Recent Tsunami Research in Japan

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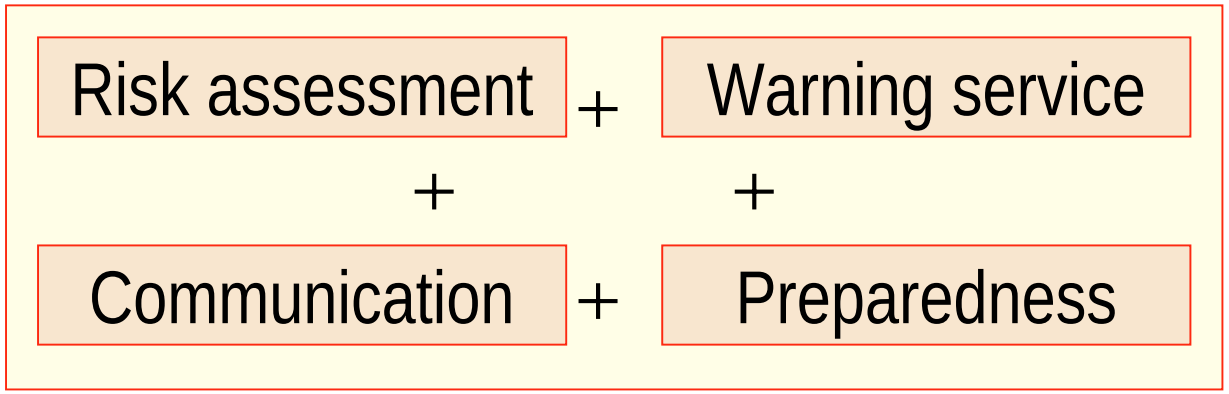
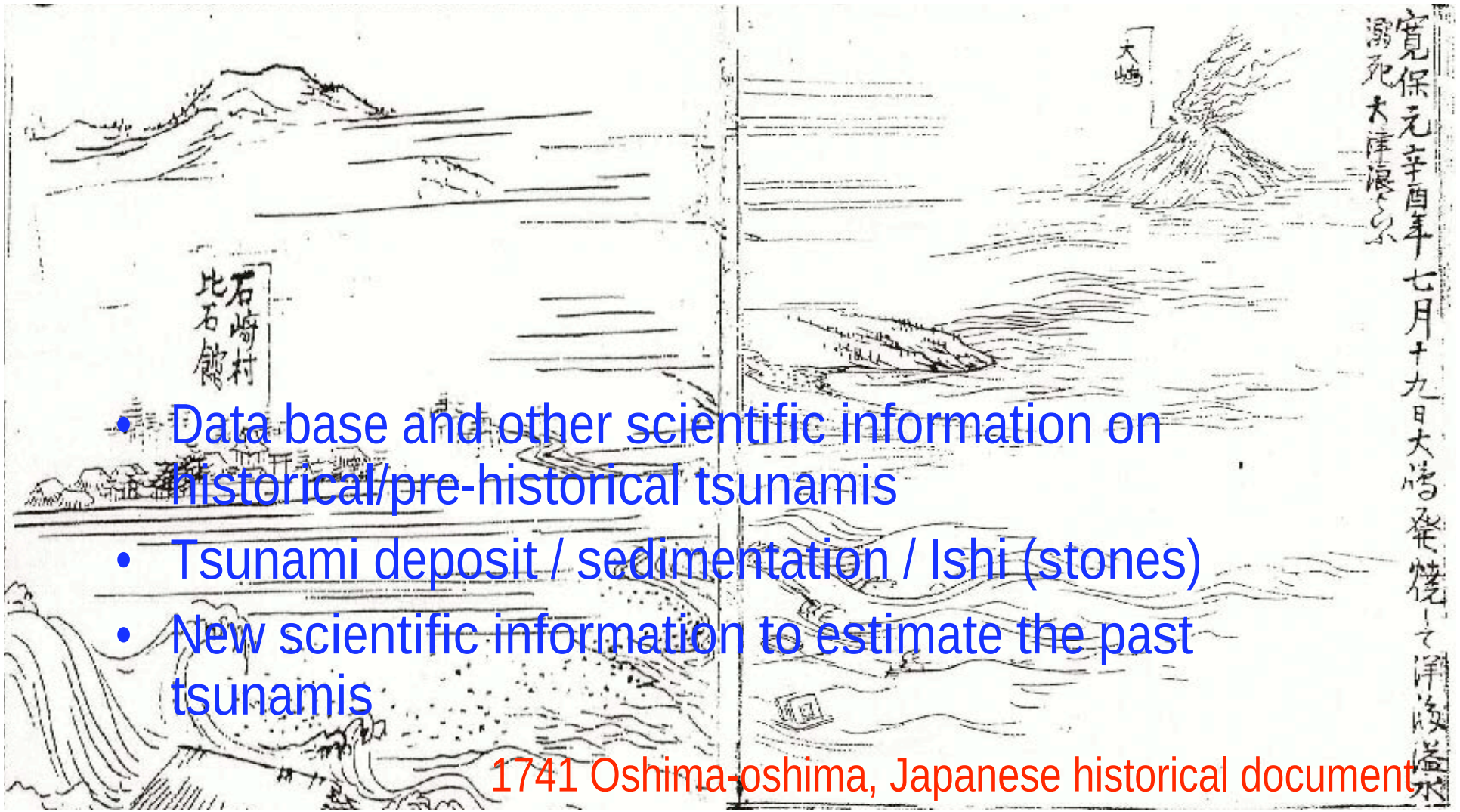
- Hazard and risk evaluation and assessment
- Primary and secondary tsunami damage, direct and in-direct damage
- Making Tsunami Inundation Mapping through community based WS
- Studying on Human response and bias for the tsunami alert/warning
- Examining Reliability in Historical and more science information
- Quantitative tsunami forecast by JMA - issuing and canceling
- Lessons from the 2006 Kuril earthquake tsunami

The Four Components of People-centred EW Systems (ISDR,2005)



- Without risk assessment to estimate the past events, the EW fails.
- In 2004 Indian ocean tsunami and Hurricane Katrina, the risk knowledge also failed to effectively penetrate public and policymaker consciousness
- Risk assessment with the historical/pre-historical tsunami data is required. We have problem of the lack of the data/limited one.

Evaluation of pre-historical tsunamis :Knowing historical and pre-historical tsunamis



- Data base and other scientific information on historical/pre-historical tsunamis
- Tsunami deposit / sedimentation / Ishi (stones)
- New scientific information to estimate the past tsunamis

1741 Oshima-oshima, Japanese historical document

Historical tsunamis in documents

Japanese documents

■Data base on earth/tsunami with Documents/oral tradition BC 2000 - present

- ✓Only date; M and tsunami heights and human loss
- ✓Limitation of area recorded, less tsunami behaviors

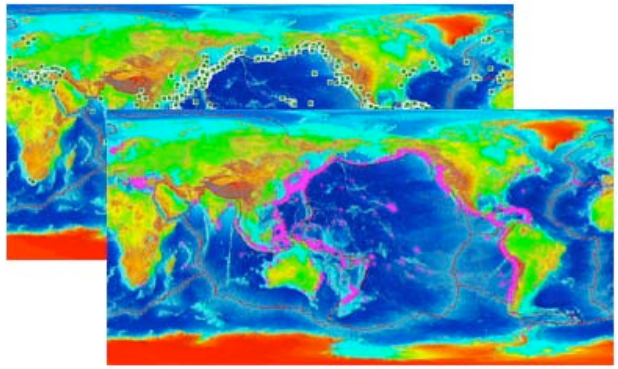
■Scientific data with source mechanism of faults AD1900 -present

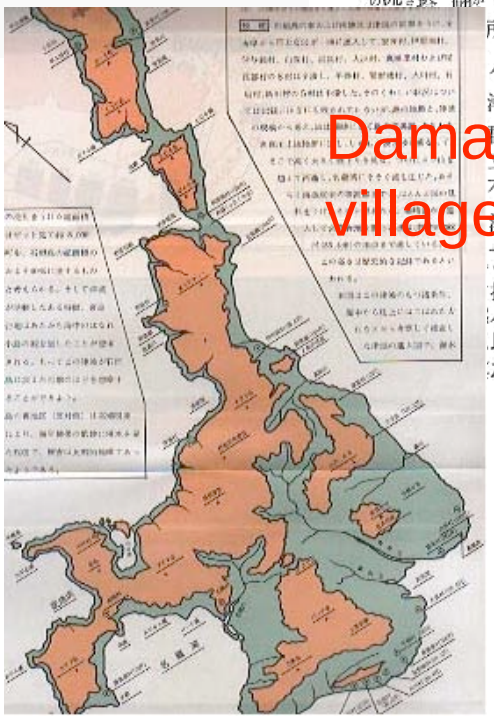
■Lack of information on the tsunami magnitude and impact on the coast

National Geophysical Data Center (NGDC)
NOAA Satellite and Information Service

The NGDC Tsunami Database contains information on tsunami events from 2000 B.C. to the present in the Atlantic, Indian, and Pacific Oceans; and the Mediterranean and Caribbean Seas.

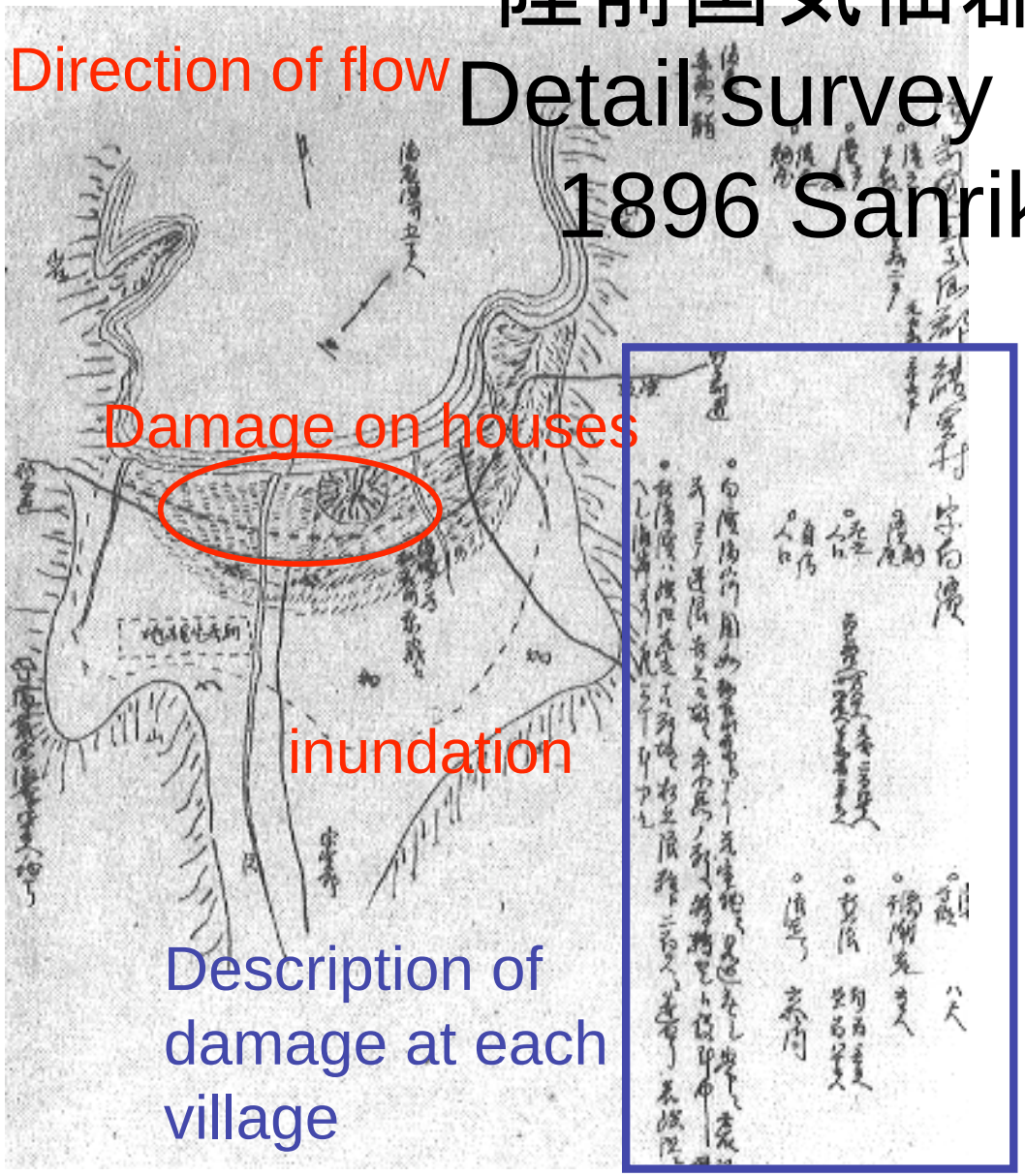
http://www.ngdc.noaa.gov/seg/hazard/tsu.shtml



