screened intervals (415–421 m and 689–695 m; Figure 2) in the observations wells will be useful in addressing these groundwater issues. Dissolved helium values should help to estimate the age of the water in the crater. If the water is extremely old, isotopic ratios of helium and other noble gases could provide information on the impact processes and materials.

Cores were also sampled and preserved to analyze for evidence of microbial activity. Yellow-green fluorescent microspheres, which are highly visible in a core sample under the microscope, were added to the core barrel before coring to check for surface contamination (adapted from *Smith et al.* [2000]).

If microbes are found, they may have been isolated for millions of years because of the unusually slow groundwater flow rates, and may have endured extreme environmental conditions during and following impact similar to those of the Earth's early history.

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INSTANT: A New International Array to Measure the Indonesian Throughflow

PAGES 369, 376

The Indonesian Throughflow (ITF) is the leakage of western tropical Pacific water into the southeastern tropical Indian Ocean through the Indonesian seas. The ITF is an important pathway for the transfer of climate signals and their anomalies around the world's oceans. While the heat and fresh water carried by the ITF are known to affect the basin budgets of both the Pacific and Indian Oceans, the magnitude and vertical distribution of the ITF are not well known, giving little guidance to the initialization and validation of ocean circulation and climate models.

In response to this lack of knowledge, the International Nusantara Stratification and Transport (INSTANT) program was established to directly measure the ITF. Scientists from Indonesia, France, Netherlands, United States, and Australia make up the collaborative INSTANT partnership.

The INSTANT field program began in August 2003 and consists of a 3-year deployment of an array of moorings and coastal pressure gauges that will directly measure sea level and full-depth in situ velocity, temperature, and salinity of the ITF. For the first time, simultaneous, multipassage, multiyear measurements will be available, and allow the magnitude and properties of the interocean transport between the Pacific and Indian Oceans to be unambiguously known. The array will also provide an unprecedented data set revealing how this complex and fascinating region responds to local and remote forcing at many timescales never before well resolved.

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Pathways Through the Indonesian Seas

The thousands of islands and numerous passages that connect a series of large, deep basins within the Indonesian seas provide a tortuous and circuitous route for the ITF (Figure 1). The tendency for ocean boundary currents to pass through the westward-most available passage, and the sill depths of the various passages, largely define this pathway. Observations and models suggest that surface to upper thermocline waters of North Pacific origin flow through the relatively shallow and most westward Makassar Strait, while lower thermocline and deeper water masses of direct South Pacific origin arrive through the eastern Maluku and Halmahera Seas, with a dense water overflow at Lifamatola Passage. The ITF exits into the Indian Ocean through the major passages along the Lesser Sunda Island chain: Lombok Strait, Ombai Strait, and Timor Passage.

During their transit, Pacific waters are converted into the distinctly fresh Indonesian Sea profile that is observed streaking across the South Indian Ocean within the zonal jet of the South Equatorial Current. The Pacific temperature and salinity stratification, as well as the local sea surface temperature, are modified by the strong air-sea fluxes, seasonal wind-induced upwelling, and large tidal forces within the Banda Sea [*Ffield and Gordon*, 1992]. Furthermore, recent monitoring programs suggest large differences in peak seasonal transport between the ITF inflow and outflow. The Banda Sea appears to act as a reservoir for warm surface waters, filling up and deepening its thermocline during the northwest monsoon, while during the southeast monsoon, Ekman divergence in the Banda Sea combined with lower sea level south of the Lesser Sunda Islands draw waters into the Indian Ocean.

However, because of possible sampling biases in the previous measurements of the inflow and outflow—the data covered different time periods, straits, and depths—transport imbalances into and out of the internal Indonesian seas cannot as yet be unambiguously determined. The modification and volume of stored waters within these seas could have a significant impact on the Indian Ocean heat, fresh water, and mass budgets and will dramatically affect the interpretation of the throughflow measurements if made over short timescales.

The Magnitude and Variability of the Indonesian Throughflow

The magnitude and variability of the ITF are still sources of major uncertainty for both the modeling and observational communities. They are the dominant sources of error in the basinwide heat and freshwater budgets for the Pacific and Indian Oceans [*Wijffels et al.*, 2001]. Though general circulation models are gradually improving, they are unable at present to reproduce the narrow passages and convoluted bottom topography of the internal Indonesian seas in order to adequately resolve the structure and variability of the ITF transport. Earlier estimates of the mean throughflow were wide-ranging (2–22 Sv) in part because of the lack of direct measurements, but also because of the real variation that can severely alias mean estimates if survey periods are not sufficiently long.

