World Ocean Atlas 2013 (WOA13) Product Documentation

This document describes WOA13 statistical and objectively analyzed field files. This description includes the types of statistical fields available, the oceanographic variables analyzed, and at which standard depth levels, time spans, time periods and grid resolutions they were analyzed. This description also includes the naming convention for the files, as well as the structure and format for the files.

For a description of the data used, and the procedures for calculating WOA statistical fields, see http://www.nodc.noaa.gov/OC5/woa13/pubwoa13.html

Please note that WOA13 will be released incrementally. Grey-shaded cells in Table 4 indicate variables and grid resolutions which have not yet been released.

1. Available grid resolution

The World Ocean Atlas 2013 has objectively analyzed climatological mean fields on both a quarter- and on a one-degree longitude/latitude grid s. Statistical fields used in quality control (but not objectively analyzed climatological means) are available on a five-degree longitude/latitude grid.

2. Available time spans and time periods

Time span refers to the years represented in the climatological mean and statistical fields. Time period refers to the divisions of a calendar year. The time periods are annual, seasonal (by three-month periods; Winter = January, February, and March; Spring, Summer, and Fall are the sequentially following three-month periods), and monthly. Time spans are mostly decadal (10 year) spans, but also include ‘all’, denoting all data used regardless of year, and ‘decav’, an average of all available (year specific) time spans. An objective analysis for a specific time period is considered to be representative of that time period for the given time span. Table 1 lists all time spans that are part of WOA13.

Table 1. Time Spans for World Ocean Atlas 2013

<table>
<thead>
<tr>
<th>Time Span</th>
<th>Abbreviation</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1955 – 1964</td>
<td>5564</td>
<td>First decade with sufficient data for climatological mean fields</td>
</tr>
<tr>
<td>1965 – 1974</td>
<td>6574</td>
<td></td>
</tr>
<tr>
<td>1975 – 1984</td>
<td>7584</td>
<td></td>
</tr>
<tr>
<td>1985 – 1994</td>
<td>8594</td>
<td></td>
</tr>
<tr>
<td>1995 – 2004</td>
<td>95A4</td>
<td></td>
</tr>
<tr>
<td>2005 – 2012</td>
<td>A5B2</td>
<td>Global coverage of Argo floats from 2005</td>
</tr>
<tr>
<td>1955 – 2012</td>
<td>decav</td>
<td>Average of six decadal means</td>
</tr>
<tr>
<td>All available years</td>
<td>all</td>
<td></td>
</tr>
</tbody>
</table>
3. Available fields

Table 2 presents the list of statistical fields and the grid resolutions at which the fields are available. Quarter-degree fields represent the world as 1440x720 quarter-degree longitude / latitude boxes. One-degree fields represent the world as 360x180 one-degree longitude / latitude boxes. Five-degree fields divide the world into 72x36 five-degree longitude / latitude boxes. Five-degree statistical fields are the fields used for standard deviation window checks to filter the data; data that pass these statistical checks are then used to calculate the quarter-degree and one-degree climatology fields.

<table>
<thead>
<tr>
<th>Field Name</th>
<th>Quarter-degree field calculated</th>
<th>One-degree field calculated</th>
<th>Five-degree field calculated</th>
<th>Field Type Code (for file names)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectively analyzed climatology</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>an</td>
</tr>
<tr>
<td>Statistical mean</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>mn</td>
</tr>
<tr>
<td>Number of observations</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>dd</td>
</tr>
<tr>
<td>Seasonal or monthly climatology minus annual climatology</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>ma</td>
</tr>
<tr>
<td>Standard deviation from statistical mean</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>sd</td>
</tr>
<tr>
<td>Standard error of the statistical mean</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>se</td>
</tr>
<tr>
<td>Statistical mean minus objectively analyzed climatology</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>oa</td>
</tr>
<tr>
<td>Number of mean values within radius of influence</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>gp</td>
</tr>
</tbody>
</table>

