

Submesoscale Dynamics in the South China Sea Cruise Report - RR1304 R/V Roger Revelle, 26 April - 5 May 2013

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1. Objectives

This effort was intended as a pilot study for future investigations of submesoscale dynamics and their role in the energy cascade in the Kuroshio-influenced northeastern South China Sea. Specific objectives for this cruise included:

- Characterize the dominant spatial and temporal scales and how they vary as a function of bathymetry and distance from Luzon Strait (Kuroshio influence).
- Identify areas of elevated mesoscale and submesoscale variability to inform upcoming experiments.
- Characterize the internal tide and develop approaches for internal wave and submesoscale variability.

2. Cruise Activities

- Run uCTD and hydrographic CTD surveys along legs defined by pre-designated waypoints (Figure 1)
- Deploy Gliders (Jane and Husker).
- Deploy moorings at M1 and M2.

4/26: Depart Kaohsiung at 1600. Underway data collection outside of Taiwan 24 nmile limit.

4/27: Sampling along r4n, r3n, r2s, and r3s segments. Hydrographic CTD and uCTD used. uCTD problems were significant.

4/28: Sampling along r3n, r4s, r4n, and r3s segments. Hydrographic CTD used.

4/29: Sampling along r3s and r4s segment. Hydrographic CTD used. VMP section 1 and glider “Jane” deployed along center of segment. VMP section 2 done along eastern end of segment.

4/30: Sampling along r2s, r1s, and r1n segments. uCTD was repaired and used along with hydrographic CTD. Moorings deployed at M1 and M2.

5/1: Sampling along r1n, r1s, and r2s segments. uCTD and hydrographic CTD. Drifters deployed at r1s (2), and r2s (4).

5/2: Sampling along r2s to r2n segment. uCTD and hydrographic CTD. Turbulence-glider Husker deployed and VMP section 3 along eastern end of segment. Drifters deployed at r3s (4).

5/3: Sampling along r3n, r2n, and r2s segments. uCTD and hydrographic CTD. Glider Husker recovered and VMP section 4 near r3n.

5/4: Sampling along r3s, r3n, and r2s segments. uCTD and hydrographic CTD. Glider Jane recovered along center of r2s and r3n segment. Measurements suspended at 1800
5/5: Arrive Kaohsiung 0800.

3. Operations Summary

Weather deteriorated in the first 4 days of the expedition. Gale force seas characterized the off-shore regions south of the r2 line. Seas along the northern segments of the r1 and r2 lines remained fair. Seas settled on the final day of the expedition.

uCTD work early in the expedition was hampered by 3 issues: 1) the software for communicating with the uCTD probes was buggy; 2) the firmware on the probes was buggy; 3) the winch system voltage control failed. The combination of all three problems required us to suspend uCTD sampling during 4/28 and 4/29. We were able to repair the winch, and update the software, but unable to improve the probe firmware. All uCTD sampling done after 4/29 involved running uCTD units for 10 minutes to complete 3 to 4 yo-yos to about 150-m depth. On 5/2 while sampling the r1 line, we lost a probe, seemingly due to snagging a long-line.

The Revelle's hydrographic CTD was rotated into the regular duty cycle of the expedition when the uCTD system was down for repairs. There was a new, somewhat automated handling system in use on the Revelle, which handled deployment and recoveries of the hydrographic package without deck personnel using taglines. This new system worked very well. We conducted 38 profiles with the hydrographic CTD, including several to full depths of roughly 3000 m.

Two gliders were used during the expedition. The OSU Slocum glider "Jane" was deployed for a 5-day mission in the area between the r2 and r3 lines. Jane was equipped with an aquadopp ADV sensor, and was deployed from the Revelle without incident. The WHOI Slocum "Husker" is a turbulence-glider, which requires deployment via rhib. Due to building seas, the deployment of Husker was postponed until 5/2 for a 1-day mission to test its readiness for use in leg 3. Husker surveyed along the eastern edge of the r3 line for 24 hours and was recovered by rhib on 5/3. Jane was recovered on 5/4 from the Revelle using a snaphook and an air tugger. It took two tries, as the first snap hook failed, and the glider got swept under the stern of the vessel as the ship attempted to reposition. The glider was not damaged.

