



# ESTIMATING LOSSES DUE TO EARTHQUAKES

Max Wyss

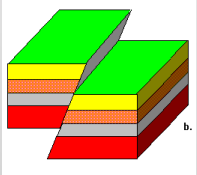
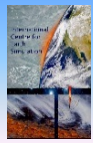
ICES (International Centre for Earth Simulation) Foundation

Nonprofit Organization, Geneva

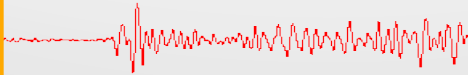
[www.icesfoundation.org](http://www.icesfoundation.org)



## The steps in calculating earthquake losses



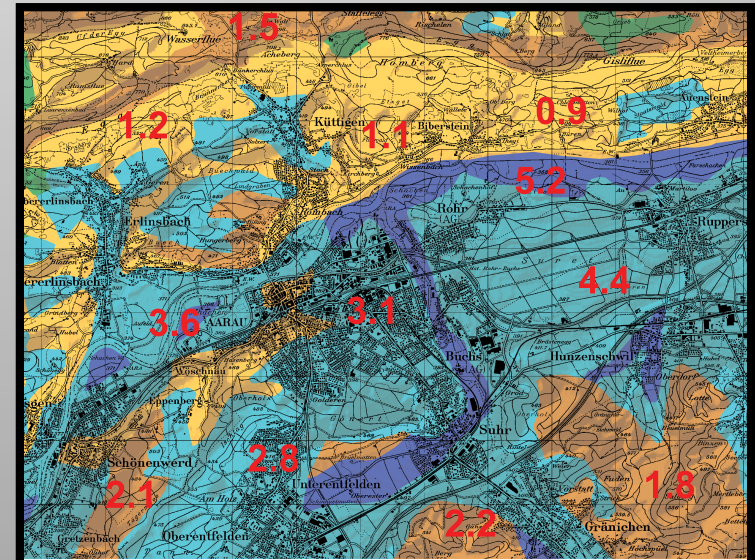
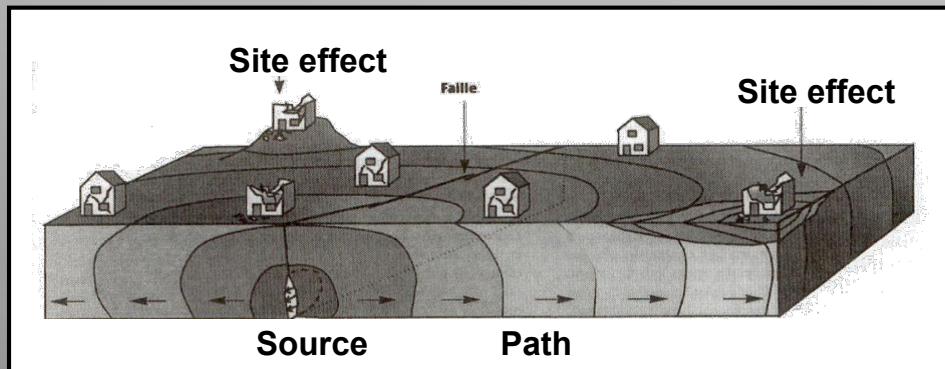
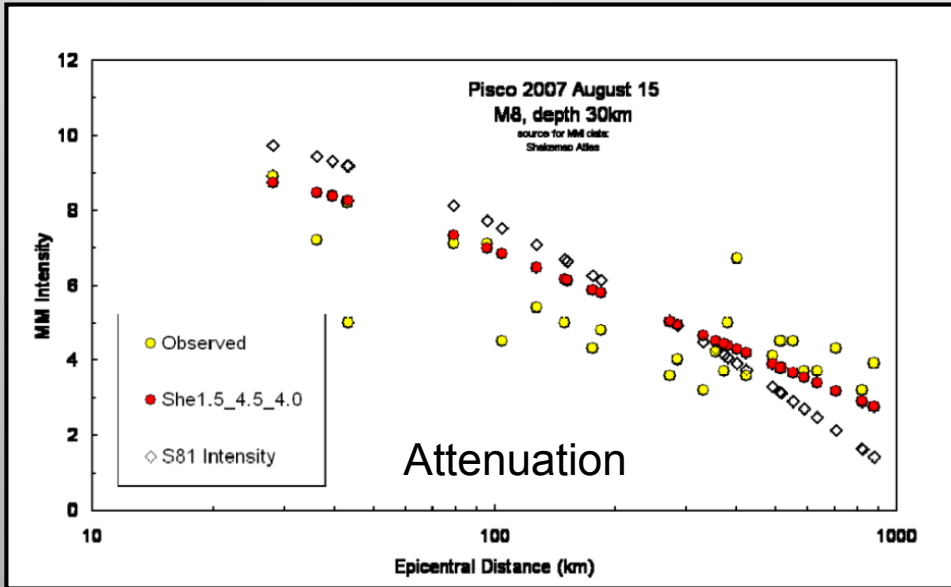
Earthquake

