



Review of the 2023 Kahramanmaraş Earthquake Sequence

May 2023



AGENDA

Overview of the Sequence

Damage Observations and

Loss Estimation

Conclusions



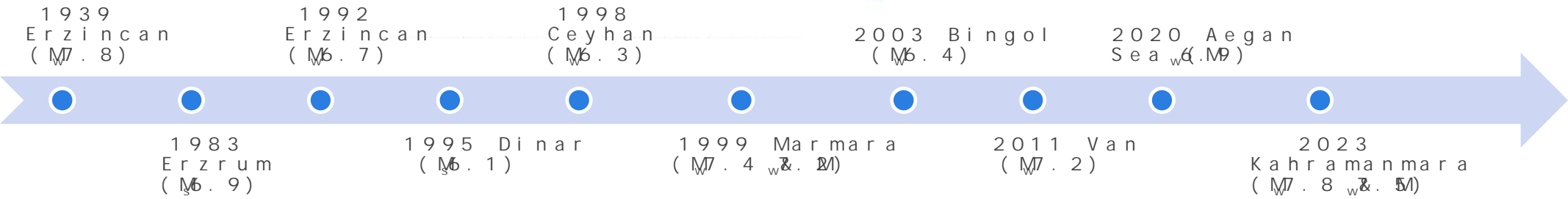
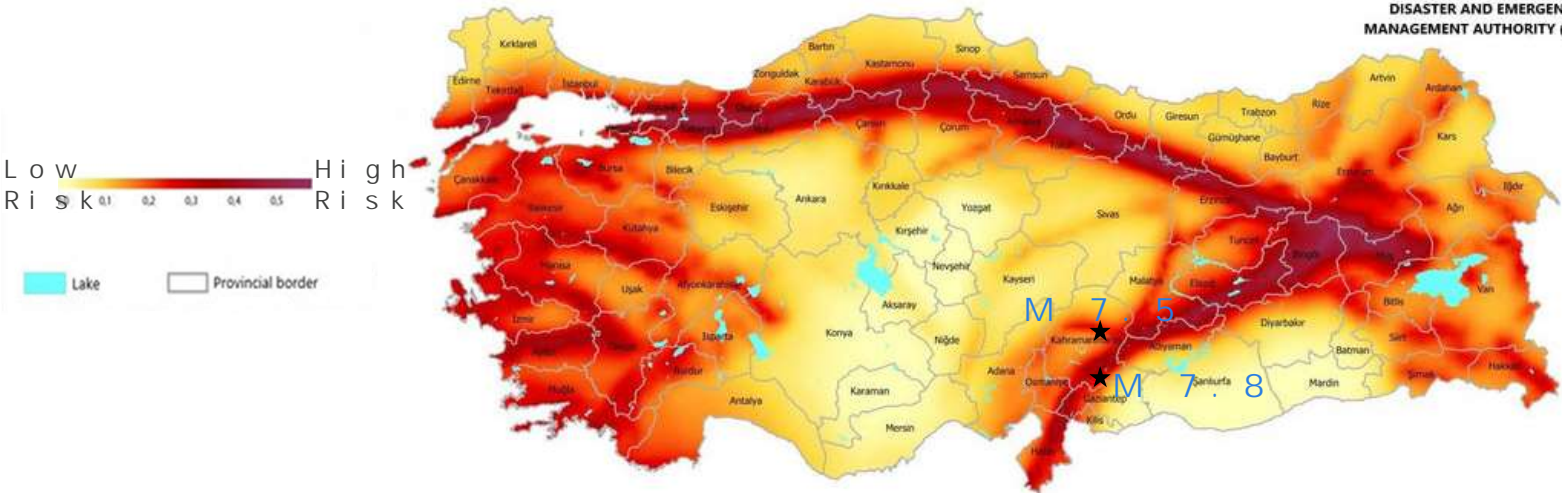
Overview of the and Regional S

Turkey, Located in a Seismically Active Region, Has Seen Many Devastating Earthquakes

