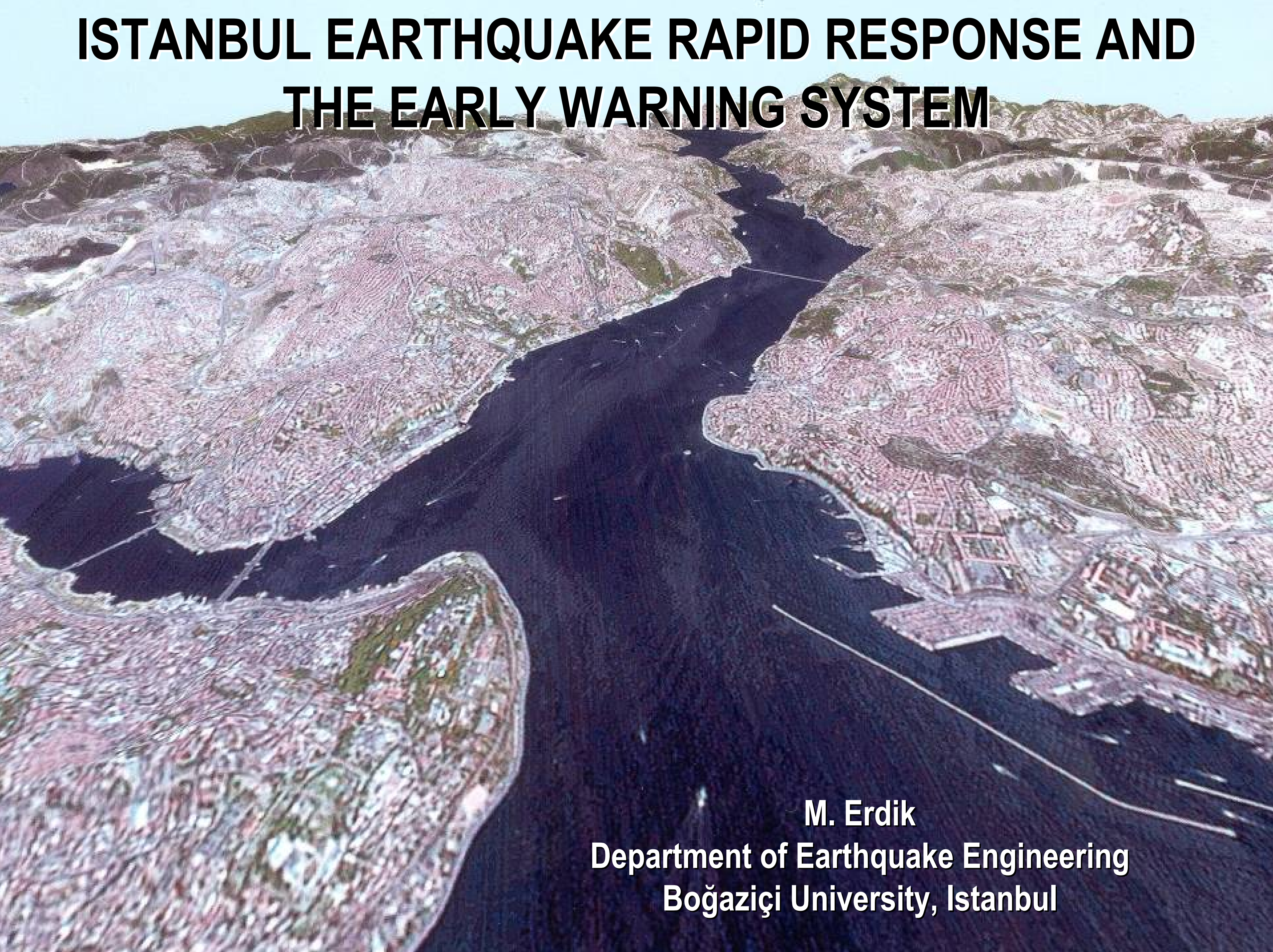
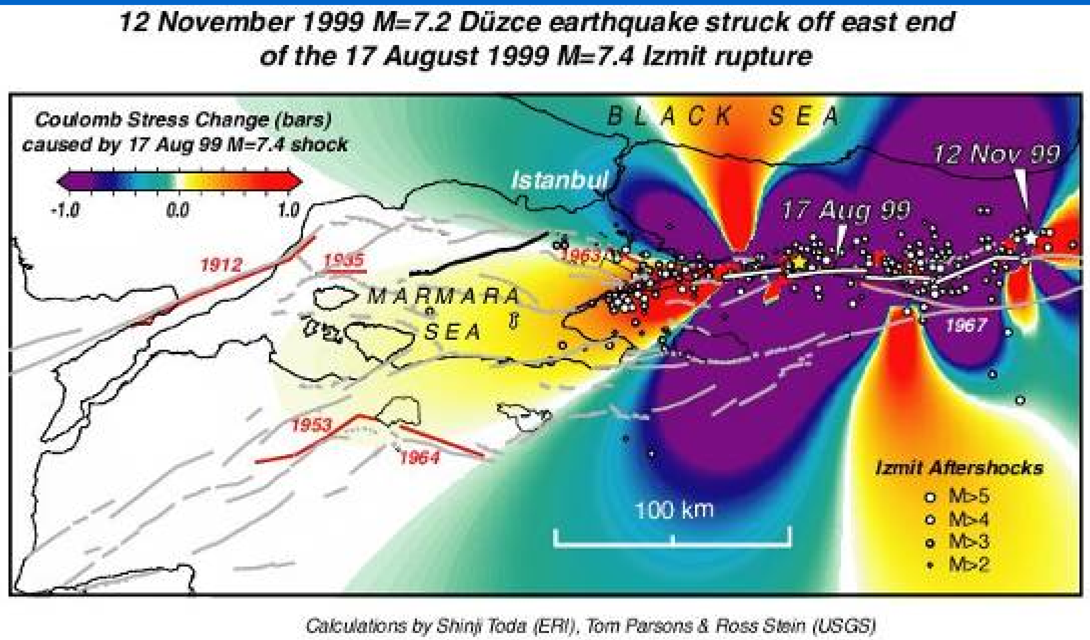
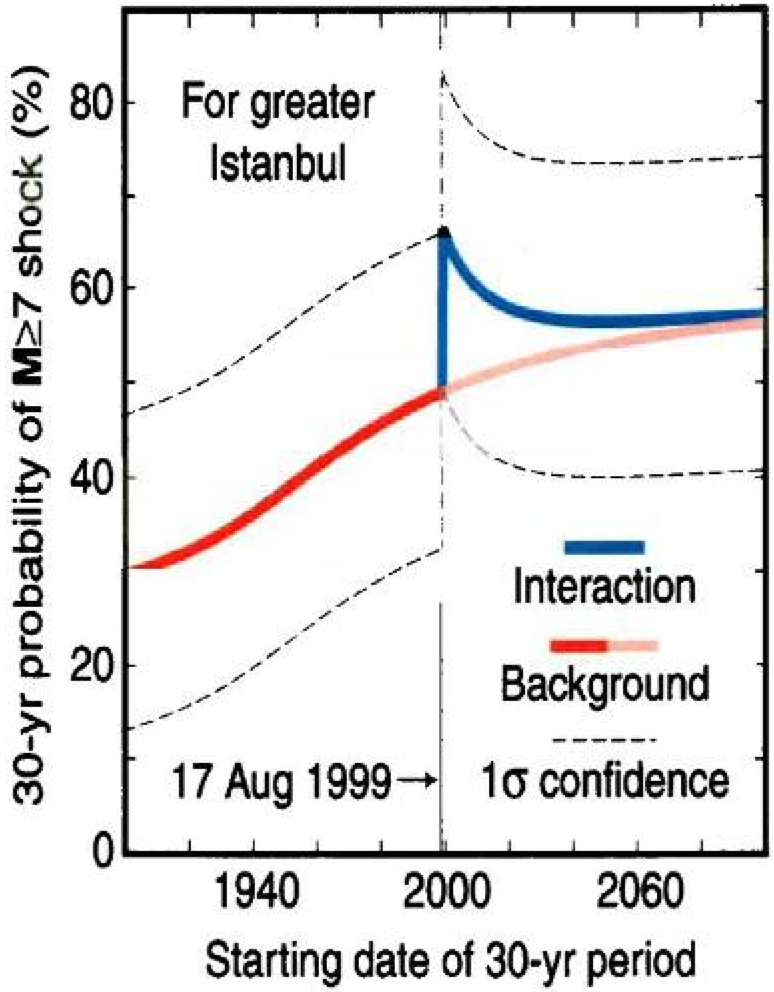
ISTANBUL EARTHQUAKE RAPID RESPONSE AND THE EARLY WARNING SYSTEM



M. Erdik
Department of Earthquake Engineering
Boğaziçi University, Istanbul

ISTANBUL THREATENED BY MAIN MARMARA FAULT





ROBABILITY OF OCCURRENCE OF A Mw=7.0+ EARTHQUAKE IN MARMARA SEA (CREATING MMI=VIII+ INTENSITY IN ISTANBUL) IS 65% IN THE NEXT 30 YEARS (Parsons et al., 2000).

Similar probabilities exist for San Francisco, however from about 7 different faults. Roger Creek and San Andreas faults contribute respectively 32% and 21% each.

Istanbul Earthquake Rapid Response and Early Warning System is designed and operated by Bogazici University with the logistical support of the Governorate of Istanbul, First Army Headquarters and Istanbul Metropolitan Municipality.

The construction of the system is realized by the GeoSig and EWE (Switzerland) consortium.

Communications are provided by AVEA GSM service provider.

One hundred (100+10) of the strong motion recorders are stationed in the Metropolitan area Rapid Damage information.

Ten (10+2) strong motion stations are sited as close as possible to the Great Marmara Fault for Earthquake Early Warning information.

60 strong motion recorders were placed on critical engineering structures.

The strong motion accelerographs utilized in the IRREW System have the following basic specifications:

Overall recording range: +/-2g
18-bit (dial-up stations) or 24-bit (on-line) resolution. The least significant bit (LSB) resolution is 0.015 mg.
On-site recording for 2 hours or more
GPS absolute time (UTC).
200 samples per second

All of the instruments were calibrated in the laboratory using a air-bed electro-magnetic shaker for calibration of the sensitivity constants of the sensors. Additional bi-directional tilt tests at site were conducted for confirmation.

