Glider Data Guidance

In the last decade, autonomous underwater glider observations have increased, and the technology has drastically improved, providing a multidisciplinary approach to oceanographic studies. Gliders allow coupling traditional oceanographic measurements such as temperature, salinity, and currents with biological and geochemical measurements such as acoustics, animal telemetry, phytoplankton and zooplankton abundance, dissolved oxygen, and nitrate. Deployed for long periods of time and traveling up to thousands of kilometers per deployment, gliders provide the vertical resolution that is often under-sampled by traditional oceanographic measurements. This guidance document outlines requirements for glider data submission to GRIIDC.

Glider Terminology:

- **Profile**: A single vertically oriented track of a glider, either upward or downward, through the water column. A profile is one-half of a dive.
- **Dive**: A single vertical profile to depth followed by a vertical profile towards the surface. A dive does not necessarily begin with or terminate with a surfacing and/or GPS fix.
- **Segment**: The set of data collected between two GPS fixes obtained while the glider is on the surface of the water.
- **Trajectory or Deployment**: A series of one or more segments completed by a glider between the time of deployment and the time of recovery.

Data Submission Format

Data should be submitted in ASCII or NetCDF format. ASCII files written in space, comma, or tab delimited variables are easily read by both humans and computers. Common file extensions include *.txt and *.cnv. Spreadsheet data (e.g. Excel) should be saved as comma separated variables (*.csv) or other text formats for submission rather than Excel workbooks (*.xls,*.xlsx). NetCDF is a widely used self-describing scientific data format that is compatible with a large number of common software analysis packages such as MATLAB.

There should be sufficient information submitted with the data, preferably inside the individual files themselves, such that the data are completely understandable. This information includes variable and parameter names (e.g., t is temperature), the units of measure (e.g., degrees Celsius), the latitude and longitude coordinates and depth where collected, and date and time when collected. Date-time should include time zone or be expressed in UTC whenever possible and ideally written in ISO 8601 format (e.g., 2023-10-25T22:34:51Z).

Filename format

The filename should include the glider name, start time of data acquisition, and whether the data is real-time (rt) or delayed mode. The date should be in ISO 8601 format and UTC.

Examples: glidername_yyyymmddTHHMMSSZ_rt.nc
Ru30_20230120T102030Z_rt.nc
Ru30_20230120T102030Z_delayed.nc

Global Attributes Information

It is important to make sure the following information is available: glider type (Seaglider, Spray glider, Slocum glider), processing level (description of the processing and/or quality control), and references for the method. The metadata should include the title; abstract; keywords; contributors' names and roles; the creator's name, email, and URL; and the date the file was created, issued, and modified.

Also required is a dataset ID and the World Meteorological Organization (WMO) ID. The dataset ID is a unique identifier for the dataset very similar to the filename which includes the glider name and the deployment time (e.g., glider-YYYYmmddTHHMM, ru30-20230101T0000). The WMO ID is a unique value assigned to a specific glider deployed/location.

Variables and Metadata

Glider data variables can be divided in three main categories: time-series, profiles, and container. Time-series variables are dependent on time; profile variables document a representative time and position for an individual profile; and container variables are used to capture metadata regarding the platform and instrumentation.

Each variable should have the following information: long name (not an acronym), units, filling value (e.g., 999), and instrument. Other variables such as accuracy, precision, resolution, name of ancillary variables (e.g., quality control), comments, and valid minimum and maximum values should be included in the NetCDF files or metadata whenever they are available. Information about the variables can be included in the NetCDF, readme file (ASCII text file), or metadata. Readme files should not be submitted in Microsoft Word format.

Time, latitude, longitude, and depth are required for all time-series variables such as temperature, salinity, and chlorophyll-a. Profile variables are not required with the submissions to GRIIDC, but if they are available, please include the profile_id and the mid-point latitude, longitude, and time.

Table 1: Summary of the variable types, description, and a NetCDF example of the attributes

