DO Worked Example

This example is provided by Kristen Fogaren (fogaren@bc.edu) on August 8, 2022. Thanks to Craig Risien (craig.risien@oregonstate.edu) for providing the code to directly pull netCDF files from THREDDS server. Pulled netCDF were converted to *.csv files and provided to allow for duplication of this worked example in any coding language.

Note: users will also need download the Gibbs Sea Water Package to add to current Matlab path

Overview

Here, we provide end-users with an example that uses discrete, Winkler-titrated oxygen measurements to correct for the storage drift (with a gain correction) and deployment drift (with a drift correction) of an OOI-provided Level 2 oxygen product to produce an oxygen product for scientific use. The Level 2 oxygen product is from an Aanderaa optode on the near-surface instrument frame on the Oregon Offshore Surface Mooring of the Coastal Endurance Array.

Assemble data

Quick look at oxygen data available on Data Explorer and saved as Data View

Look at HITL and QARTOD annotations associated with oxygen and ancillary (temp, sal, pressure) parameters

- HITL annotations and QARTOD results for oxygen data
- HITL annotations and QARTOD results for temperature data
- HITL annotations and QARTOD results for salinity data
- HITL annotations and QARTOD results for pressure data

RESULTS:

- No oxygen annotations other than UV light installation date and brief power outages
- Target data is after the installation of anti-biofouling UV lights (April 2018)
- Note, no QARTOD tests are implemented at this time for oxygen data streams
- Some temp, salinity, pressure data is "suspect/of interest" but it is unclear which QARTOD tests have been executed on Data Explorer or from the netCDF files downloaded from THREDDS server
- THREDDS server will be updated Fall 2022 to include QARTOD tests executed for CTD parameters
- **As such, QARTOD/QC results are not being used in this worked example**

Download discrete bottle summaries from Alfresco server

- https://alfresco.oceanobservatories.org/
- Find turn-around cruises that bookend deployments of interest (deployments 8 and 9)
- Endurance-11_SKQ201910S_OC1905C_Discrete_Summary.xlsx in OOI **>** Coastal Endurance Array **>** Cruise Data **>** Endurance-11a_SKQ201910S_2019-04 **>** Ship_Data **>** Water Sampling
- Endurance-12_SKQ201921S_Discrete_Summary.xlsx in OOI **>** Coastal Endurance Array **>** Cruise Data **>** Endurance-12_SKQ201921S_2019-10 **>** Ship_Data **>** Water Sampling

- Endurance-13_TN380_Discrete_Summary.xlsx in OOI **>** Coastal Endurance Array **>** Cruise Data **>** Endurance-13_TN380_2020-07 **>** Ship_Data **>** Water Sampling

Review discrete bottle summary annotations

Endurance 11, Endurance 12 and Endurance 13

- All casts followed standard SOP
- All CTD Files were processed according to SOP
- No issues with discrete samples at station of interest, CE04

