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The Naval Environmental Operational Nowcasting System (NEONS) is being developed at the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) to support research into new techniques for analysis and interpretation of environmental data. A primary objective of this workstation system is to facilitate the 'virtual sensor' concept, whereby data from a variety of sources are integrated and blended to extract information about the environment not possible using any single sensor. When these virtual sensor techniques are developed, they will be implemented on the Naval Tactical Environmental Support System (TESS(3)). One component of NEONS is an environmental database which provides storage, management, and access to a large variety of oceanographic and atmospheric data. An introduction to NEONS and its data base was presented in two papers at the Sixth International IIPS Conference in February 1990 by Shaw et al. (1990) and Jurkevics et al. (1990). This note describes further developments in the database component of NEONS within the past 12 months.

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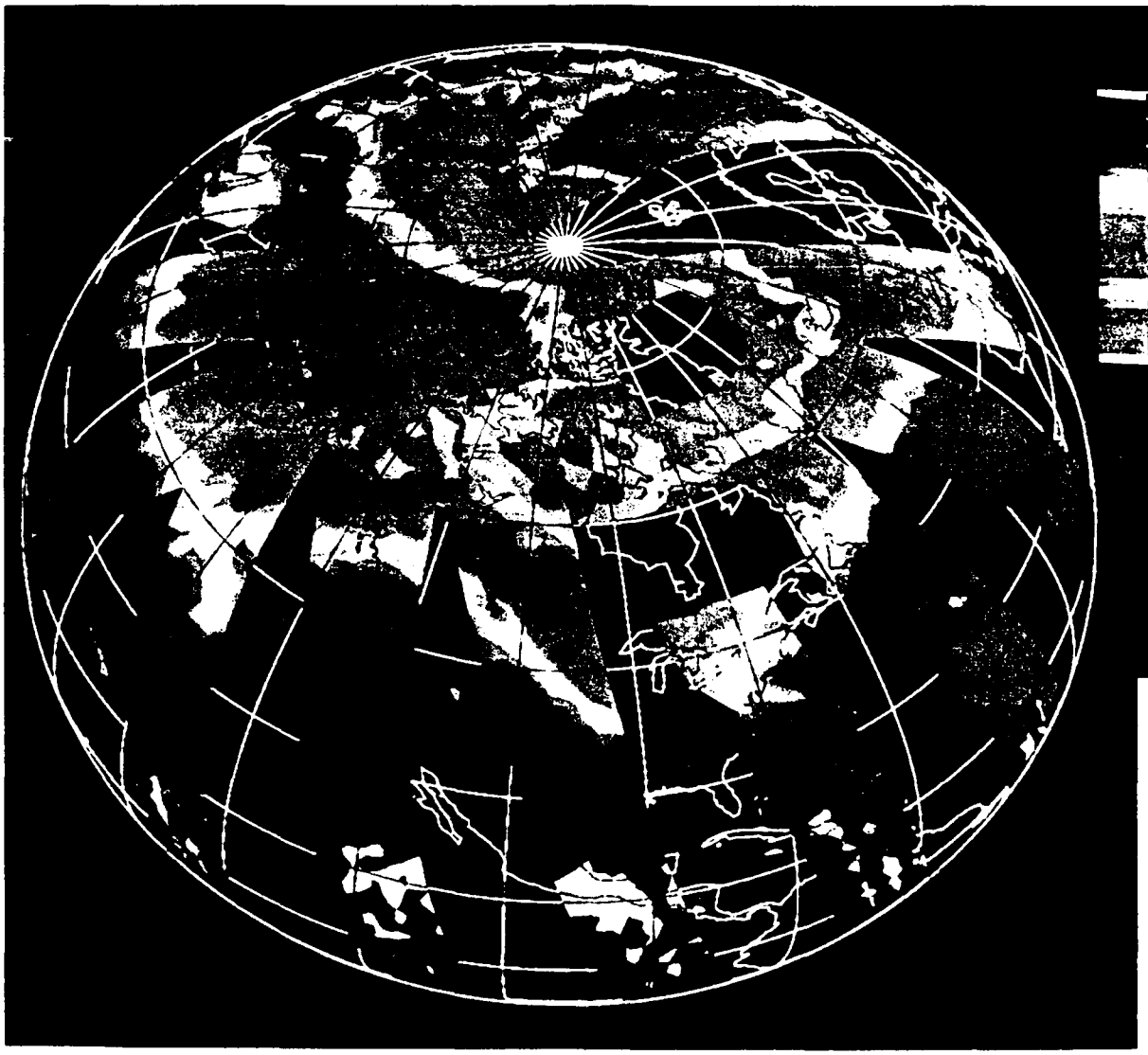

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NEONS ENVIRONMENTAL DATABASE -- RECENT DEVELOPMENTS

Andrew Jurkevics and Richard Titus
Computer Sciences Corporation
Monterey, CA 93940

Ted Tsui
Naval Oceanographic and Atmospheric Research Laboratory
Atmospheric Directorate
Monterey, CA 93943-5006

1. INTRODUCTION

The Naval Environmental Operational Nowcasting System (NEONS) is being developed at the Naval Oceanographic and Atmospheric Research Laboratory (NOARL) to support research into new techniques for analysis and interpretation of environmental data. A primary objective of this workstation system is to facilitate the 'virtual sensor' concept, whereby data from a variety of sources are integrated and blended to extract information about the environment not possible using any single sensor. When these virtual sensor techniques are developed, they will be implemented on the Naval Tactical Environmental Support System (TESS(3)). One component of NEONS is an environmental database which provides storage, management, and access to a large variety of oceanographic and atmospheric data. An introduction to NEONS and its data base was presented in two papers at the Sixth International IIPS Conference in February 1990 by Shaw et al. (1990) and Jurkevics et al. (1990). This note describes further developments in the database component of NEONS within the past 12 months.