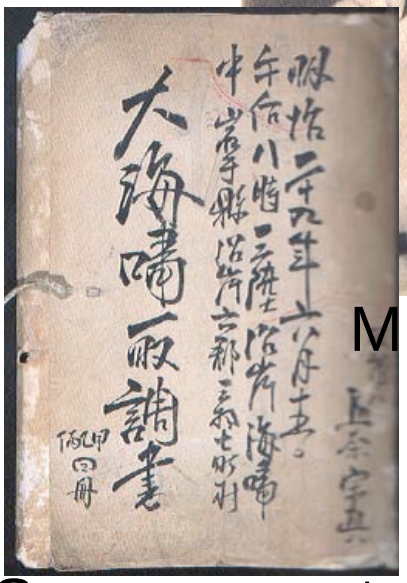


Estimated inundation area, Okinawa, Japan

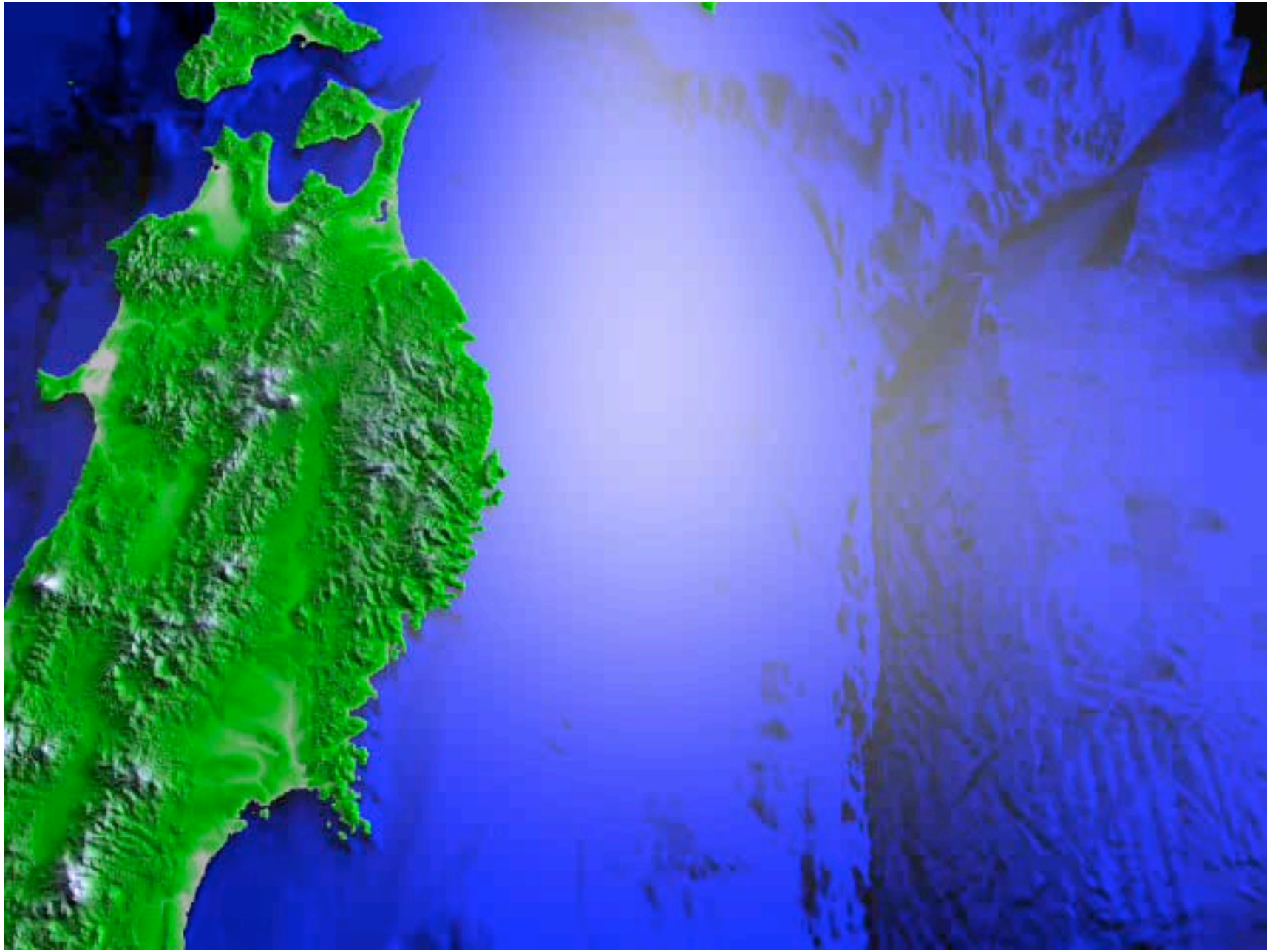
陸前国気仙郡綾里村白浜
Detail survey map attached 1896 Sanriku tsunami



Mr.Yamana



Survey report



Inundation and runup heights

Inundation depth

Human: killed >> 50cm

House: slightly damaged >> 1.0m

partially damaged >> 2-3.0m

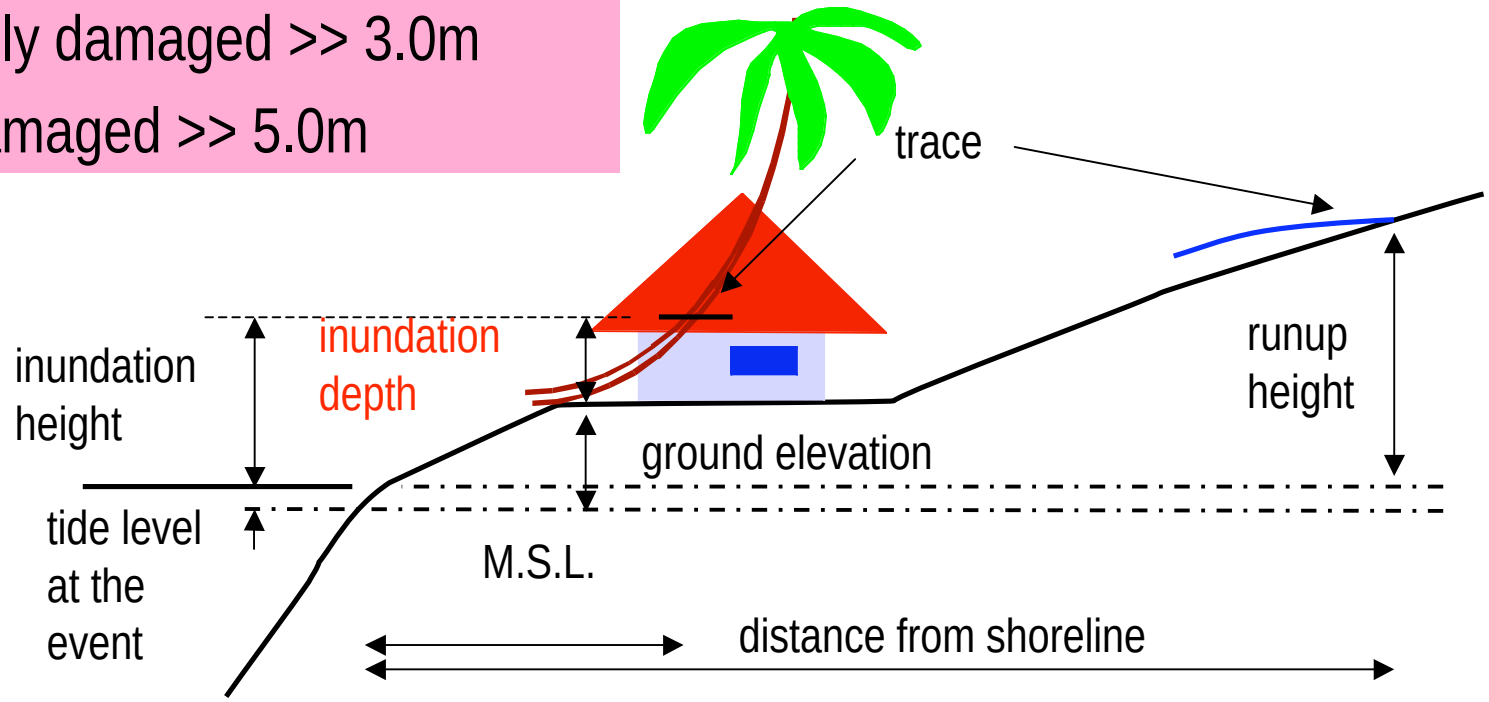
totally damaged >> 3.0m

Building: damaged >> 5.0m

Tsunami height (=runup)

⇒ (ground elevation at the village)

+(Inundation height))