The UAF VMP system was used periodically during the survey to sample turbulence levels at sites of interest as indicated by shipboard Doppler and TSG data. Four 1.5-2.5 hours "sections" were done with the VMP, each spanning a 1-2 km segment with 10 to 15 turbulence profiles to 150-200-m depth. The VMP was operated from the Revelle's stern with the ship pointing into the surface current. This proved an effective means of maintaining a safe tethered deployment of the profiler while still being able to hold heading and direction.

4. Preliminary Findings

Initial examination of data suggests we observed an active submesoscale. By the middle of the survey period, gale force winds were blowing north and south of the study site (Figure 2). Winds in the area of our survey were generally sustained at 20 knots, except at the M1 and M2 sites, which were well sheltered from the weather (Figure 3). There was a notable increase in frontal structure after May 1 (Figure 3, lower panel), as indicated by SST from the Revelle's TSG system.

Aspects of the submesoscale activity can be seen in the TSG temperature and salinity fields, along with the ship-measured Doppler currents (Figure 4). The r3n site stood out as one of the most energetic, with strong SSS and SST gradients. An intensive survey at that site revealed enhanced turbulence levels both in the near surface layer, but also below the mixed layer (Figure 5).

The combination of uCTD and CTD data is shown in Figure 6. The best uCTD coverage is along the r1, r2, and r3 lines. Examination of salinity “spice” is pending. The area between r3 and r2 was surveyed by the OSU Slocum glider. Preliminary examination of T-S structure is shown in Figure 7.

5. Science Personnel

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6. Data Sharing

The preliminary processed data from the expedition has been shared with colleagues at NTU and NSYSU. They may share this data with other partners in Taiwan. Data sharing within the US is limited to the Co-PI's of this ONR project.