Accelerograph

All of the instruments were calibrated in the laboratory using a air-bed electro-magnetic shaker. Additional bi-directional tilt tests at site were conducted during installation

IRREW System consists of the following components:

(1) Monitoring system composed of various sensors,
(2) Communication link (off-line for the Rapid Response and on-line for the Early Warning) that transmits data from the sensors to computers,
(3) Data processing facilities that converts data to information, and
(4) System that issues and communicates the rapid response information and early warning.

The **Rapid Response** part of the IRREW System is designed to satisfy the COSMOS (The Consortium of Organizations for Strong-Motion Observation Systems) Urban Strong-Motion Reference Station Guidelines for the location of instruments, instrument specifications and housing specifications.

For the location of instruments the results of deterministic earthquake hazard/risk assessment for Istanbul is used in consideration of

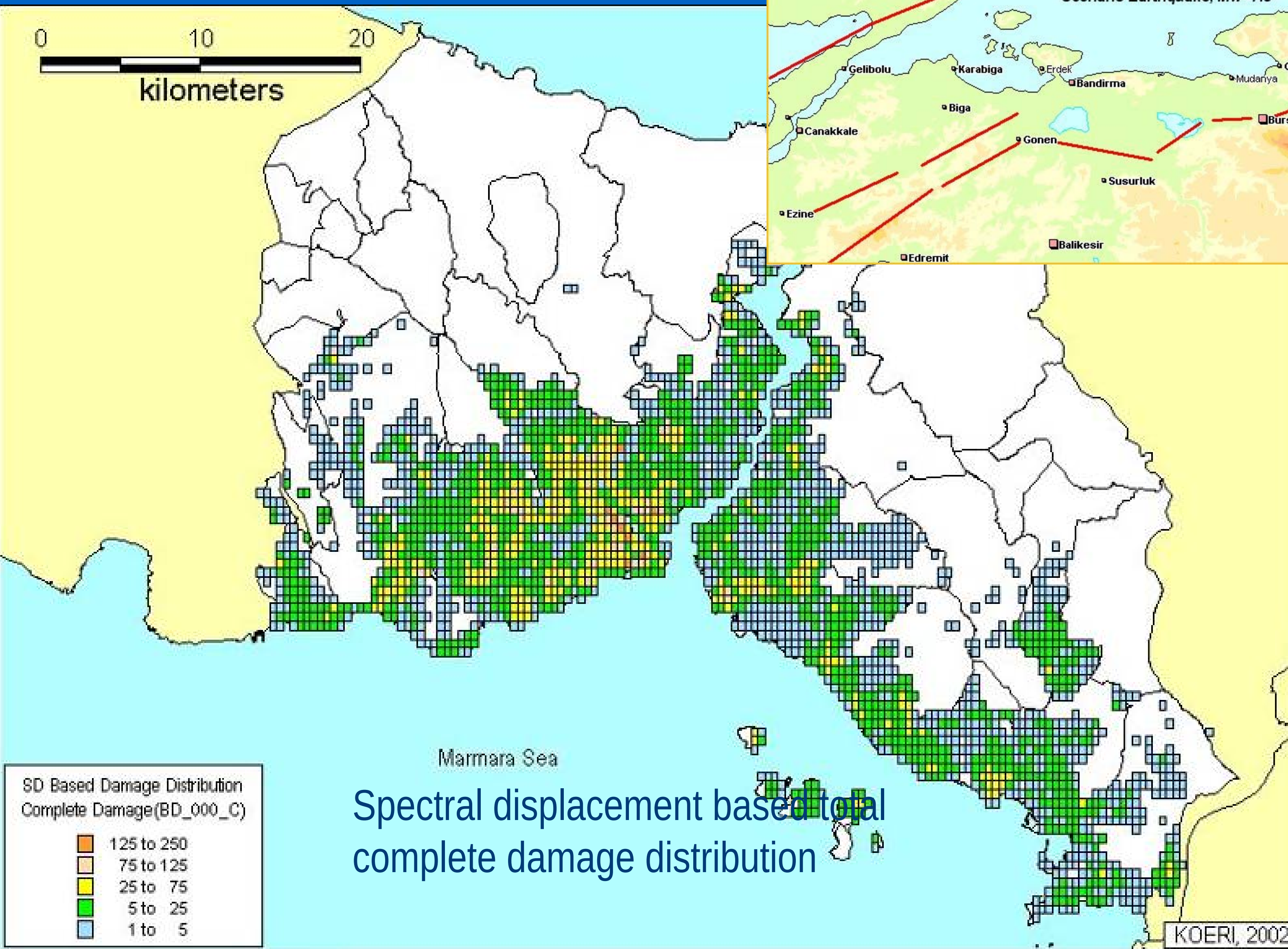
1. Highest likelihood of shaking (Short and Long Period),
2. High probability of damage (Damage Distribution Maps) and
3. High probability of casualties (Casualty Distribution Maps)

Other similar systems are:

READY (Real-time Earthquake Assessment Disaster System) - Yokohama

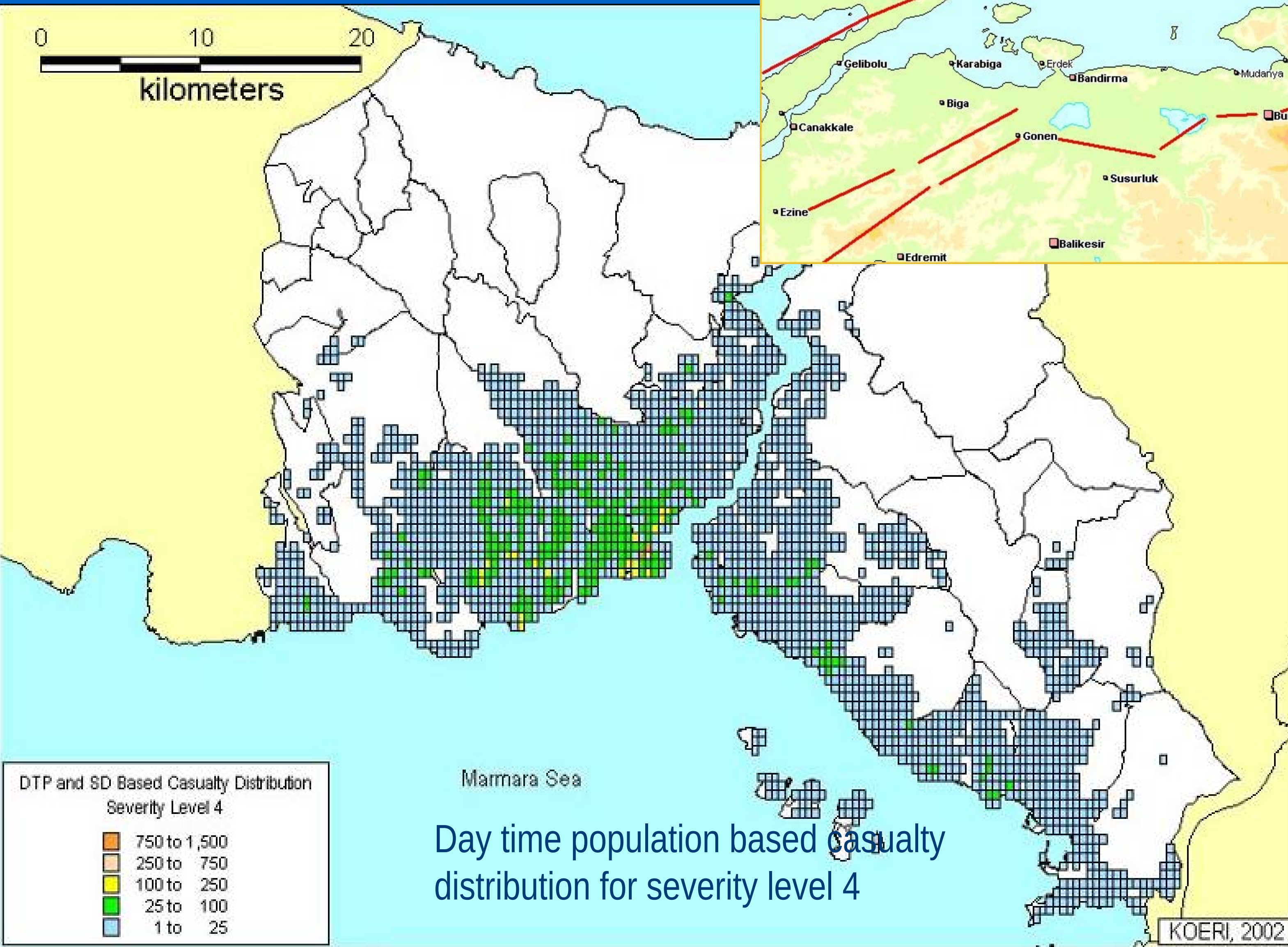
SUPREME - Tokyo Gas

SCENARIO EARTHQUAKE DAMAGE DISTRIBUTION MAP



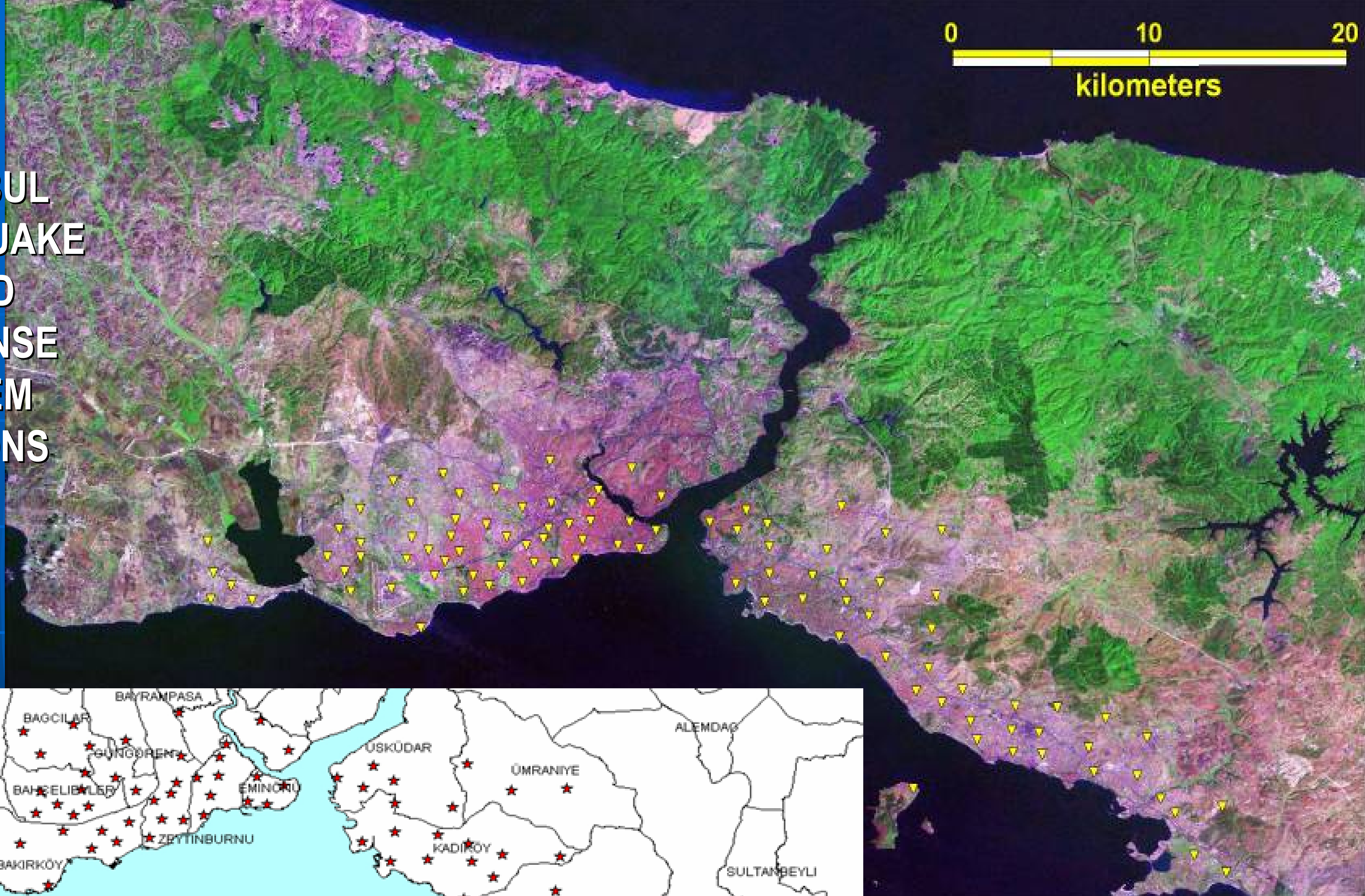
Spectral displacement based total complete damage distribution

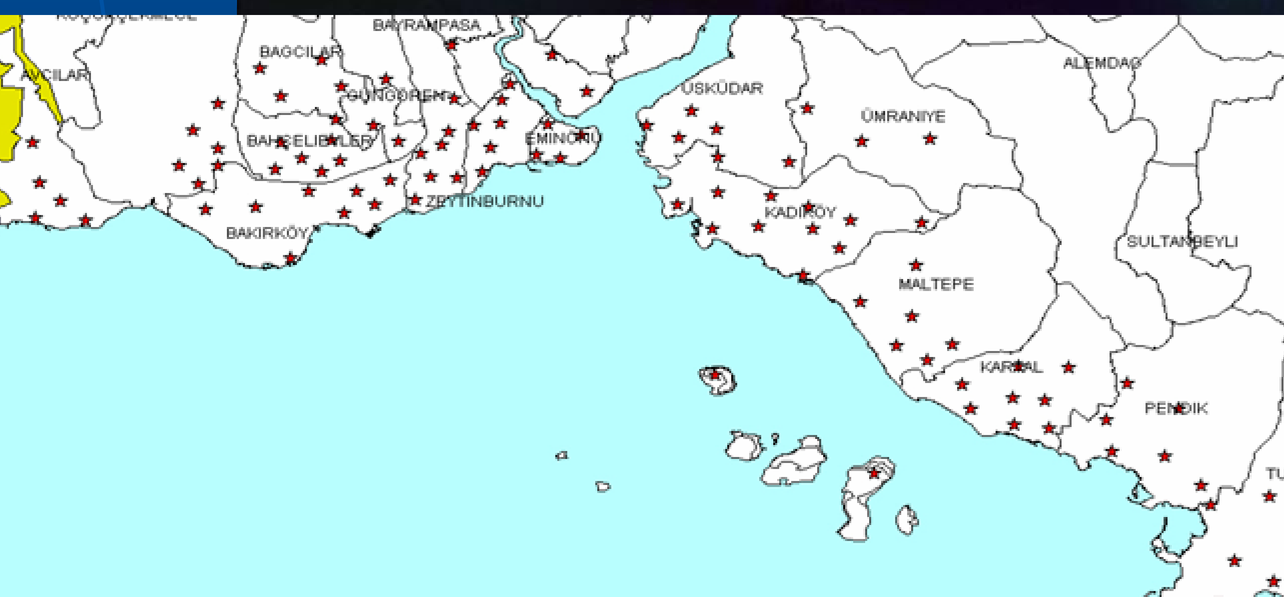
SCENARIO EARTHQUAKE LIFE LOSS MAP



Day time population based casualty distribution for severity level 4

ISTANBUL EARTHQUAKE RAPID RESPONSE SYSTEM STATIONS





The **Rapid Response** part of the IRREW has the objective of providing:

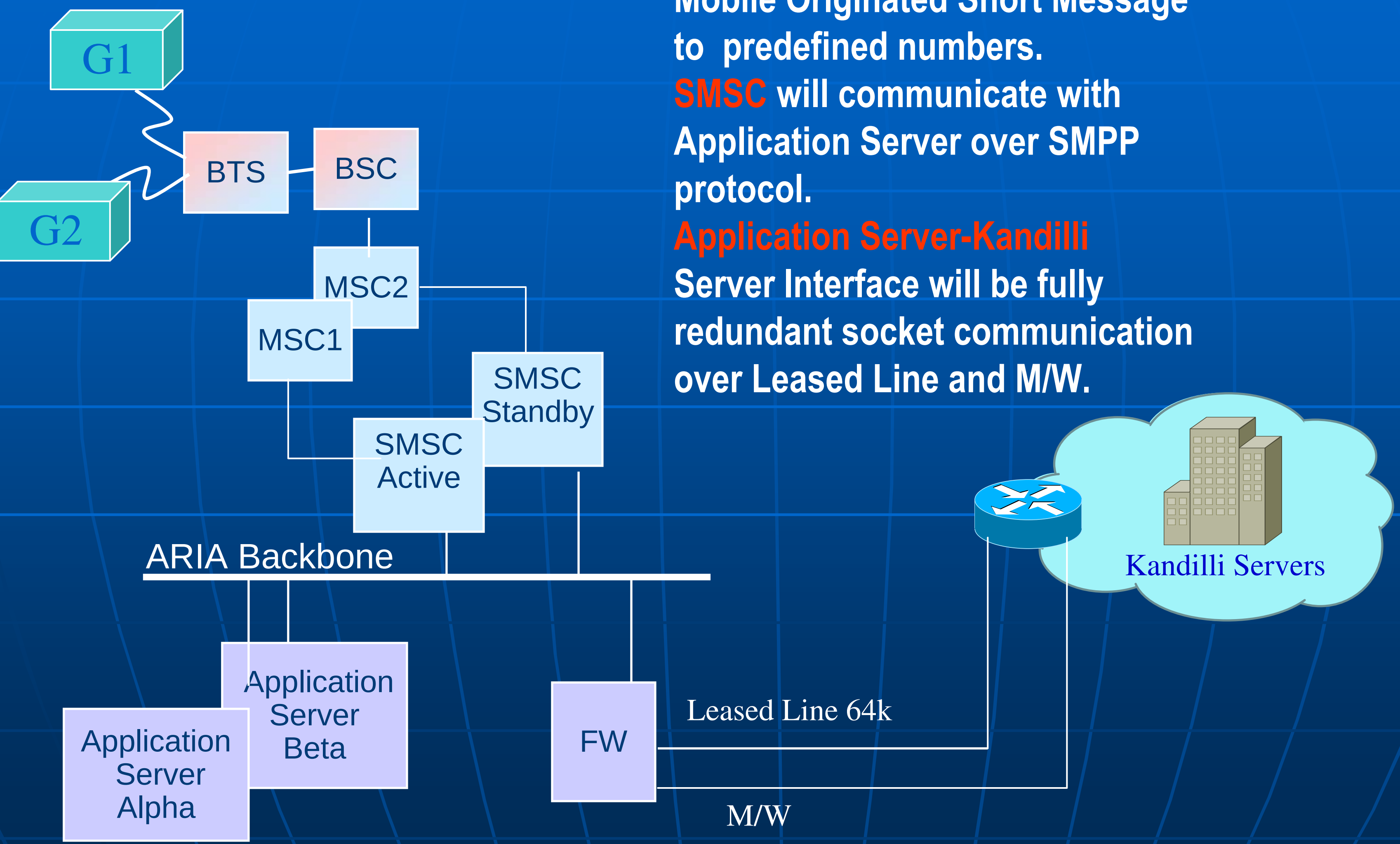
1. Reliable information for accurate, effective characterization of the shaking and damage by rapid post-earthquake maps (Shake, Damage and Casualty maps) for rapid response;
2. Recorded motion for post-earthquake performance analysis of structures;
3. Empirical basis for long-term improvements in seismic microzonation, seismic provisions of building codes and construction guidelines; and
4 Seismological data to improve the understanding of earthquake generation at the source and seismic wave propagation.

After triggered by an earthquake, each station processes the streaming three-channel strong motion data to yield the

- Spectral accelerations at specific periods,
- 12Hz filtered PGA and
- PGV

and sends these parameters in the form of SMS messages at every 20s directly to the main data center through the GSM communication system by using several base stations, microwave system and landlines.

Data Transmission over SMS



Gx – SMSC interface will be Mobile Originated Short Message to predefined numbers.

