ACHIEVEMENT OF WOCE SHIPBOARD ADCP DATA ASSEMBLY CENTER

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Shipboard Acoustic Doppler Profiler (SADCP) is a sophisticated, modern instrument that can measure upper ocean currents using the Doppler effect. Heading and position information provided by the ship's navigation supplement the ADCP data to estimate absolute current motions. Historically quality data have been made available within the upper 300 meters of the ocean; yet more recently new technology has extended the range down to as much as 1200 meters.

WOCE Data Assembly Center for ADCP is co-located at Japan Oceanographic Data Center and the Joint Archive for Shipboard ADCP (JASADCP), collaboration between the US NOAA and the E. Firing ADCP Lab at the University of Hawaii. The co-DACs have centralized WOCE cruises that produced quality-controlled, absolute currents through solicitations to principle investigators and chief scientists. The co-DACs create a standard format of hourly time and 10-m depth averages in both an ASCII text and a WOCE/COARDS compatible netCDF format. Quality control was left to the data originators; however, the co-DACs reviewed the data for obvious error.

More than 275 cruises of SADCP data have been collected through WOCE. SADCP netCDF and ASCII data files, cruise track and sample vector plots, and metadata for each cruise are organized into a folder of the WOCE Global Data Version 3.0 DVD, which is comprised of folders from the other WOCE DACS such as hydrography, current meters, and sea level, to name a few. This DVD also includes all cruises held by the JASADCP, for a total of 553 cruises. The Version 3.0 DVD allows easy cross-referencing among datasets from the various DACs via integration tools. In addition, a basic HTML browser specific for the SADCP can guide one to the data or products via WOCE IDs or by ship or region. One can also access data by simply identifying the desired cruise ID and changing directories on the folder to the appropriate location. For those who would like a CDROM copy of the DVD folder, please send a request directly to either of the two co-DACs. One can also easily download the data directly via the internet.

ONLINE ACCESS TO WOCE GLOBAL DATA V3

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The entire WOCE Global Data V3, including all the related documentation, has been put online, as part of the TPAC/Antarctic CRC oceanographic digital library. These data are available to the entire community from 18th November, in time for this conference.

The data files in the WOCE Global Data V3 are in netCDF format. The content of the netCDF files meets the COARDS naming convention for ocean and atmospheric variables. The combination of COARDS and netCDF makes the underlying structure of the WOCE data uniform across instruments and cruises, and therefore more manageable for analysis. The netCDF files themselves can be made directly available through the Open Data Access Protocol (OpenDAP, formerly DODS) using any application that has the appropriate OpenDAP libraries.

The applications include web browsers, ncBrowse, Ferret, Grads and languages such as MATLAB, C, Java, and FORTRAN. This means that users will be able to use fetch data from within their application for direct analysis. We will demonstrate the TPAC digital library with different programming and application interfaces to the WOCE Global Data V3.

THE STORY OF THE WOCE DATA INFORMATION UNIT
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The WOCE Data Information Unit (DIU) evolved over the past fifteen years in parallel with the WOCE program. It was conceived as a means for scientists to determine what data had been collected by WOCE and to obtain them. At the same time, the WOCE data system developed as a distributed system of Data Access Centers where the various datasets were collocated with scientists who were working with them.

From its beginnings as a simple mailing list, the DIU has used the technology of the time to disseminate information about the status of the WOCE program and of WOCE datasets. DIU access began through TELEMAIL, and then in turn used Gopher, the Internet, and the World Wide Web. Today the DIU information database is available on CDs and DVDs, with the means for scientists to search across the holdings of the WOCE DACs to locate and obtain the measurements themselves.

The original ideas for the WOCE data system were developed without a full knowledge of how those ideas could be implemented. The system that now exists makes the early development ideas seem primitive and optimistic.

