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WORLD OCEAN DATABASE 2005 TUTORIAL

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For updates on the data, documentation, and additional information about the WOD05 please refer to:

http://www.nodc.noaa.gov/OC5/indprod.html

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I. Introduction

The purpose of this informal tutorial is to introduce new users to the *World Ocean Database 2005* (WOD05), outline the WOD05 environment, and to provide step-by-step examples of: 1) how to select WOD05 online data by location (geographically sorted over World Meteorological Organization squares); 2) use programs (wodFOR.f and wodASC.f) to read and output ASCII data; and 3) decompress data files and read data using the Ocean Data View (ODV) software (http://odv.awi.de/). This document is not a substitute for the complete document for the WOD05. For more detailed information on WOD05 see Boyer *et al.*, 2006 and Johnson *et al.*, 2006 available at: http://www.nodc.noaa.gov/OC5/WOD05/docwod05.html.

It is important to mention one additional means of obtaining data is through a user-defined subset and/or in a comma-separated (also known as comma-delimitated) format. This user-defined subset is WOD*select*. WOD*select* will not be described in this tutorial.

The WOD05 data are available in the Data Sets & Products page at http://www.nodc.noaa.gov/OC5/WOD05/pr_wod05.html.

Finally, this tutorial has been written for the Microsoft Windows 2000 environment on personal computers.

II. Examples of Extracting and Reading WOD Data

While this tutorial provides examples of several ways to use WOD05 data, it is important to point out that the DVD provides yearly (time) sorted data only. Since the time-sorted selection process is similar to the geographically sorted, we provide an example of extracting geographically sorted data only. Sections on reading data and importing data into ODV are relevant to the DVD.

(1) Geographically Sorted Data: The geographically sorted data are organized by ten-degree latitude-longitude squares following the World Meteorological Organization (WMO) ten-degree square numbering scheme (Figure 1). This geographical location option allows the user to select data within the desired WMO square and download data at observed (O) or interpolated to standard (S) depths. Table 1 shows the standard levels and their depths. After selecting observed or standard depths, the user can select the dataset (*i.e.* instrument type) of interest (Figure 2).

Example 1: Select and extract the Ocean Station Data (OSD) at observed depths with geographic coordinates between the 0°-10°N and between 160°-170°W. Note the radio-buttons for selection among observed or standard depths are located above the WMO map (see Figure 1 or http://www.nodc.noaa.gov/OC5/WOD05/data05geo.html).

The region of interest is located in WMO square number 7016 (North Pacific basin) as shown in Figure 1. Positive and negative longitudes in the WOD05 denote the Eastern and Western Hemispheres, positive and negative latitude denote the Northern and Southern Hemispheres respectively.

Selecting data by dataset type: Within each ten-degree WMO square the data are organized by dataset. The file with the desired data is OSDO7016.gz (Figure 2). This file contains 307 casts. The file naming convention used is as follows: OSD denotes instrument type; O denotes observed depth levels; 7016 denotes the WMO square number; filename extension .gz indicates that data file is compressed by gzip utility.

Select and save OSDO7016.gz to your work directory.

