

Damage due to the Tsunami of 2011 Tohoku Earthquake and Roles of IRIDeS, Tohoku University

5 October 2012

Seminar on Disaster Research in the UK and
Collaboration with Japan

Tohoku University, Sendai, Japan

Fumihiko Imamura, Prof. Tsunami Eng,
IRIDeS, Tohoku Univ.

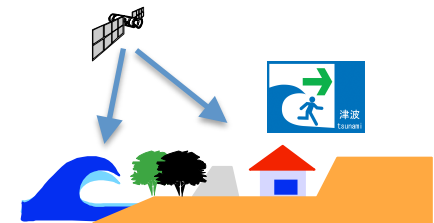
- Historical earthquake and tsunami hazard/disaster
- Earthquake and tsunami recorded in Tohoku Area
- Tsunami damage due to the 2011 Tohoku Earthquake
- Toward reconstruction and future implication
- Role of IRIDeS

F.Imamura, DRRCR



Past Activity of earthquakes and tsunamis in Tohoku

Why we fail to estimate/predict the 2011 Eq and tsunami ?



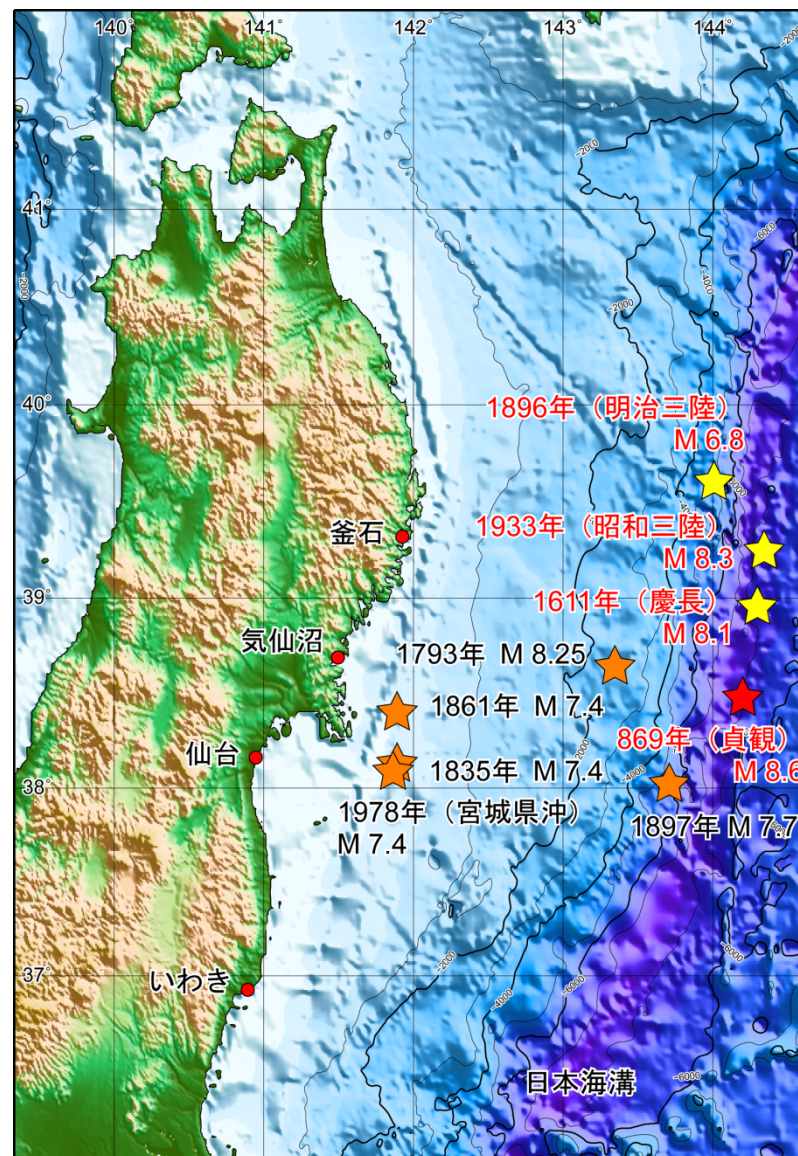
Historical Tsunamis recorded in Tohoku

- Tsunamis struck mainly Sanriku coast
- Fewer records in Miyagi and Fukushima coast
- Large Tsunamis occurred by events closer to the Japan Trench
- Small Tsunamis by off-the-coast Miyagi

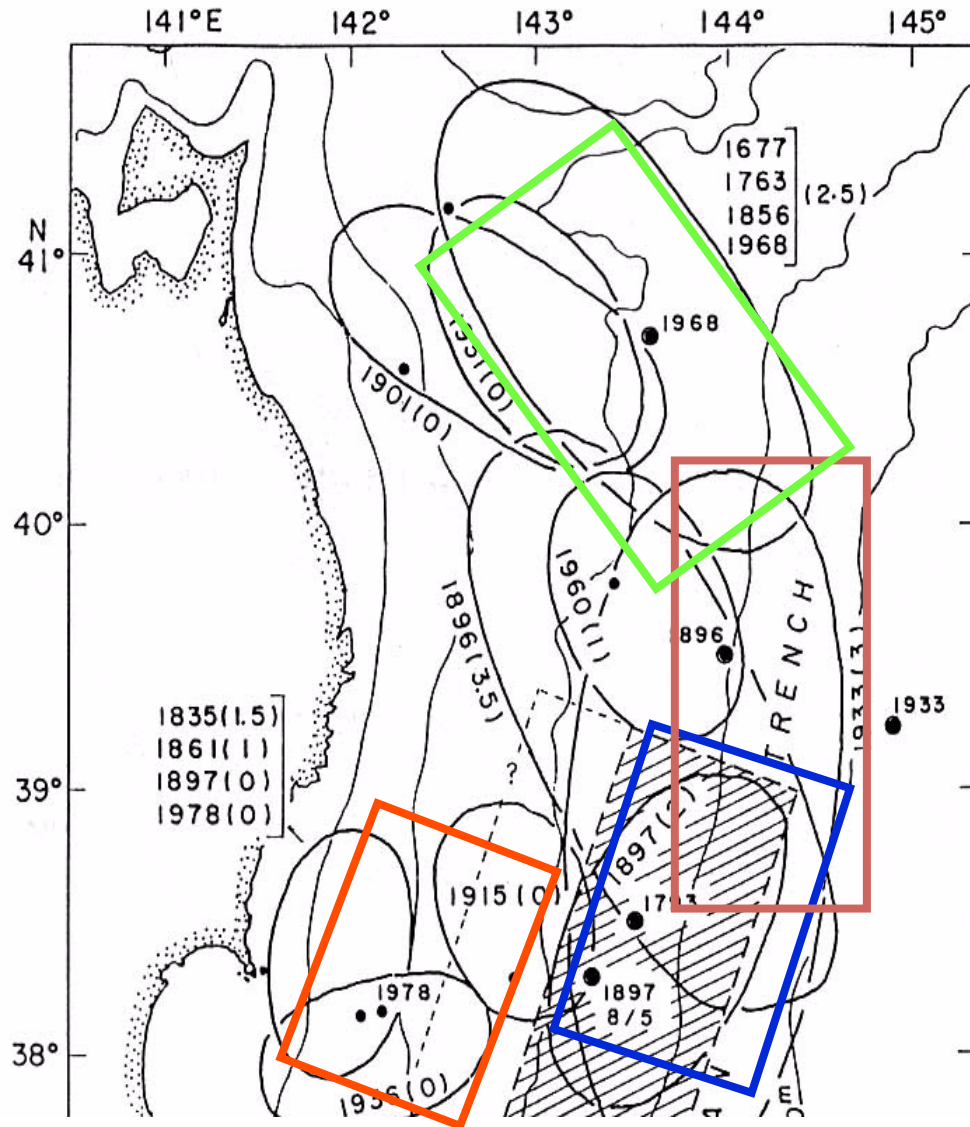
| Occurrence Date | | | Magnitude | |
|------------------|-------------------|------|-----------|--|
| Western Calender | Japanese Calender | EQ | Tsunami | |
| 13 July, 869 | 貞観11年 5月26日 | 8.6 | 4 | |
| 2 Dec, 1611 | 慶長16年10月28日 | 8.1 | 3 | |
| 17 Feb, 1793 | 寛政 5年 1月 7日 | 8.25 | 2 | |
| 20 July, 1835 | 天保 6年 6月25日 | 7.4 | 2 | |
| 21 Oct, 1861 | 文久 1年 9月18日 | 7.4 | 1 | |
| 15 June, 1896 | 明治29年 | 6.8 | 4 | |
| 3 Mar, 1933 | 昭和 8年 | 8.3 | 3 | |
| 12 Jun, 1978 | 昭和53年 | 7.4 | 0 | |

Above: Historical Tsunami observation hitting Tohoku Pacific coast.

