Glider Observations of Upper Ocean Structure in the Bay of Bengal

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LONG-TERM GOALS

The Bay of Bengal (BoB) is remarkable in that its major currents change directions seasonally with the monsoons, in concert with extremely strong fluxes of fresh water from precipitation and river input. The overarching goal of the proposed effort is to quantify important processes in the fresh water budget of the BoB, including the effects of submesoscale processes and internal waves.

OBJECTIVES

The extreme fresh water input in the BoB poses challenges scientifically and technically, because of the existence of a fresh, light surface layer. We advance a program with two major objectives, one scientific, and one technical:

- Observe the evolution of upper ocean structure in the central Bay of Bengal using gliders and floats
- Improve glider technology to overcome fresh, buoyant surface layers
- Establish a new technology to observe turbulence with profiling floats

APPROACH

We use two approaches to observe the upper ocean in the BoB. First, we deploy Spray underwater gliders to resolve simultaneously vertical and submesoscale horizontal structure in the BoB. Second, we deploy floats in two modes: rapidly profiling to observe high-frequency phenomena, and with a 5-day repeat to contribute to the large-scale Argo observations in the BoB.

WORK COMPLETED

We have focused on using autonomous technology to observe the BoB. Summarized below are our efforts using SOLO-II floats in rapid profiling mode, with a long Argo-style 5-day cycle, and our use of underwater gliders (Figure 1).

In collaboration with J. Moum and E. Shroyer (Oregon State University), we mounted χpods on a SOLO-II floats with a goal of measuring thermal dissipation in the upper 50 m. Our first try at this new technology, in summer 2014, failed as the floats mission lasted less than a day, likely because the float was hit by the vessel or towed equipment. Undeterred, we deployed two more of these floats, dubbed χSOLOs during the summer 2015 Revelle cruise. Both these floats (serial numbers 8371 and 8382) had successful missions, one of 13 days, and one of 9 days. The floats profiled repeatedly to 50 m, repeating the cycle every 24 minutes, with a total 1321 dive cycles completed. Preliminary results from χSOLO 8371 show the strong fresh water input and diurnal heating in the BoB (Figure 2).

SOLO-II profiling float 8119 was deployed at 1330Z 21 November 2013, at 16.23°N, 86.96°E. During the first part of its mission, the float profiled continuously between the surface and 250 m, with a cycle taking about 100 min. Profile 229 at 1732Z 07 December 2013 at 17.07°N, 84.44°E was the end of continuous profiling. At this time, the float began parking at 1000 m, and profiling to 2000 m every 5 days. Two additional SOLO-II floats (8134 and 8134) were deployed during the November Revelle cruise; these continue missions of profiles to 2000 m every 5 days. Two of these floats are now in the BoB's western boundary current off India (8119) and off Sri Lanka (8137).

Two glider missions have been completed. Spray 24 was deployed on 14 November 2013 and recovered on 19 June 2014 for a duration of 217 days, with both operations from the R/V Revelle. Spray 24 completed 529 dives to as deep as 1000 m, covering 2728 km over ground and 2841 km through water. The mission consisted of a transit from the deployment location at 15.17°N, 86.10°E to 17°N, 88°E, then a long line southward to 9°N, 88°E. At this time, to extend the mission length, the glider began drifting at depth thus conserving battery. The glider was piloted to the operations are of the R/V Revelle in June for recovery. Spray 26 was deployed on 19 June 2014 upon recovery of Spray 24. Spray 26 transited to the southern end of the long line at 9°N, 88°E, then proceeded northward. Unfortunately, the CTD failed about one month into the mission. The glider was recovered by the R/V Sagar Nidhi on 25 August 2014 after a mission of 68 days, having done 336 dives to as deep as 1000 m, covering 1601 km over ground and 1753 km through water.

ONR's investment in gliders has catalyzed research around the world. I was invited to write a review on research enabled by underwater gliders for the Annual Review of Marine Science (Rudnick, 2015). This review, which is now in press and available online, makes clear ONR's role in the earliest developments of glider technology, through the pioneering work of AOSN, and including the scientific results streaming from gliders today.

RESULTS

The most important results of this year involve the successful missions of the two χSOLOs during the summer cruise of the R/V Revelle. Temperature/salinity data was collected on a vertical scale of 0.2 m to as shallow as 0.6 m depth on a typical dive. In combination with turbulence data from the χpods, we anticipate a new description of the processes that establish the thin surface layer of the BoB.

