第3次作业

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摘要：本文使用的程序和文档发布于<https://grwei.github.io/SJTU_2021-2022-2-MS8402/>.

关键词：词1，词2

Homework 3

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**Abstract****:** The programs and documents used in this article are published at <https://grwei.github.io/SJTU_2021-2022-2-MS8402/>.

**Keywords:** keyword 1, keyword 2

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# Question 1

Plot the spatial pattern of the stream function for the subtropical-gyre circulation based on  
the mathematical expression we derived in class (Hint: use the commands “contour” or “contourf” in Matlab or Python to make this plot).

## Solution

结果示于图1.1.



图1.1 第1题图

# Question 2

Download one global ocean reanalysis product during a winter month (Hint: you can find  
different products produced by different research agencies at <https://reanalyses.org/ocean/overview-current-reanalyses>, and download the monthly-mean data), and plot the vertical profiles of the stratification frequency *N* for one location in the tropical ocean, one location in the mid-latitude ocean and one location in the polar ocean (give the longitude and latitude information for these locations). Describe the differences in these profiles and try to give the reasons.

## Solution

使用CMEMS Global Ocean Ensemble Reanalysis product (<https://doi.org/10.48670/moi-00024>) 的global-reanalysis-phy-001-031-grepv2-mnstd-daily dataset中的2019年1月的全球海水位温和盐度数据（分别对应变量thetao\_mean和so\_mean）. 在北半球的热带、中纬度和极地地区分别选点（图2.1），记为A, B, C. 遵循TEOS-10规范 ([McDougall et al., 2011](#_ENREF_2))，计算浮力频率（图2.2）. 另外，使用ORAS5 global ocean reanalysis monthly data ([Hao et al., 2018](#_ENREF_1)) 的2022年1月海表温度和盐度数据，绘制纬向平均的海表面温度和盐度分布（图2.3）.

由图2.2可见，位于热带的A点（5.75°N, -77.50°E）在10米深度附近存在一个浮力频率的极大值（），位于极地的C点（81.75°N, 141.25°E）在33米深度附近存在一个的极大值（），而位于中纬度的B点（45.25°N, -125.75°E）在83米深度附近存在一个的极大值（）.

根据图2.1，对上述结果作如下解释：

（1）在位于热带的A地点处，在海表附近有一个薄至数米的高温低盐混合层，这混合层很可能是由ITCZ下较高的降水减蒸发量，以及较强的向下净辐射加热作用来维持. 混合层下方存在一个温度、盐度梯度均很大的跃层，跃层内温度梯度向上而盐度梯度向下，温、盐梯度均加强向下的密度梯度，这导致了A点处10米深度附近较大的浮力频率值.

（2）在位于极地的C地点处，1月时正是寒冷的极夜，表层海水因长波辐射降温和对北极极寒大气的强烈散热而形成一个厚约数十米的低温混合层. 同时，这混合层也是低盐的，这可能与极夜海水结冰析盐（难道不是造成海表盐度增加？或者，新生的高盐海水迅速沉底，对流调整的结果是海表低盐度混合层维持？），或海冰融化（在极夜？），或某种洋流有关，需结合海洋学常识和其他资料作进一步分析. 其下，是一个具有较大的向下的盐度梯度，和较小的向下的温度梯度的跃层. 温、盐梯度方向分别利于削弱、加强向下的密度梯度，综合结果是位势密度梯度在混合层内几乎为零甚至略向上，在温（盐）跃层内向下. 上述原因导致了C点处海表附近浮力频率很小，甚至在某些点处为微弱的负数，负值量级约83米深度附近出现浮力频率的极值，但不及A点的强.

（3）在位于中纬度的B地点处，海表附近有一厚约50米的高温、低盐混合层，其下是一温、盐梯度不很大的跃层. 故其浮力频率的极值比A, C两点的小.

（4）当海洋局部发生静力不稳定（），就容易触发对流调整，这种调整倾向于恢复海水“上轻下重”的静力稳定配置，故的状态通常不易长时间维持，除非有某种持续的外强迫作用（例如，辐射加热/降温等）. 本例采取的数据是按月平均的结果，局地、暂时的静力不稳定信号难以被捕捉，故位势密度梯度基本上是向下的，相应地，而浮力频率基本上是正值（图2.2）.



