A User Guide to Mexec

A Matlab-based Bespoke Processing Suite

for Ship-based Oceanographic Data

Version 4 (subset of ocp\_hydro\_matlab)

Yvonne L. Firing, N. Penny Holliday, Alejandra L. Sanchez-Franks

Ocean Circulation and Processes Subgroup

Marine Physics and Ocean Climate

National Oceanography Centre

Southampton

Contents

1. Introduction

1.1 About this guide

1.2 What is Mexec?

1.3 Caveats, changes and bugs

2. Setting up a new cruise

3. CTD and Niskin bottle sample data

3.1 SeaBird data acquisition and processing

3.2 Mexec data processing

3.3 Water bottle sample data

3.4 Sensor calibration in Mexec

3.5 Outputting data in other formats

4. Underway data: navigation, surface and bathymetry data

4.1 TECHSAS/SCS data access

4.2 Preparation at the start of the cruise

4.3 Mexec data processing

Appendices

A. A bit more detail on Mexec functions

B. Handy hints and tips

C. List of cruise-specific options

D. Known bugs and planned changes

# 1. Introduction

## 1.1 About this guide

This guide, and Mexec, are designed for those wishing to process CTD and underway data at sea. The underway portion is applicable to ships running SCS or TECHSAS systems. Basic familiarity with UNIX/Linux, shell scripting, and Matlab is assumed.

Throughout, > is used to indicate examples of steps run from the command line, including shell scripts, and >> for steps run from Matlab. Variables or parts of filenames that must be substituted with values are in italic (e.g. a reference to m\_daily\_proc(*day*) indicates that the day number should be substituted for *day*; opt\_*cruise*.m refers to opt\_dy113.m, opt\_jc238.m, etc.; ctd\_*cruise*\_*nnn*\_2db.nc refers to one of a set of files, with *cruise* replaced by the cruise designation and *nnn* replaced by the 3-digit form of the station number).

The following sections give instructions for setting up Mexec processing for a cruise (Section 2); processing CTD data (Section 3); and processing underway data (Section 4). A brief description of Mexec is given below, with a few more details in Appendix A, but in general this is meant to be a guide to a standard set of steps with limited variations. Example processing checklists are included in Appendix \*\*\*.

This guide was first written by Penny Holliday and has been updated for v3 by Yvonne Firing and Alejandra Sanchez Franks and for v4 by Yvonne Firing.

## 1.2 What is Mexec?

Mexec is a system for processing, quality control, and integration of hydrographic data including CTD and water sample data and standard underway streams. It consists of Matlab and shell scripts, and interfaces with output of the SeaBird software (for collection and initial processing of CTD data), and with external libraries for processing of LADCP and VMADCP data. It saves its output as NetCDF files with a particular set of metadata and conventions (referred to here as Mstar files, see 1.2.3). The Matlab scripts are part of git repository git.noc.ac.uk/OCP/ocp\_hydro\_matlab, and the shell scripts are in git.noc.ac.uk/OCP/mexec\_exec.

The Mexec libraries were developed over a number of years by scientists at the UK National Oceanography Centre, Southampton, principally Brian King and Yvonne Firing, with contributions from many others including D. Desbruyeres, G. Evans, C. Florindo Lopez, N.P. Holliday, L. Houpert, E. Kent, G. McCarthy, B. Moat, A. Sanchez-Franks, D. Smeed, Z. Szuts, and E. Woodward (?I think: efw\*\*\*), as well as from external collaborators including E.P. Abrahamsen, K. Baumeister, S. Gary, and D. Ham, They use the Seawater (C. Morgan and L. Pender), GSW (SCOR/IAPSO WG127), and gamma\_n (D. Jackett and T. McDougall) libraries in calculations. They interface with the LDEO IX LADCP processing software (M. Visbeck and A. Thurnherr), and read in underway data from SCS,, TechSAS, and RVDAS (NOC/NMF) as well as VMADCP data from CODAS (University of Hawaii Currents Group).

The code has undergone numerous revisions, more recently preserved as git commits (before 2018 preserved in each cruise’s end-of-cruise backup of the processing workstation). Major changes since 2014 include:

JR15003 (2015/16): start of mexec\_processing\_scripts\_v3, with introduction of cruise options files (see 1.2.2).

JC159 (2018): introduction of git for version control, using three repositories (now superseded and no longer maintained, see below): git.noc.ac.uk/MEXEC/mexec\_processing\_scripts, git.noc.ac.uk/MEXEC/mexec, and git.noc.ac.uk/MEXEC/mexec\_exec.

JC191 (2020): revision of netcdf file-interface code to use Matlab-native functions (replacing bespoke functions developed before the Matlab-native functions were available).

JC211 (2021): addition of interface to NMF RVDAS underway data acquisition system, as well as function for saving from Matlab workspace to Mstar files using Matlab save-like interface, and (enabled by this function) the start of simplification of processing steps and reduction in number of intermediate Mstar files

JC238 (2022): version 4: continued simplification of processing steps, merge of mexec and mexec\_processing\_scripts along with other related Matlab code into a single git repository, git.noc.ac.uk/OCP/ocp\_hydro\_matlab, and shifting of (maintained) mexec\_exec repository from git.noc.ac.uk/MEXEC/ to git.noc.ac.uk/OCP/.

Some attempts at backwards compatibility have been made, with the goal that newer code could be used to reprocess older cruises’ data (without starting completely from scratch), for instance if new bottle samples analysed ashore become available, or calibrations are reconsidered. Where file name patterns (e.g. for merged intermediate files) have changed, the aim is for code to be compatible with both old and new versions. Backwards compatibility is also maintained for some variable names but not all . When cruise options files were introduced on JR15003, processing choices from previous cruises were captured, and earlier cruises’ options files were generally kept up to date with changes to code through DY113. Changes from JC211 on (e.g. to option names, how they are specified, or in which scripts they are used) have been only partially propagated back to earlier cruises’ options files as of this point, so reprocessing earlier cruises’ data may require more editing of the options files.

### 1.2.1 History files and data file version control for multiple people processing data

Each step that goes into a Mstar file is recorded both in the header comment field and in a history file for the processing stream (so, although there are multiple ctd Mstar files for each station, there will be a single ctd history file for each station). The history files are found in mexec\_housekeeping/history/.

To prevent conflicts over modifying Mstar files, editing one also sets a lock file, in mexec\_housekeeping/version/, which will normally be reset in closing the program. If a program is interrupted mid-run, however, the flag may have to be reset manually using mreset.m.

### 1.2.2 Processing options and parameters

A number of processing parameters and variables (e.g. which CTD is primary, the calibration functions for conductivity and other parameters, etc.) change from cruise to cruise. From Mexec v3 on, rather than editing the various scripts that may contain these parameters, they are set centrally, with modifications contained in one script (per cruise), as follows: processing scripts and functions call get\_cropt.m, which

1. calls the setdef\_cropt\_\*.m scripts to set any defaults using switch/case on two (string) variables: scriptname (generally the name of the calling script) and oopt;
2. calls opt\_*cruise*.m to set cruise-specific options, again using switch/case on scriptname and oopt; and
3. calls check\_cropt.m to (for some cases) check and warn about invalid or unset options.

The defaults are split, purely for convenience/readability, across four scripts: setdef\_cropt\_cast.m contains defaults relating to CTD casts, setdef\_cropt\_sam.m those relating to sample data, setdef\_cropt\_uway.m those relating to underway streams, and setdef\_cropt\_other.m contains defaults relating to everything else (csv output files, multi-cast gridding, etc.). These setdef\*.m scripts contain explanations for each set of options and therefore may be useful to examine (see also Help mode, below), but general users should not edit them. Instead, make changes to opt\_*cruise*.m for your cruise – it is recommended that you not duplicate (unchanged) default settings in this file -- and raise an issue if you think the defaults themselves should change.

Help mode: on Linux/Unix systems, get\_cropt can be called on the Matlab command line to find out about options:

>> help\_cropt = 1; scriptname = ‘’; oopt = ‘’; get\_cropt

Displays a list of scriptnames and oopts in any of the setdef\_cropt\_\*.m.

>> help\_cropt = 1; scriptname = scriptname; oopt = ‘’; get\_cropt

Displays a list of all calls to get\_cropt in file scriptname.m, if this file exists, and if not, of all files which use scriptname = scriptname to call get\_cropt.

>> help\_cropt = 1; scriptname = scriptname; oopt = oopt; get\_cropt

Displays which of the setdef\_cropt\_\*.m contains this (scriptname, oopt) case (and therefore a help string explaining it), along with a list of opt\_\*.m files which contain it (and therefore examples of modifying the defaults).

