INFORMATION TECHNOLOGY USE IN SEAWATCH INDONESIA.

Dr. B. P. Thrane, MSc.*

Abstract

In this paper we will present the use of information technology in the SEAWATCH Indonesia environmental surveillance system. The SEAWATCH Indonesia system consists of a network of buoys deployed in Indonesian territorial waters. The buoys measure environmental and meteorological data automatically. The SEAWATCH system uses information technology extensively from the buoy to the end user of the SEAWATCH data.

The computer centre consists of a network of five SUN workstations under the Solaris UNIX operating system. A number of personal computers are also connected to this network. A complete software package for storage, analysis, presentation, simulation and distribution of the data is included in the SEAWATCH system

I. INTRODUCTION

The parameters measured by the SEAWATCH buoys, such as water temperature, seawater conductivity, current speed and direction are stored digitally on the buoy itself. The internal hard disk stores all the measured parameters and these data can be recovered when the buoy is taken ashore for maintenance. Every hour, average values of the parameters are packed in a 32-byte package. This compressed data package is sent from each buoy to the SEAWATCH computer centre via the Inmarsat satellite. In the computer centre, the package is decompressed and the data are entered into the main database. The buoy data can therefore be viewed nearly in real time. Critical situations like algae blooms can thus be forecasted in an efficient way.

The ORKAN package includes tools for storage, analysis and data presentation. The data analysis software includes tidal wave analysis, statistical analysis and extreme analysis. A flexible plotting program can present the time series of the buoy data in different formats: for example Rose vector diagrams of the wind and current data, drift patterns of a virtual object floating with the current etc. OceanGIS is a geographic information system software based on the ARC/INFO package. Presentations of the buoy position, data time series and simulations can be made with a map background. The OceaNet system provides services for data distribution. Every day a set of data consisting of the last seven days is prepared. The data set can be customised for each external user.

* Advisor, SEAWATCH Indonesia

The external user connects to the computer centre by means of a modem and the corresponding data set can be downloaded. The OceanInfo program enables the external user to download and view the last week's data easily. The end user has therefore access to the present situation in the buoy area every day. In this paper we will concentrate on the storage, analysis, presentation and distribution tools, as the simulation will be presented in another paper.

II. SOFTWARE FOR COMMUNICATION BETWEEN THE BUOYS AND THE READ-DOWN STATION

The raw data measured by the instruments in the buoys are very valuable. The data is expensive to collect and can be sold for a high price. The data security during collection and transmission of the data is therefore a major issue in the SEAWATCH system.

The raw data is stored in the internal hard-disk of the buoy. The data on this hard-disk can only be read and decompressed by dedicated software developed by OCEANOR. Several solutions can be chosen for the transmission of the data to the read-down station. In the case of SEAWATCH Indonesia, the Inmarsat satellite communication system has been chosen. This satellite system has a wide coverage area that makes it possible to place buoys anywhere in Indonesia. The system is also very secure because the data messages are sent to a unique identification number (like a telephone number) which identifies every read-down station.

The cheapest and smallest data package that can be transmitted by the Inmarsat system is 256 bits long. By a simple, yet very secure procedure, all the parameters measured by the buoy are packed into a 256-bit file. To be able to decode these files, one has to know the sequence of the parameters, the number of bits per parameter and the resolution and the offset of each parameter. Furthermore, the way the data is compressed changes every time the buoy is maintained. If anybody should be able to get hold of the raw data files transmitted via the Inmarsat system, it would be almost impossible to decode the message.

Every hour a new file is prepared and sent to the read-down station. The SEAWATCH Indonesia read-down station consists of an Inmarsat modem and a SUN workstation computer. The computer automatically reads the message from the Inmarsat modem, decompresses the 256-bit file and inserts the data into the ORKAN database. The ORKAN database and software will be presented in the following paragraph.