图2.1 第2题图a



图2.2 第2题图b



图2.3 第2题图c. 数据来源：ORAS5 global ocean reanalysis monthly data ([Hao et al., 2018](#_ENREF_1)).

References

Hao, Z., Magdalena, A.-B., Mogensen, K., & Steffen, T. (2018). OCEAN5: The ECMWF Ocean Reanalysis System and its Real-Time analysis component. In: ECMWF.

McDougall, Barker, T. J., & M, P. (2011). Getting started with TEOS-10 and the Gibbs Seawater (GSW) oceanographic toolbox. *Scor/Iapso WG*, *127*, 1-28.

1. 本文使用的MATLAB程序源代码

本文使用的程序和文档发布于<https://grwei.github.io/SJTU_2021-2022-2-MS8402/>.

* 1. 主程序

|  |  |
| --- | --- |
| 1 | %% hw3.m |
| 2 | % Description: MATLAB code for homework 3 (MS8402, 2022 Spring) |
| 3 | % Author: Guorui Wei (危国锐) (313017602@qq.com; weiguorui@sjtu.edu.cn) |
| 4 | % Student ID: 120034910021 |
| 5 | % Created: 2022-04-01 |
| 6 | % Last modified: 2022-04-07 |
| 7 | % Data: [1] [ORAS5 global ocean reanalysis monthly data from 1958 to present](https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-oras5) |
| 8 | %       [2] [Global Ocean Ensemble Physics Reanalysis GLOBAL\_REANALYSIS\_PHY\_001\_031](https://doi.org/10.48670/moi-00024) |
| 9 | % Toolbox: [3] [Gibbs-SeaWater (GSW) Oceanographic Toolbox](http://www.teos-10.org/software.htm) |
| 10 |  |
| 11 | %% Initialize project |
| 12 |  |
| 13 | clc; clear; close all |
| 14 | init\_env(); |
| 15 |  |
| 16 | %% Question 1 |
| 17 |  |
| 18 | epsilon = .1; |
| 19 | tau\_0 = 1; |
| 20 | N = 127; |
| 21 | x = linspace(0,1,N); |
| 22 | y = x; |
| 23 | [X,Y] = meshgrid(x,y); |
| 24 | psi = pi\*tau\_0\*(1-X-exp(-X/epsilon)).\*sin(pi\*Y); |
| 25 |  |
| 26 | % fig. |
| 27 | figure("Name","Question 1") |
| 28 | t\_TCL\_pt\_SP = tiledlayout(1,1,"TileSpacing","tight","Padding","tight"); |
| 29 | t\_Axes = nexttile(t\_TCL\_pt\_SP,1); |
| 30 | [~,c\_contour] = contour(t\_Axes,X,Y,psi,"Fill","off"); |
| 31 | clabel([],c\_contour,c\_contour.TextList([1,idivide(end+1,uint8(2)),end]),"Interpreter",'latex') |
| 32 | c = colorbar(t\_Axes,"Location","eastoutside","TickLabelInterpreter","latex"); |
| 33 | c.Label.String = "\psi"; |
| 34 | set(t\_Axes,"YDir",'normal',"TickLabelInterpreter",'latex',"FontSize",10,'Box','off',"TickDir","out"); |
| 35 | ylabel(t\_Axes,"$y$","Interpreter",'latex'); |
| 36 | xlabel(t\_Axes,"$x$","Interpreter",'latex'); |
| 37 | title(t\_Axes,sprintf("$\\psi = (1-x-\\mathrm{e}^{-x/\\varepsilon}) \\pi \\tau\_0 \\sin{\\pi y},\\quad \\tau\_0 = %.3g$, $\\varepsilon = %.3g.$",tau\_0,epsilon),"Interpreter",'latex') |
| 38 | [~,t\_title\_s] = title(t\_TCL\_pt\_SP,"\bf 2022 Spring MS8402 Homework 3 Q1","Guorui Wei 120034910021","Interpreter",'latex'); |
| 39 | set(t\_title\_s,'FontSize',8) |