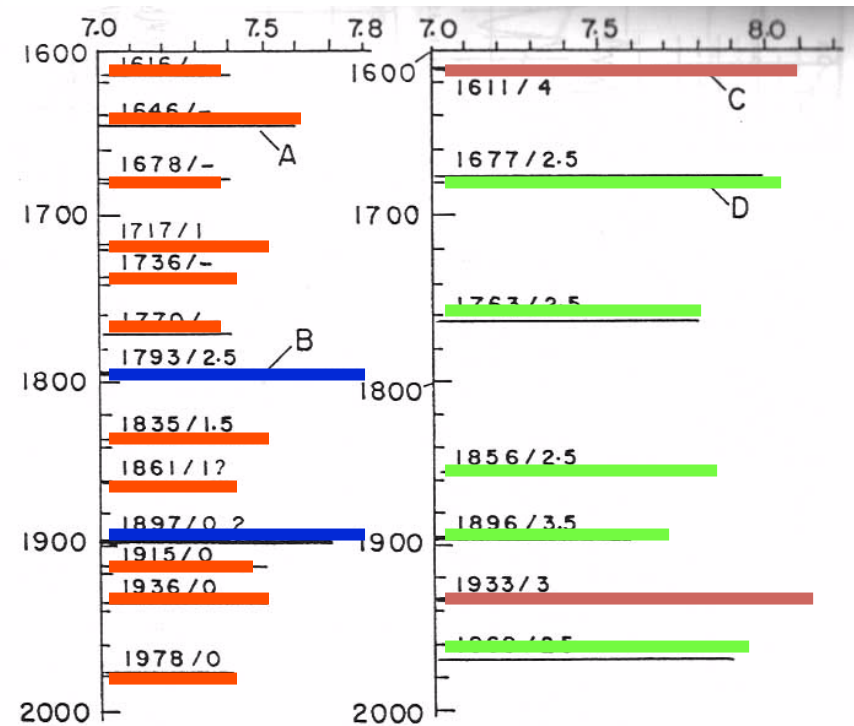
Right: Wave source, based on Watanabe 1985.



Historical Earthquakes and Tsunamis Off-the-Coast Sanriku and Miyagi



Year (y-axis) and Magnitude (x-axis)



Off-the-coast Miyagi EQ occurs once in 37 years

中央防災会議での評価結果との比較

Large difference in projected and actual height of tsunami

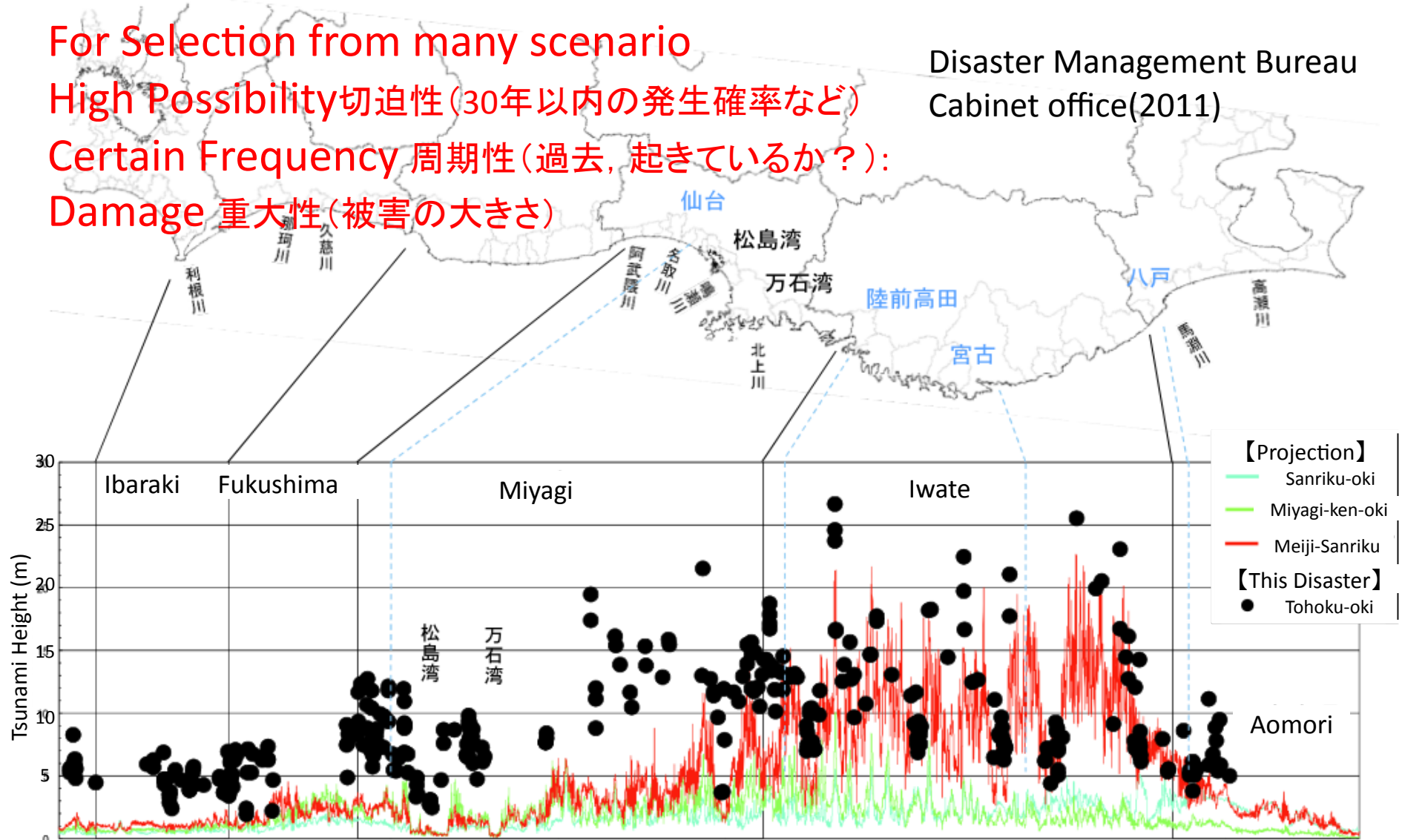
For Selection from many scenario

High Possibility 切迫性 (30年以内の発生確率など)

Certain Frequency 周期性 (過去, 起きているか?):

Damage 重大性 (被害の大きさ)

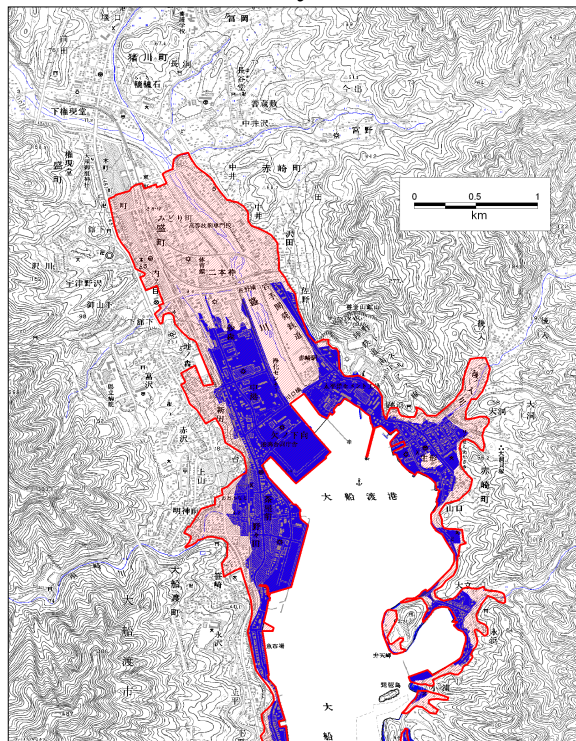
Disaster Management Bureau
Cabinet office (2011)



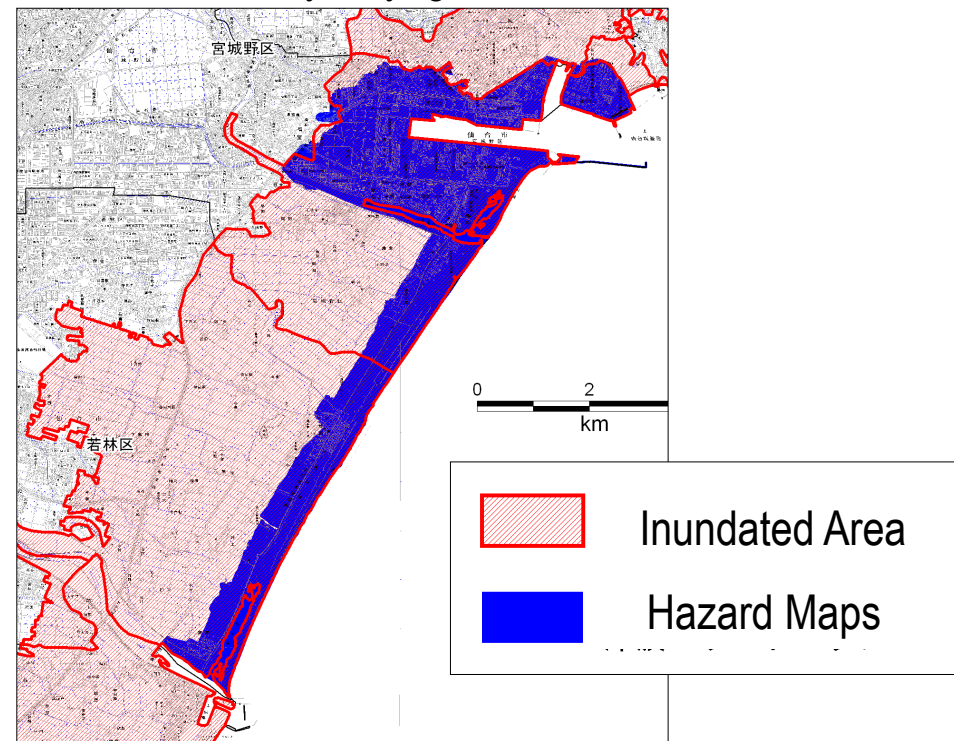
Disaster Prevention

- The inundation area far exceeded that indicated in municipal hazard maps.