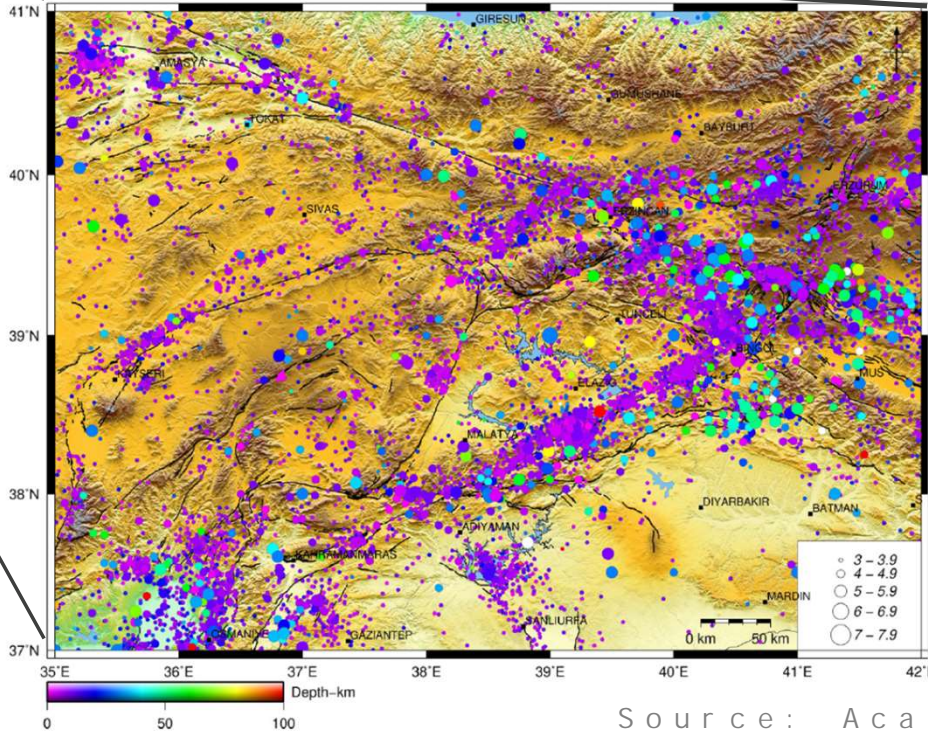
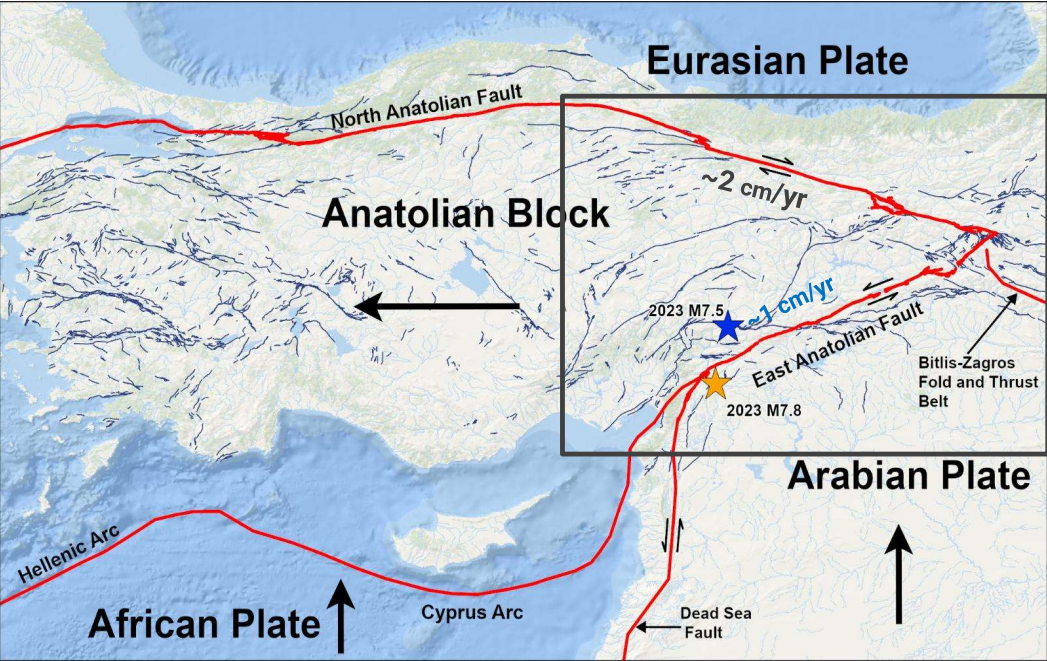
2018 Seismic Hazard Map of Turkey



DISASTER AND EMERGENCY MANAGEMENT AUTHORITY (AFAD)

