LIDAR Studies of Small-Scale Lateral Dispersion in the Ocean

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LONG-TERM GOALS

Our long-term goal is to better understand lateral mixing processes on scales of 0.1-10 km in the ocean. This includes the underlying mechanisms and forcing, as well as the temporal, spatial, and scale variability of such mixing. The particular goal of the present work is to directly observe the processes governing lateral stirring at these scales via high resolution dye release experiments using airborne LIDAR. The broad impacts of this research range from a better understanding of ocean ecosystems and ocean health, to improved parameterizations in numerical models, to a variety of other practical purposes.

OBJECTIVES

This annual report marks the end of year 1 of a 5 year study as part of the "Scalable Lateral Mixing and Coherent Turbulence" (a.k.a., LatMix) DRI. The goal of the present work is to conduct a series of dye release experiments in the seasonal pycnocline and upper ocean to understand lateral dispersion and frontal processes on scales of 10 m to 10 km. The main effort of the present work is a collaboration between J. Ledwell and E. Terray (WHOI), M. Sundermeyer (UMass Dartmouth), and J. Prentice and B. Concannon (NAVAIR).

This project is being performed jointly with a collaborative NSF grant to J. Ledwell, E. Terray, and M. Sundermeyer (see "Related Projects" below). ONR is providing support for the airborne LIDAR operations, and is supplementing our efforts in the field and in analysis under the NSF support.

APPROACH

The vertical and horizontal dispersion and advection of dye release experiments will be monitored on spatial scales of meters to several kilometers in the horizontal, 1-10 meters in the vertical, and on time scales of minutes to hours, up to 4 days. Sampling of the dye will be performed using airborne LIDAR, as well as *in situ* sensors lowered and towed from a ship. Additional measurements of optical characteristics, hydrography, currents, and internal wave characteristics will be used to identify particular driving mechanisms of the observed dispersion. The dye experiments will be coordinated with AUV and microstructure measurements by other investigators to discern forcing mechanisms

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responsible for the dispersion. The dye experiments will also be guided by numerical modeling process studies by other investigators under the DRI, and will provide data for testing such models.

WORK COMPLETED

An engineering field test was conducted in September, 2008, and was reported on in our FY08 annual report under grant number N00014-08-1-0545. A second, more extensive engineering field test / pilot cruise will be conducted in spring, 2010, with the main field efforts to be conducted in summer 2011 and 2012.

Our main efforts in the current reporting year have been to continue our analysis of the 2008 engineering test, and to plan for upcoming field efforts in 2010, 2011, and 2012. To this end, we have completed the following work:

1.) We participated in planning meetings for the LatMix DRI in Monterey in Dec, 2008 and in Chicago in June 2009. We also continue to exchange information with other DRI participants toward planning and coordinating LatMix field efforts, numerical modeling studies, and theoretical analysis. As part of this, we recently produced a draft Site 1 field / cruise plan which was circulated to all DRI participants. We also continue to examine possible field sites for the main Site 1 field experiments.

2.) We have begun planning an engineering field test / pilot cruise for Spring 2010. Participants will include the WHOI and UMass dye PIs, the NAVAIR LIDAR group, the UMass AUV group (Goodman), and possibly other DRI participants.

3.) We continue to work with the NAVAIR LIDAR group, led by Drs. Jennifer Prentice and Brian Concannon, to identify system parameters for their new LIDAR system that optimally enable them to detect and map fluorescent dye patches. Modifications of their LIDAR system are planned for winter 2009, and will be tested as part of the 2010 field tests / pilot study.

4.) Under separate funding (DURIP and collaborative NSF – see "Related Projects" below), we have begun to acquire new field instrumentation that will be used in the upcoming LatMix DRI / NSF field experiments. This includes a SATLANTIC Apparent Optical Properties System, a Sea Sciences Acrobat tow sled, and a new micro CTD and fluorometer sampling package for small-scale surveys of the dye patches.

5.) We continue to explore and develop improved methods for inverting LIDAR waveforms to obtain absolute dye concentrations following our work under previous funding (Terray et al., 2005; Sundermeyer et al., 2007). This includes consideration of LIDAR system characteristics, and ocean optical properties, including effects of multiple scattering. Our primary efforts thus far have been to review the LIDAR literature, and to better understand the constraints associated with the improved methods.

RESULTS

Our engineering field test was conducted in September, 2008, and was reported on in our FY08 annual report under grant number N00014-08-1-0545. Subsequent analysis of data from those tests revealed that:

- The dye signal for the LIDAR will be quite strong at 20 m depth and may well be detectable beyond 50 m depth in clear water.

- It is possible to deploy too much dye - blocking the deeper waters from the light. The experiments must be planned accordingly.
- The aircraft navigation system must be in better condition than it was for the pilot experiment in order to efficiently survey a dye patch. NAVAIR and the pilot are aware of this and claim that their nav system was not its usual self for the experiment.

A second engineering field test / pilot cruise will be conducted in spring, 2010, with the main field efforts to be conducted in summer 2011 and 2012. Further field results will follow those efforts.

RELATED PROJECTS

The above work and findings represent a joint effort on the part of LatMix DRI PIs Ledwell and Terray (WHOI) and Sundermeyer (UMass Dartmouth) under ONR grants N00014-09-1-0175 and N00014-09-1-0194, respectively.

Field instrumentation to be used in the upcoming DRI field work is being purchased in part under DURIP grant N00014-09-1-0825, and in part under a related NSF project entitled "Collaborative Research: LIDAR Studies of Lateral Dispersion in the Seasonal Pycnocline", NSF Awards OCE-0751734 (UMass) and OCE-0751653 (WHOI).

The PIs efforts under the ONR LatMix DRI are being performed in coordination with the PIs efforts under the above mentioned NSF Awards OCE-0751734 (UMass) and OCE-0751653 (WHOI).

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PUBLICATIONS

None to report (yet).