Ofunato City, Iwate Pref.



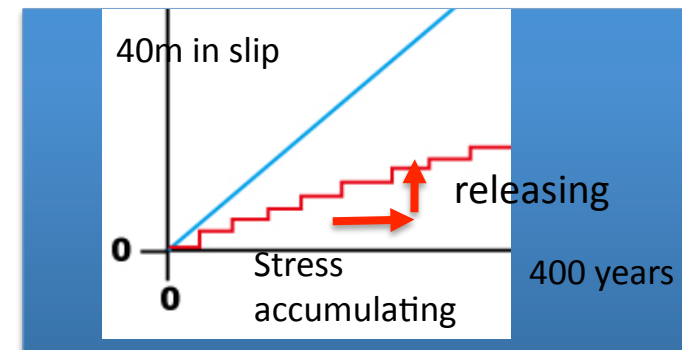
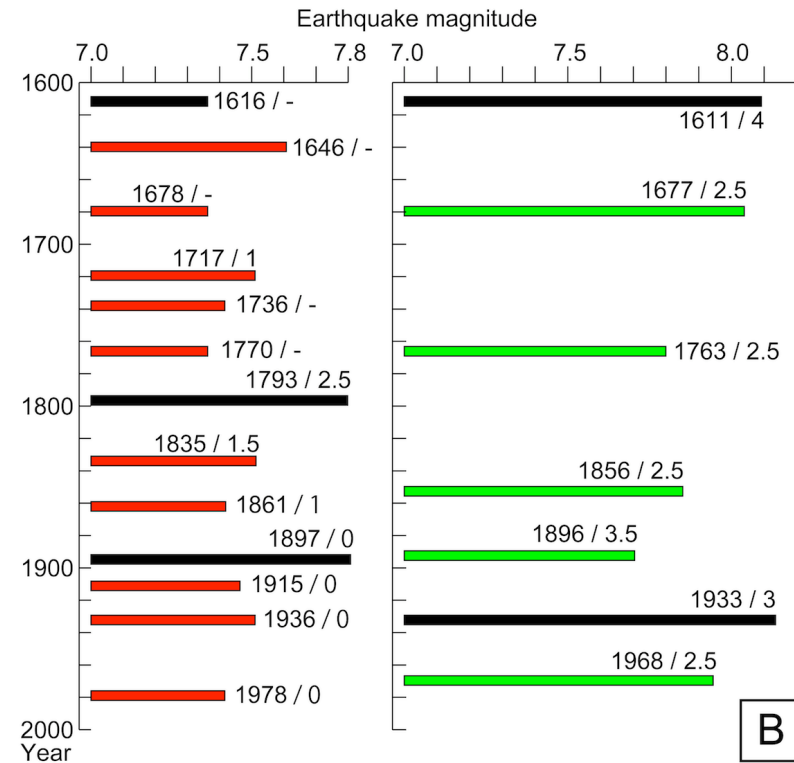
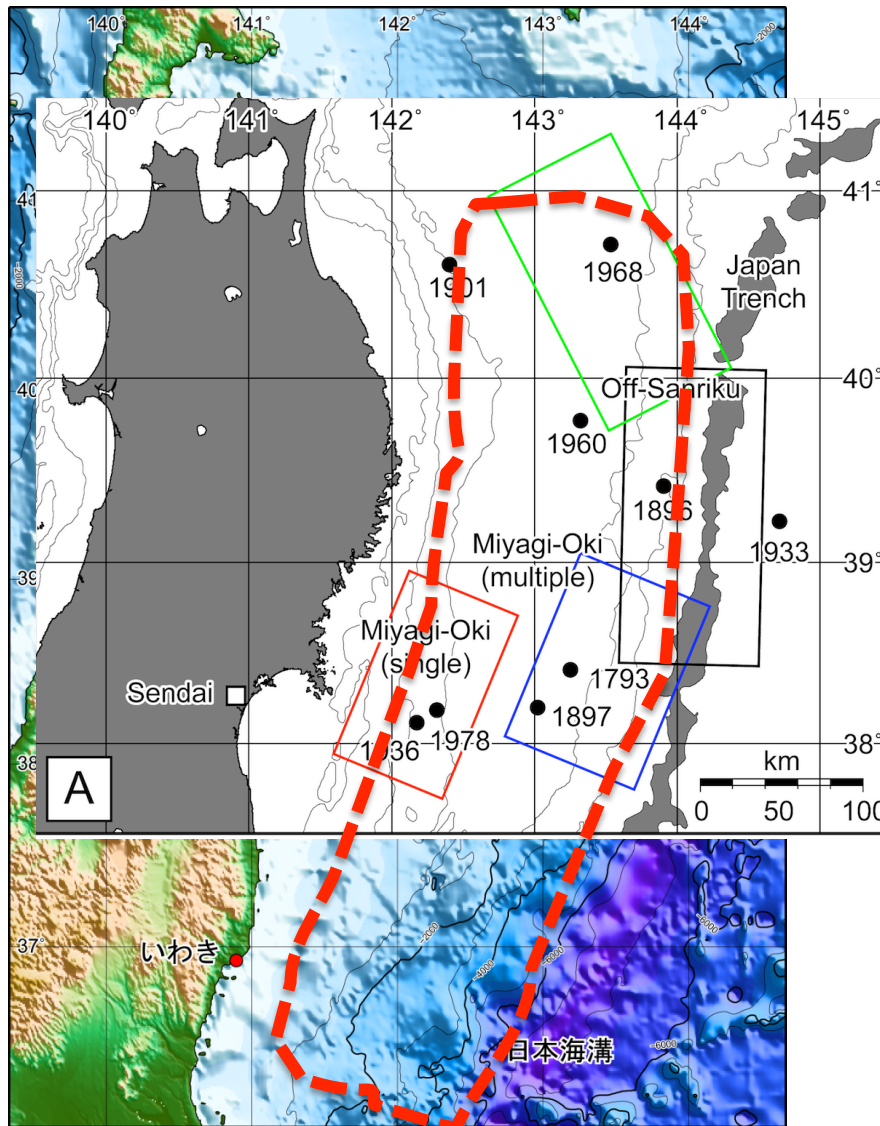
Sendai City, Miyagi Pref.



Source: Cabinet Office

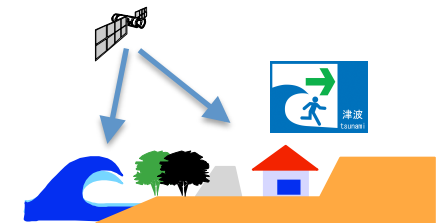
Disaster Management Bureau
Cabinet office(2011)

Historical tsunamis in Tohoku for 400 years and the 2011 Tohoku Eq.



- T.Hatori, Distributions of Seismic Intensity and Tsunami of the 1793 Miyagi Oki Earthquake, Northeastern Japan, *Bulletin of Earthquake Research Institute, University of Tokyo*, **62**, 297-309 (1987).

Overcoming the limitation of 400 years data



三代実録 Old document, AD869

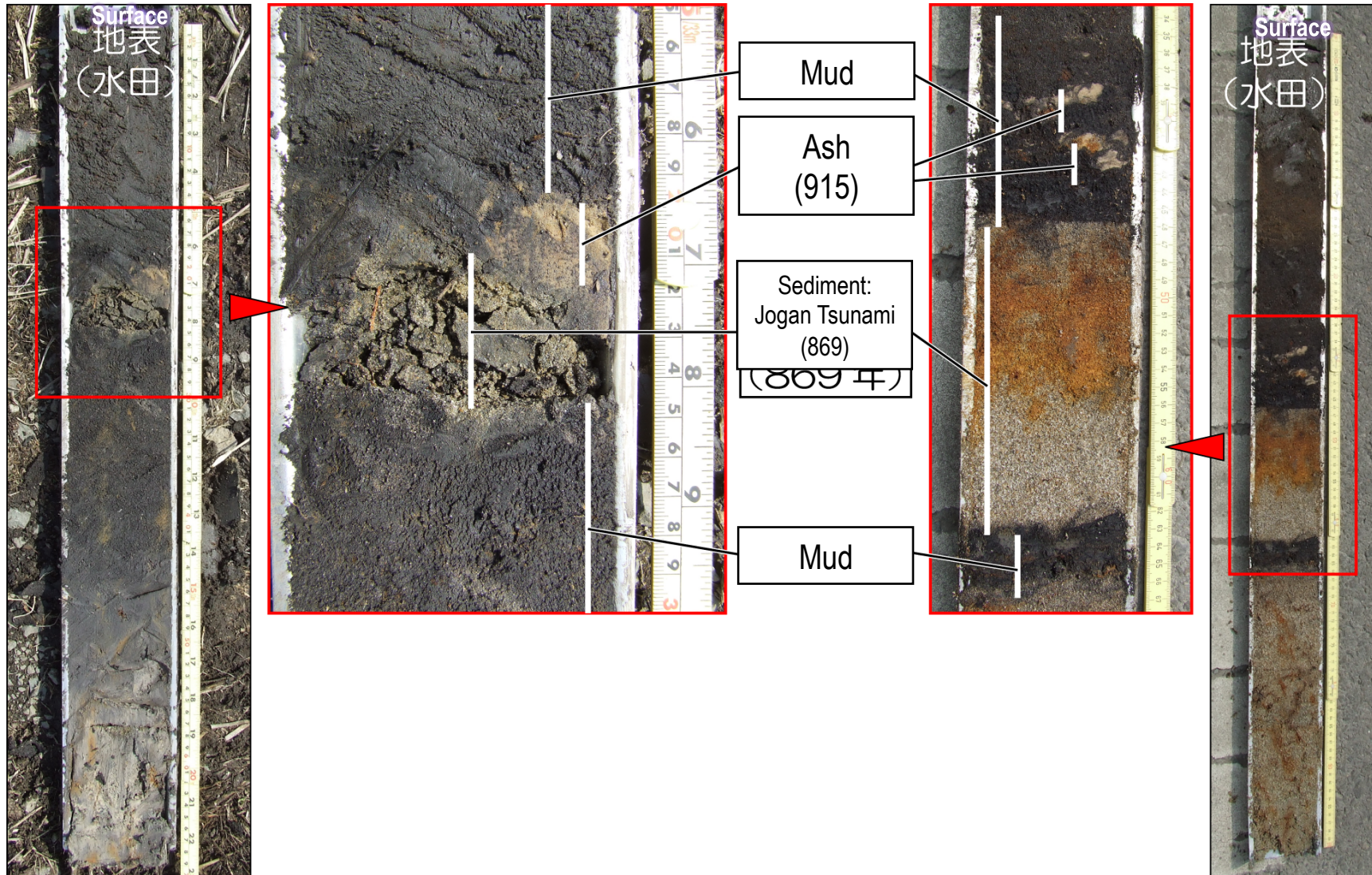
(貞觀十一年五月)
二十六日癸未
陸奥国地大震動
流光如昼隱映 頃之
人民叫呼 伏不能起
或屋仆压死 或地裂埋殮
馬牛駭奔 或相昇踏
城郭倉庫門櫓墻壁
頽落顛覆 不知其數
海口哮吼 声似雷霆
驚寿湧潮 沂回漲長
忽至城下 去海數千百里
浩々不辨其矣
原野道路 總為滄溟
乘船不遑 登山難及
溺死者千許 資産苗稼
殆無子遺

