MAST 467/667: Introduction to Polar Oceanography (Fall 2021)

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Workshop/Homework-9: Surface Mixed Layer

Data: Ocean Melts Greenland (OMG) at https://omg.jpl.nasa.gov/portal/

Introduction. We are more than ready for scientific work. The next step will be to use our bin average profile data of potential temperature, absolute salinity, and potential density to estimate surface mixed layer (SML) properties such as its depth, salinity, temperature, and density. You will first need to define what constitutes an SML. Table-1 lists a few criteria that people used in the past that relate to a temperature difference ΔT=SST-0.2, say, where SST us the properly defined sea surface temperature. For example the depth z_{SML} of the SML is the bin depth z where we first find $T(z_{MLD}) > \Delta T$ starting with the SST at z=0. The table is taken from the peer-reviewed paper

Kara, A.B, P.A. Rochford, and H.E. Hurlburt: An optimal definition for ocean mixed layer depth, J. Geophys. Res., 105, 16803-16821, 2000.

Table 1. Commonly Used ILD and MLD Criteria

Temperature–Based Criterion		Density–Based Criterion	
Author	ΔT	Author	$\Delta\sigma_t$
Thompson [1976]	SST–0.2°C	*Miller* [1976]	$0.125\,\sigma_t$
Lamb [1984]	SST–1.0°C	*Levitus* [1982]	$0.125\,\sigma_t$
Price et al. [1986]	SST–0.5°C	*Lewis et al.* [1990]	$0.13\,\sigma_t$
Kelly and Qiu [1995]	SST–0.5°C	*Spall* [1991]	$0.125\,\sigma_t$
Martin [1985]	SST–0.1°C	*Sprintall and Tomczak* [1992]	$0.5\,(\partial\sigma_t/\partial T)$
Wagner [1996]	SST–1.0°C	*Huang and Russell* [1994]	$0.125\,\sigma_t$
Obata et al. [1996]	SST–0.5°C	*Ohlmann et al.* [1996]	$0.5\,(\partial\sigma_t/\partial T)$
Monterey and Levitus [1997]	SST–0.5°C	*Monterey and Levitus* [1997]	$0.5\,(\partial\sigma_t/\partial T)$

Temperature– and density–based criteria (ILD and MLD, respectively) used for determining the ocean surface layer depth. SST–0.2°C, for example, indicates that the layer depth is defined as the depth where the temperature is 0.2°C less than the SST. Note that most use $0.125\sigma_t$ for the MLD definition because it corresponds to the water mass characteristics of Subtropical Mode Water in the North Atlantic as explained by *Levitus* [1982].

Goal. Using loops and conditional data assignments within R or MatLab

Assignment:

1_Choose a criterion from this table to define your mixed layer depth.

2_Estimate the z_{SML} for one cast along with the mean and standard deviation of the (a) potential temperature θ_0 (at surface pressure) and (b) absolute salinity S_A for the mixed layer.

3_Check your estimate by plotting surface values for one cast and indicate the mixed layer depth as a constant θ_0 and S_A. Adjust your criteria to be "reasonable" for temperature, salinity, and density.

4_Compare this surface profile with an estimate of the stability frequency

$$N^2 (z) = -g/\rho_0 \, \partial\rho/\partial z$$

that quantifies the vertical density stratification. You probably estimate N (in sec^{-1}) or N^2 (in sec^{-2}) from one of the gsw routines that we used to estimate water properties.

5_Does the $N^2(z)$ indeed have a minimum within the surface mixed layer where it should be close to zero? If not, please refine your definition of the SML.

6_Repeat the above for all profiles in your study area.

7_Plot the z_{SML} versus temperature, salinity, and density as a scatterplot for all casts.