

Modeling wave run-up and inundation in Singapore

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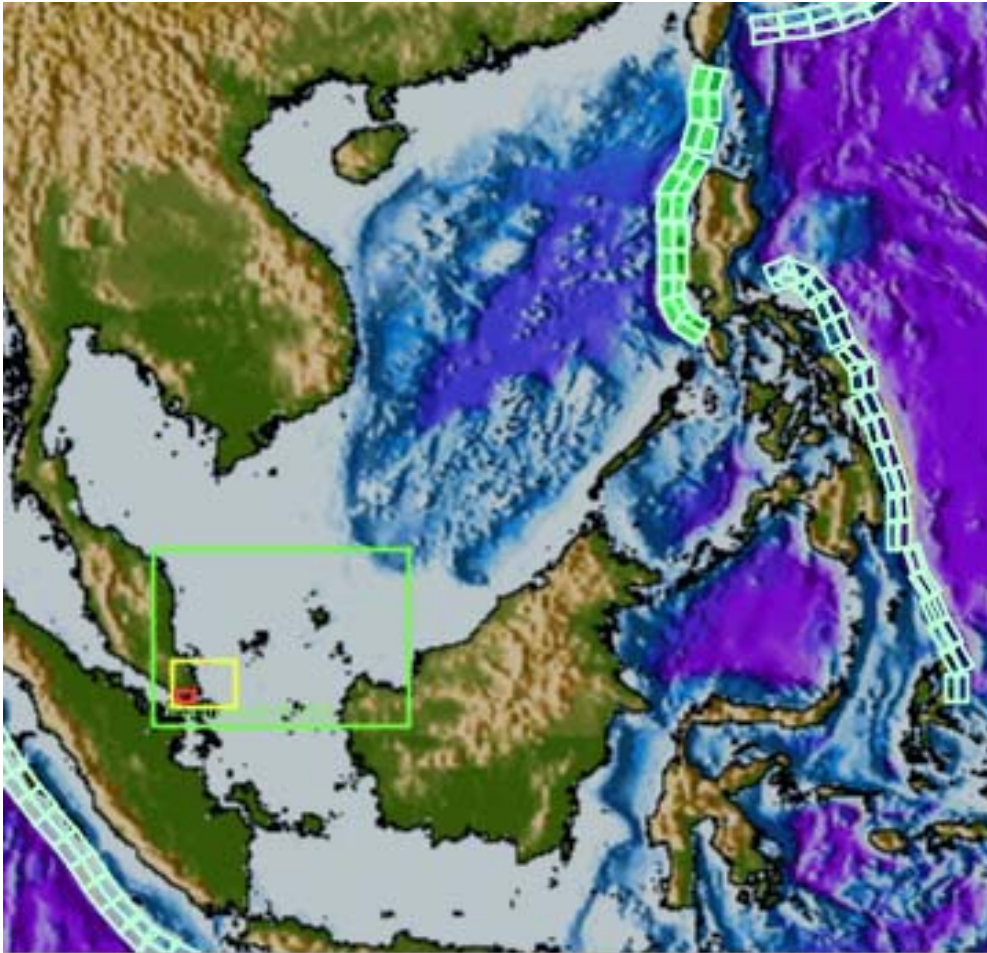


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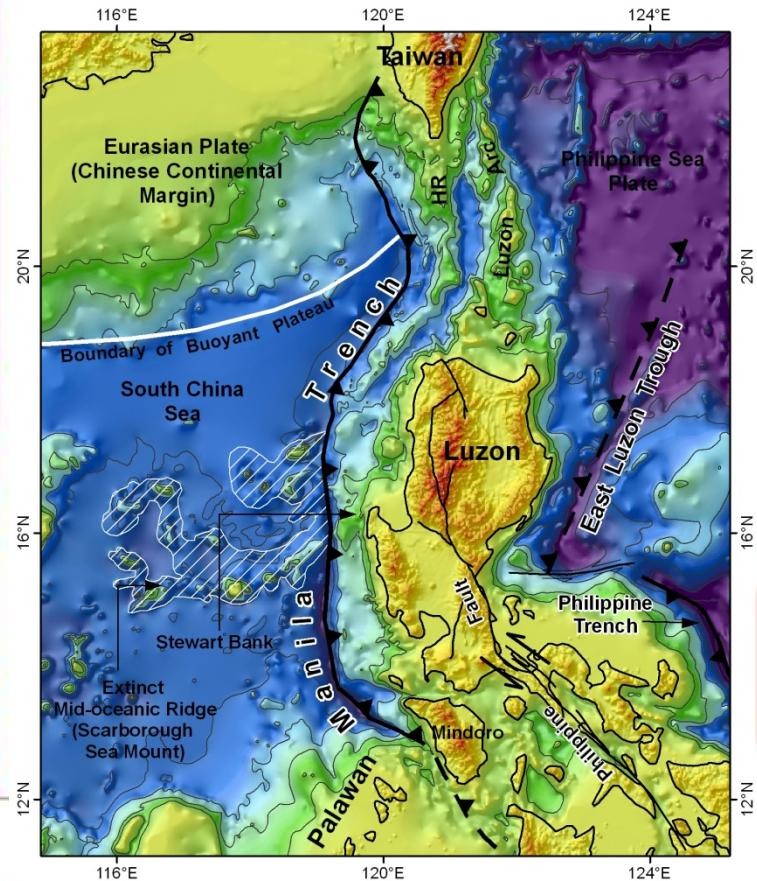
Operational Tsunami Prediction and Assessment System (OTPAS)

- Two Singapore teams: NUS team and NTU team
- NTU is responsible for two items:
 - Tsunamigenic earthquake description and forecast
 - Modelling of tsunami wave run-up and inundation for Singapore.

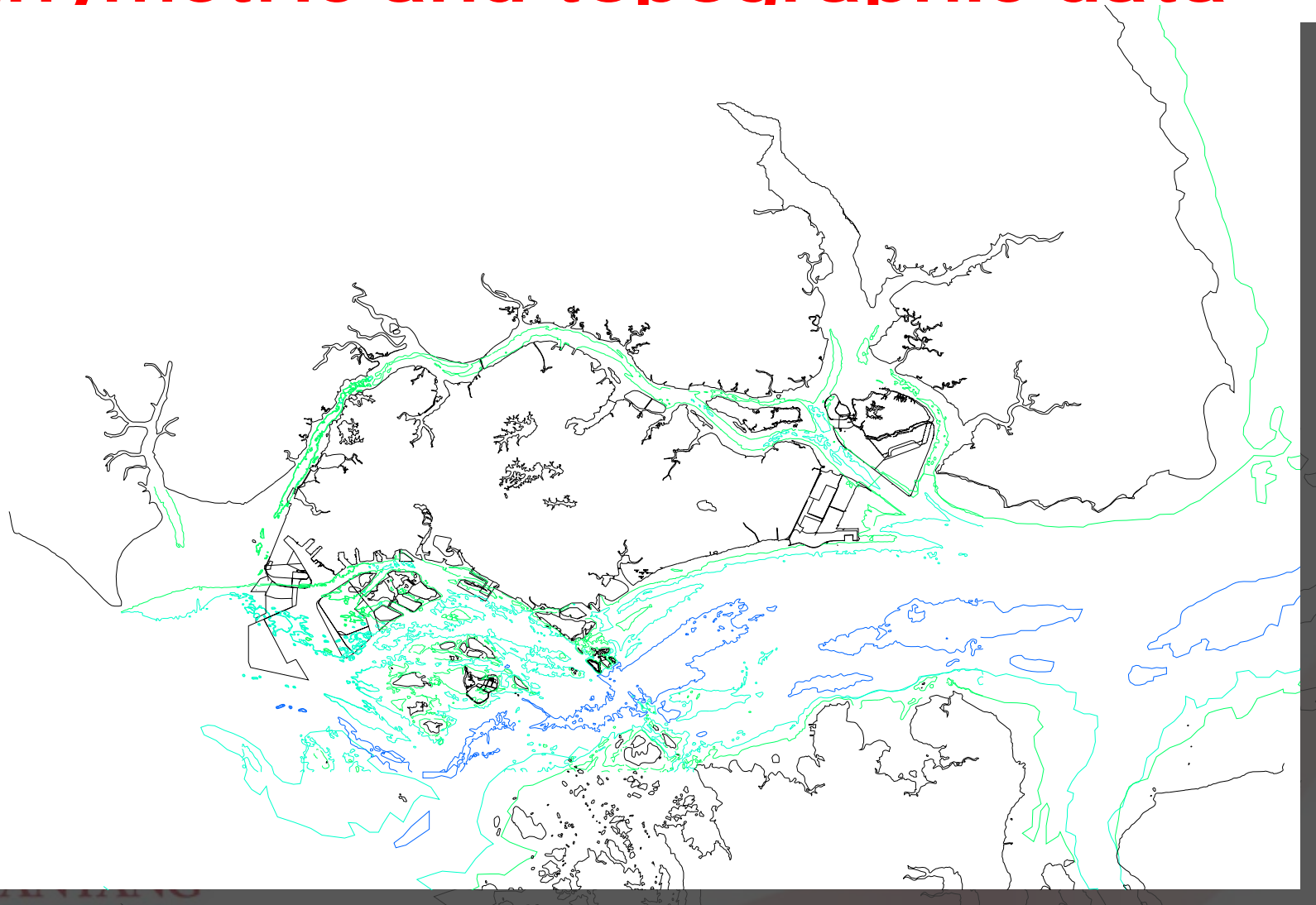
Potential earthquake sources for Singapore



