A Real-time Ocean Reanalyses Intercomparison Project in the Context of Tropical Pacific Observing System and ENSO Monitoring

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An ensemble of nine operational ocean reanalyses (ORAs) is now routinely collected at Climate Prediction Center of NCEP, and is used to monitor the consistency across temperature analyses in real-time in support of climate monitoring, diagnostics, and prediction. The ensemble approach allows a more reliable estimate of climate signal, measured by the ensemble mean, as well as noise in our estimation of climate signal, measured by the ensemble spread. The real-time estimation of signal-to-noise ratio assists the prediction of climate modes such as ENSO and beyond ENSO.

The ensemble spread, as a measure of uncertainties in ORAs, is shown to partially link to the Tropical Pacific Observing System (TPOS). The full deployment of the TAO array significantly reduced the uncertainties among temperature analyses in the equatorial Pacific, thus clearly highlighting the positive influence of the TAO data on constraining ocean analyses. The availability of the Argo data helped to reduce the analysis uncertainty north of 8N and south of 8S significantly. The uncertainties in total temperature reduced significantly in 2015 due to the recovery of the TAO/TRITON array to approach the value before the TAO crisis in 2012. However, uncertainties in anomalous temperature still remained much higher than the pre-2012 value, probably due to uncertainties in the reference climatology. This highlights the importance of the long-term stability of the observing system for anomaly monitoring.
The influences of the TAO data loss on the estimation of D20 anomalies during 2012-2015 were assessed. In 2012 and 2013, the signal was weak, while the noise was comparable to the signal in the eastern equatorial Pacific where many TAO moorings were down. The 2015/16 El Niño was very well observed due to the recovery of the TAO moorings by the end of 2014, and the signal-to-noise ratio in D20 anomalies was relatively high. The ensemble ORAs have been used to study the characteristics of the evolution of the 2015/16 El Niño and place it in the context of historical ENSO events since 1979.

Key words: Ocean reanalysis, Tropical Pacific Observing System, ENSO

The PSD Air-Sea Flux Database

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PSD has created a synthesis of air-sea flux observations from 41 research cruises conducted between 1991 and 2016. The data are combined into a single, easy-to-read, file with 25,000 observations at 1-hr time resolution. They variables include time, location, near-surface mean meteorological variables, turbulent and radiative fluxes, and other navigational data. Both bulk (COARE35 flux algorithm) and direct covariance turbulent fluxes are provided. There are 16,000 hrs of direct fluxes. The observations span 54 S to 70 N degrees latitude; all oceans except for the Arctic are included. In this poster we describe the observation system, the cruises, the data file, and give some summary analysis statistics.

Key words: Air-Sea flux; Database

SAMOS: Entering a Second Decade of Successful Data Stewardship

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The authors will describe the successes and lessons learned from the Shipboard Automated Meteorological and Oceanographic Systems (SAMOS) initiative. Since 2005, SAMOS has acquired, quality controlled, and distributed underway surface meteorological and oceanographic observations from 44 oceanographic research vessels. Research vessels provide underway observations at high-temporal frequency (1 min. sampling interval) that include navigational (position, course, heading, and speed), meteorological (air temperature, humidity, wind, surface pressure, radiation, rainfall), and oceanographic (surface sea temperature and salinity) samples. Vessels recruited to the SAMOS initiative collect a high concentration of data within the U.S. continental shelf, around Hawaii and the islands of the tropical Pacific, and frequently operate well outside routine shipping lanes, capturing observations in extreme ocean environments (Southern, Arctic, South Atlantic, and South Pacific oceans) desired by the air-sea exchange, modeling, and satellite remote sensing communities.

This poster will highlight the data stewardship practices of the SAMOS initiative. The authors will focus on metadata collection, standard data formats, uniform quality evaluation procedures, use of interoperable vocabularies, and finally routine distribution and archival practices. We will describe lessons learned over the past decade, describe interactions with vessel operators to improve data quality, provide examples of best practices for instrument siting/exposure on research vessels, and describe professional development activities for research vessel technicians. We will also report on engagement activities that focus on disseminating SAMOS best practices to international research vessel operators. Finally, we will report on recent contributions by SAMOS to the International Comprehensive Ocean Atmosphere Data Set (ICOADS). For ICOADS, the SAMOS team has applied the SAMOS quality control flags and used the metadata collected to ensure the highest quality SAMOS records are submitted to ICOADS.