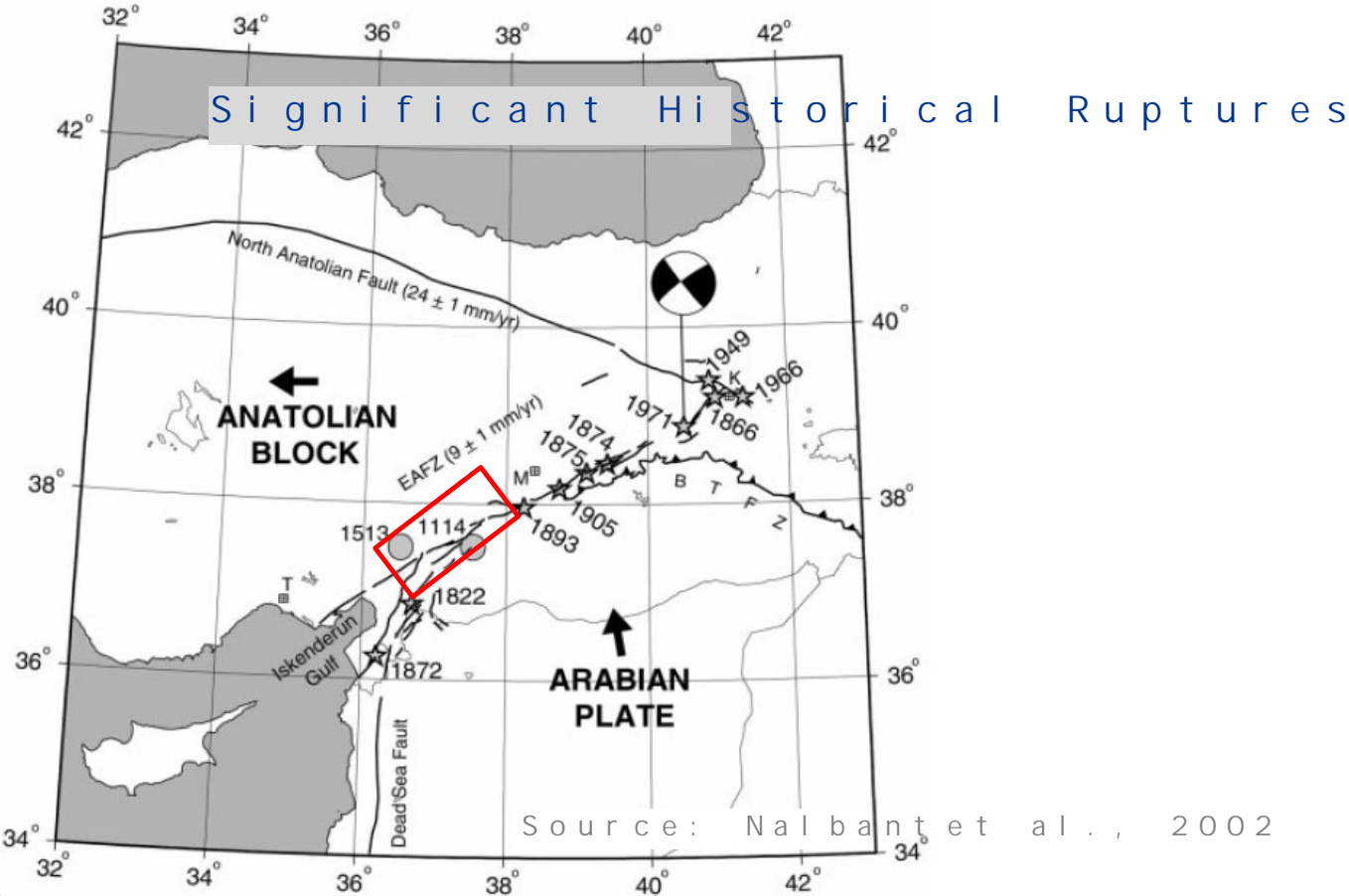


Region Impacted by 2023 Earthquake of a Complex Tectonic Setting



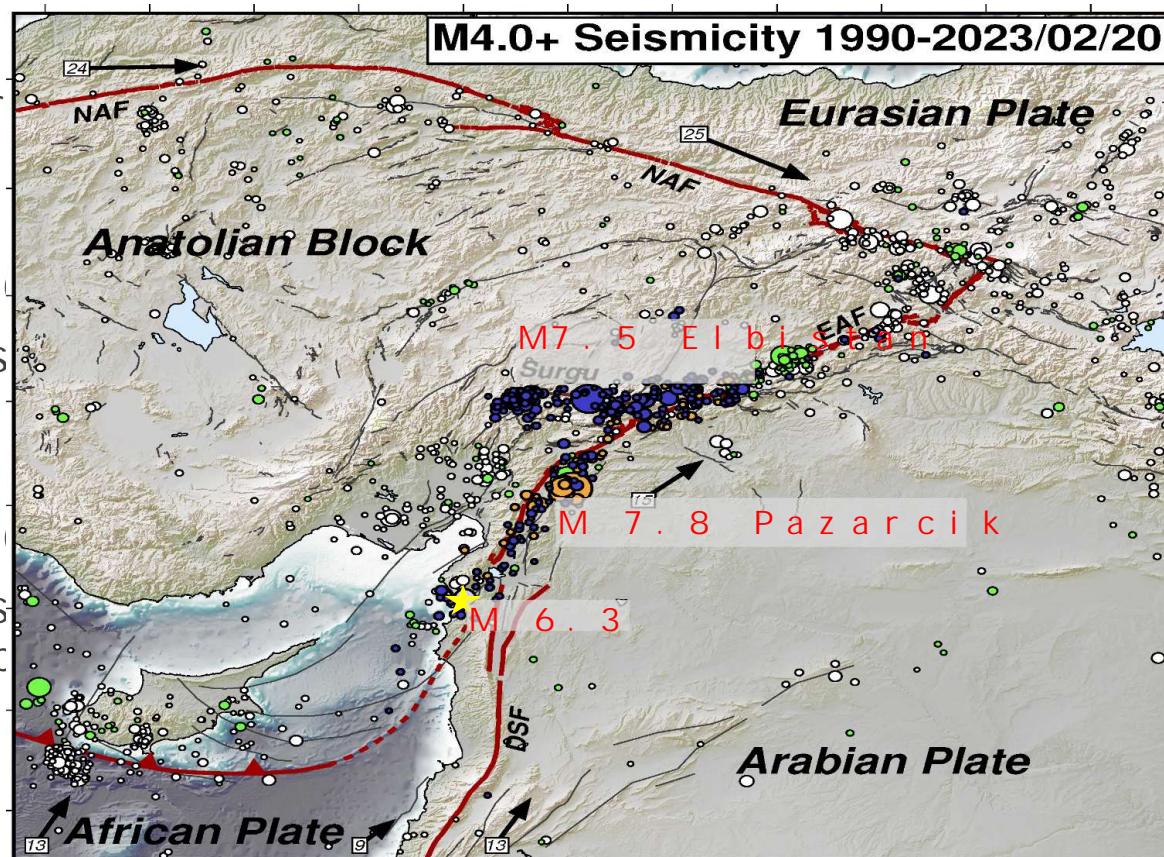
Source: Acairel

A "Seismic Gap" in the Kahramanmaraş Eastern Anatolian Fault (EAF)



Kahramanmara Earthquake Mainshock Moment Equivalent to 500 Years of

- Mainshock M7.8 Pazarcik southern EAF (Feb 2023)
 - Depth of ~18km
 - Rupture length of ~300km
- Triggered M7.5 Elbilisli Sürüğü (Feb 2023)
 - Depth of ~10km
 - Rupture length of ~100km
- M6.3 aftershock on SDF and northern EAF (Feb 2023)