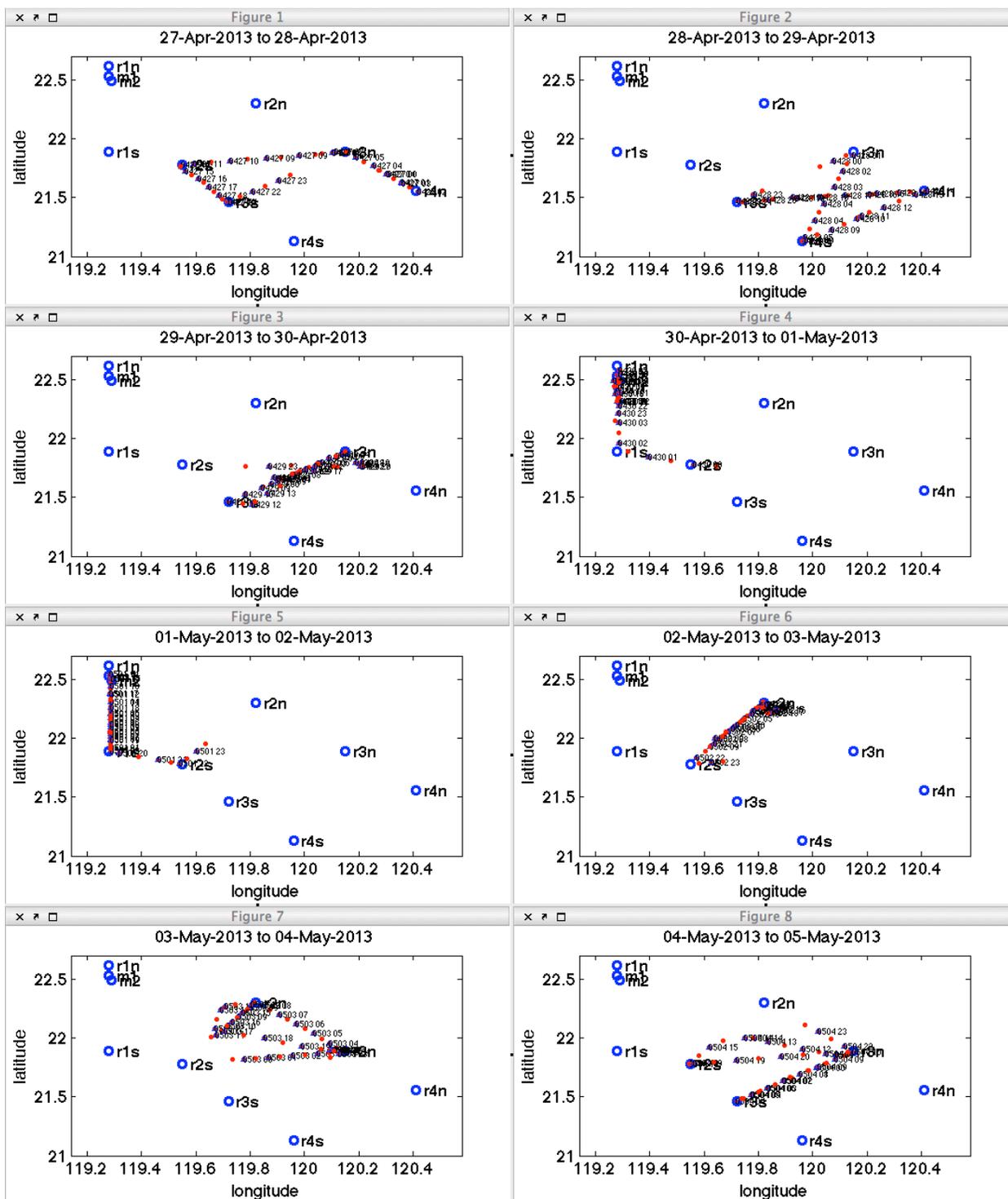


Figure 1. Maps showing transect activity during each day of the expedition. These positions are from the Revelle navigation log, with positions marked at approximately each hour. Dates and times (local) are given. The “r” and “m” waypoints are shown in each panel.