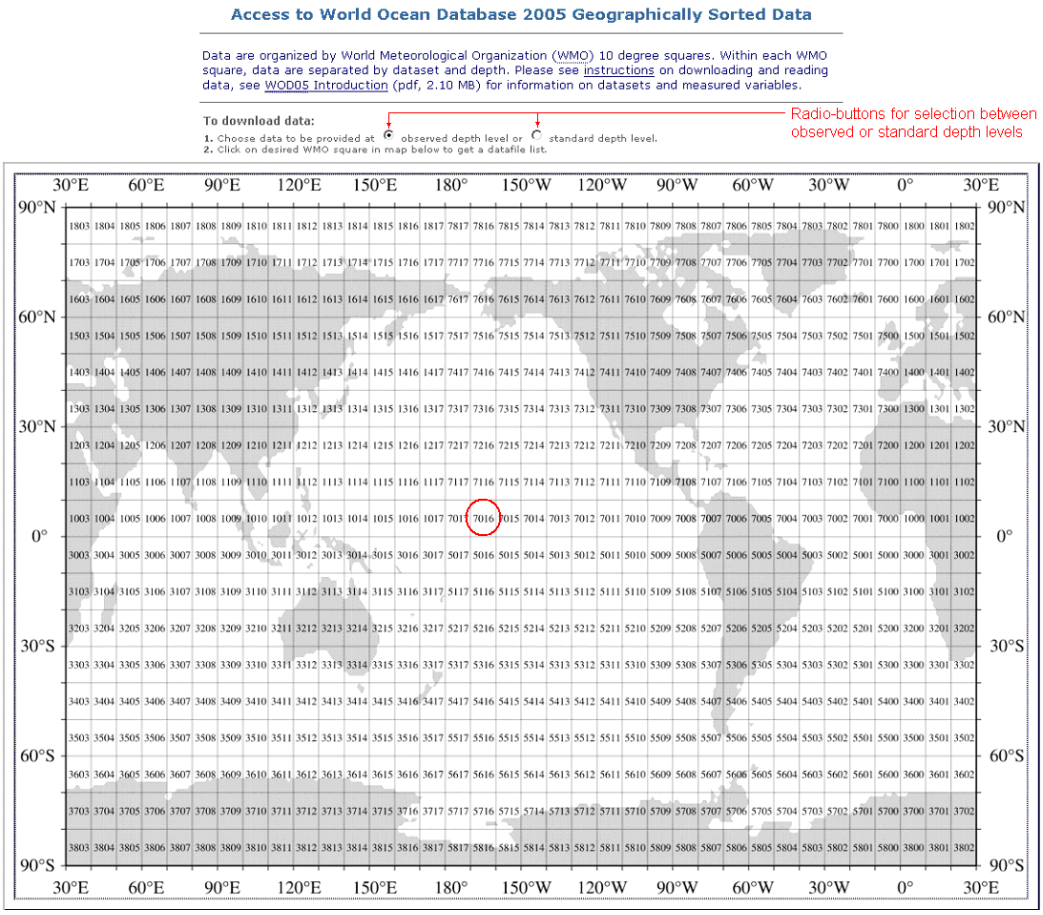

Figure 1. WOD05 Geographical Selection from WMO ten-degree squares (see http://www.nodc.noaa.gov/OC5/WOD05/data05geo.html).

WMO 7016 - Observed Depth Data
Please see information on downloading and reading data

Dataset		File Name (size)
OSD	Bottle, low resolution CTD and XCTD, and plankton data	OSDO7016.gz (0.1 MB)
MBT	MBT, DBT, and Micro BT data	MBTO7016.gz (0.5 MB)
CTD	High resolution CTD data	CTDO7016.gz (2.4 MB)
XBT	Expendable bathythermograph data	XBTO7016.gz (5.4 MB)
PFL	Profiling float data	PFLO7016.gz (0.1 MB)
MRB	Moored buoy data	MRBO7016.gz (0.2 MB)
DRB	Drifting buoy data	no data in selected WMO
APB	Autonomous Pinniped Bathythermograph data	no data in selected WMO
UOR	Undulating Oceanographic Recorder data	no data in selected WMO
GLD	Glider data	no data in selected WMO
SUR	Surface data are not geographically sorted. The entire dataset is available in a single file	SURF_ALL.gz (21.6 MB)

Figure 2. WOD05 Download screen of WMO square 7016 observed data.

If you have WinZip installed on your machine, the *WinZip* dialog box will appear (Figure 3) which allows decompression of OSDO7016.gz. To decompress OSDO7016.gz highlight the file, click on **Extract** and select the desired location for the data file. Close the *WinZip* dialog after decompression.

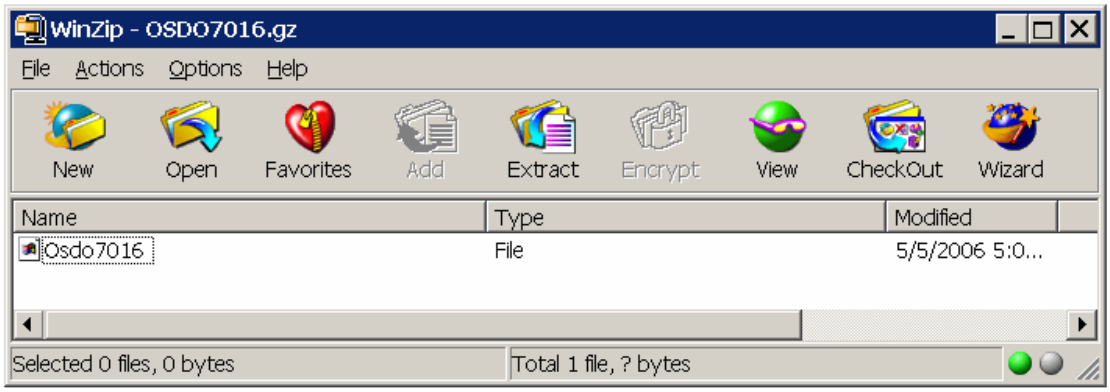

Figure 3. WinZip dialog box used for file extraction.

(2) Decompressing data: An alternative to WinZip is gzip. This is freeware that we have provided in the **utilities** page at http://www.nodc.noaa.gov/OC5/WOD05/utils05.html. The **utilities** page contains utilities used for decompressing data for DOS and UNIX environments. To decompress OSDO7016.gz, use the following command: *gzip –nd OSDO7016.gz*. (Refer to the **utilities** page or the gzip site at: http://www.gzip.org.)

