Data File Descriptions

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This document defines the data structure and variables saved within the QA, stat, and ops ".mat" files for each site.

The variables defined below are used in this guide to indicate array size:

N = number of measurements taken in time
B = number of measurement bins in the vertical direction
n = number of measurement ensembles in time (multiple measurements in time averaged to one ensemble value)
b = number of measurement bins, after QA & statistical pruning procedures

QA files:

- *config*
  - This struct is an output of the RDADCP package. See https://www.eoas.ubc.ca/~rich/ for further descriptions.
- *data*
  - *time* (1xN) [datetime]
  - *depth* (1xN) [m]: depth of ADCP below surface
  - *pitch* (1xN) [º] : relative to ADCP oriented directly up
  - *roll* (1xN) [º]: relative to ADCP oriented directly up
  - *heading* (1xN) [º]: with respect to magnetic north
  - *temperature* (1xN) [ºC]: measured water temperature
  - *east_vel* (BxN): [m/s] true east-west component of velocity
  - *north_vel* (BxN) [m/s]: true north-south component of velocity
  - *vert_vel* (BxN) [m/s]: vertical component of velocity
  - *error_vel* (BxN) [m/s]: mismatch between two estimates for vertical velocity
  - *speed* (BxN) [m/s]: velocity magnitude (horizontal and vertical components)
  - *dir_vel* (BxN) [º]: direction of horizontal velocity (true north = 0 degrees, CW positive)
  - *intens* (Bx4xN): echo intensity
  - *corr* (Bx4xN): beam correlation count
  - *perc_good* (Bx4xN) [%]: percent good
  - *bins* (Bx1) [m]: distance from seabed to center of each measurement bin
  - *horz_vel* (BxN) [m/s]: horizontal velocity (signed ebb (+) and flood (-))
- *QA*
  - *corr_min*: minimum average beam correlation count for valid data, set by user
  - *intens_min*: minimum average beam echo intensity for valid data, set by user
  - *surface_bins*: number of bins below surface to discard in QA process, set by user based on visual review of velocity and ancillary information

    - *max_bin*: optional fixed bin number at which to cap profiles, set by user. Overrides surface_bins.
    - *time* [serial date number]: processing time stamp
- *raw_type*: raw data type (“Raw Workhorse” for all files)
- *tilt_angle* (1xN) [º]: total tilt angle of ADCP (Eq. 1)
- *z_cutoff* (1xN) [m]: time-varying cutoff depth below surface for sidelobe routine, as defined by Lentz et al. (2022)

Stat files:

- *bins* (1xb): bin number
- *ebb (*ebb currents)*, fld* (flood currents), and *comp* (composite of ebb and flood, potentially excluding limited current speeds around slack water)
    - *d_mean* (bx1) [º]: principal axis for ebb, flood, or composite currents
    - *d_sigma* (bx1): standard deviation of direction
    - *d_asym* (bx1) [º]: directional asymmetry between ebb and flood (*comp* only)
    - *s_mean* (bx1) [m/s]: mean speed for ebb, flood, or composite currents, optionally excluding slack conditions
    - *s_max* (1xb) [m/s]: max speed
    - *s_asym* (bx1): ratio of mean ebb/mean flood speed (*comp* only)
    - *ds_dz* (bx1) [m/s per m]: mean vertical shear
    - *P_mean* (bx1) [kW/m^2]: mean power density
    - *P_asym* (bx1): ratio of mean ebb/mean flood power density (*comp* only)
    - *h* [m]: mean distance from seabed to surface
- *Cycle*: information about individual current cycles (i.e., mid-water currents in a single direction)
    - *T_cycle* (# of tidal cycles x b) [hr]: cycle duration
    - *u_cycle* (# of tidal cycles x b) [m/s]: max amplitude of cycle
    - *davg_cycle* (# of tidal cycles x b) [º]: mean direction of cycle
    - *dstd_cycle* (# of tidal cycles x b): standard deviation of direction of cycle
- *d_bins* (1x360) [º]: directional bin centers for velocity probability distributions
- *ellipse*: structure containing *u, v, w* components over pairs of ebb/flood cycles
- *ens_d* (nxb) [º]: ensemble average horizontal velocity direction
- *ens_d_PA* (nxb) [º]: current direction mapped into ebb and flood principal axis coordinates
- *ens_h* (nx1) [m]: ensemble average distance from seabed to surface
- *ens_s* (nxb) [m/s]: ensemble average horizontal velocity (signed ebb (+) and flood (-))
- *ens_t* (nx1) [serial date number]: timestamps for start of each ensemble
- *ens_u* (nxb) [m/s]: ensemble average east velocity
- *ens_v* (nxb) [m/s]: ensemble average north velocity
- *ens_w* (nxb) [m/s]: ensemble average vertical velocity
- *jpdf_vd* (# of v bins x 360 x b): joint probability distribution of horizontal velocity and direction
- *num_ok_bins*: number of measurement bins left after QA & stat pruning procedures