**Short description of the statistical fields in WOA13**

- **Objectively analyzed climatologies** are the objectively interpolated mean fields for an oceanographic variable at standard depth levels for the World Ocean.
- The **statistical mean** is the average of all interpolated data values that pass quality control checks at each standard depth level for each variable in each quarter-degree, one-degree, or five-degree square which contain at least one measurement for the given oceanographic variable.
- The **number of observations** of each variable in each quarter-degree, one-degree, or five-degree square of the World Ocean at each standard depth level.
- The **standard deviation** about the statistical mean of each variable in each quarter-degree, one-degree, or five-degree square at each standard depth level.
- The **standard error of the mean** of each variable in each quarter-degree, one-degree, or five-degree square at each standard depth level.
The seasonal or monthly climatology minus the annual climatology at each quarter-degree or one-degree square at each standard depth.

The statistical mean minus the climatological mean at each quarter-degree or one-degree square at each standard depth. This value is used as an estimate of interpolation and smoothing error.

The number of one-degree squares within the smallest radius of influence around each quarter-degree or one-degree square that contain a statistical mean value.

In addition to the statistical fields found in http://www.nodc.noaa.gov/OC5/WOA13/woadata13.html, there are two types of mask files (ending in suffix .msk). These files contain information used to calculate the statistical fields.

- The landsea_XX.msk contains the standard depth level number at which the bottom of the ocean is first encountered at each quarter-degree or one-degree square for the entire world. Land will have a value of 1, corresponding to the surface. Values of standard depth levels are listed in Table 3.

- The basin_XX.msk contains the basin code number defined for each grid square at each standard depth from the surface to 5500m. Each basin is identified by a code number that ranges from 1 to 58. The basin code number in a given quarter-degree and one-degree square may change with increased depth level. Appendix 1 lists the geographic basin names, the code number associated with each basin, and the standard depth level at which the given basin is first encountered.

XX in the above mask names is either 01 (one-degree) or 04 (quarter-degree), depending on the resolution used to generate the land-sea and basin masks. These mask files are found at http://data.nodc.noaa.gov/woa/WOA13/MASKS/.


The statistical fields were calculated for six oceanographic variables: temperature, salinity, dissolved oxygen, nitrate, phosphate, and silicate. Due to the irregularity in data distribution at various depths for different variables, not all variables were analyzed at all depths for all averaging periods (annual, individual seasons and months). Table 4 lists the depth limits for each variable for each averaging period.

Temperature and Salinity fields are available on one-degree and quarter-degree grids as follow:

- One-degree annual, seasonal, and monthly fields are available for 5564, 6574, 7584, 8594, 95A4, A5B2, and 'decav' time spans;
- Quarter-degree annual and seasonal fields are available for 5564, 6574, 7584, 8594, 95A4, A5B2, and 'decav' time spans;
- Quarter-degree monthly fields are ONLY available for A5B2 and 'decav' time spans.

One-degree and quarter-degree grids Temperature and Salinity fields are NOT available for the 'all' time span.

Oxygen, Nitrate, Phosphate, and Silicate fields are available ONLY for one-degree grid and for the 'all' time span.

Five-degree grid statistics are available only for 'all' time span.
Table 3. Depths associated with each standard level number

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>Level</th>
<th>Depth (m)</th>
<th>Level</th>
<th>Depth (m)</th>
<th>Level</th>
<th>Depth (m)</th>
<th>Level</th>
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</thead>
<tbody>
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<td>0</td>
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<td>36</td>
<td>2300</td>
<td>70</td>
<td>5700</td>
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<tr>
<td>5</td>
<td>2</td>
<td>500</td>
<td>37</td>
<td>2400</td>
<td>71</td>
<td>5800</td>
<td>105</td>
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<tr>
<td>10</td>
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<td>38</td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 4. Depth ranges and standard depth levels numbers for annual, seasonal, and monthly statistics of each available oceanographic variable.