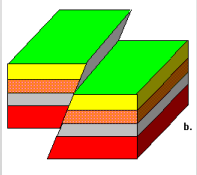


Accurate parameters: X, Y, Z, M

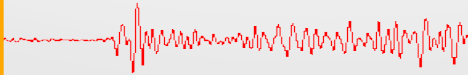


Earth transmission properties: ground motion





Earthquake



Accurate parameters: X, Y, Z, M



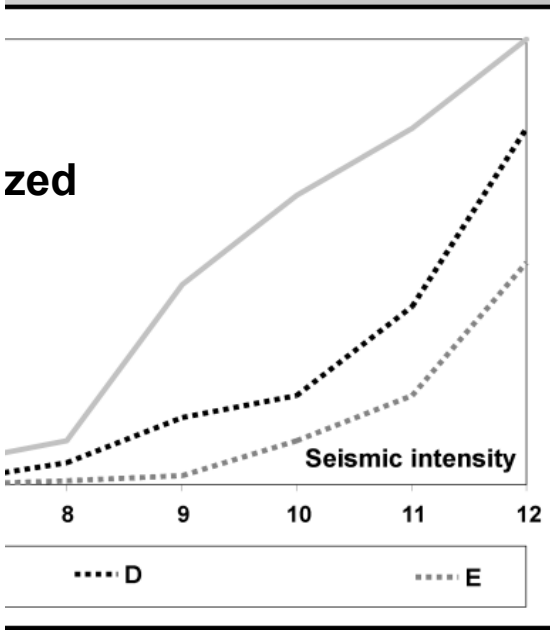
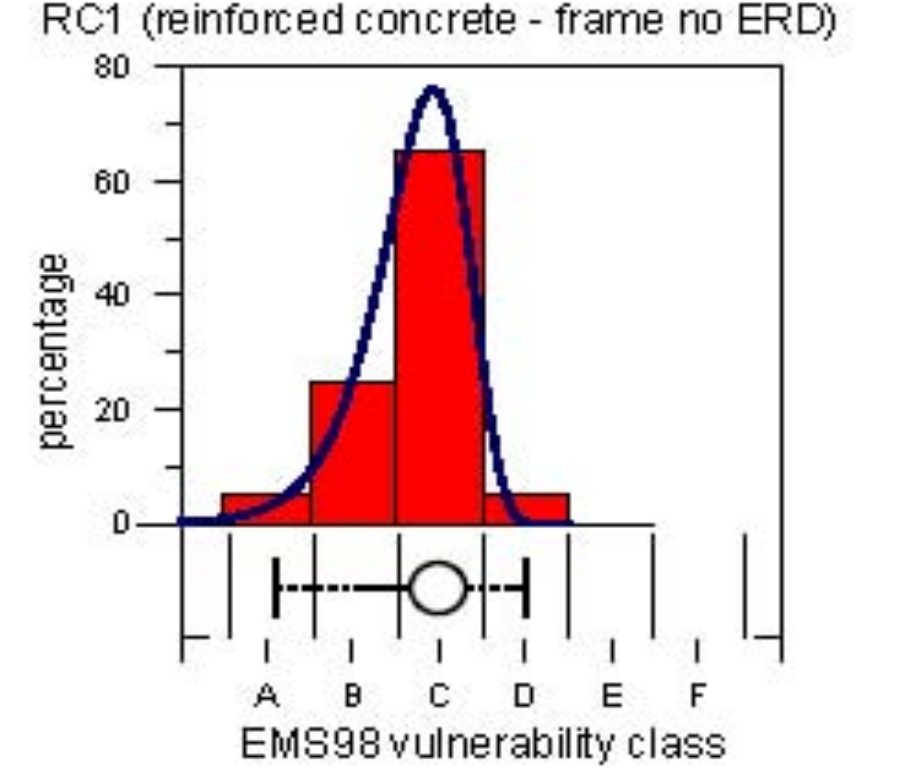
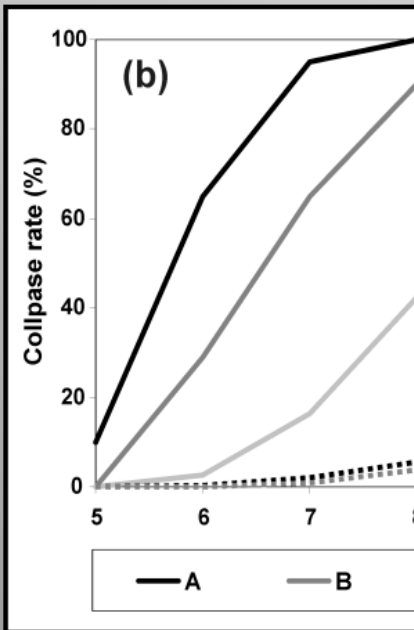
Damage to buildings

