Intergovernmental Oceanographic Commission
Training Course Report **86**

IODE/GOOS/JCOMM Combined Modeling and Data Management Training Workshop ("Jamboree")

Supported by the IOC, JCOMM and the Government of Flanders

Ostend, Belgium
September 5-10, 2005

UNESCO

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1. EXECUTIVE SUMMARY

The joint JCOMM/GOOS Panel for Capacity Building and IODE held the Combined Modeling and Data Management Training Workshop (the "Jamboree"), 5–10 September 2005, in the IOC Project Office for IODE in Oostende, Belgium. It was attended by trainees from the Indian Ocean region, Africa, and Central/South America.

The purposes of the workshop were:

- To train attendees to implement national services for warnings of wind waves and storm surges; and
- To improve interaction/ understanding between modelers and data managers.

A team of modeling experts from India and Norway designed a PC-based "Numerical Modeling Laboratory" (NML), including all necessary components for ocean numerical forecasting, as well as an Experimentation Plan for the tuning and validation of the selected models. The Jamboree was observed by IODE data management trainers, with a view toward developing a modeling curriculum in OceanTeacher-IODE training tool. The students performed sequential experiments in modeling and application of data for tuning and validation.
These attendees have learned;

- Principal, scientific functioning of selected numerical models;
- Operational setup with topography/bathymetry, forcing fields and graphics;
- Exercising model sensitivities and case studies;
- Searching for relevant observation data on the Internet; and
- Skills to lecture this knowledge to colleagues at the national/regional level.

The present workshop is seen as Phase I in the development of a future series of JCOMM/IODE/GOOS workshops. The specific technical results from the various modeling experiments are reported at http://ioc.unesco.org/oceanteacher/OpModWorkshop/index.htm.

The data management trainers met subsequent to the Jamboree activity to develop a wide-ranging series of recommendations for future capacity-building work. These included:

- **Results and Lessons Learned** – The wide use of the GRIB format in the meteorological modeling community will require concerted action to make these products usable by the oceanographic community where it is almost unknown; lack of documentation of models remains a problem, as well as scant knowledge among related disciplines about the availability of models and their capabilities; open-ended teaching methods used by JCOMM may offer some value to specialized IODE courses in the future.
- **Recommendations for Future Training in MetOcean Hazards** – The Jamboree agenda of activities should be augmented by a tsunami model(s), and by the addition of format conversion tools for "typical" oceanographic data file formats; a Jamboree 2 could take place when these additions have been made; fully developed, the "Jamboree" agenda would include training for wind waves, storm surges and tsunami surges.

- **Recommendations for Future Training in General Ocean Modeling** – The IODE program should expand to include a more general coastal ocean circulation model, capable of assimilating data from wide suite of operational sources, including satellite data and global- or basin-scale models.
- **Long-Term Trainee Support** – The IODE will endeavor to provide a HELP Desk, a permanent website, and a "Virtual Laboratory" for continued, post-session interaction and training among the participants. Major new sections are needed in OceanTeacher to support this work and future training.

2. INTRODUCTION AND OBJECTIVES

The joint GOOS/JCOMM Panel for Capacity Building, working jointly with IODE, held the Combined Modelling and Data Management Training Workshop (CMDM) 5 – 10 September 2005, in the IOC Project Office for IODE in Ostend, Belgium, with major preparations having taken also by the Norwegian Meteorological Institute. The workshop with its popular name "Jamboree" was attended by trainees from countries of the Indian Ocean region, Africa, and Central/South America.

The purposes of the CMDM workshop were:

- To initiate improved interaction/mutual understanding between ocean numerical modelers and ocean data managers;
- To enable attendants to implement national services for warnings of wind waves, storm surges, and potential application services such as oil spill simulations.

Consequently, a team of modeling experts from India and Norway designed a PC based "Numerical Modeling Laboratory" (NML), including all necessary components for ocean numerical forecasting. NML included a small number of freeware, transportable numerical ocean models termed 'community models'. The NML contributed to a "*recipe*" for corresponding observation data requirements for the tuning and validation of the models applied. An initial version of this "recipe" was formed by a small team of data managers (DM), who attended the workshop and observed a series of numerical experiment to demonstrate the rationale of this recipe. It is the aim that trainees having participated in JAMBOREE will be 'trained to become trainers', and as such qualify as future CB focal/resource persons in their home country or region.

The designed NML was applied also in a separate, similar workshop in Beijing 25 – 29 July, with attendants from South China Sea facing countries. At this workshop, data management issues had less priority, but an experimentation plan (Tropical Ocean Waves and Storm Surges) was prepared with several similarities to the CMDM. 4 resource persons from the Beijing workshop participated in CMDM workshop, where attendants exercised experiments in numerical modeling and the application of observed data for model tuning and validation. The CMDM workshop will reflect the scientific background for ocean data acquisition and numerical modeling. The 'trained trainees' will thereby perceive the dynamic interaction between science and observations and models, and in their subsequent trainer activities be enabled to transfer this knowledge to trainees in their country and region.

