

# **Cruise and Data Report: R/V *Shana Rae* operations in support of April 2015 AirSWOT campaign, April 17-20, 2015**

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## **Background:**

AirSWOT is an aircraft mounted instrument for measuring and imaging sea surface height (SSH), and it is similar to the SWOT (Surface Water Ocean Topography) instrument that will be deployed on a satellite in 2020. A field campaign was conducted in April 2015 to examine the performance of AirSWOT and to better understand how the measurement is affected by surface waves and currents. Supporting measurements were collected from the RV *Shana Rae*, the RV *Fulmar*, and a second aircraft (a Partenavia P68 operated by Aspen Helicopter, Oxnard, CA for UCSD/SIO).

From 17-20 April 2015, the R/V *Shana Rae*, a 50-foot research vessel, was used for collection of Underway CTD (or UCTD) measurements and for deployment and recovery of three EM/APEX floats in a study area off the central California coast. The UCTD measurements are being used to estimate the sea surface height signal associated with variations in ocean density structure. The EM/APEX floats provide time series of the same, as well as vertical profiles of ocean velocity. The purpose of this report is to document the shipboard operations on the R/V *Shana Rae* and the resulting UCTD and EM/APEX data sets.

## **Synopsis of operations:**

The *Shana Rae* sailed from Santa Cruz Small Craft Harbor at 1500 Z on April 17, 2015, deployed 3 EM-APEX profiling floats in the AirSWOT study area, carried out hydrographic sampling with the UCTD, recovered the floats, and returned to port, arriving at 1700 Z on April 20.

A UCTD section was collected along the satellite tracks sampled by the SARAL/AltiKa altimeter on April 17, and sampling was conducted in a 40kmx40km region in a “feature survey” for a two day period. 158 UCTD casts were completed (Figure 1).

There was substantial uncertainty in the plan because the area of operation is in US Navy aviation warning area (W-283 and W-285), and there were restrictions on

aircraft operations related to military exercises. The “whiskey areas” are closed during the day (loosely, business hours) on weekdays.

After the floats are placed, the float planning software will run automatically incorporating the dive cycle float location (running one float cycle behind real-time) and daily ROMS forecast to minimize X-Y displacement and maximize vertical cycles. The relative weighting of these two objectives will be set at float deployment based on team choice (e.g. expected number of cycles) but can also be adjusted during the deployment.

1 x EM-APEX float deployed to feature of interest. When the feature of interest is identified by the team, the float planning software can be used to analyze for a range of deployment locations (in the future) what the future position of the float will be (e.g. with respect to a fixed target). This will allow consideration of the projected float trajectory in the float deployment location. If the feature of interest can be identified in the ROMS simulation and a time-varying track provided, the float planning software can be programmed to perform dive profiling to track the feature. This would be similar to the above “on-satellite-track” float planning except that we are attempting to station keep on a moving feature.

