VI. Data Format Specifications

This section goes into all the details of each data set, including data formats, vocabularies and server end-points.

A. High-Frequency Radios (HFR)

1. Data flow

The HFR sites report along-track (radial) velocities (bearing and range) every 15 minutes, basically the time it takes for the HFR to make a single swath or sweep of the ocean surface. The data are collected locally on a Linux box known as the Wera server at each site. It's then periodically SCP'd via the route that is current on each site's failover router directly to *lawelawe* (the setup has two Internet connections at each site, a broadband and if it goes down, it automatically fails over to GSM; Kaena Pt's GSM is currently inoperable until he gets an external cellular antenna). The data are copied, after being sent to *lawelawe*, to the HFR "lab server" as a means of backup.

The raw data are then processed by the HFR group. This processing includes computing averaged hourly files in Matlab binary format. The resulting files are then placed on *lawelawe*[20] in `/export/lawelawe0/radlab/hioos/`*sitename* where *sitename* is one of `kak`, `kal`, `kok`, *etc*. (note that there is a legacy site, `koo` that is not used). The files are of the form *yyyydddhhmm*`_`*site*`.RAD_Beam.mat`, where *yyyy* is the four-decimal year, *ddd* is the three-decimal day-of-year, *hh* is the hour and *mm* is the minute (*e.g.*, `20102790200_kak.RAD_Beam.mat`).

The HFR data are then converted in two different ways: from Matlab binary to ASCII .ruv files that are read by the National HFR site at UCSD/Scripps, and from Matlab binary to NetCDF for serving on the PacIOOS TDS. Note the local TDS service is just for local model assimilation and this link is not advertised.

Conversion to ASCII: The raw files are converted to ASCII via an hourly cron script, **`conv_HFR.s`**, that runs at 20 minutes past the hour. The script accesses programs in `/export/lawelawe/jimp/HFR`, primarily `convert_HFR_mat2ASCII.F`, to convert the Matlab binary files into ASCII. The program reads input of time (as year, month, day, hour, minute and second) and location (as three character code). All values are read from the Matlab files except time, which is read from the file name. An example call is:

```
convert_HFR_mat2ascii 2016 08 28 13 00 00 kak
```

[20] *lawelawe* will be used throughout to refer to the main PacIOOS server machine, lawelawe.soest.hawaii.edu

and this will read from an input file called `20162411300_kak.RAD_Beam.mat` and create a file called `RDL_kak_2016_08_28_130000.ruv` with data from August 28, 2016 at 1:00PM for station KAK.

The ASCII files are copied to a site-specific subdirectory in `/export/lawelawe1/hfrnet` where they are retrieved by the National HFR group at Scripps. This group converts the raw, radial velocities to vectors by combining data from overlapping HFR and then servers the data via the National network. These files are then used for the overlays in the local PacIOOS Data Explorer. Scripps looks for new files by filename (date in the filename, not file creation time), but the local processing looks for recently modified files. Thus, if the local HFR group posts a set of new files, these will all get processed as new, but the National network will only pick the ones for "today".

Conversion to NetCDF: Separate cron scripts are run to convert the Matlab binary files into NetCDF for inclusion in the PacIOOS TDS. These scripts are site-specific and contain the site in the script name, for example **`conv_HFR_kak2cdf.s`** converts the data for the KAK site. These scripts are run at 5, 7, 9 …, 17 minutes past the hour (every hour). The scripts use programs in `/export/lawelawe1/hfr/src` to convert the Matlab binary files into NetCDF so the data can be included in the TDS. The programs are unique for each site since they have different ranges and resolutions (*e.g.*, **`convert_kak_netcdf`**, a compiled version of `convert_HFR_mat2netcdf.F`, is used to make the NetCDF file for the KAK site). This program requires the Matlab library glnxa64, so this must be loaded first. Similar to the conversion program for Matlab-to-ASCII, times are obtained from the filename.

The generated NetCDF files are put in `/export/lawelawe1/hfr/`*`sitename`*`_netcdf/`*`year`*`/`*`month`*, where *`sitename`* is one of `kak`, `kal` or `kok`; *`year`* is the 4-digit year and *`month`* is the 2-digit month. The filenames are then of the form `RDL_`*`kkk_yyyy_ddd_hhmm`*`.nc`, again with *`kkk`* being the site name (three letter abbreviation), *`yyyy`* the year, *`ddd`* the day of the year (0 to 366), *`hh`* the hour and *`mm`* the minute. The cron job looks for all files with creation/modified times less than 70 minutes old, copies them over, and makes the NetCDF file. The dates in the output filenames are based on the input filenames.

An important note is that the conversion program for binary-to-ASCII compiles fine on *`lawelawe`*, but the binary-to-NetCDF codes do not. These have to be compiled on *`lii.soest.hawaii.edu`* (files in `/export/lii/jimp/OOS/HIOOS/HFR`). Secondly, since the range (and possibly bearing) seem to change without notice, the conversion programs for binary-to-NetCDF now have a default number of ranges (125) and bearings (245). If the actually observations are less than this, the arrays

are filled with NaN's. Table 20 gives the actual range numbers from recent (as of this edit) files.

In summary:

1. Convert Matlab binary files to ASCII for HFRNET (`conv_HFR.s`):

- `convert_HFR_mat2ascii.F` used to convert .mat to .ruv
- one executable for all sites, **`convert_HFR_mat2ascii`**, and it reads at command line the year, month, day, hour, minute, second and location; *e.g.*, **`convert_HFR_mat2ascii`** `< 2014 08 28 06 00 00 kak`
- lat/lon specified in program ("origin" in ASCII file)
- slat/slon read from matlab file, used to calculate ranges
- time is obtained from input filename

2. Convert Matlab binary files to NetCDF files for TDS (`conv_HFR_*2cdf.s`):

- `convert_HFR_mat2netcdf.F` used to convert .mat to .nc
- executables are different for each site, *e.g.*, **`convert_kal_netcdf`**, and they read at command line the year, day, hour, minute and location, *e.g.*, **`convert_kal_netcdf`** `< 2014 128 10 30 kal`
- lat/lon specified in global attributes (program)
- slat/slon read from matlab file, written as variable
- time is obtained from input filename
- range and bearing are standardized to 125x245, respectively; NaN's are used to fill in values then are replaced with actual observations if available

Location	Site name	Range Res	Range	First valid data	File freq	Filesize per file	Filesize per year
Koko Head	KOK	1.5 km	110 km	09-12-2011	60 min	738,900	6.47 GB
Kaka'ako	KAK	0.6 km	60 km	10-09-2014	60 min	738,900	6.47 GB
Barber's Pt.	KAL	1.5 km	150 km	09-25-2010	60 min	738,900	6.47 GB
Kaena Pt.	KNA	1.5 km	110 km	03-26-2013	60 min	738,900	6.47 GB
Keaukaha	KKH	0.6 km	50 km	12-17-2013	60 min	738,900	6.47 GB
Pepe'ekeo	PPK	0.6 km	50 km	05-06-2015	60 min	738,900	6.47 GB
Kapiolani	KAP	1.5 km	150 km	09-13-2015	60 min	738,900	6.47 GB

Table 20. HFR data specifics.

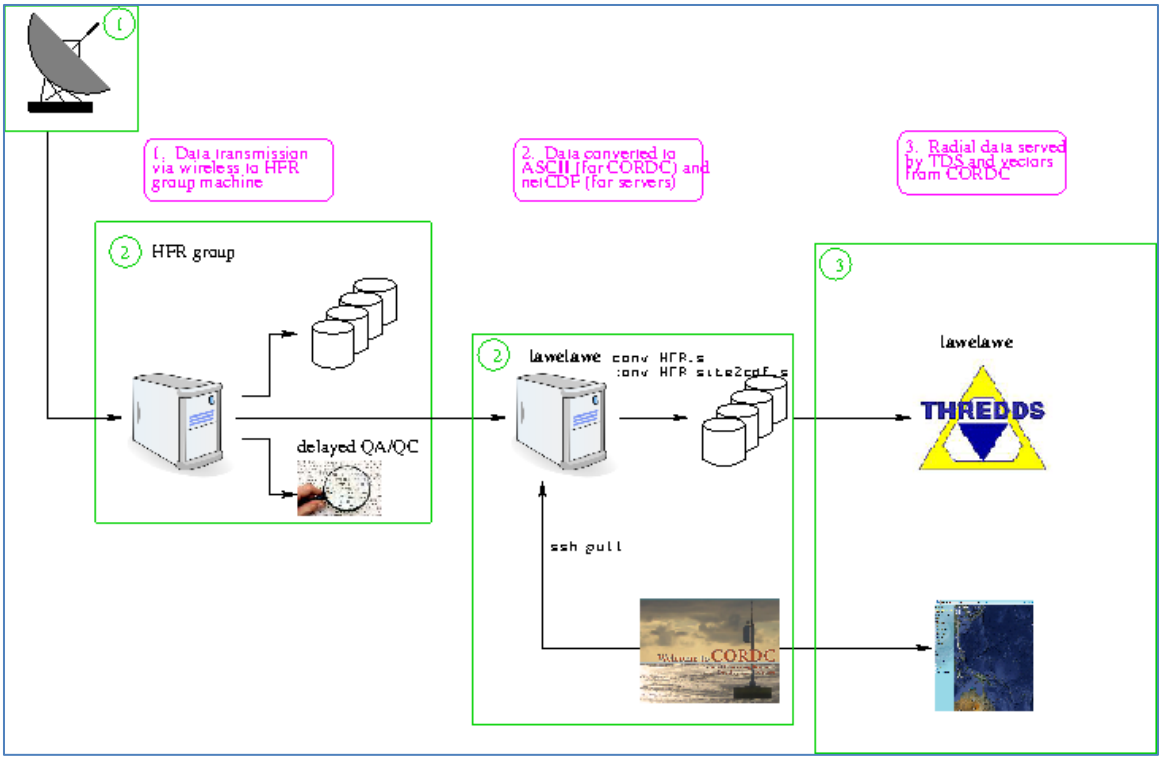

Figure 21. Generic data flow for HFR. The data are acquired from each site by the HRF group, and Matlab binary files are supplied to the PacIOOS disk (1), converted (2) and put on the servers (3).

2. File naming convention

- RDL_sitename_yyyy_ddd_HHMM.nc, where
  - Sitename is one of KAK, KNA, KAL, KOK
  - yyyy is four-digit year
  - ddd is day of the year
  - HHMM is hour/minute

3. Data format specification

```
netcdf RDL_kal_2013_178_1700 {
dimensions:
 range = 125 ;
 bearing = 245 ;
 z = 1 ;
 time = UNLIMITED ; // (1 currently)
variables:
 float x-origin ;
       x-origin:long_name = “longitude of HFR at zero range” ;
       x-origin:short_name = “slon” ;
       x-origin:units = “degrees_east” ;
 float y-origin ;
       y-origin:long_name = “latitude of HFR at zero range” ;
       y-origin:short_name = “slat” ;
       y-origin:units = “degrees_north” ;
 float range(range) ;
       range:long_name = “range to cell” ;
       range:units = “km” ;
 float bearing(bearing) ;
```

```
      bearing:long_name = “bearing to cell clockwise from north”
;
      bearing:units = “degrees” ;
 float z(z) ;
      z:long_name = “depth below mean sea level” ;
      z:standard_name = “depth” ;
      z:axis = “z” ;
      z:units = “meters” ;
 int time(time) ;
      time:long_name = “time” ;
      time:standard_name = “time” ;
      time:axis = “t” ;
      time:units = “minutes since 2008-01-01 00:00:00” ;
 float lat(range, bearing) ;
      lat:long_name = “latitude” ;
      lat:standard_name = “latitude” ;
      lat:axis = “y” ;
      lat:units = “degrees_north” ;
      lat:_FillValue = -999.f ;
 float lon(range, bearing) ;
      lon:long_name = “longitude” ;
      lon:standard_name = “longitude” ;
      lon:axis = “x” ;
      lon:units = “degrees_east” ;
      lon:_FillValue = -999.f ;
 float accu(time, z, range, bearing) ;
      accu:long_name = “accuracy of the Bragg estimate in cell” ;
      accu:units = “m/s” ;
      accu:_FillValue = -999.f ;
 float powr(time, z, range, bearing) ;
      powr:long_name = “relative power of cell” ;
      powr:units = “dB” ;
      powr:_FillValue = -999.f ;
 float urad(time, z, range, bearing) ;
      urad:long_name = “radial current in cell” ;
      urad:standard_name =
“radial_sea_water_velocity_away_from_instrument” ;
      urad:units = “m/s” ;
      urad:_FillValue = -999.f ;
 float vari(time, z, range, bearing) ;
      vari:long_name = “variance of grid interpolation” ;
      vari:units = “unknown” ;
      vari:_FillValue = -999.f ;

// global attributes:
      :title = “Results from Kalaeloa HFR, raw 15-minute data
provided by SOEST RADLAB group, P. Flament, PI.  Data are radial
velocities.....x-origin = -
157.08360.....y-origin =
21.29750.....” ;
      :Conventions = “CF-1.4” ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units

x-origin	longitude of HFR at zero range	slon		degrees_east
y-origin	latitude of HFR at zero range	slat		degrees_north
range(range)	range to cell			km
bearing(bearing)	bearing to cell clockwise from north			degrees
z(z)	depth below mean sea level		depth	meters
time(time)	time		time	minutes since 2008-01-01 00:00:00
lat(range,bearing)	latitude		latitude	degrees_north
lon(range,bearing)	longitude		longitude	degrees_east
accu(time,z,range,bearing)	accuracy of the Bragg estimate in cell			m/s
powr(time,z,range,bearing)	relative power of cell			dB
urad(time,z,range,bearing)	radial current in cell		radial_sea_water *velocityaway* from_instrument	m/s
vari(time,z,range,bearing)	variance of grid interpolation			unknown

Table 21. HFR variable list.

5. Data distribution

Near-Real Time Surface Ocean Velocity, Hawaii, 1 km Resolution

- Metadata: http://pacioos.org/metadata/HFRADAR_USHI_hourly_RTV_1km.html
- Voyager: http://pacioos.org/voyager/index.html?b=20.838278%2C-158.535461%2C21.460737%2C-157.364731&t=h&o=hfrad::1
- TDS: http://hfrnet.ucsd.edu/thredds/HFRADAR_USHI_hourly_RTV.html?dataset=HFRNet/USHI/1km/hourly/RTV
- WMS: http://hfrnet.ucsd.edu/thredds/wms/HFRNet/USHI/1km/hourly/RTV?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://hfrnet.ucsd.edu/thredds/wcs/HFRNet/USHI/1km/hourly/RTV?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://hfrnet.ucsd.edu/thredds/ncss/grid/HFRNet/USHI/1km/hourly/RTV/dataset.html
- OPeNDAP: http://hfrnet.ucsd.edu/thredds/dodsC/HFRNet/USHI/1km/hourly/RTV.html

Near-Real Time Surface Ocean Velocity, Hawaii, 2 km Resolution

- Metadata: http://pacioos.org/metadata/HFRADAR_USHI_hourly_RTV_2km.html
- Voyager: http://pacioos.org/voyager/index.html?b=20.838278%2C-158.535461%2C21.460737%2C-157.364731&t=h&o=hfrad::1
- THREDDS: http://hfrnet.ucsd.edu/thredds/HFRADAR_USHI_hourly_RTV.html?dataset=HFRNet/USHI/2km/hourly/RTV
- WMS: http://hfrnet.ucsd.edu/thredds/wms/HFRNet/USHI/2km/hourly/RTV?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://hfrnet.ucsd.edu/thredds/wcs/HFRNet/USHI/2km/hourly/RTV?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://hfrnet.ucsd.edu/thredds/ncss/grid/HFRNet/USHI/2km/hourly/RTV/dataset.html
- OPeNDAP: http://hfrnet.ucsd.edu/thredds/dodsC/HFRNet/USHI/2km/hourly/RTV.html

Near-Real Time Surface Ocean Velocity, Hawaii, 6 km Resolution

- Metadata: http://pacioos.org/metadata/HFRADAR_USHI_hourly_RTV_6km.html
- Voyager: http://pacioos.org/voyager/index.html?b=20.838278%2C-158.535461%2C21.460737%2C-157.364731&t=h&o=hfrad::1
- THREDDS: http://hfrnet.ucsd.edu/thredds/HFRADAR_USHI_hourly_RTV.html?dataset=HFRNet/USHI/6km/hourly/RTV
- WMS: http://hfrnet.ucsd.edu/thredds/wms/HFRNet/USHI/6km/hourly/RTV?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://hfrnet.ucsd.edu/thredds/wcs/HFRNet/USHI/6km/hourly/RTV?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://hfrnet.ucsd.edu/thredds/ncss/grid/HFRNet/USHI/6km/hourly/RTV/dataset.html
- OPeNDAP: http://hfrnet.ucsd.edu/thredds/dodsC/HFRNet/USHI/6km/hourly/RTV.html

B. Beach cameras

1. Data flow

The beach camera still images and animations are placed directly on the PacIOOS server by Chris Kontoes (Mark Merrifield, PI). The two cameras (Sheraton and

Waimea), have two different views and take both still and animated images. The animations are based on images taken within the hour (typically 5 minute intervals). The images placed on *lawelawe* are always called "`color.jpg`" and animations are called "`movie.avi`". The times are determined by the directory structure; the directory name has the data and time. Files are copied over every hour for daylight hours only (typically 07:00 to 17:00 HST) via an hourly cron job (**`copy_beachcams.s`**).

Location	Site name	View	Valid dates	Filesize per file (hr)	Filesize per year
Sheraton	sheraton1	toward Diamond Head	02-05-2009 10-13-2013	211,807 442,212	850 MB 1.78 GB
	sheraton2	straight down	02-05-2009 10-13-2013	261,961 451,482	1.05 GB 1.81 GB
Waimea	waimea1	toward ocean	02-05-2009 10-14-2013	186,399 187,490	748 MB 752 MB
	waimea2	along shore	02-05-2009 10-14-2013	126,057 164,488	506 MB 660 MB

Table 22. File specifications for beach camera images.

2. File naming convention

The files are supplied directly to disk with the names `color.jpg` and `movie.avi`. The directory structure gives the data and time, *e.g.*, a picture from the Sheraton at noon on in August 28, 2011 would be named
`/export/lawelawe1/beach_cam/sheraton1/2011-08-28/20110828T120000/color.jpg`

3. Data format specification

The files are jpeg images and avi animations.

4. Data vocabulary

N/A

5. Data distribution

The beach camera images are not distributed via a data service. They can be saved off the web page in real-time, or requests can be emailed to the data group for specific sets of images. These will be handled on a case by case basis, and images would be made available on the SOEST ftp server.

C. Near-shore sensors (NSS)

1. Data flow

The near-shore sensor (NSS) network is composed of individual platforms with multiple sensors. These platforms are mounted to piers or other such structures

and measure temperature and salinity in the near surface. Some additionally measure pressure, chlorophyll (florescence) and turbidity.

In short, data from sensors that have telemetry enabled are put into a database by DataTurbine (DT) every four minutes. There are two different DT sites, the "real-time" DT (RBNB) and the "archive" DT. It is not always the case that these two match, *i.e.*, there could be data on one server that is not on the other. The two different DT sites are:

1. Archive: http://bbl.ancl.hawaii.edu/kilonalu-data/
2. Realtime: http://bbl.ancl.hawaii.edu:8080/RBNB/

The sensor data are placed in directories based on location name and instrument. Note that the list below is for the archive DT; the real-time side doesn't pre-append the location:

- NS01: `alawai/AW01XX_002CTDXXXXR00/DecimalASCIISampleData/`
- NS02: `alawai/AW02XX_001CTDXXXXR00/DecimalASCIISampleData/`
- NS03: `alawai/WK01XX_001CTDXXXXR00/DecimalASCIISampleData/`
- NS04: `alawai/WK02XX_001CTDXXXXR00/DecimalASCIISampleData/`
- NS05: `pacioos/PIAS01_001CTDXXXXR00/DecimalASCIISampleData/`
- NS06: `pacioos/PIFM02_002CTDXXXXR00/DecimalASCIISampleData/` (note this was PIFM01 until 08/2011, and PIFM02_001 until 06/2014)
- NS07: `pacioos/PIMI01_001CTDXXXXR00/DecimalASCIISampleData/`
- NS08: `pacioos/PIPL01_001CTDXXXXR00/DecimalASCIISampleData/`
- NS09: `pacioos/PIGM01_001CTDXXXXR00/DecimalASCIISampleData/`
- NS10: `alawai/MB01XX_001CTDXXXXR00/DecimalASCIISampleData/`
- NS11: `pacioos/PINM01_002CTDX008R00/DecimalASCIISampleData/`
- NS12: `maui/MU02XX_001YCTDXXXR00/DecimalASCIISampleData/`
- NS13: `maui/MU01XX_001YCTDXXXR00/DecimalASCIISampleData/`
- NS15: `pacioos/PIGM01_002CTDX002R00/DecimalASCIISampleData/`
- NS16: `alawai/MB02XX_001CTDXXXXR00/DecimalASCIISampleData/`

At present processing is done once per day pulling data from the "archive" server. This is done via a cron job run at 16:00 HST (**`conv_nss_data`**) which is a link to `/export/lawelawe1/nss/src/`**`conv_nss_data`**.

This script gets the current day (Hawaii time), pulls data from DT via **`wget`** from the directory for that day (today). Note that DT puts files into a directory structure with subdirectories for year, then month, and finally day. Within the "day" subdirectory are individual files whose name includes the creation time. All these times are UTC, but the times listed in the files themselves are local time. For example the process for an NSS in Hawaii, ten hours behind UTC, would be:

II. On March 9, 2012 at 16:00 HST the download/conversion script is run
III. It acquires all data in the directory …/2012/03/09
IV. The files in this directory are named *`inst`*`20120309000317` (00:03:17 for March 9 2012) through *`inst`*`20120309230317` (23:03:17 for March 9 2012)
V. The first line of the first file has time 14:00 and the last line is 14:59 for March 8 (this is one hour in local time and corresponds to 00:00 March 9 UTC)
VI. The last file has times 13:00 through 13:59 for March 9 (again, this is local time and corresponds to 23:00 through 23:59 UTC)

The conversion script gets local time via the "**`date`**" command. Note that "today" in HST, if run at 16:00, is "yesterday" in GMT, so the script gets all data from a complete single day, *e.g.*, the script run at 16:00 HST on January 2, 2011 will get all data for January 2, 2011 and create a file with Jan02 in the file name.

All data are concatenated into a single file (`infile`) and then the program **`conv2netcdf`** (binary form of `write_netcdf.f`) is run to create a NetCDF file. As noted above, the times in the raw, ASCII files are local times, while the file name convention is UTC (the single exception is NS-11 that reports in UCT). The program **`conv2netcdf`** will convert from local time to UTC, so the NetCDF files have a filename, and time within the file, in UTC.

If there are missing data for an entire day, a file is still made with all missing data. The next step in the conversion is to create a link in the sensor/`agg` directory, then using **`ncrcat`**, create a single aggregate file.

Processing these files exposed a few issues in both the data collection and conversion. In summary:

1. The format of the data on the DataTurbine is not consistent, sometimes being preceded with a hash mark (#), sometimes not; sometimes fields are separated by a comma, sometimes not; *etc*.

2. Sensors sometimes move, in which case they should get a new ID number (*e.g.*, see PIFM01 and PIFM02; same sensor just got moved). In processing we keep this all as NS06 (probably need to address this).
3. The sensors require coefficients and offsets. These get changed every time the sensors are recalibrated. It is important that the NSS group pass this information to the DMG.

The file conversion also includes two calculations (potentially) to convert input voltages to values. This typically involves a "dark count" and a "scale factor" and is used for both chlorphyll and turbidity calculations. The calculation is then applied as:

$$\text{flor} = \text{scale factor}_c \times (\text{measured value} - \text{dark counts}_c)$$
$$\text{turb} = \text{scale factor}_t \times (\text{measured value} - \text{dark counts}_t)$$

The dark counts and scale factors are obtained from the WET Labs FLNTU characterization sheets and get updated every time the instrument is calibrated. The current calibration coefficients are summarized in Table 23 (note some NSS do not carry a FLTNUS and thus no calibration coefficients are listed). The actual spec sheets can be found at https://sites.google.com/site/hioosdmac/nearshore-sensors

Note that NS-01 stopped in April, 2013 and NS-09 stopped in January, 2011.

Site	FLNTUS	Calibration Date	Effective Date	dark_c	scale_c	dark_t	scale_t
NS-01	860	Nov 27, 2007	Aug 15, 2008	0.099	10.0	0.065	5.0
	860	Oct 05, 2009	Oct 19, 2009	0.099	10.0	0.063	5.0
	1630	Nov 09, 2009	Jun 30, 2010	0.068	10.0	0.037	5.0
	860	Oct 25, 2010	Nov 10, 2010	0.065	10.0	0.076	5.0
	1630	Nov 09, 2009	Feb 04, 2011	0.068	10.0	0.037	5.0
	1630	Jul 18, 2012	Mar 27, 2012	0.071	10.0	0.040	5.0
NS-02	861	Nov 27, 2007	Jul 28, 2008	0.099	10.0	0.065	5.0
	861	Apr 30, 2010	Apr 30, 2010	0.088	10.0	0.064	5.0
	2568	Feb 08, 2012	Mar 19, 2013	0.078	10.0	0.066	5.0
	1675	Mar 15, 2013	Apr 05, 2013	0.070	10.0	0.084	20.0
	1628	Apr 14, 2013	Dec 09, 2015	0.066	10.0	0.062	5.0
	1675	Jan 25, 2016	Mar 11, 2016	0.067	10.0	0.085	20.0
NS-03	n/a						
NS-04	n/a						
NS-05	1310	Jun 17, 2009	Jun 09, 2010	0.062	25.0	0.079	199.0
	1310	Jun 15, 2011	Aug 25, 2011	0.059	10.0	0.079	5.0
	1310	Nov 27, 2012	Nov 01, 2013	0.061	11.0	0.080	5.0
	1310	Mar 03, 2016	Apr 28, 2016	0.060	12.0	0.079	6.0
NS-06	1309	Jun 17, 2009	May 07, 2010	0.069	25.0	0.068	197.0
	861	Nov 30, 2012	Feb 13, 2013	0.093	13.0	0.069	5.0
	861	Sep 01, 2015	Nov 05, 2015	0.048	10.0	0.064	5.0
NS-07	1534	Jul 13, 2009	May 01, 2010	0.060	10.0	0.066	5.0
	1534	Mar 13, 2014	Jul 23, 2014	0.058	10.0	0.067	5.0
	1534	Oct 14, 2015	Oct 23, 2015	0.058	10.0	0.068	5.0
NS-08	1676	Jan 7, 2010	May 24, 2010	0.052	10.0	0.066	5.0
	1676	Sep 17, 2012	Oct 10, 2012	0.067	10.0	0.065	5.0
NS-09	1675	Jan 07, 2010	May 20, 2010	0.071	10.0	0.084	5.0
	1675	Jun 09, 2011	Jun 09, 2011	0.070	10.0	0.084	5.0
NS-10	860	Oct 25, 2010	May 31, 2011	0.065	10.0	0.076	5.0
	860	Jan 30, 2012	Feb 16, 2012	0.064	10.0	0.075	5.0
NS-11	1628	Nov 05, 2009	Sep 15, 2011	0.065	10.0	0.057	5.0
	1628	Apr 15, 2013	May 01, 2013	0.066	10.0	0.062	5.0
NS-12	n/a						
NS-13	n/a						
NS-14	n/a						
NS-15	1309	Jun 17, 2009	Jul 07, 2012	0.069	25.0	0.068	197.0
	2568	Feb 08, 2012	Jul 16, 2013	0.078	10.0	0.066	5.0
	1309	May 14, 2014	Jun 01, 2014	0.070	51.0	0.069	204.0
	1309	Mar 26, 2015	Jun 04, 2015	0.070	52.0	0.069	184.0
	1310	Oct 17, 2017	Dec 11, 2017	0.064	11.0	0.081	6.0
NS-16	1630	Aug 14, 2013	Jan 15, 2014	0.070	10.0	0.040	5.0
	2568	Feb 08, 2012	Jul 31, 2015	0.078	10.0	0.066	5.0

Table 23. NSS Calibration Coefficients.

Location	ID	Lat	Lon	DT Name	First valid data	Filesize per year[21]
Waikiki YC	NS-01	21.29	-157.84	AW01XX_002CTDXXXXR00	08/15/08	5.89 MB
Hawaii YC	NS-02	21.29	-157.84	AW02XX_001CTDXXXXR00	07/28/08	5.85 MB
Hilton	NS-03	21.28	-157.84	WK01XX_001CTDXXXXR00	01/15/09	5.85 MB
Aquarium	NS-04	21.26	-157.82	WK02XX_001CTDXXXXR00	12/15/09	5.85 MB
Am. Samoa	NS-05	-14.28	-170.69	PIAS_001CTDXXXXR00	06/08/10	6.00 MB
FSM	NS-06	6.96	158.22	PIFM02_002CTDXXXXR00	05/07/10	7.29 MB
RMI	NS-07	7.11	171.37	PIMI01_001CTDXXXXR00	05/02/10	7.49 MB
Palau	NS-08	7.34	134.46	PIPL01_001CTDXXXXR00	05/24/10	7.48 MB
Guam	NS-09	13.32	144.66	PIGM01_001CTDXXXXR00	05/20/10	5.89 MB
Maunalua Bay	NS-10	21.28	-157.71	MB01XX_001CTDXXXXR00	05/31/11	5.85 MB
Saipan	NS-11	15.16	145.77	PINM01_002CTDX008R00	09/15/11	5.85 MB
Kihei, Maui	NS-12	20.73	-156.46	MU02XX_001YCTDXXXR00	07/19/14	3.41 MB
Kahului, Maui	NS-13	20.89	-156.47	MU01XX_001YCTDXXXR00	02/05/14	3.41 MB
Maui	NS-14					
Guam	NS-15	13.42	144.79	PIGM01_002CTDX002R00	07/06/12	5.75 MB
Wailupe	NS-16	21.27	-157.76	MB02XX_001CTDXXXXR00	01/15/14	4.67 MB

Table 24. Near-shore sensor locationa and IDs.

[21] This is the size of the daily netCDF files, not the raw ASCII files, but both are saved to disk

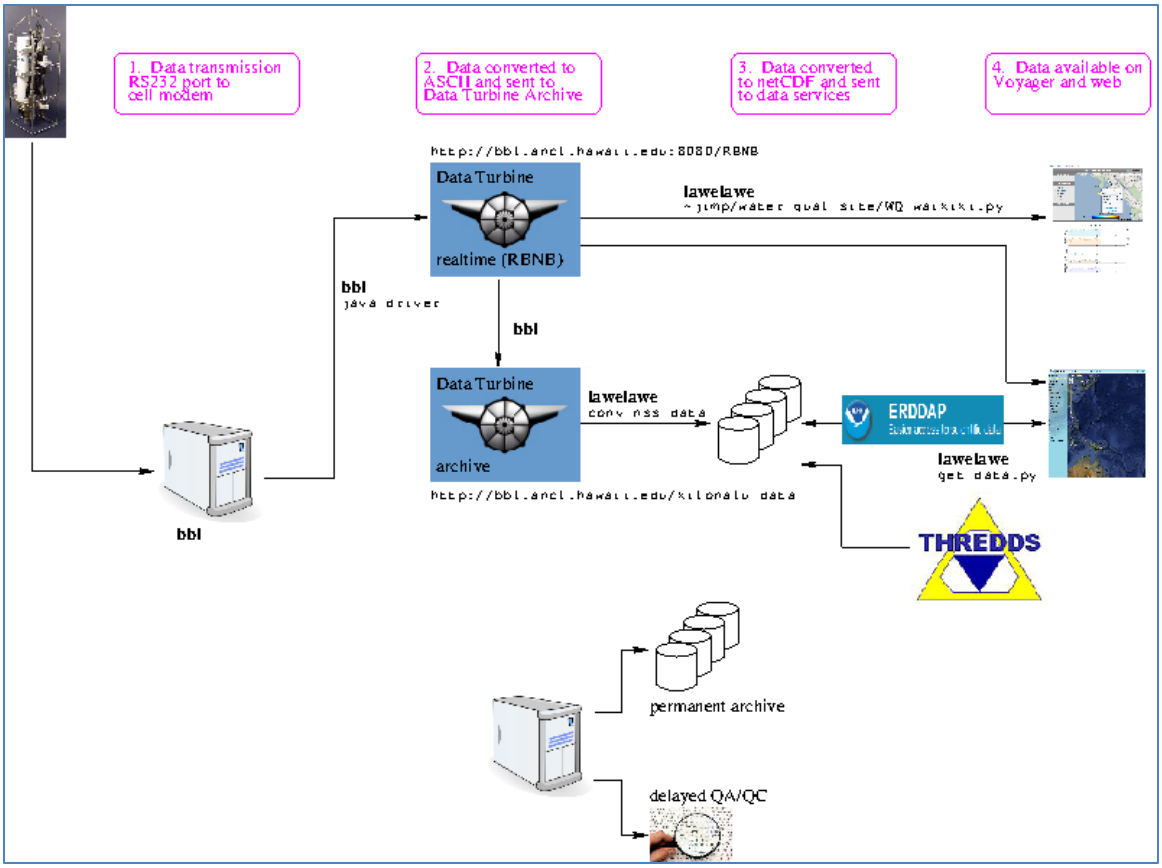

Figure 22. Data flow chart for near-shore sensors. Note that not all are telemetered in real-time.

2. File naming convention

All files are put in `/export/lawelawe1/nss` under subdirectories for the sensor, raw data (by year) and NetCDF data (by year), *e.g.*, `/export/lawelawe1/nss/ns01/netcdf_data_2010` and then have filenames with the sensor number, year, month and day, *e.g.*, `ns01_2010_01_30.nc`. These files are about 13K per day, or 4.7MB per year (per sensor).

3. Data format specification

```
netcdf ns01_2013_04_04 {
dimensions:
 time = UNLIMITED ; // (360 currently)
 z = 1 ;
 lat = 1 ;
 lon = 1 ;
variables:
 float time(time) ;
       time:long_name = "Time" ;
       time:standard_name = "time" ;
       time:short_name = "time" ;
       time:axis = "T" ;
       time:units = "minutes since 2008-01-01 00:00:00" ;
 float z(z) ;
       z:long_name = "depth below mean sea level" ;
       z:standard_name = "depth" ;
```

```
      z:short_name = "depth" ;
      z:axis = "z" ;
      z:units = "meters" ;
 float lat(lat) ;
      lat:long_name = "Latitude" ;
      lat:standard_name = "latitude" ;
      lat:short_name = "lat" ;
      lat:axis = "Y" ;
      lat:units = "degrees_north" ;
 float lon(lon) ;
      lon:long_name = "Longitude" ;
      lon:standard_name = "longitude" ;
      lon:short_name = "lon" ;
      lon:axis = "X" ;
      lon:units = "degrees_east" ;
 float temp(time, z, lat, lon) ;
      temp:long_name = "Temperature" ;
      temp:standard_name = "sea_water_temperature" ;
      temp:short_name = "temp" ;
      temp:units = "Celsius" ;
      temp:valid_range = 11., 31. ;
      temp:_FillValue = -999.f ;
 float cond(time, z, lat, lon) ;
      cond:long_name = "Conductivity" ;
      cond:standard_name = "sea_water_electrical_conductivity" ;
      cond:short_name = "cond" ;
      cond:units = "S m-1" ;
      cond:valid_range = 0., 50. ;
      cond:_FillValue = -999.f ;
 float turb(time, z, lat, lon) ;
      turb:long_name = "Turbidity" ;
      turb:standard_name = "turbidity_of_sea_water" ;
      turb:short_name = "turb" ;
      turb:units = "ntus" ;
      turb:valid_range = 0., 10. ;
      turb:_FillValue = -999.f ;
 float flor(time, z, lat, lon) ;
      flor:long_name = "Chlorophyll" ;
      flor:standard_name =
"chlorophyll_concentration_in_sea_water" ;
      flor:short_name = "flor" ;
      flor:units = "kg m-3" ;
      flor:valid_range = 0., 10. ;
      flor:_FillValue = -999.f ;
 float salt(time, z, lat, lon) ;
      salt:long_name = "Salinity" ;
      salt:standard_name = "sea_water_salinity" ;
      salt:short_name = "salt" ;
      salt:units = "1e-3" ;
      salt:valid_range = 10., 40. ;
      salt:_FillValue = -999.f ;
 float pres(time, z, lat, lon) ;
      pres:long_name = "Pressure" ;
      pres:standard_name = "sea_water_pressure" ;
      pres:short_name = "pres" ;
      pres:units = "dbar" ;
      pres:valid_range = 0., 100. ;
      pres:_FillValue = -999.f ;
```

```
// global attributes:
       :title = "Near Shore sensor 1 located at the Waikiki Yacht
Club. Instrument is a Sea-Bird Electronics model 16plus V2 coupled
with a WET Labs ECO-FLNTUS combination sensor. The package is
fixed to a piling ~0.5m below msl: M. McManus/R. Timmerman.    " ;
       :Conventions = "CF-1.4" ;
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
time(time)	Time	time	time	minutes since 2008-01-01 00:00:00
z(z)	depth below mean sea level	depth	depth	meters
lat(lat)	Latitude	lat	latitude	degrees_east
lon(lon)	Longitude	lon	longitude	degrees_north
temp(time,z,lat,lon)	Temperature	temp	sea_water_temperature	Celsius
cond(time,z,lat,lon)	Conductivity	cond	sea_water_electrical_conductivity	S m-1
turb(time,z,lat,lon)	Turbidity	turb	turbidity_of_sea_water	ntu
flor(time,z,lat,lon)	Chlorophyll	flor	chlorophyll_concentration_in_sea_water	kg m-3
salt(time,z,lat,lon)	Salinity	salt	sea_water_salinity	1e-3
pres(time,z,lat,lon)	Pressure	pres	sea_water_pressure	dB

Table 25. Near-shore sensor variable list.