SMSC will communicate with Application Server over SMPP protocol.

Application Server-Kandilli Server Interface will be fully redundant socket communication over Leased Line and M/W.

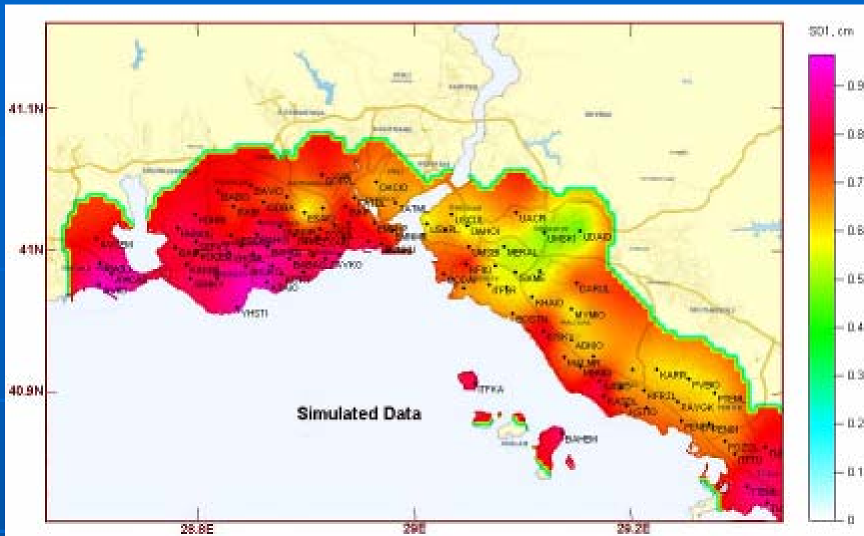
MAIN DATA CENTER

Spectral displacements obtained from the SMS messages sent from stations are interpolated to determine the spectral displacement values at the center of each geo-cell (0.01° x 0.01°).

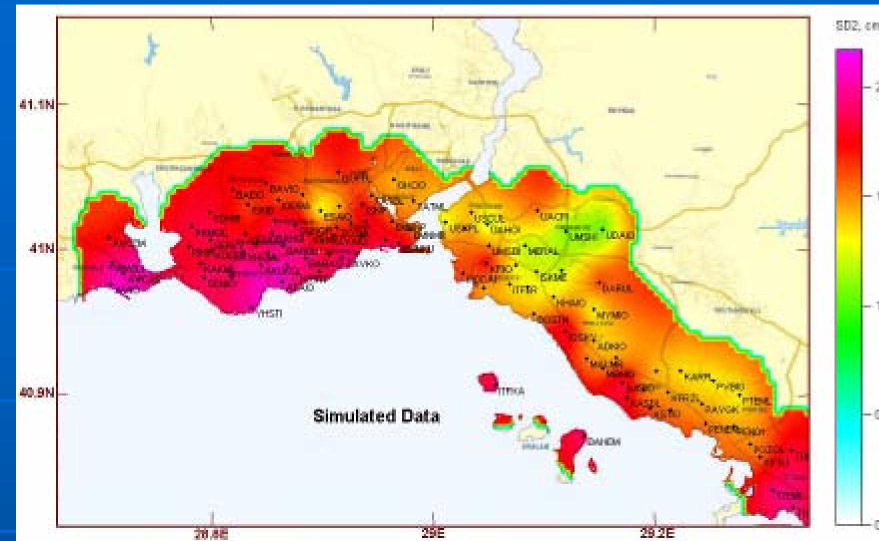
The seismic demand at the center of each geo-cell is computed using these spectral displacements.

Using the capacities of the buildings (24 types) in each geo-cell the building damage is computed by using the spectral-displacement based fragility curves (HAZUS Procedure).

