Proceedings of the First Workshop of the TOGA-TAO Implementation Panel

(Honolulu, 9-10 November 1992)

Edited by
Michael J. McPhaden
NOAA/PMEL, Seattle

1. SUMMARY

A first workshop of the TOGA-TAO Implementation Panel was held at the East-West Center at the University of Hawaii in Honolulu on 9–10 November 1992. The purposes of this workshop were to 1) formalize the organizational structure and terms of reference for the Panel, and 2) begin the process of defining strategies that will ensure uninterrupted implementation and long-term maintenance of the TOGA-TAO array. The workshop was attended by 15 participants representing the United States, Japan, Korea, Australia, Germany, and Taiwan. In addition, written input was provided in absentia by a representative from France.

Accomplishments of the workshop include 1) establishment of an organizational structure including terms of reference, membership, and proposed sponsorship by the International TOGA Scientific Steering Group; 2) a detailed plan for TAO cruises in 1993, and an outline of cruise activities for the first half of 1994; and 3) the development of plans for increased coordination and interaction with several programs of overlapping scientific interest.

2. OVERVIEW OF THE TOGA-TAO ARRAY

2.1 Status of the Array

The TOGA-TAO array was designed to provide oceanographic and meteorological observations critical for describing, understanding, modeling, and predicting short-term climate variability, the most prominent mode of which is the El Niño/Southern Oscillation phenomenon. As of November 1992, the array consisted of 53 ATLAS moorings and 6 current meter moorings spanning the region 8°N to 8°S, 95°W to 137°E (Figure 1). ATLAS moorings measure surface winds, air temperature, relative humidity, sea surface temperature (SST) and subsurface temperatures to 500 m depth; daily averages and some spot hourly meteorological data are telemetered to shore in real-time via Service Argos. ATLAS data are also transferred by Service Argos to the Global Telecommunications System (GTS) for distribution to operational oceanographic and meteorological centers. Ocean current measurements are made at selected locations along the equator; at four of these sites, surface meteorology and upper ocean current profiles are telemetered to shore via Service Argos in real-time from PROTEUS moorings. The array is presently supported by the United States, France, Japan, Korea, and Taiwan. In 1992 approximately 340 days of shiptime were required to service the array (east of the dateline, 190 days on NOAA ships; west of the dateline, 120 days on the RV *Le Noroit* and 30 days on the RV *Wecoma*).

TAO Array

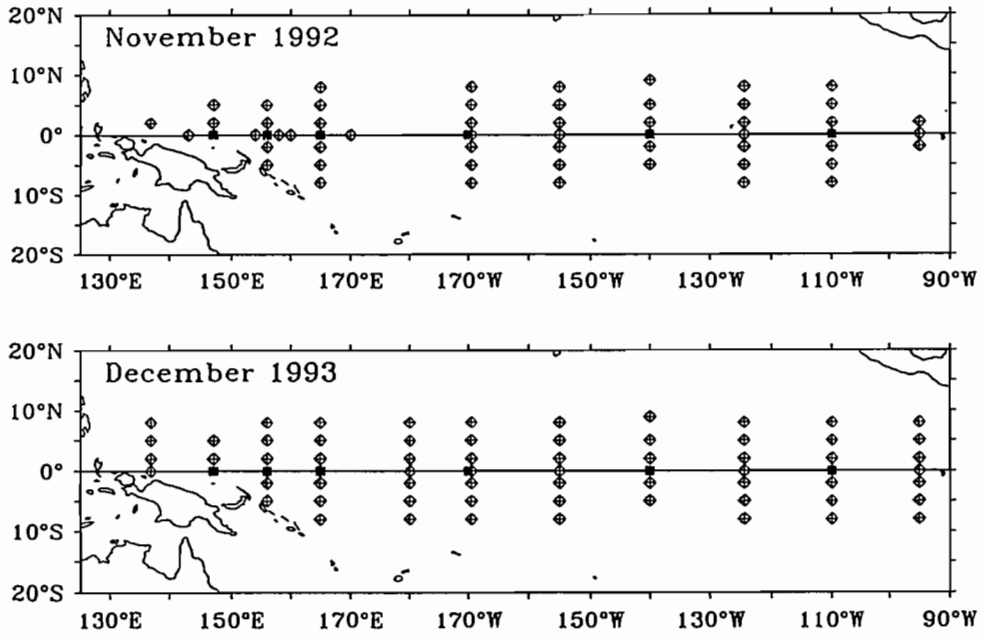

Figure 1. Schematic of the TOGA–TAO Array in November 1992 and December 1993. Diamonds indicate ATLAS moorings and squares indicate current meter moorings.