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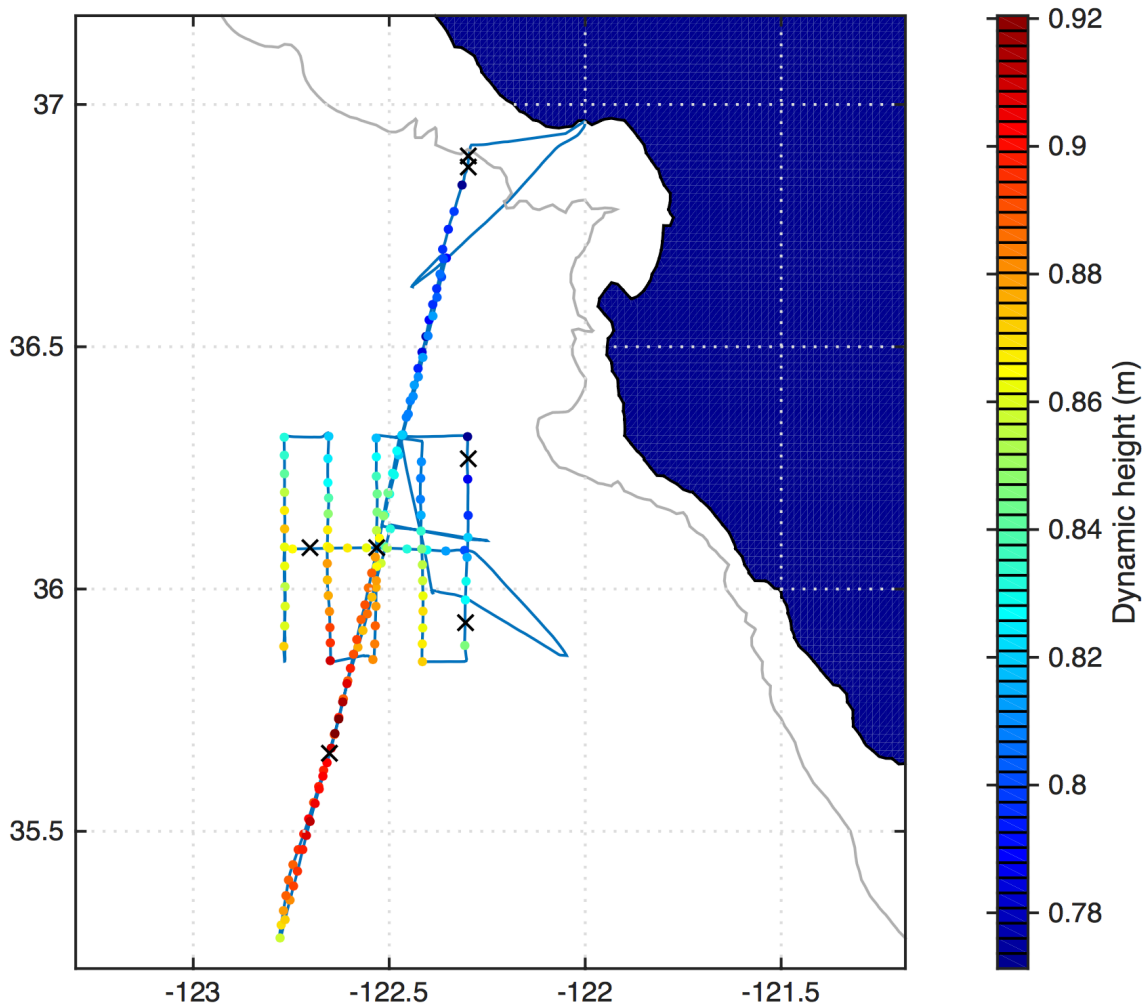


Figure 1. *Shana Rae* cruise track (blue line). Dots mark the locations of UCTD casts deeper than 480 dbar, and are colored by the dynamic height relative to that depth. Black X's mark the locations of shallower UCTD casts. The gray contour is the 500-m isobath.

### ***Principle Investigators***

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 EM-APEX: James Girton [girton@apl.washington.edu](mailto:girton@apl.washington.edu)

### ***Personnel on board***

Captain: Jim Christmann [jaxmann@shanarae.com](mailto:jaxmann@shanarae.com)  
 Mate: Gene Sofen  
 Science: Ben Hodges [bhodes@whoi.edu](mailto:bhodes@whoi.edu)  
 Science: Ben Pietro [bpietro@whoi.edu](mailto:bpietro@whoi.edu)  
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### ***Cruise narrative***

*17 April:*

UCTD sampling commenced at 1630 Z at the intersection of the continental shelfbreak (represented in Figure 1 by the 500-m isobath, gray) with the April 17<sup>th</sup>

SARAL/AltiKa satellite groundtrack. The *Shana Rae* proceeded at about 7 knots south-south-westward along the track, collecting ~500-m-deep profiles of temperature and salinity every 15-20 minutes, for an average horizontal spacing of 4-5 km. A brief stop was made upon reaching the crossing point of the April 15<sup>th</sup> SARAL/AltiKa groundtrack at 1830 Z to deploy EM-APEX float 6665. At 2300 Z, shortly before reaching the crossing point of the April 14<sup>th</sup> Jason groundtrack, EM-APEX float 6667 was deployed.

*18 April:*

After the deployment of 6667, UCTD sampling was suspended, and the *Shana Rae* made an eastward jaunt off the track she'd been following to deploy EM-APEX float 6675. The deployment took place at 0030 Z, and the *Shana Rae* returned to the track to resume UCTD sampling. At 1000 Z, at the nominal range of 200 km from Santa Cruz, the *Shana Rae* reversed course and continuing UCTD sampling along the same track, repeating the southern portion of the transect. At 2030 Z, the northern boundary of the 'feature survey' area was reached, and UCTD sampling was suspended briefly during the transit to the northeast corner of the survey box. The *Shana Rae* turned due south at 2100 Z and commenced the UCTD feature survey.

