SIO176 HW5

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Due 14 May 2020

1 Plots

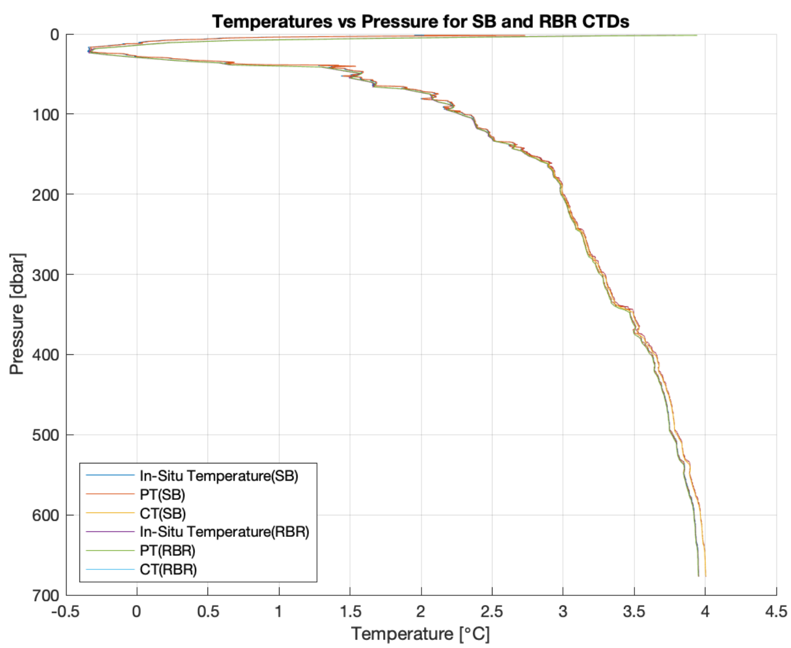

Figure 1: In situ Temperature, Potential Temperature, Conservative Temperature vs pressure