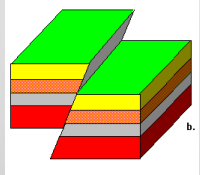
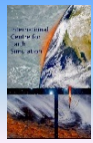


Building fragility data base

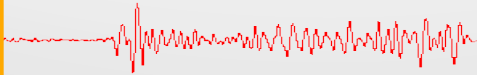


Earth transmission properties: ground motion





**Earthquake**



**Accurate parameters: X, Y, Z, M**



**Damage to buildings**



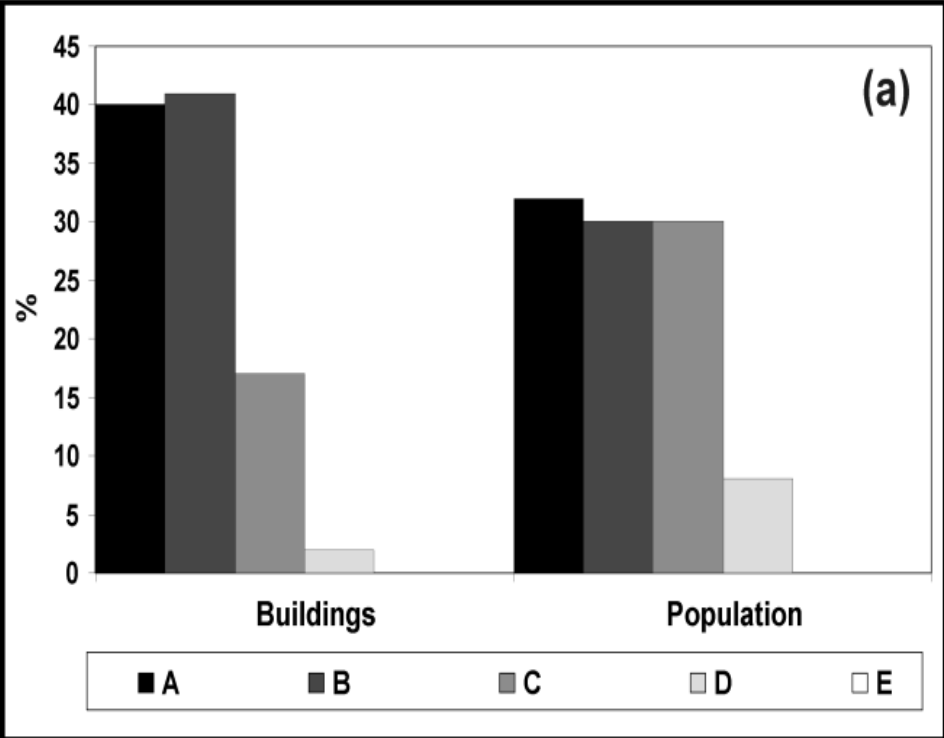
**Building fragility data base**

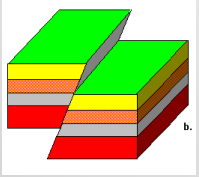


**Earth transmission properties: ground motion**



**Population data base**





Earthquake



Accurate parameters: X, Y, Z, M



Damage to buildings



Building fragility data base



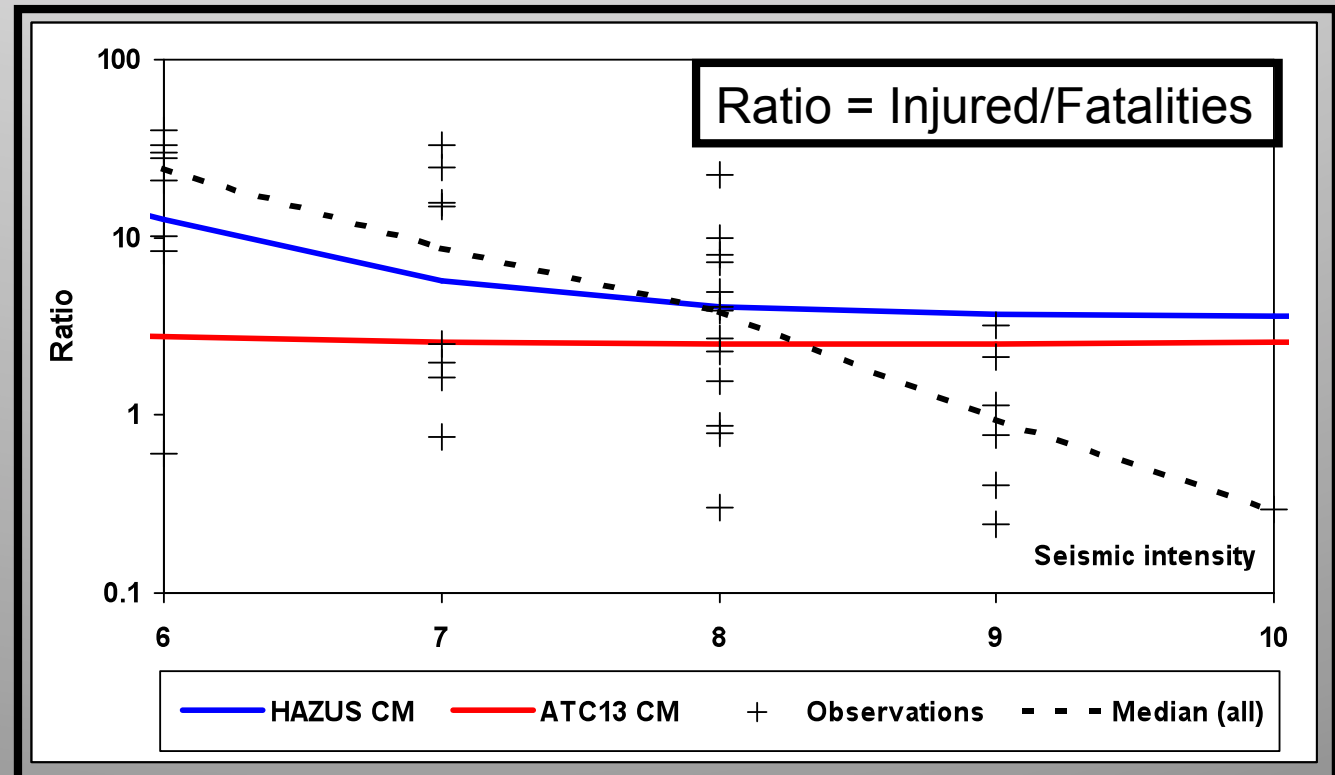
Earth transmission properties: ground motion

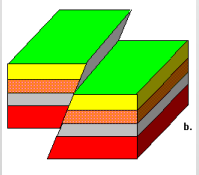


Population data base



Casualty Matrix





**Earthquake**



**Accurate parameters: X, Y, Z, M**



**Damage to buildings**

**Building fragility data base**

**Earth transmission properties: ground motion**

**Population data base**

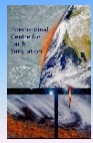
**Estimated Results:**  
➤ **Building damage**  
➤ **Number of fatalities**  
➤ **Number of injured**

**THE JOB OF QLARM**

**Responsible Government Rescue Agency:**  
➤ **mobilizing (yes/no)**  
➤ **offer of help (yes/no)**

**Disaster Manager:**  
**Mitigate or accept help (yes/no)**

**Prevent or help injured**



## Real time loss estimates

Provided

Map of mean damage expected in settlements (2 million worldwide)

