Department of Earth and Planetary Sciences
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A Beginner's Note on

SEISMIC HAZARD IN IRAN

v1.5

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1 Foreword to v1.5

Since we compiled the first draft of our introductory notes on seismic hazard in Iran in Spring 2015, we have received fruitful comments from both colleages and the target readers. We had also discovered numerous errors in the first version of the manuscript which we had initially posted online. Besides, we noticed that there were much better ways to cover some of the concepts presented in the first version.

As a result of all the above, we decided to rewrite (and in many instances rethink) many of the ideas which were originally presented in a crude and/or perhaps incomplete way. This document – at least to some extent – is the product of such a process. The one thing we kept in mind while drafting this version was that "this is, for all intents and purposes, going to serve as a beginner's guide" and therefore, many of the (sometimes cruicial) aspects of the ideas would not find their ways to the final version. Also, we decided to keep this in the form of a short memo and not to deviate much from the first draft – hence, calling this v1.5!

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2 Introduction

2.1 Iran: A Seismic Country

Located in the Alpine-Himalayan seismic belt (Fig. 1), Iran hosts a large number of earthquakes. Iran is one of the most seismic countries in the region, along with Greece, Turkey, Italy and the rest of the Adreatic countries as 96,379 earthquakes were recorded by the Iranian Seismological Center (IRSC)[1] between 2006 and 2015 (Fig. 2(a)). Obviously, this number is a victim to catalog completeness[2] (e.g. Engdahl & Villaseor, 2002) and the actual figure is arguably much larger as, for instance, the number of Iranian seismic stations has significantly increased over time. IRSC has currently 124 seismic stations in the country, 19 of which are not operational (IRSC website, Accessed 2015).

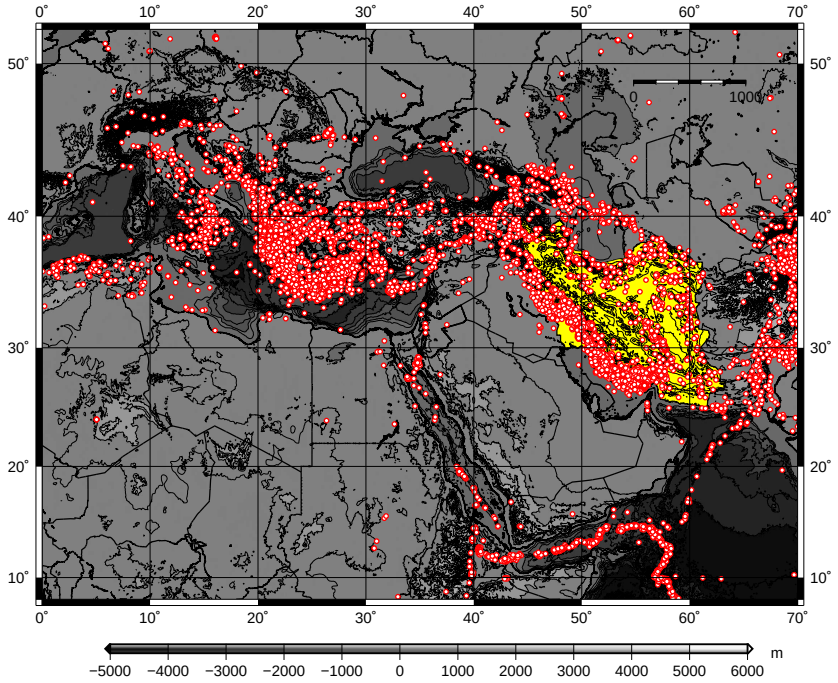
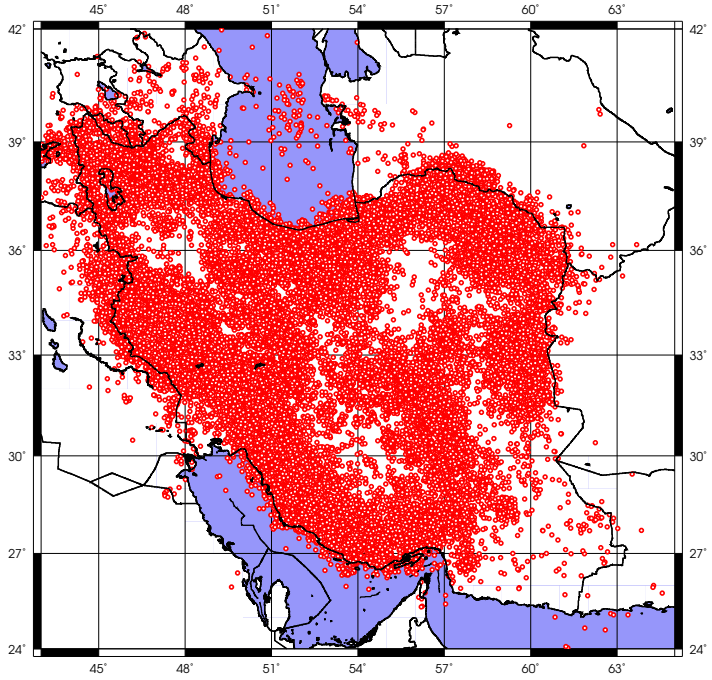