| 40 | exportgraphics(t\_TCL\_pt\_SP,"..\\doc\\fig\\hw3\_Q1.emf",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 41 | exportgraphics(t\_TCL\_pt\_SP,"..\\doc\\fig\\hw3\_Q1.png",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 42 |  |
| 43 | %% Question 2: init |
| 44 |  |
| 45 | % import data |
| 46 | clear; clc; close all; |
| 47 | path\_votemper = "global-reanalysis-phy-001-031-grepv2-mnstd-monthly\_1649316520167.nc"; % The temperature of a parcel of sea water would have if moved adiabatically to sea level pressure. This variable is a 3D field. |
| 48 | path\_vosaline = path\_votemper; % The salt content of sea water as measured on the practical salinity units (PSU) scale. This variable is a 3D field. |
| 49 | finfo = ncinfo(path\_votemper); |
| 50 | vec\_lat = ncread(path\_votemper,'latitude'); |
| 51 | vec\_lon = ncread(path\_votemper,'longitude'); |
| 52 | [nav\_lat,nav\_lon] = meshgrid(vec\_lat,vec\_lon); |
| 53 | deptht = ncread(path\_votemper,'depth'); |
| 54 | votemper = ncread(path\_votemper,'thetao\_mean',[1,1,1,1],[Inf,Inf,Inf,1]); |
| 55 | vosaline = ncread(path\_vosaline,'so\_mean',[1,1,1,1],[Inf,Inf,Inf,1]); |
| 56 | % |
| 57 | n\_lat\_bin = 255; |
| 58 |  |
| 59 | Q2\_zonal\_average(n\_lat\_bin,'on'); |
| 60 | % |
| 61 | lat\_center = [6,45,74,82]; |
| 62 | lat\_tol = 0.5; |
| 63 | % |
| 64 | ind\_depth\_thrs = find(deptht > 750,1); |
| 65 | TF\_is\_ocean = ~isnan(vosaline(:,:,ind\_depth\_thrs)); |
| 66 | ind\_N2\_min = nan(size(lat\_center)); |
| 67 | ind\_N2\_max = ind\_N2\_min; |
| 68 | ind\_N2\_avg\_min = ind\_N2\_min; |
| 69 | ind\_N2\_avg\_max = ind\_N2\_min; |
| 70 | val\_N2\_min = ind\_N2\_min; |
| 71 | val\_N2\_max = ind\_N2\_min; |
| 72 | val\_N2\_avg\_min = ind\_N2\_min; |
| 73 | val\_N2\_avg\_max = ind\_N2\_min; |
| 74 | for i = 1:length(lat\_center) |
| 75 | [ind\_N2\_min(i),ind\_N2\_max(i),ind\_N2\_avg\_min(i),ind\_N2\_avg\_max(i),val\_N2\_min(i),val\_N2\_max(i),val\_N2\_avg\_min(i),val\_N2\_avg\_max(i)] = Q2\_gsw\_N2\_min\_max(lat\_center(i),lat\_tol,TF\_is\_ocean,nav\_lon,nav\_lat,deptht,votemper,vosaline); |
| 76 | end |
| 77 |  |
| 78 | %% Question 2 |
| 79 |  |
| 80 | ind\_tropi = ind\_N2\_max(1); |
| 81 | ind\_mid = ind\_N2\_max(2); |
| 82 | ind\_polar = ind\_N2\_max(4); |
| 83 | ind\_vec = [ind\_tropi,ind\_mid,ind\_polar]; |
| 84 | % |
| 85 | SP = nan(length(deptht),length(ind\_vec)); |
| 86 | pt = SP; |
| 87 | p = SP; |
| 88 | SA = SP; |
| 89 | CT = SP; |
| 90 | pot\_rho = SP; |
| 91 | N2 = nan(length(deptht)-1,length(ind\_vec)); |
| 92 | p\_mid = N2; |
| 93 | for i = 1:length(ind\_vec) |
| 94 | [x,y] = ind2sub(size(nav\_lon),ind\_vec(i)); |
| 95 | [SP(:,i),pt(:,i),p(:,i),SA(:,i),CT(:,i),N2(:,i),p\_mid(:,i),pot\_rho(:,i)] = Q2\_gsw\_N2(x,y,nav\_lon,nav\_lat,deptht,votemper,vosaline); |
| 96 | end |
| 97 | % |
| 98 | figure("Name","Q2\_pt\_SP\_vertical\_profile") |