One-letter codes are first letter of file names for given variable.

<table>
<thead>
<tr>
<th>Oceanographic Variable (one-letter code)</th>
<th>Depths for Annual Climatology</th>
<th>Depths for Seasonal Climatology</th>
<th>Depths for Monthly Climatology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature (t)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-1500 meters (57 levels)</td>
</tr>
<tr>
<td>Salinity (s)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-1500 meters (57 levels)</td>
</tr>
<tr>
<td>Oxygen (o)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-1500 meters (57 levels)</td>
</tr>
<tr>
<td>Nitrate (n)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-500 meters (37 levels)</td>
<td>0-500 meters (37 levels)</td>
</tr>
<tr>
<td>Phosphate (p)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-500 meters (37 levels)</td>
<td>0-500 meters (37 levels)</td>
</tr>
<tr>
<td>Silicate (i)</td>
<td>0-5500 meters (102 levels)</td>
<td>0-500 meters (37 levels)</td>
<td>0-500 meters (37 levels)</td>
</tr>
</tbody>
</table>

5. Data formats

WOA13 data files are available in four formats:

- Climate and Forecast (CF) compliant netCDF,
- Comma-separated value (csv) format,
- ArcGIS-compatible shapefiles,
- Compact grid format (a legacy WOA ASCII format)

Appendix 3 gives an example of the csv format and Appendix 4 gives an example of the structure of the netCDF file. The legacy ASCII format is provided for applications that have been set up to read this format in previous WOA releases. Usage of this format is not encouraged, as it does not explicitly give depth, possibly resulting in confusion when reading WOA13 files in software set up for previous releases of World Ocean Atlas, or vice-versa. For information regarding to the legacy WOA ASCII format, please see http://data.nodc.noaa.gov/woa/WOA09/DOC/woa09documentation.pdf. Each csv file contains all depths for a single statistical field; please note that this differs from the csv files released for WOA09.

5.1. FILE NAMING CONVENTION

All files, regardless of format, are follows the same naming convention:

\texttt{woa13\_[DECA\]_[v][tp][ft][gr].[form_end]}
Where:

[DECA] represents decade, the time span (years) represented by the objectively analyzed means and other statistical fields as listed in Table 1;

[v] represents the oceanographic variable using one-letter code as listed in Table 4;

[tp] represents the averaging period, two digit code as follows:
- 00 – annual statistics, all data used;
- 01 to 12 – monthly statistics (starting with 01 – January, to 12 – December);
- 13 to 16 – seasonal statistics:
  - Season 13 – North Hemisphere winter (January - March);
  - Season 14 – North Hemisphere spring (April - June);
  - Season 15 – North Hemisphere summer (July - September);
  - Season 16 – North Hemisphere autumn (October - December);

[ft] represents field type, describing the calculated statistic represented in the file, as listed in Table 2

[gr] represents the grid size, two digit code as follows:
- 04 – quarter-degree grid resolution
- 01 – one-degree grid resolution
- 5d – five-degree grid resolution

[form_end] format suffix (filename extension), dependent on format as follows:
- csv – comma-separated value format
- nc – netCDF format
- dbf, shp, shx – shapefiles (when downloaded will be in a .tar file together)
- dat – compact grid data format (legacy WOA ASCII format)

Example: woa13_95A4_s02an01.nc is a file containing World Ocean Atlas 2013, February objectively analyzed salinity on one-degree grid resolution for the years 1995-2004 in netCDF format.

6. Utilities


A. Installing gzip for the first time

DOS Users: The file gzip124.exe is a self-extracting DOS executable.

Copy gzip124.exe to your hard drive,

Run gzip124.exe and use the file gzip.exe to uncompress data as described in Section B.

