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OCEAN PC and a Distributed Network for Ocean Data

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Introduction

The Intergovernmental Oceanographic Commission (IOC) wishes to develop an integrated software package for oceanographic data entry and access in developing countries. The software, called "OCEAN-PC", would run on low cost PC microcomputers and would encourage and standardize: 1) entry of local ocean observations, 2) quality control of the local data, 3) merging local data with historical data, 4) improved display and analysis of the merged data, and 5) international data exchange. OCEAN-PC will link existing MS-DOS oceanographic programs and data sets with table-driven format conversions. Since many ocean data sets are now being distributed on optical discs (Compact Discs - Read Only Memory, CD-ROM, Mass et al. 1987), OCEAN-PC will emphasize access to CD-ROMs.

OCEAN-PC would be modelled after WMO's successful Climate Computer (CLICOM) which has been installed in over one hundred locations to form a internationally distributed system for entry, display and exchange of meteorological data. OCEAN-PC would be installed in many locations globally to form a similar distributed system for oceanographic data.

An eventual goal of OCEAN-PC is to link with an electronic network of workstations and database management systems which is now being developed. This system is based on the Naval Environmental Operational Nowcasting System (NEONS) which is a fast, flexible data base management system designed for maximal use of computer and data exchange standards. NEONS database systems have been installed at several Navy and NOAA facilities and in Canada and Australia. The systems form a distributed network so that users can browse files on a local database or on a remote system over INTERNET to download data of interest. The network thus allows transparent, timely exchange of environmental data: each site does its own thing with its data and shares it in at high speed with others.

Development of OCEAN-PC

IOC has proposed two avenues for the development of OCEAN-PC: 1) assemble and distribute a "shoebox" of floppy discs of available oceanographic programs and CD-ROMs of historical ocean data files, and 2) develop a plan to link the programs to form an integrated package entry, quality control, archive and display

of oceanographic data. The shoebox of programs will be available soon and this paper describes the present plan t integrate the programs. Shoebox programs include the ATLAST program for vertical oceanographic sections (Rhines 1991) and a program for satellite image analysis (Robinson et al. 1991).

Many problems exist that must be faced in linking available oceanographic programs and data sets. A major one is that we oceanographers use a multitude of data formats. Format conversions are often required to move data between programs. Each format conversion causes delays, possible data errors and losses, and software maintenance costs. Due to complexity of format conversions, international data exchange is inhibited as is merging of local data sets to form global data sets. Also because of the multitude oμ ocean data formats, available oceanographic programs are hard-coded to only a few specific formats and thus lack flexibility. Although a program may read and write data in several formats, once the program is compiled and distributed, it is limited to these formats.

An example is the GulfPlot program which is being developed by the Minerals Management Service in New Orleans and which is an initial component o f OCEAN-PC (Brown 1992). GulfPlot was originally developed for mapping ocean data o• a PC and exchange of data on electronic mail bulletin boards. GulfPlot is widely used in the Gulf of Mexico region with a many types of ocean data, including locations of ocean fronts and boundaries, tracks of drifting buoys, locations of oil spills, and strandings of marine mammals. Many of these data files are routinely posted on the OMNET GULF.MEX bulletin board. GulfPlot can now accept data from other sources, including the ATLAST program for vertical contour sections and ice edge data on the OMNET SEA.ICE bulletin board. Interfaces to other data sets, including ROSCOP data files and research ship tracks are being developed. The program can operate in any area globally and output data to commercial software (WordPerfect and SURFER).

Similarly, there is no standard format for CD-ROM data sets. An example of this is the CD-ROM of TOGA data for 1985-86 developed by the Jet Propulsion Laboratory (Halpern et al. 1990). This CD-ROM contains eleven different data sets and eleven different data extract programs. While there are ocean temperature and salinity profile data on the TOGA CD-ROM, the TOGA extract software can not read the two new CD-ROMs issued by NODC of several million profiles globally (NODC 1991). In general, it is not possible to read all CD-ROMs with a single set of software and thus users who wish to use data from several CD-ROMs are faced with an array of noncompatible programs.

Besides the data format problem, a second problem in designing OCEAN-PC is that of data sequence. For fast access to data, particularly from slow CD-ROM readers, all data required for a particular application must be available at the same time; PCs are too small for sorting large data files. For making: 1) contour oceanographic sections, the data should be sorted by ship and then time, 2) synoptic maps, the data should be sorted by time and the latitude or longitude, and 3) time series, the data should be sorted by area and then time. An example of

the importance of this is the difficulty of making oceanographic sections with ATLAST from data on the NODC CD-ROMs. The NODC CDs are sorted by Marsden Square and instrument type and thus much time is required to extract an oceanographic cruise.