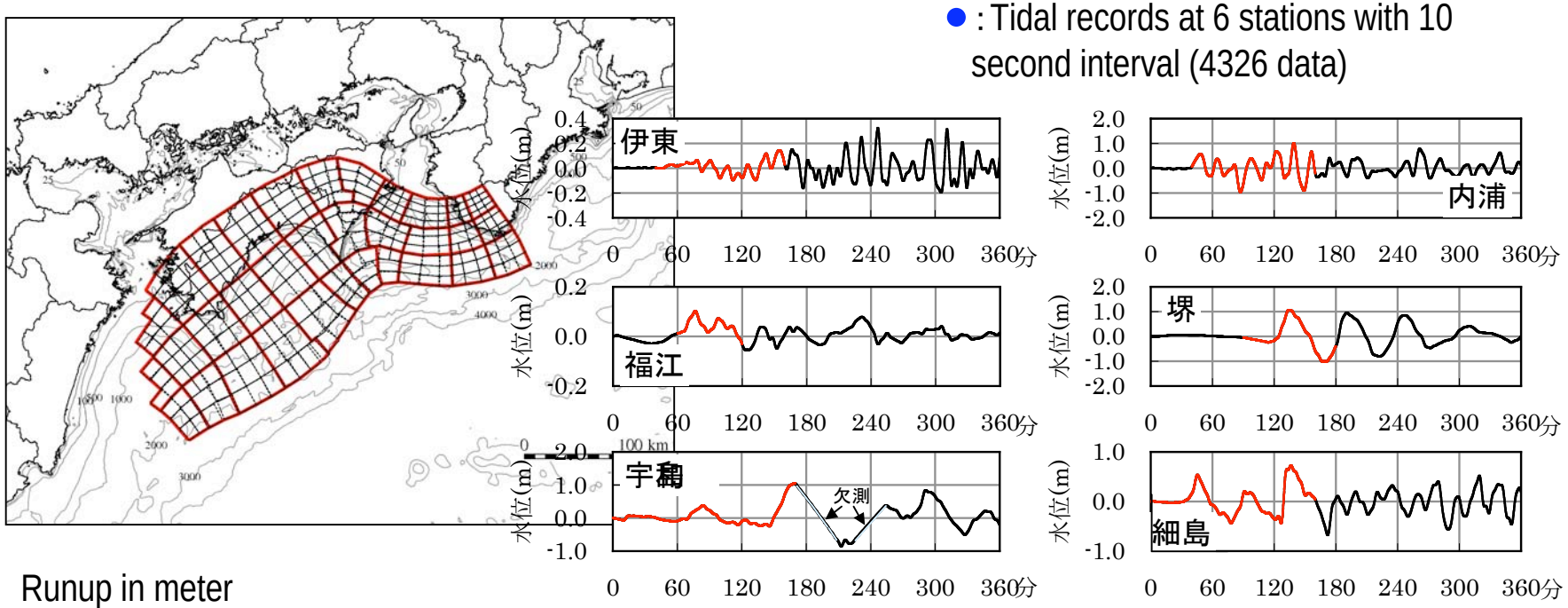


Check the reliability of historical data by comparison with numerical model

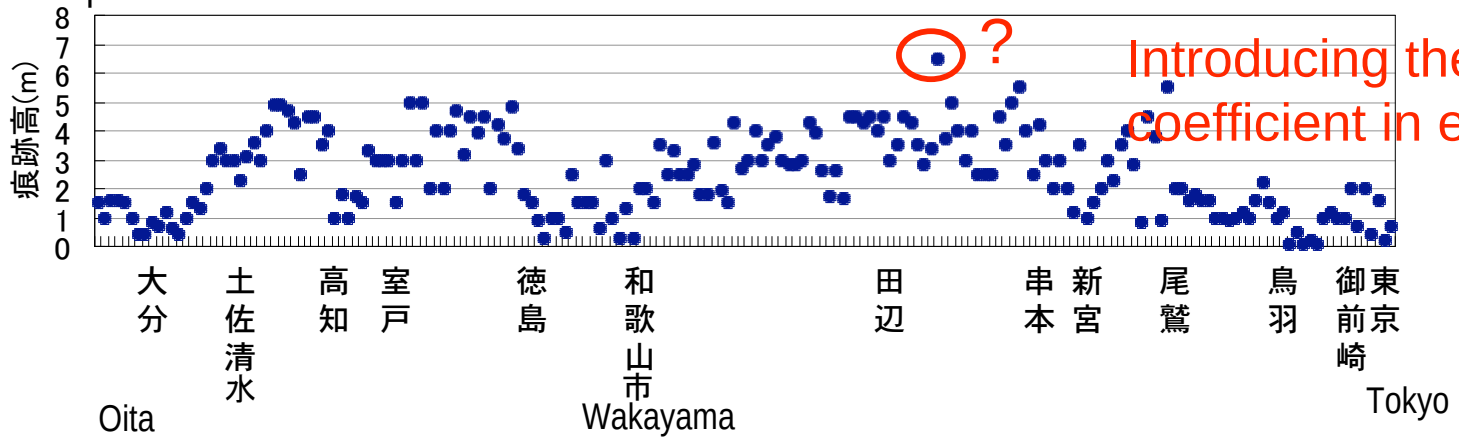
Runup and tidal records used for tsunami inversion

● : Runup data at 192 points

● : Tidal records at 6 stations with 10 second interval (4326 data)



Runup in meter



Introducing the weight coefficient in error function

Let people not forget the memory
-example of picture 1896 Sanriku tsunami

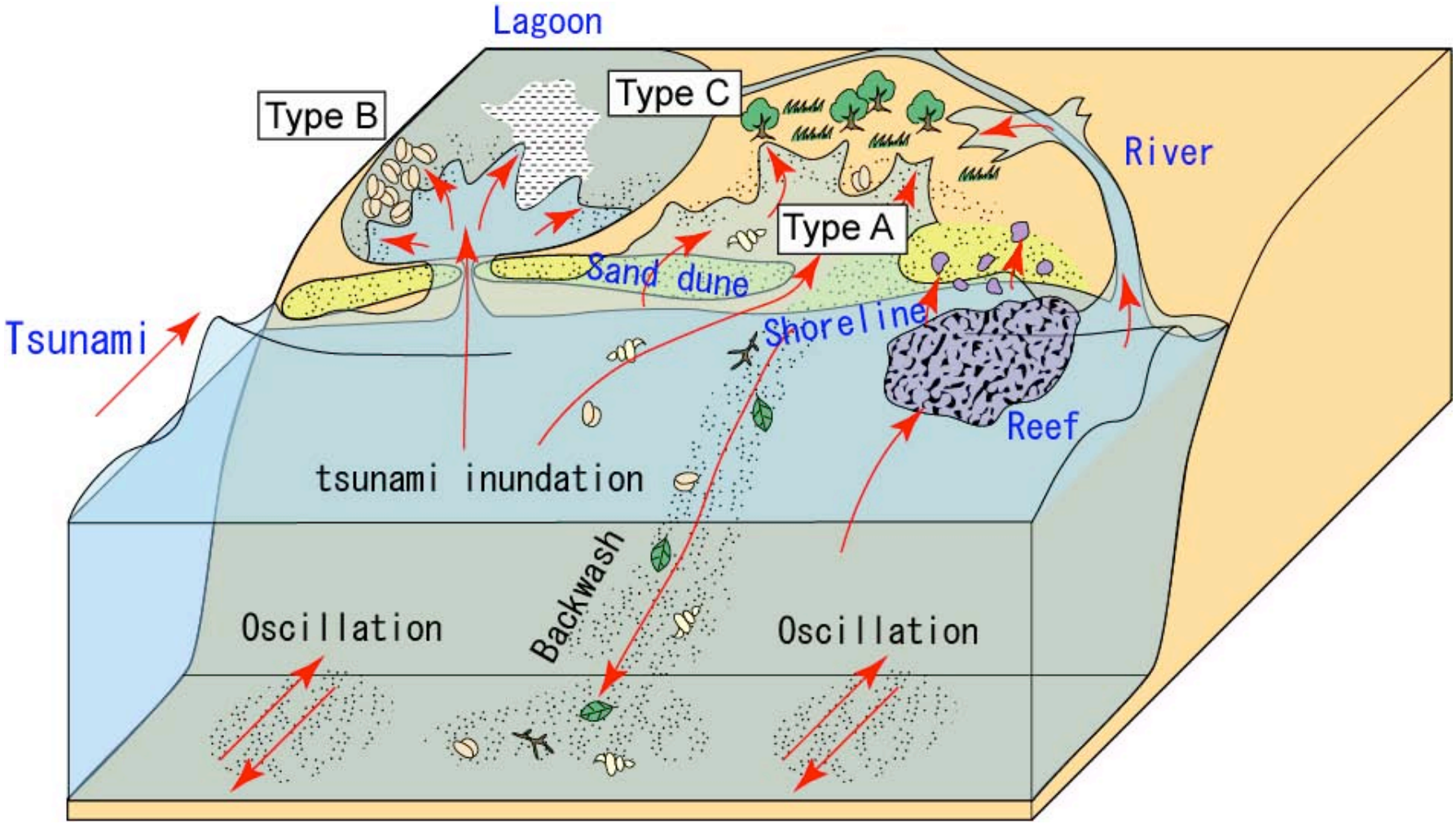
Evidences of tsunamis

- Traces/marks on the land/house/trees have disappeared for many years
- However, there are some evidences remaining for long time and containing scientific information
  - Sand Sedimentation due to tsunamis resulting tsunami layers
  - Coral rocks moved by tsunamis

Tsunami Sedimentation

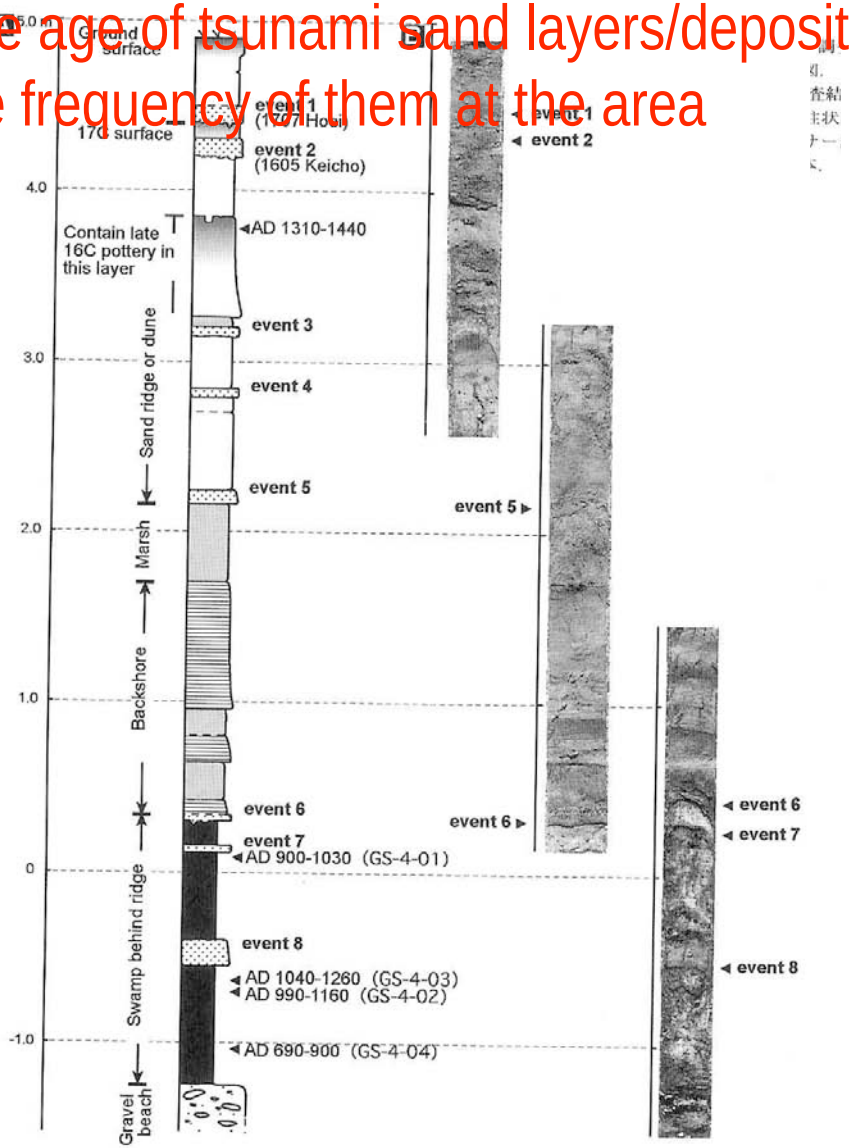
(Modified after Minoura and Nakaya, 1991)

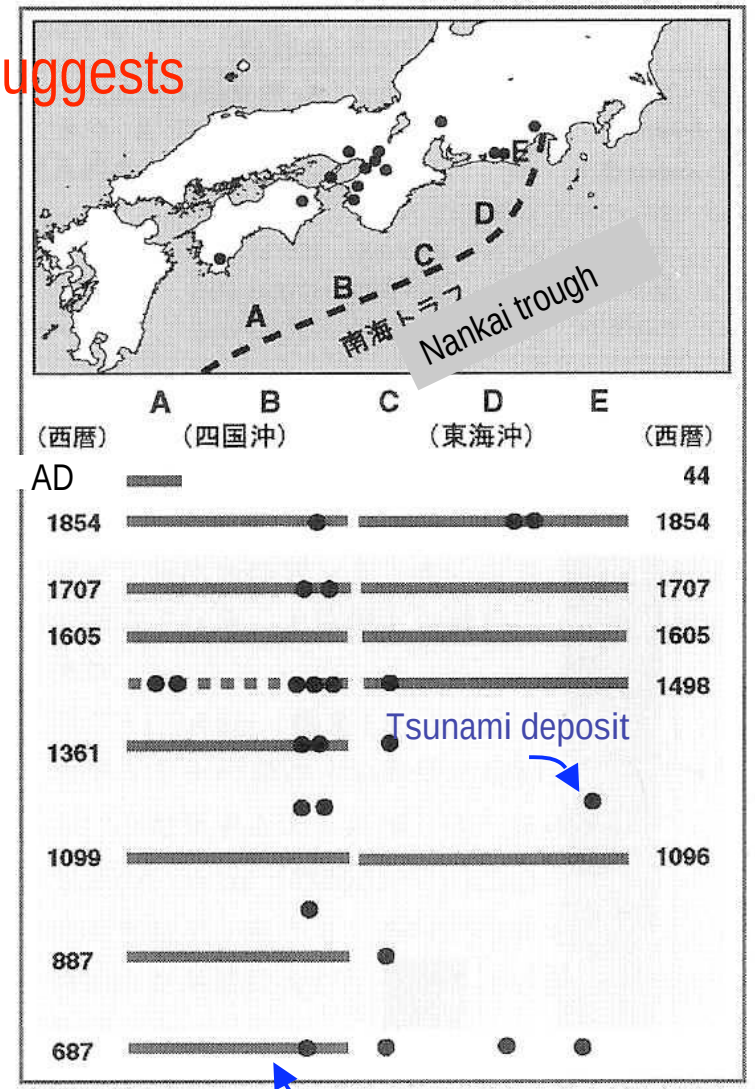
1983 Japan sea tsunami



The case of Tokai/Tonankai in Japan

The age of tsunami sand layers/deposit suggests the frequency of them at the area