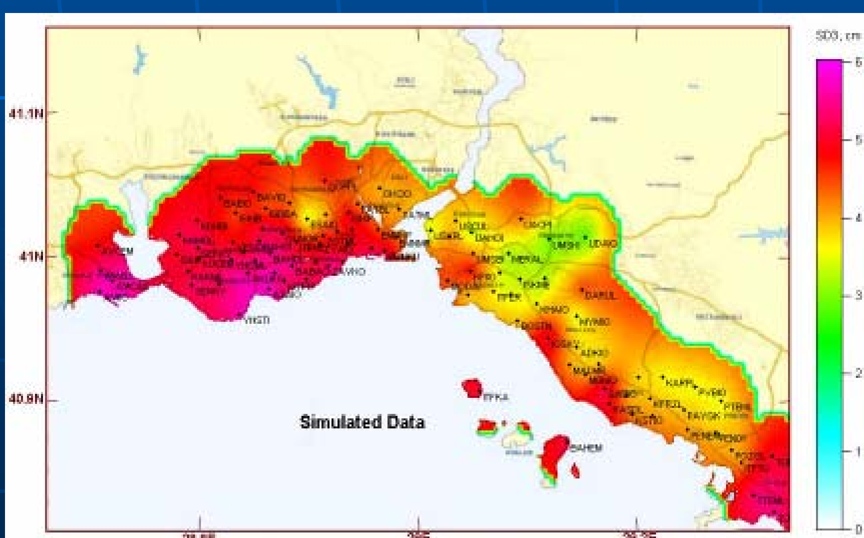
SD @ 5.0Hz



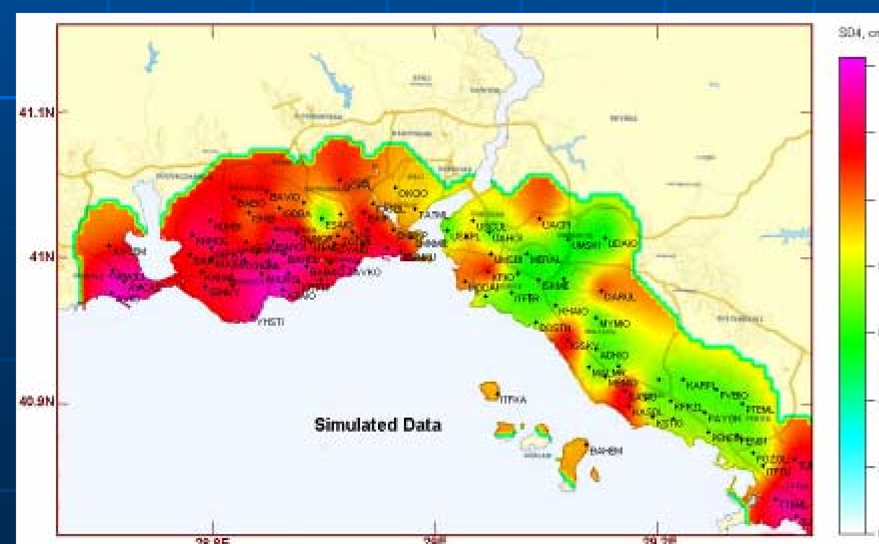
SD @ 3.33Hz

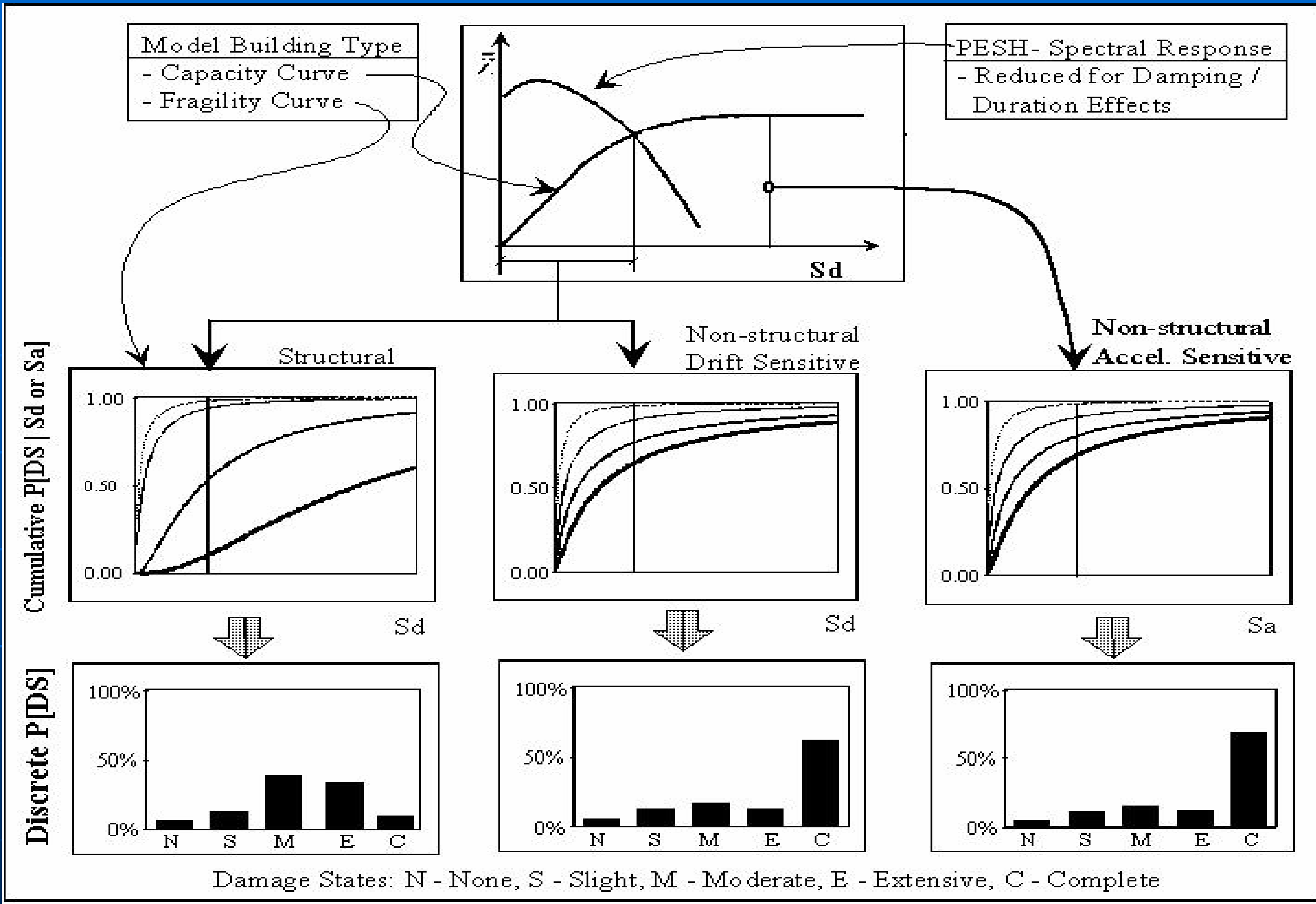


SD @ 2.0Hz



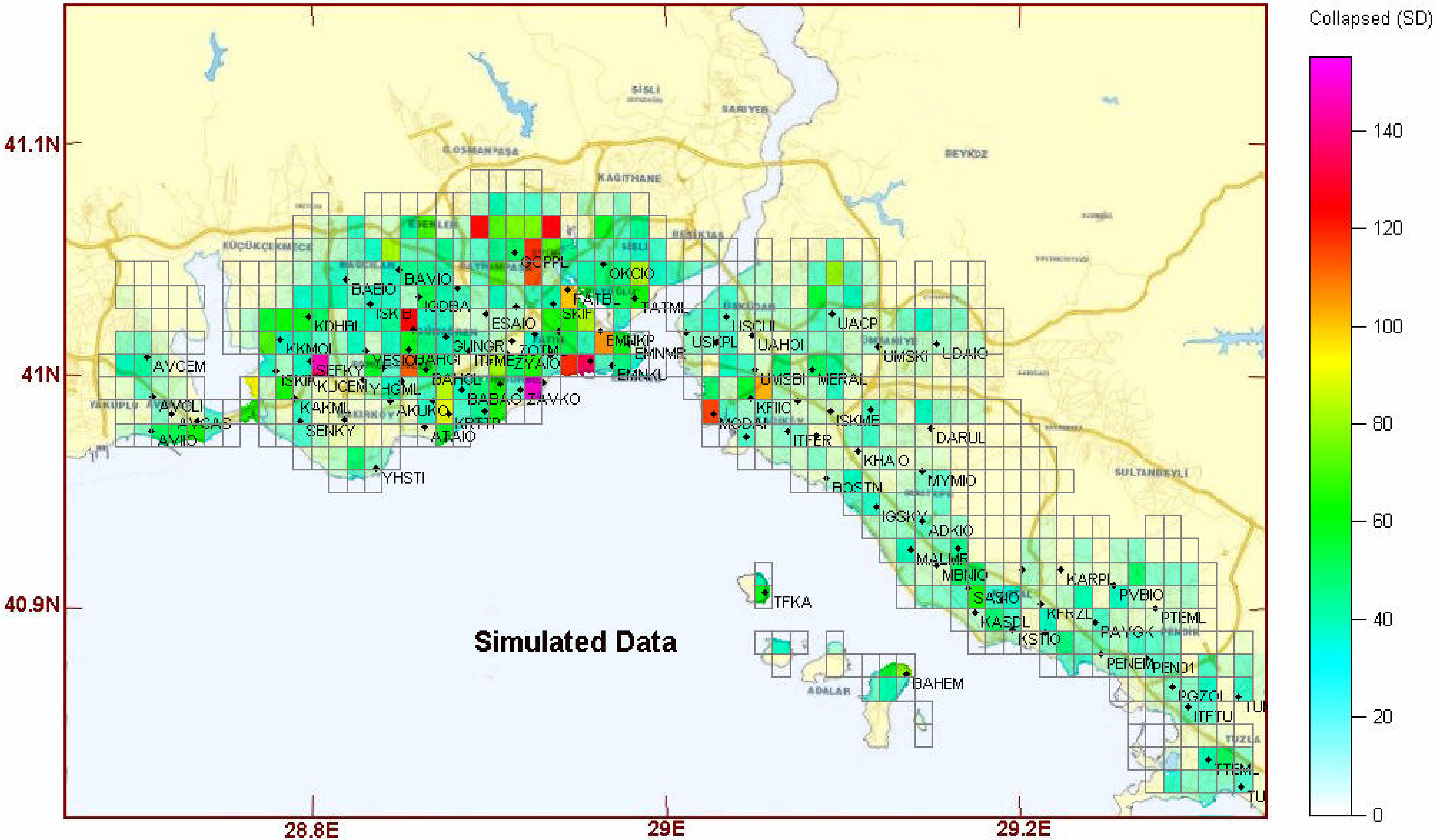
SD @ 1.11Hz





HAZUS-type Building Damage Assessment

NUMBER OF COLLAPSED BUILDINGS PER CELL (Simulated from random data and communicated to end users every day at 10am)



RAPID RESPONSE INFORMATION

COMMUNICATION OF RAPID RESPONSE INFORMATION (DAMAGE MAPS)
(+ Mobile Phones and PDA's)

http://www.koeri.boun.edu.tr/depremmuh/EWRR/EWRRMain.htm - Microsoft Internet Explorer

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Boğaziçi Üniversitesi

Kandilli Observatory And Earthquake Research Institute

Istanbul Early Warning and Rapid Response System

İstanbul Deprem Erken Uyarı Ve Acil Müdahale Projesi

İstanbul EWRR Sistem

Ana Sayfa

Acil Müdahale
İstasyon Haritası,En Büyük İvme Haritası,Spektral Deplasmanlar Haritası,Hasar Dağılım Haritası

Erken Uyarı
İstasyon Haritası, Gerçek Zamanlı Veri

Ana Veri Merkezi
Sistem ve Cihazlar ,Sistemin Teknik Özellikleri

Kayıtlar
Kaydedilen yer ivme verileri

Resimler

İstanbul EWRR System

Main Page

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Rapid Response
Station Maps, Peak Acceleration Maps, Damage Distribution..

Early Warning
Station Maps, real time data monitoring...

Main Data Center
System and instruments, technical descriptions...

Recorded Events
Last recorded strong ground motion data...