UNIX Users:

Copy gzip124.tar to your UNIX system

Run the following command: tar -xvf gzip124.tar

This command will create a directory named gzip-1.2.4 that includes the gzip source code and documentation about copyrights, compression methods and how to compile and install the gzip code. Read through the README file and when ready to build the gzip executable, follow instructions in the INSTALL file.
B. Decompressing data from WOA

To decompress the WOA files, it is recommended to first copy the data files to a hard disk. Use `gzip` to decompress selected files or a directory and all subdirectories with one command. The `gzip` utility has a limited help menu accessible with the `-h` option (e.g. `gzip -h`); additional information may be found at [www.gzip.org](http://www.gzip.org).

To decompress a single file:

```
gzip -nd <filename>
```

To decompress the contents of a directory and all of its subdirectories:

```
gzip -ndr <directoryname>
```

If an older version of `gzip` is used, the `-n` option is required in order to preserve the correct file names.
Appendix 1. Basins defined for objective analysis and the shallowest standard depth level for which each basin is defined.

<table>
<thead>
<tr>
<th>#</th>
<th>BASIN</th>
<th>STANDARD DEPTH LEVEL</th>
<th>#</th>
<th>BASIN</th>
<th>STANDARD DEPTH LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Atlantic Ocean</td>
<td>1*</td>
<td>30</td>
<td>North American Basin</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>Pacific Ocean</td>
<td>1*</td>
<td>31</td>
<td>West European Basin</td>
<td>82</td>
</tr>
<tr>
<td>3</td>
<td>Indian Ocean</td>
<td>1*</td>
<td>32</td>
<td>Southeast Indian Basin</td>
<td>82</td>
</tr>
<tr>
<td>4</td>
<td>Mediterranean Sea</td>
<td>1*</td>
<td>33</td>
<td>Coral Sea</td>
<td>82</td>
</tr>
<tr>
<td>5</td>
<td>Baltic Sea</td>
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<td>34</td>
<td>East Indian Basin</td>
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</tr>
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<td>Black Sea</td>
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<td>35</td>
<td>Central Indian Basin</td>
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</tr>
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<td>Red Sea</td>
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<td>Southwest Atlantic Basin</td>
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</tr>
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<td>8</td>
<td>Persian Gulf</td>
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<td>37</td>
<td>Southeast Atlantic Basin</td>
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<td>Hudson Bay</td>
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<td>56</td>
<td>Bay of Bengal</td>
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<td>77</td>
<td>57</td>
<td>Java Sea</td>
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<td>Fiji Basin</td>
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<td>58</td>
<td>East Indian Atlantic Basin</td>
<td>97</td>
</tr>
</tbody>
</table>

*Basins marked with a “*” can interact with adjacent basins in the objective analysis.
## Appendix 2 Sample from csv file format

File=woa13_5564_t00an01.csv

#WOA13ANNUAL temperature Climatological mean
#COMMA SEPARATED LATITUDE, LONGITUDE, AND VALUES AT DEPTHS

(M): 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 95, 100, 125,
150, 175, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450, 475, 500, 550, 600, 650,
700, 750, 800, 850, 900, 950, 1000, 1050, 1100, 1150, 1200, 1250, 1300, 1350, 1400,
1450, 1500, 1550, 1600, 1650, 1700, 1750, 1800, 1850, 1900, 1950, 2000, 2050, 2100, 2200,
2300, 2400, 2500, 2600, 2700, 2800, 2900, 3000, 3100, 3200, 3300, 3400, 3500, 3600,
3700, 3800, 3900, 4000, 4100, 4200, 4300, 4400, 4500, 4600, 4700, 4800, 4900, 5000,
5100, 5200, 5300, 5400, 5500,

-77.500,-178.500,-0.396,-0.485,-0.554,-0.595,-0.661,-0.729,-0.825,-0.899,-0.976,-1.061,-1.128,-1.185,-1.239,-1.258,-1.278,-1.290,-1.303,-1.294,-1.299,-1.297,-1.300,-1.294,-1.284,-1.353,-1.347,-1.497,-1.671,-1.681,-1.765,-1.871,-1.956,-2.026,-2.054,-2.096,-2.097,-2.098,-2.049,-2.011,-1.958,