6.5 Australia (G. Meyers for J. Godfrey, CSIRO)

The interannual variations of rainfall on a continental scale in Australia are influenced as much by patterns of sea surface temperature in the Indian Ocean as by patterns in the Pacific Ocean. An analysis of rainfall by the Australian Bureau of Meteorology showed that one of the dominant modes of variation is associated with a synoptic scale cloud-band that extends across the country from the Northwest Shelf to Victoria, and that the interannual strength of this mode is highly correlated with Indian Ocean SST. The continental scale rainfall during recent episodes of ENSO provide examples of how the Indian Ocean influences prediction-skill in Australia. In the canonical ENSO drought develops in the eastern third of the country. However, during the episode of 1986–87 the drought was largely moderated apparently due to the Indian Ocean influence, and again in 1991–92 it was moderated in Victoria.

Australia therefore strongly recommends extension of TAO into the Indian Ocean for the purpose of better understanding the role of ocean dynamics in the development of Indian Ocean SST. From a global perspective, outcomes of the development would be improved ability to predict the Asian and Australian Monsoons and to predict cyclone activity.

The R/V *Franklin* is scheduled for two voyages in the Indian Ocean in 1994, and could be used for TAO. M. Tomczak of Flinders University will deploy WOCE moorings off the Australian coast and make a hydrographic section south of Sri Lanka in August/September. S. Godfrey will carry out surface heat flux experiments on the return voyage.

Australian and German oceanographers are trying to make the logistical arrangements to deploy a mooring from R/V *Sonne* in August 1993 and recover it by R/V *Franklin* approximately 1 year later, while a visit to the site by R/V *Sonne* may be possible in early 1994. The equipment for the mooring would be provided by both sides. Australian technicians trained by PMEL in TAO mooring technology are available. Godfrey would like to continue the moorings south of the Bay of Bengal from *Franklin* in 1994 if collaborators could be found. Proposals to use *Franklin* for recovery in 1995 will be due in June 1993.

6.7 France (J. Picaut, ORSTOM)

After a first meeting between S. P. Hayes and J. Picaut in Seattle in September 1984, it was decided that the SURTROPAC Group in ORSTOM-Noumea and the Ocean Climate Research Division at NOAA/PMEL in Seattle would work together for the installation and maintenance of a line of ATLAS moorings along 165°E as part of the TOGA program. With the help of the R/V *Coriolis*, two ATLAS moorings were first installed in July 1985. Subsequently, funds for one to two ATLAS per year was made available to NOAA until 1990 by the SURTROPAC Group through direct ORSTOM funding and through contracts with MRT (Ministere de la Recherche et de la Technologie) and PNEDC (Programme National d'Études de la Dynamique du Climat). By 1990, the 165°E line had increased to 5 ATLAS moorings and a new line was planned along 156°E as part of the COARE Enhanced Monitoring Array. This expansion of the international TOGA-TAO effort (Hayes et al., 1991) was made possible with the arrival in Noumea of the R/V *Le Noroit* in early 1991 to replace the RV Coriolis which was retired after 25 years of service.

This cooperation between ORSTOM-Noumea and NOAA/PMEL was extended in 1991 to include the maintenance of PROTEUS moorings (McPhaden et al., 1992) at 0°, 165°E and at 0°, 156°E. Presently, the SURTROPAC Group is responsible for maintaining 12 moorings of the TOGA-TAO array along 165°E and 156°E with the R/V *Le Noroit*. During each semi-annual SURTROPAC and COARE156 cruise along these meridians, a team of U.S. technicians goes onboard *Le Noroit* to work with 2 electronics technicians of the SURTROPAC Group. These SURTROPAC technicians acquired the necessary knowledge for repairing and servicing TAO moorings through several visits to NOAA/PMEL, and through participating in cruises onboard NOAA research vessels.