5. Data distribution[22]

PacIOOS Nearshore Sensor 01: Waikiki Yacht Club, Oahu, Hawaii

- Metadata: http://pacioos.org/metadata/NS01agg.html
- HTML: http://pacioos.org/focus/waterquality/wq_oahu.php
- Voyager: http://pacioos.org/voyager/index.html?b=21.26694%2C-157.87744%2C21.308287%2C-157.80427&o=qual:2::p0NS01p1
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/nss_hioos.html?dataset=NS01agg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/nss01_agg.graph?time%2Ctemperature&.draw=lines

[22] Only one NSS is given as an example here; all NSS are available in a similar way using the same services but with different specifications (*e.g.,* NS02agg instead of NS01agg, *etc.*).

- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=6963be769a1c6f6396b17b26a2413f1
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/nss/ns01agg.html

D. Gliders

1. Data flow

There have been a few different gliders funded via HIOOS/PacIOOS: sg114, sg139 sg523 and sg513. Difficulties in keeping the gliders in the water have reduced their presence as part of the PacIOOS data system, and they are typically deployed one at a time. When active, the glider data are included in the PacIOOS DMS and are mainly used directly by the ocean models via assimilation.

The gliders measure temperature, salinity and depth (along with position) every few minutes (configurable) on successive dives. The early deployments were for 3.5 hour dives. Each time the glider is deployed, the data stream is designated to belong to a new mission.

Gliders report in NetCDF format and the files are written to the SOEST ftp server. When the glider group notifies that a glider is deployed on a new mission, a cron script (**`get_glider.s`**) will be initiated to copy the output from the SOEST ftp server to local disk. There are several files for each glider, including log and engineering files (.log, .eng, and .pro). The files with measured data are compressed NetCDF files. The files have the glider number and dive number in them, *e.g.*, `p5230487.nc.gz` for glider number 523 and dive number 0487. The files are copied from `/home/ftp1/ftp/pub/pilot/`***`glider`*** where ***`glider`*** is the glider number (*e.g.*, sg523). Within this directory the various dives for the current mission are reported in compressed files. The script looks for recent files, copies them to `/export/lawelawe1/glider/`***`glider_mission`***, where ***`glider`*** is the glider number and ***`mission`*** is the mission number.

File sizes vary depending on the dive cycle, variables measured and other factors. Typical files are about 100K per dive with four or five dives per day (note a dive includes two profiles, one descending and one ascending).

Since the PacIOOS gliders were active, IOOS has setup a glider data assembly center (DAC). RA's are now encouraged to forward their glider data to the DAC for distribution, and PacIOOS will do this with future missions (see https://ioos.github.io/ioosngdac/). The older glider data are on the PacIOOS servers but have not been sent to the DAC since the missions predate the DAC and approved standard file format. At some point these netCDF files could be converted to the DAC format and then archived there, but there is no plan yet for this.

2. File naming convention

File names include the glider number and dive number. Note for typical PacIOOS operations, a dive is a single up/down profile and a single surfacing (and transmission). Other glider groups run multiple dives between transmission surfacing.

3. Data format specification

```
netcdf p5230803 {
dimensions:
 gc_time = 13 ;
 log_gps_time = 3 ;
 time = 341 ;
variables:
 double sg_cal_sbe_temp_freq_max ;
 double sg_cal_Tau20 ;
 double sg_cal_vbd_max_cnts ;
 double sg_cal_rho0 ;
 double sg_cal_wlbbfl2_chl_scale ;
 double sg_cal_o_e ;
 double sg_cal_wlbbfl2_650_dark ;
 double sg_cal_o_a ;
 double sg_cal_o_c ;
 double sg_cal_o_b ;
 char sg_cal_calibcomm ;
       sg_cal_calibcomm:value = "SN: 0073  CAL: 17-Jan-12" ;
 double sg_cal_t_j ;
 double sg_cal_Foffset ;
 double sg_cal_t_h ;
 double sg_cal_t_i ;
 double sg_cal_c_g ;
 double sg_cal_pump_power_slope ;
 double sg_cal_wlbbfl2_cdom_scale ;
 char sg_cal_comm_oxy_type ;
       sg_cal_comm_oxy_type:value = "SBE 43f" ;
 double sg_cal_wlbbfl2_chl_dark ;
 double sg_cal_t_g ;
 double sg_cal_ctcor ;
 double sg_cal_roll_max_cnts ;
 double sg_cal_wlbbfl2_650_scale ;
 double sg_cal_cpcor ;
 double sg_cal_Pcor ;
 char sg_cal_id_str ;
       sg_cal_id_str:value = "523" ;
 double sg_cal_sbe_temp_freq_min ;
 double sg_cal_abs_compress ;
 char sg_cal_calibcomm_oxygen ;
       sg_cal_calibcomm_oxygen:value = "SN: 0243  CAL:19-Jun-12" ;
 double sg_cal_pitchbias ;
 double sg_cal_hd_a ;
 double sg_cal_hd_c ;
 double sg_cal_hd_b ;
 double sg_cal_c_i ;
 double sg_cal_c_h ;
 double sg_cal_c_j ;
 double sg_cal_pitch_max_cnts ;
 double sg_cal_pump_power_intercept ;
 double sg_cal_sbe_cond_freq_min ;
```

```
 double sg_cal_pump_rate_slope ;
 double sg_cal_pump_rate_intercept ;
 double sg_cal_Soc ;
 double sg_cal_temp_ref ;
 double sg_cal_sbe_cond_freq_max ;
 double sg_cal_roll_min_cnts ;
 double sg_cal_pitch_min_cnts ;
 double sg_cal_vbd_cnts_per_cc ;
 double sg_cal_vbd_min_cnts ;
 double sg_cal_volmax ;
 double sg_cal_mass ;
 double sg_cal_therm_expan ;
 double sg_cal_wlbbfl2_cdom_dark ;
 char sg_cal_mission_title ;
       sg_cal_mission_title:value = "HiOOS mission " ;
 double log_CAPUPLOAD ;
 char log_KALMAN_Y ;
       log_KALMAN_Y:value = "1854.6,-557.9,-459.8,-10758.5,-270.1"
;
 char log_MHEAD_RNG_PITCHd_Wd ;
       log_MHEAD_RNG_PITCHd_Wd:value = "40.6,13517,-17.6,-10.000"
;
 double log_PHONE_DEVICE ;
 double log_VBD_DBAND ;
 double log_T_NO_W ;
 double log_SURFACE_URGENCY ;
 double log_XPDR_VALID ;
 char log_SENSORS ;
       log_SENSORS:value =
"SBE_CT,SBE_O2,WL_BBFL2VMT,nil,nil,nil,nil,nil" ;
 double log_VBD_PUMP_AD_RATE_APOGEE ;
 double log_T_MISSION ;
 double log_FIX_MISSING_TIMEOUT ;
 double log_RAFOS_CORR_THRESH ;
 double log_D_SAFE ;
 char log_SPEED_LIMITS ;
       log_SPEED_LIMITS:value = "0.173,0.268" ;
 double log_FG_AHR_10Vo ;
 double log_VBD_TIMEOUT ;
 double log_P_OVSHOOT ;
 double log_TGT_DEFAULT_LAT ;
 double log_COMPASS2_DEVICE ;
 double log_PITCH_TIMEOUT ;
 double log__XMS_NAKs ;
 double log_D_NO_BLEED ;
 double log_VBD_MAXERRORS ;
 double log_FG_AHR_24Vo ;
 double log_SURFACE_URGENCY_TRY ;
 double log_C_ROLL_DIVE ;
 double log_TCM_TEMP ;
 char log_DEVICES ;
       log_DEVICES:value =
"Pitch_motor,Roll_motor,VBD_pump_during_apogee,VBD_pump_during_sur
face,VBD_valve,Iridium_during_init,Iridium_during_connect,Iridium_
during_xfer,Transponder_ping,GUMSTIX_24V,GPS,TT8,LPSleep,TT8_Activ
e,TT8_Sampling,TT8_CF8,TT8_Kalman,Analog_circuits,GPS_charging,Com
pass,RAFOS,Transponder,Compass2" ;
 char log_DATA_FILE_SIZE ;
```

```
      log_DATA_FILE_SIZE:value = "19229,341" ;
double log_VBD_MAX ;
double log_T_TURN ;
double log_RAFOS_DEVICE ;
double log_C_ROLL_CLIMB ;
double log_R_PORT_OVSHOOT ;
double log_LOGGERDEVICE1 ;
double log_ALTIM_TOP_MIN_OBSTACLE ;
double log_PRESSURE_YINT ;
double log_ROLL_DEG ;
double log_CALL_WAIT ;
double log_ROLL_TIMEOUT ;
double log_CALL_TRIES ;
double log_ALTIM_BOTTOM_PING_RANGE ;
double log_SEABIRD_C_J ;
double log_HEAD_ERRBAND ;
double log_SEABIRD_C_H ;
double log_C_VBD ;
char log_10V_AH ;
      log_10V_AH:value = "10.1,78.504" ;
char log_IRIDIUM_FIX ;
      log_IRIDIUM_FIX:value = "2059.45,-15803.33,201002,171759" ;
double log_PITCH_CNV ;
double log_KERMIT ;
double log_PITCH_ADJ_DBAND ;
double log_VBD_MIN ;
double log_RAFOS_PEAK_OFFSET ;
double log_PITCH_MIN ;
double log_HD_B ;
double log_HD_C ;
double log_PHONE_SUPPLY ;
double log_MINV_24V ;
double log_PITCH_AD_RATE ;
double log_SEABIRD_C_G ;
double log_INT_PRESSURE_SLOPE ;
double log_ALTIM_SENSITIVITY ;
double log_HEADING ;
double log__SM_DEPTHo ;
double log_COMM_SEQ ;
double log_KALMAN_USE ;
char log_TGT_NAME ;
      log_TGT_NAME:value = "HOME" ;
double log_ALTIM_PING_DEPTH ;
char log_CFSIZE ;
      log_CFSIZE:value = "260165632,213909504" ;
double log_UPLOAD_DIVES_MAX ;
double log_D_BOOST ;
double log_RHO ;
double log_ALTIM_PING_DELTA ;
double log_ROLL_MAX ;
double log_D_CALL ;
double log_HD_A ;
double log_FERRY_MAX ;
char log_SM_CCo ;
      log_SM_CCo:value = "2153,18.73,0.375,0,0,1535,310.05" ;
double log_D_FLARE ;
double log_T_GPS ;
double log_D_SURF ;
```

```
 double log_PITCH_VBD_SHIFT ;
 double log_PITCH_MAX ;
 double log_TCM_PITCH_OFFSET ;
 double log_XPDR_INHIBIT ;
 double log_APOGEE_PITCH ;
 double log_C_PITCH ;
 char log_CAP_FILE_SIZE ;
       log_CAP_FILE_SIZE:value = "48241,0" ;
 double log_MASS ;
 double log_T_ABORT ;
 char log_SENSOR_MAMPS ;
       log_SENSOR_MAMPS:value =
"24.000,19.000,105.000,0.000,0.000,0.000,0.000,0.000" ;
 double log_SPEED_FACTOR ;
 double log_VBD_CNV ;
 double log_STROBE ;
 double log_COMPASS_DEVICE ;
 double log_PRESSURE_SLOPE ;
 double log_ALTIM_TOP_PING_RANGE ;
 double log_T_GPS_CHARGE ;
 double log_ID ;
 double log_DEVICE4 ;
 double log_PITCH_GAIN ;
 double log_DEVICE2 ;
 double log_DEVICE3 ;
 double log_DEVICE1 ;
 char log_KALMAN_CONTROL ;
       log_KALMAN_CONTROL:value = "0.251,0.050" ;
 double log__SM_ANGLEo ;
 double log_T_TURN_SAMPINT ;
 char log_SENSOR_SECS ;
       log_SENSOR_SECS:value =
"224.682,172.342,799.862,0.000,0.000,0.000,0.000,0.000" ;
 double log__XMS_TOUTs ;
 double log_CAPMAXSIZE ;
 char log_SM_GC ;
       log_SM_GC:value =
"1.91,0.00,0.00,18.73,0.000,0.000,0.375,32,1872,1535,-8.10,-
0.79,310.05" ;
 char log_ERRORS ;
       log_ERRORS:value = "0,0,0,0,0,0,0,0,0,0,0,0,0,0,1" ;
 char log_KALMAN_X ;
       log_KALMAN_X:value = "-103965.5,-1081.0,-691.7,103499.1,-
1313.7" ;
 double log_N_FILEKB ;
 double log_ESCAPE_HEADING ;
 double log_ROLL_CNV ;
 double log_DEEPGLIDER ;
 double log_USE_ICE ;
 double log_LOGGERDEVICE2 ;
 double log_TGT_RADIUS ;
 double log_R_STBD_OVSHOOT ;
 char log_DEVICE_MAMPS ;
       log_DEVICE_MAMPS:value =
"218.595,98.943,454.064,375.063,0.000,103.000,160.000,223.000,420.
000,0.000,50.000,19.800,2.190,19.800,39.800,45.800,81.800,12.000,0
.000,8.000,0.000,30.000,0.000" ;
 double log_ICE_FREEZE_MARGIN ;
```

```
double log_TGT_AUTO_DEFAULT ;
double log_D_ABORT ;
double log_INT_PRESSURE_YINT ;
double log_COURSE_BIAS ;
double log_TCM_ROLL_OFFSET ;
double log_N_GPS ;
double log_LOGGERS ;
double log_INTERNAL_PRESSURE ;
double log_T_DIVE ;
double log_MAX_BUOY ;
double log_FILEMGR ;
double log_D_TGT ;
double log_AH0_10V ;
double log_SEABIRD_T_H ;
double log_SEABIRD_T_I ;
double log_SEABIRD_T_J ;
double log_T_GPS_ALMANAC ;
double log_N_NOSURFACE ;
double log_CF8_MAXERRORS ;
char log_TGT_LATLONG ;
      log_TGT_LATLONG:value = "2114.730,-15753.100" ;
double log_ROLL_MIN ;
double log_SEABIRD_T_G ;
double log_FG_AHR_10V ;
double log_TGT_DEFAULT_LON ;
double log_DIVE ;
double log_RELAUNCH ;
double log_SIM_PITCH ;
double log_HEAPDBG ;
double log_USE_BATHY ;
char log_24V_AH ;
      log_24V_AH:value = "24.8,70.839" ;
double log_ROLL_ADJ_DBAND ;
double log_DEVICE6 ;
double log_ESCAPE_HEADING_DELTA ;
double log_ROLL_AD_RATE ;
double log_AD7714Ch0Gain ;
double log_MEM ;
double log_SIM_W ;
double log_AH0_24V ;
double log_DEVICE5 ;
double log_MINV_10V ;
double log_VBD_BLEED_AD_RATE ;
double log_SM_CC ;
double log_D_PITCH ;
double log_FG_AHR_24V ;
double log_T_LOITER ;
double log_CALL_NDIVES ;
double log_COMPASS_USE ;
double log_D_FINISH ;
double log_ROLL_MAXERRORS ;
double log_UNCOM_BLEED ;
double log_ALTIM_TOP_TURN_MARGIN ;
double log_TT8_MAMPS ;
double log_PITCH_DBAND ;
double log_SEABIRD_C_I ;
double log_N_NOCOMM ;
double log_D_OFFGRID ;
```

```
 double log_VBD_PUMP_AD_RATE_SURFACE ;
 double log_RAFOS_HIT_WINDOW ;
 double log_ALTIM_PULSE ;
 double log_NAV_MODE ;
 double log_XPDR_PINGS ;
 double log_D_GRID ;
 double log_T_WATCHDOG ;
 double log__CALLS ;
 double log_DEEPGLIDERMB ;
 double log_T_RSLEEP ;
 char log_DEVICE_SECS ;
       log_DEVICE_SECS:value =
"18.425,23.275,354.600,18.725,0.000,29.817,39.987,758.148,14.000,0
.000,29.199,513.715,302.867,301.057,1053.034,1003.018,0.000,747.79
4,0.000,1039.001,0.000,5.662,0.000" ;
 double log_XPDR_DEVICE ;
 double log_ALTIM_FREQUENCY ;
 double log_SURFACE_URGENCY_FORCE ;
 double log_PITCH_MAXERRORS ;
 double log_ROLL_ADJ_GAIN ;
 double log_GLIDE_SLOPE ;
 double log_GPS_DEVICE ;
 double log_MOTHERBOARD ;
 double log_PITCH_ADJ_GAIN ;
 double log_MISSION ;
 double log_ALTIM_BOTTOM_TURN_MARGIN ;
 double log_HUMID ;
 double gc_st_secs(gc_time) ;
       gc_st_secs:missing_value = NaN ;
       gc_st_secs:units = "seconds" ;
       gc_st_secs:standard_name = "time" ;
       gc_st_secs:description = "Start of GC time in GMT epoch
format" ;
 double gc_pitch_ctl(gc_time) ;
       gc_pitch_ctl:missing_value = NaN ;
 double gc_vbd_ctl(gc_time) ;
       gc_vbd_ctl:missing_value = NaN ;
 double gc_depth(gc_time) ;
       gc_depth:missing_value = NaN ;
 double gc_ob_vertv(gc_time) ;
       gc_ob_vertv:missing_value = NaN ;
 int gc_data_pts(gc_time) ;
       gc_data_pts:missing_value = -1 ;
 double gc_end_secs(gc_time) ;
       gc_end_secs:missing_value = NaN ;
       gc_end_secs:units = "seconds" ;
       gc_end_secs:standard_name = "time" ;
       gc_end_secs:description = "End of GC time in GMT epoch
format" ;
 double gc_pitch_secs(gc_time) ;
       gc_pitch_secs:missing_value = NaN ;
 double gc_roll_secs(gc_time) ;
       gc_roll_secs:missing_value = NaN ;
 double gc_vbd_secs(gc_time) ;
       gc_vbd_secs:missing_value = NaN ;
 double gc_vbd_i(gc_time) ;
       gc_vbd_i:missing_value = NaN ;
 int gc_gcphase(gc_time) ;
```

```
      gc_gcphase:missing_value = -1 ;
 double gc_pitch_i(gc_time) ;
      gc_pitch_i:missing_value = NaN ;
 double gc_roll_i(gc_time) ;
      gc_roll_i:missing_value = NaN ;
 int gc_pitch_ad(gc_time) ;
      gc_pitch_ad:missing_value = -1 ;
 int gc_roll_ad(gc_time) ;
      gc_roll_ad:missing_value = -1 ;
 int gc_vbd_ad(gc_time) ;
      gc_vbd_ad:missing_value = -1 ;
 int gc_pitch_retries(gc_time) ;
      gc_pitch_retries:missing_value = -1 ;
 int gc_pitch_errors(gc_time) ;
      gc_pitch_errors:missing_value = -1 ;
 int gc_roll_retries(gc_time) ;
      gc_roll_retries:missing_value = -1 ;
 int gc_roll_errors(gc_time) ;
      gc_roll_errors:missing_value = -1 ;
 int gc_vbd_retries(gc_time) ;
      gc_vbd_retries:missing_value = -1 ;
 int gc_vbd_errors(gc_time) ;
      gc_vbd_errors:missing_value = -1 ;
 char log_GPS1 ;
      log_GPS1:value = "$GPS1,183449,2110.091,-
15759.077,18,0.8,19,9.8" ;
      log_GPS1:description = "String reported in logfile for GPS1
fix (first surface position before dive)" ;
 char log_GPS2 ;
      log_GPS2:value = "$GPS2,185132,2110.081,-
15759.137,28,0.8,28,9.8" ;
      log_GPS2:description = "String reported in logfile for GPS2
fix (last surface position before dive)" ;
 char log_GPS ;
      log_GPS:value = "$GPS,260713,192854,2110.079,-
15758.970,14,1.5,14,9.8" ;
      log_GPS:description = "String reported in logfile for GPS
fix (first surface position after dive)" ;
 double log_gps_time(log_gps_time) ;
      log_gps_time:missing_value = NaN ;
      log_gps_time:units = "seconds" ;
      log_gps_time:standard_name = "time" ;
      log_gps_time:description = "time in GMT epoch format" ;
 double log_gps_lat(log_gps_time) ;
      log_gps_lat:missing_value = NaN ;
      log_gps_lat:units = "decimal degrees" ;
      log_gps_lat:standard_name = "lat" ;
      log_gps_lat:description = "gps fix latitude" ;
 double log_gps_lon(log_gps_time) ;
      log_gps_lon:missing_value = NaN ;
      log_gps_lon:units = "decimal degrees" ;
      log_gps_lon:standard_name = "lon" ;
      log_gps_lon:description = "gps fix longitude" ;
 double eng_elaps_t_0000(time) ;
      eng_elaps_t_0000:units = "seconds" ;
      eng_elaps_t_0000:standard_name = "time" ;
      eng_elaps_t_0000:description = "seconds since start of
mission" ;
```

```
 double eng_elaps_t(time) ;
       eng_elaps_t:units = "seconds" ;
       eng_elaps_t:standard_name = "time" ;
       eng_elaps_t:description = "seconds since start of dive" ;
 double eng_depth(time) ;
       eng_depth:units = "cm" ;
       eng_depth:standard_name = "depth" ;
       eng_depth:description = "vertical distance below the
surface" ;
 double eng_head(time) ;
 double eng_pitchAng(time) ;
 double eng_rollAng(time) ;
 double eng_pitchCtl(time) ;
 double eng_rollCtl(time) ;
 double eng_vbdCC(time) ;
 double eng_rec(time) ;
 double eng_GC_phase(time) ;
 double eng_sbect_condFreq(time) ;
 double eng_sbect_tempFreq(time) ;
 double eng_sbe43_O2Freq(time) ;
 double eng_wlbbfl2vmt_wl600ref(time) ;
 double eng_wlbbfl2vmt_wl600sig(time) ;
 double eng_wlbbfl2vmt_Chlref(time) ;
 double eng_wlbbfl2vmt_Chlsig(time) ;
 double eng_wlbbfl2vmt_Cdomref(time) ;
 double eng_wlbbfl2vmt_Cdomsig(time) ;
 double eng_wlbbfl2vmt_L2VMTtemp(time) ;
       eng_wlbbfl2vmt_L2VMTtemp:units = "C" ;
       eng_wlbbfl2vmt_L2VMTtemp:standard_name = "temperature" ;
       eng_wlbbfl2vmt_L2VMTtemp:description = "As reported by the
instrument" ;
 double time(time) ;
       time:missing_value = NaN ;
       time:units = "seconds" ;
       time:standard_name = "time" ;
       time:description = "sample time in GMT epoch format" ;
       time:reference = "00:00Z 1 January 1970" ;
 double depth(time) ;
       depth:missing_value = NaN ;
       depth:units = "m" ;
       depth:standard_name = "depth" ;
       depth:description = "distance below the surface, corrected
for latitude" ;
 double latitude(time) ;
       latitude:missing_value = NaN ;
       latitude:units = "Decimal degrees" ;
       latitude:standard_name = "lat" ;
       latitude:description = "sample latitude" ;
 double longitude(time) ;
       longitude:missing_value = NaN ;
       longitude:units = "Decimal degrees" ;
       longitude:standard_name = "lon" ;
       longitude:description = "sample longitude" ;
 double pressure(time) ;
       pressure:missing_value = NaN ;
       pressure:units = "dbar" ;
       pressure:standard_name = "sea_water_pressure" ;
 double temp_nolag(time) ;
```

```
      temp_nolag:missing_value = NaN ;
      temp_nolag:units = "C" ;
      temp_nolag:standard_name = "temperature (in situ)" ;
      temp_nolag:description = "not corrected for first-order
lag" ;
 double conductivity_nolag(time) ;
      conductivity_nolag:missing_value = NaN ;
      conductivity_nolag:units = "S m^-1" ;
      conductivity_nolag:standard_name =
"electrical_conductivity" ;
      conductivity_nolag:description = "not corrected for first-
order lag" ;
 double salinity_nolag(time) ;
      salinity_nolag:missing_value = NaN ;
      salinity_nolag:units = "none" ;
      salinity_nolag:standard_name = "salinity" ;
      salinity_nolag:description = "not corrected for first-order
lag" ;
 double temp(time) ;
      temp:missing_value = NaN ;
      temp:units = "C" ;
      temp:standard_name = "temperature (in situ)" ;
      temp:description = "corrected for first-order lag" ;
 double conductivity(time) ;
      conductivity:missing_value = NaN ;
      conductivity:units = "S m^-1" ;
      conductivity:standard_name = "electrical_conductivity" ;
      conductivity:description = "corrected for first-order lag"
;
 double salinity(time) ;
      salinity:missing_value = NaN ;
      salinity:units = "none" ;
      salinity:standard_name = "salinity" ;
 double sigma_t(time) ;
      sigma_t:missing_value = NaN ;
      sigma_t:units = "kg/m^3" ;
      sigma_t:standard_name = "potential density" ;
      sigma_t:ref_pressure = "0" ;
 double theta(time) ;
      theta:missing_value = NaN ;
      theta:units = "C" ;
      theta:standard_name = "potential temperature" ;
      theta:description = "corrected for first-order lag" ;
 double density(time) ;
      density:missing_value = NaN ;
      density:units = "kg/m^3" ;
      density:standard_name = "density (in situ)" ;
 double sigma_theta(time) ;
      sigma_theta:missing_value = NaN ;
      sigma_theta:units = "kg/m^3" ;
      sigma_theta:standard_name = "potential density" ;
      sigma_theta:ref_pressure = "0" ;
 double horiz_speed_pitch_w(time) ;
      horiz_speed_pitch_w:missing_value = NaN ;
      horiz_speed_pitch_w:units = "cm/s" ;
      horiz_speed_pitch_w:standard_name = "Horizontal speed, from
observed pitch and vertical velocity" ;
 double horz_speed_pitch_buoy_hdm(time) ;
```

```
       horz_speed_pitch_buoy_hdm:missing_value = NaN ;
       horz_speed_pitch_buoy_hdm:units = "cm/s" ;
       horz_speed_pitch_buoy_hdm:standard_name = "Horizontal speed
from model (buoy and pitch)" ;
 double vert_speed_pitch_buoy_hdm(time) ;
       vert_speed_pitch_buoy_hdm:missing_value = NaN ;
       vert_speed_pitch_buoy_hdm:units = "cm/s" ;
       vert_speed_pitch_buoy_hdm:standard_name = "Vertical speed
from model (buoy and pitch)" ;
 double glide_angle_hdm(time) ;
       glide_angle_hdm:missing_value = NaN ;
       glide_angle_hdm:units = "cm/s" ;
       glide_angle_hdm:standard_name = "Glide angle from model
(buoy and pitch)" ;
 double north_displacement_hdm(time) ;
       north_displacement_hdm:missing_value = NaN ;
       north_displacement_hdm:units = "m" ;
       north_displacement_hdm:standard_name = "Northward
displacement from model" ;
 double east_displacement_hdm(time) ;
       east_displacement_hdm:missing_value = NaN ;
       east_displacement_hdm:units = "m" ;
       east_displacement_hdm:standard_name = "Eastward
displacement from model" ;
 double Buoyancy(time) ;
       Buoyancy:missing_value = NaN ;
 double u_da ;
       u_da:units = "m/s" ;
       u_da:standard_name = "depth average current" ;
       u_da:description = "Eastward component of depth averaged
current" ;
 double v_da ;
       v_da:units = "m/s" ;
       v_da:standard_name = "depth average current" ;
       v_da:description = "Northward component of depth averaged
current" ;
 double u_mag ;
       u_mag:units = "cm/s" ;
       u_mag:standard_name = "depth average current" ;
       u_mag:description = "Magnitude of the depth averaged
current" ;
 double u_dir ;
       u_dir:units = "degrees" ;
       u_dir:standard_name = "depth average current" ;
       u_dir:description = "True direction of the depth averaged
current" ;

// global attributes:
       :Conventions = "CF-1.0" ;
       :instrumentid = "SG523" ;
       :title = "SG523 HiOOS mission " ;
       :institution = "University of Washington Applied Physics
Lab" ;
       :history = "Written Fri Jul 26 19:34:32 2013" ;
       :dive_number = 803 ;
       :file_version = 2.1 ;
       :base_station_version = 2.4 ;
       :seaglider_software_version = 66.06 ;
```

```
        :file_data_type = "timeseries" ;
}
```

4. Data vocabulary[23]

Variable	Long name	Short name	Standard Name	Units
time(time)			time	seconds since 1970-01-01 T00:00:00Z
depth(time)			depth	m
latitude(time)			latitude	degrees_north
longitude(time)			longitude	degrees_east
temp(time)		temp	sea_water_temperature	Celsius
salinity(time)		salt	sea_water_salinity	1e-3
pressure(time)		pres	sea_water_pressure	dbar
conductivity(time)			sea_water_electrical_conductivity	S m-1
density(time)			sea_water_density	kg m-3

Table 26. Glider variable list.

5. Data distribution[24]

PacIOOS Ocean Gliders: SeaGlider 114: Mission 3

- Metadata: http://pacioos.org/metadata/sg114_3_agg.html
- HTML: http://hahana.soest.hawaii.edu/seagliders/history114.html
- Voyager: http://pacioos.org/voyager/index.html?b=20.985046%2C-158.124769%2C21.312929%2C-157.540091&o=glide::d2v2c52
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/glide.html?dataset=sg114_3_agg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/sg114_3.graph?longitude%2Clatitude&.draw=lines
- SOS: http://oos.soest.hawaii.edu/thredds/sos/hioos/glider/sg114_3_agg?service=SOS&version=1.0.0&request=GetCapabilities
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/glider/sg114_3_agg.html

[23] The variables displayed via OPeNDAP is a small subset of the total number in the data set. The format specification lists all the variables while this table is just those served via OPeNDAP.

[24] Only one glider mission is given as an example here; all missions are available in a similar way using the same services but with different specifications (*e.g.,* sg114_4 instead of sg114_3, *etc.*).

E. Water Quality Buoys (WQB)

1. Data flow

There have been five active water quality buoys (see Table 27). There are similar buoys in Kaneohe Bay, but as yet these are not incorporated into the PacIOOS DMS. The buoys are maintained in co-operation with NOAA/PMEL and record atmospheric CO_2 and O_2, as well as oceanic CO_2, O_2, temperature, salinity, turbidity and fluorescence.

The KN and AW buoys were placed in operation in July 2008. The CO_2 data are sent via Iridium to PMEL where they are processed. In addition, data get recorded every 20 minutes (it is an average of four measurements) and sent via email. Mike Tomlinson has been receiving these emails and is responsible for post-processing the data. Due to funding cuts this was discontinued in mid-2015.

At present, one email gets generated every twenty minutes. These emails are addressed to `wqb@hokulea.soest.hawaii.edu`, from `storx@example.com`, with a subject line of the form "STOR-X sn0062 Log File (2008263.raw)". The data are included as an attachment in base-64 encoding. The data are also sent to a private company, Intelesense, for archive and distribution.

Python scripts are used to pull the data directly off the SOEST IMAP server, strip out the attachment, decode it, parse the data line, and store it on disk via DataTurbine. Similar to the NSS, there are two instances of these data on the DT, one in the archive http://bbl.ancl.hawaii.edu/kilonalu-data/ :

- `alawai/WQAW01_XXXCTDX001R00/DecimalASCIISampleData/`
- `kilonalu/WQKN01_XXXCTDX001R00/DecimalASCIISampleData/`

and the other in the real-time archive http://bbl.ancl.hawaii.edu:8080/RBNB/

- `WQAW01_XXXCTDX001R00/ DecimalASCIISampleData`
- `WQKN01_XXXCTDX001R00/ DecimalASCIISampleData`

Daily cron job are run at 02:05 and 02:06 AM each day (**`conv_dt_wqbaw_data.s`** and **`conv_dt_wqbkn_data.s`**). These script pulls the raw ASCII data from the DT archive via **`wget`** and run **`conv2netcdf`** to make daily NetCDF files.

The Big Island buoys are handled in a very different way. Previously, Satlantic would provide data telemetry for WQB03, but this was discontinued. For WQB04, YSI manages the telemetry.

The buoy is located in Hilo Bay and records temperature, salinity, turbidity, cholorphyll, pH and dissolved oxygen. The instruments are managed through a YSI data logger, and YSI provides the telemetry for the system. This is done via hourly ftp to the SOEST server. The files have four records (ideally) one line for every fifteen minutes for a total of 96 records per day.

There are then two scripts that get run. First, **conv_wqb04_DT.s** runs every hour at ten past the hour. This script converts the data files on the ftp server to a simple CSV. These new files are then ingested into DataTurbine via a separate script.

Second, **conv_wqb04.s** runs each day at 3:00PM local time. This script pulls the daily files from DataTurbine and creates a netCDF file. More details follow.

