Further, the necessary precision of the information needed for planning and forecasts of possible future food insecurity is far lower than that required to estimate current food aid needs. FEWS NET has recently begun to assess future changes in food security status due to biophysical and socioeconomic events through a twice-a-year projection of food security conditions. The food security outlook product has pushed forecasts and statistical projections of observations into the forefront of the early warning activity. Integrating projections with remote sensing observations will greatly improve the utility and integration of forecasts into operational networks.

References

Barnett, T. P., D. W. Pierce, and R. Schnur (2001), Detection of anthropogenic climate change in the world's oceans, *Science, 292*, 270–274.

Brown, M. E., J. E. Pinzon, K. Didan, J. T. Morisette, and C. J. Tucker (2006), Evaluation of the consistency of long-term NDVI time series derived from AVHRR, SPOT-Vegetation, SeaWiFS, MODIS and LandSAT ETM+, *IEEE Trans. Geosci. Remote Sens., 44*(7), 1787–1793.

Brown, M. E., J. E. Pinzon, and S. D. Prince (2007), Using satellite remote sensing data in a spatially explicit Price model, *Land Econ.*, in press.

Funk, C. C., and M. E. Brown (2006), Intra-seasonal NDVI change projections in semi-arid Africa, *Remote Sens. Environ., 101*(2), 249–256.

Funk, C., et al. (2003), Estimating Meher crop production using rainfall in the "Long Cycle" region of Ethiopia, Univ. of Calif. and U.S. Geol. Surv. EROS Data Cent., Santa Barbara, Calif.

Funk, C., et al. (2005), Recent drought tendencies in Ethiopia and equatorial-subtropical eastern Africa, Famine Early Warning Systems Network special report. (Available at http://www.fews.net/)

Funk, C. C., V. P. Verdin, and G. Husak (2007), Integrating observation and statistical forecasts over sub-Saharan Africa to support Famine Early Warning, paper presented at the 87th American Meteorological Society Annual Meeting, San Antonio, Tex., 13–18 Jan.

Hoerling, M., J. Hurrell, J. Eischeid, and A. Phillips (2006), Detection and attribution of twentieth-century northern and southern African rainfall change, *J. Clim., 19*, 3989–4008.

Husak, G., J. Michaelsen, and C. C. Funk (2007), Use of the gamma distribution to represent monthly rainfall in Africa for drought monitoring applications, *Int. J. Climatol.*, in press.

May, R. (2005), Open letter from the Royal Society to G8 energy and environment ministers, R. Soc., London. (Available at http://www.royalsoc.ac.uk/page.asp?id=3834)

Murphy, S., and K. McAfee (2005), U.S. food aid: Time to get it right, Inst. for Agric. and Trade Policy, Minneapolis, Minn.

Verdin, J. P., C. Funk, G. Senay, and R. Choularton (2005), Climate science and famine early warning, *Philos. Trans. R. Soc. London, Ser. B, 360*(1463), 2155–2168.

Author Information

Molly E. Brown, Science Systems and Applications, Inc., NASA Goddard Space Flight Center, Greenbelt, Md.; E-mail: molly.brown@nasa.gov; Christopher C. Funk, Climate Hazards Group, Department of Geography, University of California, Santa Barbara; Gideon Galu, U.S. Geological Survey and the Famine Early Warning Systems Network, Nairobi, Kenya; Richard Choularton, Chemonics International and the Famine Early Warning Systems Network, Washington, D. C.

NEWS

Mixing and Stirring in the Southern Ocean

PAGES 382–383

The vertical and horizontal mixing of waters within the ocean affects the Earth's climate because it controls the poleward transport of heat and carbon within the ocean, the structure of the large-scale currents, and the character of water that upwells and interacts with the atmosphere. Particularly in the Southern Ocean, ocean general circulation models can show different behavior depending on the exact representation of mixing. To date, however, measurements of this mixing have not been available because of the remoteness and difficult working conditions in the Southern Ocean.

The Diapycnal and Isopycnal Mixing Experiment in the Southern Ocean (DIMES) seeks to understand the regional importance of the Southern Ocean to global circulation by measuring large- and small-scale mixing processes. In the ocean, water moves primarily along surfaces of constant potential density (isopycnals), but it can also mix and change density between these surfaces in what is known as diapycnal mixing. This experiment, a joint effort between U.S. and U.K. scientists, will begin fieldwork in early 2009.