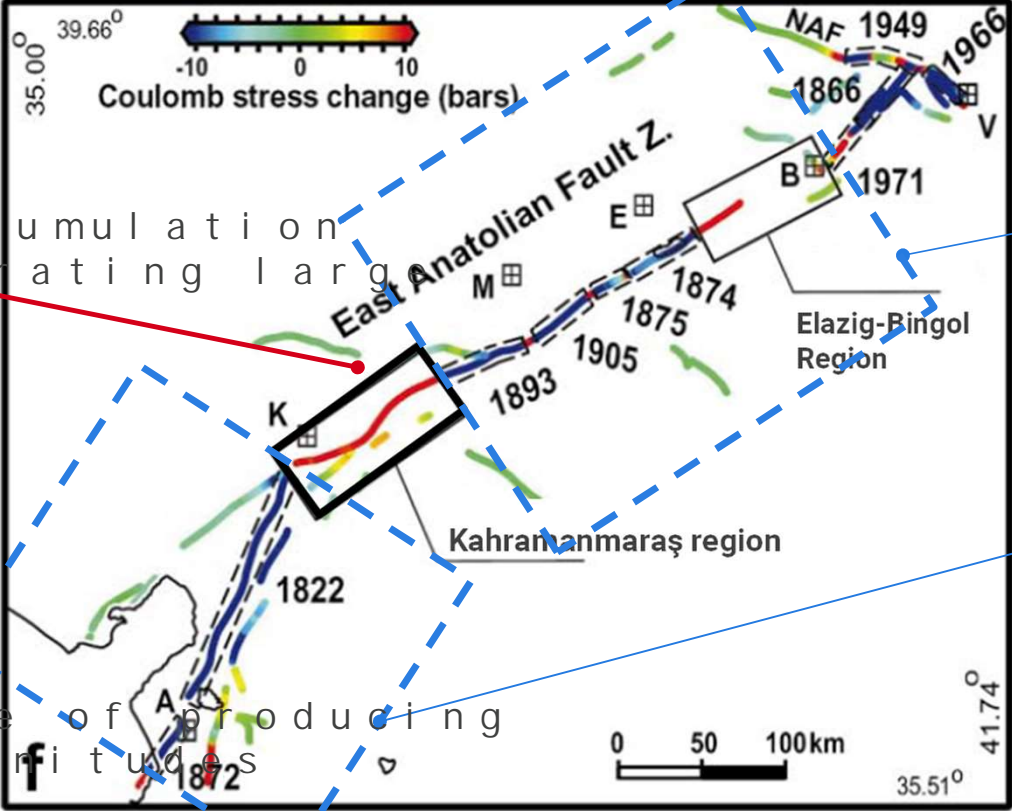


Source: USGS

Seismicity Models Should Correct Probability in the Kahramanmaraş

• High stress accumulation capable of generating large earthquakes

Region is capable of producing even higher magnitudes

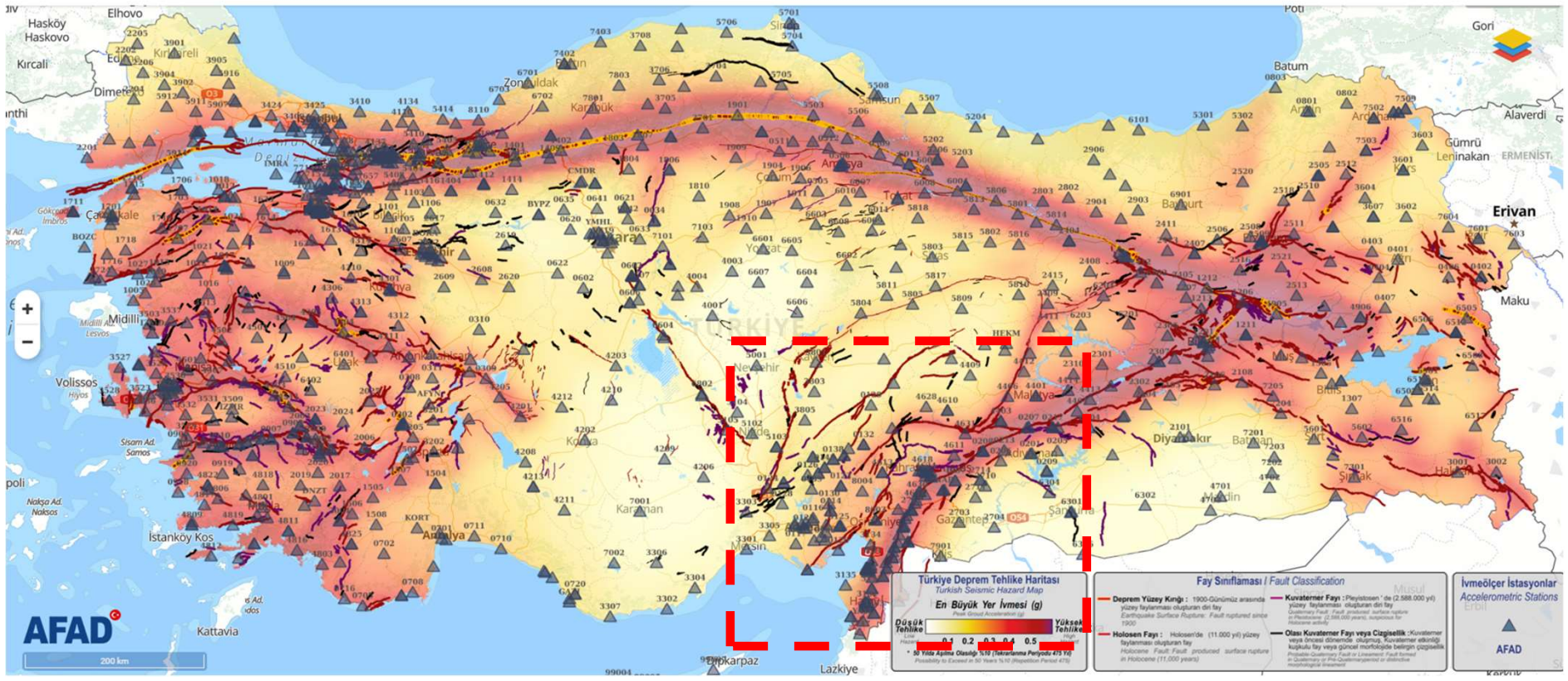


NE segment characterized by frequent

South EAF - No section

The Network of Seismic Recording Provided Data on Near Fault Stron

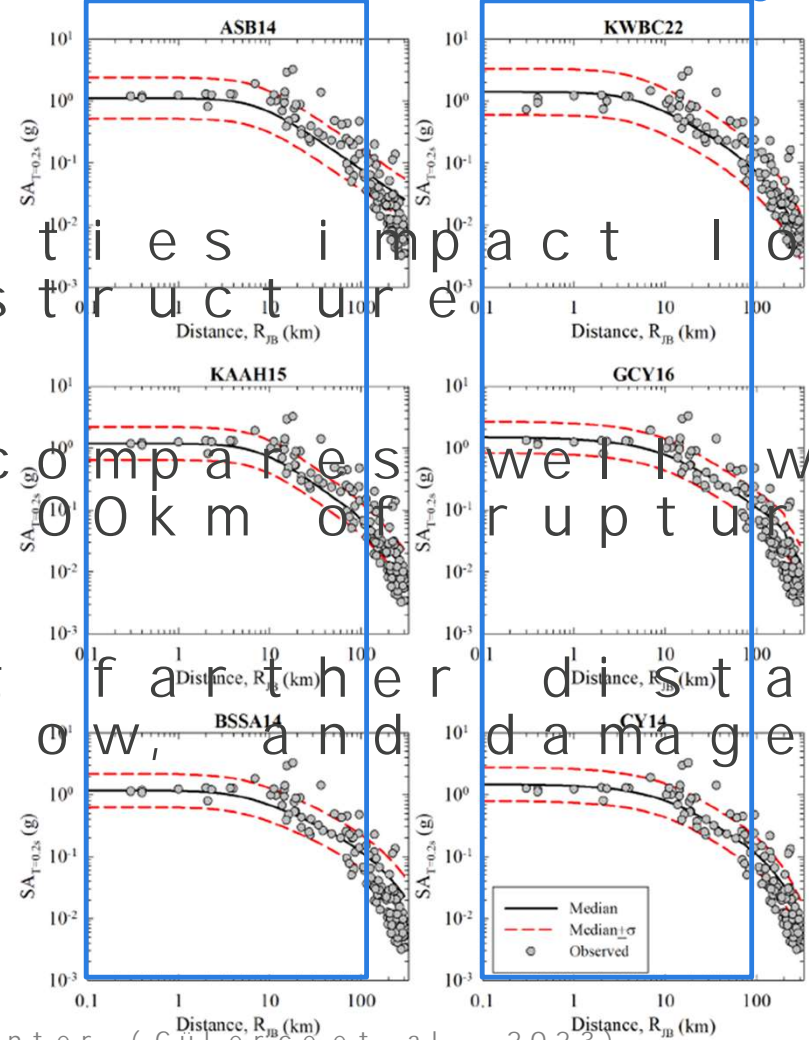
AFAD R.T. MINISTRY OF INTERIOR
Disaster and Emergency Management Presidency
Department of Earthquake
Türkiye Acil Durumlar Bakanlığı Depolama ve Arama Genel Müdürlüğü



