Coastal Inundation Forecasting Demonstration Project (CIFDP)

Don Resio and Val Swail
Co-Chairs, CIFDP Steering Group
Exposure to coastal inundation is large and growing

- Population is attracted to coasts by an abundance of local resources
  - Growing coastal population
  - Urbanising coastal zone
  - Tourism, recreation, retirement...
- In many parts of the world, the population is directly exposed to the coastal hazards and this will increase with Climate Change and Sea Level Rise.
- A reactive approach to adaptation increases vulnerability.
Exposure to coastal inundation is large and growing

Benefit of Climate Mitigation: Asset exposure avoided by 2070s

(Nicholls et al, 2010)
Exposure to coastal inundation is large and growing

- Critical risks in coastal areas are related to storm surges, tsunamis, heavy rainfall and river flooding, associated/combined with wave run-up/ overtopping and sea level rise.
- The greatest potential for loss of life related to a Hurricane/Typhoon is from the storm surge (nine out of ten victims).
Coastal Inundation Management
Applying available techniques for integrated operational forecasting/warning

- Baseline topography/bathymetry
- Observations (in-situ, remote sensing)
- **Operational open-source models adapted to regions** (hydrodynamic, TC/XTC, wave, storm surge, tidal, ...)
  - Combining models? Combining outputs?
- **Operational skills**
- Risk analysis / mapping / decision support tools
Challenge: Institutional Collaboration for Coastal Inundation Management
Demonstration Project: CIFDP

To provide an example of cooperative work as a strategy for building improved operational forecasts and warnings capability for coastal inundation, that can be sustained by the responsible national agencies:

- Implementation of open-source coastal inundation end-to-end forecasting and warning operational systems – while working to ensure technical quality and system validation (local effects and experience can be very important)
- Developing cross-cutting cooperation of national stakeholders and user communities of different disciplines
- Building communication platforms between researchers, forecasters and disaster managers involved in coastal inundation management

http://www.jcomm.info/CIFDP
CIFDP Implementation: key players

- JCOMM
- WMO
- CHy

**Project Steering Group**
(Coastal Inundation Experts & Social Science Experts representing WMO-JCOMM/CHy)

**National Coordination Team**
- National Forecasting Agencies
- Regional Programmes (e.g. RSMC, RIMES)
- Disaster Management Agencies
- Other National Agencies

**System Developer**

**External Experts**

**International Disaster Response Agencies**

**Relevant Programmes & Groups**
• **Identification of national requirements** where CIFDP will be implemented, and roles of stakeholders.

• **Platform for collaboration and communication**, to improve interactions of responsible national agencies with stakeholders and partners (Disaster Management, Civil Protection Agencies, local governments, etc)
  – Improved and integrated service delivery for disaster management
  – better understanding of user requirements, and spontaneous user feedback.

• **Demonstration of operability for open-source coastal inundation end-to-end forecasting and warning**
  – Technical guidance material (procedure, guides, etc.)
  – Building Best Practices

• **Specialized training** to enhance the capabilities of responsible national agencies to produce and provide storm surge forecasting, coastal inundation forecasting and warning services.
Strategy for CIFDP implementation

- CIFDP will be implemented through **national sub-projects**, launched for a country that meets the essential requirement. WMO will provide guidance through the Project Steering Group (PSG), will provide financial support for initiation, will facilitate fundraising for implementation.

- Each sub-project would be designed based on **users’ perspectives and requirements**, considering only existing and available open source techniques. Final products of the Demonstration Project should be operated and maintained by a responsible national operational agency for storm surge warning and flood warning;

- The developed procedure/best practice should be applicable to (neighbouring) countries with common issues and interests, and should be closely linked to and cooperating with related projects and activities.

http://www.jcomm.info/CIFDP
CIFDP: National commitment for initiation

http://www.jcomm.info/CIFDP

- **Lead / Participation of operational forecast agency(ies)**
  - Availability of qualified staff to run the system in 24x7 mode
  - Computer and communication infrastructure
  - Commitment to sharing all data and information relevant to the inundation forecast process.