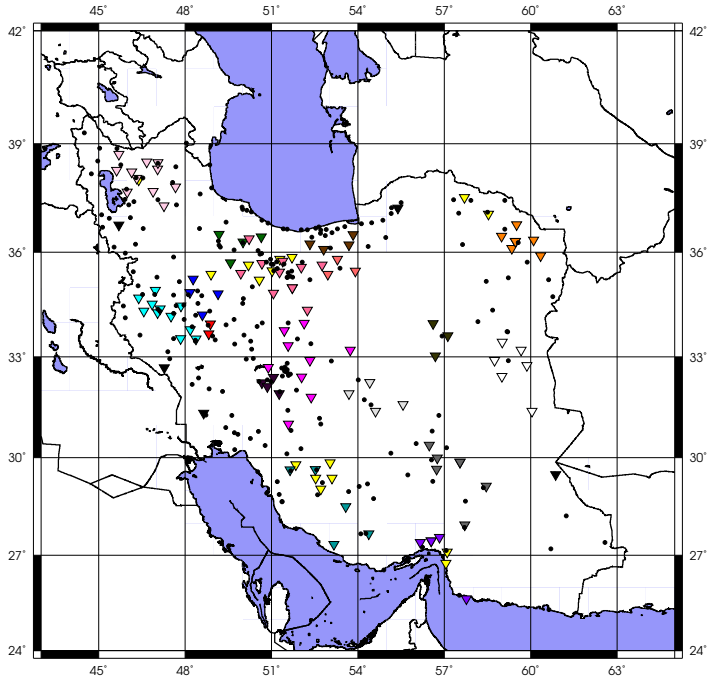
Figure 1: Seismicity of the Alpine-Himalayan belt. Topography is shown as different shades of black/white (ETOPO2). Red circles represent earthquakes (EHB). Iran is shown with yellow.

[1] `http://irsc.ut.ac.ir/`

[2] How many of the earthquake were actually recorded by the seismic network and are included in the earthquakes catalog.



(a)



(b)

Figure 2: (a) Earthquakes (red dots) recorded by IRSC through 2006–2015; (b) IRSC stations. Subnetworks are shown with different colors. Black triangles and black dots represent the non-operational stations and major cities, respectively.

Seismicity of Iran – almost immediately – brings about an important question: *Are earthquakes the primary source of loss in Iran?* In other words, with the huge number of recorded events in the country, should the primary goal of any Iranian policymaker be allocating the country's resources to mitigate the loss from earthquakes? If not, how should they allocate their resources to appropriately accomodate the earthquake hazard issue?

Answering the above questions, as we will talk about throughout this manuscript, requires various considerations in different fields, many of which are not even remotely related to seismic or geological studies (see 4) and are well beyond the scope of this text. However, a good way to address the priority issue would be to consider various sources of hazard and evaluate the "seriousness" of seismic hazard among them.