Estimate of number of fatalities

Estimate of number of injured

Map of shaking intensity

List of nearby airports with shaking intensity

Missing

Schools and hospitals

Critical facilities

\$ Losses





# QLARM real-time output



## Earthquake Loss Estimate

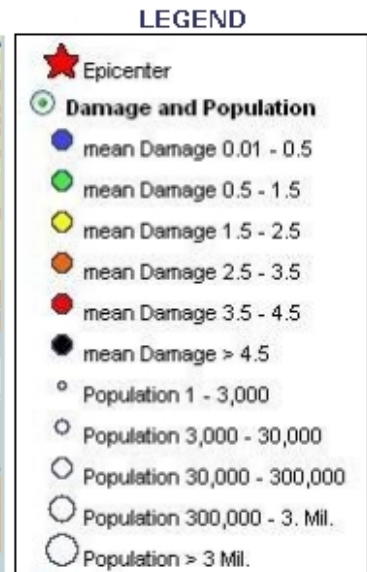
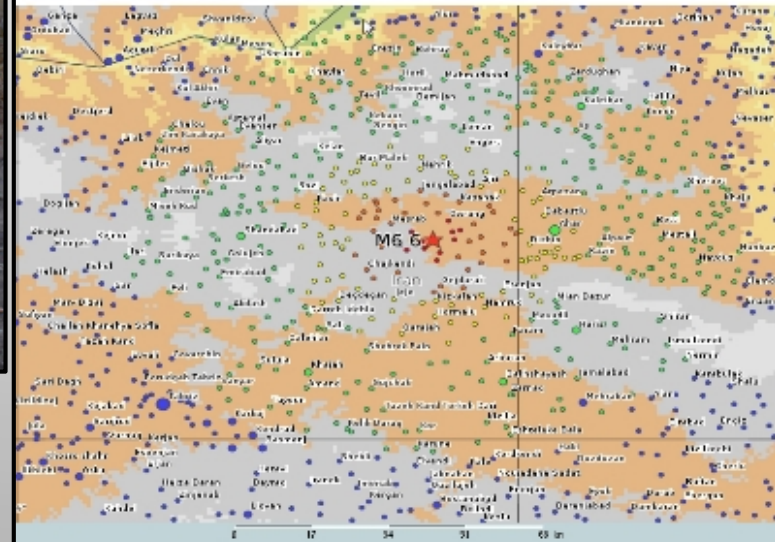
The following Earthquake has been Reported:

Date: 2012/08/11 12:34:36 6  
Region: IRAN  
Latitude: 38.45 N  
Longitude: 46.83 E  
Magnitude: 6.6 M  
Depth: 10 km  
Source: GFZ

**ESTIMATE OF HUMAN LOSSES**  
Injured Exp. min/max: 400/3000  
Fatalities Exp. min/max: 100/500



### MAP OF MEAN DAMAGE BY SETTLEMENT



If you wish to receive alerts, sign up at [www.icesfoundation.org](http://www.icesfoundation.org)