Manila Trench



Bathymetric and topographic data



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Legend

— 10m

— 20 m

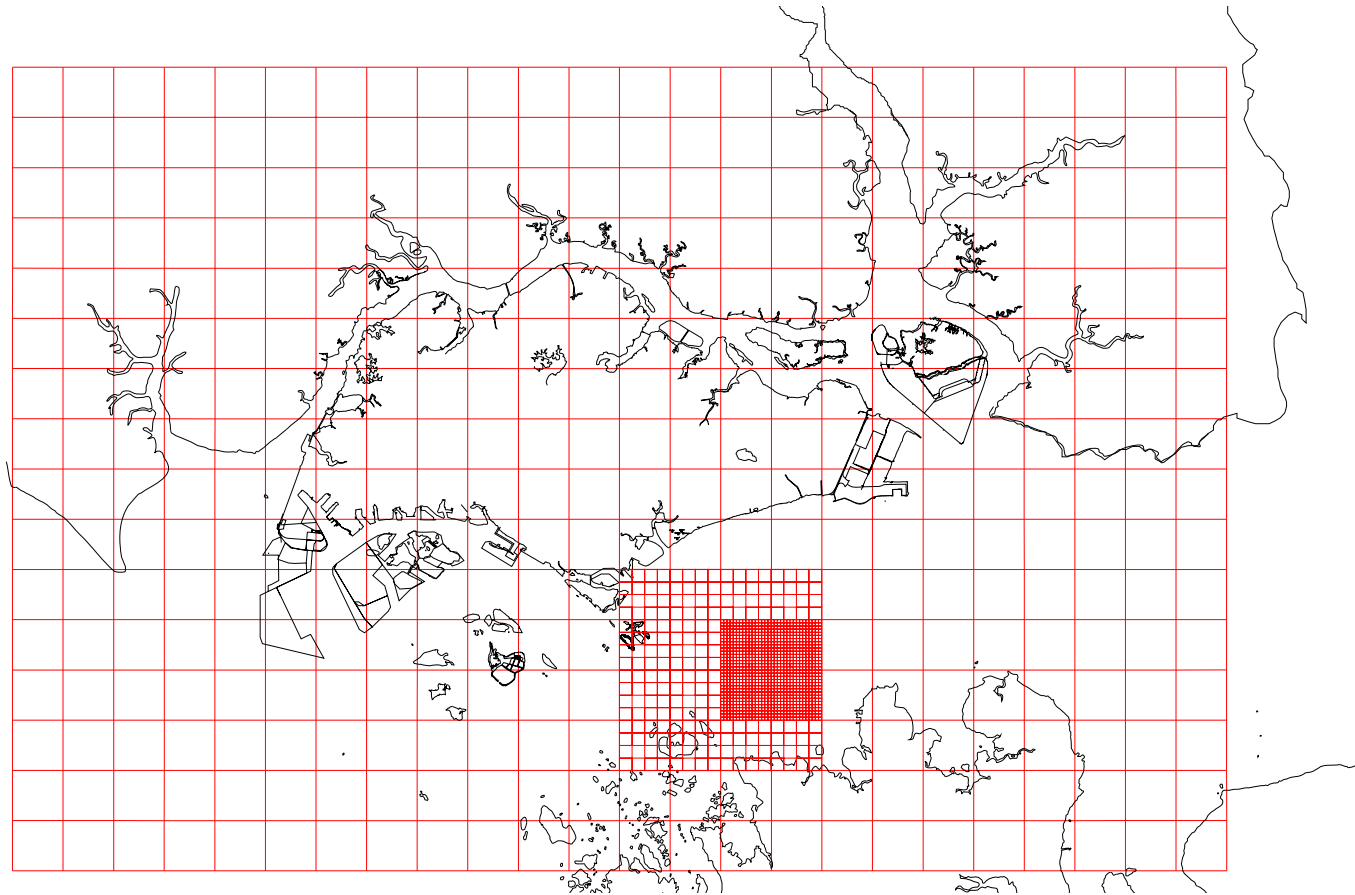
— 50m

Objectives

Development of run-up, wave dissipation and inundation models integrated with tsunami propagation model

- Effects of sediment entrainment on wave dissipation
- Movable seabed and shoreline change
- Variable friction coefficient
- Inundation map and evacuation plan

Fine grid for inundation



Benchmark tests with existing Inundation Models

- MOST (ComMIT, NOVAA)
- TUNAMI-N2 (Tohoku University, Japan)
- ComCot (Cornell Model, US)
- DHI MIKE-21 (DHI model)
- Others