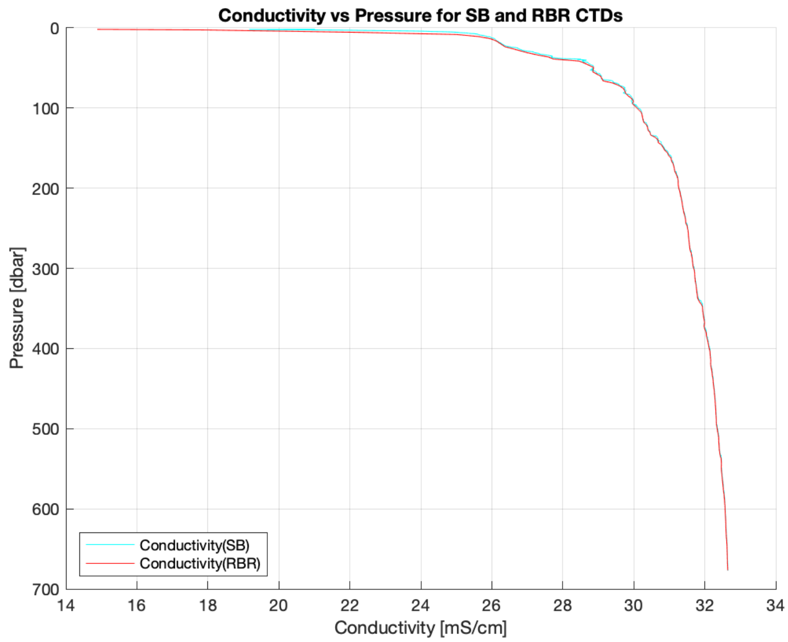

Figure 2: Conductivity vs Pressure

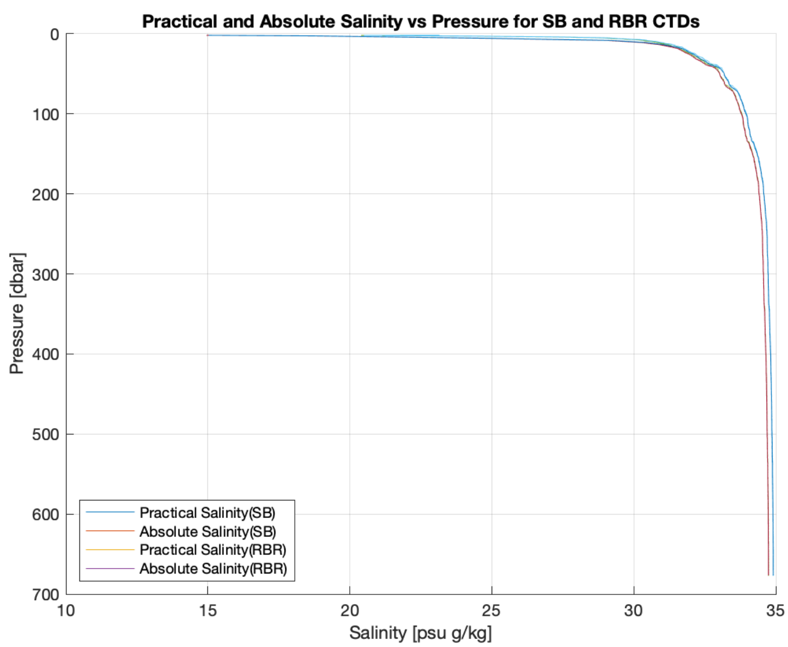

Figure 3: Practical salinity and Absolute salinity vs pressure [SP in units of psu, SA in units of g/kg]

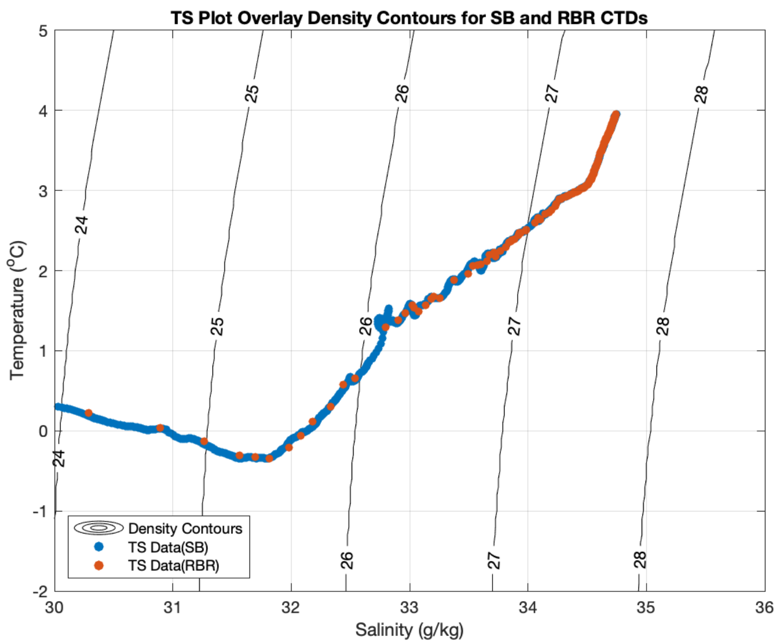

Figure 4: Potential Temperature vs Practical Salinity diagram, overlaying potential density lines