Download Data

- This code uses local function to read in netCDFs directly from the THREDDS server and into data structures
- Reads in data for dissolved oxygen, salinity, temperature, pressure

```
% Read in data from OOI THREDDS server and display netCDF information
deployment8 = pull_DO_Data_from_THREDDS('deployment0008');
```

```
Source:
           https://thredds.dataexplorer.oceanobservatories.org/thredds/dodsC/ooigoldcopy/public/CE04OSSM-RID27-04-DO
Format:
           classic
Global Attributes:
           node                              = 'RID27'
           comment                           = ''
           publisher_email                   = ''
           sourceUrl                         = 'http://oceanobservatories.org/'
           collection_method                 = 'recovered_host'
           stream                            = 'ctdbp_cdef_dcl_instrument_recovered'
           featureType                       = 'point'
           creator_email                     = ''
           publisher_name                    = 'Ocean Observatories Initiative'
           date_modified                     = '2021-07-29T05:52:12.880883'
           keywords                          = ''
           cdm_data_type                     = 'Point'
           references                        = 'More information can be found at http://oceanobservatories.org/'
           Metadata_Conventions              = 'Unidata Dataset Discovery v1.0'
           date_created                      = '2021-07-29T05:52:12.880880'
           id                                = 'CE04OSSM-RID27-03-CTDBPC000-recovered_host-ctdbp_cdef_dcl_instrument
           requestUUID                       = '4b40e49b-8d23-4d17-86d5-404a12d511fa'
           contributor_role                  = ''
           summary                           = 'Dataset Generated by Stream Engine from Ocean Observatories Initiati
           keywords_vocabulary               = ''
           institution                       = 'Ocean Observatories Initiative'
           naming_authority                  = 'org.oceanobservatories'
           feature_Type                      = 'point'
           infoUrl                           = 'http://oceanobservatories.org/'
           license                           = ''
           contributor_name                  = ''
           uuid                              = '4b40e49b-8d23-4d17-86d5-404a12d511fa'
           creator_name                      = 'Ocean Observatories Initiative'
           title                             = 'Data produced by Stream Engine version 1.18.0 for CE04OSSM-RID27-03-
           sensor                            = '03-CTDBPC000'
           standard_name_vocabulary          = 'NetCDF Climate and Forecast (CF) Metadata Convention Standard Name T
           acknowledgement                   = ''
```

```
            Conventions                         = 'CF-1.6'
            project                             = 'Ocean Observatories Initiative'
            source                              = 'CE04OSSM-RID27-03-CTDBPC000-recovered_host-ctdbp_cdef_dcl_instrument
            publisher_url                       = 'http://oceanobservatories.org/'
            creator_url                         = 'http://oceanobservatories.org/'
            nodc_template_version               = 'NODC_NetCDF_TimeSeries_Orthogonal_Template_v1.1'
            subsite                             = 'CE04OSSM'
            processing_level                    = 'L2'
            history                             = '2021-07-29T05:52:12.880843 generated from Stream Engine'
            Manufacturer                        = 'Sea-Bird Electronics'
            ModelNumber                         = 'SBE 16plus V2'
            SerialNumber                        = '16-7240'
            Description                         = 'CTD Pumped: CTDBP Series C'
            FirmwareVersion                     = 'Not specified.'
            SoftwareVersion                     = 'Not specified.'
            AssetUniqueID                       = 'CGINS-CTDBPC-07240'
            Notes                               = 'Not specified.'
            Owner                               = 'Not specified.'
            RemoteResources                     = '[]'
            ShelfLifeExpirationDate             = 'Not specified.'
            Mobile                              = 'False'
            AssetManagementRecordLastModified = '2021-07-23T11:39:14.448000'
            time_coverage_start                 = '2019-04-20T20:15:08.092000'
            time_coverage_end                   = '2019-10-21T19:00:02.961000'
            time_coverage_resolution            = 'P896.80S'
            geospatial_lat_min                  = 44.3645
            geospatial_lat_max                  = 44.3645
            geospatial_lat_units                = 'degrees_north'
            geospatial_lat_resolution           = 0.1
            geospatial_lon_min                  = -124.9402
            geospatial_lon_max                  = -124.9402
            geospatial_lon_units                = 'degrees_east'
            geospatial_lon_resolution           = 0.1
            geospatial_vertical_units           = 'meters'
            geospatial_vertical_resolution      = 0.1
            geospatial_vertical_positive        = 'down'
            lat                                 = 44.3645
            lon                                 = -124.9402
            DODS.strlen                         = 36
            DODS.dimName                        = 'string36'
            DODS_EXTRA.Unlimited_Dimension      = 'obs'
Dimensions:
            obs         = 17722 (UNLIMITED)
            maxStrlen64 = 64
Variables:
    obs
            Size:       17722x1
            Dimensions: obs
            Datatype:   int32
            Attributes:
                        _ChunkSizes = 1024
    preferred_timestamp
            Size:       64x17722
            Dimensions: maxStrlen64,obs
            Datatype:   char
            Attributes:
                        _FillValue  = 'e'
                        comment     = 'Timestamp preferred as official record.'
                        units       = '1'
                        long_name   = 'Preferred Timestamp'
                        _ChunkSizes = [10000     14]
    pressure_qartod_executed
            Size:       64x17722
            Dimensions: maxStrlen64,obs
            Datatype:   char
```

```
       Attributes:
                   tests_executed = 'gross_range_test'
                   standard_name  = 'sea_water_pressure status_flag'
                   long_name      = 'Seawater Pressure Individual QARTOD Flags'
                   references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                   comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                   coordinates    = 'time lat lon depth'
                   _ChunkSizes    = 507
   temp_qartod_results
       Size:       17722x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned     = 'true'
                   long_name     = 'Seawater Temperature QARTOD Summary Flag'
                   references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                   comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                   flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                   coordinates   = 'time lat lon depth'
                   flag_values   = [1  2  3  4  9]
                   standard_name = 'sea_water_temperature status_flag'
                   _FillValue    = -1
                   _ChunkSizes   = 10000
   pressure_qartod_results
       Size:       17722x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned     = 'true'
                   flag_values   = [1  2  3  4  9]
                   flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                   standard_name = 'sea_water_pressure status_flag'
                   long_name     = 'Seawater Pressure QARTOD Summary Flag'
                   references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                   comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                   coordinates   = 'time lat lon depth'
                   _FillValue    = -1
                   _ChunkSizes   = 10000
   temp
       Size:       17722x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue             = -9999999
                   comment                = 'Seawater temperature near the sensor.'
                   long_name              = 'Seawater Temperature'
                   precision              = 4
                   coordinates            = 'time lat lon depth'
                   data_product_identifier = 'TEMPWAT_L1'
                   standard_name          = 'sea_water_temperature'
                   units                  = 'ºC'
                   ancillary_variables    = 'temp_qartod_results temp_qartod_executed'
                   _ChunkSizes            = 10000
   practical_salinity
       Size:       17722x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue             = -9999999
                   comment                = 'Salinity is generally defined as the concentration of dissolved sa
                   long_name              = 'Practical Salinity'
                   precision              = 4
                   coordinates            = 'time lat lon depth'
                   data_product_identifier = 'PRACSAL_L2'
                   standard_name          = 'sea_water_practical_salinity'
```

```
                    units                   = '1'
                    ancillary_variables     = 'practical_salinity_qartod_results practical_salinity_qartod_execut
                    _ChunkSizes             = 10000
    ingestion_timestamp
           Size:       17722x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Ingestion Timestamp, UTC'
                    _FillValue  = -9999
                    comment     = 'The NTP Timestamp for when the granule was ingested'
                    _ChunkSizes = 10000
    port_timestamp
           Size:       17722x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    _FillValue  = -9999999
                    comment     = 'Port timestamp, UTC'
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Port Timestamp, UTC'
                    _ChunkSizes = 10000
    provenance
           Size:       64x17722
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    name        = 'provenance'
                    coordinates = 'time lat lon depth'
                    _ChunkSizes = [10000     36]
    deployment
           Size:       17722x1
           Dimensions: obs
           Datatype:   int32
           Attributes:
                    name        = 'deployment'
                    _ChunkSizes = 10000
    dcl_controller_timestamp
           Size:       64x17722
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    _FillValue  = 'e'
                    comment     = 'Timestamp from the DCL controller'
                    precision   = 0
                    long_name   = 'DCL Controller Timestamp'
                    units       = '1'
                    _ChunkSizes = [10000      5]
    id
           Size:       64x17722
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    name        = 'id'
                    _ChunkSizes = [10000     36]
    practical_salinity_qartod_executed
           Size:       64x17722
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                    references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    coordinates    = 'time lat lon depth'
                    long_name      = 'Practical Salinity Individual QARTOD Flags'
```

```
                tests_executed = 'gross_range_test'
                standard_name  = 'sea_water_practical_salinity status_flag'
                _ChunkSizes    = 507
pressure
       Size:       17722x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                _FillValue              = -9999999
                comment                 = 'Seawater Pressure refers to the pressure exerted on a sensor in si
                long_name               = 'Seawater Pressure'
                precision               = 3
                coordinates             = 'time lat lon depth'
                data_product_identifier = 'PRESWAT_L1'
                standard_name           = 'sea_water_pressure'
                units                   = 'dbar'
                ancillary_variables     = 'pressure_qartod_results pressure_qartod_executed'
                _ChunkSizes             = 10000
depth
       Size:       17722x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                comment     = 'Depth (m) calculated from pressure (dbar) and latitude.'
                precision   = 3
                long_name   = 'Depth calculated from pressure'
                units       = 'm'
                axis        = 'Z'
                _FillValue  = -9999999
                _ChunkSizes = 10000
internal_timestamp
       Size:       17722x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                _FillValue  = -9999999
                comment     = 'Internal timestamp, UTC'
                units       = 'seconds since 1900-01-01'
                long_name   = 'Internal Timestamp, UTC'
                _ChunkSizes = 10000
practical_salinity_qartod_results
       Size:       17722x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                _Unsigned     = 'true'
                flag_values   = [1  2  3  4  9]
                flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                standard_name = 'sea_water_practical_salinity status_flag'
                long_name     = 'Practical Salinity QARTOD Summary Flag'
                references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                coordinates   = 'time lat lon depth'
                _FillValue    = -1
                _ChunkSizes   = 10000
time
       Size:       17722x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                calendar      = 'gregorian'
                units         = 'seconds since 1900-01-01 0:0:0'
                _FillValue    = -9999999
                long_name     = 'time'
                standard_name = 'time'
```

```
                    axis          = 'T'
                    _ChunkSizes   = 10000
    temp_qartod_executed
           Size:       64x17722
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                    tests_executed = 'gross_range_test'
                    standard_name  = 'sea_water_temperature status_flag'
                    long_name      = 'Seawater Temperature Individual QARTOD Flags'
                    coordinates    = 'time lat lon depth'
                    _ChunkSizes    = 507
    driver_timestamp
           Size:       17722x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    comment     = 'Driver timestamp, UTC'
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Driver Timestamp, UTC'
                    _FillValue  = -9999999
                    _ChunkSizes = 10000
Source:
           https://thredds.dataexplorer.oceanobservatories.org/thredds/dodsC/ooigoldcopy/public/CE04OSSM-RID27-04-DO
Format:
           classic
Global Attributes:
           node                              = 'RID27'
           comment                           = ''
           publisher_email                   = ''
           sourceUrl                         = 'http://oceanobservatories.org/'
           collection_method                 = 'recovered_host'
           stream                            = 'dosta_abcdjm_dcl_instrument_recovered'
           featureType                       = 'point'
           creator_email                     = ''
           publisher_name                    = 'Ocean Observatories Initiative'
           date_modified                     = '2021-07-29T05:52:12.639247'
           keywords                          = ''
           cdm_data_type                     = 'Point'
           references                        = 'More information can be found at http://oceanobservatories.org/'
           Metadata_Conventions              = 'Unidata Dataset Discovery v1.0'
           date_created                      = '2021-07-29T05:52:12.639244'
           id                                = 'CE04OSSM-RID27-04-DOSTAD000-recovered_host-dosta_abcdjm_dcl_instrume
           requestUUID                       = '4b40e49b-8d23-4d17-86d5-404a12d511fa'
           contributor_role                  = ''
           summary                           = 'Dataset Generated by Stream Engine from Ocean Observatories Initiati
           keywords_vocabulary               = ''
           institution                       = 'Ocean Observatories Initiative'
           naming_authority                  = 'org.oceanobservatories'
           feature_Type                      = 'point'
           infoUrl                           = 'http://oceanobservatories.org/'
           license                           = ''
           contributor_name                  = ''
           uuid                              = '4b40e49b-8d23-4d17-86d5-404a12d511fa'
           creator_name                      = 'Ocean Observatories Initiative'
           title                             = 'Data produced by Stream Engine version 1.18.0 for CE04OSSM-RID27-04-
           sensor                            = '04-DOSTAD000'
           standard_name_vocabulary          = 'NetCDF Climate and Forecast (CF) Metadata Convention Standard Name T
           acknowledgement                   = ''
           Conventions                       = 'CF-1.6'
           project                           = 'Ocean Observatories Initiative'
           source                            = 'CE04OSSM-RID27-04-DOSTAD000-recovered_host-dosta_abcdjm_dcl_instrume
           publisher_url                     = 'http://oceanobservatories.org/'
```

```
        creator_url                      = 'http://oceanobservatories.org/'
        nodc_template_version            = 'NODC_NetCDF_TimeSeries_Orthogonal_Template_v1.1'
        subsite                          = 'CE04OSSM'
        processing_level                 = 'L2'
        history                          = '2021-07-29T05:52:12.639203 generated from Stream Engine'
        Manufacturer                     = 'Aanderaa'
        ModelNumber                      = 'Optode 4831'
        SerialNumber                     = '220'
        Description                      = 'Dissolved Oxygen Stable Response: DOSTA Series D'
        FirmwareVersion                  = 'Not specified.'
        SoftwareVersion                  = 'Not specified.'
        AssetUniqueID                    = 'CGINS-DOSTAD-00220'
        Notes                            = 'Not specified.'
        Owner                            = 'Not specified.'
        RemoteResources                  = '[]'
        ShelfLifeExpirationDate          = 'Not specified.'
        Mobile                           = 'False'
        AssetManagementRecordLastModified = '2021-07-23T11:39:10.640000'
        time_coverage_start              = '2019-04-20T20:15:17.159000'
        time_coverage_end                = '2019-10-21T19:03:17.762000'
        time_coverage_resolution         = 'P9.69S'
        geospatial_lat_min               = 44.3645
        geospatial_lat_max               = 44.3645
        geospatial_lat_units             = 'degrees_north'
        geospatial_lat_resolution        = 0.1
        geospatial_lon_min               = -124.9402
        geospatial_lon_max               = -124.9402
        geospatial_lon_units             = 'degrees_east'
        geospatial_lon_resolution        = 0.1
        geospatial_vertical_units        = 'meters'
        geospatial_vertical_resolution   = 0.1
        geospatial_vertical_positive     = 'down'
        lat                              = 44.3645
        lon                              = -124.9402
        DODS.strlen                      = 14
        DODS.dimName                     = 'string14'
        DODS_EXTRA.Unlimited_Dimension   = 'obs'
Dimensions:
        obs         = 1641018 (UNLIMITED)
        maxStrlen64 = 64
Variables:
    obs
        Size:       1641018x1
        Dimensions: obs
        Datatype:   int32
        Attributes:
                    _ChunkSizes = 1024
    practical_salinity
        Size:       1641018x1
        Dimensions: obs
        Datatype:   double
        Attributes:
                    _FillValue              = NaN
                    comment                 = 'Salinity is generally defined as the concentration of dissolved sa
                    data_product_identifier = 'PRACSAL_L2'
                    precision               = 4
                    coordinates             = 'time lat lon depth'
                    long_name               = 'Practical Salinity'
                    standard_name           = 'sea_water_practical_salinity'
                    units                   = '1'
                    instrument              = 'CE04OSSM-RID27-03-CTDBPC000'
                    stream                  = 'ctdbp_cdef_dcl_instrument_recovered'
                    _ChunkSizes             = 10000
    raw_temperature
        Size:       1641018x1
```

```
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Raw temperature, voltage from thermistor.'
                   precision   = 1
                   coordinates = 'time lat lon depth'
                   long_name   = 'Thermistor Voltage'
                   units       = 'mV'
                   _ChunkSizes = 10000
estimated_oxygen_concentration_qc_executed
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
red_phase
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Phase measurement with red excitation.'
                   precision   = 3
                   coordinates = 'time lat lon depth'
                   long_name   = 'Red Light Phase'
                   units       = 'degrees'
                   _ChunkSizes = 10000
dcl_controller_timestamp
       Size:       64x1641018
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Timestamp from the DCL controller'
                   precision   = 0
                   long_name   = 'DCL Controller Timestamp'
                   units       = '1'
                   _ChunkSizes = [10000      5]
dosta_abcdjm_cspp_tc_oxygen_qc_results
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
product_number
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int16
       Attributes:
                   _FillValue  = 0
                   comment     = 'Aanderaa product/model number.'
                   precision   = 0
                   coordinates = 'time lat lon depth'
                   long_name   = 'Product Number'
                   units       = '1'
                   _Unsigned   = 'true'
                   _ChunkSizes = 10000
estimated_oxygen_saturation_qc_results
```

```
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
driver_timestamp
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   units       = 'seconds since 1900-01-01'
                   long_name   = 'Driver Timestamp, UTC'
                   comment     = 'Driver timestamp, UTC'
                   _FillValue  = -9999999
                   _ChunkSizes = 10000
id
       Size:       64x1641018
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   name        = 'id'
                   _ChunkSizes = [10000     36]
dissolved_oxygen_qc_executed
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
provenance
       Size:       64x1641018
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   coordinates = 'time lat lon depth'
                   name        = 'provenance'
                   _ChunkSizes = [10000     36]
internal_timestamp
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   units       = 'seconds since 1900-01-01'
                   long_name   = 'Internal Timestamp, UTC'
                   _FillValue  = -9999999
                   comment     = 'Internal timestamp, UTC'
                   _ChunkSizes = 10000
blue_phase
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   long_name   = 'Blue Light Phase'
                   precision   = 3
                   coordinates = 'time lat lon depth'
                   units       = 'degrees'
                   _FillValue  = -9999999
                   comment     = 'Phase measurement with blue excitation.'
                   _ChunkSizes = 10000
serial_number
```

```
       Size:       64x1641018
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Serial Number'
                   precision   = 0
                   coordinates = 'time lat lon depth'
                   long_name   = 'Serial Number'
                   units       = '1'
                   _ChunkSizes = [10000      3]
temp_compensated_phase
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   units       = 'degrees'
                   long_name   = 'Temperature Compensated Phase'
                   precision   = 3
                   _FillValue  = -9999999
                   comment     = 'Temerature compensated phase.'
                   coordinates = 'time lat lon depth'
                   _ChunkSizes = 10000
optode_temperature_qc_executed
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
dissolved_oxygen
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = -9999999
                   comment                 = 'Dissolved Oxygen Concentration from the Stable Response Dissolved
                   long_name               = 'DO - Pressure Temp Sal Corrected'
                   precision               = 4
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOXYGEN_L2'
                   standard_name           = 'moles_of_oxygen_per_unit_mass_in_sea_water'
                   units                   = 'µmol kg-1'
                   ancillary_variables     = 'estimated_oxygen_concentration practical_salinity temp'
                   _ChunkSizes             = 10000
dissolved_oxygen_qc_results
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
calibrated_phase
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOCONCS-DEG_L0'
                   units                   = 'degrees'
                   precision               = 3
```

```
                    _FillValue              = -9999999
                    comment                 = 'Calibrated phase difference, used to calculate temperature compens
                    long_name               = 'Calibrated Phase Difference'
                    _ChunkSizes             = 10000
    ingestion_timestamp
           Size:       1641018x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    long_name   = 'Ingestion Timestamp, UTC'
                    _FillValue  = -9999
                    comment     = 'The NTP Timestamp for when the granule was ingested'
                    units       = 'seconds since 1900-01-01'
                    _ChunkSizes = 10000
    port_timestamp
           Size:       1641018x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    _FillValue  = -9999999
                    comment     = 'Port timestamp, UTC'
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Port Timestamp, UTC'
                    _ChunkSizes = 10000
    estimated_oxygen_saturation
           Size:       1641018x1
           Dimensions: obs
           Datatype:   single
           Attributes:
                    precision   = 3
                    long_name   = 'Dissolved Oxygen Saturation'
                    units       = 'percent'
                    _FillValue  = -9999999
                    comment     = 'Oxygen saturation is the percentage of dissolved oxygen relative to the absolu
                    coordinates = 'time lat lon depth'
                    _ChunkSizes = 10000
    optode_temperature_qc_results
           Size:       1641018x1
           Dimensions: obs
           Datatype:   int8
           Attributes:
                    _Unsigned   = 'true'
                    coordinates = 'time lat lon depth'
                    _FillValue  = -1
                    _ChunkSizes = 10000
    deployment
           Size:       1641018x1
           Dimensions: obs
           Datatype:   int32
           Attributes:
                    name        = 'deployment'
                    _ChunkSizes = 10000
    estimated_oxygen_concentration
           Size:       1641018x1
           Dimensions: obs
           Datatype:   single
           Attributes:
                    comment                 = 'Dissolved Oxygen (DO) Concentration from the Stable Response Disso
                    units                   = 'µmol L-1'
                    _FillValue              = -9999999
                    long_name               = 'DO'
                    precision               = 3
                    coordinates             = 'time lat lon depth'
                    data_product_identifier = 'DOCONCS_L1'
                    _ChunkSizes             = 10000
```

```
optode_temperature
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   units       = 'ºC'
                   _FillValue  = -9999999
                   comment     = 'Oxygen sensor ambient temperature'
                   precision   = 3
                   coordinates = 'time lat lon depth'
                   long_name   = 'Optode Temperature'
                   _ChunkSizes = 10000
int_ctd_pressure
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = NaN
                   comment                 = 'Seawater Pressure refers to the pressure exerted on a sensor in si
                   data_product_identifier = 'PRESWAT_L1'
                   precision               = 3
                   coordinates             = 'time lat lon depth'
                   long_name               = 'Seawater Pressure'
                   standard_name           = 'sea_water_pressure'
                   units                   = 'dbar'
                   _ChunkSizes             = 10000
estimated_oxygen_concentration_qc_results
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
preferred_timestamp
       Size:       64x1641018
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Timestamp preferred as official record.'
                   units       = '1'
                   long_name   = 'Preferred Timestamp'
                   _ChunkSizes = [10000     14]
temp
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = NaN
                   comment                 = 'Seawater temperature near the sensor.'
                   data_product_identifier = 'TEMPWAT_L1'
                   precision               = 4
                   coordinates             = 'time lat lon depth'
                   long_name               = 'Seawater Temperature'
                   standard_name           = 'sea_water_temperature'
                   units                   = 'ºC'
                   instrument              = 'CE04OSSM-RID27-03-CTDBPC000'
                   stream                  = 'ctdbp_cdef_dcl_instrument_recovered'
                   _ChunkSizes             = 10000
dosta_abcdjm_cspp_tc_oxygen
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
```

```
       Attributes:
                   ancillary_variables     = 'calibrated_phase optode_temperature'
                   units                   = 'µmol L-1'
                   comment                 = 'Dissolved Oxygen (DO) Concentration from the Stable Response Disso
                   long_name               = 'DO - Temp Corrected'
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOCONCS_L1'
                   _FillValue              = -9999999
                   _ChunkSizes             = 10000
red_amplitude
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Amplitude measurement with red excitation.'
                   precision   = 1
                   coordinates = 'time lat lon depth'
                   long_name   = 'Red Light Amplitude'
                   units       = 'mV'
                   _ChunkSizes = 10000
dosta_abcdjm_cspp_tc_oxygen_qc_executed
       Size:       1641018x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
depth
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue  = NaN
                   comment     = 'Depth (m) calculated from pressure (dbar) and latitude.'
                   long_name   = 'Depth calculated from pressure'
                   units       = 'm'
                   precision   = 3
                   instrument  = 'CE04OSSM-RID27-03-CTDBPC000'
                   stream      = 'ctdbp_cdef_dcl_instrument_recovered'
                   axis        = 'Z'
                   _ChunkSizes = 10000
blue_amplitude
       Size:       1641018x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   long_name   = 'Blue Light Amplitude'
                   units       = 'mV'
                   _FillValue  = -9999999
                   comment     = 'Amplitude measurement with blue excitation.'
                   precision   = 1
                   coordinates = 'time lat lon depth'
                   _ChunkSizes = 10000
time
       Size:       1641018x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   calendar      = 'gregorian'
                   _FillValue    = -9999999
                   long_name     = 'time'
                   standard_name = 'time'
```

```
                    units         = 'seconds since 1900-01-01 0:0:0'
                    axis          = 'T'
                    _ChunkSizes   = 10000
    estimated_oxygen_saturation_qc_executed
            Size:       1641018x1
            Dimensions: obs
            Datatype:   int8
            Attributes:
                    _Unsigned   = 'true'
                    coordinates = 'time lat lon depth'
                    _FillValue  = -1
                    _ChunkSizes = 10000
```

```
deployment9 = pull_DO_Data_from_THREDDS('deployment0009');
```

```
Source:
            https://thredds.dataexplorer.oceanobservatories.org/thredds/dodsC/ooigoldcopy/public/CE04OSSM-RID27-04-DO
Format:
            classic
Global Attributes:
            node                              = 'RID27'
            comment                           = ''
            publisher_email                   = ''
            sourceUrl                         = 'http://oceanobservatories.org/'
            collection_method                 = 'recovered_host'
            stream                            = 'ctdbp_cdef_dcl_instrument_recovered'
            featureType                       = 'point'
            creator_email                     = ''
            publisher_name                    = 'Ocean Observatories Initiative'
            date_modified                     = '2021-07-29T05:52:27.656765'
            keywords                          = ''
            cdm_data_type                     = 'Point'
            references                        = 'More information can be found at http://oceanobservatories.org/'
            Metadata_Conventions              = 'Unidata Dataset Discovery v1.0'
            date_created                      = '2021-07-29T05:52:27.656763'
            id                                = 'CE04OSSM-RID27-03-CTDBPC000-recovered_host-ctdbp_cdef_dcl_instrument
            requestUUID                       = 'f433bc8f-0797-441f-84b8-202ec2327873'
            contributor_role                  = ''
            summary                           = 'Dataset Generated by Stream Engine from Ocean Observatories Initiati
            keywords_vocabulary               = ''
            institution                       = 'Ocean Observatories Initiative'
            naming_authority                  = 'org.oceanobservatories'
            feature_Type                      = 'point'
            infoUrl                           = 'http://oceanobservatories.org/'
            license                           = ''
            contributor_name                  = ''
            uuid                              = 'f433bc8f-0797-441f-84b8-202ec2327873'
            creator_name                      = 'Ocean Observatories Initiative'
            title                             = 'Data produced by Stream Engine version 1.18.0 for CE04OSSM-RID27-03-
            sensor                            = '03-CTDBPC000'
            standard_name_vocabulary          = 'NetCDF Climate and Forecast (CF) Metadata Convention Standard Name T
            acknowledgement                   = ''
            Conventions                       = 'CF-1.6'
            project                           = 'Ocean Observatories Initiative'
            source                            = 'CE04OSSM-RID27-03-CTDBPC000-recovered_host-ctdbp_cdef_dcl_instrument
            publisher_url                     = 'http://oceanobservatories.org/'
            creator_url                       = 'http://oceanobservatories.org/'
            nodc_template_version             = 'NODC_NetCDF_TimeSeries_Orthogonal_Template_v1.1'
            subsite                           = 'CE04OSSM'
            processing_level                  = 'L2'
            history                           = '2021-07-29T05:52:27.656733 generated from Stream Engine'
            Manufacturer                      = 'Sea-Bird Electronics'
            ModelNumber                       = 'SBE 16plus V2'
            SerialNumber                      = '16-50153'
            Description                       = 'CTD Pumped: CTDBP Series C'
```

```
            FirmwareVersion                   = 'Not specified.'
            SoftwareVersion                   = 'Not specified.'
            AssetUniqueID                     = 'CGINS-CTDBPC-50153'
            Notes                             = 'Not specified.'
            Owner                             = 'Not specified.'
            RemoteResources                   = '[]'
            ShelfLifeExpirationDate           = 'Not specified.'
            Mobile                            = 'False'
            AssetManagementRecordLastModified = '2021-07-23T11:39:13.853000'
            time_coverage_start               = '2019-10-21T18:00:10.284000'
            time_coverage_end                 = '2020-07-11T14:15:05.596000'
            time_coverage_resolution          = 'P899.40S'
            geospatial_lat_min                = 44.378
            geospatial_lat_max                = 44.378
            geospatial_lat_units              = 'degrees_north'
            geospatial_lat_resolution         = 0.1
            geospatial_lon_min                = -124.946
            geospatial_lon_max                = -124.946
            geospatial_lon_units              = 'degrees_east'
            geospatial_lon_resolution         = 0.1
            geospatial_vertical_units         = 'meters'
            geospatial_vertical_resolution    = 0.1
            geospatial_vertical_positive      = 'down'
            lat                               = 44.378
            lon                               = -124.946
            DODS.strlen                       = 36
            DODS.dimName                      = 'string36'
            DODS_EXTRA.Unlimited_Dimension    = 'obs'
Dimensions:
            obs         = 25346 (UNLIMITED)
            maxStrlen64 = 64
Variables:
    obs
            Size:       25346x1
            Dimensions: obs
            Datatype:   int32
            Attributes:
                        _ChunkSizes = 1024
    preferred_timestamp
            Size:       64x25346
            Dimensions: maxStrlen64,obs
            Datatype:   char
            Attributes:
                        _FillValue  = 'e'
                        comment     = 'Timestamp preferred as official record.'
                        units       = '1'
                        long_name   = 'Preferred Timestamp'
                        _ChunkSizes = [10000     14]
    pressure_qartod_executed
            Size:       64x25346
            Dimensions: maxStrlen64,obs
            Datatype:   char
            Attributes:
                        tests_executed = 'gross_range_test'
                        standard_name  = 'sea_water_pressure status_flag'
                        long_name      = 'Seawater Pressure Individual QARTOD Flags'
                        references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                        comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                        coordinates    = 'time lat lon depth'
                        _ChunkSizes    = 507
    temp_qartod_results
            Size:       25346x1
            Dimensions: obs
            Datatype:   int8
            Attributes:
```

```
                    _Unsigned     = 'true'
                    long_name     = 'Seawater Temperature QARTOD Summary Flag'
                    references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                    flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                    coordinates   = 'time lat lon depth'
                    flag_values   = [1  2  3  4  9]
                    standard_name = 'sea_water_temperature status_flag'
                    _FillValue    = -1
                    _ChunkSizes   = 10000
    pressure_qartod_results
           Size:       25346x1
           Dimensions: obs
           Datatype:   int8
           Attributes:
                    _Unsigned     = 'true'
                    flag_values   = [1  2  3  4  9]
                    flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                    standard_name = 'sea_water_pressure status_flag'
                    long_name     = 'Seawater Pressure QARTOD Summary Flag'
                    references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                    coordinates   = 'time lat lon depth'
                    _FillValue    = -1
                    _ChunkSizes   = 10000
    temp
           Size:       25346x1
           Dimensions: obs
           Datatype:   single
           Attributes:
                    _FillValue              = -9999999
                    comment                 = 'Seawater temperature near the sensor.'
                    long_name               = 'Seawater Temperature'
                    precision               = 4
                    coordinates             = 'time lat lon depth'
                    data_product_identifier = 'TEMPWAT_L1'
                    standard_name           = 'sea_water_temperature'
                    units                   = 'ºC'
                    ancillary_variables     = 'temp_qartod_results temp_qartod_executed'
                    _ChunkSizes             = 10000
    practical_salinity
           Size:       25346x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    _FillValue              = -9999999
                    comment                 = 'Salinity is generally defined as the concentration of dissolved sa
                    long_name               = 'Practical Salinity'
                    precision               = 4
                    coordinates             = 'time lat lon depth'
                    data_product_identifier = 'PRACSAL_L2'
                    standard_name           = 'sea_water_practical_salinity'
                    units                   = '1'
                    ancillary_variables     = 'practical_salinity_qartod_results practical_salinity_qartod_execut
                    _ChunkSizes             = 10000
    ingestion_timestamp
           Size:       25346x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Ingestion Timestamp, UTC'
                    _FillValue  = -9999
                    comment     = 'The NTP Timestamp for when the granule was ingested'
                    _ChunkSizes = 10000
```

```
port_timestamp
       Size:       25346x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Port timestamp, UTC'
                   units       = 'seconds since 1900-01-01'
                   long_name   = 'Port Timestamp, UTC'
                   _ChunkSizes = 10000
provenance
       Size:       64x25346
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   name        = 'provenance'
                   coordinates = 'time lat lon depth'
                   _ChunkSizes = [10000     36]
deployment
       Size:       25346x1
       Dimensions: obs
       Datatype:   int32
       Attributes:
                   name        = 'deployment'
                   _ChunkSizes = 10000
dcl_controller_timestamp
       Size:       64x25346
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Timestamp from the DCL controller'
                   precision   = 0
                   long_name   = 'DCL Controller Timestamp'
                   units       = '1'
                   _ChunkSizes = [10000      5]
id
       Size:       64x25346
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   name        = 'id'
                   _ChunkSizes = [10000     36]
practical_salinity_qartod_executed
       Size:       64x25346
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                   references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                   coordinates    = 'time lat lon depth'
                   long_name      = 'Practical Salinity Individual QARTOD Flags'
                   tests_executed = 'gross_range_test'
                   standard_name  = 'sea_water_practical_salinity status_flag'
                   _ChunkSizes    = 507
pressure
       Size:       25346x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue              = -9999999
                   comment                 = 'Seawater Pressure refers to the pressure exerted on a sensor in si
                   long_name               = 'Seawater Pressure'
                   precision               = 3
                   coordinates             = 'time lat lon depth'
```

```
                    data_product_identifier = 'PRESWAT_L1'
                    standard_name           = 'sea_water_pressure'
                    units                   = 'dbar'
                    ancillary_variables     = 'pressure_qartod_results pressure_qartod_executed'
                    _ChunkSizes             = 10000
    depth
           Size:       25346x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    comment     = 'Depth (m) calculated from pressure (dbar) and latitude.'
                    precision   = 3
                    long_name   = 'Depth calculated from pressure'
                    units       = 'm'
                    axis        = 'Z'
                    _FillValue  = -9999999
                    _ChunkSizes = 10000
    internal_timestamp
           Size:       25346x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    _FillValue  = -9999999
                    comment     = 'Internal timestamp, UTC'
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Internal Timestamp, UTC'
                    _ChunkSizes = 10000
    practical_salinity_qartod_results
           Size:       25346x1
           Dimensions: obs
           Datatype:   int8
           Attributes:
                    _Unsigned     = 'true'
                    flag_values   = [1  2  3  4  9]
                    flag_meanings = 'pass not_evaluated suspect_or_of_high_interest fail missing_data'
                    standard_name = 'sea_water_practical_salinity status_flag'
                    long_name     = 'Practical Salinity QARTOD Summary Flag'
                    references    = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    comment       = 'Summary QARTOD test flags. For each datum, the flag is set to the most signi
                    coordinates   = 'time lat lon depth'
                    _FillValue    = -1
                    _ChunkSizes   = 10000
    time
           Size:       25346x1
           Dimensions: obs
           Datatype:   double
           Attributes:
                    calendar      = 'gregorian'
                    units         = 'seconds since 1900-01-01 0:0:0'
                    _FillValue    = -9999999
                    long_name     = 'time'
                    standard_name = 'time'
                    axis          = 'T'
                    _ChunkSizes   = 10000
    temp_qartod_executed
           Size:       64x25346
           Dimensions: maxStrlen64,obs
           Datatype:   char
           Attributes:
                    references     = 'https://ioos.noaa.gov/project/qartod https://github.com/ioos/ioos_qc'
                    comment        = 'Individual QARTOD test flags. For each datum, flags are listed in a string
                    tests_executed = 'gross_range_test'
                    standard_name  = 'sea_water_temperature status_flag'
                    long_name      = 'Seawater Temperature Individual QARTOD Flags'
                    coordinates    = 'time lat lon depth'
```

```
                    _ChunkSizes    = 507
    driver_timestamp
            Size:       25346x1
            Dimensions: obs
            Datatype:   double
            Attributes:
                        comment     = 'Driver timestamp, UTC'
                        units       = 'seconds since 1900-01-01'
                        long_name   = 'Driver Timestamp, UTC'
                        _FillValue  = -9999999
                        _ChunkSizes = 10000
Source:
            https://thredds.dataexplorer.oceanobservatories.org/thredds/dodsC/ooigoldcopy/public/CE04OSSM-RID27-04-DO
Format:
            classic
Global Attributes:
            node                              = 'RID27'
            comment                           = ''
            publisher_email                   = ''
            sourceUrl                         = 'http://oceanobservatories.org/'
            collection_method                 = 'recovered_host'
            stream                            = 'dosta_abcdjm_dcl_instrument_recovered'
            featureType                       = 'point'
            creator_email                     = ''
            publisher_name                    = 'Ocean Observatories Initiative'
            date_modified                     = '2021-07-29T05:52:26.961295'
            keywords                          = ''
            cdm_data_type                     = 'Point'
            references                        = 'More information can be found at http://oceanobservatories.org/'
            Metadata_Conventions              = 'Unidata Dataset Discovery v1.0'
            date_created                      = '2021-07-29T05:52:26.961293'
            id                                = 'CE04OSSM-RID27-04-DOSTAD000-recovered_host-dosta_abcdjm_dcl_instrume
            requestUUID                       = 'f433bc8f-0797-441f-84b8-202ec2327873'
            contributor_role                  = ''
            summary                           = 'Dataset Generated by Stream Engine from Ocean Observatories Initiati
            keywords_vocabulary               = ''
            institution                       = 'Ocean Observatories Initiative'
            naming_authority                  = 'org.oceanobservatories'
            feature_Type                      = 'point'
            infoUrl                           = 'http://oceanobservatories.org/'
            license                           = ''
            contributor_name                  = ''
            uuid                              = 'f433bc8f-0797-441f-84b8-202ec2327873'
            creator_name                      = 'Ocean Observatories Initiative'
            title                             = 'Data produced by Stream Engine version 1.18.0 for CE04OSSM-RID27-04-
            sensor                            = '04-DOSTAD000'
            standard_name_vocabulary          = 'NetCDF Climate and Forecast (CF) Metadata Convention Standard Name T
            acknowledgement                   = ''
            Conventions                       = 'CF-1.6'
            project                           = 'Ocean Observatories Initiative'
            source                            = 'CE04OSSM-RID27-04-DOSTAD000-recovered_host-dosta_abcdjm_dcl_instrume
            publisher_url                     = 'http://oceanobservatories.org/'
            creator_url                       = 'http://oceanobservatories.org/'
            nodc_template_version             = 'NODC_NetCDF_TimeSeries_Orthogonal_Template_v1.1'
            subsite                           = 'CE04OSSM'
            processing_level                  = 'L2'
            history                           = '2021-07-29T05:52:26.961243 generated from Stream Engine'
            Manufacturer                      = 'Aanderaa'
            ModelNumber                       = 'Optode 4831'
            SerialNumber                      = '485'
            Description                       = 'Dissolved Oxygen Stable Response: DOSTA Series D'
            FirmwareVersion                   = 'Not specified.'
            SoftwareVersion                   = 'Not specified.'
            AssetUniqueID                     = 'CGINS-DOSTAD-00485'
            Notes                             = 'Not specified.'
```

```
            Owner                              = 'Not specified.'
            RemoteResources                    = '[]'
            ShelfLifeExpirationDate            = 'Not specified.'
            Mobile                             = 'False'
            AssetManagementRecordLastModified = '2021-07-23T11:39:07.643000'
            time_coverage_start                = '2019-10-21T17:43:07.464000'
            time_coverage_end                  = '2020-07-11T14:18:01.400000'
            time_coverage_resolution           = 'P10.01S'
            geospatial_lat_min                 = 44.378
            geospatial_lat_max                 = 44.378
            geospatial_lat_units               = 'degrees_north'
            geospatial_lat_resolution          = 0.1
            geospatial_lon_min                 = -124.946
            geospatial_lon_max                 = -124.946
            geospatial_lon_units               = 'degrees_east'
            geospatial_lon_resolution          = 0.1
            geospatial_vertical_units          = 'meters'
            geospatial_vertical_resolution     = 0.1
            geospatial_vertical_positive       = 'down'
            lat                                = 44.378
            lon                                = -124.946
            DODS.strlen                        = 14
            DODS.dimName                       = 'string14'
            DODS_EXTRA.Unlimited_Dimension     = 'obs'
Dimensions:
            obs         = 2276823 (UNLIMITED)
            maxStrlen64 = 64
Variables:
    obs
            Size:       2276823x1
            Dimensions: obs
            Datatype:   int32
            Attributes:
                        _ChunkSizes = 1024
    practical_salinity
            Size:       2276823x1
            Dimensions: obs
            Datatype:   double
            Attributes:
                        _FillValue              = NaN
                        comment                 = 'Salinity is generally defined as the concentration of dissolved sa
                        data_product_identifier = 'PRACSAL_L2'
                        precision               = 4
                        coordinates             = 'time lat lon depth'
                        long_name               = 'Practical Salinity'
                        standard_name           = 'sea_water_practical_salinity'
                        units                   = '1'
                        instrument              = 'CE04OSSM-RID27-03-CTDBPC000'
                        stream                  = 'ctdbp_cdef_dcl_instrument_recovered'
                        _ChunkSizes             = 10000
    raw_temperature
            Size:       2276823x1
            Dimensions: obs
            Datatype:   single
            Attributes:
                        _FillValue  = -9999999
                        comment     = 'Raw temperature, voltage from thermistor.'
                        precision   = 1
                        coordinates = 'time lat lon depth'
                        long_name   = 'Thermistor Voltage'
                        units       = 'mV'
                        _ChunkSizes = 10000
    estimated_oxygen_concentration_qc_executed
            Size:       2276823x1
            Dimensions: obs
```

```
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
red_phase
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Phase measurement with red excitation.'
                   precision   = 3
                   coordinates = 'time lat lon depth'
                   long_name   = 'Red Light Phase'
                   units       = 'degrees'
                   _ChunkSizes = 10000
dcl_controller_timestamp
       Size:       64x2276823
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Timestamp from the DCL controller'
                   precision   = 0
                   long_name   = 'DCL Controller Timestamp'
                   units       = '1'
                   _ChunkSizes = [10000      5]
dosta_abcdjm_cspp_tc_oxygen_qc_results
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
product_number
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int16
       Attributes:
                   _FillValue  = 0
                   comment     = 'Aanderaa product/model number.'
                   precision   = 0
                   coordinates = 'time lat lon depth'
                   long_name   = 'Product Number'
                   units       = '1'
                   _Unsigned   = 'true'
                   _ChunkSizes = 10000
estimated_oxygen_saturation_qc_results
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
driver_timestamp
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
```

```
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Driver Timestamp, UTC'
                    comment     = 'Driver timestamp, UTC'
                    _FillValue  = -9999999
                    _ChunkSizes = 10000
id
       Size:       64x2276823
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                    name        = 'id'
                    _ChunkSizes = [10000     36]
dissolved_oxygen_qc_executed
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                    _Unsigned   = 'true'
                    coordinates = 'time lat lon depth'
                    _FillValue  = -1
                    _ChunkSizes = 10000
provenance
       Size:       64x2276823
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                    coordinates = 'time lat lon depth'
                    name        = 'provenance'
                    _ChunkSizes = [10000     36]
internal_timestamp
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Internal Timestamp, UTC'
                    _FillValue  = -9999999
                    comment     = 'Internal timestamp, UTC'
                    _ChunkSizes = 10000
blue_phase
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                    long_name   = 'Blue Light Phase'
                    precision   = 3
                    coordinates = 'time lat lon depth'
                    units       = 'degrees'
                    _FillValue  = -9999999
                    comment     = 'Phase measurement with blue excitation.'
                    _ChunkSizes = 10000
serial_number
       Size:       64x2276823
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                    _FillValue  = 'e'
                    comment     = 'Serial Number'
                    precision   = 0
                    coordinates = 'time lat lon depth'
                    long_name   = 'Serial Number'
                    units       = '1'
                    _ChunkSizes = [10000      3]
temp_compensated_phase
       Size:       2276823x1
```

```
       Dimensions: obs
       Datatype:   single
       Attributes:
                   units       = 'degrees'
                   long_name   = 'Temperature Compensated Phase'
                   precision   = 3
                   _FillValue  = -9999999
                   comment     = 'Temerature compensated phase.'
                   coordinates = 'time lat lon depth'
                   _ChunkSizes = 10000
optode_temperature_qc_executed
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
dissolved_oxygen
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = -9999999
                   comment                 = 'Dissolved Oxygen Concentration from the Stable Response Dissolved
                   long_name               = 'DO - Pressure Temp Sal Corrected'
                   precision               = 4
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOXYGEN_L2'
                   standard_name           = 'moles_of_oxygen_per_unit_mass_in_sea_water'
                   units                   = 'µmol kg-1'
                   ancillary_variables     = 'estimated_oxygen_concentration practical_salinity temp'
                   _ChunkSizes             = 10000
dissolved_oxygen_qc_results
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
calibrated_phase
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOCONCS-DEG_L0'
                   units                   = 'degrees'
                   precision               = 3
                   _FillValue              = -9999999
                   comment                 = 'Calibrated phase difference, used to calculate temperature compens
                   long_name               = 'Calibrated Phase Difference'
                   _ChunkSizes             = 10000
ingestion_timestamp
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   long_name   = 'Ingestion Timestamp, UTC'
                   _FillValue  = -9999
                   comment     = 'The NTP Timestamp for when the granule was ingested'
                   units       = 'seconds since 1900-01-01'
```