**REMARKS:** SECOND MESSAGE REGARDING THIS EARTHQUAKE; calculated with the GFZ epicenter and magnitude. However, the EMSC gives M6.1, thus the first loss estimate sent a few minutes ago may be more accurate.

### ESTIMATED EXPOSURE

Intensity	Population
V	2130086
VI	223293
VII	145919
VIII	34509
IX	6132
X	
XI	
XII	

6 Nov 2015



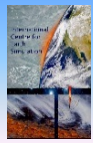
[www.wapmerr.org](http://www.wapmerr.org)



## CONCLUSIONS REAL-TIME ALERTS

Usually we estimate fatalities correctly within a factor of 2 in 30 minutes

Error sources are omnipresent and errors do happen

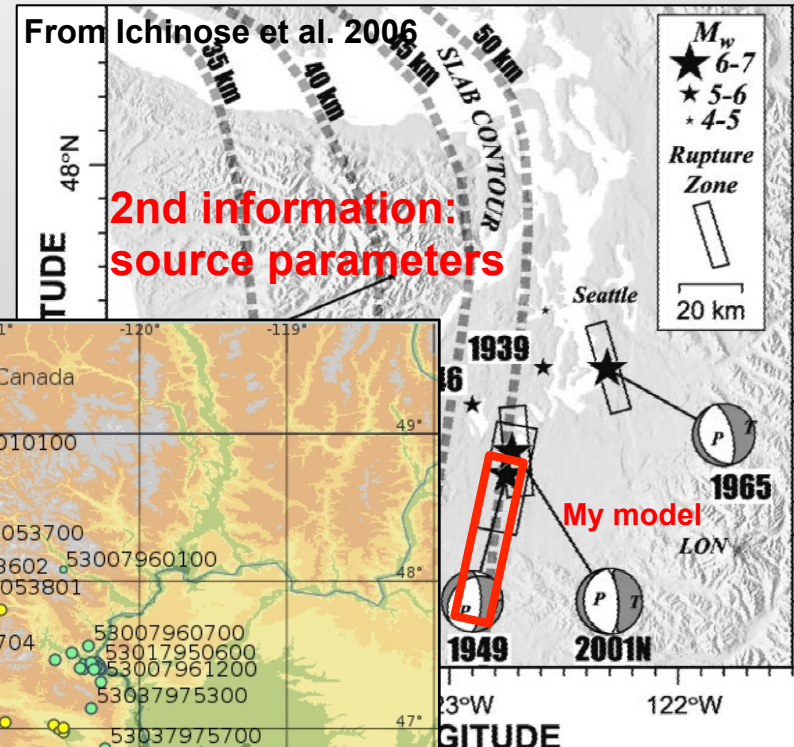
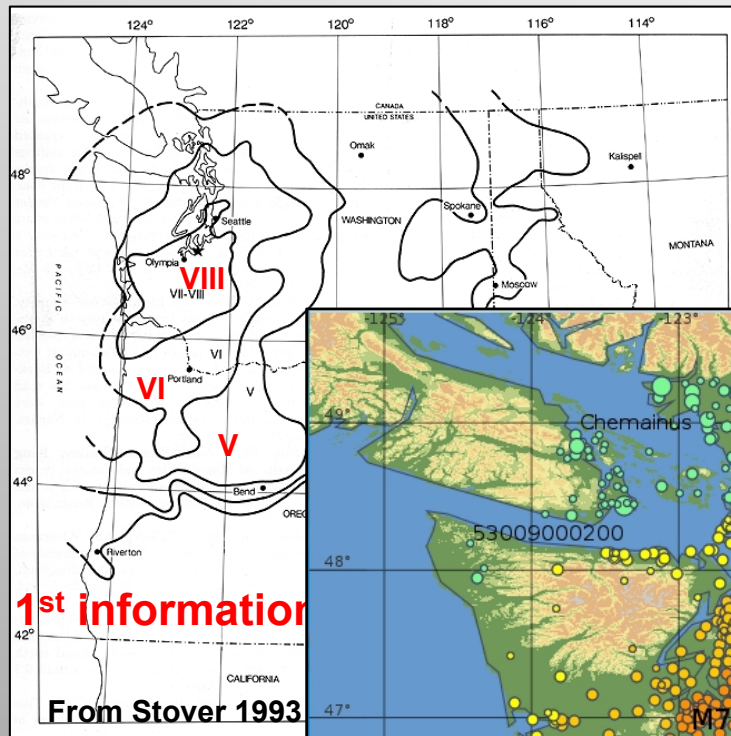