Information obtained or modified during the course of Mexec processing, but which pertains to the cruise data rather than a particular choice for processing, may be contained in either opt\_*cruise*.m or in a separate text file specified in one of the opt\_*cruise*.m cases. For instance, a list of salinity sample flags to modify might be set in the msal\_01 case of opt\_*cruise*.m, or read in from a list by msam\_02b.m. \*\*\* To determine processing choices that went into a given data file, in addition to the comment field, the metadata includes the commit active when the data file was most recently modified; the setdef\_cropt\_\*.m and opt\_*cruise*.m files in that commit thus contain a record of corresponding processing parameters.

### 1.2.3 Mexec conventions

Mexec uses global variables for passing arguments to functions. This means if you clear the workspace you will have to re-run m\_common.m before using any other Mexec programs.

The reason for this setup is that many of the original functions that performed calculations and did file i/o (now in ocp\_hydro\_matlab/file\_tools/mexec/) were designed to be run in an interactive mode, prompting for successive inputs on the command line. To call these functions within other scripts or functions, therefore, a global variable (MEXEC\_A.MARGS\_IN) is used and queried for the inputs. Because the list of inputs depends on the previous choices, the best way to figure out how to use one of these functions is to call it in interactive mode (with empty or missing MEXEC\_A.MARGS\_IN) and follow the prompts.

Partially in v3 and increasingly in v4, these functions are being superseded, first by increased calculations in the workspace, and second by functions that take input arguments in a more Matlab-standard format. This guide thus assumes users will interact with Mexec by running the wrapper scripts (ocp\_hydro\_matlab/mexec\_processing\_scripts and subdirectories, described below) and modifying the cruise options file, ocp\_hydro\_matlab/mexec\_processing\_scripts/cruise\_options/opt\_*cruise*.m, and will not need to directly call the ocp\_hydro\_matlab/file\_tools/mexec/ functions (or edit them except for some specifying underway file information, detailed in Section \*\*\*).

### 1.2.4 Mstar file format and quick guide to interacting with existing Mstar files

Mexec generates NetCDF files, with a particular format (set of attributes), referred to here as Mstar files. While these NetCDF files can be read with ncdisp.m and ncread.m (or equivalent programs in other languages), there are specific Mexec scripts for interfacing with them.

You must have mexec\_processing\_scripts on your Matlab path. Each time you start Matlab:

>> m\_setup % to add paths and set global variables

If you clear the workspace variables:

>> m\_common % to set global variables

To load an Mstar file:

>> [d, h] = mload(filename, ‘/’); % loads all data and header information from filename

Both d and h are structures, d containing “data” and h containing “header” information. The names of the variables in the structure d are also given in h.fldnam, while their units are in h.fldunt. Times in Mstar files (generally in seconds) are relative to the time specified by the vector h.data\_time\_origin [yyyy mm dd HH MM SS] or [yyyy mm dd]. The .nc suffix of filename is not required but the path is.

To save variables from the workspace to an Mstar file:

>> mfsave(filename, d, h) % where d and h are like Mstar data and header structures; see help mfsave for other options

## 1.3 Changes and bugs

To submit edits, report bugs or suggest changes, raise a pull request or issue at git.noc.ac.uk/OCP/ocp\_hydro\_matlab or git.noc.ac.uk/OCP/mexec\_exec, or email [yvonne.firing@noc.ac.uk](mailto:yvonne.firing@noc.ac.uk). (Please see the lists of known bugs and planned additions in Appendix D first.)

We would like to record cruise-specific options used as well as integrate user improvements, so we encourage you to create a pull request or send us your scripts at the end of your cruise. To make it easier for us to track and integrate changes, please put any new scripts/functions that you think might be added to and maintained in the code base into ocp\_hydro\_matlab/ (and, ideally, in the issue or email include some context about your changes and/or additions), and keep any code that is working code just for your cruise (e.g. quick/specific code making plots of data) in a separate directory (i.e. outside ocp\_hydro\_matlab).

# 2. Setting up a new cruise and using Mexec

2.1 Before the cruise

1. Get the two git repositories.

If you have git and a login to git.noc.ac.uk with an ssh key linked to the OCP group, clone the master branch:

> cd ${PROGDIR} #wherever you choose to keep the software

> git clone [git@git.noc.ac.uk/OCP/ocp\_hydro\_matlab.git](mailto:git@git.noc.ac.uk/OCP/ocp_hydro_matlab.git)

> git clone [git@git.noc.ac.uk/OCP/mexec\_exec.git](mailto:git@git.noc.ac.uk/OCP/mexec_exec.git)

Generally the master branch is the version you should use, but in special cases you may instead want to work from a different cruise branch:

> cd ${PROGDIR}/ocp\_hydro\_matlab

> git branch *other\_branch*

> git fetch origin *other\_branch*

> git checkout origin *other\_branch*

> git pull origin *other\_branch*

Otherwise, download the desired branch (probably the master branch) from <http://git.noc.ac.uk/OCP/ocp_hydro_matlab> and <http://git.noc.ac.uk/OCP/mexec_exec>, and unpack in ${PROGDIR}.

1. Determine or decide on your cruise designation, typically 2-3 letters denoting the ship and 3-5 letters denoting the cruise number, e.g. dy113, jr18002, nbp0705. This will be used in various places and is the variable meant by (italic) *cruise* through the rest of this document.

a) If you are using git, for each of the repositories, create and switch to a new branch for your cruise:

> cd ${PROGDIR}/ocp\_hydro\_matlab

> git branch *cruise*

> git checkout *cruise*

> cd ${PROGDIR}/mexec\_exec

> git branch *cruise*

> git checkout *cruise*

3) Add mexec\_exec and its subdirectories to your shell path (in .bashrc or equivalent). Add ocp\_hydro\_matlab to your Matlab startup path.

4) Edit the cruise name and processing base directory (e.g. /local/users/pstar/dy113/mcruise/) in mexec\_exec/conf\_scripts/conf\_script\_mexec. You may also need to edit the underway data system and a flag for whether LADCP data are acquired. Run to configure the cruise directory structure:

> conf\_script\_mexec

This will set up a processing directory structure, including relative symbolic links so that the directory structure can be copied elsewhere (e.g. at the end of a cruise) and processing continued.

1. Edit ocp\_hydro\_matlab/mexec\_processing\_scripts/m\_setup.m.

Most things you (may) need to modify are near the top of the file, including cruise designation (stored as MEXEC\_G.MSCRIPT\_CRUISE\_STRING), and year of the data time origin. The “quiet” flag determines how much information will be displayed to the screen while programs are running.

6) Generate an empty cruise-specific options file, ocp\_hydro\_matlab/mexec\_processing\_scripts/cruise\_options/opt\_*cruise*.m, replacing *cruise* with your cruise reference (in the same form as you set in m\_setup.m, e.g. dy113). See below, as well as other files in that directory, for examples.

## 2.2 On the ship

7) Remotely mount data filesystems, and if necessary set up symbolic links, e.g.

> ln -s /mnt/Data/current\_cruise ~/mounts/mnt\_cruise\_data

The NOC OCP seagoing workstations have mount points for Cook and Discovery in /etc/fstab and preserved under ~/mounts/, e.g. \*\*\*

8) Edit shell scripts in mexec\_exec/: ctd\_syncscript, lad\_syncscript (for LADCP), and uhdas\_01\_linkmerge (if reading UHDAS/CODAS data).

These scripts will be used to sync data from the remote directories to the processing directory structure, and will need to be edited to reflect file naming conventions in the remote directories (e.g. ~/mounts/CTD/Data/CTD\_DY113\_001.cnv vs. ~/mounts/CTD/Data/Processed/ctd\_dy113\_001\_01.cnv, etc.).

You may also want to use mexec\_exec/cruise\_backup to sync the processing directory and scripts to an external hard drive; in this case, edit the directories set near the top of cruise\_backup, and (recommended) add it to your crontab file to run regularly.

9) Set up or link underway data processing

a) ocp\_hydro\_matlab/file\_tools/mexec/mtechsas/mtnames.m (for TECHSAS) or ocp\_hydro\_matlab/file\_tools/mscs/msnames.m (for SCS): add or comment/uncomment lines as necessary to reflect the stream names available on your cruise. If adding a new type of stream you can decide on the Mexec abbreviation. \*\*\*mrvdas

b) ocp\_hydro\_matlab/mexec\_processing\_scripts/underway/m\_setudir.m: if you added new Mexec stream abbreviations in a), add them and the directories where you wish those streams to be processed to the list in m\_setudir.m. In any case you may need to uncomment/comment out newly relevant/irrelevant lines.

Note: if new underway streams become available during the cruise, remove ocp\_hydro\_matlab/mexec\_processing\_scripts/underway/m\_udirs.m and regenerate it, and the new directories, by running m\_setudir.m.