The experiment is motivated by the hypothesis that mixing in the Southern Ocean interior plays a controlling role in the dynamics of how the ocean circulates water on a global scale, a phenomenon called the meridional overturning circulation. Past studies of this circulation have often assumed that water travels southward in the ocean interior, upwells along isopycnals in the Southern Ocean, and is transformed by air-sea exchanges as it returns northward at the ocean surface, with negligible diapycnal mixing in the ocean interior. 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 Antarctic Circumpolar Current (ACC) encounters rough topography.

In the experiment, diapycnal mixing will be measured by tracking the vertical spreading of a tracer patch of 480 kilograms of trifluoromethyl sulfur pentafluoride (CF_3SF_5) that will be released at 60°S, 110°W near 1300-meter depth. At this depth, the tracer patch is expected to take about 3 years to advect into Drake Passage and through the Scotia Sea. High-resolution measurements of the vertical variations in the ocean (known as fine structure and microstructure) to be collected by U. S. and U.K. vertical (free-falling) profilers will provide instantaneous measures of diapycnal mixing. These measures will be augmented by floats that measure vertical velocity shear in the tracer layer and by electromagnetic Autonomous Profiling Explorer (APEX) floats that measure fine-scale shear and stratification year-round over the upper 1500 meters of the water column.

Isopycnal 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 experiment cruises, and inverse modeling methods are planned to synthesize the observations. Finally, analysis of experiment data will take advantage of satellite altimetry in order to assess surface mixing processes and to evaluate how observations are distributed relative to the meandering dynamical features of the Southern Ocean. Models run at the Los Alamos National Laboratory (LANL), the National Oceanography Centre, Southampton (NOCS), and the University of East Anglia will be used to further guide the experiment and to interpret the results.

DIMES offers a range of opportunities for complementary work. The experiment's 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 that could support ancillary float programs or permit the deployment of additional acoustically tracked Argo floats in the Antarctic Circumpolar Current region. Complementary efforts aimed at improving measurements and assimilation of meteorology and surface fluxes would be especially welcome. The experiment's research cruises also have the potential for biogeochemical measurements in a region of high importance, within a well-characterized physical environment.

Ultimately, results from the experiment should facilitate improvements in the representation of mixing in numerical models of the ocean and climate. While modeling efforts funded as part of the experiment focus on issues specific to the field program and 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.

A schematic timeline of the experiment, a map, and other information are available at http://dimes.ucsd.edu.

Acknowledgments

DIMES investigators include Peter Lazarevich and Louis St. Laurent (Florida State University, Tallahassee); Timothy F. Duda, John M. Toole, and W. Brechner Owens (Woods Hole Oceanographic Institution (WHOI), Woods Hole, Mass.), Joseph H. LaCasce (WHOI and University of Oslo); James B. Girton and Luc Rainville (Applied Physics Laboratory, University of Washington, Seattle); Harry L. Bryden, Brian A. King, and David A. Smeed (National Oceanography Centre (NOC), Southampton, U.K.); Andrew J. Watson, Karen J. Heywood, David P. Stevens, and Marie-Jose Messias (University of East Anglia, Norwich, U.K.); Michael P. Meredith and Emily F. Shuckburgh (British Antarctic Survey); and Mark E. Inall (Scottish Association for Marine Science). Mathew Maltrud (Los Alamos National Laboratory), Julie McClean (Scripps Institution of Oceanography, La Jolla, Calif.), and Andrew Coward, Mei-Man Lee, and Beverly de Cuevas (NOC) have helped DIMES by providing preliminary modeling studies. DIMES is funded by the U.S. National Science Foundation, the U.K. Natural Environment Research Council, and the British Antarctic Survey.

Author Information

Sarah T. Gille, Scripps Institution of Oceanography, La Jolla, Calif.; E-mail: sgille@ucsd.edu; Kevin Speer, Florida State University, Tallahassee; James R. Ledwell, Woods Hole Oceanographic Institution, Woods Hole, Mass.; and Alberto C. Naveira Garabato, National Oceanography Centre, Southampton, U.K.