Attendants represented a mixture of DM expertise and NML expertise, and the aim was to equip them with a toolkit for installation of operational services where both DM and NML play complementary roles. DM attendants would successfully have completed the ODINAFRICA training programme (3 years) and work in an IODE data center as data managers, as well as have proven experience in knowledge transfer (training) at the local level. These attendants will learn:

- Requirements in data and data quality control for numerical modeling;
- The scientific background and motivation for ocean observations;
- Defining locations for sustained observations platforms;
- Managing datastreams of sustained observation platforms;
- Skills to transfer acquired knowledge to colleagues at the national level.

Modeling attendants were selected on the basis of having lead responsibilities at a forecasting or operational modeling center/network, plus a general knowledge of the way numerical prediction models work. Their home position and responsibility should be appropriate for the potential and subsequent implementation of operational, numerical models for prediction of the coastal/marine environment (e.g. ocean waves, coastal circulation and storm surge, tsunamis, pollution dispersion, etc.) They should also declare intention/willingness to engage in CB activities at their national and regional levels, both in terms of lecturing others, as well as assisting with implementations of models and data managements. These attendants will have learned:

- Principal, scientific functioning of selected numerical models;
- Operational setup with topography/bathymetry, forcing fields, graphics for presentation and modes of dissemination;
- Exercising model sensitivities and case studies;
- Methodology for acquisition/search for relevant observation data through IODE systems;
- Skills to lecture this knowledge to colleagues at the national/regional level.

The present workshop will be seen as a phase I in the development of a more constructive series of workshops co-organized by IODE and JCOMM. The experience from the CMDM workshop will form basic advisory material for this more long term Capacity Building effort.

3. PARTICIPANTS

The workshop was planned to include two integrated groups of scientists: expert and trainee modelers, and marine data managers from the IODE marine data management training programs (ODINAFRICA, ODINCARSA and ODINCINDIO). The modeling activities described in detail below and in Annex II were designed to provide a thorough, stand-alone educational program for the modeling trainees, while the overall activity was planned as a test bed for the data managers to assess what additional educational materials should be provided in the "OceanTeacher" resource of the IODE for its broad range of marine data and information training curricula. Initially, 4 modelers were invited, along with 1 data manager, from each of the above IODE regions. Almost as many experts, lecturers and resource persons were also invited, to insure a rich background of knowledge and skills. The list of participants and lecturers is provided as Annex II.

4. WORKSHOP PROGRAMME

Introduction

The core substance of this workshop was to provide experimenters with a set of forcing fields, plus a set of numerical wave and ocean models, and a plan for experiments where observation data are needed. Three experimentation groups were organized, each with one experiment leader and a reporter to record the results.

Purpose of the modeling experiments

The purpose of the experiments is primarily to enable trainees to run operational, local/regional oceanographic (wave, storm surge, circulation) forecasting models with corresponding application of ocean observation data., and secondly to familiarize with application models in support of oil spill combat and search and rescue. The experiments are organized in terms of case studies, either real time, historical or hypothetical ones. Trainees were trained to carry out the hardware/software (operational) installation of numerical models, presented with the most important features of the models, and subsequently performed JEP exercises to focus on issues such as:

- Forecast sensitivity to accuracy of input fields and basin geometry,
- Forecast sensitivity to model differences
- Utility of ensemble forecasting,
- Time/spatial variation in model outputs,
- Methods and sources for validation of forecasts,

- Assessment of benefits in homeland forecasting,
- Advancing science/research in related modeling or observations,
- Requirements for ocean data management related to model applications.

The latter issue shall be emphasized; and a new Course Manual (see Annex III) has been prepared as an additional element to the OceanTeacher.

Subsequent to the workshop, the IODE Project Office will institute a Long Term Trainee Support activity to continue to advise and assist trainees as they proceed to implement domestic services, or they themselves become trainers in their own country or region. The support activity will include relevant IODE and JCOMM experts working on a non-cost basis via emails, submitting summary reports to respective governing bodies, as appropriate.

JEP Laboratory requirements.

Prior to the workshop, a PC laboratory is set up, with the following prerequisites:

- 18 to 20 strong PC's provided by IODE/Oostende, including one PC as a "hub" for the others, providing input data from Internet and other data sources, and access to peripheral units such as printers;
- A minimum set of software tools for compilation of model source codes, provision of data transfers, graphics for presentation of results;
- A template specification of model characteristics, accessible forcing data needed; wind/pressure fields, ocean currents data, bathymetry;
- A "Strawman" advisory guiding modelers to observational data sources, which can serve to (1) Validate, model outputs, and (2) Tune the models if required. To some extent, case studies may be identified where such data are available.

Numerical Model Tools

Also prior to the workshop, numerical models need to be installed and prepared for experiments. It is a precondition that models are flexibly coded so they can be implemented for any geographical area with any resolution. The model experiments have been set up so as not to violate the "lab framework defined above". Within these restrictions, experimentation groups designed their own experiments.

The first 3 of the numerical models listed below were preinstalled and made ready for the JEP experiments. The other two will be presented and potentially made ready for experiments in a later workshop.

