Early Student Support for the Origins of the Kuroshio and Mindanao Current

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LONG-TERM GOAL

Autonomous underwater gliders are proving to be valuable tools for ocean sampling, and are being adopted remarkably rapidly by the oceanographic community. Oceanography has been primarily an observational science in the sense that almost every known phenomenon in the ocean was observed before it was predicted theoretically. Thus, new ways of observing the ocean have resulted in new scientific discoveries. The primary long-term goal of this project is to demonstrate the use of gliders to address basic scientific problems.

OBJECTIVES

Gliders are fulfilling the promise of continuous, sustained observation of the ocean down to length scales on the order of kilometers, a range now commonly termed the submesoscale. Gliders are proving to be especially useful in boundary currents. Glider data are being assimilated into regional ocean models, and because they are sustained in the region of interest, these data are often found to be profoundly influential in the predicted ocean state. We propose to use glider data to address these major issues:

- The temporal and spatial modulation of the submesoscale
- Variability of western boundary currents
- The value of glider data in assimilating models

APPROACH

The approach uses data sets that either exist or are currently being collected to address the objectives above. Through a variety of funding, including ONR, NOAA, and NSF, we are compiling rich data sets from various locations around the globe using Spray (Rudnick et al., 2010). In this project, we propose to focus on data from four of these efforts. As part of the ongoing DRI Origins of the Kuroshio and Mindanao Current (OKMC), sections across the North Equatorial Current (NEC) and the Mindanao Current are being continuously occupied in an effort that is planned to last 4 years. An

ONR-funded program of glider deployments in the Kuroshio in the region of the Luzon strait provides continuous observations during the period April 2007 through June 2008. With NOAA funding, we are continuously occupying three sections in the California Current (Davis et al., 2008; Todd et al., 2011a; Todd et al., 2012), with the earliest observations dating from 2005. We recently concluded an NSF-funded program studying the modulation of thermohaline fine-structure in the subtropical gyre north of Hawaii, with observations spanning July 2007 to December 2009. The purpose of this proposal is to analyze these four data sets.

An essential element of the approach is the training of graduate students. The intention is to have one graduate student supported by this project at all times. The first intended recipient was Robert Todd, who defended his PhD in April 2011. The next graduate student supported was Kate Foco, a first-year student in Fall 2011. The current recipient of support is Martha Schonau, who plans to do her thesis research on glider data from OKMC. She joined the project in June 2012, so she has yet to go far in research, but her work is promising.

WORK COMPLETED

Although funding arrived too late to provide direct salary support for Robert Todd, the project has aided the preparation for publication of the final part of his thesis. This publication (Todd et al. 2011c), submitted to the Journal of Geophysical Research, addresses thermohaline structure, down to the submesoscale, in the California Current. This study combines data from underwater gliders with an assimilating model. The model allows calculation of an adjoint that shows the origins of water that ends up at a given location. Layers of thermohaline variance were identified in the observations, and were then traced back in time using the model adjoint. This work directly addresses two of our long-term goals of quantifying the submesoscale, and of using glider data assimilating models.

Martha Schonau is focusing on glider data in the North Equatorial Current (NEC). As a first task, she is comparing glider data to the Argo float climatology for the region. Not surprisingly, the same general feature appear in both glider and float data. However, gliders produced a reliable mean in three years, while the float data comprises over ten years. Also, the direct measurement of currents by gliders has revealed undercurrents that are only hinted at in the float climatology.

RESULTS

Scientific results of the combined glider/modeling study of thermohaline structure are as follows:

- Layers of high thermohaline variance are found associated with the major water masses of the California Current System
- Origins of these water masses, as revealed by the assimilating model, are consistent with historical inferences from hydrography
- Effective diffusivities derived from the assimilating model indciate the importance of stirring, and are consistent with previous estimates from drifters.

The first scientific results from OKMC involve glider sections across the NEC, where persistent undercurrents were observed.

IMPACT/APPLICATIONS

- The value of gliders in a regional application is being proved
- The combination of glider observations and an assimilating model allow inference of such difficult to observe quantities as diffusivity
- The success of these glider/model estimates of ocean state suggest that such a system will also be valuable in prediction.
- Graduate students trained in the collection and analysis of glider data will be well positioned to be leaders in autonomous observation of the ocean.

RELATED PROJECTS

Glider data from the Origins of the Kuroshio and Mindanao Current DRI is the focus of analysis moving forward. This project takes advantage of glider technology that has been developed through grants from several agencies including ONR, NSF, and NOAA.

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PUBLICATIONS

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