- Files are supplied by YSI to SOEST ftp server every hour on the hour (/home/ftp1/ftp/pub/hioos/incoming)
- The file name is composed of a Unix epoch time[25] based on the file creation/arrival time. As an example, the file that arrives on the ftp server at 21:00 Nov 13th 2016 is called 1497106800.csv where the Unix epoch time 147106800 corresponds to Nov 13th at 21:00 local (HST) time. *The file name is in local time.*

-rw-r--r-- 1 jimp pacioos 516 Nov 13 21:00 1479106800.csv

- Each file *ideally* contains four lines of data, one line per fifteen minutes. Occasionally there are empty files; when this happens the next incoming file should have the missing data (so new file will have more than four data lines). Time is given in the file in both epoch time and calendar time, but there appears to be an error here. The calendar/clock time appear to be local. For example, the file that arrives at 21:00 will have data for the prior hour (19:15, 19:30, 19:45 and 20:00). The epoch time (first column titled UnixTimestamp) is however in UTC. Using the same example, the epoch time 1479064500 (first line, first column) corresponds to a UTC date of Nov 13th at 19:15 (matching the second and third columns). Thus, the two times in the file match if UTC is assumed, however YSI confirmed the time in the file to be local time, and YSI recommended we ignore the first column. *It is therefore assumed that the times in the file are local time and the Unix stamp is incorrect*.

UnixTimestamp,Date,Time,HBB SystemBattery,HBB…
1479064500,2016-11-13,19:15:00,12.63,-0.30,7.47,107.40,28.25,25.69,31.60
1479065400,2016-11-13,19:30:00,12.63,-0.30,7.72,110.40,28.25,25.37,35.00
1479066300,2016-11-13,19:45:00,12.64,-0.30,7.72,111.10,29.10,25.50,42.40
1479067200,2016-11-13,20:00:00,12.65,-0.30,7.63,111.40,30.61,25.80,61.20

- Files are converted once per hour using **conv_wqb04_DT.s** which is run at 10 past the hour. This script converts the CSV format above into a space delimited file. The new file is placed in /export/lawelawe1/wqb/wqbk04/for_DT and has a name like wqb04.2016-12-20_11:15:00.dat:

[25] This site http://www.epochconverter.com/ will convert back and forth

2016-12-20 11:15:00 0.00 6.49 92.800000 30.69 24.60 1.20
2016-12-20 11:30:00 0.00 6.54 93.500000 30.30 24.63 1.70
2016-12-20 11:45:00 0.00 6.59 94.000000 30.03 24.65 1.50
2016-12-20 12:00:00 0.00 6.88 96.000000 27.13 24.37 1.60

- These files are then inserted into DataTurbine [John Maurer redo of Marcia's script]. There is one file per day, running from 14:15 day-1 to 14:00 day. This is a complete day in UTC time (midnight to midnight). This is a problem in that really it should go 14:00 day-1 to 13:45 day (14:00 is the start of the new day, but presently it's listed as the last record of the old day).
- Once in DT, the script **conv_wqb04.s** converts them into netCDF. This is done daily at 3:00PM local time. This script reads time from the file and converts it to UTC, so the input file is a complete UTC day in local time (14:00 to 13:45) and the netCDF file is 00:00 to 23:45). The script accesses the program write_netcdf.f compiled as conv2netcdf and run with the input of current time in ISO format:

  date -u +%Y-%m-%dT%H:%M:%S-10:00 | ./conv2netcdf

  - Note the files from 2010 through 2015 are different from those thereafter. Jason Adolf provided these files after processing and Joe entered them into DataTurbine using a different script.
  - Example sequence:

1. Data are ftp'd to the SOEST anonymous ftp server
   a. file name: 1486864800.csv
   b. date range: 11 Feb 14:15 to 11 Feb 15:00
   c. arrives: 11 Feb 16:00
2. Data are converted for Data Turbine
   a. script: conv_wqb04_DT.s
   b. run time: every hour at 10 past the hour
   c. output file: wqb04.2017-02-11_14:15:00.dat
3. Data are aggregated to single (whole) data and placed on Data Turbine[26]
   a. script: John's
   b. run time: unknown
   c. output file: WQB04_20170212000000.10.1.dat
4. Data are converted to netCDF
   a. script: conv_wqb04.s
   b. run time: 15:00 daily
   c. output file: wqb04_2017_02_11.nc

[26] The daily files start at 14:00 and end at 13:45 the next day. The hourly files start at 15 past the hour, so this means the daily file needs to first time entry of the first hourly file from the previous hour and then skip the last time entry of the last hourly file

Location	ID	DataTurbine ID	First valid data	Filesize per year
Ala Wai	WQBAW	WQAW01_XXXCTDX001R00	06/06/08	5.28 MB
Kilo Nalu	WQBKN	WQKN01_XXXXCTDX001R00	08/07/08	5.64 MB
Kiholo	WQB03	(Satlantic web grab)	12/01/12	2.02 MB
Hilo Bay	WQB04	(YSI ftp)	10/23/10	5.46 MB
Kaloko Bay	WQB05	(YSI)		

Table 27. Water quality buoy file specifications.

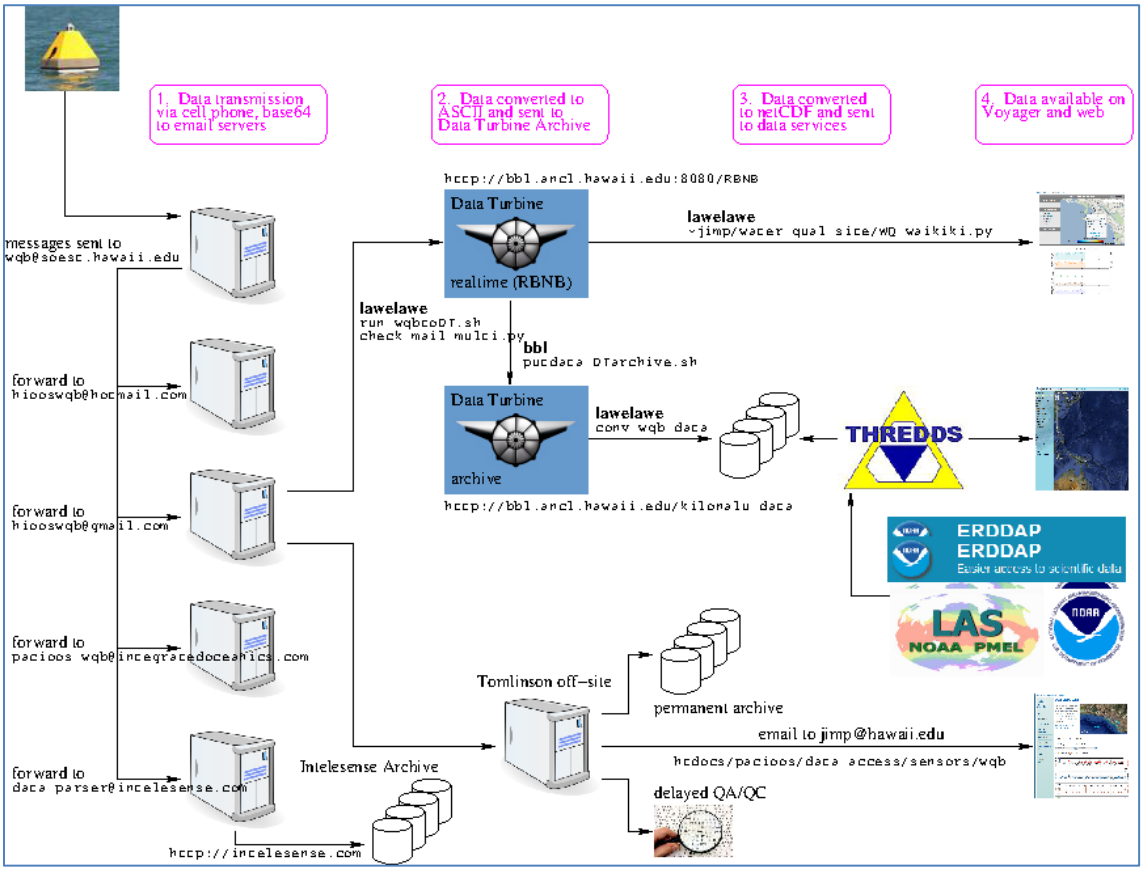

Figure 23. Schematic for WQB data streams. Data are initially sent via email to different machines, then ultimately put into the DMS.

2. File naming convention

The raw files are copied to `/export/lawelawe1/wqb/`*`platform`*`/raw_data_`*`year`*, where *`platform`* is either `wqbkn` or `wqbaw` and *`year`* is the 4-digit year. The daily NetCDF files are

name by buoy and time, *e.g.*, `wqbaw_2010_12_30.nc` and put in the same root directory as the raw data but subdirectory `netcdf_data_`*`year`*.

The YSI-delievered data are place in `/home/ftp1/ftp/pub/hioos/incoming`. The files have names of the form `Univ`*`yyyymmddHHMMSS`*`.csv`, for example, `Univ20130829222115.csv`.

Data for the Oahu buoys were also archived and served by Intelesense. This was setup by the PI (DeCarlo) and is only accessible to his group. These data could be downloaded from the Intelesence web site (http://www.intelesense.net/). First, a login is required (userid is xxx, password is xxxxxx). Next, there is a link to "view data", and all the platforms get listed. By selecting one of these, there is an option to "download" data, and the criteria should be "all fields", "sensor timezone", "American date format", "cronological order", and "CSV" format. The resulting file is then saved locally as `WQB-wqb-`*`xx`*`.csv` where *`xx`* is `aw` for the Ala Wai buoy and `kn` for the Kilo Nalu buoy.

3. Data format specification

```
netcdf wqbkn_2013_08_14 {
dimensions:
 time = UNLIMITED ; // (72 currently)
 name_strlen = 5 ;
variables:
 char station_name(name_strlen) ;
       station_name:long_name = "wqbkn" ;
       station_name:cf_role = "timeseries_id" ;
 int qc_flag ;
       qc_flag:long_name = "Quality control status" ;
       qc_flag:short_name = "qc_flag" ;
       qc_flag:valid_range = 0, 2 ;
       qc_flag:flag_values = 0, 1, 2 ;
       qc_flag:flag_meanings = "no_qc_applied realtime_qc_applied
delayed_mode_qc_applied" ;
       qc_flag:units = "0" ;
 float time(time) ;
       time:long_name = "Time" ;
       time:standard_name = "time" ;
       time:short_name = "time" ;
       time:axis = "T" ;
       time:units = "minutes since 2008-01-01 00:00:00 -10:00" ;
 float alt ;
       alt:long_name = "depth below mean sea level" ;
       alt:standard_name = "depth" ;
       alt:short_name = "depth" ;
       alt:axis = "z" ;
       alt:units = "meters" ;
 float lat ;
       lat:long_name = "Latitude" ;
       lat:standard_name = "latitude" ;
       lat:short_name = "lat" ;
       lat:axis = "Y" ;
       lat:units = "degrees_north" ;
 float lon ;
```

```
        lon:long_name = "Longitude" ;
        lon:standard_name = "longitude" ;
        lon:short_name = "lon" ;
        lon:axis = "X" ;
        lon:units = "degrees_east" ;
 float temp_raw(time) ;
        temp_raw:long_name = "Temperature (raw)" ;
        temp_raw:standard_name = "sea_water_temperature" ;
        temp_raw:short_name = "temp_raw" ;
        temp_raw:units = "Celsius" ;
        temp_raw:coordinates = "time lat lon alt" ;
        temp_raw:valid_range = 10., 35. ;
        temp_raw:_FillValue = -999.f ;
        temp_raw:observation_type = "measured" ;
 int temp_qd(time) ;
        temp_qd:long_name = "Temperature quality descriptor" ;
        temp_qd:short_name = "temp_qd" ;
        temp_qd:valid_range = -9, 4 ;
        temp_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
        temp_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
        temp_qd:units = "0" ;
 float temp(time) ;
        temp:long_name = "Temperature (processed)" ;
        temp:standard_name = "sea_water_temperature" ;
        temp:short_name = "temp" ;
        temp:units = "Celsius" ;
        temp:coordinates = "time lat lon alt" ;
        temp:valid_range = 10., 35. ;
        temp:_FillValue = -999.f ;
        temp:observation_type = "measured" ;
 float cond_raw(time) ;
        cond_raw:long_name = "Conductivity (raw)" ;
        cond_raw:standard_name =
"sea_water_electrical_conductivity" ;
        cond_raw:short_name = "cond_raw" ;
        cond_raw:units = "S m-1" ;
        cond_raw:coordinates = "time lat lon alt" ;
        cond_raw:valid_range = 0., 10. ;
        cond_raw:_FillValue = -999.f ;
        cond_raw:observation_type = "measured" ;
 int cond_qd(time) ;
        cond_qd:long_name = "Conductivity quality descriptor" ;
        cond_qd:short_name = "cond_qd" ;
        cond_qd:valid_range = -9, 4 ;
        cond_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
        cond_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
        cond_qd:units = "0" ;
 float cond(time) ;
        cond:long_name = "Conductivity (processed)" ;
        cond:standard_name = "sea_water_electrical_conductivity" ;
        cond:short_name = "cond" ;
        cond:units = "S m-1" ;
        cond:coordinates = "time lat lon alt" ;
        cond:valid_range = 0., 10. ;
```

```
      cond:_FillValue = -999.f ;
      cond:observation_type = "measured" ;
 float salt_raw(time) ;
      salt_raw:long_name = "Salinity (raw)" ;
      salt_raw:standard_name = "sea_water_salinity" ;
      salt_raw:short_name = "salt_raw" ;
      salt_raw:units = "1e-3" ;
      salt_raw:coordinates = "time lat lon alt" ;
      salt_raw:valid_range = 10., 40. ;
      salt_raw:_FillValue = -999.f ;
      salt_raw:observation_type = "calculated" ;
      salt_raw:comment = "salinity is calculated from measured
temp and condc" ;
 int salt_qd(time) ;
      salt_qd:long_name = "Salinity quality descriptor" ;
      salt_qd:short_name = "salt_qd" ;
      salt_qd:valid_range = -9, 4 ;
      salt_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
      salt_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
      salt_qd:units = "0" ;
 float salt(time) ;
      salt:long_name = "Salinity (processed)" ;
      salt:standard_name = "sea_water_salinity" ;
      salt:short_name = "salt" ;
      salt:units = "1e-3" ;
      salt:coordinates = "time lat lon alt" ;
      salt:valid_range = 10., 40. ;
      salt:_FillValue = -999.f ;
      salt:observation_type = "calculated" ;
      salt:comment = "salinity is calculated from measured temp
and condc" ;
 float oxyg_raw(time) ;
      oxyg_raw:long_name = "Dissolved oxygen (raw)" ;
      oxyg_raw:standard_name =
"mass_concentration_of_oxygen_in_sea_water" ;
      oxyg_raw:short_name = "doxy_raw" ;
      oxyg_raw:units = "kg m-3" ;
      oxyg_raw:coordinates = "time lat lon alt" ;
      oxyg_raw:valid_range = 0., 10. ;
      oxyg_raw:_FillValue = -999.f ;
      oxyg_raw:observation_type = "calculated" ;
      oxyg_raw:comment = "oxygen is calculated from measured T,
S, P, V (DO thermistor voltage) and U (DO phase delay); see global
attrib calib_oxyg; and from mg/L to kg/m3 by oxy*1.4276/1000.0" ;
 int oxyg_qd(time) ;
      oxyg_qd:long_name = "Oxygen quality descriptor" ;
      oxyg_qd:short_name = "doxy_qd" ;
      oxyg_qd:valid_range = -9, 4 ;
      oxyg_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
      oxyg_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
      oxyg_qd:units = "0" ;
 float oxyg(time) ;
      oxyg:long_name = "Dissolved oxygen (processed)" ;
```

```
      oxyg:standard_name =
"mass_concentration_of_oxygen_in_sea_water" ;
      oxyg:short_name = "doxy" ;
      oxyg:units = "kg m-3" ;
      oxyg:coordinates = "time lat lon alt" ;
      oxyg:valid_range = 0., 10. ;
      oxyg:_FillValue = -999.f ;
      oxyg:observation_type = "calculated" ;
      oxyg:comment = "oxygen is calculated from measured T, S, P,
V (DO thermistor voltage) and U (DO phase delay); see global
attrib calib_oxyg; and from mg/L to kg/m3 by oxy*1.4276/1000.0" ;
 float flor_raw(time) ;
      flor_raw:long_name = "Chlorophyll (raw)" ;
      flor_raw:standard_name =
"mass_concentration_of_chlorophyll_in_sea_water" ;
      flor_raw:short_name = "flor_raw" ;
      flor_raw:units = "kg m-3" ;
      flor_raw:coordinates = "time lat lon alt" ;
      flor_raw:valid_range = 0., 10. ;
      flor_raw:_FillValue = -999.f ;
      flor_raw:observation_type = "calculated" ;
      flor_raw:comment = "flor is calculated from voltage using
scale factor (FSF) and dark count (FDC); see global attrib
calib_flnt; and from ug/L to kg m-3 by flor*1E-6" ;
 int flor_qd(time) ;
      flor_qd:long_name = "Chlorophyll quality descriptor" ;
      flor_qd:short_name = "flor_qd" ;
      flor_qd:valid_range = -9, 4 ;
      flor_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
      flor_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
      flor_qd:units = "0" ;
 float flor(time) ;
      flor:long_name = "Chlorophyll (processed)" ;
      flor:standard_name =
"mass_concentration_of_chlorophyll_in_sea_water" ;
      flor:short_name = "flor" ;
      flor:units = "kg m-3" ;
      flor:coordinates = "time lat lon alt" ;
      flor:valid_range = 0., 10. ;
      flor:_FillValue = -999.f ;
      flor:observation_type = "calculated" ;
      flor:comment = "flor is calculated from voltage using scale
factor (FSF) and dark count (FDC); see global attrib calib_flnt;
and from ug/L to kg m-3 by flor*1E-6" ;
 float turb_raw(time) ;
      turb_raw:long_name = "Turbidity (raw)" ;
      turb_raw:standard_name = "sea_water_turbidity" ;
      turb_raw:short_name = "turb_raw" ;
      turb_raw:units = "ntu" ;
      turb_raw:coordinates = "time lat lon alt" ;
      turb_raw:valid_range = 0., 10. ;
      turb_raw:_FillValue = -999.f ;
      turb_raw:observation_type = "calculated" ;
      turb_raw:comment = "turb is calculated from voltage using
scale factor (TSF) and dark count (TDC); see global attrib
calib_flnt" ;
```

```
 int turb_qd(time) ;
       turb_qd:long_name = "Turbidity quality descriptor" ;
       turb_qd:short_name = "turb_qd" ;
       turb_qd:valid_range = -9, 4 ;
       turb_qd:flag_values = -9, 0, 1, 2, 3, 4 ;
       turb_qd:flag_meanings = "missing_value
quality_not_evaluated failed/bad questionable/suspect passed/good
interpolated/adjusted" ;
       turb_qd:units = "0" ;
 float turb(time) ;
       turb:long_name = "Turbidity (processed)" ;
       turb:standard_name = "sea_water_turbidity" ;
       turb:short_name = "turb" ;
       turb:units = "ntu" ;
       turb:coordinates = "time lat lon alt" ;
       turb:valid_range = 0., 10. ;
       turb:_FillValue = -999.f ;
       turb:observation_type = "calculated" ;
       turb:comment = "turb is calculated from voltage using scale
factor (TSF) and dark count (TDC); see global attrib calib_flnt" ;

// global attributes:
       :project = "PacIOOS" ;
       :Conventions = "CF-1.6" ;
       :featureType = "timeSeries" ;
       :cdm_data_type = "Station" ;
       :title = "Water Quality Buoy: Kilo Nalu" ;
       :insitution = "UH/SOEST" ;
       :date_created = "2013-08-15Z12:06:01 " ;
       :abstract = "The water quality buoys are part of the
Pacific Islands Ocean Observing System (PacIOOS) and are designed
to measure a variety of ocean parameters at fixed points.  WQBKN
is located at the Kilo Nalu Nearshore Reef Observatory near
Kakaako Waterfront Park and Kewalo Basin off Ala Moana Boulevard
in Honolulu.  Continuous sampling of this area provides a record
of baseline conditions of the chemical and biological environment
for comparison when there are pollultion events such as storm
runoff or a sewage spill." ;
       :calib_oxyg = "SBE63-0270, Calib 28-Sep-12: A0=1.0513E0,
A1=-1.50E-3, A2=4.1212E-1, B0=-2.36858E-1, B1=1.6366E0,
TA0=6.213918E-4, TA1=2.622048E-4, TA2=-5.482486E-7, TA3=1.356114E-
7 (effective date 10-25-2012)    " ;
       :calib_flnt = "FLNTUS-2597, Calib 08-Mar-12: FSF=10,
FDC=0.56, TSF=5, TDC=0.077 (effective date 10-25-2012)
" ;
       :keywords = "Turbidity, Chlorophyll, Oxygen, Fluorescence,
Scattering, Water Temperature, Conductivity, Salinity" ;
       :references = "http://pacioos.org" ;
       :platform_code = "WQBKN" ;
       :naming_authority = "PacIOOS" ;
       :geospatial_lat_min = "21.2887 " ;
       :geospatial_lat_max = "21.2887 " ;
       :geospatial_lon_min = "-157.865" ;
       :geospatial_lon_max = "-157.865" ;
       :geospatial_vertical_min = "-1.0" ;
       :geospatial_vertical_max = "-1.0" ;
       :time_coverage_start = "" ;
       :time_coverage_end = "2013-08-14T21:41:23-10:00" ;
```

```
        :local_time_zone = "-10." ;
        :data_center = "PacIOOS" ;
        :data_center_email = "jimp@hawaii.edu" ;
        :author_email = "jimp@hawaii.edu" ;
        :author = "Dr. J. T. Potemra" ;
        :principal_investigator = "Prof. Eric H. De Carlo" ;
        :principal_investigator_email = "edecarlo@hawaii.edu" ;
        :technical_contact = "Mike Tomlonson" ;
        :technical_contact_email = "tomlinson86@q.com" ;
        :citation = "Citation to be used in publications should
follow the form: \"PacIOOS.[year-of-data-download],[Title],[Data
access URL], accessed [date-of-access].\"" ;
        :acknowledgement = "Data provided by PacIOOS
(http://pacioos.org) which is part of the U.S. Integrated Ocean
Observing System (IOOS) and are funded in part by the National
Oceanic and Atmospheric Administration (NOAA) award
#NA11NOS0120039." ;
        :distribution_statement = "PacIOOS data may be re-used,
provided that related metadata explaning the data have been
reviewed by the user, and that the data are appropriately
acknowledged.  Data, products and services from PacIOOS are
provided \"as is\" without and warranty as to fitness for a
particular purpose." ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
station_name(name_strlen)	wqbkn			
qc_flag	Quality control status	qc_flag		0: no qc app 1: realtime qc 2: delayed qc
time(time)	Time	time	time	minutes since 2008-01-01 00:00:00 -10:00
alt	depth below mean sea level	depth	depth	meters
lat	Latitude	lat	latitude	degrees_north
lon	Longitude	lon	longitude	degrees_east
temp_raw(time)	Temperature (raw)	temp_raw	sea_water_temperature	Celsius
temp_qd(time)	Temperature quality descriptor	temp_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
temp(time)	Temperature (processed)	temp	sea_water_temperature	Celsius
cond_raw(time)	Conductivity (raw)	cond_raw	sea_water_electrical_conductivity	S m-1
cond_qd(time)	Conductivity quality descriptor	cond_qd		-9: missing val 0: no eval 1: failed/bad

				2: questionabl 3: pass/good 4: interp/adj
cond(time)	Conductivity (processed)	cond	sea_water_electrical_conductivity	S m-1
salt_raw(time)	Salinity (raw)	salt_raw	sea_water_salinity	1e-3
salt_qd(time)	Salinity quality descriptor	salt_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
salt(time)	Salinity (processed)	salt	sea_water_salinity	1e-3
oxyg_raw(time)	Dissolved oxygen (raw)	doxy_raw	mass_concentration_of_oxygen_in_sea_water	kg m-3
oxyg_qd(time)	Oxygen quality descriptor	doxy_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
oxyg(time)	Dissolved oxygen (processed)	doxy	mass_concentration_of_oxygen_in_sea_water	kg m-3
oxy2_raw(time)	Dissolved oxygen saturation (raw)	oxyg_raw	fractional_saturation_of_oxygen_in_sea_water	1
oxy2_qd(time)	Oxygen saturation quality descriptor	oxyg_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
oxy2(time)	Dissolved oxygen saturation (processed)	oxyg	fractional_saturation_of_oxygen_in_sea_water	1
flor_raw(time)	Chlorophyll (raw)	flor_raw	mass_concentration_of_chlorophyll_in_sea_water	kg m-3
flor(time)	Chlorophyll quality descriptor	flor_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
flor(time)	Chlorophyll (processed)	flor	mass_concentration_of_chlorophyll_in_sea_water	kg m-3
turb_raw(time)	Turbidity	turb_ra	sea_water_turbi	ntu

	(raw)	w	dity	
turb_qd(time)	Turbidity quality descriptor	turb_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
turb(time)	Turbidity (processed)	turb	sea_water_turbidity	ntu
ph01_raw(time)	pH (raw)	ph01-raw	sea_water_ph_reported_on_total_scale	1
ph01_qd(time)	pH quality descriptor	ph01_qd		-9: missing val 0: no eval 1: failed/bad 2: questionabl 3: pass/good 4: interp/adj
ph01(time)	pH (processed)	ph01	sea_water_ph_reported_on_total_scale	1

Table 28. Water quality buoy variable list.

5. Data distribution[27]

PacIOOS Water Quality Buoy 03: Kiholo Bay, Big Island, Hawaii

- Metadata: http://pacioos.org/metadata/WQB03agg.html
- HTML: http://pacioos.org/focus/waterquality/wq_hawaii.php
- Voyager: http://pacioos.org/voyager/index.html?b=19.842249%2C-155.966291%2C19.883984%2C-155.893121&o=qual:1::p0WQB-03p1
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/wqb.html?dataset=WQB03agg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/wqb03_agg.graph?time%2Ctemperature&.draw=lines
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=c6345cd283c6e7761ec340648b419781
- SOS: http://oos.soest.hawaii.edu/thredds/sos/hioos/wqb/wqb03agg?service=SOS&version=1.0.0&request=GetCapabilities
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/wqb/wqb03agg.html
- Other: http://hawaii.loboviz.com/loboviz/

[27] Only one buoy is given as an example here; all buoys are available in a similar way using the same services but with different specifications (*e.g.,* wqbaw instead of wqb03, *etc.*).

F. Model output (Atmospheric)

1. Data flow

The atmospheric model is the Weather Research and Forecast (WRF) model and is run by D. Chen's group. At present there are three model grids saved from the local runs: a main Hawaiian Islands grid (wrf_hi) that extends from roughly 165°W to 150°W, 17°N to 24°N at 7 km resolution; an Oahu grid (wrf_oa) that extends from 158.5°W to 157.5°W, 21°N to 22°N at 1.5 km resolution; and an Maui grid (wrf_mo) that extends from 159°W to 155.6°W, 20.2°N to 21.9°N at 2 km resolution.

The models are run each day and are used to force the ocean wave and circulation models. The data archived and served by PacIOOS are actually converted by the ocean circulation model (ROMS) and are on the ocean model grid. A cron script, **`copy_ocn_output`**, is run each day at 1:15 PM HST to copy the output files from the modeling cluster machine (*observer*) to the data server. The files are copied from `/home/observer/dmac/0day/ocn` to `/export/lawelawe1/model/atm`. An additional step is required to convert the raw data times (which are in fractional seconds) to whole integers (**`conv_wrf_time.s`** is used).

2. File naming convention

The input files are named `wfr.nc`, `wrf-oahu.nc` and `wrf-mo.nc`. These files are saved in directories `wrf_hi`, `wrf_oa` and `wrf_mo` and given time-stamps in the name, *e.g.*, `wrf_20120130.nc`, `wrf_oa_20120130.nc` and `wrf_mo_20120130.nc` for output from January 1, 2012. These dates are given by "today" from the **`date`** command.

The files contain hourly output. The Hawaiian Islands and Maui grids contain a single-day hindcast and six-day forecast (total of seven days of output), while the Oahu grid has a half-day hindcast and two-day forecast (total of 2.5 days of output). The saved variables are surface air temperature, pressure, rain rate, wind speed (zonal and meridional), longwave and shortwave radiation, relative humidity and sea surface temperature. Since the model output is processed first by the ocean model, it contains the ROMS conventions for grid variables (*e.g.*, eta and xi).

The output files are approximately 180MB, 10MB and 100MB per day for the Hawaiian Island, Oahu and Maui grids, respectively. This gives a total of 106GB per year for all three grids. The model configurations occasionally change, and this makes it difficult to serve the output as continuous records in time. The most recent output extends back to mid-May 2010.

WRF Grid	Hawaiian Islands	Oahu	Maui	CNMI	GUAM	Samoa
Lon range	165.0°W 150.0°W	158.5°W 157.5°W	159.0°W 155.6°W	116.0°E 149.0°E	142.9°W 147.0°W	174.1°W 168.7°W

Lon res	6.5 km	1.5 km	2.0 km	12.0 km	3.0 km	3.0 km
Lon pts	216	78	180	293	148	196
Lat range	17.0°N 24.0°N	21.0°N 22.0°N	20.2°N 21.9°N	10.0°N 27.0°N	11.9°N 16.0°N	16.1°S 11.9°S
Lat res	6.5 km	1.5 km	1.5 km	12.0 km	2.0 km	3.0 km
Lat pts	136	63	93	160	148	155
Depth rng	surface	surface	surface	surface	surface	surface
Depth res	0	0	0	0	0	0
Depth pts	1	1	1	1	1	1
Time range	7.5 days (6 forecast)	2.5 days (2 forecast)	7.5 days (6 forecast)	7.5 days (6 forecast)	7.5 days (6 forecast)	7.5 days (6 forecast)
Time res	hourly	hourly	hourly	hourly	hourly	hourly
Time pts	181	61	181	181	181	181
Time start	05-14-2010	06-22-2010	05-14-2010	06-13-2013	06-13-2013	09-25-2013
Variables	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh
File size	191,667,056	10,839,164	109,229,476	305,863,556	142,919,504	198,217,148
File name	`wrf_*.nc`	`wrf_oa_*.nc`	`wrf_mo_*.nc`	`wrf_ma_*.nc`	`wrf_gu_*.nc`	`wrf_sa_*.nc`

Table 29. Atmospheric model grid specifications.

3. Data format specification

```
netcdf wrf_oa_20130819 {
dimensions:
 qair_time = 61 ;
 srf_time = 61 ;
 lrf_time = 61 ;
 wind_time = 61 ;
 rain_time = 61 ;
 pair_time = 61 ;
 tair_time = 61 ;
 eta = 63 ;
 xi = 78 ;
variables:
 double qair_time(qair_time) ;
       qair_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
       qair_time:long_name = "surface air relative humidity time"
;
 double srf_time(srf_time) ;
       srf_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
       srf_time:long_name = "solar shortwave radiation flux time"
;
 double lrf_time(lrf_time) ;
       lrf_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
       lrf_time:long_name = "net longwave radiation flux time" ;
 double wind_time(wind_time) ;
       wind_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
       wind_time:long_name = "surface u-wind component time" ;
 double rain_time(rain_time) ;
       rain_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
       rain_time:long_name = "rain fall rate time" ;
 double pair_time(pair_time) ;
       pair_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
```

```
      pair_time:long_name = "surface air pressure time" ;
double tair_time(tair_time) ;
      tair_time:units = "minutes since 2000-01-01 00:00:00 GMT" ;
      tair_time:long_name = "surface air temperature time" ;
float xi(xi) ;
      xi:long_name = "xi coordinate index" ;
float eta(eta) ;
      eta:long_name = "eta coordinate index" ;
float lat(eta, xi) ;
      lat:long_name = "Latitude" ;
      lat:units = "degrees_north" ;
float lon(eta, xi) ;
      lon:long_name = "Longitude" ;
      lon:units = "degrees_east" ;
float Tair(tair_time, eta, xi) ;
      Tair:long_name = "surface air temperature" ;
      Tair:units = "Celsius" ;
      Tair:coordinates = "lon lat" ;
      Tair:field = "Tair, scalar, series" ;
      Tair:time = "tair_time" ;
float Pair(pair_time, eta, xi) ;
      Pair:long_name = "surface air pressure" ;
      Pair:units = "millibar" ;
      Pair:coordinates = "lon lat" ;
      Pair:field = "Pair, scalar, series" ;
      Pair:time = "pair_time" ;
float rain(rain_time, eta, xi) ;
      rain:long_name = "rain fall rate" ;
      rain:units = "kilogram meter-2 second-1" ;
      rain:coordinates = "lon lat" ;
      rain:field = "rain, scalar, series" ;
      rain:time = "rain_time" ;
float Uwind(wind_time, eta, xi) ;
      Uwind:long_name = "surface u-wind component" ;
      Uwind:units = "meter second-1" ;
      Uwind:coordinates = "lon lat" ;
      Uwind:field = "u-wind, scalar, series" ;
      Uwind:time = "wind_time" ;
float Vwind(wind_time, eta, xi) ;
      Vwind:long_name = "v-wind component at 10m" ;
      Vwind:units = "meter second-1" ;
            Vwind:coordinates = "lon lat" ;
      Vwind:field = "v-wind, scalar, series" ;
      Vwind:time = "wind_time" ;
float lwrad_down(lrf_time, eta, xi) ;
      lwrad_down:long_name = "net longwave radiation flux" ;
      lwrad_down:units = "watt meter-2" ;
      lwrad_down:coordinates = "lon lat" ;
      lwrad_down:field = "longwave radiation, scalar, series" ;
      lwrad_down:time = "lrf_time" ;
float swrad(srf_time, eta, xi) ;
      swrad:long_name = "solar shortwave radiation flux" ;
      swrad:units = "watt meter-2" ;
      swrad:coordinates = "lon lat" ;
      swrad:field = "shortwave radiation, scalar, series" ;
      swrad:time = "srf_time" ;
float Qair(qair_time, eta, xi) ;
      Qair:long_name = "surface air relative humidity" ;
```

```
       Qair:units = "percentage" ;
       Qair:coordinates = "lon lat" ;
       Qair:field = "Qair, scalar, series" ;
       Qair:time = "qair_time" ;
 float sst(tair_time, eta, xi) ;
       sst:long_name = "atmospheric guess for sst" ;
       sst:units = "Celsius" ;
       sst:coordinates = "lon lat" ;
       sst:field = "SST, series" ;
       sst:time = "tair_time" ;

// global attributes:
       :title = "nc Bulk Forcing Data" ;
       :author = "Operational" ;
       :type = "ROMS forcing" ;
       :Conventions = "CF-1.0" ;
       :history = "Mon Aug 19 13:19:16 2013:
/usr/local/bin/ncatted -a long_name,qair_time,c,c,surface air
relative humidity time temp7.nc\n",
             "Mon Aug 19 13:19:16 2013: /usr/local/bin/ncatted -a
units,qair_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:16 2013: /usr/local/bin/ncatted -a
long_name,srf_time,c,c,solar shortwave radiation flux time
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,srf_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
long_name,lrf_time,c,c,net longwave radiation flux time
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,lrf_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
long_name,wind_time,c,c,surface u-wind component time temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,wind_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
long_name,rain_time,c,c,rain fall rate time temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,rain_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
long_name,pair_time,c,c,surface air pressure time temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,pair_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
long_name,tair_time,c,c,surface air temperature time temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncatted -a
units,tair_time,c,c,minutes since 2000-01-01 00:00:00 GMT
temp7.nc\n",
             "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
qair_time[qair_time]=floor(qair_time*24.0*60.0+0.5) temp6.nc
temp7.nc\n",
```

```
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
srf_time[srf_time]=floor(srf_time*24.0*60.0+0.5) temp5.nc
temp6.nc\n",
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
lrf_time[lrf_time]=floor(lrf_time*24.0*60.0+0.5) temp4.nc
temp5.nc\n",
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
wind_time[wind_time]=floor(wind_time*24.0*60.0+0.5) temp3.nc
temp4.nc\n",
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
rain_time[rain_time]=floor(rain_time*24.0*60.0+0.5) temp2.nc
temp3.nc\n",
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
pair_time[pair_time]=floor(pair_time*24.0*60.0+0.5) temp1.nc
temp2.nc\n",
            "Mon Aug 19 13:19:15 2013: /usr/local/bin/ncap2 -s
tair_time[tair_time]=floor(tair_time*24.0*60.0+0.5) sample.nc
temp1.nc" ;
      :nco_openmp_thread_number = 1 ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
qair_time(qair_time)	surface air relative humidity time			minutes since 2000-01-01 00:00:00 GMT
srf_time(srf_time)	solar shortwave radiative flux time			minutes since 2000-01-01 00:00:00 GMT
lrf_time(lrf_time)	net longwave radiative flux time			minutes since 2000-01-01 00:00:00 GMT
wind_time(wind_time)	surface u-wind component time			minutes since 2000-01-01 00:00:00 GMT
rain_time(rain_time)	rain fall rate time			minutes since 2000-01-01 00:00:00 GMT
pair_time(pair_time)	surface air pressure time			minutes since 2000-01-01 00:00:00 GMT
tair_time(tair_time)	surface air temperature time			minutes since 2000-01-01 00:00:00 GMT
xi(xi)	xi coordinate index			
eta(eta)	eta coordinate index			
lat(eta,xi)	Latitude			degrees_north
lon(eta,xi)	Longitude			degrees_east
Tair(tair_time,eta,xi)	surface air temperature			Celsius
Pair(pair_time,eta,xi)	surface air			mbar

	pressure			
rain(rain_time,eta,xi)	rain fall rate			kg m-2 s-1
Uwind(wind_time,eta,xi)	surface u-wind component			m s-1
Vwind(wind_time,eta,xi)	surface v-wind component			m s-1
lwrad_down(lrf_time,eta,xi)	net longwave radiation flux			W m-2
swrad_down(lrf_time,eta,xi)	solar shortwave radiation flux			W m-2
Qair(qair_time,eta,xi)	surface air relative humidity			percentage
sst(tair_time,eta,xi)	atmospheric guess for sst			Celsius

Table 30. Atmospheric model variable specifications.