| 99 | t\_TCL\_pt\_SP = tiledlayout(1,2,"TileSpacing","tight","Padding","tight"); |
| 100 | t\_Axes\_pt = nexttile(t\_TCL\_pt\_SP); |
| 101 | t\_Axes\_pt = Q2\_plot\_vertical(t\_Axes\_pt,pt,p,ind\_vec,nav\_lat,nav\_lon,"potential temperature $(^{\circ}{\rm{C}})$","pressure (dbar)","temperature"); |
| 102 | t\_Axes\_SP = nexttile(t\_TCL\_pt\_SP); |
| 103 | t\_Axes\_SP = Q2\_plot\_vertical(t\_Axes\_SP,SP,p,ind\_vec,nav\_lat,nav\_lon,"Salinity (psu)","pressure (dbar)","Salinity"); |
| 104 | % |
| 105 | [~,t\_title\_s] = title(t\_TCL\_pt\_SP,"\bf 2022 Spring MS8402 Homework 3 Q2","Guorui Wei 120034910021","Interpreter",'latex'); |
| 106 | set(t\_title\_s,'FontSize',8) |
| 107 | % |
| 108 | exportgraphics(t\_TCL\_pt\_SP,"..\\doc\\fig\\hw3\_Q2\_pt\_SP\_vertical\_profile.emf",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 109 | exportgraphics(t\_TCL\_pt\_SP,"..\\doc\\fig\\hw3\_Q2\_pt\_SP\_vertical\_profile.png",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 110 | % |
| 111 | figure("Name","Q2\_rho\_N2\_vertical\_profile") |
| 112 | t\_TCL\_rho\_N2 = tiledlayout(1,2,"TileSpacing","tight","Padding","tight"); |
| 113 | t\_Axes\_rho = nexttile(t\_TCL\_rho\_N2); |
| 114 | t\_Axes\_rho = Q2\_plot\_vertical(t\_Axes\_rho,pot\_rho,p,ind\_vec,nav\_lat,nav\_lon,"potential density $(\rm{kg}/\rm{m}^3)$","pressure (dbar)","density"); |
| 115 | t\_Axes\_N2 = nexttile(t\_TCL\_rho\_N2); |
| 116 | t\_Axes\_N2 = Q2\_plot\_vertical(t\_Axes\_N2,N2,p\_mid,ind\_vec,nav\_lat,nav\_lon,"$N^2$ $(\rm{rad}^2 / s^2)$","pressure (dbar)","Stratification frequency"); |
| 117 | % |
| 118 | [~,t\_title\_s] = title(t\_TCL\_rho\_N2,"\bf 2022 Spring MS8402 Homework 3 Q2","Guorui Wei 120034910021","Interpreter",'latex'); |
| 119 | set(t\_title\_s,'FontSize',8) |
| 120 | % |
| 121 | exportgraphics(t\_TCL\_rho\_N2,"..\\doc\\fig\\hw3\_Q2\_rho\_N2\_vertical\_profile.emf",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 122 | exportgraphics(t\_TCL\_rho\_N2,"..\\doc\\fig\\hw3\_Q2\_rho\_N2\_vertical\_profile.png",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 123 |  |
| 124 | %% local functions |
| 125 |  |
| 126 | %% Initialize environment |
| 127 | function [] = init\_env() |
| 128 | % Initialize environment |
| 129 | % |
| 130 | % set up project directory |
| 131 | if ~isfolder("../doc/fig/") |
| 132 | mkdir ../doc/fig/ |
| 133 | end |
| 134 | % configure searching path |
| 135 | mfile\_fullpath = mfilename('fullpath'); % the full path and name of the file in which the call occurs, not including the filename extension. |
| 136 | mfile\_fullpath\_without\_fname = mfile\_fullpath(1:end-strlength(mfilename)); |
| 137 | addpath(genpath(mfile\_fullpath\_without\_fname + "../data"), ... |