*19 April:*

The fifth, westernmost meridional transect of the feature survey was completed at 1830 Z. The single zonal transect was carried out from west to east across the middle of the box between 2030 and 2330 Z.

*20 April:*

Following completion of the survey, UCTD sampling was suspended, and the two southern EM-APEX floats were located and recovered: 6675 at 0130 Z followed by 6667 at 0430 Z. One of 6667's electrodes was found to be loose after recovery, and the hiss of air leaking into the evacuated pressure case could be heard; the likely cause was contact with a boathook during recovery. The *Shana Rae* then returned to the intersection of the northern boundary of the survey box with the April 17<sup>th</sup> SARAL/AltiKa line to resume the northward UCTD transect along that line. Sampling continued as far as the deployment location of EM-APEX float 6665. The final UCTD cast occurred at 1100 Z. EM-APEX float 6665 was then located and recovered, and the *Shana Rae* returned to port, arriving at 1700 Z.

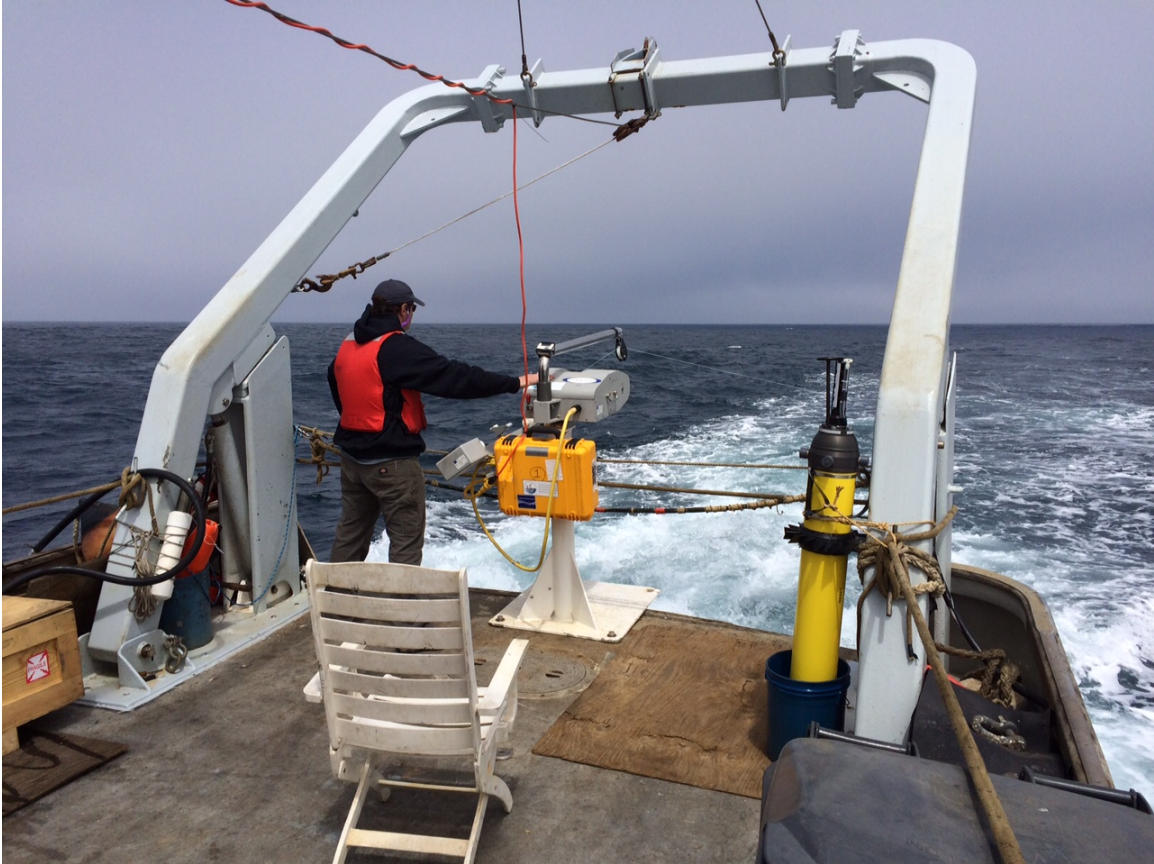


Figure 2. UCTD sampling in progress from the stern of the *Shana Rae* while an EM-APEX float soaks in a bucket in preparation for deployment.