1. DNMI Wave Modeling System based on WAM (Guidance by M. Reistad and R. Bokhorst)
2. India Information Technology Storm Surge Modeling (Guidance by S. Dube)

3. DNMI Storm Surge model (Guidance by Ø. Saetra)
4. DNMI Search and Rescue support model (Presentation only)
5. Regional 3D circulation model (Presentation only)

All models are freeware, open source coded, and transportable to any resolution and geographical area. Copies were provided in CD. Introductions and scientific backgrounds for the models were given at the beginning of the workshop.

Suggested areas for model simulations

The areas selected for numerical simulations and comparison/validation towards observation data were:

- One area in the Indian Ocean .
- One area in the Gulf of Guinea or outside West Africa
- One area in the Caribbean Sea
- One area at the Pacific side of Central America

Input fields

- Bathymetry downloaded from Internet
- Wind/pressure fields from a variety of sources

Ocean observation data

These data are needed for model tuning and/or validation of results from the experiments (numerical data assimilation is beyond the remits of the workshop). It is conceivable that at the time of the workshop, no predefined linkage has been set up for immediate access/provision of such data. The exception would be if some specific case studies have been identified where this is possible, and a Strawman suggestion for "model-data" combination will be presented.

At the conclusion of the workshop, however, a "Recipe" for the combination of models and observational data will be drafted and discussed, and possibly included in a future OceanTeacher course manual.

Experiments

The following text provides "Strawman" guidelines for experiment group leaders. Leaders will be prepared to teach how to access necessary forcing data etc. Leaders are free to define their groups experiments, but should target major issues such as model sensitivies. Leaders are encouraged to identify case studies which in particular demonstrate major issues of interest. Modeling areas and resolutions will be decided the beginning of the workshop.

JEP Group A - Task leader: Magnar Reistad

Wind Waves modeling.

Objective:

To study the sensitivity of wave fields (integrated parameters such as Hs) to a storm track's and the wind fields features. In present day operational forecasting, these have large error bars. Training in model implementation, such as access to forcing data, will be emphasized.

Suggested actions:

Have at their disposal 3 historical sets numerical wind fields. They can also create artificial wind fields by means of simple algorithms that would be available at the workshop. They could also create an "ensemble" forecasting study by manipulating the track positions of the moving storm fields. Specify boundary conditions and initialization.

Reporting:

Describe the setup and rationale of the experiments. Illustrate with maps the forcing fields applied. Illustrate results by mapping fields and plotting time series. In the case of "ensemble forecasting" illustrate results by showing shift in positions of extremes etc. Suggest a useful model output to operational forecasters.

Requirement for ocean data:

The group will formulate requirements to relevant data for validation of real case experiments, for tuning of models in a preoperational phase, and for possible assimilation. These requirements will be transferred to the Ocean Teacher.

JEP Group B . Task leader: Professor Shishir Dube

Storm Surge Modeling.

Objective:

To study storm surge simulation sensitivity to variability and perceived error bars in the forcing wind/pressure fields as well as the geometrical shapes of the basins of incidents.

Suggested actions:

Create a set of “artificial” wind fields wind/pressure fields given by simple algorithms available at the workshop. Specify boundary conditions and initialization. Manipulate tracks and forcing fields to simulate “ensemble”, as per advice from the experiment board.

Reporting:

Describe the setup and rationale of the experiments. Illustrate forcing fields by examples. Illustrate model results by mappings and time series. Suggest a useful output to operational forecasters.

Requirements to ocean data:

Formulate such requirements by keeping in view needs for model forcing, validation, tuning, and assimilation.

JEP Group C – Task leader: Øyvind Saetra

Storm Surge Modeling under Extratropical Conditions.

Objective:

To install, set up and operate an operational storm surge model for different model domains. The model will be tested on selected historical storms, and whenever possible, be validated by comparing the results against sea-level observations. Focus will be on defining new model domains, retrieving bathymetry and atmospheric forcing data and adjust the model parameters such as time step according to the grid resolution etc.

Suggested actions:

3 or 4 selected historical atmospheric data sets from the ERA40 reanalysis will be made available on GRIB format. To enable the students to set up the storm surge modeling for any chosen area, a global bathymetry database (ETOPO2) will be provided together with the software necessary to extract the data and store it on a file format that can be identified by the numerical model. The students will be encouraged to set up and run the model for an area that is of particular interest to them. The model results will be converted to GRIB format and displayed with the GRADS plotting software. If possible, the results should also be compared with those obtained with the model used under task group B. For areas and time period when observations of sea-surface elevation is available, the student shall compare the results and calculate some basic statistical parameters and try to determine the quality of the model performance.

Reporting:

Describe the setup and rationale of the experiments. Illustrate with maps the forcing fields applied. Illustrate results by mapping fields and plotting time series. The report shall also discuss the model performance compared with the observations and discuss any possible systematic errors etc.

Requirement for ocean data:

The group will formulate requirements to relevant data for validation of real case experiments and for tuning of models in a preoperational phase. These requirements will be transferred to the Ocean Teacher.