5. Data distribution[28]

Weather Research and Forecasting (WRF) Regional Atmospheric Model: CNMI

- Metadata: http://pacioos.org/metadata/wrf_cnmi.html
- Voyager: http://pacioos.org/voyager/index.html?b=9.65111%2C115.606527%2C27.202359%2C149.268637&o=wfore:1:f:d5
- THREDDS: http://oos.soest.hawaii.edu/thredds/catalog/hioos/model/atm/wrf_cnmi/catalog.html?dataset=wrf_cnmi/WRF_CNMI_Regional_Atmospheric_Model_best.ncd
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/WRF_CNMI_Best.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=wrf_cnmi&varid=Tair-wrf_cnmi
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=dd82b9995039128d739ee2c16b8c8f6
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/model/atm/wrf_cnmi/WRF_CNMI_Regional_Atmospheric_Model_best.ncd?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hioos/model/atm/wrf_cnmi/WRF_CNMI_Regional_Atmospheric_Model_best.ncd?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/model/atm/wrf_cnmi/WRF_CNMI_Regional_Atmospheric_Model_best.ncd/dataset.html

[28] Only one model domain is given as an example here; all domains are available in a similar way using the same services but with different specifications (*e.g.,* wfr_oahu instead of wrf_cnmi, *etc.*).

- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/model/atm/wrf_cnmi/WRF_CNMI_Regional_Atmospheric_Model_best.ncd.html

G. Model output (Wave)

1. Data flow

The two models output forecasts in different formats: the WW3 in ASCII and the SWAN in Matlab binary format. The cron script, **`copy_ore_output`**, is run each day at 1:00 PM HST just before the ocean circulation model download. The script copies the raw model output from `/home/observer/dmac/0day/ore` to `/export/lawelawe/jimp/waves` and runs two different conversion programs. These are FORTRAN programs that convert between the model output format and NetCDF. There is a different executable for each grid since the parameters are different. For the WW3, **`write_global_nc`** and **`write_hawaii_nc`** are based on `write_global_nc.f` and `write_hawaii_nc.f`, respectively (the difference is in the metadata and variable dimensions).

For SWAN, the executables are based on `write_regional_nc.F` which is then compiled using `makefile.reg` to specify one of **`write_kauai_nc`**, **`write_oahu_nc`**, **`write_maui_nc`** and **`write_bigi_nc`** for each grid. Note that this conversion requires a Matlab-FORTRAN library that is not installed on *lawelawe*, so the programs have to be compiled elsewhere.

The WW3 model outputs files such as `ww3_global_out.`*`var`*, where *`var`* is one of the several variables output (`dir`, `dp`, `dpl`, `fp`, `hs`, `pnr`, `t`, `wsf`). There are additional files for swell- and wind-driven waves (`out` is replaced by `swell` and/or `wind`) and for the Hawaii grid (`global` is replaced by `hawaii`). The SWAN output is in a single file, one per domain, in the form *`grid`*`.mat` where *`grid`* is one of `kauai`, `oahu`, `maui`, or `bigisland`.

2. File naming convention

The output files are saved in `/export/lawelawe1/model/ore/swan` and `/ww3`. There are then subdirectories for each domain (`bigisland`, `oahu`, `maui` and `kauai` for SWAN, and `global` and `hawaii` for ww3). The individual files have names with model, grid and date, *e.g.*, `ww3hawaii_20110828.nc` for WW3 output on the Hawaiian Island grid for August 28, 2011 (note that for legacy reasons the global output filenames actually contain "`pac`" instead of "`global`"). The dates are read from the model output files, both the ASCII WW3 output and Matlab binary SWAN output. The output dates are typically two days prior to current, for example the download and conversion done on August 28th will copy from the "day0" directory and create a file with a date of August 26th. At 2:00PM HST, the "day0" files get moved to "day1", so if there is a problem the file conversion can be re-run (note that only the past seven days are saved in directories "day1" through "day7".

The files contain hourly output for a 7.5-day forecast (181 points). The saved variables are different for the two models. WW3 predicts significant wave height, period, and direction for peak, swell and wind waves. The SWAN output contains significant wave height, period and direction for mean and peak waves.

The output files are approximately 1.5GB for the global model, 90MB for the Hawaii Islands, 109MB for Kauai, 82MB for the Big Island, 60MB for Oahu and 49MB for Mauai. This gives a total of 675GB per year for all grids. The model configurations occasionally change, and this makes it difficult to serve the output as continuous records in time. The most recent output extends to June 2010 for the SWAN output, November 2010 for the global WW3 and June 2011 for the Hawaiian Island WW3.

SWAN Grid	Hawaii Island	Oahu	Maui	Kauai
Lon range	156.2°W 154.7°W	158.35°W 157.60°W	157.4°W 155.9°W	160.35°W 159.20°W
Lon res	1 km	0.5 km	1 km	0.5 km
Lon pts	151	151	151	231
Lat range	18.85°N 20.35°N	21.20°N 21.75°N	20.4°N 21.3°N	21.70°N 22.35°N
Lat res	1 km	0.5 km	1 km	0.5 km
Lat pts	151	111	91	131
Time range	7.5 day (6 day forecast)	7.5 days (6 day forecast)	7.5 days (6 day forecast)	7.5 days (6 day forecast)
Time res	hourly	hourly	hourly	hourly
Time pts	181	181	181	181
Time start	06-29-2010	06-29-2010	06-29-2010	06-29-2010
File size	82,544,012	60,679,052	49,746,572	109,549,452
File name	`swan_bigi_*`	`swan_oahu_*`	`swan_maui_*`	`swa_kauai_*`

SWAN Grid	Guam	Apra	Samoa
Lon range	144.50°W 145.05°W	144.61°W 144.69°W	171.00°E 170.40°E
Lon res	0.5 km	50 m	0.5 km
Lon pts	111	161	121
Lat range	13.14°N 13.75°N	13.41°N 13.48°N	14.40°S 14.15°S
Lat res	0.5 km	50 m	0.5 km
Lat pts	121	141	51
Time range	7.5 days (6 day forecast)	7.5 days (6 day forecast)	7.5 days (6 day forecast)
Time res	hourly	hourly	hourly
Time pts	181	181	181
Time start	05-16-2012	05-15-2012	02-19-2013

File size	48,624,332	82,182,012	22,342,892
File name	swan_guam_*.nc	swan_apra_*.nc	swa_tutu_*.nc

Table 31. SWAN wave model variable definitions.

WW3 Grid	Global	Hawaii	CNMI	Samoa
Lon range	0.0° to 359.5°W	161.0° to 154.0°W	143.5° to 146.5°E	174.0° to 169.0°W
Lon res	50 km	0.5 km	5.5 km	5.5 km
Lon points	720	141	61	101
Lat range	77.5°S to 77.5°N	18.0° to 23.0°N	12.2° to 15.7°N	15.0° to 13.0°S
Lat res	50 km	0.5 km	5.5 km	5.5 km
Lat points	311	101	71	41
Time range	7.5 days	7.5 days	7.5 days	7.5 days
Time res	hourly	hourly	hourly	hourly
Time points	181	181	181	181
Time start	11-07-2010	06-21-2011	05-16-2012	02-12-2013
File size	1,459,071,172	92,799,652	28,225,652	26,987,652
File name	ww3pac_*.nc	ww3hawaii_*.nc	ww3mariana_*.nc	ww3samoa_*.nc

Table 32. WW3 wave model variable definitions.

3. Data format specification

SWAN output:

```
netcdf swan_oahu_20130818 {
dimensions:
 lon = 151 ;
 lat = 111 ;
 z = 1 ;
 time = UNLIMITED ; // (181 currently)
variables:
 float lon(lon) ;
       lon:long_name = “longitude” ;
       lon:standard_name = “longitude” ;
       lon:short_name = “lon” ;
       lon:axis = “x” ;
       lon:units = “degrees_east” ;
 float lat(lat) ;
       lat:long_name = “latitude” ;
       lat:standard_name = “latitude” ;
       lat:short_name = “lat” ;
       lat:axis = “y” ;
       lat:units = “degrees_north” ;
 float z(z) ;
       z:long_name = “depth below mean sea level” ;
       z:standard_name = “depth” ;
       z:short_name = “depth” ;
       z:axis = “z” ;
       z:units = “meters” ;
 int time(time) ;
       time:long_name = “time” ;
       time:standard_name = “time” ;
       time:short_name = “time” ;
       time:axis = “t” ;
       time:units = “minutes since 2008-01-01 00:00:00” ;
```

```
 float shgt(time, z, lat, lon) ;
       shgt:long_name = “significant wave height” ;
       shgt:standard_name = “sea_surface_wave_significant_height”
;
       shgt:short_name = “hs” ;
       shgt:units = “meters” ;
       shgt:valid_range = 0.f, 20.f ;
       shgt:_FillValue = -999.f ;
 float mper(time, z, lat, lon) ;
       mper:long_name = “mean wave period” ;
       mper:standard_name = “sea_surface_wave_period” ;
       mper:short_name = “mper” ;
       mper:units = “seconds” ;
       mper:valid_range = 0.f, 30.f ;
       mper:_FillValue = -999.f ;
 float mdir(time, z, lat, lon) ;
       mdir:long_name = “mean wave direction” ;
       mdir:standard_name = “sea_surface_wave_from_direction” ;
       mdir:short_name = “mdir” ;
       mdir:units = “degrees” ;
       mdir:valid_range = 0.f, 360.f ;
       mdir:_FillValue = -999.f ;
 float pper(time, z, lat, lon) ;
       pper:long_name = “peak wave period” ;
       pper:standard_name = “sea_surface_peak_wave_period” ;
       pper:short_name = “pper” ;
       pper:units = “seconds” ;
       pper:valid_range = 0.f, 30.f ;
       pper:_FillValue = -999.f ;
 float pdir(time, z, lat, lon) ;
       pdir:long_name = “peak wave direction” ;
       pdir:standard_name = “sea_surface_peak_wave_from_direction”
;
       pdir:short_name = “pdir” ;
       pdir:units = “degrees” ;
       pdir:valid_range = 0.f, 360.f ;
       pdir:_FillValue = -999.f ;

// global attributes:
       :title = “Results from ORE SWAN model for Oahu.  Results
provided by Ning Li, K.-F. Cheung,
PI…..
.....
.....” ;
}
```

WaveWatchIII output:

```
netcdf ww3hawaii_20130828 {
dimensions:
 lon = 141 ;
 lat = 101 ;
 z = 1 ;
 time = UNLIMITED ; // (181 currently)
variables:
 float lon(lon) ;
       lon:long_name = "longitude" ;
```

```
      lon:standard_name = "longitude" ;
      lon:short_name = "lon" ;
      lon:axis = "x" ;
      lon:units = "degrees_east" ;
 float lat(lat) ;
      lat:long_name = "latitude" ;
      lat:standard_name = "latitude" ;
      lat:short_name = "lat" ;
      lat:axis = "y" ;
      lat:units = "degrees_north" ;
 float z(z) ;
      z:long_name = "depth below mean sea level" ;
      z:standard_name = "depth" ;
      z:short_name = "depth" ;
      z:axis = "z" ;
      z:units = "meters" ;
 int time(time) ;
      time:long_name = "time" ;
      time:standard_name = "time" ;
      time:short_name = "time" ;
      time:axis = "t" ;
      time:units = "minutes since 2008-01-01 00:00:00" ;
 float Thgt(time, z, lat, lon) ;
      Thgt:long_name = "significant wave height" ;
      Thgt:standard_name = "sea_surface_wave_significant_height"
;
      Thgt:short_name = "Thgt" ;
      Thgt:units = "meters" ;
      Thgt:valid_range = 0.f, 60.f ;
      Thgt:_FillValue = -999.f ;
 float Tper(time, z, lat, lon) ;
      Tper:long_name = "peak wave period" ;
      Tper:standard_name = "sea_surface_wave_period" ;
      Tper:short_name = "Tper" ;
      Tper:units = "seconds" ;
      Tper:valid_range = 0.f, 60.f ;
      Tper:_FillValue = -999.f ;
 float Tdir(time, z, lat, lon) ;
      Tdir:long_name = "peak wave direction" ;
      Tdir:standard_name = "sea_surface_wave_from_direction" ;
      Tdir:short_name = "Tdir" ;
      Tdir:units = "degrees" ;
      Tdir:valid_range = 0.f, 360.f ;
      Tdir:_FillValue = -999.f ;
 float shgt(time, z, lat, lon) ;
      shgt:long_name = "swell significant wave height" ;
      shgt:standard_name =
"sea_surface_swell_wave_significant_height" ;
      shgt:short_name = "shgt" ;
      shgt:units = "meters" ;
      shgt:valid_range = 0.f, 60.f ;
      shgt:_FillValue = -999.f ;
 float sper(time, z, lat, lon) ;
      sper:long_name = "swell peak wave period" ;
      sper:standard_name = "sea_surface_swell_wave_period" ;
      sper:short_name = "sper" ;
      sper:units = "seconds" ;
      sper:valid_range = 0.f, 60.f ;
```

```
        sper:_FillValue = -999.f ;
 float sdir(time, z, lat, lon) ;
        sdir:long_name = "swell peak wave direction" ;
        sdir:standard_name =
"sea_surface_swell_wave_from_direction" ;
        sdir:short_name = "sdir" ;
        sdir:units = "degrees" ;
        sdir:valid_range = 0.f, 360.f ;
        sdir:_FillValue = -999.f ;
 float whgt(time, z, lat, lon) ;
        whgt:long_name = "wind significant wave height" ;
        whgt:standard_name =
"sea_surface_wind_wave_significant_height" ;
        whgt:short_name = "whgt" ;
        whgt:units = "meters" ;
        whgt:valid_range = 0.f, 60.f ;
        whgt:_FillValue = -999.f ;
 float wper(time, z, lat, lon) ;
        wper:long_name = "wind peak wave period" ;
        wper:standard_name = "sea_surface_wind_wave_period" ;
        wper:short_name = "wper" ;
        wper:units = "seconds" ;
        wper:valid_range = 0.f, 60.f ;
        wper:_FillValue = -999.f ;
 float wdir(time, z, lat, lon) ;
        wdir:long_name = "wind peak wave direction" ;
        wdir:standard_name = "sea_surface_wind_wave_from_direction"
;
        wdir:short_name = "wdir" ;
        wdir:units = "degrees" ;
        wdir:valid_range = 0.f, 360.f ;
        wdir:_FillValue = -999.f ;

// global attributes:
        :title = "WaveWatch-III results from ORE level2 model.
Results provided by Ning Li, K.-F. Cheung,
PI.....
.....
..................." ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
lon(lon)	longitude	lon	longitude	degrees_east
lat(lat)	latitude	lat	latitude	degrees_north
z(z)	depth below mean sea level	depth	depth	meters
time(time)	time	time	time	minutes since 2008-01-01 00:00:00
shgt(time,z,lat,lon) (SWAN)	significant wave height	hs	sea_surface_wave_significant_height	meters
mper(time,z,lat,lon) (SWAN)	mean wave period	mper	sea_surface_wave_period	seconds

mdir(time,z,lat,lon) (SWAN)	mean wave direction	mdir	sea_surface_wave_from_direction	degrees
pper(time,z,lat,lon) (SWAN)	peak wave period	pper	sea_surface_peak_wave_period	seconds
pdir(time,z,lat,lon) (SWAN)	peak wave direction	pdir	sea_surface_peak_wave_from_direction	degrees
Thgt(time,z,lat,lon) (WW3)	significant wave height	Thgt	sea_surface_wave_significant_height	meters
Tper(time,z,lat,lon) (WW3)	peak wave period	Tper	sea_surface_wave_period	seconds
Tdir(time,z,lat,lon) (WW3)	peak wave direction	Tdir	sea_surface_wave_from_direction	degrees
shgt(time,z,lat,lon) (WW3)	swell significant wave height	shgt	sea_surface_swell_wave_significant_height	meters
sdir(time,z,lat,lon) (WW3)	swell peak wave direction	sdir	sea_surface_swell_wave_from_direction	degrees
whgt(time,z,lat,lon) (WW3)	wind significant wave height	whgt	sea_surface_wind_wave_significant_height	meters
wper(time,z,lat,lon) (WW3)	wind peak wave period	wper	sea_surface_wind_wave_period	seconds
wdir(time,z,lat,lon) (WW3)	wind peak wave direction	wdir	sea_surface_wave_from_direction	degrees

Table 33. Wave model variable definitions.

5. Data distribution[29]

WaveWatch III (WW3) Samoa Regional Wave Model

- Metadata: http://pacioos.org/metadata/ww3_samoa.html
- Voyager: http://pacioos.org/voyager/index.html?b=-15%2C-174%2C-13%2C-169&o=sfore:4:ft:d10
- THREDDS: http://oos.soest.hawaii.edu/thredds/catalog/hioos/model/wav/ww3/samoa/catalog.html?dataset=ww3_samoa/WaveWatch_III_Samoa_Regional_Wave_Model_best.ncd
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/NWW3_Samoa_Best.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=nww3_samoa&varid=Thgt-nww3_samoa
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=339c19e37a6e9be0e6706b4e4cdc49b3

[29] Only one model domain is given as an example here; all domains are available in a similar way using the same services but with different specifications (*e.g.,* ww3_oahu instead of ww3_samoa, *etc.*).

- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/model/wav/ww3/samoa/WaveWatch_III_Samoa_Regional_Wave_Model_best.ncd?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hioos/model/wav/ww3/samoa/WaveWatch_III_Samoa_Regional_Wave_Model_best.ncd?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/model/wav/ww3/samoa/WaveWatch_III_Samoa_Regional_Wave_Model_best.ncd/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/model/wav/ww3/samoa/WaveWatch_III_Samoa_Regional_Wave_Model_best.ncd.html

H. Model output (Ocean circulation)

1. Data flow

The cron script **`copy_ocn_output`** is run each day at 1:15 PM HST to copy the output files from the modeling cluster machine (*observer*) to the data server. The files are copied from `/home/observer/dmac/0day/ocn/`. The files are named *`grid_type`*`.nc`, where *`grid`* is one of `hiig`, `hiog`, or `hiomsg` and *`type`* is either `fore` or `assim`. These files are already in netCDF format, so no further conversion is done.

2. File naming convention

Files are copied to `/export/lawelawe1/model/ocn/`*`type`*`/`*`grid`* (where *`type`* is the run-type, either `roms_forecast` or `roms_assim`, and *`grid`* is the grid `hiig`, `hiog` or `hiomsg`) and named *`grid_type_yyyymmdd`*`.nc` (*`grid`* is one of `hiig`, `hiog`, or `hiomsg`; *`type`* is `forec` or `assim`; *`yyyy`* is four-digit year; *`mm`* is two-digit month; and *`dd`* is two-digit day). The files are already in NetCDF format and no other conversion is necessary.

The output files are approximately 2.5GB for the all-islands grids, 600 and 350MB for the Oahu grid (without and with data-assimilation, respectively), and 61MB for the south shore grid (all per day). This gives a total of 1.2TB per year for all grids. The model configurations occasionally change, and this makes it difficult to serve the output as continuous records in time. The most recent output extends back to late March 2011.

ROMS Grid	Hawaii Islands (hiig)	Oahu (hiog)	South Shore (hiomsg)	Waianae (hiomwg)
Lon range	163.8°W 152.5°W	variable	variable	variable
Lon res	4 km	2 to 0.7 km	200 to 60 m	200 to 60 m
Lon pts	294	70 (xi)	138 (xi)	58 (xi)
Lat range	17.0°N 24.0°N	variable	variable	variable
Lat res	4 km	2 to 0.7 km	200 to 60 m	200 to 60 m
Lat pts	194	170 (eta)	47 (eta)	35 (eta)
Depth rng	surface bottom	surface bottom	surface bottom	surface bottom
Depth res	variable	variable	variable	variable
Depth pts	30	30	30	20
Time range	7.125 days	7.125 days	5.0 days	2.125 days
Time res	3-hourly	3-hourly	3-hourly	3-hourly
Time pts	57	57	41	17
Time start	03-25-2011	04-01-2011	04-07-2011	06-05-2010
File size	2,878,123,344	610,236,424	69,452,972	21,076,956
File name	`hiig_forec_*`	`hiog_forec_*`	`hiomsg_forec_*`	`hiomwg_forec_*`

ROMS Grid	CNMI (mari)	Guam (marig)
Lon range	116.0°E 148.9°E	142.9°E 147.1°E
Lon res	8 km	2 km
Lon pts	432	221
Lat range	10.7°N 27.0°N	11.9°N 16.0°N
Lat res	8 km	2 km
Lat pts	230	225
Depth rng	surface bottom	surface bottom
Depth res	variable	variable
Depth pts	24	30
Time range	6.125 days	6.125 days
Time res	3-hourly	3-hourly
Time pts	49	57
Time start	09-25-2013	09-25-2013
File size	7,133,925,432	2,148,105,684
File name	`mari_forec_*.nc`	`marig_forec_*.nc`

Table 34. Specifications for ROMS (local ocean circulation model) without data assimilation (forecast runs).

ROMS Grid	Hawaii Islands (hiig)	Oahu (hiog)	CNMI (mari)
Lon range	163.8°W 152.5°W	variable	116.0°E 148.9°E
Lon res	4 km	2 to 0.7 km	8 km
Lon pts	294	70 (xi)	432
Lat range	17.0°N 24.0°N	variable	10.7°N 27.0°N
Lat res	4 km	2 to 0.7 km	8 km
Lat pts	194	170 (eta)	230
Depth rng	sea surface bottom	sea surface bottom	surface bottom
Depth res	variable	variable	variable
Depth pts	30	30	24
Time range	3.125 days	2.125 days	3.125 days
Time res	3-hourly	3-hourly	3-hourly
Time pts	25	17	25
Time start	03-26-2011	04-02-2011	09-25-2013
File size	2,571,061,176	364,661,820	3,646,374,348
File name	`hiig_assim_*.nc`	`hiog_assim_*.nc`	`mari_forec_*.nc`

Table 35. Specifications for ROMS (local ocean circulation model) with assimilation.

3. Data format convention

```
netcdf hiig_forec_20130819 {
dimensions:
 xi_rho = 294 ;
 xi_u = 293 ;
 xi_v = 294 ;
 xi_psi = 293 ;
 eta_rho = 194 ;
 eta_u = 194 ;
 eta_v = 193 ;
 eta_psi = 193 ;
 N = 30 ;
 s_rho = 30 ;
 s_w = 31 ;
 tracer = 2 ;
 boundary = 4 ;
 ocean_time = UNLIMITED ; // (57 currently)
 Nuser = 25 ;
variables:
 int ntimes ;
       ntimes:long_name = "number of long time-steps" ;
 int ndtfast ;
       ndtfast:long_name = "number of short time-steps" ;
 double dt ;
       dt:long_name = "size of long time-steps" ;
       dt:units = "second" ;
 double dtfast ;
       dtfast:long_name = "size of short time-steps" ;
       dtfast:units = "second" ;
```

```
 double dstart ;
       dstart:long_name = "time stamp assigned to model
initilization" ;
       dstart:units = "days since 2000-01-01 00:00:00" ;
 int nHIS ;
       nHIS:long_name = "number of time-steps between history
records" ;
 int ndefHIS ;
       ndefHIS:long_name = "number of time-steps between the
creation of history files" ;
 int nRST ;
       nRST:long_name = "number of time-steps between restart
records" ;
       nRST:cycle = "only latest two records are maintained" ;
 int ntsAVG ;
       ntsAVG:long_name = "starting time-step for accumulation of
time-averaged fields" ;
 int nAVG ;
       nAVG:long_name = "number of time-steps between time-
averaged records" ;
 int ndefAVG ;
       ndefAVG:long_name = "number of time-steps between the
creation of average files" ;
 int nSTA ;
       nSTA:long_name = "number of time-steps between stations
records" ;
 double Falpha ;
       Falpha:long_name = "Power-law shape barotropic filter
parameter" ;
 double Fbeta ;
       Fbeta:long_name = "Power-law shape barotropic filter
parameter" ;
 double Fgamma ;
       Fgamma:long_name = "Power-law shape barotropic filter
parameter" ;
 double nl_tnu2(tracer) ;
       nl_tnu2:long_name = "nonlinear model Laplacian mixing
coefficient for tracers" ;
       nl_tnu2:units = "meter2 second-1" ;
 double nl_visc2 ;
       nl_visc2:long_name = "nonlinear model Laplacian mixing
coefficient for momentum" ;
       nl_visc2:units = "meter2 second-1" ;
 double Akt_bak(tracer) ;
       Akt_bak:long_name = "background vertical mixing coefficient
for tracers" ;
       Akt_bak:units = "meter2 second-1" ;
 double Akv_bak ;
       Akv_bak:long_name = "background vertical mixing coefficient
for momentum" ;
       Akv_bak:units = "meter2 second-1" ;
 double rdrg ;
       rdrg:long_name = "linear drag coefficient" ;
       rdrg:units = "meter second-1" ;
 double rdrg2 ;
       rdrg2:long_name = "quadratic drag coefficient" ;
 double Zob ;
       Zob:long_name = "bottom roughness" ;
```

```
       Zob:units = "meter" ;
 double Zos ;
       Zos:long_name = "surface roughness" ;
       Zos:units = "meter" ;
 double Znudg ;
       Znudg:long_name = "free-surface nudging/relaxation inverse
time scale" ;
       Znudg:units = "day-1" ;
 double M2nudg ;
       M2nudg:long_name = "2D momentum nudging/relaxation inverse
time scale" ;
       M2nudg:units = "day-1" ;
 double M3nudg ;
       M3nudg:long_name = "3D momentum nudging/relaxation inverse
time scale" ;
       M3nudg:units = "day-1" ;
 double Tnudg(tracer) ;
       Tnudg:long_name = "Tracers nudging/relaxation inverse time
scale" ;
       Tnudg:units = "day-1" ;
 double FSobc_in(boundary) ;
       FSobc_in:long_name = "free-surface inflow, nudging inverse
time scale" ;
       FSobc_in:units = "second-1" ;
 double FSobc_out(boundary) ;
       FSobc_out:long_name = "free-surface outflow, nudging
inverse time scale" ;
       FSobc_out:units = "second-1" ;
 double M2obc_in(boundary) ;
       M2obc_in:long_name = "2D momentum inflow, nudging inverse
time scale" ;
       M2obc_in:units = "second-1" ;
 double M2obc_out(boundary) ;
       M2obc_out:long_name = "2D momentum outflow, nudging inverse
time scale" ;
       M2obc_out:units = "second-1" ;
 double Tobc_in(boundary, tracer) ;
       Tobc_in:long_name = "tracers inflow, nudging inverse time
scale" ;
       Tobc_in:units = "second-1" ;
 double Tobc_out(boundary, tracer) ;
       Tobc_out:long_name = "tracers outflow, nudging inverse time
scale" ;
       Tobc_out:units = "second-1" ;
 double M3obc_in(boundary) ;
       M3obc_in:long_name = "3D momentum inflow, nudging inverse
time scale" ;
       M3obc_in:units = "second-1" ;
 double M3obc_out(boundary) ;
       M3obc_out:long_name = "3D momentum outflow, nudging inverse
time scale" ;
       M3obc_out:units = "second-1" ;
 double rho0 ;
       rho0:long_name = "mean density used in Boussinesq
approximation" ;
       rho0:units = "kilogram meter-3" ;
 double gamma2 ;
       gamma2:long_name = "slipperiness parameter" ;
```

```
 int spherical ;
       spherical:long_name = "grid type logical switch" ;
       spherical:flag_values = 0, 1 ;
       spherical:flag_meanings = "Cartesian spherical" ;
 double xl ;
       xl:long_name = "domain length in the XI-direction" ;
       xl:units = "meter" ;
 double el ;
       el:long_name = "domain length in the ETA-direction" ;
       el:units = "meter" ;
 int Vtransform ;
       Vtransform:long_name = "vertical terrain-following
transformation equation" ;
 int Vstretching ;
       Vstretching:long_name = "vertical terrain-following
stretching function" ;
 double theta_s ;
       theta_s:long_name = "S-coordinate surface control
parameter" ;
 double theta_b ;
       theta_b:long_name = "S-coordinate bottom control parameter"
;
 double Tcline ;
       Tcline:long_name = "S-coordinate surface/bottom layer
width" ;
       Tcline:units = "meter" ;
 double hc ;
       hc:long_name = "S-coordinate parameter, critical depth" ;
       hc:units = "meter" ;
 double s_rho(s_rho) ;
       s_rho:long_name = "S-coordinate at RHO-points" ;
       s_rho:valid_min = -1. ;
       s_rho:valid_max = 0. ;
       s_rho:positive = "up" ;
       s_rho:standard_name = "ocean_s_coordinate_g2" ;
       s_rho:formula_terms = "s: s_rho C: Cs_r eta: zeta depth: h
depth_c: hc" ;
       s_rho:field = "s_rho, scalar" ;
 double s_w(s_w) ;
       s_w:long_name = "S-coordinate at W-points" ;
       s_w:valid_min = -1. ;
       s_w:valid_max = 0. ;
       s_w:positive = "up" ;
       s_w:standard_name = "ocean_s_coordinate_g2" ;
       s_w:formula_terms = "s: s_w C: Cs_w eta: zeta depth: h
depth_c: hc" ;
       s_w:field = "s_w, scalar" ;
 double Cs_r(s_rho) ;
       Cs_r:long_name = "S-coordinate stretching curves at RHO-
points" ;
       Cs_r:valid_min = -1. ;
       Cs_r:valid_max = 0. ;
       Cs_r:field = "Cs_r, scalar" ;
 double Cs_w(s_w) ;
       Cs_w:long_name = "S-coordinate stretching curves at W-
points" ;
       Cs_w:valid_min = -1. ;
       Cs_w:valid_max = 0. ;
```

```
      Cs_w:field = "Cs_w, scalar" ;
double user(Nuser) ;
      user:long_name = "user generic parameters" ;
      user:field = "user, scalar" ;
double h(eta_rho, xi_rho) ;
      h:long_name = "bathymetry at RHO-points" ;
      h:units = "meter" ;
      h:coordinates = "lon_rho lat_rho" ;
      h:field = "bath, scalar" ;
double f(eta_rho, xi_rho) ;
      f:long_name = "Coriolis parameter at RHO-points" ;
      f:units = "second-1" ;
      f:coordinates = "lon_rho lat_rho" ;
      f:field = "coriolis, scalar" ;
double pm(eta_rho, xi_rho) ;
      pm:long_name = "curvilinear coordinate metric in XI" ;
      pm:units = "meter-1" ;
      pm:coordinates = "lon_rho lat_rho" ;
      pm:field = "pm, scalar" ;
double pn(eta_rho, xi_rho) ;
      pn:long_name = "curvilinear coordinate metric in ETA" ;
      pn:units = "meter-1" ;
      pn:coordinates = "lon_rho lat_rho" ;
      pn:field = "pn, scalar" ;
double lon_rho(eta_rho, xi_rho) ;
      lon_rho:long_name = "longitude of RHO-points" ;
      lon_rho:units = "degree_east" ;
      lon_rho:standard_name = "longitude" ;
      lon_rho:field = "lon_rho, scalar" ;
double lat_rho(eta_rho, xi_rho) ;
      lat_rho:long_name = "latitude of RHO-points" ;
      lat_rho:units = "degree_north" ;
      lat_rho:standard_name = "latitude" ;
      lat_rho:field = "lat_rho, scalar" ;
double lon_u(eta_u, xi_u) ;
      lon_u:long_name = "longitude of U-points" ;
      lon_u:units = "degree_east" ;
      lon_u:standard_name = "longitude" ;
      lon_u:field = "lon_u, scalar" ;
double lat_u(eta_u, xi_u) ;
      lat_u:long_name = "latitude of U-points" ;
      lat_u:units = "degree_north" ;
      lat_u:standard_name = "latitude" ;
      lat_u:field = "lat_u, scalar" ;
double lon_v(eta_v, xi_v) ;
      lon_v:long_name = "longitude of V-points" ;
      lon_v:units = "degree_east" ;
      lon_v:standard_name = "longitude" ;
      lon_v:field = "lon_v, scalar" ;
double lat_v(eta_v, xi_v) ;
      lat_v:long_name = "latitude of V-points" ;
      lat_v:units = "degree_north" ;
      lat_v:standard_name = "latitude" ;
      lat_v:field = "lat_v, scalar" ;
double lon_psi(eta_psi, xi_psi) ;
      lon_psi:long_name = "longitude of PSI-points" ;
      lon_psi:units = "degree_east" ;
      lon_psi:standard_name = "longitude" ;
```