***EM-APEX floats***

Float S/N	6665	6667	6675
Deploy date	17 April 2015	17 April 2015	18 April 2015
Deploy time (Z)	1839	2256	0037
Deploy latitude	36° 41.14' N	36° 07.77' N	36° 06.01' N
Deploy longitude	122° 21.24' W	122° 30.88' W	122° 15.02' W
Recover date	20 April 2015	20 April 2015	20 April 2015
Recover time* (Z)	1135	0430	0130
Recover latitude*	36° 37.45' N	35° 59.65' N	35° 52.01' N
Recover longitude*	122° 26.43' W	122° 23.40' W	122° 03.01' W

*\* Recovery times and locations are approximate*

**Data:**

A preliminary version of the UCTD data is available at the following link:

<http://uop.who.edu/projects/AirSWOT/>

For EM-APEX float data inquiries, contact James Girton ([girton@apl.washington.edu](mailto:girton@apl.washington.edu)).

Underway Conductivity Temperature Depth (UCTD) casts were taken during a time period of about 2.5 days, with a geographic sampling that used straight sections. These sections are shown in figure 1. The colors denote the different sections, with the starting point of the section represented with an open square symbol. The legend has sections numbered in chronological order, as they were collected. The two longest sections were about 180 km (section 1, red) and 110 km (section 2, green), while other sections were around 40 to 50 km long. Median distance between casts was 3.7 km. First 5 m of UCTD data were not used.

From conductivity, temperature and pressure, density was computed. A 3-dimensional view of the density anomaly, is shown in figure 2. Casts maximum depth varied between 450 and 500 m.

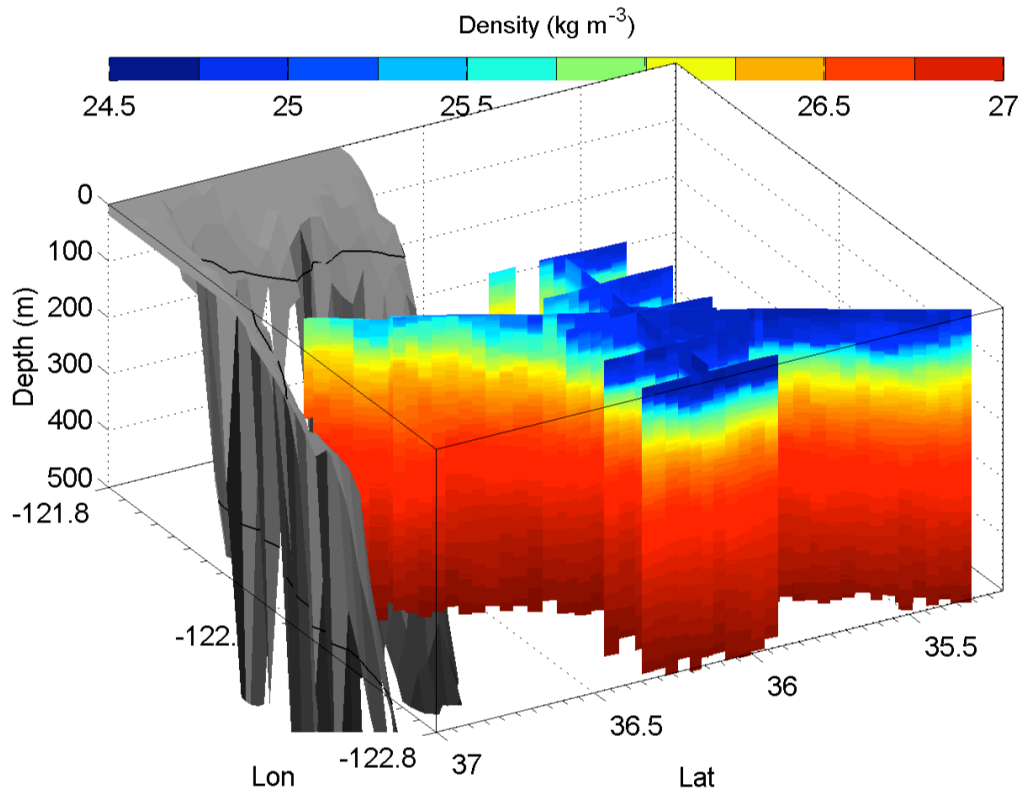


Figure 2. Density anomaly profiles from UCTD casts during AirSWOT campaign in April 2015. Grey shading denotes bathymetry, and the viewing angle is from the northwest.