5. SUMMARY RECOMMENDATIONS

As stated above, the following material is directed solely toward the needs of the IODE marine data management training program to assess what additional resources, activities and coursework should be provided to support operational ocean modeling training work. The specific results from the modeling experiments and the various technical presentations are covered in the Jamboree Website at http://ioc.unesco.org/oceanteacher/OpModWorkshop/index.htm.

Results and Lessons Learned

- The meteorological modeling community focuses heavily on the use of the GRIB format, which is almost entirely unknown in the general oceanographic community. The oceanographic modeling community uses both GRIB and NetCDF, but recent developments point toward gradual movement toward NetCDF and away from GRIB. Within this developing situation, the ocean data managers should focus on all non-GRIB model outputs that can be used/disseminated without further conversion (i.e. ASCII tables, ASCII grids).
- The meteorological modeling community can and should consider simple output formats to enlarge their “customer base” within the larger environmental sciences community. Accommodation to the “formats problem” must arise within the modeling community, simply because only they know where and how additional formats can be generated by their complex model codes.
- Concerning input data, the data managers should concern themselves with the quality and quantity of data that can be provided for input to models, but should not specifically work to convert data to GRIB. Providing data to the modelers in simple ASCII formats (or perhaps working binary formats, such as the Met.No binary format) should be sufficient.
- The “one man dog” problem remains a formidable obstacle to ocean modeling, whereby a specific model is often only operable or usable by a single knowledgeable person,

absent good documentation. This underscores the need for HELP Desk activities, better documentation, and continuing education.

- There is a lack of documentation for individual models, particularly specific implementations (or modifications) of global community models. Researchers from outside the modeling community have difficulty finding out what models are available, how they work and what they simulate, and where to find expertise on their use. Further, it is often also impossible or difficult for "outsiders" to locate the basic program codes and documentation, even for widely used models; no global library exists.
- The teaching methodology used in the Jamboree (i.e. open-ended experiments) worked extremely well. The IODE data management courses are more highly structured. While probably appropriate to the material we have traditionally taught, we should be able to emulate/incorporate some features of this method in the more advanced courses.
- It will be extremely invigorating to the IODE training program to develop connections with the dynamic and mission-driven meteorological modeling community.

Recommendations for Future Met-Ocean/Hazards Modeling Workshops

- Jamboree 1 is now over, but it will be he model for future joint activities which should be supported by the IOC and JCOMM.
- An "Intersessional Jamboree" (or "Jamboree 1.5") should be considered, to provide the following additions to the previous agenda. Using the facilities of the Virtual Laboratory (see below), this activity would have the following goals:
    - Addition of a tsunami model, carefully selected to insure maximum credibility among the potential user community and the entire geosciences community. This relatively high-profile selection should be coordinated closely with the IOC's other tsunami activities.
    - Addition of conversion utilities for newly generated high-resolution bathymetric data to the Met.No binary working format
    - Addition of additional simple ASCII output formats and/or NetCDF to the existing suite of models
    - All of the Jamboree 1 students should be included in this activity
- A Jamboree 2 should be developed, following the successful completion of the expansion activities of Jamboree 1.5. It would be directed at the training of a new suite of students and should include the entire new curriculum.

Recommendations for Future Comprehensive Ocean Modeling Workshops

- In addition to the above recommendations for future training work with wave- and surge-oriented modeling work, the data managers also recommend development of training resources with more comprehensive ocean circulation models
- It would be valuable and is feasible for the IODE training program to incorporate educational materials and curricula covering classical ocean models, possible through the use of the Virtual Laboratory concept (see below). To insure acceptance within the global community, the desired training should include:
  - Carefully selected general circulation models that are recognized within the broad ocean modeling community as validated for regional (preferably coastal) use (i.e. 100-km to 1000-km scales)
  - Models that can assimilate a wide variety of open source operational data, especially satellite data
  - Models that can assimilate boundary conditions from operational global or basin-scale models (e.g. HYCOM)
  - Models that are indicated to be compatible with (or possibly include) ecological components or other environmental simulation methodologies (e.g. mass transport, search and rescue, oil spills, pollutant dispersion, etc.)

Long-Term Trainee Support

- WEBSITE: The IODE Project Office will incorporate all of the reports documents and other resource materials from Jamboree 1 into the existing website (http://ioc.unesco.org/oceanteacher/OpModWorkshop/index.htm). This combined resource will be maintained permanently for reference by the students and as a record of the continued development of all training materials. A draft of the revised website will be available for review and comment by participants by September 30, 2005.
- VIRTUAL LABORATORY: The IODE Project Office is investigating the feasibility and desirability of developing a collaborative server facility that hosts joint or individual modeling activities of various students who may lack certain computer platform resources to perform the modeling in their home institutions. The VL would include:
  - Protected login and telecommunications, allowing distant students to access, maintain and manage their own resource areas on the server
  - Selected, up-to-date model codes
  - Model documentation
  - Shared experiments and their documentation (possible)
- DIRECT INTERACTION: As is the practice with IODE training programs, long-term support will be provided for the community of concerned students:

- HELP Desk – The IODE will moderate the activity, but refer all technical questions to the cognizant modelers (e.g. Met.No scientists)
- List Server – To facilitate group communications

Additions to OceanTeacher

It is clear that OceanTeacher currently contains only limited materials pertaining to operational modeling. Observations during the present Jamboree, as well as previous comments by reviewers, have led to the following near-term objectives:

- A new Course Manual was completed during the workshop (DM 205: Ocean Modeling Data Support) and has been added to the OceanTeacher curriculum (see Annex III). It is extremely loose in its organization, allowing for many different approaches to specific training activities, but it is one of the largest courses, in terms of links to the Digital Library. For this reason, it should be used carefully, after considering and selecting only those sections which are pertinent to the model(s) selected for training.
- Add material to the Digital Library about modeling and models at smaller scales than the current emphasis on global- and basin-scale models. Additionally, augment existing materials relating to modeling biological and ecological processes.
- Add new format converters:
  - Conversion of ASCII grids (e.g. Surfer GRD format) to the Met.No binary working format
  - Provide a converter/sub setter to produce regional land masks from an existing global land mask available at http://nsidc.org/data/icesat/surface_types.html.
- Add specific materials on the IIT, WAM and MIPOM models used in this Jamboree.
- Add materials on LINUX installation, specifically any quality instructional material relating to dual operating systems.
- Add a "Model Domain" to the formats integration schematics.

ANNEX I

COURSE PROGRAM AND TIMETABLE

[All institutional affiliation and national origin information for persons named below is provided in Annex II]

1. **First Week**
    a. Pre-installation and testing of NML (Friday, 2 September & Saturday, 3 September) - Tentatively with this minimum requirement, example given by wave modellers:
    b. The WAM model we provide is tested on Linux Redhat 9 (kernel 2.4) only, but it could be compiled and run on any Linux/Unix system.
    c. WAM is compiled with the FORTRAN 77 compiler, g77, which is the GNU Project F77 compiler available with LINUX.
    d. Operating System: Redhat 9 should be ready installed. Additional programs needed:
        i. Perl5, comes with LINUX (available at www.perl.com), freeware
        ii. GrADS LINUX binary, available at http://grads.iges.org/grads, freeware
        iii. wgrib and gribmap, available with the GrADS binary, freeware
        iv. gnuplot 3.8 or higher (must include pm3d module). Used for spectral and timeserie plots. Freeware
        v. shell scripts, fortran conversion programs. Provided by Norwegian Meteorological Institute, freeware
    e. All necessary software will be provided to each trainee on CDs (DVD) along with the instruction on their installation.
2. **Second Week**
    a. Introductory and frame-setting lectures (Monday, 5 September)
        i. 0830-0930: Registration
        ii. 0930-0945: Welcome by hosting agency IODE/VLIZ (Vladymyrov)
        iii. 1000: Address by supporting agencies (Mees)
        iv. 1000-1030: Introduction on ‘operational oceanography’. (Haugan
        v. 1030-1100: Introduction to JCOMM (Andrioli & Guddal)
        vi. 1100-1130: Coffee break
        vii. 1130-1200: Round table participant introductions. Both trainees, resource persons, members of the steering committee, and observers are invited to express their expectation to the workshop
        viii. 1200-1230: Overview of the workshop, reference to the similar Beijing workshop. Plan for organization of experiment groups (Guddal)

ix. 1230-1300: The OceanTeacher programme (Brown)

x. 1300-1400: Lunch

xi. 1400-1700: Installation of the operational system (LINUX&tools) and model implementation under the resource persons' supervision. There were 3 experimentation groups, each group with 5–6 trainees and one group leader. The group leader already had a "master PC" with all programs and data ready before the workshop. This PC was used to teach the trainees the whole installation process. The overall installation processes in all groups was guided and advised by Hernandez and Bokhorst. Note that the installation process, in particular the model software parts, continued also on Tuesday.

b. Topical Lectures (Tuesday, 6 September)

i. 0830-0900: Scientific lecture 1: Wave research (Reistad)

ii. 0900-0930: Scientific lecture 2: Modelling tropical cyclone storm surges (S. Dube)

iii. 0930-1000: Scientific lecture 3: Storm surge modeling (Saetra)

iv. 1000-1030: Coffee break

v. 1030-1300: Continued installation and preparation for experiments

vi. 1300-1400: Lunch break

vii. 1400-1430: Scientific lecture 4: Applications in ocean modeling (search and rescue) (Breivik , Norway)

viii. 1430-1500 : Scientific lecture 5: Circulation (Korotaev)

ix. 1500-1530: Scientific lecture 6: Ecological modeling (Korotaev)

x. 1530-1600: Coffee break

xi. 1600-1730: Options for additional presentations or inputs from trainees. Continued installation/implementation

c. Experiments (Wednesday 7 September; 0830-1730)

i. Presentation of a tentative plan of experiments (area configuration etc.). Group leader use this plan only as a Strawman (Guddal)

ii. Consideration of requirements for ocean observation data (Reistad)

iii. Review of software/hardware and links configuration for experiments (Hernandez,Bokhorst)

iv. Organization of experiments in groups; leaders and rapporteurs (Guddal)

v. Groupwise experiments for the remainder of the day

d. Experiments (Thursday 8 September; 0830-1730)

i. Continued experiments

ii. Half way briefing of progress in experimentations. Corrective actions if necessary

iii. Agreement on details of the remaining part of the workshop

e. Final Experimental Work (Friday, 9 September; 0830-1730)

i. Finalizing experiments, compilation of reports etc.