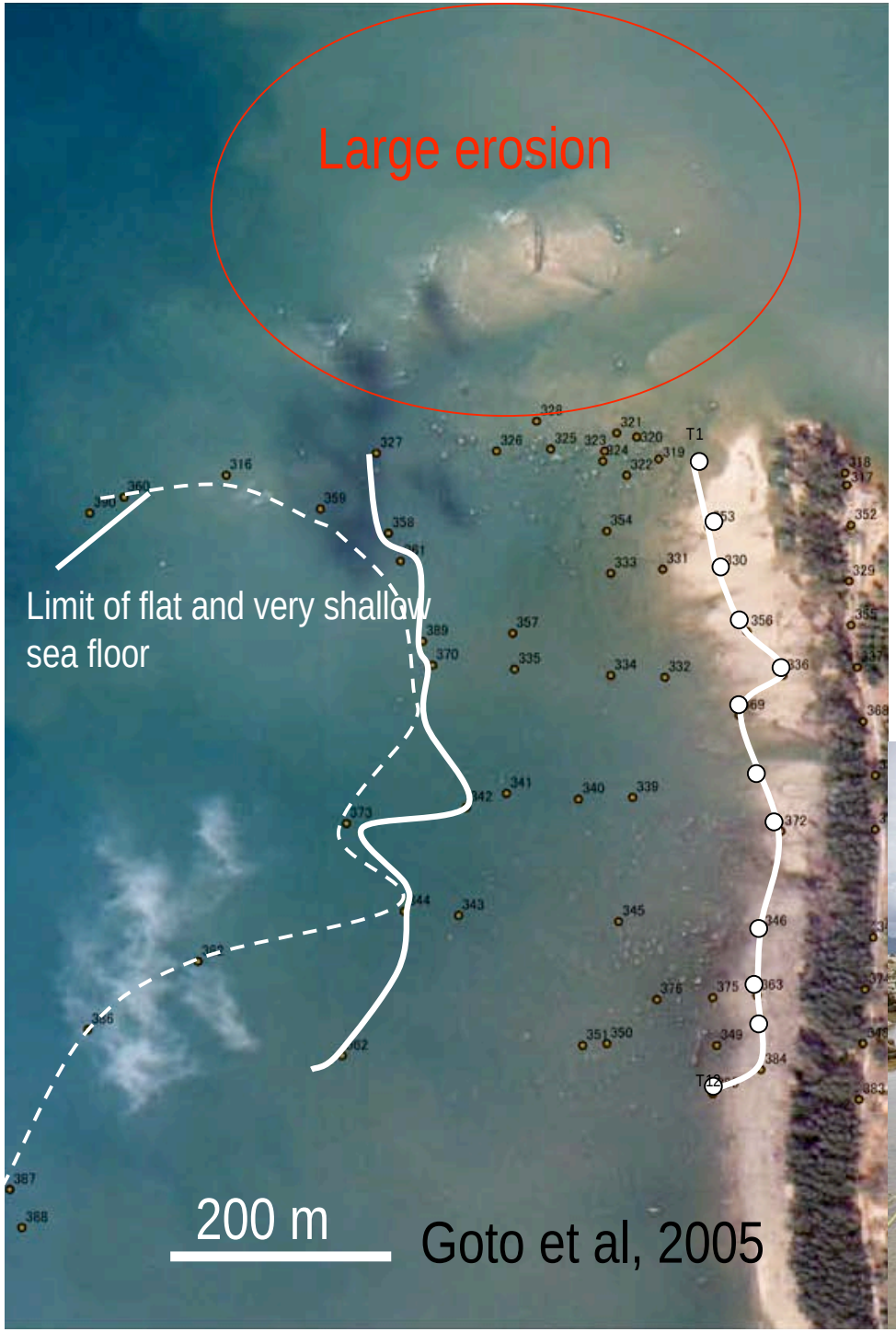


AD

図5 南海トラフ沿いの歴史地震（寒川, 2001による）.
年代測定の結果から，灰色で
されたイベント堆積物に対応

Modified after Takada et al. (2002)

2004 Indian ocean tsunami Impact on the coastal environment



- Large change of topography
- Coral rocks removed, tsunami ishi
- Damage on mangrove

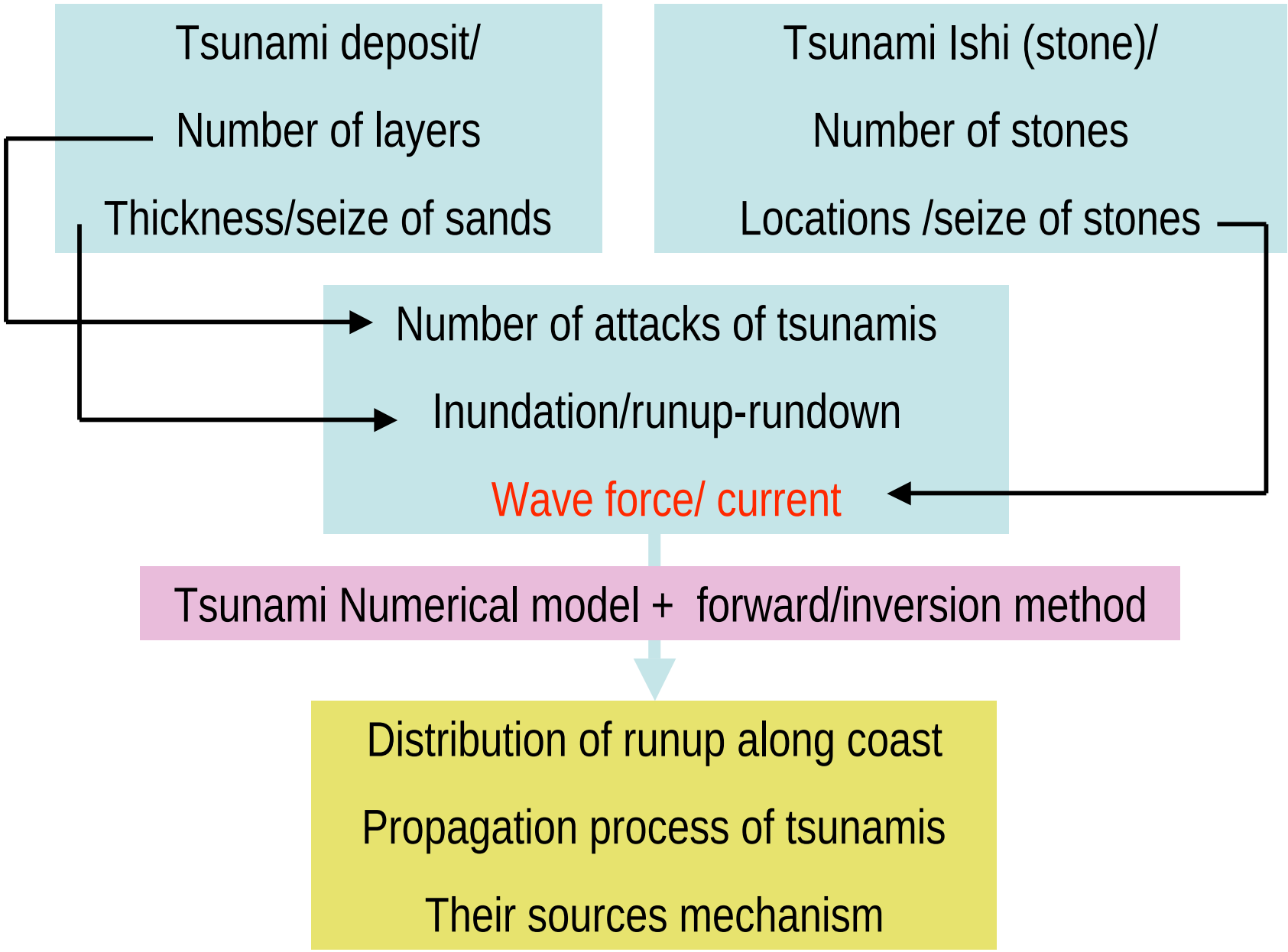
Tsunami boulders transported by the 2004 Indian Ocean tsunami at Khao Lak, Thailand

Goto et al., (in press)

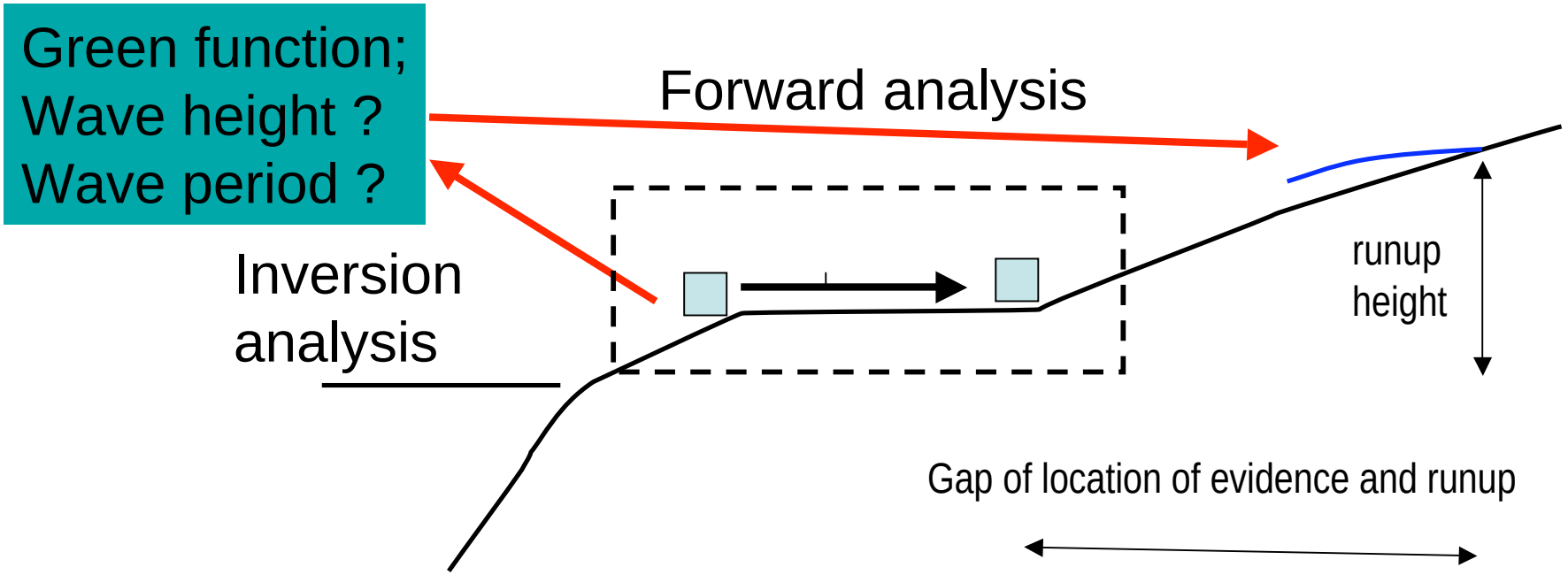
Tetra-pot transported by the tsunamis at Akita coast (1983 Nihonkai-Chubu Earthquake and tsunami)

The position, size and weight of brocks suggest us the information the process of runup with wave force and hydraulics

