Optimization of the Number and Location of Tsunami Stations for the Tsunami Warning in South China Sea

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Motivation

Is data sufficient?
Can we use less data?

How many buoys?
Where to locate?
Methodology

- Inversions of tsunami data using every possible combination of tsunami stations:
  - 2011 Tohoku event: 28 tsunami stations
  - 1 station: \( \binom{28}{1} = 28 \) possibilities
  - 2 stations: \( \binom{28}{2} = 378 \) possibilities
  - ....
  - 28 stations: use all stations

- Judging criteria: the inverse residue

\[
\sum_{n=1}^{28} \left( \frac{\text{Prediction} - \text{Data}}{\max(\text{Data})} \right)^2
\]
1 station: 28 possibilities
2 stations: 378 possibilities
3 stations: 3000 possibilities (upper bound)
4 stations: 3000 possibilities (upper bound)
Using 5 stations:

\[ \text{nchoosek}(28,5) = 98,280 \]
\[ \text{Resampled} = 3,000 \]
Results for 2011 Tohoku

Large residue drop for the first 2~4 stations.

Minor residue drop for the rest.

Residue increases due to 3000 maximum inversions – failure to capture the least residue

Large residue drop for the first 2~4 stations.

Almost zero residue drop for the rest.
1 Station, Near- or Far-Field?
2~4 buoys are sufficient for inversion of tsunami to constrain earthquake source if they are optimally located.

Some near-field stations with short and high-amplitude leading waves give bad predictions.
The Manila Trench
Results for the Manila Trench

F2

F3

Residue

Residue Reduced Adding +1 Stations

Number of Used Stations

Number of Used Stations
Results for the Manila Trench

Averaged Residue over Three Faults:

![Graph 1: Residue vs. Number of Used Stations](image1)

![Graph 2: Residue Reduced Adding +1 Stations vs. Number of Used Stations](image2)
Near- or Far-Field?

Example: F2
Station 123

Tsunami Patch: Mw = 8.88

Down Dip (km)

Depth from Seafloor (km)

122
Buoys of HX

Residue = 0.62

Min Residue = 0.45
HXs for F1
Best: 123, 116
Top 30 in video.

Trade-off:
Residue Distance.
Conclusions

- 2~4 buoys are sufficient for inversion of tsunami to constrain earthquake source if they are optimally located; adding more data does not significantly improve the results.

- Some near-field stations with short and high-amplitude leading waves tend to exaggerate model error, and thus give bad predictions.

- HX buoys have small residue in the inversions; the location can be further optimized.
Thank you!
Station 130, F2

Tsunami Patch: Mw = 8.83

Down Dip (km)

Depth from Seafloor (km)

122
HXs for F2
HXs for F3