Gliders monitor western boundary current transport in the Solomon Sea

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1. Project Summary

The western boundary current in the Solomon Sea is the primary pathway by which waters from the subtropical South Pacific reach the equatorial zone and the Equatorial Undercurrent in particular. It is, therefore, an important link of the shallow overturning circulation that supports interannual to decadal climate variability in the Pacific, and which provides the "memory" carried by the ocean. This project seeks to observe and understand fluctuations of the transport through the Solomon Sea. Underwater gliders are used to make 9-12 transects each year crossing the Sea to build a time series of transport variability. Analysis of this time series is determining how and why transport and water properties vary, how these affect and are affected by ENSO (El Niño/Southern Oscillation) and decadal variability, and local impacts affecting Solomon Sea residents.

The glider data can be viewed and plotted in near real-time at spray.ucsd.edu and is available for downloading from this server with a password available on request. This data is intended to be useful to climate analysts seeking to understand and predict interannual-decadal variability in the Pacific, especially those building simulation and prediction models of ENSO and the Pacific's shallow overturning circulation.

The glider transects have been operating since July 2007, with increasingly-frequent crossings of the Solomon Sea towards our target of monthly sections. This repeat schedule is designed to accurately monitor the interannual transport fluctuations, primarily to resolve the ENSO signal; as almost no previous data was available, the target is based on our evolving experience with the initial years of glider sampling. To better understand the errors due to shorter-timescale variability, during FY12 we deployed PIES (Pressure Inverted Echo Sounders) and mini-temperature/salinity moorings at each end of the glider line. These measure summary cross-Sea values at hourly intervals, providing an estimate of short-term signals that the glider may have missed.

This report covers the part of the Solomon Sea glider project conducted by the PI (Kessler) at NOAA/PMEL. This element involves on-site operations in the Solomon Sea, and is conducted integrally as part of the parent project of the same title, with Drs. Uwe Send and Russ Davis (Scripps/UCSD) as PIs and Kessler as Co-PI. Other aspects of this project, including the scientific accomplishments and data output, are discussed in the longer Send-Davis-Kessler report.

The PMEL portion of the glider funding is entirely for PI travel to the Solomon Sea region. There are three goals for this travel: (1) To deploy and recover gliders and associated moorings; (2) To negotiate and maintain our EEZ clearances; (3) To manage in-country capabilities (operational contacts, boat charters, customs, internal shipping).

The glider program is different from many others in that we work from shore using local small boats; in addition, to fully sample the western boundary current, the gliders approach within 3km of the coast on both sides of the Solomon Sea. These mean that our operations are conspicuous to the local people, and that our sampling is sensitive to governments in that we make measurements very near to coasts, populations, and economic activity (fishing). Thus, relations with the two governments involved (Papua New Guinea and the Solomon Islands) can be delicate and require ongoing diplomacy to maintain. Both governments are wary of foreign researchers, and insist that the findings be shared accessibly with them (beyond the usual requirements of sending copies of the data and published articles) and that their peoples receive some benefit, typically by contributing to their educational systems, also by training local personnel. To meet this requirement, I give regular lectures at schools, colleges and churches. I meet with stakeholders and local government officials as requested. In the Solomon Islands where we have a substantial presence, I liaise with the Solomon Islands Meteorological Service and lecture to their personnel on results from this project. Since the national governments are weak and much actual governance is conducted locally, it is essential to meet regularly with provincial and tribal leaders so that they accept gliders in their fishing areas. Additional benefit results by being a visible, beneficial representative of the United States in these regions where Americans are not often seen.

The key difference between what is attempted here and more ordinary, limited-duration ocean observations is establishing an *ongoing monitoring* presence, with the development of a long time series essential to diagnosing the place of the western boundary current in the climate of the Pacific. That implies a correspondingly ongoing obligation to address the needs of the host countries (and they insist on this), and to be prepared to meet the unique challenges of working in such a remote region. It is this piece of the work that the PMEL funding supports.

2. Scientific and Observing System Accomplishments

As noted above, the PMEL portion of the glider funding is entirely for PI travel to the Solomon Sea region. There are three goals for this travel: (1) To deploy and recover gliders and associated moorings; (2) To negotiate and maintain our EEZ clearances; (3) To manage in-country capabilities (operational contacts, boat charters, customs, internal shipping).

The PI made three trips to the region in FY12 to support the project's objectives:

- In February 2012, he traveled to Misima, Papua New Guinea and to Gizo, Solomon Islands for the initial deployment of the PIES moorings (from locally-chartered boats).
- In April 2012, he traveled to Gizo, Solomon Islands to deploy two gliders.
- In July 2012, he traveled to the region on a French research vessel to deploy the mini-temperature/salinity moorings next to the two PIES, and to (acoustically) download data from the first few months of the PIES.

