Satellite Observations of Surface Fronts, Currents and Winds in the Northeast South China Sea

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LONG-TERM GOALS

The long-range goal of this proposal is to improve our understanding of surface currents and fronts in the northeast South China Sea and their influence on acoustic propagation across the shelfbreak in this low-latitude setting. We are using satellite measurements of sea surface temperature, color, height and winds to identify and analyze the regional surface fronts and mesoscale eddy features and collaborate with other ASIAEX investigators to reach this goal.

OBJECTIVES

Relatively little is known about the general circulation and fronts in the northeast South China Sea. Past work suggests a northeastward current over the outer shelf (the South China Sea Warm Current) and a southwestward current over the slope containing Kuroshio water from the Luzon Strait, however, there exist few *in situ* direct current measurements to support this schematic. AVHRR imagery shows that the Kuroshio can bifurcate in the Luzon Strait, with some of its transport entering the South China Sea west of Taiwan. Wind stress (Farris and Wimbush, 1996) and wind stress curl (Metzger and Hurlburt, 2001) have been shown to be relevant to the penetration of the Kuroshio and subsequent shedding of large mesoscale eddies, which may influence flow over the Chinese continental margin directly.

The Asian Seas International Acoustics EXperiment (ASIAEX) was developed to investigate the propagation of low frequency sound across the shelfbreak in this region. As part of this program, two one-month field studies were conducted, featuring high-resolution SeaSoar/ADCP surveys and moored acoustic and physical oceanographic measurements. One objective of the physical measurements was to observe the current and thermohaline fields near the shelfbreak with sufficient spatial and temporal resolution to help interpret the variability observed in the acoustic data. As part of this latter effort, we are using satellite data to help describe surface features and their evolution during the two field studies. In addition, we are using satellite data collected beyond the two field studies (limited to satellite

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14. ABSTRACT
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availability) to better understand the larger-scale surface variability in the eastern South China Sea on time scales of days to years, and the relationship between this regional variability and that observed in the two smaller-scale shelfbreak field studies.

APPROACH

We began collecting and processing AVHRR, ocean color, and altimeter data for the eastern South China Sea in January 2000, with one objective being to provide early descriptions of the surface features observed in the area of the study to ASIAEX investigators prior to the two field programs. The collection of the remote sensing data has continued for two full years (into spring, 2002). Archived data prior to the field programs (from the beginning of each satellite data stream) was obtained to complete a 3-year plus data set. This time period encompasses the pilot and main (April 2000 -May 2001) field studies while allowing annual mean fields to be computed and seasonal and interannual differences to be identified. This will allow the pilot and main field study periods to be placed within the longer-term temporal context. For example, a multi-year sea surface temperature (SST), sea surface height (SSH) and wind stress curl fields were computed and are being analyzed to identify mesoscale current features and variability. The locations of fronts and eddies will be analyzed to determine whether the features observed during the two field studies were typical and whether these features are correlated with wind stress curl. In 2003, final data processing will be completed and scientific analysis and collaborations with other investigators continued and completed.

WORK COMPLETED

We have extended our archive of satellite-derived data sets for the South China Sea into the spring of 2002. These data sets include high and low resolution sea surface temperature data from the Advanced Very High Resolution Radiometer (AVHRR) from 1990 to present, ocean color images from SeaWiFS from 1997 to present, scatterometer wind fields from QuikSCAT from 1999 to present and altimeter sea surface height anomalies from TOPEX from 1993 to present. We have added low-resolution sea surface temperature data from the Tropical Rainfall Measuring Mission (TRMM). Wind stress and wind stress curl was derived from the QuikSCAT winds on a 0.25^{o}x0.25^{o} grid. Monthly statistics and climatologies were calculated from each of these data sets.

RESULTS

Our analysis during this past year has focused on integrating altimeter sea surface height data with sea surface temperature data. Figure 1 shows the location of the four TOPEX/Poseidon tracks that surround the ASIAEX study region to the west of the Luzon Strait. Tracks 051 and 088 cross the region of the large-scale deep-water SeaSoar surveys and tracks 012 and 229 are located to the west. Sea surface temperature images from AVHRR are limited due to persistent cloud cover during the field observations. However, the sea surface temperature images acquired from TRMM provided low-resolution coverage under cloudy conditions. This provided enough temporal and spatial resolution to analyze surface features in the region and to validate mesoscale features visible in SSH anomalies. Figure 2 shows SST images from April 26, 2000 (left) and April 18, 2001 (right). Previous analysis of SSH demonstrated that conditions are considerably different prior to the two field programs in the spring of 2000 and 2001. These figures support the differences in mesoscale circulation between the two years seen in the SSH analysis. In the spring of 2000, there is a large-scale anti-cyclonic circulation between the Luzon Strait and the shelf-break. In contrast, during the spring of 2001, there is a small cyclonic circulation near the shelf-break bringing cold shelf water into the basin.

