SIO176 HW6

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Due 21 May 2020

1 A. Description of ARGO Floats

1. What is it used to measure? (Describe the principle of operation - i.e. how you get the physical variable from the measured quantity)
Globally, there are nearly 4000 ARGO floats that measure temperature, salinity, and pressure of the upper 2000m of the ocean in 3x3 grid boxes(long x lat). The total cycle time is about 10 days. Firstly, the float descends to 1000m from the surface (6 hours). Once at 1000m, it drifts with the currents for the majority of the cycle (9 days). Next, the ARGO float descends to 2000m. Once here, it ascends starts ascending to the surface while collecting temperature, salinity, and pressure data. Once at the surface it is able to transmit data via satellite. Most of the floats since 2017 now use GPS to establish float positions while using Iridium to transmit data. This allows a faster transmission time of data and allows a 2-way communication between the float if it is desirable to change float path. The float is a 2m tall metal cylinder that is equipped with a CTD to measure oceanic parameters, batteries to power it, and an internal reservoir, pump external bladder system. This system allows the float to change its buoyancy in order to remain at certain depths or pressure levels. If it wants to ascend, it will increase its buoyancy by decreasing the container density (increasing volume by blowing up the external bladder) and vice versa if it wants to descend. There is also Deep ARGO, BGC ARGO, and ARGOMix. Deep argo floats can withstand the pressures of the deep ocean 5000m and are useful because most of the ocean lies beneath 2000m. BGC ARGO are biogeochemical floats which measure dissolved oxygen, nitrate, pH, chlorophyll fluorescence, and backscatter as well as temperature and salinity. ARGOMix measures small-scale turbulent mixing which happens to have a large influence on the large-scale circulation. There are many applications. For example, BCG ARGO can drift with phytoplankton blooms, observe polynya dynamics, and carbon outgassing/intake in the southern ocean (SOCCOM).

2. Provide an example of how this instrument would be used to answer a question of interest to oceanographers.

The general ocean circulation is known so most of the time we can characterize what types of bodies of water *should* be moving into a certain region. However what if there is anomalous signal somewhere, i.e. a low dissolved oxygen body of water that shouldn't be there? If oceanographers wanted to find where this water came from, we could trace the path of the ARGO float measuring these anomalies to see where the water came from.

2 B. Description of Surface Drifter - Buoys

1. What is it used to measure? (Describe the principle of operation - i.e. how you get the physical variable from the measured quantity)

`https://gdp.ucsd.edu/ldl/svp/`

The drifter we observed in lab is a Surface Velocity Program Barometer (SVPB) Drifter. It includes a barometer at the top of the buoy to measure air pressure at the sea surface and a thermistor on the bottom of the buoy to measure sea surface temperature. Also, it is able to measure ocean currents at 15m depth. The buoy is attached to a holey sock drogue by a stainless steel tether which reaches a total depth of 15m. Because of the drogue experiences a large drag force, the drifter essentially moves with the near-surface ocean currents. This fact, coupled with GPS-based tracking (uses Iridium I think), we are able to observe the near-surface current velocities. There are different models of drifters and these include additional instruments such as an anemometer and compass to measure horizontal wind speed and direction, a salinity sensor to measure salt content, and a radiative flux sensor that measures visible-IR fluxes to calculate surface humidity (I didn't catch why this is important – I think it was something along the lines of better predicting surface pressure thus better predictions of weather?). Furthermore, there's a specific buoy called the Directional Wave Spectra Drifter (DWSD) which houses a high-performance GPS engine with incorporated software algorithms to compute the directional wave spectra. Raw data is processed real-time. Buoys send the data to satellites which then send the data to ground-stations which send the data to SIO-servers. Here, we are able to view real-time statistics of the data. Finally, the data is relayed and distributed to other collaborators such as AOML and GTS.

2. Provide an example of how this instrument would be used to answer a question of interest to oceanographers.

This isn't related to the ocean really but I remember during the lab lecture, there was a VIS-IR sensor to measure humidity. Would it be possible to incorporate a radiative flux sensor to measure incoming and scattered shortwave radiation and global longwave radiation? If this was possible (though I think they have to be stationary and above surrounding objects to receive an accurate measurement) these data could be incorporated into climate models and the global radiative budget. So I doubt this is feasible but it was just a thought. Otherwise, maybe surface drifters are able to measure near-surface currents. Perhaps there was an oil spill in the ocean and we wanted to see where the oil would be advected to (better than remote sensing because satellites are limited in the data it can observe on sub-surface currents). We could place some number of drifters in the center of the oil spill and see where they drift to (assuming the oil moves with the currents and the drifters also move with the currents).

3 C. Synthesis of Maximenko et al. (2009)

1. What question was addressed? 2.What was the approach/method? – with specific references to the measurements collected by this instrument/sensor including mode of deployment and steps taken in analyzing the data. 3.What are the findings? 4.Implications and remaining questions 5.Include one key figure that shows the results with a descriptive figure caption.