10) Edit template files in ocp\_hydro\_matlab/mexec\_processing\_scripts/varlists/ \*\*\*deprecated?

Template files are used to control lists of variables within scripts. They include ctd\_renamelist.csv, sam\_varlist.csv, dcs\_varlist.csv, and cchdo\_varlist.csv and cchdo\_ctd\_varlist.csv which determine lists of variables to be loaded for CTD, bottle sample, and other files, and how (if) they will be renamed. For SCS ships, there is also the set of scs\_renamelist\_source.csv files.

The list of variable names that you require in each file will vary from cruise to cruise depending on which samples are being collected. The ctd\_, sam\_, and cchdo\_ template files put in place by the conf\_script contain many possible variables, so in most cases you will just need to delete lines. The scs\_ files may need to be edited but most likely not.

c) ocp\_hydro\_matlab/mexec\_processing\_scripts/varlists/mcvars\_list.m: make sure the two lists in this file include all the variables you want to carry through CTD processing and sample comparison, respectively. It is not necessary to comment out variables you don’t have.

2.3 Using Mexec

Each time Matlab is started, run m\_setup.m to initialize the environment for Mexec processing by adding paths and generating global variables. If you clear all variables at any point, run m\_common.m to regenerate them.

# 3. CTD data and water bottle sample data

## 3.1 Sea Bird data acquisition and processing

The first step is to select the SBE output variables in the SBE data acquisition software, SeaSave. Record the setup by saving a .XMLCON file. It is essential that the output variables include scan and pressure temperature, and it is highly useful for them to include NMEA latitude and longitude if those streams are available (generally the case on modern research vessels). For some variables (e.g. turbidity), the conversion from voltage to physical units may result in loss of precision, so better results may be obtained by outputting the raw voltage stream.

Here is an example from JC086.

# name 0 = timeS: Time, Elapsed [seconds]

# name 1 = depSM: Depth [salt water, m]

# name 2 = prDM: Pressure, Digiquartz [db]

# name 3 = t090C: Temperature [ITS-90, deg C]

# name 4 = t190C: Temperature, 2 [ITS-90, deg C]

# name 5 = c0mS/cm: Conductivity [mS/cm]

# name 6 = c1mS/cm: Conductivity, 2 [mS/cm]

# name 7 = sal00: Salinity, Practical [PSU]

# name 8 = sal11: Salinity, Practical, 2 [PSU]

# name 9 = sbeox0V: Oxygen raw, SBE 43 [V]

# name 10 = sbeox0Mm/Kg: Oxygen, SBE 43 [umol/Kg]

# name 11 = sbeox0ML/L: Oxygen, SBE 43 [ml/l]

# name 12 = xmiss: Beam Transmission, Chelsea/Seatech/WET Labs CStar [%]

# name 13 = flC: Fluorescence, Chelsea Aqua 3 Chl Con [ug/l]

# name 14 = turbWETbb0: Turbidity, WET Labs ECO BB [m^-1/sr]

# name 15 = altM: Altimeter [m]

# name 16 = scan: Scan Count

# name 17 = ptempC: Pressure Temperature [deg C]

# name 18 = pumps: Pump Status

# name 19 = latitude: Latitude [deg]

# name 20 = longitude: Longitude [deg]

# name 21 = flag: 0.000e+00

For combining CTD data with Niskin bottle sample data, the CTD data file names should incorporate a unique integer cast number, referred to here as station number – not to be confused with a number or alphanumeric designating a planned station/site. (For instance, imagine a cruise starts with a test CTD followed by a full CTD both at site A-55, and then a CTD at site A-53: the cast or station numbers for Mexec processing could be (1, 2, 3) or (990, 1, 2) or even (10, 9, 15) – but not 55, 55, 54, nor 1.1, 1.2, 2.)

## 3.1.1 SBE Data Processing

On the CTD logging computer, the SBE Data Processing software should be used for initial processing when the cast is finished, by running the following three steps:

1. Data Conversion to convert the raw frequency and voltage data to engineering units as appropriate by applying the manufacturer's calibrations stored in the CON file and saving both downcast and upcast to an ASCII format (.cnv) file.

* This may include oxygen hysteresis correction using SBE default parameters, but it is recommended not to apply the correction here but instead to apply it in mexec processing (this makes it easier to change the parameters if necessary). If you decide to correct for oxygen hysteresis at this stage you will need to to change the dooxyhyst flag in the mctd\_02 case of opt\_*cruise*.m).

The output file names should contain the three-digit sequential station/cast number (ideally, something like ctd\_cruise\_nnn.cnv).

1. Align CTD to align the oxygen sensor in time relative to pressure. Recommended: set the output name to \_align so that, for input CTD\_CRUISE\_nnn.cnv, this step will produce CTD\_CRUISE\_nnn\_align.cnv.
2. Cell Thermal Mass to correct the pressure and conductivity. Recommended: set the output name to \_ctm so that, for input CTD\_\_CRUISE\_nnn\_align.cnv, this step will produce CTD\_­CRUISE\_nnn\_align\_ctm.cnv.

The first and last .cnv files (that is, original and \_align\_ctm), as well as the .bl and .ros files, should be copied to /local/users/pstar/cruise/data/ctd/ASCII\_FILES, while .hex, .hdr, and .XMLCON files should be copied to RAW\_CTD\_FILES. On unix/linux systems you can use (mexec\_exec) ctd\_syncscript to do this after editing cruise name and location of original files.

## 3.2 Mexec CTD data processing

### 3.2.1 Output file types

ctd\_*cruise*\_*nnn*\_\*.nc contain CTD time series or profiles, with different stages of processing, editing, and averaging (see below).

dcs\_*cruise*\_*nnn*.nc contains information about scans (start, bottom, end of cast) and positions

fir\_*cruise*\_*nnn*.nc contains information about bottle firing times and corresponding CTD and winch data

sam\_*cruise*\_all.nc is a combined (all-station) file containing the data from the fir\_*cruise*\_*nnn*.nc files along with analysed bottle sample data.

win\_*cruise*\_nnn.nc contains winch information\*\*\*

### 3.2.2 Processing steps to do immediately following a cast

The basic steps for CTD processing following a cast are:

> ctd\_syncscript

Copies .hex, .cnv, \_align\_ctm.cnv, and .bl files from acquisition computer to processing workstation.

>> stn = *n*; ctd\_all\_part1 % *n* is the integer station number

ctd\_all\_part1.m calls the following:

mctd\_01.m loads and renames variables (as set in varlists\*\*\* and cruise options files) and saves in ctd\_*cruise*\_*nnn*\_raw.nc.

mctd\_02.m does conversions, edits, and corrections as set in cruise options files, calling ctd\_apply\_autoedits.m, ctd\_apply\_oxyhyst.m, select\_calibrations.m, and apply\_calibrations.m to produce ctd\_*cruise*\_*nnn*\_raw\_cleaned.nc and ctd\_*cruise*\_*nnn*\_24hz.nc files. The only default action is to apply (the manufacturer default) correction for oxygen hysteresis, but examples are available for code to remove out of range values, certain scan ranges, spikes, and/or times when the pumps were off; it is generally not recommended to apply these before first examining data (as problems may be masked). Once sample data are available, the mctd\_02 case of the cruise options file is also where calibration functions can be specified (with a setting to apply to all stations or only a subset).

mctd\_03.m selects primary sensors (as set in cruise options files), computes derived variables (e.g. salinity) and averages to 1 Hz, using grid\_profile.m, producing ctd\_*cruise*\_*nnn*\_psal.nc.

mdcs\_01.m guesses start and bottom of cast and saves in dcs\_*cruise*\_*nnn*.nc.

>> stn = *n*; mdcs\_03g

mdcs\_03g.m brings up a GUI for selection or confirmation of cast start, bottom, and end based on P, T, C, and pumps flag; any modifications are added to dcs\_*cruise*\_*nnn*.nc.

For the start of the downcast, select the lowest pressure after the CTD has soaked and been brought to the surface before descending (unless it was brought too close to the surface, causing erroneous conductivity values, in which case, select the start of the good data). For the end of the upcast, select the last scan for which there was good in-water oxygen, temperature, conductivity and salinity data (note that oxygen data becomes out-of-water before the other variables because of the different sensor response times).