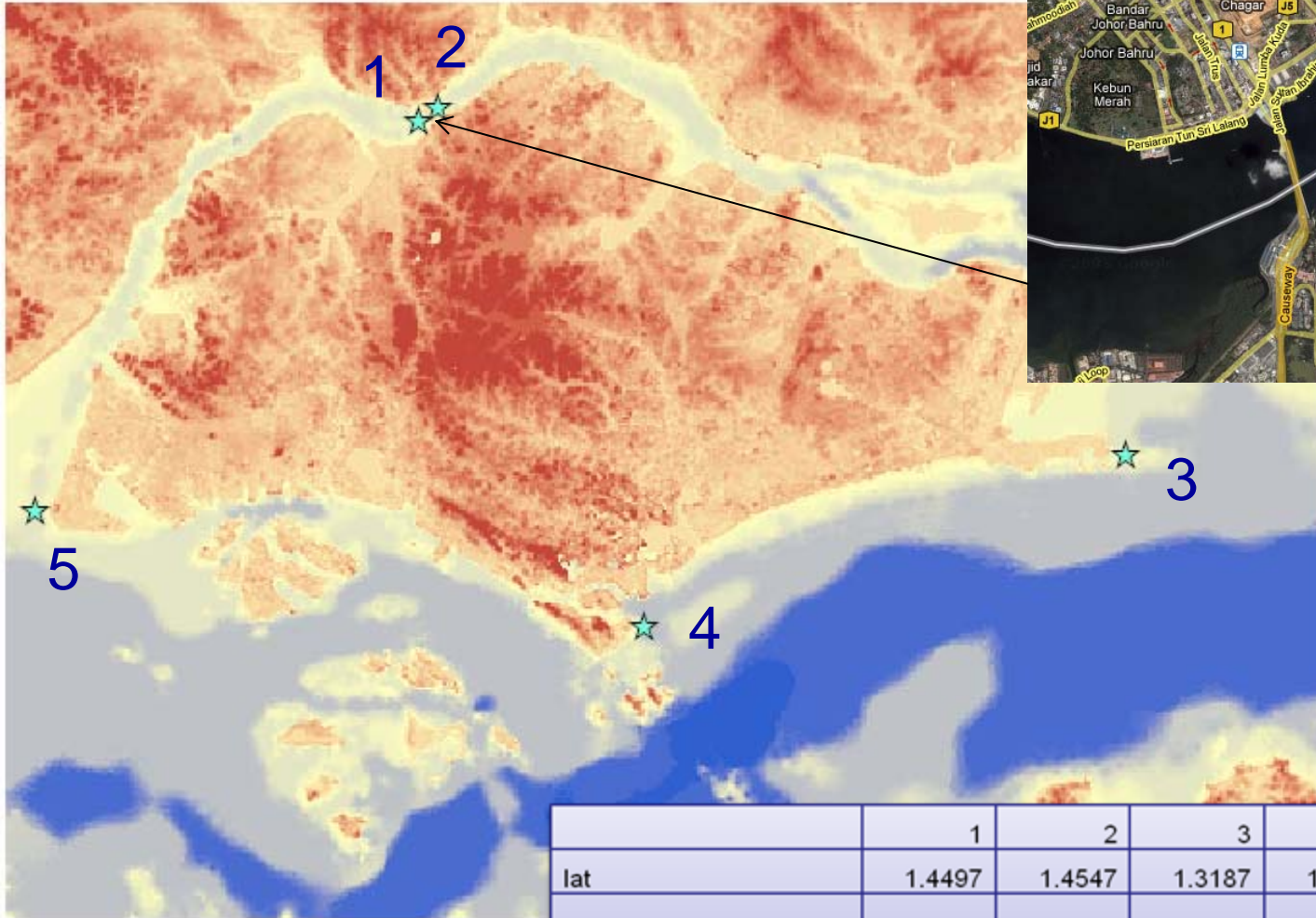
MOST and ComMIT

- ComMIT is used for the inundation study
- Rupture length of 1000km was assumed, equivalent to Mw9.3 earthquake.
- 520 x 360 grids are used for grid A , B and C
- 37 hours of physical time were modeled. About 8 hour-computer time.
- Dry land depth of inundation < 0.1m
- Time step = 2.52s

Grid A, B and C

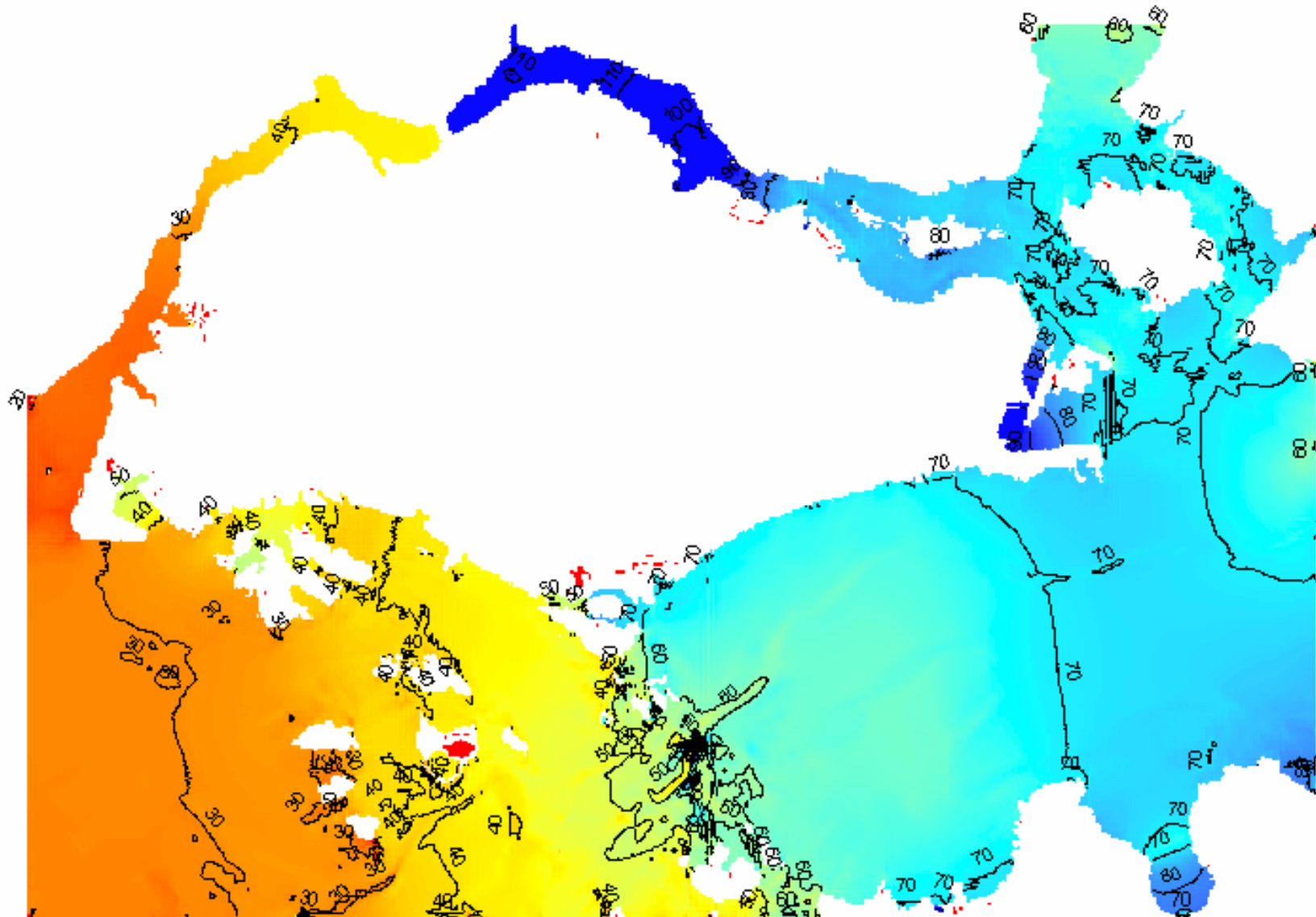
	A-grid	B-grid	C-grid
Dimensions	520 x-points (lon) by 360 y-points (lat)	520 x-points (lon) by 360 y-points (lat)	520 x-points (lon) by 360 y-points (lat)
Latitude Scope	0.8957 degrees to 2.3317 degrees	1.0557 degrees to 1.7737 degrees	1.1357 degrees to 1.4947 degrees
Longitude Scope	103.3606 degrees to 105.4366 degrees	103.5206 degrees to 104.5586 degrees	103.6006 degrees to 104.1196 degrees
Latitude spacing even, delta-Latitude	445.2800 meters	222.6400 meters	111.3200 meters
Maximum depth	-63.0 meters	-44.0 meters	-199.3 meters
Maximum height	651.0 meters	424.0 meters	185.9 meters
Maximum timestep (CFL condition)	17.9 seconds	10.ri7 seconds	2.52 seconds

Locations of virtual gages



	1	2	3	4	5
lat	1.4497	1.4547	1.3187	1.2507	1.2967
lon	103.7636	103.7706	104.0416	103.8516	103.6126
Depth [m]	7.9555	8.6297	8.8367	16.909	7.8161
Distance from land [m]	310m	<50m	740m	360m	530m