- *p_bins* (1 x # of p bins) [kW/m^2]: power density bin centers for probability distribution, with number of bins determined by the user
- *pdf_p* (# of p bins x b): probability distribution of power density
- *pdf_s* (# of s bins x b): probability distribution of speed
- *pdf_v* (# of v bins x b): probability distribution of horizontal velocity
- *profile_log*
    - *logfits* (1 x # of s intervals): struct for each s interval, containing fit coefficients (z0, ushear) and goodness of fit struct
    - *s_center* (1 x # of s intervals) [m/s]: mid-water speeds for evaluating log fits, with number of s intervals determined by the user
    - *z0* (nx1): z0 values corresponding to the appropriate profile at each time step
    - *ushear* (nx1) [m/s]: shear velocity values corresponding to the appropriate profile at each time step
    - *mid_s* (nx1) [m/s]: mid-water speed at each time step
    - *R2* (1xn): goodness of fit R^2 of appropriate profile at each time step
- *profile_power*
    - *powerfits* (1 x # of s intervals): struct for each s interval, containing fit coefficient (a) and goodness of fit struct
    - *s_center* (1 x # of s intervals) [m/s]: mid-water speeds for evaluating log fits, with number of s intervals determined by the user
    - *a* (nx1): alpha value corresponding to appropriate profile at each time step
    - *mid_z* (nx1) [m]: mid-water distance from seabed
    - *mid_s* (nx1) [m/s]: mid-water speed at each time step
    - *R2* (1xn): goodness of fit R^2 of appropriate profile at each time step
- *res_s:* struct containing residual current analysis
    - *t* (cropped n x 1) [serial date number]: timestamps with start and end of time series cropped
    - *s* (cropped n x b) [m/s]: unfiltered velocities
    - *s_filter* (cropped n x b) [m/s]: low pass filtered velocities
- *s_bins* (1 x # of s bins) [m/s]: speed bin centers for probability distribution, with number of bins determined by the user
- *site*: struct containing site location (*lat* and *lon)*
- *slack_t* (# slack pts x b) [serial date number]: interpolated times of slack water
- *stat_options:* options defined by user for running stats code
    - *avg_type*: 'mean' or 'median' (median is not recommended except for comparative purposes). Used to calculate principal axis, mean speed and mean power density.
    - *num_ens*: number of ensembles to average for statistics calculation
    - *z_target*: depth relative to seabed [m] at which to calculate statistics. [] processes all depths (recommended)
    - *max_bin*: fixed bin number at which to cap profiles. Set to zero to use NaN threshold to determine full bins.
    - *ref*: 1 = seabed as reference (z>0), 2 = surface as reference (z<0)
    - *rho* [kg/m^3]: nominal water density (1025 for seawater)

    - *nan_max*: maximum allowable fraction of NaN values for bin to still be considered complete
    - *cycle_T_threshold* [hr]: minimum cycle duration, used to screen for "cycles" that are merely oscillations around slack water
    - *residual_half_amp_T* [hr]: PL64 filter half-amplitude period (40 recommended for strong tidal currents)
    - *calc_profile_power*: 1=yes, 0=no
    - *profile_power_min_s* [m/s]: min speed for which to calculate power law fit
    - *calc_profile_log*: 1=yes, 0=no
    - *dir_min_s* [m/s]: minimum speed to be considered ebb or flood, rather than slack. Used to exclude directional aberrations around slack water
    - *vel_min_s* [m/s]: minimum speed to be included in mean speed analysis. Set to zero to include all velocities
    - *power_min_s* [m/s]: minimum speed to be included in power density analysis. Set to zero to include all velocities
    - *hist_ds* [m/s]: interval for speed probability distribution
    - *hist_dd* [º]: interval for joint probability distribution of speed and direction
    - *hist_dp* [kW/m^2]: interval for probability distribution of power density
- *t_ens* [s]: ensemble duration
- *v_bins* (1 x # of v bins) [m/s]: horizontal velocity bin centers for probability distribution, with number of bins determined by the user
- *z* (bx1) [m]: vertical bin depths with respect to the surface