>> stn = *n*; ctd\_all\_part2

ctd\_all\_part2.m calls the following:

mctd\_04.m separates down and up casts, optionally applies m\_loopedit.m to the downcast data, and averages to 2 dbar, producing ctd\_*cruise*\_*nnn*\_2db.nc and ctd\_*cruise*\_*nnn*\_2up.nc.

mfir\_01.m gets times and scans of Niskin bottle firing from .bl file, along with Niskin bottle numbers (default: 1:24) and flags (default: 2 for all fired bottles, 9 otherwise) from cruise options files, and puts in fir\_*cruise*\_*nnn*.nc.

mfir\_03.m gets CTD data from these scans from the 1-Hz \_psal.nc file and adds to fir\_*cruise*\_*nnn*.nc.

mwin\_01.m gets winch information from the underway stream and saves in win\_*cruise*\_*nnn*.nc.

mwin\_to\_fir.m adds the winch information to fir\_*cruise*\_*nnn*.nc.

mfir\_to\_sam.m puts the data from fir\_*cruise*\_*nnn*.nc into appended sam\_*cruise*\_all.nc.

station\_summary.m adds position, start and end time, depth obtained by calling best\_station\_depths.m, and information from sam\_*cruise*\_all.nc for this station to station\_summary\_*cruise*.nc and table station\_summary\_*cruise*.txt. Rather than storing station depths in a text file, they are calculated by best\_station\_depths.m. Immediately following a cast, it will try to calculate them from CTD+altimeter; later you can specify to include information from the LADCP (if available), but in any case, if you have casts that are not full-depth, you should use the underway bathymetry data to fill in a list of bottom depths under the best\_station\_depths case in opt\_*cruise*.m.

mdep\_01.m adds the depths to the various ctd\_*cruise*\_*nnn*\_\*.nc files.

>> stn = *n*; mctd\_checkplots

mctd\_checkplots.m produces a set of plots to check for sensor drift or other problems. It will make plots comparing the two sensors, plots comparing up- and downcast data. It will also make plots comparing station *n* with other stations, first querying for either some number of preceding stations (including 0) or a list of specific station numbers to use. If you notice loops/static instabilities here, you can activate the cruise option to apply loop editing in mctd\_04.m.

>> stn = *n*; mctd\_rawshow

mctd\_rawshow.m allows inspection of 24 Hz data. If this reveals editing needed (e.g. spikes that are large enough to affect averaged data), there are normally two options:

1. specify automatic edits (based on scan ranges, data ranges, behaviour if pumps go off, and despiking) in opt\_*cruise*.m under mctd\_02.m case; and/or
2. >> stn = *n*; mctd\_rawedit

mctd\_rawedit.m brings up a GUI for selecting and deleting spikes in the data (starting from ctd\_*cruise*\_*nnn*\_raw\_cleaned.nc if available, ctd\_*cruise*\_*nnn*\_raw.nc otherwise), and saves the selections to ctd\_*cruise*\_*nnn* \_raw\_cleaned.nc, as well as recording them in (text file) mplxyed\_*yyyymmdd*\_*HHMMSS*\_ctd\_*cruise*\_*nnn*

If there are significant instrument or cable problems, the inspection may show spikes in pressure or temperature that are large enough to affect the other data streams, requiring reprocessing from before the cellTM stage\*\*\* details in \*\*\*.

If automatic edits were added or mctd\_rawedit was used,

>> stn = *n*; ctd\_all\_postedit

ctd\_all\_postedit.m reruns mctd\_02, mctd\_03, mctd\_04, mfir\_03, and mfir\_to\_sam to apply edits and propagate changes to the ctd\_*cruise*\_*nnn*\_raw\_cleaned.nc file through to other files.

If necessary, iterate the rawedit and postedit steps, and/or mctd\_checkplots.m, ctd\_all\_part2.m to loopedit.

Contingencies: If you need to restart processing from the mctd\_01 stage, \*\*\* file write permissions, and what to do about history files in this starting-from-scratch case. If you need to add variables, \*\*\*. Clobbered the ctd files but still have the mplxyed files, \*\*\*. Proliferation of wk files.

## 3.3 Water Bottle Sample Data

### 3.3.1 Loading data

The aim of the sample data processing for CTD profiles is to create a master sample data file, sam\_cruise\_all.nc, populated with CTD firing data, sensor data, and subsequently the water sample data as they become available. The CTD winch, firing and sensor data are pasted into the sam\_cruise\_nnn.nc files during running of ctd\_all\_part2.m, as described above. This section describes how the water sample data are included in the process.

To link analysed water sample data with the corresponding CTD data (and with each other) we use CTD cast number (referred to here as station number) and what we refer to as station number (CTD cast or station number, relies on the two parameters that in combination uniquely

Scripts including msal\_01.m, moxy\_01.m, mnut\_01.m, mco2\_01.m, mcfc\_01.m, miso\_01.m (etc.) perform the following steps, depending on parameters and code specified in opt\_cruise.m:

1. Read in sample data from excel (single or multiple sheet) or ascii csv files (with or without header lines preceding one or more column header rows and zero or more units rows) or from netcdf or Matlab files. Currently, for excel/csv files, every data row is required to have a value for every column (e.g. if station number is a column, even if the file contains a single station, the number must be filled in on each line).
2. Map variable (or column) names to standardized names used in the Mexec processing and Mstar files, and check units (if supplied) or add them (if not).
3. Parse information files, or Matlab files. All sample data must first be saved in ascii csv files; Mexec scripts read the ascii files and create Mstar files for each sample type (the '\_01' scripts), and paste data from these into sam\_cruise\_nnn.nc (the '\_02' scripts). msam\_apend.m then concatenates the profile files into sam\_cruise\_all.nc.

Now mexec scripts (all of them?) will read ascii .csv or excel files, as many as are available, save to Mstar files for each sample type, and also to the combined sample file.

Underway samples are treated in a similar way, and saved in tsg\_cruise\_all.nc (see Section 4.1.6).

The key decisions at the start of the process involve settling on a consistent and suitable format for the ascii files. Information logged on a given type of sample should be put into a csv file to be read in using Matlab’s dataset utility. The order of columns does not matter, but certain column headers are required, as described in the help for msal\_standardise\_avg.m and moxy\_01.m. Absent data should be -999, while flag values for bottles not sampled should be 9. Sample data should be flagged according to WOCE standard flags given in the GO-SHIP Repeat Hydrography manual (<http://www.go-ship.org/HydroMan.html>). Another file, bot\_cruise\_01.csv, should be constructed to give quality flags for the Niskin bottles themselves (see Section 2 point xi).

• Salinity: ascii concatenated comma-separated-value file sal\_cruise\_01.csv. The spreadsheets from each salinometer run should have header information corresponding to the run. The data values are then concatenated into sal\_cruise\_01.csv, removing from this file the header information except for the single (first) row of column headers, which become database field names. See help for msal\_01.m and msal\_standardise\_avg.m for examples of acceptable formats, ways to number samples and indicate standard sea water samples, etc.

• Oxygen: ascii comma-separated-value files oxy\_cruise\_nnn.csv The files should be prepared with header lines and a range of columns of data. See moxy\_01.m.

• Nutrients: ascii comma-separated-value files nut\_cruise\_nnn.csv. The files should be prepared with header lines and a range of columns of data. See \*\*\*

Carbon

CFCs

### 3.3.2 Checking data

smallscript\_load\_botcaldata

msam\_checkbottles\_01

msam\_checkbottles\_02

msec\_run\_mgridp

flags: initial flags should be 2 (bottle good, sampled), 3 (leaking [and did not sample]), 4 (did not trip correctly [wire not released or bottle was seen to snap closed on landing]), 7 (unknown problem [maybe leaking but not so obviously we didn’t sample]), 9 (did not sample, no further information). Then after examining data update initial flags of 2 or 7 to 2 (good), 3 (several sample values suspicious so probably leaking), 4 (clearly sample is from a different depth, i.e. did not trip correctly), 9 (did not sample)?

## 3.4. Sensor Calibration

The steps below are described in the simplest order, assuming temperature, conductivity, and oxygen are all being calibrated. However, steps can be skipped or run out of order (for instance, oxygen values could be compared before calibrating temperature and salinity, as long as the associated uncertainty is kept in mind). These scripts can be run on all stations, or on a specified list of stations if calibration data for all are not available, or if only some stations have changed flags. Keep in mind, however, that the goal is to calibrate each sensor, not each cast; comparisons may not be very useful until sufficient data are accumulated.

### 3.4.1 Evaluating calibration data

>> caldata\_all\_part1 % optionally first set klist to a list of stations; otherwise uses klist from opt\_*cruise* smallscript case

caldata\_all\_part1.m puts temperature and salinity calibration data in the master sample file by calling the following scripts for a list of stations: (\*\*\*msbe35 only if directory found\*\*\*)

msbe35\_01.m reads in the SBE35 ascii files listed in lsbe (this file can be generated by listing on the command line). Cruise-specific options can be used to set flags for quality of reading (for instance, if a bottle were fired on the fly, the SBE35 reading would be questionable or bad).

msbe35\_02.m pastes them into sam\_cruise\_nnn.nc

msal\_01.m reads the comma-delimited concatenated bottle salinity file sal\_cruise\_01.csv into matlab and saves data from station nnn as sal\_cruise\_nnn.nc. Cruise-specific options allow the salinometer bath temperature and conductivity ratio offset to be set, if they are not included in the csv file. msal\_01.m calls:

msal\_standardise\_avg.m. This function will compute offsets, if not supplied, and optionally produce plots of different readings to allow bad readings to be excluded or bad samples to be flagged by editing opt\_cruise.m.

msal\_02.m pastes the bottle salinity into sam\_cruise\_nnn.nc

msam\_02.m computes residuals

msam\_apend.m concatenates the station sample files into sam\_cruise\_all.nc.

