The CSIRO netCDF version of the NODC World Ocean Atlas 2005

M.A. Collier and P.J. Durack

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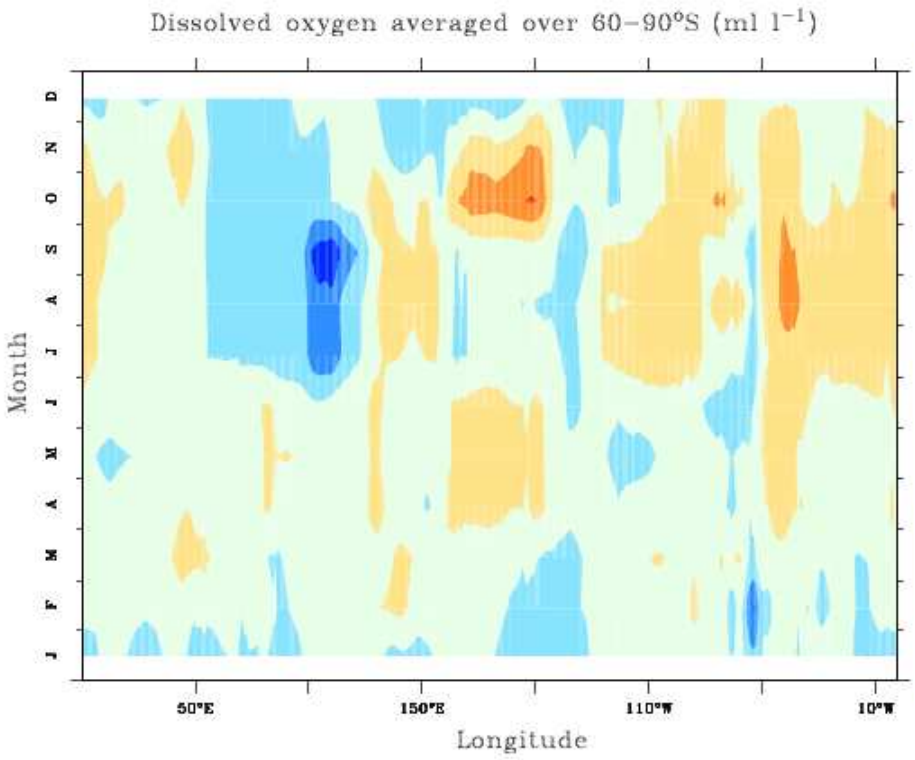

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Research Paper No. 15

November 2006

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1 Abstract

This document lists the files that make up the CSIRO *netCDF* version of the NODC World Ocean Atlas 2005. This Climate and Forecasting Metadata conventions conforming *netCDF* format file archive derives from the *ASCII* text format files of the World Ocean Atlas 2005 available freely over the Internet and has the major advantage of being able to be imported into most plotting and analysis tools, or numerical models, that can read *netCDF* files. The files within contain temporal and spatial representation of *in-situ* temperature, salinity, oxygen and dissolved inorganic nutrients.

2 Background

The purpose of this data archive is to supply the CSIRO and broader scientific community with a machine transparent, portable and self-describing version of the World Ocean Atlas 2005 (*National Oceanographic Data Centre*, 2006; *Locarnini et al.*, 2006; *Antonov et al.*, 2006; *Garcia et al.*, 2006a,b) dataset. This Atlas is referred to by the National Oceanographic Data Center (NODC - `http://www.nodc.noaa.gov`) with the identifier WOA05. NODC offers the WOA05 in *ASCII* text format that is highly portable but not generally compact, self-describing or very efficient for processing and visualising. The *ASCII* or *netCDF* version of the WOA05 can be used to initialise numerical models, verify numerical model solutions, or for general oceanographic and meteorological analysis. This work is effectively an up-date of earlier work by *Collier* (2003), using the latest raw data and taking into account improvements that have been made in data and metadata conventions since then.

Both gridded 5° by 5° and 1° by 1° longitude/latitude *ASCII* text format files are available from the NODC. Only the 1° by 1° dataset was converted into *netCDF* format, as a coarser horizontal version (eg. 5° by 5°) can be readily generated from the finer horizontal version through standard *netCDF* tools such as FERRET, NCO or Tcl-Nap[1].

The standard levels for the analysed fields are 0, 10, 20, 30, 50, 75, 100, 125, 150, 200, 250, 300, 400, 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500, 1750, 2000, 2500, 3000, 3500, 4000, 4500, 5000 and 5500 metres. The tables in Section 3 list the depths for which a particular variable is valid.

[1]FERRET, NCO and Tcl-Nap softwares are freely available over the Internet

3 *netCDF* files

A summary of the directory structure holding the raw (ASCII) and processed (netCDF) WOA05 data files is provided in Figure 1. This schematic also provides a useful summary of where Tcl-Nap processing scripts and their input/output data are located. Note that all directory names end in a "/" character, as is often used on computers with a UNIX opearting system, to distinguish them from all other files.

To locate the *netCDF* files described in this report, you will need access to the High Performance Scientific Computing (HPSC[2]) machine (owned and operated by CSIRO) "cherax"[3]. The directory where the data are found is called "~IPCC/WOA05". Section 7 (Appendix 2) lists several utilities that were essential in creating the data archive described here.

There are three time-invariant files in this data set, used to determine land-sea (landsea.nc), basin locations (basin.nc) and mixing numbers (minnumber.nc). They are found in ~IPCC/WOA05/processed/other.

landsea.nc: the land-sea mask gives the depth of each water column at each longitude/latitude point on the earth's surface. "Dry" (land) grid-cells are given by the $missing_value$ attribute in the *netCDF* file. "Wet" (sea) grid-cells range in value between 1 and 40. The extra levels beyond the thirty-three that were listed in Section 2 are 6000, 6500, 7000, 7500, 8000, 8500 and 9000 metres.

basin.nc: the earth's ocean basins are labelled with a number in the range between 1 and 58. Please refer to the WOA05 document for further information.

mixnumber.nc: contains the mixing number for each one-degree square at each standard depth. The mix number is an integer between -2 and 2. Please refer to the WOA05 document for further information.