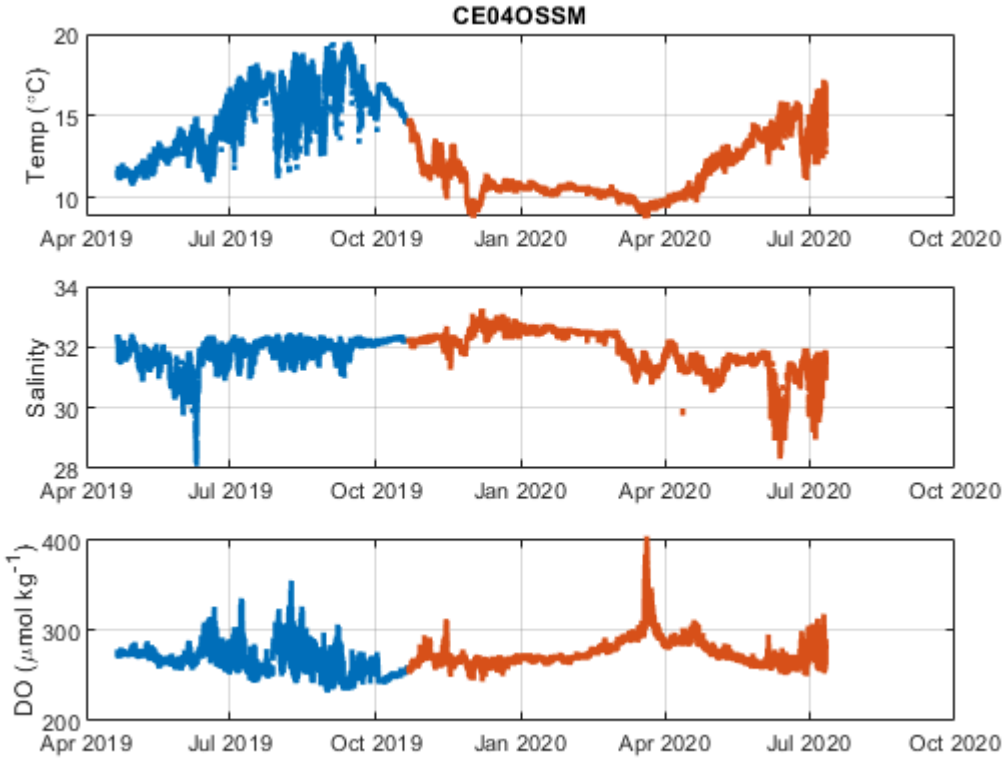
```
                    _ChunkSizes = 10000
port_timestamp
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                    _FillValue  = -9999999
                    comment     = 'Port timestamp, UTC'
                    units       = 'seconds since 1900-01-01'
                    long_name   = 'Port Timestamp, UTC'
                    _ChunkSizes = 10000
estimated_oxygen_saturation
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                    precision   = 3
                    long_name   = 'Dissolved Oxygen Saturation'
                    units       = 'percent'
                    _FillValue  = -9999999
                    comment     = 'Oxygen saturation is the percentage of dissolved oxygen relative to the absolu
                    coordinates = 'time lat lon depth'
                    _ChunkSizes = 10000
optode_temperature_qc_results
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                    _Unsigned   = 'true'
                    coordinates = 'time lat lon depth'
                    _FillValue  = -1
                    _ChunkSizes = 10000
deployment
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int32
       Attributes:
                    name        = 'deployment'
                    _ChunkSizes = 10000
estimated_oxygen_concentration
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                    comment                 = 'Dissolved Oxygen (DO) Concentration from the Stable Response Disso
                    units                   = 'µmol L-1'
                    _FillValue              = -9999999
                    long_name               = 'DO'
                    precision               = 3
                    coordinates             = 'time lat lon depth'
                    data_product_identifier = 'DOCONCS_L1'
                    _ChunkSizes             = 10000
optode_temperature
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                    units       = 'ºC'
                    _FillValue  = -9999999
                    comment     = 'Oxygen sensor ambient temperature'
                    precision   = 3
                    coordinates = 'time lat lon depth'
                    long_name   = 'Optode Temperature'
                    _ChunkSizes = 10000
int_ctd_pressure
```

```
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = NaN
                   comment                 = 'Seawater Pressure refers to the pressure exerted on a sensor in si
                   data_product_identifier = 'PRESWAT_L1'
                   precision               = 3
                   coordinates             = 'time lat lon depth'
                   long_name               = 'Seawater Pressure'
                   standard_name           = 'sea_water_pressure'
                   units                   = 'dbar'
                   _ChunkSizes             = 10000
estimated_oxygen_concentration_qc_results
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
preferred_timestamp
       Size:       64x2276823
       Dimensions: maxStrlen64,obs
       Datatype:   char
       Attributes:
                   _FillValue  = 'e'
                   comment     = 'Timestamp preferred as official record.'
                   units       = '1'
                   long_name   = 'Preferred Timestamp'
                   _ChunkSizes = [10000     14]
temp
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue              = NaN
                   comment                 = 'Seawater temperature near the sensor.'
                   data_product_identifier = 'TEMPWAT_L1'
                   precision               = 4
                   coordinates             = 'time lat lon depth'
                   long_name               = 'Seawater Temperature'
                   standard_name           = 'sea_water_temperature'
                   units                   = 'ºC'
                   instrument              = 'CE04OSSM-RID27-03-CTDBPC000'
                   stream                  = 'ctdbp_cdef_dcl_instrument_recovered'
                   _ChunkSizes             = 10000
dosta_abcdjm_cspp_tc_oxygen
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   ancillary_variables     = 'calibrated_phase optode_temperature'
                   units                   = 'µmol L-1'
                   comment                 = 'Dissolved Oxygen (DO) Concentration from the Stable Response Disso
                   long_name               = 'DO - Temp Corrected'
                   coordinates             = 'time lat lon depth'
                   data_product_identifier = 'DOCONCS_L1'
                   _FillValue              = -9999999
                   _ChunkSizes             = 10000
red_amplitude
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
```