WOCE IN SITU SEA LEVEL: FAST DELIVERY DATA ASSEMBLY CENTER
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The University of Hawaii Sea Level Center (UHSLC) is the site of the near real-time component of the WOCE Sea Level Data Assembly Center (DAC). The fast delivery database involves the collection, processing, and distribution of in situ sea level data from around the world in a time frame (typically 30-45 days after the observation is made) that supports joint analyses with satellite altimeter data and the validation of various operational ocean models. The UHSLC effort is complemented by the slow delivery DAC maintained at the Bidston Oceanographic Data Centre which collects sea level data at key sites where near real-time acquisition is not feasible.

In addition to the individual time series themselves, the UHSLC provides a number of products that utilize the WOCE sea level data. Sea level deviation and anomaly (from long-term monthly means) maps are posted at the UHSLC Website each month for comparison with associated altimeter products. Time series of upper ocean volume anomaly and major equatorial current system indices for the Pacific Ocean are computed from in situ sea level data and made available on a quarterly basis as part of the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology. The UHSLC fast delivery data have also been used successfully to identify temporal drifts in TOPEX/Poseidon altimeter measurements. A small subset of WOCE sea level sites now includes continuous GPS measurements for the ongoing monitoring of altimeter drift.

ncBROWSE: DODS/OPENDAP DATA ACCESS AND 3-D GRAPHICS
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The netCDF data file format has become a de facto standard in the oceanographic and atmospheric science community. Its advantages include its flexibility and machine-independence, and a wide variety of analysis and visualization software has been developed to utilized data in netCDF format. However, few of these software applications have been designed to utilize the full range of netCDF file structures and conventions.

ncBrowse is a Java application that provides flexible, interactive graphical displays of data and metadata (attributes) from a wide range of netCDF data file conventions. ncBrowse also provides desktop access to remote netCDF files using simple HTTP or the OPeNDAP (formerly known as DODS) protocols. New features include animation and 3D visualizations. ncBrowse has proven quite popular, with over 3700 downloads by 1852 unique sites in 49 countries, and an active email discussion group. ncBrowse is supported for Unix, Windows and Mac OS, and is freely available at http://www.epic.noaa.gov/java/ncBrowse.

WOCE SOUTHERN OCEAN ATLAS AND DATABASE
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The WOCE Southern Ocean Atlas is the first web-based hydrographic atlas for the region south of 30°S. WOCE measurements are presented as property-property plots, vertical sections and maps, and users can also produce custom plots online with simple interactive tools. A printed version of the atlas will include a selection of these WOCE products and property maps derived from a new Southern Ocean Database. This database includes about 9,900 WOCE stations, which were used to select about 84,000 stations from the historical archives that had acceptable T-S data. All of these stations were examined to identify data outliers (about 30,000 T-S points and 10,000 nutrient values were flagged), and to reject nutrient profiles that fell outside the WOCE standards (about 16,000 stations had one or more nutrients flagged). These data will be used to generate a series of objectively mapped property fields. Improvements over available climatologies result from higher quality data and innovations in mapping techniques.

THE WOCE 'DELAYED-MODE' SEA LEVEL DATA SET
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The British Oceanographic Data Centre (BODC) acts as the WOCE 'Delayed-mode' Sea Level Data Assembly Centre (DAC) providing the fully quality controlled comprehensive sea level data set at the end of the project. This complements the University of Hawaii Sea Level Center's role as the 'Fast-delivery' DAC. This poster illustrates the work and data holdings of the 'Delayed-mode' Centre.

The delayed-mode sea level data set presently assembled comprises approximately 3550 site years of data that have been acquired from over 160 sites in 25 countries worldwide. Several sites have data extending back over 80 years and approximately 35 extend over 40 years. The comprehensive WOCE Sea Level Data Set also includes data from bottom pressure recorder deployments at about 20 locations (50 records, each usually of approximately 1 year in length). Most of these data have been collected as part of the Proudman Oceanographic Laboratory's ACCLAIM project in the South Atlantic.