<p>Türkiye Deprem Tehlike Haritası Türkish Seismic Hazard Map</p> <p>En Büyük Yer İvmesi (g) Peak Ground Acceleration (g)</p> <p>Düşük Tehlike 0.1 0.2 0.3 0.4 0.5 Yüksek Tehlike</p> <p>* 50 Yıllık Aşırı Olasılık %10 (Tekrarlanma Periyodu 475 Yıl) * Possibly to Exceed in 50 Years %10 Recurrence Period (475 Yr)</p>	<p>Fay Sınıflaması / Fault Classification</p> <ul style="list-style-type: none"> Deprem Yüzeşi Kırığı : 1900-Günümüz arasında oluşan fay Earthquake Surface Rupture: Fault ruptured since 1900 Holosen Fay : Holosen'de (11.000 yıl) yüzeyde oluşan fay Holocene: Fault produced surface rupture in Holocene (11,000 years) Kuvaterner Fay : Pleistosen'de (2.588.000 yıl) oluşan fay Quaternary Fault: Fault produced surface rupture in Pleistocene (2,588,000 years), subsequent fault Olmuş Kuvaterner Fay veya Çizgisellik : Kuvaterner veya öncesi dönemde oluşmuş, Kuvaterner dönemi başlangıcına kadar fay veya çizgisellikte belgelenmiş çizgisellik Discontinued Quaternary Fault or Lineament: Fault formed in Quaternary or Pre-Quaternary period or otherwise morphologically inactivated 	<p>İvmeölçer İstasyonları Accelerometric Stations</p> <p>▲ AFAD</p>
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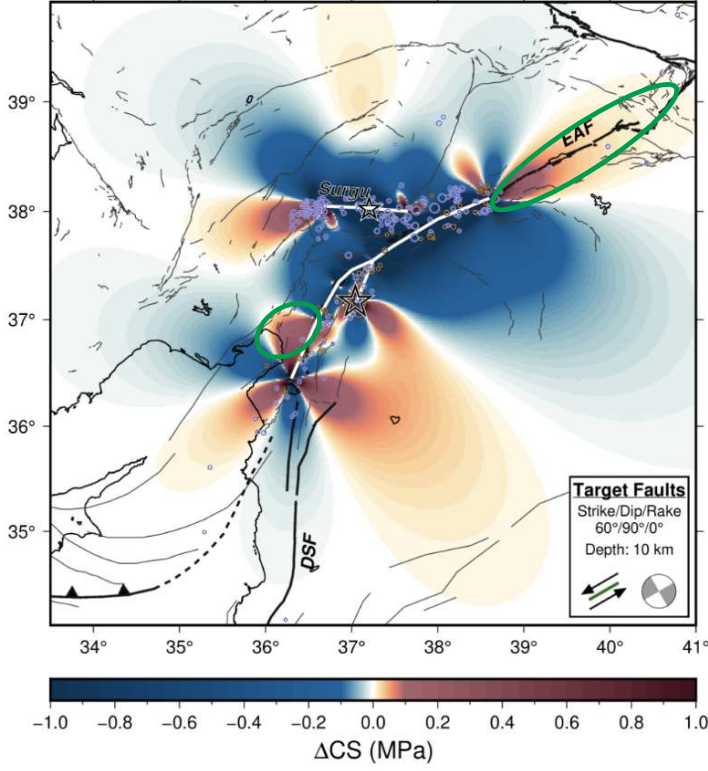
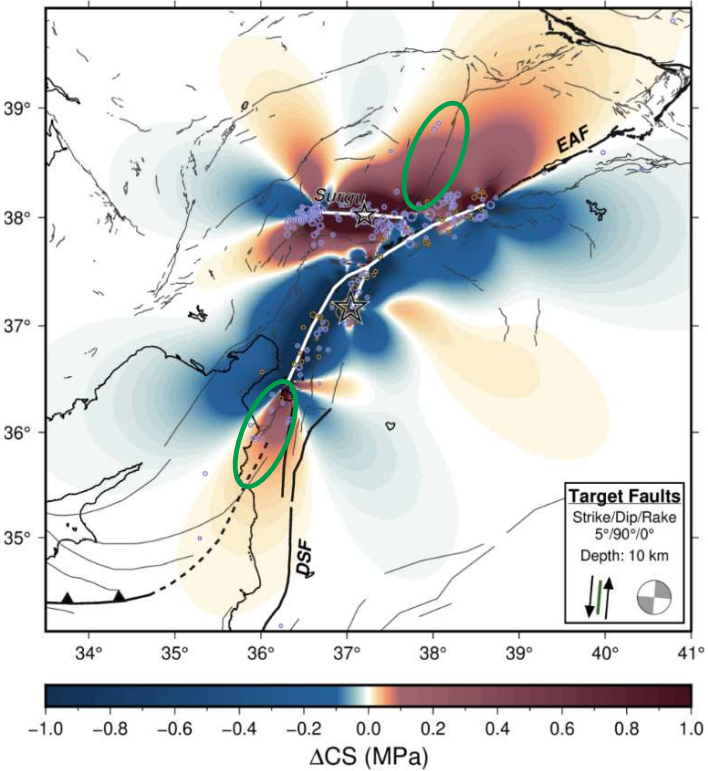
Ground Motion Models Generally Pe