2. OVERVIEW OF DATABASE DESIGN

The NEONS database is built around a commercial relational database management system (DBMS). A wide variety of environmental data including satellite images, satellite soundings, numerical model outputs, atmospheric and oceanographic conventional reports, and climatology data are being handled routinely. The database schema is organized so all environmental data fall within three generic data categories: image, grid, and lat-lon-time. Lat-lon-time and grid data are packed into variable-length bit streams based on the WMO formats BUFR (ECMWF, 1988) and GRIB (Stackpole, 1988) and stored in relational tables. The use of a commercial DBMS in conjunction with the generic data approach results in more than one order of magnitude reduction in software effort. It also simplifies system design, reduces data volume by packing, provides portability, extensibility, network transparency, and a data interface based on industry-standard Structured Query Language (SQL). An application-program interface is provided by a set of routines which contain embedded SQL; data browsing is done using a fourth-generation language (4GL) program. Users access all environmental data on the basis of geophysical characteristics instead of physical storage properties such as record formats, files, directories, or network nodes. Thus, for example, lat-lon-time data are accessed by parameter, report type and latitude, longitude, and time range. Grid-point data are accessed by model, parameter, level, time and forecast time.

3. ENHANCEMENTS TO DATABASE

Progress on the NEONS database has continued within the past year. Several new atmospheric, oceanographic, and climatologic data sets have been added as instances of the generic data types. Networking capabilities have been added (see next section). The schema has been extended to include a geographic realm which includes coastlines, bathymetry, topography, and land surface type data. The primary 'grid' environmental data type, which handles outputs from ocean and atmospheric numerical models, has been extended to include spherical harmonic coefficients in GRIB format. Satellite orbital elements and image navigation capability have been added. A naming convention and glossary of environmental data names have been developed in cooperation with Fleet Numerical Oceanography Center (FNOC). This glossary currently contains over 1,100 entries. Finally, the commercial DBMS from Empress Software Inc. used by NEONS has been upgraded to the latest release, resulting in a 35 percent performance improvement over the previous version.

4. NETWORKING CAPABILITIES

NEONS networking capability supports transparent distribution of data over a local area network. Environmental data may be placed on any network node and accessed from any other node. (This transparent networking is currently restricted to workstations from a single hardware manufacturer.) Also, existing data can be moved between nodes without shutting down the database. The total size of any particular data set, for example, grid fields from the NOGAPS atmospheric model, is determined by the total storage capacity on the network. This 'scalable storage' is accomplished by allocating a series of relational tables for a given data set such as NOGAPS. The system administrator controls the size and placement of each of each table. When a given table grows to, say, 200 megabytes, a new one is allocated and ingest continues. Users access individual fields by parameter, level, and time, not the actual tables or network nodes.

Data exchange between remote systems running the NEONS database is accomplished using an external format which is simply the database internal format for image, grid, or lat-lon-time data copied to an external file. Interfaces to BUFR, GRIB, and netCDF data formats are currently under development.

5. DATABASE PERFORMANCE

The following timing results give an indication of database performance. They were obtained using a Hewlett-Packard 9000 835 computer, which is rated at 14 MIPS and 1.7 MFLOPS. These times are the total central processing unit (CPU) usage and include all NEONS software, Empress DBMS software, and operating-system services.

Grid-point data: read 50 global NOGAPS grid fields, each containing 144 x 288 = 41,472 points in 13 seconds.

Lat-lon-time data: read 20,000 surface-land reports, each containing 27 environmental parameters in 15 seconds.

Image data: read a satellite image containing 1024 lines by 1024 samples by 4 bands (6, 8, 10, & 12 bits) in 10 seconds.

In each case the datasets were selected from the database, unpacked, and placed into program variables. These times are nearly independent of the total volume of each data type (total count of NOGAPS fields or surface land reports) resident in the database due to the indexing system used within NEONS.

6. STATUS OF OPERATIONAL NEONS

A copy of the NEONS database system has been installed for operational use or evaluation at the following sites: NOARL Atmospheric Directorate (using), Institute for Naval Oceanography (using), NOAA Center for Ocean Analysis and Prediction (using), FNOC (evaluating), Naval Oceanographic Office (evaluating), Wood's Hole Oceanographic Institute (evaluating), and the Canadian Atmospheric Environmental Service (evaluating).

Groundwork is currently being laid for implementation of the NEONS database on the large-scale computer at FNOC. Two Cray Y-MP computers have been selected as the FNOC next-generation large-scale computer system. One will run numerical models and the other will perform file service. Three issues must be addressed before the NEONS database can be implemented in this environment. First, database performance on the Cray computers must be demonstrated to be acceptable for operational work. Second, a commercial DBMS package which supports the NEONS data architecture must be available on this hardware. Third, the NEONS if necessary to ensure it includes all operational environmental data. Representatives from FNOC, NOARL, and Cray Research Inc. are currently working on these issues. If all goes well, a version of the NEONS database should be operational on the large-scale computer within one year.

7. FUTURE PLANS

Future plans for the NEONS database at NOARL include the following:

a) add new environmental data sets which fall within the current generic categories;

b) extend the schema to include environmental data such as weather radar and side-scan sonar which do not fit into the current schema;

c) implement the database on a network of heterogeneous hardware platforms;

d) implement a file server consisting of an optical-disk jukebox to provide transparent high-capacity on-line storage; and

e) assist with the implementation of NEONS in the Navy operational large-scale computer environment.

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