(3) Reading data using sample programs: The **programs** page (http://www.nodc.noaa.gov/OC5/WOD05/programs05.html) contains sample programs written in FORTRAN and C for reading the WOD05 data.

The below FORTRAN program wodFOR.f shows how to read select WOD05 data from a file. This program is interactive in the sense that it prompts the user for the incoming file name (*e.g.*, OSDO7016) and number of stations to be displayed. The program can read data from any dataset at observed or standard depths. First, copy wodFOR.f to your working directory and make (compile) an executable or use the existing complied wodFOR.exe. It is assumed that the user is familiar with compiling FORTRAN programs (*e.g.*, UNIX environment: g77 -o <executable_file> <program_file.f>). The data should be decompressed by either WinZip, gzip, or other compression utility prior to running wodFOR.exe.

Example 2: Suppose that the name of the executable is wodFOR.exe (or any other name). To execute wodFOR.exe, type: wodFOR.exe. The program prompts the user for the data file name as input. Enter the file name: **OSDO7016**. The next prompt is to enter the number of desired casts. For Example 2, since the casts are displayed on your screen, enter the number **5**. The program displays the user-selected number of casts in the OSDO7016 data file. Table 2 shows the first cast in OSDO7016.

Each dataset contains different variables. For example, OSD include chemical, physical, and biological variables (Table 3). The sample output from wodFOR.exe shows the WOD05 unique cast number 159608 contains six variables (1=temperature, 2=salinity, 3=oxygen, 4=phosphate, 6=silicate, and 9=pH) as a function of depth (refer to Table 3 for codes). Each cast includes variable-specific and secondary header codes denoting meteorological data, originator's methods and instruments, ship and cruise name, *etc.* (Refer to **codes table** page (http://www.nodc.noaa.gov/OC5/WOD05/codes05.html) for codes.)

A note on other sample programs: Any of the FORTRAN or C programs can read WOD05 data from any dataset shown in Figure 2. The FORTRAN program wodASC.f reads the WOD05 data from a user-selected file and outputs a user-selected variable as a function of depth in either tab-separated or comma-separated format. The output from wodC.c is the same as wodFOR.f. The user can modify these programs according to specific needs.

(4) Reading data using Ocean Data View: ODV is used for visualization and analysis of oceanographic data by allowing the user to generate property-property plots, maps, and sections (transects). The software can be downloaded from http://odv.awi.de/. ODV will read (import) selected WOD05 data files in both gzip compressed or decompressed format. Example 3 illustrates how to open a new collection and import single and/or multiple data files into ODV. To use this tutorial ODV version 3.1 or higher must be installed. This document is not a substitute for the ODV User's Guide. Please refer to the ODV User's Guide available at:
http://odv.awi-bremerhaven.de/fileadmin/user_upload/odv/misc/odvGuide.pdf

IMPORTANT – Versions of ODV prior to 3.1 do not support the WOD05 data. It is a possibility that data may not be correctly imported.

Example 3: Create a new data collection and import a single WOD05 data file (OSDO7016) into ODV.

Opening a new data collection: In the upper menu bar of ODV (Figure 4), click on the **File** tab to open the file menu. Then click on **New** to create a New_ODV_Collection in your working directory (otherwise, any existing collection can be used if available). ODV will then request a name for the new collection. In Example 3, enter **demo1s** (as for "demo 1 single file", or any other meaningful file name) in the File name window. Click on **Save**. This will create the collection named **demo1s.var**.

Figure 4 shows ODV when a new collection is created and prior to importing data. Since no data have been imported, the ODV internal number of stations is zero, shown as [0/0]. Also, notice that the Global Map is blank, (*i.e.* no data distribution).

