UNESCO-IOC INTERNATIONAL TRAINING COURSE ON TSUNAMI NUMERICAL MODELLING: COURSE I - TSUNAMI SOURCES AND TSUNAMI PROPAGATION

Two Sessions of Course I are being offered:
8-19 May 2006, Kuala Lumpur, Malaysia
5-16 June 2006, Oostende, Belgium

(organized by ITIC in collaboration with the Ad Hoc Group of Experts)

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PROVISIONAL AGENDA

Course I will emphasize understanding of the physics of tsunamis, its generating sources and mechanisms especially those from earthquakes, and how tsunami modelling is carried out through the description of the tsunami source, the generation of the wave, and the propagation of the wave from the source to distances offshore. The method of instruction will be through lectures and hands-on computer activities that illustrate and reinforce concepts taught by the Instructors. Course II will focus on propagating the wave from offshore to the coast to estimate tsunami inundation and runup, and then to use these results to develop tsunami evacuation maps for coastal communities.

1. INTRODUCTION: TSUNAMI GENERALIA

- 1.1. Characteristics of waves
  - 1.1.1. Nature
  - 1.1.2. Tsunami Wave Characteristics - Velocity, Wavelength, Period
    - 1.1.2.1. Propagation on the high seas
    - 1.1.2.2. Interaction with coastlines and run-up
- 1.2. Sources of tsunamis
  - 1.2.1. Earthquakes
  - 1.2.2. Landslides
  - 1.2.3. Volcanic Eruptions
  - 1.2.4. Meteoritic impacts
- 1.3. Size of tsunamis - Tsunami Intensity and Magnitude Scales
  - 1.3.1. Modified Sieber Tsunami Scale (Ambraseys, 1962)
  - 1.3.2. Murty Loomis Tsunami Intensity Scale
  - 1.3.3. Shuto Tsunami, Intensity Scale
  - 1.3.4. New Tsunami Intensity Scale (Papadopoulos and Imamura, 2001)
  - 1.3.5. Imamura-Iida Magnitude Scale
  - 1.3.6. Other
- 1.4. Effects of tsunamis
  - 1.4.1. Flooding
  - 1.4.2. Destruction
  - 1.4.3. Transport
  - 1.4.4. Sedimentation
  - 1.4.5. Erosion

2. OCEAN HAZARDS AND WAVE DESCRIPTIONS

2.1. General Review of Hazards
  2.1.1. Floods, Volcanic Eruptions. Hurricane/cyclones (incl storm surge), Drought,
  2.1.2. Earthquakes, Tsunamis, coastal erosion, mean sea level rise

2.2. Oceans Waves
  2.2.1. Water level changes
  Mean sea level, tides, storm surges, continental shelf waves, seiches, surface gravity waves
  2.2.2. Use of these processes for developing risk and

2.3. Waves, Classification, Transformations
  2.3.1. Basic Wave Parameters
    2.3.1.1. Basic Equations of the Wave Motion
    2.3.1.2. Wave Length, Celerity, Group Velocity
    2.3.1.3. Constancy of Wave Period
  2.3.2. Classification of Waves According to Period
  (Short, Intermediate and Long Waves)
  Wave Behavior in Shallow Water
  2.3.3. Wave Transformation (Refraction, Diffraction, Shoaling, Breaking)
    2.3.3.1. Long Waves and Abnormal Waves In Nature
    2.3.3.2. Tidal Waves, Swell Waves, Seiches, Freak Waves, Resonance of Basins

3. HISTORICAL DATABASES - TSUNAMI CATALOGUE AND PALEOTSUNAMIS

3.1. Tsunami Catalogıue
  3.1.1. History of Tsunamis and Historical Tsunamis
  3.1.2. The Storegga Slide, The Santorini / (Thera) Eruption, The Karakatau Eruption
  3.1.3. World Tsunamis: Pacific, Atlantic, Indian Ocean, Caribbean, Mediterranean Earthquakes and Tsunamis
  3.1.4. Historical tsunamis – Milestones
    3.1.4.1. The Pacific
      3.1.4.1.1. 1868 Arica
      3.1.4.1.2. 1896 Japan
      3.1.4.1.3. 1946 Aleutian
      3.1.4.1.4. 1960 Chile
      3.1.4.1.5. 1964 Alaska
      3.1.4.1.6. 1975 Kuriles
      3.1.4.1.7. 1992 Nicaragua
      3.1.4.1.8. 1995 Manzanillo
      3.1.4.1.9. 1998 PNG
    3.1.4.2. The Atlantic
      3.1.4.2.1. 1755 Lisbon
      3.1.4.2.2. 1929 Newfoundland