```
      lon_psi:field = "lon_psi, scalar" ;
 double lat_psi(eta_psi, xi_psi) ;
      lat_psi:long_name = "latitude of PSI-points" ;
      lat_psi:units = "degree_north" ;
      lat_psi:standard_name = "latitude" ;
      lat_psi:field = "lat_psi, scalar" ;
 double angle(eta_rho, xi_rho) ;
      angle:long_name = "angle between XI-axis and EAST" ;
      angle:units = "radians" ;
      angle:coordinates = "lon_rho lat_rho" ;
      angle:field = "angle, scalar" ;
 double mask_rho(eta_rho, xi_rho) ;
      mask_rho:long_name = "mask on RHO-points" ;
      mask_rho:flag_values = 0., 1. ;
      mask_rho:flag_meanings = "land water" ;
      mask_rho:coordinates = "lon_rho lat_rho" ;
 double mask_u(eta_u, xi_u) ;
      mask_u:long_name = "mask on U-points" ;
      mask_u:flag_values = 0., 1. ;
      mask_u:flag_meanings = "land water" ;
      mask_u:coordinates = "lon_u lat_u" ;
 double mask_v(eta_v, xi_v) ;
      mask_v:long_name = "mask on V-points" ;
      mask_v:flag_values = 0., 1. ;
      mask_v:flag_meanings = "land water" ;
      mask_v:coordinates = "lon_v lat_v" ;
 double mask_psi(eta_psi, xi_psi) ;
      mask_psi:long_name = "mask on psi-points" ;
      mask_psi:flag_values = 0., 1. ;
      mask_psi:flag_meanings = "land water" ;
      mask_psi:coordinates = "lon_psi lat_psi" ;
 double ocean_time(ocean_time) ;
      ocean_time:long_name = "time since initialization" ;
      ocean_time:units = "seconds since 2000-01-01 00:00:00" ;
      ocean_time:calendar = "gregorian" ;
      ocean_time:field = "time, scalar, series" ;
 float zeta(ocean_time, eta_rho, xi_rho) ;
      zeta:long_name = "free-surface" ;
      zeta:units = "meter" ;
      zeta:time = "ocean_time" ;
      zeta:coordinates = "lon_rho lat_rho ocean_time" ;
      zeta:field = "free-surface, scalar, series" ;
      zeta:_FillValue = 1.e+37f ;
 float ubar(ocean_time, eta_u, xi_u) ;
      ubar:long_name = "vertically integrated u-momentum
component" ;
      ubar:units = "meter second-1" ;
      ubar:time = "ocean_time" ;
      ubar:coordinates = "lon_u lat_u ocean_time" ;
      ubar:field = "ubar-velocity, scalar, series" ;
      ubar:_FillValue = 1.e+37f ;
 float vbar(ocean_time, eta_v, xi_v) ;
      vbar:long_name = "vertically integrated v-momentum
component" ;
      vbar:units = "meter second-1" ;
      vbar:time = "ocean_time" ;
      vbar:coordinates = "lon_v lat_v ocean_time" ;
      vbar:field = "vbar-velocity, scalar, series" ;
```

```
        vbar:_FillValue = 1.e+37f ;
 float u(ocean_time, s_rho, eta_u, xi_u) ;
        u:long_name = "u-momentum component" ;
        u:units = "meter second-1" ;
        u:time = "ocean_time" ;
        u:coordinates = "lon_u lat_u s_rho ocean_time" ;
        u:field = "u-velocity, scalar, series" ;
        u:_FillValue = 1.e+37f ;
 float v(ocean_time, s_rho, eta_v, xi_v) ;
        v:long_name = "v-momentum component" ;
        v:units = "meter second-1" ;
        v:time = "ocean_time" ;
        v:coordinates = "lon_v lat_v s_rho ocean_time" ;
        v:field = "v-velocity, scalar, series" ;
        v:_FillValue = 1.e+37f ;
 float temp(ocean_time, s_rho, eta_rho, xi_rho) ;
        temp:long_name = "potential temperature" ;
        temp:units = "Celsius" ;
        temp:time = "ocean_time" ;
        temp:coordinates = "lon_rho lat_rho s_rho ocean_time" ;
        temp:field = "temperature, scalar, series" ;
        temp:_FillValue = 1.e+37f ;
 float salt(ocean_time, s_rho, eta_rho, xi_rho) ;
        salt:long_name = "salinity" ;
        salt:time = "ocean_time" ;
        salt:coordinates = "lon_rho lat_rho s_rho ocean_time" ;
        salt:field = "salinity, scalar, series" ;
        salt:_FillValue = 1.e+37f ;
 float AKv(ocean_time, s_w, eta_rho, xi_rho) ;
        AKv:long_name = "vertical viscosity coefficient" ;
        AKv:units = "meter2 second-1" ;
        AKv:time = "ocean_time" ;
        AKv:coordinates = "lon_rho lat_rho s_w ocean_time" ;
        AKv:field = "AKv, scalar, series" ;
 float AKt(ocean_time, s_w, eta_rho, xi_rho) ;
        AKt:long_name = "temperature vertical diffusion
coefficient" ;
        AKt:units = "meter2 second-1" ;
        AKt:time = "ocean_time" ;
        AKt:coordinates = "lon_rho lat_rho s_w ocean_time" ;
        AKt:field = "AKt, scalar, series" ;
 float AKs(ocean_time, s_w, eta_rho, xi_rho) ;
        AKs:long_name = "salinity vertical diffusion coefficient" ;
        AKs:units = "meter2 second-1" ;
        AKs:time = "ocean_time" ;
        AKs:coordinates = "lon_rho lat_rho s_w ocean_time" ;
        AKs:field = "AKs, scalar, series" ;
 float shflux(ocean_time, eta_rho, xi_rho) ;
        shflux:long_name = "surface net heat flux" ;
        shflux:units = "watt meter-2" ;
        shflux:negative_value = "upward flux, cooling" ;
        shflux:positive_value = "downward flux, heating" ;
        shflux:time = "ocean_time" ;
        shflux:coordinates = "lon_rho lat_rho ocean_time" ;
        shflux:field = "surface heat flux, scalar, series" ;
        shflux:_FillValue = 1.e+37f ;
 float ssflux(ocean_time, eta_rho, xi_rho) ;
        ssflux:long_name = "surface net salt flux, (E-P)*SALT" ;
```

```
       ssflux:units = "meter second-1" ;
       ssflux:negative_value = "upward flux, freshening (net
precipitation)" ;
       ssflux:positive_value = "downward flux, salting (net
evaporation)" ;
       ssflux:time = "ocean_time" ;
       ssflux:coordinates = "lon_rho lat_rho ocean_time" ;
       ssflux:field = "surface net salt flux, scalar, series" ;
       ssflux:_FillValue = 1.e+37f ;
 float EminusP(ocean_time, eta_rho, xi_rho) ;
       EminusP:long_name = "bulk_flux surface net freswater flux,
(E-P)" ;
       EminusP:units = "meter second-1" ;
       EminusP:negative_value = "upward flux, freshening (net
precipitation)" ;
       EminusP:positive_value = "downward flux, salting (net
evaporation)" ;
       EminusP:time = "ocean_time" ;
       EminusP:coordinates = "lon_rho lat_rho ocean_time" ;
       EminusP:field = "EminusP, scalar, series" ;
       EminusP:_FillValue = 1.e+37f ;
 float sustr(ocean_time, eta_u, xi_u) ;
       sustr:long_name = "surface u-momentum stress" ;
       sustr:units = "newton meter-2" ;
       sustr:time = "ocean_time" ;
       sustr:coordinates = "lon_u lat_u ocean_time" ;
       sustr:field = "surface u-momentum stress, scalar, series" ;
       sustr:_FillValue = 1.e+37f ;
 float svstr(ocean_time, eta_v, xi_v) ;
       svstr:long_name = "surface v-momentum stress" ;
       svstr:units = "newton meter-2" ;
       svstr:time = "ocean_time" ;
       svstr:coordinates = "lon_v lat_v ocean_time" ;
       svstr:field = "surface v-momentum stress, scalar, series" ;
       svstr:_FillValue = 1.e+37f ;

// global attributes:
       :file = "hiig_his.nc" ;
       :format = "netCDF-3 classic file" ;
       :Conventions = "CF-1.4" ;
       :type = "ROMS/TOMS history file" ;
       :title = "HIIG FORE" ;
       :rst_file = "hiig_rst.nc" ;
       :his_file = "hiig_his.nc" ;
       :avg_file = "hiig_avg.nc" ;
       :sta_file = "hiig_sta.nc" ;
       :grd_file = "../grid/roms-hiig-grid-ncom.nc" ;
       :ini_file = "ini.nc" ;
       :frc_file_01 = "hiig-frc.nc" ;
       :frc_file_02 = "../ncfiles/qcorr_wrf.nc" ;
       :frc_file_03 = "../ncfiles/ncom-sss.nc" ;
       :frc_file_04 = "tide.nc" ;
       :bry_file = "hiig-bry.nc" ;
       :clm_file = "hiig-clim.nc" ;
       :script_file =
"/share/forecast/ocean/pacioos/hawaii/work/ocean.in" ;
```

```
       :spos_file =
"/share/forecast/ocean/pacioos/hawaii/roms/nlm-
hiig/hiog_stations.in" ;
       :svn_url = "https:://myroms.org/svn/src" ;
       :svn_rev = "Unversioned directory" ;
       :code_dir = "/share/forecast/ocean/roms/src" ;
       :header_dir = "/share/forecast/ocean/pacioos/roms/nlm-hiig"
;
       :header_file = "hiig.h" ;
       :os = "Linux" ;
       :cpu = "x86_64" ;
       :compiler_system = "ifort" ;
       :compiler_command = "/share/apps/openmpi-ifort/bin/mpif90"
;
       :compiler_flags = "-heap-arrays -ip -O3 -free" ;
       :tiling = "008x008" ;
       :history = "ROMS/TOMS, Version 3.4, Monday - August 19,
2013 -  9:15:22 AM" ;
       :ana_file = "/share/forecast/ocean/pacioos/roms/nlm-
hiig/../include/ana_btflux.h,
/share/forecast/ocean/pacioos/roms/nlm-
hiig/../include/ana_hmixcoef.h,
/share/forecast/ocean/pacioos/roms/nlm-
hiig/../include/ana_nudgcoef.h" ;
       :CPP_options = "hiig, ADD_FSOBC, ADD_M2OBC, ANA_BSFLUX,
ANA_BTFLUX, ASSUMED_SHAPE, AVERAGES, BULK_FLUXES, CLIMA_TS_MIX,
CURVGRID, DIFF_GRID, DJ_GRADPS, DOUBLE_PRECISION, EAST_FSCHAPMAN,
EAST_M2FLATHER, EAST_M3NUDGING, EAST_M3RADIATION, EAST_TNUDGING,
EAST_TRADIATION, EMINUSP, LMD_CONVEC, LMD_MIXING, LMD_NONLOCAL,
LMD_RIMIX, LMD_SHAPIRO, LMD_SKPP, LMD_SPLINE LONGWAVE_OUT,
M3CLIMATOLOGY, M3CLM_NUDGING, MASKING, MIX_GEO_TS, MIX_S_UV, MPI,
NONLINEAR, NONLIN_EOS, NORTH_FSCHAPMAN, NORTH_M2FLATHER,
NORTH_M3NUDGING, NORTH_M3RADIATION, NORTH_TNUDGING,
NORTH_TRADIATION, PERFECT_RESTART, POWER_LAW, PROFILE,
QCORRECTION, RADIATION_2D, RI_HORAVG, RI_VERAVG, !RST_SINGLE,
SALINITY, SOLAR_SOURCE, SOLVE3D, SOUTH_FSCHAPMAN, SOUTH_M2FLATHER,
SOUTH_M3NUDGING, SOUTH_M3RADIATION, SOUTH_TNUDGING,
SOUTH_TRADIATION, SPONGE, SSH_TIDES, STATIONS, TCLIMATOLOGY,
TCLM_NUDGING, TS_U3HADVECTION, TS_C4VADVECTION, TS_DIF2, UV_ADV,
UV_COR, UV_U3HADVECTION, UV_C4VADVECTION, UV_LDRAG, UV_TIDES,
UV_VIS2, VAR_RHO_2D, VISC_GRID, WEST_FSCHAPMAN, WEST_M2FLATHER,
WEST_M3NUDGING, WEST_M3RADIATION, WEST_TNUDGING, WEST_TRADIATION"
;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
hc	S-coordinate parameter, critical depth			meter
Cs_r(s_rho)	S-coordinate stretching curves at RHO-points			
h(eta_rho,xi_rho)	bathymetry at RHO-points		sea_floor_depth	meter

angle(eta_rho,xi_rho)	angle between XI-axis and EAST			radians
mask_rho(eta_rho,xi_rho)	mask on RHO-points			
mask_u(eta_u,xi_u)	mask on U-points			
mask_v(eta_v,xi_v)	mask on V-points			
zeta(time,eta_rho,xi_rho)	free-surface		sea_surface_height	meter
u(time,s_rho,eta_u,xi_u)	u-velocity component		eastward_sea_water_velocity	meter sec-1
v(time,s_rho,eta_v,xi_v)	v-velocity component		northward_sea_water_velocity	meter sec-1
temp(time,s_rho,eta_rho,xi_rho)	potential temperature		sea_water_potential_temperature	Celcius
salt(time,s_rho,eta_rho,xi_rho)	salinity		sea_water_salinity	1e-3
time_offset(time)	offset hour from start of run		forecast_period	hours since 2011-03-25T00:00:00Z
s_rho(s_rho)	S-coordinate at RHO-points		ocean_s_coordinate_g2	
lon_rho(eta_rho,xi_rho)	longitude of RHO-points		longitude	degrees_east
lat_rho(eta_rho,xi_rho)	latitude of RHO-points		latitude	degrees_north
lon_u(eta_u,xi_u)	longitude of U-points		longitude	degrees_east
lat_u(eta_u,xi_u)	latitude of U-points		latitude	degrees_north
lon_v(eta_v,xi_v)	longitude of V-points		longitude	degrees_north
lat_v(eta_v,xi_v)	latitude of V-points		latitude	degrees_east
ocean_time(ocean_time)	time since initialization			seconds since 2000-01-01 00:00:00
time(time)	Forecast time for ForecastModelRunCollection		time	hours since 2011-03-25T00:00:00Z
time_run(time)	run times for coordinate time		forecast_reference_time	hours since 2011-03-25T00:00:00Z

Table 36. Ocean model variable definitions.

5. Data distribution[30]

Regional Ocean Modeling System (ROMS): Waikiki

- Metadata: http://pacioos.org/metadata/roms_hiomsag_forecast.html
- Voyager: http://pacioos.org/voyager_dev/index.html?b=21.209486%2C-158.01104%2C21.373269%2C-157.7187&t=h&o=ofore:1:f:d9
- THREDDS: http://oos.soest.hawaii.edu/thredds/catalog/hioos/roms_forec/hiomsag/catalog.html?dataset=roms_hiomsag_forecast/ROMS_Waikiki_Regional_Ocean_Model_best.ncd
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=hiroms_hiomsag&varid=temp-hiroms_hiomsag
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/roms_forec/hiomsag/ROMS_Waikiki_Regional_Ocean_Model_best.ncd?service=WMS&version=1.3.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/roms_forec/hiomsag/ROMS_Waikiki_Regional_Ocean_Model_best.ncd/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/roms_forec/hiomsag/ROMS_Waikiki_Regional_Ocean_Model_best.ncd.html

I. Model output (Tide)

1. Data flow

PacIOOS serves output from two tide models. One is a barotropic model run for the entire Pacific. This model is based on code from the Oregon State University (OSU Tidal Prediction Software, or OTPS). The original program works on single points, and this was modified to work on the Pacific basin at 2°x2° intervals. A series of FORTRAN programs are compiled and then run on a local machine. The output is then modified with two additional steps. First, **`ncap`** is used to convert the time to be sequential minutes since January 1, 2011. Second, **`ncatted`** is used to convert the variable names and attributes to be CF compliant.

The second tide model run by PacIOOS is a fully-baroclinic model for the Hawaiian Islands. This model is based on Matlab code supplied by Glenn Carter. The harmonics are computed from seasonal-mean stratification. Similar to the Pacific bartropic model, the baroclinic model is run each year to provide a yearly forecast. The output are also hourly, but the horizontal grid is more fine, roughly 1x1 km. Because of this, two domains are run separately, one for the Big Island and the other for the rest of the main Hawaiian Islands. This model output also requires some conversion. The raw output is in flat IEEE binary (GrADS format). The GrADS files

[30] Only one model domain is given as an example here; all domains are available in a similar way using the same services but with different specifications (*e.g.,* roms_hiig instead of roms_hiomsg, *etc.*).

are converted to NetCDF using `conv_netcdf.gs`, then the times are modified with **`change_time.s`** (basically using **`ncap`**) and **`change_attrib.s`** (using **`ncatted`**).

2. File naming convention

The Pacific (barotropic) model produces daily files with hourly output. The output files are of the form `Pactide_`*`yyyy_mm_dd`*`.nc`, where *`yyyy`* is the 4-digit year, *`mm`* is the 2-digit month and *`dd`* is the 2-digit day of the month. The model grid is 2°x2° (higher resolution could be run but it would be computationally expensive), and the domain is 66°S to 66°N, 118°E to 70°W or roughly the entire Pacific. The output are stored in `/export/lawelawe1/model/tide/pacific`.

Results from the regional (baroclinic) model are stored in `/export/lawelawe1/model/tide/netcdf_data/`*`aa`*`/AAtide_`*`yyyy_mm_dd`*`.nc` where *`aa`* is the location (either `bi` or `mhi`), *`yyyy`* is the 4-digit year, *`mm`* is the 2-digit month, and *`dd`* is the two digit day.

Grid	Pacific	Kauai-Oahu-Maui	Big Island
Lon range	118°E to 70°W	160.69°W to 155.49°W	156.73°W to 154.01°W
Lon res	2°	1.0 km	1.0 km
Lon points	87	521	273
Lat range	66°S to 66°N	20.48° to 22.89°N	18.13° to 22.33°N
Lat res	2°	1.0 km	1.0 km
Lat points	67	242	221
Depth levels	1 (barotropic)	3	3
Time range	daily	daily	daily
Time res	hourly	hourly	hourly
Time points	24	24	24
Time start	01-01-2011	01-01-2008	01-21-2008
File size	3,362,400	169,461,852	81,093,044
File name	`Pactide_*_*_*.nc`	`MHItide_*_*_*.nc`	`BItide_*_*_*.nc`

Table 37. Time model specifications (note the Pacific domain is a barotropic model; the other two are baroclinic).

3. Data format specification

Pacific (barotropic) model:

```
netcdf Pactide_2013_12_31 {
dimensions:
 time = 24 ;
 lon = 87 ;
 lat = 67 ;
 lev = 1 ;
variables:
 double time(time) ;
       time:long_name = "Time" ;
       time:units = "minutes since 2011-01-01 00:00" ;
 double lon(lon) ;
```

```
        lon:units = "degrees_east" ;
        lon:long_name = "Longitude" ;
        lon:standard_name = "longitude" ;
 double lat(lat) ;
        lat:units = "degrees_north" ;
        lat:long_name = "Latitude" ;
        lat:standard_name = "latitude" ;
 double ssh(time, lat, lon) ;
        ssh:_FillValue = -999.99 ;
        ssh:units = "meters" ;
        ssh:long_name = "tidal elevation" ;
        ssh:standard_name = "sea_surface_height" ;
        ssh:missing_value = -999.99f ;
 double lev(lev) ;
        lev:units = "1" ;
        lev:long_name = "Level" ;
        lev:positive = "down" ;
 double u(time, lev, lat, lon) ;
        u:_FillValue = -999.99 ;
        u:units = "meter second-1" ;
        u:long_name = "u-velocity component" ;
        u:standard_name = "eastward_sea_water_velocity" ;
        u:missing_value = -999.99f ;
 double v(time, lev, lat, lon) ;
        v:_FillValue = -999.99 ;
        v:units = "meter second-1" ;
        v:long_name = "v-velocity component" ;
        v:standard_name = "northward_sea_water_velocity" ;
        v:missing_value = -999.99f ;

// global attributes:
        :history = "Fri Dec 21 09:59:55 2012: ncatted -a
missing_value,v,c,f,-999.99
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
standard_name,v,c,c,northward_sea_water_velocity
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
long_name,v,c,c,v-velocity component
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
units,v,c,c,meter second-1 ./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
missing_value,u,c,f,-999.99
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
standard_name,u,c,c,eastward_sea_water_velocity
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
long_name,u,c,c,u-velocity component
./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
units,u,c,c,meter second-1 ./netcdf_data/Pactide_2013_12_31.nc\n",
              "Fri Dec 21 09:59:55 2012: ncatted -a
missing_value,ssh,c,f,-999.99
./netcdf_data/Pactide_2013_12_31.nc\n",
```

```
            "Fri Dec 21 09:59:55 2012: ncatted -a
standard_name,ssh,c,c,sea_surface_height
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
long_name,ssh,c,c,tidal elevation
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
units,ssh,c,c,meters ./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
positive,lev,c,c,down ./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
long_name,lev,c,c,model level number
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a units,lev,m,c,1
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
units,time,c,c,minutes since 2011-01-01 00:00
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
long_name,time,c,c,Time ./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
standard_name,lat,c,c,latitude
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:59:55 2012: ncatted -a
standard_name,lon,c,c,longitude
./netcdf_data/Pactide_2013_12_31.nc\n",
            "Fri Dec 21 09:55:19 2012: ncap -s
time[time]=time+1576800 ./netcdf_data/Pactide_2013_12_31.nc
temp.nc" ;
}
```

Regional (baroclinic) model:

```
2013_12_31.nc
netcdf MHItide_2013_12_31 {
dimensions:
 longitude = 521 ;
 latitude = 242 ;
 depth = 3 ;
 time = UNLIMITED ; // (24 currently)
variables:
 double longitude(longitude) ;
       longitude:units = "degrees_east" ;
       longitude:long_name = "longitude" ;
       longitude:standard_name = "longitude" ;
 double latitude(latitude) ;
       latitude:units = "degrees_north" ;
       latitude:long_name = "latitude" ;
       latitude:standard_name = "latitude" ;
 byte depth(depth) ;
       depth:units = "%" ;
       depth:positive = "down" ;
       depth:long_name = "percent depth" ;
 double v(time, depth, latitude, longitude) ;
       v:units = "meter second-1" ;
       v:long_name = "v-velocity component" ;
       v:standard_name = "northward_sea_water_velocity" ;
       v:missing_value = -999.99f ;
```

```
        v:_FillValue = -999.99f ;
    double u(time, depth, latitude, longitude) ;
        u:units = "meter second-1" ;
        u:long_name = "u-velocity component" ;
        u:standard_name = "eastward_sea_water_velocity" ;
        u:missing_value = -999.99f ;
        u:_FillValue = -999.99f ;
    double time(time) ;
        time:units = "minutes since 2008-01-01 00:00" ;
        time:long_name = "time" ;
    double ssh(time, latitude, longitude) ;
        ssh:units = "meters" ;
        ssh:long_name = "tidal elevation" ;
        ssh:standard_name = "sea_surface_height" ;
        ssh:missing_value = -999.99f ;
        ssh:_FillValue = -999.99f ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
time(time)	Time			minutes since 2011-01-01 00:00
lon(lon)	Longitude		longitude	degrees_east
lat(lat)	Latitude		latitude	degrees_north
ssh(time,lat,lon)	tidal elevation		sea_surface_height	meters
lev(lev)	Level			
u(time,lev,lat,lon)	u-velocity component		eastward_sea_water_velocity	meter second-1
v(time,lev,lat,lon)	v-velocity component		northward_sea_water_velocity	meter second-1

Table 38. Pacific (brotropic) model specifics.

Variable	Long name	Short name	Standard Name	Units
longitude(longitude)	longitude		longitude	degrees_east
latitude(latitude)	latitude		latitude	degrees_north
depth(depth)	percent depth			%
v(time,depth,latitude,longitude)	v-velocity component		northward_sea_water_velocity	meter sec-1
u(time,depth,latitude,longitude)	u-velocity component		eastward_sea_water_velocity	meter sec-1
time(time)	time			minutes since 2008-01-01 00:00
ssh(time,latitude,longitude)	tidal elevation		sea_surface_height	meters

Table 39. Regional (baroclinic) model specifics.

5. Data distribution[31]

Barotropic Tide Model for the Pacific Basin

- Metadata: http://pacioos.org/metadata/tide_pac.html
- Voyager: http://pacioos.org/voyager/index.html?b=-66.861082%2C54.140625%2C66.861082%2C-6.152344&o=tfore:3:ft:d1
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/tide_mod.html?dataset=tide_pac
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/tide_pac_elev.graph
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/tide_pac.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=tide_pac&varid=ssh-tide_pac
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=908878c9491a24d94cb32038ca5dab
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/tide_pac?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hioos/tide_pac?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/tide_pac/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/tide_pac.html

J. Shark tracking

1. Data flow

Argos sends daily e-mails with tag locations, which are manually screened to discard bogus data points that are on land or that exceed the expected swim rate of ~4 mph. Data that passes the screen are uploaded to a custom Python CGI web interface for translation to GeoJSON format. GeoJSON files are read by PacIOOS Voyager, where custom JavaScript allows the public to map and animate tracks on top of the Google Maps API.

2. File naming convention

No files are created or stored on the local machine.

3. Data format specification

N/A

4. Data vocabulary

N/A

[31] Only one model domain is given as an example here; all domains are available in a similar way using the same services but with different specifications (*e.g.,* tide_mhi instead of tide_pac, *etc.*).

5. Data distribution

N/A

K. Data obtained from non-PacIOOS providers (ACO)

1. Data flow

The ALOHA Cabled Observatory (ACO) has numerous instruments reporting in real-time. At present, PacIOOS is only receiving the data from the Acoustic Doppler Profiler (ADP). The ACO group produces files every 8 hours in netCDF format, so PacIOOS just transfers these files and serves them without modification. The files are copied from `mana.soest.hawaii.edu` by **`ftp`**. This is done once per day at 18:00 HST via the cron script **`get_adp_data.s`**. Files are transferred to `/export/lawelawe1/aco/adcp/`*`yyyy`*`/`*`mm`* where *`yyyy`* is the four digit year and *`mm`* is the two digit month. Files contain data every 2 seconds over an 8 hour period.

2. File naming convention

Files are named by date, e.g., `adp5_20130828_08_16.nc`, for August 28, 2013 for 08:00 to 16:00. Files are approximately 7MB for a total of about 8GB per year. The archive starts in June 2011.

3. Data format specification

```
netcdf adp5_20120828_08_16 {
dimensions:
 TIME = UNLIMITED ; // (14138 currently)
 DEPTH = 20 ;
 LATITUDE = 1 ;
 LONGITUDE = 1 ;
variables:
 double TIME(TIME) ;
       TIME:FillValue = -99999. ;
       TIME:units = "days since 1950-01-01T00:00:00Z" ;
       TIME:standard_name = "time" ;
       TIME:long_name = "time" ;
       TIME:axis = "T" ;
       TIME:valid_min = 0. ;
       TIME:valid_max = 90000. ;
 double LATITUDE(LATITUDE) ;
       LATITUDE:FillValue = -99999. ;
       LATITUDE:units = "degrees_north" ;
       LATITUDE:standard_name = "latitude" ;
       LATITUDE:long_name = "Latitude of each location" ;
       LATITUDE:axis = "Y" ;
       LATITUDE:valid_min = -90. ;
       LATITUDE:valid_max = 90. ;
 double LONGITUDE(LONGITUDE) ;
       LONGITUDE:FillValue = -99999. ;
       LONGITUDE:units = "degrees_east" ;
       LONGITUDE:standard_name = "longitude" ;
       LONGITUDE:long_name = "Longitude of each location" ;
       LONGITUDE:axis = "X" ;
       LONGITUDE:valid_min = -180. ;
       LONGITUDE:valid_max = 180. ;
```

```
 float DEPTH(DEPTH) ;
       DEPTH:FillValue = -9999. ;
       DEPTH:units = "meters" ;
       DEPTH:standard_name = "depth" ;
       DEPTH:long_name = "Depth of each location" ;
       DEPTH:positive = "down" ;
       DEPTH:axis = "Z" ;
       DEPTH:valid_min = 0. ;
       DEPTH:valid_max = 6000. ;
 float TEMP(TIME) ;
       TEMP:FillValue = -999. ;
       TEMP:missing_value = -999. ;
       TEMP:units = "degree_Celsius" ;
       TEMP:standard_name = "sea_water_temperature" ;
       TEMP:long_name = "sea water temperature" ;
       TEMP:QC_indicator = 0. ;
       TEMP:QC_procedure = 0. ;
       TEMP:valid_min = -2. ;
       TEMP:valid_max = 40. ;
       TEMP:comment = "In-situ sea water temperature using
International Temperature Scale of 1990" ;
       TEMP:sensor_depth = 4726.2 ;
       TEMP:sensor_mount = "mounted_on_benthic_node" ;
       TEMP:sensor_name = "SonTek 250 KHz" ;
       TEMP:sensor_serial_number = "C117" ;
       TEMP:accuracy = 0.02 ;
       TEMP:resolution = 0.01 ;
       TEMP:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       TEMP:DM_indicator = "D" ;
       TEMP:reference_scale = "ITS-90" ;
 float UCUR(TIME, DEPTH) ;
       UCUR:FillValue = -999. ;
       UCUR:missing_value = -999. ;
       UCUR:units = "meters/second" ;
       UCUR:standard_name = "eastward_sea_water_velocity" ;
       UCUR:long_name = "current east component" ;
       UCUR:positive = "east" ;
       UCUR:valid_min = -2. ;
       UCUR:valid_max = 2. ;
       UCUR:comment = "All suspect or bad data have been replaced
with FillValue" ;
       UCUR:sensor_depth = 4726.2 ;
       UCUR:sensor_mount = "mounted_on_benthic_node" ;
       UCUR:sensor_name = "SonTek 250 KHz" ;
       UCUR:sensor_serial_number = "C117" ;
       UCUR:sensor_orientation = "upward" ;
       UCUR:accuracy = 0.005 ;
       UCUR:resolution = 0.001 ;
       UCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       UCUR:DM_indicator = "D" ;
 float VCUR(TIME, DEPTH) ;
       VCUR:FillValue = -999. ;
       VCUR:missing_value = -999. ;
       VCUR:units = "meters/second" ;
       VCUR:standard_name = "northward_sea_water_velocity" ;
       VCUR:long_name = "current north component" ;
```

```
       VCUR:positive = "north" ;
       VCUR:valid_min = -2. ;
       VCUR:valid_max = 2. ;
       VCUR:comment = "All suspect or bad data have been replaced
with FillValue" ;
       VCUR:sensor_depth = 4726.2 ;
       VCUR:sensor_mount = "mounted_on_benthic_node" ;
       VCUR:sensor_name = "SonTek 250 KHz" ;
       VCUR:sensor_serial_number = "C117" ;
       VCUR:sensor_orientation = "upward" ;
       VCUR:accuracy = 0.005 ;
       VCUR:resolution = 0.001 ;
       VCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       VCUR:DM_indicator = "D" ;
 float WCUR(TIME, DEPTH) ;
       WCUR:FillValue = -999. ;
       WCUR:missing_value = -999. ;
       WCUR:units = "meters/second" ;
       WCUR:long_name = "current upward component" ;
       WCUR:positive = "upward" ;
       WCUR:valid_min = -2. ;
       WCUR:valid_max = 2. ;
       WCUR:comment = "All suspect or bad data have been replaced
with FillValue" ;
       WCUR:sensor_depth = 4726.2 ;
       WCUR:sensor_mount = "mounted_on_benthic_node" ;
       WCUR:sensor_name = "SonTek 250 KHz" ;
       WCUR:sensor_serial_number = "C117" ;
       WCUR:sensor_orientation = "upward" ;
       WCUR:accuracy = 0.005 ;
       WCUR:resolution = 0.001 ;
       WCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       WCUR:DM_indicator = "D" ;
 float RUCUR(TIME, DEPTH) ;
       RUCUR:FillValue = -999. ;
       RUCUR:missing_value = -999. ;
       RUCUR:units = "meters/second" ;
       RUCUR:long_name = "raw current east component" ;
       RUCUR:positive = "east" ;
       RUCUR:valid_min = -2. ;
       RUCUR:valid_max = 2. ;
       RUCUR:sensor_depth = 4726.2 ;
       RUCUR:sensor_mount = "mounted_on_benthic_node" ;
       RUCUR:sensor_name = "SonTek 250 KHz" ;
       RUCUR:sensor_serial_number = "C117" ;
       RUCUR:sensor_orientation = "upward" ;
       RUCUR:accuracy = 0.005 ;
       RUCUR:resolution = 0.001 ;
       RUCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       RUCUR:DM_indicator = "D" ;
 float RVCUR(TIME, DEPTH) ;
       RVCUR:FillValue = -999. ;
       RVCUR:missing_value = -999. ;
       RVCUR:units = "meters/second" ;
       RVCUR:long_name = "raw current north component" ;
```

```
       RVCUR:positive = "north" ;
       RVCUR:valid_min = -2. ;
       RVCUR:valid_max = 2. ;
       RVCUR:sensor_depth = 4726.2 ;
       RVCUR:sensor_mount = "mounted_on_benthic_node" ;
       RVCUR:sensor_name = "SonTek 250 KHz" ;
       RVCUR:sensor_serial_number = "C117" ;
       RVCUR:sensor_orientation = "upward" ;
       RVCUR:accuracy = 0.005 ;
       RVCUR:resolution = 0.001 ;
       RVCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       RVCUR:DM_indicator = "D" ;
 float RWCUR(TIME, DEPTH) ;
       RWCUR:FillValue = -999. ;
       RWCUR:missing_value = -999. ;
       RWCUR:units = "meters/second" ;
       RWCUR:long_name = "raw current upward component" ;
       RWCUR:positive = "upward" ;
       RWCUR:valid_min = -2. ;
       RWCUR:valid_max = 2. ;
       RWCUR:sensor_depth = 4726.2 ;
       RWCUR:sensor_mount = "mounted_on_benthic_node" ;
       RWCUR:sensor_name = "SonTek 250 KHz" ;
       RWCUR:sensor_serial_number = "C117" ;
       RWCUR:sensor_orientation = "upward" ;
       RWCUR:accuracy = 0.005 ;
       RWCUR:resolution = 0.001 ;
       RWCUR:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       RWCUR:DM_indicator = "D" ;
 byte CUR_QC(TIME, DEPTH) ;
       CUR_QC:long_name = "velocity quality flag" ;
       CUR_QC:conventions = "OceanSITES reference table 2" ;
       CUR_QC:comment = "Current velocity quality flag applicable
to Eastward, Northward and Upward velocities. Velocities are
flagged bad if the amplitude is excessively low or high. An
amplitude is high if it exceeds the average of the ping before and
the ping after by 20 counts. An amplitude is low if less than 6
counts. After this the velocities are flagged bad if the absolute
deviation of the vertical velocity from its ensemble median
exceeds 0.15 m/s or if its value is less than -0.25 m/s" ;
       CUR_QC:valid_min = 0. ;
       CUR_QC:valid_max = 9. ;
       CUR_QC:flag_values = 0., 1., 2., 3., 4., 5., 7., 8., 9. ;
       CUR_QC:flag_meanings = "no_qc_performed good_data
probably_good_data bad_data_that_are_potentially_correctable
bad_data value_changed nominal_value interpolated_value
missing_value" ;
 short EAMP(TIME, DEPTH) ;
       EAMP:FillValue = -999. ;
       EAMP:missing_value = -999. ;
       EAMP:units = "counts (1 count = 0.43 dB)" ;
       EAMP:long_name = "echo_amplitude" ;
       EAMP:QC_indicator = 0. ;
       EAMP:QC_procedure = 0. ;
       EAMP:valid_min = 0. ;
       EAMP:valid_max = 200. ;
```

```
       EAMP:comment = "4-beams average amplitude per cell" ;
       EAMP:cell_methods = "TIME:point DEPTH:point LATITUDE:point
LONGITUDE:point" ;
       EAMP:DM_indicator = "D" ;

// global attributes:
       :description = "OceanSITES time-series data" ;
       :data_type = "OceanSITES time-series data" ;
       :format_version = "1.2" ;
       :platform_code = "ACO" ;
       :date_update = "2013-01-04T13:35:34Z" ;
       :institution = "Department of Oceanography/University of
Hawaii" ;
       :site_code = "ALOHA" ;
       :source = "Mooring observation" ;
       :history = "2012-08-28T16:00:00Z Data Collected, B.Howe,
R.Lukas" ;
       :data_mode = "D" ;
       :quality_control_indicator = "1" ;
       :quality_index = "1" ;
       :references = "http://www.oceansites.org, http://aco-
ssds.soest.hawaii.edu" ;
       :comment = "Current velocity at the ACO from a 250 kHz
SonTek ADP at 1.83 m above the bottom." ;
       :Conventions = "OceanSITES 1.2" ;
       :Netcdf_version = "4.0.1" ;
       :title = "Time-series Currents Data from the ALOHA Cabled
Observatory" ;
       :summary = "Oceanographic data collected at the ALOHA
Cabled Observatory deployed June, 2011. Location is approx. 100 km
north of Oahu, Hawaii. Measured properties: Current velocities
(Eastward, Northward, and Upward) and Temperature." ;
       :naming_authority = "OceanSITES" ;
       :id =
"/home/mana1/ftp/pub/aco/adp/2012/08/adp5_20120828_08_16." ;
       :cdm_data_type = "Station" ;
       :area = "Tropical Pacific Ocean" ;
       :geospatial_vertical_positive = "down" ;
       :geospatial_lat_min = 22.7387 ;
       :geospatial_lat_max = 22.7387 ;
       :geospatial_lon_min = -158.0062 ;
       :geospatial_lon_max = -158.0062 ;
       :geospatial_vertical_min = 4555.5 ;
       :geospatial_vertical_max = 4707.5 ;
       :time_coverage_start = "2012-08-28T08:00:00Z" ;
       :time_coverage_end = "2012-08-28T16:00:00Z" ;
       :institution_references = "http://aco-
ssds.soest.hawaii.edu" ;
       :contact = "rlukas@hawaii.edu" ;
       :author = "Fernando Santiago-Mandujano" ;
       :pi_name = "Bruce Howe, Roger Lukas" ;
       :distribution_statement = "Following CLIVAR standards, cf.
www.clivar.org/data/data_policy.php. Data available free of
charge. User assumes all risk for use of data. User must display
citation in any publication or product using data. User must
contact PI prior to any commercial use of data" ;
       :citation = "These data were collected and made freely
available by the ALOHA Cable Observatory under the University of
```

```
Hawaii (UH) National Science Foundation (NSF) project OCE 0216164,
0652430 and 0939570" ;
       :update_interval = "8 hours" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
TIME(TIME)	time		time	days since 1950-01-01T00:00:00Z
LATITUDE(LATITUDE)	Latitude of each location		latitude	degrees_north
LONGITUDE(LONGITUDE)	Longitude of each location		longitude	degrees_east
DEPTH(DEPTH)	Depth of each location		depth	meters
TEMP(TIME)	sea water temperature		sea_water_temperature	degree_Celsius
UCUR(TIME,DEPTH)	current east component		eastward_sea_water_velocity	meters/second
VCUR(TIME,DEPTH)	current north component		northward_sea_water_velocity	meters/second
WCUR(TIME,DEPTH)	current upward component			meters/second
RUCUR(TIME,DEPTH)	raw current east component			meters/second
RVCUR(TIME,DEPTH)	raw current north component			meters/second
RWCUR(TIME,DEPTH)	raw current upward component			meters/second
CUR_QC(TIME,DEPTH)	velocity quality flag			
EAMP(TIME,DEPTH)	echo_amplitude			counts

Table 40. ACO variable definitions.