# Scenario loss estimates



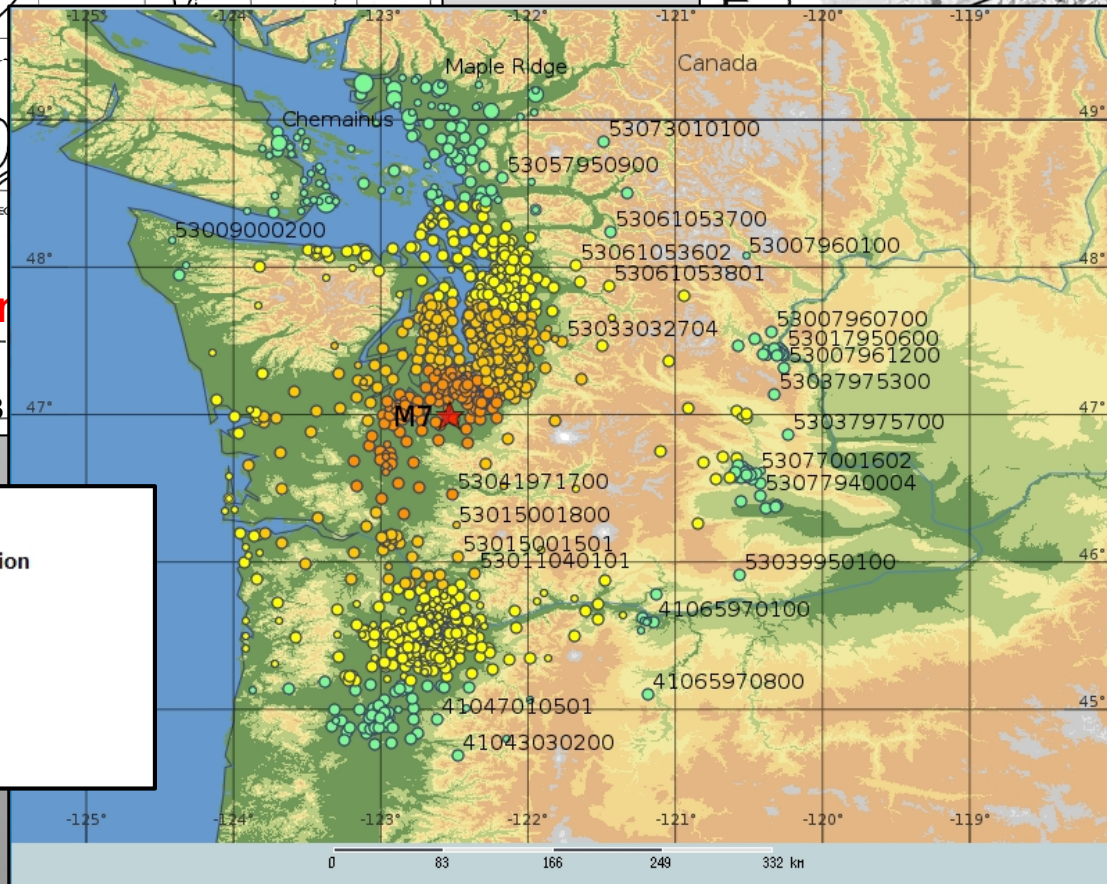
# Verifying QLARM for a country

Example: Cascadia earthquake 1949 M7



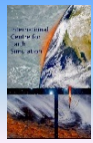
- ★ Epicenter
- Damage and Population