| 138 | genpath(mfile\_fullpath\_without\_fname + "../inc")); % adds the specified folders to the top of the search path for the current MATLAB® session. |
| 139 |  |
| 140 | return; |
| 141 | end |
| 142 |  |
| 143 | %% surface zonal average |
| 144 | function [] = Q2\_zonal\_average(n\_lat\_bin,fig\_EN) |
| 145 | % hw3 Q2 |
| 146 | % |
| 147 | arguments |
| 148 | n\_lat\_bin |
| 149 | fig\_EN string = 'on' |
| 150 | end |
| 151 |  |
| 152 | nav\_lat = ncread("..\data\sosstsst\_control\_monthly\_highres\_2D\_202201\_OPER\_v0.1.nc",'nav\_lat'); |
| 153 | [lat\_bin\_num,lat\_edges] = discretize(nav\_lat,n\_lat\_bin); |
| 154 | sosstsst = ncread("..\data\sosstsst\_control\_monthly\_highres\_2D\_202201\_OPER\_v0.1.nc",'sosstsst'); % [deg C] Water temperature close to the ocean surface. This variable is a 2D field. |
| 155 | sosaline = ncread("..\data\sosaline\_control\_monthly\_highres\_2D\_202201\_OPER\_v0.1.nc",'sosaline'); % [psu] Salt concentration close to the ocean surface. This variable is a 2D field. |
| 156 | % |
| 157 | TF\_so\_avail = ~isnan(sosstsst); |
| 158 | n\_lat\_bin = length(lat\_edges)-1; |
| 159 | lat\_bin\_avg = zeros(n\_lat\_bin,1); |
| 160 | N\_pts\_bin = lat\_bin\_avg; |
| 161 | sosstsst\_zonal\_avg = lat\_bin\_avg; |
| 162 | sosaline\_zonal\_avg = lat\_bin\_avg; |
| 163 | for bin\_num = 1:n\_lat\_bin |
| 164 | TF\_lat\_avail = (lat\_bin\_num == bin\_num) & TF\_so\_avail; |
| 165 | N\_pts\_bin(bin\_num) = nnz(TF\_lat\_avail); |
| 166 | lat\_bin\_avg(bin\_num) = mean(nav\_lat(TF\_lat\_avail)); |
| 167 | sosstsst\_zonal\_avg(bin\_num) = mean(sosstsst(TF\_lat\_avail)); |
| 168 | sosaline\_zonal\_avg(bin\_num) = mean(sosaline(TF\_lat\_avail)); |
| 169 | end |
| 170 | if (strcmpi(fig\_EN,"off")) |
| 171 | return; |
| 172 | end |
| 173 |  |
| 174 | % |
| 175 | figure("Name","Q2\_sst\_zonal\_avg") |
| 176 | t\_TCL\_1 = tiledlayout(1,1,"TileSpacing","tight","Padding","tight"); |
| 177 | t\_Axes\_1 = nexttile(t\_TCL\_1,1); |
| 178 | yyaxis(t\_Axes\_1,"left") |
| 179 | t\_plot\_sst = plot(t\_Axes\_1,lat\_bin\_avg,sosstsst\_zonal\_avg,'-',"DisplayName",'temperature'); |
| 180 | set(t\_Axes\_1,'YColor','#0072BD','XLim',[-90 90],"YDir",'normal','XTick',linspace(-90,90,7),"TickLabelInterpreter",'latex',"FontSize",10,'Box','off'); |
| 181 | xlabel(t\_Axes\_1,"latitude $(^{\circ}{\rm{N}})$","Interpreter",'latex'); |
| 182 | ylabel(t\_Axes\_1,"Sea Surface temperature $(^{\circ}{\rm{C}})$","Interpreter",'latex'); |
| 183 | yyaxis(t\_Axes\_1,"right") |
| 184 | t\_plot\_sal = plot(t\_Axes\_1,lat\_bin\_avg,sosaline\_zonal\_avg,'-',"DisplayName",'Salinity'); |
| 185 | set(t\_Axes\_1,"YDir",'normal'); |
| 186 | ylabel(t\_Axes\_1,"Sea Surface Salinity (psu)","Interpreter",'latex'); |
| 187 | title(t\_Axes\_1,"\bf Zonal Average (Jan, 2022)",'Interpreter','latex') |
