Intergovernmental Oceanographic Commission

Workshop Report No. 223

Advisory Workshop on enhancing forecasting capabilities for North Indian Ocean Storm Surges

Indian Institute of Technology Delhi (IIT Delhi)
New Delhi, India
14–17 July 2009

UNESCO

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IOC Workshop Report No.223
Paris, France, October 2009
English only

Workshop Participants (left to right: P. Bhaskaran, M. Ravichandran, S. Dube, A. Tyagi, S. Nayak, B. Lee, V. Swail, T. Murty, K. Horsburgh, and H. De Vries) (I. Jain, A. D. Rao, B. K. Bandyopadhyaya, and M. Mohapatra are not included in the picture)

For bibliographic purposes this document should be cited as follows:

Advisory Workshop on enhancing forecasting capabilities for North Indian Ocean Storm Surges, 14-17 July 2009. Paris, UNESCO, 37pp. 2009. (IOC Workshop Report No.223) (English)

(IOC/2009/WR/223)

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EXECUTIVE SUMMARY

The Meeting of the Advisory Group on enhancing the forecasting capabilities for North Indian Ocean Storm Surges (IIT-D storm surge model upgrade) was held in India at Indian Institute of Technology Delhi (IIT Delhi) during 14-17 July 2009, under the co-chairmanship of Dr Boram Lee (IOC of UNESCO) and Dr Val Swail (JCOMM). The international experts reviewed current status/performance of operational storm surge forecasting model (IIT-D Model) in the North Indian Ocean (NIO) region and addressed requirements for upgrading and improving model performance, considering the needs of the region following the recommendations made at the first JCOMM Scientific and Technical Symposium on Storm Surges held during 2-6 October 2007 at Seoul, Korea Republic (JCOMM2007SSS, http://www.surgesymposium.org). Experts also deliberated on setting up the medium-term and long-term technical workplan for the project on improving storm surge forecasting capabilities.

Highlights and recommendations from the workshop are the following:

While the storm surge prediction capability of India and further the North Indian Ocean region was generally satisfactory, the forecast was presently given only at the district level - the immediate goal was to provide forecasting with finer spatial resolution (small geographical regions) with better predictability. Experts agreed that, to be able to do this, the numerical models as well as the observational networks have to be improved. Additional research needs to be done on how to incorporate into operational use, some other important processes that presently were not included in the forecast models. With these goals in mind, the workshop has highlighted the requirements under observational data, categorized into meteorological, boundary, hydrological and location specific.

The experts group stressed the importance of the storm surge forecasting in probabilistic terms, somewhat akin to the routine weather forecasts at present. This is a more realistic approach, since it is scientifically unsound to issue definitive diagnostic forecasts, when there is so much uncertainty in the input data to the numerical models. It has been shown clearly that tide-surge interaction could change the value of the Total Water Level Envelope (TWLE) as well as the timing of the occurrence of the peak surge. Hence it is important the numerical models include the non-linear interactions between tide and storm surge. At present the only meteorological data input to the storm surge models of IIT Delhi are the pressure drop and the radius of maximum winds, in addition to the cyclone track. Since observed wind fields are now becoming more and more routinely available in real time, the numerical models should incorporate data assimilation techniques such as Kalman Filter to include observed wind data. At present the wind wave model is not part of the storm surge model. An operational wind wave model should be dynamically coupled to the storm surge model. For the cyclone season of 2010 and beyond, the coupled model (surge plus tide plus wind wave) should be first tested in a hindcast mode, and once it is established that the model performance is satisfactory. it can then be used operationally.

One of the key recommendations on data was on bathymetric data. 100 m horizontal resolution over the continental shelf is recommended in order to enable high resolution modelling. This data set should be updated every five years over the shelf, and every three years in the river delta regions such as the Meghna, Hooghly, Godavari, Krishna, Ayeyarawady etc. Another important requirement was to have an optimum network of tide gauges in the vulnerable coastal areas with a temporal resolution of one minute averaged sea level data. At present the existing and the planned tidal network together is generally satisfactory for India, with a wish list of a few more gauges located at the head of the Bay of Bengal. It was recommended to install at least two more gauges in Bangladesh and three more gauges in Myanmar, for the storm surge modelling and monitoring purpose.

The two most important meteorological parameters were again emphasized by the Experts to be more accurately monitored during the events, in addition to location of the cyclone landfall - the pressure drop and the radius of maximum sustained winds. Aircraft reconnaissance and dropsonde data may enhance the quality of the input data.

On the Hydrological side, we need data on area-weighted rainfall in river catchments as well as station data. In addition to this, for Hydrological input to surge models, we need to enhance the existing river gauge network for data on river runoff.

A most useful product will be storm surge data dossiers, which include all data from post-event surveys and also detailed data on road network, escape routes, nearby high ground (hills and mountains) and coastal infrastructure.

For the computation of inundation, we need data on shore topography, with a resolution of 5 m in the horizontal and 0.5 m in the vertical, with updates done preferably every decade. The use of crest gauges as well as chemically treated ribbons for mapping the extent of horizontal inundation and depth should be considered.

For improvements to cyclone track prediction, the Multi Model Ensemble (MME) should be enhanced through improvements in the meso-scale Numerical Weather Prediction (NWP) model, and nowcasting assimilation of the remote sensing (satellite and radar) and in-situ (buoy and ship) based data.

With regard to the capacity development and outreach, it was suggested to continue training on IIT-D model development and operation, in collaboration with ongoing programmes by WMO and IOC.

Based on advisory input as described above, the 3-year workplan was agreed by the Expert group and IIT Delhi expert team, to improve the predictability of the IIT-D Storm Surge model. Priorities were set up and agreed in view of enhancing storm surge predictability through the IIT-D Storm Surge Model, taking into account; 1) ongoing plans and activities in the North Indian Ocean region; 2) timeline and workplan for IIT model upgrade, and; 3) feasibility of each recommendation.

BACKGROUND AND OBJECTIVES

Most of the countries around the North Indian Ocean (NIO) are threatened by storm surges associated with severe tropical cyclones. The destruction due to storm surge flooding is a serious concern along the coastal regions of India, Bangladesh, Myanmar, Pakistan, Sri Lanka and Oman. Very recently the Nargis cyclone of May 2008 killed about 140,000 people in Myanmar as well as enormous property damage. Almost all of the loss of life and most of the damage from a tropical cyclone is attributable to the storm surge generated by the cyclones. Thus, provision of precise prediction and warning of storm surges is of great interest in the region.

Since 2001, the storm surge model developed by the Indian Institute of Technology Delhi (IIT Delhi) has been operated in the region of the North Indian Ocean including Bangladesh, Myanmar, Pakistan, Sri Lanka, Thailand and Oman, with the support for technology transfer from the Tropical Cyclone Programme (TCP) of WMO. This model predicts only residual storm surge at the coast line. With the advantage of simplicity in operation, this model has been used to produce and disseminate timely warnings to serve public safety.

Continuous efforts are required to improve the prediction capability of such community models. At the first JCOMM Scientific and Technical Symposium on Storm Surges (JCOMM2007SSS, http://www.surgesymposium.org), the limitations of present storm surge prediction models were discussed in detail with resulting recommendations for future actions for improvements. One of the key recommendations was to estimate the total water level envelope (TWLE) at the time of cyclone landfall for issuing effective warnings in threatened areas. TWLE is the result of the combined effect of the interaction of storm surge with tides, wind waves, and several other factor. It may also be of interest to examine the inclusion of precipitation, river flows, meso-scale forcing and remote forcing in the model.

At the national level in India there are a large number of initiatives to improve upon the operational storm surge and associated inland inundation forecast. IIT Delhi is funded and is closely working with different Government agencies, coastal authorities, National Disaster Management Authority on different issues of storm surge forecasting. Some of the major ongoing national activities in which IIT Delhi has been participating are: development of Disaster Management Plan (DMP) for cyclones and associated storm surges for mitigation in the coastal districts of Andhra Pradesh, West Bengal, Orissa and Gujarat; Development and implementation of real-time location specific models for storm surges and associated inundation for Kalpakkam region of Tamil Nadu coast of India; modelling of storm surges and associated inundation using ADCIRC as a case study for coastal Andhra Pradesh. Government of India is already in the process of increasing number of moored data buys (total 40) in the Bay of Bengal and the Arabian Sea. India Meteorological Department is enhancing Doppler Weather Radar (DWR) network in the coastal areas, Department of Space is going to launch OCEANSAT-II to have better observations on meteorological and oceanographic parameters required to improve upon the forecasting of tropical cyclones, storm surges and waves. One of the major multi institutional project, Forecast Demonstration Project (FDP) on landfalling cyclones in the Bay of Bengal by IMD has completed pre-pilot phase during 15 October-30 November 2008 and pilot and final phases are planned during 15 October-30 November 2009-10 and 15 October-30 November 2010-11 respectively. Objectives of FDP are to collect observations in the TC core environment using research aircraft and Unmanned Aerial Vehicle (UAV), demonstrate the use of drop soundings and UAV data in providing improved numerical guidance for genesis, track and intensity prediction of the Bay of Bengal Tropical Cyclones.

This Advisory Workshop was planned to effectively undertake to upgrade the community model in the North Indian Ocean region, following the recommendations made at the JCOMM Symposium on Storm Surge (JCOMM2007SSS). The objectives include:

(i) to review and verify the current status/performance of the operational storm surge forecasting model in the region (IIT-D model);

(ii) to address requirements for upgrading and improving model performance, considering the needs of the region, and;

(iii) to set up the medium-term and long-term technical workplan for the project on improving storm surge forecasting capabilities.

The Intergovernmental Oceanographic Commission (IOC) of UNESCO relied on the expertise within the WMO-IOC Joint technical Commission for Oceanography and Marine Meteorology (JCOMM), particularly members of the Expert Team on Wind Waves and Storm Surges (ETWS), to pursue these objectives. The international experts invited to this workshop closely worked with the IIT-D modelling experts, and established a team to follow up and review the activities that were decided through the workshop.

This Workshop was planned and conducted under the framework of the UNESCO extrabudgetary project on “Enhancing regional capabilities for Coastal Hazards Forecasting and Data Portal Systems”, funded by extrabudgetary contribution from Republic of Korea.

The Workshop, as well as following activities, were to open for participation of other experts on storm surge modelling (especially those from the countries of the North Indian Ocean which have been trained to use IIT-D Storm Surge Model), on a self funding basis, in order to obtain feedback from the model developers and operators in the regions.

1. OPENING OF THE WORKSHOP

The workshop was opened on Tuesday 14 July 2009 at Indian Institute of Technology Delhi (IIT Delhi). Prof Shishir Dube on behalf of IIT-D welcomed guests and participants. He started by introducing the invited guests and experts, welcoming Dr Shailesh Nayak (Secretary of Ministry of Earth Sciences, Government of India), Dr Boram Lee (IOC of UNESCO), Dr Val Swail (Chair, JCOMM Expert Team on Wind Waves and Storm Surges: ETWS), Dr. Kevin Horsburgh (United Kingdom), Dr. Hans de Vries (The Netherlands), Prof. Tad Murty (Canada), and Dr Ajit Tyagi (Director General of Meteorology, India Meteorological Department: IMD). He said that it's a great honour for IIT Delhi to host this workshop. He then invited the other participants to introduce themselves. The list of participants is included to this report as ***Annex II***.

Prof. Dube then invited Dr Shailesh Nayak and Dr Ajit Tyagi for their remarks. Dr Nayak in his address emphasized the importance of storm surge prediction in the North Indian Ocean region and gave a brief account of initiatives within the Indian Ministry of Earth Sciences (MOES) in improving the infrastructure and support to R&D for its improvement. Dr. Nayak reviewed the current status of storm surge prediction in India and mentioned that the errors in the prediction are in the range of 20 to 30% maximum. He then presented some ongoing MOES initiatives to reduce this error and bring it down to more acceptable levels, including; 1) new research work on better prediction of cyclone tracks; 2) storm surge inundation and improving the mitigation techniques, and; 3) enhancing observational networks, both for meteorological input as well as for storm surge observations through tide-gauge networks and post-event surveys, etc.