Unfortunately, a warm surface layer masks the circulation patterns seen in winter and spring SST during the summer and fall. However, the correlation between the mesoscale circulation patterns in SSH and SST provides confidence in an eddy census using the altimeter.

Wind stress and wind stress curl are thought to play an important role in the intrusion of Kuroshio water into the South China Sea and subsequent eddy formation. We have processed the scatterometer wind data to and are working to correlate the strength of the wind stress curl field with the mesoscale variability in the South China Sea.

IMPACT / APPLICATIONS

There is considerable debate over the frequency and duration of Kuroshio intrusions into the South China Sea. The long-term altimeter and scatterometer data combined with ocean color and sea surface temperature data will enable us to characterize the temporal/spatial behavior and interannual variability of this intrusion and its impact on the general circulation west and south of Taiwan and the shelf-break front.

TRANSITIONS

We have provided remote sensing data to the WHOI and Taiwanese SeaSoar groups in the ASIAEX program to provide broad scale interpretation of their *in situ* data collected in the 2000 pilot and 2001 field programs.

RELATED PROJECTS

The Asian Seas International Acoustics EXperiment (ASIAEX) was developed to investigate the propagation of low frequency sound across the shelfbreak in this region. The insights provided by the Taiwanese and WHOI SeaSoar data (G. Gawarkiewicz, personal communication) have been helpful in our analysis of the satellite data. We are working with Gawarkiewicz and other ASIAEX investigators to provide broad-scale analysis to help in the interpretation of the SeaSoar and moored array data collected during the pilot and main studies. We are also working with D. Chapman to provide sea surface height data for interpretation of various idealized model runs in the South China Sea.

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Metzger, E.J. and H.E. Hurlburt, 2001. The Nondeterministic Nature of Kuroshio Penetration and Eddy Shedding in the South China Sea. *J. Phys. Oceanogr*., **31(7)**, 1712-1732.