-77.500,-177.500,-0.488,-0.558,-0.610,-0.645,-0.702,-0.760,-0.847,-0.915,-0.982,-1.060,-1.131,-1.184,-1.241,-1.262,-1.282,-1.296,-1.309,-1.300,-1.308,-1.307,-1.312,-1.297,-1.277,-1.332,-1.327,-1.478,-1.635,-1.629,-1.723,-1.830,-1.921,-1.994,-2.042,-2.095,-2.097,-2.098,-2.049,-2.021,-1.974,

-77.500,-176.500,-0.597,-0.636,-0.662,-0.692,-0.741,-0.791,-0.884,-0.953,-1.019,-1.091,-1.150,-1.193,-1.245,-1.268,-1.288,-1.303,-1.317,-1.308,-1.319,-1.319,-1.325,-1.303,-1.278,-1.321,-1.314,-1.472,-1.605,-1.579,-1.668,-1.798,-1.896,-1.962,-2.035,-2.094,-2.095,-2.099,-2.053,-2.048,-1.989,-1.683,

-77.500,-175.500,-0.697,-0.711,-0.722,-0.742,-0.779,-0.820,-0.879,-0.960,-1.024,-1.098,-1.158,-1.197,-1.250,-1.276,-1.297,-1.314,-1.327,-1.318,-1.332,-1.335,-1.343,-1.314,-1.284,-1.312,-1.315,-1.473,-1.576,-1.535,-1.625,-1.750,-1.855,-1.937,-2.026,-2.090,-2.092,-2.098,-2.047,-2.021,-2.002,
Appendix 3 Sample from netCDF file format

```c
netcdf woa13_5564_t00_01 {

dimensions:
    nbounds = 2 ;
    lat = 180 ;
    lon = 360 ;
    depth = 102 ;
    time = 1 ;

variables:
    int crs ;
    crs:grid_mapping_name = "latitude_longitude" ;
    crs:epsg_code = "EPSG:4326" ;
    crs:longitude_of_prime_meridian = 0.f ;
    crs:semi_major_axis = 6378137.f ;
    crs:inverse_flattening = 298.2572f ;

    float lat(lat) ;
    lat:standard_name = "latitude" ;
    lat:long_name = "latitude" ;
    lat:units = "degrees_north" ;
    lat:axis = "Y" ;
    lat:bounds = "lat_bnds" ;

    float lat_bnds(lat, nbounds) ;
    lat_bnds:comment = "latitude bounds" ;

    float lon(lon) ;
    lon:standard_name = "longitude" ;
    lon:long_name = "longitude" ;
    lon:units = "degrees_east" ;
    lon:axis = "X" ;
    lon:bounds = "lon_bnds" ;

    float lon_bnds(lon, nbounds) ;
    lon_bnds:comment = "longitude bounds" ;

    float depth(depth) ;
    depth:standard_name = "depth" ;
    depth:bounds = "depth_bnds" ;
    depth:positive = "down" ;
    depth:units = "meters" ;
    depth:axis = "Z" ;

    float depth_bnds(depth, nbounds) ;
    depth_bnds:comment = "depth bounds" ;

    float time(time) ;
    time:standard_name = "time" ;
    time:long_name = "time" ;
    time:units = "months since 0000-01-01 00:00:00" ;
    time:axis = "T" ;
    time:climatology = "climatology_bounds" ;

    float climatology_bounds(time, nbounds) ;
    climatology_bounds:comment = "This variable defines the bounds of the climatological time per iod for each time" ;

    float t_an(time, depth, lat, lon) ;
    t_an:standard_name = "sea_water_temperature" ;
    t_an:long_name = "Objectively analyzed mean fields for sea_water_temperature at standard dept h levels." ;
```
t_an:cell_methods = "area: mean depth: mean time: mean";
t_an:grid_mapping = "crs";
t_an:units = "degrees_celsius";
t_an:_FillValue = 9.96921e+36f;

float t_mn(time, depth, lat, lon);
t_mn:standard_name = "sea_water_temperature";
t_mn:long_name = "Average of all unflagged interpolated values at each standard depth level for sea_water_temperature in each grid-square which contain at least one measurement."