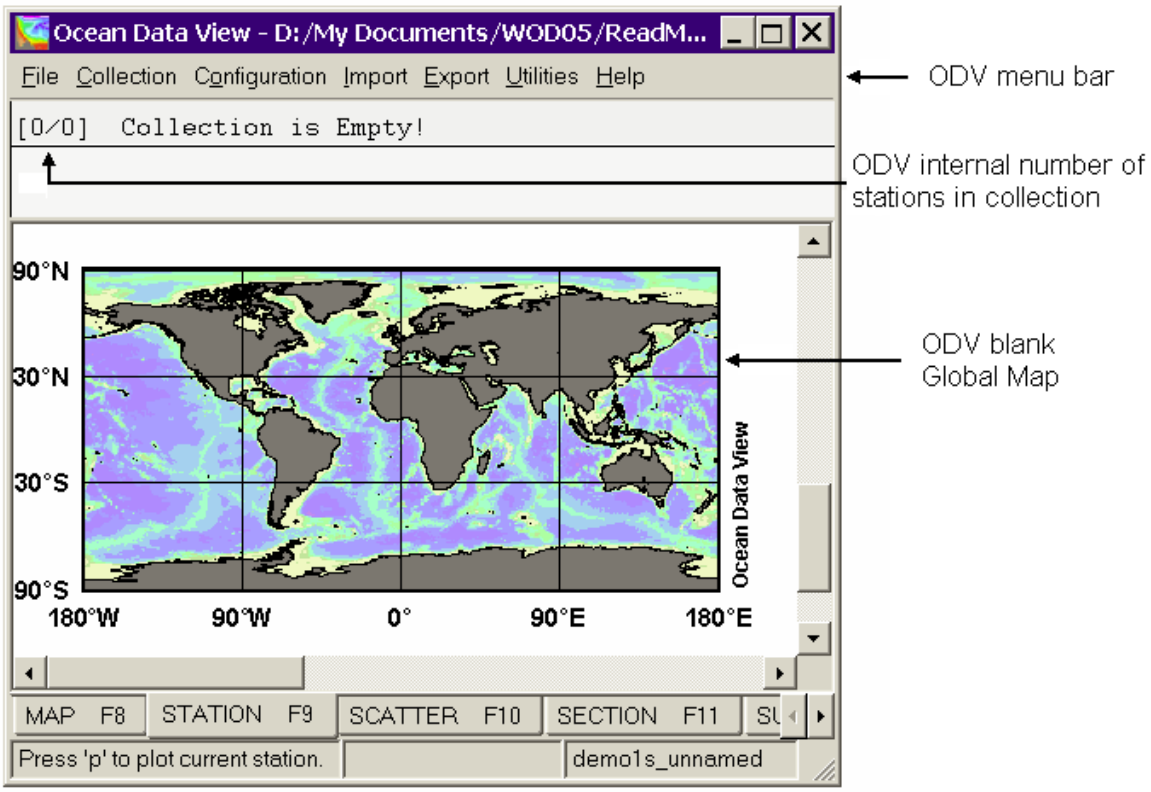

Figure 4. ODV screen after creating a new collection and prior to importing data.

Defining collection variables: In the next dialog box (Figure 5) you will define the imported data format (ARGO, user defined variables, WOCE, WOD, *etc.*).

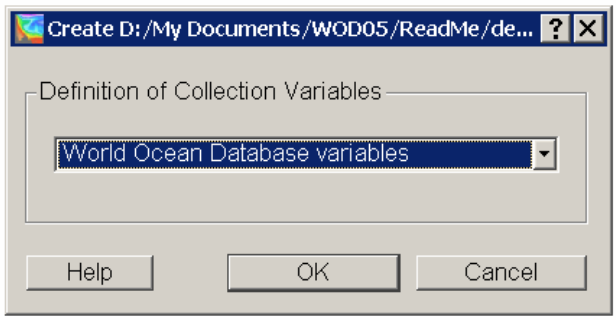

Figure 5. ODV Definition of Collection Variables.

In the pull-down window select **World Ocean Database variables** and press **OK**. A blank Global Map will appear in your ODV window.

Importing a single data file into the collection: The next step is to import data (OSDO7016.gz). In the ODV File Menu select **Import** > **NODC Formats > World Ocean Database > Single File**. In the browser window, point to the folder where you have placed OSDO7016.gz. Highlight OSDO7016.gz so that it shows in the File name window. Select **Open** to continue.

Using the *Import Options* dialog box (Figure 6) you can associate the variables of the imported data with the variables already defined in the collection. Now look at the bottom portion of the window the Variable Association frame. All of the variables defined as the WOD05 data are preceded by asterisks. To keep this exercise simply, we will not make any changes to the *Source File* or *Target Collection*. Please refer to the ODV manual for detailed information about advanced ODV features. Press **OK** to continue.

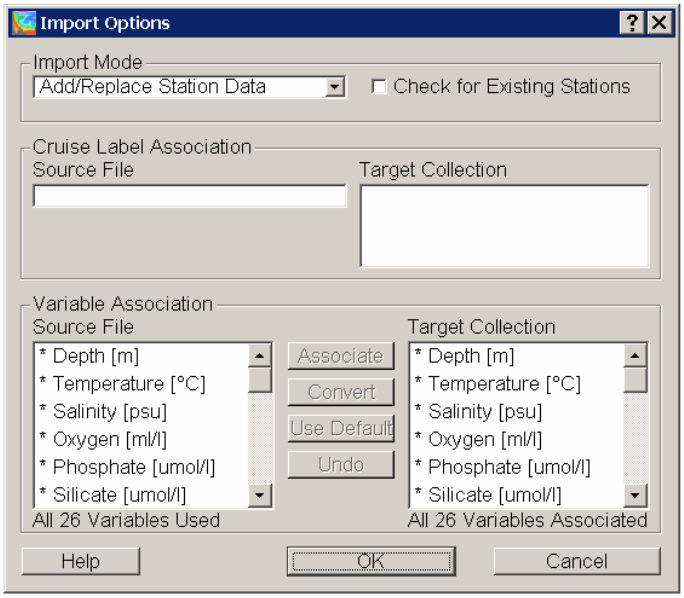

Figure 6. ODV Import Options.