PUBLICATIONS

None

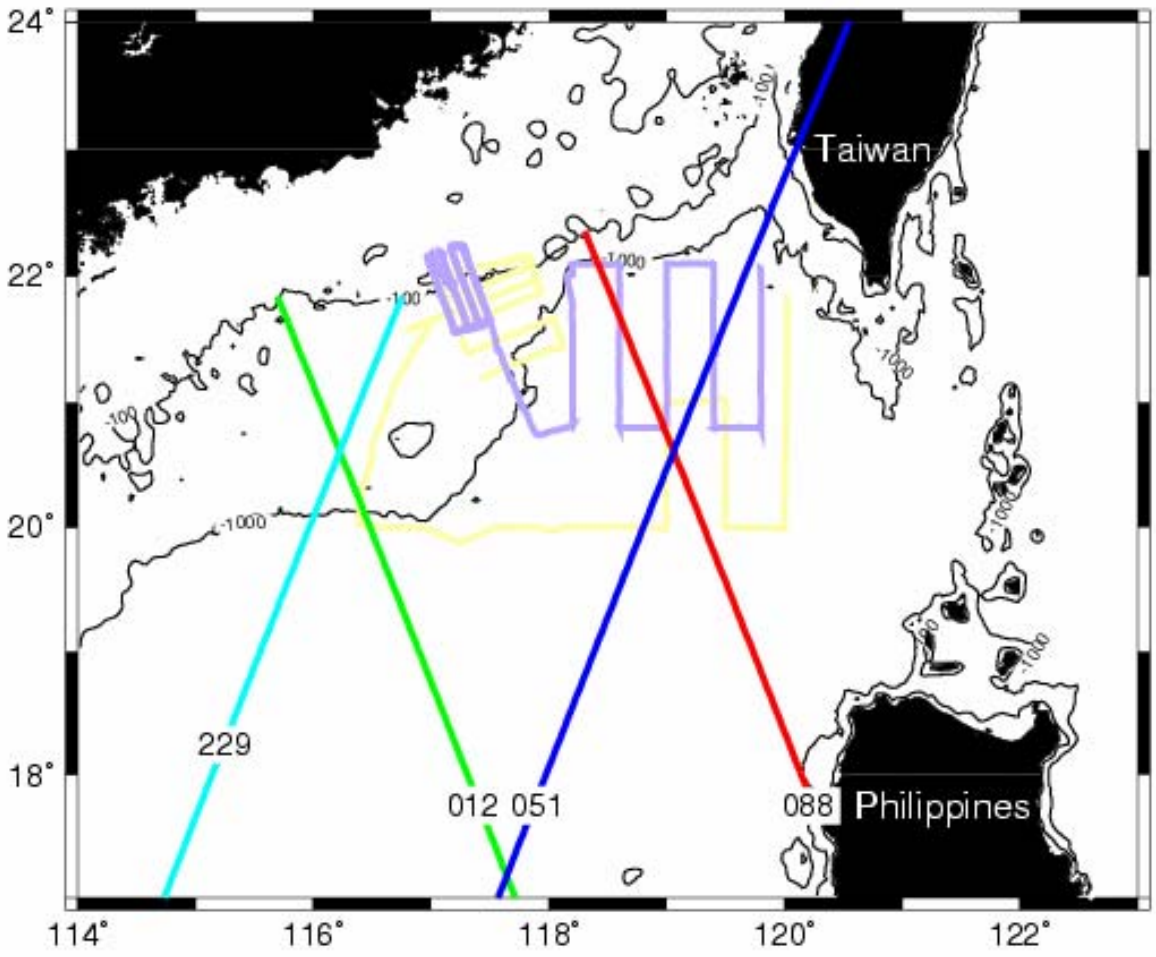

Figure 1. Map showing SeaSoar tracks for the pilot (yellow) and main (purple) field programs relative to TOPEX/Poseidon tracks 088. The deepwater surveys cross the altimeter subtracks 088 (red) and 051 (blue). The shelfbreak surveys are to the west of these subtracks and to the east of subtracks 229 (cyan) and 012 (green).

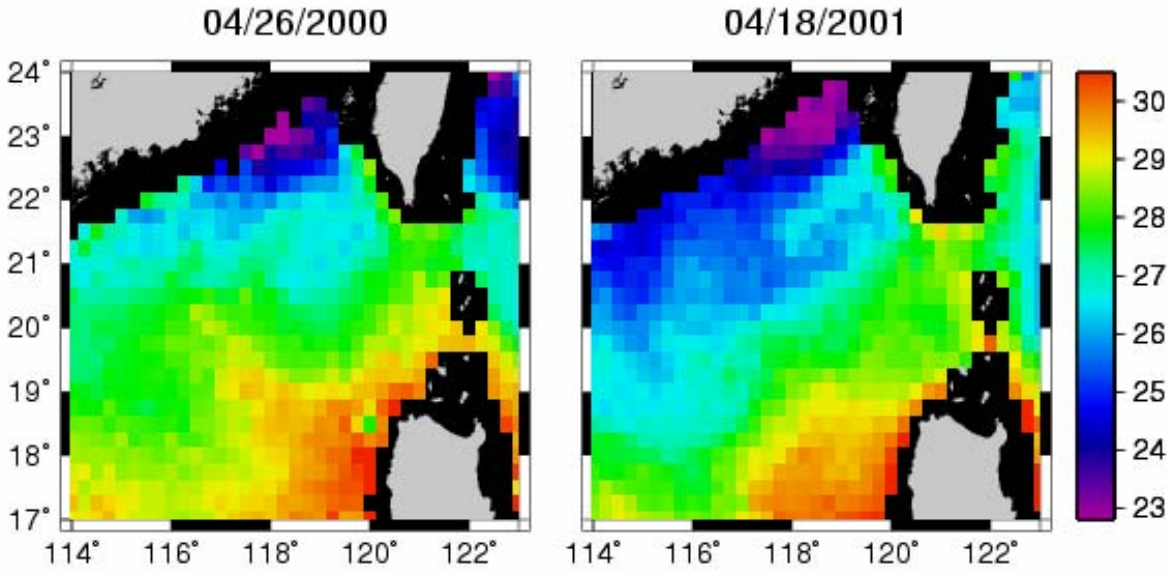

Figure 2. This figure shows the sea surface temperature from April 26, 2000 (left) and April 18, 2001 (right). The sea surface temperature shows the differences in mesoscale circulation between these two years. In 2000, there was a large anti-cyclonic circulation west of the Luzon Strait. In 2001, a small cyclonic circulation is present near the shelf-break.