int t_dd(time, depth, lat, lon);
t_dd:standard_name = "sea_water_temperature";
t_dd:long_name = "The number of observations of sea_water_temperature in each grid-square at each standard depth level."

float t_sd(time, depth, lat, lon);
t_sd:standard_name = "sea_water_temperature";
t_sd:long_name = "The standard deviation about the statistical mean of sea_water_temperature in each grid-square at each standard depth level."

float t_se(time, depth, lat, lon);
t_se:standard_name = "sea_water_temperature";
t_se:long_name = "The standard error about the statistical mean of sea_water_temperature in each grid-square at each standard depth level."

int t_oa(time, depth, lat, lon);
t_oa:standard_name = "sea_water_temperature";
t_oa:long_name = "Statistical mean value minus the objectively analyzed mean value for sea_water_temperature."

int t_gf(time, depth, lat, lon);
t_gf:standard_name = "sea_water_temperature";
t_gf:long_name = "The number of grid-squares within the smallest radius of influence around each grid-square which contain a statistical mean for sea_water_temperature."
; t_gp:cell_methods = "area: mean depth: mean time: mean";
t_gp:grid_mapping = "crs";
t_gp:units = "1";
t_gp:_FillValue = -32767;

// global attributes:
:standard_name_vocabulary = "CF-1.6";
:featureType = "Grid";
:cdm_data_type = "Grid";
:Conventions = "CF-1.6";
:title = "World Ocean Atlas 2013 : sea_water_temperature Annual 1.00 degree";
:summary = "Climatological mean temperature for the global ocean from in situ profile data";
:institution = "National Oceanographic Data Center (NODC)";
:comment = "global climatology as part of the World Ocean Atlas project";
:id = "SPECIAL";
:naming_authority = "gov.noaa.nodc";
:time_coverage_start = "0000-01-01";
:time_coverage_duration = "P01Y";
:time_coverage_resolution = "P01Y";
:geospatial_lat_min = -90.f;
:geospatial_lat_max = 90.f;
:geospatial_lon_min = -180.f;
:geospatial_lon_max = 180.f;
:geospatial_vertical_min = 0.f;
:geospatial_vertical_max = 5500.f;
:geospatial_lat_units = "degrees_north";
:geospatial_lat_resolution = "1.00 degrees";
:geospatial_lon_units = "degrees_east";
:geospatial_lon_resolution = "1.00 degrees";
:geospatial_vertical_units = "m";
:geospatial_vertical_resolution = "";
:geospatial_vertical_positive = "down";
:creator_name = "Ocean Climate Laboratory";
:creator_email = "NODC.Services@noaa.gov";
:creator_url = "http://www.nodc.noaa.gov";
:project = "World Ocean Atlas";
:processing_level = "processed";
:keywords = "<ISO_TOPIC_Category>Oceans</ISO_TOPIC_Category>";
:keywords_vocabulary = "ISO 19115";
:contributor_name = "Ocean Climate Laboratory";
:contributor_role = "Calculation of climatologies";
:publisher_name = "National Oceanographic Data Center";
publisher_url = "http://www.nodc.noaa.gov/";
publisher_email = "NODC.Services@noaa.gov";
:nodc_template_version = "NODC NetCDF Grid Template v1.0" ;
:license = "These data are openly available to the public.
Please acknowledge the use of these
data with the text given in the acknowledgment attribute." ;
:Metadata_Conventions = "Unidata Dataset Discovery v1.0" ;
:metadata_link = 
:date_created = "2013-09-29 " ;
:date_modified = "2013-09-29 " ;

data:

crs = _ ;