IMPACT/APPLICATIONS

An anticipated impact of this work will include improved technology for buoyancy-driven platforms in a buoyant surface layer. The χSOLOs may provide a fundamentally new way of observing the surface boundary layer. All temperature and salinity data from Spray gliders were sent to NAVO in real time

for assimilation into operational models. Data from SOLO-II floats were publically distributed through Argo.

PUBLICATIONS

Rudnick, D. L., 2015: Ocean research enabled by underwater gliders. *Annual Review of Marine Science*, **8,** in press, doi: 10.1146/annurev-marine-122414-033913.

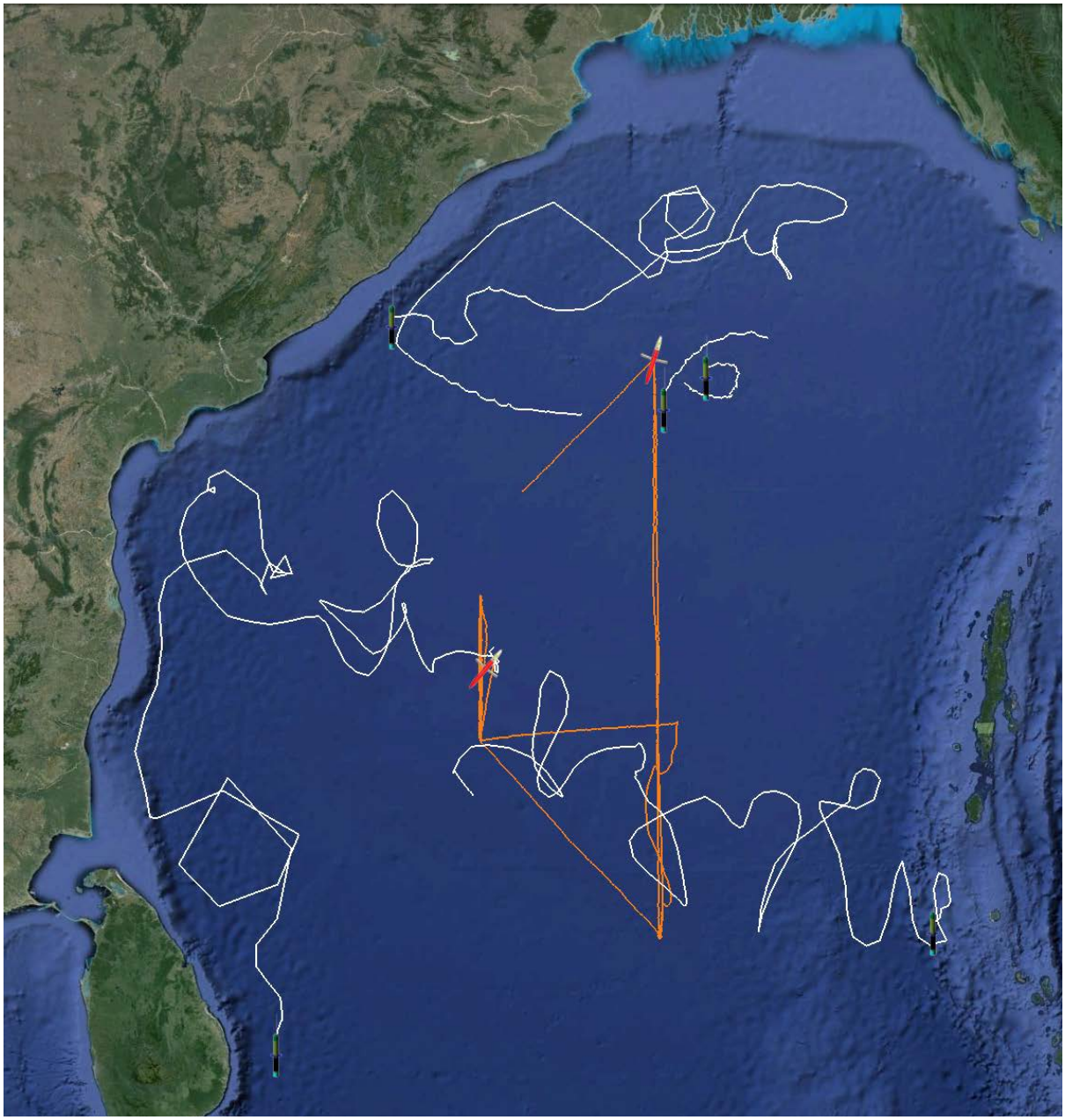

Figure 1. Tracks of SOLO-II floats (white) and Spray underwater gliders (orange) in the Bay of Bengal during November 2013 – September 2015.