[2] `http://hpsc.csiro.au/`

[3] Several centres have, however, began to serve the files described in this report through their own servers

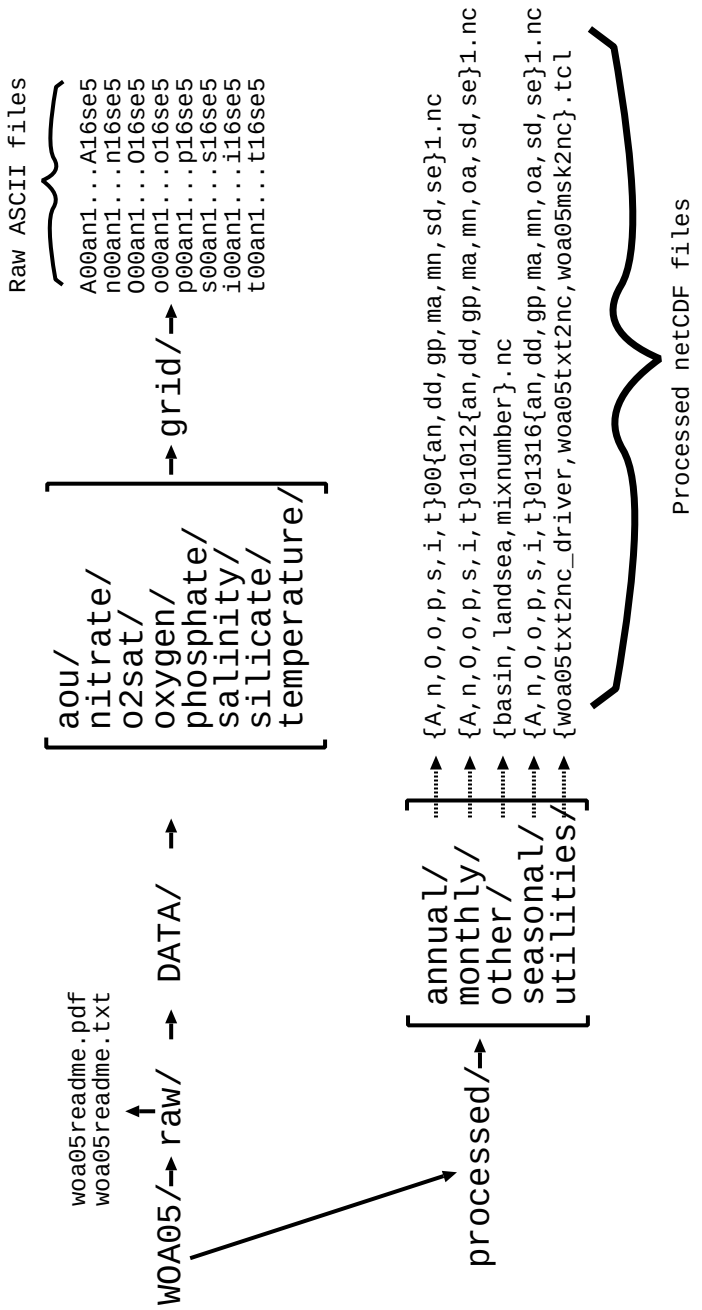

Figure 1: Directory locations of the World Ocean Atlas 2005 data.

Each of the names given in the following tables is a *netCDF* file that have the suffix ".nc". Any locations in the table with a "-" indicate that there is no valid entry, and hence no data available for that particular variable and analysis product. The naming convention for the *netCDF* files and the variable names within them follow the system described in the WOA05 documentation. However, as monthly and seasonal data are kept in a single file (rather than

12 and 4 separate files, respectively, in the original *ASCII* text format data set) the file names have been slightly altered as described below:

[v][tp][ft][g]*[*xx*]*.nc

where:

[v] = variable:

t	=	Temperature
s	=	Salinity
o	=	Dissolved oxygen
a	=	Apparent oxygen utilization
x	=	Percentage oxygen saturation
p	=	Phosphate
n	=	Nitrate
i	=	Silicate

[tp] = time period:

00	=	Annual data
0112	=	Monthly data
1316	=	Seasonal data

where the twelve months are defined as January, February, March, April, May, June, July, August, September, October, November and December respectively. The four seasons are defined based on the Northern Hemisphere as winter (January-March), spring (April-June), summer (July-September) and autumn (October-December) respectively.

[ft] = file type:

an	=	Objectively analyzed climatology
ma	=	Seasonal or monthly climatology minus annual climatology
dd	=	Number of observations
sd	=	Standard deviation from statistical mean
se	=	Standard error of statistical mean
mn	=	Statistical mean
oa	=	Statistical mean minus objectively analyzed climatology
gp	=	Numer of mean values within radius of influence

[g] = grid size:

1	=	one-degree square file
5	=	five-degree square file

For example:

t00an1.nc	≡	analysed annual *in-situ* temperature
x1316dd1.nc	≡	number of seasonal oxygen saturation observations
o0112an1.nc	≡	analysed monthly oxygen

A primary aim for the generation of this data archive was to be able to plot and analyse the World Ocean Atlas 2005 data using the software FERRET (see Acknowledgements), and to be suitable for parameter comparison with output from numerical ocean experiments. If users of the CSIRO *netCDF* version of the NODC World Ocean Atlas 2005 require modifications to the *netCDF* conventions and to suit their choice of *netCDF* software (see Disclaimer), please contact the author of this report and we will try to accommodate them in a future version release.

3.1 Annual data

Variable	Raw units	Objectively analyzed climatology	Statistical mean	Seasonal minus annual climatology	Number of mean values within radius of influence
	t00mn1	t00ma1	t00gp1		
Salinity	PPS	s00an1	s00mn1	s00ma1	s00gp1
Dissolved oxygen	$ml\ l^{-1}$	o00an1	o00mn1	o00ma1	o00gp1
Apparent oxygen utilization	$ml\ l^{-1}$	A00an1	A00mn1	A00ma1	A00gp1
Percentage oxygen saturation	%	O00an1	O00mn1	O00ma1	O00gp1
Phosphate	μM	p00an1	p00mn1	p00ma1	p00gp1
Nitrate	μM	n00an1	n00mn1	n00ma1	n00gp1
Silicate	μM	i00an1	i00mn1	i00ma1	i00gp1
Variable	Number of observations	Standard deviation from statistical mean	Standard error of statistical mean	Statistical mean minus objectively analyzed climatology	Depths (metres)
Temperature	t00dd1	t00sd1	t00se1	-	0-5500
Salinity	s00dd1	s00sd1	s00se1	-	0-5500
Dissolved oxygen	o00dd1	o00sd1	o00se1	-	0-5500
Apparent oxygen utilization	A00dd1	A00sd1	A00se1	-	0-5500
Percentage oxygen saturation	O00dd1	O00sd1	O00se1	-	0-5500
Phosphate	p00dd1	p00sd1	p00se1	-	0-5500
Nitrate	n00dd1	n00sd1	n00se1	-	0-5500
Silicate	i00dd1	i00sd1	i00se1	-	0-5500

Table 1: Name prefix for flies located under the directory ˜IPCC/WOA05/processed/annual.

3.2 Monthly data

Variable	Raw units	Objectively analyzed climatology	Statistical mean	Seasonal minus annual climatology	Number of mean values within radius of influence
Temperature	$^{\circ}C$	t0112an1	t0112mn1	t0112ma1	t0112gp1
Salinity	PPS	s0112an1	s0112mn1	s0112ma1	s0112gp1
Dissolved oxygen	$ml\ l^{-1}$	o0112an1	o0112mn1	o0112ma1	o0112gp1
Apparent oxygen utilization	$ml\ l^{-1}$	A0112an1	A0112mn1	A0112ma1	a0112gp1
Percentage oxygen saturation	%	O0112an1	O0112ma1	O0112mn1	O0112gp1
Phosphate	μM	p0112an1	p0112mn1	p0112ma1	p0112gp1
Nitrate	μM	n0112an1	n0112mn1	n0112ma1	n0112gp1
Silicate	μM	i0112an1	i0112mn1	i0112ma1	i0112gp1

Variable	Number of observations	Standard deviation from statistical mean	Standard error of statistical mean	Statistical mean minus objectively analyzed climatology	Depths (metres)
Temperature	t0112dd1	t0112sd1	t0112se1	t0112oa1	0-1500
Salinity	s0112dd1	s0112sd1	s0112se1	s0112oa1	0-1500
Dissolved oxygen	o0112dd1	o0112sd1	o0112se1	o0112oa1	0-1500
Apparent oxygen utilization	A0112dd1	A0112sd1	A0112se1	A0112oa1	0-1500
Percentage oxygen saturation	O0112dd1	O0112sd1	O0112se1	O0112oa1	0-1500
Phosphate	p0112dd1	p0112sd1	p0112se1	p0112oa1	0-500
Nitrate	n0112dd1	n0112sd1	n0112se1	n0112oa1	0-500
Silicate	i0112dd1	i0112sd1	i0112se1	i0112oa1	0-500

Table 2: Name prefix for files located under the directory ~IPCC/WOA05/processed/monthly.