5. Data distribution

ALOHA Cabled Observatory (ACO) Observations

- Metadata: http://pacioos.org/metadata/aco_adcp_agg.html
- Voyager: http://pacioos.org/voyager/index.html?o=obs:3
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/aco.html?dataset=aco_adcp_agg
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/pacioos/aco/adcp_agg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/aco_adcp_temp.html
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/aco_adcp_vel.html

L. Data obtained from non-PacIOOS providers (AIS)

1. Data flow

AIS files were obtained from ORBCOMM via their ftp site ftp.orbcomm.com (username is **xxxxx**, password is **xxxxx**). The files are in two forms, one is a so-called "long report" (type-5 message), and the others are "unchecked reports" (type-3 message). The long messages have "all_type5-raw" in the filename, while the unchecked reports have "posits-raw" in the filename.

The filenames have the form `ORBCOMM_1_0_`*`yyyymmdd_HHMMSS`*`-`*`yyyymmdd_HHMMSS`* where *`yyyymmdd`* is year, month, day and *`HHMMSS`* is hour, minute, second. We received files for August 2011 through June 2012 (note that the June 2012 file appears to end in the 19th).

The two types of files are in a raw, message format. An example line from the long messages is:

```
\g:1-2-
8588,s:rORBCOMM00,c:1312156951*6c\!AIVDM,2,1,2,A,55NM<jT2
BhqUL@KKWW9<4hU<R22222222222220t0i@8840Ht00000000000,0*23
```

and from the unchecked reports:

```
\s:rORBCOMM00u,c:1312156951*66\!AIVDM,1,1,,A,15Mqjl0000Ji
OKTGKa4bPl:f0408,0*3C
```

The files were converted to ASCII using **`gpsd-2.9.2`**. This converts GPS or Loran-2 type messages into ASCII. The script decode_data.s reads each input file and creates ASCII files named, `long_report_`*`mm_yyyy`*`.dat` and `unchecked_report_`*`mm_yyyy`*`.dat`.

These converted files have comma-delimited columns with the following variables:

unchecked reports:
sample line: 3,0,265887000,5,0,0,0,-1801550,32059700,1280,267,55,0x0,0,0x0

- col 1: 3 (message ID, can be 1, 2 or 3)
- col 2: 0 (repeat indicator, 0 is default)
- col 3: 265887000 (ship ID)
- col 4: 5 (navigational status, 0=underway w/ engine; 1=at anchor; 2=not under command; 3=restricted manoeuvrability; 4=constrained by draught; 5=moored; 6=aground; 7=engaged in fishing; 8=underway w/sail)
- col 5: 0 (rate of turn)
- col 6: 0 (speed over ground in 1/10 kts)
- col 7: 0 (position accuracy, 1=high; 0=low)
- col 8: -1801550 (longitude in 1/10000 minutes, +/-180)
- col 9: 32059700 (latitude in 1/10000 minutes, +/-90)

col 10: 1280 (course over ground in 1/10, 0-3600)
col 11: 267 (true heading)
col 12: 55 (UTC time stamp second, 0-59; 60 if not available)
col 13: 0x0 (special manoeuver indicator)
col 14: 0 (RAIM flag, 0=RAIM not in use; 1=RAIM in use)
col 15: 0x0 (communication state)

long reports:
sample line: 5,0,235066164,1009508,0,2BHL9,ST EKATERINA,37,30,30,6,5,1,11-28T14:00Z,34,LIVORNO,0

col 1: 5 (message ID)
col 2: 0 (repeat indicator)
col 3: 235066164 (ship ID)
col 4: 1009508 (IMO number)
col 5: 0 (AIS version)
col 6: 2BHL9 (call sign)
col 7: ST EKATERINA (name)
col 8: 37 (type of ship and cargo)
col 9: 30 (overall dimension)
col 10: 30 (?)
col 11: 6 (?)
col 12: 5 (?)
col 13: 1 (?)
col 14: 11-28T14:00Z (ETA)
col 15: 34 (maximum present static draught in 1/10 m)
col 16: LIVORNO (destination)
col 17: 0 (date terminal equipment ready, 0=available; 1=not available)

The unchecked reports also contain the time of the position report in the leading character string (does not appear in the decoded files). The time is reported in seconds since January 1, 1970. For example in the above,

```
\s:rORBCOMM00u,c:1312156951*66\!AIVDM,1….
```

time is recorded as 1312156951, and the message starts at !AIVDM…

These files are further converted using the script **`conv_decoded2ascii.s`** that reads the time from the raw, unchecked reports (and converts to decimal days since Jan 1, 2011) and the following fields from the decoded unchecked files (note we don't use the long report files at this point): ship id, navigational status, rate of turn, speed over ground, position accuracy, longitude, latitude, course over ground and true heading. Within this script the following conversions are also done:

1. input time in seconds since Jan 1, 1970 is converted to days since Jan 1, 2011 ($1/86400 – 14975)

2. longitude and latitude are converted from minutes*10,000 to degrees ($8/600000, $9/600000)
3. speed over ground is converted from kts*10 to kts ($6/10)
4. course over ground is converted from degrees*10 to degrees ($10/10)

Finally, the files appear to contain values for the entire globe, and since our contract is for a 30-degree square, we only extract values from that region. Thus, conv_decoded2ascii.s creates an ASCII file for each month with values for 178°W to 152°W, 5°N to 35°N with the following columns:

1. time in decimal days since Jan 1, 2011
2. ship id (integer)
3. navigational status (integer)
4. rate of turn
5. speed over ground (kts)
6. position accuracy (1=high, 0=low)
7. longitude (degrees)
8. latitude (degrees)
9. course over ground (degrees)
10. true heading (degrees)

The last step is to create a netCDF file, one per month, with each of the above variables. The entries in the raw files are not sequential in time, nor is each report time unique (*e.g.*, could get more than one report in a given time), so the data model is to have a single dimension of observation number, then variables with that dimension. The program `make_cdf.f` does this (note also that program converts the integer values to real and the time from decimal days to seconds). The program reads the ASCII files described above as input and produces a netCDF file named `orbcomm_ais_`*`mmmyyy`*`.nc` as output (*`mmm`* is 3-character month and *`yyyy`* is four digit year).

2. File naming convention

The program reads the ASCII files described above as input and produces a netCDF file named `orbcomm_ais_`*`mmmyyy`*`.nc` as output (*`mmm`* is 3-character month and *`yyyy`* is four digit year).

Note that the final file is different from others in two respects. First, it is not for a specific month but rather extends over a 30 day period from July 17th through August 16th. Second, this file was not in a message format but was already converted to an ASCII table, space delimited.

3. Data format specification

Global aggregate file:

```
netcdf orbcomm_ais_global_agg {
dimensions:
 longitude = 3600 ;
```

```
 latitude = 1801 ;
variables:
 double longitude(longitude) ;
       longitude:units = "degrees_east" ;
       longitude:long_name = "Longitude" ;
 double latitude(latitude) ;
       latitude:units = "degrees_north" ;
       latitude:long_name = "Latitude" ;
 double freq2(latitude, longitude) ;
       freq2:missing_value = -999.f ;
       freq2:_FillValue = "0" ;

// global attributes:
       :history = "Tue Jan  8 13:00:39 2013: ncatted -O -a
_FillValue,freq2,o,c,0 orbcomm_ais_global_agg.nc\n",
             "Tue Jan  8 13:00:12 2013: ncatted -O -a
_FillValue,freq2,o,f,0.0 orbcomm_ais_global_agg.nc\n",
             "Tue Jan  8 12:59:01 2013: ncatted -O -a
missing_value,freq2,o,f,-999.0 orbcomm_ais_global_agg.nc" ;
}
```

Monthly files:

```
netcdf orbcomm_ais_2011_08 {
dimensions:
 obs = UNLIMITED ; // (53611 currently)
variables:
 int obs(obs) ;
       obs:long_name = "observation" ;
       obs:short_name = "obs" ;
       obs:units = "0" ;
 float time(obs) ;
       time:long_name = "Time" ;
       time:standard_name = "time" ;
       time:short_name = "time" ;
       time:axis = "T" ;
       time:units = "seconds since 2011-01-01 00:00:00" ;
 int shipid(obs) ;
       shipid:long_name = "ship identification number (MMSI)" ;
       shipid:short_name = "ship_id" ;
       shipid:units = "0" ;
 int navstat(obs) ;
       navstat:long_name = "navigational status" ;
       navstat:short_name = "navstat" ;
       navstat:valid_range = 0, 15 ;
       navstat:flag_values = 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11,
12, 13, 14, 15 ;
       navstat:flag_meanings = "under_way_using_engine at_anchor
not_under_command restricted_manoeuvrability
constrained_by_her_draught moored aground engaged_in_fishing
under_way_sailing reserved_for_future_use reserved_for_future_use
reserved_for_future_use reserved_for_future_use
reserved_for_future_use AIS_SART_active not_defined" ;
       navstat:units = "0" ;
 float rot(obs) ;
       rot:long_name = "rate of turn" ;
       rot:short_name = "rot" ;
       rot:units = "degrees minutes-1" ;
```

```
float sog(obs) ;
      sog:long_name = "speed over ground" ;
      sog:standard_name = "platform_speed_wrt_ground" ;
      sog:short_name = "sog" ;
      sog:units = "kts" ;
int pflag(obs) ;
      pflag:long_name = "position accuracy" ;
      pflag:short_name = "pflag" ;
      pflag:valid_range = 0, 1 ;
      pflag:flag_values = 0, 1 ;
      pflag:flag_meanings = "high_<=_10m low_>_10m" ;
      pflag:units = "0" ;
float lon(obs) ;
      lon:long_name = "Longitude" ;
      lon:standard_name = "longitude" ;
      lon:short_name = "lon" ;
      lon:axis = "X" ;
      lon:units = "degrees_east" ;
float lat(obs) ;
      lat:long_name = "Latitude" ;
      lat:standard_name = "latitude" ;
      lat:short_name = "lat" ;
      lat:axis = "Y" ;
      lat:units = "degrees_north" ;
float cog(obs) ;
      cog:long_name = "course over ground" ;
      cog:standard_name = "platform_course" ;
      cog:short_name = "cog" ;
      cog:units = "deg" ;
float thead(obs) ;
      thead:long_name = "true heading" ;
      thead:short_name = "thead" ;
      thead:units = "deg" ;

// global attributes:
      :title = "NAIS ship track data from ORBCOMM.  Data  were
purchased jointly by PacIOOS, ORE, and PNMM.  The data are
restricted via agreement signed with ORBCOMM.  Data were decoded
and reformatted by jim 09/12 " ;
      :Conventions = "CF-1.6" ;
      :featureType = "point" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
obs(obs)	observation	obs		0
time(obs)	Time	time	time	seconds since 2011-01-01 00:00:00
shipid(obs)	ship identification number	ship_id		0
navstat(obs)	navigational status	navstat		0
rot(obs)	rate of turn	rot		degrees min-1

sog(obs)	speed over ground	sog		kts
pflag(obs)	position accuracy	pflag		0
lon(obs)	Longitude	lon	longitude	degrees_east
lat(obs)	Latitude	lat	latitude	degrees_north
cog(obs)	course over ground	cog	platform_course	deg
thead(obs)	true heading	thead		deg

Table 41. AIS data specifications.

5. Data distribution

The ORBCOMM data were purchased with an agreement of limited distribution. Aggregation maps are available via WMS as

- WMS: http://oos.soest.hawaii.edu/thredds/wms/ais/ais_global_20112012_grid?service=WMS&version=1.3.0&request=GetCapabilities

M. Data obtained from non-PacIOOS providers (Degree Heating Weeks)

1. Data flow

The NOAA Oceanographic Data Center (NODC) produces an estimate of coral reef health estimated by satellites. The half-degree product was released approximately every 5 to 7 days and includes SST, SST anomalies, "degree heating weeks" (an estimate of the persistence of warm water), and "hot spots" (areas where coral bleaching is likely to occur. In mid-2017 they changed to a 5-km daily product.

Data are retrieved from the NESDIS ftp site ftp.star.nesdis.noaa.gov in the directory `pub/socd/mecb/crw/data/5km/nc/`*`var`*`/`*`yyyy`* where *`var`* is the specific variable and *`yyyy`* is the year. The files are in native NetCDF format, so the only conversion needed is to aggregate the variables into a single file.

2. File naming convention

Files are named by date and placed in `/export/lawelawe1/dhw5km/data/`*`yyyy`* where *`yyyy`* is the year. The file names follow the NODC archive, *e.g.*, `merged_b5km_20130828.nc`.

3. Data format specification

```
netcdf merged_b5km_20180225 {
dimensions:
 time = 1 ;
 lat = 3600 ;
 lon = 7200 ;
variables:
 int time(time) ;
       time:long_name = "reference time of source daily sst
analysis field" ;
       time:standard_name = "time" ;
       time:axis = "T" ;
       time:calendar = "gregorian" ;
```

```
      time:units = "seconds since 1981-01-01 00:00:00" ;
      time:comment = "Nominal time of Level 4 analysis" ;
      time:coverage_content_type = "coordinate" ;
 float lat(lat) ;
      lat:long_name = "latitude" ;
      lat:standard_name = "latitude" ;
      lat:units = "degrees_north" ;
      lat:axis = "Y" ;
      lat:valid_min = -89.975f ;
      lat:valid_max = 89.975f ;
      lat:comment = "equirectangular projection and grid centers"
;
      lat:coverage_content_type = "coordinate" ;
 float lon(lon) ;
      lon:long_name = "longitude" ;
      lon:standard_name = "longitude" ;
      lon:units = "degrees_east" ;
      lon:axis = "X" ;
      lon:valid_min = -179.975f ;
      lon:valid_max = 179.975f ;
      lon:comment = "equirectangular projection and grid centers"
;
      lon:coverage_content_type = "coordinate" ;
 byte surface_flag(lat, lon) ;
      surface_flag:long_name = "Pixel characteristics flag array"
;
      surface_flag:coordinates = "lon lat" ;
      surface_flag:comment = "A 2D array, in the same size as the
data array in the X and Y directions, classifying land, missing,
and ice pixels that are all flagged by the same missing_value
(specified by the variable attribute _FillValue) in the data
array(s), along with water (data) pixels." ;
      surface_flag:flag_values = 0b, 1b, 2b, 4b ;
      surface_flag:flag_meanings = "valid-water land missing ice"
;
      surface_flag:coverage_content_type =
"thematicClassification" ;
      surface_flag:grid_mapping = "crs" ;
 float CRW_DHW(time, lat, lon) ;
      CRW_DHW:_FillValue = 251.f ;
      CRW_DHW:long_name = "analysed degree heating week" ;
      CRW_DHW:units = "degree Celsius-weeks" ;
      CRW_DHW:add_offset = 0.f ;
      CRW_DHW:scale_factor = 1.f ;
      CRW_DHW:valid_min = 0.f ;
      CRW_DHW:valid_max = 100.f ;
      CRW_DHW:coordinates = "lon lat time" ;
      CRW_DHW:reference = "Liu, G, Heron SF, Eakin CM, Muller-
Karger FE, Vega-Rodriguez M, Guild LS, De La Cour JL, Geiger EF,
Skirving WJ, Burgess TFR, Strong AE, Harris A, Maturi E, Ignatov
A, Sapper J, Li J, Lynds S (2014) Reef-scale Thermal Stress
Monitoring of Coral Ecosystems: New 5-km Global Products from NOAA
Coral Reef Watch, Remote Sensing 6(11): 11579-11606,
doi:10.3390/rs61111579." ;
      CRW_DHW:source = "npp viirs, metop-b avhrr, goese/w imager,
msg seviri, mtsat imager" ;
      CRW_DHW:comment = "Degree Heating Week for each ocean grid
point" ;
```

```
       CRW_DHW:coverage_content_type = "physicalMeasurement" ;
       CRW_DHW:grid_mapping = "crs" ;
 short crs ;
       crs:grid_mapping_name = "latitude_longitude" ;
       crs:epsg_code = "EPSG:4326" ;
       crs:semi_major_axis = 6378137.f ;
       crs:inverse_flattening = 298.2572f ;
       crs:comment = "This is a container variable that describes
the grid_mapping used by the data in this file. This variable does
not contain any data; only information about the geographic
coordinate system." ;
 float CRW_HOTSPOT(time, lat, lon) ;
       CRW_HOTSPOT:_FillValue = 251.f ;
       CRW_HOTSPOT:long_name = "analysed coral bleaching hotspot"
;
       CRW_HOTSPOT:units = "degrees Celsius" ;
       CRW_HOTSPOT:add_offset = 0.f ;
       CRW_HOTSPOT:scale_factor = 1.f ;
       CRW_HOTSPOT:valid_min = 0.f ;
       CRW_HOTSPOT:valid_max = 15.f ;
       CRW_HOTSPOT:coordinates = "lon lat time" ;
       CRW_HOTSPOT:reference = "Liu, G, Heron SF, Eakin CM,
Muller-Karger FE, Vega-Rodriguez M, Guild LS, De La Cour JL,
Geiger EF, Skirving WJ, Burgess TFR, Strong AE, Harris A, Maturi
E, Ignatov A, Sapper J, Li J, Lynds S (2014) Reef-scale Thermal
Stress Monitoring of Coral Ecosystems: New 5-km Global Products
from NOAA Coral Reef Watch, Remote Sensing 6(11): 11579-11606,
doi:10.3390/rs61111579." ;
       CRW_HOTSPOT:source = "npp viirs, metop-b avhrr, goese/w
imager, msg seviri, mtsat imager" ;
       CRW_HOTSPOT:comment = "Coral Bleaching HotSpot for each
ocean grid point" ;
       CRW_HOTSPOT:coverage_content_type = "physicalMeasurement" ;
       CRW_HOTSPOT:grid_mapping = "crs" ;
 float CRW_SST(time, lat, lon) ;
       CRW_SST:_FillValue = 251.f ;
       CRW_SST:long_name = "analysed sea surface temperature" ;
       CRW_SST:standard_name =
"sea_surface_foundation_temperature" ;
       CRW_SST:units = "degrees Celsius" ;
       CRW_SST:add_offset = 0.f ;
       CRW_SST:scale_factor = 1.f ;
       CRW_SST:valid_min = -2.f ;
       CRW_SST:valid_max = 50.f ;
       CRW_SST:coordinates = "lon lat time" ;
       CRW_SST:reference = "Liu, G, Heron SF, Eakin CM, Muller-
Karger FE, Vega-Rodriguez M, Guild LS, De La Cour JL, Geiger EF,
Skirving WJ, Burgess TFR, Strong AE, Harris A, Maturi E, Ignatov
A, Sapper J, Li J, Lynds S (2014) Reef-scale Thermal Stress
Monitoring of Coral Ecosystems: New 5-km Global Products from NOAA
Coral Reef Watch, Remote Sensing 6(11): 11579-11606,
doi:10.3390/rs61111579." ;
       CRW_SST:source = "npp viirs, metop-b avhrr, goese/w imager,
msg seviri, mtsat imager" ;
       CRW_SST:comment = "analysed night-only SST for each ocean
grid point" ;
       CRW_SST:coverage_content_type = "physicalMeasurement" ;
       CRW_SST:grid_mapping = "crs" ;
```

```
 float CRW_SSTANOMALY(time, lat, lon) ;
       CRW_SSTANOMALY:_FillValue = 251.f ;
       CRW_SSTANOMALY:long_name = "analysed sea surface
temperature anomaly" ;
       CRW_SSTANOMALY:units = "degrees Celsius" ;
       CRW_SSTANOMALY:add_offset = 0.f ;
       CRW_SSTANOMALY:scale_factor = 1.f ;
       CRW_SSTANOMALY:valid_min = -15.f ;
       CRW_SSTANOMALY:valid_max = 15.f ;
       CRW_SSTANOMALY:coordinates = "lon lat time" ;
       CRW_SSTANOMALY:reference = "Liu, G, Heron SF, Eakin CM,
Muller-Karger FE, Vega-Rodriguez M, Guild LS, De La Cour JL,
Geiger EF, Skirving WJ, Burgess TFR, Strong AE, Harris A, Maturi
E, Ignatov A, Sapper J, Li J, Lynds S (2014) Reef-scale Thermal
Stress Monitoring of Coral Ecosystems: New 5-km Global Products
from NOAA Coral Reef Watch, Remote Sensing 6(11): 11579-11606,
doi:10.3390/rs61111579." ;
       CRW_SSTANOMALY:source = "npp viirs, metop-b avhrr, goese/w
imager, msg seviri, mtsat imager" ;
       CRW_SSTANOMALY:comment = "analysed night-only SST anomaly
for each ocean grid point" ;
       CRW_SSTANOMALY:coverage_content_type =
"physicalMeasurement" ;
       CRW_SSTANOMALY:grid_mapping = "crs" ;

// global attributes:
       :Conventions = "CF-1.6, ACDD-1.3, Unidata Observation
Dataset v1.0" ;
       :ncei_template_version = "NCEI_NetCDF_Grid_Template_v2.0" ;
       :title = "NOAA Coral Reef Watch Daily Global 5-km Geo-polar
Blended Night-only Satellite Sea Surface Temperature Anomaly" ;
       :summary = "This is a product of NOAA Coral Reef Watch
daily 5 km global satellite coral bleaching heat stress monitoring
product suite." ;
       :references = "Liu, G, Heron SF, Eakin CM, Muller-Karger
FE, Vega-Rodriguez M, Guild LS, De La Cour JL, Geiger EF, Skirving
WJ, Burgess TFR, Strong AE, Harris A, Maturi E, Ignatov A, Sapper
J, Li J, Lynds S (2014) Reef-scale Thermal Stress Monitoring of
Coral Ecosystems: New 5-km Global Products from NOAA Coral Reef
Watch, Remote Sensing 6(11): 11579-11606, doi:10.3390/rs61111579."
;
       :institution = "NOAA/NESDIS/STAR Coral Reef Watch program"
;
       :history = "Mon Feb 26 10:31:12 2018: /usr/local/bin/ncks -
A b5km_ssta_20180225.nc merged_b5km_20180225.nc\nThis product is
based on CRW Version 1.0 NetCDF Standards (released on August 17,
2015) for the CRW 5 km global satellite coral bleaching heat
stress monitoring product suite." ;
       :comment = "This product is a product of the Coral Reef
Watch Daily 5-km Global Satellite Coral Bleaching Heat Stress
Monitoring Product Suite Version 3.0." ;
       :license = "The data are available for use without
restriction, but it is required to credit the NOAA Coral Reef
Watch program for any data use. Recommendations for citing and
providing credit are provided at
https://coralreefwatch.noaa.gov/satellite/docs/recommendations_crw
_citation.php. Users are referred to the footer section of Coral
Reef Watch\'s website (https://coralreefwatch.noaa.gov/index.php)
```

```
for disclaimers, policies, notices pertaining to the use of the
data." ;
       :id =
"Satellite_Daily_Global_5km_Blended_Night_SST_Anomaly" ;
       :naming_authority = "gov.noaa.coralreefwatch" ;
       :product_version = "3.0" ;
       :product_netcdf_version = "1.0" ;
       :uuid = "cb288872-6cd9-4bd0-8e48-2570e042801c" ;
       :gds_version_id = "2.0" ;
       :netcdf_version_id = "4.1.2" ;
       :date_created = "20130312T120000Z" ;
       :date_issued = "20180226T175543Z" ;
       :date_modified = "20180226T175543Z" ;
       :date_metadata_modified = "20180226T175543Z" ;
       :start_time = "20180225T000000Z" ;
       :time_coverage_start = "20180225T000000Z" ;
       :time_coverage_duration = "P1D" ;
       :stop_time = "20180226T000000Z" ;
       :time_coverage_end = "20180226T000000Z" ;
       :time_coverage_resolution = "P1D" ;
       :source = "npp viirs, metop-b avhrr, goese/w imager, msg
seviri, mtsat imager" ;
       :platform = "metop-b GOESE (GOES-13) GOESW (GOES-15)
msg/mtsat-2 npp" ;
       :sensor = "npp viirs, metop-b avhrr, goese/w imager, msg
seviri, mtsat imager" ;
       :instrument = "npp viirs, metop-b avhrr, goese/w imager,
msg seviri, mtsat imager" ;
       :platform_vocabulary = "metop-b GOESE (GOES-13) GOESW
(GOES-15) msg/mtsat-2 npp" ;
       :instrument_vocabulary = "npp viirs, metop-b avhrr, goese/w
imager, msg seviri, mtsat imager" ;
       :metadata_link =
"https://coralreefwatch.noaa.gov/satellite/bleaching5km/index.php"
;
       :keywords = "Oceans > Ocean Temperature > Sea Surface
Temperature Anomaly" ;
       :keywords_vocabulary = "NASA Global Change Master Directory
(GCMD) Science Keywords" ;
       :standard_name_vocabulary = "NetCDF Climate and Forecast
(CF) Metadata Convention Standard Name Table v27" ;
       :geospatial_bounds = "POLYGON((-90.0 180.0, 90.0 180.0,
90.0 -180.0, -90.0 -180.0, -90.0 180.0))" ;
       :geospatial_bounds_crs = "EPSG:4326" ;
       :geospatial_lon_min = -180.f ;
       :geospatial_lon_max = 180.f ;
       :geospatial_lat_min = -90.f ;
       :geospatial_lat_max = 90.f ;
       :spatial_resolution = "0.05 degree" ;
       :geospatial_lat_units = "degrees north" ;
       :geospatial_lat_resolution = 0.05f ;
       :geospatial_lon_units = "degrees east" ;
       :geospatial_lon_resolution = 0.05f ;
       :acknowledgment = "NOAA Coral Reef Watch program" ;
       :creator_type = "group" ;
       :creator_institution = "NOAA/NESDIS/STAR" ;
       :creator_name = "NOAA Coral Reef Watch program" ;
       :creator_email = "coralreefwatch@noaa.gov" ;
```

```
        :creator_url = "https://coralreefwatch.noaa.gov" ;
        :project = "NOAA Coral Reef Watch program" ;
        :program = "NOAA Coral Reef Watch program" ;
        :publisher_type = "group" ;
        :publisher_institution = "NOAA/NESDIS/STAR" ;
        :publisher_name = "NOAA Coral Reef Watch program" ;
        :publisher_url = "https://coralreefwatch.noaa.gov" ;
        :publisher_email = "coralreefwatch@noaa.gov" ;
        :contributor_name = "NOAA Coral Reef Watch program" ;
        :contributor_role = "Collecting source data and deriving
products; performing quality control of products; disseminating,
storing, and submitting data to archive." ;
        :processing_level = "L4" ;
        :cdm_data_type = "Grid" ;
        :NCO = "4.2.0" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
CRW_SST(time,latitude,longitude)	Daily global 5km satellite nighttime sea surface temperature			degrees Celsius
CRW_SSTANOMALY(time,latitude,longitude)	Daily global 5km satellite nighttime sea surface temperature anomalies			degrees Celsius
CRW_HOTSPOT(time,latitude,longitude)	Daily global 5km satellite coral bleaching hot spot			degrees Celsius
CRW_DHW(time,latitude,longitude)	Daily global 5km satellite coral bleaching degree heating weeks			degrees Celsius-weeks
surface_flag(time,latitude,longitude)	Pixel characteristics flag			none
longitude(longitude)	longitude			degrees-east
latitude(latitude)	latitude			degrees-north
time(time)				days since 1970-01-01 00:00:00

Table 42. Degree heating weeks variable specifications.

5. Data distribution

NOAA Coral Reef Watch Operational Twice-Weekly Near-Real-Time Global 50km Satellite Coral Bleaching Monitoring Products

- Metadata: http://pacioos.org/metadata/dhw.html
- Voyager: http://pacioos.org/voyager/index.html?b=-75.845169%2C-180%2C75.845169%2C180&o=sat:5:fweeks:d6
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/satellite.html?dataset=dhw
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/NOAA_DHW.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=dhw&varid=CRW_DHW-dhw
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=af866abc27c1df2b887ef6aac9a4e124
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/satellite/dhw?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hioos/satellite/dhw?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/satellite/dhw/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/satellite/dhw.html

N. Data obtained from non-PacIOOS providers (Atmospheric model)

1. Data flow

In addition to the locally-run atmospheric models, PacIOOS also downloads daily output from the Global Forecast System (GFS) model from NOAA/NCEP. This model output is used as boundary conditions for the local atmospheric models and provides global coverage at 0.5°. Output is obtained via the cron script **`get_gfs.s`** that is run daily at 9:00 AM HST. The model outputs forecasts every six hours, but we are just getting the 12:00 UTC forecast each day.

In addition to the global run at 0.5°, the higher-resolution 0.25° output is downloaded for just the Pacific (40°S to 40°N, 120°E. to 80°W). The variables and process is the same as for the global run, but the script, **`get_gfs_pacific.s`** is run at 9:30 AM HST.

The script accesses the GFS output via an OPeNDAP call in a GrADS script. The files are at http://nomads.ncep.noaa.gov:9090/dods/gfs_hd in subdirectories by date. The script first runs GrADS and **`get_gfs_0.5deg.gs`** (**`get_gfs_0.25deg.gs`** for the Pacific high-res subset) extracts certain variables and saves them to a series of NetCDF files (one per variable). The **`ncsk`** utility is then used to combine these

into a single NetCDF file. Finally, **`ncap`** is used to make the forecast time and **`ncatted`** is used to change the variable names.

The files obtained have 720 longitudes and 361 latitudes for the whole globe at 0.5° resolution. The Pacific subset is 641 by 321. There are 65 time values, representing just over eight days (3-hourly resolution). Of the many variables available in the GFS, only eight surface variables are transferred:

1. net downward longwave radiation flux (dlwrfsfc)
2. net downward shortwave radiation flux (dswrfsfc)
3. rainfall rate (pratesfc)
4. mean sea level pressure (prmslmsl)
5. relative humidity at 2m (rh2m)
6. surface temperature (tmpsfc)
7. eastward wind velocity at 10m (ugrd10m)
8. northward wind velocity at 10m (vgrd10m)

2. File naming convention

Files are copied to `/export/lawelawe1/model/atm/gfs_global/data` and have file names based on date, *e.g.*, `gfs_surf_2010_08_28.nc` for August 28, 2010. The archive starts May 6, 2011. Each file is 1.2 GB for a total of 444 GB per year.

GFS Grid	Global	Pacific
Lon range	global	120°E to 80°W
Lon res	50 km	25 km
Lon points	720	641
Lat range	global	40°S to 40°N
Lat res	50 km	25 km
Lat points	361	321
Depth range	surface	surface
Depth res	0	0
Depth points	1	1
Time range	8.125 days	8.125 days
Time res	3-hourly	3-hourly
Time points	65	65
Time start	05-06-2011	02-29-2016
Variables	T, P, r, u, v, Q_s, Q_l, Rh	T, P, r, u, v, Q_s, Q_l, Rh
File size	1,216,440,324	962,970,888
File name	`gfs_surf_*.nc`	`gfs_surf_*.nc`

Table 43. GFS (atmospheric) model variable specifications.