Recent measurements reveal an unanticipated richness in the timescales of throughflow variability from intraseasonal (40–60 days) to interannual (Pacific El Niño and Indian Ocean dipole events). The different timescales are likely the result of remote forcing by both the Pacific and Indian Ocean winds, and the local monsoon forcing within the regional Indonesian seas [*Wijffels and Meyers*, 2004]. While the recent measurements suggest the Makassar Strait inflow transport of 9.3 Sv is comparable to the

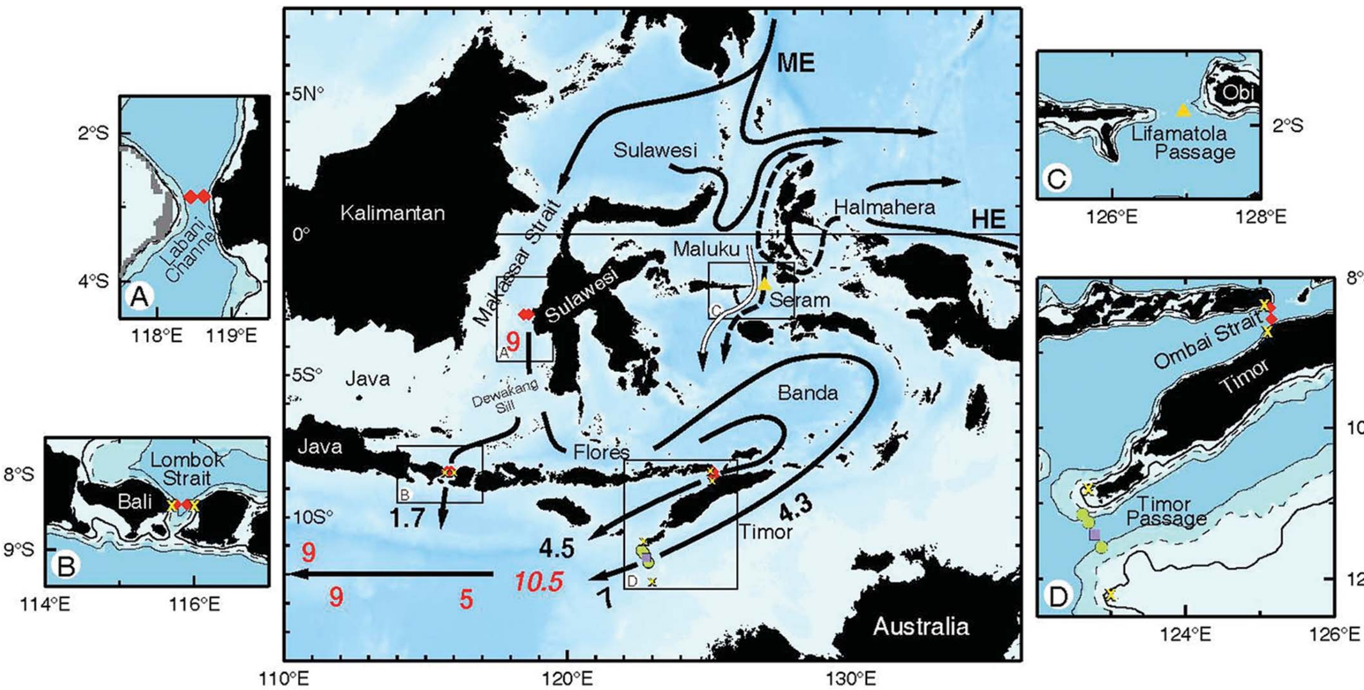

Fig. 1. Schematic of Indonesian Throughflow pathways (black numbers represent previously determined transport in Sverdrups (10^6 m^3/s), and red numbers are total transports determined for the inflow and outflow passages; see Gordon *[2001]. ME is the Mindanao Eddy and HE is the Halmahera Eddy. Insets A-D show positions of INSTANT moorings. Inset A: Makassar Strait inflow moorings (USA: red diamond) within Labani Channel. Inset C: Lifamatola Passage mooring (Netherlands: yellow triangle). Inset B and D: Lesser Sunda Island moorings in Ombai Strait and Lombok Strait (USA: red diamonds) and Timor Passage (France: purple square; Australia: green circles), and shallow coastal pressure gauge locations (USA: yellow X).*

transport sum of 10.5 Sv through the exit passages (Figure 1), these mean ITF estimates should be interpreted with caution, as the time series were made in different years and at different phases of the El Niño cycle.