III. DATA CONTROL AND PRESENTATION SOFTWARE

In order to utilise the data and information gathered, a range of software products is implemented in the SEAWATCH™ system.

a. Orkan

The SEAWATCH™ data structuring, processing and presentation tool, ORKAN, comprises complete and flexible methods for processing, presentation and storage of environmental data. The core is an efficient database for measured time series and output data from numerical models.

ORKAN's compact data storage promotes fast processing and optimal disk use.

Operational programs for control, correction and analysis of data from current meters, wave buoys, meteorological sensors, satellite data etc. are available. ORKAN is supplied with modules for data import and export. The analysis module includes tools like joint occurence tables, statistics, rose vector diagrams, progressive vector diagram and extreme analysis (Gumbel or Weibull), each with a corresponding graphical presentation. Tools for wave and tide spectrum analysis are included in the ‘Neptun’ package. Wave raytracing can be performed for different bottom topographies with the ‘Rayspec’ software.

The ORKAN software is well adapted to make routine work easy, like plotting last week’s data.

b Data Presentation.

ORKAN is configured with data presentation modules, and modules to export information from the database to spread sheets or other standard presentation systems. ORKAN is also hooked up to a Geographical Information System (GIS) called OceanGIS.

OceanGIS is based on the ARC/INFO package. It has an easy-to-use menubased interface, the user needs no prior knowledge of ARC/INFO. OceanGIS features among other tools the possibility to plot the current position of the buoys utilising the ORKAN database information. Time series of the data can also be plotted with the map as a background. Output from the numerical models (SEAWATCH3D and NOMAD) can be presented on the map, thus making it possible to merge observed, simulated data and zoning information on the same presentation.

c. Data Distribution

OceaNet is the Data Distribution Tool that is implemented in the Processing Centre for distribution of data to remote users (PC or workstations). OceaNet extracts updated data available from the database and its connected buoys and prepares the information for downloading by modem or network. It groups the available information in different file formats suited to the data.

OceaNet is divided in three main tasks:

- data storage for time series, text and administrative information. OceaNet uses the OCEANOR made ORKAN time series data base for storage of the time series from buoys and meteorological stations. Other information like reports and forecasts is handled through the use of the Oracle relational database.
- user administration implemented in Oracle. Different user profiles may be incorporated in this and tailor made to specific requirements from the users. The user profiles serve as filters, and they offer security towards not letting unauthorised users extract restricted information.

The requested information can in other words be matched towards the authorisation level of the requesting user.

- protocol software that supports network and asynchronous downloading of files from the OceaNet central to users with Internet or PC and modem.

The remote PC or workstations will have OceanInfo installed. This is an end-user PC application supporting files downloaded from OceaNet. It is implemented as a Microsoft Windows MDI (Multiple Document Interface) application. OceanInfo supports the following presentation modes:

- presentation of time series as graphs and tables
- presentation of textual information
- presentation of Object Linking and Embedding prepared reports

Users connect to the OceaNet central by using a modem or the network. Files may subsequently be downloaded to the local PC or workstation and stored to disk. Further applications for presentation and analysis may be used with the downloaded data as input.

IV. NUMERICAL MODELS

As for the software mentioned above, some numerical models is implemented in order to take full advantage of the system.

Three types of numerical models are available in SEAWATCH™:

- An ocean circulation model (SEAWATCH™ -3D)
- A general dispersion model (NOMAD)
- Two oil drift models (OILSPILL and OILSTAT)

The SEAWATCH™ -3D and NOMAD models are implemented on UNIX WorkStations, while the OILSPILL and OILSTAT models are designed for IBM PC compatibles under MS Windows. A common presentation program (Ocean2D) is designed for the WorkStation models, where the sea elevation, current velocities and the concentration field may be visualised based on output files from the models. Ocean2D is mainly intended as a tool for the model operator, while the presentation made for the SEAWATCH™ clients are based on the GIS. The different models are described in more detail in the following paragraphs.

a. Ocean Circulation And Dispersion Models

The NOMAD model is general oceanic dispersion model based on a Lagrangian concept, i.e., model particles representing a discharge of aqueous effluents or particulate matter are tracked in the 3D current field produced by the SEAWATCH™ -3D model. Turbulent dispersion is represented by random walk superimposed on the motion determined by the prescribed local current velocities. The particle positions may be initialised from a specified concentration field - or by a near field plume model, accounting for the eventual initial momentum and buoyancy of the discharge. In the later case, the model particles will follow the plume up to a point where the near field effects may be considered negligible compared to the motions determined by the ambient current and oceanic turbulence.