Dr Tyagi firstly appreciated the initiative of IOC of UNESCO through the Joint WMO-IOC technical Commission on Oceanography and Marine Meteorology (JCOMM) to organize such an important meeting in IIT-D, then mentioned the need of not only prediction of storm surge but also inland inundation associated with storm surges. He noted that, while the storm surge prediction capability of the IMD is generally satisfactory, at present the forecast is given only at the district level and the next immediate goal is to enhance the capability of IMD to issue the prediction at the Mandal or Taluk level (small geographical regions) and eventually even at the individual village level. To be able to do this extremely detailed prediction in geographical terms, the numerical models as well as the observational net works have to be improved. Dr. Tyagi informed that the IMD has been closely interacting with IIT-D and is presently using IIT model for its operational forecasting. He then noted that the IMD is in the process of major infrastructure modernization which will help in better forecasting of tropical cyclones in the region, which would eventually advance the storm surge predictability.

Dr Boram Lee described the rationales for holding this workshop, and provided information the related ongoing activities in regional and global scale. Following the recommendations by the first JCOMM Scientific and Technical Symposium on Storm Surges (JCOMM2007SSS, http://www.surgeworkshop.org) held from 2 to 6 October 2007 at Seoul, Republic of Korea, a number of activities were initiated to improve storm surge forecasting and warning systems in view of improving coastal hazard management. The IOC of UNESCO launched a project on "Enhancing regional capabilities for Coastal Hazards Forecasting and Data Portal Systems", in the framework of which this workshop was organized and supported. The WMO recently held a kickoff meeting of Coastal Inundation Forecasting Demonstration Project (CIFDP) which would address the operational aspects of the storm surge and coastal inundation modelling. As the North Indian Ocean (NIO) region, particularly Bay of Bengal region, was identified as the most surge-prone region in the world, the UNESCO project targeted to improve the storm surge predictability of this region through improving the community model, IIT-D model, that are used by many countries. She

expressed her confidence that this workshop will be able to focus on the needs of the NIO region following the recommendations made at the JCOMM2007SSS.

Dr Val Swail in his remarks emphasized on the importance of improved storm surge forecasting and explained the role of JCOMM to achieve this objective. He elaborated the link between relevant activities such as this workshop and UNESCO coastal hazard project, WMO CIFDP, and the planned ESA R&D project on storm surge application, and stressed that these activities with common objectives and goals should closely work together for synergies.

In the end Prof. O. P. Sharma, Head of the Centre for Atmospheric Sciences, IIT Delhi proposed vote of thanks.

The agenda of the meeting is attached as ***Annex I***. A list of acronyms used is attached as ***Annex III***.

2. PRESENTATIONS ON CURRENT STATUS & DISCUSSION

All presentations made during the workshop are published at the workshop web page: http://www.jcomm.info/SSindia.

2.1 Present details of the IIT-D storm surge model

Professor Shishir Dube of IIT Delhi made a detailed presentation on the current status of IIT storm surge prediction model and the data requirement. He elaborated on the factors contributing to disastrous surges in the Bay of Bengal. He also presented validation of the model both in hindcast and operational mode and limitations of present model in predicting the Total Water Level Elevations (TWLE) and inland inundation. Following are highlights of presentation:

- The forecasting system developed at IIT is based on the vertically integrated numerical storm surge models. Surface winds associated with a tropical cyclone are derived from a dynamic storm model (Jelesnianski and Taylor, 1973). The only meteorological inputs required for the model are the positions of the cyclone, pressure drop and radii of maximum winds at fixed time interval. The model can be run in a few minutes on a PC in an operational office.

- Location specific high resolution operational storm surge prediction models have been developed for Andhra, Orissa, Tamil Nadu, Gujarat coasts of India and for Bangladesh, Myanmar, Pakistan, Sri Lanka, Thailand, and Oman. Under the auspices of TCP/WMO the technology (IIT Model) has already been transferred to the meteorological and hydrological services of the region. From Cyclone Season of 2009, RSMC New Delhi is using IIT Model for providing Storm Surge Guidance to the Countries of the Region.

After detailed discussion, the Experts made following suggestions to be taken into consideration for improved storm surge forecast using IIT model:

- Use of repeated sampling data by satellite was recommended. It was also suggested that Indian agencies provide better upgraded satellite information. The Experts also indicated future need for a sensitivity experiment, in order to verify the usefulness of these data.

- Improve the existing IIT-D surge model by incorporation of nonlinear interaction of tide and surge.
- Inclusion of dynamic effect of wave set up on storm surges in IIT-D Model.
- Validation of TWLE prediction in hindcast/operational mode using the upgraded model in the cyclone season of year 2010 and 2011.
- Some kind of performance indicators should be used, not only for qualitative assessment, but also to quantify how well these enhanced models are performing, even though tests over one season are not adequate. These performance indicators should be used routinely for all the subsequent seasons.
- Investigate the benefits of probabilistic storm surge forecast.

2.2 Current status of operational storm surge forecasting and modus-operandi of the IIT-D model

Dr M. Mohapatra, Director at Cyclone Warning Centre, India Meteorological Department (IMD) made detailed presentation on the historical perspective and current status of tropical cyclone (both intensity and track) and associated storm surge forecasting at IMD and RSMC. While informing that both IMD and RSMC use IIT model for operational purpose, he made suggestions for its further improvement to have more reliable operational use. His presentation also included details on the ongoing modernization programme to upgrade observing system, high power computing, real time communication, forecasting and PWS, numerical models upgrade, ongoing field experiment especially Forecasting Demonstration Project (FDP) on landfalling cyclones in the Bay of Bengal. Pre-pilot phase of FDP was completed during 15 October-30 November 2008 and pilot and final phases are planned during 15 October-30 November 2009-10 and 15 October-30 November 2010-11 respectively. Objectives of FDP are to collect observations in the TC core environment using research aircraft and UAV, demonstrate the use of drop soundings and UAV data in providing improved numerical guidance for genesis, track and intensity prediction of the Bay of Bengal Tropical Cyclones to improve intensity and track prediction of cyclones in the Bay of Bengal. Highlights of the conclusion of his presentations are:

- RSMC, New Delhi is well equipped for monitoring and prediction of cyclonic disturbances over the north Indian Ocean and storm surges over the WMO/ESCAP panel region.
- Improvement in accuracy of meteorological inputs has resulted in more accurate prediction of storm surge.
- With the completion of ongoing modernization programme, the error is likely to reduce by about 10-15 % in next 2 years. It will further enable better storm surge prediction.
- Present mode of storm surge operational forecast in IMD involve running location specific high resolution (3 by 3 km) IITD model using forecasted track and intensity of cyclone (pressure drop and radius of maximum winds).
- IMD is willing to collaborate with IIT Delhi to achieve the objectives laid out by the workshop.
- Further refinement of the storm surge model is essential especially for prediction of coastal area inundation and total water level and location specific storm surge.

Dr Mohapatra noted that the current level of uncertainty in forecasting storm surges is 20 to 30%. During discussion session on the present operational status, the Experts recommended the following for future actions to improve the storm surge predictability of the operational system::

- Continued effort for further improvement in the NWP model and nowcasting.
- Assimilation of the remote sensing (satellite and Radar) and in-situ (buoy and Ship) based data.
- Increase of using direct observations and also satellite information, after validation/calibration. The Experts learned that, at present, the IIT-D surge model does not employ direct wind observations of wind fields, but use the wind field derived from pressure drop and radius of maximum winds. The Experts strongly recommended inserting assimilation of observed wind fields in the future.
- Looking in to the possibilities for further improvement in the MME for the track prediction. Ensemble runs are used more and more in storm surge prediction, not only in cyclone track estimation. The Experts emphasized that ensemble forecasting would be very useful technique when definitive diagnostic forecasts cannot be made, and recommended the IMD and IIT Delhi consider it for future model upgrade.

2.3 Proposal for model upgrade: Elements proposed to be included in the upgrade together with time line for those enhancements

Dr Tad Murty (Canada) made presentation on the elements proposed to be included to upgrade IIT model. He also presented the time line of inclusion of these elements. Elements proposed by him to be included are:

- Computation of inundation
- Tide-surge interaction
- Interaction with wind waves
- Effects of precipitation
- Interaction with river flow
- Contributions from topographic Rossby Waves
- Contributions from Continental Shelf Waves
- Contributions from Edge Waves
- Inclusion of mesoscale forcing
- Inclusion of remote forcing

The Experts were of the opinion that the priority should be given to tide-surge interaction and interaction with wind waves in order to improve operational storm surge forecasting in the region. While recognizing the above mentioned forcing, the Experts advised that the contributions of Rossby waves and Continental Shelf Waves are not appropriate to be incorporated in the IIT-D model, rather there should be a series of validation experiments to assess how well the IIT-D model simulates these and the implications for the necessary horizontal resolution

For inclusion of remote forcing, at least two different space scales should be considered: a large domain encompassing the whole Indian Ocean up to Antarctica in the south and the Bay of Bengal and Arabian Sea in the north. This large domain model may be coupled to other detailed small scale models, one for the Bay of Bengal and the other for the Arabian Sea. The Experts suggested that study on appropriate scale to simulate forcing terms should be conducted first, prior to considering these in the IIT-D model improvement.

2.4 Contribution of wind waves in storm surge

Prof Prasad K. Bhaskaran of IIT Kharagpur made a very detailed presentation on the contribution of wind waves in storm surge modelling. Showing results from his recent work using WAM3 he mentioned that in a combined wave-current-surge model, specifying an appropriate drag relation at the free surface is very vital for the final estimation of total surge height at any region of interest. The modified drag law relation as a function of wave age may be more appropriate to be used to integrate storm surge models. Making reference of several theoretical and experimental studies made by other workers and his recent work. Prof Bhaskaran mentioned that another important parameter which can modify the prevailing sea-surface roughness is impact of rain on surface waves. As rain can play a significant role both as a growth and damping mechanism for surface waves, inclusion of rain effects in wave model needs to be worked out more comprehensively. Since rain can alter the prevailing sea-surface leading to variation in surface drag, a wave-current-surge model which includes dynamic effect of rain on surface waves may be significant and is worth investigating. Following conclusions were drawn by him at the end of the presentation:

- Dependence of wave age on drag coefficient is known to be pivotal and its incorporation in a combined wave-current-surge model will be crucial to improve forecasting capability.
- Physical parameters such as dynamic interaction of rain on water waves and its role in modifying sea-surface roughness needs to be worked out more comprehensively.
- Effects of sea-spray and its role in altering the dynamic stability of atmosphere above the sea-surface needs to be explored in detail.
- Studies on bottom boundary layer, bottom characteristics on wave propagation needs to be more focused.
- Improved physical parameterizations in combined wave-current-surge model needs to be investigated in more detail.

After detailed discussion the Experts were of the view that problems identified by Prof. Bhaskaran are of importance for improve understanding of wave-surge interaction and improvement in the storm surge prediction. It was suggested that investigations on the drag coefficient parameterization for the stress term and scatterometer wind evaluation in hurricane winds & tropical rains may be undertaken by IIT in research mode.

The Experts agreed that there is no urgent need to develop a new wave model, as the existing operational models such as WAM are functioning well. It was also suggested to integrate wave input (from WAM) into IIT-D storm surge model run with nested coastal shore model run, as a research mode at IIT, with a view to integrate such a module into the operation in the future. Rain effect on waves, while is not an immediate issue of importance for the operational model, could be a research component.