Dynamic height was then computed with respect to different depths (200 m, 400m and 500 m) which showed little difference. Dynamic height referenced to 400m is

shown in figure 3 for all sections, as a function of latitude. Color coding is the same as in the map in figure 1. Dates at which sections were started are also indicated in the legend of each panel in figure 3. The thermosteric part of the dynamic height is dominant and shown here. Thermosteric dynamic height was computed following Pond and Pickard (page 10):

$$\text{del\_th} = (1000 / (1000 + \sigma_t) - 0.97266) * 1e-3$$

where  $\sigma_t$  is density anomaly. Integrating del\_th from surface (5 m) to 400 m with respect to pressure (in Pascals). Dynamic height is expressed in centimeters by dividing integral by factor  $9.8 * 100$ .

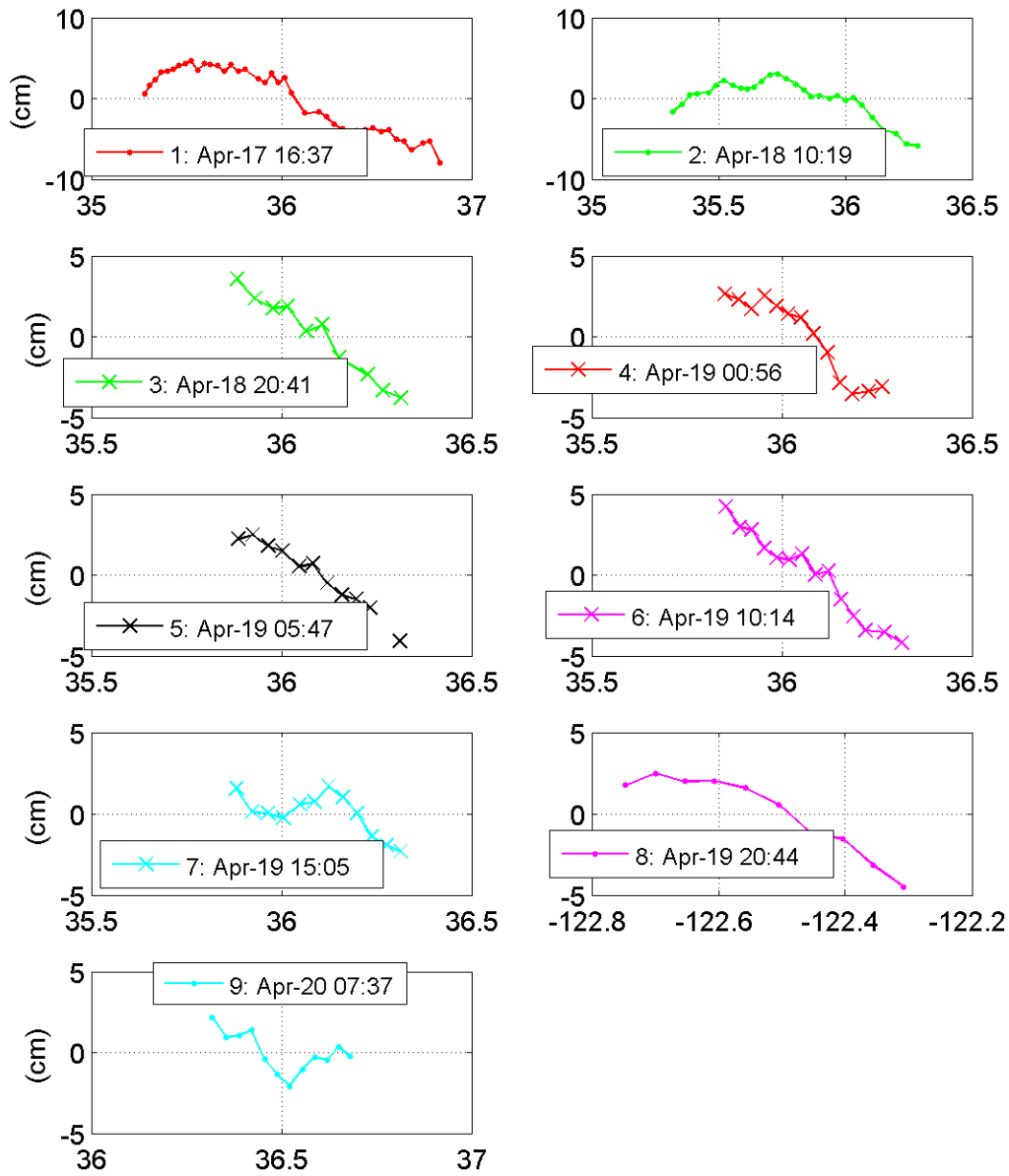


Figure 3. Thermosteric part of the dynamic height referenced to 400 m for each UCTD section. AirSWOT campaign April 2015.

