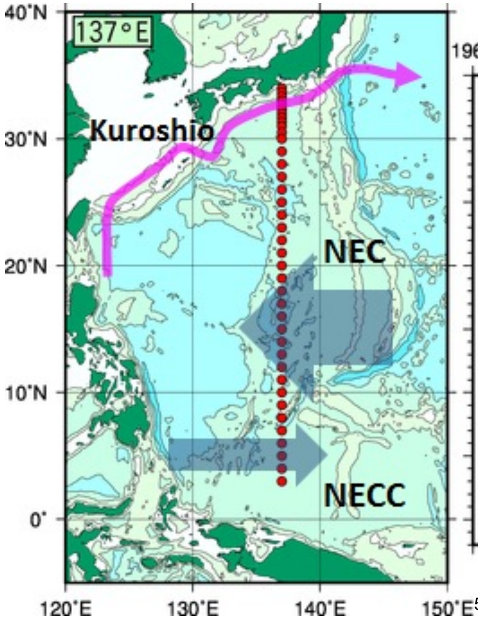
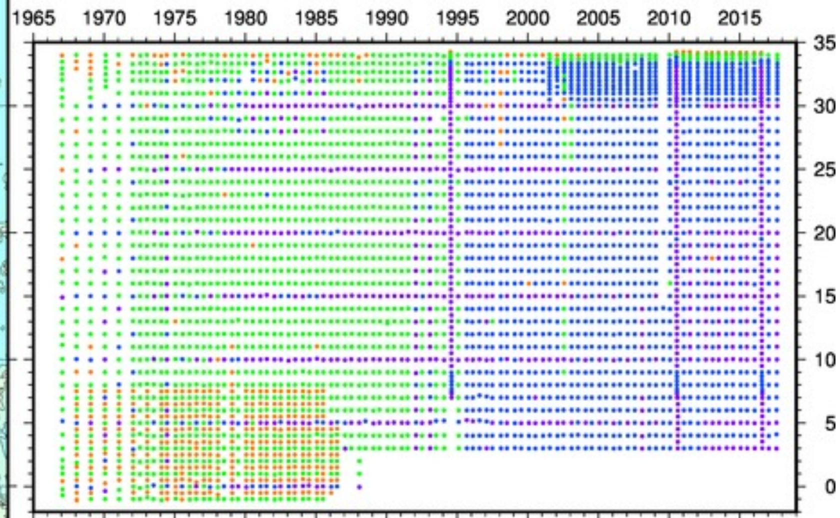
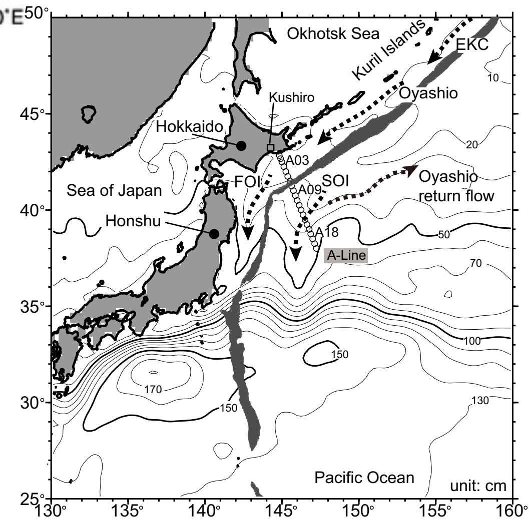
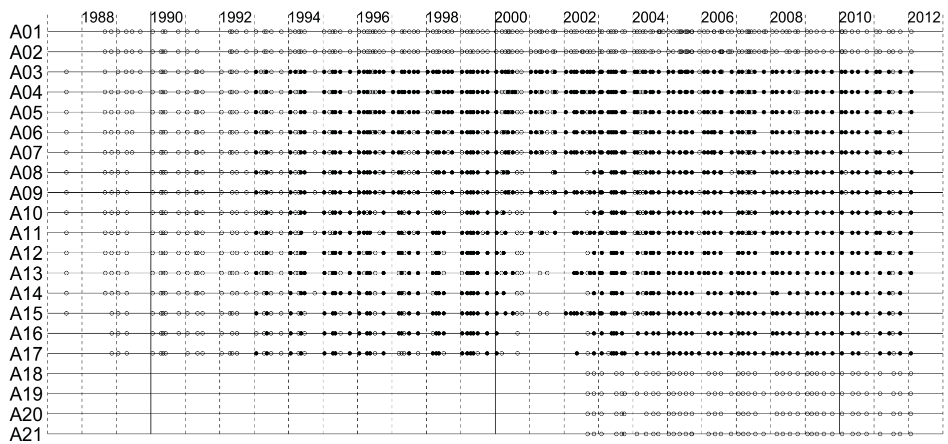




JMA 137E meridian Observation



A-line Observation



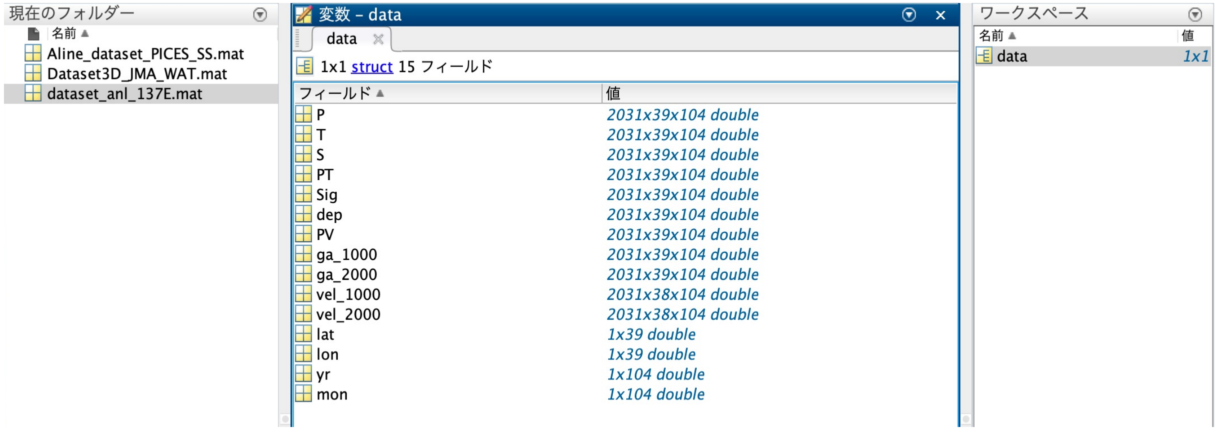
(1) Dataset

The original datasets of 137E meridian and A-line are compiled into MATLAB files (.m files) by courtesy of Dr. Honma and Ms. Otsuka of FRA.
(So, you don't have to make 3D-gridded datasets by yourself)

There are three datasets:

Aline_dataset_PICES_SS.mat	A-line Bottle sampling data
dataset_anl_137E.mat	JMA 137E long-term CTD objective analysis data
Dataset3D_JMA_WAT.mat	JMA 137E Bottle sampling data

Dataset: dataset_anl_137E.mat



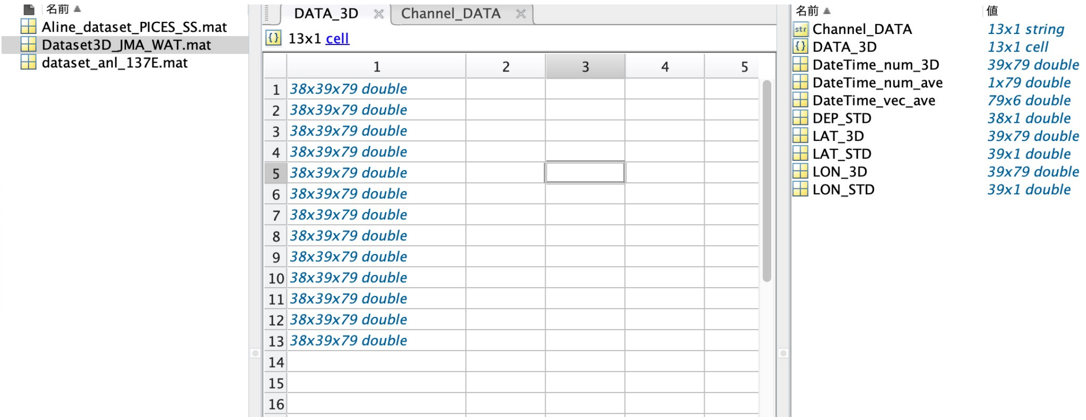
List of Variables in "data":