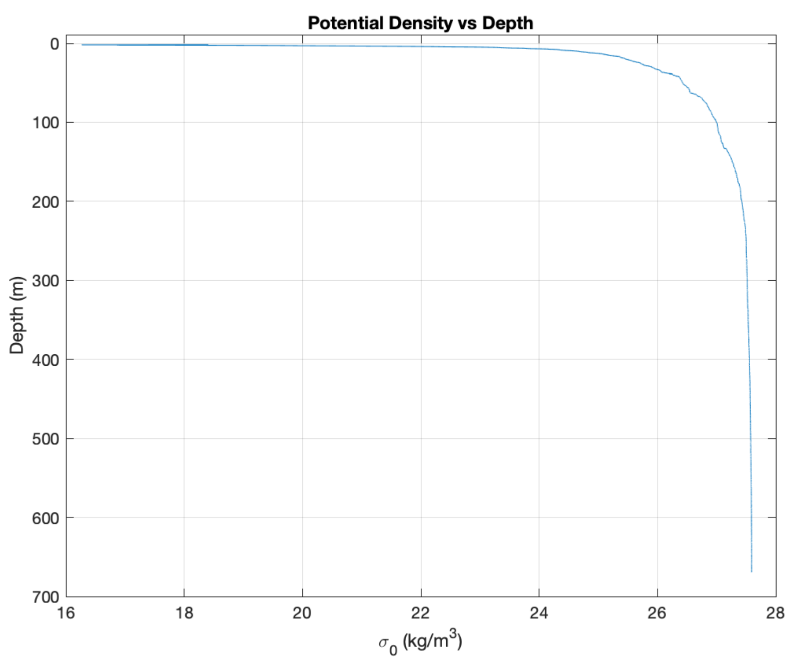

Figure 5: Potential Density vs Depth, reference pressure at 0 dbar

2 Questions

3. Determine the sample rate of the RBR instrument while knowing the Seabird Sensor samples at 16 Hz and that the data you received are the raw data.

We have two CTDs, one seabird and one rbr. We're given that the sampling rate of the seabird is 16 Hz (16 samples/second). We want to know the rbr sampling rate. There are 11077 data samples for the seabird instruments and we know that it samples at 16 Hz.

$\frac{11077 samples}{16 samples/1 second} = 692.3 seconds$

Assuming they started sampling at the same time and for the same amount of time we can calculate the sample rate of the rbr CTD by doing:

$\frac{rbr total samples}{total time} = \frac{232 samples}{692.3 seconds} = 0.335 samples * sec^{-1}$

The sample rate of the rbr is 0.335 samples $\sim$ 0.34 Hz.

4. Describe differences between the Seabird measurements (T, C, P) and the RBR (T, C, P) measurements and the implication of these differences for any of the quantities derived above. Paying attention to differences due to sampling rates, pressure dependent effects and others.

Sample Rate The sampling rate of the seabird is 16 Hz compared the rbr CTD which samples at 3 Hz. A higher resolution implies that the seabird CTD can observe the small-scale spatial variability in data whereas the rbr CTD can't.

Conductivity Using the electrode method, the seabird CTD measures change in resistivity of the current flow in a control volume of water. Then we can calculate conductivity $\sigma = \frac{L}{AR}$ where L = length of control volume and A = cross-sectional area. Furthermore, salinity can be derived from conductivity at known temperature and pressure. The advantages of this are that the measurement is not location dependent. Disadvantages include the corrosion of the metal electrodes (but the seabird has a platinum electrode so far less corrosion), more energy usage and more breakable parts. Implications are that the control volume needs to be absolutely sealed for data to be accurate. The rbr CTD uses the inductive method which employs Faraday's Law of Induction. A known frequency alternating current is passed through a coil which generates a time-varying B-field which produces another current. The conductivity depends on the electrical current induced in seawater. Then salinity is derived from conductivity. Advantages include: no corrosion (contactless - no electrode), relatively free from biofouling. Disadvantages include measurements being affected by objects in close proximity and the B-field may affect CTD electrical components. Implications are such that the CTD needs to be calibrated with the setup it's going to be employed in (such as a rosette) otherwise the data will be inaccurate. Most importantly, the conductivity readings are location-dependent and thus are temperature-corrected (temperature of warmer water may be measured because thermistor is not in same location as inductive sensor).