**Key words:** Marine Meteorology, ocean extremes, SST, salinity, data management

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**Deep Western Boundary Current measurements at 34.5 deg S in the South Atlantic: Recent results from the Southwest Atlantic MOC project**

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The Deep Western Boundary Current (DWBC) at 34.5 S in the South Atlantic carries a significant fraction of the cold deep limb of the Meridional Overturning Circulation (MOC), and therefore its variability affects the meridional heat transport and consequently the regional and global climate. Nearly 6 years of observations from a line of pressure-equipped inverted echo sounders (PIESs) have yielded an unprecedented data set for studying the characteristics of the time-varying DWBC volume transport at 34.5 S. Furthermore, the horizontal resolution of the observing array was greatly improved in December 2012 with the addition of two current-and-pressure-equipped inverted echo sounders (CPIESs) at the midpoints of the two westernmost pairs of PIES moorings. Regular hydrographic sections along the PIES/CPIES line confirm the presence of recently ventilated North Atlantic Deep Water carried by the DWBC. The time-mean absolute geostrophic transport integrated within the DWBC layer, defined between 800–4800 dbar and within longitude bounds of 51.5 to 44.5W, is -15 Sv. The observed peak-to-peak range in volume transport using these integration limits is from -89 to +50 Sv, and the temporal standard deviation is 23 Sv. Testing different vertical integration limits based on time-mean water-mass property levels yields small changes to these values, but no significant alteration to the character of the transport time series. The time-mean southward DWBC flow at this latitude is confined west of 49.5W, with recirculations dominating the flow further offshore. As with other latitudes where the DWBC has been observed for multiple years, the time variability greatly exceeds the time mean, suggesting the presence of strong coherent vortices and/or Rossby Wave-like signals propagating to the boundary from the interior.

**Key words:** Deep Western Boundary Current, Meridional Overturning Circulation, moored observations, North Atlantic Deep Water
Ocean Reference Stations: Three climate-quality time series sites in the trade wind regions

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To provide sustained, climate-quality observing of the trade wind region, we have developed surface moorings with the capability of making sustained, accurate observations at the sea surface and in the water column and have occupied three key trade wind sites: Stratus, NTAS (Northwest Tropical Atlantic Station), and WHOTS (WHOI Hawaii Ocean Timeseries Site). The poster provides examples of results for each of the three sites. At the Stratus site during 2000-2014 the southeast trade winds increased in speed while the net air-sea heat flux decreased. More recently, in concert with the PDO Index changing from negative to positive, the southeast trades have weakened. Comparisons with CMIP5 climate models show most of the models have significant warm biases in SST at Stratus. At WHOTS, working with colleagues at University of Hawaii (UH), we find a trend toward clearer skies and higher net heating while they find the upper ocean becoming cooler and saltier. Their comparisons with reanalysis products show that the reanalyses fail to capture these trends accurately. Comparison of WHOTS data with the PWP 1D upper ocean model showed poor replication of upper ocean structure over a daily cycle, and revisions to the PWP code made by UH have greatly improved performance. At NTAS, as well as at Stratus and WHOTS, the long time series allow development of local climatologies. At NTAS, departures from the climatological annual cycle in SST have been examined. Linkages to ENSO or NAO variability are not robust, but anomalous warm conditions at NTAS do correlate with the Atlantic Accumulated Cyclone Energy index, with storm conditions marked by a warm, moist atmospheric boundary layer in years with more storms.