2.5 Incorporating Continental Shelf waves, edge waves and topographic Rossby waves

Dr Tad Murty made detailed presentation on the methodology of incorporating continental shelf waves, edge waves and Topographic Rossby waves in the model. He presented results from several modelling studies and observations to show the contribution of these waves on storm surge (total water level elevation). While giving example of surge generated by Hurricane Dennis of 2005, he explained in detail how the surge was amplified due to remotely forced Rossby Waves in this case. He also discussed the dynamics of the propagation of continental shelf waves giving example from observations from Australia.

The related discussion is noted under item 2.3. The Experts reaffirmed that above topics are of research interest rather than the immediate priority. The Experts agreed on the following points regarding the above topic:

- Firstly it needs to be verified whether the IIT-D storm surge model currently simulates Topographic Rossby waves, taking into account the horizontal resolution. This could be at first in a research mode

- The topic of edge waves was determined to be a longer term research effort outside the scope of this project, considering the status of currently running models – for example, edge waves are not included in STWAVE or SWAN wave models. In the meantime, the quasi-stationary differences in along coast set-up, which the models can predict, could be included.

2.6 Contribution of meso-scale processes

In this presentation Dr Murty discussed the contribution of meso-scale processes in generating unexpected abnormal rise of water level in coastal regions. He presented observations from different regions of the globe in this regard. He mentioned that similar instances of sudden water level elevations occurring along east coast of India have been seen. He suggested it may be interesting to investigate contribution of such meso-scale processes on storm surge.

Several instances of abnormal sea level rise in a matter of minutes have been reported in the Indian media, both on the east and west coasts, particularly in the states of Orissa, Andhra Pradesh, Tamil Nadu and Kerala. Since there was no synoptic scale weather system associated with these events, they have been referred to as freak waves. In reality, these sudden water level oscillations are generated by meso-scale weather systems, such as squall lines. Since the whole event lasts only from a few to several minutes (not hours), these events could literally fall through the cracks in the synoptic weather network of which observational time scale is four times a day. Also, the synoptic network is much too coarse in spatial coverage, to catch all the meso-scale events, whose space scales are of the order of a few kilometers.

The Experts considered that, while the shortwave needs to be considered in wave models, water level rise by the meso-scale forcing could be dealt by special observing networks of automated weather stations that take observations every few minutes, for warning purpose. The Doppler Weather Radar (DWR) was also suggested as a useful tool. The Experts further suggested that a study may be taken up by the IIT Delhi to clarify whether the IIT-D model is capable of simulating the water levels generated by meso-scale forcing and its operational implication in nowcasting.

2.7 Contribution of remote forcing

In this presentation Dr Murty discussed in detail contribution of remote forcing in generating the water level and causing flooding in low lying coastal regions. While giving example from recent study carried out on these phenomena along the Kerala Coast of India, he mentioned that such phenomena causing coastal flooding is very common in this region and is locally termed as “Kallakkadal”. In is presentation he detailed the characteristics of “Kallakkadal” as follows:

- This phenomenon occurs mostly during pre-monsoon season and sometimes during post monsoon.
- It continues for a few days.
- It inundates the low lying coasts.
- During high tide the run-up, water level can reach as much as 3-4 m above Maximum Water Level (MWL).
- The associated wave characteristics are typical of swells with moderate heights (2-3 m) and long periods (~15s).
- Occurrence is more often along the southern Kerala coast than along northern coast.

During the discussion the Experts were of the view that this particular phenomenon is apparently remotely generated swell events. It was suggested that IIT Delhi may consider taking up investigation of the possible simulation of Kallakadal (remotely generated swell events) by extending the wind wave model domain up to Antarctica, so that the swell propagation is fully resolved.

The Experts further noted that this was really an issue for wave modelling. In the long term, a coastal transform model study may be useful. In this context, the Experts recommended to improve wave modelling, from existing operational ones, to better simulate the remotely forced swell events.

2.8 Inundation computation for Indian coastal region-A Case study

Prof. A. D. Rao of IIT Delhi presentated a case study of computation of inland inundation along Andhra Coast of India using ADCIRC model. Computed storm surge was validated by available observations for past three severe cylones hitting the region. He presented the capability of the model to simulate inland inundation provided detailed onshore topographic data is available.

For the bathymetric data input to this model, GEBCO data was primarily used, and was supplemented with Indian remote sensing data for coastal topography. Prof Rao noted that the GEBCO data currently meets the model requirement for the open ocean and offshore, but higher resolution bathymetric data are required over the continental shelf in order to enable high resolution modelling. The Experts strongly agreed to this point, and also recommended that such datasets should be updated every five years over the shelf, and every three years in the river delta regions in order to reflect the up-to-date status.

With regard to the analysis on coastal inundation, the need for inundation mapping was again emphasized; the mapping should consider not only the wet area in spatial terms,

but also the duration of the inundation event. The importance of post-storm surge surveys was also noted by the Experts.

The Experts, appreciating the in-depth study by Prof. Rao, were of the opinion that study for computation of inland inundation should be continued. They also noted that efforts should be made to generate required higher quality and resolution of topographic data, in particular.

3. DISCUSSION ON REQUIRED DATA AND FUTURE ACTIONS

The workshop considered the necessary requirement of data and future action by different agencies on the following components.

3.1 Data requirements for the various levels of enhancement

Based on all the presentations and following discussion, the Expert group agreed on the following recommendations on required data and future action:

Table 1: Recommendations on required data

Recommendation	By whom	Priority
Observing Data Requirement: Meteorological and Boundary Input		
Free data exchange in real-time	All concerned parties	High
Bathymetry with 100 m horizontal resolution over the continental shelf with updates preferably every 5 years. More frequent updates (may be 3 years) in the river delta regions such as Meghna, Hooghly, Ayeyarawady, etc. – considering plans for developing higher resolution models	National Hydrographic Agencies of the NIO region	High
Optimum network of tide gauges in the vulnerable coastal areas with 1-min. average data. (more tide gauges at the head of Bay of Bengal – 2 in Bangladesh, 3 in Myanmar)	Survey of India (for Indian coast) and concerned Government Authorities (for Bangladesh and Myanmar)	High
Aircraft reconnaissance and dropsonde during cyclone events for Improved estimation / forecasting of parameters associated with TC (pressure drop and radius of max. sustained winds)	IMD (N.B. currently included in plan)	High
Improved coastal surface and upper-air observations.	IMD (N.B. currently included in plan)	High
Enhancement of Coastal Doppler weather radar network	IMD (ongoing)	High
Enhanced network of coastal HF Radar for waves and currents	INCOIS, IMD	High

Recommendation	By whom	Priority
Enhanced network of moored and drifting buoys (monitoring air pressure, winds, waves, SST)	INCOIS, IMD	Medium
Satellite data for ocean winds, SST, waves, SSHA, etc.	India Ministry of Space	Medium
Tide gauges away from the coast on the continental shelf	INCOIS	Low
Data Requirement: Hydrological Input		
Area weighted rainfall in the river catchment along with station data	NMHSs in the NIO region	Low
Depth-area-duration of rainfall	NMHSs in the NIO region	Low
Enhancement of existing river gauge network for River runoff	NMHSs in the NIO region (Hydrological services)	Low
Data Requirement: Location Specific		
Coastal geomorphology	Survey of India (for Indian coast) and concerned Government Authorities in the NIO region	High
Preparation of storm surge data dossier including all post-event survey data.	INCOIS, NMHSs in the NIO region	High
On-shore topography with a resolution of 5 m in horizontal and 0.5 m in vertical with updates preferably every 10 years.	National Survey agencies, NMHSs in the NIO region	Medium
Crest gauges and possibility of using chemically treated ribbons for mapping the extent of horizontal inundation as well as depth.	NMHSs in the NIO region	Medium
Information about the land use data (including coastal infrastructure, roads)	NMHSs in the NIO region	Low

Note: Priorities are set up and agreed in view of enhancing storm surge predictability through the IIT-D Storm Surge Model, taking into account; 1) ongoing plans and activities in the North Indian Ocean region; 2) timeline and workplan for IIT model upgrade, and; 3) feasibility of each recommendation.

Higher resolution coastal bathymetric data are regarded essential for enhancing storm surge predictability. Horizontal resolution of 100 m over the continental shelf was recommended in order to enable high resolution modelling. This data set should be updated every five years over the shelf, and every three years in the river delta regions such as the Meghna, Hooghly, Godavari, Krishna, Ayeyarawady etc.

Another important requirement was to have an optimum network of tide gauges in the vulnerable coastal areas with a temporal resolution of one minute averaged sea level data. At present the existing and the planned tidal network together is generally satisfactory for India, with a wish list of a few more gauges located at the head of the Bay of Bengal. It was recommended to install at least two more gauges in Bangladesh and three more gauges

in Myanmar. Tide gauge data, averaged over one minute is required for understanding the development of the surge in the time domain, as well as tide-surge interactions.

Post-event surveys should be done to map the extent, depth and duration of inundation. Other important considerations are aircraft reconnaissance and dropsonde observations during cyclone events which will provide better estimates of the meteorological forcing parameters, such as the pressure drop and the radius of maximum winds. Improved coastal surface and upper air observations, in addition to a coastal Doppler Radar weather network are essential. For data on waves and currents, coastal HF radar is useful. Other networks recommended are: moored and drifting buoys for monitoring air pressure, winds, waves and SST, as well as satellite data for winds over the ocean, SST, waves and SSHA. Tide gauges away from the coast on the continental shelf will help capture the development of the storm surge.

As for Hydrologic input, data are needed on area-weighted rainfall in river catchments, as well as station data, and data on depth-area-duration. In addition, the existing river gauge network to monitor runoff, should be enhanced.

With regard to location-specific data, the following points are identified as important: coastal geomorphology, preparation of storm surge data dossiers, which include all the data for that particular event, as well as data from post-event surveys, on-shore topographic data, possibility of using crest gauges and chemically treated ribbons to map inundation and detailed information on coastal infrastructure , road network, escape routes, evacuation sites (cyclone shelters, nearby high ground such as hills and mountains).

3.2 Recommendations for the future

The Experts consolidated the final recommendation with priority as Table 2, with regard to the enhanced operation and regional capabilities for storm surge warning and forecasting:

Table 2: Recommendations on future actions

Recommendation	By whom	Priority
Research to Operations		
Assimilation of Remote sensing (satellite and Radar) and in-situ (buoy and Ship) based data	RSMC (Delhi)	High
Improvement in mesoscale NWP modelling (MM5, WRF, etc.) and nowcasting	IMD	Medium
Looking in to the possibilities for further improvement in the Multi-Model Ensemble for the track prediction	IMD	Medium
Quantitative Precipitation Forecast (QPF)	NMHS of the region	Low
Calibration/validation of the Jelesnianski and Taylor (1973) wind model parameters on additional NIO storms	IIT Delhi	Low
Investigations of the drag coefficient parameterization of stress and scatterometer wind evaluation in hurricane winds & tropical rains	IIT Delhi	Low

Inverting SAR waves into bathymetry	IIT Delhi	Low
Capacity Building and Outreach		
Continue training on IIT-D model development and operation, in collaboration with ongoing programmes by WMO and IOC (e.g. TCP attachment of operational meteorologists from the Panel Country Region to IIT Delhi for training in storm surge, JCOMM-IODE Jamboree, JCOMM-TCP workshop series)	IIT Delhi in collaboration with WMO-IOC JCOMM	High

It was advised that the efforts should continuously be made to develop regional capacity for storm surge modelling. As the IIT D model is already being used in the region as a community model, training opportunities on IIT D model operation should be encouraged. The Experts advised that such opportunities should be sought in collaboration with ongoing programmes by WMO and IOC (e.g. JCOMM-IODE Jamboree, JCOMM-TCP workshop series).

4. THE DEVELOPMENT OF THE 3 YEAR ACTION PLAN FOR THE PROJECT

Based upon the input from expert advisory group during first three days of the workshop, the participants agreed on the action plan of for the next three years to enhance predictability of the IIT-D Storm Surge Model. The agreed plan, as well as the deliverables in each year from the project is illustrated in Figure 1 and 2, respectively.