Present Status of OCEAN-PC

In summer 1992 under IOC funding, an initial version of OCEAN-PC will be developed by linking several programs and data sources: 1) The MMS GulfPlot mapping program, 2) A series of data entry, quality control and inventory programs developed by the International Council for Exploration of the Sea, and 3) The two NODC CD-ROMs of global temperature and salinity profiles.

The resulting program will be a minimal system to satisfy IOC's requirements. The program will be global in coverage and incorporate CD-ROM data files but will have only limited file maintenance facilities and be unable to handle additional data formats without additional hard-coded format conversions.

Future Expansions of OCEAN-PC

If funding is available, OCEAN-PC will be expanded to avoid the problems associated with hard-coded software and to add flexibility. The development will be in three phases:

PC1: Use NGDC FREEFORM table-driven format conversion software for ASCII conversions and compact binary data storage,

PC2: Extend format converter software to read and write WMO BUFR and GRIB to store large oceanographic data sets on CD-ROMs and for international data exchange, and

PC3: Incorporate NEONS Database Management System.

PC1: Table-Driven Conversions

The National Geophysical Data Center (NGDC) has recognized the importance of the format problem for exchange and archive of geophysical data> To attack the problem, NGDC has developed a table-driven program, FREEFORM, to read and write data i• fixed ASCII and binary (to the byte level) formats (Habermann and Mock 1991). Use of FREEFORM in OCEAN-PC will allow great flexibility in reading data sets and output to display programs. NGDC has already adapted FREEFORM to read the NODC CD-ROMs and is adapting it to read the ASCII data sets on the TOGA CD-ROM. OCEAN-PC will use FREEFORM to store data in binary for compact data storage and fast access.

NGDC designed FREEFORM to read CD-ROMs and other media for input to an advanced mapping program, GEO-VU, for global visualization of geophysical data. GEO-VU is an expansion of NGDC's very successful "Geophysics of North America" CD-ROM and software (NGDC 1989). GEO-VU is primarily for raster data but also can display point, line and gridded data sets. In OCEAN-PC, GEO-VU would replace GULFPLOT for greatly expanded mapping and display abilities and interface to many additional data sets, including geology, seismology, and global climate data. Also GEO-VU is programmed in C language with the "XVT" toolkit to allow operation on three graphics systems: Windows 3.0 on PCs, Apple Macintosh computers, and X-Windows on UNIX computers.

In OCEAN-PC FREEFORM will also be linked to a program being developed by Fleet Numerical Oceanography Center (FNOC) for downloading, contouring and display of weather and ocean gridded fields (Thormeyer et al. 1990). This program, NODDS PC, was developed as part of the Navy/NOAA Oceanographic Data Distribution System (NODDS) and is used in over 300 military locations for real-time access to FNOC analyses and forecasts. NODDS PC contours gridded fields, supports simple displays of satellite images, and plotting of weather and ocean observations. Users can overlay observations on fields and satellite images, grids on images, etc. The NODDS PC program will be supported for civilian users by the Ocean Applications Branch (OAB) of the National Ocean Service. In addition to real-time data and FNOC analyses and forecasts, OAB's system will store data for at least 30 days so that users can reconstruct marine events that led up to a particular event.

In support of OCEAN-PC, NOS/OAB will expand NODDS PC to use FREEFORM to access non real-time data sets on floppy discs or CD-ROMs. This will allow users to overlay real-time weather data from NODDS PC on historical data read with FREEFORM from CD-ROMs and other sources. In parallel with GEO-VU, OAB is supporting conversion of NODDS PC from MicroSoft QuickBASIC to C with the XVT windowing toolkit. NODDS PC and GEO-VU will thus become two display options in OCEAN-PC; NODDS PC for gridded meteorological and oceanographic fields and GEO-VU for raster and other geophysical data sets.

In cooperation with the NOS Ocean Observations Division, OAB will provide the NODDS PC software to merchant and other vessels to operate with OOD's SEAS (Shipboard Environmental data Acquisition System). NODDS PC and SEAS will use INMARSAT Standard C for two-way communications with fishing and other vessels: the vessels making subsurface XBT or mini-CTD profile casts and real-time SEAS reports and in return, receiving NODDS PC weather and ocean forecasts and analyses. Such a cooperative, two-way communications program will support the Global Ocean Observing System (GOOS) and help reduce the cost of XBT probes on merchant vessels for monitoring upper ocean thermal conditions.

