Investigation of EUC strengthening via analysis of SODA 2.2.6 and the TAO array (Thermal Thresholds and Projections project, ROGER project)

Website: https://www.bco-dmo.org/dataset/561186
Version: 26 June 2015
Version Date: 2015-06-26

Project
» Constraining Thermal Thresholds and Projections of Temperature Stress on Pacific Coral Reefs Over the 21st Century: Method Refinement and Application (Thermal Thresholds and Projections)
» Repeat Observations by Gliders in the Equatorial Region (ROGER)

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Dataset Description

Investigation of EUC strengthening via analysis of SODA 2.2.6 and the TAO array. Figures published in: Drenkard, E.J., and Karnauskas, K.B. 2014. Strengthening of the Pacific Equatorial Undercurrent in the SODA Reanalysis: Mechanisms, Ocean Dynamics, and Implications. *J. Climate*, 27, 2405–2416. doi:10.1175/JCLI-D-13-00359.1

Methods & Sampling

The investigators:

- calculated the linear trends in zonal velocity, and the significance of these trends, in the short, coinciding SODA and TAO time series (Figure 1; results and locations are reported in Table 1). Analysis performed on monthly and normalized time series;
- calculated the linear trends in maximum zonal velocity (SODA) and their significance over the whole equatorial Pacific domain and at a single location (See Figure 2);
- calculated the linear trends in zonal velocity and vertical density gradient at each SODA grid location in a depth-longitude transect along the equator;
- calculated the long-term, linear trends, by longitude for the windstress, surface zonal velocity and the maximum zonal velocity (over depth range 10-300m);
- calculated the climatological values, climatological linear trends and trend significance for windstress, surface zonal velocity, sea surface hight, zonal transport, and maximum EUC core velocity;
- calculated zonal momentum budget terms for the mean state of the equatorial Pacific and the decadal seasonal difference among these terms (Figures 6 & 7).

Data Processing Description

- Both monthly means and normalized, filtered (13-month running mean) time series for TAO and SODA were used for comparing concurrent records.
- Maximum zonal velocity is calculated as the maximum east west velocity occurring within the EUC core domain (2 degrees N – 2 degrees S, 150 degrees – 90 degrees W and 10 – 300m).
- Monthly means were used to calculate trends in SODA zonal velocity; a 7-yr filtering of this time series of is also shown in Figure 2.
- All longitudinal cross sections are meridionally averaged SODA data from 2 degrees N - 2 degrees S.
- The investigators calculated the zonal momentum budget terms using the equations outlined in the paper and use SODA values for temperature, salinity, sea surface height, velocity (zonal, meridional, and vertical). Values for the vertical and horizontal coefficients of eddy viscosity are approximated from literature estimates as these values were not saved during runs of the SODA reanalysis.
- Momentum budget terms were conducted along isopycnals, which were determined by density binning.

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Parameters

Parameters for this dataset have not yet been identified

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Project Information

Constraining Thermal Thresholds and Projections of Temperature Stress on Pacific Coral Reefs Over the 21st Century: Method Refinement and Application (Thermal Thresholds and Projections)

Description from NSF award abstract:
Sea surface temperature (SST) across much of the global tropics has increased by 0.5-1 degrees C in the past 4 decades and, with it, the frequency and geographic extent of coral bleaching events and reef mortality. As levels of atmospheric CO2 continue to rise, there is mounting concern that CO2-induced climate change will pose the single greatest threat to the survival of coral reefs. Averaged output of 21 IPCC climate models for a mid-range CO2 emissions scenario predicts that tropical SSTs will increase another 1.5-3 degrees C by the end of this century. Combined with current estimates of thermal thresholds for coral bleaching, the outlook for the future of coral-reef ecosystems, worldwide, appears bleak. There are several key issues that limit accurate predictions of the full and lasting impact of rising SSTs. These include (1) level of confidence in the spatial and temporal patterns of the predicted warming, (2) knowledge of thermal thresholds of different reef-building coral species, and (3) the potential for corals to increase resistance to thermal stress through repeated exposure to high temperature events.

