Earthquakes of Magnitude > 5.0 in the South China Sea region since 1900
Tsunamigenic earthquakes in the northern part of the South China Sea since 1600
Tsunami Warning Arrangement in Hong Kong

- For distant earthquake, assessment of tsunami risk is based on PTWC and NWPTAC messages.

- For earthquakes near Hong Kong, assessment will be based on intensity of locally felt tremor and location of earthquake as determined by HKO’s seismographic network.

- If a significant tsunami is expected, HKO will issue a **Tsunami Warning** within 3 hours of the estimated time of arrival (ETA) of the tsunami at Hong Kong.

- **Tsunami information bulletins** will be issued if the tsunami height at Hong Kong is likely to be insignificant or the time from ETA is more than 3 hours.
Numerical Tsunami Modelling

- **Tsunami Inundation Modeling Exchange (TIME)** project, supported by
  - International Union of Geodesy and Geophysics
  - Intergovernmental Oceanographic Commission
  - Tohoku University of Japan

- **Boussinesq Equation (x-component only)**

\[
\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -fv - g \frac{\partial h}{\partial x} - \frac{gn^2u\sqrt{u^2+v^2}}{(d+h)^{4/3}} + \frac{d^2}{3} \frac{\partial^3 u}{\partial x^2 \partial t}
\]
For near-shore tsunamis with short propagation-time, Coriolis term and dispersion term are not significant, thus:

\[
\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} = -g \frac{\partial h}{\partial x} - \frac{gn^2u\sqrt{u^2 + v^2}}{(d + h)^{4/3}}
\]

**Linear:** local acceleration, pressure gradient

**Non-linear:** advection, bottom friction
Tsunami Modelling - Linear vs Non-linear

- **Linear modelling**
  - Use Green’s Law to deduce near coast tsunami heights
  - Less computation time

- **Non-linear modelling**
  - Require high resolution bathymetry and coastline
  - Time consuming computation
Resolutions and Linearity:
- 30m (NL)
- 90m (NL)
- 270m (L)
- 810m (L)
- 2430m (L)

Local surveys

SRTM30 PLUS DEM

Modelling Grids
Mw 7.1 Earthquake on 26 December 2006

Damages caused by the earthquake

- Hengchun, Taiwan:
  - two persons died, 42 injured;
  - three houses collapsed, 134 schools and many other buildings suffered damage;
  - power blackouts in about 3,000 houses.
- Undersea telecommunication cables damaged
  - 6 out of 7 major cables serving Hong Kong were damaged;
  - Disruption to international telephone calls and Internet access for Hong Kong, Taiwan, Singapore, South Korea, Malaysia, Japan and the Philippines.

Epicentre: 21.81 120.53
Earth tremors felt in Hong Kong

- Hundred of residents called to report having felt earth tremors.
- People in a housing estate rushed to the street.
- Intensity estimated to be III to IV on the Modified Mercalli Scale based on subjective reports.
- 0.003~0.004 g recorded by strong motion accelerographs.
A severe earthquake of magnitude 7.2 occurred over the Luzon Strait at about 8:26 p.m. on 26 December 2006.

The earthquake might have generated a local tsunami near the earthquake epicentre. However, no significant tsunami is expected to affect Hong Kong.
Tsunami Travelling Time (hours)
Approximately 3 hours 45 mins
Recordings on Tide Gauges of the Hong Kong Observatory
Tsunami recorded at Tai Miu Wan

- Arrival time of the first wave 00:10 HKT on 27 Dec 2006;
- Largest wave amplitude (crest to trough): 11 cm; the first wave;
- Wave periods: 10 - 20 minutes.
Tsunami Propagation in the South China Sea
Simulated Tsunami Time Series at Tai Miu Wan

![Graph showing Simulated Tsunami Time Series at Tai Miu Wan tide gauge station.](image)
### Comparison of Simulated Tsunami Heights
**Combined Models vs. Green’s Law**

<table>
<thead>
<tr>
<th>Tsunami Height (crest to trough)</th>
<th>Linear Model + Non-Linear Model</th>
<th>Linear Model + Green’s Law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simulated</td>
<td>14 cm</td>
<td>18 cm</td>
</tr>
<tr>
<td>Recorded</td>
<td>11 cm</td>
<td></td>
</tr>
</tbody>
</table>
Hypothetical cases to compare Non-Linear models and Green’s Law
Tsunami Height Comparison
Non-Linear models v.s. Green’s Law (3 cases)
Conclusions

• Numerical tsunami modelling with nonlinear terms and high resolution bathymetry data produced a maximum tsunami wave amplitude comparable to the recorded amplitude.

• The traditional method of using linear equations and Green’s Law gave a tsunami amplitude with much larger difference.

• Nonlinear modelling and high resolution bathymetry are preferred in tsunami hazard studies along the coast of southern China.
Thank you