What was recorded (Jogan EQ in 869)

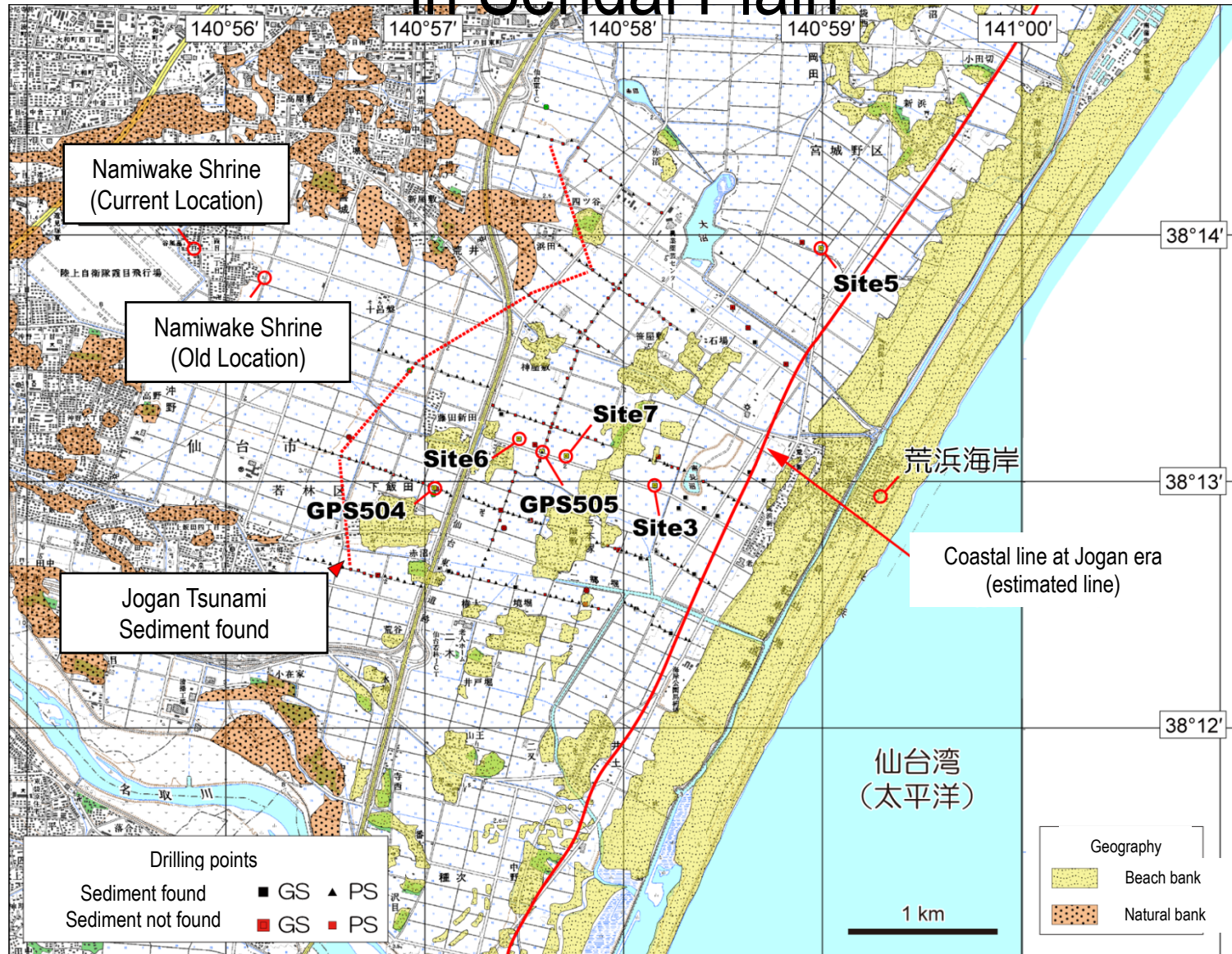
- Earthquake lights were observed
- Cracks in the ground, many were crushed to death by buildings
- Plain region was flooded by sea water
- Many drowned (1,000 people?)

Tsunami Sediment by Drilling

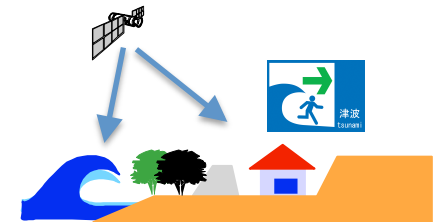
two layers; volcano ash and tsunami sand



Distribution of the 869 Jogan Tsunami Sediment in Sendai Plain

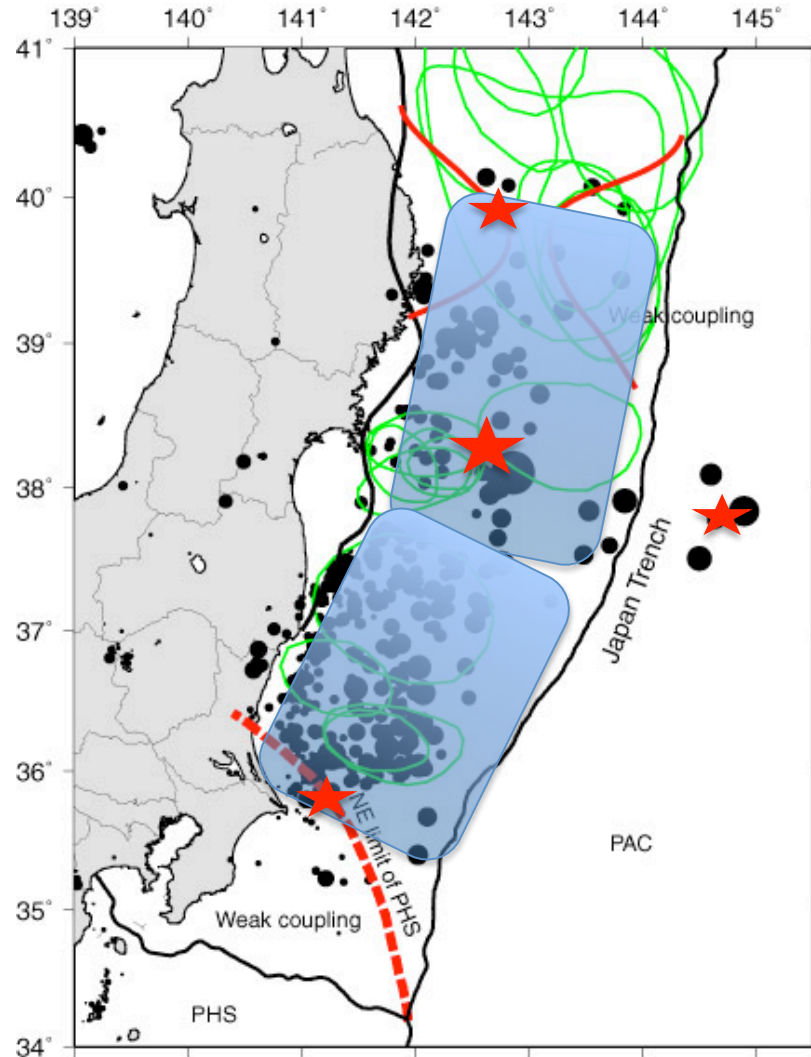


The 2011 Tohoku earthquake and tsunami



The Main-shock and Aftershock Activities

- Mainshock : M9.0 (14:46)
500km x 200km
The largest in size recorded
- Immediately after
 - Off-the-coast Sanriku M7.5 (15:08), Off-the-coast Ibaraki M7.3 (15:15), Japan Trench M7.4 (15:25)
- Aftershock activities
 - Fukushima, Ibaraki, Boso
 - Lasting aftershock activities
 - Stress transfer?

