



Lifeline Aspects

Charles Scawthorn, PEER Visiting Scholar
Shiro Takada, Prof. Emeritus, Kobe University
Mohammad Javanbarg, WRN Fellow, Kyoto University

SPA Risk



Event Summary

M_w : 9.0

Time: 11 March 2011 LT 2:45pm UTC 5:46am

Name:

Toh 東北地方太平洋沖地震（東日本大震災）
(Eastern Japan Great Earthquake Disaster)

Epicenter: 38.322°N 142.369°E

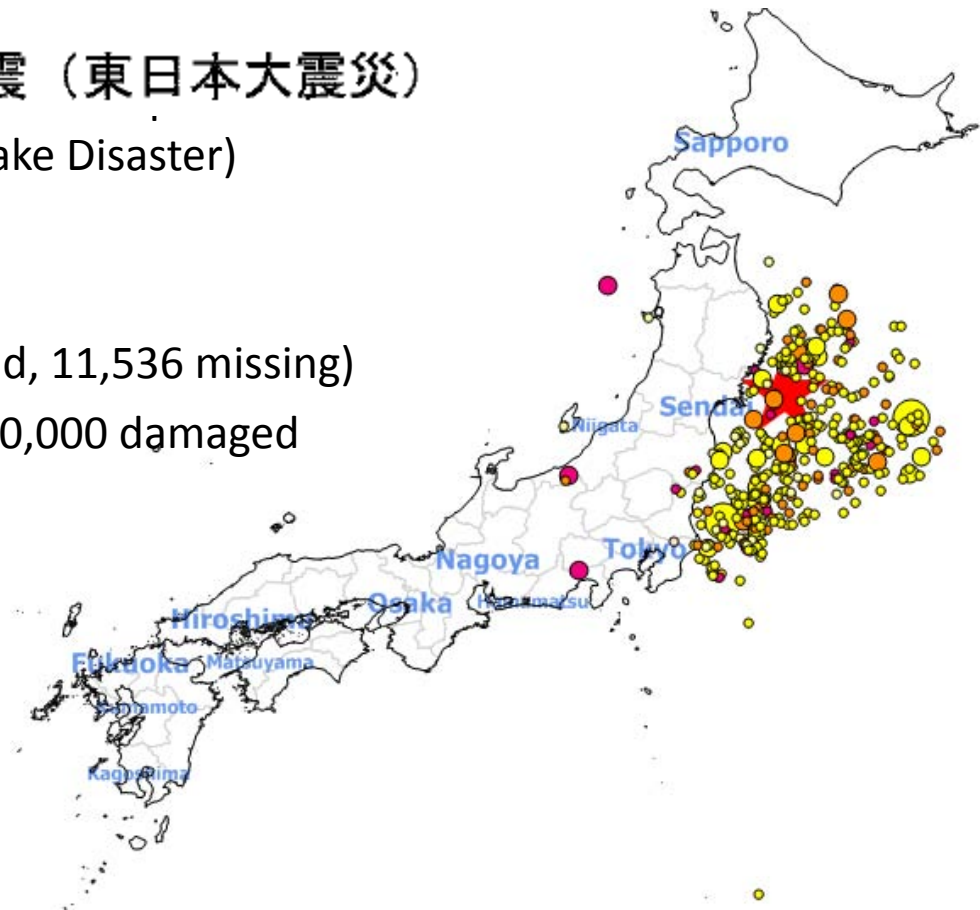
Felt: Osaka

Killed: ~ 26,000 (14,161 confirmed dead, 11,536 missing)

Housing damage: 77,000 destroyed, 260,000 damaged

Displaced: 160,000

Economic Loss: tbd, \$500 billion?



Outline

Lifelines;

- Water and wastewater
- Transport
 - Rail
 - Roads
 - Ports
 - Airports
- Energy
- Telcom

Fire following earthquake

Economics

- Observation
- Implications
 - Japan
 - Others
- Research opportunities

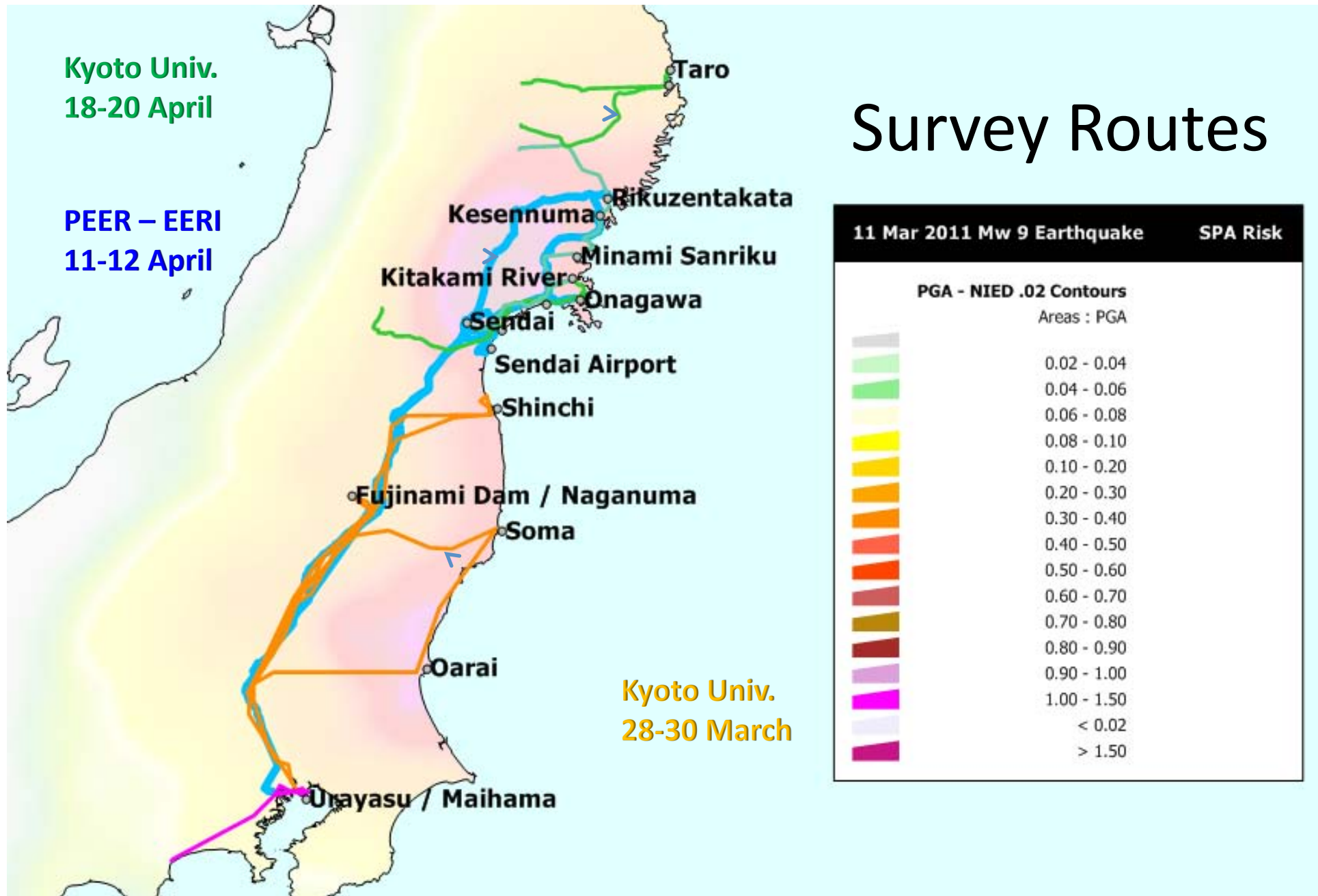
Acknowledgements

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H. Motosaka, Tohoku University.....