3.3 Seasonal data

Variable	Raw units	Objectively analyzed climatology	Statistical mean	Seasonal minus annual climatology	Number of mean values within radius of influence
Temperature	$^{\circ}C$	t1316an1	t1316mn1	t1316ma1	t1316gp1
Salinity	PSS	s1316an1	s1316mn1	s1316ma1	s1316gp1
Dissolved oxygen	$ml\ l^{-1}$	o1316an1	o1316mn1	o1316ma1	o1316gp1
Apparent oxygen utilization	$ml\ l^{-1}$	A1316an1	A1316mn1	A1316ma1	A1316gp1
Percentage oxygen saturation	%	O1316an1	O1316mn1	O1316ma1	O1316gp1
Phosphate	μM	p1316an1	p1316mn1	p1316ma1	p1316gp1
Nitrate	μM	n1316an1	n1316mn1	n1316ma1	n1316gp1
Silicate	μM	i1316an1	i1316mn1	i1316ma1	i1316gp1
Variable	Number of observations	Standard deviation from statistical mean	Standard error of statistical mean	Statistical mean minus objectively analyzed climatology	Depths (metres)
Temperature	t1316dd1	t1316sd1	t1316se1	t1316oa1	0-5500
Salinity	s1316dd1	s1316sd1	s1316se1	s1316oa1	0-5500
Dissolved oxygen	O1316dd1	o1316sd1	o1316se1	o1316oa1	0-5500
Apparent oxygen utilization	A1316dd1	A1316sd1	A1316se1	A1316oa1	0-5500
Percentage oxygen saturation	O1316dd1	O1316sd1	O1316se1	O1316oa1	0-5500
Phosphate	p1316dd1	p1316sd1	p1316se1	p1316oa1	0-500
Nitrate	n1316dd1	n1316sd1	n1316se1	n1316oa1	0-500
Silicate	i1316dd1	i1316sd1	i1316se1	i1316oa1	0-500

Table 3: Name prefix for files located under the directory ~IPCC/WOA05/processed/seasonal.

4 Sample figures

This section includes three plots that have been made directly from the data archive using the software FERRET. FERRET "go" journal scripts are given in Section **??** (Appendix 1). The files utilised are t00an1.nc (°C), O1316dd1.nc and o0112an1.nc ($ml\ l^{-1}$), respectively.

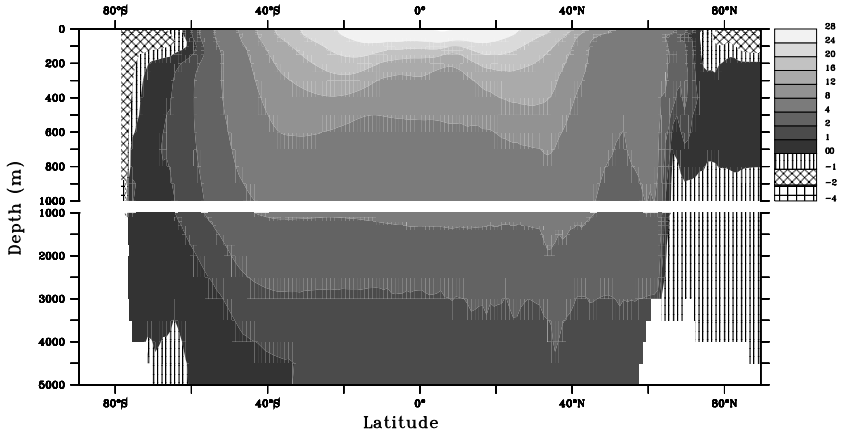

Figure 2: Annual *in-situ* temperature for the global ocean.

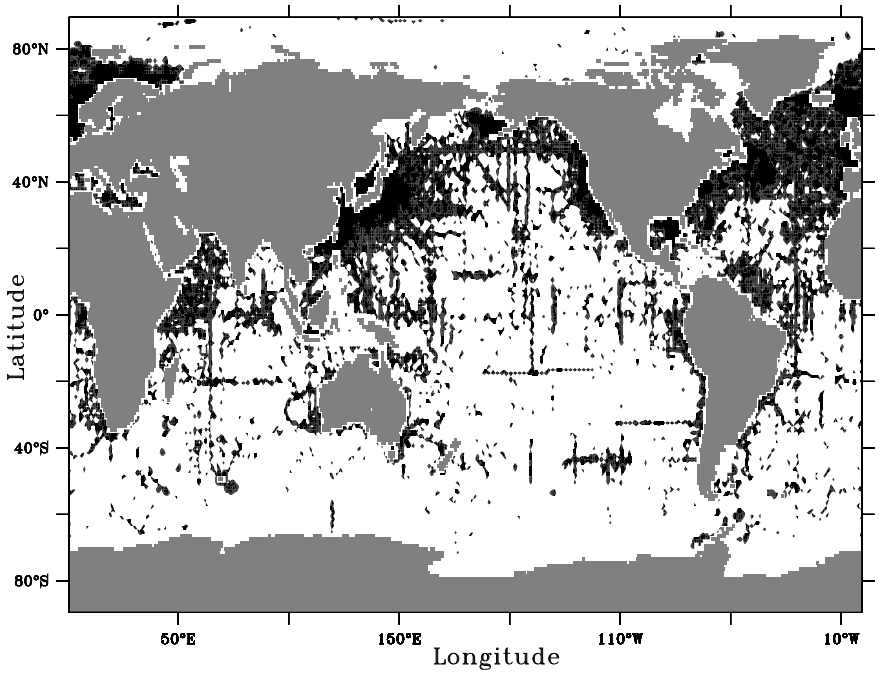

Figure 3: Location of surface oxygen saturation observations.