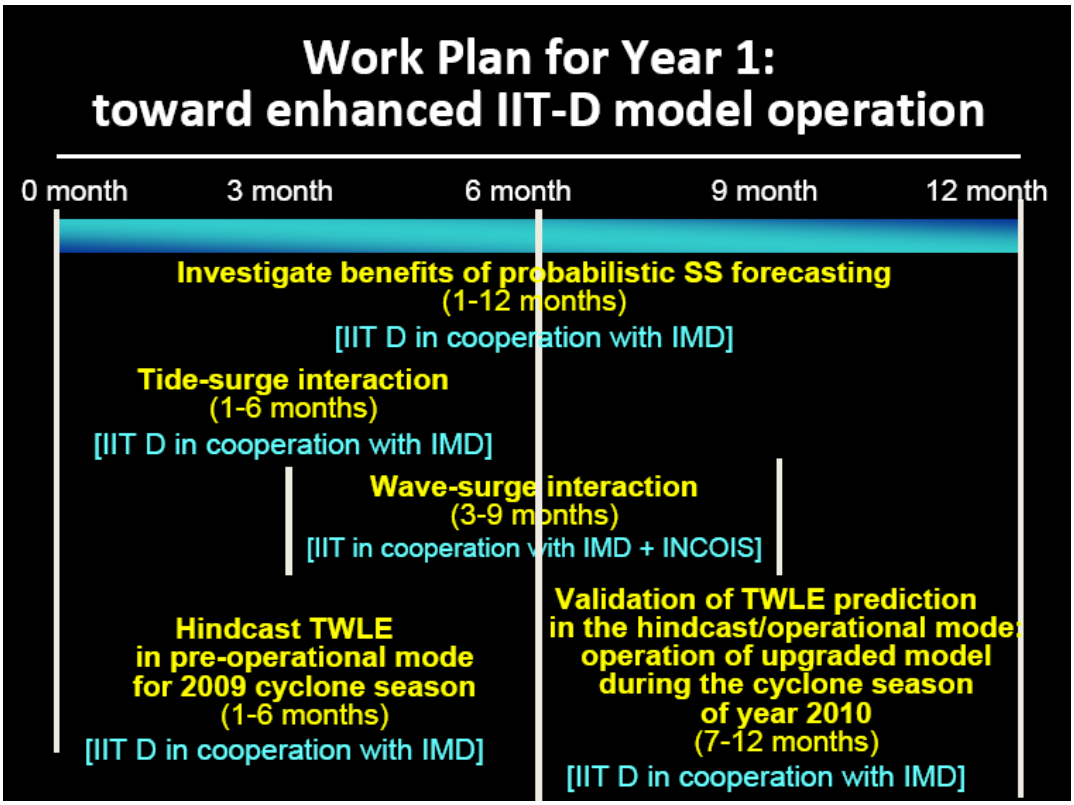

Figure 1-1: Work plan for year 1 (2009-2010)

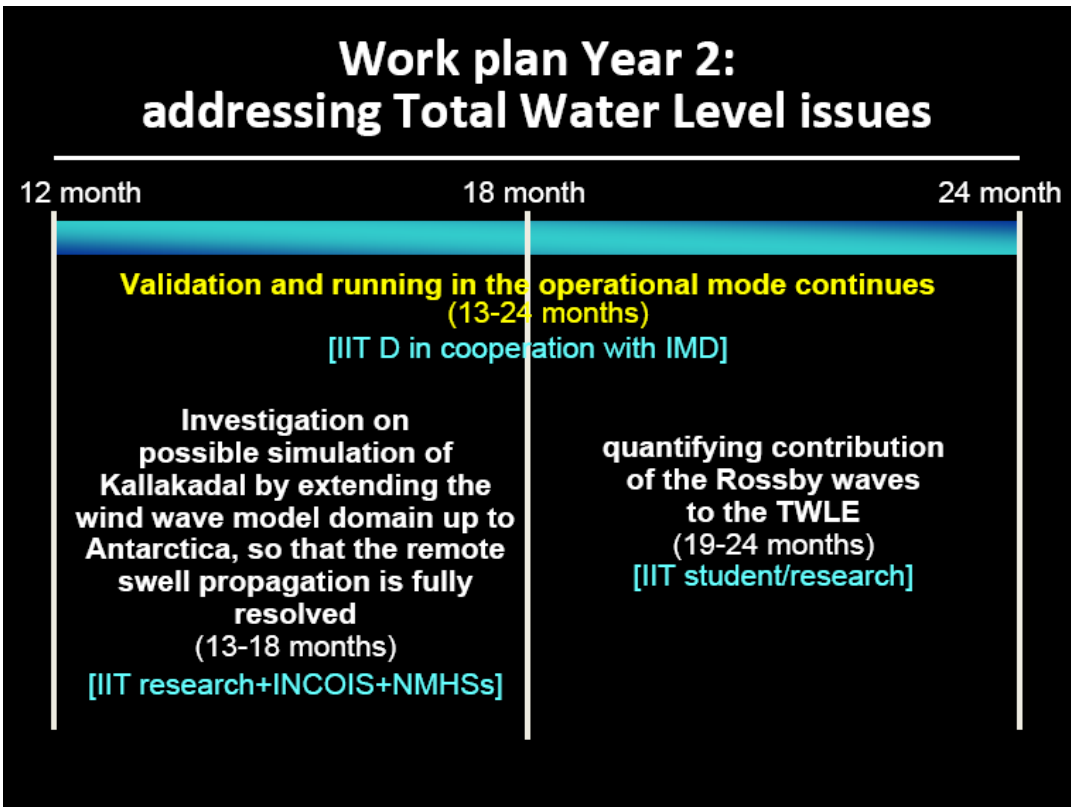

Figure 1-2: Work plan for year 1 (2010-2011)

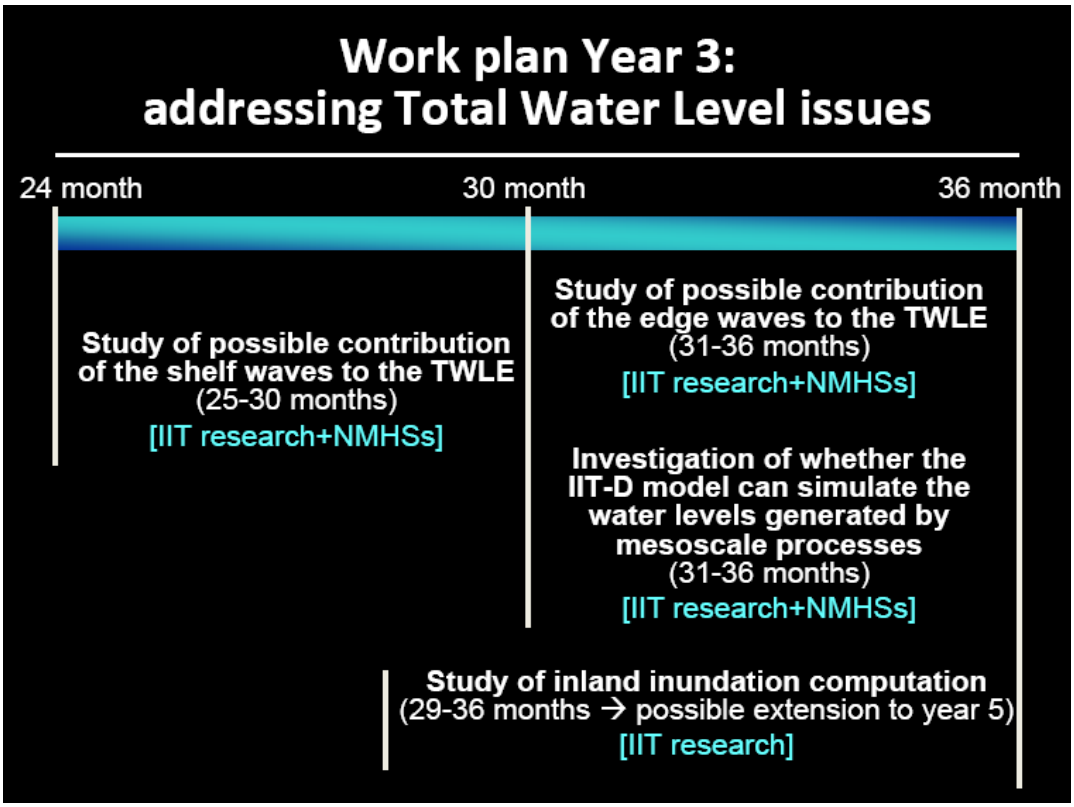

Figure 1-3: Work plan for year 3 (2011-2012)

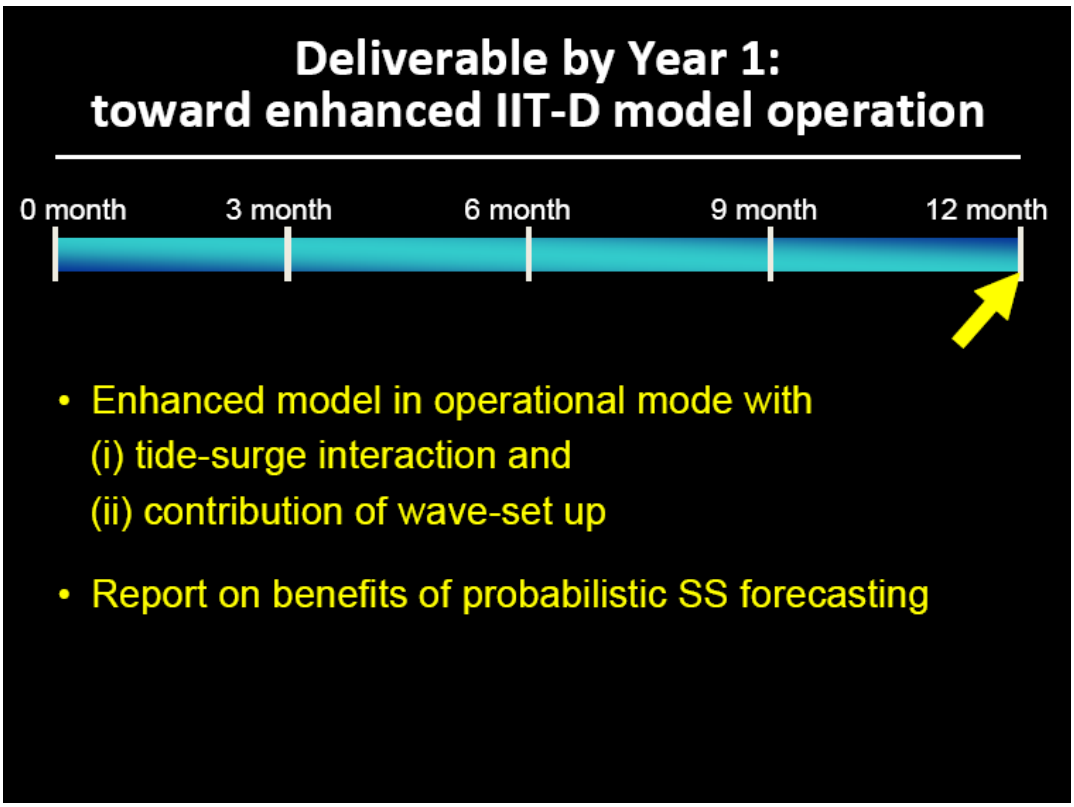

Figure 2-1: Deliverable by year 1 (2009-2010)