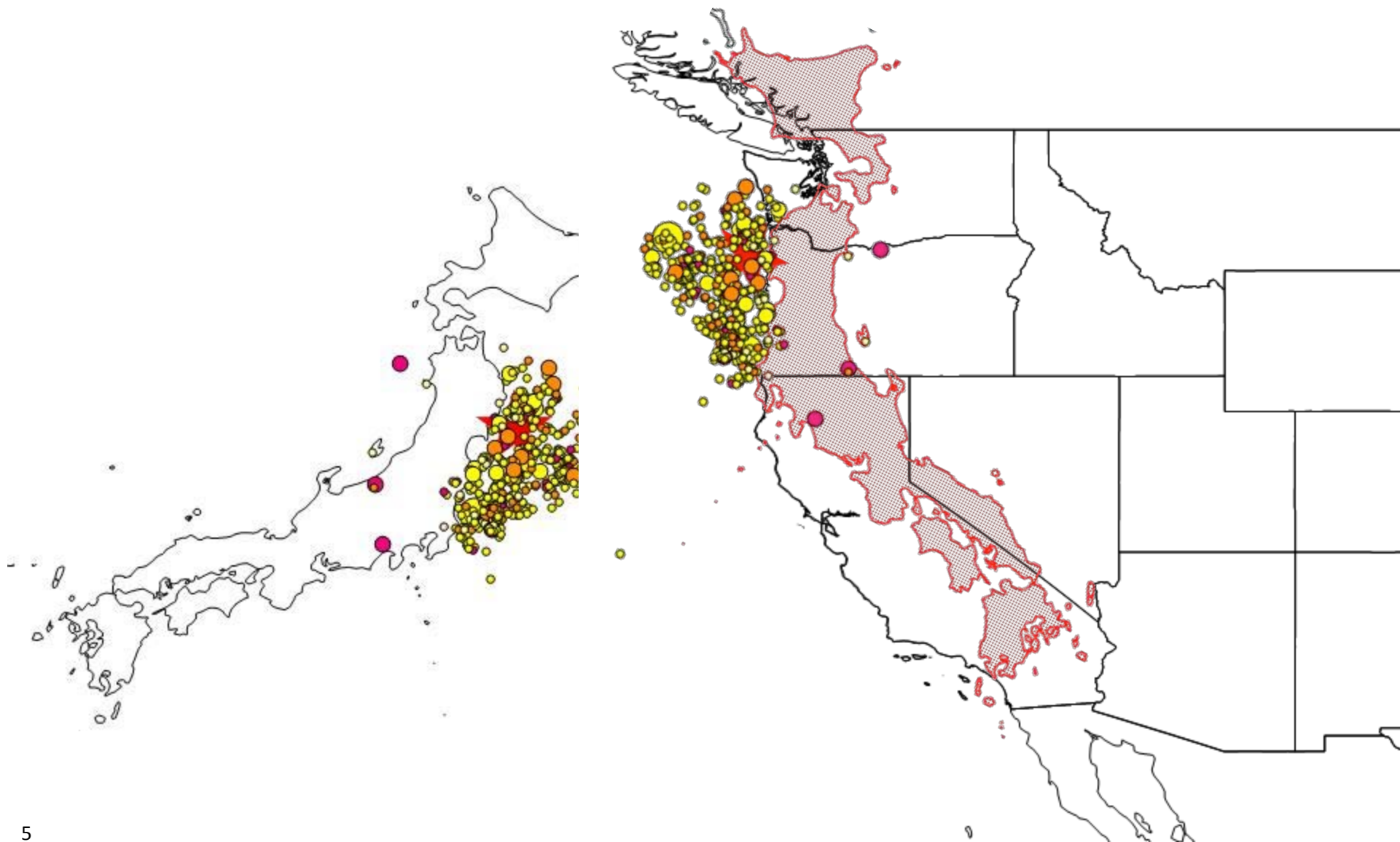
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PEER – EERI Preliminary Briefing re 11 March 2011 Tohoku Earthquake and Tsunami
Pacific Earthquake Engineering Research Center 28 April 2011

Survey Routes



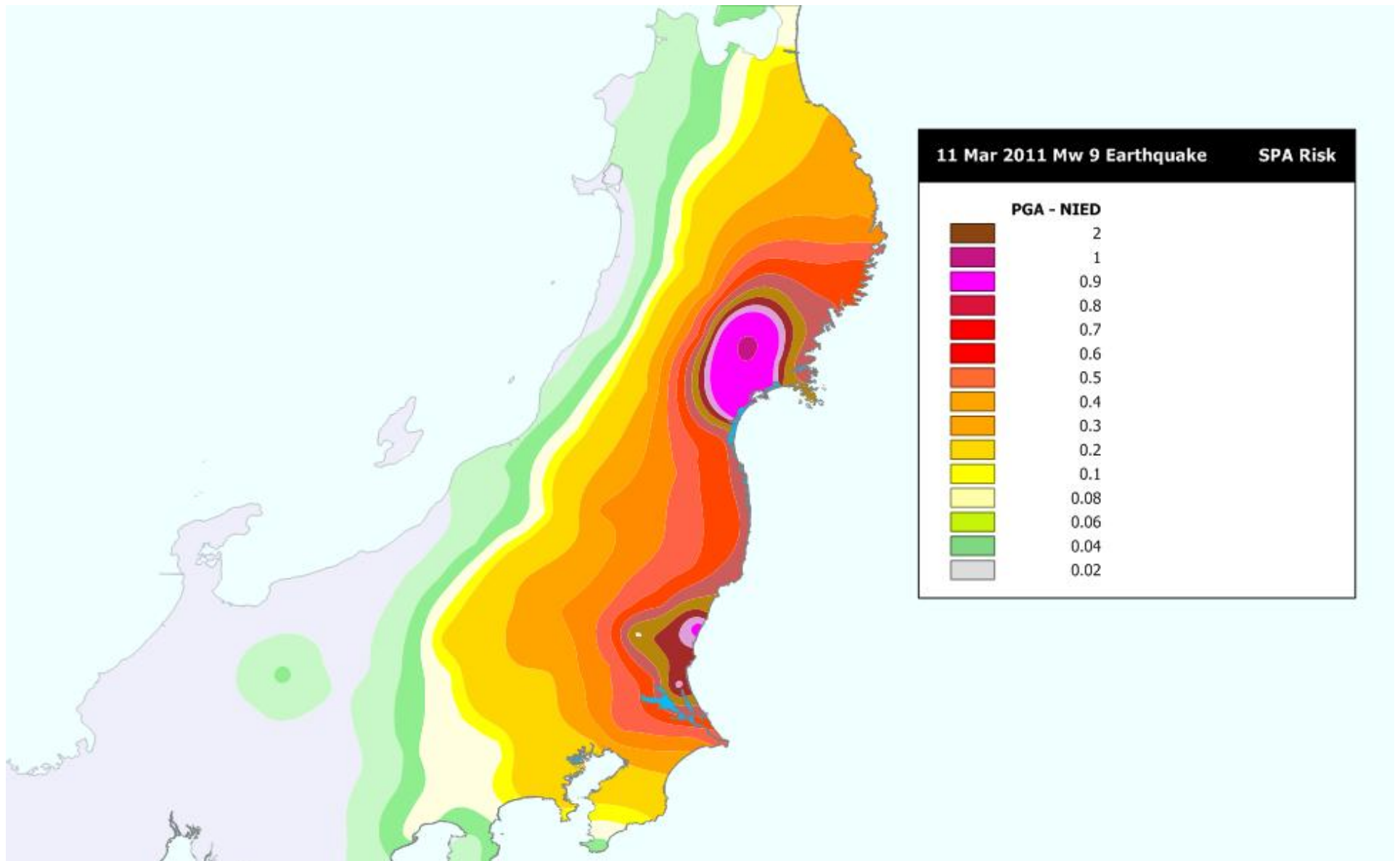
Relevance



Tohoku Tsunami entering San Francisco Bay

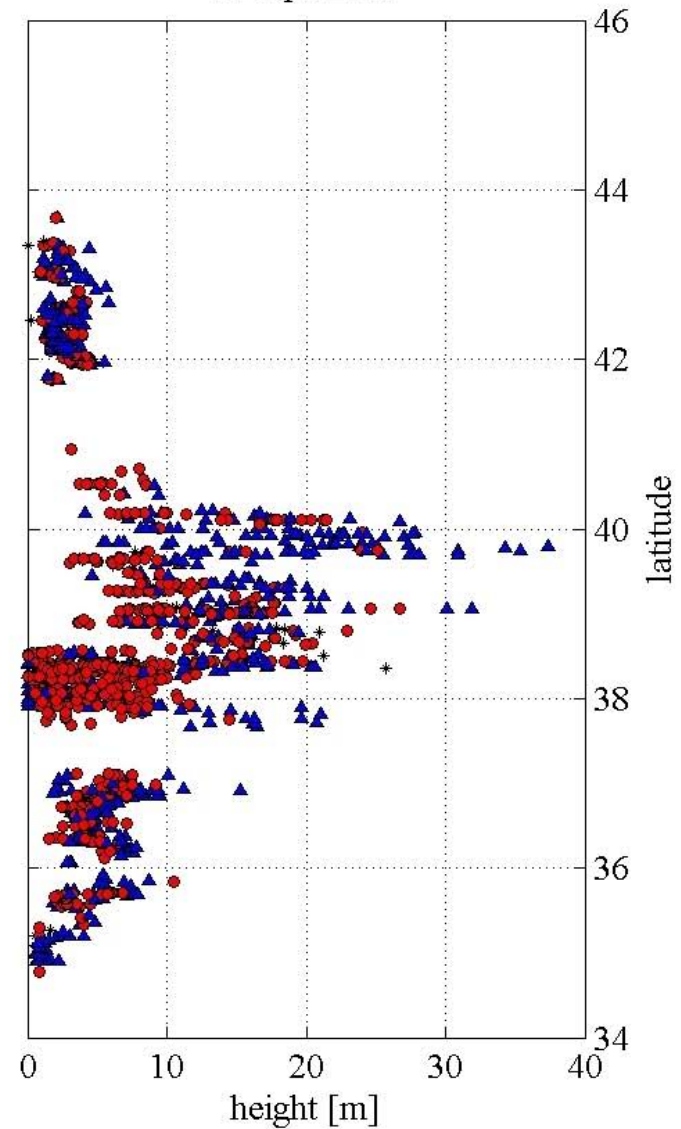
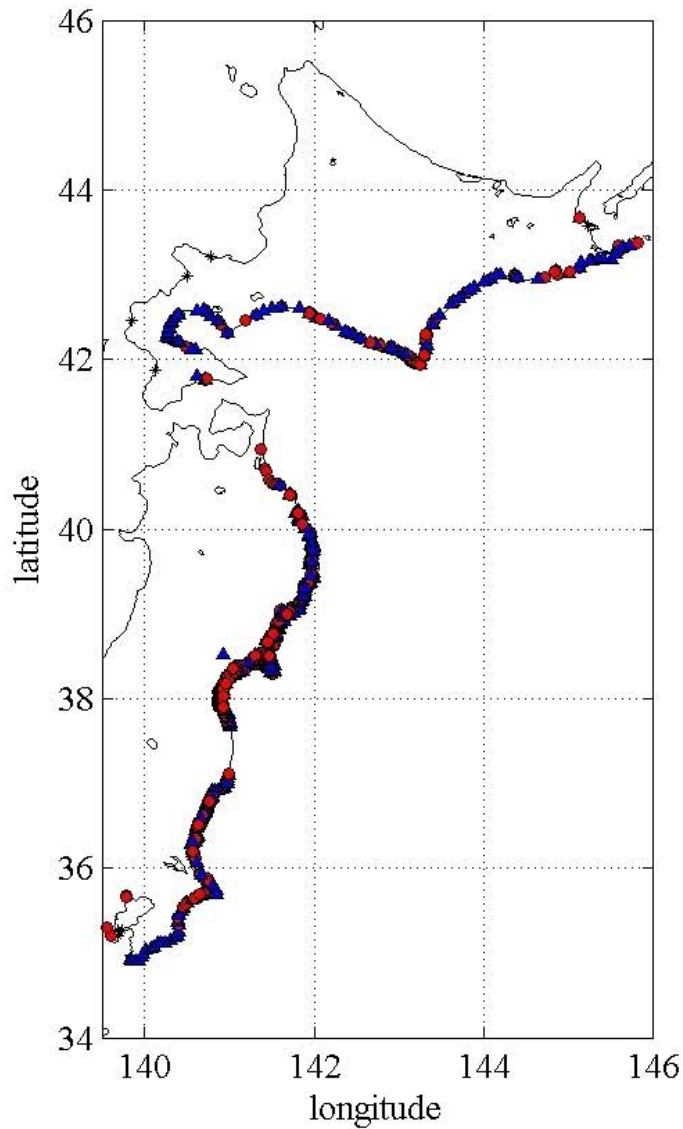