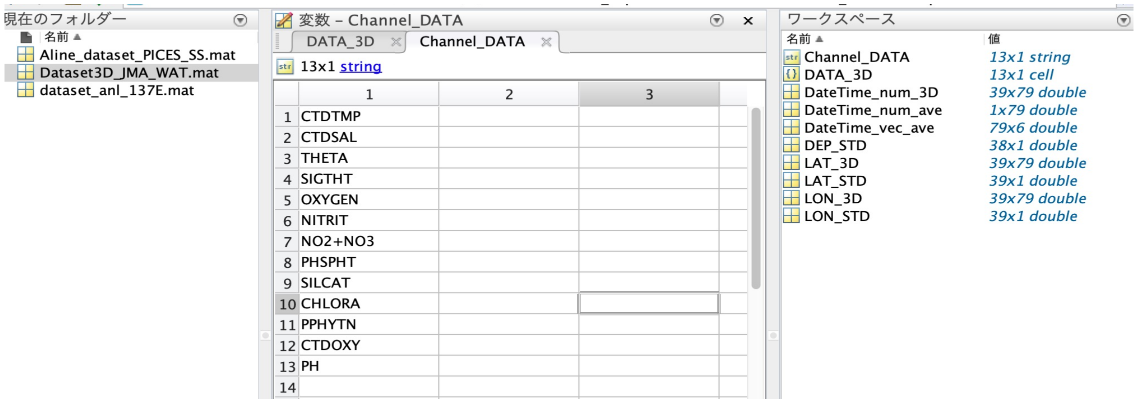
P: Pressure (dbar)
T: Temperature (^{o}C)
S: Salinity
PT: Potential temperature (^{o}C)
Sig: Potential density (σ_{θ} , kg/m^3)
dep: Depth (m)
PV: Potential vorticity (/s)
ga_1000: Geopotential anomaly referenced to 1000 dbar (m^2/s^2)
ga_2000: Geopotential anomaly referenced to 2000 dbar (m^2/s^2)
vel_1000: Geostrophic velocity referenced to 1000 dbar (m/s)
vel_2000: Geostrophic velocity referenced to 2000 dbar (m/s)
lat: Latitude (^{o}N)
lon: Longitude (^{o}E)
yr: year
mon: month

Dimensions:

2031 *	39 *	104
Layer: 0 – 2030 dbar (1dbar interval)	**Location:** 39 stations (specified by lat and lon)	**Time:** 104 cruises (specified by yr and mon)

Dataset: Dataset3D_JMA_WAT.mat





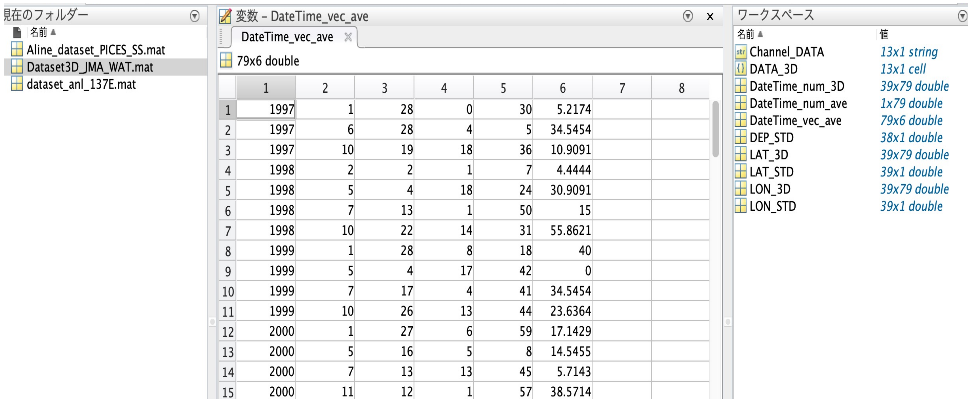
DATA_3D contains the following variables, which is listed in Chnnel_DATA:

CTDTMP: Temperature(ºC)
CTDSAL: Salinity (PSS-78)
THETA: Potential temperature (ºC)
SIGTHT: Potential density (σ_θ, kg/m^3)
NITRIT: Nitrite (umol/kg)
NO2+NO3: Nitrate + Nitrite (umol/kg)
PHSPHT: Phosphate (umol/kg)
SILCAT: Silicate (umol/kg)
CHLORA: Chlorophyll-a (ug/l)
PPHYTN: Phaeophytin (ug/l)
CTDOXY: Dissolved oxygen (umol/kg)
PH: PH

Dimensions:

38	*	39	*	79
Layer: 38 layers (specified by DEP_STD)		**Location:** 39 stations (specified by LAT_STD and LON_STD)		**Time:** 79 cruises (specified by DateTime_*)

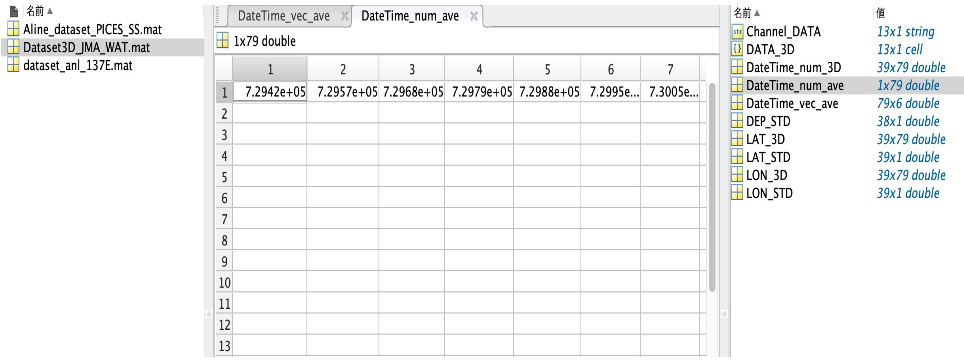
Time used in Dataset3D_JMA_WAT.mat



	1	2	3	4	5	6	7	8
1	1997	1	28	0	30	5.2174		
2	1997	6	28	4	5	34.5454		
3	1997	10	19	18	36	10.9091		
4	1998	2	2	1	7	4.4444		
5	1998	5	4	18	24	30.9091		
6	1998	7	13	1	50	15		
7	1998	10	22	14	31	55.8621		
8	1999	1	28	8	18	40		
9	1999	5	4	17	42	0		
10	1999	7	17	4	41	34.5454		
11	1999	10	26	13	44	23.6364		
12	2000	1	27	6	59	17.1429		
13	2000	5	16	5	8	14.5455		
14	2000	7	13	13	45	5.7143		
15	2000	11	12	1	57	38.5714		

名前	値
Channel_DATA	13x1 string
DATA_3D	13x1 cell
DateTime_num_3D	39x79 double
DateTime_num_ave	1x79 double
DateTime_vec_ave	79x6 double
DEP_STD	38x1 double
LAT_3D	39x79 double
LAT_STD	39x1 double
LON_3D	39x79 double
LON_STD	39x1 double

DateTime_vec_ave



	1	2	3	4	5	6	7
1	7.2942e+05	7.2957e+05	7.2968e+05	7.2979e+05	7.2988e+05	7.2995e...	7.3005e...
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							
13							

名前	値
Channel_DATA	13x1 string
DATA_3D	13x1 cell
DateTime_num_3D	39x79 double
DateTime_num_ave	1x79 double
DateTime_vec_ave	79x6 double
DEP_STD	38x1 double
LAT_3D	39x79 double
LAT_STD	39x1 double
LON_3D	39x79 double
LON_STD	39x1 double

DateTime_num_ave

DateTime_vec_ave:

- year, month, day, hour, min, sec averaged for each cruise

DateTime_num_ave:

- serial date numbers from 0^{th} Jan, 0000 year averaged for each cruise

- Using MATLAB command,
  DateTime_num_ave
  =datenum(Date_Time_vec_ave)

DateTime_num_3D:

- serial date numbers from 0^{th} Jan, 0000 year for each cast

(LAT_3D and LON_3D are also latitude and longitude of each cast)

Dataset: Aline_dataset_PICES_SS.mat

List of Variables:

Chl_a: Chlorophyll-a (ug/l)
Depth: Pressure (dbar)
Lat: Latitude (^{o}N)
Lon: Longitude (^{o}E)
Month: month of each cast
NO3: Nitrate (umol/kg)
PO4: Phosphate (umol/kg)
Salt: Salinity
Si: Silicate (umol/kg)
Sta: Station number (i.e, A01~A21)
Temp: Temperature (^{o}C)
Year: year of each cast

Dimensions:

23 * 13 * 130

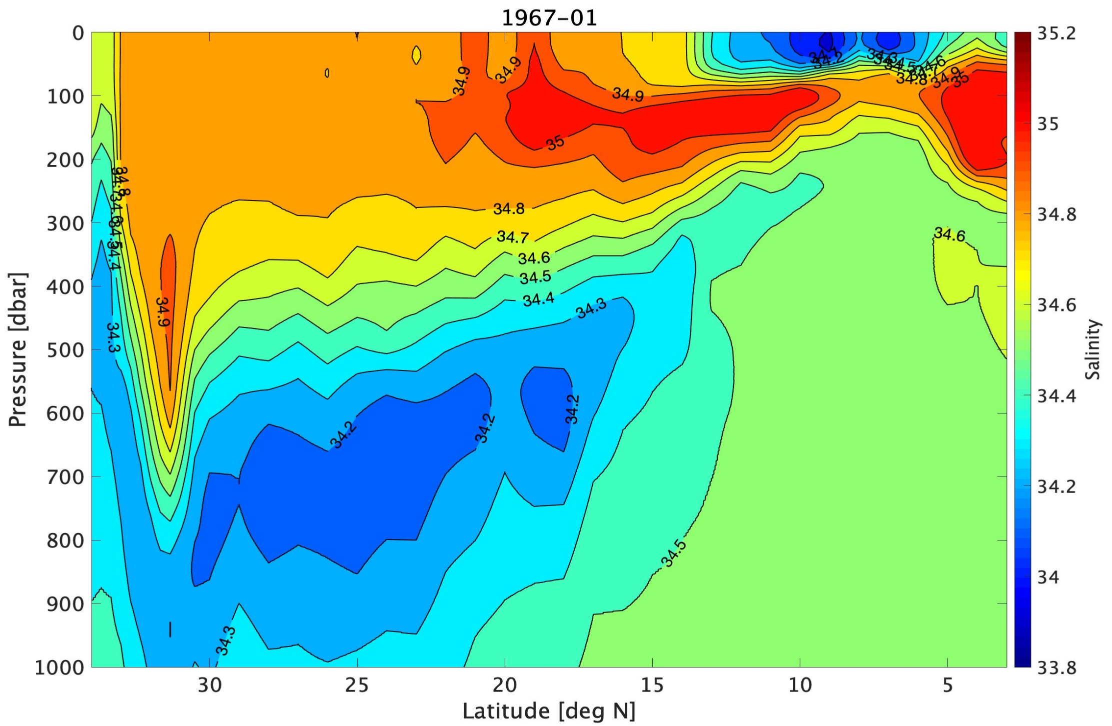
Layer:
23 layers
(specified by Depth)

Location:
13 stations
(specified by lat, lon, and Sta)

Time:
130 times
(specified by Year and Month.
For each year, Jan (Dec-Feb), Mar (Mar-Apr), May, Jul (Jun-Aug), and Oct. (Sep-Nov))

(2) Sectional distribution of physical properties -137E meridian-

- Below is the salinity distribution in Jan 1967 using dataset_anl_137E.mat.



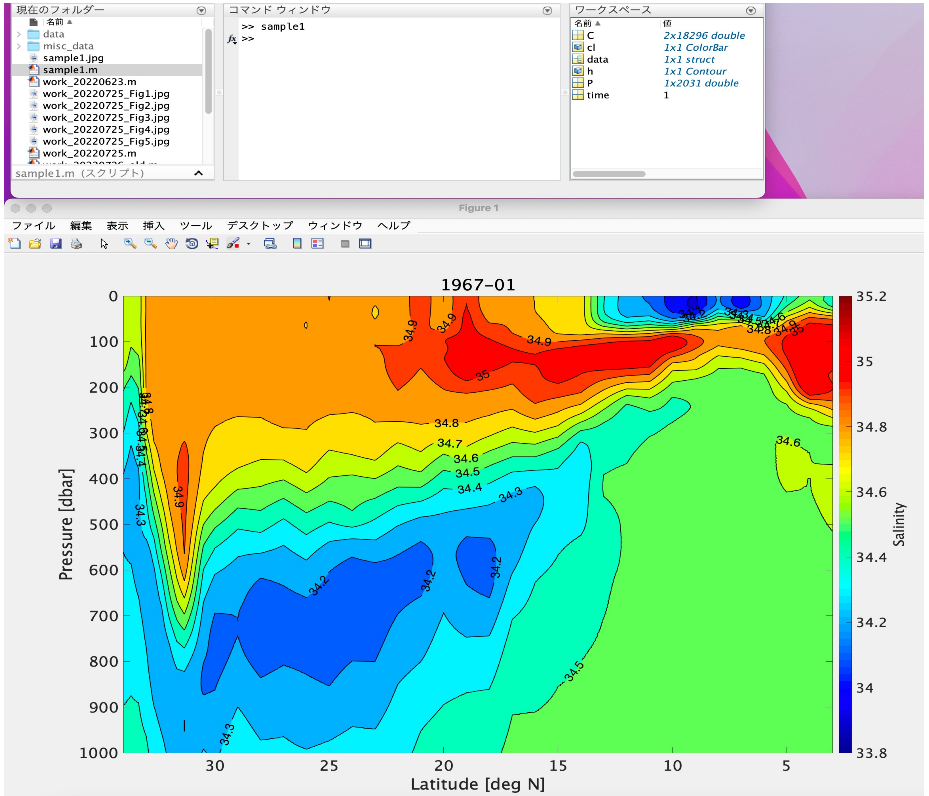
sample1.m:

```
%load dataset
load('./data/dataset_anl_137E.mat')

P    =[0:2030]; %Pressure dbar
time =1; %Cruise (1-104)

figure('Position',[0,0,1200,800])

%Plot sectional distribution
[C,h] =contourf(data.lat,P,data.S(:,:,time),[32.0:0.1:35.0]);

%Below are some settings for the figure
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
title([num2str(data.yr(time),'%2.2i'),'-',...
    num2str(data.mon(time),'%2.2i')])
cl=colorbar;
caxis([33.8,35.2]);
axis ij;
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize',20)
ylabel(cl,'Salinity')
colormap(jet);
set(h,'ShowText','on','LineWidth',1)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);

%Save figure
saveas(gcf,'sample1','jpg')
```

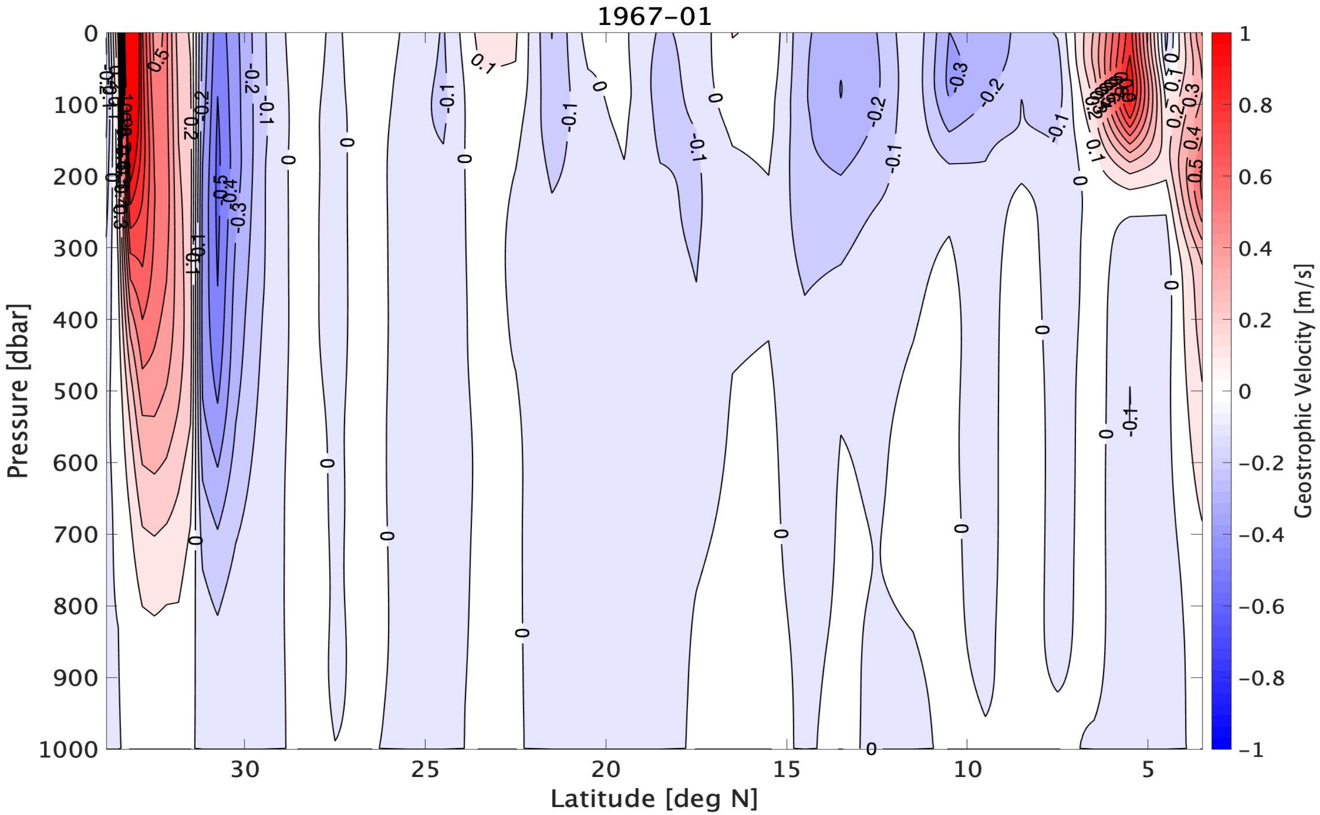
- The figure in the previous page can be drawn using the sample script on the left.