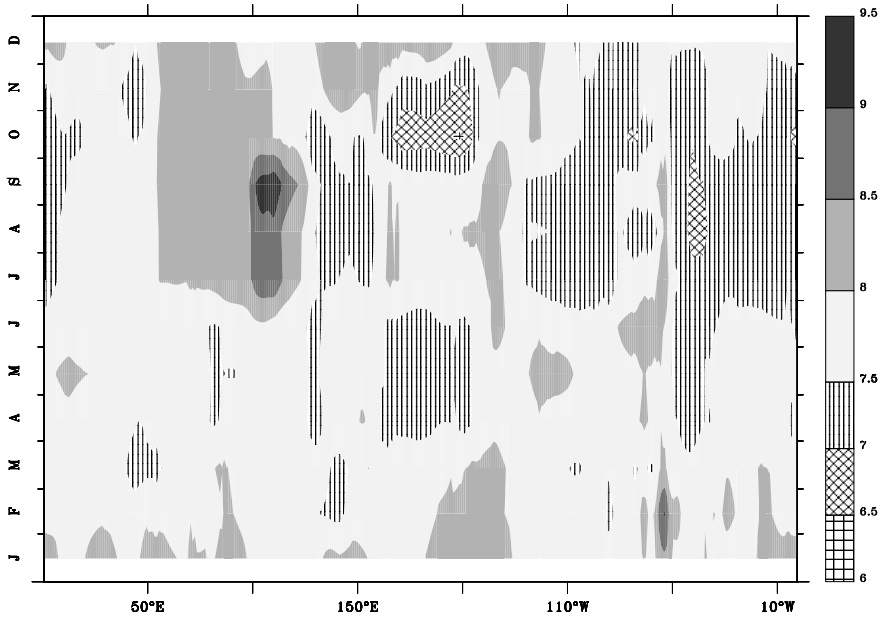

Figure 4: Dissolved oxygen averaged over 65 – 90°S.

5 Acknowledgments

Thanks to the NODC for making the *ASCII* text format files directly available on DVD and free of charge and the CSIRO HPSC (`http://www.hpc.csiro.au`) for helping to manage the archive through their massive magnetic tape/disk storage system. FERRET was used to generate the figures in this document and is available free of charge through the Internet (http://ferret.wrc.noaa.gov/Ferret).

6 Disclaimer

CSIRO did not generate the ASCII text format data for the World Ocean Atlas 2005, and takes no credit or responsibility for it. The conversion of the World Ocean Atlas 2005 ASCII text format data to *netCDF* format is quite straightforward, however, it is up to the users of the CSIRO *netCDF* version of the NODC World Ocean Atlas 2005 to check and reassure themselves of its numerical integrity and applicability to research applications. The CSIRO *netCDF* version of the NODC World Ocean Atlas 2005 archive may be modified or updated at any time without any prior warning. If you have any questions regarding this document, please contact the author, preferably by e-mail.

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6.1 woa05txt2nc_driver

```
#!/usr/bin/tclsh
#CSIRO Australia
#Mark Collier November 17 2006
#Modified     November 17 2006

source ~/.tclshrc
source ~col414/tcl_fun/dmget_tcl.tcl
source ~col414/ocean/data/woa05/utilities/woa05txt2nc.tcl

set V {t s o A O p n i}
set TP {"0112" "1316" "00"}
set FT {an mn ma gp dd sd se oa}

foreach v $V {
foreach tp $TP {
foreach ft $FT {

woa05txt2nc $v $tp $ft

};#ft
};#tp
};#v

exit
```