1. The question addressed: Is there a way to tackle the problem of reducing inaccuracies in measuring the finer scales of dynamic topography, particularly the mesoscale? They introduce three methods that have looked at estimating the ocean's dynamic topography. The first of which combines sea level data from satellite radar altimetry which GRACE's geoid model to derive the mean dynamic topography (MDT) of the ocean. The second uses hydrographic profiles, ocean drifters, and sea surface wind to synthesize near surface velocities. The third uses these same global data sets from the second in the context of the ocean surface momentum balance.

2. Their method incorporates using data from all the methods listed above but are quite independent of the methods themselves. That is, they introduce a new method to calculate a higher resolution (a mesoscale one) of the dynamic topography. My understanding of ocean dynamic topography is that it is understanding all the forces that result in the sea surface to have the "shape" that it has. These include currents, tides, geographical features (resulting in gravity anomalies) etc,. Then data gathered on all of these are coupled in one method to observe the MDT in finer resolution scales. Firstly, they begin with the momentum equation: $\frac{d\mathbf{V}}{dt} + \mathbf{k} \times f\mathbf{V} = -g\nabla(\bar{\eta} + \eta') + \frac{1}{\rho}\frac{\partial\tau}{\partial z}$. This equation is split into its two parts, one with the geostrophic velocity balancing the sea level gradient and the other with ekman velocity balancing the horizontal turbulent stress. These equations are used in a data reanalysis of satellite sea level and wind data to compute surface velocity. Next, they calculate $\bar{\eta_A}$ (mean dynamic topography) as the difference between the time-mean sea surface and geoid models. Then they refine $\bar{\eta_A}$ to mesoscale resolution using drifter and wind data. This is done by linearly regressing (least squares method – I think) the ekman velocity from the concurrent wind. Then the ekman component is subtracted from the drifter velocity resulting in geostrophic velocity which is used in the component equations to calculate two MDTs that highlight mesoscale features.

3. They are able to see small-scale features in the within the large-scale geostrophic circulation by incorporating methods B and C to method A. One example is that in this combined large-scale small-scale figure, we are able to see southward alternating striations of flow. Another feature is that we're able to see the

Azores current flowing westward. This is not really formed in the large scale circulation method A, but we can see it in B and C. Another feature is at 22N in the western North Pacific, which is a feature now only visible called the Subtropical CounterCurrent and it is an eastward striation (line). The large scale North Pacific and North Atlantic currents are more defined as they are seen as semi organized zonal westerly flows rather than a blob. There are plenty of other examples in the paper.
4. Implications include the ability to observe small scale anomalies that we have not ever observed before. This might help clarify questions that we current have no answers to about ocean circulation. Further questions are such as how will the new GOCE mission improve the gravity model improve and how will the 300 new ARGO floats that measure interior ocean data refine patterns in the mean circulation?

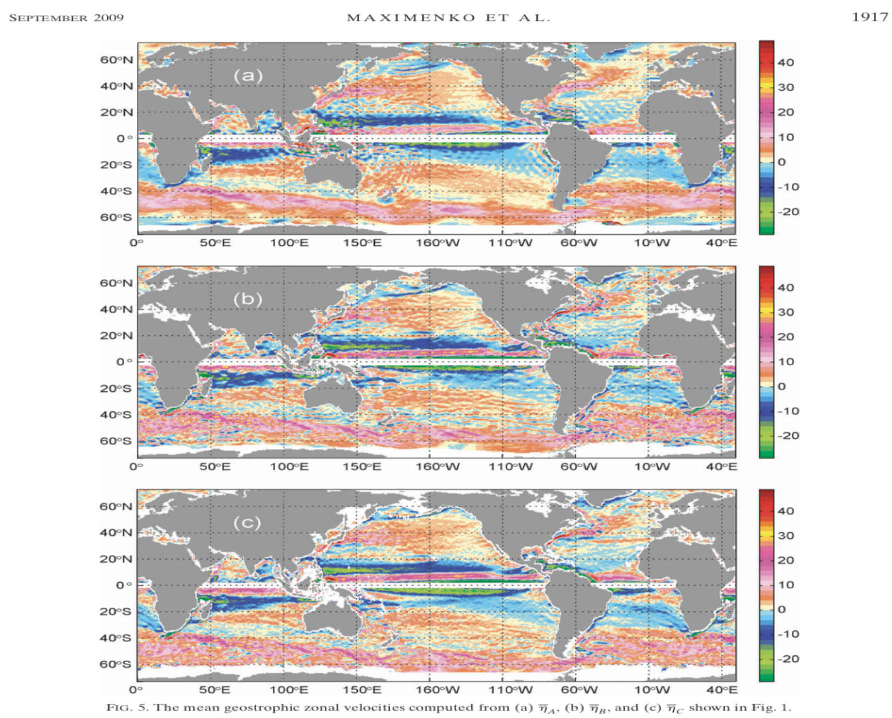

Figure 1: This plot shows mean dynamic topography by method A (large-scale method) and B and C (small-scale methods). We are able to observe clear differences in small-scale signals such as the Azores current, many counter currents and more defined large-scale flows.