Key words: air-sea flux, upper ocean, climatology
Saildrone 2016: Simultaneously measuring the environment, fishes and marine mammals in the Bering Sea


In 2016 NOAA-PMEL deployed two Saildrone ASVs for 103 days and 6000km mission in the Bering Sea. The vehicle measured 17 atmospheric and oceanic parameters, including active fish acoustic backscatter, passive acoustic and fur seal tracking. Sensor data compared favorably to ship and buoy comparisons. **Key words:** Saildrone, Autonomous Surface Vehicle, Bering Sea, PMEL

An enhanced PIRATA data set for tropical Atlantic ocean-atmosphere research (ePIRATA)

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The Prediction and Research Moored Array in the Tropical Atlantic (PIRATA) provides measurements of the upper ocean and near-surface atmosphere at 18 locations. Time series from many moorings are nearly 20 years in length. However, instrumental biases, data drop-outs, and the coarse vertical resolutions of the oceanic measurements complicate their use for research. Here an enhanced PIRATA data set (ePIRATA) is presented for the 17 PIRATA moorings with record lengths of at least seven years. Data in ePIRATA are corrected for instrumental biases, temporal gaps are filled using supplementary data sets, and the subsurface temperature and salinity time series are mapped to a uniform 5-m vertical grid. All original PIRATA data that pass quality control and do not require bias correction are retained without modification, and detailed error estimates are provided. The terms in the mixed layer heat and temperature budgets are calculated and included, with error bars. As an example of ePIRATA's application, the vertical exchange of heat at the base of the mixed layer (Qh) is calculated at each PIRATA location as the difference between the heat storage rate and sum of net surface heat flux and horizontal advection. Off-equatorial locations are found to have annual mean cooling rates of 20-60 W/m^2, while cooling at equatorial locations reaches 85-110 W/m^2 between 10W--35W and decreases to 40 W/m^2 at
0W. At most off-equatorial locations, the strongest seasonal cooling from Qh occurs when winds are weak. Possible explanations are discussed, including the importance of seasonal modulations of mixed layer depth and the diurnal cycle.

**Key words:** tropical Atlantic, mixed layer, PIRATA, surface heat flux, heat budget

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**Air-Deployable Profiling Floats**

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The development of a small profiling float that can be launched from Hurricane Hunter aircraft offers the opportunity to monitor the upper-ocean thermal structure over a time span of many months. These Argo-type profiling floats can be deployed in advance of, or during, a tropical cyclone from any aircraft equipped with an A-sized (AXBT) launch tube, or from the stern ramp of a C-130. Upon deployment, the floats parachute to the surface, detach and begin to profile. A typical rapid-sampling mission performs a 300-dbar profile every 2 hrs. The recorded temperature data is subsampled to 1-meter bins that are reported back via the Iridium satellite network, which is then automatically processed and posted to the GTS. The floats are also reprogrammable via the 2-way communication afforded by Iridium. We report on the results of deployments during the 2015 and 2016 hurricane seasons including observations of a large ocean response from passage of Hurricane Ignacio. Future plans include adding a CTD for salinity measurements from an inductive conductivity cell. A built-in inertial measurement unit offers the possibility of measuring the surface wave field between profiles.

**Key words:** hurricane, ocean heat content, hydrography

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**The California Underwater Glider Network**

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The overarching goal of the California Underwater Glider Network (CUGN) is to sustain baseline observations of climate variability in the California Current System (CCS). The CUGN uses Spray underwater gliders making repeated dives from the surface to 500 m and back, repeating the cycle every 3 hours, and traveling 3 km in the horizontal during that time. The CUGN includes gliders on three of the traditional cross-shore CalCOFI lines: 66.7, 80.0 and line 90.0. The glider missions typically last 100
days, and cover over 2000 km, thus providing 4-6 sections on lines extending 350-500 km offshore. Since 2005 the CUGN has covered 230,000 km over ground in 11,000 glider-days, while doing 100,000 dives. These data are used to produce a climatology whose products are, for each observed variable, a mean field, an annual cycle, and the anomaly from the annual cycle. The analysis includes a weighted least-squares fit to derive the mean and annual cycle, and an objective map to produce the anomaly. The final results are variables on rectangular grids in depth, distance offshore, and time. The mean fields are finely resolved sections across the main flows in the CCS, including the poleward California Undercurrent and the equatorward California Current. The annual cycle shows a phase change from the surface to the thermocline, reflecting the effects of air/sea fluxes at the surface and upwelling in the thermocline. The interannual anomalies are examined with an emphasis on climate events of the last ten years including the 2009-2010 El Niño, the 2010-2011 La Niña, the warm anomaly of 2014-2015, and the 2015-2016 El Niño.