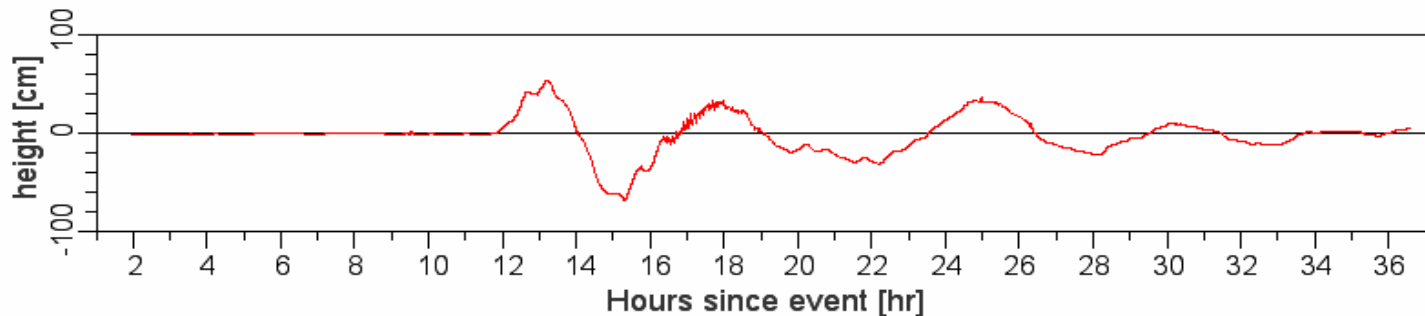
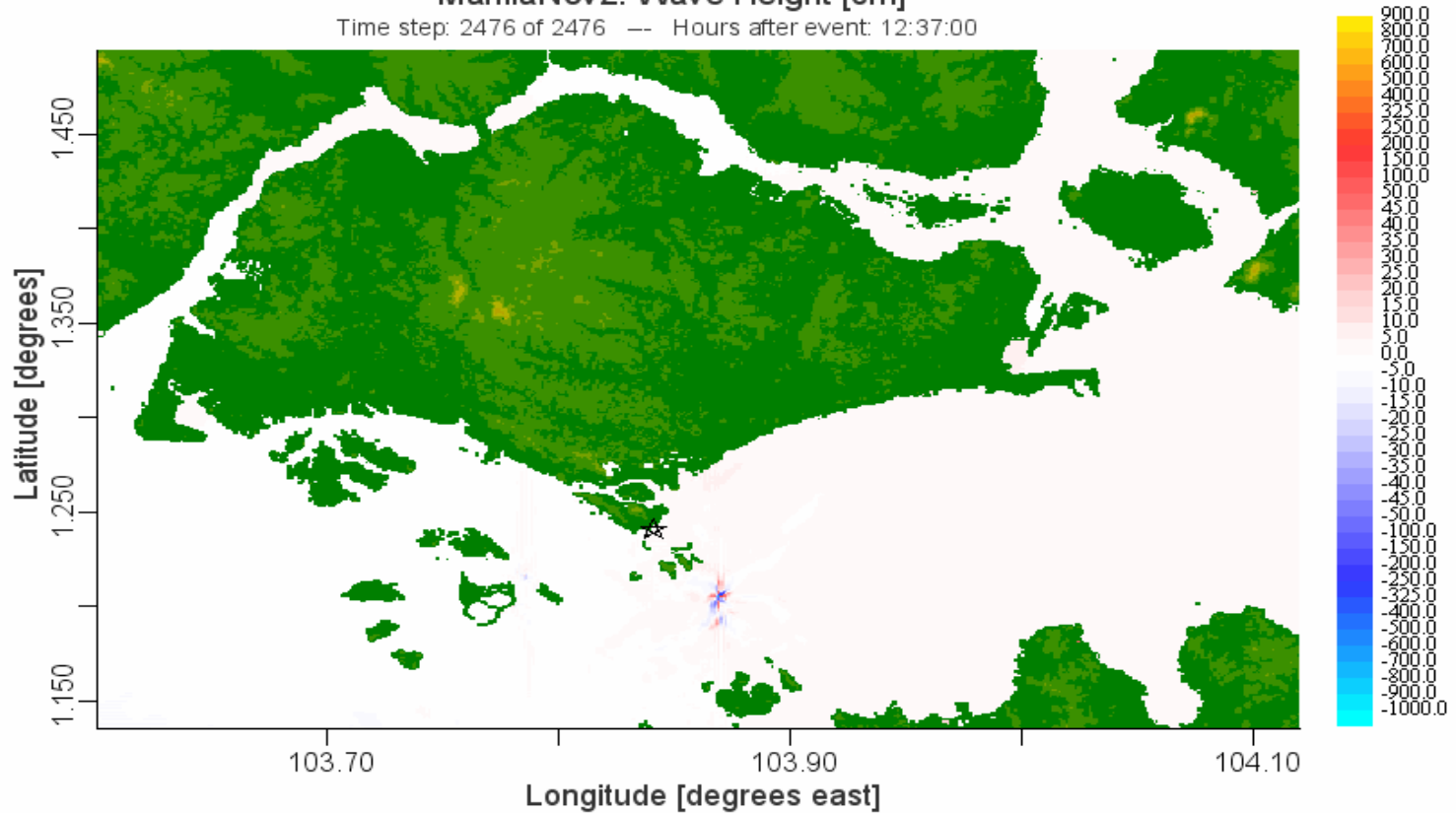
Maximum wave height map



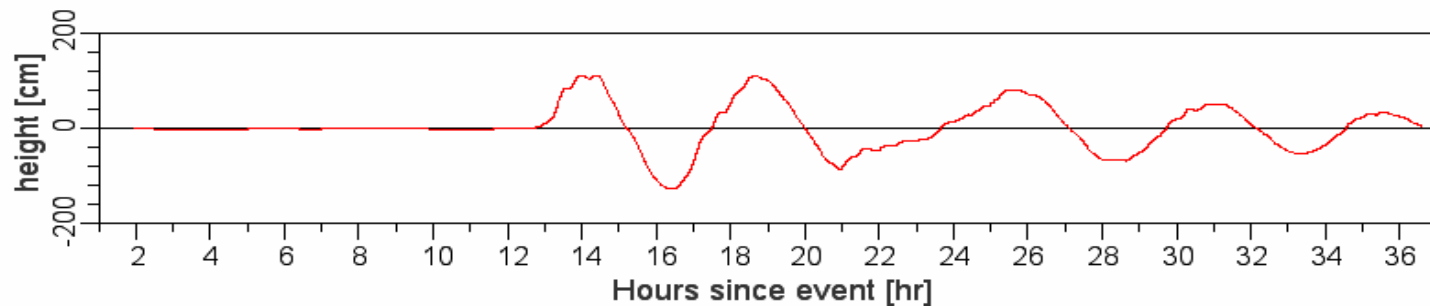
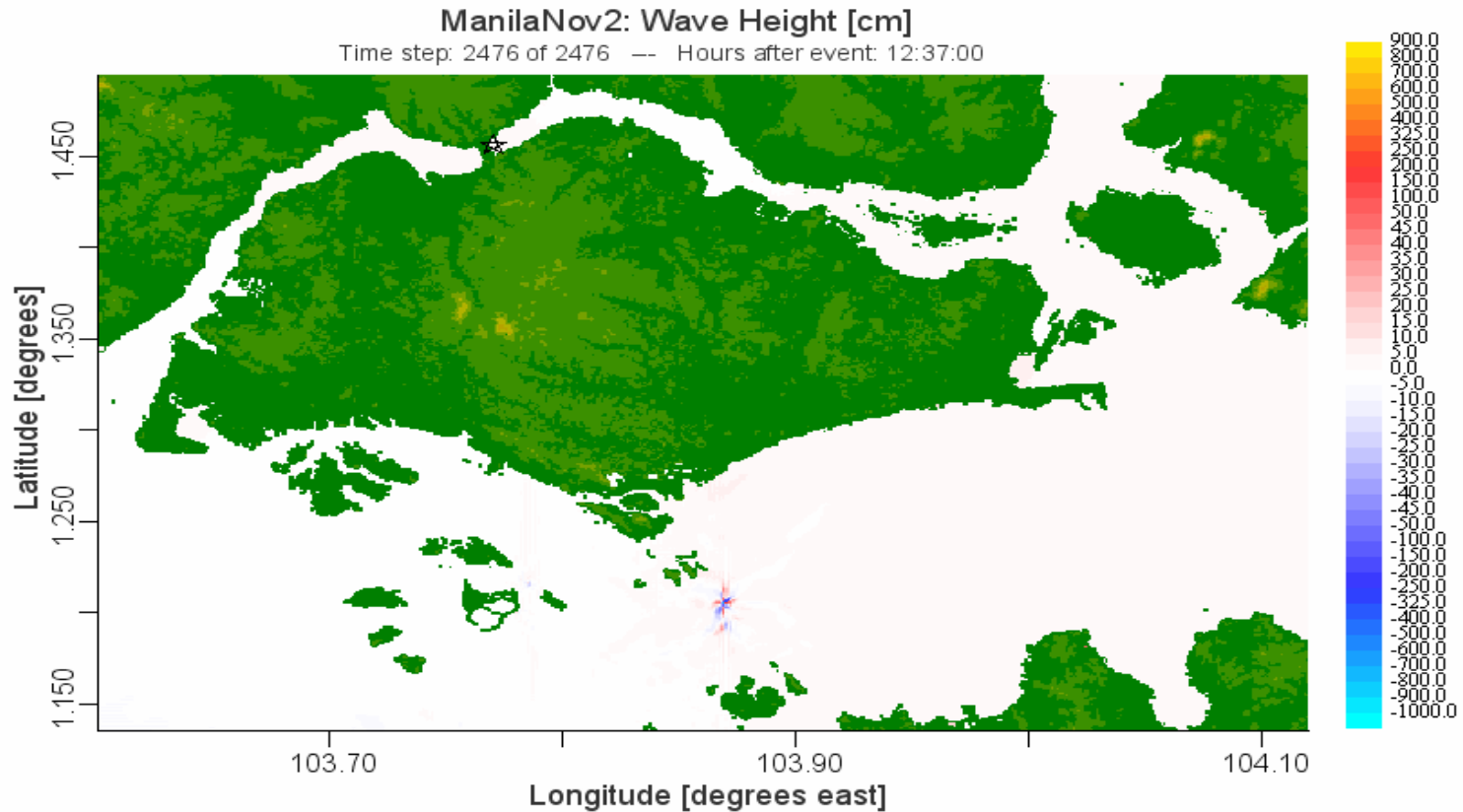
Wave height near Marina Bay