Temperature The seabird CTD have the thermistor lined up with the conductivity sensor into one unit called the TC Cell. This improves the accuracy of data because you know you're measuring the seawater parameters of the same water parcel. The rbr CTD has a separate housing for its thermistor which measures temperature by measuring the change in resistance of a semiconductor material as a function of temperature. Thermistor is not located in the same place as inductive unit so temperature measured may vary from temperature of water the conductivity is measuring, leading to an offset.

Pressure The seabird CTD measures pressure with an integrated in-housing strain-gauge pressure sensor. The rbr CTD measures pressure with a piezo-resistive transducer. Depth is then derived by hydrostatic relationship: $p = \rho g h$, with the assumption that density of seawater is constant, which is fairly reasonable in water.

5. Consider the seabird data alone in T/S plots. You will find loops caused by a temporal lag between the conductivity and temperature sensors. Find the sign, which parameter is delayed with respect to which and the magnitude of lag that reduces loops to a minimum. Plot T/S before and after (zoomed in).

I think it is the *temperature data that is lagging behind the conductivity measurements. I shifted the temperature data forward one data point in space* and I found that if I shifted it anymore than that, the shifted data looked even worse and had more loops. At one data point shift in temperature ahead of conductivity, I observe that the shifted data has its loops reduced.

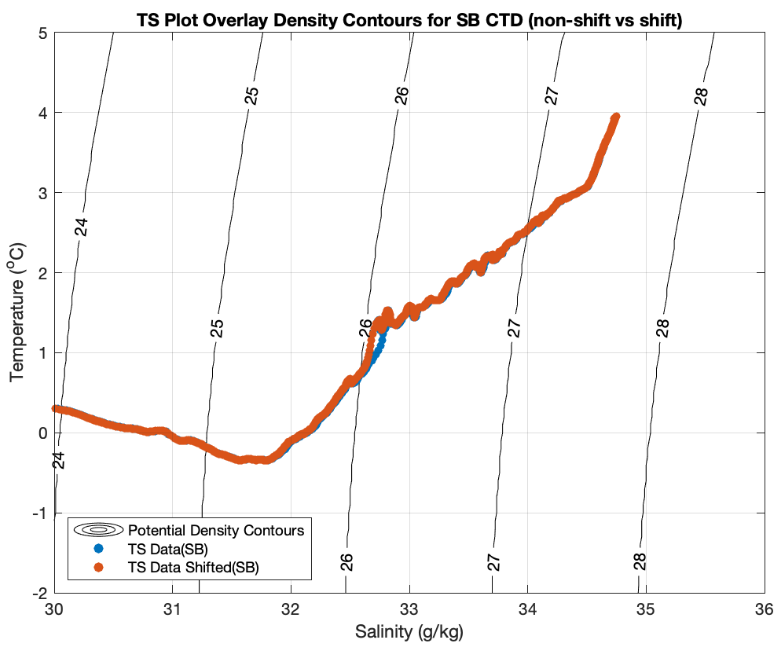

Figure 6: Seabird CTD T/S Plot non-shift vs shifted data

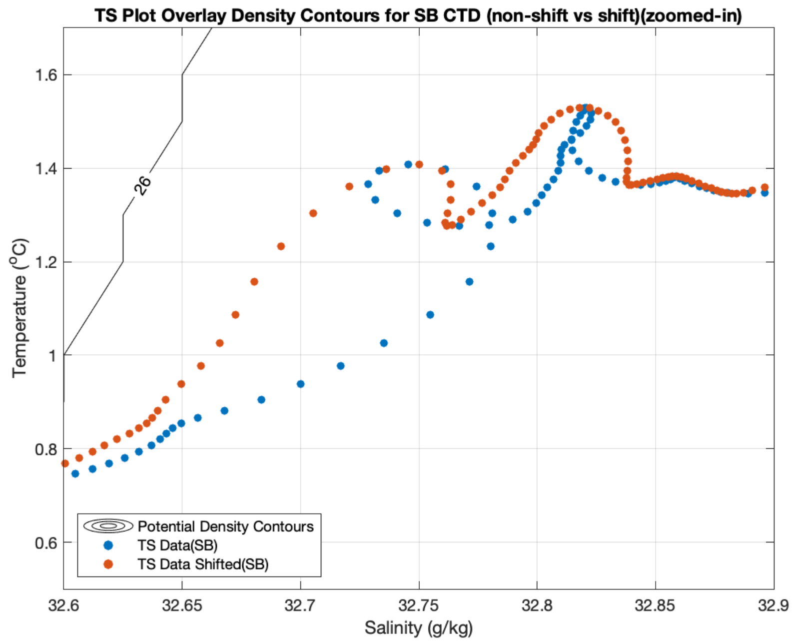

Figure 7: Seabird CTD T/S Plot non-shift vs shifted data (zoomed in)