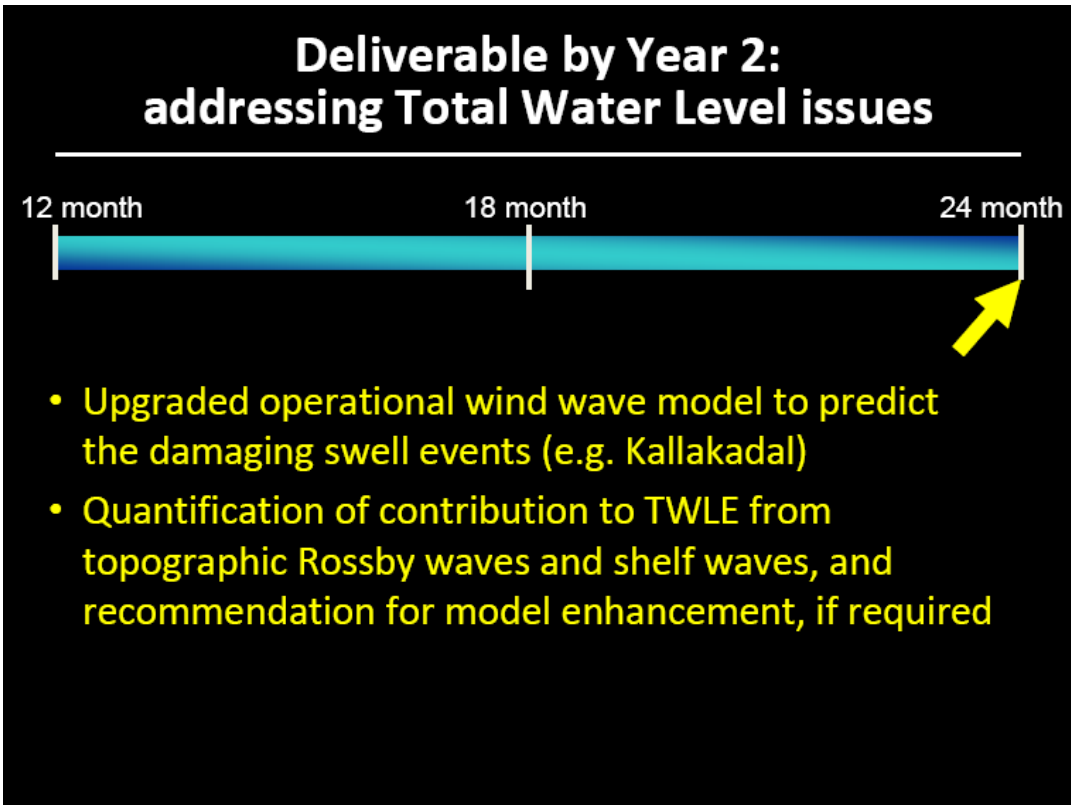

Figure 2-2: Deliverable by year 2 (2010-2011)

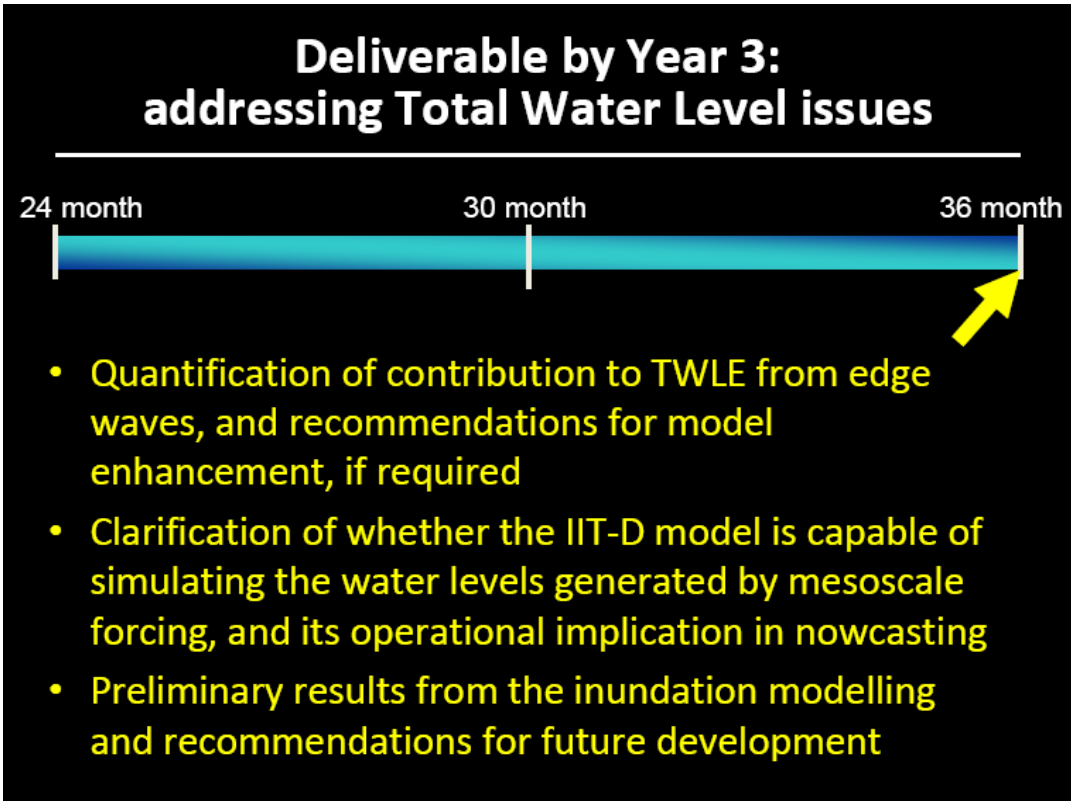

Figure 2-3: Deliverable by year 3 (2011-2012)

Note: In Figures 1-1 to 1-3, those items marked with yellow colour indicate high priority, and to be immediately implemented in operational mode. The items described with white colour indicate lower priority, and recommended as longer term research mode.

5. ORGANIZATION AND WORKPLAN

5.1 Recommendations on the composition of the Scientific Advisory Committee and IIT Delhi Team

The group of international experts and IIT Delhi expert team both agreed that the workshop in conjunction with the consulting process have been extremely fruitful exercise to obtain expertise for model upgrade project, that would benefit the overall North Indian Ocean region. It was also considered with satisfaction that the objectives and expected results of this workshop would well meet the goal of the UNESCO Extrabudgetary project for "Enhancing regional capabilities for Coastal Hazards Forecasting", which serves to implement the JCOMM work plan and further the IOC Action on mitigating natural hazards. Therefore it was agreed to continue the activities, and the current expert group would continue to serve as the Scientific Advisor Committee for the project on enhancing forecasting capabilities for North Indian Ocean Storm Surges (IIT-D storm surge model upgrade).

As the arrangement at present, the Committee would comprise the international experts on storm surge modelling as well as the UNESCO project coordinator, and closely work with the IIT-D expert team. It was agreed that the project would be led by two Co-chairs – leader of the Scientific Advisory Committee and leader of the IIT expert team. The IIT-D

team would continue implementing the workplan that was agreed by this workshop, closely linked with the related national projects that are under way in India.

The composition of the Scientific Advisory Committee and IIT-D expert team is agreed as following:

Expert Scientific Advisory Committee (providing scientific and technical advice)

Dr Kevin Horsburgh (UK) - leader

Dr Boram Lee (IOC of UNESCO) - project coordinator

Dr Donald Resio (USA)

Dr Val Swail (Canada, chair/JCOMM ETWS)

Dr Hans de Vries (The Netherlands)

Prof. Joannes Westerink (USA)

IIT-Delhi working group (responsible for model upgrade tasks)

Prof. Shishir Dube - leader

Prof. Prasad Bhaskaran

Dr Indu Jain

Prof. Tad Murty

Prof. A. D. Rao

The participants thanked again to Mr Val Swail, current leader of the international expert group, for his excellent leadership up to present in initiating the project and the workshop.

5.2 Proposal for additional opportunities

It was proposed to convene the second workshop in February 2011, to review the progress of the project and renew the work plan, as necessary. Detailed plan would be determined in consultation with the Scientific Advisory Committee and IIT-D expert team.

Some ongoing and planned activities that are related to this project were considered by the Committee and IIT-D team, including the WMO JCOMM-CHy Coastal Inundation Forecasting Demonstration Project (CIFDP), and the planning process of the ESA Storm Surge project in coordination with the IOC of UNESCO. The Committee considered that this project should be in close coordination with those projects in coming years.

6. CLOSURE OF MEETING

Four day workshop was a considerable success, which provided a platform for Indian Scientists to interact with distinguished international experts. Dr Boram Lee thanked IIT Delhi for hospitality, hard working staff and excellent organization of the Workshop. She mentioned

that the outcome of the workshop covered detailed work plan and actions which will be of great importance in enhancing the operational storm surge forecasting in the region.

Prof. Shishir Dube thanked IOC of UNESCO for organizing this important workshop at IIT Delhi. He also thanked all the experts and participants for providing very important input.

The meeting closed at 17:30 on Friday 17 July 2009.

ANNEX I

PROGRAMME

ADVISORY WORKSHOP ON ENHANCING FORECASTING CAPABILITIES FOR NORTH INDIAN OCEAN STORM SURGES
(IIT-D STORM SURGE MODEL UPGRADE)

Dates: 14-17 July 2009
Venue: CAS, Indian Institute of Technology (IIT) Delhi, India

14 JULY 2009 (TUESDAY)

0900-1000: ***OPENING SESSION***

Welcome: Indian Institute of Technology Delhi (IIT Delhi),

Secretary, MoES, Government of India

and DG, India Meteorological Department (IMD)

Concept & Objectives: Boram Lee, IOC of UNESCO

Remarks: Val Swail, JCOMM Expert Team on Wind Waves and Storm Surges (ETWS)

SESSION 1 (CHAIR: BORAM LEE)

1000-1045 Present details of the IIT-D storm surge model - Shishir K. Dube

1045-1115 Comments on the presentation and suggestions – Members of Expert Advisory Group

1115-1145 Tea/Coffee Break

1145-1230 Current status of operational storm surge forecasting and modus operandi of the IIT-D model – M. Mohapatra, IMD

1230-1300 Comments on the presentation and suggestions – Members of Expert Advisory Group

1300-1430 Lunch Break

SESSION 2 (CHAIR: VAL SWAIL)

1430-1515 Proposal for model upgrade: Elements proposed to be included in the upgrade together with time line for those enhancements – Tad Murty

1515-1545 Comments on the presentation and suggestions – Members of Expert Advisory Group

1545-1615 Tea/Coffee Break

1615-1700 Discussion on Day 1 Presentations

15 JULY 2009 (WEDNESDAY)

SESSION 3 (CHAIR: VAL SWAIL)

0900-0945 Contribution of wind waves in storm surge – Prasad Bhaskaran

0945-1015 Comments on the presentation and suggestions – Members of Expert Advisory Group

1015-1045 Tea/Coffee Break

1045-1130 Incorporating Continental shelf waves, edge waves and Topographic Rossby waves – Tad Murty

1130-1200 Comments on the presentation and suggestions – Members of Expert Advisory Group

1200-1230 Contribution of meso-scale processes – Tad Murty

1230-1300 Comments on the presentation and suggestions – Members of Expert Advisory Group

1300-1430 Lunch Break

SESSION 4 (CHAIR: BORAM LEE)

1430-1515 Contribution of remote forcing – Tad Murty

1515-1545 Comments on the presentation and suggestions – Members of Expert Advisory Group

1545-1615 Tea/Coffee Break

1615-1700 Discussion on Day 2 Presentations

16 JULY 2009 (THURSDAY)

SESSION 5 (CHAIR: BORAM LEE)

0900-0945 Inundation computation for Indian coastal region-A Case study – A. D. Rao

0945-1015 Comments on the presentation and suggestions – Members of Expert Advisory Group

1015-1045 Tea/Coffee Break

1045-1300 Discussion: future requirements for precipitation quantification, river flow quantification, inundation computation and recommendations for other agencies on what we require from them

1300-1430 Lunch Break

SESSION 6 (CHAIR: VAL SWAIL)

