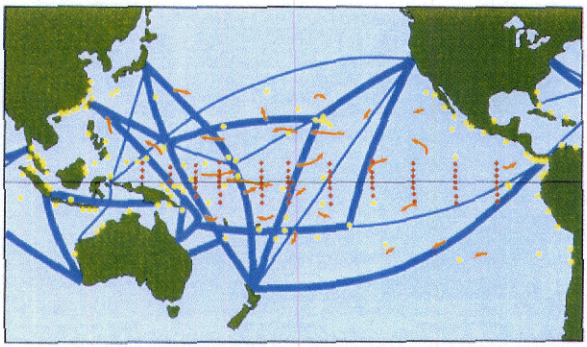
improved instrumentation for monitoring of the global climate system.

The Tropical Ocean Global Atmosphere (TOGA) project was a decade-long research initiative (1985–94) of the World Climate Research Programme, managed by an international consortium, to improve monitoring of the Pacific Ocean as the basis for understanding and predicting the El Niño phenomenon. At the heart of the TOGA project is the TAO array of approximately 70 moored ocean buoys extending across the equatorial Pacific Ocean to systematically measure ocean and meteorological data (Figure II.1). The Atlas buoys of the array are moored and measure surface winds, air temperature and relative humidity, and temperatures in the upper 500 metres of the ocean. The Current Meter buoys measure ocean currents and additional parameters such as shortwave radiation and rainfall.

The TAO array is managed by the Data Buoy Cooperation Panel and coordinated with WMO and the IOC. Observations from the TAO array are automatically collected using the Global Telecommunication System (GTS) of WMO and are available to national Meteorological Services and for meteorological and oceanographic research. A typical Atlas buoy of the TAO array is in Figure II.2. Data are also collected at the US National Oceanic and Atmospheric Administration (NOAA) Pacific Marine Environment Laboratories (PMEL) for archival and analysis. PMEL maintains an Internet site and provides free access to data, and to a range of products obtained by analysis of the data.

Additional information on the vertical temperature structure of the ocean is given by XBT dropped from merchant ships of a fleet of Volunteer Observing Ships coordinated by WMO. The XBT instruments provide better vertical resolution and wider geographical coverage than do sensors on moored buoys but significantly less frequent temporal sampling. The data are collected via the GTS of WMO for use in research and meteorological operations.

Satellites, providing near-global coverage, give spatial representation for many oceanographic and meteorological parameters not available from *in situ* measurements. However, the frequency of sampling from satellite instruments is generally less than can be achieved from *in situ* instruments. It is necessary to maintain calibration of the satellite sensors through regular *in situ* and other specialized



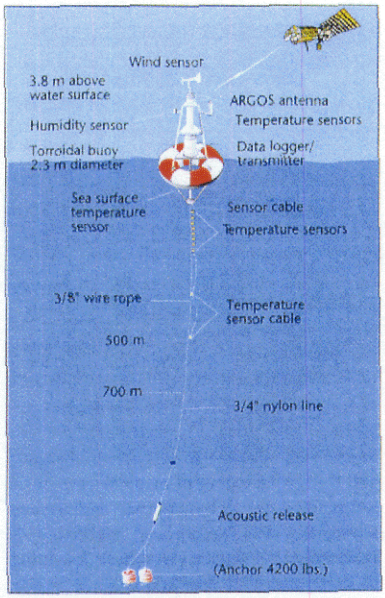


Figure II.1
The main components of the Pacific Ocean climate observing system installed for the decade-long (1985–94) Tropical Ocean Global Atmosphere (TOGA) project to research the El Niño phenomenon. Components include the TAO array of moored buoys (red dots), fixed tide gauges (yellow dots), drifting buoys (orange arrows) and the tracks of volunteer observing ships deploying XBT (dark blue). These systems continued to be available during the 1997–98 El Niño event.
(NOAA/PMEL (TAO Project), USA)

Figure II.2
A schematic diagram of an Atlas buoy of the TAO array of the equatorial Pacific Ocean showing instrumentation and mooring.
(NOAA/PMEL (TAO Project), USA)

measurements. Satellite data and analysed products that are relevant to climate monitoring are also available over the Internet.

Over the past two decades satellite instruments to measure sea surface conditions have improved. The Advanced Very High Resolution Radiometers (AVHRR) on the NOAA weather satellites provide routine near-global coverage of sea surface temperature with good accuracy when blended with ship and buoy observations.

Since 1992 the TOPEX/Poseidon satellite, a joint US and French mission, has provided near-global sea level anomaly data. These new sea level data have spatial coverage not previously possible from the existing network of coastal and island tide gauges, but depend on these gauges for