The PI also successfully negotiated 5-year clearances for the gliders and PIES moorings (through July 2017) in the EEZ waters of Papua New Guinea and the Solomon Islands. Previously we had worked with one or two-year clearances that left us with ongoing uncertainty about the legal status of the program, complications with customs, and required frequent and sometimes-difficult discussions with local authorities. The success of this negotiation puts the program on a firm footing with a timescale commensurate with the interannual sampling we conduct. As part of the agreements with the two governments, the PI committed to share the findings of this project so that these countries can benefit.

This sharing includes contributions to the educational systems (lecturing in schools), meeting with stakeholders (local government and tribal leaders), and working with the national meteorological services so that they can interpret and make use of the observations for local planning. The PI maintains an ongoing connection (in person and by e-mail) with the Dept. of Environmental Science, University of Papua New Guinea (UPNG; Port Moresby), with the Solomon Islands College of Higher Education (SICHE; Honiara), and with the Solomon Islands Meteorological Service (SIMS, Honiara). On each trip to the region the PI prepares lectures on the local ocean circulation at different levels for university, teaching college and secondary school classrooms and conducts extensive discussions with students and faculty. He also lectures in churches and village meetings, and to weather observers.

Data archiving, quality control, distribution and analysis is conducted under the auspices of the parent (CORC) project led by the Co-PIs (Send and Davis), and is discussed there. During FY12, an article describing the first four years of glider results was written and is now in press at the Journal of Physical Oceanography (Davis, Kessler and Sherman, 2012).

Performance measures for the PMEL part of the projects (see FY12 Work Plan) were to:

- Conduct 6 glider missions;
- Deploy two PIES moorings (and an initial data download from each);
- Implement and evaluate the glider sampling strategy.

During FY12, all these measures were met:

- 4 glider missions were deployed (due to scheduling difficulties with our local boat charter, the final 2 were not deployed until early Oct 2012);
- The PIES moorings were deployed in February 2012, along with nearby mini-temperature salinity moorings, and the initial 5 months of PIES data were downloaded (July 2012).

- In April 2012, we began to implement more regularly-spaced glider deployments by training a local man in Gizo to hold and later deploy gliders that we have fully prepared during our trip.

Performance measures for FY13 are to:

- Conduct 6 glider missions, attempting a regular bimonthly deployment schedule. We note that shipping delays are common, and that there is always uncertainty about the availability of the local boats we use for charters. It is unlikely that a perfectly-regular schedule is possible in this remote region that has no modern infrastracture.
- Download PIES data on each glider deployment trip (on the Solomon Islands side), and once/year on the Papua New Guinea side (which requires a special trip).
- Use the high-time-resolution PIES data to evaluate errors resulting from the nearly-bimonthly glider sampling schedule, continue to refine this sampling strategy.

2.1. Outreach and Education

As noted above (section 2), the PI has agreed to contribute to the educational systems in the Solomon Islands and Papua New Guinea as a condition of granting long research clearances. During FY12, he gave the following lectures and consultations:

- Feb 2012. Lecture at the 7th-Day Adventist Church, Misima, Papua New Guinea
- Feb 2012. Lecture at the Misima Secondary School, Papua New Guinea
- Feb 2012. Lecture at the Dept. of Environmental Science, University of Papua New Guinea, Port Moresby, Papua New Guinea
- Feb 2012. Consultation with the Milne Bay Provincial Administrator and staff, Alotau, Papua New Guinea
- Apr 2012. Lecture and discussion with weather observers/forecasters at the Solomon Islands Meteorological Service, Honiara, Solomon Islands

In the United States, the PI lectured to High School Science teachers and discussed strategies for teaching ocean circulation and climate under the auspices of the University of Washington, Program on Climate Change (August 2012).

3. Publications and Reports

3.1. Publications by Principal Investigators

Published:

Hristova, H.G., and W.S. Kessler , 2012: Surface circulation in the Solomon Sea derived from Lagrangian drifter observations. *J. Phys. Oceanogr.*, **42**, doi: 10.1175/JPO-D-11-099.1, 448–458.

Cravatte, S., W.S. Kessler, and F. Marin, 2012: Intermediate zonal jets in the tropical Pacific Ocean observed by Argo floats. *J. Phys. Oceanogr.*, **42**(9), doi: 10.1175/JPO-D-11-0206.1, 1475–1485.

Cravatte, S., A. Ganachaud, Q.-P. Duong, W.S. Kessler, G. Eldin, and P. Dutrieux, 2011: Observed circulation in the Solomon Sea from SADCP data. *Prog. Oceanogr.*, *88*(1-4), doi: 10.1016/j.pocean.2010.12.015, 116-130.

In press:
Davis, R.E., W.S. Kessler, and J.T. Sherman (2012): Gliders measure western boundary current transport from the South Pacific to the equator. *J. Phys. Oceanogr.*, doi: 10.1175/JPO-D-12-022.1.

3.2. Other Relevant Publications

None