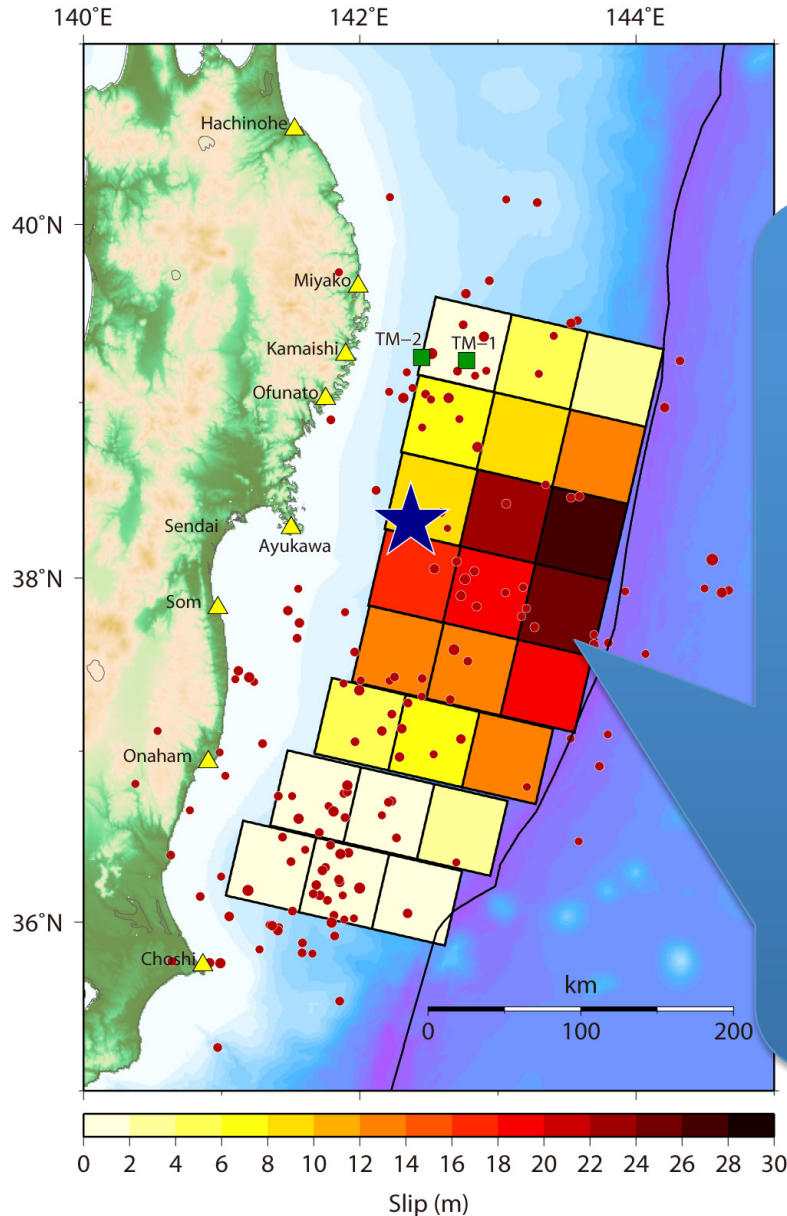


Uchida, Tohoku University

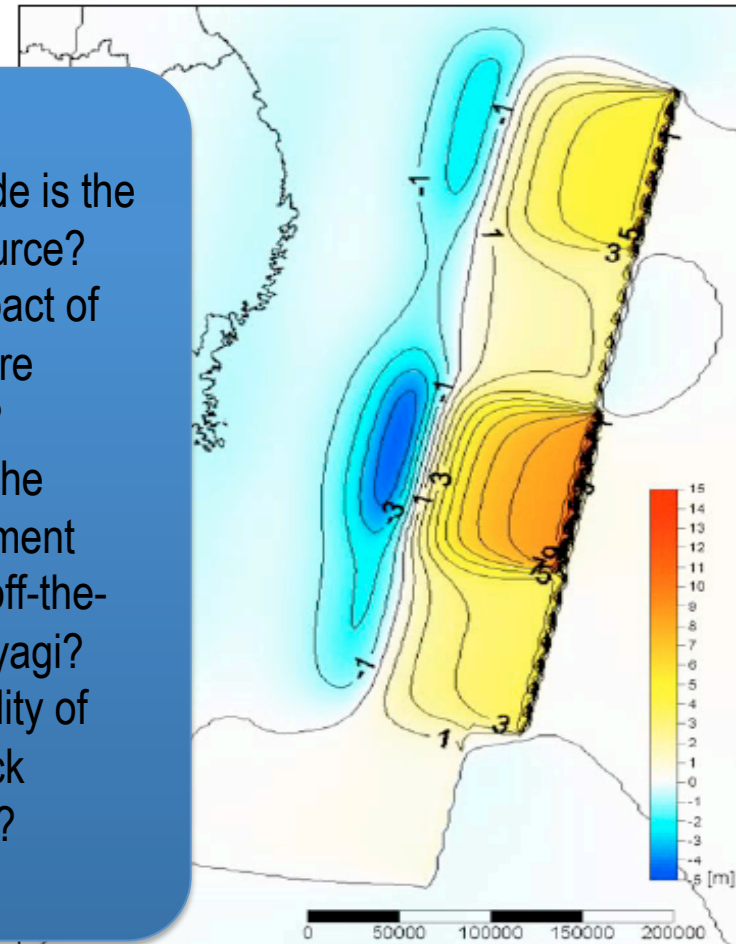
http://www.aob.geophys.tohoku.ac.jp/info/topics/20110311_news/index_html

Example of faults model for tsunami (Fujii&Satake,2011 & Tohoku Univ. models)

http://iisee.kenken.go.jp/staff/fujii/OffTohokuPacific2011/tsunami_ja.html

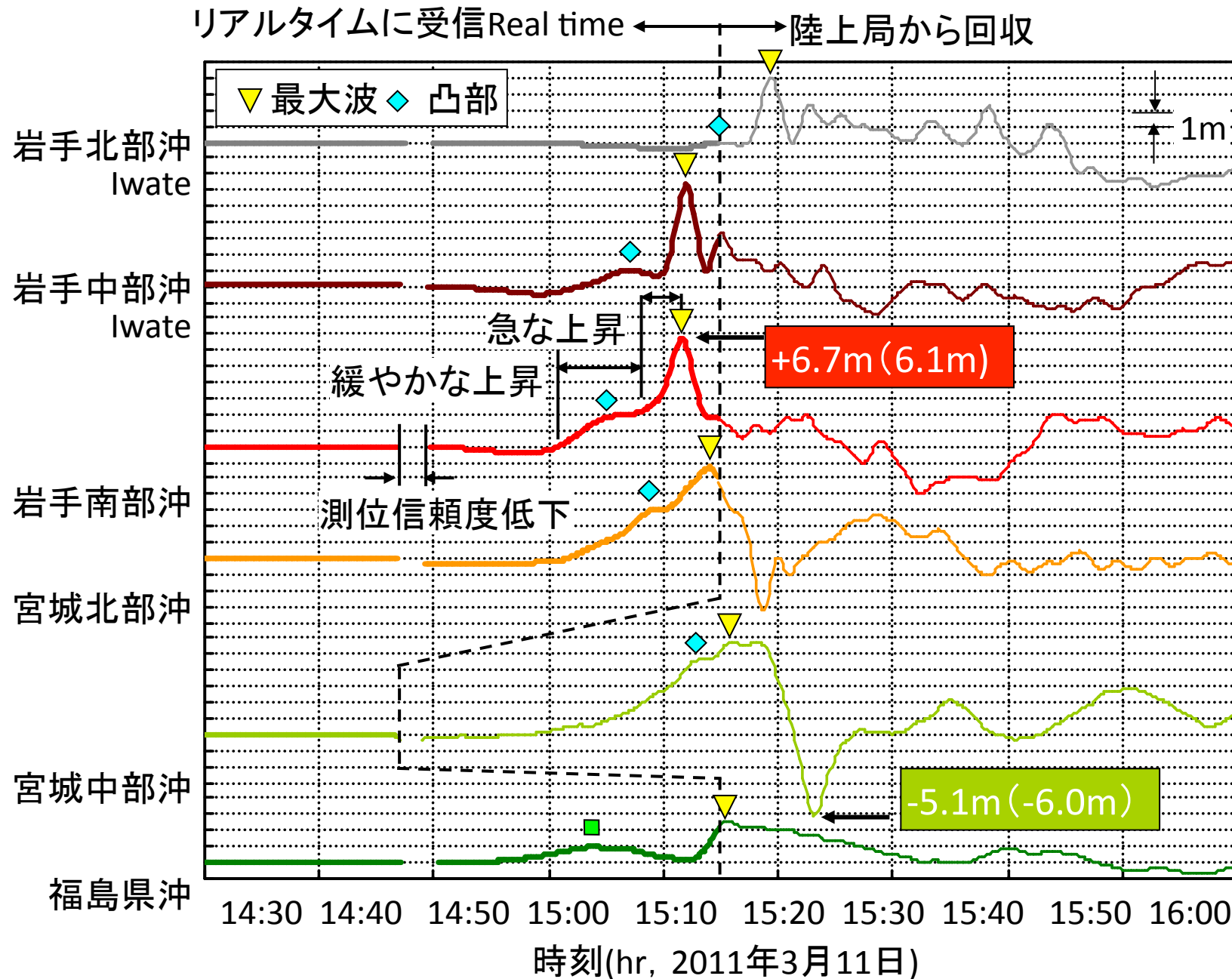


- How wide is the wave source?
- Any impact of the rupture process?
- Why is the displacement large in off-the-coast Miyagi?
- Probability of aftershock activities?