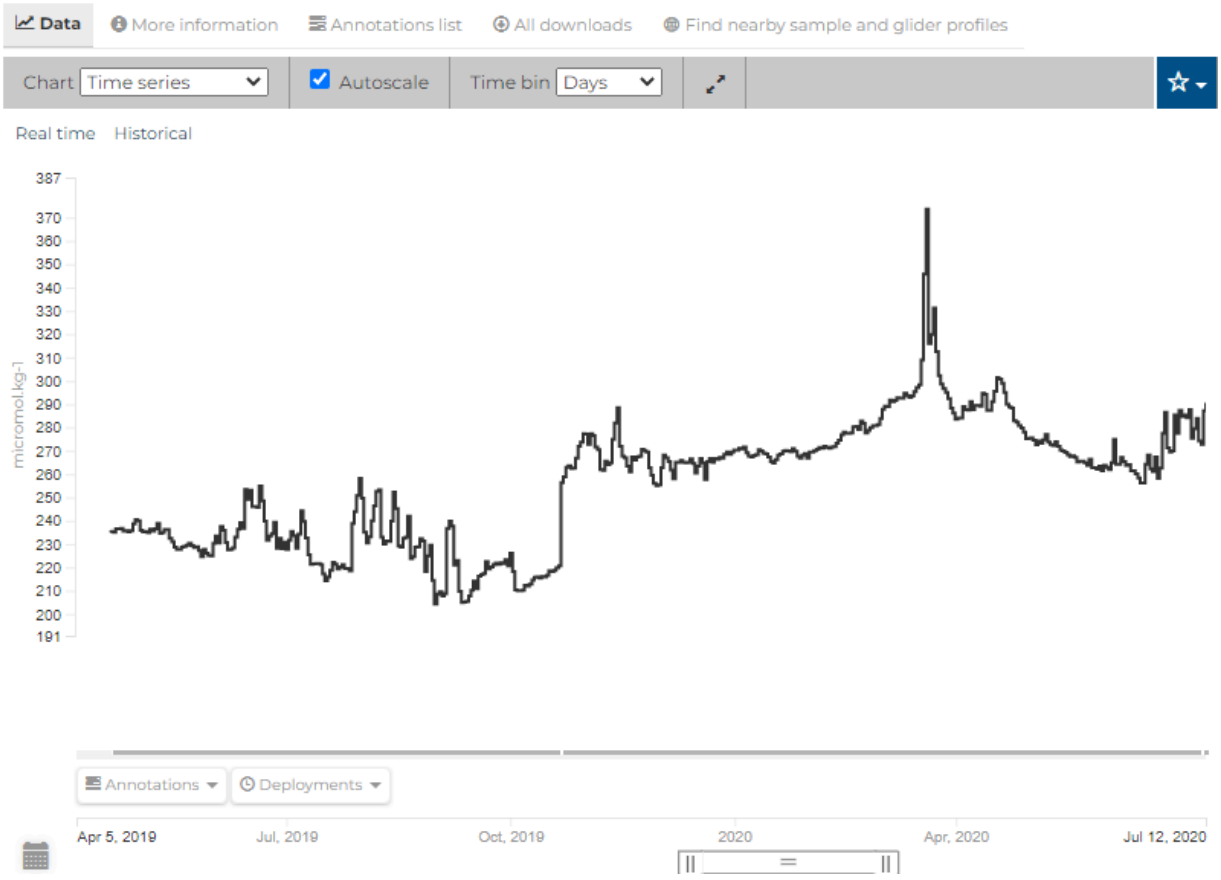
```
       Attributes:
                   _FillValue  = -9999999
                   comment     = 'Amplitude measurement with red excitation.'
                   precision   = 1
                   coordinates = 'time lat lon depth'
                   long_name   = 'Red Light Amplitude'
                   units       = 'mV'
                   _ChunkSizes = 10000
dosta_abcdjm_cspp_tc_oxygen_qc_executed
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
depth
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   _FillValue  = NaN
                   comment     = 'Depth (m) calculated from pressure (dbar) and latitude.'
                   long_name   = 'Depth calculated from pressure'
                   units       = 'm'
                   precision   = 3
                   instrument  = 'CE04OSSM-RID27-03-CTDBPC000'
                   stream      = 'ctdbp_cdef_dcl_instrument_recovered'
                   axis        = 'Z'
                   _ChunkSizes = 10000
blue_amplitude
       Size:       2276823x1
       Dimensions: obs
       Datatype:   single
       Attributes:
                   long_name   = 'Blue Light Amplitude'
                   units       = 'mV'
                   _FillValue  = -9999999
                   comment     = 'Amplitude measurement with blue excitation.'
                   precision   = 1
                   coordinates = 'time lat lon depth'
                   _ChunkSizes = 10000
time
       Size:       2276823x1
       Dimensions: obs
       Datatype:   double
       Attributes:
                   calendar      = 'gregorian'
                   _FillValue    = -9999999
                   long_name     = 'time'
                   standard_name = 'time'
                   units         = 'seconds since 1900-01-01 0:0:0'
                   axis          = 'T'
                   _ChunkSizes   = 10000
estimated_oxygen_saturation_qc_executed
       Size:       2276823x1
       Dimensions: obs
       Datatype:   int8
       Attributes:
                   _Unsigned   = 'true'
                   coordinates = 'time lat lon depth'
                   _FillValue  = -1
                   _ChunkSizes = 10000
```