3.2. Identification of Historical Tsunamis – Paleotsunami Studies

3.3. Regions of tsunami generation for each region

4. TSUNAMI GENERATION MECHANISMS

4.1. Generation Mechanisms:
  Fault Break, Co seismic Sources, Pull Apart Mechanisms,
  Submarine Mass Movements, Volcano Activities, Impact Tsunamis

4.2. Tsunami Excitation By Earthquakes

4.3. Tsunami Excitation from Submarine Landslides

4.4. Tsunami Excitation from Volcanic Eruptions

4.5. Tsunami Excitation from Impacts

5. EARTHQUAKES: GENERAL

5.1. Nature of earthquakes and seismic waves
5.2. Seismic waves
    5.2.1. Body waves
    5.2.2. Surface waves
    5.2.3. Ideas about free oscillation
    5.2.4. Ideas about Earth structure
5.3. Seismic sources
    5.3.1. Location: Seismic belts; plate tectonics
    5.3.2. The gap concept and its problems
    5.3.3. Ideas about intraplate earthquakes

6. EARTHQUAKES: DETECTION AND LOCATION; GEOMETRY

6.1. Simple ideas about location
6.2. Location from P times
    6.2.1. The depth-origin time trade off
6.3. One-station procedure. Detection algorithms
6.4. One-station procedure; Location algrorithm
6.5. Earthquake geometry: the dislocation source
    6.5.1. Strike, dip and slip angles -- The beachball
    6.5.2. Dynamic representation -- the double-couple.

7. EARTHQUAKES: MEASUREMENTS OF SIZE

7.1. Early ideas -- Intensity scales
    7.1.1. Richter -- the magnitude concept
    7.1.2. The standard magnitude scales
    7.1.3. Their shortcomings
7.2. Mm -- the mantle magnitude
7.3. Implementation of Mm – TREMORS
7.4. Mwp

8. EARTHQUAKES: SCALING LAWS

8.1. What they mean
    8.1.1. What they predict – saturation
    8.1.2. What they predict -- Plafker's rule of thumb
    8.1.3. What they predict – directivity
8.2. Violators of scaling laws
    8.2.1. "Tsunami earthquakes" and the case of Nicaragua – 1992
    8.2.2. What can be done -- Estimated Energy and THETA
    8.2.3. Implementation of THETA
8.3. Other aspects of tsunami earthquakes -- T waves and GAMMA

9. EARTHQUAKES AS TSUNAMI SOURCES

9.1. Static deformation by buried double-couple
    9.1.1. The problem
    9.1.2. The solutions: Mansinha and Smylie
        9.1.2.1. Okada
9.2. Dynamic solution: The normal mode approach
9.3. Ideas about M-TSU

10. LANDSLIDE AS TSUNAMI SOURCES

- 10.1. Evidence: Fatu Hiva
- 10.2. The PNG story
- 10.3. Other case studies
  - 10.3.1. Skagway
  - 10.3.2. Lituya Bay
  - 10.3.3. Algeria cables
  - 10.3.4. Amorgos
  - 10.3.5. Makran
  - 10.3.6. Storrega
  - 10.3.7. Theoretical models: the single force
- 10.4. Discriminating landslides

11. 2004 SUMATRA EARTHQUAKE AND TSUNAMI – LESSONS

- 11.1. Seismic Lessons
- 11.2. Geologic lessons
- 11.3. Singular observations -- their lessons and their promise
  - 11.3.1. Hydroacoustics
  - 11.3.2. Satellite altimetry
  - 11.3.3. Seismic observations
  - 11.3.4. Infrasound
- 11.4. High-frequency components to the tsunami wave
  - 11.4.1. Observations
  - 11.4.2. Implications for distant shores.

12. INDIAN OCEAN AND SOUTH CHINA SEA REGION CASE STUDIES AND SCENARIOS

- 12.1. Historical
  - 12.1.1. 1883 Krakatau
  - 12.1.2. 1994 Java
  - 12.1.3. 1977 Indonesia
  - 12.1.4. 1861 -- 1941 Andaman
  - 12.1.5. 1945 Makran
  - 12.1.6. 1934 Off Luzon
- 12.2. Scenarios
  - 12.2.1. North of Andaman ?
  - 12.2.2. Repeat of 1833
  - 12.2.3. Java
  - 12.2.4. Makran
  - 12.2.5. South China Basin
  - 12.2.6. The West Philippine arc