  (The dataset is stored in “data” folder)

- The sample script is named as sample1, and the figure is generated by simply running the script



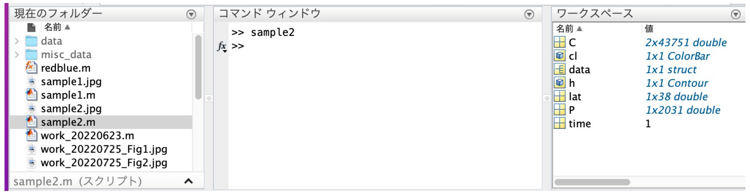
- Below is the geostrophic current velocity (referenced to 1000 dbar) in Jan 1967 using dataset_anl_137E.mat.
- Positive is eastward



sample2.m:

```
%load dataset
load('./data/dataset_anl_137E.mat')

P    =[0:2030]; %Pressure dbar
time =1; %Cruise (1-104)

%Geostrophic current velocity is calculated between adjacent
stations
lat  =(data.lat(1:end-1)+data.lat(2:end))/2;

figure('Position',[0,0,1200,800])
%Plot sectional distribution
[C,h] =contourf(lat,P,data.vel_1000(:,:,time),[-1.0:0.1:1.0]);

%Below are some settings for the figure
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
title([num2str(data.yr(time),'%2.2i'),'-',...
    num2str(data.mon(time),'%2.2i')])
cl=colorbar;
caxis([-1.0,1.0]);
axis ij;
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize',20)
ylabel(cl,'Geostrophic Velocity [m/s]')
colormap(redblue);
set(h,'ShowText','on','LineWidth',1)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);

%Save figure
saveas(gcf,'sample2','jpg')
```

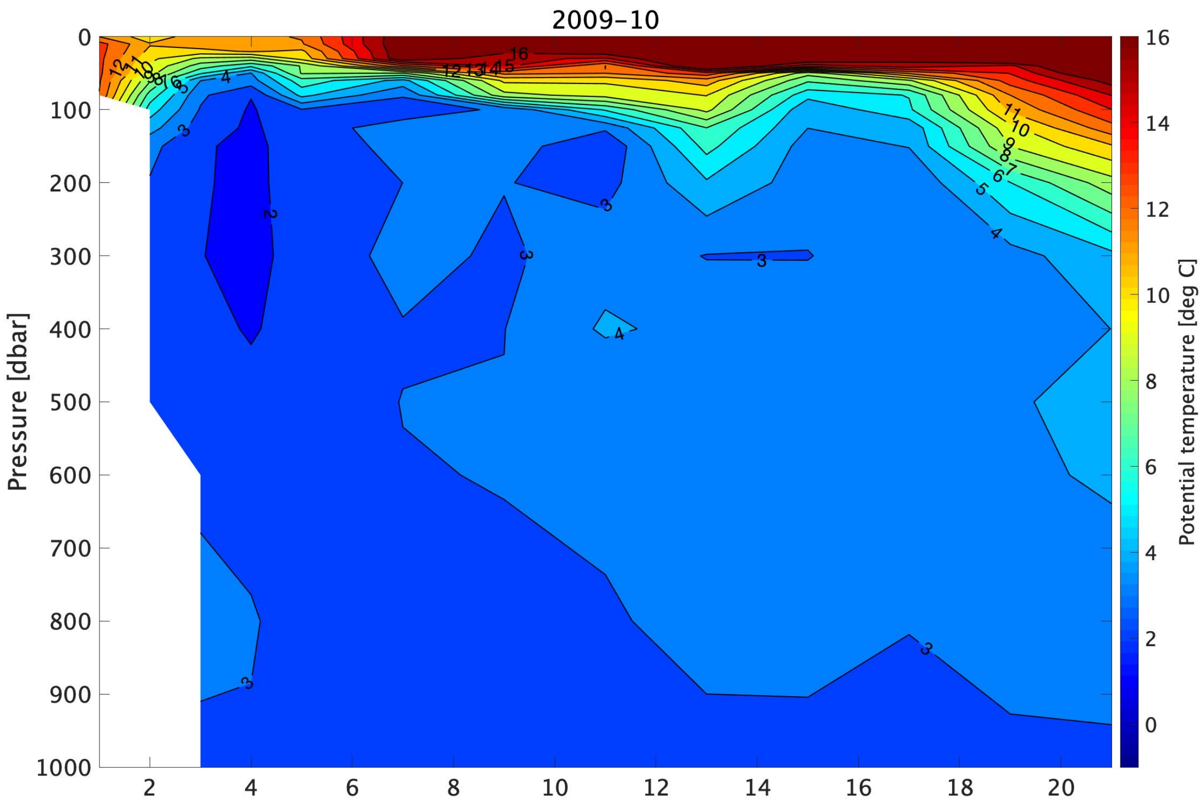
- The sample script is named as sample2, and the figure is generated by simply running the script



-For the redblue colormap, you can download it from the Mathwork File Exchange:

Sectional distribution of physical properties @ A-line

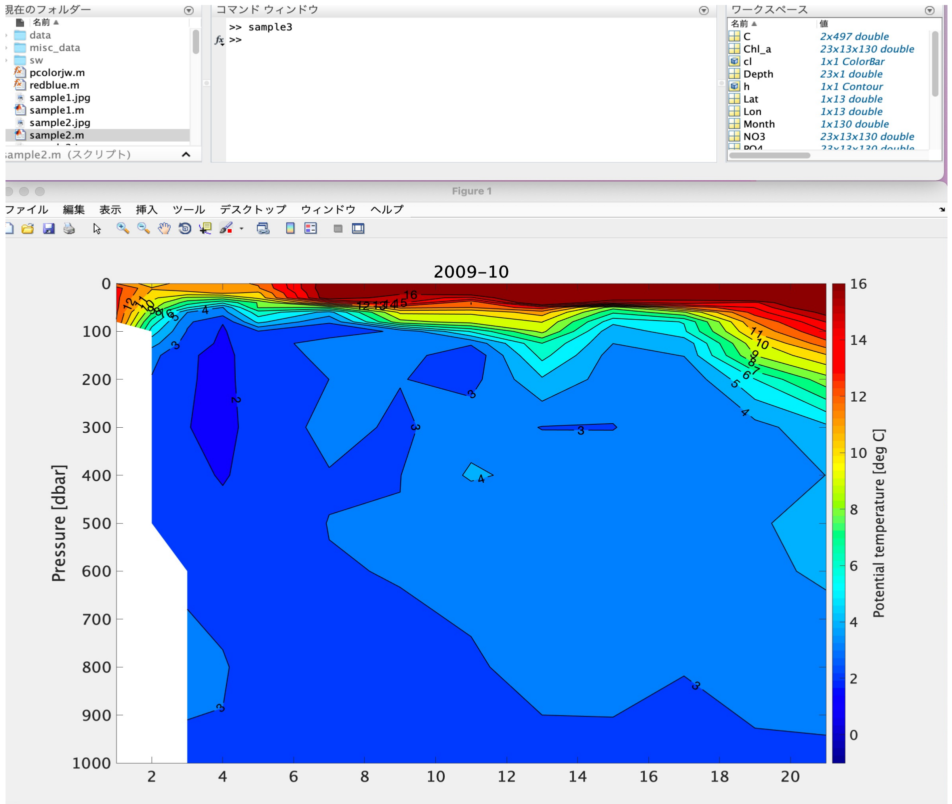
- Below is the potential temperature in Jan 2015 using Aline_dataset_PICES_SS.mat.



sample3.m:

```
%load dataset
load('./data/Aline_dataset_PICES_SS.mat')

time =100; %Cruise (1-130)

%Potential temperature
PT  = sw_ptmp(Salt(:,:,time),Temp(:,:,time),Depth,0);

figure('Position',[0,0,1200,800])
[C,h] =contourf(Sta,Depth,PT,[-1:1:16],'k-');

%Below are some settings for the figure
ylabel('Pressure [dbar]')
title([num2str(Year(time),'%2.2i'),'-',...
       num2str(Month(time),'%2.2i')])
cl=colorbar;
caxis([-1,16]);
axis ij;
set(gca,'ylim',[0,1000],'Fontsize',20)
ylabel(cl, 'Potential temperature [deg C]')
colormap(jet);
set(h,'ShowText','on','LineWidth',1)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);

%Save figure
saveas(gcf,'sample3','jpg')
```

- The figure is generated by running the sample script (sample3.m)
- SEAWATER library can be used for calculating potential temperature from temperature, salinity and pressure. The reference pressure is at seasurface.