3. Data format specification

```
netcdf gfs_surf_2013_08_28 {
dimensions:
```

```
 time = 65 ;
 longitude = 720 ;
 latitude = 361 ;
variables:
 double time(time) ;
       time:long_name = "Time" ;
       time:standard_name = "Time" ;
       time:units = "minutes since 2011-01-01 00:00" ;
 double longitude(longitude) ;
       longitude:units = "degrees_east" ;
       longitude:long_name = "Longitude" ;
 double latitude(latitude) ;
       latitude:units = "degrees_north" ;
       latitude:long_name = "Latitude" ;
 double dlwrfsfc(time, latitude, longitude) ;
       dlwrfsfc:missing_value = -999000000. ;
       dlwrfsfc:long_name = "net downward longwave radiation flux"
;
       dlwrfsfc:standard_name =
"surface_net_downward_longwave_flux" ;
       dlwrfsfc:units = "W m-2" ;
 double dswrfsfc(time, latitude, longitude) ;
       dswrfsfc:missing_value = -999000000. ;
       dswrfsfc:long_name = "net downward shortwave radiation
flux" ;
       dswrfsfc:standard_name =
"surface_net_downward_shortwave_flux" ;
       dswrfsfc:units = "W m-2" ;
 double pratesfc(time, latitude, longitude) ;
       pratesfc:missing_value = -999000000. ;
       pratesfc:long_name = "rainfall rate" ;
       pratesfc:standard_name = "precipitation_flux" ;
       pratesfc:units = "kg m-2 s-1" ;
 double prmslmsl(time, latitude, longitude) ;
       prmslmsl:missing_value = -999000000. ;
       prmslmsl:long_name = "mean sea level pressure" ;
       prmslmsl:standard_name = "air_pressure_at_sea_level" ;
       prmslmsl:units = "Pa" ;
 double rh2m(time, latitude, longitude) ;
       rh2m:missing_value = -999000000. ;
       rh2m:long_name = "relative humidity at 2m" ;
       rh2m:standard_name = "relative_humidity" ;
       rh2m:units = "percent" ;
 double tmpsfc(time, latitude, longitude) ;
       tmpsfc:missing_value = -999000000. ;
       tmpsfc:long_name = "surface temperature" ;
       tmpsfc:standard_name = "surface_temperature" ;
       tmpsfc:units = "K" ;
 double tmp2m(time, latitude, longitude) ;
       tmp2m:missing_value = -999000000. ;
       tmp2m:long_name = "air temperature at 2m" ;
       tmp2m:standard_name = "air_temperature" ;
       tmp2m:units = "K" ;
 double ugrd10m(time, latitude, longitude) ;
       ugrd10m:missing_value = -999000000. ;
       ugrd10m:long_name = "eastward wind velocity at 10m" ;
       ugrd10m:standard_name = "eastward_wind" ;
       ugrd10m:units = "m s-1" ;
```

```
 double vgrd10m(time, latitude, longitude) ;
       vgrd10m:missing_value = -999000000. ;
       vgrd10m:long_name = "northward wind velocity at 10m" ;
       vgrd10m:standard_name = "northward_wind" ;
       vgrd10m:units = "m s-1" ;

// global attributes:
       :NCO = "4.2.0" ;
       :history = "Wed Aug 28 08:09:20 2013:
/usr/local/bin/ncatted -a units,vgrd10m,c,c,m s-1 fileout.nc\n",
             "Wed Aug 28 08:09:18 2013: /usr/local/bin/ncatted -a
standard_name,vgrd10m,c,c,northward_wind fileout.nc\n",
             "Wed Aug 28 08:09:15 2013: /usr/local/bin/ncatted -a
long_name,vgrd10m,c,c,northward wind velocity at 10m
fileout.nc\n",
             "Wed Aug 28 08:09:13 2013: /usr/local/bin/ncatted -a
units,ugrd10m,c,c,m s-1 fileout.nc\n",
             "Wed Aug 28 08:09:10 2013: /usr/local/bin/ncatted -a
standard_name,ugrd10m,c,c,eastward_wind fileout.nc\n",
             "Wed Aug 28 08:09:08 2013: /usr/local/bin/ncatted -a
long_name,ugrd10m,c,c,eastward wind velocity at 10m fileout.nc\n",
             "Wed Aug 28 08:09:06 2013: /usr/local/bin/ncatted -a
units,tmp2m,c,c,K fileout.nc\n",
             "Wed Aug 28 08:09:03 2013: /usr/local/bin/ncatted -a
standard_name,tmp2m,c,c,air_temperature fileout.nc\n",
             "Wed Aug 28 08:09:01 2013: /usr/local/bin/ncatted -a
long_name,tmp2m,c,c,air temperature at 2m fileout.nc\n",
             "Wed Aug 28 08:08:59 2013: /usr/local/bin/ncatted -a
units,tmpsfc,c,c,K fileout.nc\n",
             "Wed Aug 28 08:08:56 2013: /usr/local/bin/ncatted -a
standard_name,tmpsfc,c,c,surface_temperature fileout.nc\n",
             "Wed Aug 28 08:08:54 2013: /usr/local/bin/ncatted -a
long_name,tmpsfc,c,c,surface temperature fileout.nc\n",
             "Wed Aug 28 08:08:51 2013: /usr/local/bin/ncatted -a
units,rh2m,c,c,percent fileout.nc\n",
             "Wed Aug 28 08:08:49 2013: /usr/local/bin/ncatted -a
standard_name,rh2m,c,c,relative_humidity fileout.nc\n",
             "Wed Aug 28 08:08:47 2013: /usr/local/bin/ncatted -a
long_name,rh2m,c,c,relative humidity at 2m fileout.nc\n",
             "Wed Aug 28 08:08:44 2013: /usr/local/bin/ncatted -a
units,prmslmsl,c,c,Pa fileout.nc\n",
             "Wed Aug 28 08:08:42 2013: /usr/local/bin/ncatted -a
standard_name,prmslmsl,c,c,air_pressure_at_sea_level
fileout.nc\n",
             "Wed Aug 28 08:08:39 2013: /usr/local/bin/ncatted -a
long_name,prmslmsl,c,c,mean sea level pressure fileout.nc\n",
             "Wed Aug 28 08:08:37 2013: /usr/local/bin/ncatted -a
units,pratesfc,c,c,kg m-2 s-1 fileout.nc\n",
             "Wed Aug 28 08:08:35 2013: /usr/local/bin/ncatted -a
standard_name,pratesfc,c,c,precipitation_flux fileout.nc\n",
             "Wed Aug 28 08:08:32 2013: /usr/local/bin/ncatted -a
long_name,pratesfc,c,c,rainfall rate fileout.nc\n",
             "Wed Aug 28 08:08:30 2013: /usr/local/bin/ncatted -a
units,dswrfsfc,c,c,W m-2 fileout.nc\n",
             "Wed Aug 28 08:08:27 2013: /usr/local/bin/ncatted -a
standard_name,dswrfsfc,c,c,surface_net_downward_shortwave_flux
fileout.nc\n",
```

```
            "Wed Aug 28 08:08:25 2013: /usr/local/bin/ncatted -a
long_name,dswrfsfc,c,c,net downward shortwave radiation flux
fileout.nc\n",
            "Wed Aug 28 08:08:23 2013: /usr/local/bin/ncatted -a
units,dlwrfsfc,c,c,W m-2 fileout.nc\n",
            "Wed Aug 28 08:08:20 2013: /usr/local/bin/ncatted -a
standard_name,dlwrfsfc,c,c,surface_net_downward_longwave_flux
fileout.nc\n",
            "Wed Aug 28 08:08:18 2013: /usr/local/bin/ncatted -a
long_name,dlwrfsfc,c,c,net downward longwave radiation flux
fileout.nc\n",
            "Wed Aug 28 08:08:16 2013: /usr/local/bin/ncatted -a
units,time,c,c,minutes since 2011-01-01 00:00 fileout.nc\n",
            "Wed Aug 28 08:08:13 2013: /usr/local/bin/ncatted -a
standard_name,time,c,c,Time fileout.nc\n",
            "Wed Aug 28 08:08:11 2013: /usr/local/bin/ncatted -a
long_name,time,c,c,Time fileout.nc\n",
            "Wed Aug 28 08:08:04 2013: /usr/local/bin/ncap -s
time[time]=time+1395360 fileout.nc temp.nc" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
time(time)	Time		Time	minutes since 2011-01-01 00:00
longitude(longitude)	Longitude			degrees_east
latitude(latitude)	Latitude			degrees_north
dlwrfsfc(time,latitude,longitude)	net downward longwave radiation flux		surface_net_downward_longwave_flux	W m-2
dswrfsfc(time,latitude,longitude)	net downward shortwave radiation flux		surface_net_downward_shortwave_flux	W m-2
pratesfc(time,latitude,longitude)	rainfall rate		precipitation_flux	kg m-2 s-1
prmslmsl(time,latitude,longitude)	mean sea level pressure		air_pressure_at_sea_level	Pa
rh2m(time,latitude,longitude)	relative humidity at 2m		relative_humidity	percent
tmpsfc(time,latitude,longitude)	surface temperature		surface_temperature	K
tmp2m(time,latitude,longitude)	air temperature at 2m		air_temperature	K
ugrid10m(time,latitude,longitude)	eastward wind velocity at 10m		eastward_wind	m s-1
vgrid10m(time,latitude,longitude)	northward wind velocity at 10m		northward_wind	m s-1

Table 44. GDS (atmospheric model) variable definitions.

5. Data distribution

NOAA/NCEP Global Forecast System (GFS) Atmospheric Model

- Metadata: http://pacioos.org/metadata/ncep_global.html
- Voyager: http://pacioos.org/voyager/index.html?b=-85.200475%2C-180%2C85.200475%2C180&t=h&o=wfore:6:f:d1
- THREDDS: http://oos.soest.hawaii.edu/thredds/catalog/hioos/model/atm/ncep_global/catalog.html?dataset=ncep_global/NCEP_Global_Atmospheric_Model_best.ncd
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/NCEP_Global_Best.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=ncep_global&varid=tmpsfc-ncep_global
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=ec4524a9fc8340d3405a6d5e087f52
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hioos/model/atm/ncep_global/NCEP_Global_Atmospheric_Model_best.ncd?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hioos/model/atm/ncep_global/NCEP_Global_Atmospheric_Model_best.ncd?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hioos/model/atm/ncep_global/NCEP_Global_Atmospheric_Model_best.ncd/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/model/atm/ncep_global/NCEP_Global_Atmospheric_Model_best.ncd.html

O. Data obtained from non-PacIOOS providers (SCUD)

1. Data flow

The SCUD model is run on an IPRC machine each day by Jan Hafner. The output is a single netCDF file that is placed in Jan's ftp account, `ftp://apapane.soest.hawaii.edu/users/hafner/SCUD/PACIOOS` (note that SCUD is run in different configurations, but PacIOOS just gets the realtime Pacific run). The script **`get_scud.s`** is run via cron every day at 10:00 HST and retrieves the output file.

2. File naming convention

SCUD output is stored in `/export/lawelawe1/model/scud/`*`yyyy`* and the filenames contain the date, *e.g.*, `2013-08-28.nc` has the output for August 28, 2013.

3. Data format specification

```
netcdf \2013-08-22 {
dimensions:
 longitude = 689 ;
 latitude = 529 ;
 time = UNLIMITED ; // (1 currently)
variables:
 float longitude(longitude) ;
       longitude:units = "degrees_east" ;
       longitude:title = "longitude" ;
       longitude:missing_value = -9999.f ;
       longitude:_FillValue = -9999.f ;
 float latitude(latitude) ;
       latitude:units = "degrees_north" ;
       latitude:title = "latitudes" ;
       latitude:missing_value = -9999.f ;
       latitude:_FillValue = -9999.f ;
 int time(time) ;
       time:units = "days since 1950-01-01" ;
       time:title = "datum" ;
       time:missing_value = -9999 ;
       time:_FillValue = -9999 ;
 float u(time, latitude, longitude) ;
       u:units = "m/s" ;
       u:title = "zonal_surface_current" ;
       u:missing_value = -9999.f ;
       u:_FillValue = -9999.f ;
 float v(time, latitude, longitude) ;
       v:units = "m/s" ;
       v:title = "meridional_surface_current" ;
       v:missing_value = -9999.f ;
       v:_FillValue = -9999.f ;

// global attributes:
       :title = "SCUD: Surface CUrrents from Diagnostic model" ;
       :File_type = "gridded lat/lon" ;
       :CreatedBy = "IPRC/SOEST U. of Hawaii" ;
       :CreatedOn = "2013-08-22 02:49:14 HST" ;
       :Version = "v 1.0" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
longitude(longitude)				degrees_east
latitude(latitude)				degrees_north
time(time)				days since 1950-01-01
u(time,latitude,longitude)				m/s
v(time,latitude,longitude)				m/s

Table 45. SCUD variable definitions.

5. Data distribution

Surface CUrrents from a Diagnostic model (SCUD): Pacific

- Metadata: http://pacioos.org/metadata/scud_pac.html

- Voyager: http://pacioos.org/voyager/index.html?b=-76.351896%2C-180,74.211983,180&o=ofore:9:kts:d5
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/ocn_mod.html?dataset=scud_pac
- ERDDAP,http://oos.soest.hawaii.edu/erddap/griddap/SCUD_Pac.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=scud_pac&varid=vel-scud_pac
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=a4f9ddad64b1db6560ff47c5e2ceea19
- WMS: http://oos.soest.hawaii.edu/thredds/wms/pacioos/scud/pac?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/pacioos/scud/pac?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/pacioos/scud/pac/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/pacioos/scud/pac.html

P. Data obtained from non-PacIOOS providers (Reef Fish Assessments)

1. Data flow

PacIOOS worked on an early "biological observations project" with the IOOS Program Office in late 2009. This project was initiated to try and incorporate biological data into a standard service. Prior to this project, almost all the variables that were being served by PacIOOS via SOS or THREDDS were geophysical. With small seed funding, PacIOOS worked with the PO to develop a process by which geospatial biological data could be served. The initial focus was on reef fish population assessments in the Pacific Islands, and PacIOOS partnered with the Coral Reef Ecosystem Division (CREF) division of NOAA, the National Park Service (NPS) and the Papahanaumokuakea Marine National Monument (PMNM).

Population assessments of reef fish are done by these three groups in various reef locations during different years. The surveys are done either as belt transects (BLT), towed diver surveys (TDS) or stationary point counts (SPC), and the observers record "presence, absence, abundance".

PacIOOS acquired existing databases in different formats from the three providers and put them into a consistent format (tabular, ASCII) with a developed standard. CRED acted as the primary aggregator and passed postGRES databases to PacIOOS to process. The database has not been updated since the initial setup in 2011.

2. File naming convention

The files are all contained in a postGRES database on *pacioos.soest.hawaiii.edu*.

3. Data format specification

Datasets are in ASCII tables.

4. Data Vocabulary

The data sets include several different variables including absence, abundance, presence; species and counts; geospatial information such as lat/lon/depth. The ERDDAP page has the complete list.

5. Data distribution[32]

Northwestern Hawaiian Islands, Coral Reef Monitoring, Fish Surveys, Belt Transects (BLT)

- Metadata: http://pacioos.org/metadata/PMNM_FISH_BLT.html
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/PMNM_FISH_BLT.html

Q. Data obtained from non-PacIOOS providers (Maui Water Quality)

1. Data flow

A citizen science group in Maui collects water quality measurements and posts them to the Coral Reef Monitoring Data Portal (http://monitoring.coral.org/admin/monitoring_export). Since these files are not supplied via RESTful services, a manual download via ftp is done each week. The data are manually downloaded from the web site, exported to CSV, and uploaded to *lawelawe*. The script **`get_maui_water_quality.py`** is then run to load the data into the database.

2. File naming convention

Files are named `mauiwg_`*`type`*`_`*`yyyymmdd`*`.csv` (before entering in the database), where *`type`* is either `basic` or `bacteria`, *`yyyy`* is the four digit year, *`mm`* is the two digit month and *`dd`* is the two digit day.

3. Data format specification

Data are saved as ASCII, comma-separated value files.

4. Data Vocabulary

Variable	Long name
report_id	
observer_id	
dataentry_id	
report_date	
obs_hour	

[32] The stationary point counts (SPC) and towed diver surveys are served in the same way; this is just one specific example.

data_hours	
obs_mileage	
location	
visibility	
wind	
survey_date	
survey_begin_time	
survey_end_time	
latitude	
longitude	
swell_height	
swell_direction	
current_velocity	
current_direction	
lunar_phase	
watershed	
raingauge1	
raingauge1_inches	
raingauge2	
raingauge2_inches	
raingauge3	
raingauge3_inches	
streamflow1	
streamflow2	
streamflow3	
collection_hours	
collection_min	
name	
incubator_temp	
incubator_start_hrs	
incubator_start_min	
incubator_out_temp	
incubator_out_hrs	
incubator_out_min	
total_incubation_hrs	
total_incubation_min	
large_wells	
small_wells	
mpn	
upper_95	
lower_95	
dilution_factor	
adjusted_dilution	
blank_ran	
blank_type	
blank_result	
comments	
collection_ampm	
incubator_start_ampm	
incubator_out_ampm	
wqbid	
waterquality_id	

sampler_id	
replicated	
sample_min	
sample_hrs	
sample_depth	
air_method	
air_units	
air_value	
salinity_method	
salinity_value	
conductivity_method	
conductivity_units	
conductivity_value	
ph_method	
ph_value	
water_method	
water_value	
oxygen_method	
oxygen_units	
oxygen_value	
turbidity_method	
turbidity_units	
turbidity_value	
phosphate_method	
phosphate_value	
nitrate_method	
nitrate_value	
phosphorus_method	
phosphorus_value	
nitrogen_method	
nitrogen_value	
sample_ampm	

Table 46. Maui citizen science water quality measurements variable definitions.

5. Data distribution

Maui Citizen Science Coastal Water Quality Data

- Metadata: http://pacioos.org/metadata/maui_water_quality.html
- Voyager: http://pacioos.org/voyager/index.html?b=20.466247%2C-156.954431%2C21.128688%2C-155.785074&t=m&s=1&o=qual:4::v7c50
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/maui_water_quality.html

R. Data obtained from non-PacIOOS providers (Liquid Robotics)

1. Data flow

Liquid Robotics (LR)occasionally releases wave gliders in the region and uses the PacIOOS services to display the glider tracks and values of certain measured variables. The data are supplied via an authenticated "fetch" service provided by LR. The script **`get_liquidrobotics_glider.py`** is used to get the data and

convert to JSON for making tracks on Voyager. Separately, netCDF files are made to serve the data via TDS.

2. File naming convention

Files are named with the glider name and date, *e.g.*, `aa_2013_10_24.nc` for the glider called A'a and mission on October 24, 2013.

3. Data format specification

```
netcdf aa_2013_12_07 {
dimensions:
 time = 3 ;
 name_strlen = 14 ;
variables:
 char trajectory(name_strlen) ;
       trajectory:cf_role = "trajectory_id" ;
 int time(time) ;
       time:units = "seconds since 1970-01-01T00:00:00Z" ;
       time:long_name = "time" ;
       time:standard_name = "time" ;
 float shgt(time) ;
       shgt:units = "meters" ;
       shgt:long_name = "significat wave height" ;
       shgt:standard_name = "sea_surface_wave_significant_height"
;
       shgt:coordinates = "time longitude latitude" ;
 float pper(time) ;
       pper:units = "seconds" ;
       pper:long_name = "peak wave period" ;
       pper:standard_name =
"sea_surface_wave_period_at_variance_spectral_density_maximum" ;
       pper:coordinates = "time longitude latitude" ;
 float pdir(time) ;
       pdir:units = "degrees" ;
       pdir:long_name = "peak wave direction" ;
       pdir:standard_name = "sea_surface_wave_from_direction" ;
       pdir:coordinates = "time longitude latitude" ;
 float mper(time) ;
       mper:units = "seconds" ;
       mper:long_name = "mean wave period" ;
       mper:standard_name =
"sea_surface_wave_mean_period_from_variance_spectral_density_secon
d_frequency_moment" ;
       mper:coordinates = "time longitude latitude" ;
 float longitude(time) ;
       longitude:units = "degrees_east" ;
       longitude:long_name = "longitude" ;
       longitude:standard_name = "longitude" ;
 float latitude(time) ;
       latitude:units = "degrees_north" ;
       latitude:long_name = "latitude" ;
       latitude:standard_name = "latitude" ;

// global attributes:
       :comment = "Data produced by Liquid Robotics, Inc." ;
       :time_coverage_resolution = "PT30M" ;
       :geospatial_vertical_max = "0" ;
       :geospatial_lat_units = "degrees_north" ;
```

```
       :geospatial_lon_units = "degrees_east" ;
       :references = "http://liquidr.com, http://pacioos.org" ;
       :Metadata_Conventions = "Unidata Dataset Discovery v1.0,
CF-1.6" ;
       :keywords = "Oceans &gt; Ocean Waves &gt; Significant Wave
Height, Oceans &gt; Ocean Waves &gt; Wave Period, Oceans &gt;
Ocean Waves &gt; Wave Speed/Direction" ;
       :Conventions = "Unidata Dataset Discovery v1.0, CF-1.6" ;
       :publisher_name = "Pacific Islands Ocean Observing System
(PacIOOS)" ;
       :id = "wave_glider_aa" ;
       :naming_authority = "org.pacioos" ;
       :instrumentid = "Aa" ;
       :geospatial_lat_max = "20.057237" ;
       :acknowledgment = "The Pacific Islands Ocean Observing
System (PacIOOS) is funded through the National Oceanic and
Atmospheric Administration (NOAA) as a Regional Association within
the U.S. Integrated Ocean Observing System (IOOS). PacIOOS is
coordinated by the University of Hawaii School of Ocean and Earth
Science and Technology (SOEST)." ;
       :title = "Liquid Robotics Wave Glider: Aa" ;
       :standard_name_vocabulary = "CF-1.6" ;
       :creator_email = "support@liquidr.com" ;
       :publisher_url = "http://pacioos.org" ;
       :processing_level = "near real-time (nrt)" ;
       :featureType = "Trajectory" ;
       :publisher_email = "jimp@hawaii.edu" ;
       :keywords_vocabulary = "GCMD Science Keywords" ;
       :date_issued = "2014-04-24" ;
       :geospatial_lat_min = "20.050563" ;
       :time_coverage_start = "2013-12-07T00:00:00Z" ;
       :Metadata_Link =
"http://pacioos.org/metadata/wave_glider_aa.html" ;
       :geospatial_vertical_min = "0" ;
       :date_created = "2014-04-24" ;
       :contributor_role = "distributor" ;
       :institution = "Liquid Robotics, Inc." ;
       :geospatial_lon_max = "-155.957738" ;
       :geospatial_lon_min = "-156.000122" ;
       :contributor_name = "Jim Potemra" ;
       :license = "The data may be used and redistributed for free
but is not intended for legal use, since it may contain
inaccuracies. Neither the data Contributor, University of Hawaii,
PacIOOS, NOAA, State of Hawaii nor the United States Government,
nor any of their employees or contractors, makes any warranty,
express or implied, including warranties of merchantability and
fitness for a particular purpose, or assumes any legal liability
for the accuracy, completeness, or usefulness, of this
information." ;
       :creator_name = "Liquid Robotics, Inc." ;
       :time_coverage_end = "2013-12-07T01:00:00Z" ;
       :date_modified = "2014-04-25" ;
       :summary = "Wave gliders provide very detailed information
about the physical condition of the waters in which they travel.
They are small, unmanned vehicles that can cruise along the ocean
surface for several months gathering information about wave
conditions, currents, and other water properties. Because gliders
are unmanned, they communicate with scientists on land using
```

```
satellite telemetry. Wave glider mission \"A\'a\" from Liquid
Robotics, Inc. started off the leeward (western) coast of Big
Island on October 23, 2013, recording wave height, wave direction,
and wave period every half hour. It made its way to the
Papahanaumokuakea Marine National Monument (Northwestern Hawaiian
Islands), reaching NOAA/NDBC moored buoy 51101 190 nautical miles
northwest of Kauai on November 7, 2013. It then returned to its
origin, reaching Big Island again on December 6, 2013." ;
       :project = "Pacific Islands Ocean Observing System
(PacIOOS)" ;
       :cdm_data_type = "Trajectory" ;
       :source = "Liquid Robotics, Inc. Wave Glider" ;
       :geospatial_vertical_positive = "down" ;
       :creator_url = "http://liquidr.com" ;
       :file_data_type = "timeseries" ;
       :geospatial_vertical_units = "m" ;
       :history = "Mon Dec  1 09:54:54 2014: ncatted -O -a
title,global,o,c,Liquid Robotics Wave Glider: Aa
aa_2013_12_07.nc\n",
            "Deployed W. of Big Island (2013-10-23)" ;etcdf
\2013-08-22 {
```

4. Data Vocabulary

Variable	Long name	Short name	Standard Name	Units
time	time	time	time	seconds
shgt(time)	significant wave height	shgt	sea_surface_wave_significant_height	meters
pper(time)	peak wave period	pper	sea_surface_wave_period_at_variance_spectral_density_maximum	seconds
pdir(time)	peak wave direction	pdir	sea_surface_wave_from_direction	degrees
mper(time)	mean wave period	mper	sea_surface_wave_period_at_variance_spectral_density_second_frequency_moment	seconds
longitude(time)	longitude	longitude	longitude	degrees_east
latitude(time)	latitude	latitude	latitude	degrees_north

Table 47. Liquid Robotics wave glider variable definitions.

5. Data distribution[33]

Liquid Robotics Wave Glider: Aa

- Metadata: http://pacioos.org/metadata/aa_agg.html

[33] Example for single glider A'a (aa); other missions/gliders are done similarly.

- Voyager: http://pacioos.org/voyager/index.html?b=19.555555%2C-163.555073%2C24.802602%2C-154.2002147&o=glide::d1v4c52
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/glide_wave.html?dataset=aa_agg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/Aa.graph
- SOS: http://oos.soest.hawaii.edu/thredds/sos/hioos/glider/aa_agg?service=SOS&version=1.0.0&request=GetCapabilities
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hioos/glider/aa_agg.html

S. Data obtained from non-PacIOOS providers (USGS Digital Elevation Map)

1. Data flow

Digital elevation maps, created by the United States Geological Survey (USGS) were obtained from the Scripps/UCSD satellite geodesy group (http://topex.ucsd.edu/WWW_html/srtm30_plus.html) and are saved as static tiff and netCDF files.

2. File naming convention

DEMs are stored in directories by location (*e.g.*, oahu, global, bigisland, *etc.*). Each directory has netcdf files and tif files named, for example, `hi_usgs_oahu_dem.nc` and `hi_usgs_oahu_dem.tif`.