Photo provided by K. Minoura

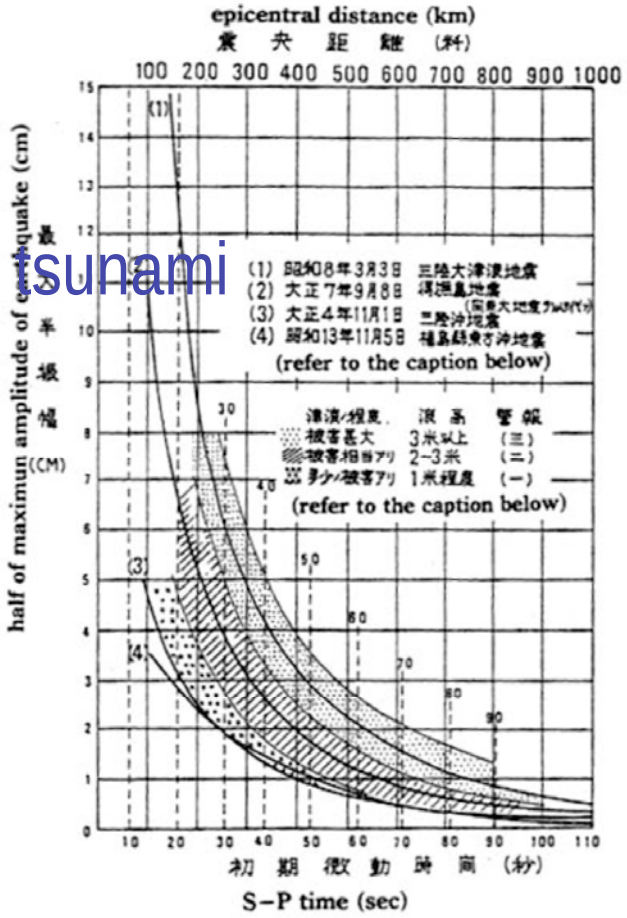

Tsunami deposit/
Number of layers
Thickness/seize of sands
Tsunami Ishi (stone)/
Number of stones
Locations /seize of stones
Number of attacks of tsunamis
Inundation/runup-rundown
Wave force/ current
Tsunami Numerical model + forward/inversion method
Distribution of runup along coast
Propagation process of tsunamis
Their sources mechanism

Estimation of runup from the evidence



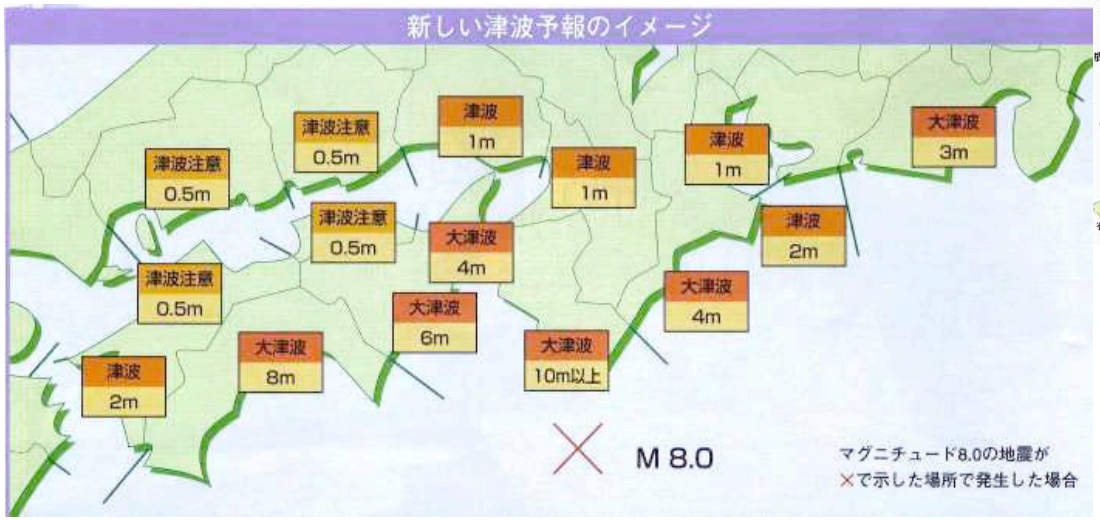
Tsunami Forecasting for near and far- field tsunamis

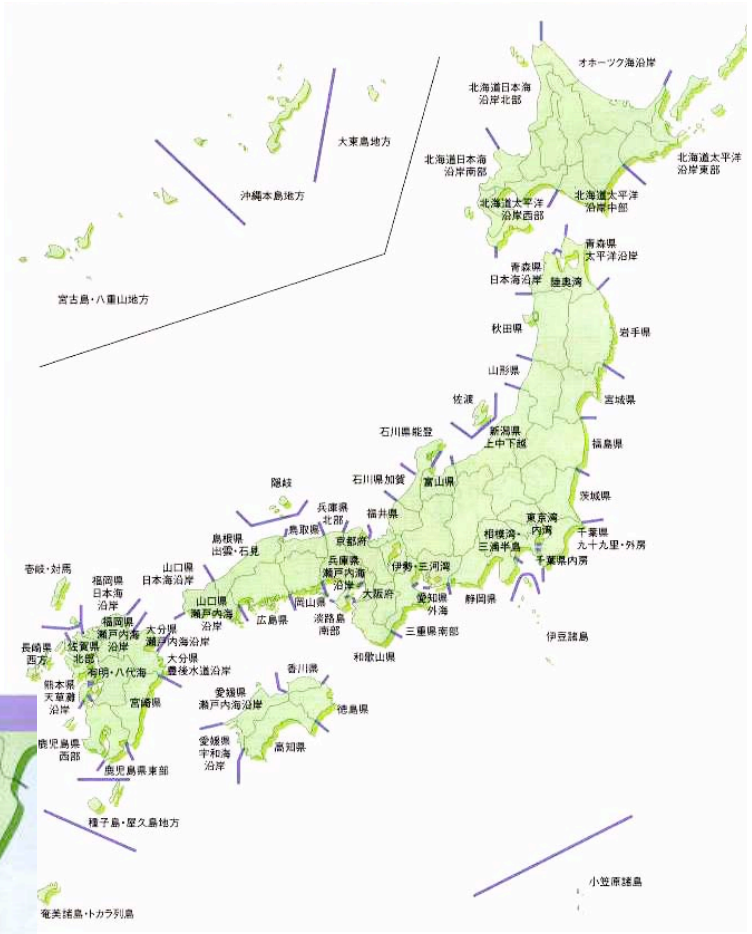
- Tsunami source << 600km
- Started in 1952 for near- field
- Started in 1965 after the 1960 Chilean tsunami
- 1952-1970 ： 22min+10.7,　2.2/year
- 1971-1983 ： 16 min+6.7
- 1983 Akita-oki 14min
- 1993 Okushiri　5 min,　　5 /year
- Now << 3 min.



A new tsunami warning system started in 1999

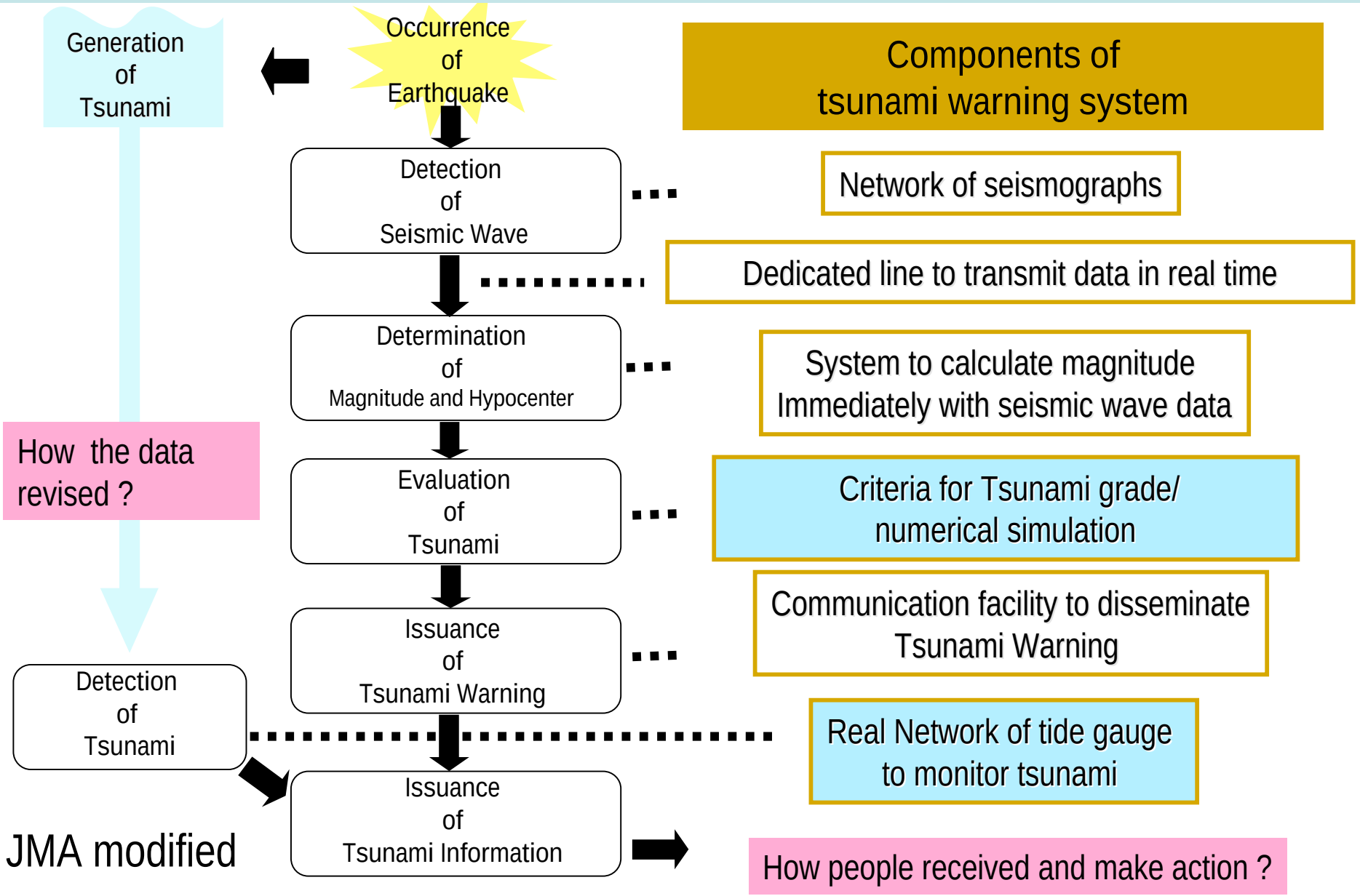
quantitative





detail
From 18 to 66 regions

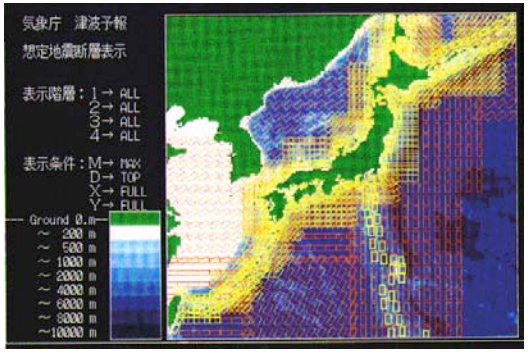
What we need for Tsunami Warning ; Issuing after generation



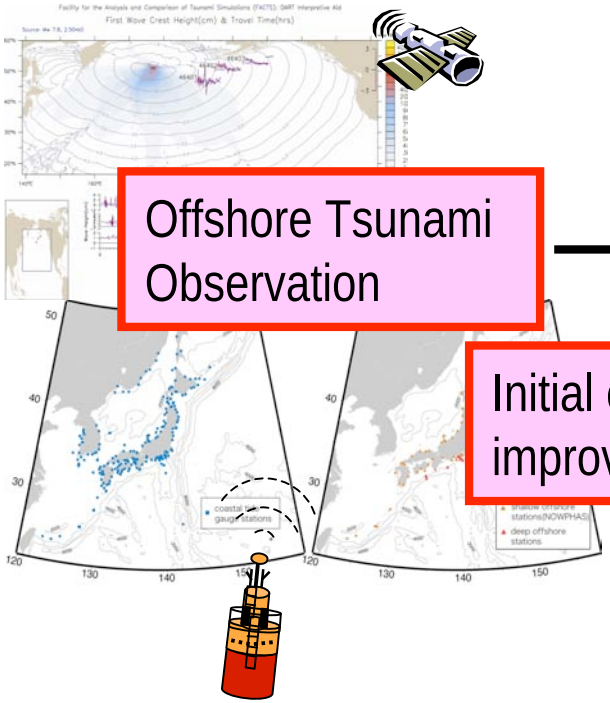
Existing Tsunami Forecast Scheme

Seismological Observation (Location,M)