f. Reporting results and conclusions (Saturday, 10 September; 0830-1200)

i. Finalizing of the modeling reports

ii. Presentations and submissions of the reports

iii. Consideration of requirements for ocean data in support of numerical regional ocean models

iv. Adjourn

3. **Data Managers' Summary Meeting**

a. Review and analysis of the workshop (Saturday 10 September (1300-1500)

i. Development of recommendations for future capacity-building efforts

Agreement and planning for this report

ANNEX II

LIST OF STUDENT TRAINEES

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ANNEX III

IODE OceanTeacher Course DM 205: Ocean Modeling Data Support (Main Pages)

[This Manual is taken directly from the catalog of courses offered by the OceanTeacher training system (http://www.oceanteacher.org). All underscored titles in the first page refer to subsequent pages]

GOAL	To introduce the Data Manager to some of the main concepts in ocean modeling, with an emphasis on the types and formats of the data needed for input to model simulations To provide a general schema for finding various data types, should they be needed for modeling a specific area of the ocean.
CONTENTS	• Introduction to Ocean Modeling • Gridded Data/Data Grids • Bathymetry & Topography • Coastline • Land-Sea Mask • Hydrography • In Situ Sea Level • Satellite-Measured Winds • Satellite-Measured Sea Surface Height • Satellite-Measured Sea Surface Temperature • Satellite Sea Surface Salinity - Nothing at present • See the SMOS website • Model Output Display • Return to Courses Catalog

[All underscored titles in the following pages are links to large sections, chapters or exercises in OceanTeacher.]

Introduction to Ocean Modeling

GOAL To provide Data Managers with the basic theoretical background for ocean modeling, with particular attention on data requirements

- OceanTeacher does not provide in-depth training in ocean modeling; this course assumes that the Data Manager has a role to play in a modeling program, confined to the provision of data for model forcing and model result verification
- To the extent that the Data Manager want to self-train in basic modeling concepts, these materials should provide that background.

LINKS
- OCEAN MODELS - Simplified PPT presentation
- [US] Navy Operational Ocean Circulation & Tide Models - Medium-difficulty website textbook, with many illustrations; some equations
- OCEAN MODELING - Monography-style, more difficult presentation with many equations; some excellent illustrations
- Return to Course beginning

Gridded Data/Data Grids

GOAL To review information about data grids/gridded data, and the types of data values that can be in the grids

- Ocean models make extensive use of data grids:
  - To supply/represent bathymetry
  - To supply/represent forcing conditions
  - To output/represent results (currents, waves, water level, etc.)
- Grid formats can be unique to the model, or they can be "standard" formats that are

widely known
- Grid values are almost universally binary, to save storage space
- Binary grid values can be any of several different "binary word" formats (byte, short integer, long integer, single precision, etc.) depending on the type of data and storage considerations
- Grids for input to or output from models are very frequently "multiple grids" in that they contain more than one grid
- Operational modeling requires efficient methods to obtain gridded input data in multiple grid files, usually automatically
- Methods using GRIB data (see below) from WMO systems are quite robust and widely used
- Methods are being developed to use NetCDF multiple grid files
- If the necessary software can be "written into" the models, then NetCDF file ingestion is efficient and automatic (OPeNDAP protocols greatly assist this work)
- If not, then the work of obtaining individual NetCDF files and converting them to useable formats is tedious

LINKS
- BINARY - If you have questions about the characteristics of binary words, consult this reference section
- GRIDDED DATA FORMATS - General information about simple data grid formats (sometimes with small internal or external headers)
- SELF-DESCRIBING DATA FORMATS - General information about Self-Describing formats that contain grids along with other metadata information about the grids
- GRIB - Very difficult format in wide use by meteorologists/weather modelers; can be translated to NetCDF by GRADS, but only if the internal structure is already known
- NetCDF - Format widely used by oceanographers and climate modelers; can easily be converted to other formats used in OceanTeacher
- XYZ FORMAT - Regardless of the elegance (or lack thereof) of the above format types, many applications still require the use of very simple spreadsheets to share data grids between systems (e.g. downloading bathymetry data from online servers). XYZ files are always simple to use, but can be extremely large because they are ASCII
- BASIC GRIDDING - Regardless of the source of the relief data, it is often necessary to grid them again to obtain the physical matrix (rows, columns) needed by the selected ocean model.
- Return to Course beginning

Bathymetry & Topography

GOAL
- To review information on how to obtain gridded bathymetry data, and some of the general concepts associated with this type of data