>> sensname = ‘temp’; ctd\_evaluate\_sensors % use the plots and fits produced to choose a calibration for temperature sensors and edit the temp\_apply\_cal case of opt\_cruise.m

ctd\_evaluate\_sensors.m compares data from the CTD to the calibration sample data. The quantity to be compared is set by variable sensname. The script generates plots of residuals against time and pressure to allow the user to get a sense of how the sensors are behaving, and to determine an appropriate calibration function to enter in to the temp\_apply\_cal (for temperature), cond\_apply\_cal (for conductivity), or oxy\_apply\_cal (for oxygen) cases of opt\_cruise.m.

It allows data to be examined in groups of primary or secondary sensors, including multiple such groupings (if a sensor was changed during the cruise, or there was an apparent calibration shift at any point). The groups of sensors must be added to the ctd\_evaluate\_sensors case of opt\_cruise.m.

The comparisons produced by ctd\_evaluate\_sensors.m may also indicate bad or questionable bottle samples (or just questionable comparisons, for instance in regions of high gradient), which can be flagged as 4 or 3 respectively by editing the msbe35\_01 (for temperature), msal\_01 (for salinity/conductivity), and moxy\_01 (for oxygen) cases of opt\_cruise.m.

msam\_checkbottles\_01

msam\_checkbottles\_02

\*\*\*show examples of each?\*\*\*

>> precalt = 1; sensname = ‘cond’; ctd\_evaluate\_sensors % and edit cond\_apply\_cal case of opt\_cruise.m

Calibrations entered into the temp\_apply\_cal, cond\_apply\_cal, or oxy\_apply\_cal cases of opt\_cruise.m can be applied to any data by calling temp\_apply\_cal etc.\*\*\* to be tested (before being applied to the Mstar files) by setting precalt, precalc, or precalo, respectively, to 1 before running ctd\_evaluate\_sensors.m. This will produce the same set of plots comparing the calibration data with the calibrated CTD data. this lets you apply the calibration to data without modifying the files, so you can test it.

### 3.4.2 Applying calibrations to CTD data

>> smallscript\_tccal

smallscript\_tccal.m applies the temperature and conductivity calibrations set in the temp\_apply\_cal and cond\_apply\_cal cases of opt\_cruise.m to the Mstar files by calling:

mctd\_tempcal.m and mctd\_condcal.m for both sensors to apply the calibrations to ctd\_cruise\_nnn\_24hz.nc

mctd\_03.m and subsequent files to propagate the calibrated data into the other Mstar files

If bottle sample flags were changed in opt\_cruise.m based on the results of ctd\_evaluate\_sensors.m, msal\_01.m and msal\_02.m should also be run, by uncommenting them in smallscript\_tccal.m.

>> caldata\_all\_part2

caldata\_all\_part2.m calls

moxy\_01.m to read the ascii file into matlab and saves as oxy\_cruise\_nnn.nc

moxy\_02.m pastes the bottle oxygens into sam\_cruise\_nnn.nc.

msam\_oxykg.m calculates bottle oxygen in units of umol/kg using CTD salinity and bottle oxygen fixing temperature. Output variables: botoxysams and botoxynoc sam\_cruise\_nnn.nc.

mnut\_01 reads the ascii file into matlab and saves as nut\_cruise\_nnn.nc

mnut\_02 pastes the bottle data into sam\_cruise\_nnn.nc

mnut\_03 computes organic from total and inorganic nutrient values in sam\_cruise\_nnn.nc

\*\*\*similarly for co2, cfcs, ch4, as appropriate\*\*\*

msam\_apend concatenates the station sample files into sam\_cruise\_all.nc.

>> sensname = ‘oxy’; ctd\_evaluate\_sensors % and edit oxy\_apply\_cal case of opt\_cruise.m

It is ideal to evaluate the oxygen calibration after conductivity and temperature calibrations have been applied, since oxygen concentration depends on density.

>> smallscript\_ocal

smallscript\_ocal.m does the equivalent of smallscript\_tccal.m for oxygen

At this point, the data in the 24hz, 1hz, psal, 2db, 2up, and sam files are all calibrated.

bottle\_data\_flags.txt and msam\_02b can be used to update flags in the sample file to make editing and inspection easier, but at some point you should move the flags from bottle\_data\_flags.txt to the msal\_01, moxy\_01, mco2\_01, mnut\_01, mcfc\_01 cases in opt\_*cruise*, and rerun those respective scripts for the necessary stations so that the flags are applied in the sal\_, oxy\_, etc. files (this is so that when those are updated and transferred to sam\_ files, msam\_02b doesn’t have to reapply them to the sam\_ files)

## 3.5 Outputting data in other formats

### 3.5.1 1hz files for LADCP processing

### 3.5.2 LADCP processing for bottom depth

To run basic processing of LADCP data from cast nnn (after mout\_1hzasc has been run):

> lad\_linkscript\_ix # to copy data from network machine

>> cd ladcp/ix

>> cfgstr.orient = ‘DL’; process\_cast\_cfgstr(nnn, cfgstr);

This will generate plots as well as matlab files in ladcp/ix/DL\_GPS/processed/nnn/

And if you have dual instruments, you can process the uplooker on its own:

>> cfgstr.orient = ‘UL’; process\_cast\_cfgstr(nnn, cfgstr);

And both together:

>> cfgstr.orient = ‘DLUL’; process\_cast\_cfgstr(nnn, cfgstr);

If you have the CTD 1 Hz file, you can include bottom tracking as a constraint:

>> cfgstr.orient = ‘DL’; cfgstr.constraints = {‘BT’}; process\_cast\_cfgstr(nnn, cfgstr);

And if you have a file\*\*\* of SADCP data for the station, …

### 3.5.3 WOCE exchange format CTD and bottle data

mout\_cchdo\_sam.m and mout\_cchdo\_ctd.m, respectively, write bottle sample and corresponding CTD data from sam\_cruise\_all.nc, and 2-dbar downcast CTD profiles from ctd\_cruise\_nnn\_2db.nc, to WOCE exchange format (ascii) files. mout\_cchdo\_ctd.m writes one station/file at a time. File headers are customized in opt\_cruise.m; the header information should include a note on which quantities are calibrated and which are not.

### 3.5.3 Summary tables

station\_summary.m produces a table of CTD casts, with columns including start, bottom, and end times; depth; number of bottles fired; number of salinity samples; and numbers of other samples, customized in opt\_cruise.m

tsg\_summary prints out/makes plots of some info from merged files (not sure this one works, some of the input files may not be current)

sam\_listing is a function that just prints the CTD data from bottle firing times for a particular station

mout\_sam\_csv

mctd\_makelists

# 4. Underway Data

## 4.1 TECHSAS/SCS/RVDAS

m\_daily\_proc

later: mtsg\_findbad, mtsg\_medav\_clean\_cal, mtsg\_bottle\_compare, mtsg\_medav\_clean\_cal, mtsg\_surfmet\_merge

### 4.1.1 Data access

Mexec uses 'short names' to access the TECHSAS and SCS streams through lookup tables set in mtnames.m and msnames.m, respectively. Additional lines can be added to mtnames or msnames, and irrelevant lines commented out, as necessary.

The following Mexec Matlab commands can be used for a quick look at TECHSAS data; substitute ms for mt for corresponding SCS commands.

help mtechsas lists the 'mt' commands

mtlookd tells you filename, start, end

mtlookdf faster version that doesnt count datacycles

mtnames lists mexec 'shortnames', full filenames in cell array.

mtdfinfo winch provides info about that datastream (eg winch)

mtgaps gyro\_s 10s lists gaps in datastream of more than 10s

mtposinfo([yyyy mm dd hhmm]) gives you position for that time

help mtlistit for how to use mtlistit to list segments of data

### 4.1.2 Preparation at the start of the cruise

m\_setudir.m, called by m\_setup.m, creates the directories in which Mstar versions of the underway data will be placed. If the ship does not record a certain data stream (eg SBE35 not used on JC) that short name is ignored by the mexec scripts. But if a processed data directory is not present, the scripts will also ignore its corresponding stream, and the data will not be processed. Therefore you can exclude certain streams from Mexec processing (if they are unimportant, or low quality) by editing m\_setudir.m at the beginning of the cruise (see Section 2).