| 188 | grid on |
| 189 | % |
| 190 | legend([t\_plot\_sst,t\_plot\_sal],"Location",'south','Interpreter','latex',"Box","off",'FontSize',10); |
| 191 | [~,t\_title\_s] = title(t\_TCL\_1,"\bf 2022 Spring MS8402 Homework 3 Q2","Guorui Wei 120034910021","Interpreter",'latex'); |
| 192 | set(t\_title\_s,'FontSize',8) |
| 193 | % |
| 194 | exportgraphics(t\_TCL\_1,"..\\doc\\fig\\hw3\_Q2\_sea\_surface\_zonal\_avg.emf",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 195 | exportgraphics(t\_TCL\_1,"..\\doc\\fig\\hw3\_Q2\_sea\_surface\_zonal\_avg.png",'Resolution',600,'ContentType','auto','BackgroundColor','none','Colorspace','rgb') |
| 196 |  |
| 197 | return; |
| 198 | end |
| 199 |  |
| 200 | %% find nearest data point |
| 201 | function [x,y,arclen] = Q2\_location\_query(lon,lat,nav\_lon,nav\_lat) |
| 202 | % find nearest data point |
| 203 | % OUTPUT: |
| 204 | % x: lon index |
| 205 | % y: lat index |
| 206 | % arclen: the lengths, arclen, of the great circle arcs connecting pairs |
| 207 | % of points on the surface of a sphere. |
| 208 | arguments |
| 209 | lon |
| 210 | lat |
| 211 | nav\_lon |
| 212 | nav\_lat |
| 213 | end |
| 214 | arclen = nan(size(nav\_lon)); |
| 215 | for j = 1:size(nav\_lon,2) |
| 216 | arclen(:,j) = distance(lat,lon,nav\_lat(:,j),nav\_lon(:,j)); |
| 217 | end |
| 218 | [arclen,I] = min(arclen,[],"all","omitnan","linear"); |
| 219 | [x,y] = ind2sub(size(nav\_lon),I); |
| 220 |  |
| 221 | return; |
| 222 | end |
| 223 |  |
| 224 | %% |
| 225 | function [SP,pt,p,SA,CT,N2,p\_mid,pot\_rho] = Q2\_gsw\_N2(x,y,nav\_lon,nav\_lat,deptht,votemper,vosaline,p\_ref,mem\_EN,path\_votemper,path\_vosaline) |
| 226 | % Q2 |
| 227 | % |
| 228 | arguments |
| 229 | x |
| 230 | y |
| 231 | nav\_lon |
| 232 | nav\_lat |
| 233 | deptht |
| 234 | votemper |
| 235 | vosaline |
| 236 | p\_ref = 0; % reference pressure of potential density |
| 237 | mem\_EN string = 'on' % accelerate by storing large data in memory |
| 238 | path\_votemper = "..\data\votemper\_control\_monthly\_highres\_3D\_202201\_OPER\_v0.1.nc"; |
| 239 | path\_vosaline = "..\data\vosaline\_control\_monthly\_highres\_3D\_202201\_OPER\_v0.1.nc"; |
| 240 | end |
| 241 |  |
| 242 | if (strcmpi(mem\_EN,"on")) |
| 243 | SP = squeeze(vosaline(x,y,:)); |
| 244 | pt = squeeze(votemper(x,y,:)); |
| 245 | else |
| 246 | SP = squeeze(ncread(path\_vosaline,'vosaline',[x,y,1,1],[1,1,Inf,1])); |
| 247 | pt = squeeze(ncread(path\_votemper,'votemper',[x,y,1,1],[1,1,Inf,1])); |
| 248 | end |
| 249 | if (nargout < 3) |
| 250 | p = uint8(0); SA = p; CT = p; N2 = p; p\_mid = p; |
| 251 | return; |
| 252 | end |
| 253 |  |
| 254 | z = -deptht; % [m] Height (z) is NEGATIVE in the ocean. |
| 255 | lat = nav\_lat(x,y); % [deg N] |