ManilaNov2: Wave Height [cm]

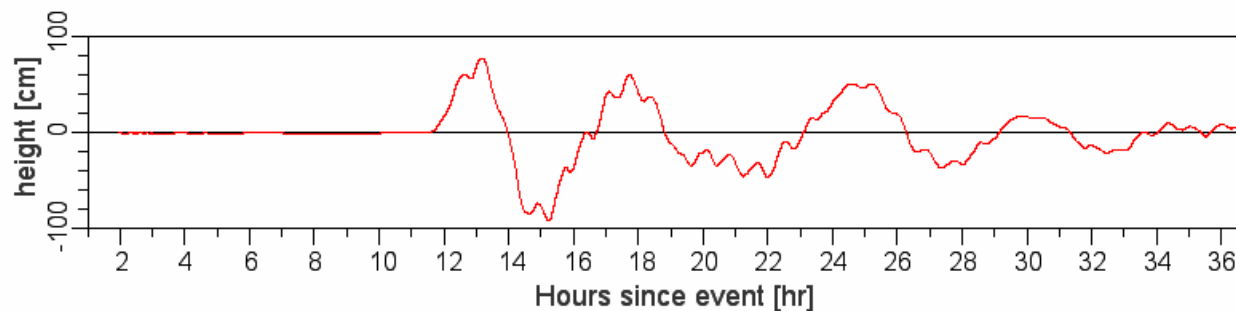
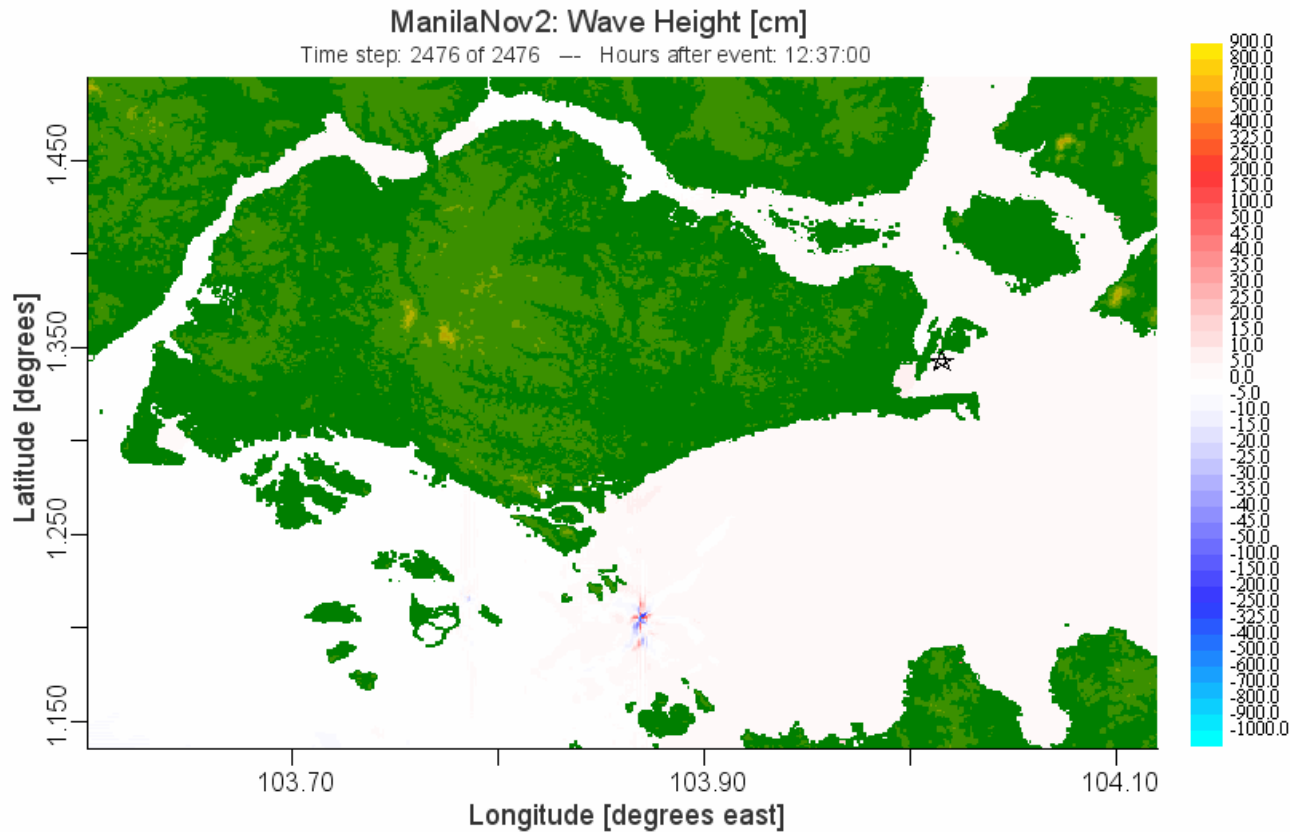
Time step: 2476 of 2476 -- Hours after event: 12:37:00