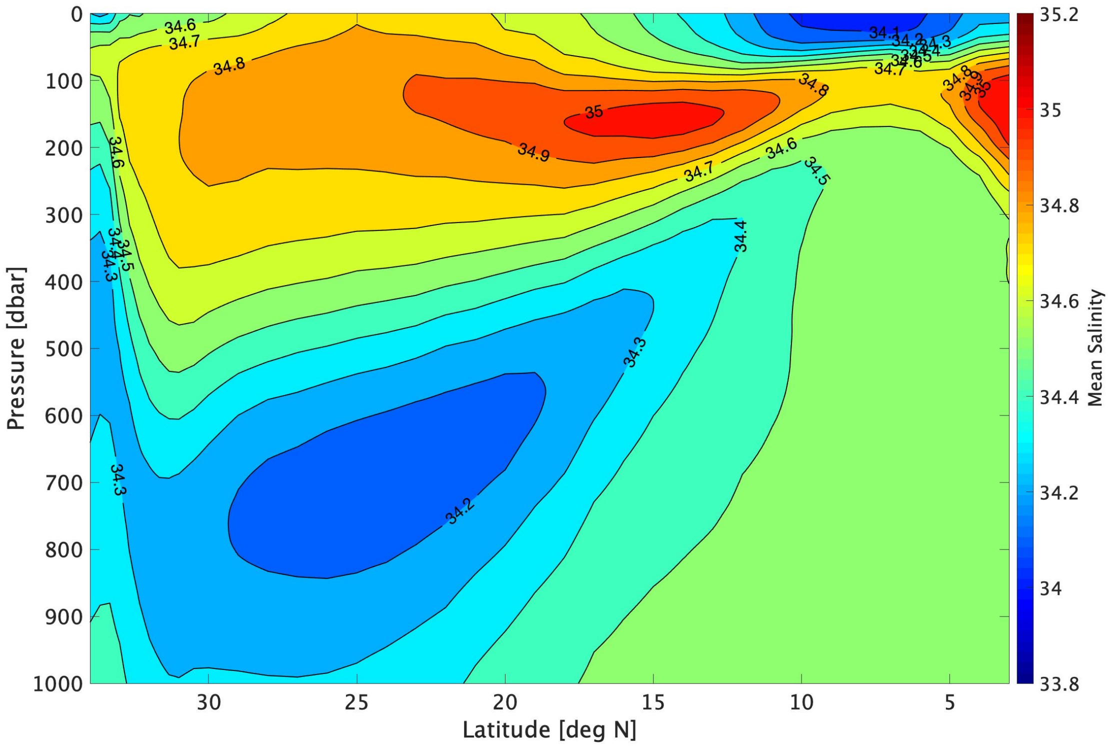


(3) Mean state and temporal variation of physical properties -137E meridian-

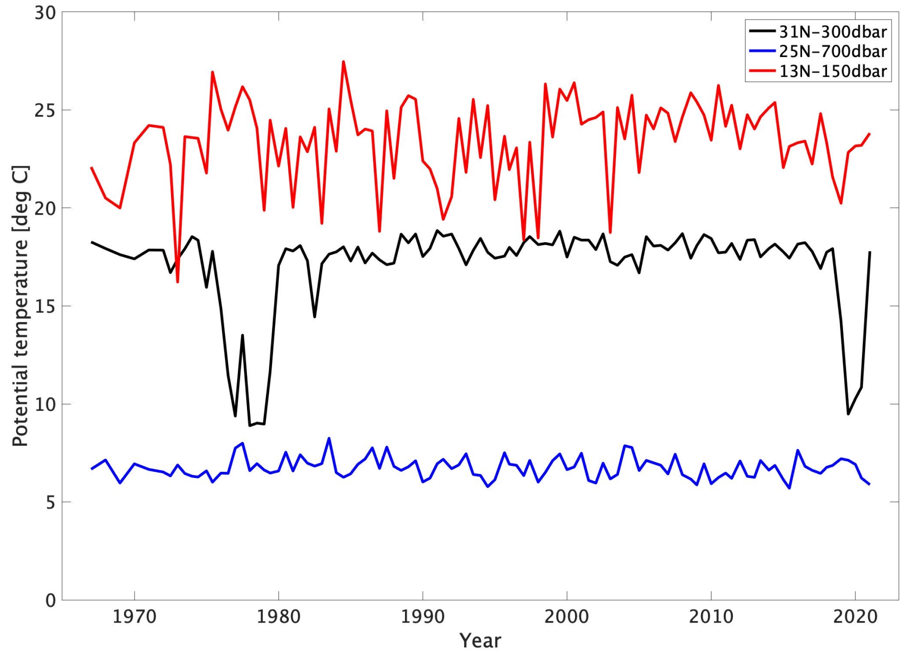
sample4.m:

```
%load dataset
load('./data/dataset_anl_137E.mat')

P    =[0:2030]; %Pressure dbar

%Calculate salinity averaged for all period
S_mean   =nanmean(data.S,3);

%Plot sectional distribution of climatological sal
figure('Position',[0,0,1200,800])

[C,h] =contourf(data.lat,P,S_mean,...
[32.0:0.1:35.0]);
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
cl=colorbar;
caxis([33.8,35.2]);
axis ij;
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize
ylabel(cl,'Mean Salinity')
colormap(jet);
set(h,'ShowText','on','LineWidth',1)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);

%Save figure
saveas(gcf,'sample4','jpg')
```

- Below is the salinity distribution averaged for all data from 1967 using dataset_anl_137E.mat.
- The figure is generated by sample4.m



sample5.m:



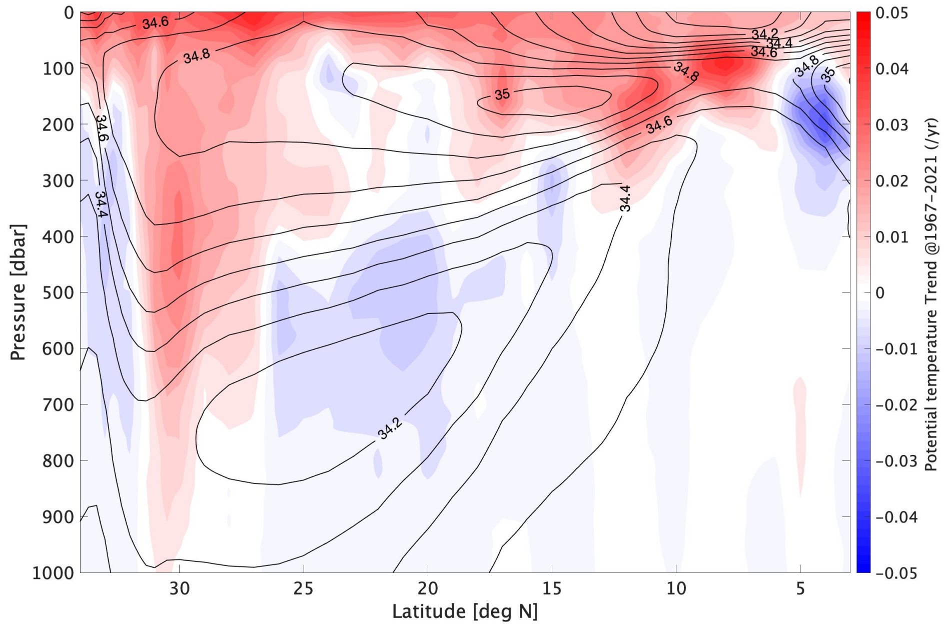

```
%load dataset
load('./data/dataset_anl_137E.mat')

%Location and Depth
P    =[0:2030]; %Pressure dbar
q_dep_STMW = P==300; %300dbar
q_loc_STMW = data.lat==31; %31N
q_dep_NPIW = P==700; %700dbar
q_loc_NPIW = data.lat==25; %25N
q_dep_NPTW = P==150; %150dbar
q_loc_NPTW = data.lat==13; %13N

%Plot sectional distribution of climatological salinity
figure('Position',[0,0,1200,800])

plot(data.yr+(data.mon-1)/12,squeeze(data.PT(q_dep_STMW,q_loc_STMW,:)),'k-','Linewidth',3)
hold on
plot(data.yr+(data.mon-1)/12,squeeze(data.PT(q_dep_NPIW,q_loc_NPIW,:)),'b-','Linewidth',3)
plot(data.yr+(data.mon-1)/12,squeeze(data.PT(q_dep_NPTW,q_loc_NPTW,:)),'r-','Linewidth',3)
legend('31N-300dbar','25N-700dbar','13N-150dbar')

xlabel('Year')
ylabel('Potential temperature [deg]')
set(gca,'xlim',[1965,2023],'ylim',[0,30],'Fontsize',20)

%Save figure
saveas(gcf,'sample5','jpg')
```