2.2 Various Forms of Non-Seismic Hazard in Iran

In order to acquire a better understanding of the level of seriousness of seismic hazards in Iran, it is useful to take a brief look at the exposure of the country to other types of natural hazards. A comparison of casualty figures helps us get a realistic feeling for designing hazard policies. A number of disastrous such hazards are listed Table 1. This endeavor is a bit smeared by the fact that there is not an official agency or institution in Iran responsible to gather and process or publish such information.

Table 1: Fatalities or damage caused by different hazards in Iran.

Hazard	**Approx. Damage or Number of Fatalities per Year**
Traffic Accidents	20,000 people[3]
Air Pollution	100,000 people
Floods	$1.8 billion
Landslides	NA
Droughtss	$1 billion
Earthquakes	3,000 people

2.2.1 Traffic Accidents

In the absence of official figures, the media have estimated the fatalities of driving accidents in Iran to be about 20,000 people each year (Ofoghi et al., 2014) as demonstrated in Fig. 3 (e.g. Alef-News, 2012). The cost of these accidents have been from 2.96% (Kazemi et al., 2013) to $\sim 7\%$ (Ayati, 2008) of the country's GDP. There is a road accident fatality in Iran every 19 minutes. In fact, there are 37 fatalities for every 1,000 automobiles in Iran (Alef-News, 2015).

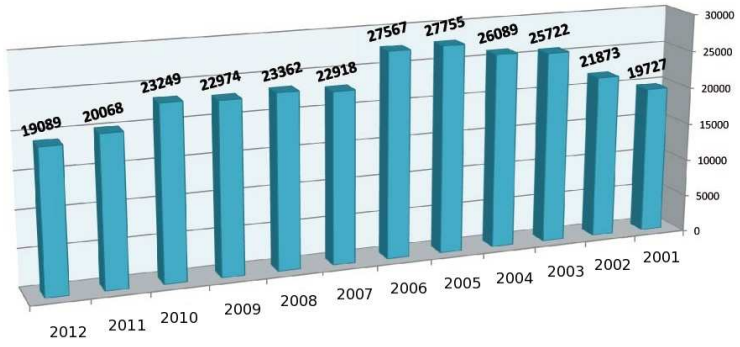


Figure 3: Number of fatalities due to driving accidents from 2001 to 2012 (Alef-News, 2012).

2.2.2 Air Pollution

Air pollution is a major cause of deaths in the metropolitan areas of Iran. Tehran, in particular, is a polluted city (CAQCT, 2013). Perhaps the most important reason for the poor air quality Tehran could be sought in the special geographic location of the city. Tehran is huge city, built on the southern slopes of the Alborz Mountains and extending far south to the central plains of the Iranian Plateau (Fig. 4). This results in the entrapment of CO, CO_2, SO_2, aerosols and other pollutants in the low-lying area (see Figs. 4 and 5). Measurements of air pollution factors shows that, the concentrations of major pollutants is way above the standard threshold (Figs. 6).