Tsunami Waveform Data Base

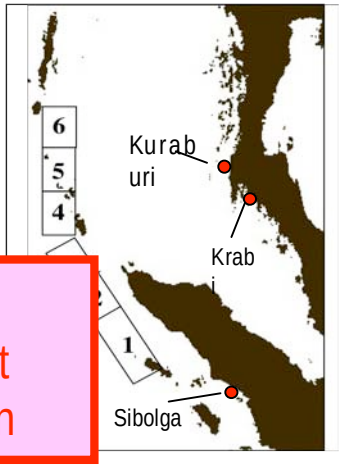


Initial estimate



Offshore Tsunami Observation

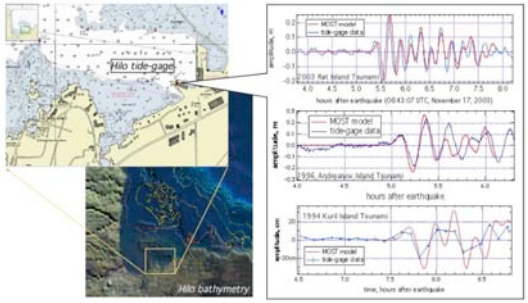
Data Assimilation



Initial estimate is improved

Adjustment of source location (X) & fault dislocation (D) by inversion

Improved Prediction of Tsunami Amplitude & Travel Times



Hirata(2005) modified

Kuril Island

Yamanaka(2006)

M=7.9

Strike　２２５

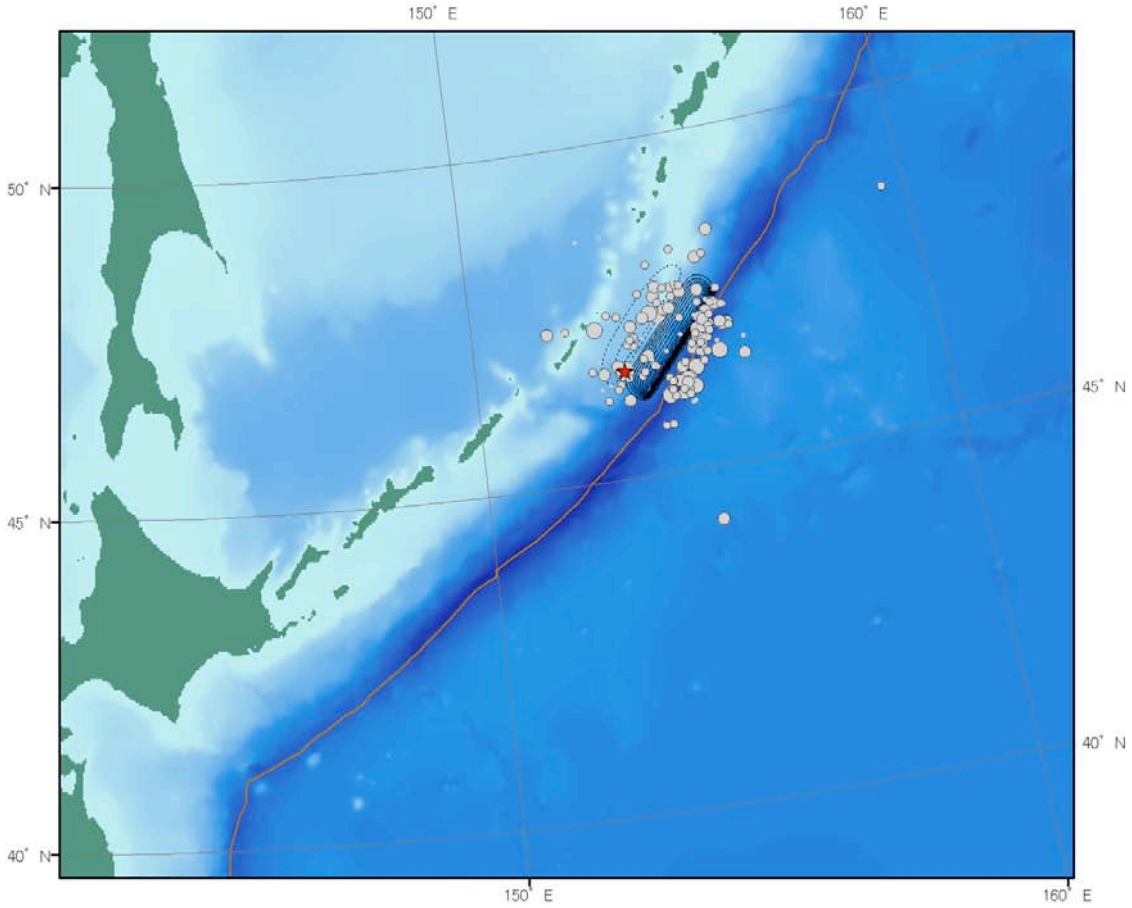
Dip　３０

Slip ９４

Depth ３０ｋｍ

Area ２００ｋｍ×５０ｋｍ

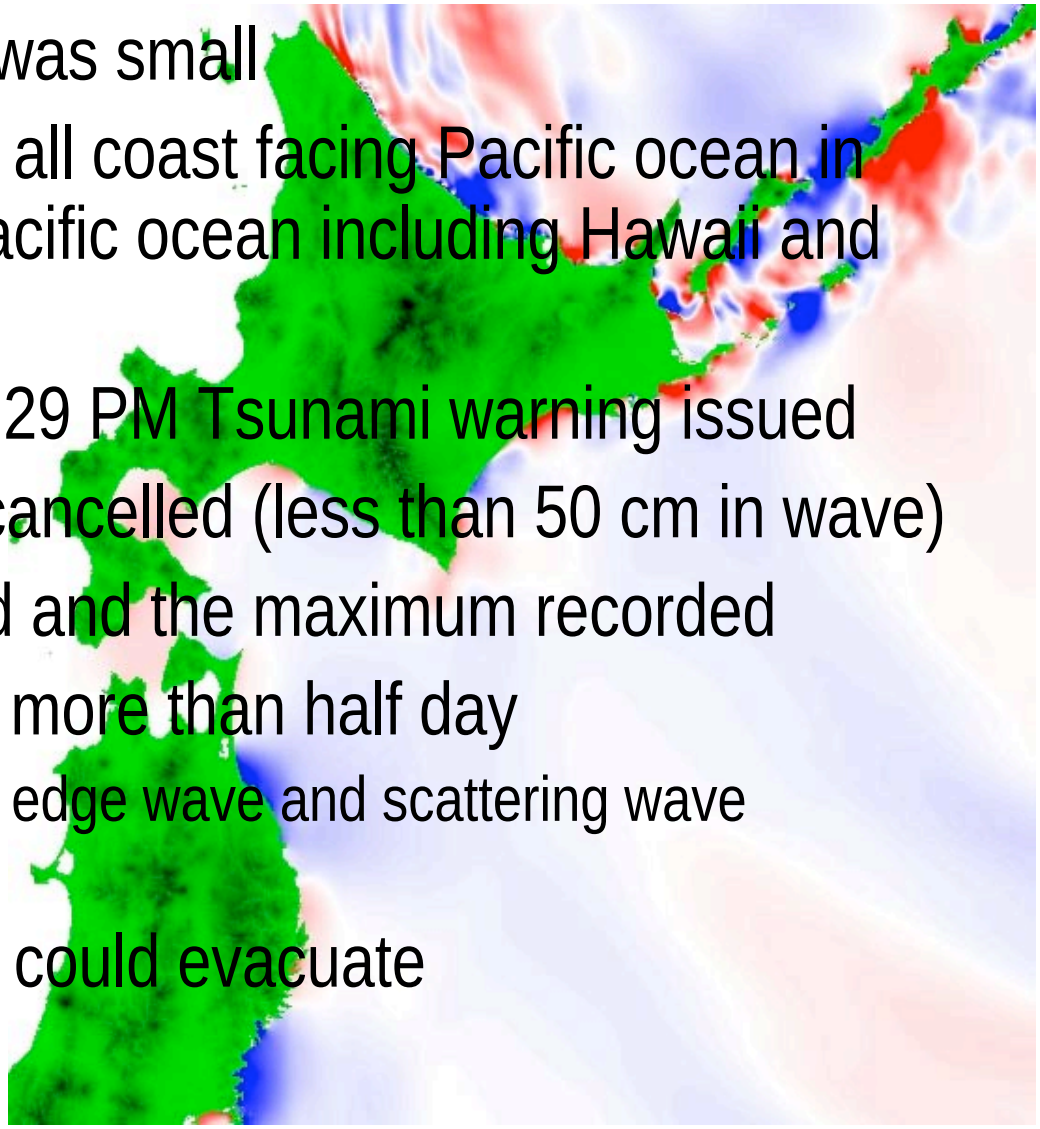
Dislocation　９．４ｍ



New problems in the 2006 Kuril

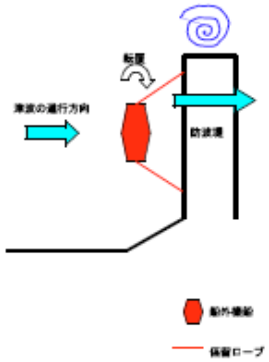
Topics

- Ground-quake in Japan was small
- The tsunami propagated all coast facing Pacific ocean in Japan and toward the Pacific ocean including Hawaii and west coast
- 20:15 PM happened, 20:29 PM Tsunami warning issued
- 23:31 PM and 1:30 AM cancelled (less than 50 cm in wave)
- 5-6 AM damage reported and the maximum recorded
- The tsunami effected for more than half day
  - Direct propagation wave, edge wave and scattering wave combined
- Only 10 % of residences could evacuate

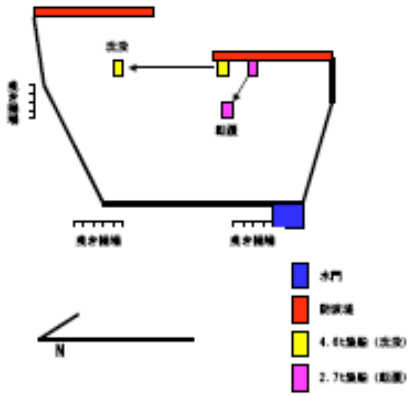


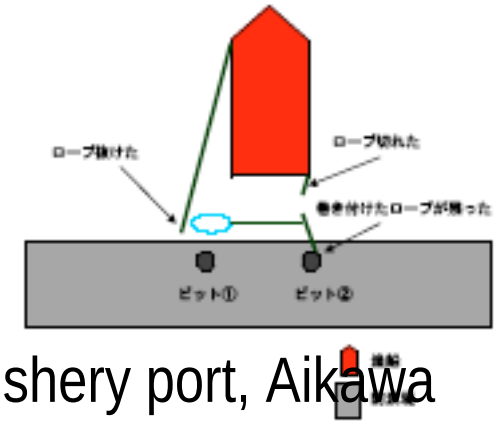
Three boats damaged by the tsunami 7 or 8 hours after