Peak Ground Accelerations

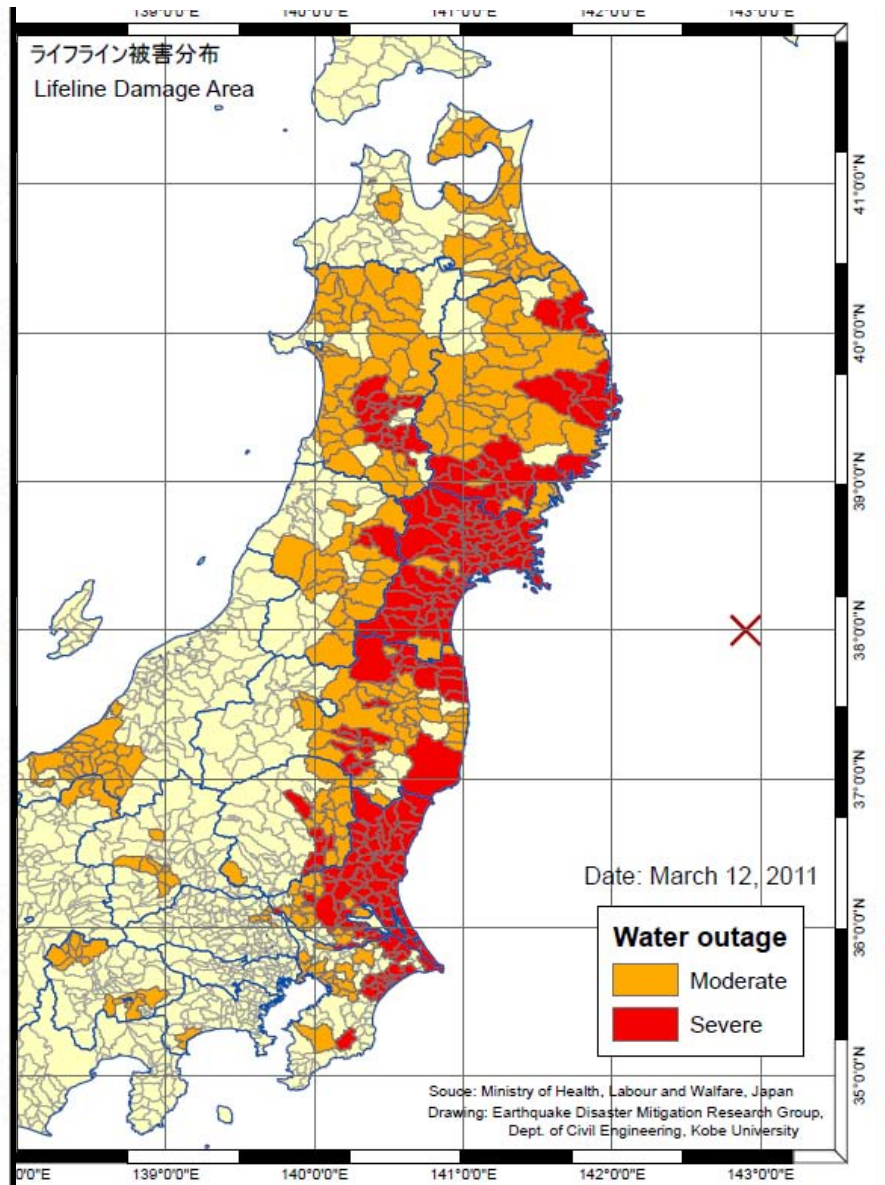
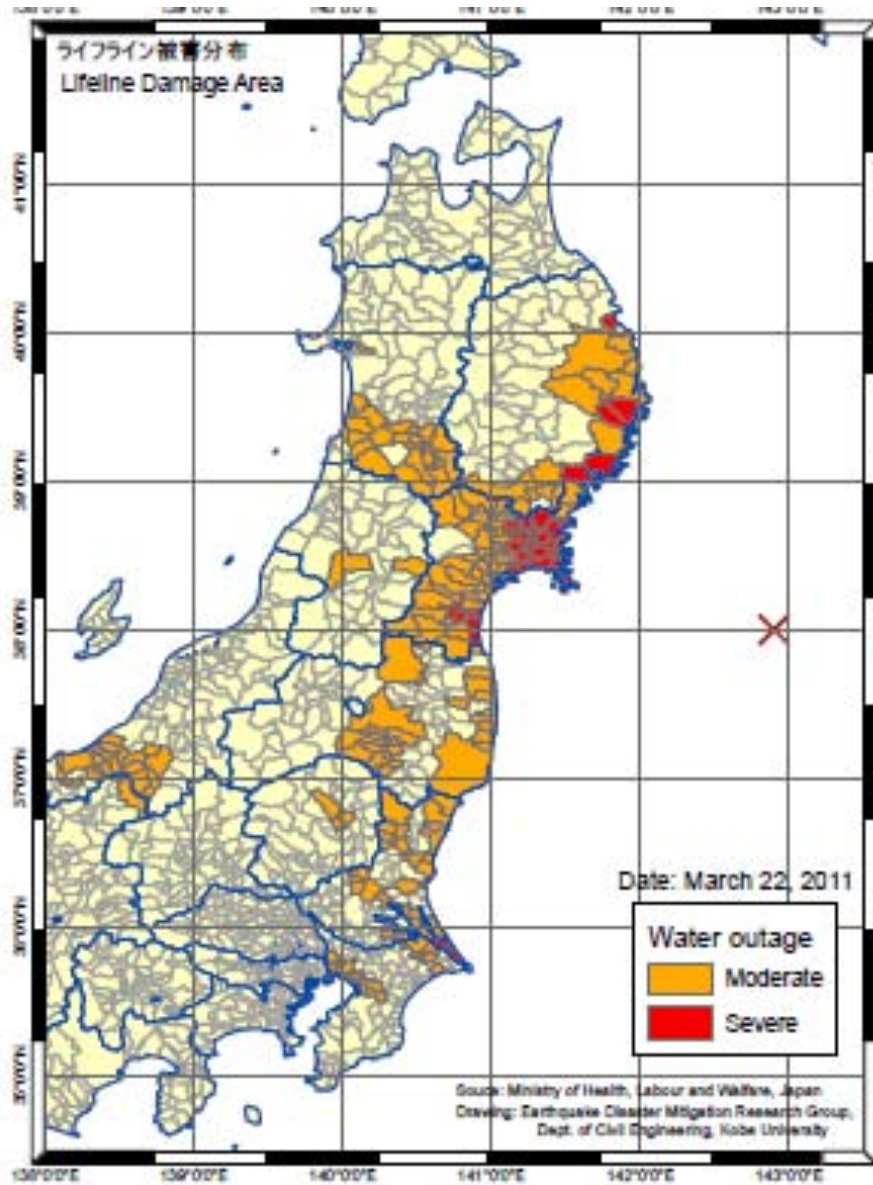