Plot Data

```
% Plot CTD/Anderra deployments by color

figure
ax1 = subplot(3,1,1);
plot(deployment8.CTDdt,deployment8.temp,'.')
hold on
plot(deployment9.CTDdt,deployment9.temp,'.')
ylabel('Temp (\circC)')
grid on
title('CE04OSSM')

ax2 = subplot(3,1,2);
plot(deployment8.CTDdt,deployment8.practical_salinity,'.')
hold on
plot(deployment9.CTDdt,deployment9.practical_salinity,'.')
ylabel('Salinity')
grid on

ax3 = subplot(3,1,3);
plot(deployment8.DOdt,deployment8.dissolved_oxygen,'.')
hold on
plot(deployment9.DOdt,deployment9.dissolved_oxygen,'.')
ylabel('DO (\mumol kg^-^1)')
grid on
linkaxes([ax3 ax2 ax1],'x')
```



- Noticable difference in downloaded dissolved oxygen data (consistent between deployments) and dissolved oxygen data on data explorer (offset between deployments, see jump ~ Oct 2019 below).



- Answer from Chris Wingard: There was a bug in the system where values from two-point calibrations were not being used in processing of oxygen data. This has been updated on the THREDDS server but it looks like Data Explorer has not updated the code it is using to reflect that change. He submitted a helpdesk ticket. 5-23-2022

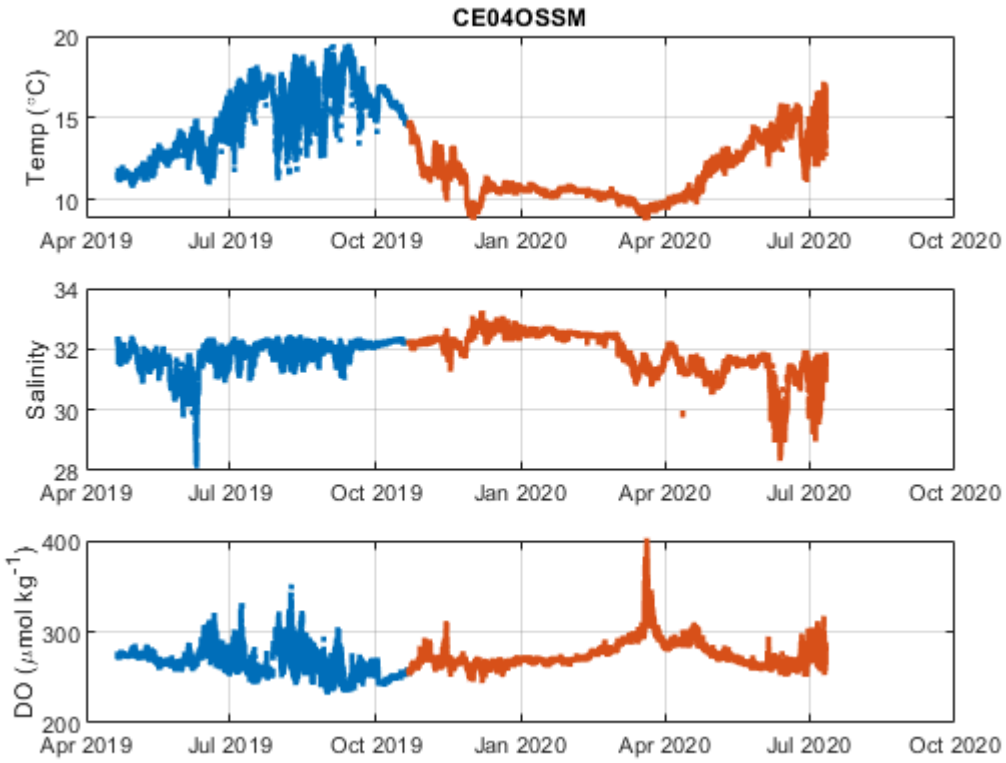
Calculate and plot median of 3-min DO burst sampling

- Aanderra sensor burst samples at 0.5 Hz for 3 minutes every 15 minutes
- The science idea behind 3 minute burst is it gives you enough data to average over a series of wave cycles, minimizing the impact of surface waves on the measurement

```
% Takes a while, inefficient loops, maybe because in structure?
% calculates median for each burst
% dissolved_oxygen_median needs CTDdt and not DOdt which includes all burst data

deployment8.dissolved_oxygen_median = NaN(1,length(deployment8.CTDdt)); % Deployment 8
for i = 1:length(deployment8.CTDdt)
    ts0 = deployment8.CTDdt(i);
    ts = find(deployment8.DOdt > ts0,1);
    deployment8.dissolved_oxygen_median(i) = median(deployment8.dissolved_oxygen(deployment8.DO
```

```
    & deployment8.DOdt > deployment8.DOdt(ts)));
end

deployment9.dissolved_oxygen_median = NaN(1,length(deployment9.CTDdt)); % Deployment 9
for i = 1:length(deployment9.CTDdt)
    ts0 = deployment9.CTDdt(i);
    ts = find(deployment9.DOdt > ts0,1);
    deployment9.dissolved_oxygen_median(i) = median(deployment9.dissolved_oxygen(deployment9.DO
    & deployment9.DOdt > deployment9.DOdt(ts)));
end
```

```
% Plot burst medians

figure
ax1 = subplot(3,1,1);
plot(deployment8.CTDdt,deployment8.temp,'.')
hold on
plot(deployment9.CTDdt,deployment9.temp,'.')
ylabel('Temp (\circC)')
grid on
title('CE04OSSM')

ax2 = subplot(3,1,2);
plot(deployment8.CTDdt,deployment8.practical_salinity,'.')
hold on
plot(deployment9.CTDdt,deployment9.practical_salinity,'.')
ylabel('Salinity')
grid on

ax3 = subplot(3,1,3);
plot(deployment8.CTDdt,deployment8.dissolved_oxygen_median,'.')
hold on
plot(deployment9.CTDdt,deployment9.dissolved_oxygen_median,'.')
ylabel('DO (\mumol kg^-^1)')
grid on
linkaxes([ax3 ax2 ax1],'x')
```