### 4.1.3 Automatic daily processing

Standard underway data (including navigation, surface air and water, and bathymetry) can be processed on a day-by-day basis by running

>> days = [nnn]; m\_daily\_proc

where days is a vector of the days you want to process, not exceeding yesterday (the last complete day).

m\_daily\_proc.m goes through the list of underway data streams found in mtnames (for techsas) or msnames (for scs), finds which ones are present in the scs or techsas link directory, and calls mday\_01.m to load them, producing a series of daily files from each data stream, located in their individual directories (e.g. bathy/sim/sim\_cruise\_dnnn\_raw.nc).

It then performs additional processing and cleaning steps on some streams by calling mday\_01\_clean\_av.m, which has cases for different streams. The automatic processing includes renaming variables to standard names (e.g. head\_gyr, depth) searching for and flagging backwards time steps or duplicate times in nav streams, NaNing out-of-range values, correcting echosounder depth for speed of sound variations based on the Carter tables, and averaging bathymetry to 30-s; output files are stream\_cruise\_dnnn\_edt.nc.

For bathymetry, when both the Simrad EA600 (sim) and the swath EM122 centre beam (em120) streams are present, msim\_02.m and mem120\_02.m are called to paste in the depths from the other instrument for subsequent comparison.

The final daily automatic processing step is to call mday\_02.m, which appends the daily file to create a master cruise file for each data stream (eg sim\_cruise\_01.nc). The list of daily files appended into the master files is given in the header information of that file.

After all daily steps have been run, mbest\_all.m, mtruew\_01.m, mtsg\_medav\_clean\_cal.m, and (for scs) upate\_allmat.m are called to produce further combined/averaged files.

Note: if daily processing is run more than once for an individual day, the master file will have the day's data appended again and may need to be recreated. It may be useful for future cruises to run the appending steps in a separate script.

The following sections contain further details of the individual data streams, manual quality control/editing steps, and the final steps operating on the appended files.

### 4.1.4 Navigation: additional processing

Bestnav: mbest\_all.m runs a series of scripts to produce the master bestnav file, bst\_cruise\_01.nc. The streams used for best position and heading are set in m\_setup.m. Scripts merge heading and position so that there is a complete file containing position, heading, course and speed made good, and distance run. The data are reduced to a 30-second time base and heading is properly vector averaged. This is the ‘definitive’ cruise navigation file. In order to avoid the problem of housekeeping variables across daily files, the bestnav processing is rerun from the start of the cruise each time it is required. There is therefore only ever one bst\_cruise\_01.nc file.

### 4.1.5 Meteorology: additional processing

Wind variables: Ship speed, position and heading from the bst navigation file are merged onto the wind data in the surfmet. The absolute wind speed is calculated and vector averaged in one multi-step script mtruew\_01.m. As with bst processing, this is rerun for the entire cruise each time the data are updated. The output files from this processing are  
met\_cruise\_true.nc  
met\_cruise\_trueav.nc  
The latter file is reduced to 1-minute averages, with correct vector averaging when required. In order to avoid ambiguity, variable units are explicit in whether wind directions are ‘towards’ or ‘from’ the direction in question. The result is a bit cumbersome, but should be unambiguous if the units are read carefully.

Note: TECHSAS stores wind speed in m/s, but says the variable unit is knots. This is corrected in mday\_01\_clean\_av.

Wind over the stern: The standard test of whether the relative wind processing has been done correctly would be to observe no change in the calculated absolute wind when the ship changes direction or speed. This can be misleading, since the anemometer sited on the foremast under-reads speed by a significant margin when the wind is over the stern. Therefore if either the ‘before’ or ‘after’ wind direction is over the stern, there can be a significant change in the apparent true wind speed during such manoeuvres.

Wind relative direction near 0/360: The age old problem of wind direction near the 0/360 boundary still remains. Since the anemometer is set up with 0/360 at the bow, the relative wind is very often around this heading. Even though the anemometer data are recorded at the data rate generated by the sensor (nominal 1 Hz), there is a problem with the raw data. In particular, when the wind is near 0/360, the TECHSAS files will sometimes contain headings in between, eg in the range 150 to 210, reminiscent of when simple numerical averaging of heading was occurring. When these bad headings are used in correct calculation of true wind, bad data are the result.

Irradiance and surface pressure

Downwelling PAR and TIR data are found in the surflight stream, which also contains barometer pressure. These streams were ingested and stored, but no further processing was undertaken.

### 4.1.6 Ocean surface variables: additional processing

Salinity is the only variable that is calibrated.

Temperature variables: On TECHSAS, sea surface temperature (that is, temperature at the seawater intake) is called temp\_r or temp\_m, while the housing temperature (temperature inside the inline CTD, applicable to the conductivity measurements) is called temp\_h. On SCS on the JCR, there are two sea surface temperature sensors, sstemp and sstemp2; the conductivity measurement temperature, tstemp, and the fluorometer temperature, sampletemp.

The appended data can be further processed as follows. These steps can be carried out at any time during the cruise, but need to be run a final time at the end since they act on the appended file.

i) run mtsg\_medav\_clean\_cal.m to average the appended file

ii) run mtsg\_findbad.m to find limits of times when the data were bad (likely when the pumps where switched off) by selecting them on a graph

iii) edit the mtsg\_cleanup case in opt\_cruise.m to hardwire in the selected bad time ranges (displayed to the screen at the end of mtsg\_findbad) as well as limits for different variables.

iv) run mtsg\_medav\_clean\_cal.m to apply the bad time limits (calling mtsg\_cleanup.m). The default is to NaN all variables within the time ranges set in opt\_cruise.m, unless opt\_cruise.m contains code excluding some variables.

v) run mtsg\_01.m to load TSG bottle sample salinity data from the concatenated salinity csv file (see Section 3.4) to an Mstar-format file.

vi) run mtsg\_bottle\_compare.m to plot bottle and TSG salinities together; determine a constant or simple time-dependent offset to bring them into alignment, or just use the smoothed difference, computed by calling filter\_bak.m and saved to tsg\_smdiff.txt.

vii) edit the tsgsal\_apply\_cal case in opt\_cruise.m with calibration determined above, or to interpolate the smoothed differences computed by mtsg\_bottle\_compare.m to the TSG times and use that series as the offset.

viii) run mtsg\_medav\_clean\_cal.m to apply calibration

You can re-run mtsg\_findbad.m and m\_tsg\_medav\_clean\_cal.m as many times as required to get a clean record.

If you want to check a calibration already applied, edit the switch at the beginning of mtsg\_bottle\_compare.m from ‘uncal’ to ‘cal’ and rerun.

### 4.1.7 Bathymetry: additional processing

Following m\_daily\_proc.m, bathymetry data can be cleaned by interactive scripts msim\_plot and mem120\_plot, which allow the user to select bad data points from the EA600 and the EM120/EM122 centre beam for each day. To incorporate the cleaned data into the appended files at the end of the cruise, remove sim\_cruise\_01.nc and em120\_cruise\_01.nc and rerun mday\_02.m for all days for these two streams (see m\_daily\_proc.m for syntax).

## 4.2 VMADCP

## 4.2.1 Vmdas plus CODAS

Vessel mounted ADCP data processed using the old University of Hawaii CODAS software (Matlab/Python hybrid version, see /local/users/pstar/cruise/sw/uh\_adcp/programs/index.html for documentation) can be loaded into daily and appended Mstar files using mcod\_01.m, mcod\_02.m, and mcod\_mapend.m. The latter sorts by time, so sequences can be added in any order or any number of times.