Tsunami Runup Height

21-Apr-2011



Water / Wastewater Supply Systems



Implications

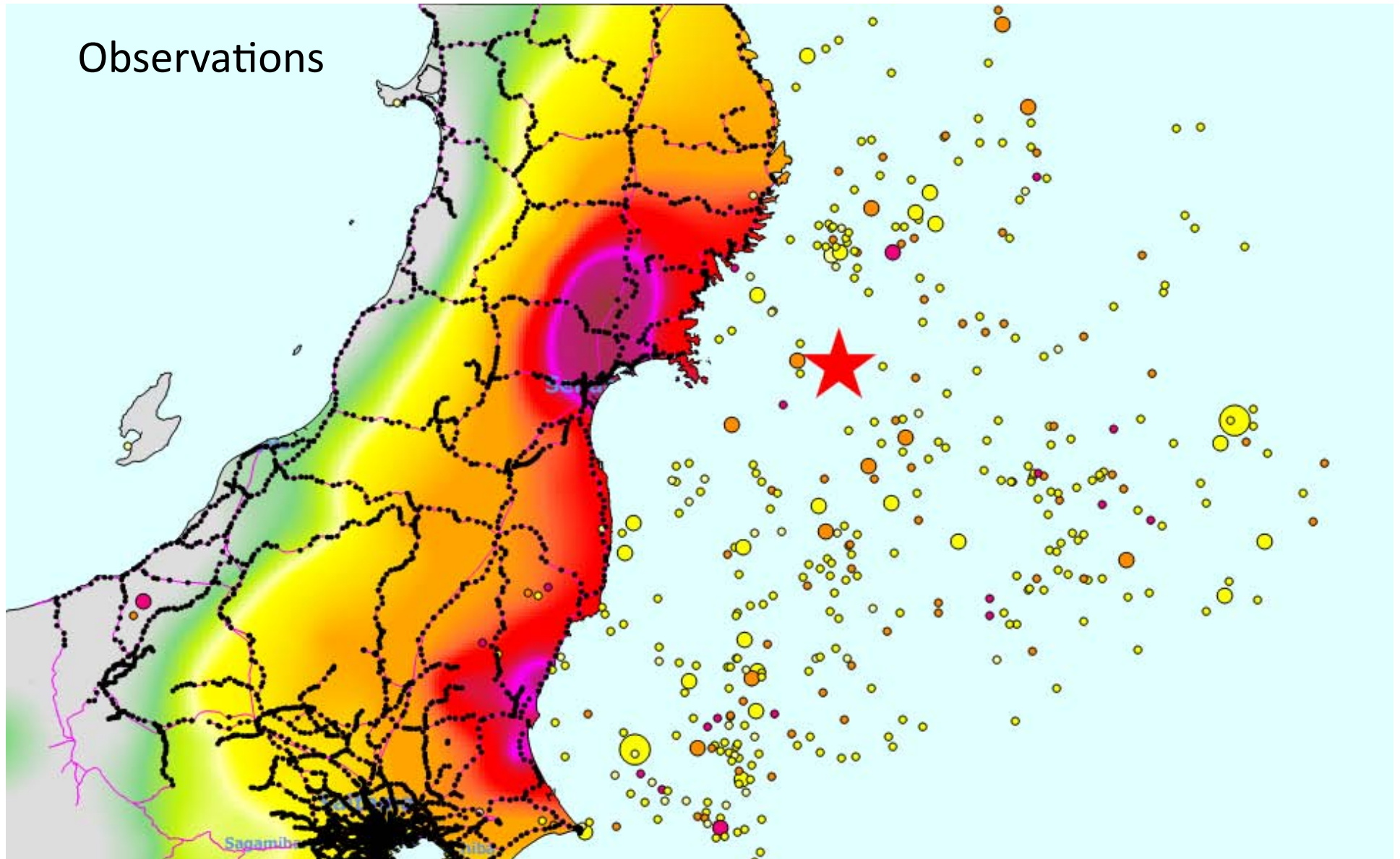
Well –known lessons

- short term shortage of water
- need to quickly provide drinking water
- no water for fire following earthquake

Research Opportunities

1. Detailed documentation of pipe break / other damage
2. Correlation with liquefaction
3. Examination of emergency water supply provision methods

Transport – Rail 1



Transport – Rail 2

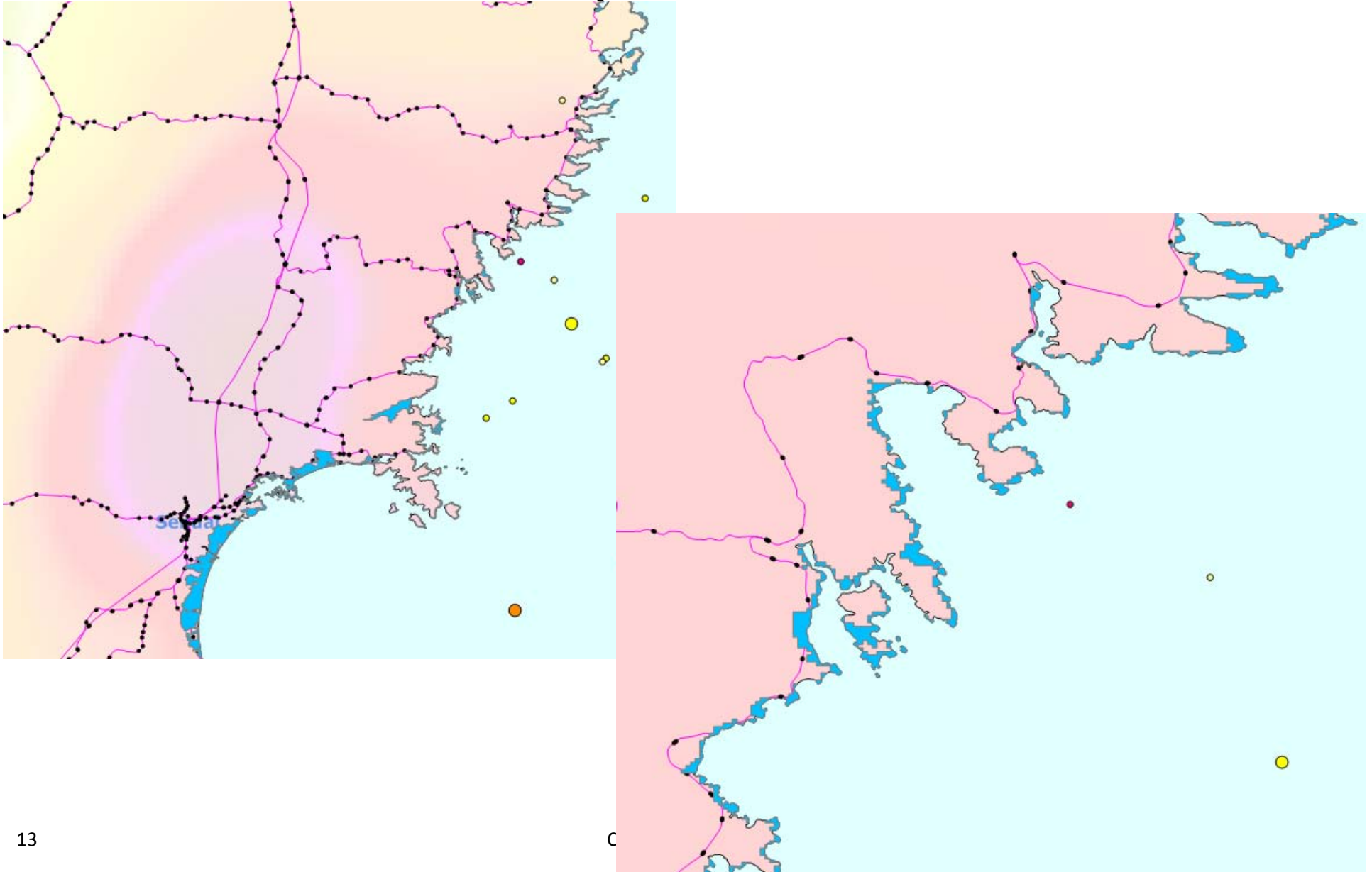
Observations

Shaking Effects on Shinkansen



Om 2011

Transport – Rail 3



Transport – Rail 4

Observations – Tsunami effects



Transport – Rail 5



Transport – Rail 6



Transport – Rail 7

Implications

- Shinkansen repaired quickly
- coastal route will take longer – probably interim use of buses
- US tsunami susceptible routes?