Compare to data from turn-around cruises

- Read in discrete bottle summaries and use local function (at end of script) to create water summary tables for site of interest
- Plots show site of interest (CE04) and location of discrete samples for oxygen
- Discrete water samples from Niskin bottles are measured for oxygen using Winkler titrations
- Temp and salinity data are from ship's CTD when Niksin bottles were fired
- Plots showing discrete data with OOI datastreams

```
% Set up workspace
addpath('G:\My Drive\Matlab_work\Functions\GSW')
cd('G:\My Drive\Matlab_work\Github\ooi-bgc-cookbook\Oxygen')

% All Endurance turn-around cruises during deployments 8 and 9
% Files pulled from Alfresco
CE11 = readtable('Endurance-11_SKQ201910S_OC1905C_Discrete_Summary.xlsx','TextType','string');
```

```
Warning: Column headers from the file were modified to make them valid MATLAB identifiers before creating
 variable names for the table. The original column headers are saved in the VariableDescriptions property.
Set 'VariableNamingRule' to 'preserve' to use the original column headers as table variable names.
```

```
CE12 = readtable('Endurance-12_SKQ201921S_Discrete_Summary.xlsx','TextType','string');
```

```
Warning: Column headers from the file were modified to make them valid MATLAB identifiers before creating
 variable names for the table. The original column headers are saved in the VariableDescriptions property.
Set 'VariableNamingRule' to 'preserve' to use the original column headers as table variable names.
```

```
CE13 = readtable('Endurance-13_TN380_Discrete_Summary.xlsx','TextType','string');
```

```
Warning: Column headers from the file were modified to make them valid MATLAB identifiers before creating
 variable names for the table. The original column headers are saved in the VariableDescriptions property.
Set 'VariableNamingRule' to 'preserve' to use the original column headers as table variable names.
```

```
showplots = 0; % 1 to display plots of CTD cast locations
Station = 'CE04';

% Pull information for samples collected at Station == CE04
CE11CE04 = water_sample_table(CE11,Station,showplots);  %( Cruise, Station, Plot)
CE12CE04 = water_sample_table(CE12,Station,showplots);
CE13CE04 = water_sample_table(CE13,Station,showplots);

% Create table for discrete sample information at just site of interest, CE04
CE_CE04 = [CE11CE04; CE12CE04; CE13CE04]
```

CE_CE04 = 34×16 table

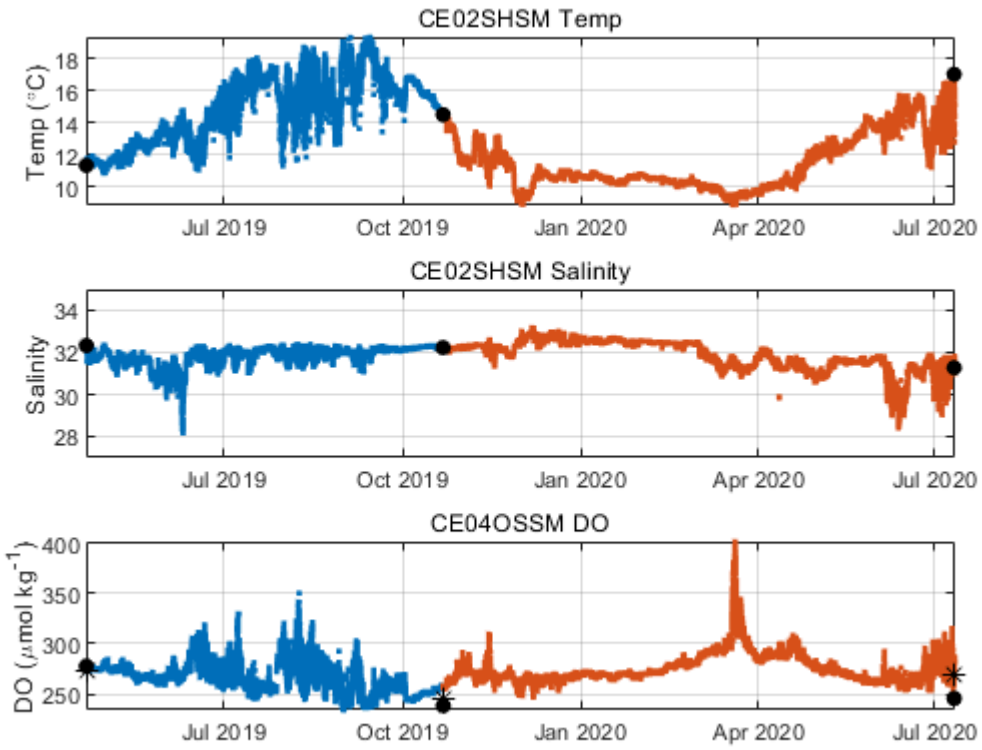
...

	Cruise	Station	Cast	Niskin_BottlePosition	CTDLatitude_deg
1	"SKQ201910S"	"CE04"	1	1	44.3605
2	"SKQ201910S"	"CE04"	1	1	44.3605
3	"SKQ201910S"	"CE04"	1	4	44.3605
4	"SKQ201910S"	"CE04"	1	4	44.3605
5	"SKQ201910S"	"CE04"	1	7	44.3605
6	"SKQ201910S"	"CE04"	1	7	44.3605
7	"SKQ201921S"	"CE04"	8	1	44.3822
8	"SKQ201921S"	"CE04"	8	1	44.3822
9	"SKQ201921S"	"CE04"	8	7	44.3830
10	"SKQ201921S"	"CE04"	8	7	44.3830
11	"SKQ201921S"	"CE04"	8	9	44.3831
12	"SKQ201921S"	"CE04"	8	9	44.3831
13	"SKQ201921S"	"CE04"	8	11	44.3831
14	"SKQ201921S"	"CE04"	8	11	44.3831

⋮

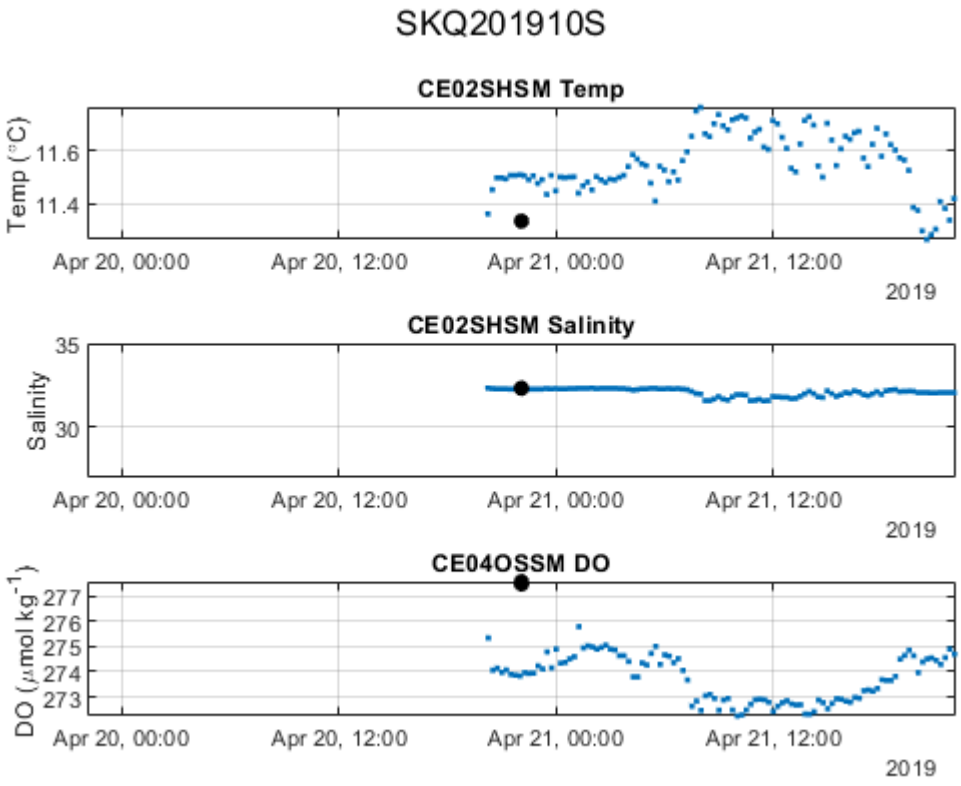
```
% Pulls out discrete temp/sal/DO data around depth of Near surface insturment frame at 7 m
ind = find(CE_CE04.CTDDepth_m > 6 & CE_CE04.CTDDepth_m < 10); % Greater than 6 but less than 10
ind = ind(1:end-2); % remove last two points during deployment 10 that occured after removal of

figure
```

```
ax1 = subplot(3,1,1);
plot(deployment8.CTDdt,deployment8.temp,'.')
hold on
plot(deployment9.CTDdt,deployment9.temp,'.')
plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
    CE_CE04.CTDTemperature1_degC(ind),'.k','MarkerSize',20)
axis tight
grid on
ylabel('Temp (\circC)')
title('CE02SHSM Temp','fontweight','normal')

ax2 = subplot(3,1,2);
plot(deployment8.CTDdt,deployment8.practical_salinity,'.')
hold on
plot(deployment9.CTDdt,deployment9.practical_salinity,'.')
plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
    CE_CE04.CTDSalinity1_psu(ind),'.k','MarkerSize',20)
axis tight
ylim([27 35])
grid on
ylabel('Salinity')
title('CE02SHSM Salinity','fontweight','normal')

ax3 = subplot(3,1,3);
plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'.')
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'.')
plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
    CE_CE04.DiscreteOxygen_umolkg(ind),'.k','MarkerSize',20)
axis tight
grid on
ylabel('DO (\mumol kg^-^1)')
linkaxes([ax3 ax2 ax1],'x')
title('CE04OSSM DO','fontweight','normal')
```

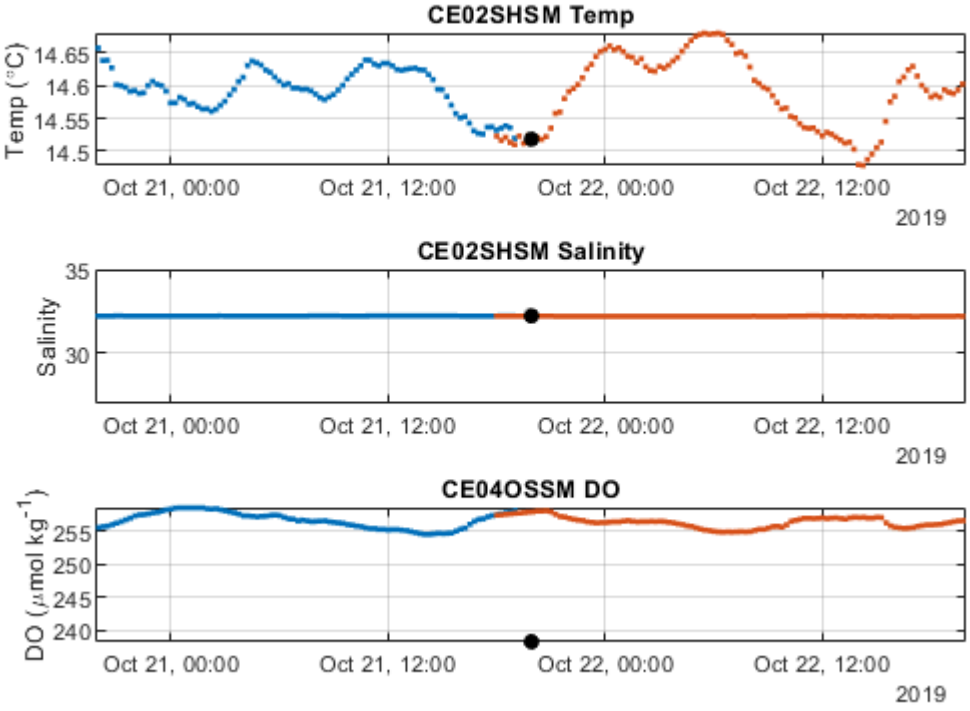



```
%% Take a closer look around turn-around cruises to check T/S from discrete samples match CTD c

for j = 1:2:length(ind) % by 2 because duplicate Winklers and only need 1 bottle closing time
    figure
    ax1 = subplot(3,1,1);
    plot(deployment8.CTDdt,deployment8.temp,'.')
    hold on
    plot(deployment9.CTDdt,deployment9.temp,'.')
    plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
        CE_CE04.CTDTemperature1_degC(ind),'.k','MarkerSize',20)
    axis tight
    grid on
    ylabel('Temp (\circC)')
    title('CE02SHSM Temp')

    ax2 = subplot(3,1,2);
    plot(deployment8.CTDdt,deployment8.practical_salinity,'.')
    hold on
    plot(deployment9.CTDdt,deployment9.practical_salinity,'.')
    plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
        CE_CE04.CTDSalinity1_psu(ind),'.k','MarkerSize',20)
    axis tight
    ylim([27 35])
    grid on
    ylabel('Salinity')
```