The INSTANT Fieldwork

A total of 11 deep-ocean moorings were deployed within the major Indonesian inflow passages of Makassar Strait and Lifamatola Passage and the exit passages of Lombok Strait, Ombai Strait, and Timor Passage (Figure 1). These subsurface moorings have a relatively dense suite of discrete velocity, temperature, and salinity sensors designed to resolve the net ITF property transports. Most moorings were instrumented with upward looking Acoustic Doppler Current Profilers (ADCPs) to measure the velocity of the surface layer. The Makassar and Lifamatola moorings also have downward looking ADCPs to measure the deep, dense water overflows. The mooring measurements will be maintained over a 3-year period, which is sufficiently long to resolve several annual cycles and capture some interannual variability. Deployment cruises also included conductivity-temperature-depth (CTD) surveys to capture the temperature and salinity structure within the Indonesian seas, and underway velocity measurements from shipboard ADCPs.

In August 2003, the first INSTANT mooring was deployed in the East Timorese waters of southern Ombai Strait from the Australian R/V *Southern Surveyor.* As for all INSTANT mooring deployments, strong tidal currents within the narrow passages made the mooring layout challenging. The rest of the INSTANT moorings were deployed in Timor Passage, northern Ombai Strait, and Lombok Strait from the Indonesian R/V *Baruna Jaya VIII* in December 2003 and January 2004, and in Makassar Strait and Lifamatola Passage from the R/V *Baruna Jaya I* in January 2004.

During the *Baruna Jaya VIII* cruise along the Lesser Sunda Islands, underway ADCP measurements suggested that in the upper 150 m, the South Java Current was strongly eastward across the Savu Sea and through Ombai Strait. This boundary current reverses semiannually in response to remote wind changes in the equatorial Indian Ocean. CTD casts in northern Ombai Strait during the cruise showed the warm, fresh water of the South Java Current had lowered the upper layer salinity compared with the August 2003 cruise. Below 150 m, a strong throughflow was found in both Ombai and Sumba Straits. In Lombok and Timor Straits, a persistent and clearly identifiable throughflow was found in the upper 300 m.

Within Makassar Strait, CTD profiles showed very low salinity marking the northwest monsoon export of fresher water from the South China Sea and the Java Sea. These fresh waters from the south act to decrease and, at times, reverse the southward flow within the Makassar Strait surface layer [*Gordon et al.*, 2003]. CTDs taken in the deep overflow across the Lifamatola Passage show that the 1940-m Lifamatola sill allows the deep water from the Pacific Ocean to enter the Banda Sea, where it must upwell through mixing with the overlying thermocline waters, thus creating a heat sink.

In the future, these quasi-synoptic views of the property characteristics from the cruise data will be interpreted in the context of the 3-year moored data that will allow changes in properties and flow to be related.

Potential Long-Term Monitoring of the Indonesian Throughflow

In the long run, cost-effective techniques for developing proxy-ITF monitoring are ultimately needed in order to determine ITF transport information over timescales long enough to be important to climate variability. One feasible approach comes from linking changes in the thermal structure to ITF transport. This approach has been successful using subsurface temperature data available from ongoing repeat transects of XBT measurements in the Indonesian seas [*Ffield et al.*, 2000; *Wijffels and Meyers*, 2004]. Another technique for proxy ITF monitoring comes from linking the changes in ITF transport to the cross-strait changes in observed or remotely sensed sea level, or (equivalently) coastal pressure gauge data or inverted echo sounders equipped with pressure gauges (PIES). The PIES technique was successfully employed by *Waworuntu et al*. [2001] to measure the throughflow by monitoring the pressure gradient along the Makassar Strait. Shallow pressure variations were observed from coastal pressure gauges deployed in the exit passages of Indonesia from 1996 to 1999 [*Hautala et al.*, 2001], and the pressure sensors were again deployed in these passages as part of the INSTANT fieldwork. The transport fluctuations are calculated assuming geostrophy to relate the cross-strait pressure gradient to velocity, and total transport is obtained by scaling the inferred surface flow to the concurrent velocity measured by the corresponding moored current meter or ADCP. In fact, the direct measurements of the ITF by the INSTANT moorings will be fruitful and necessary to help mold and ground truth the assumptions needed to convert all proxy data to ITF transport information.