- Short period intensities impact low-rise buildings and infrastructure
- Recorded intensity compares well with modern GMMs within 100 km of rupture
- GMMs overestimate at farther distances where intensity is low, and damage is small



Short-Term Increase in Seismicity Decrease in Large Magnitude Earth

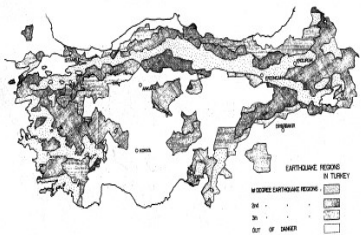
- Elevated seismicity in small to moderate earthquakes in Eastern Turkey
- Risk may have increased in the Eastern and Northern regions
- Reduced risk of large scale events in the southern Eastern Turkey



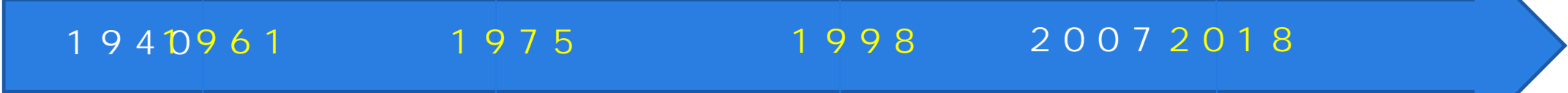
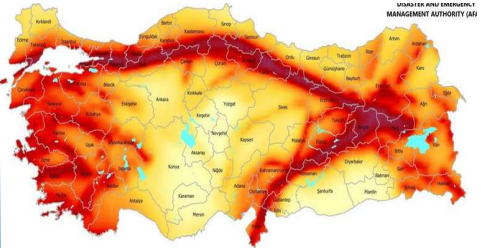
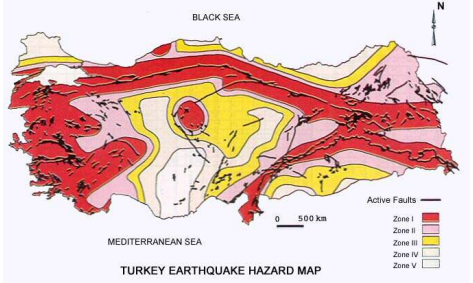
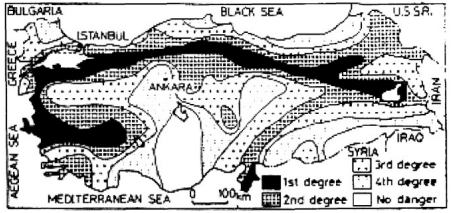


Damage Observations Lessons Learned

Seismic Design Codes in Turkey Have Significantly Changed Since their Introduction



First Turkey Seismic Code



1939
Erzincan Earthquake

Refinement in design for seismic calculation and adding regional variation requirements



1999 Duzce and Kocaeli Earthquakes

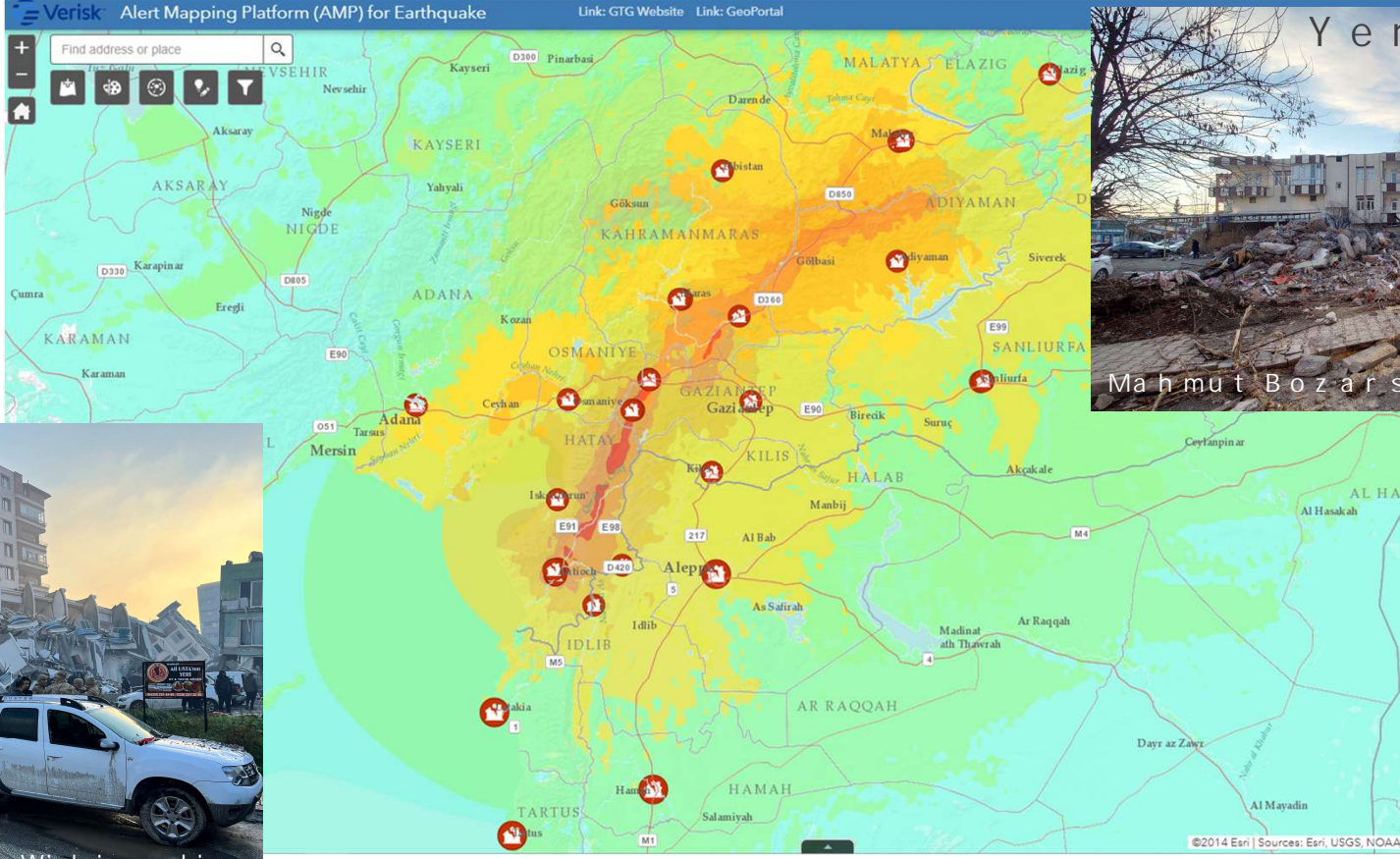
Code updated with new hazard map - no significant change in design forces