- Intensity EMS-98
- V - Rather Strong
- VI - Strong
- VII - Very Strong
- VIII - Destructive

6 Nov 2015



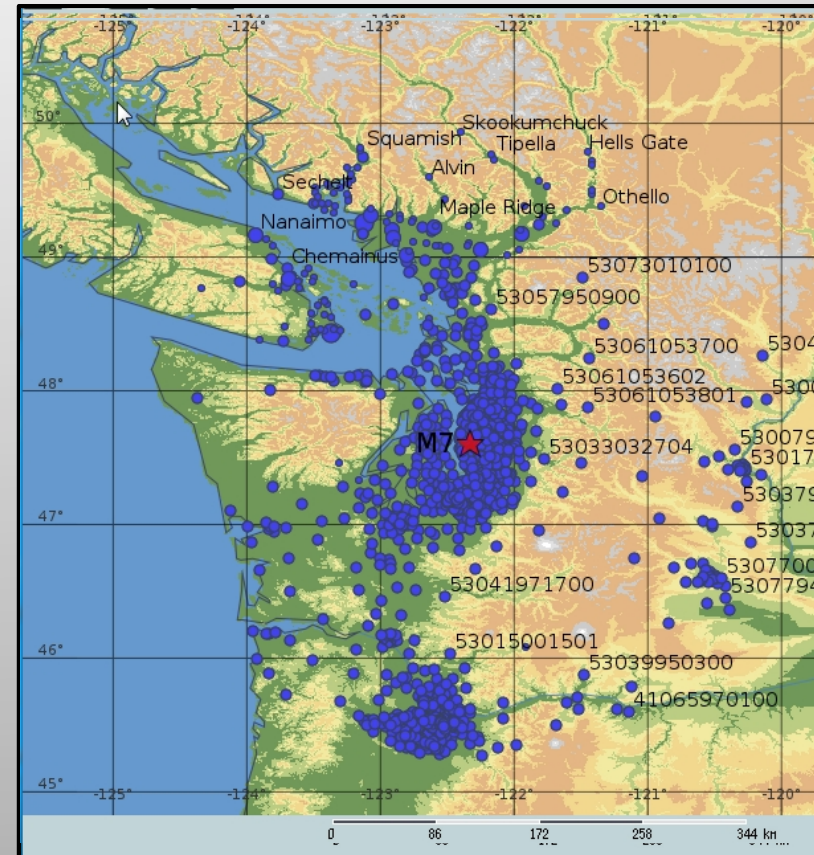
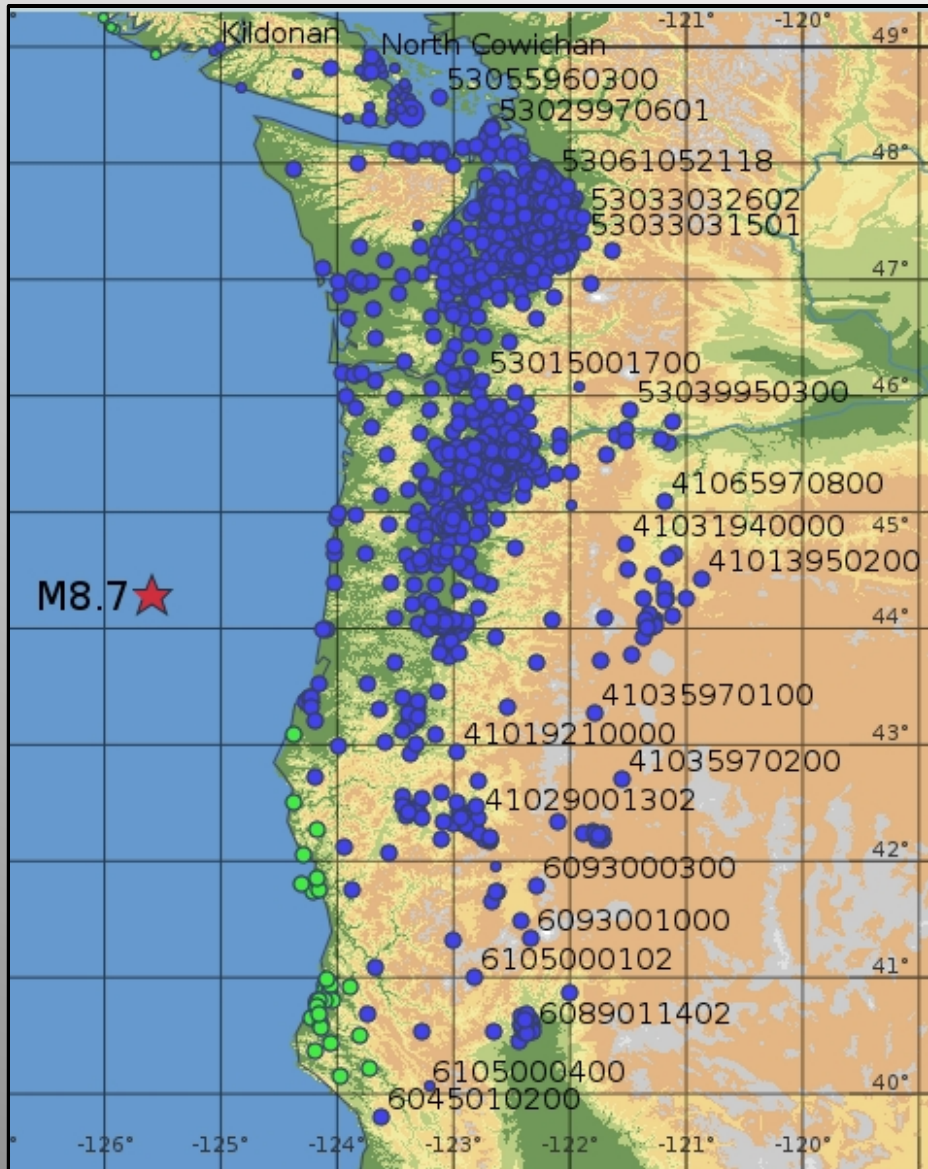
in Z, position X & Y