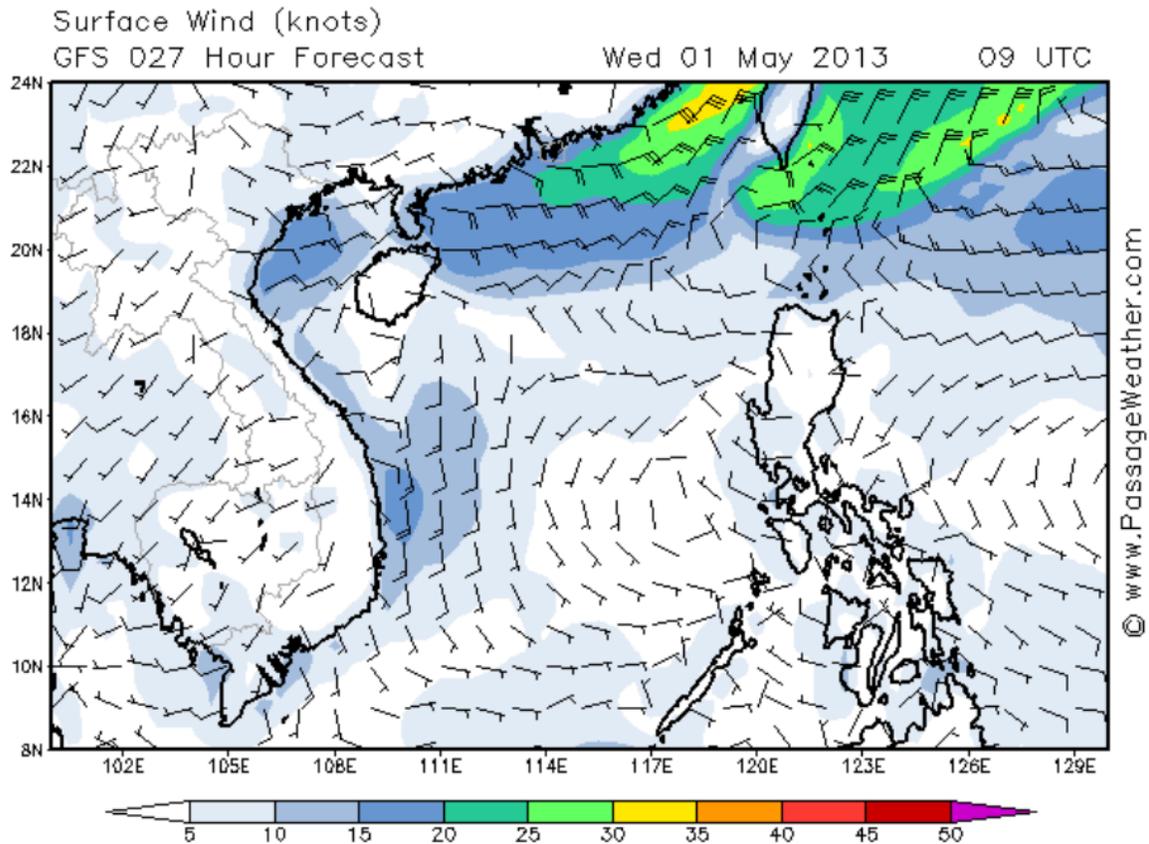


Figure 2. Wind forecast for May 1, showing gale force winds north and south of the worksite. This was the peak weather day of the survey. The northern-most sites were quite sheltered from the winds and seas.

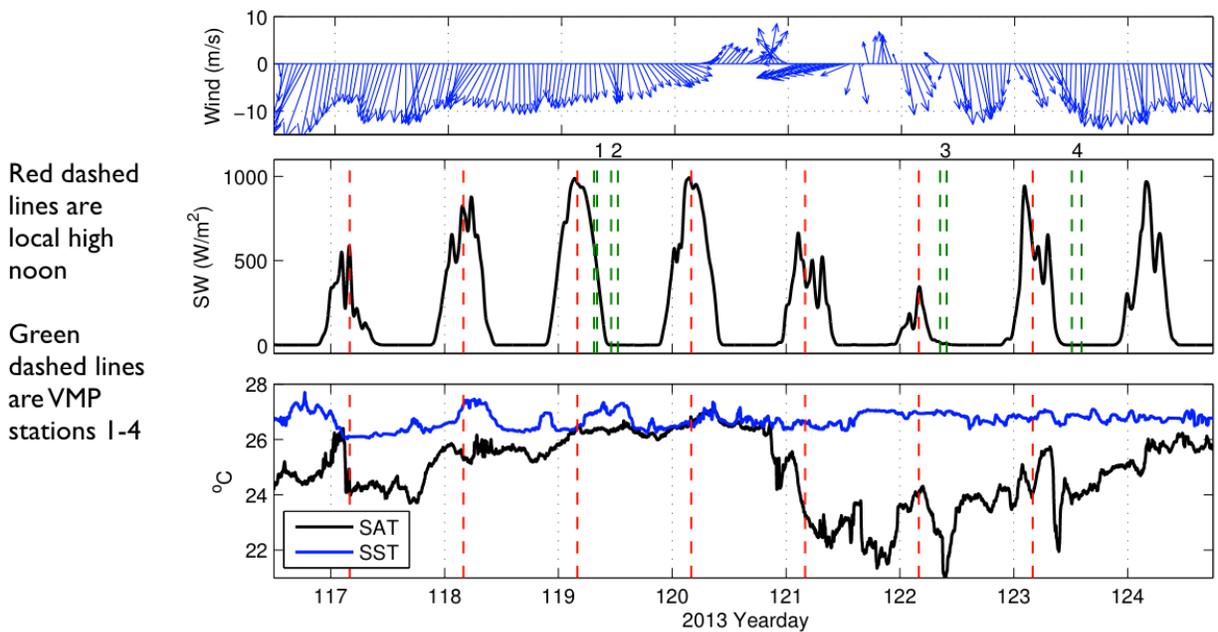


Figure 3. Time series of Revelle-measured winds, shortwave, SAT and SST.