The next dialog box is the *Selection Criteria* (Figure 7). This box provides some control on data selection. Again, for simplicity of this exercise, no changes will be made here. Press **OK** to continue.

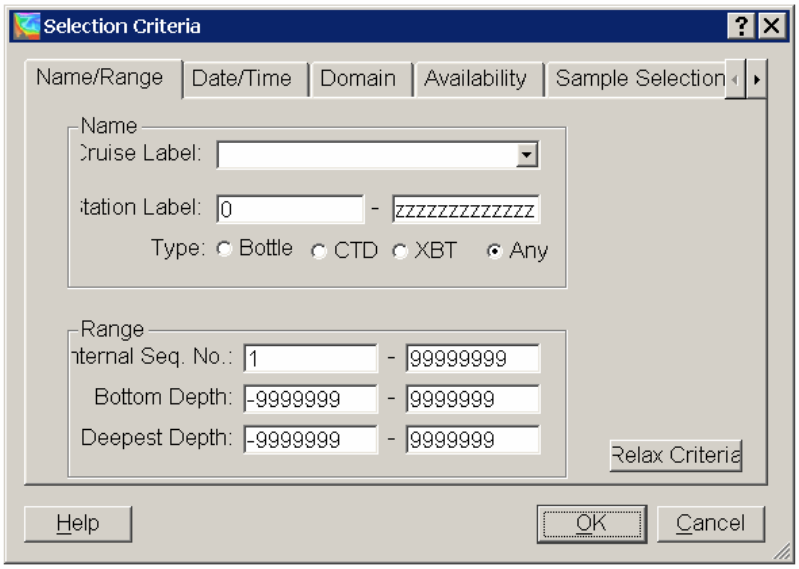

Figure 7. ODV Selection Criteria.

The next dialog box *Subsampling Parameters* (Figure 8) can be used to set a starting depth and depth interval for the imported data. No changes will be necessary, press **OK** to continue with the exercise.

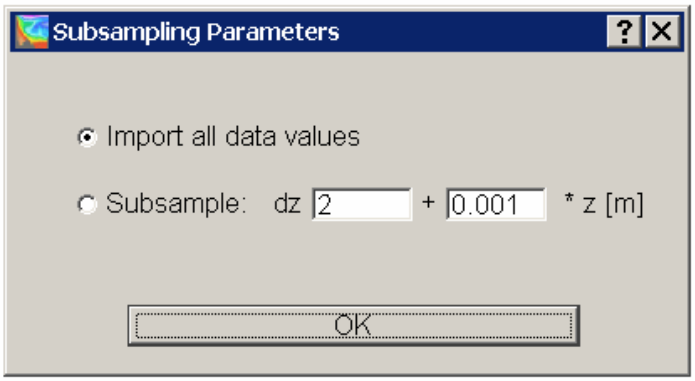

Figure 8. ODV Subsampling Parameters.

In the *Importing Station Data* dialog box (Figure 9) there will be a message that 307 stations will be imported from OSDO7016.gz. Press **OK** to import the data into ODV.

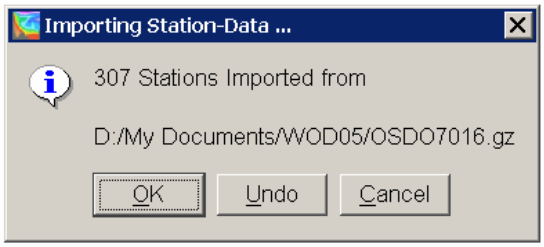

Figure 9. ODV Importing Station Data.

Distribution of the imported data will appear in the Global Map. Note that once a collection has been created, it is possible to import additional data files into the same collection. Figure 10 shows information contained in each station as displayed by ODV.

When the user selects **World Ocean Database** format, the ODV screen displays all depth-dependent variables in WOD05 (see Table 3). However, for the purpose of space in this document, we have purposely cut off variables after pH in Figure 10.