In addition to the value for real-time monitoring of the 1986–87 and 1991–92 El Niños, the TOGA-TAO array has been used by most of the SURTROPAC scientists for scientific analyses. By using the differentiated form of the zonal momentum balance, Picaut et al. (1989) were able to prove that low-frequency zonal currents are nearly in geostrophic balance at the equator. This work was extended by Picaut et al. (1990) using current measurements from three equatorial moorings in order to estimate low-frequency zonal currents from GEOSAT satellite altimetric measurements. This technique enabled Delcroix et al. (1991) to estimate the importance of equatorial Kelvin and Rossby waves in surface zonal current variability during the 1986–87 El Niño. Delcroix et al. also used ATLAS mooring data to validate the GEOSAT satellite altimetric measurements. Current meter mooring data from 0°, 165°E were used to document interannual displacements of the warm pool associated with El Niño/La Niña episodes during 1986–88 (McPhaden and Picaut, 1990). Henin (1989) compared the dynamic heights calculated from 17 ORSTOM-Noumea and US/PRC cruises with dynamic heights calculated from ATLAS moorings along 165°E, and pointed out the necessity of having salinity measurements in order to accurately determine dynamic heights in the warm pool region from TOGA-TAO data. A comparison of modelled sea level with surface dynamic heights determined from TAO moorings, and sea level determined from tide gauges and GEOSAT data, enabled Menkes et al. (1992) to find that the dissipation in Pacific equatorial long wave models is stronger than expected. Y. du Penhoat is using ATLAS winds together with BODEGA drifter measurements for a study of the diurnal cycle in SST. For the first 6 months of the TOPEX/POSEIDON mission, ATLAS moorings situated at 2°S, 156°E and 2°S, 164°E on satellite track cross-over points have been equipped with surface pressure sensors, 12–15 temperature-salinity recorders, 5–7 deep temperature

recorders, 2 bottom pressure recorders and 2 inverted echo sounders (Picaut et al., 1992). The main purpose of this new co-operation between ORSTOM-Noumea, NOAA/PMEL, NASA/Goddard Space Flight Center and Lamont Doherty Geological Observatory is to validate the TOPEX/POSEIDON altimeter with open ocean sea level measurements of 1–2 cm accuracy. This experiment will also add a lot of additional temperature and salinity information to the COARE experiment.

After servicing TAO moorings on the final regularly scheduled SURTROPAC and COARE cruises in August–September 1992, i.e. SURTROPAC-16 along 165°E and COARE156-3 along 156°E, the R/V *Le Noroit* will do a 3-month long cruise along 156°E during the Intensive Observing Period (IOP) of TOGA-COARE. At the end of the IOP in February 1993, the R/V *Le Noroit* will service TOGA-TAO moorings along 156°E, then sail back to France to be refurbished after 22 years at sea. Given the tremendous needs for research vessel shiptime in mainland France, especially for WOCE cruises, it is anticipated that no French research vessel suitable for deep ocean mooring work will be stationed in Noumea for the remainder of the TOGA program. However, it is expected that the SURTROPAC Group will not disband at the end of TOGA, which means that either *Le Noroit* or another French research vessel would have to be sent to Noumea in support of post-TOGA field work. Discussions on how to develop and maintain operational oceanographic measurements as part of GOOS have started in France under IFREMER leadership.

References

Delcroix, T., J. Picaut and G. Eldin, 1991: Equatorial Kelvin and Rossby waves evidenced in the Pacific Ocean through GEOSAT sea level and surface current anomalies. *J. Geophys. Res., 96*, 3249–3262.

Hayes, S. P., L. J. Mangum, J. Picaut, A. Sumi and T. Takeuchi, 1991: TOGA-TAO: A moored array for real-time measurements in the tropical Pacific. *Bull. Am. Met. Soc., 72*, 339–347.

Henin, C., 1989: Thermohaline variability along 165°E in the western tropical Pacific Ocean (January 1984–January 1989). Proc. Western Pacific International Meeting and Workshop on TOGA-COARE. ORSTOM, Noumea, J. Picaut, R. Lukas and T. Delacroix, eds., 155–163.