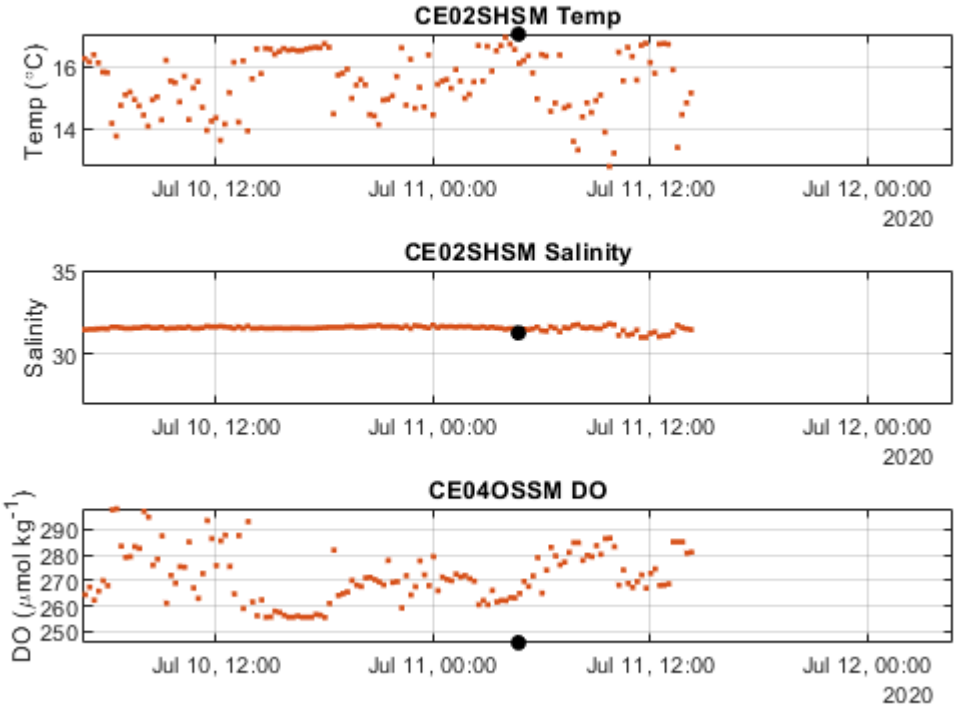
```
    title('CE02SHSM Salinity')

    ax3 = subplot(3,1,3);
    plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'.')
    hold on
    plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'.')
    plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
        CE_CE04.DiscreteOxygen_umolkg(ind),'.k','MarkerSize',20)
    axis tight
    grid on
    ylabel('DO (\mumol kg^-^1)')
    linkaxes([ax3 ax2 ax1],'x')
    xlim([CE_CE04.CTDBottleClosureTime_UTC(ind(j))-1 CE_CE04.CTDBottleClosureTime_UTC(ind(j))+1
    title('CE04OSSM DO')
    sgtitle([CE_CE04.Cruise(ind(j))])
end
```



SKQ201921S



TN380



- Temperature and Salinity of CTD cast at time of bottle firing matches pretty well with Temp and salinity recorded by the deployed CTD
- Indicates that we can use the discrete Oxygen Samples to correct the deployed oxygen sensors

Use Winklers to make gain correction and Plot Gain Corrected Data

Gain = Winkler value/Sensor value

Gain corrected data = sensor value * gain value

```
% Make table with just Winkler titrations of interest for depths and
% deployment times
Winkler = CE_CE04(ind,:)
```

```
Winkler = 6×16 table
```

...

	Cruise	Station	Cast	Niskin_BottlePosition	CTDLatitude_deg
1	"SKQ201910S"	"CE04"	1	4	44.3605
2	"SKQ201910S"	"CE04"	1	4	44.3605
3	"SKQ201921S"	"CE04"	8	9	44.3831
4	"SKQ201921S"	"CE04"	8	9	44.3831
5	"TN380"	"CE04"	10	7	44.3758
6	"TN380"	"CE04"	10	7	44.3758

```
cruise = unique(Winkler.Cruise) % Find unique cruise names
```

```
cruise = 3×1 string
"SKQ201910S"
"SKQ201921S"
"TN380"
```

```
Wink_time = unique(Winkler.CTDBottleClosureTime_UTC)
```

```
Wink_time = 3×1 datetime
20-Apr-2019 22:06:37
21-Oct-2019 19:56:16
11-Jul-2020 04:43:16
```

```
% Look at mean and standard deviation of duplicate Winkler titrations
Wink_Deploy8_start = nanmean([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(1))])
```

```
Wink_Deploy8_start = 277.5179
```

```
std = nanstd([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(1))])
```

```
std = 0.0616
```

```
Wink_Deploy8_end = nanmean([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(2))])
```

```
Wink_Deploy8_end = 238.2993
```

```
Wink_Deploy9_start = Wink_Deploy8_end
```

```
Wink_Deploy9_start = 238.2993
```

```
std = nanstd([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(2))])
```

```
std = 0.0308
```

```
Wink_Deploy9_end = nanmean([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(3))])
```

```
Wink_Deploy9_end = 245.5655
```

```
std = nanstd([Winkler.DiscreteOxygen_umolkg(Winkler.Cruise == cruise(3))])
```

```
std = 0.0618
```

```
% Compare to median DO value
sensorDO_Deploy8_start = deployment8.dissolved_oxygen_median(find(deployment8.CTDdt > Wink_time
```

```
sensorDO_Deploy8_start = 273.9594
```

```
sensorDO_Deploy9_start = deployment9.dissolved_oxygen_median(find(deployment9.CTDdt > Wink_time
```

```
sensorDO_Deploy9_start = 258.0053
```

```
% Gain = Winkler value/Sensor value
gain8 = Wink_Deploy8_start/sensorDO_Deploy8_start
```

```
gain8 = 1.0130
```

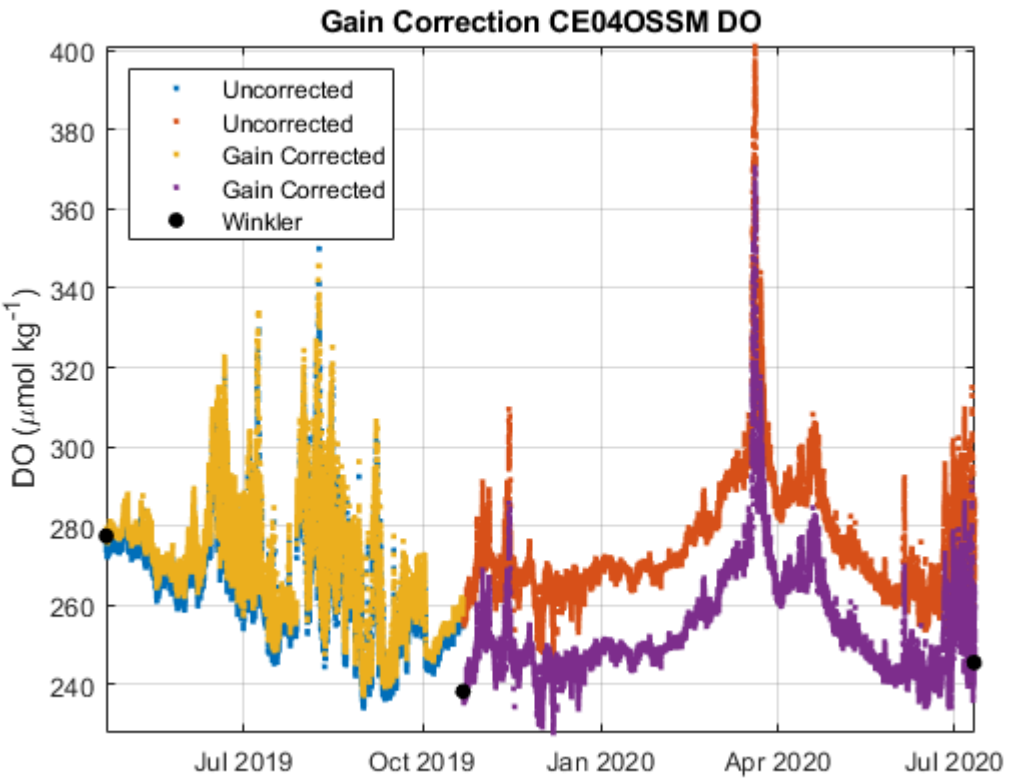
```
gain9 = Wink_Deploy9_start/sensorDO_Deploy9_start
```

```
gain9 = 0.9236
```

```
% Adjust deployments for storage gain
% Gain corrected data = sensor value * gain value
deploy8gain = deployment8.dissolved_oxygen_median*gain8;
deploy9gain = deployment9.dissolved_oxygen_median*gain9;
```

```
% Plot gain corrected data
figure
plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'.')
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'.')
plot(deployment8.CTDdt + minutes(1.5),deploy8gain,'.')
hold on
plot(deployment9.CTDdt + minutes(1.5),deploy9gain,'.')
plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
```

```
    CE_CE04.DiscreteOxygen_umolkg(ind),'.k','MarkerSize',20)
axis tight
grid on
ylabel('DO (\mumol kg^-^1)')
legend('Uncorrected','Uncorrected','Gain Corrected','Gain Corrected','Winkler','Location','NW')
title('Gain Corrected CE04OSSM DO','fontweight','bold')
```



Calculate In situ Drift Correction

```
% Calculate in situ drift correction for Deployment 8
x8 = [Wink_time(1); Wink_time(2)];
y8 = [1; Wink_Deploy8_end/(deploy8gain(end))]; % in situ adjustment 1 to Winkler/sensor(already

% Find drift correction at each timepoint between Winkler samples
deploy8drift = interp1(x8,y8,deployment8.CTDdt); % Interp in situ drift correction for deployme

% Set drift correction to each timepoint before Winkler Sample to no drift
deploy8drift(isnan(deploy8drift)) = 1; % Assumes brief period of Aanderra data before Winkler h

% Calculate in situ drift correction for Deployment 9
% Find DO median time at Collection of end of Deployment 9 Winklers
sensorDO_Deploy9_end = deploy9gain(find(deployment9.CTDdt > Wink_time(3),1));
```

```
sensorDO_Deploy9_end = 244.7257
```

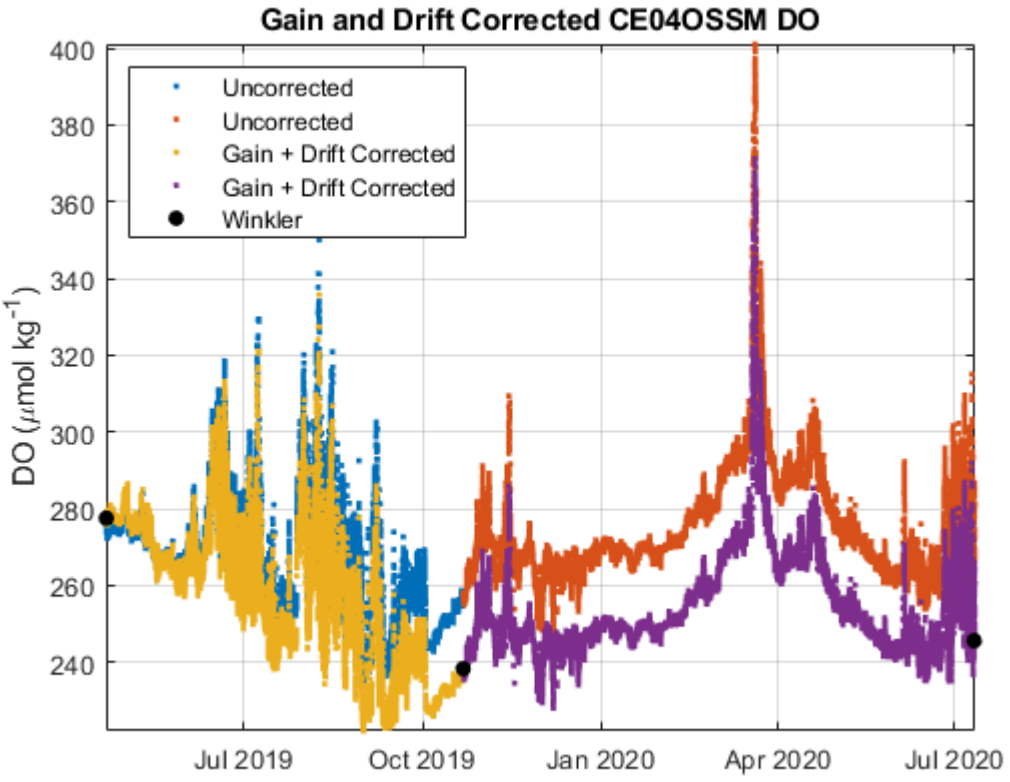
```
x9 = [Wink_time(2); Wink_time(3)];
y9 = [1; Wink_Deploy9_end/sensorDO_Deploy9_end]; % in situ adjustment 1 to Winkler/sensor(alrea

% Find drift correction at each timepoint between Winkler samples
deploy9drift = interp1(x9,y9,deployment9.CTDdt); % Interp in situ drift correction for deployme

% Set drift correction before deployment Winkler to 1
deploy9drift(1:8) = 1;
% Set drift correction after recovery Winkler to last same drift as last
% value
deploy9drift(end-38:end) = Wink_Deploy9_end/sensorDO_Deploy9_end;
```

Calculate final corrected oxygen and Plot Data

DO corrected = sensor DO * gain correction * timeseries of drift correction

```
% Calculate corrected oxygen by deployment
% DO corrected = sensor DO * gain correction * timeseries of drift correction
deployment8.deploy8corrected = deploy8gain.*deploy8drift';
deployment9.deploy9corrected = deploy9gain.*deploy9drift';
```