6.2 woa05txt2nc

```
proc woa05txt2nc {v tp ft} {

##!/usr/bin/tclsh
##CSIRO Australia
##Mark Collier October 5 2006
##Modified     October 5 2006
##source ~/.tclshrc
##source ~col414/tcl_fun/dmget_tcl.tcl

set tdir $::env(TMPDIR)

set clobber "yes"
set clobber "no"

if {$ft == "an"} {
nap "history = 'Objectively analyzed climatology'"
} elseif {$ft == "mn"} {
nap "history ='Statistical mean'"
} elseif {$ft == "dd"} {
nap "history ='Number of observations'"

} elseif {$ft == "ma"} {
nap "history ='Seasonal or monthly climatology minus annual climatology'"

} elseif {$ft == "sd"} {
nap "history ='Standard deviation from statistical mean'"
} elseif {$ft == "se"} {
nap "history ='Standard error from statistical mean'"
} elseif {$ft == "oa"} {
nap "history ='Statistical mean minus objectively analyzed climatology'"
} elseif {$ft == "gp"} {
nap "history ='Number of mean values within radius of influence'"
} else {
puts "ft=$ft doesn't exist."
return
}

set g "1"
```

```
set xx ""

if {$v == "c" || $v == "z"} {
puts "Variable $v not supported in WOA05."
return
}

if {$v == "t"} {
set idir [glob ~col414/WOA05/DATA/temperature/grid]
} elseif {$v == "s"} {
set idir [glob ~col414/WOA05/DATA/salinity/grid]
} elseif {$v == "o"} {
set idir [glob ~col414/WOA05/DATA/oxygen/grid]
} elseif {$v == "A"} {
set idir [glob ~col414/WOA05/DATA/aou/grid]
} elseif {$v == "O"} {
set idir [glob ~col414/WOA05/DATA/o2sat/grid]
} elseif {$v == "p"} {
set idir [glob ~col414/WOA05/DATA/phosphate/grid]
} elseif {$v == "n"} {
set idir [glob ~col414/WOA05/DATA/nitrate/grid]
} elseif {$v == "i"} {
set idir [glob ~col414/WOA05/DATA/silicate/grid]
} else {
puts "Variable $v unknown in WOA05."
return
}

set ifil ${v}${tp}${ft}${g}
set ofil ${ifil}.nc
if {$tp == "00"} {
set odir [glob ~col414/ocean/data/woa05/annual]
} elseif {$tp == "0112"} {
set odir [glob ~col414/ocean/data/woa05/monthly]
} elseif {$tp == "1316"} {
set odir [glob ~col414/ocean/data/woa05/seasonal]
} else {
puts "Time period $tp doesn't exist."
return
}
```

```
if {[file isfile $odir/$ofil] == 1 && $clobber == "no"} {
puts "$odir/$ofil exists and noclobber set."
return
}

puts "Input file=$idir/$ifil"
puts "Output file=$odir/$ofil"
puts "Temporaray file=$tdir/$ofil"
if {[file isfile $odir/$ofil] == 1 && $clobber == "yes"} {
file delete -force $tdir/$ofil
file delete -force $odir/$ofil
}

if {$tp == "0112"} {
catch {unset ifils}
foreach m {01 02 03 04 05 06 07 08 09 10 11 12} {
lappend ifils $idir/${v}${m}${ft}${g}
};#m
dmget_tcl $ifils
file delete -force $idir/$ifil;set tfil [open $idir/$ifil w];close $tfil
puts "Temporarily concatenating files:"
foreach f $ifils {
puts "$f"
exec /bin/cat $f >> $idir/$ifil
};#f

} elseif {$tp == "1316"} {
catch {unset ifils}
foreach m {13 14 15 16} {
lappend ifils $idir/${v}${m}${ft}${g}
};#m
dmget_tcl $ifils
file delete -force $idir/$ifil;set tfil [open $idir/$ifil w];close $tfil
puts "Temporarily concatenating files:"
foreach f $ifils {
puts "$f"
exec /bin/cat $f >> $idir/$ifil
};#f
};#tp
```

```
if {$tp == "00"} {

  if {$ft == "oa"} {
  puts "Selection tp=$tp ft=$ft doesn't exist."
  return
  }

  if {$v == "c"} {
  set ndep_tst "1a"
  } elseif {$v == "z"} {
  set ndep_tst "1b"
  } else {
  set ndep_tst "33"
  }

  if {$v == "c" && $ft == "ma" } {
  puts "Selection tp=$tp, v=$v and ft==$ft doesn't exist."
  return
  } elseif {$v == "z" && ($ft == "ma" || $ft == "gp" || $ft == "sd" || $ft == "se" || $ft
  puts "Selection tp=$tp, v=$v and ft==$ft doesn't exist."
  return
  }

nap "time = f64{182.5}"
nap "time_bnds = f64{{0} {365}}"
nap "time_bnds=transpose(time_bnds,{1 0})"

} elseif {$tp == "0112"} {

  if {$v == "p" || $v == "n" || $v == "i" || $v == "o" || $v == "A" || $v == "O"} {
  set ndep_tst "14"
  } else {
  set ndep_tst "24"
  }

  if {$v == "c" || $v == "z"} {
  puts "Selection tp=$tp and v=$v doesn't exist."
  return
  }
```

```
nap "time = f64{15 44 73.5 104 134.5 165 195.5 226.5 257 287.5 318.5 349}"
nap "time_bnds0 = f64{0 30 58 89 119 150 180 211 242 272 303 334}"
nap "time_bnds1 = f64{30 58 89 119 150 180 211 242 272 303 334 364}"
nap "time_bnds = transpose(time_bnds0 /// time_bnds1,{1 0})"

} elseif {$tp == "1316"} {

  if {$v == "c" || $v == "z"} {
  set ndep_tst "1"
  } elseif {$v == "p" || $v == "n" || $v == "i"} {
  set ndep_tst "14"
  } else {
  set ndep_tst "33"
  }

  if {$v == "z" && ($ft == "an" || $ft == "gp" || $ft == "sd" || $ft == "se" || $ft == "oa
  puts "Selection tp=$tp, v=$v and ft=$ft doesn't exist."
  return
  }

nap "time = f64{44.5 134.5 226.0 318.0}"
nap "time_bnds0 = f64{0 89 180 272}"
nap "time_bnds1 = f64{89 180 272 364}"
nap "time_bnds = transpose(time_bnds0 /// time_bnds1,{1 0})"
}

if {$ndep_tst == "33"} {
nap "depth = f64{0 10 20 30 50 75 100 125 150 200 250 300 400 500 600 700 800 900 1000
1100 1200 1300 1400 1500 1750 2000 2500 3000 3500 4000 4500 5000 5500}"

} elseif {$ndep_tst == "24"} {
nap "depth = f64{0 10 20 30 50 75 100 125 150 200 250 300 400 500 600 700 800 900 1000
1100 1200 1300 1400 1500}"

} elseif {$ndep_tst == "14"} {
nap "depth = f64{0 10 20 30 50 75 100 125 150 200 250 300 400 500}"

} elseif {$ndep_tst == "10"} {
nap "depth = f64{0 10 20 30 50 75 100 125 150 200}"
```

```
} elseif {$ndep_tst == "7"} {
nap "depth = f64{0 10 20 30 50 75 100}"

} elseif {$ndep_tst == "1"} {
nap "depth = f64{0}"

} elseif {$ndep_tst == "1a"} {
nap "depth = f64{50}"
nap "depth_bnds = f64{{0} {100}}"
nap "depth_bnds=transpose(depth_bnds,{1 0})"

} elseif {$ndep_tst == "1b"} {
nap "depth = f64{100}"
nap "depth_bnds = f64{{0} {200}}"
nap "depth_bnds=transpose(depth_bnds,{1 0})"

} else {
puts "Don't know that many depths."
return
}

nap "lat = -89.5 .. 89.5 ... 1.0"
nap "lon = 0.5 .. 359.5 ... 1.0"

nap "ntim = nels(time)"
nap "ndep = nels(depth)"
nap "nlat = nels(lat)"
nap "nlon = nels(lon)"

set ntim_tcl [$ntim v]
set ndep_tcl [$ndep v]
set nlat_tcl [$nlat v]
set nlon_tcl [$nlon v]

nap "lon_bnds0 = 0.0 .. 359.0 ... 1.0"
nap "lon_bnds1 = 1.0 .. 360 ... 1.0"

nap "lat_bnds0 = -90.0 .. 89.0 ... 1.0"
nap "lat_bnds1 = -89.0 .. 90.0 ... 1.0"
```

```
nap "lat_bnds = transpose(lat_bnds0 /// lat_bnds1,{1 0})"
nap "lon_bnds = transpose(lon_bnds0 /// lon_bnds1,{1 0})"

$time_bnds set dim time bnds
$lat_bnds set dim lat bnds
$lon_bnds set dim lon bnds

set ntimm1_tcl [expr $ntim_tcl-1]
set ndepm1_tcl [expr $ndep_tcl-1]
set nlatm1_tcl [expr $nlat_tcl-1]
set nlonm1_tcl [expr $nlon_tcl-1]

set numbers_per_line 10;set npl_tcl $numbers_per_line;set nplm1_tcl [expr $npl_tcl-1]