The full round of processing from VMDAS to Mstar, including the calls to CODAS quick\_adcp.py and gautoedit.m, can be run for a sequence or set of sequences using wrapper scripts vmadcp\_proc.m and vmadcp\_edit.m, as follows:

>> doall = 1; vmadcp\_proc % runs vmadcp\_linkscript to sync and link files; writes q\_py.cnt using initial angle and amplitude set in opt\_cruise.m, and calls quick\_adcp.py to load data into database; calls mcod\_01, mcod\_02, mcod\_mapend

This script will prompt for the instrument to use (75 or 150, probably), sequence number or vector of sequence numbers, and possibly the mode (narrowband or broadband), if not set in opt\_cruise.m

If this fails on “cannot find asetup”, it may indicate there’s not enough data in the sequence

Optional additional processing (better done on multiple sequences, and can be done back at home):

At some point, examine cal/botmtrk/btcaluv.out and cal/watertrk/adcpcal.out (in whichever sequence directories they are found; they will not be generated for every sequence), to refine the angle and amplitude calibrations. Add these to the vmadcp\_proc aa75 and/or aa150 cases in opt\_cruise.m. Once you have done this, you can rerun vmadcp\_proc.m, setting doall = 2:

>> doall = 2; vmadcp\_proc % writes q\_pyrot.cnt using angle and amplitude set in opt\_cruise.m and calls quick\_adcp.py to apply angle and/or amplitude corrections; calls mcod\_01, mcod\_02, mcod\_mapend

>> vmadcp\_edit % writes q\_pyedit.cnt, calls gautoedit.m to enable interactive data editing, calls quick\_adcp.py to apply edits; calls mcod\_01.m, mcod\_02.m, mcod\_mapend.m

### 4.2.2 Python CODAS

In pycodas terminal (prompt should start with (pycodas) bash-4.2$)

0) If you previously applied calibrations (angle, amplitude, xducer\_dx or \_dy) to data in postprocessing:

rm -rf /local/users/pstar/cruise/data/vmadcp/postprocessing/DY113/proc\_editing/os\*

1) uhdas\_01 #syncs data from acquisition computer to koaeula

2) uhdas\_02 #syncs to postprocessing/proc\_editing (and makes links if necessary)

3) uhdas\_03 #copies previously made edits (archived in proc\_archive) to proc\_editing so they will be applied to newly expanded dataset; adds new data to dataset

4) cd ~/cruise/data/vmadcp/postprocessing/DY113/proc\_editing

5) cd os150nb

6) dataviewer.py -e & #edit using selectors and/or thresholds; remember to apply edits to every segment of time series

7) quick\_adcp.py --steps2rerun apply\_edit:navsteps:calib --auto

8.1) cat cal/watertrk/adcpcal.out

8.2) cat cal/watertrk/guess\_xducerxy.out

8.2) cp -Rp . ../os150nb\_a

9) quick\_adcp.py --steps2rerun apply\_edit:rotate:navsteps:calib --rotate\_amplitude amp --rotate\_angle ang --xducer\_dx dx --xducer\_dy dy --auto #if adcpcal.out shows amplitude or angle calibration needed

10.1) cd ..

10.2) dataviewer.py -c os150nb\_a os150nb & #to see the effect of the edits and calibration. If you are not happy with them, repeat 6)-9). When you are happy:

10.4) rm -rf os150nb\_a #only keep the edited, calibrated version here now

11) cd ../os75nb #and repeat 6)-10)

12) cd ..

13) dataviewer.py -c os75nb os150nb & #to compare two instruments and check for additional needed edits; if any noticed, follow steps above

14) uhdas\_04 #generates .nc files in ~/cruise/data/vmadcp/DY113/postprocessing/proc\_edit/os75nb/contour/ and os150nb/contour/

15) uhdas\_05 #syncs proc\_edit to proc\_archive

In matlab

16 – 19) vmadcp\_stations\_to\_ladcp(start\_station, end\_station)

16) os = 75; nbb = 1; mvad\_01

os = 150; nbb = 1; mvad\_01

%makes mstar format files containing vmadcp data in /local/users/pstar/cruise/data/vmadcp/mproc/

17) stn = nnn; cast = ‘ctd’; os = 75; nbb=1; mvad\_03

stn = nnn; cast = ‘ctd’; os = 150; nbb=1; mvad\_03

%vmadcp upper ocean velocity profiles corresponding to ctd station nnn; run for each station for which new or edited vmadcp data are available

18) mvad\_for\_ladcp(‘ctd’,nnn,75,1)

mvad\_for\_ladcp(‘ctd’,nnn,150,1)

%makes file of station nnn data to be used as constraint in LADCP processing

19) cfgstr.orient = ‘DLUL’; cfgstr.constraints = {‘GPS’;’BT’;’SADCP’}; process\_cast\_cfgstr(nnn, cfgstr);

can’t process cast 79 using os150 ‘ctd’ method because there is too little good data (too short a time on station)

Making plots:

new:

use sectinfotest.txt as a model (transposed format, includes section names)

quick\_plots.py --inst os150nb --sifile sectinfotest.txt --sect cb

and similarly for the other sections listed in the sectinfo file (you’ll have to run the command more times as it will only make plots for one section each time)

# Appendices

## A. A bit more detail about Mexec functions

The Mexec functions found in subdirectories of mexec\_v3/source/ can either interactively query for inputs, or take inputs from global cell array MEXEC\_A.MARGS\_IN (or both, if MEXEC\_A.MARGS\_IN has fewer elements than the function is expecting). Future versions may evolve towards more standard argument parsing, without the querying mode.

More detail: MEXEC\_A having been declared a global variable by m\_setup, it is available within any function by calling m\_common. Within each top-level function (e.g. msave, mcalib), MEXEC\_A.MARGS\_IN is copied to MEXEC\_A.MARGS\_IN\_LOCAL and cleared. Then m\_getinput and/or m\_getfilename are called each time an input variable is required, assigning the next element of MEXEC\_A.MARGS\_IN\_LOCAL, or, if it is empty, querying for input. Some functions take lists of indeterminate length, in which case passing the string ‘/’ or ‘ ‘ or ‘-1’ (depending on the function) will terminate the loop to move on to the next type of input.

Many of the functions won’t accept the same file for input and output file, hence the use of temporary wk\*.nc files.

## B. Handy Hints and Tips

\* If a file crashes in a script it may be left with an "open to write" flag and subsequent scripts will fail. Reset using "mreset".

\* Once or twice in Mstar scripts we got a mysterious error message along the lines of "not a binary mat file" or "a preference with that name or group already exists". Just re-run the program and next time it will likely be fine; if not, try >> clear all; m\_setup; if that doesn’t work, exit and restart matlab.

Because of the interactive prompting options, sometimes a prompt will appear even if you have passed input arguments in MEXEC\_A.MARGS\_IN. If Matlab says “Busy|”, you don’t need to do anything even if it looks like it is asking for input.

\* In matlab/Mstar to open a Mstar nc file: mload

To save data to struct array d, header info to array h:

>> [d h]=mload('filename','/') % ‘/’ means all vars, or you can list the ones you want.

\* >> m\_read\_header(file) allows you to read the header info only

\* >> mhistory: returns to you the text you need to copy into a script to recreate the program steps you just ran.

## C. List of cruise-specific options

These are the cruise-specific options currently included in the Mexec scripts. Not all of these need to be set for every cruise; many have default values, assigned in get\_cropt.m. Look in the opt\_cruise.m files for examples of settings for each of these parameters, and in the scripts corresponding to each case for how they are used. Recall that oopt is an optional string variable (used to distinguish between multiple calls to get\_cropt.m in a given script)

