# Using MODUS toolbox with ReDAPT MetOcean data

* MATLAB processing scripts are provided to streamline the processing of sub-sets of MetOcean data from the ReDAPT project
  + The available ‘Data query’ script must be used to extract desired data sub-set(s) from CUBE first.
* Tools for different steps in processing turbulence metrics have been kept separate to allow each to be used in isolation or modified/adapted as desired, making the toolbox as modular as possible.
* Functions have been developed to process one sensor direction/beam at a time. Processing of multiple directions/beams in series must be implemented by the user
* An example script that implements all sub-functions to process a ReDAPT dataset is included in the folder – see: ‘Process\_data\_v1.mat’
* An example script to consolidate results of multiple processed datafiles is included in the folder – see: ‘Consolidate\_Data\_v1.mat’
* Further information, inputs/outputs, and description of method is provided as needed in each function/script.
* For example process flowchart illustrating use of functions, see end of document.

**Nomenclature:**

|  |  |
| --- | --- |
|  |  |
| CUBE | The CUBE dataset – ALL available post-processed data from the ReDAPT project ( >200 GB) |
| Hm0 | Significant wave height |
| Ref (data) | Reference data regarding sensor/data properties as included with extracted subsets of MetOcean data from CUBE – eg. Uref, hm0 |
| PSD | Power Spectral Density |
| QC | Quality Control |
| Rstress | Reynolds stress |
| TI | Turbulence intensity |
| TKE | Tubulent kinetic energy |
| Tref | Reference timestamp (for reference data values) – in increments equal to length of Tstat |
| Tstat | Period of stationarity (default is 5 minutes) |
| Uref | Reference velocity – Mean rotor average inflow for each Tstat |

## Function List: General Post-Processing & QC

|  |  |
| --- | --- |
| **Function** | **Description** |
| Calc\_xyvel\_v | Uses along-beam ADCP velocity measurements to calculate velocities as aligned with SENSOR axes (x, y, z). Optionally can include corrections for pitch & roll |
| detrend\_lin3D\_v | Uses least squares regression to remove linear trend from each Tstat, ignoring any NaN values. Also outputs mean and standard deviation of Tstats. |
| PSD\_noisebias\_v | Finds sensor Doppler noise bias using fits to PSD plots (Richard, 2013) |
| QC\_cellbins\_v | Checks that the configureation for depth/distance bins does not change during Tstat ensemble. If it does, the ensemble is set to NaN’s |
| QC\_interp\_v | Interpolates across small gaps in data, ‘kills’ Tstat ensembles that contain more than the user defined percentage of NaN values (sets all values to NaN) |
| structureFunction\_v | Spatial structure function for use in calculating TKE dissipation. Required sub-function for calc\_Diss\_ function. |
| trim\_refdata\_v | Trims reference data (Tref, Uref) to match only periods when measured sensor data is available in dataset. |
| Tstat\_reshape\_v | Reshapes measured datasets into periods of stationarity – adds additional dimension to measured data arrays. |

## Function List: Parameter Calculation

|  |  |
| --- | --- |
| approx\_Diss\_v | Approximates TKE dissipation using TKE density and integral lengthscale, as per George, 2013 (p. 65). Needs validating against other methods. See:  <http://www.turbulence-online.com/Publications/Lecture_Notes/Turbulence_Lille/TB_16January2013.pdf> |
| calc\_Diss\_v | Calculates TKE dissipation using spatial structure function method |
| calc\_Lscale\_v | Calculates integral lengthscales using autocorrelation function method for each Tstat |
| calc\_macro\_Lscale\_v | Calculates the “macro” lengthscale using Roach’s (1986) spectral method, as implemented by el-Gabry (2014) |
| calc\_Prod\_v | Calculated TKE production due to velocity shear, Outputs are production and velocity shear over depth. |
| calc\_Rstress\_v | Calculates Reynolds stresses Rxz & Ryz from standard deviation of along-beam ADCP velocity fluctuations |
| calc\_TI\_v | Calculates TI, including noise bias correction |
| calc\_TKE\_Lu\_v | Calculates TKE for each Tstat at each depth bin using ADCP data. Uses Lu & Lueck’s (1999) theoretical formulation. |
| calc\_TKE\_Osalusi\_v | Calculates TKE for each Tstat at each depth-bin using ADCP data. Uses Osalusi’s (2009) theoretical formulation. |
| Lscale\_transform\_v | Geometric transform of ADCP along-beam ( lengthscales to the primary flow axes (. As per the RDI manual, same as the transform of velocities. |

## Supporting Functions/Files:

Used by above functions. These must be in same folder, or on MATLAB filepath:

|  |  |
| --- | --- |
| Interp1gap.mat | Function used in interp\_QC\_ |
| Cube\_refs.mat | Used by get\_hm0\_ – contains reference values for all data in CUBE. Can also be used to get other reference data if desired |
| dynamicDateTicks | Converts MATLAB datenumbers to date vectors on plots |
| Padconcatenation | Concatenates matrices and pads smaller dimensions if they are not equal. |

## Further Work

* Smoothing of ACF for lengthscale calculation – is it appropriate? Does it improve results?
* Definition of integral lengthscale from ACF – check ESDU guidance, may have different definition (centrum of area under ACF rather than zero crossing point)
* Pitch & roll corrections for TKE & Rstress – is it possible for ADCP data? Quantify effect
* Effect of ADCP heading on TKE & Rstress – how big is effect? How does it bias results?

## Process Flowchart

Recommended/example order of use of functions. Steps that must be user-implemented are noted with yellow border. It is assumed that data has already been extracted from CUBE using the available Query script (as per Brian Sellar) and resulting ‘datafiles’ are located in the same folder.