set characters_per_number 8;set cpn_tcl $characters_per_number;set cpnm1_tcl [expr $cpn_tc

nap "shape = (ntim//ndep//nlat//nlon)"

set ido 0
set ido 1
nap "nline=ntim*ndep*nlat*nlon/$npl_tcl"
set nline_tcl [$nline v]

if {$clobber == "yes"} {
nap "array_tmp = reshape(f32(_),shape)"
}

if {$ido == 1} {

nap "array_tmp = reshape(f32(_),shape)"

set ifh [open $idir/$ifil r]

set time_tcl 0
set depth_tcl 0
set lat_tcl 0
set lon_tcl 0

for {set l 0} {$l<$nline_tcl} {incr l} {
set line [gets $ifh]
```

```
for {set i 0} {$i<$npl_tcl} {incr i} {

$array_tmp set value [expr [string range $line [expr $i*$cpn_tcl] [expr ($i*$cpn_tcl)+$cpn
"$time_tcl,$depth_tcl,$lat_tcl,$lon_tcl"

set latm1_tcl [expr $lat_tcl-1]
set lonm1_tcl [expr $lon_tcl-1]
set timem1_tcl [expr $time_tcl-1]
set depthm1_tcl [expr $depth_tcl-1]

if {$depth_tcl == $ndepm1_tcl && $lat_tcl == $nlatm1_tcl && $lon_tcl == $nlonm1_tcl} {
incr time_tcl
set depth_tcl 0
set lat_tcl 0
set lon_tcl -1

} elseif {$lat_tcl == $nlatm1_tcl && $lon_tcl == $nlonm1_tcl} {
incr depth_tcl
set lat_tcl 0
set lon_tcl -1

} elseif {$lon_tcl == $nlonm1_tcl} {
incr lat_tcl
set lon_tcl -1

} elseif {$time_tcl == $ntim_tcl} {

puts "Finished."
}

##puts "[string range $line [expr $i*8] [expr ($i*8)+7]]"

incr lon_tcl

};#i

};#l

close $ifh
```

```
};#ido

#return

nap "array=f32(array_tmp<(-99.0))"
nap "array=array*1e20"
$array set missing 1e20
nap "f32(array=array+array_tmp)"
$array set missing 1e20

$lon set unit degrees_east
$lat set unit degrees_north

$array set dim time depth lat lon
$array set coo time depth lat lon

$array netcdf $tdir/$ofil ${v}${tp}${ft}${g}

$time_bnds set missing
$time_bnds netcdf $tdir/$ofil time_bnds
$lat_bnds set missing
$lat_bnds netcdf $tdir/$ofil lat_bnds
$lon_bnds set missing
$lon_bnds netcdf $tdir/$ofil lon_bnds

nap "long_name = 'longitude'"
nap "units = 'degrees_east'"
nap "standard_name = 'longitude'"
nap "axis = 'X'"
nap "bounds = 'lon_bnds'"
$long_name netcdf $tdir/$ofil lon:long_name
$units netcdf $tdir/$ofil lon:units
$standard_name netcdf $tdir/$ofil lon:standard_name
$axis netcdf $tdir/$ofil lon:axis
$bounds netcdf $tdir/$ofil lon:bounds

nap "long_name = 'latitude'"
nap "units = 'degrees_north'"
nap "standard_name = 'latitude'"
nap "axis = 'Y'"
```

```
nap "bounds = 'lat_bnds'"
$long_name netcdf $tdir/$ofil lat:long_name
$units netcdf $tdir/$ofil lat:units
$standard_name netcdf $tdir/$ofil lat:standard_name
$axis netcdf $tdir/$ofil lat:axis
$bounds netcdf $tdir/$ofil lat:bounds

nap "long_name = 'time'"
nap "units = 'days since 0000-01-01 00:00:00'"
nap "standard_name = 'time'"
nap "axis = 'T'"
nap "calendar = 'gregorian'"
nap "bounds = 'time_bnds'"
$long_name netcdf $tdir/$ofil time:long_name
$units netcdf $tdir/$ofil time:units
$standard_name netcdf $tdir/$ofil time:standard_name
$axis netcdf $tdir/$ofil time:axis
$calendar netcdf $tdir/$ofil time:calendar
$bounds netcdf $tdir/$ofil time:bounds

nap "long_name = 'depth'"
nap "units = 'm'"
nap "standard_name = 'depth'"
nap "axis = 'Z'"

if {$ndep_tst == "1a" || $ndep_tst == "1b"} {
$depth_bnds set dim depth bnds
nap "bounds = 'depth_bnds'"
$depth_bnds set missing
$depth_bnds netcdf $tdir/$ofil depth_bnds
$bounds netcdf $tdir/$ofil depth:bounds
}

nap "positive = 'down'"
$long_name netcdf $tdir/$ofil depth:long_name
$units netcdf $tdir/$ofil depth:units
$standard_name netcdf $tdir/$ofil depth:standard_name
$axis netcdf $tdir/$ofil depth:axis
$positive netcdf $tdir/$ofil depth:positive
```

```
if {$v == "t"} {
nap "long_name = 'Temperature'"
nap "standard_name = 'temperature'"
nap "units = 'K'"
} elseif {$v == "s"} {
nap "long_name = 'Salinity'"
nap "standard_name = 'salinity'"
nap "units = '1e-3'"
} elseif {$v == "o"} {
nap "long_name = 'Dissolved Oxygen'"
nap "standard_name = 'dissolved_oxygen'"
nap "units = 'ml l-1'"
} elseif {$v == "A"} {
nap "long_name = 'Apparent Oxygen Saturation'"
nap "standard_name = 'apparent_oxygen_saturation'"
nap "units = 'ml l-1'"
} elseif {$v == "O"} {
nap "long_name = 'Percentage Oxygen Saturation'"
nap "standard_name = 'percentage_oxygen_saturation'"
nap "units = 'percent'"
} elseif {$v == "p"} {
nap "long_name = 'Phosphate'"
nap "standard_name = 'phosphate'"
nap "units = 'u M'"
} elseif {$v == "n"} {
nap "long_name = 'Nitrate'"
nap "standard_name = 'nitrate'"
nap "units = 'u M'"
} elseif {$v == "i"} {
nap "long_name = 'Silicate'"
nap "standard_name = 'silicate'"
nap "units = 'u M'"
} elseif {$v == "c"} {
nap "long_name = 'Chlorophyll'"
nap "standard_name = 'chlorophyll'"
nap "units = 'mg m-3'"
} elseif {$v == "z"} {
nap "long_name = 'Zooplankton Biomass'"
nap "standard_name = 'zooplankton_biomass'"
```

```
if {$xx == ""} {
puts "Problem, xx=$xx should not be case when v=$z."
return
} elseif {$xx == "cc"} {
nap "units = 'mg C m-3'"
} else {
nap "units = 'ml m-3'"
}

} else {
puts "Don't know v=$v."
return
}

$long_name netcdf $tdir/$ofil ${v}${tp}${ft}${g}:long_name
$units netcdf $tdir/$ofil ${v}${tp}${ft}${g}:units
$standard_name netcdf $tdir/$ofil ${v}${tp}${ft}${g}:standard_name

nap "mv = f32(1e20)"
$mv netcdf $tdir/$ofil ${v}${tp}${ft}${g}:missing_value

nap "title = 'World Ocean Atlas 2005'"

nap "institution = 'CSIRO (CSIRO Marine and Atmospheric Research, Melbourne, Australia)'"

nap "source = 'ocean: WOA05 (1.0x1.0L33)'"
nap "project_id = 'Fourth Assessment'"
nap "experiment_id = 'climate of the 20th Century experiment (20C3M)'"
nap "contact = 'Mark Collier (Mark.Collier@csiro.au), Paul Durack (Paul.Durack@csiro.au)'"
nap "realization = '1'"
nap "Conventions = 'CF-1.0'"
nap "references = 'Model described by Gordon et al. The CSIRO Mk3 Climate System Model, 20
www.dar.csiro.au/publications/gordon_2002a.pdf'"
nap "history = 'Tcl version: ${::tcl_patchLevel}, NAP version: ${::nap_patchLevel}'"
nap "table_id = 'Table O1e'"

$title netcdf $tdir/$ofil :title
$institution netcdf $tdir/$ofil :institution
$source netcdf $tdir/$ofil :source
$project_id netcdf $tdir/$ofil :project_id
```

```
$experiment_id netcdf $tdir/$ofil :experiment_id
$realization netcdf $tdir/$ofil :realization
$Conventions netcdf $tdir/$ofil :Conventions
$references netcdf $tdir/$ofil :references
$history netcdf $tdir/$ofil :history
$table_id netcdf $tdir/$ofil :table_id

puts "Copying file $tdir/$ofil to $odir/$ofil ..."
file rename -force $tdir/$ofil $odir/$ofil

if {$tp == "0112" || $tp == "1316"} {
file delete -force $idir/$ifil
}

return
exit

};#proc
```

