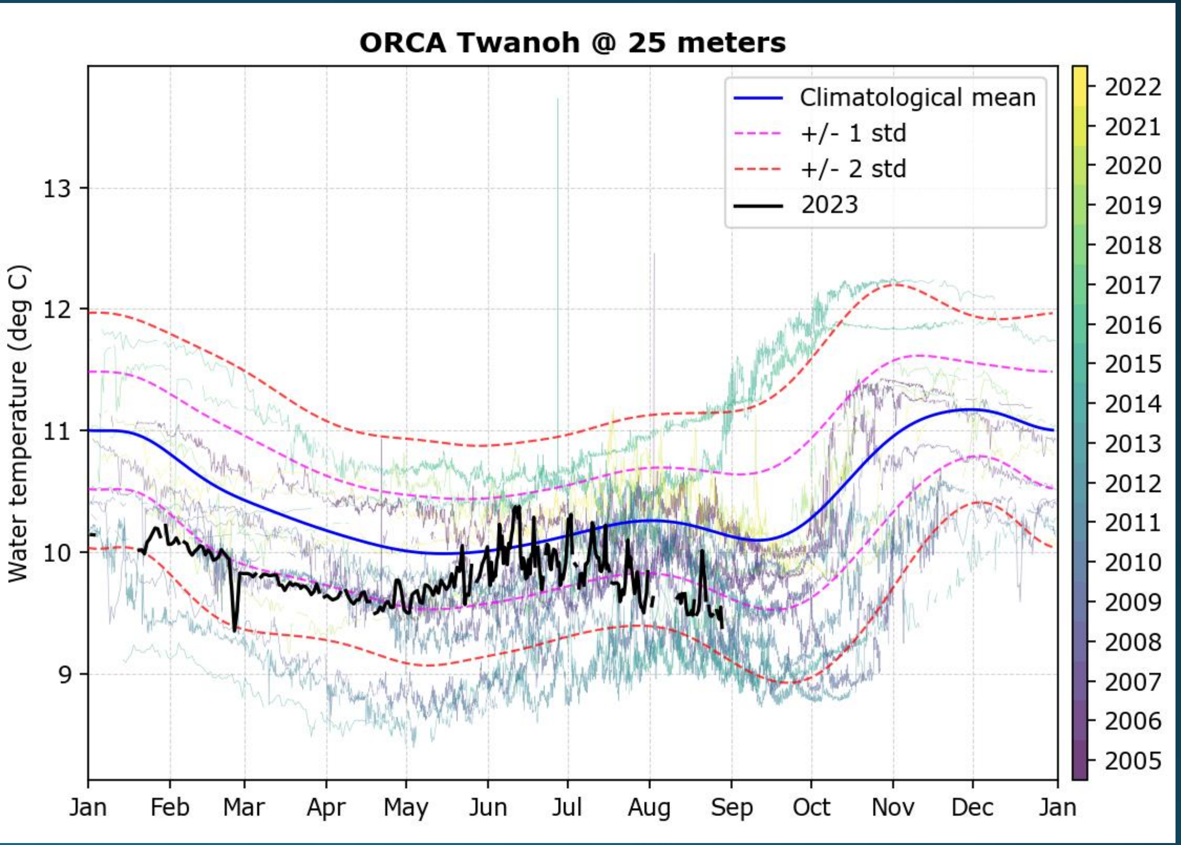
- Using a 2nd order Lanczos filter, with a 6-week time-dimension half-width and 2.5 z-units (dbar or m) z-dimension half-width

- Use periodic boundaries in the time-dimension (i.e., smoother loops around from December to January)