**Key words:** California Current System, underwater gliders, climatology, annual cycle, El Niño

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**Air-Launched Autonomous Profilers in the Arctic**

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The Arctic Heat Open Science Experiment provides persistent near real-time ocean observations in the Chukchi and Beaufort Seas using innovative technologies, including the MRV Air-Launched Autonomous Micro-Observer (ALAMO) profiling float. ALAMO floats deployed during the 2016 summer field season have delivered hundreds of high-resolution full water column profiles. Two floats deployed in September have endured the winter and are still active. The floats bridge longstanding observation gaps at the atmosphere-ice-ocean interface and to within 1 m of the bottom. A suite of weather and ocean-sensing instruments carried on the NOAA Twin Otter used to deploy floats allows complementary data to be collected from above the marine atmospheric boundary layer to the sea bottom, over a wide area, in a matter of days, and through seasons. Data are published as rapidly as possible on project websites and
via the Global Telecommunications System (GTS). Open science facilitates timely and responsive observations for use in weather and sea-ice forecasts, for rapid model and reanalysis assimilation, and supports research activities across disciplines.

**Key words:** Arctic, Autonomous Floats, Open Science

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**Weddell Sea Moorings 1999 – 2017**

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Two near-bottom focused moorings M2 and M3 have been maintained in the northwest Weddell Sea since early 1999. Recently recovered data have extended the time series observations of outflowing Weddell Deep and Bottom waters to 18 years from inception (with gaps). Here we present the time series of potential temperature and salinity at the bottom and 500 m above the bottom at M2 and M3, highlighting seasonal and significant interannual changes in temperature and salinity, notably an apparent recent decline in benthic salinity at M3.

**Key words:** deep salinity, Weddell Deep Water, Antarctic

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**Direct Community Benefits from NOAA's Support of the CCHDO**

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The CLIVAR and Carbon Hydrographic Data Office (CCHDO) brings together, verifies, and corrects content and format errors in the CTD, hydrographic and tracer data used in large-scale ocean carbon, global change, water mass, and circulation studies. The CCHDO makes it possible for all data users to cope with the temporal-, content-, and format-related file diversity different data originators engender. Not only are the data easier to use, their quality and usefulness are enhanced by the CCHDO's careful assembly of documentation with the data, helping to assure a data service lifetime far into the future. The CCHDO supports CLIVAR and carbon science programs, and is a
data component of a global observing system for the physical climate/CO2 system. The data are used to help quantify the uptake and storage of anthropogenic CO2 by the ocean, to document long-term trends in ocean warming, and to determine heat and freshwater fluxes. NOAA support supplements existing National Science Foundation support for the CCHDO, and targets work that supports NOAA objectives.

Direct benefits of this support to NOAA investigators and programs include broadened accessibility of CCHDO data to all users, such as modelers and students; improved access to CTD data reformatted by the CCHDO to a common readability standard from cruises of special interest to Argo; reports of new and updated data to Argo at regular intervals; and estimating the suitability of new CTD data for Argo purposes.

The CCHDO is using NOAA support to develop two new tools for data users: (1) a tool which will locate the nearest CCHDO CTD/hydrographic profile(s) to a given location (such as the location of an Argo float), and (2) a tool which will deliver in one data file all CCHDO CTD or bottle profiles which meet user-specified criteria (focusing on geographic limits at present).