Pictures

Done Internet

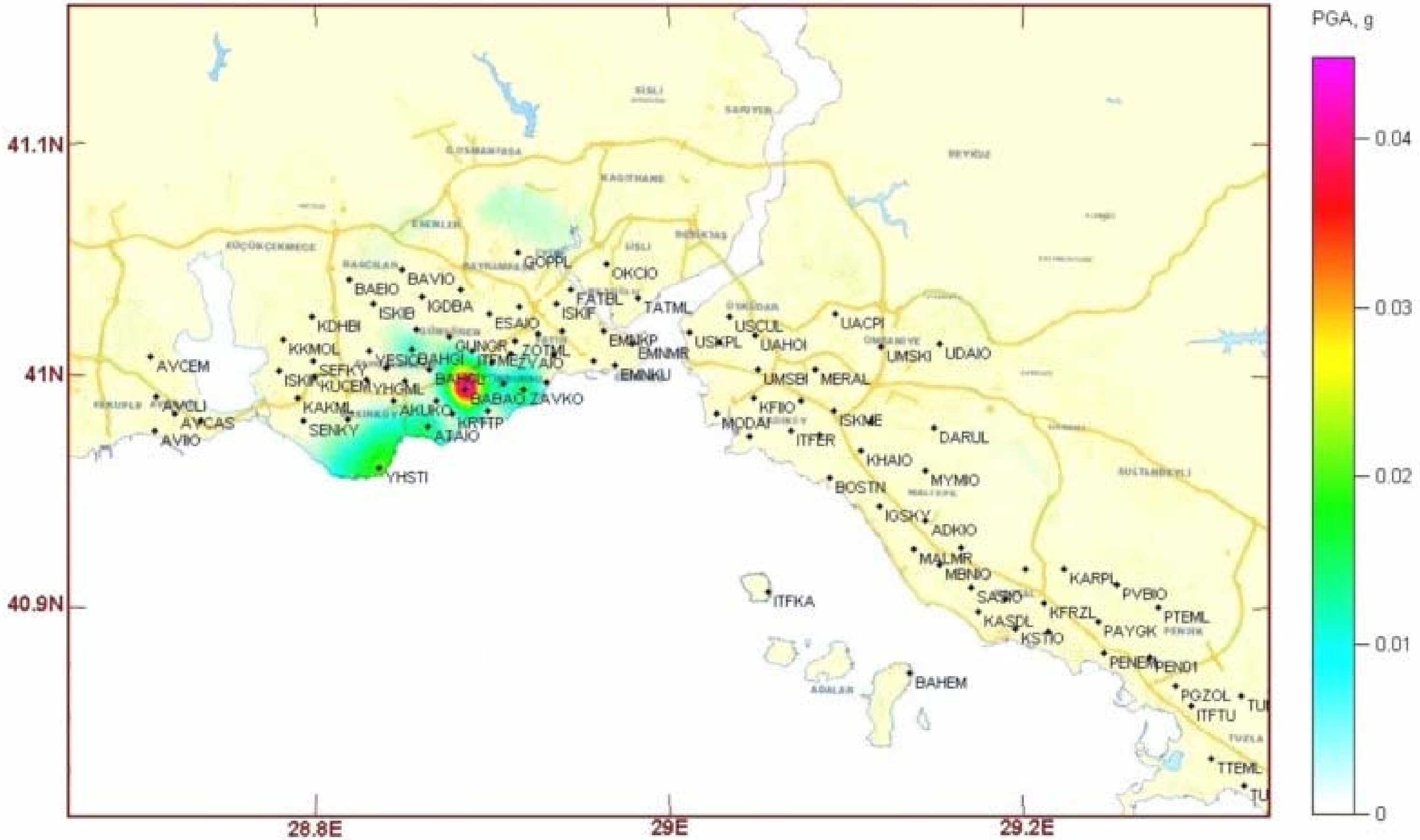
JANUARY 30, 2003 TEKIRDAG EARTHQUAKE

DATE : 30 January 2003, 23:51(gmt)
LOCATION : 40,8 N 27,7 E
MAGNITUDE : 2,7

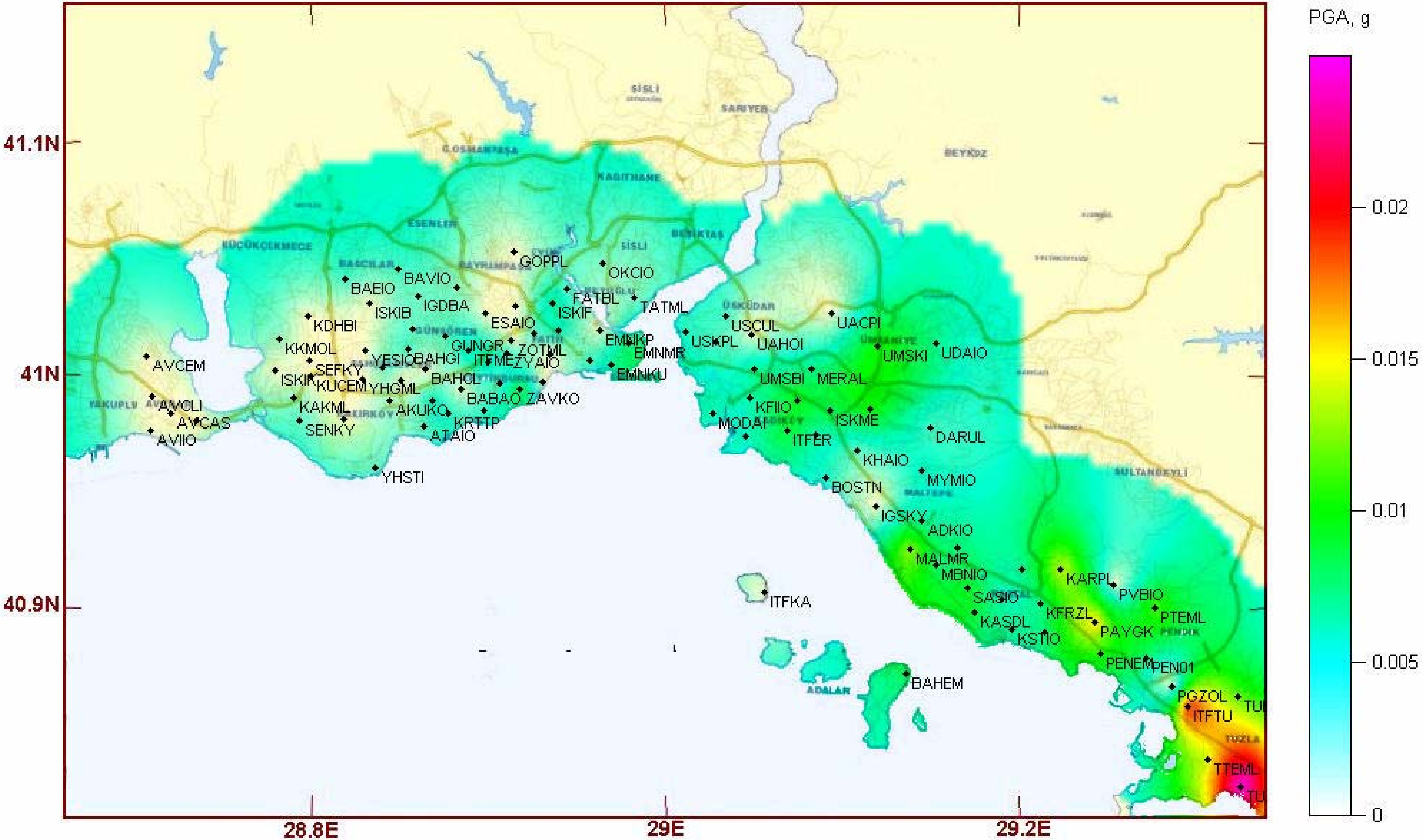
- PEAK ACCELERATION MAP
- DAMAGE DISTRIBUTION MAP
- RECORDED EVENTS;
  - ATAIO
  - BABAO
  - BAHGI
  - YHSTI
  - ZAVKO
  - ZYTAL

Contact Address: Bogazici University Kandilli Observatory and Earthquake Research Institute, Earthquake Engineering Department, Cengelkoy 81220 ,Istanbul ,TURKEY, E-mail:inet2@boun.edu.tr

BOGAZICI UNIVERSITY
KANDILLI OBSERVATORY AND EARTHQUAKE RESEARCH INSTITE EARTHQUAKE ENGINEERING DEPARTMENT

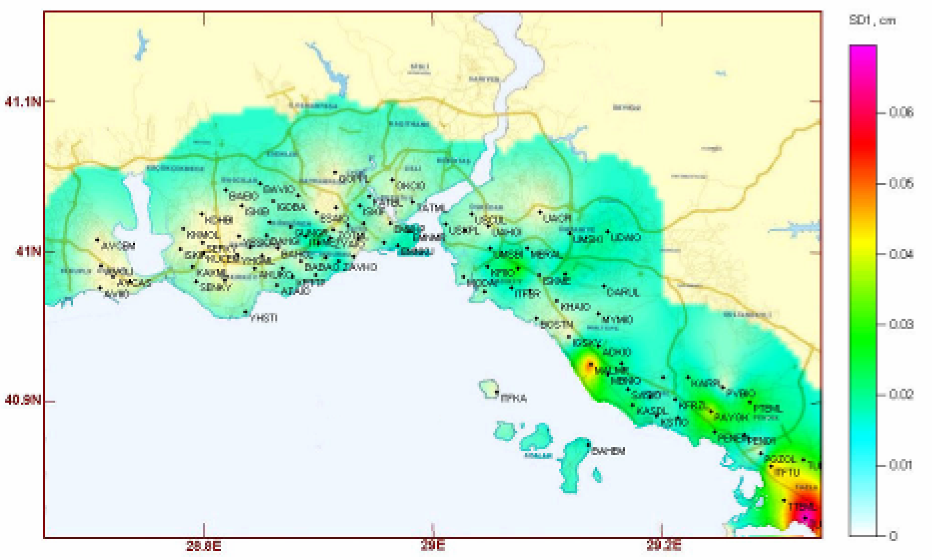


Contact Address: Bogazici University Kandilli Observatory and Earthquake Research Institute, Earthquake Engineering Department, Cengelkoy 81220 ,Istanbul ,TURKEY, E-mail:inet2@boun.edu.tr

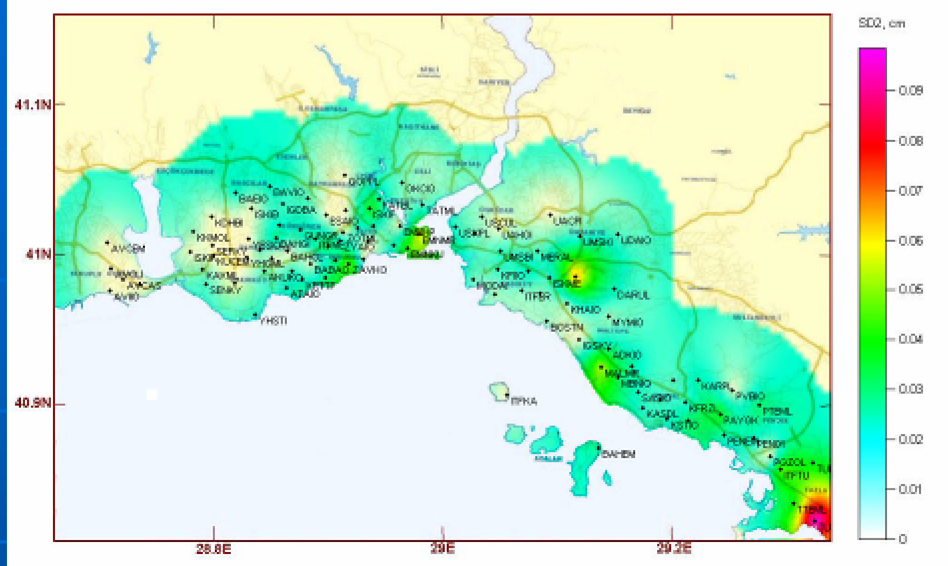


PGA Distribution

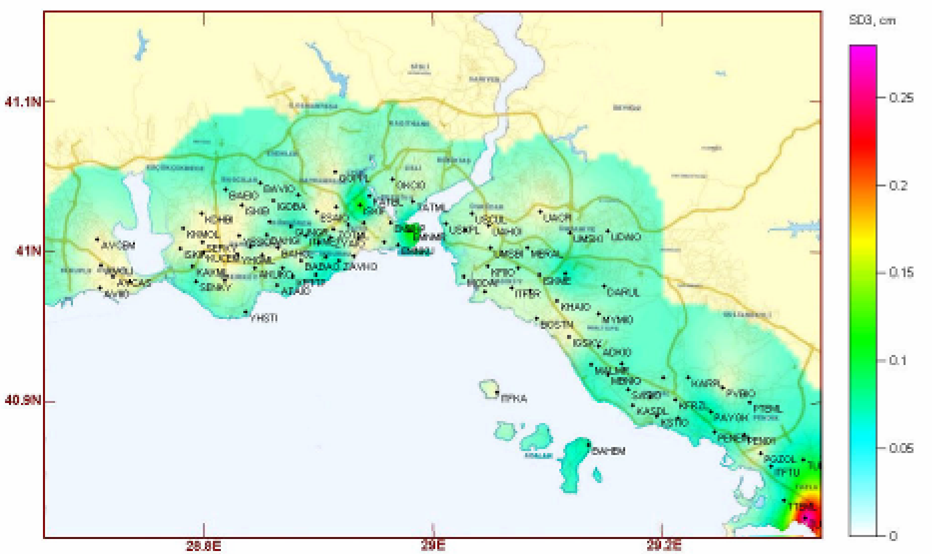
SD @ 5.0Hz



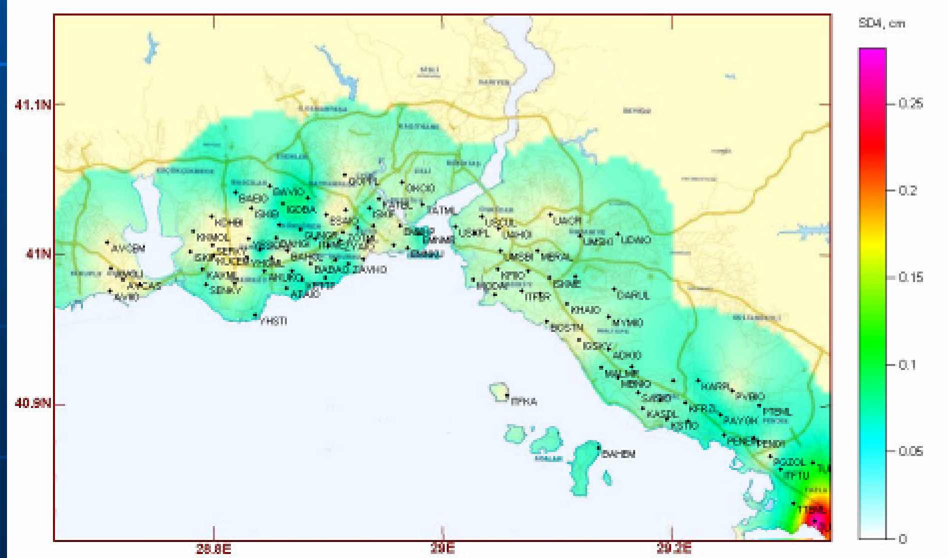
SD @ 3.33Hz



SD @ 2.0Hz



SD @ 1.11Hz



Building Damage Distribution

EXPANSION OF THE ISTANBUL EARTHQUAKE RAPID RESPONSE SYSTEM

ISTANBUL EARTHQUAKE EARLY WARNING SYSTEM

The Early Warning part of the I-NET 10+2 strong motion stations were located as close as possible to the Great Marmara Fault zone in “on-line” mode.