- The above is the potential temperature timeseries at 31N & 300 dbar, 25N & 700dbar, and 13N &150dbar (where the STMW, NPIW, NPTW usually exists) using dataset_anl_137E.mat.

sample6.m:

- The below is the linear trend map of potential temperature overlaid by mean salinity contours using dataset_anl_137E.mat. (as in Oka et al. 2018)

```
%load dataset
load('./data/dataset_anl_137E.mat')
P =[0:2030]; %Pressure dbar
S_mean   =nanmean(data.S,3); %Mean salinity

%Linear trend Analysis
data_date =datenum(data.yr,data.mon,15); %middle of each month (unit in day)
PT_trend  =nan(size(data.PT,1),size(data.PT,2)); %initialize matrix

for ii=1:1001 %down to 1000 dbar
for jj=1:size(data.S,2)
    p =polyfit(data_date,squeeze(data.PT(ii,jj,:))',1);
    PT_trend(ii,jj) =p(1) *365; %linear trend per year
end
end

%plot sectional distribution of salinity trend
figure('Position',[0,0,1200,800])
contourf(data.lat,P,PT_trend,20,'edgecolor','none');
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize',20)
colormap(redblue);
cl=colorbar;
ylabel(cl,'Potential temperature Trend @1967-2021 (/yr) ')
caxis([-0.05,0.05]);
axis ij;
hold on
%Mean Salinity contour
[C,h] =contour(data.lat,P,S_mean(:,:,1),'k-');
set(h,'LevelStep',0.1,'ShowText','on','LineWidth',1,'TextStep',get(h,'LevelStep')*2)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);
saveas(gcf,'sample6','jpg')
```

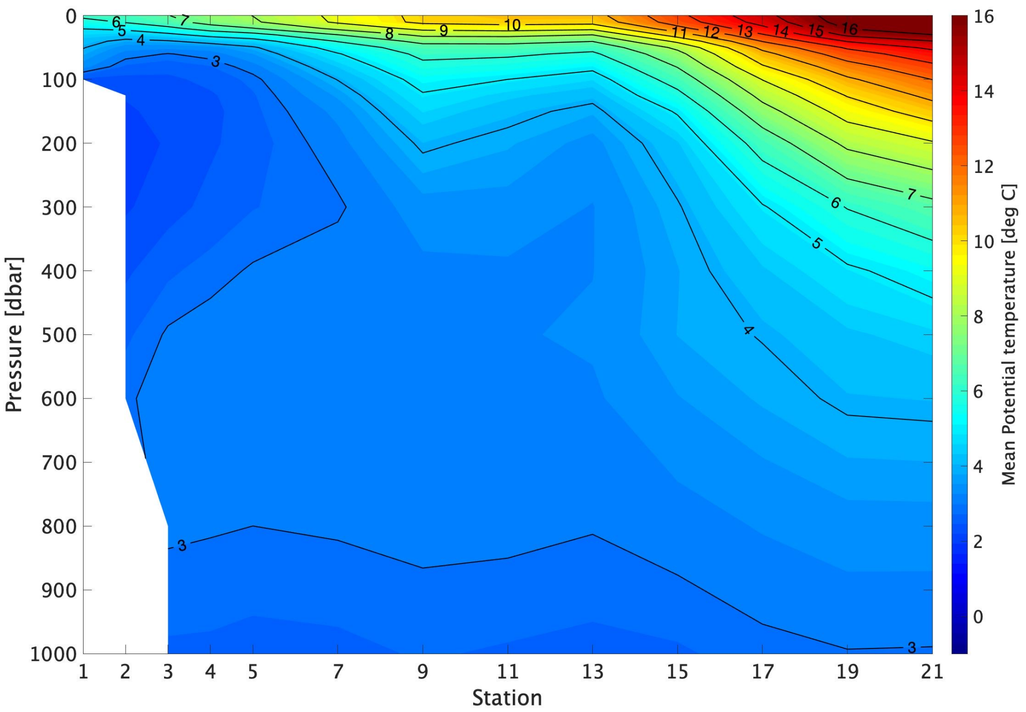


sample7.m:

Mean state and temporal variation @ A-line

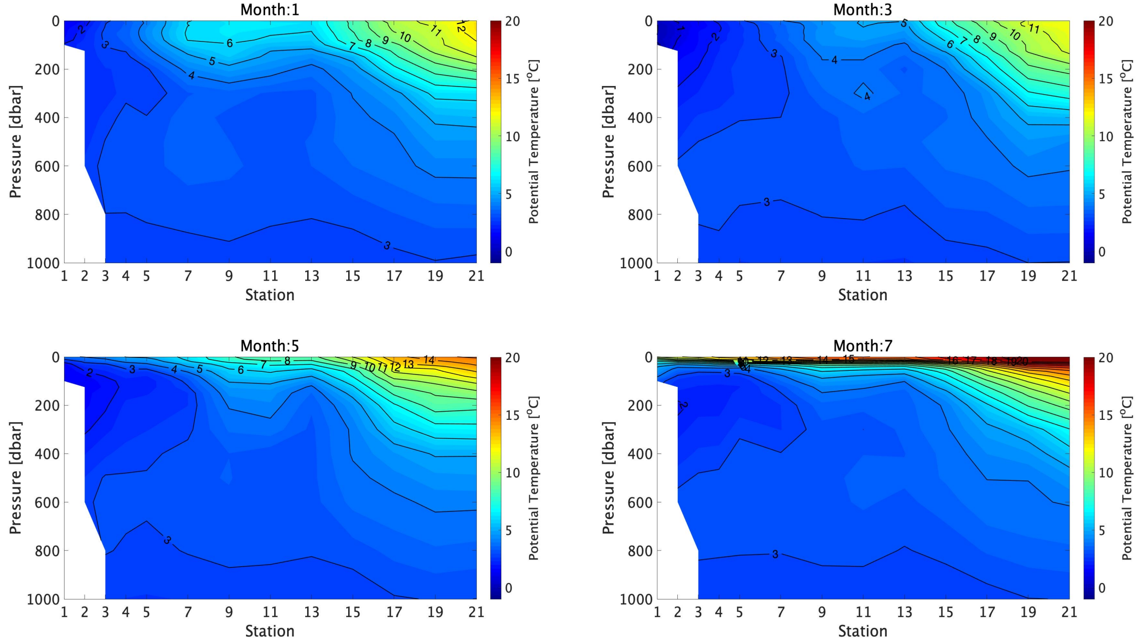
```
%load dataset
load('./data/Aline_dataset_PICES_SS.mat')

%Potential temperature
for ii=1:size(Temp,3)
    PT(:,:,ii)  = sw_ptmp(Salt(:,:,ii),Temp(:,:,ii),Depth,0);
end

%Calculate climatological mean
PT_clim =nanmean(PT,3);

figure('Position',[0,0,1200,800])
contourf(Sta,Depth,PT_clim,[-1:0.1:16],'Linestyle','none')

%Below are some settings for the figure
cl=colorbar;
caxis([-1,16])
set(gca,'ylim',[0,1000],'ydir','reverse',...
    'XTick',[1:5,7:2:21],'fontsize',20)
xlabel('Station')
ylabel('Pressure [dbar]')
ylabel(cl, 'Mean Potential temperature [deg C]')
colormap(jet)

%contours are overlaid
hold on
[C,h] =contour(Sta,Depth,PT_clim,[-1:1:16],'k-');
set(h,'ShowText','on','LineWidth',1)
clabel(C,h,'Fontsize',16,'LabelSpacing',800);

%Save figure
saveas(gcf,'sample7','jpg')
```

- Below is the mean potential temperature for all period using Aline_dataset_PICES_SS.mat.
- The figure is generated by running sample7.m



sample8.m:

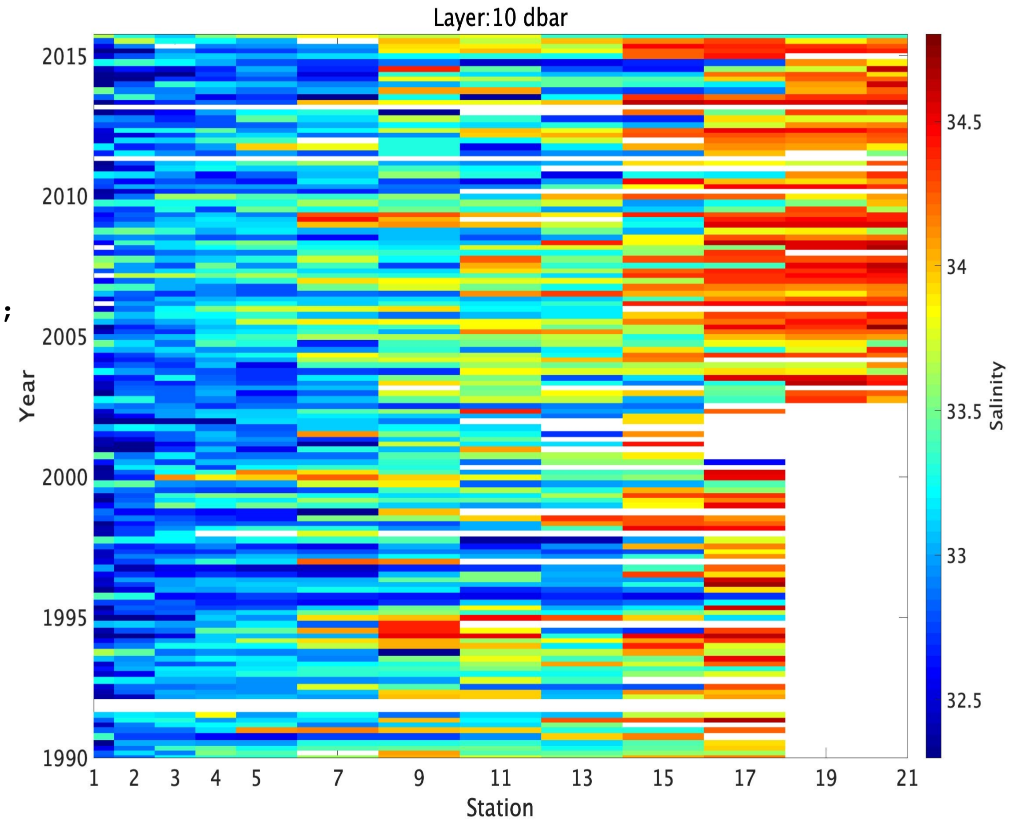
```
%load dataset
load('./data/Aline_dataset_PICES_SS.mat')

%Potential temperature
for ii=1:size(Temp,3)
    PT(:,:,ii)  = sw_ptmp(Salt(:,:,ii),Temp(:,:,ii),Depth,0);
end

figure('Position',[0,0,2000,1000])
for ii=1:4 %except for Oct

    %Calculate seasonal mean etc.
    PT_mean(:,:,ii) =nanmean(PT(:,:,Month==Month(ii)),3);

    subplot(2,2,ii)
    contourf(Sta,Depth,PT_mean(:,:,ii),...
        [-1:0.1:20],'Linestyle','none')
    cl=colorbar;
    caxis([-1,20])
    set(gca,'ydir','reverse','ylim',[0,1000],...
        'XTick',[1:5,7:2:21],'fontsize',20)
    xlabel('Station')
    ylabel('Depth [m]')
    ylabel(cl, 'Potential Temperature [^oC]')
    colormap(jet)
    title(['Month:',num2str(Month(ii))])
    %contours are overlaid
    hold on
    [C,h] =contour(Sta,Depth,PT_mean(:,:,ii),[-1:1:20],'k-');
    set(h,'ShowText','on','LineWidth',1)
    clabel(C,h,'Fontsize',16,'LabelSpacing',800);

end

%Save figure
saveas(gcf,'sample8','jpg')
```



- Above is the seasonal variation of potential temperature using Aline_dataset_PICES_SS.mat.
- The figure is generated by running sample8.m

sample9.m:

```
%load dataset
load('./data/Aline_dataset_PICES_SS.mat')

dep =2; %10 dbar

figure('Position',[0,0,1200,800])
pcolorjw(Sta,Year+(Month-1)/12,permute(Salt(dep,:,:),[1,3,2]));
set(gca,'XTick',[1:5,7:2:21],'fontsize',20)
colormap(jet);
cl=colorbar;
caxis([32.3,34.8])
xlabel('Station')
ylabel('Year')
ylabel(cl, 'Salinity')

title(['Layer:',num2str(Depth(dep)),' dbar'])

%Save figure
saveas(gcf,'sample9','jpg')
```

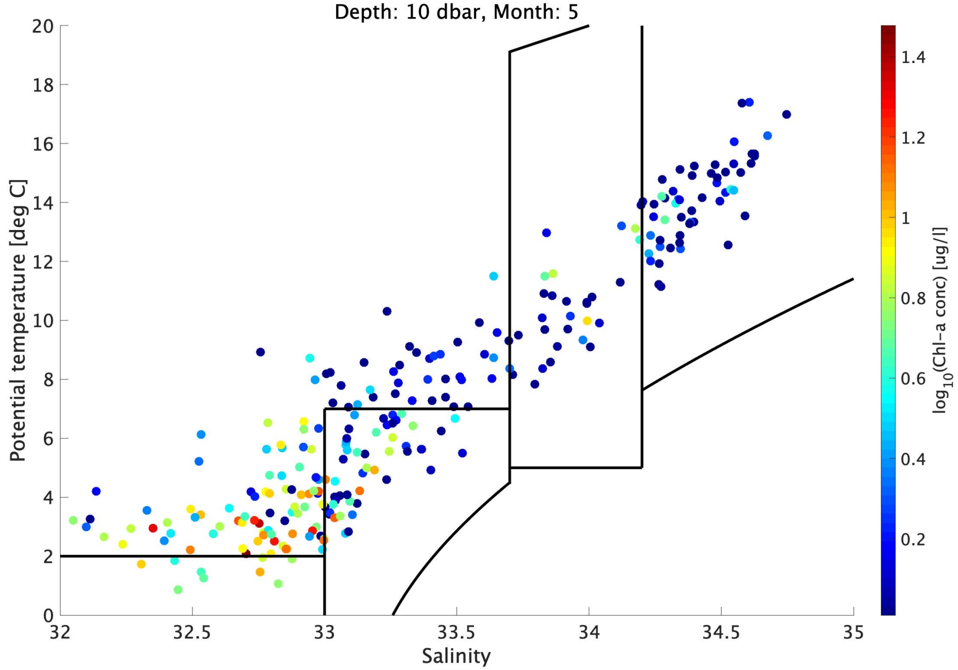


- Above is the temporal variation of salinity at 10 dbar using Aline_dataset_PICES_SS.mat.
- The figure is generated by running sample9.m

sample10.m:

```
%load dataset
load('./data/Aline_dataset_PICES_SS.mat')

%Potential temperature
for ii=1:size(Temp,3)
    PT(:,:,ii)  = sw_ptmp(Salt(:,:,ii),Temp(:,:,ii),Depth,0);
end

dep =2; %10 dbar
mon =5; %May
X =reshape(Salt(dep,:,Month==mon),1,[]);
Y =reshape(PT(dep,:,Month==mon),1,[]);
Z =reshape(Chl_a(dep,:,Month==mon),1,[]);

%Plot sectional distribution of climatological salinity
figure('Position',[0,0,1200,800])
scatter(X,Y,100,log10(Z),'filled')
set(gca,'xlim',[32,35],'ylim',[0,20],'Fontsize',20)
caxis([0.01,log10(30)])
cl=colorbar;
xlabel('Salinity')
ylabel('Potential temperature [deg C]')
ylabel(cl,'log_{10}(Chl-a conc) [ug/l]')
colormap(jet)
title(['Depth: ',num2str(Depth(dep)),...
    ' dbar, Month: ',num2str(mon)])
hold on

%Watermass classification by Hanawa and Mitsudera
Hanawa_Mitsudera_1987

%Save figure
saveas(gcf,'sample10','jpg')
```