- **Initial National Agreement** between participating national institutions
  - To be basis of Definitive National Agreement (DNA)
  - Establishment of National Coordination Team (NCT), to ensure sustainable operation by national agencies as well as continuous engagement of “USERS” of forecasting services

National Meteorological and Hydrological Services (NMHSs), in cooperation with other national stakeholders, should play the key role in developing, implementing and applying the results of this Project.
CIFDP: Technical foundation

- Assessment of the regional coastal inundation forecasting/warning capacities
- Identify gaps
- Provide an overview on the technical aspects for definition

Each Sub-Project Plan and following documentation will include:

- Existing models and modeling capabilities
- Communication / access to real-time data and quantitative forecast data
- Boundary (Bathymetry, DEM...), GIS Data and data for Validation
- Organisational aspects

The project will focus on integrating the forecasting models already in operational use as ‘plug-and-play’ modules. The modelling components will be developed and adapted to fit in an open, flexible and easily extendable forecasting system: the future CIFDP system.

http://www.jcomm.info/CIFDP
Civil Infrastructures for Disaster Prevention (CIFDP):
Recommended Forecast Systems Application

- Forecast Tropical Cyclone Characteristics
  (Responsible National & Regional Agencies: e.g. RSMC)
  (Considerations of ensemble or other probability variations)
  - Rainfall
  - Wind Fields: Wind Stresses + pressures
  - Tide
  - River Model
    - Boundary Conditions
    - Incoming River Discharges
  - Surge Model
    - Coupled
  - Wave Model
    - Coupled

Forecast Inundation

Calibration/Validation
The project will be implemented in a phased approach that leaves scope for adjustment in the next phases to fit the prevailing requirements:

**Phase 0**: Project preparation

**Phase 1**: Information gathering – Project Adaptation

**Phase 2**: System Development / Implementation

**Phase 3**: Pre-operational testing

**Phase 4**: Live Running and Evaluation
**CIFDP: Linkage with R&D**

**eSurge**: Satellite for surge studies ([http://www.storm-surge.info](http://www.storm-surge.info))
- ESA DUE (Data User Element) Project for 2011-2013
  - To contribute through Earth Observation to an integrated approach to storm surge, wave, sea-level and flood forecasting as part of a wider optimal strategy for building an improved forecast and warning capability for coastal inundation.
  - To increase the use of the advanced capabilities of ESA and other satellite data for Storm Surge applications.
CIFDP: Linkage with R&D

- The core of *eSurge* is an archive (*eSurge Event Analysis and Repository Service: SEARS*) including hindcasts demonstrating the usefulness of EO data assimilation, for which EO data are catalogued and linked in a database.

- Example of *eSurge* input data:
  - **Processed coastal products from altimeter** (ERS, Envisat, Geosat, TOPEX, JASON, CryoSat): measurement of the **Total Water Level Envelope (TWLE)**
  - Passive Microwave (SSM/I, AMSRE, TMI, WindSat)
  - Scatterometer (ERS, QuickScat, ASCAT, NSCAT, OceanSat-2)
  - SAR (ERS, ENVISAT, RADARSAT, COSMOSkyMed, TerraSAR-X, RISAT...)
  - Optical/IR data (MERIS, MODIS, AATSR, AVHRR, geostationary satellites)
  - NWP and NOP model outputs
  - Storm Surge model output and forcing
  - Flood maps
  - In situ (e.g. Tide Gauges)
NASA/CNES Jason-1/2 (10 day repeat)  ESA Envisat (35 day repeat)
CIFDP: Linkage with R&D

NIO Storm Surge Model Improvement

: for IIT-D model (2009-2012), UNESCO/IOC pilot project with India

- Based on the results of Storm Surge Symposium (2007, Seoul)
  - Recommendations for capacity building through enhancing regional community models, and for technical development, in particular, improving operations

- Addressed requirements for upgrading and improving model performance, in terms of enhanced **observations**, **operation** for storm surge forecasting, **research** requirements, and **capacity development**;

- Reviewed performance of the current operational storm surge forecasting model (IIT-D Model) in the North Indian Ocean (NIO) region, and implemented R&D;

- **Reviewed the status in the Region** (observations, model operation) against the identified requirements, and **exchanged knowledge** between countries.
Increase in storm surge zone (Dasgupta et al., World Bank, 2009)

estimated impact of future storm surge increases associated with more intense storms and a 1 m sea-level rise)
No Operational Flood Forecasting Provided!