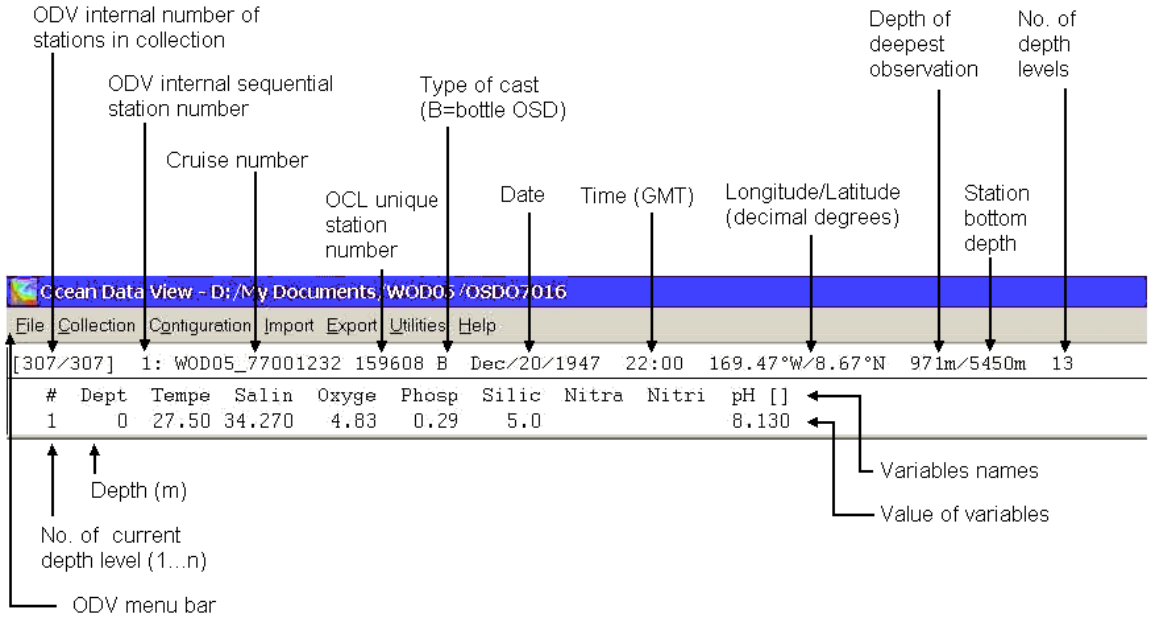

Figure 10. WOD05 cast information and profile data as displayed by Ocean Data View (ODV). All the information corresponds to the WOD05 format unless specified otherwise. Some cast information such as profile bottom depth might not exist in all casts.

Example 4: Open a new collection and import several OSD data files into ODV.

Opening a new data collection: In the ODV menu bar (Figure 4) click on the **File** tab to open the File Menu. Click on **New** to create a New_ODV_Collection in your working directory (or you can open any existing collection if one is available). ODV will then request a name for the new collection under file name. Enter *demo2m* (demo 2 multiple

files; or any other file name) in the File name window and click **Save**. This will create the collection file named *demo2m.var*.

Defining collection variables: In the next dialog box (similar to Figure 5) you will define your collection variables. In the pull-down window select **World Ocean Database Variables** and press **OK** to continue. A blank Global Map will appear in your ODV window.

Importing multiple data files into the collection: This step requires a text (ASCII) file that contains a listing of the data file names to be imported. For Example 4, create a file named *multifile.lst* (or any other file name) in the working directory with the following data file names (one file name per line):

OSDO7201.gz
OSDO7202.gz
OSDO7203.gz

In the ODV File Menu bar (Figure 4), select **Import** > **NODC Formats > World Ocean Database > Multiple Files**. In the browser window select the folder where you have placed the file *multifile.lst*. Highlight *multifile.lst* so that it shows in the File name window and select **Open**. Browse to the working directory and select the *multifile.lst* file. Click **Open** to continue.

In the *Import Options* dialog box (Figure 6) press **OK** to continue.

In the *Selection Criteria* dialog box (Figure 7) press **OK** to continue.

In the *Subsampling Parameters* dialog box (Figure 8) press **OK** to continue.

When the Multiple Files option is used, the *Importing Station Data* dialog box (Figure 9) will not appear on the screen. When importing is completed, data distribution will appear on the Global Map. The ODV internal number of stations (see Figure 10) will show the total number of imported stations (11,572) for the entire collection created.

ODV and WOD variable quality flags: ODV has four variable quality flags: Good, Unknown, Questionable, and Bad. These quality flags in ODV translate to WOD variable quality flags as illustrated in Tables 4 and 5. Since ODV does not have a single entire-profile quality flag, the WOD entire-profile quality flags are assigned to each depth and variable within that profile. As described in the ODV User's Guide, ODV handles the WOD "entire station" and "individual observed level sample" flags separately. ODV then uses the maximum of the two flags as the quality flag of the sample. The WOD variables that received full quality control are: temperature, salinity, oxygen, phosphate, silicate, and nitrate. Other WOD05 variables received limited quality control such as basin data ranges for: pH, Chlorophyll, Alkalinity, Partial pressure of carbon dioxide, Dissolved Inorganic carbon, Tritium, Helium, Delta Helium-3, Delta Carbon-14, Delta Carbon-13, Argon, Neon, Chlorofluorocarbon 11, Chlorofluorocarbon 12, Chlorofluorocarbon 113, and Delta Oxygen-18.