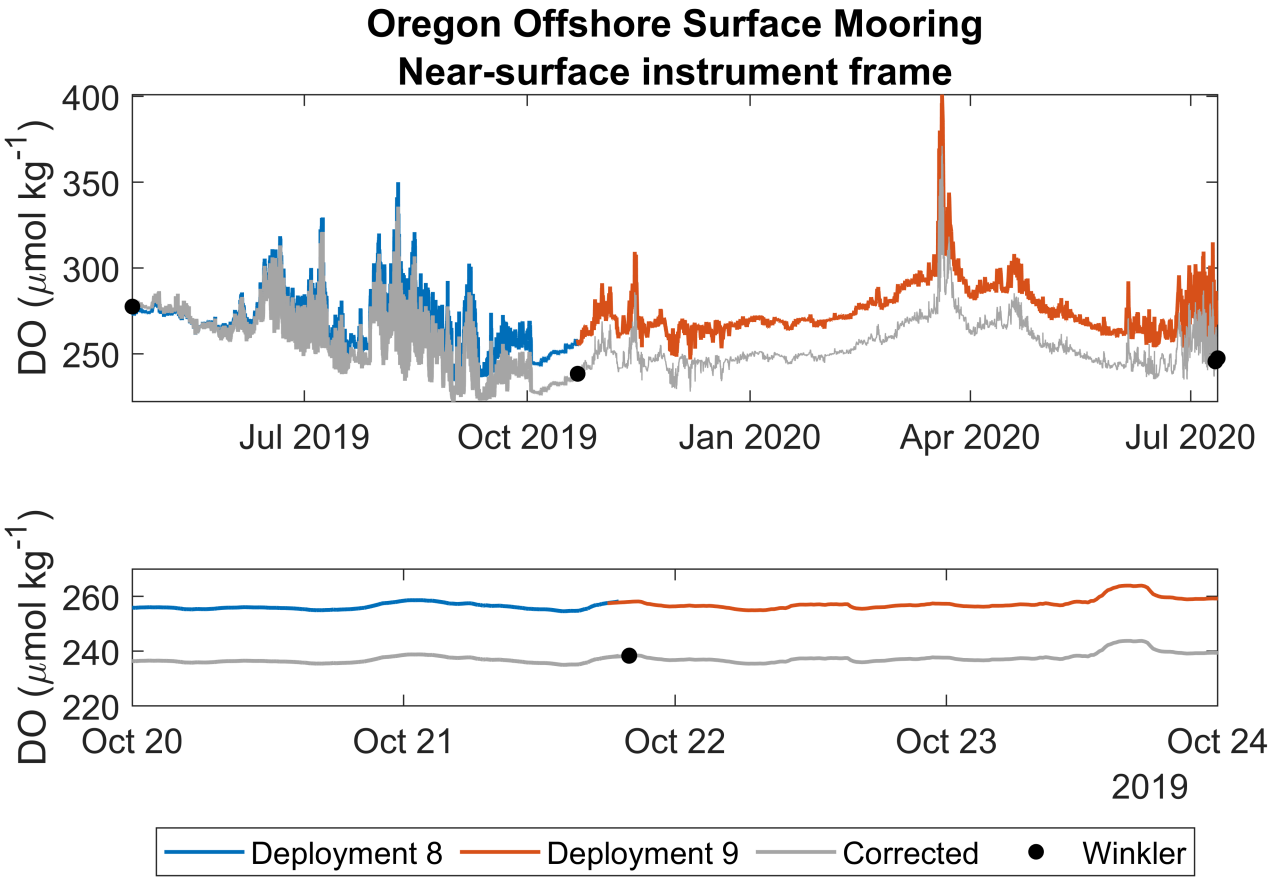
```
% Plot gain corrected and drift corrected data
figure
plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'.')
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'.')
plot(deployment8.CTDdt + minutes(1.5),deployment8.deploy8corrected,'.')
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.deploy9corrected,'.')
plot(CE_CE04.CTDBottleClosureTime_UTC(ind),...
    CE_CE04.DiscreteOxygen_umolkg(ind),'.k','MarkerSize',20)
axis tight
grid on
ylabel('DO (\mumol kg^-^1)')
legend('Uncorrected','Uncorrected','Gain + Drift Corrected','Gain + Drift Corrected','Winkler',
title('Gain and Drift Corrected CE04OSSM DO','fontweight','bold')
```



Make the finalized pretty plot

```
blue = [0     0.44706     0.74118];
red = [0.85098     0.32549    0.098039];
grey = [0.65098     0.65098     0.65098];

f0 = figure;
f0.Position = [200 200 700 500];
subplot(2,1,1)
f = gca;
plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'Color',blue,'Linewid
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'Color',red,'Linewidt
plot(deployment8.CTDdt + minutes(1.5),deployment8.deploy8corrected,'Color',grey,'Linewidth',1.4
plot(CE_CE04.CTDBottleClosureTime_UTC(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),...
    CE_CE04.DiscreteOxygen_umolkg(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),'.k','Marke
plot(deployment9.CTDdt + minutes(1.5),deployment9.deploy9corrected,'Color',grey)
plot(CE_CE04.CTDBottleClosureTime_UTC(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),...
    CE_CE04.DiscreteOxygen_umolkg(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),'.k','Marke
axis tight
f.FontSize =13;
ylabel('DO (\mumol kg^-^1)')
title({['Oregon Offshore Surface Mooring'] 'Near-surface instrument frame'})

subplot(2,1,2)
f = gca;
plot(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median,'Color',blue,'Linewid
```

```
hold on
plot(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median,'Color',red,'Linewidt
plot(deployment8.CTDdt + minutes(1.5),deployment8.deploy8corrected,'Color',grey,'Linewidth',1.4
plot(CE_CE04.CTDBottleClosureTime_UTC(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),...
    CE_CE04.DiscreteOxygen_umolkg(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),'.k','Marke
plot(deployment9.CTDdt + minutes(1.5),deployment9.deploy9corrected,'Color',grey,'Linewidth',1.4
plot(CE_CE04.CTDBottleClosureTime_UTC(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),...
    CE_CE04.DiscreteOxygen_umolkg(CE_CE04.CTDDepth_m > 5 & CE_CE04.CTDDepth_m < 10),'.k','Marke
ylim([220 270])
xlim([datetime(2019,10,20,'TimeZone','UTC') datetime(2019,10,24,'TimeZone','UTC')])
f.FontSize =13;
ylabel('DO (\mumol kg^-^1)')
legend('Deployment 8','Deployment 9','Corrected','Winkler','Location','southoutside',"Orientati
```




```
% Export data on finalized plots as csv
writetable(Winkler,'Winkler.csv','Delimiter',',')

Deploy8Table = table(deployment8.CTDdt + minutes(1.5),deployment8.dissolved_oxygen_median',depl
    'VariableNames',{'datetime','oxygen_uncorrected_umol_kg','oxygen_corrected_umol_kg'});
Deploy9Table = table(deployment9.CTDdt + minutes(1.5),deployment9.dissolved_oxygen_median',depl
    'VariableNames',{'datetime','oxygen_uncorrected_umol_kg','oxygen_corrected_umol_kg'});

writetable(Deploy8Table,'Deploy8File.csv','Delimiter',',')
```

```
writetable(Deploy9Table,'Deploy9File.csv','Delimiter',',')
```

```
% Export median oxygen data, gain corrected oxygen data, and final (gain + drift
% corrected) oxygen data for worked-example checkpoints
Deployment8Outputs = table(deployment8.CTDdt,deployment8.dissolved_oxygen_median',deploy8gain',
    'VariableNames',{'datetime','DO_median_umol_kg','DO_gain_corrected_umol_kg','DO_gain_drift_

Deployment9Outputs = table(deployment9.CTDdt,deployment9.dissolved_oxygen_median',deploy9gain',
    'VariableNames',{'datetime','DO_median_umol_kg','DO_gain_corrected_umol_kg','DO_gain_drift_


writetable(Deployment8Outputs,'Deployment8_Outputs.csv','Delimiter',',')
writetable(Deployment9Outputs,'Deployment9_Outputs.csv','Delimiter',',')
```

Localized functions below

```
function deployment = pull_DO_Data_from_THREDDS(deploy_num)
%   deploy_num = 'deployment0012' % string of deployment you want
options = weboptions('Timeout', 600);

site = 'CE04OSSM-RID27-04-DOSTAD000-recovered_host-dosta_abcdjm_dcl_instrument_recovered';
base_catalog_url = 'https://thredds.dataexplorer.oceanobservatories.org/thredds/catalog/ooigold

catalog = webread(strcat(base_catalog_url,site,'/catalog.html'),options);
nclist = regexp(catalog,'<a href=''([^>]+.nc)''>','tokens');
base_url = 'https://thredds.dataexplorer.oceanobservatories.org/thredds/dodsC/';

[~, ind] = find(contains(string(nclist),deploy_num) == 1);
    CTDind = ind(1); % CTD listed first
    DOSTAind = ind(2); % DOSTA listed second

% For first file : CTD
CTD_url_thredds = nclist{1,CTDind}{1,1};
CTD_url_thredds = strcat(base_url,CTD_url_thredds(22:end),'#fillmismatch');
ncdisp(CTD_url_thredds) % Displays all info for variables in netCDF

% For second file: DOSTA
DOSTA_url_thredds = nclist{1,DOSTAind}{1,1};
DOSTA_url_thredds = strcat(base_url,DOSTA_url_thredds(22:end),'#fillmismatch');
ncdisp(DOSTA_url_thredds) % Displays all info for variables in netCDF

time = ncread(CTD_url_thredds,'time');
deployment.CTDdn = datenum(1900,1,1,0,0,0)+(time/60/60/24);
deployment.CTDdt = datetime(deployment.CTDdn,'ConvertFrom','datenum','TimeZone','UTC'); clear t
deployment.pressure_qartod_executed = ncread(CTD_url_thredds,'pressure_qartod_executed');
deployment.pressure_qartod_results = ncread(CTD_url_thredds,'pressure_qartod_results');
deployment.pressure = ncread(CTD_url_thredds,'pressure');
deployment.temp_qartod_executed = ncread(CTD_url_thredds,'temp_qartod_executed');
deployment.temp_qartod_results = ncread(CTD_url_thredds,'temp_qartod_results');
```

```
deployment.temp = ncread(CTD_url_thredds,'temp');
deployment.practical_salinity = ncread(CTD_url_thredds,'practical_salinity');
deployment.practical_salinity_qartod_executed = ncread(CTD_url_thredds,'practical_salinity_qart
deployment.practical_salinity_qartod_results = ncread(CTD_url_thredds,'practical_salinity_qarto
deployment.depth = ncread(CTD_url_thredds,'depth');
deployment.deployment = ncread(CTD_url_thredds,'deployment');

time = ncread(DOSTA_url_thredds,'time');
deployment.DOdn = datenum(1900,1,1,0,0,0)+(time/60/60/24);
deployment.DOdt = datetime(deployment.DOdn,'ConvertFrom','datenum','TimeZone','UTC'); clear tim
deployment.dissolved_oxygen_qc_executed = ncread(DOSTA_url_thredds,'dissolved_oxygen_qc_execute
deployment.dissolved_oxygen_qc_results = ncread(DOSTA_url_thredds,'dissolved_oxygen_qc_results'
deployment.dissolved_oxygen = ncread(DOSTA_url_thredds,'dissolved_oxygen');
deployment.lat = ncreadatt(DOSTA_url_thredds,'/','lat');
deployment.lon = ncreadatt(DOSTA_url_thredds,'/','lon');

end

function [DS] = water_sample_table(cruise,Station,showplots)
DS = table(cruise.Cruise(cruise.Station == Station), cruise.Station(cruise.Station == Station),
    cruise.CTDLatitude_deg_(cruise.Station == Station),cruise.CTDLongitude_deg_(cruise.Station
    cruise.CTDBottleClosureTime_UTC_(cruise.Station == Station),cruise.CTDDepth_m_(cruise.Stati
    cruise.CTDSalinity1_psu_(cruise.Station == Station), cruise.CTDOxygen_mL_L_(cruise.Station
    'VariableNames',{'Cruise','Station','Cast','Niskin_BottlePosition','CTDLatitude_deg','CTDLo
    'CTDDepth_m','CTDTemperature1_degC','CTDSalinity1_psu','CTDOxygen_mL_L','DiscreteOxygen_mL_

DS.CTDBottleClosureTime_UTC = datetime(DS.CTDBottleClosureTime_UTC,'InputFormat','yyyy-MM-dd''T

DS.DiscreteOxygen_mL_L(DS.DiscreteOxygen_mL_L == -9999999) = NaN; % Replaces flag for missing d
DS.DiscreteOxygen_umolL = double(DS.DiscreteOxygen_mL_L)*44.661; % convert from ml/l to umol/l

% Code taken from OOI Github
pref = 0; % Reference pressure (db)
SA = gsw_SA_from_SP(DS.CTDSalinity1_psu, DS.CTDPressure_db, DS.CTDLongitude_deg, DS.CTDLatitude
CT = gsw_CT_from_t(SA, DS.CTDTemperature1_degC, DS.CTDPressure_db);
pdens = gsw_rho(SA, CT, pref); % potential referenced to p=0

% Convert from volume to mass units:
DS.DiscreteOxygen_umolkg = 1000*DS.DiscreteOxygen_umolL./pdens;
DS.CTDOxygen_umolkg = 1000*DS.CTDOxygen_mL_L*44.661./pdens;

% Location of Oregon Shelf Offshore Surface Mooring
CE04OSSM = [44.37868, -124.94508]; % From OOI Website
dn = datenum(mean(DS.CTDBottleClosureTime_UTC,'omitnan')); % For Figure title

    if showplots == 1
        figure
        plot(CE04OSSM(2),CE04OSSM(1),'.k','MarkerSize',30)
        hold on
        plot(DS.CTDLongitude_deg,DS.CTDLatitude_deg,'*','MarkerSize',10)
        title([Station ': ' datestr(dn,'mmmm yyyy')])
        grid on
        legend('CE04','Cast w/ DO','Location','northeastoutside')
```

```
        casts = unique(DS.Cast);
        for i = 1:length(casts)
            text(DS.CTDLongitude_deg(DS.Cast == casts(i)),DS.CTDLatitude_deg(DS.Cast == casts(i
        end
    end
end
```