| 256 | p = gsw\_p\_from\_z(z,lat); |
| 257 | if (nargout < 4) |
| 258 | SA = uint8(0); CT = SA; N2 = SA; p\_mid = SA; |
| 259 | return; |
| 260 | end |
| 261 |  |
| 262 | if (min(isnan(SP),[],"all")) |
| 263 | SA = uint8(0); CT = SA; N2 = SA; p\_mid = SA; |
| 264 | warning("warning: no data! (x,y) = (%i,%i)\n",x,y); |
| 265 | return; |
| 266 | end |
| 267 | lon = nav\_lon(x,y); % [deg E] |
| 268 | [SA,in\_ocean] = gsw\_SA\_from\_SP(SP,p,lon,lat); |
| 269 | CT = gsw\_CT\_from\_pt(SA,pt); |
| 270 | %     if(~min(gsw\_infunnel(SA,CT,p))) |
| 271 | %         warning("warning: not in funnel! (x,y) = (%i,%i)\n",x,y); |
| 272 | %     end |
| 273 | if (nargout < 6) |
| 274 | N2 = uint8(0); p\_mid = N2; |
| 275 | return; |
| 276 | end |
| 277 |  |
| 278 | [N2,p\_mid] = gsw\_Nsquared(SA,CT,p,lat); |
| 279 | if (nargout < 8) |
| 280 | return; |
| 281 | end |
| 282 |  |
| 283 | pot\_rho = gsw\_rho(SA,CT,p\_ref); |
| 284 |  |
| 285 | return; |
| 286 | end |
| 287 |  |
| 288 | %% |
| 289 | function [ind\_N2\_min,ind\_N2\_max,ind\_N2\_avg\_min,ind\_N2\_avg\_max,val\_N2\_min,val\_N2\_max,val\_N2\_avg\_min,val\_N2\_avg\_max] = Q2\_gsw\_N2\_min\_max(lat\_center,lat\_tol,TF\_is\_ocean,nav\_lon,nav\_lat,deptht,votemper,vosaline,p\_ref,mem\_EN,path\_votemper,path\_vosaline) |
| 290 | % Q2 |
| 291 | % |
| 292 | arguments |
| 293 | lat\_center |
| 294 | lat\_tol |
| 295 | TF\_is\_ocean |
| 296 | nav\_lon |
| 297 | nav\_lat |
| 298 | deptht |
| 299 | votemper |
| 300 | vosaline |
| 301 | p\_ref = 0; % reference pressure of potential density |
| 302 | mem\_EN string = 'on' % accelerate by storing large data in memory |
| 303 | path\_votemper = "..\data\votemper\_control\_monthly\_highres\_3D\_202201\_OPER\_v0.1.nc"; |
| 304 | path\_vosaline = "..\data\vosaline\_control\_monthly\_highres\_3D\_202201\_OPER\_v0.1.nc"; |
| 305 | end |
| 306 |  |
| 307 | % params |
| 308 | depth\_max = 750; |
| 309 | % |
| 310 | tStart = tic; |
| 311 | loc\_ind\_linear = find(abs(nav\_lat-lat\_center) < lat\_tol & TF\_is\_ocean); |
| 312 | N2\_min = nan(size(loc\_ind\_linear)); |
| 313 | N2\_max = N2\_min; |
| 314 | N2\_avg = N2\_min; |
| 315 | for i = 1:length(loc\_ind\_linear) |
| 316 | [x,y] = ind2sub(size(nav\_lon),loc\_ind\_linear(i)); |
| 317 | [~,~,~,~,~,N2,~,~] = Q2\_gsw\_N2(x,y,nav\_lon,nav\_lat,deptht,votemper,vosaline,p\_ref,mem\_EN,path\_votemper,path\_vosaline); |
| 318 | N2\_min(i) = min(N2(deptht<depth\_max),[],"omitnan"); |
| 319 | N2\_max(i) = max(N2(deptht<depth\_max),[],"omitnan"); |
| 320 | N2\_avg(i) = mean(N2(deptht<depth\_max),"omitnan"); |
| 321 | %         fprintf("\rDone: %i/%i, (%.2f N, %.2f E), N2\_min = %.2g, N2\_max = %.2g.", ... |
| 322 | %             i,length(loc\_ind\_linear),nav\_lat(loc\_ind\_linear(i)),nav\_lon(loc\_ind\_linear(i)),N2\_min(i),N2\_max(i)); |
