Improving understanding and prediction of climate variability and change in the Australian region

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Australia has marked climate variability and is potentially sensitive to the impact of climate change. Our project is a coordinated plan, consisting of a number of separate projects, which use satellite altimeter data to improve our understanding and prediction of both climate change and variability, particularly in the Australian region. Our studies are supported by in-situ observational programs and the development of numerical models.

Satellite Altimeter Verification

Satellite altimetry is the only practical way of measuring global sea level change. Calibration and inter-calibration of altimeters is essential if altimeters are to reliably compute long-term variations in sea level. Resolving absolute bias and bias drift at accuracies better than a centimetre and a mm/yr respectively requires continuous observations at verification sites for at least a decade.

At a co-located permanent GPS and tide gauge site at Burnie, Tasmania, an absolute calibration of the Jason-1 (and T/P, ERS/ENVISAT) altimeter will be conducted using fixed GPS receivers, GPS buoys and an array of current meters, pressure gauges, and meteorological instruments.

To study bias drift, a number of tide gauge sites throughout Australia, the South Pacific (AusAid South Pacific Sea level and Climate Monitoring Project) and the eastern Indian Ocean will be used to compare against the Jason-1 altimeter data. Land motion estimates at these sites will be estimated from permanent or episodic GPS sites. This work is done in conjunction with the Australian Marine Science and Technology Limited, the Australian National Tidal Facility (NTF) and the Australian Surveying and Land Information Group (AUSLIG).

Understanding and predicting Australian seasonal-to-interannual climate variability

Australia experiences marked climate variability on interannual time scales. This variability strongly impacts agricultural production, water supply and the frequency and intensity of forest fires. Sea surface temperatures (SSTs) in the Pacific and Indian Oceans are important controls for much of Australia with Southern Ocean temperatures being important on the southern margin of Australia.

The overall goal is to build a global coupled ocean-atmosphere model capable of simulating Australian climate variability and providing realistic projections of the coupled system as an input to climate forecasts up to a year in advance.

For accurate projections, the ocean component of the coupled model must be initialised with a realistic temperature structure. To improve the spatial coverage beyond that available from in situ data sets from eXpendableBathyThermographs (XBTs) and the Tropical Atmosphere Ocean (TAO) Array, satellite sea surface height (SSH) and SST data are being used to infer sub-surface ocean temperatures (synthetic XBTs). A comparison of ocean temperatures measured at the TAO array and inferred from the satellite data is shown in figure 1.

To understand Australian climate variability, improve the model and to build confidence in the model projections, both the coupled and the ocean-only models are currently being run in hindcast mode.

Dynamics of the Antarctic Circumpolar Current (ACC)

The Southern Ocean plays a critical role in decadal and centennial climate variability and in determining the timing and regional impact of climate change. Its circumpolar extent allows interbasin exchange and thus adds a global dimension to the ocean's vertical overturning circulation that dominates ocean heat transport and storage.

This project aims to better understand the dynamics of the ACC, including assessing the variability of the eastward volume, heat and freshwater transport of the ACC, understanding the role of eddies in the meridional transport of momentum and heat, and the development of ocean models of the ACC system.

Full depth hydrographic sections (completed annually from 1991 to 1996 and then once every five years) and upper ocean XBT sections (six sections each summer season) have been used to estimate the baroclinic transport of the ACC. The in-situ data have been used to define a relationship between SSH and the baroclinic transport function such that the altimeter data can be used to derive an ongoing record of the ACC transport. In-situ current meter observations are also being used to estimate poleward transport of heat and momentum for comparison with satellite observations.