- Bathymetric data (ocean depths) and topographic data (land heights) together are called RELIEF DATA.
- Relief data are needed to create the physical domains of earth system models. Most ocean models require bathymetry in the form of a data grid (or gridded data file)
- In the case of extremely highly resolved coastal models, it may be necessary to perform new bathymetry surveys to get the data to create the necessary grid. For larger model domains, existing global datasets can often be used

LINKS
- SELECTED DATA ANALYSES & PRODUCTS
    - MEASURED AND ESTIMATED SEAFLOOR TOPOGRAPHY - The original 2-minute "global" bathymetry, but it only covers 64N to 72S. Obtain an XYZ file and re-grid with Surfer
    - GEODAS GRID TRANSLATOR - Use this website for the greatest

flexibility is obtaining gridded data, for the entire earth; includes Smith & Sandwell data. The grids should be suitable for use, or you can obtain an XYZ file and re-grid it.

- BASIC GRIDDING - Regardless of the source of the relief data, it is often necessary to grid them again to obtain the physical matrix (rows, columns) needed by the selected ocean model.
- Return to Course beginning

Coastline

GOAL
- To review the various coastline datasets available for modeling purposes

- There are many different coastlines available, in various resolutions
- Only the WVS/GSHHS is recommended for global use; US coastal modeling can benefit from the Medium Resolution product
- Coastline data can be used to improve output graphics, and thereby orient the viewer
- Coastline data can be used to improve bathymetric grids, by using the XY values of the coastline points as XY0 data triplets. this "forces" the gridding process to yield good values near the shore

LINKS
- COASTLINES - Read this to get an overview, and to understand these acronyms
- WVS - Available from these sources
  - GEBCO
  - COASTLINE EXTRACTOR
- GSHHS - Use the SHP link to obtain a usable dataset (quite large however!)
- US MEDIUM RESOLUTION COASTLINE - Available from this source
  - COASTLINE EXTRACTOR
- Return to Course beginning

Land-Sea Masks

GOAL
- To introduce the concept of land-sea masks to students, and to show how they are created and used for modeling

- A "land-sea mask" is a data grid that represents all land points with a one (numerical) value and all water points with another (numerical) value.
- Masks are used to describe the earth environment to some physical models. Typically, the model "knows" which physics to apply in the water and that this process should not extend onto the land
- Masks are derived from pre-existing bathymetric data, or from analysis of imagery

LINKS
- LAND-SEA MASKS
- Return to Course beginning

Hydrography

GOAL
- To review the importance of hydrographic data for ocean modeling, and some methods for obtaining & using appropriate data

- The time-varying internal density field in the ocean is a primary forcing function to determine currents and other dynamic properties (e.g. mixing)
- Density is based on the parameters salinity & temperature, plus the depth
- Salinity and temperature fields can be obtained from climatologies based on data (such as the World Ocean Atlas), or from ocean models that include thermodynamic formulas to simulate salinity/temperature flux (e.g. river flow, radiative heat transfer, evaporation, ice physics).
- Small-scale models can use salinity and temperature fields from climatologies or from large-scale model output.

LINKS
- NATIONAL VIRTUAL OCEAN DATA SYSTEM (NVODS)
  - WORLD OCEAN ATLAS 2001 - Seasonal and monthly analyzed means for salinity and temperature
- GODAE MODEL INTERCOMPARISON
  - Many different sets of salinity and temperature data from climatologies and simulations

- USGODAE DATA SETS
    - Many different sets of salinity and temperature data from climatologies and simulations. See especially the NAVY GDEM MONTHLY TEMPERATURE/SALINITY
- Return to Course beginning

In Situ Sea Level

GOAL
- To review information about how to obtain tide data from international and national sources

- Although some ocean circulation models do not include tides, tidal currents may be highly significant near shore and should be included in such cases
- Tide data is used (sometimes with altimeter data) in global models to calculate tidal constants everywhere on the globe
- These constants are used to provide tidal "forcing" to regional (or small-scale) models and tide models. Forcing can take many different physical and mathematical forms
- The Global Sea-Level Observing System (GLOSS) is the archive for many nationally-operated stations
- The University of Hawaii Sea Level Center (UHSLC) is another sea level data center; it shares many data files with GLOSS
- A part of the in situ sea level signal is not tidal, being related to regional- to basin-scale circulation; this is covered in the lesson on Satellite Sea Surface Height

LINKS
- GLOSS PROGRAM
    - GLOSS STATION HANDBOOK - Download hourly datafiles in many cases; some links to national data centers where other data may be found
- UHSLC GRAPHIC DATA CATALOG AND SERVER INTERFACE - Different levels of quality control and frequency of observations/averaging
- NATIONAL OCEANOGRAPHIC DATA CENTERS - Contact information for all IODE affiliates, where other data may be found
- Return to Course beginning

Winds

GOAL
- To review information about the role and importance of wind data in ocean modeling, with an emphasis on obtaining the necessary data from archives

- WINDS: The dominant driving source for the surface layer of the world's oceans. [From the TAMU Glossary]
- Wind "data" are available as gridded climatological means (usually monthly averages), gridded simulation products from atmospheric models (at frequencies down to hourly), or time-series data from real observing stations
- The International Comprehensive Ocean Atmosphere Data Set (COADS or ICOADS) is the major historical compilation of marine surface data
- Wind data can be presented as wind velocity (U and V components) at the surface (defined as 10 m height). Or a derived quantity, wind stress, τ (Greek tau), can be calculated, using any of a number of different schemes. Modelers must determine whether they want to calculate stress within their model, or to use an acceptable existing wind stress analysis.