Type	Description	Variables	Examples (NetCDF)
Trajectory variables	Character array that identifies the deployment	• Trajectory variable contains text using the format: Glider-YYYYmmddTHHMM	char trajectory(traj_strlen) ; trajectory:cf_role = "trajectory_id" ; trajectory:comment = "A single deployment..." ; trajectory:long_name = "Trajectory/Deployment Name" ;
Profile variables	Dimensionless variables used to provide access to individual profiles from the aggregated dataset	• Unique identifier for the profile (1 to number of profiles in a trajectory) • Latitude, longitude, and time refer to the mid-point of the profile • Depth-average current (u- and v-components) of the net current measured while the glider is underwater • Quality control if applicable	int profile_id ; profile_id:FillValue = -999 ; profile_id:comment = "Sequential profile number ..." ; profile_id:long_name = "Profile ID" ; profile_id:valid_max = 2147483647 ; profile_id:valid_min = 1 ; double u ; u:_FillValue = -999. ; u:comment = "The depth-averaged current ..." ; u:long_name = "Depth-Averaged Eastward ⋯" ; u:observation_type = "calculated" ; u:platform = "platform" ; u:standard_name = "eastward_sea_water_velocity" ; u:units = "m s-1" ; u:valid_max = 10. ; u:valid_min = -10. ;
Time-series variables	Dimensioned along the time axis	• Time stamp corresponding to the acquisition of the sensor data for the profile • Latitude, longitude, depth, and pressure along the time variable • All measurements collected along track (time) such as temperature, salinity, chlorophyll-a, etc. • Quality control variables if applicable	double time(time) ; time:ancillary_variables = "time_qc" ; time:calendar = "gregorian" ; time:long_name = "Time" ; time:observation_type = "measured" ; time:standard_name = "time" ; time:units = "seconds since 1970-01-01T00:00:00Z" ; Double temperature(time); temperature:FillValue = -999. ; temperature:accuracy = “ ” ; temperature:ancillary_variables = "temperature_qc" ; temperature:coordinates ="time latitude longitude depth" ; temperature:instrument = "instrument_ctd" ; temperature:ioos_category = "Temperature" ; temperature:long_name = "Sea Water Temperature" ; temperature:observation_type = "measured" ; temperature:platform = "platform" ; temperature:standard_name = "sea_water_temperature" ; temperature:units = "Celsius" ; temperature:valid_max = 40. ; temperature:valid_min = -5. ;
Container variables	Used to store metadata about glider and instruments	Platform = metadata about the glider Instrument variables (e.g., CTD) to store information about the instruments	int platform ; platform:_FillValue = -999 ; platform:comment = "Slocum ⋯" ; platform:id = "ruXX" ; platform:instrument = "instrument_ctd" ; platform:long_name = "Glider name" ; platform:type = "platform" ; platform:wmo_id = " " ; # WMO ID specific to this glider int instrument_ctd ; instrument_ctd:_FillValue = -999 ; instrument_ctd:calibration_date = "Date ISO 8601 " ;

			instrument_ctd:calibration_report = " " ; instrument_ctd:comment = "pumped CTD" ; instrument_ctd:factory_calibrated =" Date ISO 8601 "; instrument_ctd:long_name = "Seabird Glider CTD" ; instrument_ctd:make_model = "Seabird GPCTD" ; instrument_ctd:platform = "platform" ; instrument_ctd:serial_number = "xxxx" ; instrument_ctd:type = "platform" ;

Quality Control Flags

Users are encouraged to provide quality control flags when available. This array conveys information on the data quality of each value of the measured variable. The quality control flag matrix and the variable of interest are thus the same size. Table 2 provides the simple set of flags and associated descriptions adopted by U.S. Integrated Ocean Observing System (IOOS). For additional information regarding flags, see the Manual for the Use of Real-Time Oceanographic Data Quality Control Flags (U.S. National Ocean Service, U.S. IOOS 2020) posted on the U.S. IOOS QARTOD website. The U.S. IOOS QARTOD website also provides quality control guidelines for all the different types of real-time in-situ oceanographic observations.

Table 2: Quality control flags for real-time data (UNESCO 2013)

QC Flag	Description
Pass = 1	Data have passed critical real-time quality control tests and are deemed adequate for use as preliminary data.
Not evaluated = 2	Data have not been QC-tested, or the information on quality is not available.
Suspect or high interest = 3	Data are suspect or of high interest to data providers and users. They are flagged suspect to draw further attention to them by operators.
Fail = 4	Data are considered to have failed one or more critical real-time QC checks. If they are disseminated at all, it should be readily apparent that they are not of acceptable quality.
Missing data = 9	Data are missing; used as a placeholder.

Example of temperature quality flags in NetCDF file

byte temperature_qc(time);

temperature_qc:_FillValue = -127b ;
temperature_qc:flag_meanings = "no_qc_performed good_data probably_good_data bad_data_that_are_potentially_correctable bad_data value_changed not_used not_used interpolated_value missing_value" ;
temperature_qc:flag_values = 0b, 1b, 2b, 3b, 4b, 5b, 6b, 7b, 8b, 9b ;
temperature_qc:long_name = "temperature Quality Flag" ;
temperature_qc:standard_name = "sea_water_temperature status_flag" ;
temperature_qc:valid_max = 9b ;

temperature_qc:valid_min = 0b

References

NetCDF file specifications: https://github.com/ioos/ioosngdac/wiki/NetCDF-Specification

NGDAC website: https://gliders.ioos.us/

Paris. Intergovernmental Oceanographic Commission of UNESCO, 2013. Ocean Data Standards, Vol.3: Recommendation for a Quality Flag Scheme for the Exchange of Oceanographic and Marine Meteorological Data. (IOC Manuals and Guides, 54, Vol. 3.) 12 pp. http://www.nodc.noaa.gov/oceanacidification/support/MG54_3.pdf

U.S. Integrated Ocean Observing System, 2020. Manual for the Use of Real-Time Oceanographic Data Quality Control Flags, Version 1.2. 24 pp. https://doi.org/10.25923/w8y6-d298

U.S. IOOS QARTOD website: https://ioos.noaa.gov/project/qartod/