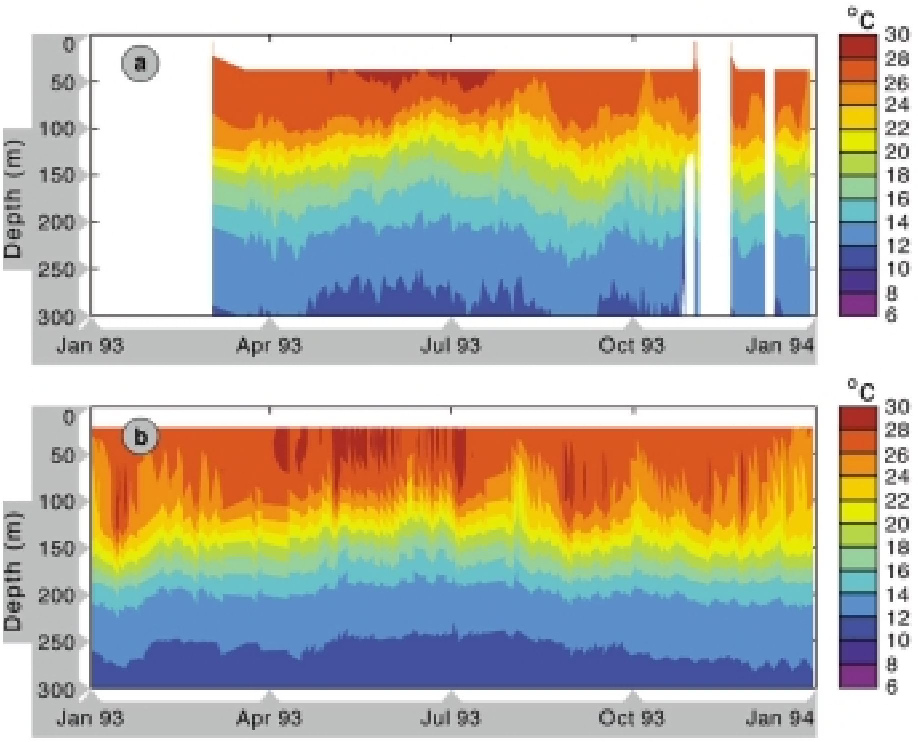

Figure 1: (a) TAO array temperatures in the upper 300 m at site 0°N, 205°E for the period March 1993 to January 1994. (b) Synthetic XBT temperatures at the same site inferred from satellite sea surface height data.

Understanding and modelling the Australian Exclusive Economic Zone (EEZ)

To provide a basis for the management of the Australian EEZ, an Ocean Analysis and Prediction System (Oceans EEZ) is being developed. The primary objective is to implement an operational nowcast system for mesoscale ocean conditions.

Oceans EEZ integrates historical oceanographic observations, fast-delivery altimeter data, SST and other remotely sensed products, and modelling activities over the continental shelf, slope and deep ocean regions to provide a comprehensive description of surface currents, temperatures, salinities, and nutrients. All historical hydrographic data within the region 0-60ºS, 90-200ºE have been used to produce a high resolution (1/4º) ocean climatology atlas enabling a mean surface steric height field to be determined.

During March 1999, complementary oceanographic observations were made along T/P ground-tracks within a few days of satellite overpasses. Figure 2 shows surface currents along the cruise tracks derived from ADCP (Acoustic Doppler Current Profiler) measure-ments (arrows) and the combined CARS/altimeter height anomaly field for the same period. Along section AB (lower panel), the height fields from the CTD and CARS/altimeter also agree well.

This approach is being used to study major current systems and coastal processes around Australia, and their biological impacts (e.g., rock lobster, larval dispersion) and their management implications. Other applications involve search and rescue, pollution prediction, ship routing and naval operations.