Tohoku Univ. model

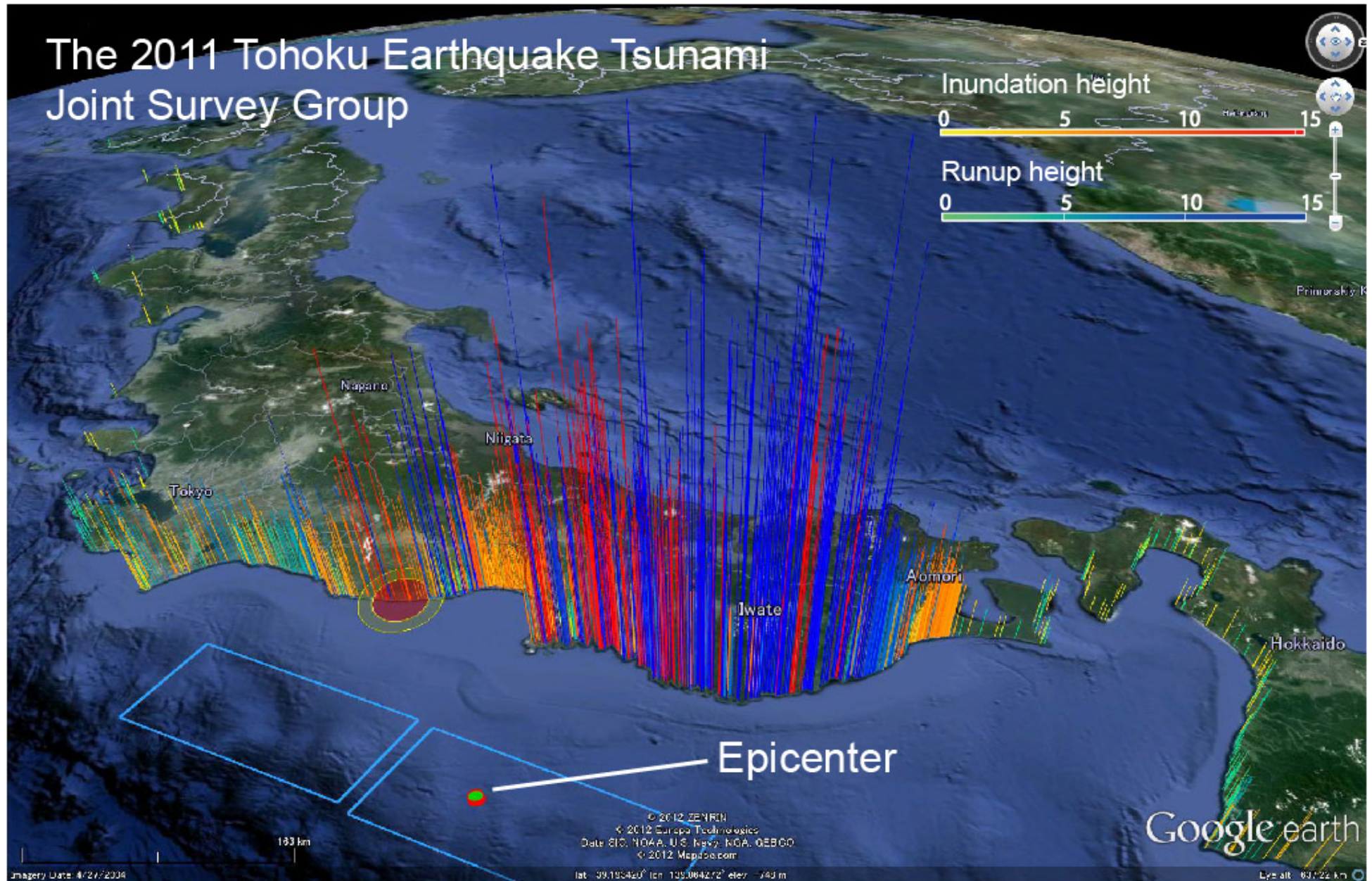
第1波の「緩やかな上昇」と「急な上昇」 GPS monitoring



これまでの調査結果

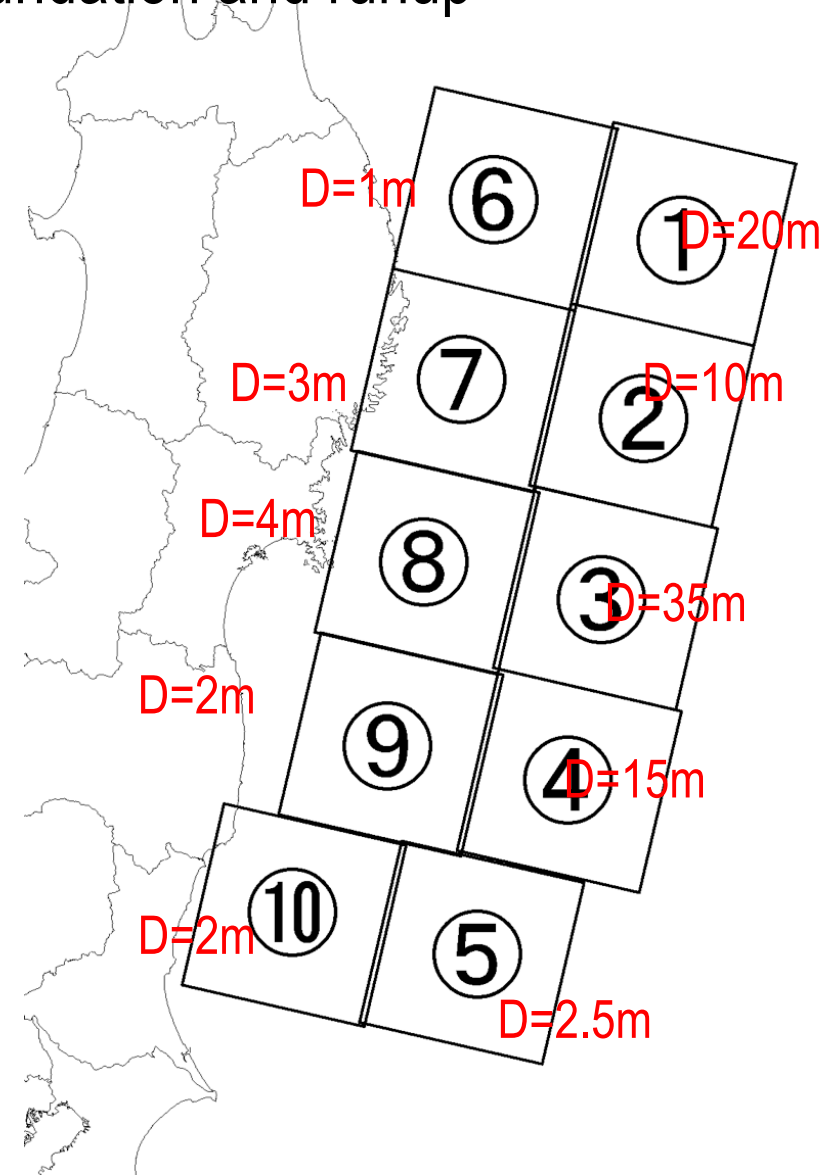
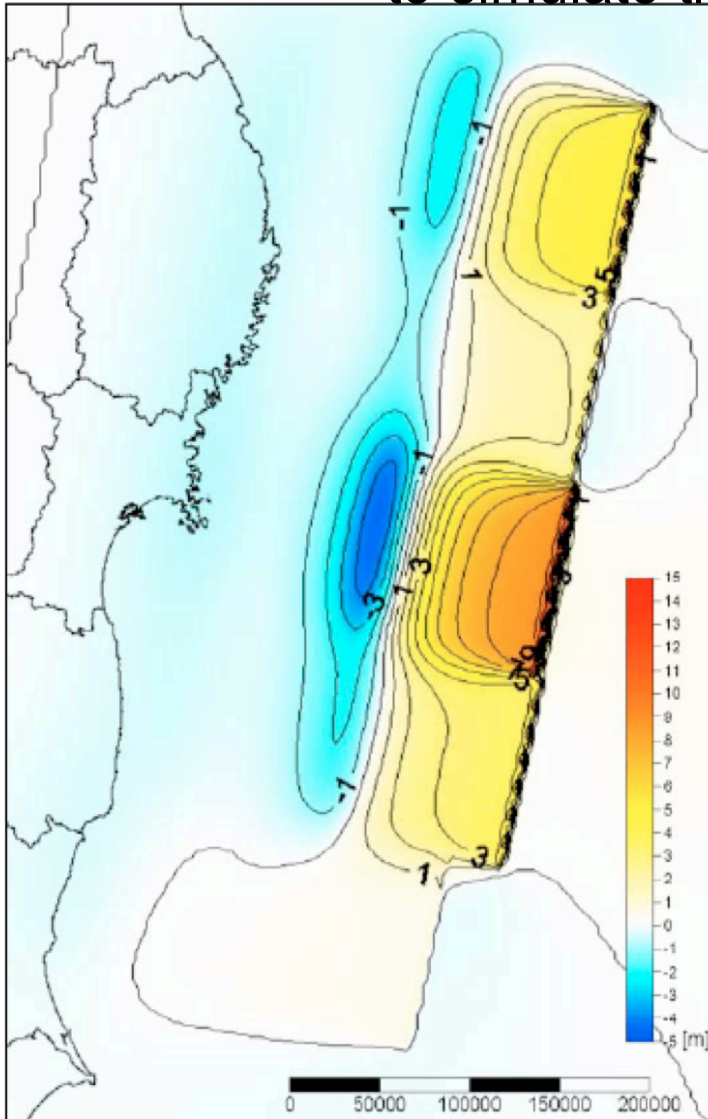
参加:約100名