6.3 woa05msk2nc

```
#!/usr/bin/tclsh
#CSIRO Australia
#Mark Collier November 17 2006
#Modified     November 17 2006

source ~/.tclshrc
source ~col414/tcl_fun/dmget_tcl.tcl

set tdir $::env(TMPDIR)

set idir [glob ~col414/WOA05/MASKS]
set odir [glob ~col414/ocean/data/woa05/other]

set v landsea
set v mixnumber
set v basin

if {$v == "landsea"} {
nap "long_name_v = 'Standard Depth Level'"
nap "standard_name_v = 'standard_depth_level'"
nap "units_v = ''"
} elseif {$v == "mixnumber"} {
nap "long_name_v = 'Mixing number'"
nap "standard_name_v = 'mixing_number'"
nap "units_v = ''"
} elseif {$v == "basin"} {
nap "long_name_v = 'Basin'"
nap "standard_name_v = 'basin'"
nap "units_v = ''"
} else {
puts "Variable $v not known."
return
}

set ifil $v.msk
set ofil $v.nc

file delete -force $tdir/$ofil
```

```
file delete -force $odir/$ofil

nap "time = f64{182.5}"
nap "time_bnds = f64{{0} {365}}"
nap "time_bnds=transpose(time_bnds,{1 0})"

nap "lat = -89.5 .. 89.5 ... 1.0"
nap "lon = 0.5 .. 359.5 ... 1.0"

if {$v == "landsea"} {
nap "depth = f64{0}"
} else {
nap "depth = f64{0 10 20 30 50 75 100 125 150 200 250 300 400 500 600 700 800 900 1000
1100 1200 1300 1400 1500 1750 2000 2500 3000 3500 4000 4500 5000 5500}"
}

nap "ntim = nels(time)"
nap "ndep = nels(depth)"
nap "nlat = nels(lat)"
nap "nlon = nels(lon)"

set ntim_tcl [$ntim v]
set ndep_tcl [$ndep v]
set nlat_tcl [$nlat v]
set nlon_tcl [$nlon v]

nap "lon_bnds0 = 0.0 .. 359.0 ... 1.0"
nap "lon_bnds1 = 1.0 .. 360 ... 1.0"

nap "lat_bnds0 = -90.0 .. 89.0 ... 1.0"
nap "lat_bnds1 = -89.0 .. 90.0 ... 1.0"

nap "lat_bnds = transpose(lat_bnds0 /// lat_bnds1,{1 0})"
nap "lon_bnds = transpose(lon_bnds0 /// lon_bnds1,{1 0})"

$time_bnds set dim time bnds
$lat_bnds set dim lat bnds
$lon_bnds set dim lon bnds

set ntimm1_tcl [expr $ntim_tcl-1]
```

```
set ndepm1_tcl [expr $ndep_tcl-1]
set nlatm1_tcl [expr $nlat_tcl-1]
set nlonm1_tcl [expr $nlon_tcl-1]

set numbers_per_line 10;set npl_tcl $numbers_per_line;set nplm1_tcl [expr $npl_tcl-1]
set characters_per_number 8;set cpn_tcl $characters_per_number;set cpnm1_tcl [expr $cpn_tc

if {$v == "landsea"} {
nap "shape = (ntim//nlat//nlon)"
} else {
nap "shape = (ntim//ndep//nlat//nlon)"
}

nap "array_tmp = reshape(f32(_),shape)"

set ifh [open $idir/$ifil r]

set time_tcl 0
set depth_tcl 0
set lat_tcl 0
set lon_tcl 0

nap "nline=ntim*ndep*nlat*nlon/$npl_tcl"
set nline_tcl [$nline v]

for {set l 0} {$l<$nline_tcl} {incr l} {
set line [gets $ifh]
for {set i 0} {$i<$npl_tcl} {incr i} {

$array_tmp set value [expr [string range $line [expr $i*$cpn_tcl] [expr ($i*$cpn_tcl)+$cpn
"$time_tcl,$depth_tcl,$lat_tcl,$lon_tcl"

set latm1_tcl [expr $lat_tcl-1]
set lonm1_tcl [expr $lon_tcl-1]
set timem1_tcl [expr $time_tcl-1]
set depthm1_tcl [expr $depth_tcl-1]

if {$depth_tcl == $ndep_tcl && $lat_tcl == $nlat_tcl && $lon_tcl == $nlon_tcl} {
incr time_tcl
set depth_tcl 0
```

```
set lat_tcl 0
set lon_tcl -1

} elseif {$lat_tcl == $nlatm1_tcl && $lon_tcl == $nlonm1_tcl} {
incr depth_tcl
set lat_tcl 0
set lon_tcl -1

} elseif {$lon_tcl == $nlonm1_tcl} {
incr lat_tcl
set lon_tcl -1
}

incr lon_tcl
};#i
};#l

close $ifh

nap "array=f32(array_tmp<(-99.0))"
nap "array=array*1e20"
$array set missing 1e20
nap "f32(array=array+array_tmp)"
$array set missing 1e20

$lon set unit degrees_east
$lat set unit degrees_north

$array set dim time depth lat lon
$array set coo time depth lat lon

$array netcdf $tdir/$ofil $v

$time_bnds set missing
$time_bnds netcdf $tdir/$ofil time_bnds
$lat_bnds set missing
$lat_bnds netcdf $tdir/$ofil lat_bnds
$lon_bnds set missing
$lon_bnds netcdf $tdir/$ofil lon_bnds
```

```
nap "long_name = 'longitude'"
nap "units = 'degrees_east'"
nap "standard_name = 'longitude'"
nap "axis = 'X'"
nap "bounds = 'lon_bnds'"
$long_name netcdf $tdir/$ofil lon:long_name
$units netcdf $tdir/$ofil lon:units
$standard_name netcdf $tdir/$ofil lon:standard_name
$axis netcdf $tdir/$ofil lon:axis
$bounds netcdf $tdir/$ofil lon:bounds

nap "long_name = 'latitude'"
nap "units = 'degrees_north'"
nap "standard_name = 'latitude'"
nap "axis = 'Y'"
nap "bounds = 'lat_bnds'"
$long_name netcdf $tdir/$ofil lat:long_name
$units netcdf $tdir/$ofil lat:units
$standard_name netcdf $tdir/$ofil lat:standard_name
$axis netcdf $tdir/$ofil lat:axis
$bounds netcdf $tdir/$ofil lat:bounds

nap "long_name = 'time'"
nap "units = 'days since 0000-01-01 00:00:00'"
nap "standard_name = 'time'"
nap "axis = 'T'"
nap "calendar = 'gregorian'"
nap "bounds = 'time_bnds'"
$long_name netcdf $tdir/$ofil time:long_name
$units netcdf $tdir/$ofil time:units
$standard_name netcdf $tdir/$ofil time:standard_name
$axis netcdf $tdir/$ofil time:axis
$calendar netcdf $tdir/$ofil time:calendar
$bounds netcdf $tdir/$ofil time:bounds

nap "long_name = 'depth'"
nap "units = 'm'"
nap "standard_name = 'depth'"
nap "axis = 'Z'"
nap "positive = 'down'"
```

```
$long_name netcdf $tdir/$ofil depth:long_name
$units netcdf $tdir/$ofil depth:units
$standard_name netcdf $tdir/$ofil depth:standard_name
$axis netcdf $tdir/$ofil depth:axis
$positive netcdf $tdir/$ofil depth:positive

$long_name_v netcdf $tdir/$ofil $v:long_name
$units_v netcdf $tdir/$ofil $v:units
$standard_name_v netcdf $tdir/$ofil $v:standard_name

nap "mv = f32(1e20)"
$mv netcdf $tdir/$ofil $v:missing_value

nap "title = 'World Ocean Atlas 2005'"

nap "institution = 'CSIRO (CSIRO Marine and Atmospheric Research, Melbourne, Australia)'"

nap "source = 'ocean: WOA05 (1.0x1.0L33)'"
nap "project_id = 'Fourth Assessment'"
nap "experiment_id = 'climate of the 20th Century experiment (20C3M)'"
nap "contact = 'Mark Collier (Mark.Collier@csiro.au), Paul Durack (Paul.Durack@csiro.au)'"
nap "realization = '1'"
nap "Conventions = 'CF-1.0'"
nap "references = 'Model described by Gordon et al. The CSIRO Mk3 Climate System Model,
2002, www.dar.csiro.au/publications/gordon_2002a.pdf'"
nap "history = 'Tcl version: ${::tcl_patchLevel}, NAP version: ${::nap_patchLevel}'"
nap "table_id = 'Table O1d'"

$title netcdf $tdir/$ofil :title
$institution netcdf $tdir/$ofil :institution
$source netcdf $tdir/$ofil :source
$project_id netcdf $tdir/$ofil :project_id
$experiment_id netcdf $tdir/$ofil :experiment_id
$realization netcdf $tdir/$ofil :realization
$Conventions netcdf $tdir/$ofil :Conventions
$references netcdf $tdir/$ofil :references
$history netcdf $tdir/$ofil :history
$table_id netcdf $tdir/$ofil :table_id

puts "Copying file $tdir/$ofil to $odir/$ofil ..."
```

```
file rename -force $tdir/$ofil $odir/$ofil

return
exit
```