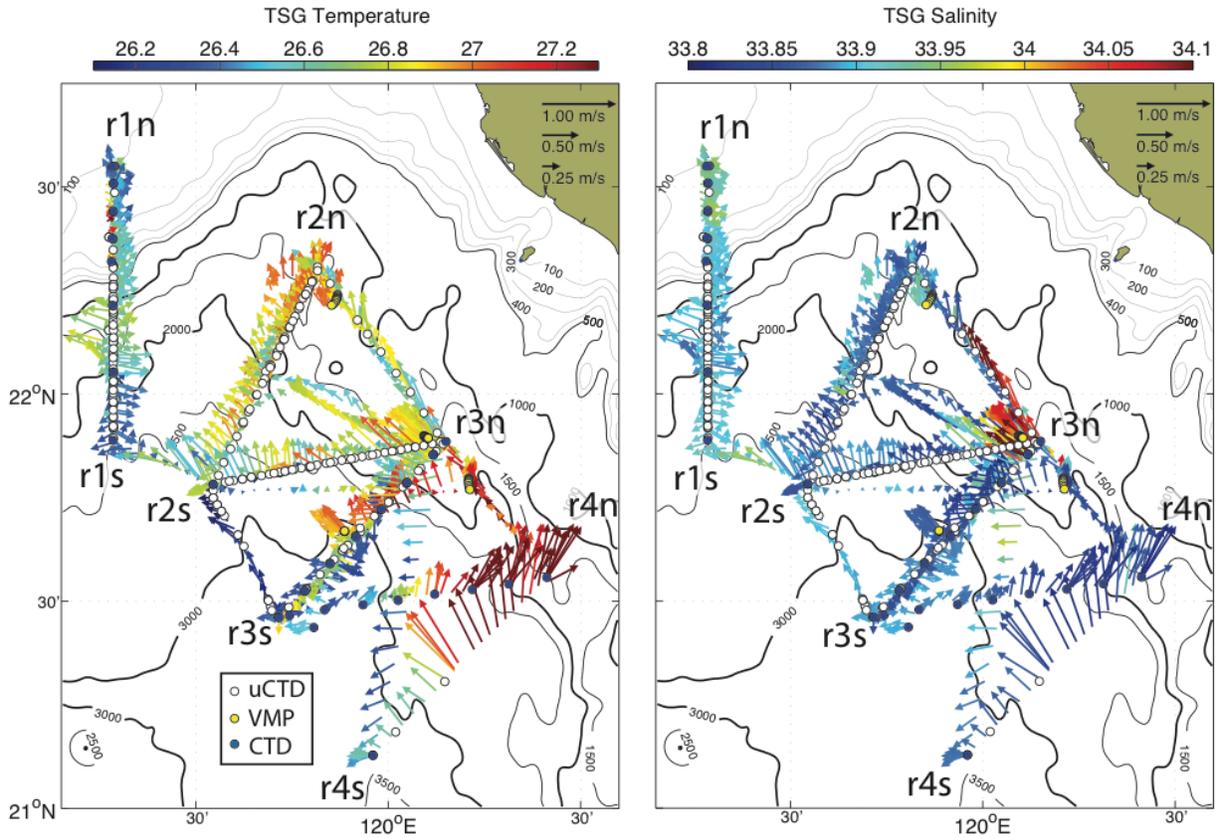


Figure 4. The full transect grid of the expedition, indicating uCTD, CTD, and VMP sample locations, as well as Doppler measured velocity vectors and TSG SST and SSS.