Data Transmission is provided with Spread Spectrum Radio Modem and Satellite.

The continuous on-line data from these stations is used to provide real time warning for emerging potentially disastrous earthquakes.

ISTANBUL EARTHQUAKE EARLY WARNING SYSTEM

Considering the complexity of fault rupture and the short fault distances involved, a simple and robust Early Warning algorithm, based on the exceedance of specified threshold time domain amplitude levels (band-pass filtered accelerations and the cumulative absolute velocity) is implemented.

The early warning information (consisting three alarm levels) will be (are) communicated to the appropriate servo shut-down systems of the recipient facilities, which will automatically decide proper action based on the alarm level.

Depending on the location of the earthquake (initiation of fault rupture) and the recipient facility the alarm time can be as high as about 8s.

EW BASED ON EXCEEDANCE OF FILTERED PGA TRESHOLD – *CURRENLY APPLIED PROCEDURE*

- All online acceleration data from all stations will be low-pass filtered at selectable frequencies of 12 and 25 Hz.
- When any acceleration (on any channel) in a given station exceeds a selectable first threshold value (20 mg) it will be considered a vote
- Whenever we have 3 (selectable) station votes within a selectable time interval of (5s) after the first vote it will be declared the first alarm.
- After the first alarm, whenever we have 3 (selectable) votes for the second acceleration threshold value (50 mg) within selectable time interval of (5s) after the first vote it will be declared the second alarm.
- After the second alarm, whenever we have 3 (selectable) votes for the third acceleration threshold value (100 mg) within selectable time intervals of (5s) after the second vote it will be declared the third alarm.

EW BASED ON CUMULATIVE ABSOLUTE VELOCITY (CAV) – *ALTERNATE PROCEDURE*

CAV (t) = Integral from 0 to t [abs (a).dt]   (g-sec)

- The CAV from acceleration data are computed for only those 1s intervals where PGA is greater than 3mg. When any CAV (on any channel) in a given station exceeds a selectable first threshold CAV value (20 mg.s) it will be considered a vote.
- Whenever we have 3 (selectable) votes for the first threshold CAV value within selectable time interval of (5s) after the first vote it will be declared the first alarm.
- After the first alarm, whenever we have 3 (selectable) votes for the second threshold CAV value (40 mg.s) within selectable time intervals of (5s) after the first vote it will be declared the second alarm.
- After the second alarm, whenever we have 3 (selectable) votes for the third CAV threshold value (70 mg.s) within selectable time intervals of (5s) after the second vote it will be declared the third alarm.

EW BASED ON PATTERN RECOGNITION (NEURAL NETWORK)
M. Böse, University of Karlsruhe

- Methodology for earthquake early-warning as a *pattern recognition task* on condition that the earthquake source mechanism is approximately stationary in the area of interest.

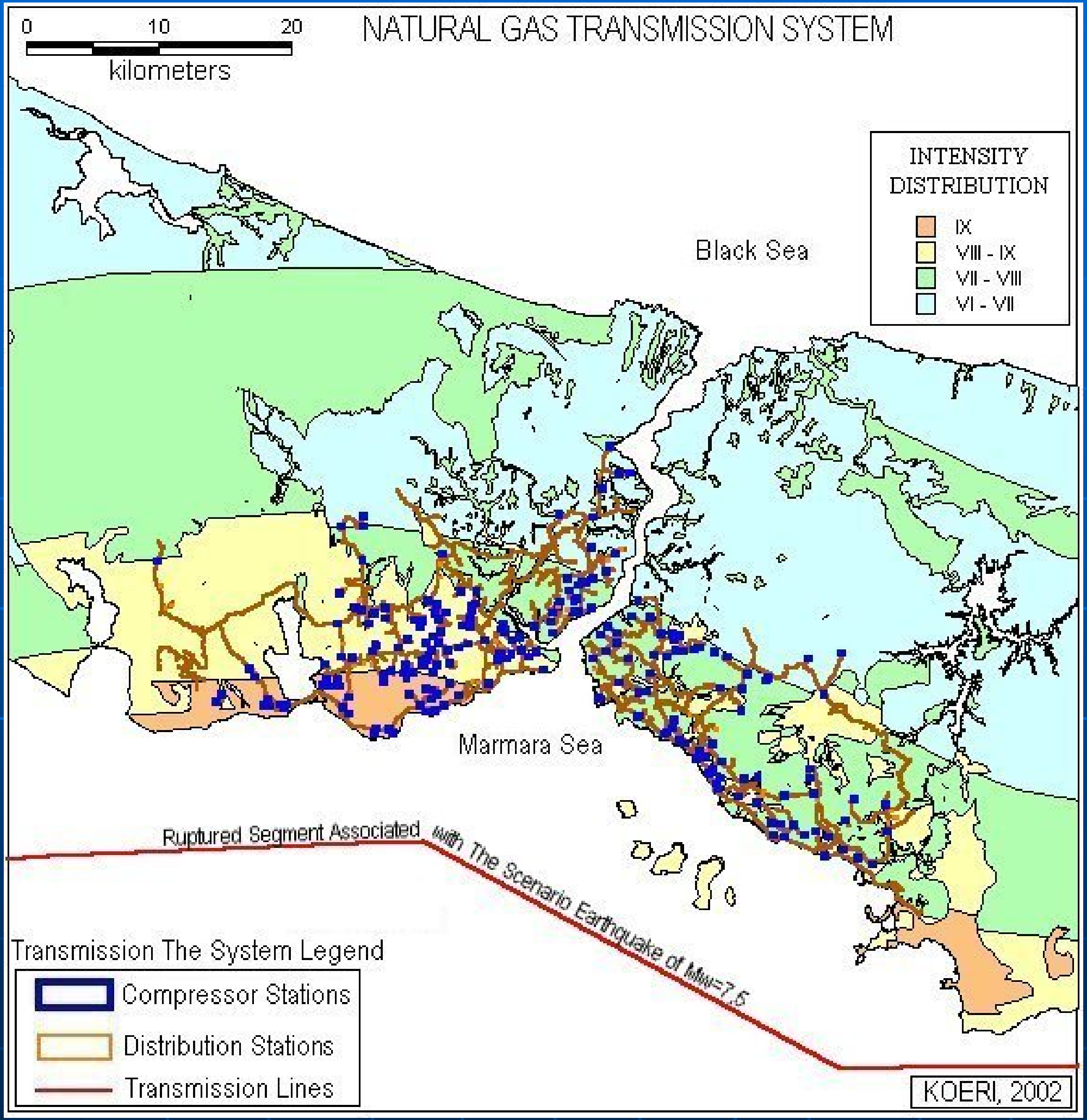
- The seismic patterns are defined by the shape and frequency content of the parts of accelerograms that are available at each time step. From these, parameters relevant to seismic damage, such as peak ground acceleration (PGA), peak ground velocity (PGV) and response spectral amplitudes at certain periods are estimated using Artificial Neural Networks (ANN).

- The pattern recognition technique is combined with an additional rule-based system in order to detect inconsistencies between ground motion estimations and measurements. This combination provides a reliable and accurate system for early-warning that is demanded by its huge social and economic impact.