3 Matlab Code

```
%% Header
% Tyler Barbero
% SIO 176
% HW 5
% TEOS-Routines
%% Load data
load CTD57.mat;
load CTD57_RBR065584.mat;
lat = 65.9;
long = -37.9;
%% Convert files
SP = gsw_SP_from_C(cond,temp,pres);
SA = gsw_SA_from_SP(SP,pres,long,lat);
PT = gsw_pt0_from_t(SA,temp,pres);
CT = gsw_CT_from_pt(SA,PT);
SP1 = gsw_SP_from_C(condrbr,temprbr,presrbr);
SA1 = gsw_SA_from_SP(SP1, presrbr,long,lat);
PT1 = gsw_pt0_from_t(SA1,temprbr,presrbr);
```

```
CT1 = gsw_CT_from_pt(SA1,PT1);
%% Summary of functions:
% convert to practical salintiy from conductivity
%gsw_SP_from_C(cond,temp,pres)
% convert to absolute salinity from practical salinity
%gsw_SA_from_SP(SP,pres,long,lat)
% convert to potential temperature_knot from absolute
    salinity
%gsw_pt0_from_t(SA,temp,pres)
% convert to conservative temperature from potential
    temperature
%gsw_CT_from_pt(SA,PT)
% derive in-situ density from absolute salinity and
    conservative
% temperature, pressure)
%gsw_rho(SA,CT,pres)
% derive potential density from reference 0 dbar
%sigma0 = gsw_sigma0(SA,CT)
% derive height from pressure
%height = gsw_z_from_p(p,lat,{geo_strf_dyn_height},{
    sea_surface_geopotental})
% derive depth from height
%depth = gsw_depth_from_z(z) z = height
%% Plots!!!

%% In situ Temperature, Potential Temperature,
    Conservative Temperature versus pressure
figure(1);
hold on;
plot(temp,pres);
plot(PT,pres);
plot(CT,pres);
plot(temprbr,presrbr);
plot(PT1,presrbr);
plot(CT1,presrbr);
set(gca, "Ydir", 'reverse')
xlabel('Temperature [\circC]')
ylabel('Pressure [dbar]')
title('Temperatures vs Pressure for SB and RBR CTDs')
legend({'In-Situ Temperature(SB)','PT(SB)','CT(SB)','
    In-Situ Temperature(RBR)','PT(RBR)','CT(RBR)'},'
    location','Southwest');
grid on;
saveas(gcf,'~/Desktop/SIO176/HW5/fig1.png')
%% Conductivity versus pressure.
figure(2);
```

```
hold on
plot(cond,pres, 'c');
plot(condrbr,presrbr, 'r')
xlabel('Conductivity [mS/cm]')
ylabel('Pressure [dbar]')
title('Conductivity vs Pressure for SB and RBR CTDs')
legend({'Conductivity(SB)','Conductivity(RBR)'},'location','Southwest')
set(gca, 'Ydir', 'r')
grid on;
saveas(gcf,'~/Desktop/SIO176/HW5/fig2.png')
%% Practical salinity and Absolute salinity, versus pressure
figure(3);
hold on;
plot(SP,pres);
plot(SA,pres);
plot(SP1,presrbr);
plot(SA1,presrbr);
xlabel('Salinity [psu g/kg]')
ylabel('Pressure [dbar]')
title('Practical and Absolute Salinity vs Pressure for SB and RBR CTDs')
legend({'Practical Salinity(SB)','Absolute Salinity(SB)','Practical Salinity(RBR)','Absolute Salinity(RBR)'},'location', 'Southwest');