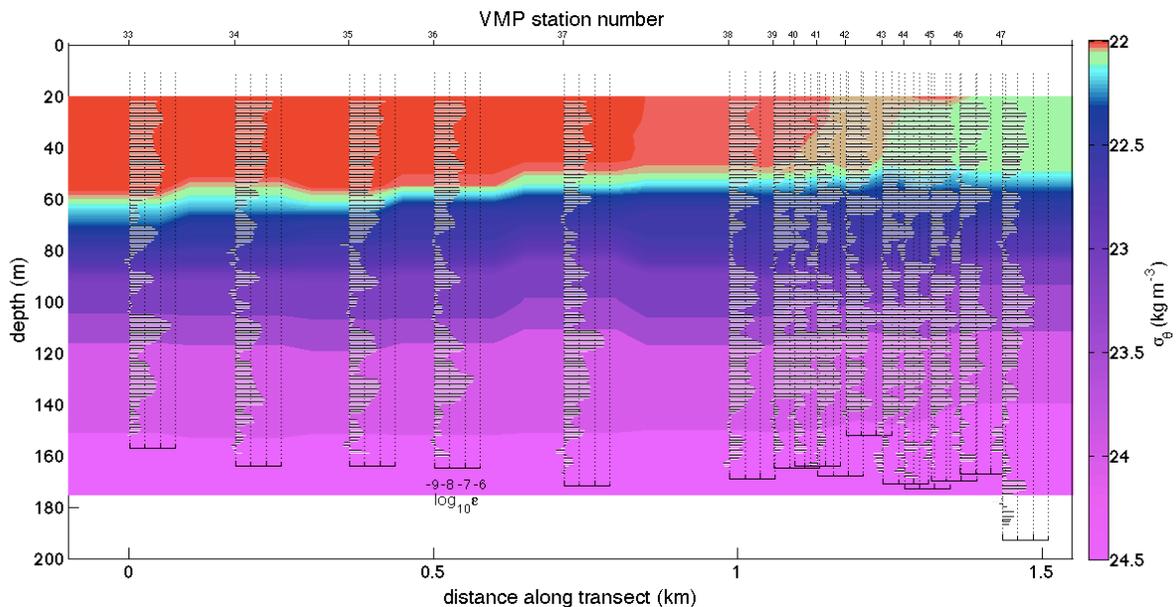


Figure 5. Turbulence section near r3n. Density (σ_θ) and turbulence levels (TKE dissipation rates) are shown along a strong front. The section runs from west to east, and the winds were out of the north.