**Key words:** CTD data, hydrographic data, data curation, data user services

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**Net community production at the NOAA Kuroshio Extension Observatory**

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Seven years of data from the NOAA Kuroshio Extension Observatory (KEO) surface mooring, located in the North Pacific Ocean carbon sink region, were used to evaluate drivers of mixed-layer carbon cycling. A time-dependent mass balance approach relying on two carbon tracers was used to diagnostically evaluate how surface ocean processes influence mixed-layer carbon concentrations over the annual cycle. Results indicate that the annual physical carbon input is predominantly balanced by biological carbon uptake during the intense spring bloom. Net annual gas exchange that adds carbon to the mixed layer and the opposing influence of net precipitation that dilutes carbon concentrations make up smaller contributions to the annual mixed-layer carbon budget. Decomposing the biological term into annual net community production (aNCP) and
calcium carbonate production (aCaCO₃) yields $7 \pm 3$ mol C m⁻² yr⁻¹ aNCP and $0.5 \pm 0.3$ mol C m⁻² yr⁻¹ aCaCO₃, giving an annually integrated particulate inorganic carbon to particulate organic carbon production ratio of $0.07 \pm 0.05$, as a lower limit. Although we find that vertical physical processes dominate carbon input to the mixed layer at KEO, it remains unclear how horizontal features, such as eddies, influence carbon production and export by altering nutrient supply as well as the depth of winter ventilation. As a first step for addressing this, a highly-leveraged pilot study at KEO “Carbon Hot Spot” has been proposed to NSF. Carbon Hot Spot would help show how ocean carbon uptake, carbon cycling, and sequestering of carbon by mode water formation are influenced by mesoscale and submesoscale processes, and will help guide future monitoring and studies in western boundary current regions. U.S. CLIVAR and OCB are co-sponsoring an "Ocean Carbon Hot Spots Workshop" Sep 25-26, 2017 at MBARI. Abstracts are due May 19, 2017.

Key words: KEO, Carbon Hot Spot, Net Community Production

An improved near-surface velocity climatology for the global ocean from drifter observations

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This work updates the methods of Lumpkin and Johnson (2013) to derive an updated climatology of ocean surface currents by (a) incorporating data from undrogued drifters, and (b) introducing a new estimation method designed to further reduce the smoothing of spacial gradients. The result is a global climatology at unprecedented resolution, ideal for model validation, refined calculations of the ocean's mean dynamic topography, and improved knowledge of ocean circulation patterns and their variations.

Key words: drifters, surface currents

The Global Tropical Moored Buoy Array

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The Pacific Marine Environmental Laboratory (PMEL) Global Tropical Moored Buoy Array (GTMBA) Program is a multi-national effort to provide data in real-time for
climate research and forecasting. The GTMBA includes three major components, the first of which is the Tropical Atmosphere Ocean (TAO) array in the Pacific, complemented in the western basin by the Triangle Trans-Ocean Buoy Network (TRITON) maintained by the Japan Agency for Marine-Earth Science and Technology (JAMSTEC). PMEL originally designed and, beginning in 1984, implemented TAO before turning over responsibility for operating the array to NOAA’s National Data Buoy Center (NDBC) in 2005. The Atlantic counterpart to TAO/TRITON is the Prediction and Research Moored Array in the Tropical Atlantic (PIRATA), designed and maintained by PMEL scientists in collaboration with NOAA’s Atlantic Oceanographic and Meteorological Laboratory (AOML) and institutions in Brazil and France. PMEL scientists also designed and have maintained the Research moored Array for African-Asian-Australian Monsoon Analysis and prediction (RAMA) in the Indian Ocean in collaboration with institutions in India, Indonesia, China, Japan, France and the eight countries involved in the Bay of Bengal Large Marine Ecosystem (BOBLME) program.

The major phenomenological foci of the GTMBA are:

- El Niño/Southern Oscillation (ENSO) in the Pacific
- Interhemispheric dipole mode, equatorial warm events, and hurricanes in the Atlantic
- Monsoons, Indian Ocean Dipole, and intraseasonal variability in the Indian Ocean.