1430-1530 Discussion: data requirements for the various levels of enhancement

1530-1600 Tea/Coffee Break

1600-1700 Discussion: data requirements for the various levels of enhancement

17 JULY 2009 (FRIDAY)

SESSION 7 (CHAIR: BORAM LEE)

Summary report and recommendations (with Tea/Coffee break 1100-1130)

- the development of the 3 year (or 5-year) action plan for this project
- recommendations on the composition of the Scientific Advisory Committee (i.e. same people as the workshop, additions, replacements),
- proposals for additional opportunities (e.g. a second workshop during year 3, for example, to discuss the next stages of the enhancement, most notably inundation aspects)

1300-1430 Lunch Break

SESSION 8 (CHAIR: VAL SWAIL)

1430-1530 Discussion on other related issues

1530-1600 Tea/Coffee Break

1600-1630 Closing

Remarks by Dr Val Swail, Dr Boram Lee

Vote of Thanks: IIT Delhi

ANNEX II

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ANNEX III

LIST OF ACRONYMS

CHy	Commission for Hydrology, WMO
CIFDP	Coastal Inundation Forecasting Demonstration Project, WMO (http://www.jcomm.info/CIFDP)
DMP	Disaster Management Plan
DWR	Doppler Weather Radar
ETWS	Expert Team on Wind Waves and Storm Surges, JCOMM
ESCAP	Economic and Social Commission for Asia and the Pacific, UN
FDP	Forecast Demonstration Project, India
IIT Delhi	Indian Institute of Technology Delhi, India
IMD	India Meteorological Department, India
INCOIS	Indian National Centre for Ocean Information Services, India
IOC	Intergovernmental Oceanographic Commission, UNESCO, UN
IODE	International Oceanographic Data and Information Exchange, IOC
JCOMM	WMO-IOC Joint technical Commission for Oceanography and Marine Meteorology
JCOMM2007SSS	the first JCOMM Scientific and Technical Symposium on Storm Surges, 2-6 October 2007, Seoul, Korea (http://www.surgesymposium.org)
MME	Multi Model Ensemble
MOES	Ministry of Earth Sciences, India
MWL	Maximum Water Level
NIO	North Indian Ocean
NWP	Numerical Weather Prediction
QPF	Quantitative Precipitation Forecast
RSMC	Regional Specialized Meteorological Center
TCP	Tropical Cyclone Programme, WMO
TWLE	Total Water Level Envelope
UAV	Unmanned Aerial Vehicle
UN	United Nations
UNESCO	United Nations Educational, Scientific and Cultural Organization, UN
WMO	World Meteorological Organization, UN

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No.	Title	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand, 24-29 September 1973 UNDP (CCOP),	E (out of stock)
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (UNESCO Technical Paper in Marine Sciences, No. 20).	E (out of stock) S (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean; Monte Carlo, 9-14 September 1974.	E,F E (out of stock)
4	Report of the Workshop on the Phenomenon known as 'El Niño'; Guayaquil, Ecuador, 4-12 December 1974.	E (out of stock) S (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources; Kingston, Jamaica, 17-22 February 1975	E (out of stock) S
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Suva, Fiji, 1-6 September 1975.	E
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/UNESCO/ EAC; Nairobi, Kenya, 25 March-2 April 1976.	E, F,S, R
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters; Penang, 7-13 April 1976	E (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience; Mauritius 9-13 August 1976.	E, F, S, R
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring; Monaco, 14-18 June 1976	E, F E (out of stock) R
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976.	E, S (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions; Port of Spain, Trinidad, 13-17 December 1976	E (out of stock), S
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects; Fort-de-France, Martinique, 28 November-2 December 1977.	E, F, S
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area; Port of Spain, Trinidad, 16-18 January 1978.	E, S
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas; Abidjan, Côte d'Ivoire, 2-9 May 1978	E, F
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific; Santiago de Chile, 6-10 November 1978.	E (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	E, F, R
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS); Moscow, 9-11 April 1979.	E
17 suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceano-graphic Products and the IGOSS Data Processing and Services System; Moscow, 2-6 April 1979.	E
18	IOC/UNESCO Workshop on Syllabus for Training Marine Technicians; Miami, U.S.A., 22-26 May 1978 (UNESCO reports in marine sciences, No. 4 published by the Division of Marine Sciences, UNESCO).	E (out of stock), F, S (out of tock), R
19	IOC Workshop on Marine Science Syllabus for Secondary Schools; Llantwit Major, Wales, U.K., 5-9 June 1978 (UNESCO reports in marine sciences, No. 5, published by the Division of Marine Sciences, UNESCO).	E (out of stock), S, R, Ar
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources; Bandung, Indonesia, 17-21 October 1978	E
21	Second IDOE Symposium on Turbulence in the Ocean; Liège, Belgium, 7-18 May 1979.	E, F, S, R
22	Third IOC/WMO Workshop on Marine Pollution Monitoring; New Delhi, 11-15 February 1980.	E, F, S, R
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific; Tokyo, 27-31 March 1980.	E, R
24	WESTPAC Workshop on Coastal Transport of Pollutants; Tokyo, Japan, 27-31 March 1980.	E (out of stock)
25	Workshop on the Inter-calibration of Sampling Procedures of the IOC/ WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters; Bermuda, 11-26 January 1980.	E (Superseded by IOC Technical Series No.22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region; Mexico City, 24 September- 5 October 1979.	E, S
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific; Nouméa, New Caledonia, 9-15 October 1980.	E
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes. Lima, 20 April-5 May 1980.	E
29	WESTPAC Workshop on Marine Biological Methodology; Tokyo, 9-14 February 1981.	E
30	International Workshop on Marine Pollution in the South-West Atlantic; Montevideo, 10-14 November 1980.	E (out of stock) S
31	Third International Workshop on Marine Geoscience; Heidelberg, 19-24 July 1982.	E, F, S
32	UNU/IOC/UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E, F, S
32 Suppl.	Papers submitted to the UNU/IOC/ UNESCO Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime; Paris, France, 27 September-1 October 1982.	E
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR); Halifax, 26-30 September 1963.	E
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa); Tenerife, 12-17 December 1963.	E, F, S
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific; Suva, Fiji, 3-7 October 1983.	E
36	IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, Portugal, 28 May-2 June 1984.	E
36 Suppl.	Papers submitted to the IOC/FAO Workshop on the Improved Uses of Research Vessels; Lisbon, 28 May-2 June 1984	E
37	IOC/UNESCO Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs; Colombo, 8-13 July 1985.	E
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region; Basrah, Iraq, 8-12 January 1984.	E
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific; Suva, Fiji, 24-29 September 1985.	E
40	IOC Workshop on the Technical Aspects of Tsunami Analysis, Prediction and Communications; Sidney, B.C., Canada, 29-31 July 1985.	E
40 Suppl.	First International Tsunami Workshop on Tsunami Analysis, Prediction and Communications, Submitted Papers; Sidney, B.C., Canada, 29 July-1 August 1985.	E
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2); Dakar, Senegal, 28 October- 1 November 1985.	E
43	IOC Workshop on the Results of MEDALPEX and Future Oceano-graphic Programmes in the Western Mediterranean; Venice, Italy, 23-25 October 1985.	E
44	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E (out of stock) S
44 Suppl.	IOC-FAO Workshop on Recruitment in Tropical Coastal Demersal Communities, Submitted Papers; Ciudad del Carmen, Campeche, Mexico, 21-25 April 1986.	E
45	IOCARIBE Workshop on Physical Oceanography and Climate; Cartagena, Colombia, 19-22 August 1986.	E
46	Reunión de Trabajo para Desarrollo del Programa "Ciencia Oceánica en Relación a los Recursos No Vivos en la Región del Atlántico Sud-occidental"; Porto Alegre, Brasil, 7-11 de abril de 1986.	S
47	IOC Symposium on Marine Science in the Western Pacific: The Indo-Pacific Convergence; Townsville, 1-6 December 1966	E
48	IOCARIBE Mini-Symposium for the Regional Development of the IOC-UN (OETB) Programme on 'Ocean Science in Relation to Non-Living Resources (OSNLR)'; Havana, Cuba, 4-7 December 1986.	E, S
49	AGU-IOC-WMO-CPPS Chapman Conference: An International Symposium on 'El Niño'; Guayaquil, Ecuador, 27-31 October 1986.	E
50	CCALR-IOC Scientific Seminar on Antarctic Ocean Variability and its Influence on Marine Living Resources, particularly Krill (organized in collaboration with SCAR and SCOR); Paris, France, 2-6 June 1987.	E
51	CCOP/SOPAC-IOC Workshop on Coastal Processes in the South Pacific Island Nations; Lae, Papua-New Guinea, 1-8 October 1987.	E
52	SCOR-IOC-UNESCO Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects upon Living Resources and the Atmosphere; Paris, France, 6-10 May 1985.	E
53	IOC Workshop on the Biological Effects of Pollutants; Oslo, 11-29 August 1986.	E
54	Workshop on Sea-Level Measurements in Hostile Conditions; Bidston, UK, 28-31 March 1988.	E
55	IBCCA Workshop on Data Sources and Compilation, Boulder, Colorado, 18-19 July 1988.	E
56	IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Cleveland, Australia, 24-30 July 1988.	E
57	IOC Workshop on International Co-operation in the Study of Red Tides and Ocean Blooms; Takamatsu, Japan, 16-17 November 1987.	E
58	International Workshop on the Technical Aspects of the Tsunami Warning System; Novosibirsk, USSR, 4-5 August 1989.	E
58 Suppl.	Second International Workshop on the Technical Aspects of Tsunami Warning Systems, Tsunami Analysis, Preparedness,	E

