

## **Origins of the Kuroshio and Mindanao Currents**

Steven R. Jayne  
Woods Hole Oceanographic Institution  
MS 29, Clark 209A  
Woods Hole, MA 02543-1541  
phone: (508) 289-3520 fax: (508) 457-2163 email: [sjayne@whoi.edu](mailto:sjayne@whoi.edu)

Award Number: N00014-10-1-0268  
<http://kirin.apl.washington.edu/okmc/>

### **LONG-TERM GOALS**

The long-term goal of this work is to understand the ocean's circulation in the bifurcation region of the Kuroshio and Mindanao Currents. The westward flowing North Equatorial Current runs into the Philippine coast and bifurcates into the northward Kuroshio and the southward Mindanao Current. The partitioning of the flow into the Kuroshio and Mindanao Currents is an important observable. Quantifying these flows and understanding bifurcation dynamics are essential to improving predictions of regional circulation, and to characterizing property transports that ultimately affect Pacific climate.

### **OBJECTIVES**

The objective of the OKMC program is to make observations of circulation in the area of the western Pacific Ocean where the North Equatorial Current runs into the western boundary near the Philippine Archipelago and bifurcates into the northward-flowing Kuroshio Current and the southward-flowing Mindanao Current. The observations made during OKMC include glider transects, surface drifters and profiling floats. It is anticipated that the mapped circulation will be used elucidate the ocean dynamics in the bifurcation region, and will help us understand what sets the partitioning of the current transports between the Kuroshio and Mindanao Currents. It will also provide improved estimates of the transport of the Mindanao Current, which has been poorly observed historically.

### **APPROACH**

Our approach is to produce objective maps of the circulation utilizing the observations made by the surface drifters and profiling floats and combine them with the sea surface height (observed by satellite altimeters and referenced to the newest generation of geoids), and historical surface drifters and Argo float profiles and trajectories.

### **WORK COMPLETED**

The objective mapping procedures have been tested and validated for the time-mean circulation. The mapping technique is different than traditional objective mapping techniques in that we impose physical constraints on the mapped circulation such as no flow through land in order to make it more consistent with the known physics. This past year, we have rederived the the parameterization for

## Report Documentation Page

*Form Approved*  
*OMB No. 0704-0188*

Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.

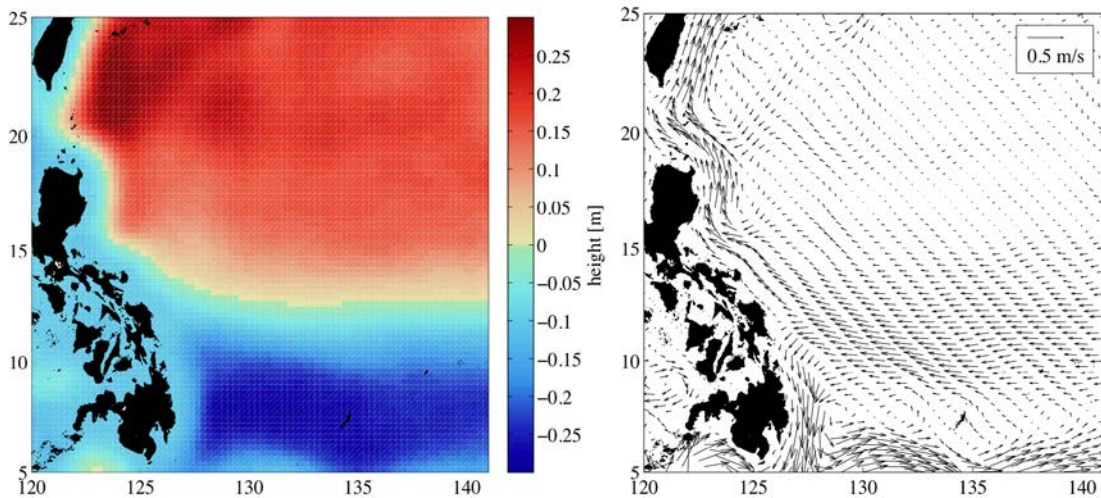
1. REPORT DATE <b>30 SEP 2014</b>		2. REPORT TYPE		3. DATES COVERED <b>00-00-2014 to 00-00-2014</b>	
4. TITLE AND SUBTITLE <b>Origins of the Kuroshio and Mindanao Currents</b>				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) <b>Woods Hole Oceanographic Institution, 266 Woods Hole Rd, Woods Hole, MA, 02543</b>				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT <b>Approved for public release; distribution unlimited</b>					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT <b>unclassified</b>	b. ABSTRACT <b>unclassified</b>	c. THIS PAGE <b>unclassified</b>			