2023 Kahramanmaraş earthquake sequence

Code updated with refined contours of design hazard

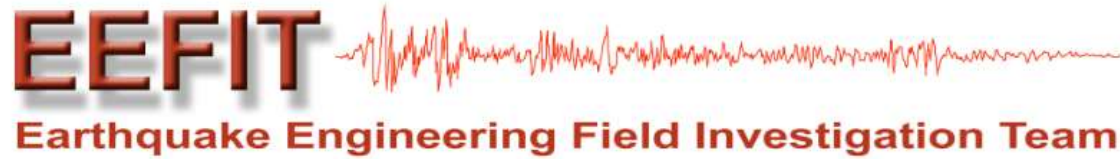
The Earthquake Sequence Has Caused Damage and Destruction



Several Reliable Damage and Vulnerability Surveys and Publications Now Exist



The 2023 Kahramanmaraş, Turkey, Earthquake Sequence Clearinghouse
M7.8 | M7.5 FEBRUARY 6, 2023 AT 01:17 UTC



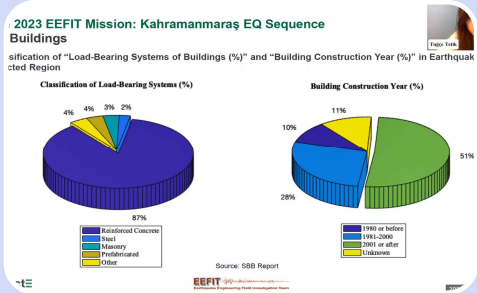
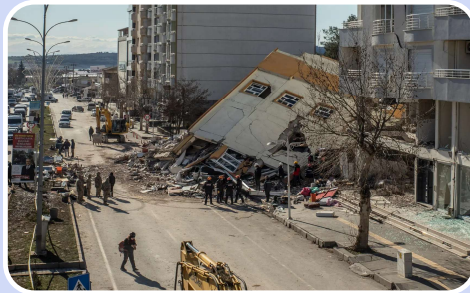
EEFIT Mission: February 2023 Turkey earthquake



MIDDLE EAST TECHNICAL UNIVERSITY

Preliminary Reconnaissance Report on
February 6, 2023, Pazarcık $M_w=7.7$ and Elbistan
 $M_w=7.6$, Kahramanmaraş-Türkiye Earthquakes

Reconnaissance Reports and Damage Recurring Vulnerability Issues in



RC & URM
dominant
building
inventory

Mid-High
most severely
damaged

Significant
building
observed

Common
problems
story and
ductility

Non-structural
components
failures
to building
vulnerable

EEFIT studies
found that
>50% built
in the affected
region
built after
2001

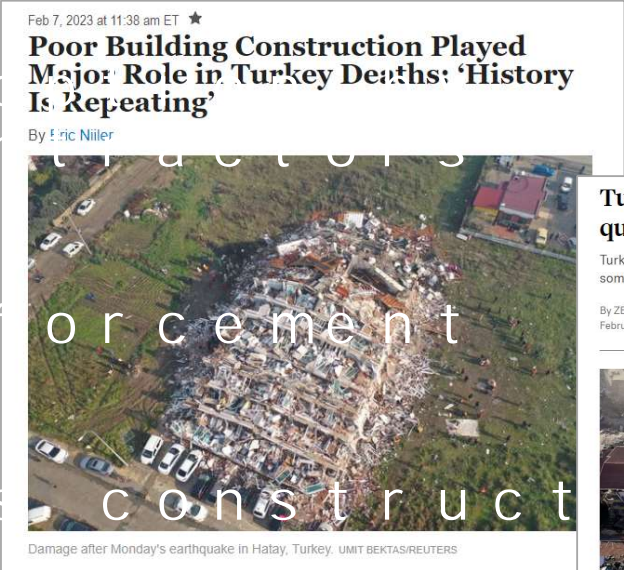
Extensive Damage in Turkey and Syria of Building Code Adoption and Enforcement