When discharges of particulate material are considered, each model particle may be allocated a terminal velocity selected from a prescribed distribution of settling or rise velocities determined by the size distribution and density of the discharged materials. Submodules for handling decay processes of the discharged material are also available, including, e.g., decay of radioactive materials, dissolution of water soluble fractions from dispersed droplets and volatilisation of dissolved fractions to the atmosphere. We also plan to include submodels representing the fate of oil spills in the NOMAD model, including gravity spreading, evaporation of volatile fractions, formation of water in oil emulsions and natural dispersion.

The SEAWATCH™ -3D model is an ocean circulation model designed for simulations of the sea elevation, currents and density (salt and temperature). The model uses a boundary fitted co-ordinates grid in the horizontal, which follows the coastal line, while a constant number of levels is used in the vertical in as sigma-co-ordinates system. The horizontal diffusion coefficient is parameterised as a function of the horizontal velocity (Smagorinsky formulation), which allows the coefficient to vary in time and space.

Coastal and estuarine areas often show steep gradients in their temperature and salinity characteristics, such that the use of conventional finite difference numerical schemes introduces errors in the form of artificial numerical diffusion or numerical dispersion, which often manifest themselves in the form of short-wave oscillations. For example, the use of lower order schemes produces numerical diffusion which is the accumulated in each time step, while the use of second-order or higher order accuracy schemes can produce negative values in the solution due to disperse ripples. A method that has been developed by Smorarkiewicz (1983, 1984), has been implemented to overcome this problem. This method is based on an iterative approach of the upstream scheme. The major advantages of this scheme are its transportive property, i.e., that any perturbation will be transported only in the direction of the velocity, and its capacity to conserve the positive value of the variable.

To make the grid generation more efficient the GIS is integrated with a grid generation program. By this system the user can specify a coarse grid, which is later interpolated and smoothed to obtain the computational grid. Finally, the depth at the grid centre is obtained from a world map database or data digitised at OCEANOR.

The output from these models may be visualised by the *Ocean2D*. This program enables plots of depth contours, sea level contours, and current velocity vectors at specified depths based on output from different time steps produced by the SEAWATCH™ -3D model. Particle trajectories may also be plotted from a number of selected positions in the simulation area. The same program can also be used for presentation of particle positions or concentration contours in different depths based on the output for different time steps from the NOMAD model. The concentration field is obtained from the particle positions by a procedure which distributes the mass allocated to each particle in a disc with a radius proportional to the local mean particle separation. The concentration values - which are obtained as a sum of the contributions from all particles - are saved in a regular mesh, with a mesh size proportional to the zoom area. In this way, zooming into smaller areas of the plume may reveal details in the concentration field.

The SEAWATCH™ -3D and NOMAD models are presently implemented for the North Sea, Norwegian Sea and Barents Sea (the NABAS) region in conjunction with SEAWATCH™ Europe, and in the Gulf of Thailand in conjunction with SEAWATCH™ Thailand.

B. Oilspil Modelling

As indicated previously, two oil drift models are also included in SEAWATCH™. The OILSPILL model is designed for predictions of drift and fate of oil from an actual oil spill, while the OILSTAT model is a statistical oil slick trajectory model, to be used for consequence studies and oil spill contingency planning. Both models are based on the wind rift factor concept, i.e., the oil drift velocity is presumed to be a sum of a local wind induced drift (3% rule), superimposed on tidal currents and a seasonal permanent background current. The wind data used in the OILSPILL model are entered interactively by the user, in terms of updated observations and wind forecasts, while a database with historical wind data for the region of concern are used in the OILSTAT model.