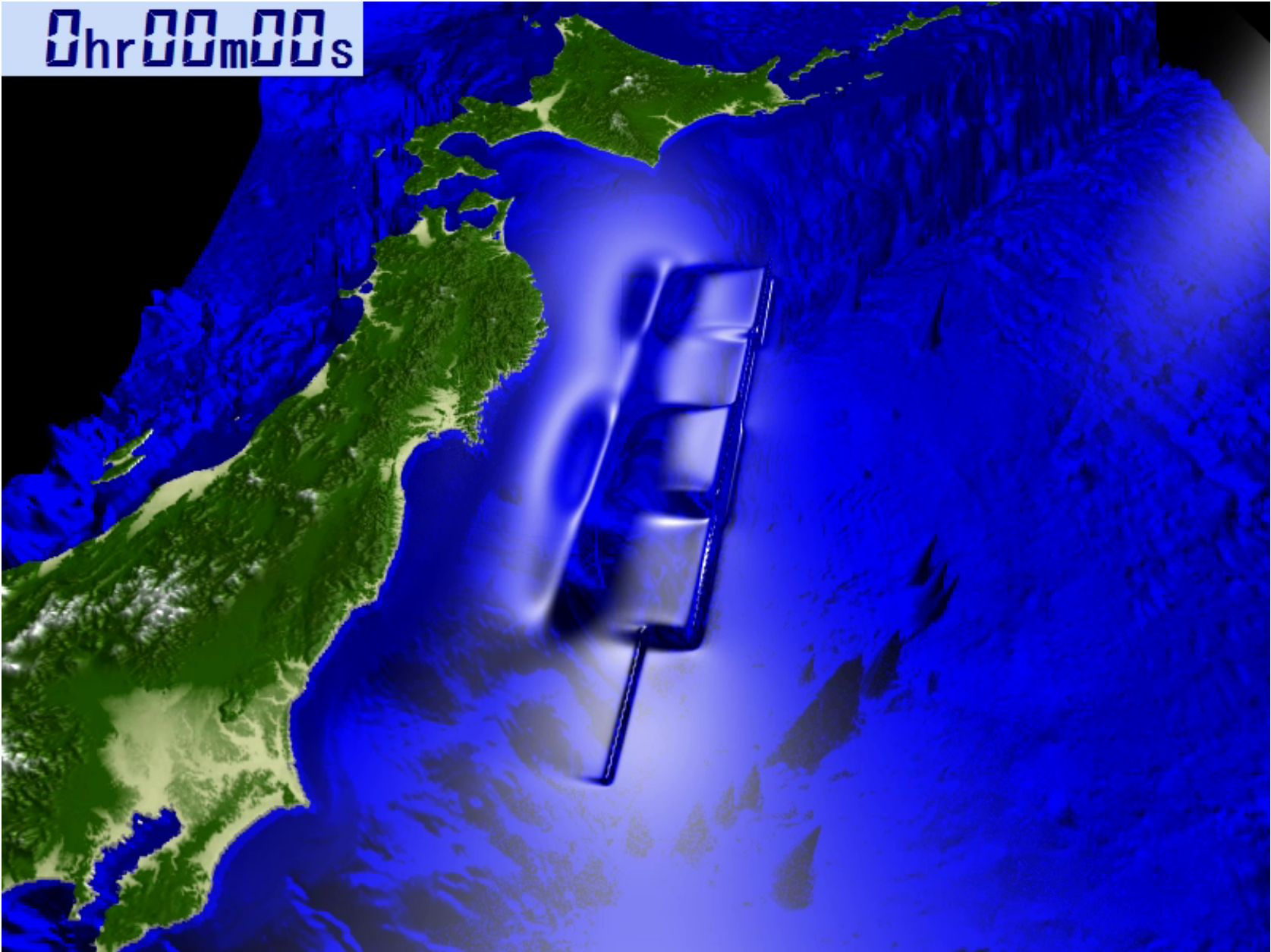
測点:約400点(1ヶ月) => 現在4,000点

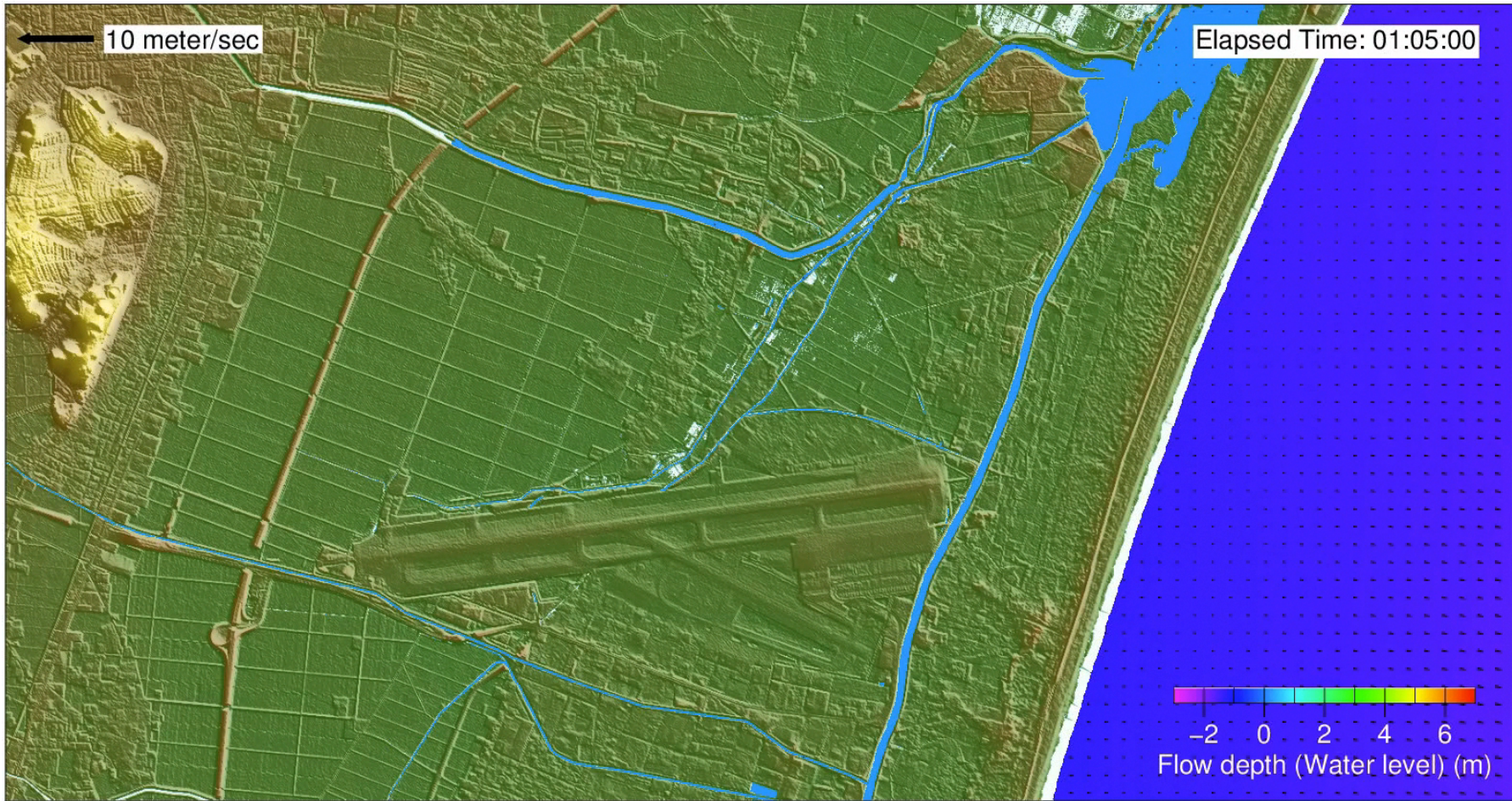


Tohoku Univ. model Vers.1.0

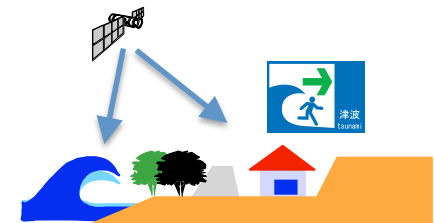
to simulate the inundation and runup







Damage due to the 2011 Tohoku earthquake tsunami



The tsunami attacking Sendai area

15:56 JT on March 11



(共同通信)

http://www.boston.com/bigpicture/2011/03/massive_earthquake_hits_japan.html

The 1st Tsunami Struck Sendai Plain

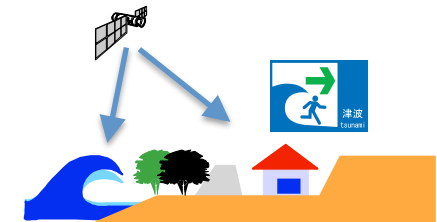
15:56, 11 March



(Source: Mainichi Shimbun) http://www.boston.com/bigpicture/2011/03/massive_earthquake_hits_japan.html