The GTMBA provides high quality moored data throughout the global tropics for improved description, understanding, and prediction of intraseasonal to decadal climate variability. GTMBA data are available in real-time to operational centers worldwide via the Global Telecommunications System (GTS); near real-time and delayed-mode data are also freely available on the web at [http://www.pmel.noaa.gov/gtmba/data-access/disdel](http://www.pmel.noaa.gov/gtmba/data-access/disdel). The GTMBA is a NOAA contribution to the Global Ocean Observing System (GOOS), the Global Climate Observing System (GCOS), and the Global Earth Observing System of Systems (GEOSS).

**Key words:** moored buoys, equatorial measurements, tropical climate variability

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**MOVE - The Meridional Overturning Variability Experiment at 16 N**

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MOVE has been making observations of the Atlantic meridional overturning circulation (AMOC) at 16°N continuously since 2000. The time series is now long enough to discuss multi-year variability and compare the results to those from observations at other latitudes, from numerical simulations, and from space-based observations. Fluctuations and trends in volume transport as well as temperature-salinity properties are discussed, with possible linkages to the source regions of the water masses. The AMOC is a key oceanic mechanism for meridional heat transport in the world climate system, and changes in its strength are expected to have large-scale influence on e.g. mid-latitude temperature and weather patterns. The goal of MOVE is to provide baseline observations of AMOC variability, and the ongoing analyses are bringing these measurements into a basin-wide spatial context.

**Key words:** Atlantic meridional overturning, AMOC

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**Quantifying and understanding long-term changes in the global distribution of N2O in the Ocean**

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Nitrous oxide (N2O) is an important greenhouse gas and contributes to stratospheric ozone depletion. Atmospheric N2O has increased significantly from ~270 parts per billion (ppb) in the early 1900s to ~328 ppb today. As the ocean is a significant source of atmospheric N2O, changes in ocean stratification, circulation, biogeochemical processes, and dissolved oxygen levels in the coming decades may impact oceanic N2O production and the flux of N2O to the atmosphere.

We have amended the analytical methods we use for routinely measuring dissolved concentrations of the transient tracers, chlorofluorocarbons and sulfur hexafluoride during CLIVAR/GO-SHIP Repeat Hydrography Program. We now make dissolved N2O measurements to good precision from the same water samples at nominal extra expense and effort. We present full-depth, high-resolution measurements of dissolved N2O along hydrographic sections across the Atlantic and Pacific oceans that will be reoccupied at approximately 10 year intervals.
Our goals are to provide a baseline set of N2O measurements to determine N2O’s current global oceanic distribution so that we can detect long-term changes in concentrations and fluxes of N2O, possibly in response to ocean deoxygenation. These N2O data, since they accompany time-dependent tracer data, can be used to help evaluate and improve models of the rates of N2O production/consumption and transport in sub-surface waters. Meridional sections in the Pacific Oceans reveal extremely high concentrations adjacent to tropical oxygen minimum zones, however the specific metabolic pathways producing these very high N2O levels remain unknown.

New developments in laser spectroscopy provide site-specific isotopic composition of dissolved N2O, and allow identification of specific N2O production pathways for improved predictions of the impacts of changing ocean oxygen levels on ocean and atmospheric N2O levels.

**Key words:** GO-SHIP, Nitrous Oxide, Ocean Oxygen changes

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**The NOAA-PMEL Ocean Tracer**

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The PMEL Ocean Tracer Program is measuring full water column distributions of dissolved chlorofluorocarbons (CFCs) along key sections in the global ocean at approximately decadal intervals as part of the international CLIVAR/GO-SHIP Repeat Hydrography program. These measurements are used as benchmarks of ocean circulation models’ upper ocean turnover rates, and to estimate water mass formation and ventilation rates throughout the World Ocean. These rates are critical to quantify the ocean’s uptake of anthropogenic CO2 and heat and, when compared with older sections, changes in ocean ventilation. The anthropogenic CFC signals have penetrated to abyssal depths in high latitude deep-water formation regions and are being transported equatorward in deep flows, providing a unique way to estimate the rate at which the anthropogenic CO2 and heat will be transported and stored in the deep ocean on decade-to-century time scales. In this decade, the anthropogenic CFC signals are easily measurable in the major oceanic oxygen deficient zones. The CFC tracers provide estimates of the rates at which atmospheric gases, including oxygen, are
ventilated into and consumed within these important oceanic regions that are forecasted to be undergoing significant expansion. PMEL has also developed methods for measuring sulfur hexafluoride (SF6), a new transient tracer, and nitrous oxide (N2O) on the same water samples as the CFCs. SF6 measurements, combined with the CFCs, provides a means to estimate the impacts that mixing has on tracer ages. These combined CFC/SF6 datasets are improving estimates of upper ocean oxygen consumption and CO2 uptake rates, and provide an improved means of estimating decadal changes in ocean ventilation.