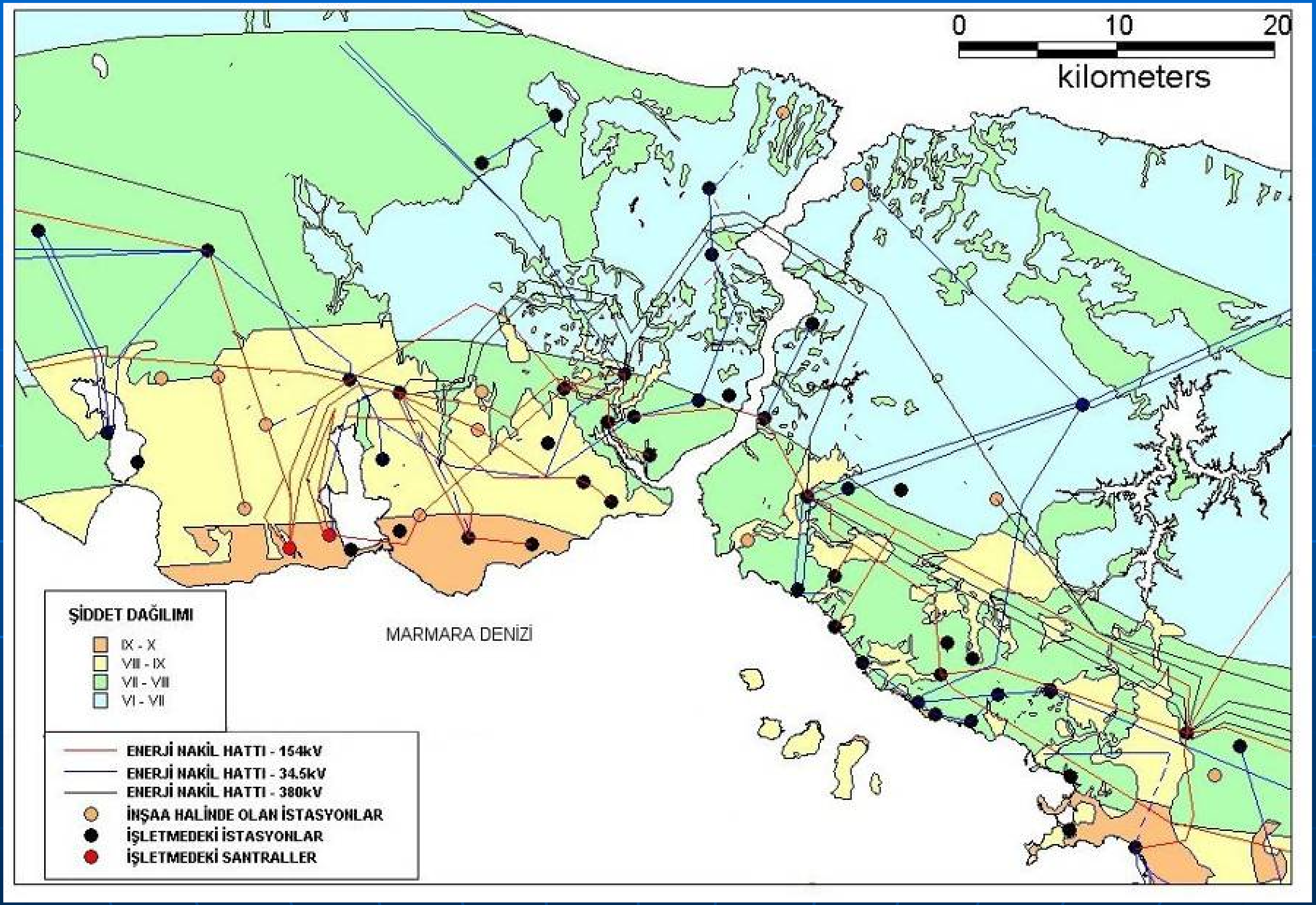
İŞ-KULE

ENRON-TRAKYA ELEKTRIK

FAST TRAIN AND TUBE TUNNEL

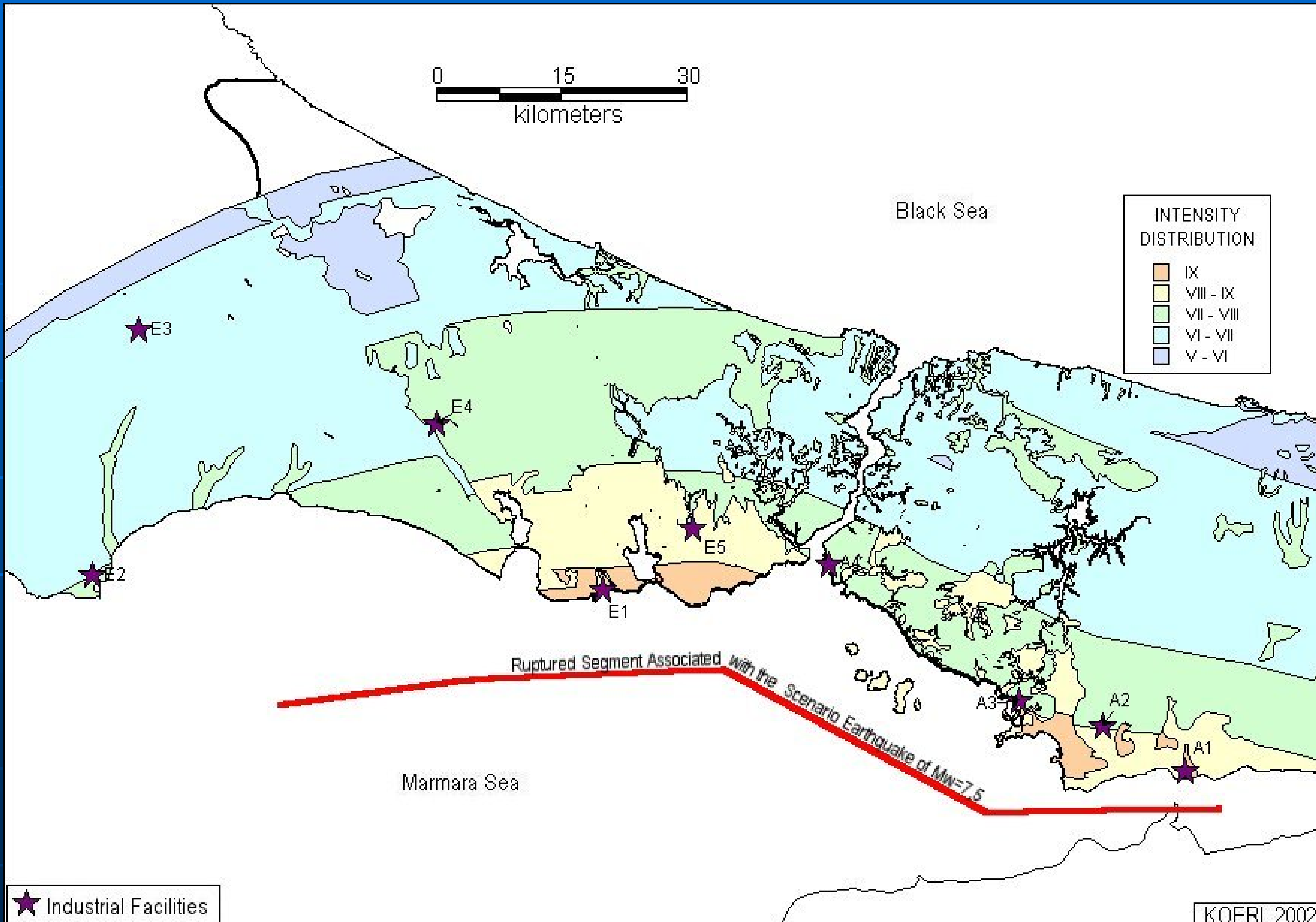


NATURAL GAS DISTRIBUTION SYSTEM

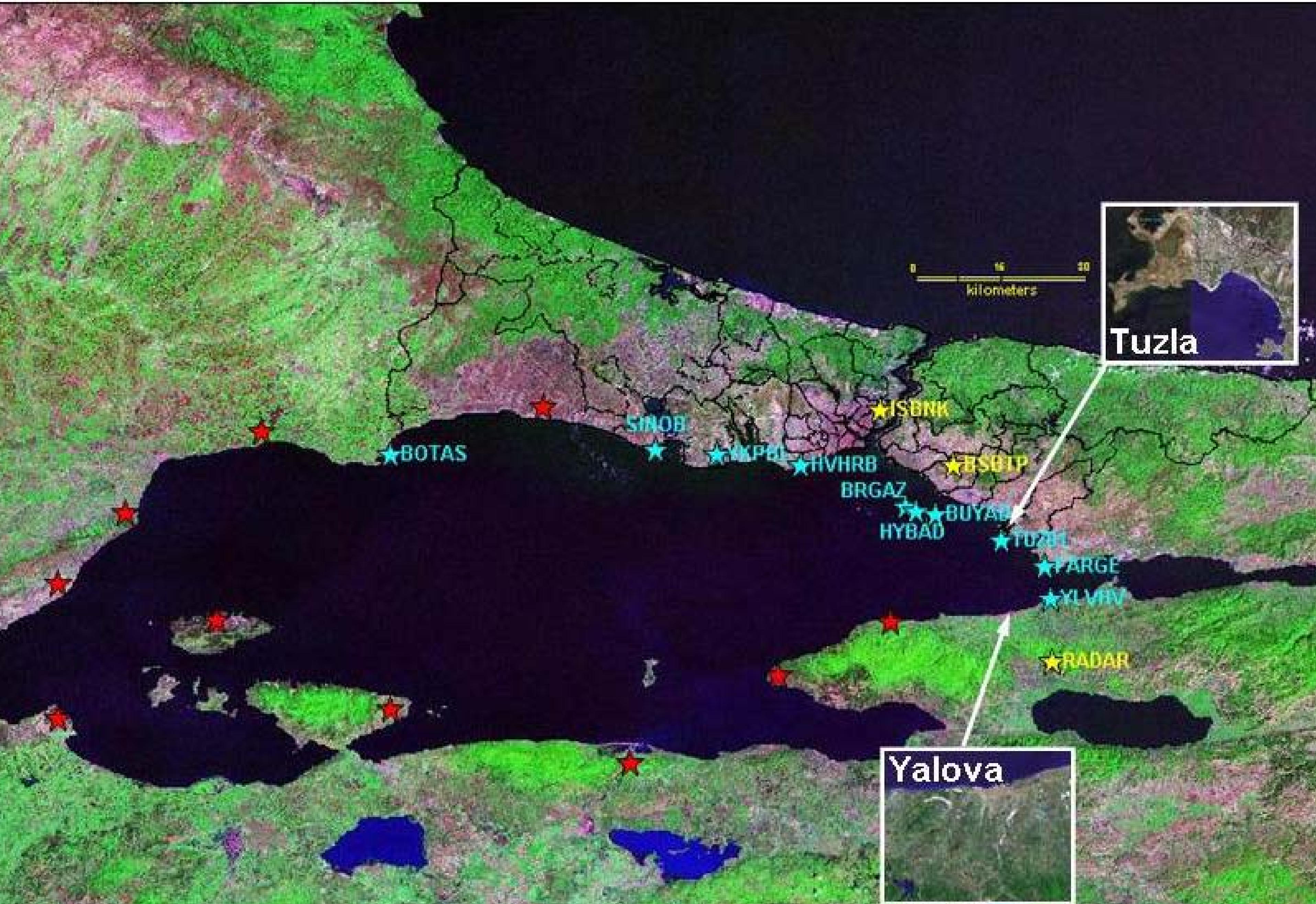


ELECTRIC POWER DISTRIBUTION SYSTEM

HEAVY INDUSTRY



EXPANSION OF THE ISTANBUL EARTHQUAKE EARLY WARNING SYSTEM



THANK YOU