11/16朝方に，被害を発見
気仙沼市の只越漁港で3隻、
石巻市の相川漁港で1隻、
旧歌津町の港漁港で1隻の漁船が転覆

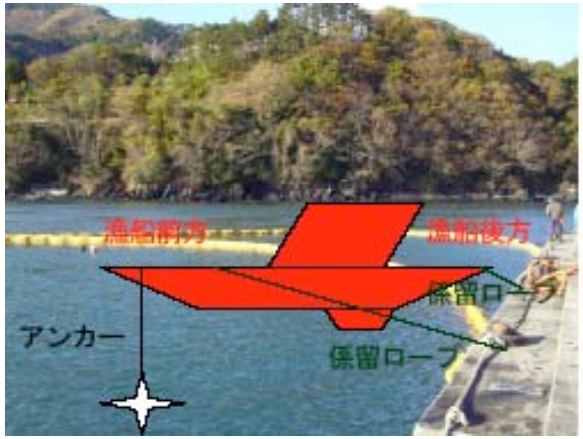


Fishery port, Tadakoshi





Fishery port, Aikawa



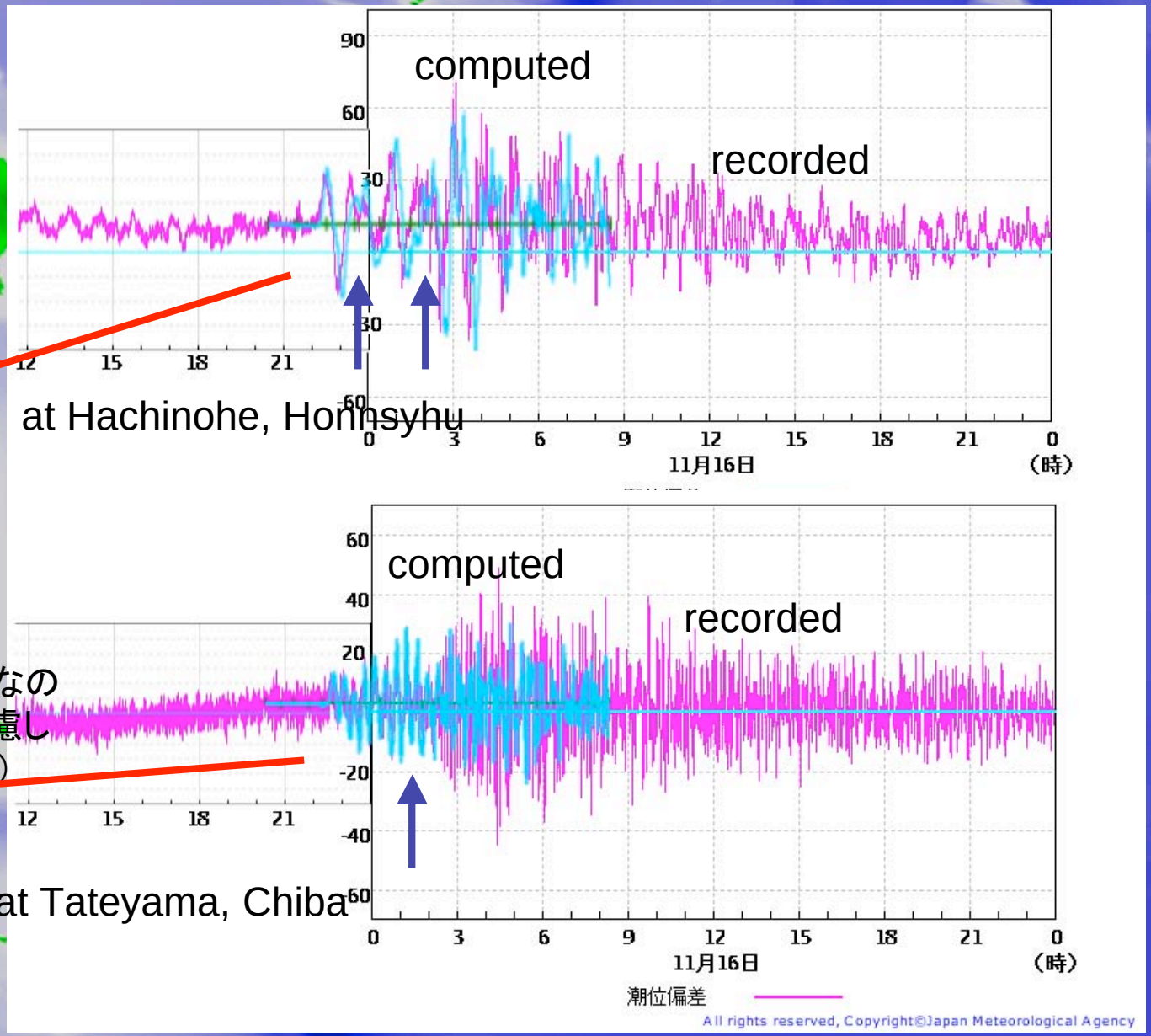
検潮記録にシミュレーション結果を重ね合わせてみました

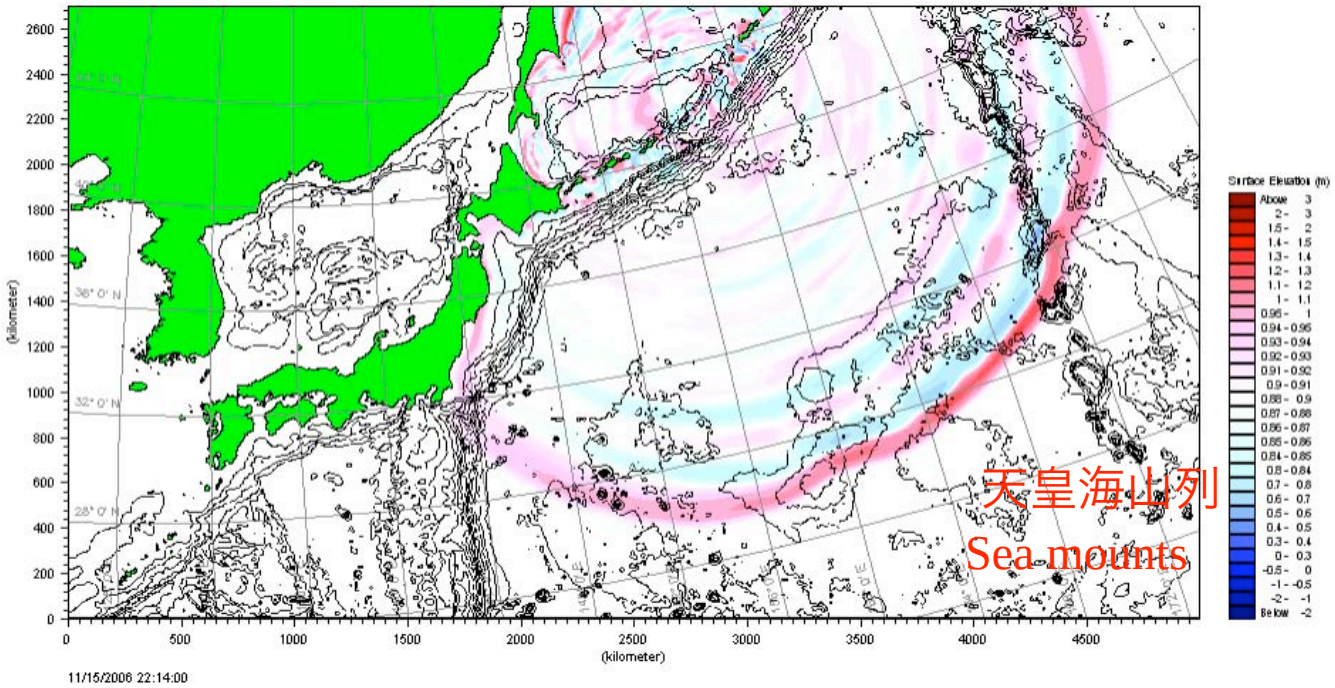
八戸

比較的よく一致

館山

後半の成分が過小評価なのは天皇海山の反射を考慮していないため？（要確認）

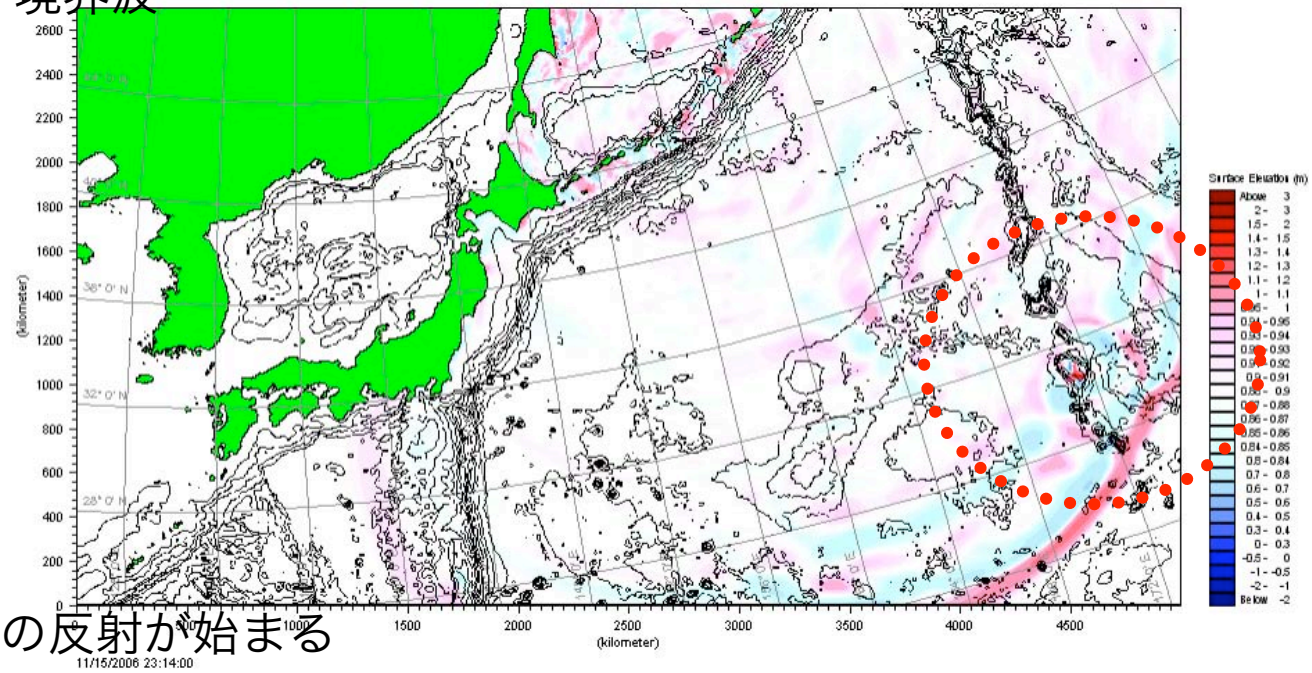




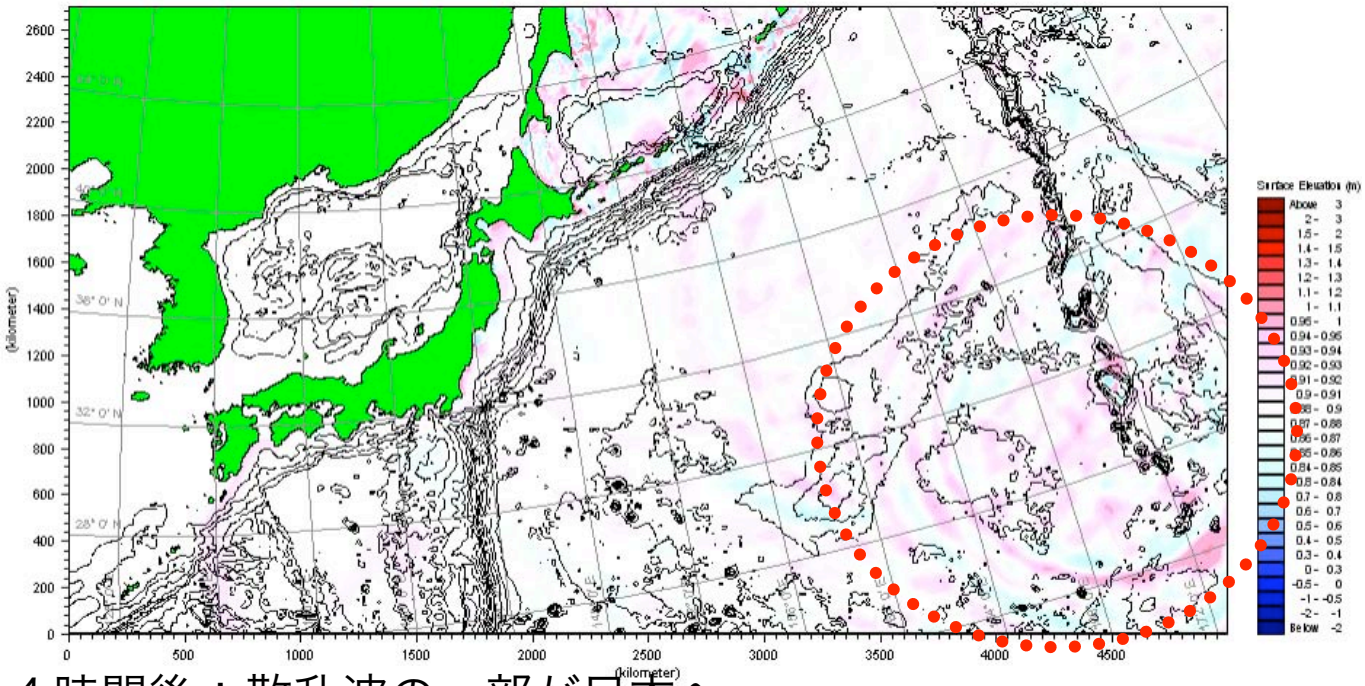
2.5時間後：直接波、境界波

Tsunami analysis

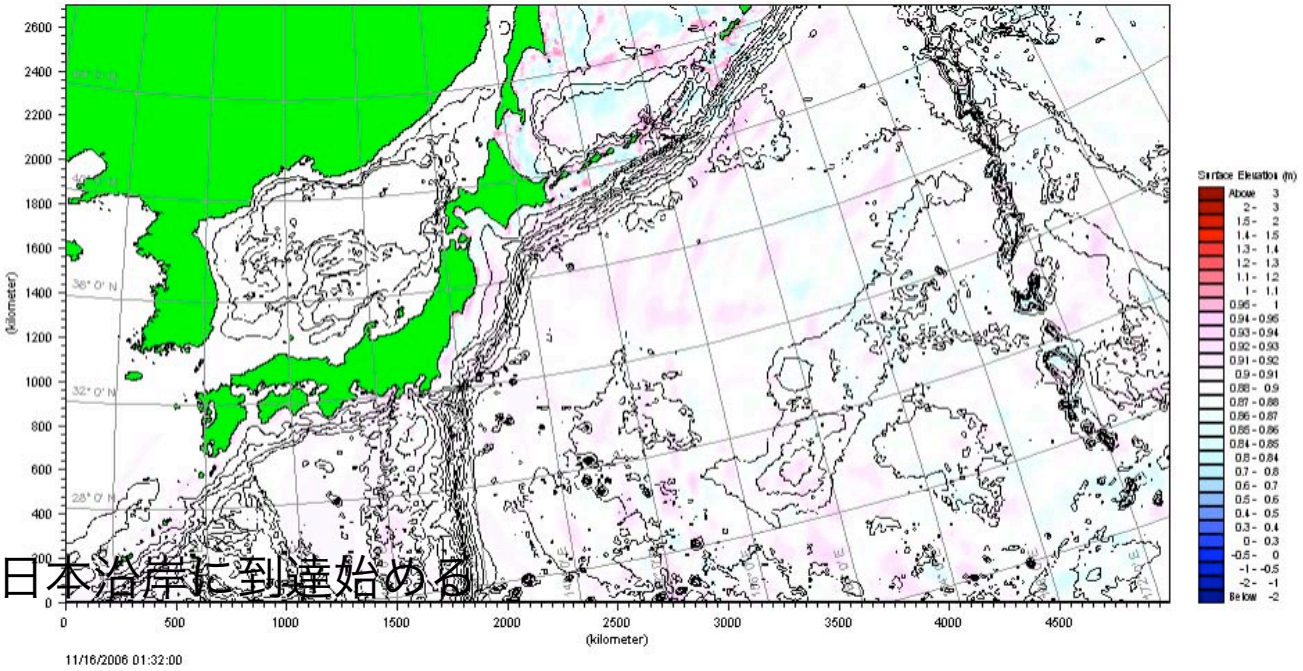
- linear long wave
- dx=1.35km
- 8 hours