The INSTANT program offers the possibility for additional experiments to take place over the 3-year deployment period. Such activities would benefit by being carried out during the INSTANT field phase, and would add value to the INSTANT data set. Examples of value enhancements include studies of biodiversity and primary productivity, ARGO float deployments, and microstructure measurements, among others. In this sense, INSTANT may be viewed as an umbrella program for these experiments, the moorings being at the core.

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NSF Geosciences Advisory Committee Seeks Input

PAGE 370

The Geosciences Advisory Committee of the U.S. National Science Foundation (NSF) is soliciting the views and concerns of the geosciences community in advance of the committee's fall meeting scheduled for 27–29 October at NSF Headquarters in Arlington, Virginia. At this meeting, the committee will consider current and future geoscience plans and programs; priority areas in cooperation with other NSF directorates; and additional issues of relevance to the community.

The chair and members welcome the views and concerns of the geosciences community so they may better represent their constituencies at upcoming meetings of the committee.

To contact current members or to obtain additional information about the committee, including meeting summaries and agenda, visit the Web site: http://www.geo.nsf.gov/geo/about/advisory.htm

The NSF Directorate for Geosciences, through its divisions of atmospheric, earth, and ocean sciences, supports research focusing on understanding and predicting Earth's environment and its habitability. The Advisory Committee consists of representatives of the geosciences community who serve terms of 3 years. The current chair is Robert Detrick of the Woods Hole Oceanographic Institution, Woods Hole, Mass.

MEETINGS

Assessing Hydrological Extreme Events With Geospatial Data and Models

PAGES 371, 375

Prediction of river basin hydrological response to extreme meteorological events is a primary concern in areas with frequent flooding, landslides, and debris flows. Natural hydrogeological disasters in many regions lead to extensive property damage, impact on societal activities, and loss of life. Hydrologists have a long history of assessing and predicting hydrologic hazards through the combined use of field observations, monitoring networks, remote sensing, and numerical modeling. Nevertheless, the integration of field data and computer models has yet to result in prediction systems that capture space-time interactions among meteorological forcing, land surface characteristics, and the internal hydrological response in river basins.

Capabilities for assessing hydrologic extreme events are greatly enhanced via the use of geospatial data sets describing watershed properties such as topography, channel structure, soils, vegetation, and geological features. Recent advances in managing, processing, and visualizing cartographic data with geographic information systems (GIS) have enabled their direct use in spatially distributed hydrological models [e.g., *Beven*, 2000; *Vieux*, 2001; *Maidment*, 2002]. In a distributed model application, geospatial data sets can be used to establish the model domain, specify boundary and initial conditions, determine the spatial variation of parameter values, and provide the spatial model forcing. By representing a watershed through a set of discrete elements, distributed models simulate water, energy, and mass transport in a landscape and provide estimates of the spatial pattern of hydrologic states, fluxes, and pathways.

Distributed hydrologic models provide an effective simulation tool for exploring hydrological processes and predicting the effects of change on watershed response. With the advent of remote sensing and geospatial data, the use of distributed models is increasingly viewed as a means for improving hydrologic understanding, providing quantitative predictions, and interpolating observations via model physics. Recently, the Distributed Model Intercomparison Project (DMIP) highlighted the use of spatially explicit models for flood simulation in gauged and ungauged basins [*Smith et al.*, 2004].
In the foreseeable future, the conjunctive use of distributed modeling and field or remote observations will permit the comparison of spatial patterns of hydrologic states and fluxes which ultimately increase our insight into the hydrological processes operating in a basin [e.g., *Grayson and Bloschl*, 2000].

Collaborative Agreement Established

Recognizing the importance of hydrological hazards and the need to enhance predictive capacity, the Massachusetts Institute of Technology (MIT) and the Consiglio Nazionale delle Ricerche (CNR) of Italy have established a collaborative agreement to conduct bilateral investigations on climate change and hydrogeological disasters, with an emphasis on Mediterranean regions. Recently celebrating its 10-year anniversary (http://smd.src.cnr.it/Irpi/CNR-MIT/index.html), the CNR-MIT Agreement focuses on the potential impact of climatic changes on floods, landslides, and droughts. Major research topics addressed through the