The main purpose of *the OILSTAT model* is to obtain a statistical picture of oil drift from a spill site selected by the user. The statistics include minimum drift time *to* - and the probability for oil contamination *of* adjacent open sea and coastal areas. The results are presented as contour plots on a map of the region of concern. The model is designed as a trajectory model, where a large number of instantaneous oil spills are tracked from a specified position, each starting randomly in time within the available time series of historical wind data. Each trajectory is tracked to a maximum drift time of e.g. 30 days, or until the trajectory eventually crosses the coastline.

OILSPILL simulates drift and fate of continuous oil spills based on wind observations and forecasts entered by the user. The user also enters the spill site, the spill rate and the duration of the spill, together with the oil type. A number of predefined oil types are installed in the model, with oil properties such as fraction evaporated, flash point and pour point, oil viscosity, water content and viscosity of the water-in-oil emulsion defined for different degrees of weathering. The oil data are computed as a function of time for a standard set of environmental conditions (wind speed and sea temperature) by an oil-weathering model, partly based on input from laboratory studies of the oils of concern.

The oil drift model is based on a particles-in-fluid concept, where the oil spill is represented by model particles released subsequently during the predescribed spill period. Each particle is tracked by the surface current, represented as a sum of wind and wave induced drift, the tidal current and a permanent background current. *Near field spreading* is based on a terminal thickness approach, i.e., the particles needed in one time step are presumed to occupy an area inversely proportional to the prescribed thickness of the slick in the near field, and proportional to the amount of oil discharged per time step. The axial dimension of the seed area is determined by the surface current at the release time. *Far field spreading* of the oil is presumed to be dominated bay shear spreading, i.e., the spreading mechanism is supposed to be due to entrainment and subsequently resurfacing of oil droplets in the wind induced current shear in the surface layer.

The properties of the oil are obtained during the simulation by updating the evaporative exposure time derived from the wind history during the drift period. The incremental exposure time in one time step is proportional to the ratio between the actual wind speed and the wind speed used in the computations of the oil property table i.e., $E_{n+1} = E_n + Dt\ W/W_{Ref}$. The fraction evaporated and the oil properties corresponding to a given exposure time may then be obtained by interpolation in time in the oil properties table. Loss of surface oil due to natural dispersion is computed by a similar concept, i.e., and exposure time is updated by presuming that the dissipation rate is proportional to the wind speed squared. The fraction of the oil remaining after natural dispersion may then be computed from this exposure time and a dissipation rate α defined at the standard wind speed, i.e., $Q = Q_0 exo(-a\ E_d)$. The dissipation rate at the standard wind speed is reduced with increasing water content in order to account for the reduction in the dissipation rate due to formation of water-in-oil emulsion.

The output from the model includes the oil mass budget (amounts of oil released, oil remaining on sea, evaporated, dispersed and stranded), and contour maps of the thickness and extent of the oil spill at various times during the simulation period. The oil properties, including film thickness, water content, viscosity, flash point and pour point, may be determined interactively in any position of the slick by pointing and clicking with the PC-mouse.

The oil drift models have been extensively calibrated by dumping limited amounts of various types of oil at sea while observing gravity spreading, evaporation of volatile fractions, formation of water in oil emulsions and natural dispersion.For ducted oil spills, NOMAD is the model to be used.

V. CONCLUSION

The SEAWATCH system implemented in Indonesia uses information technology extensively. Information technology covers the whole range of the system: data collection, data storage, data analysis, data distribution and numerical modelling. Information technology enables the SEAWATCH Indonesia staff to do monitoring, forecasting, planning and modelling in an efficient way. Many different tools makes it possible to study the Indonesian territorial waters in different areas such as biology, physical oceanography, zoning and meteorology. The numerical models gives a means of forecasting and prevention of pollution events or algae blooms.

REFERENCE

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