Research Opportunities

- selected case studies of tsunami forces on rail bridges
- scouring of track, signaling
- economic impact due to loss of RR

Transport – Highway

Observations

- shaking – bridges, abutment settlements
- tsunami – washout of coastal bridges

Implications

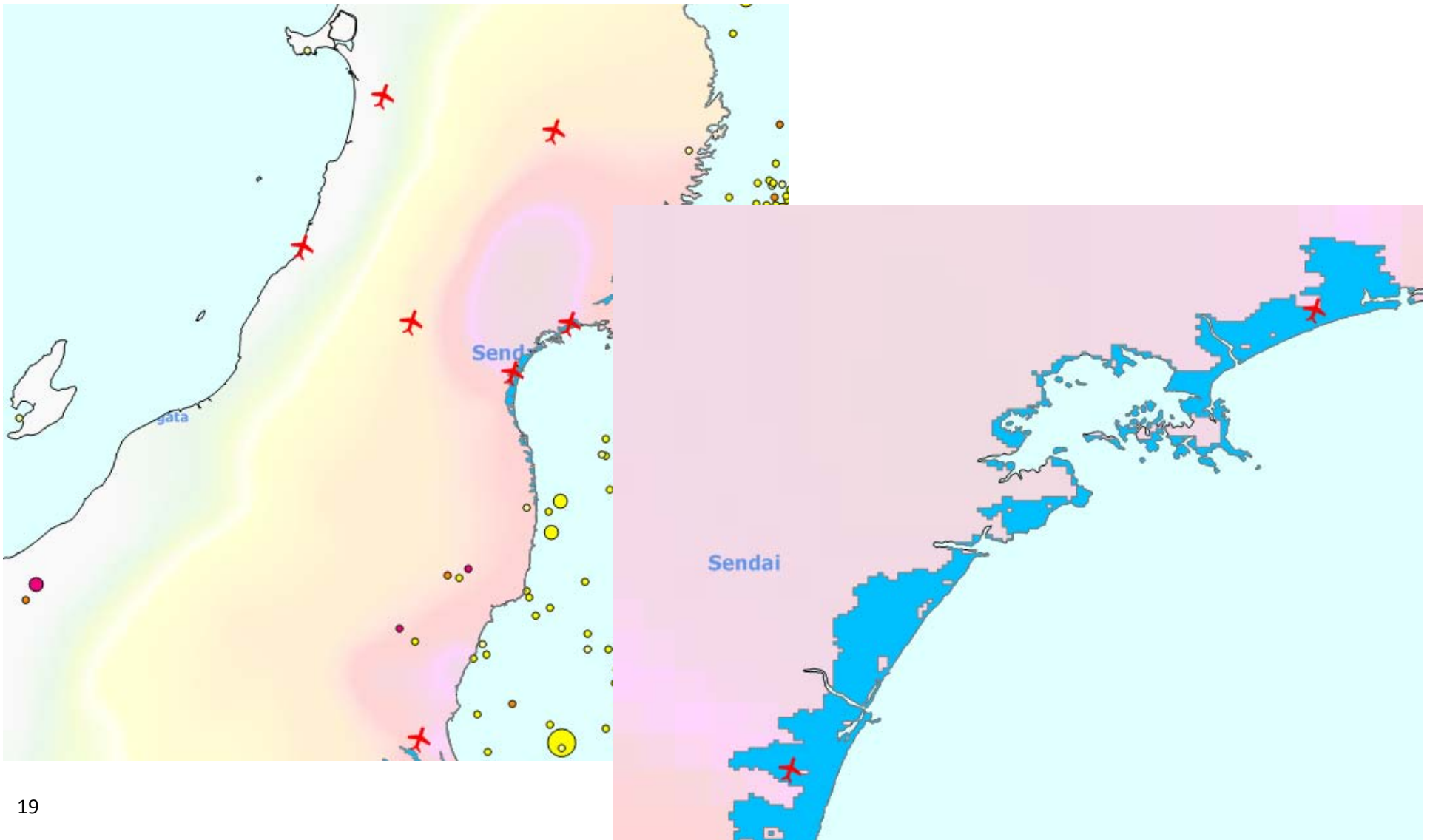
- Expressways repaired rather quickly
- coastal routes generally in service
- US tsunami susceptible routes?



Research Opportunities

- selected case studies of tsunami forces on bridges
- scouring of pavement
- economic impact due to loss of transport

Transport – Airports 1



Transport – Airports 2



Transport – Airports

Observations

- National air traffic disrupted
- Sendai airport, regional hub, shut for a month

Implications

- air traffic restored quickly
- airport on shore – NRT, KIX, SFO, LAX, JFK, LGA...

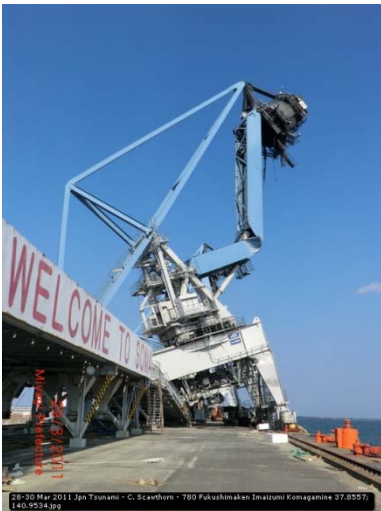
Research Opportunities

- selected case studies of tsunami effects on air terminals, hangers, appurtenances
- scouring of runway pavement
- economic impact due to loss of transport

Transport - Ports

Observations

- Shipping – Port of Sendai, Ishinomaki, Soma, Hitachinaka all significantly damaged
- about 7% of port capacity down for a significant period
- impacts on supply chain
- Fishing – 19,000 fishing boats destroyed



Ports - Fishing



Damaged Vessels

Name	DWT
Drilling ship Chikyu	27161
Coral Ring	75395
Shirouma	77739
Shiramizu	91439
C. S. Victory	32385
Chinasteel Integrity	175775
Asia Symphony	6175
Glovis Mercury	6901
Khrizolitoviy	523
Koshin Maru	1592
Emu Arrow	51800
Total	546885



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Transport - Ports

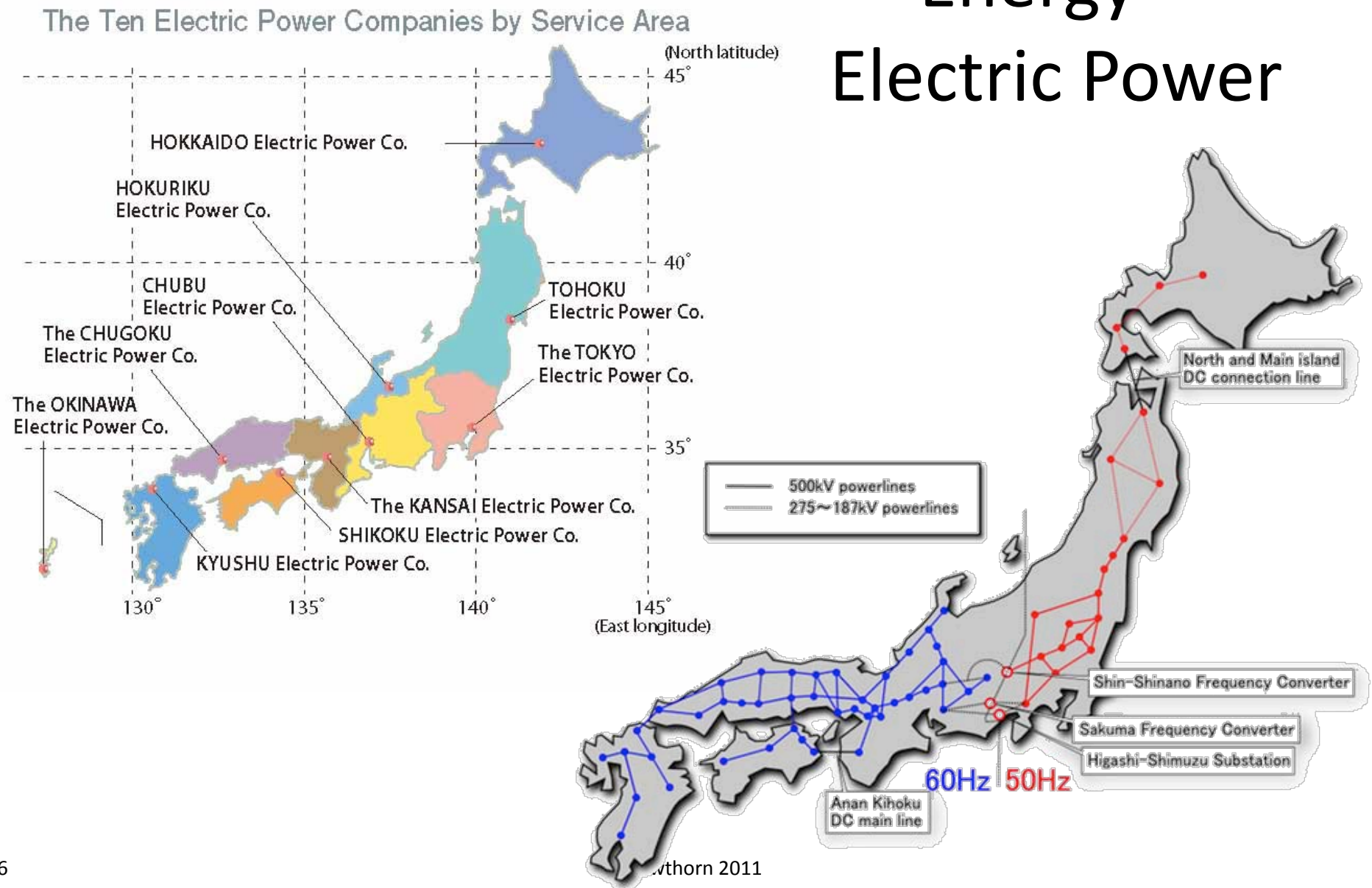
Implications

- major damage to ports, warehouses
- fishing boats: 19,000 destroyed (37% EJ) \$ 2 ~ 5 billion ? (insured?)
- 45% of fishing ports E. Japan destroyed
- Next tsunami – Ports Nagoya, Kobe? LA/LB?