TS diagram



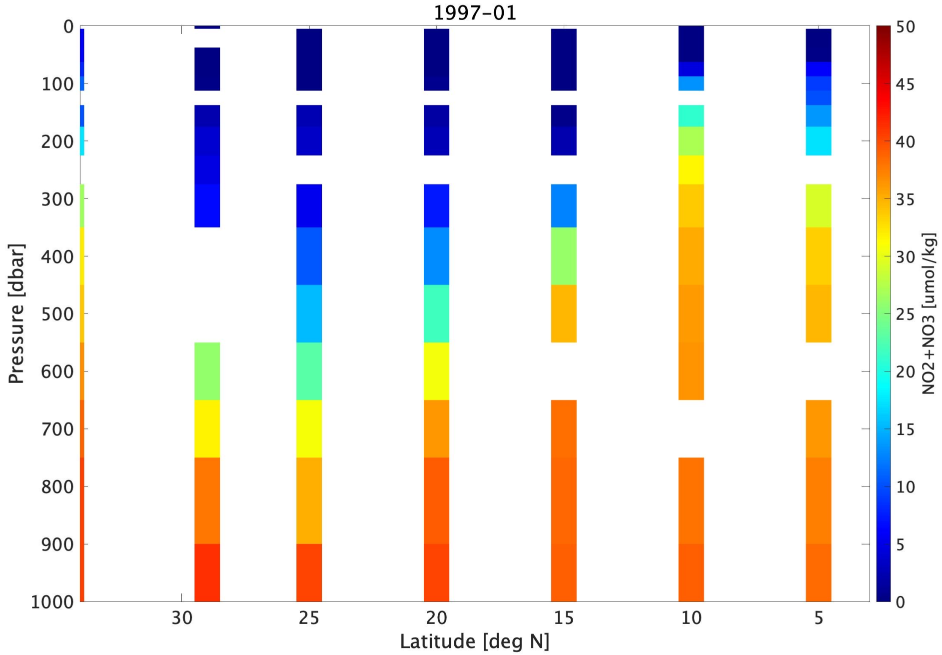
- Above is the temperature-salinity (TS) diagram colored with Chl-a concentration at 10 dbar in May using Aline_dataset_PICES_SS.mat.
- Black solid lines denote watermass classification by Hanawa and Mitsudera (1987)

(3) Sectional distribution of biogeochemical properties -137E meridian-

sample11.m:

```
%load dataset
load('./data/Dataset3D_JMA_WAT.mat')

NO3 =DATA_3D{strcmp(Channel_DATA,'NO2+NO3')};
Time=1;

figure('Position',[0,0,1200,800])

%Plot sectional distribution
pcolorjw(LAT_STD,DEP_STD,NO3(:,:,Time));

%Below are some settings for the figure
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
title([num2str(DateTime_vec_ave(Time,1),'%2.2i'),'-',...
num2str(DateTime_vec_ave(Time,2),'%2.2i')])
cl=colorbar;
caxis([0,50]);
axis ij;
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize',20)
ylabel(cl,'NO2+NO3 [umol/kg]')
colormap(jet);

%Save figure
saveas(gcf,'sample11','jpg')
```

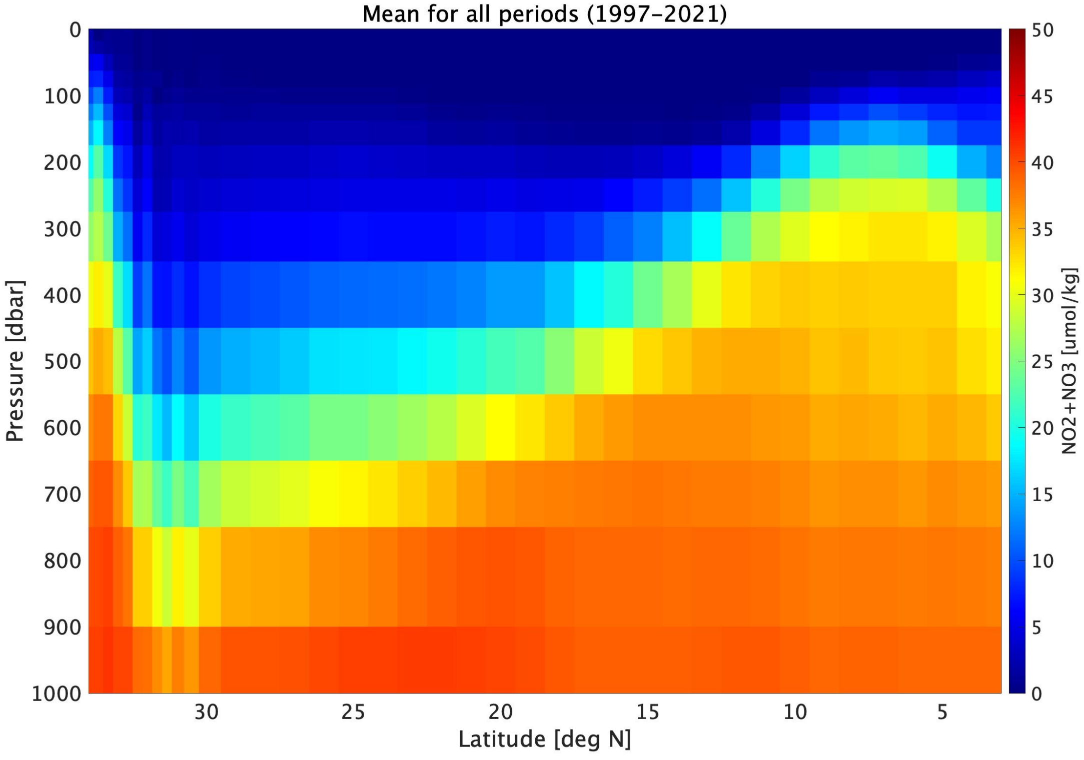
- Below is the nitrate + nitrite distribution in Jan 1997 using Dataset3D_JMA_WAT.mat.



sample12.m:

```
%load dataset
load('./data/Dataset3D_JMA_WAT.mat')

NO3 =DATA_3D{strcmp(Channel_DATA,'NO2+NO3')};
NO3_mean =nanmean(NO3,3);

figure('Position',[0,0,1200,800])

%Plot sectional distribution
pcolorjw(LAT_STD,DEP_STD,NO3_mean);

%Below are some settings for the figure
xlabel('Latitude [deg N]')
ylabel('Pressure [dbar]')
title('Mean for all periods (1997-2021)')
cl=colorbar;
caxis([0,50]);
axis ij;
set(gca,'ylim',[0,1000],'xdir','reverse','Fontsize',20)
ylabel(cl,'NO2+NO3 [umol/kg]')
colormap(jet);

%Save figure
saveas(gcf,'sample12','jpg')
```

- Below is the nitrate + nitrite distribution averaged over 1997-2021 using Dataset3D_JMA_WAT.mat.



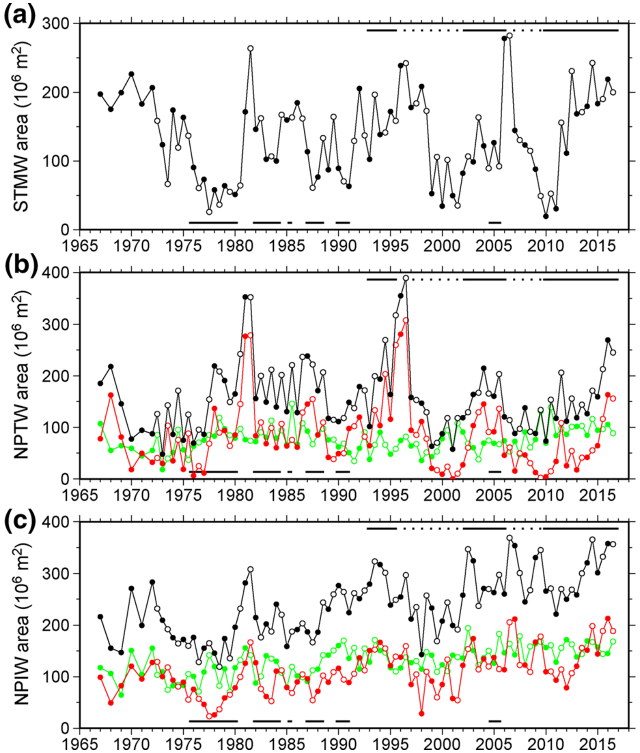


Fig. 8 Time series of cross-sectional area of **a** STMW, **b** NPTW, and **c** NPIW in the 137°E section during 1967–2016, calculated from optimally interpolated *T/S* data of Nakano et al. (2007). Here, STMW is defined as regions of PV < 2.0×10^{-10} m^{-1} s^{-1} and θ = 16–19.5 °C (e.g., Suga et al. 1989), NPTW as regions of S > 34.9 north of 7°N (e.g., Suga et al. 2000), and NPIW as regions of S < 34.2 at depths greater than 200 dbar (e.g., Shuto 1996). Dots (circles) represent winter (summer) observations. Red (green) plots in **b** and **c** indicate the area north (south) of 18°N and 25°N, respectively. Horizontal bars at the bottom of each panel denote large-meander periods of the Kuroshio. Solid (dotted) bars at the top of each panel indicate stable (unstable) periods of the KE after October 1992

Definitions of STMW, NPTW, NPIW

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