Chapter 4: Tsunamis

Japan Tsunami

* March 11, 2011
* Killing ~16,000 people
* M9.0 earthquake beneath the seafloor
* Damage of $235 B USD
* Tsunami propagated throughout the pacific ocean causing 2m high waves in Chile
* Only 58% of people in highest impacted areas heeded the tsunami warning and evacuated to higher ground
* Lessons?
  + Japan was unprepared for the size of the tsunami
  + Earthquake and tsunami education is necessary for people living/visiting on the east coast
  + Unanticipated secondary effects (ex. destruction of nuclear reactors)
  + Warning system alone is not enough

Tsunami – a series of waves caused by a displacement of large volumes of water, typically in an ocean or large lake

* Triggered by:
  + Large earthquakes
    - Earthquake rupture in the seafloor pushes water upwards
    - Typically requires M7.5 or higher to generate a damaging tsunami
    - Tsunamis move rapidly in the deep ocean
      * Spacing (frequency) of crests is large and amplitude is small
    - Tsunami nears land, loses speed, gains height
      * Depth of ocean decreases, slowing tsunami waves to 45km/h
      * More water piles up, increasing amplitude and frequency
    - Tsunami moves inland, destroying everything in path
      * The run-up – max horizontal and vertical distances that the largest wave reaches as it travels inland
      * Edge waves that follow along the shore
    - Distant tsunami – tele-tsunami – travels thousands of kms across the open ocean and strikes remote shorelines with little loss of energy
    - Local tsunami – affects shorelines near the source of the earthquake
    - EX. Indonesia Tsunami
      * Dec 26, 2004
      * Killing ~230,000 people
      * M9.1 earthquake off west coast of sumatra
  + Landslides
    - Submarine landslides cause water to become displaced in lakes or oceans
    - Landslides can fall into the ocean from mountains, causing waves to form
    - Volcano flank collapse
  + Explosive volcanic eruption
    - Less common than earthquake triggered
    - 2nd most deadly tsunami was triggered by the Krakatoa erption
      * between java and Sumatra
      * eruptions on August 26/27 1883
      * explosion heard 5000km away
  + Impact in the ocean of an asteroid or comet

Regions at Risk

* Most coastlines of all oceans and some lake shorelines
* Coasts near the sources of tsunami
  + Earthquakes, landslides, volcanoes
  + Subduction zones capable of generating M9 earthquakes
    - Cascadia zone, Chilean trench, off coast of Japan
* around the pacific ocean, Mediterranean sea, NE Indian Ocean

Effect of Tsunamis

* Primary effects are related to flooding and erosion
  + Tear up beaches, coastal vegetation and houses
  + Debris covered ground
  + Drowning
  + Death and injury
* Secondary effects
  + Fires (ruptured natural gas lines or ignition of flammable chemicals released from damaged tanks)
  + Pollution of freshwater supplies (contaminated seawater, damages wastewater treatment systems, rotting animal carcasses and plants)
  + Disease outbreaks (from contact of polluted water or soil)
  + Long lasting mental health problems in survivors

Causes of tsunami

* Offshore earthquakes
* Landslides
* Explosive eruptions of island volcanoes
* Asteroid and comet impacts

Caused by tsunami

* Erosion
* Sediment deposition

Minimizing the Tsunami Hazard

* Detection and warning
  + Monitor earthquake zones
  + Tsunami warning system
    - Seismographs to detect earthquakes
    - Tidal gauges to determine sea level changes
    - Buoy sensors to detect tsunami in open ocean
* Structural control
  + Building codes for susceptible coastline areas
* Tsunami inundation maps (runup)
  + Show the height to which water is likely to rise
* Land use
  + Native vegetation may provide defense
  + Development of land must be monitored
* Probability analysis
  + Similar to earthquake analysis
* Education
  + Signs of tsunami
  + Differences between tsunami watch and warning
* Tsunami readiness
  + 24h emergency operation centres
  + alert the public
  + plan with emergency drills
  + community awareness