McPhaden, M. J., H. B. Milburn, A. I., Nakamura, and A. J. Shepherd, 1991: PROTEUS-Profile telemetry of upper ocean curents. *Sea Tech., 32*, 10–19.

McPhaden, M. J. and J. Picaut, 1990: El Niño/Southern Oscillation displacements of the western equatorial Pacific warm pool. *Science, 250*, 1385–1388.

Menkes, C., J. P. Boulanger, and J. Picaut, 1992: Dissipation in a Pacific long wave equatorial model using tide gauge, mooring and GEOSAT data (in preparation).

Picaut, J., A. J. Busalacchi, T. Delcroix and M. J. McPhaden, 1992: Rigorous open-ocean validation of TOPEX/POSEIDON sea level in the western equatorial Pacific. TOPEX/POSEIDON Joint Verification Plan, Jet Propulsion Laboratory Publication 92-9, pp. V14–16.

Picaut, J., S. P. Hayes and M. J. McPhaden, 1989: Use of the geostrophic approximation to estimate time varying zonal currents at the equator. *J. Geophys. Res., 94*, 3228–3236.

Picaut, J., A. J. Busalacchi, M. J. McPhaden, and B. Camusat, 1990: Validation of the geostrophic method for estimating zonal currents at the equator from GEOSAT altimeter data. *J. Geophys. Res., 95*, 3015–3024.

7.2 The XBT Network and TAO (G. Meyers, CSIRO and N. Smith, BMRC, Australia)

The TOGA/WOCE XBT network in the tropical oceans was planned to use all of the regularly traveled shipping routes, following three sampling strategies developed for different purposes. The purpose of low density sampling is to document large scale patterns of upper layer heat content and to provide a global data set for assimilation in models. The minimum sampling density is one XBT profile per 1.5° latitude by 7.5° longitude, repeated monthly. The coverage of shipping routes obtained in 1991 is nearly complete in the Pacific Ocean, 50% to 100% complete in the Atlantic Ocean and considerably less than 50% in the Indian Ocean. The purpose of frequently repeated transequatorial sections is to monitor the time variation of major currents at six longitudes in the Pacific Ocean and four each in the Atlantic and Indian Oceans. The sampling rate on the selected lines is 18 transects per year with an XBT profile at each degree of latitude. In 1991 this level of sampling was achieved on three lines in the Pacific Ocean and one in the Indian. The purpose of the third sampling strategy, called high density sampling, is to document well resolved synoptic transects of the currents, including narrow currents associated with the continental boundaries, fronts and eddys. Examples of results from the first two modes of sampling were presented.

The XBT network and TAO have been developed separately primarily because they have different capabilities and serve different purposes. However, the time is right to begin considering how the two data sets can be combined to map the thermal variations with large scales. Maps of the depth of the 20°C isotherm were prepared using the thermal analysis system at Bureau of Meteorology Research Center in Melbourne, with all of the available data (XBT and TAO combined) and with XBT-only and TAO-only data sets. The analyses were prepared directly from the observations without using a dynamical model. The mapping errors provided by the statistical analysis scheme showed in a quantitative way how the two networks are complementary. Together they provide a framework covering about half of the tropical Pacific Ocean where the normalized mapping errors (rms error/rms signal) are less than 0.6. Ideally, a model with the correct physics could carry information forward in time filling in the data sparse areas with equally accurate information. The combined data set had a (dimensional) mapping error of 7 m averaged in the equatorial band 7.5°N to 7.5°S, while the XBT data alone achieves a mapping error of 9 m and the TAO data alone an error of 8 m.

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Joël PICAUT
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***** Michael J. MCPHADEN

* ORSTOM, Nouméa ** CSIRO, Canberra *** CSIRO, Hobart
**** BMRC, Melbourne ***** NOAA/PMEL, Seattle

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/Picaut, J.
/Radenac, M. H.
/Eldin, G.
/Rual, P.
Bradley, F.
Godfrey, S.
Meyers, G.
Smith, N.
McPhaden, M.J.

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