LINKS
- NATIONAL VIRTUAL OCEAN DATA SYSTEM (NVODS)
    - Many different wind climatologies
- GODAE MODEL INTERCOMPARISON
    - Some wind climatologies
- USGODAE DATA SETS
    - Wind climatologies and gridded winds from models
- PO.DAAC OCEAN ESIP TOOL (POET) - Satellite winds from a number of sensors
- FORMAT CONVERSION - See the methods in Groups N or S, depending on the format used

- Return to Course beginning

Satellite-Measured Sea Surface Height

GOAL
- To review information about processes affecting sea surface height, as measured from satellites, and the use of this information in modeling

- The difference between the instantaneous surface of the actual ocean and a hypothetical ocean at rest (acted upon only by gravity) is the sea surface height (SSH). SSH can be measured by altimeters.
- The sea surface height is primarily the sum of 2 major influences: tides and large-scale ocean circulation features (currents, eddies, seasonal variations, etc.)
- Tide signals range up to the order of 10 m (very close to shore; semi-enclosed areas) but are very small in the deep sea
- Ocean dynamic signals range up to the order of 1 m
- Altimeter data can be provided as short-term "deviations" from the average SSH. Major current system might not even appear in the deviations grid if the current remained at it s long-term average location
- "Anomalies" are calculated from deviations by removing the annual and semiannual harmonics. Anomaly maps show interannual changes.

LINKS
- OCEAN PARAMETERS MEASURED BY SATELLITE SENSORS
  - Dynamic Topography
- AVISO LIVE ACCESS SERVER - Best online source of operational altimeter data
- COLORADO CENTER FOR ATMOSPHERIC RESEARCH (CCAR) ALTIMETER DATA ARCHIVE - Also very useful, but does not provide data grids
- PO.DAAC OCEAN ESIP TOOL (POET) - Anomaly grids
- FORMAT CONVERSION - See the methods in Groups N or S, depending on the format used
- Return to Course beginning

Satellite-Measured Sea Surface Temperature

GOAL
- To review SST concepts, sources of data and the various delivery systems available, and the typical formats employed

- Sea Surface Temperature (SST) is the most widely measured ocean parameter, both by satellites and by ships
- SST has two meanings:
  - Bulk SST is for a depth of approximately 1 m (also called "bucket temperature"), and is the surface measurement taken at ocean stations
  - Skin SST is the temperature in the surface micron of seawater, and it is the quantity measured directly by satellite sensors. Skin SST is often somewhat cooler [O(0.3K)] than Bulk SST due to surface cooling
  - Relationships between Bulk SST and Skin SST are the subject of continuing research
- SST grids can be used to drive ocean models if the SST grid can be converted to an estimate of subsurface density distribution, through known relationships between S and T for the known water masses in particular region of interest
- SST grids combined with SSH measurements give an improved method to drive ocean models because the SSH removes ambiguities about the subsurface density distribution

LINKS
- OCEAN PARAMETERS MEASURED BY SATELLITE SENSORS
  - Bulk SST and Skin SST
- OPENDAP DATA FROM LIVE ACCESS SERVERS - Downloading 10-km SST data from a US Navy website
- DOWNLOAD SEA SURFACE TEMPERATURE (SST) IMAGES - The user can specify either HDF or NetCDF formats for the products
- There are many many other websites where satellite SST data can be

downloaded easily and in useful formats. Go to the SELECTED DATA ANALYSES & PRODUCTS section to browse for suitable resources

- FORMAT CONVERSION - See the methods in Groups N or S, depending on the format used
- Return to Course beginning

ANNEX IV

Acronym list

CB	Capacity Building
CMDM	Combined Modeling and Data Management Training Workshop
DM	Data managers
DNMI	Norwegian Meteorological Institute
GOOS	Global Ocean Observing System (IOC-WMO-UNEP-IOSU)
JEP	Jamboree Experimentation Plan
HYCOM	Hybrid Coordinate Ocean Model
IOC	Intergovernmental Oceanographic Commission (of UNESCO)
IODE	International Oceanographic Data and Information Exchange Program
JCOMM	WMO/IOC Joint Technical Commission for Oceanography and Marine Meteorology
NML	Numerical Modeling Laboratory
ODINAFRICA	Ocean Data and Information Network for Africa
ODINCARSA	Ocean Data and Information Network for IOCARIBE and South America
ODINCINDIO	Ocean Data and Information Network for the Central Indian Ocean Region