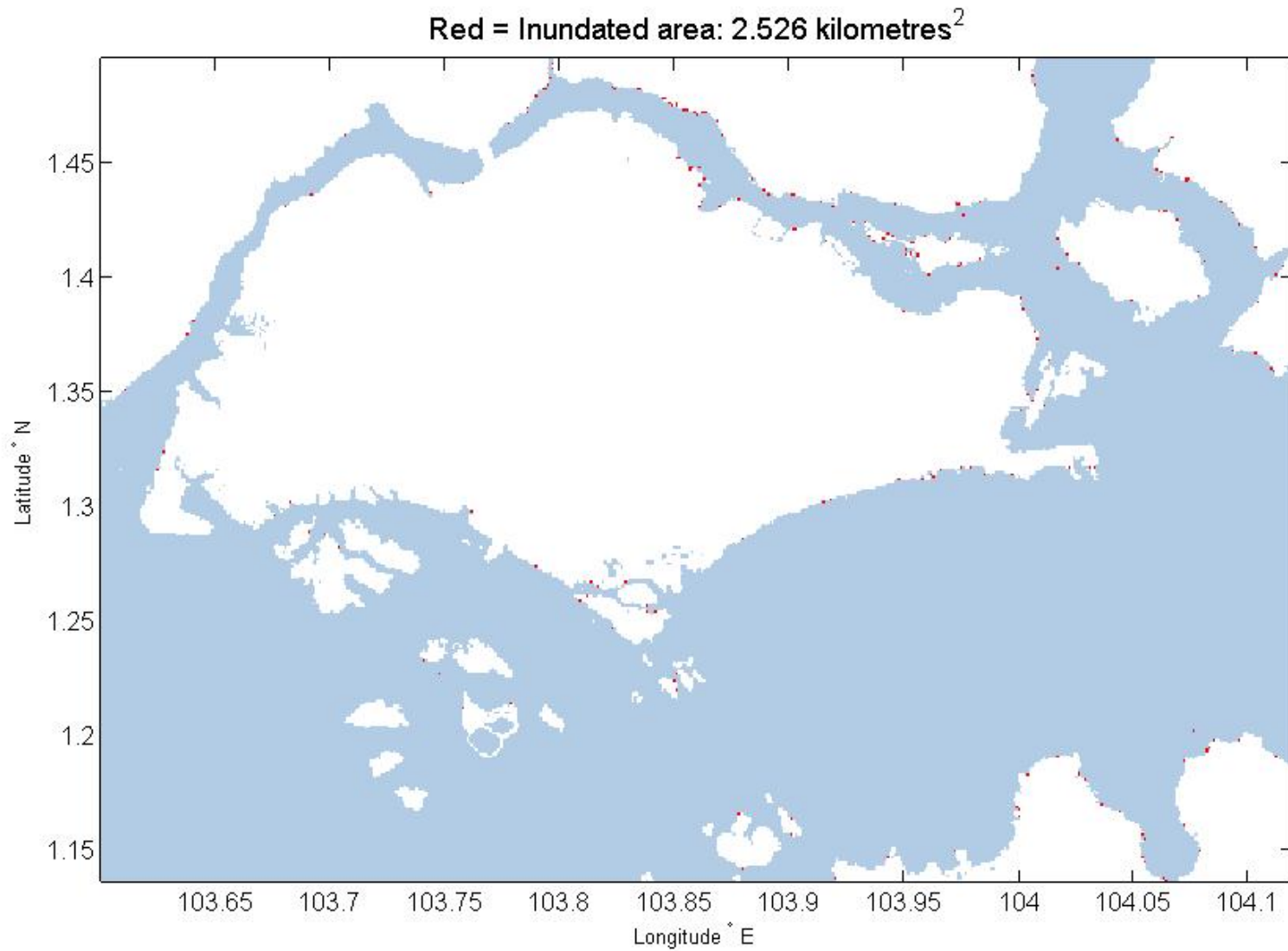
Wave height in Johor Strait



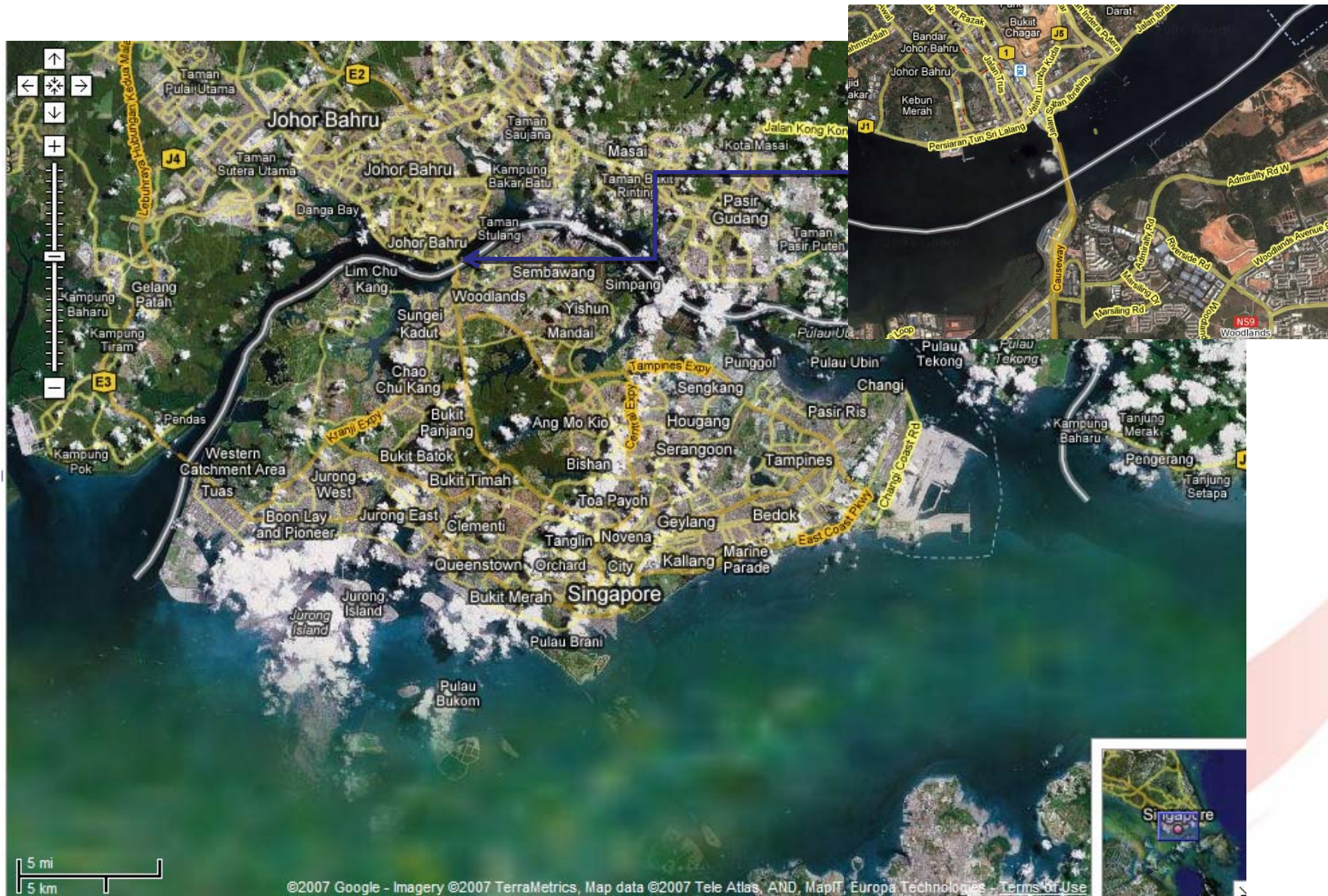
Wave height near Changi Airport



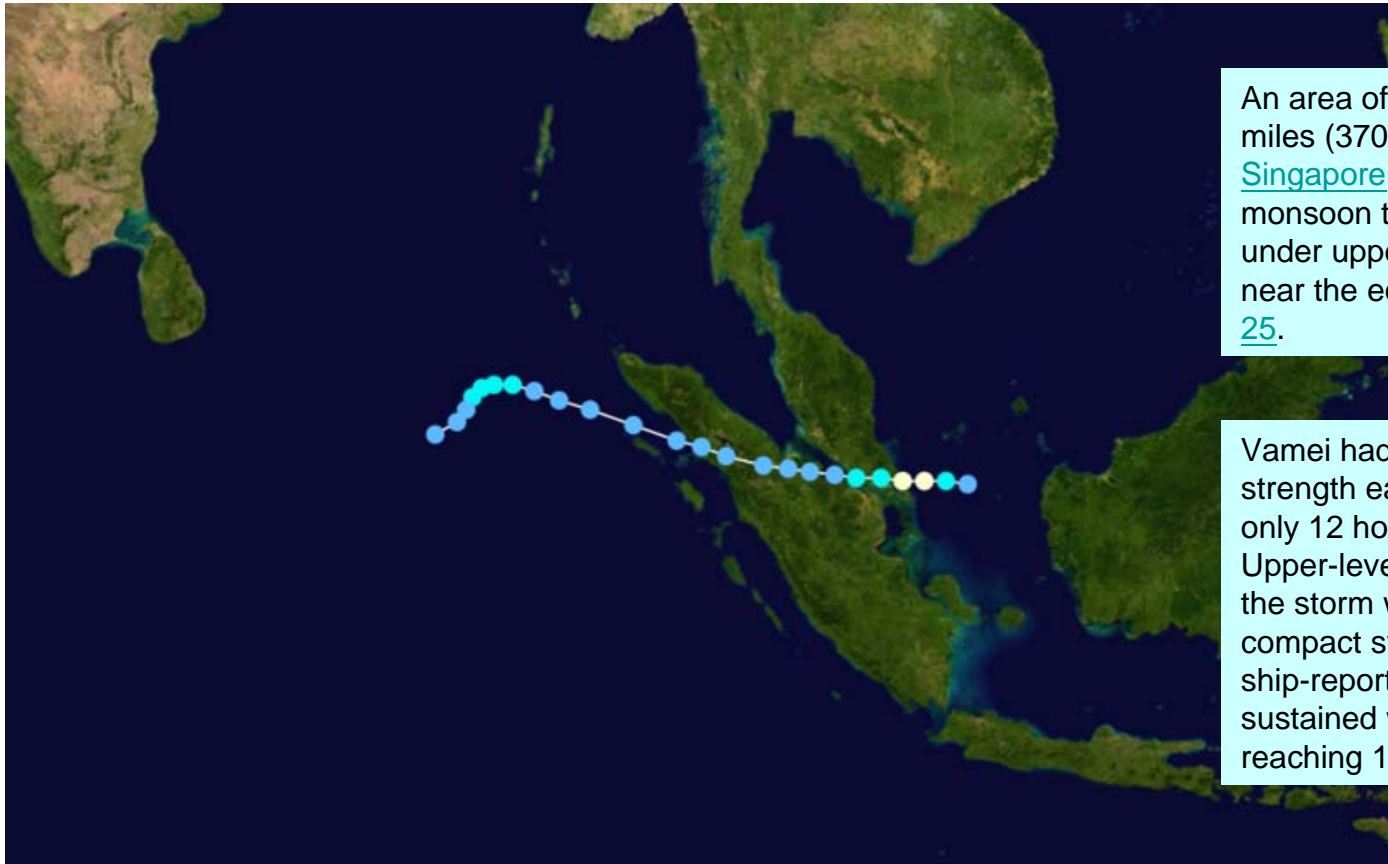
Inundation areas



Johor-Singapore Causeway



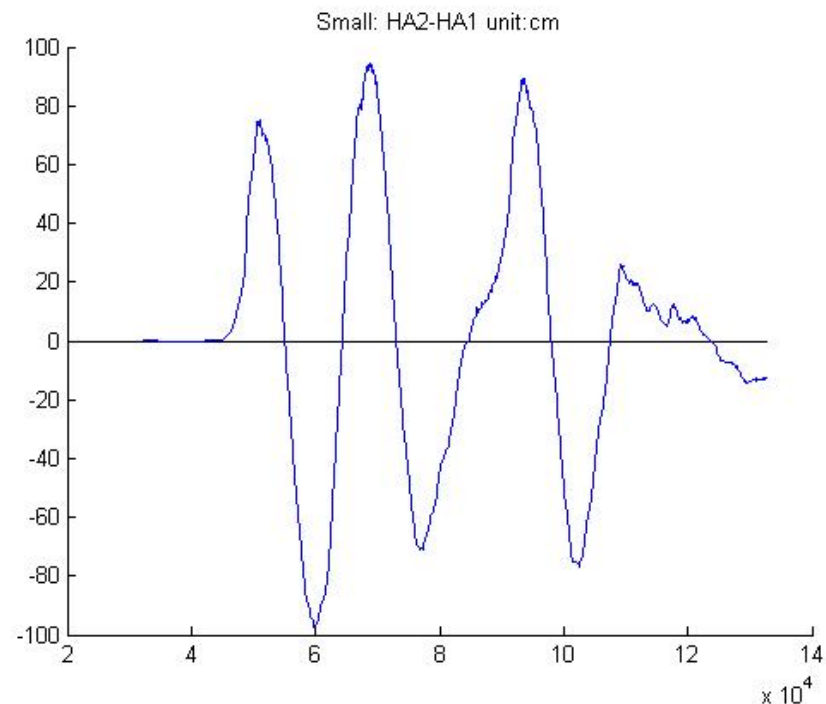
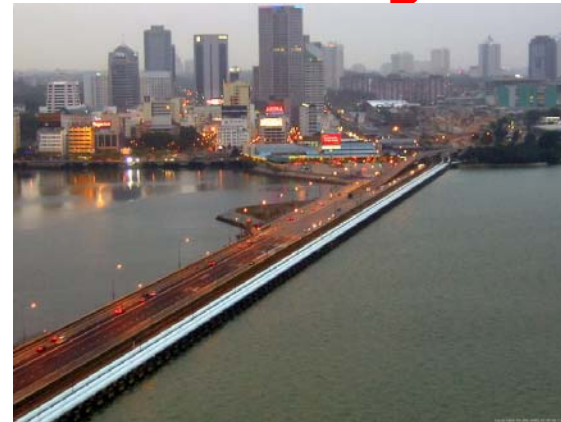