New skeletal markers have been developed that constrain the thermal thresholds and adaptive potential of multiple, individual coral colonies across 3-D space and through time. The method, based on 3-D CAT scan reconstructions of coral skeletons, has generated initial data from two coral species in the Red Sea, Great Barrier Reef and Phoenix Islands. Results showed that large, abrupt declines in skeletal growth occur at thresholds of accumulated heat stress defined by NOAA's Degree Heating Weeks Index (DHWs). In addition, there was a significant correlation between host lipid reserve, an independent measure of stress and mortality risk, and rates of skeletal growth. Because the coral skeleton archives the history of each coral's response to and recovery from successive, documented thermal anomalies, this approach pinpoints the thermal thresholds for sub-lethal impacts, the recovery time (if any) following a return to normal oceanographic conditions, and tests for a dampened response following successive events, indicative of acclimation.

This research program builds on initial work, focusing on method refinement and application to corals on two central Pacific reefs. With contrasting thermal histories, these reefs are considered at greatest risk from future ocean warming. In parallel, new experiments will be run on an ocean general-circulation model (OGCM) that is well suited to the tropical Pacific and of sufficiently high resolution, both horizontal and vertical, to maximize projections of thermal stress on specific central Pacific Reef sites over the next few decades. The OGCM output will also be of sufficient temporal resolution to compute DHWs, thus addressing a major limitation of the direct application of global climate model output (as archived for the IPCC AR4) toward coral-reef studies. Specifically, this study will: (1) collect multiple new, medium-length (15-30 yrs) cores and branches from two dominant reef-building species at 1-30m depth in the Gilbert and Jarvis Islands, central tropical Pacific; (2) apply 3-D CAT scanning and image analysis techniques to quantify systematically thermal thresholds, rates of recovery and resilience for each species, at each reef site and with depth; (3) quantify energetic reserve and symbiont genotype amongst thermally more- and less- resilient colonies, establishing a quantitative link between calcification stress and mortality risk, and determining the physiological basis for calcification responses to thermal stress; (4) use an OGCM specifically tailored to the tropical Pacific to produce a dynamically consistent set of forecasts for near-term climate change at the target reef sites; and (5) combine coral data with model output and refine the projected thermal stress forecast, in degree heating weeks, for corals in this central Pacific Island group over the 21st century.

Repeat Observations by Gliders in the Equatorial Region (ROGER)

Coverage: Pacific Equatorial Front and Equatorial Undercurrent (EUC) around the Galapagos Archipelago

Description from NSF award abstract:
The objectives of this project are to quantify the variability in the position and strength of the Pacific Equatorial Front and Equatorial Undercurrent (EUC), and the partitioning of flow around the Galapagos Archipelago. The field work will consist of three sustained high-resolution glider transects to assess variability of the Equatorial Current System, including the obstruction of the EUC by the Galapagos Archipelago. A section at 93W will be representative of the EUC and equatorial front to the west of the Archipelago, and two sections connecting the northern and southern ends of this section to the Archipelago will quantify how the EUC is partitioned into pathways. Using four gliders, each section will be repeated every 10 days, thus barely resolving tropical instability wave variability at a period of 20 days. Spray gliders equipped with CTD and ADPs will profile to 500 m every 3 hours, covering 3 km during the dive cycle. Scientific analyses, including the interpretation of the observations using a new high-resolution model, will focus on quantifying the temporal evolution on scales from seasons to weeks in the Equatorial Current System down to horizontal scales of 10 km. Estimates will be made of horizontal fluxes of mass, heat, and salt. The pathway of the EUC will be determined. Observations will be compared and analyzed with a hierarchy of extant numerical models of the Equatorial Current System and an ongoing data assimilation analysis of the Equatorial Pacific.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1031971
NSF Division of Ocean Sciences (NSF OCE)	OCE-1233282

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