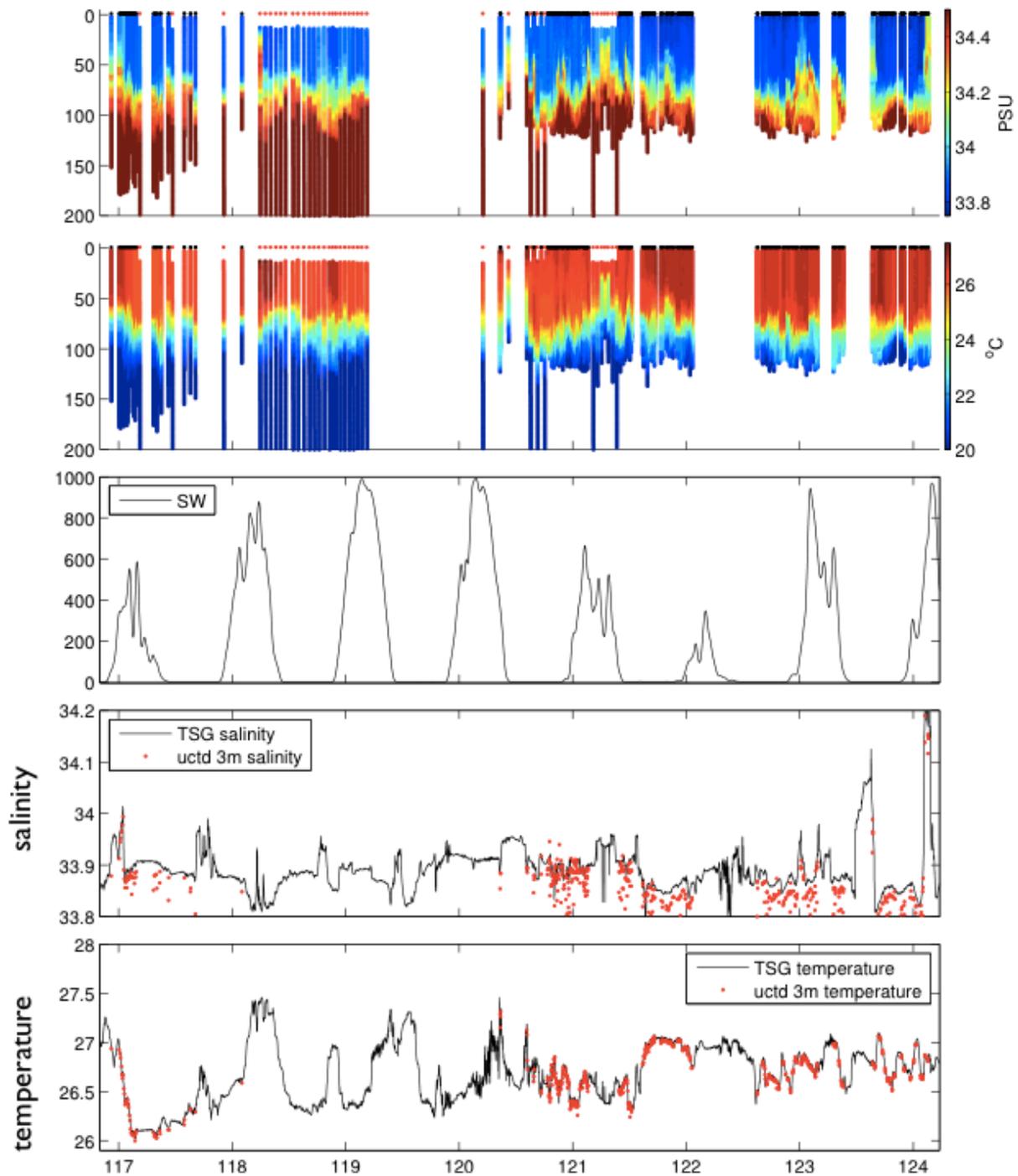


Figure 6. Time series of uCTD and CTD temperature and salinity data collected during the expedition. The upper panels show data from both CTD platforms, hydrographic CTD casts are those that go deeper than 200 m. Middle panel shows the time series of shortwave radiation. Lower panels show a comparisons of TSG measured salinity and temperature with shallowest data from the uCTD. uCTD salinities show considerable scatter, due to both sensor noise, and residence time issues. uCTD temperature is highly correlated with the TSG.

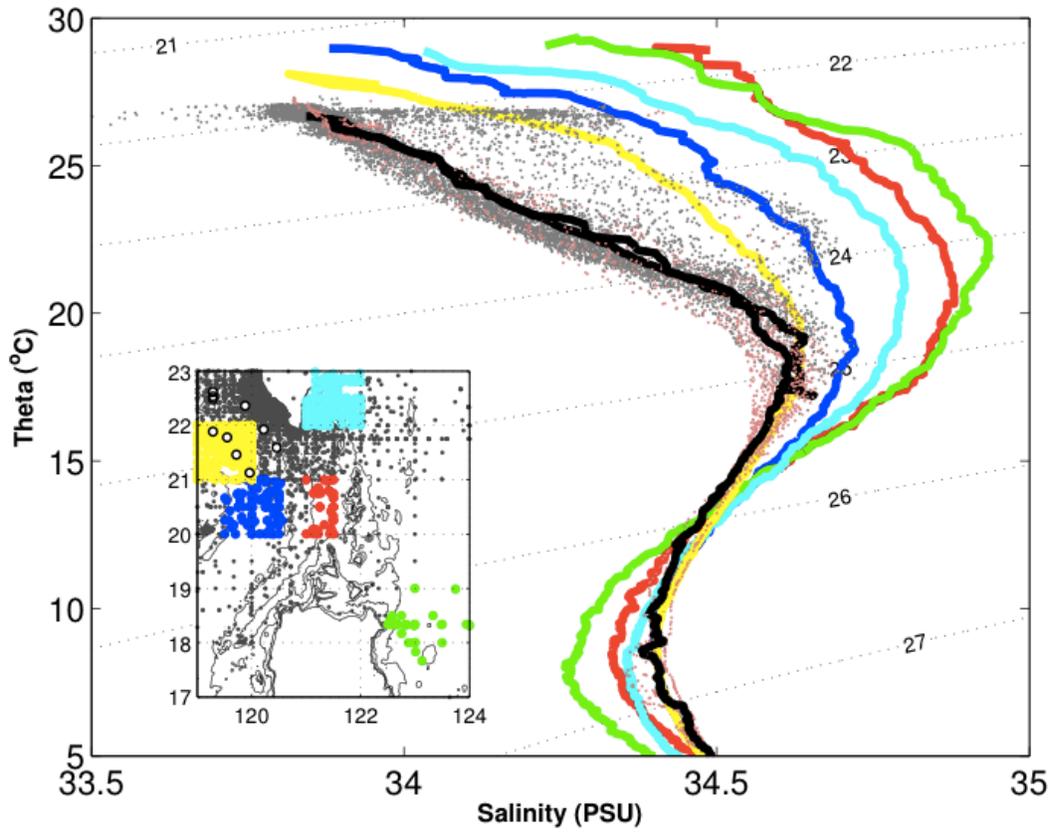


Figure 7. T-S diagram showing distribution of uCTD and CTD measured data(scattered point, and black curve), relative to climatological data from the nearby areas (colored curves).