Data are quality controlled using a sophisticated software system, developed in-house. In addition to the rapid visualisation of the data, this incorporates tidal analysis, time shifting, gap filling, data value flagging and the production of daily and monthly mean values. Data documentation is compiled, with special attention paid to benchmark and datum history information.

Once data have been quality controlled, accompanying information checked, and documentation complied, they are available from the BODC web-site, via a DODS server and as part of the WOCE Global Data Set due to be released on DVD in November 2002. Other products available from the 'Delayed-mode' Sea Level DAC include the results of tidal analyses of the data, the Permanent Service for Mean Sea Level (PSMSL) monthly and annual mean sea level data set and the IOC GLOSS Station Handbook.

eWOCE - ELECTRONIC ATLAS OF WOCE DATA
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Most WOCE data streams are now compiled in integrated, global or basin-wide sets that, when used with the Ocean Data View (ODV) visualization software, constitute an "Electronic Atlas of WOCE Data" (eWOCE) that allows graphical display and interactive analysis in many different ways. Owing to built-in interactive controls, eWOCE complements and goes beyond the printed atlases. These eWOCE datasets are on DVD2 of the WOCE Global Data v.3.0 data release:

1. Hydrographic, nutrient and tracer data from the WOCE Hydrographic Program (>18,000 stations, separate data collections for bottle and CTD data).
2. More than 1 million temperature and salinity profiles from the Upper Ocean Thermal Program (organized by basin; high density lines separated).
3. Velocity and hydrographic data for >1300 moored current meters
4. Shipboard velocity profiles for >240,000 stations and 540 cruises from the ADCP Program.
5. Trajectories and velocity data >12,000 drifters from the Surface Velocity Program (daily data organized by years, 1979-2000).
6. Trajectories, velocity and temperature data for 1040 floats from the Subsurface Float Program.
7. Hourly sea level data for 161 stations from the delayed mode Sea Level Program (1900-2000).
8. Hourly sea level data for 129 stations from the fast-delivery Sea Level Program (1985-2001).
9. More than 31,000 temperature and salinity profiles from more than 1600 profiling floats.

Data for wind, sea-surface temperature and sea-surface height from satellites and meteorological data for WHP lines can be used directly from the netCDF files in the respective data directories. More than 350 section plots of temperature, salinity, oxygen, nutrients and tracers along WHP cruise tracks are available in the eWOCE Gallery. The gallery figures are accessed through interactive maps using your web browser. No additional software installation is required for viewing the gallery plots.

DACs and Programmatic Products

UNIVERSITY OF HAWAII'S ASIA-PACIFIC DATA-RESEARCH CENTER (APDRC)
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The APDRC was recently established within the International Pacific Research Center (IPRC) at the University of Hawaii. The vision of the APDRC is to link data management and preparation activities to research activities within a single center, and to provide one-stop shopping of climate data and products to local researchers and collaborators, the national climate research community and the general public. At present, primary activities are to continue the upgrade of user-friendly data servers in collaboration with our partners at NOAA/PMEL, and to continue to build our archive of served data and products. Web access to the WOCE v3 data is a top priority.

The APDRC currently runs a Live Access Server (LAS) and an EPIC server, both developed at NOAA/PMEL. The LAS allows visualization and downloading of gridded products in various formats. Most data sets served by the LAS are also served via our DODS/OPeNDAP server. EPIC is also a web-based, data search and display system suited for in situ data. Locating and selecting individual station data from large collections is a challenge. We enhanced the EPIC's capability and configured OPeNDAP into EPIC to serve and export in situ data files. In addition, APDRC is running an OPeNDAP Catalog/Aggregation Server (CAS), developed by Unidata at UCAR, to serve climate data and products (model output and satellite-derived). These products are often stored as multiple files, but the CAS allows access to the whole data set or any subset that cuts across the multiple files via a single request command from DODS-enabled client software.