Research opportunities

- Data / quantify impacts on ports, by various sectors, types of traffic
- supply chain – resilience?
- broader regional economic impacts

Energy – Electric Power



Energy - Power

Observations

- in general, shaking had little effect
- tsunami affected some EHV substations, T&D, but major impact on generation stations
- 8 major fossil stations down
- the Fukushima NPP crisis
- 11 % national generation lost
- 'rolling brownouts' coming this summer



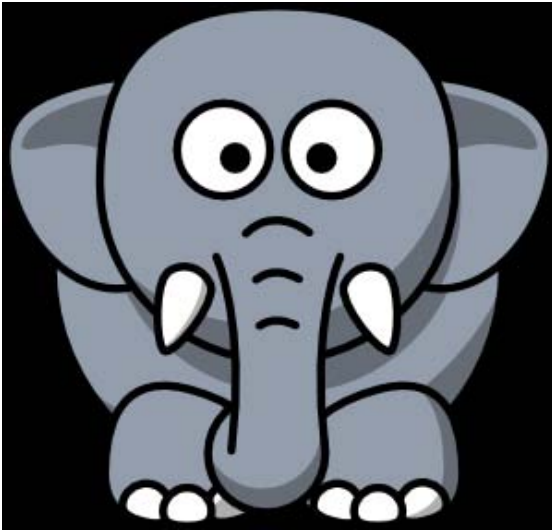
Energy - Power

Implications

- vulnerability of power stations in other locations – Tokyo, Nagoya, Osaka, LA/LB...
- economic impact of mid-term on-going shortages

Research Opportunities

- network analysis of power grids
- tsunami ‘proofing’ of waterside generating stations
- regional economic impacts of electric power disruption



Energy – Nuclear Power

JAPAN NEWS | APRIL 28, 2011, 10:24 A.M. ET

Tepco Postpones Daring Plan to Tame Nuclear Plant

By MITSURU OBE

TOKYO—Officials postponed a plan to ramp up efforts to cool nuclear fuel at the stricken Fukushima Daiichi nuclear complex amid concerns that the use of thousands of additional metric tons of water could result in dangerous leaks.



Telcom

Observations

Generally did well – even most cell towers survived
However, early response hampered by saturation

Implications

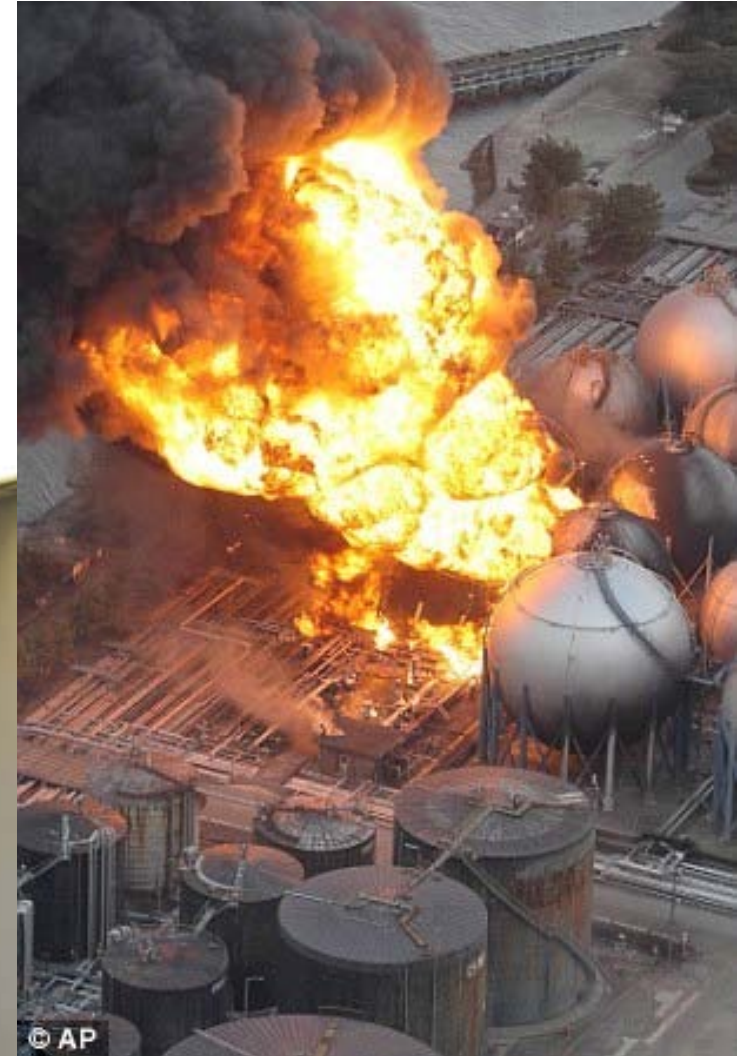
Communication, communication, communication

Research Opportunities

What is or who has the best system?



Fire following earthquake



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大島

気仙沼港

鹿折川

Fire following earthquake

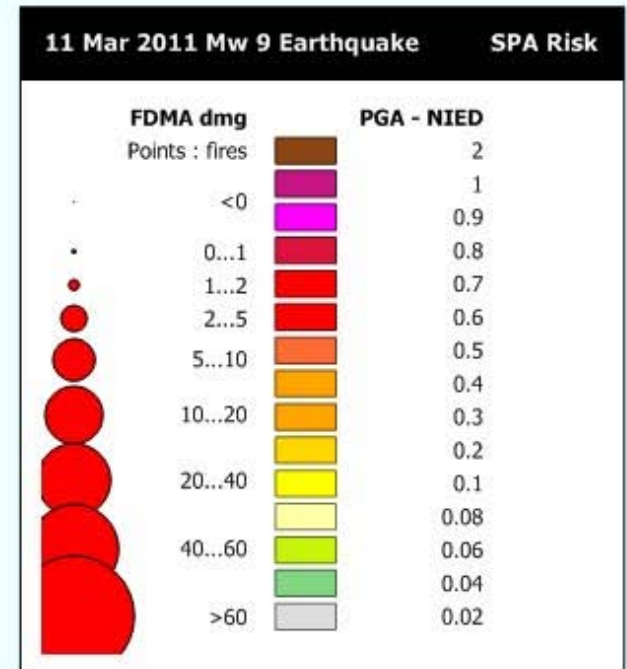
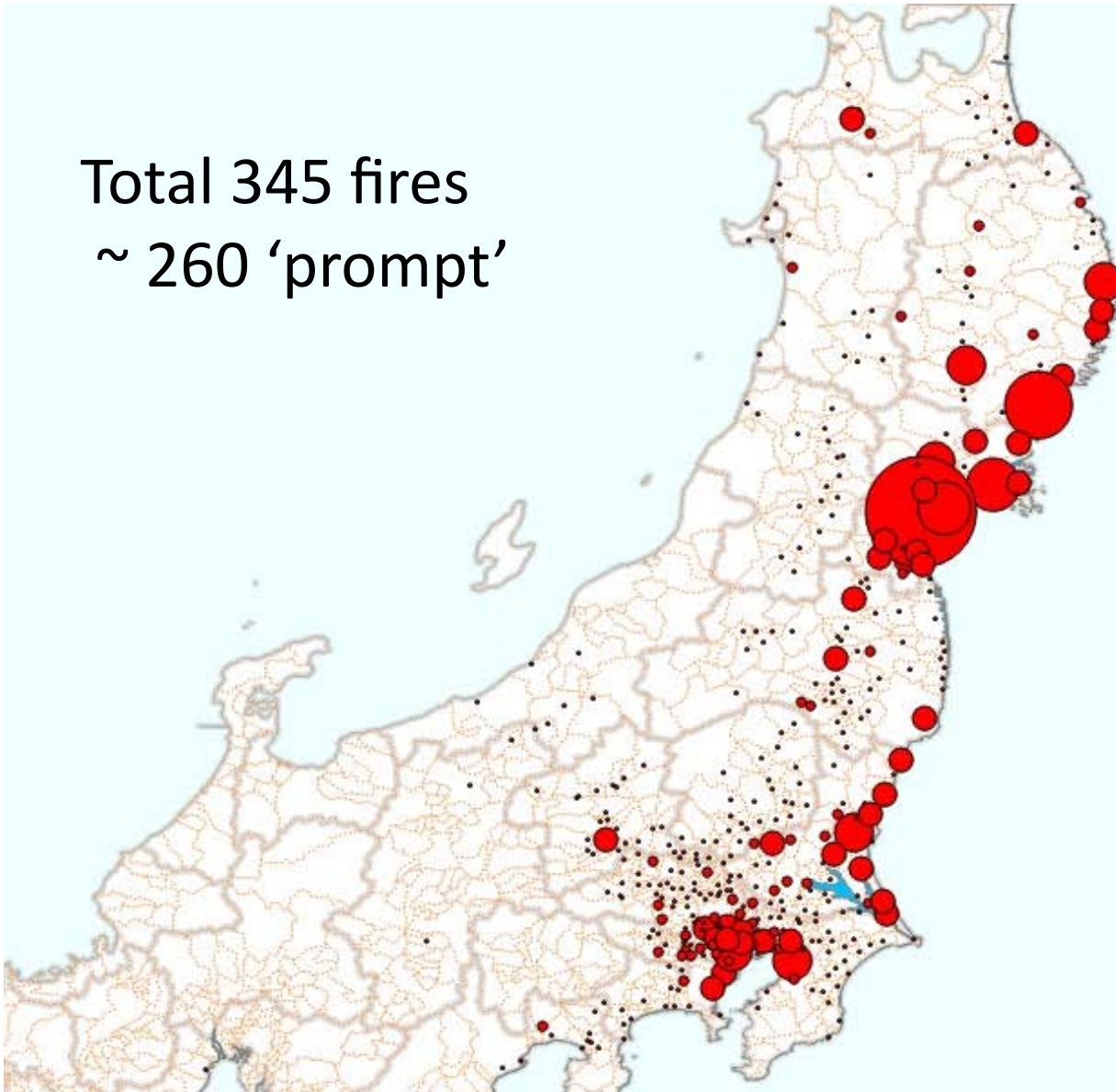