No.	Title	Languages
	Observation and Instrumentation. Submitted Papers; Novosibirsk, USSR, 4-5 August 1989.	
59	IOC-UNEP Regional Workshop to Review Priorities for Marine Pollution Monitoring Research, Control and Abatement in the Wider Caribbean; San José, Costa Rica, 24-30 August 1989.	E, F, S
60	IOC Workshop to Define IOCARIBE-TRODERP proposals; Caracas, Venezuela, 12-16 September 1989.	E
61	Second IOC Workshop on the Biological Effects of Pollutants; Bermuda, 10 September- 2 October 1988.	E
62	Second Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region; Accra, Ghana, 13-17 June 1988.	E
63	IOC/WESTPAC Workshop on Co-operative Study of the Continental Shelf Circulation in the Western Pacific; Bangkok, Thailand, 31 October-3 November 1989.	E
64	Second IOC-FAO Workshop on Recruitment of Penaeid Prawns in the Indo-West Pacific Region (PREP); Phuket, Thailand, 25-31 September 1989.	E
65	Second IOC Workshop on Sardine/Anchovy Recruitment Project (SARP) in the Southwest Atlantic; Montevideo, Uruguay, 21-23 August 1989.	E
66	IOC ad hoc Expert Consultation on Sardine/ Anchovy Recruitment Programme; La Jolla, California, U.S.A., 1989	E
67	Interdisciplinary Seminar on Research Problems in the IOCARIBE Region; Caracas, Venezuela, 28 November- 1 December 1989.	E (out of stock)
68	International Workshop on Marine Acoustics; Beijing, China, 26-30 March 1990.	E
69	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Leningrad, USSR, 28-31 May 1990.	E
69 Suppl.	IOC-SCAR Workshop on Sea-Level Measurements in the Antarctica; Submitted Papers; Leningrad, USSR, 28-31 May 1990.	E
70	IOC-SAREC-UNEP-FAO-IAEA-WHO Workshop on Regional Aspects of Marine Pollution; Mauritius, 29 October - 9 November 1990.	E
71	IOC-FAO Workshop on the Identification of Penaeid Prawn Larvae and Postlarvae; Cleveland, Australia, 23-28 September 1990.	E
72	IOC/WESTPAC Scientific Steering Group Meeting on Co-Operative Study of the Continental Shelf Circulation in the Western Pacific; Kuala Lumpur; Malaysia, 9-11 October 1990.	E
73	Expert Consultation for the IOC Programme on Coastal Ocean Advanced Science and Technology Study; Liège, Belgium, 11-13 May 1991.	E
74	IOC-UNEP Review Meeting on Oceanographic Processes of Transport and Distribution of Pollutants in the Sea; Zagreb, Yugoslavia, 15-18 May 1989.	E
75	IOC-SCOR Workshop on Global Ocean Ecosystem Dynamics; Solomons, Maryland, U.S.A., 29 April-2 May 1991.	E
76	IOC/WESTPAC Scientific Symposium on Marine Science and Management of Marine Areas of the Western Pacific; Penang, Malaysia, 2-6 December 1991.	E
77	IOC-SAREC-KMFRI Regional Workshop on Causes and Consequences of Sea-Level Changes on the Western Indian Ocean Coasts and Islands; Mombasa, Kenya, 24-28 June 1991.	E
78	IOC-CEC-ICES-WMO-ICSU Ocean Climate Data Workshop Goddard Space Flight Center; Greenbelt, Maryland, U.S.A., 18-21 February 1992.	E
79	IOC/WESTPAC Workshop on River Inputs of Nutrients to the Marine Environment in the WESTPAC Region; Penang, Malaysia, 26-29 November 1991.	E
80	IOC-SCOR Workshop on Programme Development for Harmful Algae Blooms; Newport, U.S.A. 2-3 November 1991.	E
81	Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control; Paris, France, 12-13 October 1992.	E
82	BORDOMER 92: International Convention on Rational Use of Coastal Zones. A Preparatory Meeting for the Organization of an International Conference on Coastal Change; Bordeaux, France, 30 September-2 October 1992.	E
83	IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 12-13 October 1992.	E
84	Workshop on Atlantic Ocean Climate Variability; Moscow, Russian Federation, 13-17 July 1992	E
85	IOC Workshop on Coastal Oceanography in Relation to Integrated Coastal Zone Management; Kona, Hawaii, 1-5 June 1992.	E
86	International Workshop on the Black Sea; Varna, Bulgaria, 30 September – 4 October 1991	E
87	Taller de trabajo sobre efectos biológicos del fenómeno «El Niño» en ecosistemas costeros del Pacífico Sudeste; Santa Cruz, Galápagos, Ecuador, 5-14 de octubre de 1989.	S only (summary in E, F, S)
88	IOC-CEC-ICSU-ICES Regional Workshop for Member States of Eastern and Northern Europe (GODAR Project); Obninsk, Russia, 17-20 May 1993.	E
89	IOC-ICSEM Workshop on Ocean Sciences in Non-Living Resources; Perpignan, France, 15-20 October 1990.	E
90	IOC Seminar on Integrated Coastal Management; New Orleans, U.S.A., 17-18 July 1993.	E
91	Hydroblack'91 CTD Intercalibration Workshop; Woods Hole, U.S.A., 1-10 December 1991.	E
92	Réunion de travail IOCEA-OSNLR sur le Projet « Budgets sédimentaires le long de la côte occidentale d'Afrique » Abidjan, côte d'Ivoire, 26-28 juin 1991.	E
93	IOC-UNEP Workshop on Impacts of Sea-Level Rise due to Global Warming. Dhaka, Bangladesh, 16-19 November 1992.	E
94	BMTC-IOC-POLARMAR International Workshop on Training Requirements in the Field of Eutrophication in Semi-enclosed Seas and Harmful Algal Blooms, Bremerhaven, Germany, 29 September-3 October 1992.	E
95	SAREC-IOC Workshop on Donor Collaboration in the Development of Marine Scientific Research Capabilities in the Western Indian Ocean Region; Brussels, Belgium, 23-25 November 1993.	E
96	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Zanzibar, United Republic of Tanzania, 17-21 January 1994.	E
96 Suppl.	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 1. Coastal Erosion; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
96 Suppl	IOC-UNEP-WMO-SAREC Planning Workshop on an Integrated Approach to Coastal Erosion, Sea Level Changes and their Impacts; Submitted Papers 2. Sea Level; Zanzibar, United Republic of Tanzania 17-21 January 1994.	E
97	IOC Workshop on Small Island Oceanography in Relation to Sustainable Economic Development and Coastal Area Management of Small Island Development States; Fort-de-France, Martinique, 8-10 November, 1993.	E
98	CoMSBlack '92A Physical and Chemical Intercalibration Workshop; Erdemli, Turkey, 15-29 January 1993.	E
99	IOC-SAREC Field Study Exercise on Nutrients in Tropical Marine Waters; Mombasa, Kenya, 5-15 April 1994.	E
100	IOC-SOA-NOAA Regional Workshop for Member States of the Western Pacific - GODAR-II (Global Oceanographic Data Archeology and Rescue Project); Tianjin, China, 8-11 March 1994.	E
101	IOC Regional Science Planning Workshop on Harmful Algal Blooms; Montevideo, Uruguay, 15-17 June 1994.	E
102	First IOC Workshop on Coastal Ocean Advanced Science and Technology Study (COASTS); Liège, Belgium, 5-9 May 1994.	E
103	IOC Workshop on GIS Applications in the Coastal Zone Management of Small Island Developing States; Barbados, 20-22 April 1994.	E
104	Workshop on Integrated Coastal Management; Dartmouth, Canada, 19-20 September 1994.	E
105	BORDOMER 95: Conference on Coastal Change; Bordeaux, France, 6-10 February 1995.	E
105 Suppl.	Conference on Coastal Change: Proceedings; Bordeaux, France, 6-10 February 1995	E
106	IOC/WESTPAC Workshop on the Paleographic Map; Bali, Indonesia, 20-21 October 1994.	E
107	IOC-ICSU-NIO-NOAA Regional Workshop for Member States of the Indian Ocean - GODAR-III; Dona Paula, Goa, India, 6-9 December 1994.	E
108	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Paris, France, 9-12 May 1995.	E
108 Suppl.	UNESCO-IHP-IOC-IAEA Workshop on Sea-Level Rise and the Multidisciplinary Studies of Environmental Processes in the Caspian Sea Region; Submitted Papers; Paris, France, 9-12 May 1995.	E
109	First IOC-UNEP CEPPOL Symposium; San José, Costa Rica, 14-15 April 1993.	E
110	IOC-ICSU-CEC regional Workshop for Member States of the Mediterranean - GODAR-IV (Global Oceanographic Data Archeology and Rescue Project) Foundation for International Studies, University of Malta, Valletta, Malta, 25-28 April 1995.	E
111	Chapman Conference on the Circulation of the Intra-Americas Sea; La Parguera, Puerto Rico, 22-26 January 1995.	E
112	IOC-IAEA-UNEP Group of Experts on Standards and Reference Materials (GESREM) Workshop; Miami, U.S.A., 7-8 December 1993.	E
113	IOC Regional Workshop on Marine Debris and Waste Management in the Gulf of Guinea; Lagos, Nigeria, 14-16 December 1994.	E
114	International Workshop on Integrated Coastal Zone Management (ICZM) Karachi, Pakistan; 10-14 October 1994.	E
115	IOC/GLOSS-IAPSO Workshop on Sea Level Variability and Southern Ocean Dynamics; Bordeaux, France, 31 January 1995	E
116	IOC/WESTPAC International Scientific Symposium on Sustainability of Marine Environment: Review of the WESTPAC Programme, with Particular Reference to ICAM, Bali, Indonesia, 22-26 November 1994.	E
117	Joint IOC-CIDA-Sida (SAREC) Workshop on the Benefits of Improved Relationships between International Development Agencies, the IOC and other Multilateral Inter-governmental Organizations in the Delivery of Ocean, Marine Affairs and Fisheries Programmes; Sidney B.C., Canada, 26-28 September 1995.	E
118	IOC-UNEP-NOAA-Sea Grant Fourth Caribbean Marine Debris Workshop; La Romana, Santo Domingo, 21-24 August 1995.	E
119	IOC Workshop on Ocean Colour Data Requirements and Utilization; Sydney B.C., Canada, 21-22 September 1995.	E
120	International Training Workshop on Integrated Coastal Management; Tampa, Florida, U.S.A., 15-17 July 1995.	E
121	Atelier régional IOC-CERESCOR sur la gestion intégrée des zones littorales (ICAM), Conakry, Guinée, 18–22 décembre 1995	F
122	IOC-EU-BSH-NOAA-(WDC-A) International Workshop on Oceanographic Biological and Chemical Data Management, Hamburg, Germany, 20-23 May 1996	E
123	Second IOC Regional Science Planning Workshop on Harmful Algal Blooms in South America; Mar del Plata, Argentina, 30 October–1 November 1995.	E, S
124	GLOBEC-IOC-SAHFOS-MBA Workshop on the Analysis of Time Series with Particular Reference to the Continuous Plankton Recorder Survey; Plymouth, U.K.,4-7 May 1993.	E
125	Atelier sous-régional de la COI sur les ressources marines vivantes du Golfe de Guinée ; Cotonou, Bénin, 1-4 juillet 1996.	E