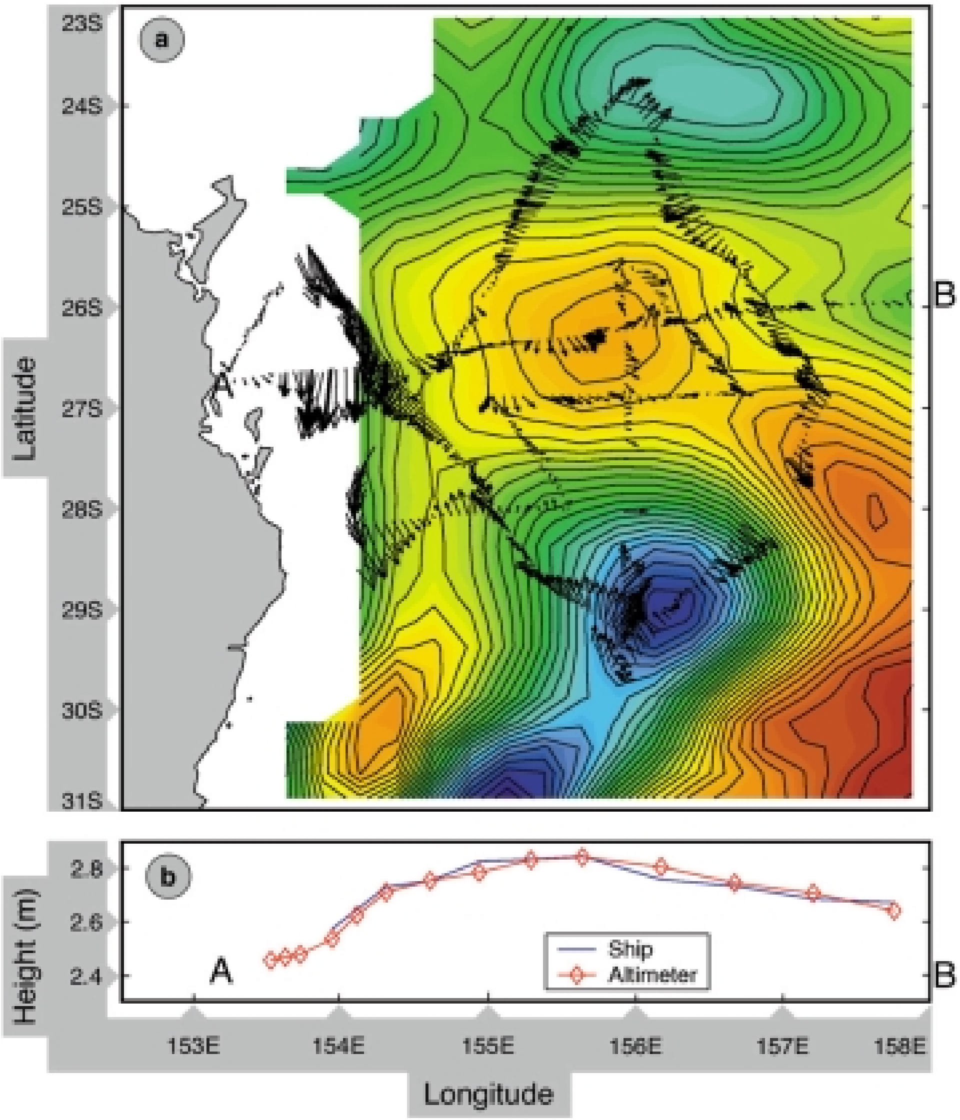

Figure 2: (a) Tasman Sea region of Franklin cruise. Black arrows are surface currents along the cruise tracks derived from the ADCP data, the shaded and contoured areas correspond to the steric height field obtained from CARS climatology and an altimeter height anomaly field. The contour interval is 2.5 cm. Red shading is warmer water and blue shading is colder water. (b) The steric height field along section AB derived from the CARS/altimeter height anomaly field (red) and from CTD measurements (blue). Heights are relative to 2000 dB level.

Other Projects

Satellite altimeter data are also being used to support other projects. These include projects aimed at understanding the basin to global scale circulation and variability, the understanding of western boundary currents and, in collaboration with U.K. scientists, testing of the high resolution OCCAM global ocean model. A study of the transport and variability of the East Australian Current (EAC) has shown that the variability of the EAC transport is related to instabilities that form in the western Tasman Sea, perhaps triggered by anomalies propagating westward across the Tasman Sea. As these instabilities propagate southward they grow in intensity. A further study will investigate the boundary current on the eastern flank of the Kerguelen Plateau where numerical models show large bottom pressure variations. This study will also be of interest to the GRACE mission.

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