The Tcl-Nap code ~IPCC/WOA05/raw/utilities/woa05txt2nc_driver.tcl generates all annual, seasonal and monthly netCDF files in the CSIRO netcdf version of the NODC World Ocean Atlas 2005. It loops over all combinations of variable, season and file type. It calls on the Tcl-Nap script woa05txt2nc.tcl (procedure woa05txt2nc) to achieve this, not all combinations are available and the procedure will report this, however, continue with the next combination. The Tcl-Nap script woa05msk2nc.tcl generates the three time invariant files described in Section 3, it is simply executed for each case by a simple variable identifier at the beginning of the script. These scripts can be executed from any machine or account which includes a Tcl-Nap installation and the raw ASCII text format files with ease.

7 Appendix 2: Example *FERRET* plotting scripts

Script for figure 2:

```
set memory/size=50 cancel data/all cancel var/all cancel viewport

ppl dfltfnt TR

let iprint=0 let iprint=1 !generate metacode and postscript and
transfer postscript

define view/xlimits=.01,.99/ylimits=.45,.95 top define
view/xlimits=.01,.99/ylimits=.20,.70 bot

use "annual/t00an1.nc"

cancel viewport set viewport top let var1=t00an1[x=@ave,z=0:1000]
let var2=t00an1[x=@ave,z=1000:5000]

fill/axes=0,0,0,0/nolab/nokey/pal=greyscale var1

let ylo = ($ppl$yorg) let ymid = ylo + ($ppl$ylen)*8/29 let yhi =
ylo + ($ppl$ylen) let xlo = ($ppl$xorg) + ($ppl$xlen) + .2 let xhi =
xlo + .6

if ‘iprint eq 1‘ then set mode metafile:xsection.gm endif

fill/axes=1,0,1,1/set_up/nolab/nokey/lev=(0)(1)(2)(4,28,4)/pal=greyscale
var1 ppl shakey 1, 1, 0.08, 0, 4, 6, ‘xlo‘, ‘xhi‘, ‘ymid‘, ‘yhi‘

ppl fill
fill/over/axes=1,0,1,1/set_up/nolab/key/lev=(-4)(-2)(-1)(0)/pal=black/pat=3patterns
var1 ppl shakey 1, 1, 0.08, 0, 4, 6, ‘xlo‘, ‘xhi‘, ‘ylo‘, ‘ymid‘

ppl fill/over pattern solid

set viewport bot
fill/axes=0,1,1,1/nolab/nokey/lev=(0)(1)(2)(4,28,4)/pal=greyscale
var2
fill/over/axes=0,1,1,1/nolab/nokey/lev=(-4)(-2)(-1)(0)/pal=black/pat=3patterns
var2
```

```
label -105.0,2000.0,-1.0,90,.16 "Depth (m)" label
-15.0,6000.0,-1.0,0,.16 "Latitude"

if ‘iprint eq 1‘ then cancel mode metafile sp Fprint -p portrait -l
cps -R -o xsection.ps xsection.gm endif
```

Script for figure 3:

```
set memory/size=50 cancel data/all cancel var/all cancel viewport

ppl dfltfnt TR

let iprint=0 let iprint=1 !generate metacode and postscript and
transfer postscript

use "seasonal/c1316dd1.nc"

if ‘iprint eq 1‘ then set mode metafile:horizontal.gm endif

cancel viewport fill/nolab/nokey/pal=black/lev=(1,5,1)(200,1000,200)
c1316dd1[l=@sum] go fland

label 165.0,-105.0,-1.0,0,.16 "Longitude" label
-20.0,-20.0,-1.0,90,.16 "Latitude"

if ‘iprint eq 1‘ then cancel mode metafile sp Fprint -p portrait -l
cps -R -o horizontal.ps horizontal.gm endif
```

Script for figure 4:

```
set memory/size=50 cancel data/all cancel var/all cancel viewport

ppl dfltfnt TR

let iprint=0 let iprint=1 !generate metacode and postscript and
transfer postscript

use "monthly/o0112an1.nc"

let var=o0112an1[y=60s:90s@ave,z=0]

fill/axes=0,0,0,0/nolab/nokey/lev=(-999)/pal=inverse_greyscale var

let ylo = ($ppl$yorg) let ymid = ylo + ($ppl$ylen)*1.2/3.4 let yhi =
ylo + ($ppl$ylen) let xlo = ($ppl$xorg) + ($ppl$xlen) + .3 let xhi =
xlo + .6

if ‘iprint eq 1‘ then set mode metafile:hovmoller.gm endif

fill/axes=1,1,1,1/set_up/nolab/nokey/lev=(7.6,9.6,.4))/pal=inverse_greyscale
var ppl shakey 1, 1, 0.08, 0, 4, 6, ‘xlo‘, ‘xhi‘, ‘ymid‘, ‘yhi‘

ppl fill

label 165.0,-900.0,-1.0,0,.16 "Longitude" label
-25.0,3790.0,-1.0,90,.16 "Month"

fill/over/axes=1,1,1,1/set_up/nolab/key/lev=(6.4,7.6,.4)/pal=black/
\ pat=3patterns var ppl shakey 1, 1, 0.08, 0, 4, 6, ‘xlo‘, ‘xhi‘,
‘ylo‘, ‘ymid‘

ppl fill/over pattern solid

if ‘iprint eq 1‘ then cancel mode metafile sp Fprint -p portrait -l
cps -R -o hovmoller.ps hovmoller.gm endif
```

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