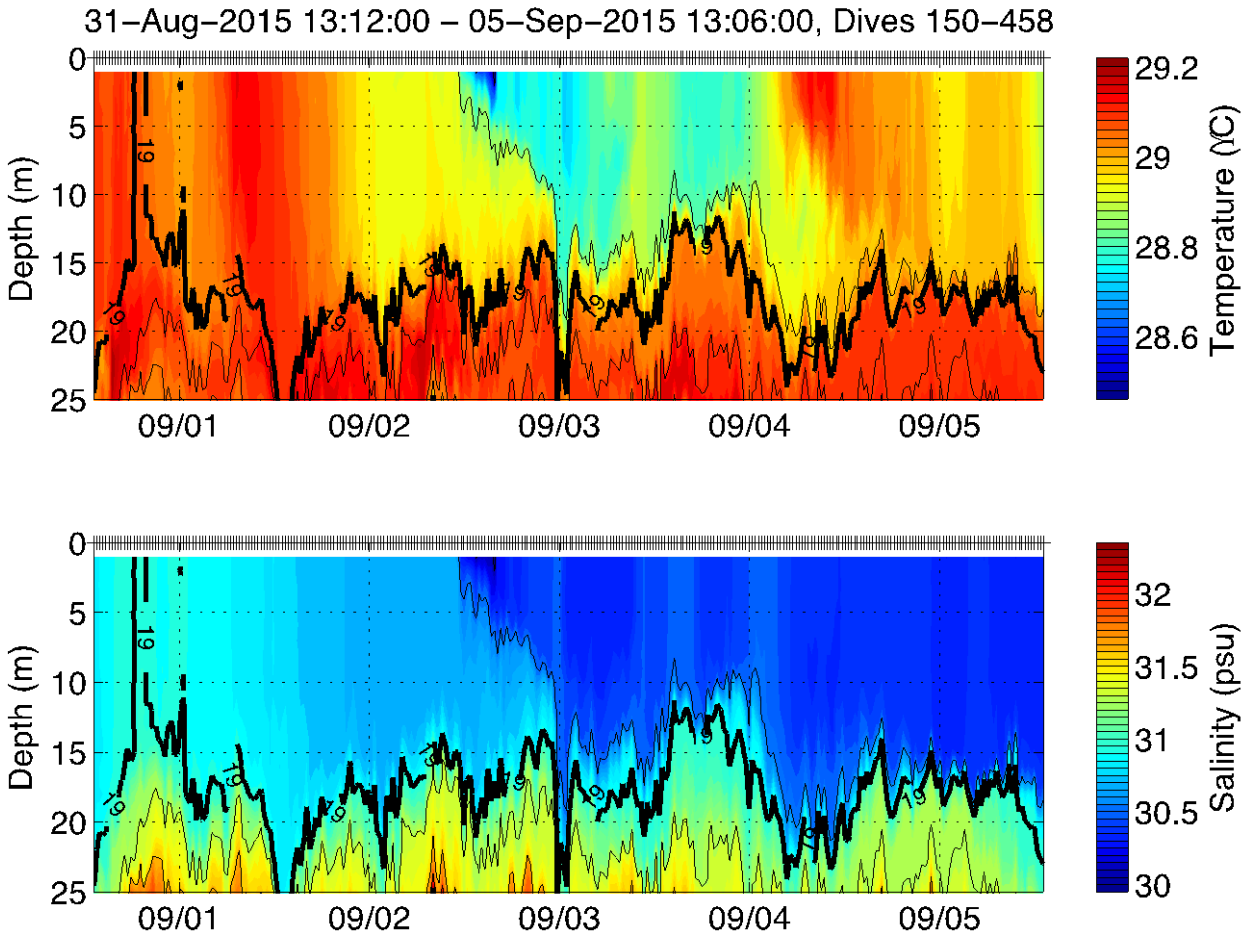

Figure 2. Temperature and salinity (color shading) and potential density (black contours) as functions of time and depth from a prototype χSOLO in the Bay of Bengal. The upper 25 m are shown from a float that profiled over the upper 50 m. Time tick marks are at midnight GMT, near the time of sunrise at the float's location. Note the shallow cold, fresh layer formed by rainfall on 2 September. The diurnal cycle is apparent in temperature.