Cyclone warning + Storm Surge Height Forecast. But no integrated coastal inundation forecasts.
• Participation by more than 50 governmental agencies’ representatives, regional officers, and NGOs

• National Stakeholders agreed on
  • the respective roles and general direction of the project toward an integrated, open-source, operational coastal inundation forecasting system *(National Agreement, National Coordination Team)*
  • Critical user requirements (*users: disaster managers such as Bangladesh Disaster Management Board, and execution agencies including NGOs*)
  • Key elements for technical development of CIFDP-B
  • Year-1 Workplan for the CIFDP-B
CIFDP-B: Timeline

**Phase 0**
Project preparation

**Phase 1**
Information gathering

**Phase 2**
System implementation

**Phase 3**
Pre-operational testing & technical capacity building

**Phase 4**
Operational evaluation

- **March 2011:**
  Initial National Agreement

- **2011**
  Tropical cyclone season

- **2012**
  Tropical cyclone season

- **2013**
  Tropical cyclone season

- **2014**

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- **28 November – 1 December 2011:**
  Stakeholders and technical workshop

- **Spring 2012 ~ Spring 2013:**
  Simulated Multi-agency exercise and technical capacity building events

- **Spring 2014:**
  Evaluation Workshop with Media partners and end-users
CIFDP-DR (Dominican Republic): extreme events in coastal zones

Heavy Rainfall & Flooding

Comparación de datos de precipitación Histórica-Mensual

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Hurricanes
CIFDP-DR: identified issues and challenges

- The transmission of data is difficult due to steep terrain, stormy weather (satellite interference) and a lack of infrastructure (fibre optic cable); reliable transmissions cannot always be attained.
- Vandalism of environmental sensors is a big problem. Many instruments are stolen and the parts sold on the black market. Resources are needed to provide security and protect the measurement platforms.
- Maintenance of the networks is costly, especially for such a small, impoverished nation.
- Retention of qualified personnel is challenging.
- Training of personnel and technicians is difficult.
- There is a lack of up-to-date bathymetric data along the coast (the existing database is more than a decade old). The Navy has collected bathymetry data, but only at 10 ports in the Dominican Republic.
- There is a 30 m x 30 m resolution DEM available but no land cover/classification data (essential for friction/drag calculations) is available.
- Cooperation between institutions has not been well established.
Countries that intend to develop a sub-project are invited to prepare and deliver to WMO an Initial National Agreement between participating national agencies responsible for coastal inundation forecasting and warning, to be the basis of a Definitive National Agreement (DNA).
Potential Role of RMSC Miami in Dominican Republic CIFDP Effort

- CIFDP is focused on implementation within individual countries – but will help establish:
  - Links to RA-IV SSWS
  - Standards for “best practices”
  - International coordination with RMSC

- RSMC Miami will potentially play a key role in the planned CIFDP effort in the Dominican Republic both in the provision of meteorological forecasts and predicted surges
The Operational Storm Surge Prediction System for the National Hurricane Center

Jamie Rhome and Dr. Cristina Forbes
NOAA/National Hurricane Center
SLOSH Model

- **SLOSH**: Sea, Lake, and Overland Surges from Hurricanes (Jelesnianski et al 1992)

- Extremely computationally efficient coastal ocean model used by NWS to run:
  
  1) Real-time operational storm surge prediction simulations,
  2) Hypothetical simulation studies to assist evacuation planning,
  3) Historical simulations for validation purposes, and
  4) Probabilistic storm surge forecasts (P-Surge).

- Easy to run – seconds to minutes on a desktop/laptop PC

- GUIs for running SLOSH, displaying results, and converting products to different formats (pcs, tiff, gif, shapefile, kml)
SLOSH Limitations

• SLOSH does not include:
  – Wind-generated waves (tests are being conducted with SLOSH coupled to the SWAN nearshore wave model)
  – Explicit astronomical tides (experimental version currently being tested which incorporate tides into SLOSH)

• Limited parametric wind model
The SLOSH model is being extended to include wave contributions to surges. It will also be important to couple the model (loosely or tightly) to hydrologic models in the area.
SLOSH Operational Basins

- Have higher resolution in the area of interest near the coast
- Telescope outward concentrically to lower resolution offshore
- Basins have different shapes to conform to coastal geometry:
  - Hyperbolic
  - Elliptical
  - Polar
- 37 operational basins that cover the east coast, Gulf of Mexico, Bahamas, Puerto Rico, Virgin Islands, and Hawaii

A new grid for SLOSH will need to be built for the Dominican Republic
Thank you

Courtesy of Don Resio