The APDRC currently serves the WOCE current meter DAC data via EPIC. In addition, EPIC serves the CTD and bottle data, and some "test" Argo float data. The CAS serves SST, satellite winds, and satellite sea level products. We plan to serve the final WOCE v3 data via DODS/OPeNDAP, EPIC, LAS and CAS servers. In addition to the WOCE data, the APDRC will continue to serve global climate data and products in support of CLIVAR research activities.

ACHIEVEMENTS OF WOCE DAC/SAC FOR SURFACE METEOROLOGY AND FLUXES
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The WOCE Surface Meteorology Data Assembly Center (DAC) collected, quality controlled, and distributed nearly 80 million surface meteorological observations collected on WOCE hydrographic cruises. The final WOCE archive contains uniformly formatted and quality controlled surface meteorology data from 82% of completed WOCE cruises. The Surface Fluxes Special Analysis Center (SAC) produced and distributed surface turbulent flux products and distributed additional gridded flux products created by other institutes.

The DAC examined potential applications of research vessel (R/V) meteorological data. WOCE R/V data proved ideal for validation of new satellite wind sensors (scatterometers) and for evaluating uncertainties in global reanalysis surface flux fields. R/V data also helped to evaluate several measurement problems common to marine observing systems. The SAC developed a new objective method to produce monthly surface turbulent flux fields.

WOCE data management has provided a model for the collection, quality control, and delivery of underway meteorological data. Integration across a variety of ocean and atmospheric data streams is one legacy of both the DAC/SAC and WOCE as a whole. The FSU DAC/SAC has begun archiving underway data from two NOAA R/Vs. Continued international data collection and archival are anticipated under new climate initiatives (e.g., CLIVAR, GOOS).

THE WOCE HYDROGRAPHIC ATLAS SERIES

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For many people, atlases of oceanographic expeditions define what the ocean looks like and how it behaves. Such "snapshots" of the ocean at a particular time have proved of great value to generations of oceanographers, being easy to access, study and reference. Compared to earlier efforts, WOCE was the largest oceanographic "experiment" ever, with broader scope, greatly increased horizontal and vertical sampling density, improved accuracy and precision and a greater abundance of properties sampled. We are therefore producing a series of four atlases, concentrating respectively on the hydrography of the Southern, Pacific, Atlantic and Indian Oceans. The Southern Ocean is given a separate volume to highlight the unique circumpolar exchange of heat, freshwater and dissolved components with the rest of the ocean basins.

Each volume includes vertical sections along WOCE one-time lines of up to fifteen measured parameters; horizontal property maps (on depth and isopycnal surfaces) and theta-property scatter plots. The electronic versions of all products in the printed atlases are available on CDs, along with additional parameters, depth and isopycnal maps. The horizontal maps combine WOCE data with the best available historical data in each ocean. The printed scatter plots show all measured parameters against potential temperature only; additional combinations may be obtained from the electronic versions of the atlases.

It is envisioned that the first volume of the atlases (the Southern Ocean) will be available in June/July 2003. The complete atlas series will likely become the benchmark volumes in oceanography and serve as world reference standards for years to come.

ACHIEVEMENTS OF THE WOCE UPPER OCEAN THERMAL DATA ASSEMBLY CENTRE

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The collection of upper ocean temperature data by research and national operational programs began more than 20 years ago. In the mid-1980s, TOGA had both a research and operational requirement for upper ocean temperature data. The program established a series of lines along which samples were to be collected, and developed an organization to pool resources and share the sampling responsibility. WOCE adopted the collection system with little modification. A key component that was missing was the organization of the data management system. In early 1990, the Global Temperature and Salinity Profile Program (GTSPP) began. A major goal of GTSPP was to modernize the international data system for both temperature and salinity data. The WOCE Upper Ocean Thermal (UOT) group and GTSPP combined forces and implemented the UOT Data Assembly Centre (DAC). Included in the DAC were three national data centres and three oceanographic research centres. The key features built into the DAC activities included:
- the systematic capture of data circulating on the GTS in real-time,
- a standardized procedure for quality control for both real-time and delayed mode data,
- the methodical capture of the delayed mode data,
- oceanographic research centres providing scientific quality control of the data,
- standardized techniques for managing data versions and processing,
- the union of real-time and delayed mode into a single archive, and
- a management partnership among oceanographic research organizations and national data centers

The WOCE UOT DAC combined the talents of many individuals and organizations around the world. This strategy for distributing the work and many of the key features pioneered by the DAC have been carried over into a number of programs both in the national and international arenas.