<u>Ops files (seabed- or surface-referenced):</u>

- *AEP_perc_diff* (1x7) [%]: percent difference between rotor averaged AEP and hub height AEP for each estimation method (e.g., tangent fit, log law fit)
    - 1: hub height speed (*note*: difference = 0)
    - 2: log law fit (‘log’)
    - 3: power law fit (‘power’)
    - 4: constant profile (‘const’)
    - 5: tangent fit (‘tangent’)
    - 6: semi-empirical (constant profile at surface, linear decrease to zero at seabed) (‘linear’)
    - 7: interpolation of data over rotor swept area (only possible for turbine at mid-water where no extrapolation is required, 100% difference if data not available)
- *d* (nx1) [º]: direction at hub height
- *d_bins* (1x360) [º]: directional bin centers for velocity probability distributions
- *d_mean* [º]: mean direction at hub height
- *d_sigma*: standard deviation of direction
- *flag_extrapolatedHubData*: 1=hub height data is extrapolated, 0=hub height data exists
- *flag_TooShallow*: 1=site is too shallow for specified turbine, 0=otherwise
- *flag_TooSlow*: 1=currents are too slow for specified cut-in speed, 0=otherwise
- *generation*:
    - *power_avg* (1x7) [MW]: average power generated for each estimation method

    - *cf* (1x7): capacity factor for each estimation method
    - *power_max* (1x7) [MW]: maximum power generated for each estimation method
    - *est_AEP* (1x7) [GWh/yr]: estimated annual energy production
    - time_rated (1x7) [%]: percentage of time at rated power for each estimation method
    - *energy_vpdf* (# of v bins x 7): probability distribution of energy generation as function of horizontal velocity for each estimation method
    - *energy_spdf* (# of v bins x 7): probability distribution of energy generation as function of horizontal speed
- *h_data* (nx1)[m]: ensemble average depth referenced to either surface or seabed
- *jpdf_vd* (# of v bins x 360): joint probability distribution of horizontal velocity and direction at hub height
- *num_ok_bins*: number of measurement bins left after QA & stat pruning procedures
- *operation*
    - *windows* (# of windows x 3): duration of operating period [hr] (:,1), operating state (1=operating, 2=idle) (:,2), total time elapsed [days] (:,3)
    - *f_op*: fraction of time operating
    - *f_on* (1 x # duration bins): probability distribution of operating durations
    - *f_off* (1 x # duration bins): probability distribution of idle durations
    - *T_bins* (1 x # duration bins): duration bins for probability distributions
    - *Region* (1xn): power output region (1 through 4)
    - *Region_change* (1 x # of region changes): indices at which region changes occur
- *P* (nx7) [MW]: time series of turbine power generation for each estimation method
- *p_bins* (1 x # of power density bins) [kW/m^2]: power density bin centers
- *pdf_p* (# of power density bins x 1): probability distribution of power density
- *pdf_s* (# of speed bins x 1): probability distribution of speed
- *pdf_v* (# of velocity bins x 1): probability distribution of horizontal velocity
- *rho* [kg/m^3]: nominal water density (1025 for seawater)
- *s* (nx1) [m/s]: ensemble average speed at hub height
- *s3_const, s3_linear, s3_log, s3_power, s3_tangent* (nx1) [m^3/s^3]: rotor averaged horizontal velocity cubed for each extrapolation method
- *s3_data* (nx1) [m^3/s^3]: rotor-averaged horizontal velocity cubed for existing data (only populated if data are available over the entire rotor swept area)
- *s_bins* (1 x # of speed bins) [m/s]: speed bin centers for probability distribution
- *s_const, s_linear, s_log, s_power, s_tangent* (n x extrapolated b) [m/s]: complete vertical speed profile combining data and extrapolated values
- *s_data* (nxb) [m/s]: vertical speed profile for existing data only (no extrapolation)
- *s_tangent_hub* (nx1) [m/s]: speed at hub height, using tangent extrapolation, if needed due to hub height data being not otherwise available
- *site*: struct containing site location (*lat* and *lon*), and hub height average power density (*p_current*)
- *t* (nx1) [serial date number]: timestamps for start of each ensemble
- *turbine*:

    - *ref*: 1 = seabed referenced (moored or fixed platform), 2 = surface referenced (floating platform)
    - *tip_dist* [m]: distance from blade tips to seabed or to surface
    - *D* [m]: turbine diameter
    - *hub* [m]: hub height
    - *min_depth* [m]: minimum depth required relative to MLLW
    - *num_rotor*: number of rotors per platform
    - *eta*: “water-to-wire” efficiency
    - *cutin_u* [m/s]: cut-in speed
    - *yaw*: 0 = passive yaw, -999 = power-optimized fixed yaw angle
    - *rated_u* [m/s]: rated speed
    - *A* [m^2]: rotor swept area
    - *rated_p* [MW]: rated power
    - *angle* [º]: optimal deployment angle, calculated only if *yaw* = -999
- *v_bins* (1 x # of v bins) [m/s]: horizontal velocity bin centers for probability distribution
- *z* [m]: hub height relative to surface or seabed
- *z_data* (bx1) [m]: vertical bin depths with respect to the surface or seabed, for existing data only
- *z_full* (extrapolated b x 1) [m]: vertical bin depths with respect to the surface or seabed, for existing data and extrapolated data combined