Section 1 was the longest continuous section, and ran from southwesterly for 180 km. Figure 4 shows in detail the hydrography (temperature and salinity) and dynamic height (referenced to 400 m) for section 1.



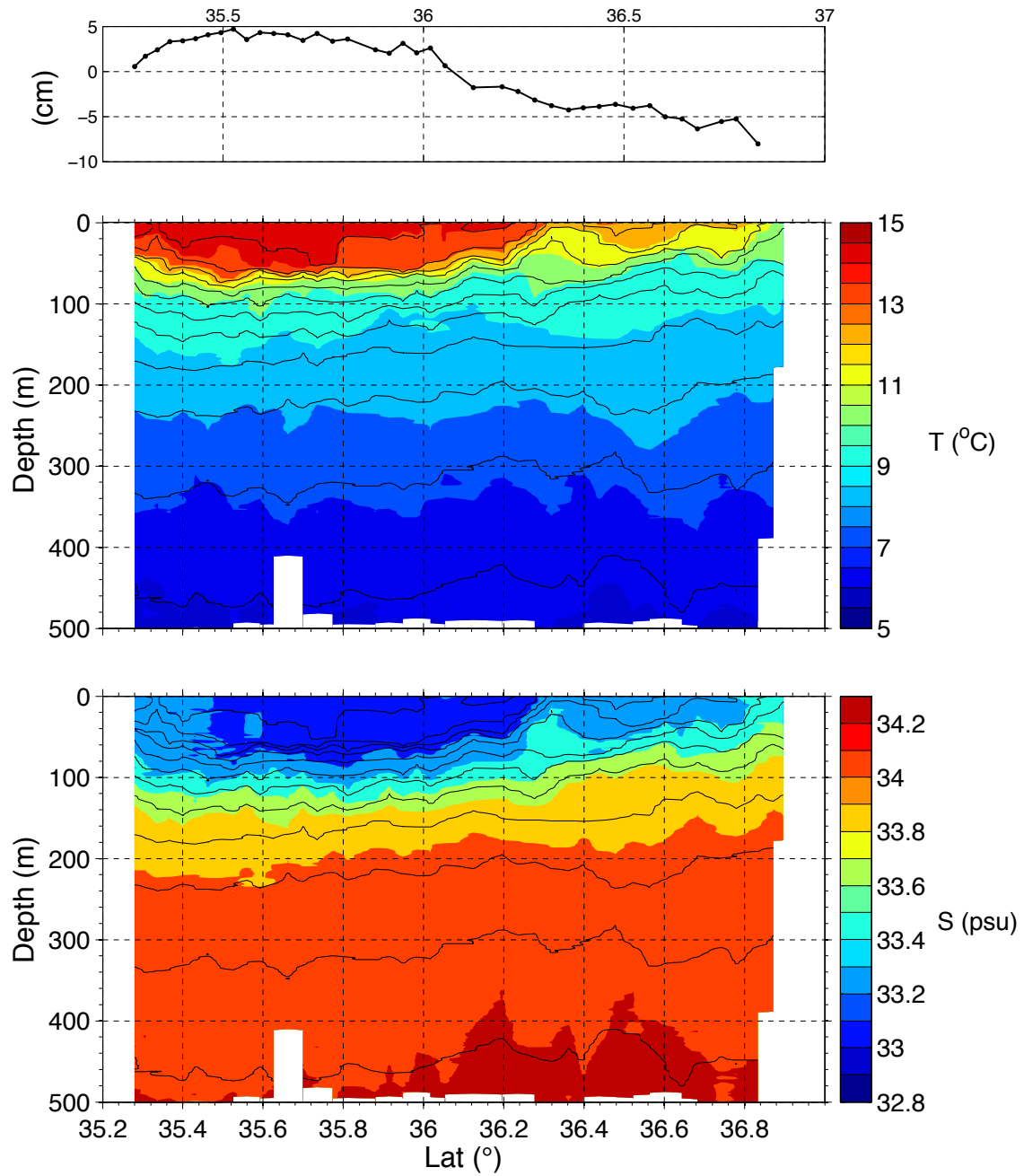


Figure 4. Dynamic height referenced to 400 m (top) , temperature (center) and salinity (bottom) for UCTD section 1 (see Fig. 1). AirSWOT UCTD campaign April 2015.