removing the wind-driven Ekman component of the surface drifter velocities. We also have incorporated the beta-plane geostrophic balance at the Equator into our mapping technique.

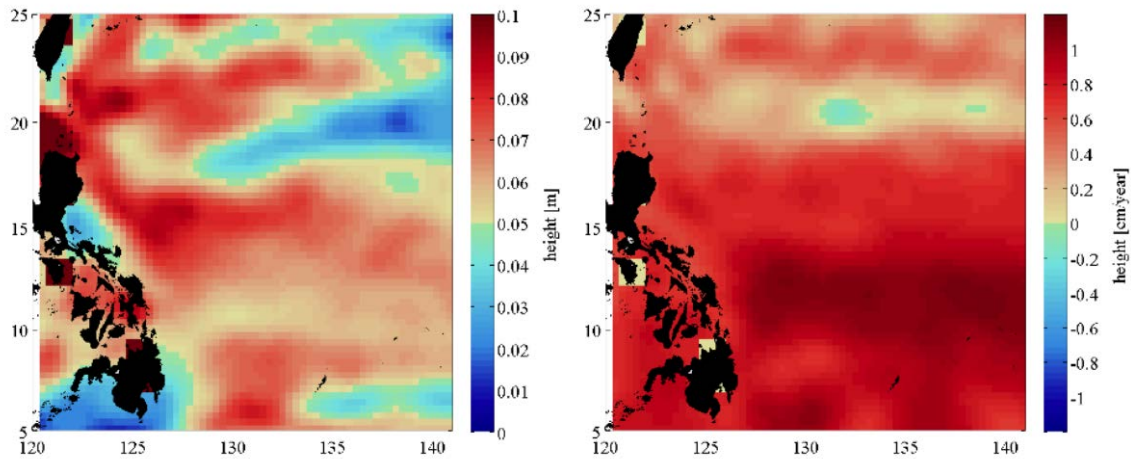
## RESULTS

Altimeter derived circulation is noisy, and unphysical near the coast. But estimates of the large-scale circulation from velocity (drifter) data alone are too weak due to noise in drifter data and the objective mapping technique. This can be overcome if we include both data types, sea surface height and surface drifter velocities to make a combined estimate. Additionally, the unrealistic flow through topography implied by the sea surface height can be overcome with a dynamic constraint that specifies no flow through topography. An objectively mapped surface circulation in the bifurcation region is shown in Figure 1.

We must also contend with the fact that the observations are not all simultaneous in time and space, and therefore need to be adjusted to the same time period. This can be accomplished by calculating the seasonal cycle and secular trend from the observations. For example, in Figure 2, we show the amplitudes of these terms. It is noteworthy that this region has the highest rate of sea level change anywhere in the world.



**Figure 1: Objectively mapped time-averaged sea surface height (right) and surface geostrophic current (left). The mapped fields are estimated by objectively mapping the sea surface height, surface drifters (corrected for Ekman velocities) and the constraint of no flow through topography.**



**Figure 2: Annual amplitude of the annual cycle (right) and secular trend (left) in sea surface height. Note this region has the largest secular trend of increasing sea surface in the world.**

## IMPACT/APPLICATIONS

It is anticipated that the mapped circulation will be used to elucidate the ocean dynamics in the bifurcation region, and will help us understand what sets the partitioning of the current transports between the Kuroshio and Mindanao Currents. It will also provide improved estimates of the transport of the Mindanao Current which has been poorly observed historically.

## RELATED PROJECTS

Similar maps of the sea surface height and velocity field are being developed for the global ocean for the Argo program (<http://www.argo.net>) and the Ocean Surface Topography Science team (<https://sealevel.jpl.nasa.gov/science/ostscienceteam>).