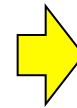


Building a resilient society Toward the future

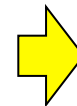


Rebuilding of Tsunami-Resilient City by Integrating Measures (MLIT,2011)

- ① Development of Basic Principles for Promotion of Rebuilding of Tsunami-Resistant City by Integrating Measures
- ② Determination of expected tsunami inundation area / inundation depth based on the scientific knowledge available
- ③ Development of Promotion Plan for Rebuilding of Tsunami-Resistant City by Integrating Measures
- ④ Improvement of Tsunami Protection Structures
utilization/improvement of inner levees, etc
- ⑤ Establishment of warning/evacuation procedures
prepare tsunami hazard maps, conduct evacuation drills, designate evacuation facilities, etc
- ⑥ Regulation of land use and building structures
introduce land use regulation and building code for medical/welfare facilities and residential homes, accounting for tsunami risks of the sites



Protecting tsunami



Evacuating from tsunami



Resisting tsunami

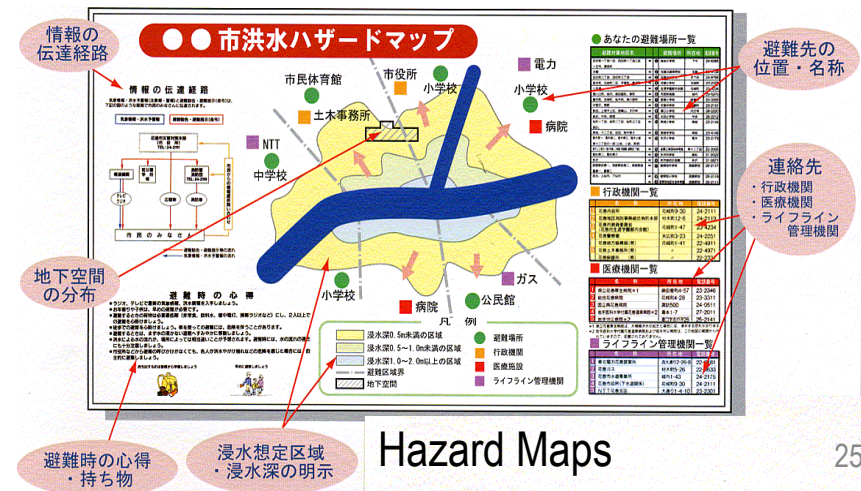
Examples of structures for soft measure



Evacuation Routes and steps



Tsunami evacuation building



Hazard Maps

Past Protections in Multi-layers, Damage by the 2011 and Plan for Tsunami Resilient city in Sendai

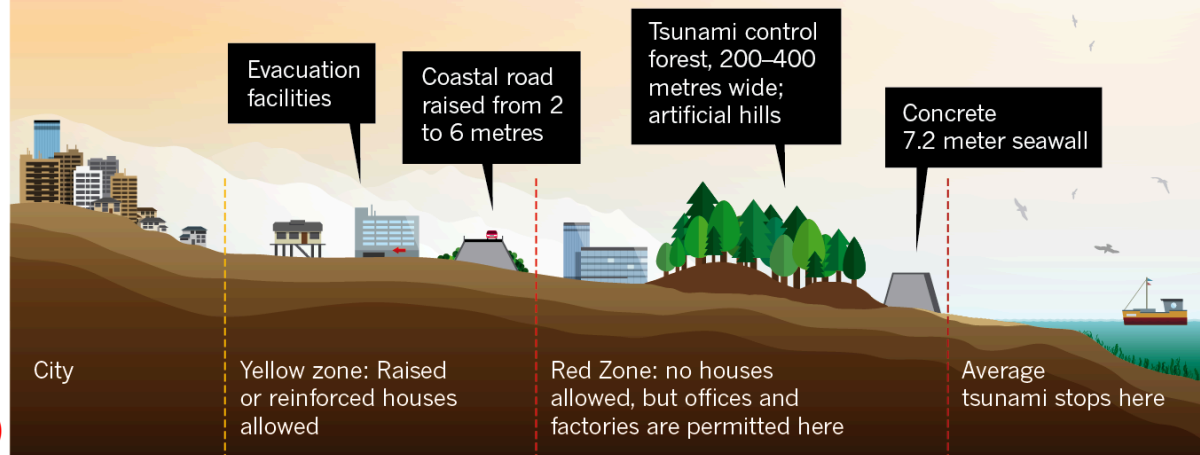


Only two temples were damaged among 100 with 1,000 years history in the affected area

Cyranoski (Nature, Vo.483, 2011)

PLAN FOR A TSUNAMI-RESISTANT CITY

Sendai is considering refashioning its coastal area. A raised seawall would block typical tsunamis and an elevated coastal road would protect against giant ones. Zoning restrictions would lower the number of fatalities.

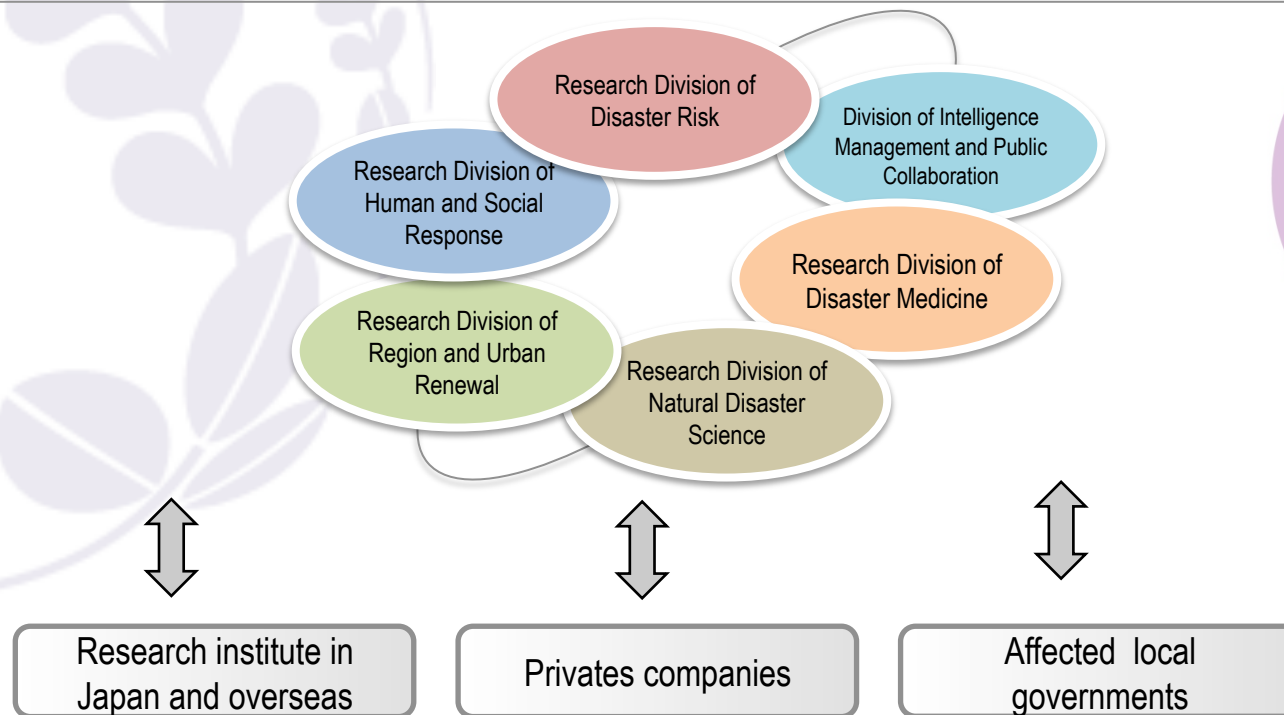


Establishment of International Research Institute of Disaster Science (IRIDeS) in Tohoku University

Our institute's missions are

- 1) Restructuring of disaster prevention and reduction technologies based on reality of the 2011 off the Pacific coast of Tohoku earthquake and tsunami disaster,
- 2) construction of "Disaster area supportology" in the event of a disaster,
- 3) advancement of anti-hazard performance and upgrading for multiple-fail-safe in urban areas as disaster recovery projects,
- 4) mechanism research on mega earthquake and tsunami phenomena and development of next-generation early detection technology of earthquake tsunami occurrence,
- 5) establishment of disaster medicine and medical service system of responding appropriately to wide area massive disaster, and
- 6) regenerating region and urban and creation of disaster digital archive pass down to the next generation.

IRIDeS will take the leading role for causing paradigm shift on catastrophic disaster measures and responses by accomplishing 6 missions.



English Name: IRIDeS

- International Research Institute of Disaster Science
- Plural of IRIS
- Symbol of Desire, nobility

Logo Mark Design

- Japanese Saying “Reverse of Disaster makes Fortune”
- Reverse of Disaster kanji character
- Tohoku University's symbol color