No.	Title	Languages
126	IOC-UNEP-PERSGA-ACOPS-IUCN Workshop on Oceanographic Input to Integrated Coastal Zone Management in the Red Sea and Gulf of Aden. Jeddah, Saudi Arabia, 8 October 1995.	E
127	IOC Regional Workshop for Member States of the Caribbean and South America GODAR-V (Global Oceanographic Data Archeology and Rescue Project); Cartagena de Indias, Colombia, 8-11 October 1996.	E
128	Atelier IOC-Banque Mondiale-Sida/SAREC-ONE sur la Gestion Intégrée des Zones Côtières ; Nosy Bé, Madagascar, 14-18 octobre 1996.	E
129	Gas and Fluids in Marine Sediments, Amsterdam, the Netherlands; 27-29 January 1997.	E
130	Atelier régional de la COI sur l'océanographie côtière et la gestion de la zone côtière ;Moroni, RFI des Comores, 16-19 décembre 1996.	E
131	GOOS Coastal Module Planning Workshop; Miami, USA, 24-28 February 1997	E
132	Third IOC-FANSA Workshop; Punta-Arenas, Chile, 28-30 July 1997	S/E
133	Joint IOC-CIESM Training Workshop on Sea-level Observations and Analysis for the Countries of the Mediterranean and Black Seas; Birkenhead, U.K., 16-27 June 1997.	E
134	IOC/WESTPAC-CCOP Workshop on Paleogeographic Mapping (Holocene Optimum); Shanghai, China, 27-29 May 1997.	E
135	Regional Workshop on Integrated Coastal Zone Management; Chabahar, Iran; February 1996.	E
136	IOC Regional Workshop for Member States of Western Africa (GODAR-VI); Accra, Ghana, 22-25 April 1997.	E
137	GOOS Planning Workshop for Living Marine Resources, Dartmouth, USA; 1-5 March 1996.	E
138	Gestión de Sistemas Oceanográficos del Pacífico Oriental; Concepción, Chile, 9-16 de abril de 1996.	S
139	Sistemas Oceanográficos del Atlántico Sudoccidental, Taller, TEMA;Furg, Rio Grande, Brasil, 3-11 de noviembre de 1997	S
140	IOC Workshop on GOOS Capacity Building for the Mediterranean Region; Valletta, Malta, 26-29 November 1997.	E
141	IOC/WESTPAC Workshop on Co-operative Study in the Gulf of Thailand: A Science Plan; Bangkok, Thailand, 25-28 February 1997.	E
142	Pelagic Biogeography ICoPB II. Proceedings of the 2nd International Conference. Final Report of SCOR/IOC Working Group 93; Noordwijkerhout, The Netherlands, 9-14 July 1995.	E
143	Geosphere-biosphere coupling: Carbonate Mud Mounds and Cold Water Reefs; Gent, Belgium, 7–11 February 1998.	E
144	IOC-SOPAC Workshop Report on Pacific Regional Global Ocean Observing Systems; Suva, Fiji, 13-17 February 1998.	E
145	IOC-Black Sea Regional Committee Workshop: 'Black Sea Fluxes' Istanbul, Turkey, 10-12 June 1997.	E
146	Taller Internacional sobre Formacíon de Capacidades para el Manejo de las Costas y los Oéanos en le Gran Caribe, La Habana, – Cuba, 7–10 de Julio de 1998 / International Workshop on Management Capacity-Building for Coasts and Oceans in the Wider Caribbean, Havana, Cuba, 7–10 July 1998	S/E
147	IOC-SOA International Training Workshop on the Intregration of Marine Sciences into the Process of Integrated Coastal Management, Dalian, China, 19-24 May 1997.	E
148	IOC/WESTPAC International Scientific Symposium – Role of Ocean Sciences for Sustainable Development Okinawa, Japan, 2-7 February 1998.	E
149	Workshops on Marine Debris & Waste Management in the Gulf of Guinea, 1995-97.	E
150	First IOCARIBE-ANCA Workshop Havana, Cuba, 29 June-1 July 1998.	E
151	Taller Pluridisciplinario TEMA sobre Redes del Gran Caribe en Gestión Integrada de Áreas Costeras Cartagena de Indias, Colombia, 7-12 de septiembre de 1998.	S
152	Workshop on Data for Sustainable Integrated Coastal Management (SICOM) Maputo, Mozambique, 18-22 July 1998	E
153	IOC/WESTPAC-Sida (SAREC)	E
154	IOC-Sida-Flanders-SFRI Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA project) Capetown, South Africa, 30 November-11 December 1998.	E
155	Science of the Mediterranean Sea and its applications UNESCO, Paris 29-31 July 1997	E
156	IOC-LUC-KMFRI Workshop on RECOSCIX-WIO in the Year 2000 and Beyond, Mombasa, Kenya, 12-16 April 1999	E
157	'98 IOC-KMI International Workshop on Integrated Coastal Management (ICM), Seoul, Republic of Korea 16-18 April 1998	E
158	The IOCARIBE Users and the Global Ocean Observing System (GOOS) Capacity Building Workshop, San José, Costa Rica, 22-24 April 1999	E
159	Oceanic Fronts and Related Phenomena (Konstantin Fedorov Memorial Symposium) – Proceedings, Pushkin, Russian Federation, 18-22 May 1998	E
160	Under preparation	
161	Under preparation	
162	Workshop report on the Transports and Linkages of the Intra-americas Sea (IAS), Cozumel, Mexico, 1-5 November 1997	E
163	Under preparation	
164	IOC-Sida-Flanders-MCM Third Workshop on Ocean Data Management in the IOCINCWIO Region (ODINEA Project), Cape Town, South Africa, 29 November – 11 December 1999	E
165	An African Conference on Sustainable Integrated Management; Proceedings of the Workshops. An Integrated Approach, (PACSICOM), Maputo, Mozambique, 18 –25 July 1998	E, F
166	IOC-SOA International Workshop on Coastal Megacities: Challenges of Growing Urbanization of the World's Coastal Areas; Hangzhou, P.R. China, 27 –30 September 1999	E
167	IOC-Flanders First ODINAFRICA-II Planning Workshop, Dakar, Senegal, 2-4 May 2000	E
168	Geological Processes on European Continental Margins; International Conference and Eight Post-cruise Meeting of the Training-Through-Research Programme, Granada, Spain, 31 January – 3 February 2000	E
169	International Conference on the International Oceanographic Data & Information Exchange in the Western Pacific (IODE-WESTPAC) 1999, ICIWP '99, Langkawi, Malaysia, 1-4 November 1999	E ***(electronic copy only)***
170	IOCARIBE-GODAR-I Cartagenas, Colombia, February 2000	***under preparation***
171	Ocean Circulation Science derived from the Atlantic, Indian and Arctic Sea Level Networks, Toulouse, France, 10-11 May 1999	E
172	(*Under preparation*)	
173	The Benefits of the Implementation of the GOOS in the Mediterranean Region, Rabat, Morocco, 1-3 November 1999	E, F
174	IOC-SOPAC Regional Workshop on Coastal Global Ocean Observing System (GOOS) for the Pacific Region, Apia, Samoa, 16-17 August 2000	E
175	Geological Processes on Deep-water European Margins, Moscow-Mozhenka, 28 Jan.-2 Feb. 2001	E
176	MedGLOSS Workshop and Coordination Meeting for the Pilot Monitoring Network System of Systematic Sea Level Measurements in the Mediterranean and Black Seas, Haifa, Israel, 15-17 May 2000	E
177	*(Under preparation)*	
178	*(Under preparation)*	
179	*(Under preparation)*	
180	Abstracts of Presentations at Workshops during the 7th session of the IOC Group of Experts on the Global Sea Level Observing System (GLOSS), Honolulu, USA, 23-27 April 2001	E
181	*(Under preparation)*	
182	*(Under preparation)*	
183	Geosphere/Biosphere/Hydrosphere Coupling Process, Fluid Escape Structures and Tectonics at Continental Margins and Ocean Ridges, International Conference & Tenth Post-cruise Meeting of the Training-through-Research Programme, Aveiro, Portugal, 30 January-2 February 2002	E
184	*(Under preparation)*	
185	*(Under preparation)*	
186	*(Under preparation)*	
186	*(Under preparation)*	
187	Geological and Biological Processes at deep-sea European Margins and Oceanic Basins, Bologna, Italy, 2–6 February 2003	E
188	Proceedings of 'The Ocean Colour Data' Symposium, Brussels, Belgium, 25-27 November 2002	E
189	Workshop for the Formulation of a Draft Project on Integrated Coastal Management (ICM) in Latin America and the Caribbean (LAC), Cartagena, Colombia, 23–25 October 2003	E F ***(electronic copy only)***
	Taller de Formulación de un Anteproyecto de Manejo Costero Integrado (MCI) en América Latina y el Caribe (ALC), Cartagena, Colombia, 23–25 de Octubre de 2003	
190	First ODINCARSA Planning Workshop for Caribbean Islands, Christchurch, Barbados, 15–18 December 2003	E ***(electronic copy only)***
191	North Atlantic and Labrador Sea Margin Architecture and Sedimentary Processes — International Conference and Twelfth Post-cruise Meeting of the Training-through-research Programme, Copenhagen, Denmark, 29–31 January 2004	E
192	Regional Workshop on Coral Reefs Monitoring and Management in the ROPME Sea Area, Iran I.R., 14–17 December 2003	E ***(under preparation)***
193	Workshop on New Technical Developments in Sea and Land Level Observing Systems, Paris, France, 14–16 October 2003	E ***(electronic copy only)*** ***(under preparation)***
194	IOC/ROPME Planning Meeting for the Ocean Data and Information Network for the Central Indian Ocean Region	
195	Workshop on Indicators of Stress in the Marine Benthos, Torregrande-Oristano, Italy, 8–9 October 2004	E
196	International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean within a Global Framework, Paris, France, 3–8 March 2005	E
197	Geosphere-Biosphere Coupling Processes: The TTR Interdisciplinary Approach Towards Studies of the European and North African Margins; International Conference and Post-cruise Meeting of the Training-Through-Research Programme, Morocco, 2-5 February 2005	E
198	Second International Coordination Meeting for the Development of a Tsunami Warning and Mitigation System for the Indian Ocean, Grand Baie, Mauritius, 14–16 April 2005	E
199	International Conference for the Establishment of a Tsunami and Coastal Hazards Warning System for the Caribbean and Adjacent Regions, Mexico, 1–3 June 2005	E
200	Lagoons and Coastal Wetlands in the Global Change Context: Impacts and Management Issues — Proceedings of the International Conference, Venice, 26–28 April 2004 (*ICAM Dossier N° 3*)	E
201	Geological processes on deep-water European margins - International Conference and 15th Anniversary Post-cruise Meeting of the Training-Through-Research Programme, Moscow/Zvenigorod, Russian Federation, 29 January–4 February 2006	E
202	Proceedings of 'Ocean Biodiversity Informatics': an international conference on marine biodiversity data management Hamburg, Germany, 29 November–1 December 2004	E
203	IOC-Flanders Planning Workshop for the formulation of a regional Pilot Project on Integrated Coastal Area Management in Latin America, Cartagena de Indias, Colombia, 16–18 January 2007	*E* ***(electronic copy only)***
204	Geo-marine Research along European Continental Margins, International Conference and Post-cruise Meeting of the Training-through-research Programme, Bremen, Germany, 29 January–1 February 2007	E
205	IODE/ICAM Workshop on the development of the Caribbean marine atlas (CMA), United Nations House, Bridgetown, Barbados, 8–10 October 2007	E ***(electronic copy only)***
206	IODE/JCOMM Forum on Oceanographic Data Management and Exchange Standards, Ostend, Belgium, 21–25 January 2008	*(Under preparation)*
207	SCOR/IODE Workshop on Data Publishing, Ostend, Belgium, 17–18 June 2008	*(Under preparation)*
208	JCOMM Technical Workshop on Wave Measurements from Buoys, New York, USA, 2–3 October 2008 (IOC-WMO publication)	*(Under preparation)*

No.	Title	Languages
209	Collaboration between IOC and OBIS towards the Long-term Management Archival and Accessibility of Ocean Biogeographic Data, Ostend, Belgium, 24–26 November 2008	*(Under preparation)*
210	Ocean Carbon Observations from Ships of Opportunity and Repeat Hydrographic Sections (IOCCP Reports, 1), Paris, France, 13–15 January 2003	E ***(electronic copy only)***
211	Ocean Surface pCO_2 Data Integration and Database Development (IOCCP Reports, 2), Tsukuba, Japan, 14–17 January 2004	E ***(electronic copy only)***
212	International Ocean Carbon Stakeholders' Meeting, Paris, France, 6–7 December 2004	E ***(electronic copy only)***
213	International Repeat Hydrography and Carbon Workshop (IOCCP Reports, 4), Shonan Village, Japan, 14–16 November 2005	E ***(electronic copy only)***
214	Initial Atlantic Ocean Carbon Synthesis Meeting (IOCCP Reports, 5), Laugavatn, Iceland, 28–30 June 2006	E ***(electronic copy only)***
215	Surface Ocean Variability and Vulnerability Workshop (IOCCP Reports, 7), Paris, France, 11–14 April 2007	E ***(electronic copy only)***
216	Surface Ocean CO2 Atlas Project (SOCAT) 2nd Technical Meeting Report (IOCCP Reports, 9), Paris, France, 16–17 June 2008	E ***(electronic copy only)***
217	Changing Times: An International Ocean Biogeochemical Time-Series Workshop (IOCCP Reports, 11), La Jolla, California, USA, 5–7 November 2008	E ***(electronic copy only)***
218	Second Joint GOSUD/SAMOS Workshop, Seattle, Washington, USA, 10–12 June 2008	E ***(electronic copy only)***
219	International Conference on Marine Data management and Information Systems (IMDIS), Athens, Greece, 31 March–2 April 2008	E
220	Geo-marine Research on the Mediterranean and European-Atlantic Margins. International Conference and TTR-17 Post-cruise Meeting of the Training-through-research Programme, Granada, Spain, 2–5 February 2009	E ***(electronic copy only)***
221	Surface Ocean CO_2 Atlas Project Pacific Regional Workshop, Tsukuba, Japan, 18-20 March, 2009	E ***(electronic copy only)***
222	Surface Ocean CO_2 Atlas Project Atlantic and Southern Oceans Regional Meeting, Norwich, UK, 25-26 June, 2009	E ***(electronic copy only)***
223	Advisory Workshop on enhancing forecasting capabilities for North Indian Ocean Storm Surges, Indian Institute of Technology (IIT), Delhi, New Delhi, India, 14–17 July 2009	E ***(electronic copy only)***