|  |  |  |  |
| --- | --- | --- | --- |
| CTD data processing | | | |
| scriptname | | oopt | what it does |
| mctd\_02 | | corraw | edits to be applied to raw file |
| mctd\_02b | | hyst | oxygen hysteresis parameters and function call |
| mctd\_03 | | 24hz | edit 24hz for instance to replace fouled scans from one CTD with data from another |
| 1hz |  |
| psal | exclude and interpolate over bad scans for a particular set of parameters |
| s\_choice | set primary salinity sensor and list of stations on which to use alternate as primary |
| o\_choice | same for oxygen |
| mctd\_04 | | pretreat | remove some data before averaging to 2db; or use upcast data for 2db (on some station(s)) |
| mdcs\_03 | | vstring | single oxygen sensor or two oxygen sensors |
| mfir\_03 | | fillstr |  |
| mwin\_01 | |  | set acceptable time window by station |
| mwin\_03 | |  | fix some winch wireout data when underway logging missing |
| mctd\_checkplots | | pf1 | list of parameters to plot |
| sdata1 | salinity to plot (psal vs asal) |
| odata1 | oxygen to plot (1 or 2 sensors) |
| mctd\_rawshow | | pshow5 | parameters to plot on one figure |
| pshow2 | parameters to plot on another figure |
| pshow4 | parameters to plot on a third figure |
| mctd\_rawedit | | badscans | set scans to edit out of raw data (rather than choosing graphically) |
| pshow1 | parameters to plot together for editing |
| populate\_station\_depths | | fnin | input text file list of station depths |
| bestdeps | edit some of these depths |
| smallscript | | klist | list of stations to batch process |
| Sample data and sensor calibrations | | | |
| scriptname | | oopt | what it does |
| ctd\_evaluate\_sensors | | tsensind | set station numbers on which different primary and secondary sensors were used |
| csensind |
| osensind |
| cond\_apply\_cal | | switch on sensor to set conductivity calibration factor as a function of station, pressure, and temperature | |
| oxy\_apply\_cal | | switch on sensor to set oxygen calibration coefficients alpha (function of station) and beta (function of pressure) | |
| numoxy | |  | number of oxygen sensors present |
| temp\_apply\_cal | | switch on sensor to set temperature offset | |
| tsgsal\_apply\_cal | |  | set salinity offset |
| fluorcal | |  | set calibration function for fluorescence |
| msal\_standardise\_avg | |  |  |
| mbot\_00 | |  | default Niskin numbers |
| mbot\_01 | | infile | full path to bottle csv file |
| botflags | default Niskin bottle flags |
| mcfc\_02 | | infile1 | input data file |
| cfclist | list of types of cfcs measured |
| msbe35\_01 | | flag | flag bottles which might have closed too quickly for a good sbe35 reading |
| msal\_01, mtsg\_01 | | salcsv | sets input file name |
|  | | cellT | set cellT if not in file |
|  | | offset | set offset if standards or offset are not in file |
|  | | flag | set bottle/bottle reading flags by station and (Niskin) position |
|  | | indata |  |
|  | | sstdagain | run msal\_standardise\_avg a second time? |
| msal\_standardise\_avg | | std2use | set standards readings to exclude |
| sam2use | set sample readings to exclude; set sample bottle quality flags |
| mtsg\_medav\_clean\_cal | | smdiff | load smoothed differences saved by mtsg\_bottle\_cleanup, to use for calibration |
| mtsg\_bottle\_compare | | dbbad | exclude bad sample data (or bad comparison) |
| sdiff | smoothed differences |
| mtsg\_cleanup | | kbadlims | sets of start and end times of bad data to NaN |
| vout | change from default (which is to just NaN all variables between kbadlims); this is also the place to do something like NaN a given variable when it is out of range |
| moxy\_01 | | oxycsv | set input file name |
| oxybotnisk | translate from bottle rows in the oxygen spreadsheets to Niskin numbers |
| flags | set flags by station and (Niskin) position |
| moxy\_ccalc | | oxypars | set parameters for computing oxygen concentration from titre |
| blstd | blank and standard titre volumes |
| botvols | sample bottle volumes file |
| Summaries | | | |
| scriptname | oopt | | what it does |
| mcchdo\_01 | expo | | WOCE expo code and section ID for hydro section |
| outfile | | file to write exchange-format bottle sample data |
| headstr | | header information to write to file |
| mcchdo\_02 | expo | | as above |
| outfile | | file to write exchange-format CTD data |
| station\_summary | optsams | | cell arrays of sample types collected |
|  | stnmiss | | stations not to include |
|  | cordep | | corrected depth field |
|  | comments | |  |
|  | altdep | |  |
|  | varnames | | standard variable names (the optional samples will be appended) |
| Underway data | | | |
| scriptname | oopt | | what it does |
| mday\_01\_clean\_av | cnav\_fix | | by default the function cnav\_fix will be applied to the cnav stream to correct an error in labeling minutes as decimal degrees; if this is not necessary (i.e. already fixed), the correction can be switched off |
| morecorr | | use the Mexec short name (called abbrev in this script) to switch on non-standard cleaning/calibration operations |
| msim\_plot | sbathy | | file of atlas bathymetry |
| mem120\_plot | sbathy | | file of atlas bathymetry |
| vmadcp\_proc | aa0\_75 | | approximate/nominal alignment angle and amplitude for 75 kHz and 150 kHz |
| aa0\_150 | |
| aa75 | | additional (refined) rotation and amplitude corrections  based on btm/watertrk |
| aa150 | |

## D. Known bugs and future changes

### D.1. Bugs

~~If a function is interrupted, some fields of MEXEC\_A are not cleared properly such that filenames being written to the history file can accumulate.~~ Resolved, jc159.

Possibly relatedly, errors involving MEXEC\_A.MARGS\_OT may come up (clear all, run m\_setup, and try again).

~~Warning about not finding an exact case match for “redef” or something like that (ignore, unless it turns into an error, in which case, restart Matlab).~~ Resolved, jc159, however see next item.

Issues with different versions of matlab/versions of snctools and mexcdf not properly setting row/col dimensions in .nc files. Workaround for v2011a forces underway data to be rows/columns\*\*\* . . . does not work on v2014b. \*\*\*

Matlab netcdf errors about “a preference with that name or group already exists” occur, apparently when multiple Matlab sessions are accessing the low-level netcdf functions at the same time. The only response is to start again at the point of interruption and hope there won’t be more coincidences, although in extreme cases it may be necessary to restart one or multiple Matlab sessions. The error seems particularly likely to be triggered by running m\_setup, so one adaptation is to keep a couple of Matlab sessions running and set up, rather than starting a new one while Mexec scripts are running in another window . . . however this only reduces rather than eliminates the occurrence of these errors.

Error using netcdflib

Library failure in call to open. eacces:permissionDenied. Error message from the NetCDF

library: "Permission denied".

Error in netcdf.open (line 50)

[varargout{:}] = netcdflib ( 'open', filename, mode );

Error in nc\_attput>nc\_attput\_tmw (line 41)

ncid =netcdf.open(ncfile, nc\_write\_mode );

Error in nc\_attput (line 28)

nc\_attput\_tmw ( ncfile, varname, attribute\_name, attval )

Error in m\_openio (line 20)

nc\_attput(ncfile.name,nc\_global,'openflag','W'); % set to W if file is open to write.

Usual state is R.

Error in mheadr (line 22)

ncfile = m\_openio(ncfile);

Error in mctd\_02a (line 98)

mheadr

Error in ctd\_all\_part1 (line 16)

stn = stnlocal; mctd\_02a; %rename variables following templates/ctd\_renamelist.csv

This means you should remove ctd/ctd\_cruise\_nnn\_raw.nc (or even ctd/ctd\_cruise\_nnn\*.nc) and start again. Make a note on the processing logsheet.

If the beginning part of this error occurs when running smallscript\_botnav, in terminal:

chmod u+w ctd/ctd\_dy113\_nnn\_raw\*.nc

Exit with error because file /local/users/pstar/dy113/mcruise/data/ctd/ctd\_dy113\_002\_2db.nc is already open for write

It may be the case that this program has crashed or been interrupted before, leaving the write flag set in the file

If required you can reset the write flag using

mreset(filename) or mreset(ncfile)

where filename or ncfile.name is a char string containing the name of the mstar file

Error in m\_openot (line 27)

ncfile = m\_exitifopen(ncfile); % exit if write flag set

Error in mcalc (line 57)

ncfile\_ot = m\_openot(ncfile\_ot);

Error in mctd\_04 (line 176)

mcalc

>> mreset('ctd/ctd\_dy113\_002\_2db.nc')

About to reset mstar openflag on file ctd/ctd\_dy113\_002\_2db.nc.

Do you really want to do this ?

Reply y/yes. Default is no. y

File ctd/ctd\_dy113\_002\_2db.nc has been modified

Attempt to reference field of non-structure array.

Error in mtposinfo (line 51)

tin = pdata.time+MEXEC\_G.uway\_torg;

Error in mctd\_02a (line 111)

[botlat botlon] = mtposinfo(tbotmat);

Error in ctd\_all\_part1 (line 16)

stn = stnlocal; mctd\_02a; %rename variables following templates/ctd\_renamelist.csv

run techsas\_linkscript in terminal (have to do this each new day UTC)

some error about f.ladcpdo

run lad\_linkscript\_ix and make sure LADCP files were copied/links were made

D.2 Planned future changes

Add loopedit?!?

At least: further reducing querying for input when MEXEC\_A.MARGS\_IN has been supplied; hopefully: more normal functional input argument handling (rather than using global variables for all input arguments or prompting for input)

Separate out initial setup of directories, version files etc. from adding paths from setting global variables (?)

More documentation of functions—but please point out where specifically this is missing!

Use matlab’s built-in netcdf support; perform more operations in scripts (rather than passing to mexec source functions) and just have functions to read and write mstar format (no need for mapend, mcalc, etc., and probably no need for m\_write\_header, m\_print\_header etc. as separate functions as opposed to optional operations of the basic reading and writing functions)

Possible condensation of mfir, mwin, mdcs scripts (fewer intermediate Mstar files). Generally reducing file i/o by not writing every intermediate step to a file (this is part of the change to built-in netcdf support above anyway).

Updating mtsg\_lagsal, tsglag, mtow\_04, msam\_nutkg, mcfc\_03 to use gsw rather than sw

checking fluor scripts

Script to append despiked bathymetry data (or option in m\_daily\_processing to stop for despiking along the way?)

D.2.a unnecessary functions/scripts in mexec source (i.e. could be done significantly quicker and/or more concisely)

mcrange

pretty much all the special netcdf handling functions

I already got rid of the function whose entire contents was “return” so that’s something

mtruew\_01 seems to undo/redo some of its own calculations? maybe? hard to tell. also it claims to be adding documentation but the docstrings are still unclear.

D.2.b functions/scripts in mexec source that need better documentation

all of them