Fire following earthquake

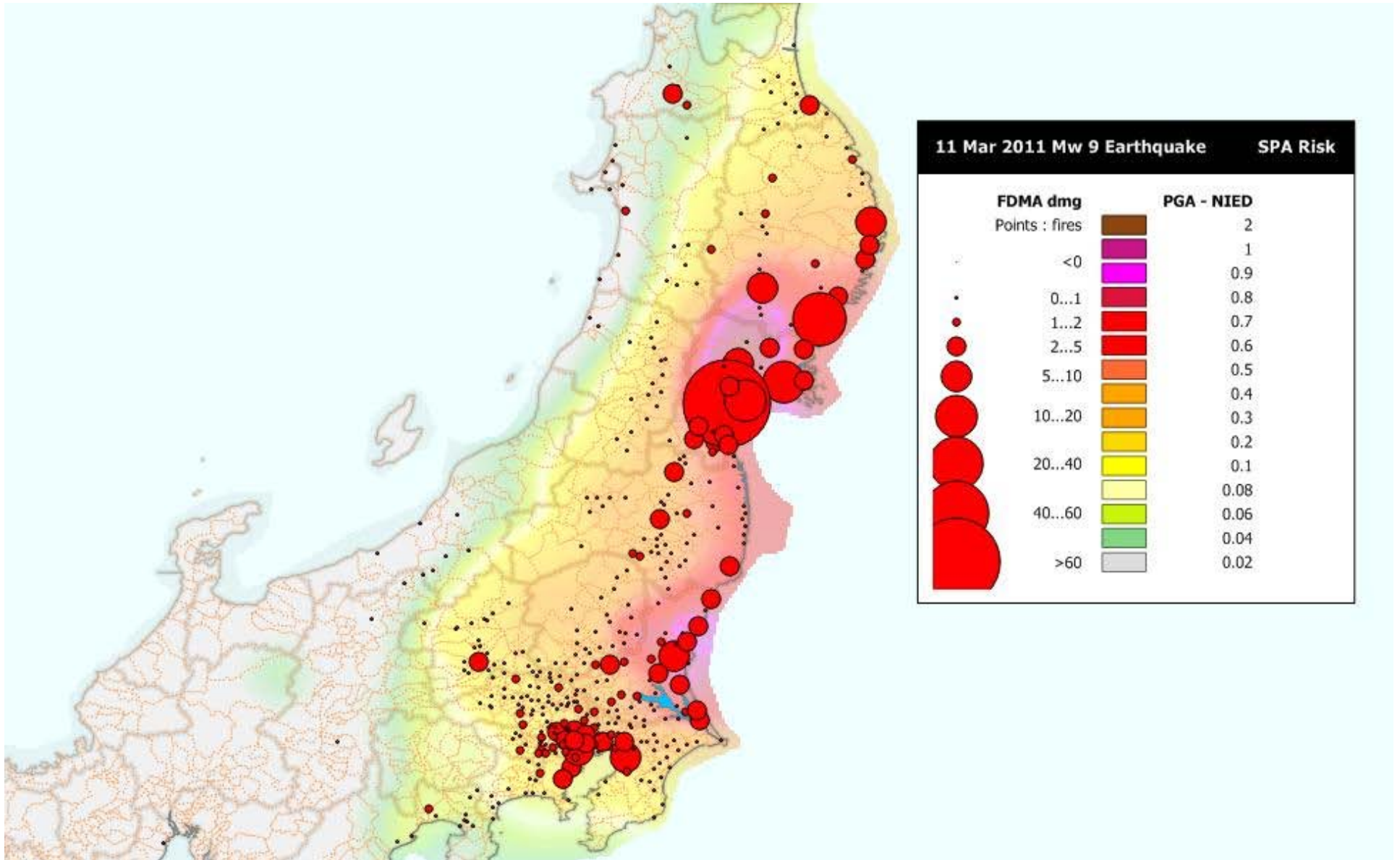


Fire following earthquake

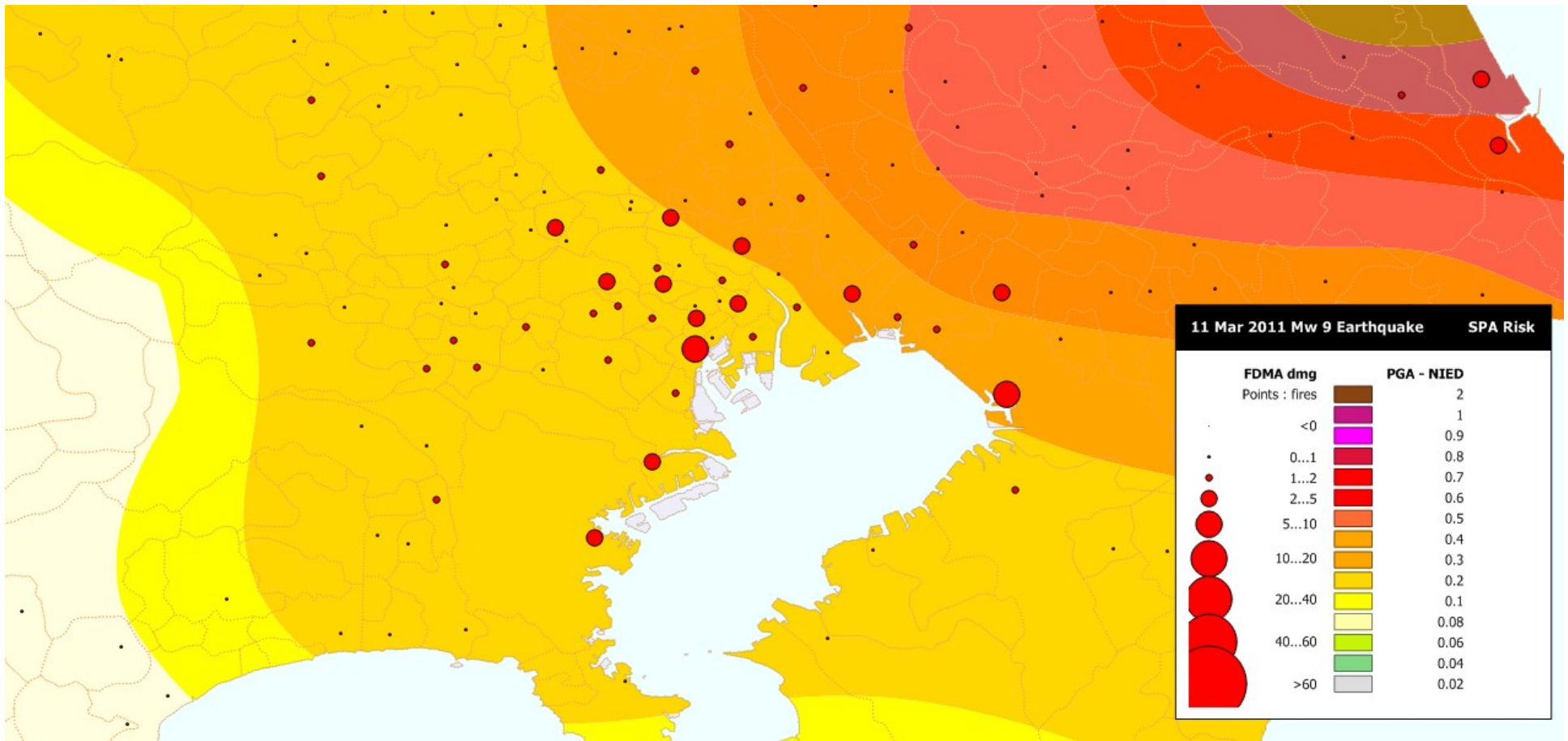
Total 345 fires
~ 260 'prompt'



