The Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES)

The Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES) is a joint United States and United Kingdom program that will measure mixing in the interior of the Southern Ocean, with fieldwork starting in early 2009. The experiment is motivated by the hypothesis that mixing in the Southern Ocean interior, owing to small-scale turbulence and mesoscale eddy fluxes, plays a controlling role in the ocean's meridional overturning circulation (MOC). The prevalent view of the Southern Ocean MOC assumes that southward eddy mass transport and along-isopycnal mixing in the interior are balanced by diabatic processes in the upper-ocean mixed layer, with negligibly weak interior diapycnal mixing. However, recent observational studies have called this view into question by suggesting that interior diapycnal mixing may be intense in some parts of the Southern Ocean, particularly where the flow of the Antarctic Circumpolar Current (ACC) over rough topography generates internal waves that drive turbulent mixing upon breaking [e.g. *Heywood et al.*, 2002; *Naveira Garabato et al.*, 2004, 2007; *Sloyan*, 2005]. Significant interior diapycnal mixing may short-circuit the MOC water mass transformation thought to occur primarily at the ocean surface. DIMES is therefore aimed at measuring both isopycnal and diapycnal mixing processes of water parcels traveling within the Antarctic Circumpolar Current (ACC) from the smooth topography upstream of Drake Passage into the topographically rough Scotia Sea (see Figure 1).

Understanding the magnitude of mixing rates as well as their geographic and vertical variation is important for evaluating the large-scale ocean circulation. As a number of modeling studies have demonstrated, the global strength of the MOC depends critically on the model's representation of mixing processes in the Southern Ocean interior[e.g. *Danabasoglu et al.*, 1994; *Gregory*, 2000; *Gnanadesikan, et al.*, 2004; *Hallberg and Gnanadesikan*, 2006]. These mixing processes also control the poleward transport of heat within the ocean, the structure of the ACC, and the character of water that upwells and interacts with the atmosphere.

DIMES will take a multi-pronged approach to measuring mixing. Figure 1 provides a schematic time-line of the research program. Diabatic mixing across isopycnal surfaces will be measured by tracking the vertical spreading of a tracer patch released at 110ºW near 1300 m depth (yellow star in Figure 1) in the Upper Circumpolar Deep Water (UCDW). At this level, the tracer patch is expected to take about three years to advect into Drake Passage and through the Scotia Sea. Finestructure and microstructure measurements collected by US and UK free-falling profilers will provide instantaneous measures of diapycnal mixing. These will also be augmented with shearmeter float measurements in the tracer layer and with EM-APEX floats measuring finescale shear and stratification year-round over the upper 1500 m of the water column. Isopycnal (or adiabatic) mixing and dispersion parameters will be determined from acoustically tracked isopycnal-following floats deployed in the same layer as the tracer, and also from the horizontal dispersion of the tracer patch. A mooring array in Drake Passage will measure the set of physical processes by which eddies and internal waves can interact. Hydrographic observations will be made during DIMES cruises, and Bernoulli and box inverse modeling methods are planned to synthesize the observations. Finally, analysis of DIMES data will take advantage of satellite altimetry, both to assess surface mixing

processes and also to evaluate how observations are distributed relative to the meandering dynamical features of the Southern Ocean. The Los Alamos National Laboratory Parallel Ocean Program (POP) and the National Oceanography Centre, Southampton OCCAM have been used to plan the experiment and will be used to further guide it and to interpret the results.

DIMES offers a range of opportunities for complementary work. The DIMES research cruises will visit remote parts of the southeastern Pacific, presenting opportunities for surface drifter and Argo float deployment. DIMES will deploy a major sound source array in the Antarctic Circumpolar Current region that could support ancillary float programs or permit the deployment of additional RAFOS-enabled Argo floats. Complementary efforts aimed at improving measurements and assimilation of meteorology and surface fluxes would be especially welcome as a means to better assess surface diabatic transformation processes. Further, DIMES research cruises hold great potential for biogeochemical measurements in a remote region of high biogeochemical importance, within an extraordinarily well characterized physical environment.

Ultimately, the DIMES experiment should provide results for improving the representation of mixing processes in numerical models of the ocean and climate. Modeling efforts funded as part of DIMES focus on issues specific to the field program but do not cover hypothesis-driven modeling of the circulation or detailed testing of mixing parameterizations in climate models. The DIMES project team welcomes interactions with modeling groups interested in these activities. The DIMES website is: http://dimes.ucsd.edu/

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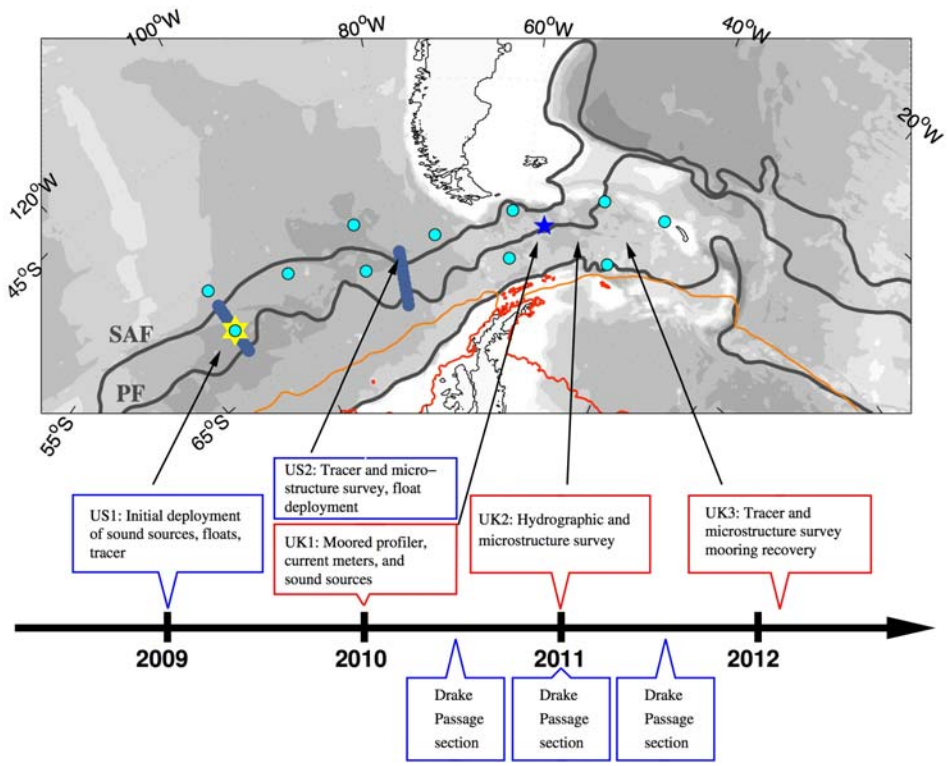

Fig. 1: Geographic location and time-line of the DIMES field program. SAF: Sub Antarctic Front; PF: Polar Front; Cyan dots: Sound sources; Blue dots: float releases; Yellow star: Tracer release; Blue star: Mooring array.