13. TSUNAMI PROPAGATION PROCESS

- 13.1. Tsunami Propagation – including reflection, refraction processes, generation of seiches – important to highlight the effect of mid-ocean ridges, Island chains (e.g. the effects of Maldives island chain on Sri Lanka)1883 Krakatau
- 13.2. Shoaling
- 13.3. Run-up
- 13.4. Inundation

14. **<u>IMPACT ASSESSMENT</u>**
   - 14.1. Paleo- and Post-Tsunami Surveys and Assessment, Contribution to Mitigation and Risk Assessment
   - 14.2. Implications of Tsunamis on Coastal and Marine Structures
     - 14.2.1.1. Added Mass Concept
     - 14.2.1.2. Forces on an Object
     - 14.2.1.3. Drag Force of the Floating Object
     - 14.2.1.4. Inertia Forces On The Object in the Fluid
     - 14.2.1.5. Lift Forces on the Objects in Fluids

15. **<u>MITIGATION STRATEGIES</u>**
   - 15.1. Planning for the Tsunami Hazard
   - 15.2. International Protective and Preventive Measures
     - 15.2.1.1. Functioning of the Warning System
     - 15.2.1.2. Hazard Perception by the Public
     - 15.2.1.3. Awareness through Public Education
     - 15.2.1.4. Conclusion
   - 15.3. Tsunami Coming What Must Be Done
   - 15.4. Coastal Protection Structures/Wetlands/Vegetation

16. **<u>HYDRODYNAMICS OF TSUNAMI IN RELATION TO MODELING</u>**
   - 16.1. Governing Equations, Approximations and Assumptions behind
     - 16.1.1. Theoretical Approach
     - 16.1.2. Numerical Approach
     - 16.1.3. Model inputs and outcomes
     - 16.1.4. Interpretations of Model Results

17. **<u>MODEL COMPARISONS</u>**
   - 17.1. Different models available
   - 17.2. Application scenarios for different models – advantages and limitations
   - 17.3. Comparison of models – TIME Programme, TUNAMI-F/N, MOST, VOF, NTC, ANUGA, MIKE21, TUNA, UAF Tsunami Model, FVWAVE, etc

18. **<u>TSUNAMI SOURCE MODELING - TSUNAMI PROPAGATION MODELING HANDS-ON USE OF SIMULATION SOFTWARE FOR CASE STUDIES</u>**

This section will focus on tsunami modeling using simulation software developed by the Ad Hoc Group of Experts to illustrate how modeling is used to understand real scenarios. Experts will guide class participants through exercises, simulation comparisons, and discussions to give them experience in how to conduct a well-posed modeling study and how the results of the simulations are used to make conclusions about the real world. Case studies and examples will focus on the Indian Ocean modeling application. Much of Week 2 will concentrate on this section.

   - 18.1. Modeling in a Regular Shaped Basin
     - 18.1.1. Test Basins and Dimensional Parameters (2D - 3D Regular Shaped Basins)

   - 18.2. Modeling / Testing of Long Wave Motion in 2D Problem Amplitude Evolution on a Sloping Plane

   - 18.3. Application of the Model to 3D Regular Shaped Basins
     - 18.3.1. Fault Parameters and Related Tsunami Sources (3D Problem)

18.3.2. Exercises, Comparisons and Discussions

18.4. Participant Workshops on Tsunami Generation

18.5. Simulation/Animation of Tsunami Propagation in 3D Basins
  18.5.1. Simulation/Animation of Tsunami Motion and Long Wave Transformation in a Basin of a Sloping Plane
  Exercises, Comparisons and Discussions
  18.5.2. Simulation/Animation of Tsunami Motion and Long Wave Transformation in a Basin where Small Obstacles (Islands) and Long Barriers (Breakwaters, Peninsulas) exist – highlight reflection and scale effects
  Exercises, Comparisons and Discussions

18.6. Determination and Discussion on Water Surface Fluctuations at Selected Locations in Study Basins
  Exercises, Comparisons and Discussions
18.7. Discussion on Tsunami Generation and Propagation Related to Study Cases
18.8. Modify and Adopt the Available Depth Data for Efficient Tsunami Modeling
18.9. Participants Workshops on Tsunami Generation and Propagation on Assigned Cases

18.10. Overall Discussion

19. REVIEW OF TSUNAMI PROPAGATIONS IN CASE STUDIES AS BASIC INFORMATION FOR ADVANCED MODELING
19.1. Chilean Earthquake and Tsunami, 1960
19.2. Okushiri Tsunami, 1993
19.3. Papua New Guinea Tsunami, 1998
19.4. Results of all modelling efforts on 2004 Indian Ocean Tsunami

20. NEXT STEPS – COASTAL INUNDATION AND RUNUP
20.1. Data Requirements
20.2. Course II plans