Key words: chlorofluorocarbons, CFCs, anthropogenic, ventilation, carbon dioxide, tracers

Simulating ENSO SSTA from TAO/Triton winds: The impacts of 20 years of buoy observations in the waveguide and comparison with reanalysis products

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The fundamental importance of near-equatorial zonal wind stress in the evolution of the tropical Pacific Ocean’s seasonal cycle and El Niño-Southern Oscillation (ENSO) events is well known. It has been two decades since the TAO/Triton buoy array was deployed, in part to provide accurate surface wind observations across the Pacific waveguide. It is timely to revisit the impact of TAO/Triton winds on our ability to understand the evolution of SST in this region. This work shows that forced ocean model simulations of SST anomalies (SSTAs) during the periods with a reasonably high buoy data return rate can reproduce the major elements of SSTA variability during ENSO events, using a wind stress field computed from TAO/Triton observations only. Forcing with reanalysis wind fields does not give similarly satisfactory results. Comparison of several reanalysis wind fields with TAO/Triton observations reveals substantial differences in variability and trends. In particular, the negative trend in the ERA-Interim reanalysis is much larger than, and the NCEP reanalysis variability much less than seen in the TAO/Triton observations. There are also mean biases. Thus, even with the TAO/Triton observations available for assimilation into these wind products, there remain oceanically important differences. The direct wind observations from the TAO/Triton array remain critical to understanding the evolution of the coupled ocean atmosphere system in the equatorial Pacific and evaluating reanalysis products.

Key words: ENSO, wind stress, SSTA, forced ocean model
Long-term Trends in OAFlux Satellite Analysis and at OceanSITES

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The ocean-surface wind and buoyancy flux forcings are the most direct climate indicator of how the ocean changes in response to the global climate change. Long-term sustained buoy flux measurements and high-quality multi-decadal satellite flux data record are crucial to our ability to document trends and variability in ocean-surface forcing functions and to determine the nature and extent of the change. Currently, full-flux measurements are available at 23 OceanSITES locations. For those sites that provide long-term data records, marked contrasting decadal trends are readily seen. For instance, the buoy wind time series of ~30 years in the western-central equatorial Pacific at 170°W reveal a persistent westward intensification of the trade winds, while those in the eastern equatorial Pacific at 110°W shows no significant long-term trend. Meanwhile, the wind time series at the North Atlantic Station (NTAS; 15° N, 51°W) suggests a weakening of the trade winds in the Atlantic. The contrasting changes of the trade winds between the eastern and western equatorial Pacific and between the Pacific and Atlantic are well captured by the OAFlux satellite high-resolution vector wind analysis that is newly developed from merging 15 satellite sensors. The satellite analysis and OceanSITES observations both indicate that the anomalous strengthening of the Pacific trade winds is associated with an increased heat uptake in the warm pool and a reduced heat uptake in the cold tongue. The pattern is in a way similar to the pattern of La Niña. The climate implications of these changes are significant, because the tropical ocean holds the primary memory of the climate system on longer time scales. We will integrate the satellite data record and buoy observations at OceanSITES to provide a complete documentation of the changes in the tropical Pacific and Atlantic ocean-atmosphere system in the past two decades.

Key words: air-sea fluxes, decadal trend and variability, trade winds, tropical atmosphere-ocean interaction