PC2: Extend FREEFORM to BUFR and GRIB

FREEFORM will be expanded to read and write data in the two binary formats being developed by WMO for improved real-time global exchange of weather and ocean observations on the Global Telecommunications System (GTS). These are the Binary Universal Format for data Representation (BUFR) for observations and GRIdded Binary for gridded fields (Stackpole 1990). BUFR is a table-driven format and is sufficiently flexible for use with many types of environmental observations. Use of BUFR and GRIB in OCEAN-PC will allow: 1) compatibility with the GTS and 2) compactness for efficient storage and fast retrieval on relatively slow CD-ROM readers. While BUFR has not been widely used in oceanography (only in the IGOSS/IODE GTSPP program), GRIB is commonly used in meteorology and for some CD-ROM data (e.g. ECMWF weather fields on the TOGA CD-ROM).

To handle BUFR and GRIB, the FREEFORM software will be extended to read and write data down to the bit level. Also, the format descriptor tables in FREEFORM will be linked to WMO's data descriptor tables for BUFR and GRIB which will require standardization of names and units of environmental variables. Many oceanographic variables have already been defined by the IODE General Format 3.

Incorporation of BUFR and GRIB formats in OCEAN-PC will allow compatibility with an evolving internationally distributed network of database management systems as described later. Experiments will be made to store large data sets in BUFR and GRIB on CD-ROMs. This work would be in close cooperation with NODC who can prepare and publish CD-ROMs. For fast access to data from relatively slow CD-ROM readers, experiments will be made to determine optimum sort sequences for specific applications.

PC3: Incorporate NEONS Database Management System

The file structure of the OCEAN-PC must be designed for flexible, fast extracts and retrievals. Initial versions of OCEAN-PC will use BASIC random access files and binary files generated by FREEFORM. Later versions of OCEAN-PC will test data storage in BUFR and GRIB formats. These file structures are simple and convenient but lack the flexibility of a database management system. A modern database system is the NEONS database management system which has been installed on a desktop UNIX microcomputer. Incorporation of NEONS in an advanced version of OCEAN-PC would allow linkage with an evolving international network of database systems for fast, timely international data exchange.

Distributed Network of Database Systems

The Naval Environmental Operational Nowcasting System (NEONS, Shaw et al. 1990, Jurkevics et al. 1990) was developed by the Naval Research Laboratory (NRL) in Monterey, CA. NEONS is based on the commercial database management system and was designed for maximal use of standards, including UNIX, X-

Windows, INTERNET communications, and the WMO BUFR and GRIB data formats. NEONS was designed to take advantage of fast new RISC processors and is compute bound whereas many other database systems are input/output bound.

NEON systems are installed at several Navy sites and also in Canada and Australia. The Navy offered the NEONS software to NOAA at no cost and NOS/OAB has supported its use within NOAA. To date NEON systems have been installed at NOS/OAB, the National Climate Data Center (NCDC) in Asheville, NC, and the Climate Monitoring and Diagnostics Laboratory (CMDL) in Boulder, CO. Several additional NOAA installations are proposed. The NEONS at NOS/OAB serves as a file server for distributing FNOC weather and ocean data to users with NODDS PC software.

NRL is developing browse software which will be the user's window into the NEONS network. Using this software, the user graphically specifies for what area of the world and what time period he desires data and then the software queries the database (either locally or remotely over INTERNET) so he can progressively refine his request to data types and data sets of interest. The browse software will use FREEFORM to format the downloaded data as specified by the user and in the future, display the QC characteristics of the downloaded data.

The several NEON systems form the basis for an internationally distributed network of database management systems where each system can browse files on other systems and download data sets of interest. For example in the Global Climate Perspectives System, NCDC in Asheville is loading global temperature and precipitation and other data into their NEONS. The Climate Analysis Center in Washington DC has accessed NCDC's database over INTERNET, browsed files and downloaded data. Meanwhile CMDL in Boulder is loading surface marine weather data (COADS) and other data into their NEONS for local and remote access.

NEONS incorporates software to convert data to UNIDATA's NetCDF format for use by display and analysis programs and for international exchange. Software to also convert data to NASA's Common Data Format (CDF) and to the University of Illinois Supercomputing Center's Hierarchical Data Format (HDF) will be developed.

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