Lack of code adoption by builders and contractors

Lack of code enforcement

Leniency toward building permits

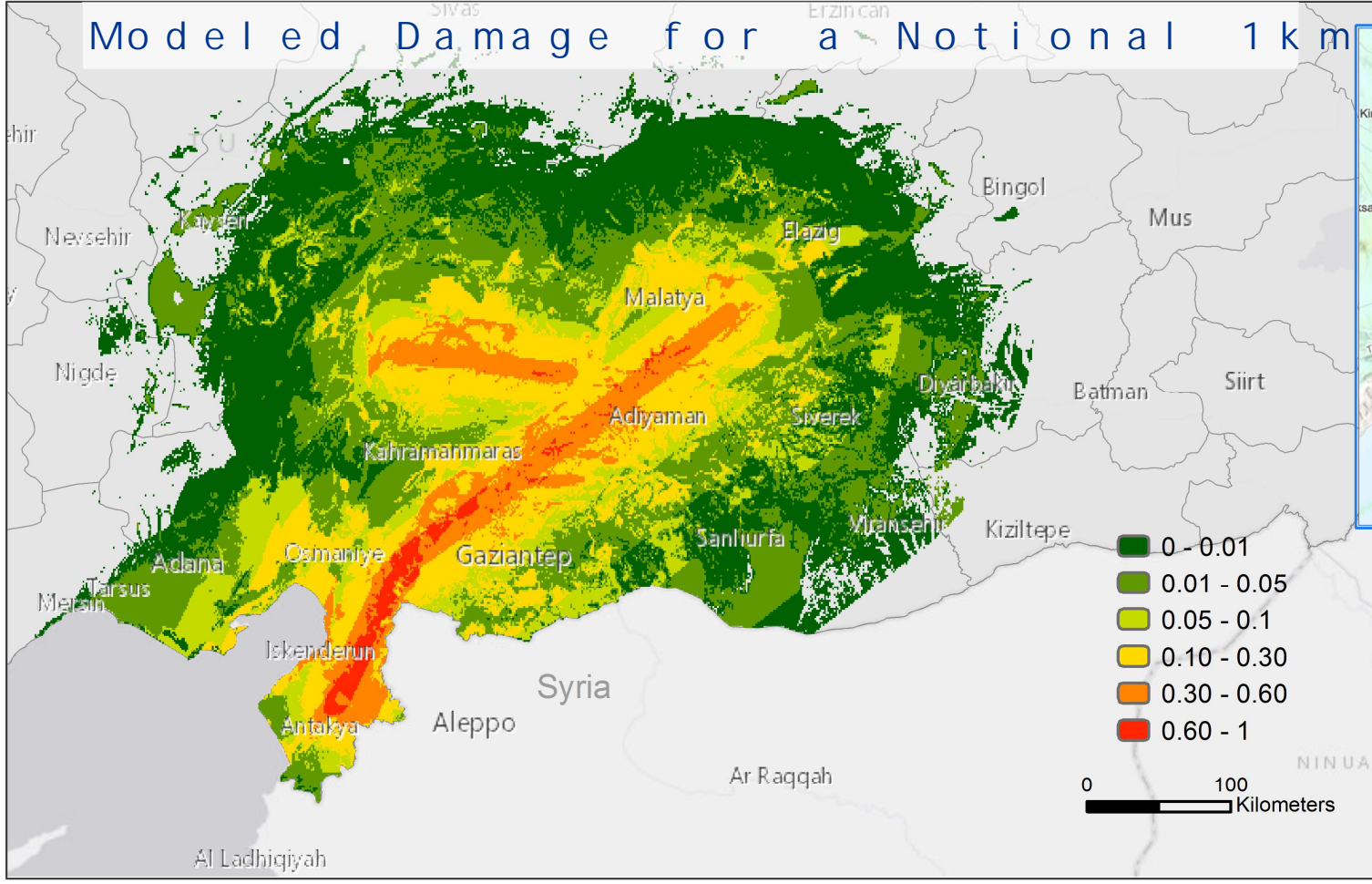
Poor construction quality





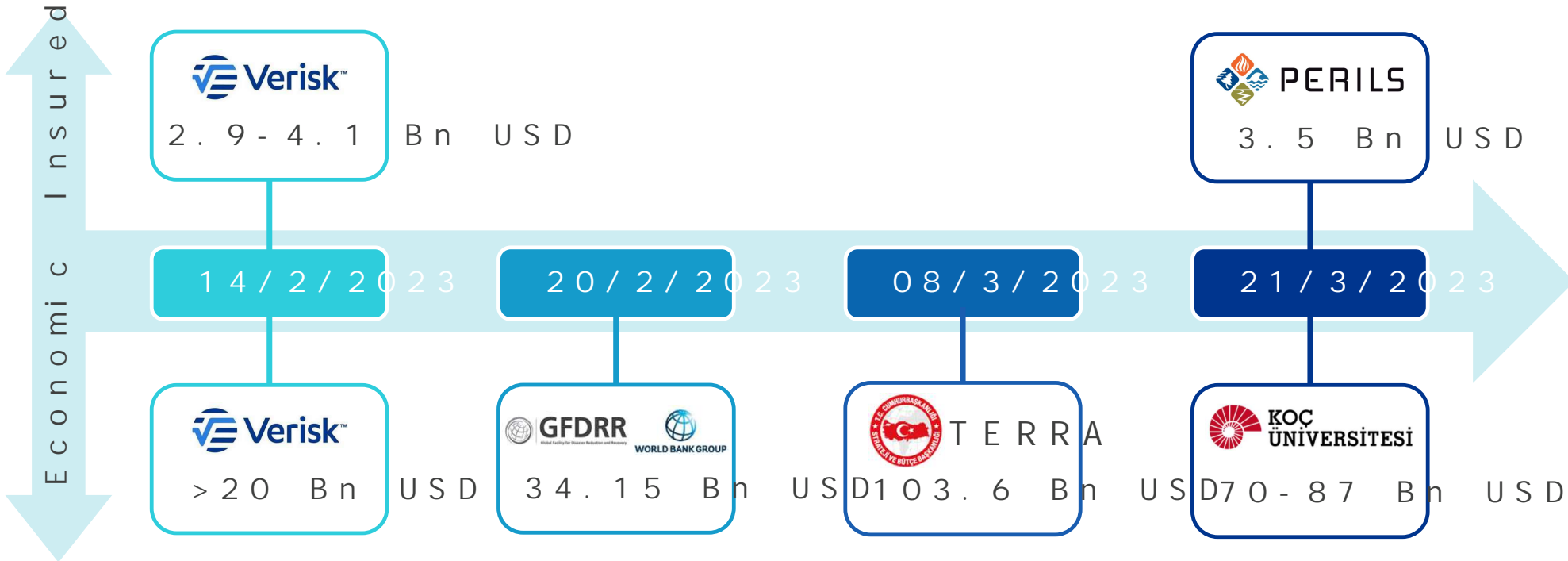
Losses from the
Kahramanmaraş
Earthquake Sequence

Model Correctly Captures the Extent of Damage at Local Level



Location of significant concentrations of USGS shake maps

Various Insured and Economic Loss Have Been Published



Conclusions

Main Conclusions