DACs and Programmatic Products

THE WOCE HYDROGRAPHIC PROGRAM OFFICE

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The WOCE Hydrographic Program Office (WHPO) gathers, merges, and makes available data from the WHP (CTD and water sample data); improves the adherence of data to WHP format and content specifications; and assembles and provides relevant documentation. WHP data directories on the WOCE Version 3 data set contain data and documentation for the WHP One-Time Survey cruises, for the WHP Repeat Hydrography cruises, and for WOCE Time Series Stations. Organization of cruise data and documentation is hierarchical by WHP program, ocean basin, WHP line designator, and cruise date. Maximum station information is present in "WOCE" data files. "WHP-Exchange" data files are easiest to read, and are the basis for the "WOCE netCDF" data files.

The WHPO plans to continue operations in the post-WOCE era, at a reduced level, assembling and distributing WHP-like data and documentation. The preferred data file formats will be the "WHP-Exchange" formats. A new 'Guide to Submitting and Exchanging Profile Data and Documentation' is expected to be ready in early 2003 and will be widely distributed by the WHPO.

PERL scripts which permit assembly of WHP full-basin data sets from the individual cruise holdings on the WOCE Version 3 data set will be distributed from the WHPO web site.

Updates to WHP data continue to be made daily. The WHPO will continue to maintain a data and information web site, and will occasionally produce and distribute data disk updates compatible with the WOCE Version 3 data disks.

JAVA OCEANATLAS AND THE ATLAS OF OCEAN SECTIONS

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Java OceanAtlas is a Java application that provides a graphic exploration environment to examine and plot oceanographic vertical profile data. The original root of the application is the program Atlast developed by Peter Rhines, and the Mac OS applications OceanAtlas and Power OceanAtlas. Java OceanAtlas, now in version 3.1, brings many new and improved features. Installers are available for Mac OS 9 and X, Windows, Solaris, and Linux.

Java OceanAtlas plots property-property, offset profiles, contours, and maps, using color as a plotted variable to aid interpretation. There is a comprehensive data display window. All Java OceanAtlas plots are linked and may be browsed by sample and/or by station. Plots can be re-scaled, resized or have recolored. Selected areas of most plots can be replotted. Standard levels, scales, contours, and colors can be changed via user interfaces similar to those in commercial applications. Java OceanAtlas provides data filtering and exporting. Profile data of arbitrary parameter composition can be imported in several standard community formats including spreadsheets, WOCE 'WHP-Exchange', NODC 'SD2', and EPIC netCDF. Java OceanAtlas will work with any pressure-indexed parameters.

A companion data set development—the Atlas of Ocean Sections—provides vertical section data usable by Java OceanAtlas and other applications. Data include pre-1990s sets for pressure, T, S, dissolved oxygen, and nitrate, phosphate, and silicate from more than 2000 ocean sections (including the major pre-WOCE trans-oceanic sections), data extracted from the mean property fields in the Levitus WOA98 compilation, and fully assembled multi-parameter basin-scale sections from the WOCE Hydrographic Program.

Java OceanAtlas and the Atlas of Ocean Sections data sets are available as free downloads from http://odf.ucsd.edu/joa. A free copy of the Atlas of Ocean Sections v2 CD-ROM, including Java OceanAtlas, is at http://podaac.jpl.nasa.gov/order/order_displaytools.html.