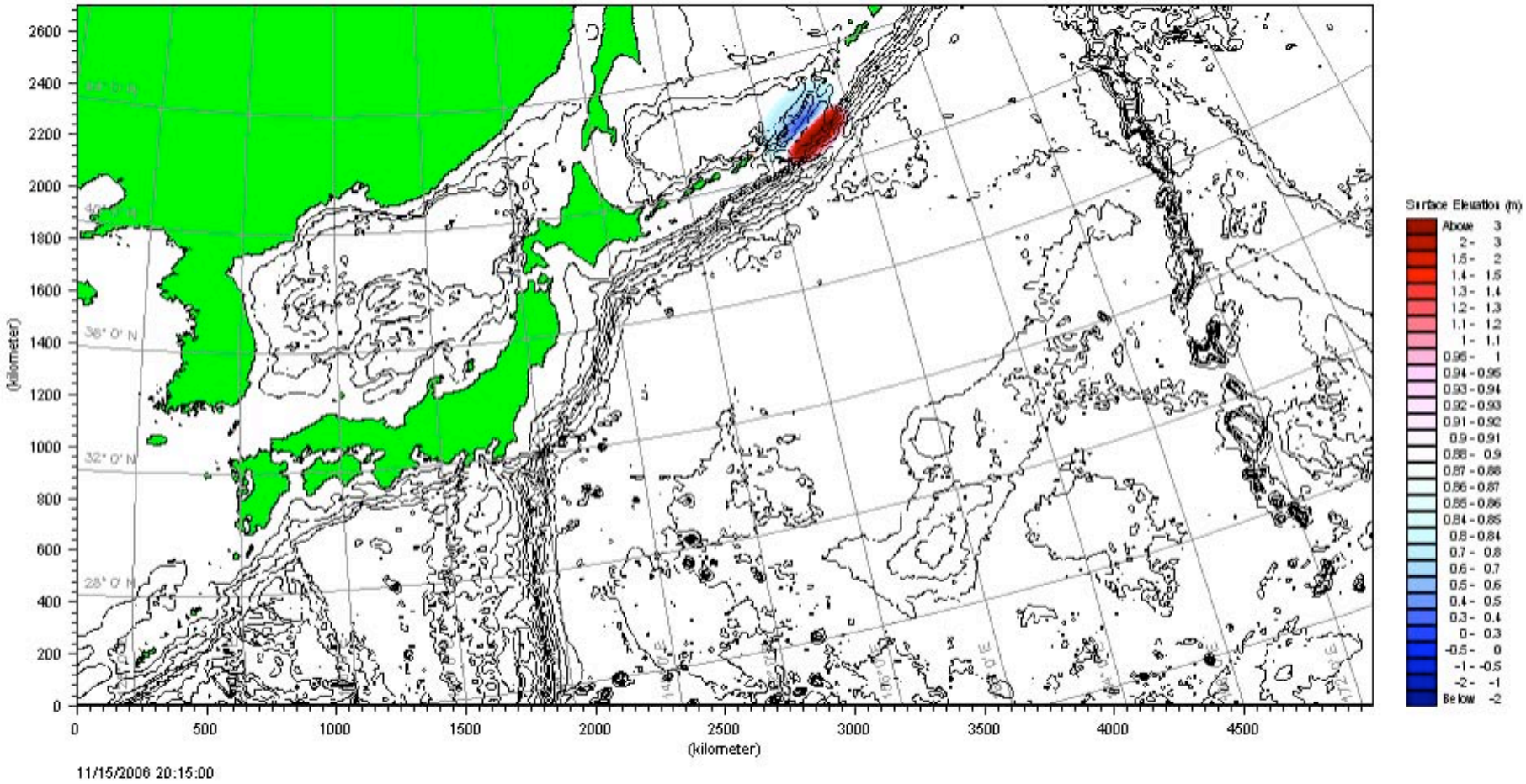
３時間後：海山列での反射が始まる



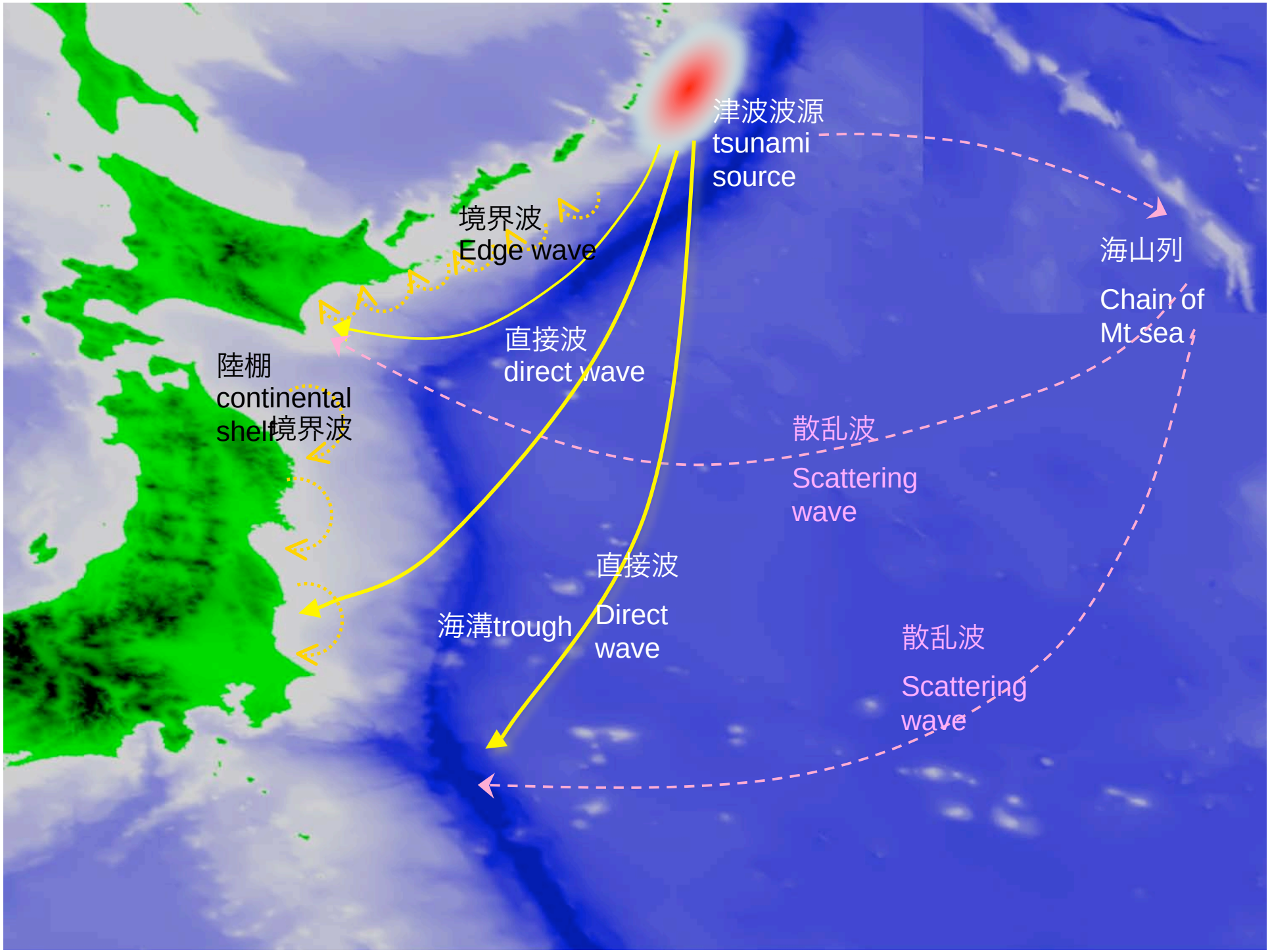
４時間後：散乱波の一部が日本へ



５－６時間後：散乱波が日本沿岸に到達始める



CG; DCRC, Tohoku Univ. and Alfa consultant


津波波源
tsunami
source
境界波
Edge wave
直接波
direct wave
陸棚
continental
shelf境界波
海山列
Chain of
Mt.sea
散乱波
Scattering
wave
直接波
Direct
wave
海溝trough
散乱波
Scattering
wave

Topics

- What is criteria to cancel a warning for residence and people in sea ?
- Only 5 % residences could evacuate. How can we ensure them make action for tsunami evacuation.