3. Data format specification

```
netcdf hi_usgs_oahu_dem {
dimensions:
 lat = 4943 ;
 lon = 6829 ;
variables:
 float elev(lat, lon) ;
       elev:long_name = "elevation" ;
       elev:_FillValue = NaNf ;
       elev:standard_name = "height" ;
       elev:units = "meters" ;
       elev:positive = "up" ;
 double lat(lat) ;
       lat:standard_name = "latitude" ;
       lat:long_name = "latitude" ;
       lat:units = "degrees_north" ;
 double lon(lon) ;
       lon:standard_name = "longitude" ;
       lon:long_name = "longitude" ;
       lon:units = "degrees_east" ;

// global attributes:
       :Conventions = "CF-1.5" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units

lon	longitude	lon	longitude	degrees_east
lat	latitude	lat	latitude	degrees_north
elev	elevation	evel	height	meters

Table 48. USGS DEM variable definitions.

5. Data distribution[34]

USGS 10-m Digital Elevation Model (DEM): Hawaii: Oahu

- Metadata: http://pacioos.org/metadata/usgs_dem_10m_oahu.html
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/dem.html?dataset=usgs_dem_10m_oahu
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/usgs_dem_10m_oahu.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=usgs_dem_10m_oahu&varid=elev-usgs_dem_10m_oahu
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=689b41f352755224f38317d7b3ecd66e
- WMS: http://oos.soest.hawaii.edu/thredds/wms/usgs_dem_10m_oahu?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/usgs_dem_10m_oahu?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/usgs_dem_10m_oahu/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/usgs_dem_10m_oahu.html

T. Data obtained from non-PacIOOS providers (Benthic Habitat Map)

1. Data flow

These data were taken from the "Shallow Water Benthic Habitat Maps" DVD's produced by the National Ocean Service Center for Coastal Monitoring and Assessment Biogeography Branch (September 2007). The files were loaded into the PacIOOS GeoServer and from there ported to data services.

2. File naming convention

N/A

3. Data format specification

N/A

[34] This is an example for a single DEM, Oahu. The other files are served in the same manner with the same services.

4. Data Vocabulary

N/A

5. Data distribution

NOAA Shallow-Water Benthic Habitats: Insular Pacific

- Metadata: http://pacioos.org/metadata/benthic_habitats.html
- Voyager: http://pacioos.org/voyager/index.html?b=-11.078081%2C-171.114292%2C-11.034615%2C-171.041208&o=benth:1::d11
- WMS: http://pacioos.org/ogc/benthic_habitats?service=WMS&version=1.1.1&request=GetCapabilities
- WFS: http://pacioos.org/ogc/benthic_habitats?service=WFS&version=1.1.0&request=GetCapabilities
- Other: http://ccma.nos.noaa.gov/products/biogeography/hawaii_cd_07/
- Other: http://ccma.nos.noaa.gov/ecosystems/coralreef/nwhi/
- Other: http://ccma.nos.noaa.gov/products/biogeography/palau/
- Other: http://ccma.nos.noaa.gov/ecosystems/coralreef/us_pac_mapping.aspx

U. Data obtained from non-PacIOOS providers (misc layers)

1. Data flow

There are several geospatial layers that are served through TDS/ERDDAP and available on Voyager. These are all static layers and include things like distance to coast, bathymetry, *etc*.

2. File naming convention

Various

3. Data format specification

Various

4. Data vocabulary

Various

5. Data distribution

PacIOOS Boundaries: EEZs and Geographic

- Metadata: http://pacioos.org/metadata/pacioos_boundaries.html
- Voyager: http://pacioos.org/voyager/index.html?t=m&o=geog:1+2+7+5+6%2Cbound:4+5
- WMS: http://pacioos.org/ogc/pacioos_boundaries?service=WMS&version=1.1.1&request=GetCapabilities
- WFS: http://pacioos.org/ogc/pacioos_boundaries?service=WFS&version=1.1.0&request=GetCapabilities

- Other: http://www.nauticalcharts.noaa.gov/csdl/mbound.htm

Distance to Nearest Coastline: 0.01-Degree Grid[35]
- Metadata: http://pacioos.org/metadata/dist2coast_1deg.html
- Voyager: http://pacioos.org/voyager/index.html?b=-85.200475%2C-180%2C85.200475%2C180&o=nav:5%2Cnav:6
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/dist2coast.html?dataset=dist2coast_1deg
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/dist2coast_1deg.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=dist2coast_1deg&varid=dist-dist2coast_1deg
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=eba3652b92c3df358334673821ab158
- WMS: http://oos.soest.hawaii.edu/thredds/wms/dist2coast_1deg?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/dist2coast_1deg?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/dist2coast_1deg/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/dist2coast_1deg.html

ETOPO5 Global Surface Relief
- Metadata: http://pacioos.org/metadata/etopo5.html
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/bathymetry.html?dataset=etopo5
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/etopo5.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=etopo5&varid=ROSE-etopo5
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=6218adc134776eab52449069f8dac993
- WMS: http://oos.soest.hawaii.edu/thredds/wms/etopo5?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/etopo5?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/etopo5/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/etopo5.html

[35] There are also layers for 0.04-degree resolution, and both sets include land and ocean only (three layers total for each resolution).

FEMA Flood Hazard Zones: State of Hawaii

- Metadata: http://pacioos.org/metadata/flood_hazard_zones.html
- Voyager: http://pacioos.org/voyager/index.html?b=21.226889%2C-158.22012%2C21.556788%2C-157.635441&t=m&o=flzn:1
- WMS: http://pacioos.org/ogc/flood_hazard_zones?service=WMS&version=1.1.1&request=GetCapabilities
- WFS: http://pacioos.org/ogc/flood_hazard_zones?service=WFS&version=1.1.0&request=GetCapabilities
- Other: http://planning.hawaii.gov/gis/download-gis-data-expanded/

Main Hawaiian Islands Multibeam Bathymetry Synthesis: 1-km Bathymetry and Topography[36]

- Metadata: http://pacioos.org/metadata/hmrg_bathytopo_1km_mhi.html
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/bathymetry.html?dataset=hmrg_bathytopo_1km_mhi
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/hmrg_bathytopo_1km_mhi.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=hmrg_bathytopo_1km_mhi&varid=z-hmrg_bathytopo_1km_mhi
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=8c8e5e0d3dbc86767c5cb7b944cc8a4
- WMS: http://oos.soest.hawaii.edu/thredds/wms/hmrg_bathytopo_1km_mhi?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/hmrg_bathytopo_1km_mhi?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/hmrg_bathytopo_1km_mhi/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/hmrg_bathytopo_1km_mhi.html

PacIOOS Marine Species Spatial Distributions

- Metadata: http://pacioos.org/metadata/species_dist.html

[36] There are also layers for the 50m synthesis and a combined 50m bathymetry and topography layer.

- Voyager: http://pacioos.org/voyager/index.html?b=17.845511%2C-162.155429%2C23.153049%2C-152.800571&t=m&o=botds:1:d1n300i-1
- WMS: http://pacioos.org/ogc/species_dist?service=WMS&version=1.1.1&request=GetCapabilities

NOAA/NGDC Regional Bathymetry (10 meter for Tutuila, Guam, and Wake; 180 meter for Mariana Trench; 90 meter for American Samoa)

- Metadata: http://oos.soest.hawaii.edu/pacioos/metadata/as_ngdc_tutma_bathy90m_hillshade.html
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/bathymetry.html?dataset=ngdc_bathy_90m_amsamoa
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/ngdc_bathy_90m_amsamoa.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?catid=ngdc_bathy_90m_amsamoa&dsid=ngdc_bathy_90m_amsamoa&varid=elev-ngdc_bathy_90m_amsamoa
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=248f3dcfbbf8c25a184516b251824c3b
- WMS: http://oos.soest.hawaii.edu/thredds/wms/ngdc_bathy_90m_amsamoa?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/ngdc_bathy_90m_amsamoa?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/ngdc_bathy_90m_amsamoa/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/ngdc_bathy_90m_amsamoa.html

NOAA/PIBHMC Regional Bathymetry (1 meter for Apra Harbor; 2 meter for Agrihan; 5 meter for Northeast Bank, Ofu And Olosega, Rose Atoll, Swains, Tau, Alamagan, Asuncion, Farallon De Medinilla, Marpi Bank, Maug, Rota, Saipan, Tinian, Guam, Baker Island, Howland Island, Jarvis Island, Johnston Atoll, Kingman Reef, Palmyra Atoll; 10 meter for Swains, Agrihan, Alamagan, Asuncion, Farallon De Pajaros, Guguan, Maug, Pagan, Sarigan, Supply Reef; 20 meter for Northeast Bank, Jarvis Island, Johnston Atoll, Kingman Reef; 40 meter for Rose Atoll, Swains, Baker Island, Howland Island, Palmyra Atoll; 60 meter for Rota and Guam)

- Metadata: http://oos.soest.hawaii.edu/pacioos/metadata/pibhmc_bathy_10m_swains.html

- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/bathymetry.html?dataset=pibhmc_bathy_10m_swains
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/pibhmc_bathy_10m_swains.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?catid=pibhmc_bathy_10m_swains&dsid=pibhmc_bathy_10m_swains&varid=elev-pibhmc_bathy_10m_swains
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=dcaeae80992965249b10d2e330154287
- WMS: http://oos.soest.hawaii.edu/thredds/wms/pibhmc_bathy_10m_swains?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/pibhmc_bathy_10m_swains?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/pibhmc_bathy_10m_swains/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/pibhmc_bathy_10m_swains.html

USGS 10 meter Digital Elevation Model (Ofu and Olosega, Tau, Tutuila, Aguijan, Rota, Saipan, Tinian, Chuuk, Kosrae, Pohnpei, Guam, Big Island, Kahoolawe, Kauai, Lanai, Maui, Molokai, Niihau, Oahu, and Palau)

- Metadata: http://oos.soest.hawaii.edu/pacioos/metadata/usgs_dem_10m_kosrae.html
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/dem.html?dataset=usgs_dem_10m_kosrae
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/usgs_dem_10m_kosrae.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?catid=usgs_dem_10m_kosrae&dsid=usgs_dem_10m_kosrae&varid=elev-usgs_dem_10m_kosrae
- DChart: http://oos.soest.hawaii.edu/dchart/index.html?dsetid=6cfc9e0b285daa2681eb3402758ea42
- WMS: http://oos.soest.hawaii.edu/thredds/wms/usgs_dem_10m_kosrae?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/usgs_dem_10m_kosrae?service=WCS&version=1.0.0&request=GetCapabilities

- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/usgs_dem_10m_kosrae/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/usgs_dem_10m_kosrae.html

V. Data re-served from external sites (Hawaii State DoH water quality)

1. Data flow

The State of Hawaii Department of Health (DOH) Clean Water Branch (CWB) maintains a Beach Monitoring Quality Assurance Program through which specific beaches are monitored for various parameters. Measurements of bacteria levels (*Enterococcus* and *Clostridium perfingens*) are used to assess water quality. These and other water measurements (temperature, salinity, pH, *etc*.) are collected periodically (from a few times per week to monthly) at several beaches throughout the state.

2. File naming convention

N/A

3. Data format specification

N/A

4. Data vocabulary

Variable	Units
longitude	degrees_east
latitude	degrees_north
time	meters
location_id	CWB identifier
location_name	
number_concentration_of_enterococcus_in_sea_water	CFU/100 mil
number_concentration_of_clostridium_perfringens_in_sea_water	CFU/100 mil
sea_water_quality_alert	1
sea_water_temperature	degrees C
sea_water_salinity	PSU
sea_water_turbidity	NTU
sea_water_ph_reported_on_total_scale	pH
mass_concentration_of_oxygen_in_sea_water	mg/L
fractional_saturation_of_oxygen_in_sea_water	percent

Table 49. State of Hawaii DOH water quality variable definitions.

5. Data distribution

Hawaii Clean Water Branch (CWB) Beach Water Quality Data

- Metadata: http://pacioos.org/metadata/cwb_water_quality.html
- HTML: http://pacioos.org/focus/cwb/cwb_oahu.php
- Voyager: http://pacioos.org/voyager/index.html?region=hi&t=m&s=1&o=qual:3::v6c50n1

- ERDDAP: http://oos.soest.hawaii.edu/erddap/tabledap/cwb_water_quality.html

W. Data re-served from external sites (OceanWatch satellite data)

1. Data flow

The Pacific Islands Fisheries Science Center (PIFSC) operates a regional OceanWatch node for the central Pacific (http://oceanwatch.pifsc.noaa.gov). As part of this service they provide a variety of satellite measurements including SST, salinity, winds, *etc*. for the PacIOOS domain. These data are supplied both in TDS and LAS, and PacIOOS servers can link into this and re-serve the data via the PacIOOS services. The data served include:

- MODIS Aqua Ocean Color (weekly, monthly and near-real-time)
- SeaWiFS Ocean Color (weekly and monthly)
- VIIRS NASA Ocean Color (weekly and monthly)
- ASCAT Ocean Surface Winds (daily)
- QuikSCAT Ocean Surface Winds (3-day, weekly and monthly)
- Merged AVISO Sea-Surface Height and Geostrophic Currents (weekly, monthly and near-real-time))
- GOES Sea-Surface Temperature (2-day)
- Global GOES-POES Sea-Surface Temperature (2-day, weekly, monthly)
- AVHRR Pathfinder Sea-Surface Temperature v4.1 (weekly and monthly)
- AVHRR-GAC Sea-Surface Temperature (3-day)
- AVHRR Pathfinder Sea-Surface Temperature v5 and v5.1 (weekly and monthly)
- CCMP Ocean Surface Winds (monthly)
- Aquarius Sea-Surface Salinity (weekly and monthly)
- NPP VIIRS Ocean Color (weekly)
- MODIS Aqua Ocean Color (monthly)
- SeaWiFS Monthly Ocean Color (Climatology)
- AVHRR Pathfinder v5 Monthly Sea-Surface Temperature (Climatology)
- MODIS Aqua Monthly Ocean Color (Climatology)
- Smith and Sandwell v8.2 - Topography and Bathymetry

2. File naming convention

N/A

3. Data format specification

N/A

4. Data vocabulary

N/A

5. Data distribution

Pacific Islands Fisheries Science Center (PIFSC)[37]

- THREDDS: http://oos.soest.hawaii.edu/thredds/remoteCatalogService?catalog=http://oceanwatch.pifsc.noaa.gov/thredds/catalog.xml
- OPENDAP**:** http://oceanwatch.pifsc.noaa.gov/thredds/dodsC/aqua/weekly
- WCS**:** http://oceanwatch.pifsc.noaa.gov/thredds/wcs/aqua/weekly
- WMS**:** http://oceanwatch.pifsc.noaa.gov/thredds/wms/aqua/weekly
- NCSS**:** http://oceanwatch.pifsc.noaa.gov/thredds/ncss/grid/aqua/weekly

X. Data re-served from external sites (Wave Buoys)

1. Data flow

PacIOOS maintains a set of wave buoys throughout the insular Pacific. The data are transmitted via Iridium to the Coastal Data Information Program (CDIP) at UCSD. CDIP provides the data management for the wave buoys deployed by PacIOOS as well as the deep-water wave buoys around Hawaii. The PacIOOS servers access the data from CDIP and re-serve it through local servers.

2. File naming convention

N/A

3. Data format specification

N/A

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
wave height				meters
wave from direction				degrees_north
wave period				seconds
water temperature				degrees C

Table 50. Wave buoy variable definitions.

5. Data distribution[38]

PacIOOS Wave Buoy 098: Mokapu Point, Oahu, Hawaii

- Metadata: http://pacioos.org/metadata/cdip098.html
- HTML: http://pacioos.org/wavebuoy/mokapubuoy.php
- Voyager: http://pacioos.org/voyager/index.html?b=21.148524%2C-158.486994%2C21.802829%2C-157.317637&o=wave:1::c52p0098p1
- Other: http://www.ndbc.noaa.gov/station_page.php/?station=51202
- Other: http://cdip.ucsd.edu/?nav=historic&xitem=stn_home&stn=098

[37] Example shown is for weekly MODIS data; other data are served similarly.
[38] PacIOOS provides all the near-shore wave buoy data via Voyager in a similar way, this is a single example for buoy 098.

Y. Data re-served from external sites (Tide gauge)

1. Data flow

The UH Sea Level Center maintains the global tide gauge network and provides the data via OPeNDAP. PacIOOS now links into the UHSLC rather than periodically downloading the data.

[**OLD WAY**: UHSLC would provide netCDF (and ASCII) formats via ftp. To allow users to access these data via the PacIOOS data servers, the data are downloaded and added to the DMS. The downloads are done via **`get_uhslc_data.s`** that runs daily at 10:00AM local time. This script ftp's the data from *ilikai.soest.hawaii.edu*, the main UHSLC archive site, from the "fast" directory. Sea level data are released in near-real-time in the fast directory, or in delayed model after QC has been done. The delayed mode files, called "research quality", sometimes take a while to be updated, so only the fast data are distributed via the PacIOOS DMS.]

2. File naming convention

N/A

[**OLD WAY**: There are three types of files based on temporal resolution. These include hourly, daily and monthly files. The file have a single letter prefix (h, hourly; d, daily; or m, montly) followed by a three-digit station id number, *e.g.*, `m699.nc` contains monthly data for tide gauge 699 (which happens to be in Singapore).]

3. Data format specification

```
netcdf m699 {
dimensions:
 time = 304 ;
 depth = 1 ;
 latitude = 1 ;
 longitude = 1 ;
variables:
 float time(time) ;
       time:FORTRAN_format = " " ;
       time:units = "day since 1985-1-1 0:0:0" ;
       time:type = "EVEN" ;
 float depth(depth) ;
       depth:FORTRAN_format = " " ;
       depth:units = "m" ;
       depth:type = "EVEN" ;
       depth:epic_code = 3 ;
 float latitude(latitude) ;
       latitude:FORTRAN_format = " " ;
       latitude:units = "degree_north" ;
       latitude:type = "EVEN" ;
       latitude:epic_code = 500 ;
 float longitude(longitude) ;
       longitude:FORTRAN_format = " " ;
       longitude:units = "degree_east" ;
       longitude:type = "EVEN" ;
       longitude:epic_code = 502 ;
 float sea_level_m_208(time, depth, latitude, longitude) ;
       sea_level_m_208:name = "sea_level_m" ;
```

```
       sea_level_m_208:long_name = "SEA LEVEL (monthly)      " ;
       sea_level_m_208:generic_name = "SLm" ;
       sea_level_m_208:FORTRAN_format = "f7.3" ;
       sea_level_m_208:units = "m" ;
       sea_level_m_208:epic_code = 208 ;

// global attributes:
       :INST_TYPE = "FLOAT GAUGE" ;
       :DATA_TYPE = "TIME" ;
       :DATA_SUBTYPE = "H" ;
       :DATA_ORIGIN = "UHSLC" ;
       :COORD_SYSTEM = "GEOGRAPHICAL" ;
       :Conventions = "PMEL-EPIC/TIME" ;
       :EXPERIMENT = "WOCE" ;
       :PROJECT = "FAST" ;
       :MOORING = "699" ;
       :DELTA_T = "MONTHLY" ;
       :VAR_DESC = "SEA LEVEL" ;
       :DESCRIPT = "AVERAGE DATA" ;
       :VAR_FILL = "1.e35" ;
       :DRIFTER = 0 ;
       :WATER_DEPTH = 0 ;
       :FILL_FLAG = 1 ;
       :PROG_CMNT1 = "conversion from ascii" ;
       :COMPOSITE = 0 ;
       :POS_CONST = 0 ;
       :DEPTH_CONST = 0 ;
       :WOCETIME = "YYYYMMDDhh" ;
       :WOCEstartTIME_MONTHLY = 1985011512 ;
       :WOCEendTIME_MONTHLY = 2010041500 ;
       :MINIMUM_SLH_VALUE_MONTHLY = 1.469f ;
       :MAXIMUM_SLH_VALUE_MONTHLY = 1.976f ;
       :DOC_001 = "
\r" ;
       :DOC_002 = "              QUALITY ASSESSMENT OF SEA LEVEL
DATA                \r" ;
       :DOC_003 = "                                by the
\r" ;
       :DOC_004 = "     UH SEA LEVEL CENTER/NATIONAL OCEANOGRAPHIC
DATA CENTER     \r" ;
       :DOC_005 = "                    JOINT ARCHIVE FOR SEA LEVEL
\r" ;
       :DOC_006 = "                           updated: 27 Feb
2009\r" ;
       :DOC_007 = "Station  : Tanjong Pagar             Latitude:
01 15.7N\r" ;
       :DOC_008 = "Country  : Singapore               Longitude:
103 51.2E\r" ;
       :DOC_009 = "JASL #   : 699A                Time Meridian:
120E (GMT + 8 hr)  \r" ;
       :DOC_010 = "GLOSS #  : 044  Originator #:          NODC #:
10101305           \r" ;
       :DOC_011 = "Contributor  : Maritime and Port of Singapore
Authority\r" ;
       :DOC_012 = "               Hydrographic Department\r" ;
       :DOC_013 = "               7B Keppel Road #13-07\r" ;
       :DOC_014 = "               Tanjong Pagar Complex\r" ;
       :DOC_015 = "               Singapore 089055\r" ;
```

```
       :DOC_016 = "Originator   : same
\r" ;
       :DOC_017 = "Original Data: analog; digital (acoustic)\r" ;
       :DOC_018 = "Instrmnt Type: A.OTT Float Type; Acoustic gauge
(12/1996+)\r" ;
       :DOC_019 = "Digitzd Intvl: 1 hour; 6 min (acoustic)\r" ;
       :DOC_020 = "Present Data : Hourly, daily, and monthly
values obtained by:     \r" ;
       :DOC_021 = "      Hourly : digitized from chart paper
(analog);\r" ;
       :DOC_022 = "               spot sampled on hour (6 min)\r"
;
       :DOC_023 = "      Daily  : 119-point convolution filter
(Bloomfield, 1976)    \r" ;
       :DOC_024 = "               centered on noon applied to the
hourly data        \r" ;
       :DOC_025 = "               with respective periods of the
95, 50, and 5%      \r" ;
       :DOC_026 = "               amplitude points at 124.0, 60.2,
and 40.2 hours    \r" ;
       :DOC_027 = "      Monthly: Simple average of all daily
values; calculated if  \r" ;
       :DOC_028 = "               7 or fewer days are missing
\r" ;
       :DOC_029 = "Span of data : 01 Jan 1984 - 31 Dec 2008\r" ;
       :DOC_030 = "Gaps > 1 mon : 30 Apr 1995 - 30 Jun 1995;31 Aug
1995 - 11 Nov 1995\r" ;
       :DOC_031 = "               05 May 2001 - 02 Jul 2001;31 Dec
2001 - 06 Feb 2002\r" ;
       :DOC_032 = "Time Refernce: GMT (hours 00-23)   Space-filler
Flag   :-9999     \r" ;
       :DOC_033 = "Units        : millimeters         Missing Data
Flag   : 9999     \r" ;
       :DOC_034 = "Existing     : Yes                 Operational
: Yes      \r" ;
       :DOC_035 = "Sat. Trans.  : No                  Distribution
: 1988-2008\r" ;
       :DOC_036 = "Refernce Levl: The sea level heights are
referred to the chart    \r" ;
       :DOC_037 = "               datum which is also the zero
level of the tide     \r" ;
       :DOC_038 = "               gauge. Bench mark information is
available upon    \r" ;
       :DOC_039 = "               request from the contributors.
\r" ;
       :DOC_040 = "Comment      : The residual series are very
noisy, which is       \r" ;
       :DOC_041 = "               due to shallow water tides that
are not   \r" ;
       :DOC_042 = "               resolved by the harmonic
analysis or due to timing \r" ;
       :DOC_043 = "               drifts of less than 15 minutes.
Since the newer\r" ;
       :DOC_044 = "               acoustic gauge of higher timing
resolution, a\r" ;
       :DOC_045 = "               similar signature remains.
Thus, it is clear\r" ;
```

```
       :DOC_046 = "                the timing is relatively good
and the fluctuations\r" ;
       :DOC_047 = "                in the residuals are a
reflection of unresolved\r" ;
       :DOC_048 = "                tidal constituents.  The
differences \r" ;
       :DOC_049 = "                in daily values with Keppel
Harbor and Johor \r" ;
       :DOC_050 = "                Bahru suggest subtle level
shifts on 28 Aug 1984,\r" ;
       :DOC_051 = "                29 Oct 1984, 9 Nov 1984, 9 May
1985, 01 May 1986.\r" ;
       :DOC_052 = "                The differences also show
unusually low values \r" ;
       :DOC_053 = "                for most of 1987. The data of
the acoustic gauge\r" ;
       :DOC_054 = "                are of higher quality.\r" ;
       :DOC_055 = "                \r" ;
       :DOC_056 = "      CI MISSING              REPLACED GAPS
QUESTIONABLE      \r" ;
       :DOC_057 = "YEAR (%) DATA                 OR BAD DATA
FLUCTUATIONS      \r" ;
       :DOC_058 = "---- --- -------------------- -------------- -
------------------\r" ;
       :DOC_059 = "1984 100 none                 none
none\r" ;
       :DOC_060 = "1985 100 none                 none
none     \r" ;
       :DOC_061 = "1986 100 none                 none
none     \r" ;
       :DOC_062 = "1987  99 197-202              none
none\r" ;
       :DOC_063 = "1988  99 92-95                none
none\r" ;
       :DOC_064 = "1989  95 250-257,309-319      none
none\r" ;
       :DOC_065 = "1990  97 314-316,323-326,331- none
none\r" ;
       :DOC_066 = "         334,358-362\r" ;
       :DOC_067 = "1991  93 33-39,70-72,83-89,   none
none\r" ;
       :DOC_068 = "         91-100,335-338\r" ;
       :DOC_069 = "1992  88 7-16,189-219,225-230 none
none\r" ;
       :DOC_070 = "1993 100 none                 none
none\r" ;
       :DOC_071 = "1994  90 10-32,161-167,170-   none
none\r" ;
       :DOC_072 = "         173,352-358\r" ;
       :DOC_073 = "1995  50 46-55,58-67,97-110,  none
none\r" ;
       :DOC_074 = "         120-181,205-206,210-\r" ;
       :DOC_075 = "         215,243-314,332-338,\r" ;
       :DOC_076 = "         345-353\r" ;
       :DOC_077 = "1996  95 80-98                none
none\r" ;
       :DOC_078 = "1997 100 none                 (03)091-(16)091
none\r" ;
```

```
       :DOC_079 = "                                (17)191-
(01)192\r" ;
       :DOC_080 = "                                (17)359-
(16)360\r" ;
       :DOC_081 = "1998 100 none                   none
none\r" ;
       :DOC_082 = "1999  95 119-123,140-153,       (21)282-(04)283
none\r" ;
       :DOC_083 = "         349-351\r" ;
       :DOC_084 = "2000  99 353-355                none
none\r" ;
       :DOC_085 = "2001  82 29-36,125-183,         none
none\r" ;
       :DOC_086 = "         361-362,365\r" ;
       :DOC_087 = "2002  90 1-37                   (17)144-(00)145
none\r" ;
       :DOC_088 = "                                (17)145-
(01)146\r" ;
       :DOC_089 = "                                (11)146-
(02)147\r" ;
       :DOC_090 = "                                (13)147-
(01)148\r" ;
       :DOC_091 = "2003 100 none                   none
none\r" ;
       :DOC_092 = "2004  97 12-14,70-72,172-174, none
none\r" ;
       :DOC_093 = "         213-215,220-224\r" ;
       :DOC_094 = "2005  97 109-116,158-160,274- (15)255-(08)256
none\r" ;
       :DOC_095 = "         276,326-327            (11)261-
(18)261\r" ;
       :DOC_096 = "                                (09)262-
(00)263\r" ;
       :DOC_097 = "                                (08)263-
(01)264\r" ;
       :DOC_098 = "2006  99 291-292                (13)363-(00)364
none\r" ;
       :DOC_099 = "2007  99 12-15                  none
none\r" ;
       :DOC_100 = "2008  99 366                    none
none\r" ;
       :CREATION_DATE = "12:45 25-JUN-2010" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
time(time)				days since 1985-01-01 0:0:0
depth(depth)				m
longitude(longitude)				degrees_east
latitude(latitude)				degrees_north
sea_level_m_208(time,depth,latitude,longitude)	SEA LEVEL (monthly)			m

Table 51. Tide gauge variable specifications.

5. Data distribution

The tide gauge data are provided and served by the University of Hawaii Sea Level Center (UHSLC, http://uhslc.soest.hawaii.edu), and PacIOOS provides access to these data through our data servers. There is no transfer or duplication of the data, the PacIOOS server catalogs point to the UHSLC services. Previously, the UHSLC did not provide data transport other than ftp, so PacIOOS would actually transfer the data over and serve it.

- THREDDS: http://oos.soest.hawaii.edu/thredds/remoteCatalogService?catalog=http://uhslc.soest.hawaii.edu/thredds/uhslc_quality.xml

Z. Data re-served from external sites (HYCOM)

1. Data flow

In addition to the locally run models, PacIOOS also downloads daily output from the US Navy model HYCOM (Hybrid Coordinate Ocean Model)[39]. HYCOM runs daily and is archived and distributed by the Asia Pacific Data Research Center (APDRC); the APDRC gets daily output via an agreement with NRL and the HYCOM consortium. The PacIOOS servers point to the APDRC server catalogs, and there are no actual data transfers between the two.

The global output is 1/12°, and contain the top ten vertical levels in the model (top 200 meters of the ocean). The output includes temperature, salinity, horizontal velocity and surface fluxes.

2. File naming convention

N/A

3. Data format specification

```
netcdf global {
dimensions:
 lat = 2170 ;
 lev = 10 ;
 lon = 4500 ;
 time = 2794 ;
 time2d = 863 ;
variables:
 double time(time) ;
       time:grads_dim = "t" ;
       time:grads_mapping = "linear" ;
       time:grads_size = "2794" ;
       time:grads_min = "00z08may2008" ;
       time:grads_step = "1dy" ;
       time:units = "days since 0001-01-01 00:00:00" ;
       time:long_name = "time" ;
       time:minimum = "00z08may2008" ;
```

[39] The Navy operational model used to be NCOM, and PacIOOS would do daily downloads, but this was discontinued in March 2013.

```
      time:maximum = "00z31dec2015" ;
      time:resolution = 1.f ;
double lev(lev) ;
      lev:units = "meters" ;
      lev:positive = "down" ;
      lev:name = "Depth" ;
      lev:grads_dim = "z" ;
      lev:grads_mapping = "levels" ;
      lev:long_name = "altitude" ;
      lev:minimum = 0. ;
      lev:maximum = 200. ;
      lev:resolution = 22.22222f ;
double lat(lat) ;
      lat:grads_dim = "y" ;
      lat:grads_mapping = "levels" ;
      lat:grads_size = "2170" ;
      lat:units = "degrees_north" ;
      lat:long_name = "latitude" ;
      lat:minimum = -78.64 ;
      lat:maximum = 46.8781 ;
      lat:resolution = 0.05786911f ;
double lon(lon) ;
      lon:grads_dim = "x" ;
      lon:grads_mapping = "linear" ;
      lon:grads_size = "4500" ;
      lon:units = "degrees_east" ;
      lon:long_name = "longitude" ;
      lon:minimum = 74.16003 ;
      lon:maximum = 434.08003 ;
      lon:resolution = 0.08f ;
double time2d(time2d) ;
      time2d:grads_dim = "t" ;
      time2d:grads_mapping = "linear" ;
      time2d:grads_size = "863" ;
      time2d:grads_min = "00z21aug2013" ;
      time2d:grads_step = "1dy" ;
      time2d:units = "days since 1-1-1 00:00:0.0" ;
      time2d:long_name = "time" ;
      time2d:minimum = "00z21aug2013" ;
      time2d:maximum = "00z31dec2015" ;
      time2d:resolution = 1.f ;
float temperature(time, lev, lat, lon) ;
      temperature:_CoordinateAxes = "time lev lat lon " ;
      temperature:_FillValue = 1.267651e+30f ;
      temperature:missing_value = 1.267651e+30f ;
      temperature:long_name = "potential temperature (degc) " ;
      temperature:units = "Celsius" ;
      temperature:standard_name =
"sea_water_potential_temperature" ;
float salinity(time, lev, lat, lon) ;
      salinity:_CoordinateAxes = "time lev lat lon " ;
      salinity:_FillValue = 1.267651e+30f ;
      salinity:missing_value = 1.267651e+30f ;
      salinity:long_name = "salinity (psu) " ;
      salinity:units = "1e-3" ;
      salinity:standard_name = "sea_water_salinity" ;
float u(time, lev, lat, lon) ;
      u:_CoordinateAxes = "time lev lat lon " ;
```

```
        u:_FillValue = 1.267651e+30f ;
        u:missing_value = 1.267651e+30f ;
        u:long_name = "eastward velocity (m/s) " ;
        u:units = "meter second-1" ;
        u:standard_name = "eastward_sea_water_velocity" ;
 float v(time, lev, lat, lon) ;
        v:_CoordinateAxes = "time lev lat lon " ;
        v:_FillValue = 1.267651e+30f ;
        v:missing_value = 1.267651e+30f ;
        v:long_name = "northward velocity (m/s) " ;
        v:units = "meter second-1" ;
        v:standard_name = "northward_sea_water_velocity" ;
 float qtot(time2d, lat, lon) ;
        qtot:_FillValue = 1.267651e+30f ;
        qtot:missing_value = 1.267651e+30f ;
        qtot:long_name = "surface downward heat flux in air (w/m2)
" ;
        qtot:units = "watt meter-2" ;
        qtot:standard_name = "surface_downward_heat_flux_in_air" ;
 float emp(time2d, lat, lon) ;
        emp:_FillValue = 1.267651e+30f ;
        emp:missing_value = 1.267651e+30f ;
        emp:long_name = "water flux into ocean (kg/m2/s) " ;
        emp:units = "kg m-2 s-1" ;
        emp:standard_name = "water_flux_into_ocean" ;
 float t_trend(time2d, lat, lon) ;
        t_trend:_FillValue = 1.267651e+30f ;
        t_trend:missing_value = 1.267651e+30f ;
        t_trend:long_name = "surface temperature trend (degc/day) "
;
        t_trend:units = "Celsius day-1" ;
        t_trend:standard_name =
"tendency_of_sea_surface_temperature" ;
 float s_trend(time2d, lat, lon) ;
        s_trend:_FillValue = 1.267651e+30f ;
        s_trend:missing_value = 1.267651e+30f ;
        s_trend:long_name = "surface salinity trend (psu/day) " ;
        s_trend:units = "1e-3 day-1" ;
        s_trend:standard_name = "tendency_of_sea_surface_salinity"
;
 float ssh(time2d, lat, lon) ;
        ssh:_FillValue = 1.267651e+30f ;
        ssh:missing_value = 1.267651e+30f ;
        ssh:long_name = "sea surface elevation (m) " ;
        ssh:units = "meter" ;
        ssh:standard_name = "sea_surface_height" ;
 float mlt(time2d, lat, lon) ;
        mlt:_FillValue = 1.267651e+30f ;
        mlt:missing_value = 1.267651e+30f ;
        mlt:long_name = "ocean mixed layer thickness (m) " ;
        mlt:units = "m" ;
        mlt:standard_name = "ocean_mixed_layer_thickness" ;

// global attributes:
        :title = "HYbrid Coordinate Ocean Model (HYCOM): Global" ;
        :Conventions = "Unidata Dataset Discovery v1.0, CF-1.4" ;
        :dataType = "Grid" ;
```

```
      :documentation =
"http://apdrc.soest.hawaii.edu/datadoc/hycom_global.php" ;
      :history = "HYCOM aggregated via NcML from University of
Hawaii Asia-Pacific Data-Research Center (APDRC) GrADS Data Server
(GDS) OPeNDAP for redistribution by PacIOOS data servers, J.
Maurer (04/2013), HYCOM changed: now provides mlt rather than mld
and mlp (02/2014)" ;
      :id = "hycom_global" ;
      :naming_authority = "org.pacioos" ;
      :Metadata_Conventions = "Unidata Dataset Discovery v1.0,
CF-1.4" ;
      :Metadata_Link =
"http://pacioos.org/metadata/hycom_global.html" ;
      :summary = "Global HYbrid Coordinate Ocean Model (HYCOM)
and U.S. Navy Coupled Ocean Data Assimilation (NCODA) 3-day, daily
forecast at approximately 9-km (1/12-degree) resolution. This is a
demonstration product from the HYCOM Consortium and is provided as
is. While considerable effort has been made to implement all model
components in a thorough, correct, and accurate manner, numerous
sources of error are possible. As such, please use these data with
the caution appropriate for any ocean related activity." ;
      :keywords = "Earth Science > Atmosphere > Atmospheric
Radiation > Heat Flux, Earth Science Services > Models > Ocean
General Circulation Models (OGCM)/Regional Ocean Models, Earth
Science Services > Models > Weather Research/Forecast Models,
Earth Science > Oceans > Ocean Circulation > Fresh Water Flux,
Earth Science > Oceans > Ocean Circulation > Ocean Currents, Earth
Science > Oceans > Ocean Circulation > Ocean Mixed Layer, Earth
Science > Oceans > Ocean Temperature > Ocean Mixed Layer, Earth
Science > Oceans > Ocean Temperature > Sea Surface Temperature,
Earth Science > Oceans > Salinity/Density > Salinity, Earth
Science > Oceans > Sea Surface Topography > Sea Surface Height" ;
      :keywords_vocabulary = "GCMD Science Keywords" ;
      :standard_name_vocabulary = "CF-1.4" ;
      :comment = "These model data are provided by the HYCOM
Consortium as served via the Asia-Pacific Data-Research Center
(APDRC) (http://apdrc.soest.hawaii.edu) GrADS Data Server (GDS).
3D variables start at 2008-05-08 while 2D variables start at 2013-
08-21." ;
      :geospatial_lat_min = -78.64 ;
      :geospatial_lat_max = 46.8781 ;
      :geospatial_lon_min = 0. ;
      :geospatial_lon_max = 360. ;
      :geospatial_vertical_min = 0. ;
      :geospatial_vertical_max = 200. ;
      :geospatial_vertical_positive = "down" ;
      :time_coverage_start = "2008-05-08T00:00:00Z" ;
      :geospatial_lat_units = "degrees_north" ;
      :geospatial_lon_units = "degrees_east" ;
      :geospatial_vertical_units = "meters" ;
      :time_coverage_resolution = "P1D" ;
      :creator_email = "forum@hycom.org" ;
      :creator_name = "HYCOM Consortium" ;
      :creator_url = "http://hycom.org" ;
      :date_created = "2013-04-23" ;
      :date_issued = "2013-04-23" ;
      :date_modified = "2014-06-23" ;
      :institution = "University of Hawaii" ;
```

```
      :project = "Pacific Islands Ocean Observing System
(PacIOOS)" ;
      :contributor_name = "Jim Potemra" ;
      :contributor_role = "distributor" ;
      :publisher_email = "info@pacioos.org" ;
      :publisher_name = "Pacific Islands Ocean Observing System
(PacIOOS)" ;
      :publisher_url = "http://pacioos.org" ;
      :license = "The data may be used and redistributed for free
but is not intended for legal use, since it may contain
inaccuracies. Neither the data Contributor, University of Hawaii,
PacIOOS, NOAA, State of Hawaii nor the United States Government,
nor any of their employees or contractors, makes any warranty,
express or implied, including warranties of merchantability and
fitness for a particular purpose, or assumes any legal liability
for the accuracy, completeness, or usefulness, of this
information." ;
      :acknowledgment = "The Pacific Islands Ocean Observing
System (PacIOOS) is funded through the National Oceanic and
Atmospheric Administration (NOAA) as a Regional Association within
the U.S. Integrated Ocean Observing System (IOOS). PacIOOS is
coordinated by the University of Hawaii School of Ocean and Earth
Science and Technology (SOEST)." ;
      :cdm_data_type = "Grid" ;
      :source = "HYbrid Coordinate Ocean Model (HYCOM) and Navy
Coupled Ocean Data Assimilation (NCODA), http://hycom.org" ;
      :references =
"http://apdrc.soest.hawaii.edu/datadoc/hycom_global.php,
http://hycom.org, http://pacioos.org" ;
}
```

4. Data vocabulary

Variable	Long name	Short name	Standard Name	Units
time(time)	time			days since 0001-01-01 0:0:0
lev(lev)	altitude			m
lon(lon)	longitude			degrees_east
lat(lat)	latitude			degrees_north
time2(time2)	time			days since 0001-01-01 0:0:0
temperature(time, lev, lat, lon)	potential temperature		sea_water_temperature	C
salinity(time, lev, lat, lon)	salinity		sea_water_salinity	PSU
u(time, lev, lat, lon)	eastward velocity		eastward_sea_water_velocity	m s-1
v(time, lev, lat, lon)	northward velocity		northward_sea_water_velocity	m s-1
qtot(time2, lat, lon)	surface downward		surface_downward_heatflu	W m-2

	heat flux in air		x_in_air	
emp(time2, lat, lon)	water flux into ocean		water_flux_into_ocean	kg m-2 s-1
t_trend(time2, lat, lon)	surface temperature trend		tendency_of_sea_surface_temperature	C day-1
s_trend(time2, lat, lon)	surface salinity trend		tendency_of_sea_surface_salinity	PSU day-1
ssh(time2, lat, lon)	sea surface elevation		sea_surface_height	m
mlt(time2, lat, lon)	ocean mixed layer thickness		ocean_mixed_layer_thickness	m

Table 52. HYCOM variable definitions.

5. Data distribution

HYbrid Coordinate Ocean Model (HYCOM): Global

- Metadata: http://pacioos.org/metadata/hycom_global.html
- Voyager: http://pacioos.org/voyager/index.html?b=-85.200475%2C-180%2C85.200475%2C180&o=ofore:5:f:d1
- THREDDS: http://oos.soest.hawaii.edu/thredds/idd/ocn_mod.html?dataset=hycom_global
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/HYCOM_Global_3D.graph
- ERDDAP: http://oos.soest.hawaii.edu/erddap/griddap/HYCOM_Global_2D.graph
- LAS: http://oos.soest.hawaii.edu/las/UI.vm?dsid=hycom_global&varid=temperature-hycom_global
- WMS: http://oos.soest.hawaii.edu/thredds/wms/pacioos/hycom/global?service=WMS&version=1.3.0&request=GetCapabilities
- WCS: http://oos.soest.hawaii.edu/thredds/wcs/pacioos/hycom/global?service=WCS&version=1.0.0&request=GetCapabilities
- NCSS: http://oos.soest.hawaii.edu/thredds/ncss/grid/pacioos/hycom/global/dataset.html
- OPeNDAP: http://oos.soest.hawaii.edu/thredds/dodsC/pacioos/hycom/global.html

AA. Data re-served from external sites (Ocean Acidification/CO2 buoys)

1. Data flow

Several buoys are deployed throughout the PacIOOS region that include sensors for measuring ocean acidification, namely pH and CO_2. These buoys include some in the Tropical Atmosphere and Ocean (TAO) array, long timeseries sites such as the

Hawaii Ocean Timeseries (HOT) and some of the PacIOOS WQB. The CO_2 data are typically used in climate studies and are subject to a strict and complex data quality analysis. This is done by the NOAA Pacific Marine Environmental Laboratory (PMEL) who then release the data. The PacIOOS WQB (described earlier) provide data to the PacIOOS servers, but the CO2 data are held at PMEL for analysis.

PacIOOS shows these buoys on web pages, but does not hold or serve the data. Instead, users are directed to contact PMEL for access. This was done at PMEL's request and will continue until otherwise directed.

2. File naming convention

N/A

3. Data format specification

N/A

4. Data vocabulary

N/A

5. Data distribution

Data are only available from PMEL; requests made through Voyager are directed to email adrienne.sutton@noaa.gov