Verification:  
Using information (2)  
I must match info (1)

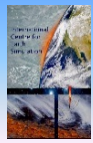


# Deterministic Loss Scenarios

# Examples: Cascadia



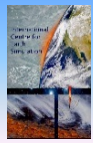
Hypothetical intensity calculations  
 Damage is moderate,  
 \$ losses substantial  
 Human losses minor

**Expected Deaths due to Hypothetical Earthquakes in the Himalaya (Wyss, March, 2005)**

	Location.	Lat. (deg.)	Lon. (deg.)	Depth (km)	M	Expected Deaths (thousand)	Number Injured (thousand)	No Settle I ≥ 7	No Settle I ≥ 5
1	Assam	27.8	92.3	25	8.1	24 - 49	52 - 99	160	1900
2	Bhutan	27.3	89.5	25	8.1	76 - 151	163 - 274	270	2500
3	<b>Katmandu</b>	28.1	84.2	25	8.1	21 - 42	45 - 86	330	2600
4	W. Nepal	28.7	81.8	25	8.1	11 - 22	24 - 53	370	2800
5	Garhwal	29.7	79.6	25	8.1	58 - 115	125 - 230	380	3000
6	Dehra Dun	30.7	77.7	25	8.1	96 - 199	210 - 433	450	3300
7	<b>Kashmir</b>	33.0	75.0	25	8.1	67 - 137	146 - 293	550	4000

**Reported Fatalities due to M7.6 Kashmir Earthquake of October 2005: 85,000**

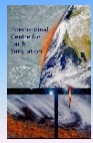
**Reported Fatalities due to M7.8 Gorkha Earthquake of April 2015: 10,000**



## DSIRABLE INITIATIVES

There are many known ways to improve the estimates:

- Location and type of schools
- Location and type of health facilities
- Location and type of critical facilities
- Location and number of seasonal tourists
- **Open Street Map crowdsourcing: location, type number of buildings**
- **Tandem InSAR satellites: Building heights to within  $\pm 3$  m**
- Adding values of dwellings, office and industrial buildings for *\$ loss estimates*
- Add soil conditions for estimating amplification
- Refining housing properties (especially regional variations)
- Updating world population
- Calculating losses due to tsunami (large separate project, but exists)
- Calculating losses due to flooding
- Calculating losses due to forest fires
- Landslides



Thank you for your attention

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