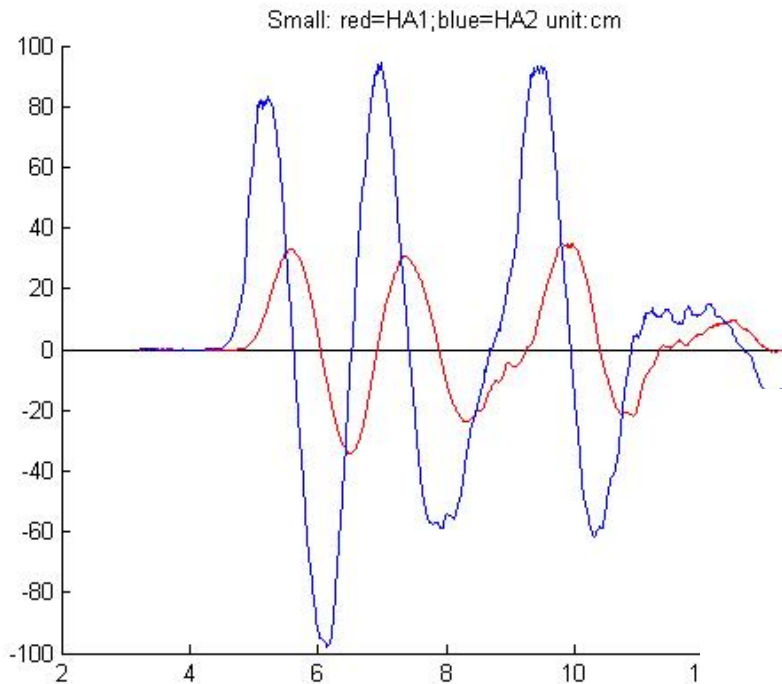
Tropical Storm Vamei (Dec 2001)



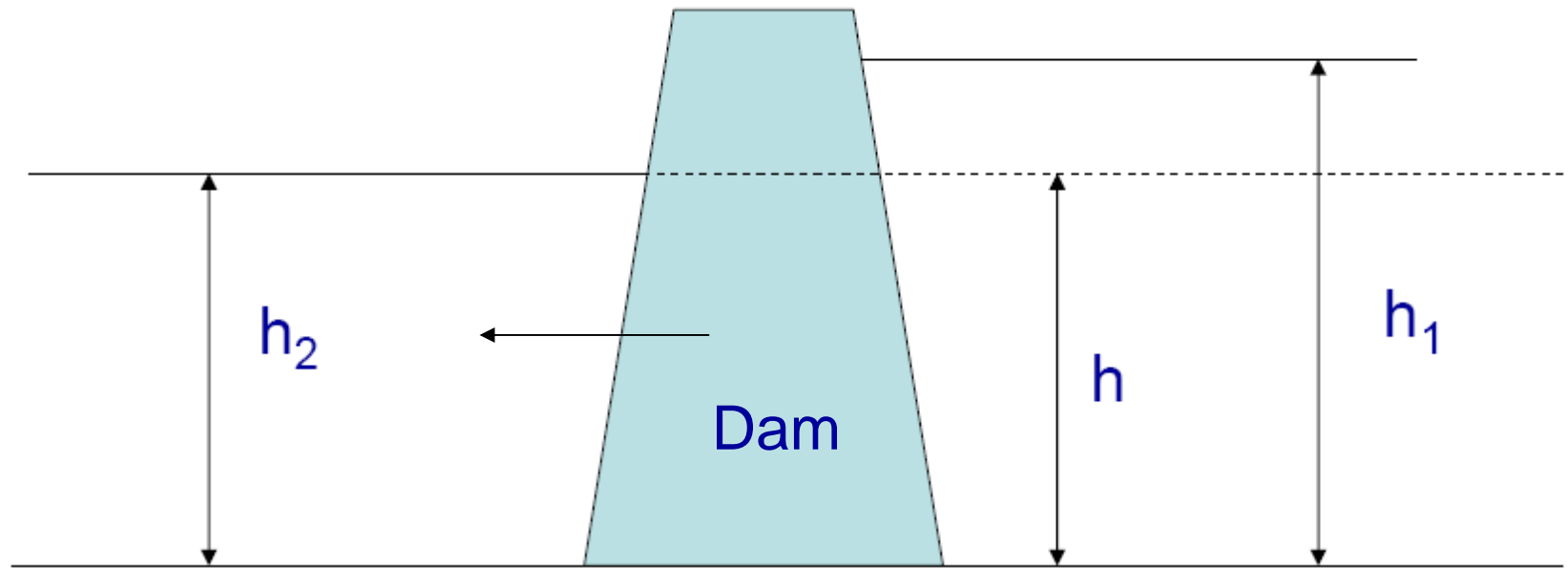
An area of convection 230 miles (370 km) east of [Singapore](#) developed from a monsoon trough disturbance under upper level divergence near the equator on [December 25](#).