(5) Reporting data problems, suggestions, and comments about WOD05: If any errors are found in WOD05, please contact the Ocean Climate Laboratory (OCL) at OCL.help@noaa.gov and the problems will be corrected. Comments or suggestions for improving WOD05 would be greatly appreciated. Updates to programs and changes to WOD05 will be posted on the National Oceanographic Data Center/OCL Web site at: http://www.nodc.noaa.gov/OC5.

III. References

Boyer, T.P., J.I. Antonov, H.E. Garcia, D.R. Johnson, R.A. Locarnini, A.V. Mishonov, M.T. Pitcher, O.K. Baranova, I.V. Smolyar, 2006. *World Ocean Database 2005*. S. Levitus, Ed., NOAA Atlas NESDIS 60, U.S. Government Printing Office, Wash., D.C., 190 pp., DVDs.

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Schlitzer, R., 2006. Ocean Data View, http://odv.awi.de/.

Table 1. Standard levels and their depths (meters).

Depth	Level #	Depth	Level #	Depth	Level #	Depth	Level #
0	1	250	11	1200	21	4500	31
10	2	300	12	1300	22	5000	32
20	3	400	13	1400	23	5500	33
30	4	500	14	1500	24	6000	34
50	5	600	15	1750	25	6500	35
75	6	700	16	2000	26	7000	36
100	7	800	17	2500	27	7500	37
125	8	900	18	3000	28	8000	38
150	9	1000	19	3500	29	8500	39
200	10	1100	20	4000	30	9000	40

Table 2. Sample data output (Cast No. 159608) from the OSDO7016 using wodFOR.f. The output shows six variables as a function of depth; quality flags; and secondary header codes. Letters "f" and "o" denote WOD05 and originator's quality flags, respectively; numbers in parenthesis indicate significant digits; "VarFlag" indicates whole profile quality flag; missing values are denoted as -999.99.

```
Input File Name:

 Enter number of casts to view (0=view entire file)
 ---------------------------------------------------------
 Output from ASCII file, cast# 159608
 ---------------------------------------------------------

 CC  cruise Latitude Longitude YYYY MM DD    Time    Cast  #levels
 77    1232   8.670  -169.470  1947 12 20   22.00   159608     13

 Number of variables in this cast:  6

 Originators Cruise Code: 77470418

     z  fo     1        fo    2        fo    3        fo    4        fo    6        fo    9        fo

    0.0 00   27.500 (4) 00   34.270 (4) 00    4.830 (3) 00    0.290 (2) 00    5.000 (1) 00    8.130 (3) 00
   24.0 00   27.510 (4) 00 -999.990 (0) 00 -999.990 (0) 00 -999.990 (0) 00 -999.990 (0) 00 -999.990 (0) 00
   48.0 00   27.490 (4) 00   34.350 (4) 00    4.810 (3) 00    0.260 (2) 00    6.000 (1) 00    8.140 (3) 00
   72.0 00   26.330 (4) 00   35.010 (4) 00    4.430 (3) 00    0.420 (2) 00    9.000 (1) 00    8.110 (3) 00
   96.0 00   21.160 (4) 00   34.880 (4) 00    3.810 (3) 00    0.650 (2) 00    9.000 (1) 00    8.050 (3) 00
  144.0 00   13.990 (4) 00   34.560 (4) 00    2.780 (3) 00    1.550 (3) 00   21.000 (2) 00    7.910 (3) 00
  194.0 00   11.100 (4) 00   34.650 (4) 00    0.750 (2) 00    2.520 (3) 00   32.000 (2) 00    7.730 (3) 00
  293.0 00    9.720 (3) 00   34.700 (4) 00    0.570 (2) 00    2.520 (3) 00   41.000 (2) 00    7.710 (3) 00
  392.0 00    8.960 (3) 00   34.660 (4) 00    0.540 (2) 00    2.810 (3) 00   49.000 (2) 00    7.660 (3) 00
  491.0 00    8.140 (3) 00   34.620 (4) 00    0.630 (2) 00    2.900 (3) 00   56.000 (2) 00    7.670 (3) 00
  587.0 00    6.310 (3) 00   34.560 (4) 00    0.450 (2) 00    3.120 (3) 00   68.000 (2) 00    7.640 (3) 00
  779.0 00    5.460 (3) 00   34.560 (4) 00    0.960 (2) 00    3.040 (3) 00   86.000 (2) 00    7.630 (3) 00
  971.0 00    4.590 (3) 00   34.580 (4) 00    1.470 (3) 00    3.060 (3) 00   98.000 (2) 00    7.710 (3) 00

VarFlag:              0             4             0             3             3             0
 Secondary header #  1       126. (3)
 Secondary header #  3      6185. (4)
 Secondary header #  7       130. (3)
 Secondary header # 10      5450. (4)
 Secondary header # 18         3. (1)
 Secondary header # 19         9. (1)
 Secondary header # 21         4. (1)
 Secondary header # 29         7. (1)
 Secondary header # 99   2006124. (7)
```

Table 3. Depth-dependent variables in WOD05.