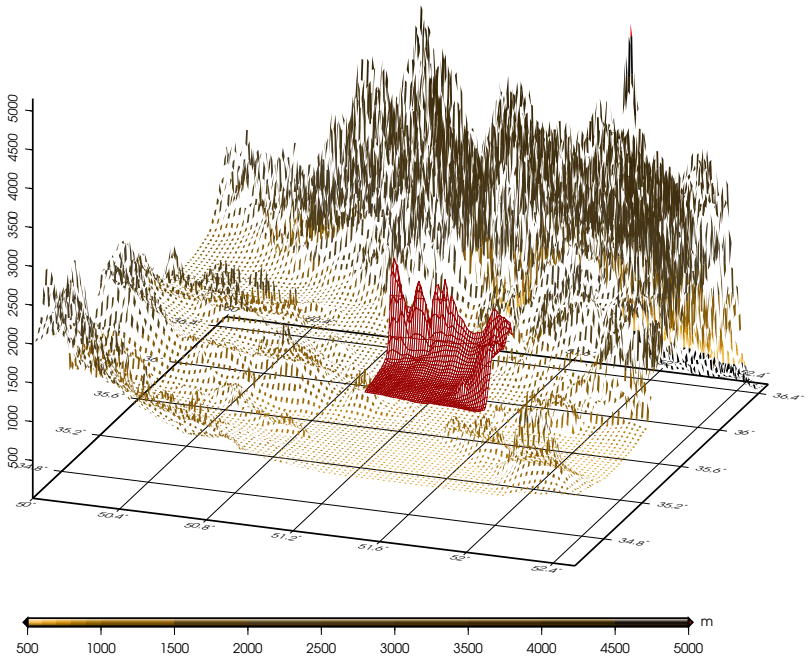


Figure 4: Topography of Tehran region. The area in red represents the metropolitan Tehran (topography data from GEBCO, 2008).

Figure 5: Tehran on a polluted day (Ahadi et al., 2015).

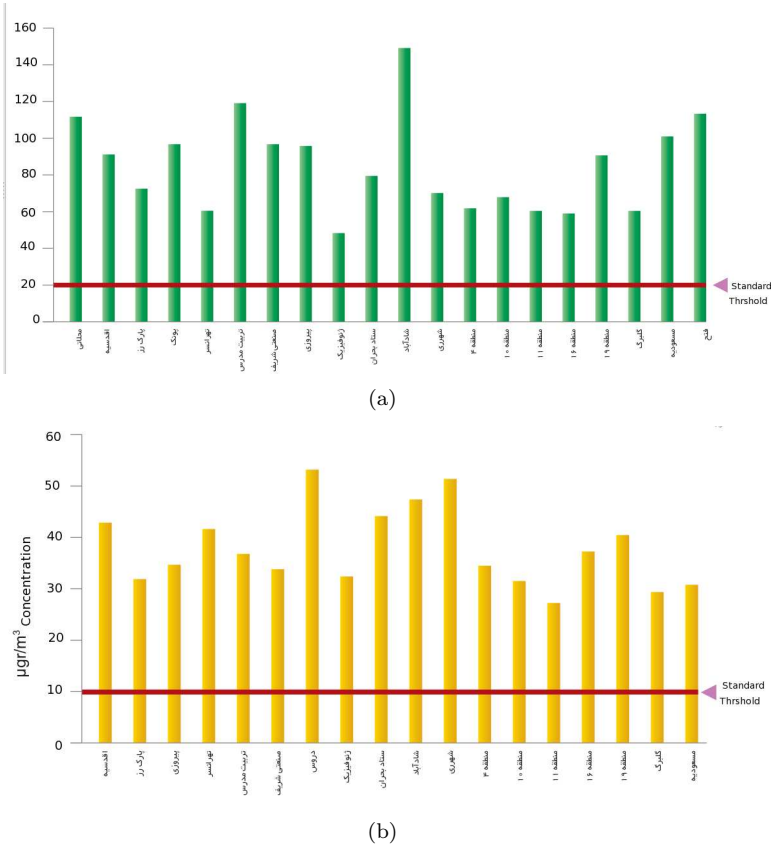


Figure 6: Concentration of (a) carbon monoxide and (b) aerosols in 18 stations in Tehran (Taghian-Pour & Yavari, 2013).

As a result of the poor quality of Tehran and other major cities of Iran, about 310 Iranians lost their lives every day in 2012 (Entekhab-News, 2012-04-07) which adds up to 100,000 people for the whole year. In fact, the environmental authorities of Tehran have stated that the air pollution fatalities have exceeded the casualties of the country's eight-year war with Iraq (Fars-News, 2013-11-11). On many occasions, schools and other administrative offices in major Iranian cities, specially Tehran, are closed due to air pollution. Financial loss from every such "school holiday" in Iran is estimated to mount to $40 million. The Iranian daily economic cycle is estimated to be disrupted by $\sim 70\%$ due to air polution (Entekhab-News, 2015-20-05).