set(gca, 'ydir', 'r')
grid on;
saveas(gcf,'~/Desktop/SIO176/HW5/fig3.png')
%% Potential Temperature versus Practical Salinity diagram, overlaying potential density lines.
figure(4)
% create density contour overlay
sx = [30:.1:36];
ty = [-2:.1:5];
[S,T] = meshgrid(sx,ty);
% derive rho values
p_ref = 0;
rho = gsw_rho(S,T,p_ref);
% convert to potential density from in-situ rho
PotDEN = round(rho-1000,2);
contour(S,T,PotDEN, [24:28],'k','ShowText','on');
hold on;
scatter(SP,PT,25,'filled');
scatter(SP1,PT1,25,'filled');
xlim([30 36])
```

```
ylim([-2 5])
xlabel('Salinity (g/kg)')
ylabel('Temperature (^oC)')
title('TS Plot Overlay Density Contours for SB and RBR CTDs')
legend({'Density Contours','TS Data(SB)','TS Data(RBR)'},'location','Southwest')
grid on;
saveas(gcf,'~/Desktop/SIO176/HW5/fig4.png')
%% Plot Potential Density vs Depth (figure 5)
figure(7)
height = gsw_z_from_p(pres,lat);
depth = gsw_depth_from_z(height);
PD = gsw_sigma0(SA,CT)
plot(PD,depth)
set(gca, 'ydir', 'r')
xlabel('\sigma_0 (kg/m^3)')
ylabel('Depth (m)')
ylim([-10 700])
title('Potential Density vs Depth')
grid on
saveas(gcf,'~/Desktop/SIO176/HW5/fig7.png')
%% Consider SB Data for TS plot, Try to shift temp, conductivity data
%after shift non zoom
figure(5)
condshift = cond(1:end-1); % changing dimensions tomatch temp shift
tempshift = temp(2:end); % delaying temp one step
presshift = pres(1:end-1); % changing dimensions tomatch temp shift
SPshift = gsw_SP_from_C(condshift,tempshift,presshift);
SAshift = gsw_SA_from_SP(SPshift,presshift,long,lat);
PTshift = gsw_pt0_from_t(SAshift,tempshift,presshift);
contour(S,T,PotDEN,[24:28],'k','ShowText','on');
hold on
scatter(SP,PT,25,'filled');
scatter(SPshift,PTshift,25,'filled');
xlim([30 36])
ylim([-2 5])
xlabel('Salinity (g/kg)')
ylabel('Temperature (^oC)')
title('TS Plot Overlay Density Contours for SB CTD (non-shift vs shift)')
```

```
legend({'Potential Density Contours','TS Data(SB)','TS
    Data Shifted(SB)'},'location','Southwest')
grid on
saveas(gcf,'~/Desktop/SIO176/HW5/fig5.png')
%% Zoomed in version after shift (5)
figure(6)
contour(S,T,PotDEN,[24:28],'k','ShowText','on');
hold on
scatter(SP,PT,25,'filled');
scatter(SPshift,PTshift,25,'filled');
xlim([32.6 32.9])
ylim([0.5 1.7])
xlabel('Salinity (g/kg)')
ylabel('Temperature (^oC)')
title('TS Plot Overlay Density Contours for SB CTD (
   non-shift vs shift)(zoomed-in)')
legend({'Potential Density Contours','TS Data(SB)','TS
    Data Shifted(SB)'},'location','Southwest')
grid on
saveas(gcf,'~/Desktop/SIO176/HW5/fig6.png')
```