Vamei had reached typhoon strength early on [December 27](#), only 12 hours into its existence. Upper-level steering flow forced the storm westward, where the compact system reached a ship-reported peak of 87 mph sustained winds and gusts reaching 120 mph

Wave heights on two sides of Johor-Singapore Causeway



Excess load on Johor-Singapore Causeway



Conclusion

For the hypothetical Manila Trench rupture

- The arrival time is about 12 hours
- The maximum wave height is in general less than 1 m
- The maximum wave height of about 1m occurs in Johor Strait
- The inundation area is small. The inundation areas are small, isolated patches.
- There may be a tsunami induced excess load on the causeway in Johor Strait.

Thanks for your attention



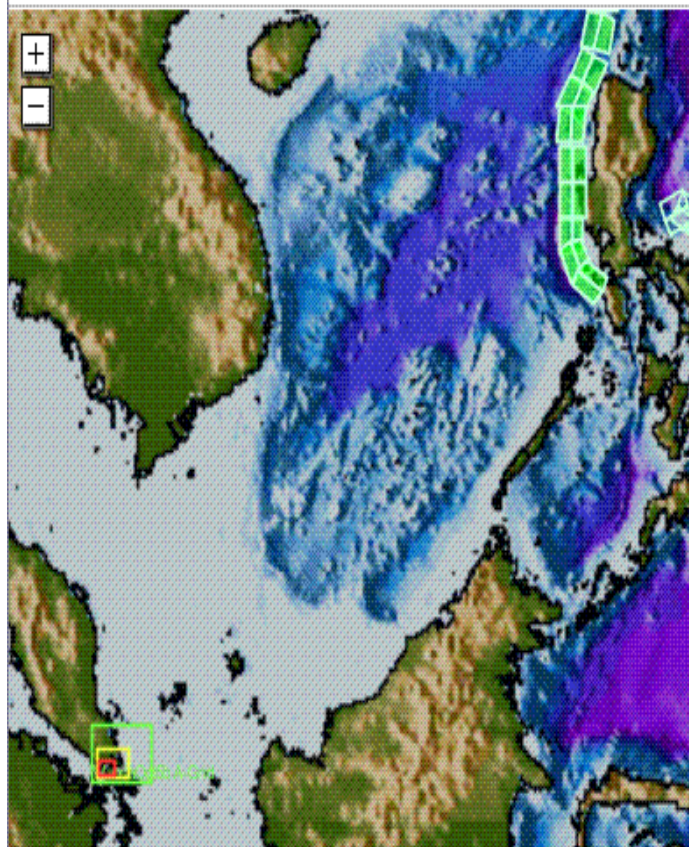
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ComMIT Input parameters



Total Magnitude: Mw

Name	% Mag	Slip
wpsza1	1.1	5.00
wpszb1	1.1	5.00
wpsza2	2.1	10.00
wpszb2	2.1	10.00
wpsza3	4.3	20.00
wpszb3	4.3	20.00
wpsza4	5.3	25.00
wpszb4	5.3	25.00
wpsza5	6.4	30.00
wpszb5	6.4	30.00
wpsza6	8.5	40.00
wpszb6	8.5	40.00
wpsza7	8.5	40.00
wpszb7	8.5	40.00
wpsza8	6.4	30.00
wpszb8	6.4	30.00

Add/Del

Jump:

Minimum amp. of input offshore

Minimum depth of offshore (r

Dry land depth of inundation i

Friction coefficient (n**2)

Let A-Grid and B-Grid run up

Max eta before blow-up (m)

Time step (sec)

Total number of time steps in

Time steps between A-Grid c

Time steps between B-Grid c

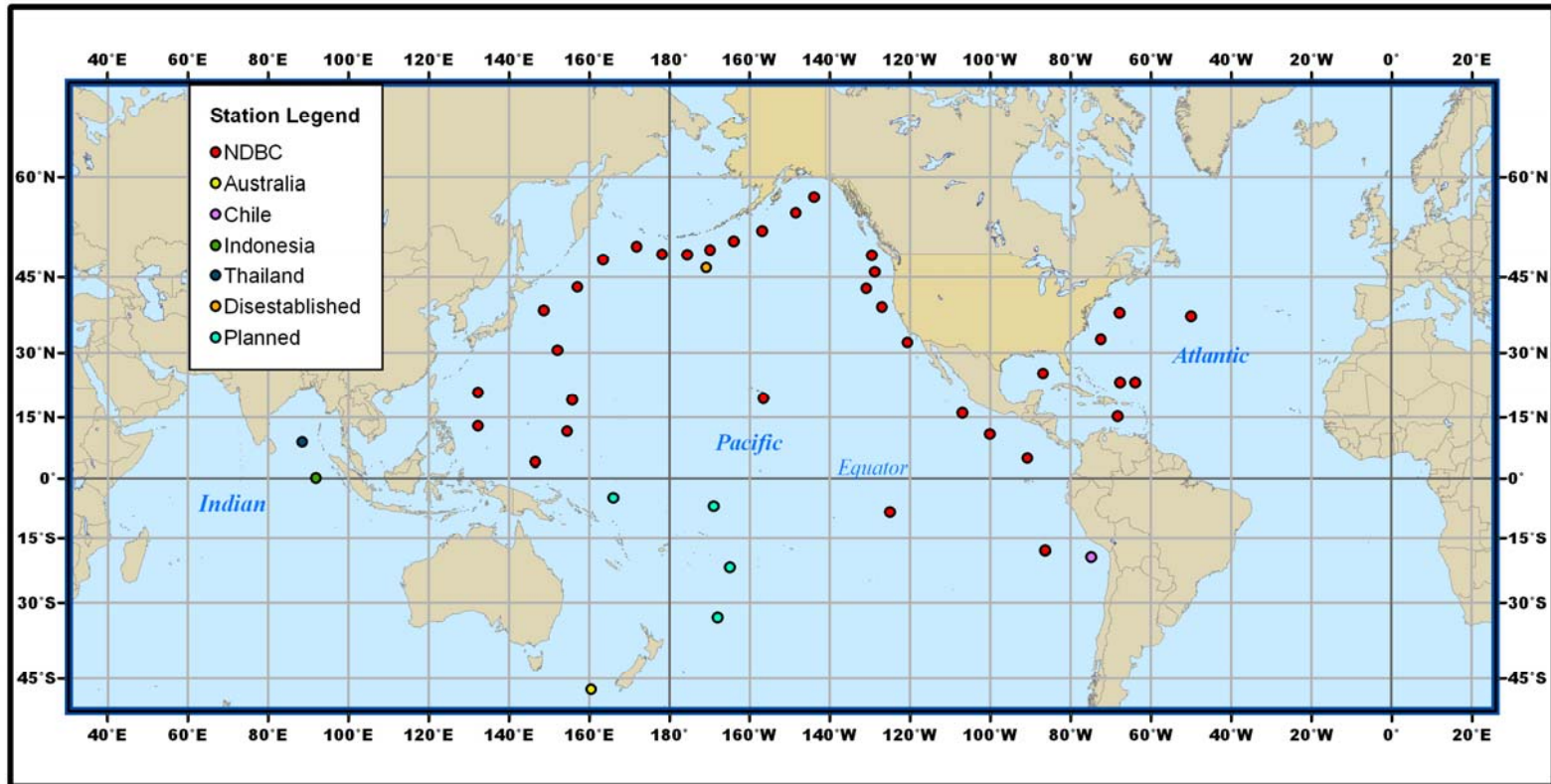
Time steps between output s

Time steps before saving fir

Save output every n-th grid pc



DART Stations



Mercator Projection
Central Meridian: 150 W
WGS 1984

DART and Tsunameter Stations

(As of November, 2007)



DART II