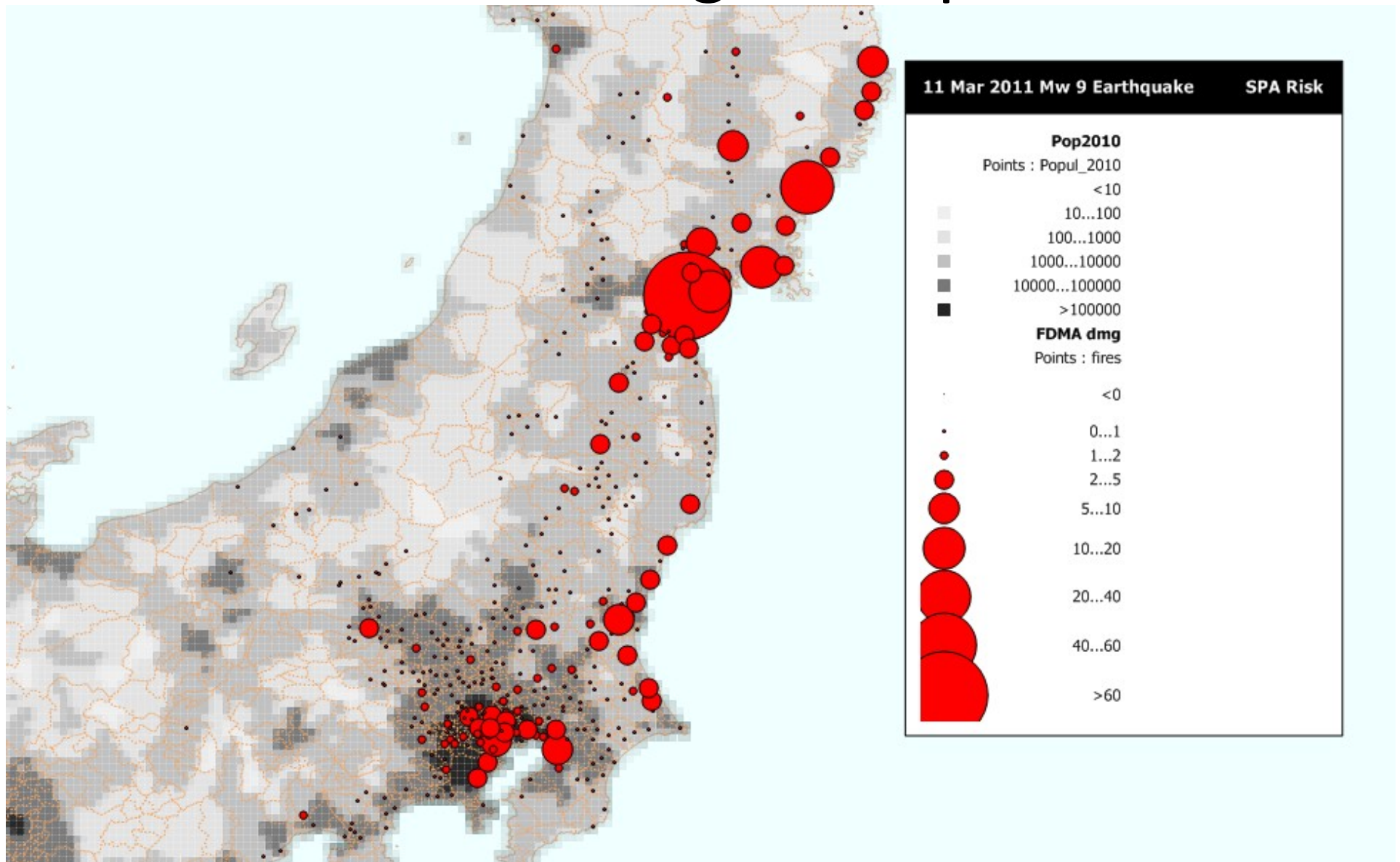
Fire following earthquake



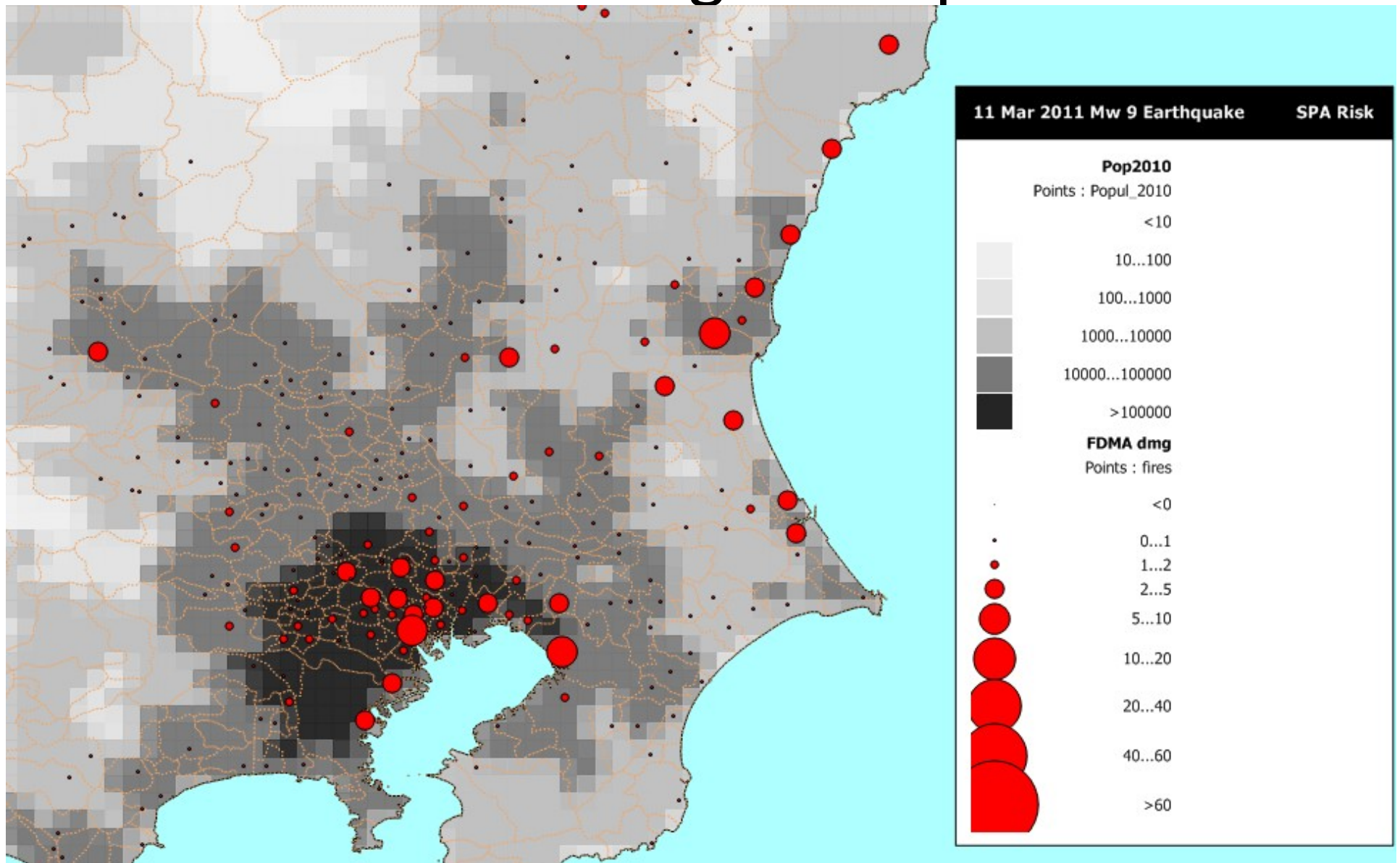
Fire following earthquake



Fire following earthquake



Fire following earthquake



Fire following earthquake



Fire following earthquake

Observations

- ~345 fires following earthquake, due to both shaking and tsunami
- several urban conflagrations
- two major oil refinery fires (1 shaking, 1 tsunami)
- LPG Tank cars scattered by tsunami
- 30+ ignitions in Tokyo

Implications

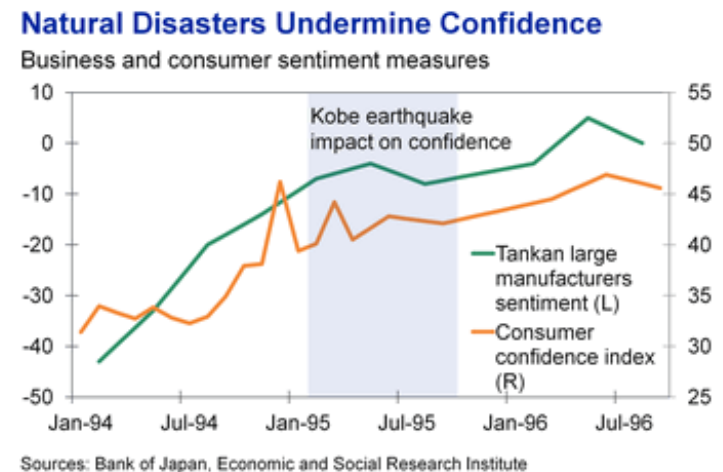
- Japan, US very vulnerable to fire following earthquake
- refineries in LA / LB and SFBA

Research Opportunities

- Tohoku ignitions >> all previous ignitions
- Get the data! Digest / understand it! Applicable to US?
- impacts of loss of water supply
- fire department response?

Economic Aspects

- Current estimate \$300 billion → \$500 billion loss
(3~5x previous disaster, one current estimate \$470 billion)
- 60~70% of businesses in region affected
- ~4% GDP ~ Kobe but much wider area (infrastructure effect greater)
- impacts on the Japanese economy? The global economy?
 - Toyota can't meet production in US
 - Casio will not meet production goals....
- modification of just in time production
- fiscal strains on Japan



Thank you

Questions?

cscawthorn@berkeley.edu