Code	Parameter	WOD05 standard unit or scale	Dataset(s) where variable(s) is/are stored
1	Temperature	Degrees Celsius (°C)	OSD, CTD, MBT, XBT, SUR, APB, MRB, PFL, UOR, DRB, GLD
2	Salinity	Dimensionless (unitless)	OSD,CTD, SUR, MRB, PFL, UOR, DRB, GLD
3	Oxygen [O_2]	Milliliter per liter (ml l^{-1})	OSD, CTD, PFL, UOR
4	Phosphate [HPO_4^{-2}]	Micromole per liter (µM)	OSD
6	Silicate [$Si(OH)_4$]	Micromole per liter (µM)	OSD
8	Nitrate [NO_3^-] and Nitrate+Nitrite	Micromole per liter (µM)	OSD
9	pH	Dimensionless	OSD, SUR
11	Total Chlorophyll [Chl]	Microgram per liter (µg l^{-1})	OSD, CTD, SUR, UOR
17	Total Alkalinity [TALK]	Milliequivalent per liter (meq l^{-1})	OSD, SUR
20	Partial pressure of carbon dioxide [pCO_2]	Microatmosphere (µatm)	OSD, SUR
21	Dissolved Inorganic carbon [DIC]	Millimole per liter (mM)	OSD
24	Transmissivity (BAC)[1]	Per meter (m^{-1})	CTD
25	Pressure	Decibar	OSD, CTD, UOR, GLD, PFL
26	Air temperature	Degree Celsius (°C)	SUR
27	CO_2warming	Degree Celsius (°C)	SUR
28	xCO_2atmosphere	Parts per million (ppm)	SUR
29	Air pressure	Millibar (mbar)	SUR
30	Latitude[3]	Degrees	SUR, APB, UOR
31	Longitude[3]	Degrees	SUR, APB, UOR
32	Julian year-day[2,3]	Day	SUR, APB, UOR
33	Tritium [^3H]	Tritium Unit (TU)	OSD
34	Helium [He]	Nanomol per liter (nM)	OSD
35	Delta Helium-3 [Δ^3He]	Percent (%)	OSD
36	Delta Carbon-14 [$\Delta^{14}C$]	Per mille (‰)	OSD
37	Delta Carbon-13 [$\Delta^{13}C$]	Per mille (‰)	OSD
38	Argon [Ar]	Nanomol per liter (nM)	OSD
39	Neon [Ne]	Nanomol per liter (nM)	OSD
40	Chlorofluorocarbon 11 (CFC 11)	Picomole per liter (pM)	OSD
41	Chlorofluorocarbon 12 (CFC 12)	Picomole per liter (pM)	OSD
42	Chlorofluorocarbon 113 (CFC113)	Picomole per liter (pM)	OSD
43	Delta Oxygen-18 [$\Delta^{18}O$]	Per mille (‰)	OSD

Table 4. Mapping of WOD05 "entire station" and "standard level" quality codes to ODV quality codes. This table corresponds to Table 15.4 of Appendix 15.2 in the ODV User's Guide.

Word Ocean Database 2005 Quality Codes			**Corresponding ODV Quality Flag**	
	Entire station	**Individual depth observations**		
0	accepted station	accepted value	**0**	good
1	failed annual standard deviation check	duplicates or inversions in recorded depth (same or less than previous depth)	**4**	questionable
2	two or more density inversions (Levitus, 1982 criteria)	density inversion	**4**	questionable
3	flagged cruise		**4**	questionable
4	failed seasonal standard deviation check		**4**	questionable
5	failed monthly standard deviation check		**4**	questionable
6	failed annual and seasonal standard deviation check		**4**	questionable
7	bull's-eye from standard level data or failed annual and monthly standard deviation check		**4**	questionable
8	failed seasonal and monthly standard deviation check		**4**	questionable
9	failed annual, seasonal, and monthly standard deviation check		**4**	questionable

Table 5. Mapping of WOD05 "individual observed level" quality codes to ODV quality codes. This table corresponds to Table 15.5 of Appendix 15.2 in the ODV User's Guide.

Word Ocean Database 2005 Quality Codes		**Corresponding ODV Quality Flag**	
	Individual observed level parameters		
0	accepted value	**0**	good
1	range outlier (outside of broad range check)	**4**	questionable
2	failed inversion check	**4**	questionable
3	failed gradient check	**4**	questionable
4	observed level "bull's-eye" flag and zero gradient check	**4**	questionable
5	combined gradient and inversion checks	**4**	questionable
6	failed range and inversion checks	**8**	bad
7	failed range and gradient checks	**8**	bad
8	failed range and questionable data checks	**8**	bad
9	failed range and combined gradient and inversion checks	**8**	bad