| 323 | end |
| 324 | [val\_N2\_min,ind\_min] = min(N2\_min,[],"omitnan",'linear'); |
| 325 | [val\_N2\_max,ind\_max] = max(N2\_max,[],"omitnan",'linear'); |
| 326 | [val\_N2\_avg\_min,ind\_avg\_min] = min(N2\_avg,[],"omitnan",'linear'); |
| 327 | [val\_N2\_avg\_max,ind\_avg\_max] = max(N2\_avg,[],"omitnan",'linear'); |
| 328 | ind\_N2\_min = loc\_ind\_linear(ind\_min); |
| 329 | ind\_N2\_max = loc\_ind\_linear(ind\_max); |
| 330 | ind\_N2\_avg\_min = loc\_ind\_linear(ind\_avg\_min); |
| 331 | ind\_N2\_avg\_max = loc\_ind\_linear(ind\_avg\_max); |
| 332 | fprintf("\nSummary: %.1f secs used, %i points processed.\n" + ... |
| 333 | "lat = %.2f N, lat\_tol = %.2f deg, depth\_max = %.2f m.\n" + ... |
| 334 | "N2\_min = %.2e (%.2f N, %.2f E),\n" + ... |
| 335 | "N2\_max = %.2e (%.2f N, %.2f E),\n" + ... |
| 336 | "N2\_avg\_min = %.2e (%.2f N, %.2f E),\n" + ... |
| 337 | "N2\_avg\_max = %.2e (%.2f N, %.2f E).\n", ... |
| 338 | toc(tStart),length(loc\_ind\_linear), ... |
| 339 | lat\_center,lat\_tol,depth\_max, ... |
| 340 | val\_N2\_min,nav\_lat(ind\_N2\_min),nav\_lon(ind\_N2\_min), ... |
| 341 | val\_N2\_max,nav\_lat(ind\_N2\_max),nav\_lon(ind\_N2\_max), ... |
| 342 | val\_N2\_avg\_min,nav\_lat(ind\_N2\_avg\_min),nav\_lon(ind\_N2\_avg\_min), ... |
| 343 | val\_N2\_avg\_max,nav\_lat(ind\_N2\_avg\_max),nav\_lon(ind\_N2\_avg\_max)); |
| 344 |  |
| 345 | return; |
| 346 | end |
| 347 |  |
| 348 | %% |
| 349 | function [t\_Axes] = Q2\_plot\_vertical(t\_Axes,x\_data,y\_data,ind\_vec,nav\_lat,nav\_lon,xlabel\_str,ylabel\_str,axes\_title\_str) |
| 350 | % Q2 |
| 351 | % |
| 352 | arguments |
| 353 | t\_Axes |
| 354 | x\_data |
| 355 | y\_data |
| 356 | ind\_vec |
| 357 | nav\_lat |
| 358 | nav\_lon |
| 359 | xlabel\_str |
| 360 | ylabel\_str |
| 361 | axes\_title\_str |
| 362 | end |
| 363 |  |
| 364 | hold on |
| 365 | for i = 1:length(ind\_vec) |
| 366 | t\_plot\_pt = plot(t\_Axes,x\_data(:,i),y\_data(:,i),'-',"DisplayName",sprintf("%.2f$^{\\circ}{\\rm{N}}$, %.2f$^{\\circ}{\\rm{E}}$",nav\_lat(ind\_vec(i)),nav\_lon(ind\_vec(i)))); |
| 367 | end |
| 368 | hold off |
| 369 | grid on |
| 370 | set(t\_Axes,"YDir",'reverse',"TickLabelInterpreter",'latex',"FontSize",10,'Box','off'); |
| 371 | xlabel(t\_Axes,xlabel\_str,"Interpreter",'latex'); |
| 372 | ylabel(t\_Axes,ylabel\_str,"Interpreter",'latex'); |
| 373 | legend(t\_Axes,"Location",'best','Interpreter','latex',"Box","off",'FontSize',10); |
| 374 | %     title(t\_Axes,axes\_title\_str,"Interpreter",'latex') |
| 375 |  |
| 376 | return; |
| 377 | end |
| 378 |  |

* 1. 子程序

本文使用的程序和文档发布于<https://grwei.github.io/SJTU_2021-2022-2-MS8402/>.

本文使用的*Gibbs-SeaWater (GSW) Oceanographic Toolbox*可从<http://www.teos-10.org/software.htm>获取.