Climatology Data

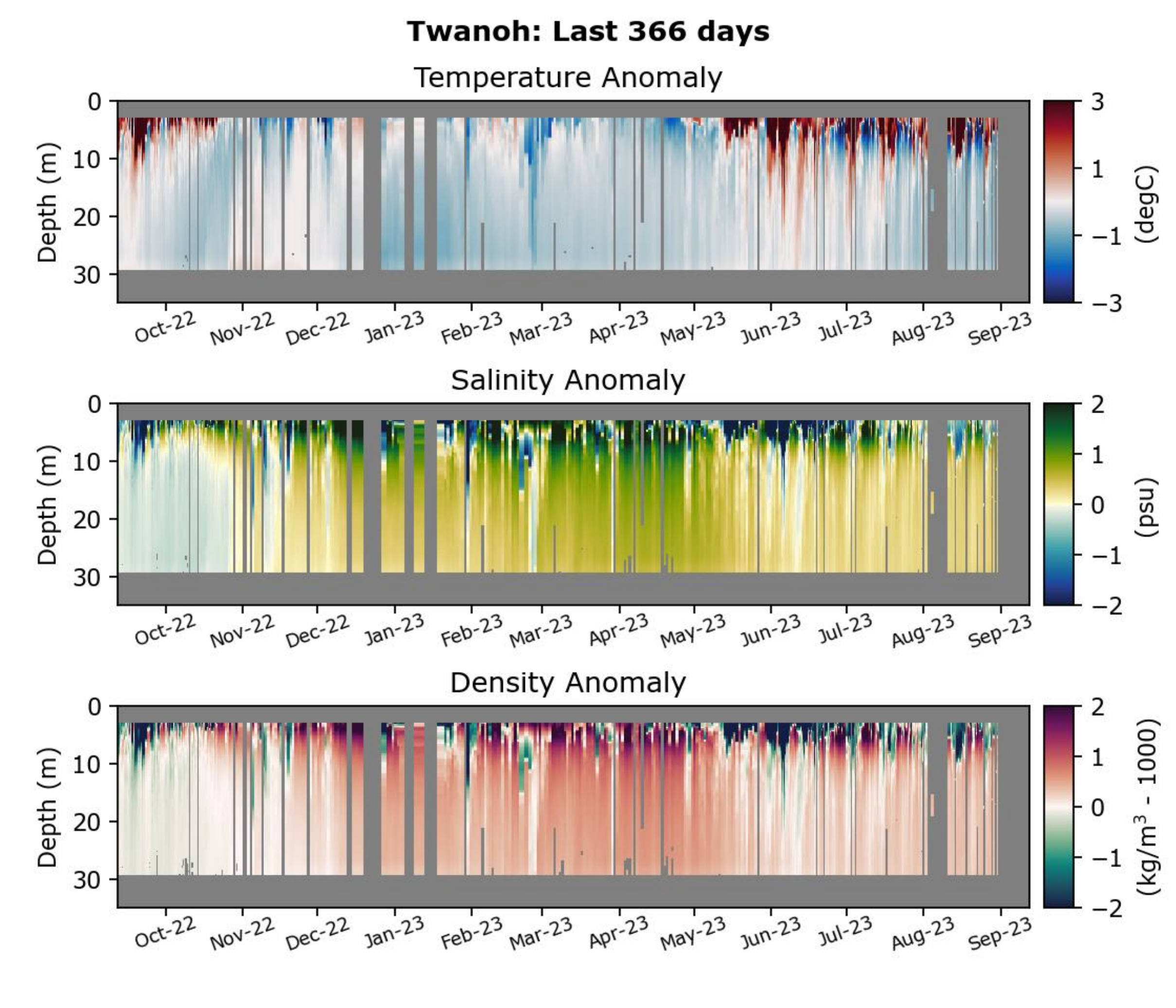


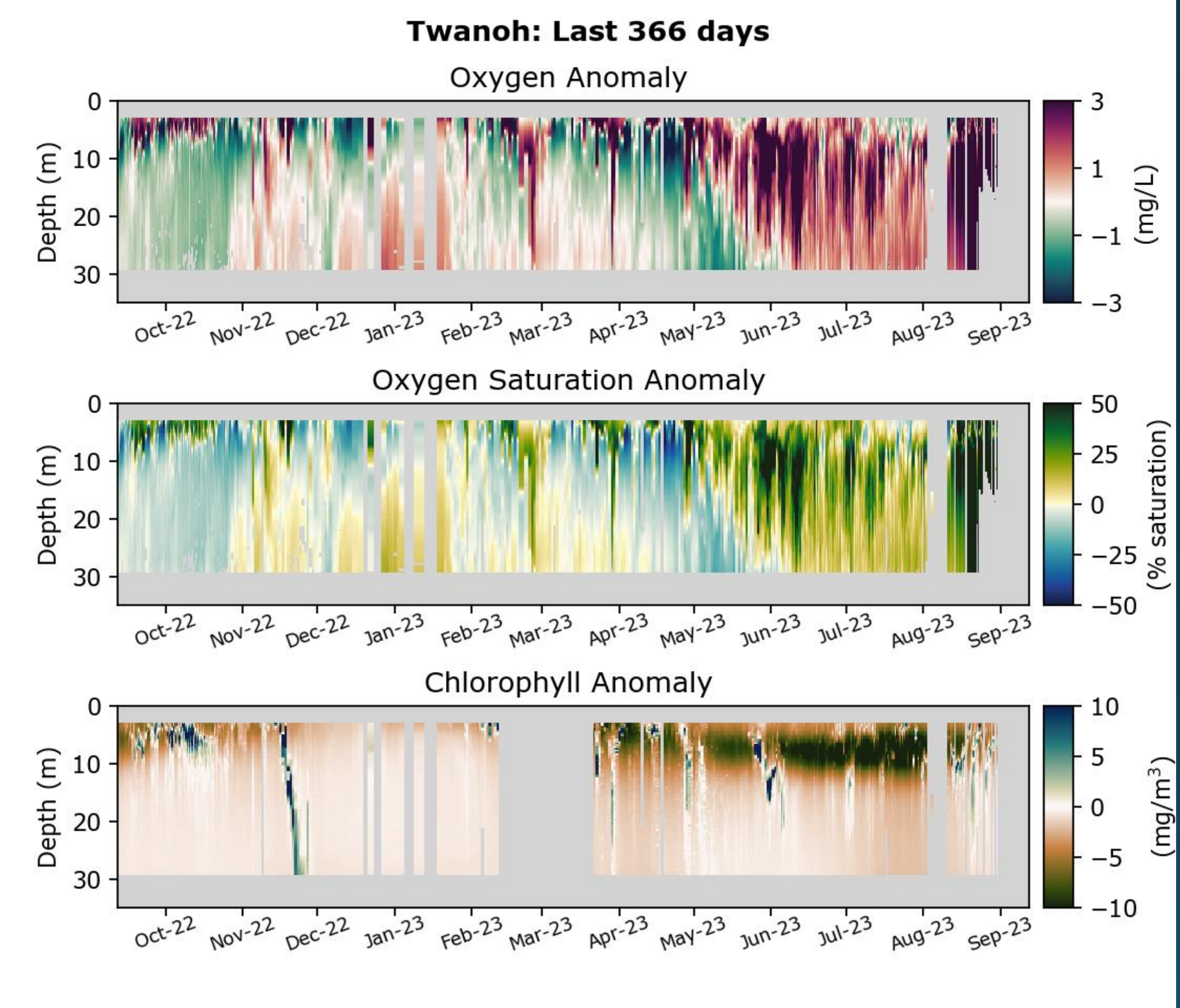


Anomalies

- Anomaly data is only calculated from depth-gridded data
- To find anomalies, we take the day-of-year for any given cast, and subtract of the climatological mean for the same day-of-year

Anomaly Data





Data Access

- All data has been posted to an ERDDAP server, hosted on the NWEM server: https://nwem.apl.washington.edu/erddap/index.html
  - All buoys have L1-L4 data products, with 1.00 and 0.25 gridding for L2-L4 products (11 products per buoy)
  - Immediately after data processing, all data is added to the ERDDAP data directory
  - The data directory refreshes itself:
    - Every 15 seconds for changed files
    - Every 15 minutes for added files

- Typical time from completing sampling cast to posting on ERDDAP is <6 hours; mostly limited by how often we are able to connect to buoys

NWEM ERDDAP

Any questions?

Seth Travis: setht1@uw.edu