Programming of the V Winter Course of the UnB Seismological Observatory

1: Waveform inversion for moment tensor (ISOLA)
Prof. Dr. Jiří Zahradník (Charles University in Prague, Czech Republic) Dr. Efthimios Sokos (University of Patras, Greece), Prof. Dr. Ronnie Quintero (Seismological and Volcanological Observatory of Costa Rica – Costa Rica), Prof. Dr. Juan M Gómez (Universidad Autonoma de México - Mexico), Dr. Patricia Pedraza (Servicio Geológico Colombiano - Colombia), Prof. Dr. Silvina Nascif Suvire (University of San Juan - Argentina), Prof. Dr. Silvana Spagnotto (University of São Luiz - Argentina), Prof. Dr. Celeste Bollini (University of La Plata - Argentina), Prof. Dr. O'Leary Matos - (Director of the Cuban Seismological Studies Center -Cuba), Dr. Fabio Luiz Dias (National Observatory – Brazil), Dr. Juraci Mario de Carvalho (UnB - Brazil), Prof. Dr. Lucas Vieira Barros (UnB - Brazil)

11/16 - 11/20, 9:00 am - 17:00.

Lecture 1: Urban seismology: how seismometers record cultural activities
Prof. Dr. Susanne Taina Ramalho Maciel (UnB)
16/11 - 17:00 - 18:00

Lecture 2: Risk Management and Dam Safety
Prof. Dr. André Pacheco de Assis (UnB)
17/11 - 17:00 - 18:00

Lecture 3: DATA ANALYSIS OF THE CARTAGO EARTHQUAKE OF MAY 4, 1910 AND ITS POSSIBLE RELATION TO CURRENT SEISMIC ACTIVITY
Prof. Dr. Ronnie Quintero (UNA - Costa Rica)
11/18 - 17:00 - 18:00

Lecture 4: South America High-Resolution Waveform Tomography
MSc. Bruna Chagas de Melo
19/11 - 17:00 - 18:00

Lecture 5: History of the Pacajus earthquake, effects and consequences
MSc. Francisco das Chagas Brandão (Civil Defense Ceara State)
11/20 - 14:00 pm - 14:20 pm

Lecture 6: Behavior in the event of earthquakes, experience developed within the framework of the application of human security standards in institutions
Eng. Natália Segura Lobo (UNA – Costa Rica)
11/20 - 14:15 - 15:00

Lecture 7: Paleosismicity and historical seismicity in Northeastern Brazil: implications for seismic risk
Prof. Dr. Hilário Bezerra (UFRN)
11/20 15:00 - 15:45

Lecture 8: Northeastern Brazil: A Natural Laboratory for Intra-Plate Seismicity Studies
Prof. Dr. Marcelo Assumpção (USP)
11/20 - 16:00 pm -16:45

Lecture 9: Book launch: Brazilian participation in the verification of the Comprehensive Nuclear-Test- Ban Treaty - CTBT
Prof. Dr. Lucas Vieira Barros (UnB)
20/11 - 17:00 - 18:00

Course 1: Waveform inversion for moment tensor (ISOLA)
It is a postgraduate course of waveforms inversion for obtaining source parameters of local and regional earthquakes. It will meet the demand for knowledge from Geoscientists of Latin America (LA) and other part of the world and will be taught by professors from UnB and external to UnB. The course will use the ISOLA software, recently developed and already with wide application in the inversion for the Moment Tensor, created by the teachers who will teach the course (Jiří Zahradník, Efthimios Sokos).

Lecture 1: Urban seismology: how seismometers record cultural activities
In recent years, the study of urban sources has become a seismology research field active, with the most varied objectives. It is possible, for example, to monitor traffic in large cities, record movements of a significant number of people, or obtain microzonation maps. Also, with the advancement in environmental noise imaging techniques, the design of urban sources is of great interest to the scientific community. The records of urban tremors are also a strong ally in scientific dissemination, since the interpretation of the seismic signal has a concrete, and often effective, meaning for people. In this lecture, we will show the results of the analysis of seismic noise in Brasília, and the main advances in this area.

Lecture 2: Risk Management and Dam Safety
The lecture will focus on the main modes of dam failure and safety, introducing the concepts of engineering risks, both from a qualitative and quantitative perspective. Thus, the risk metric will be discussed, as well as the overall cost concept of the structure. Finally, aspects of the probabilistic approach, quantification of the probability of failure for the different failure dams modes will be discussed, and monetization of the consequence of a possible rupture and the risk itself, within a context of risk management as a decision-making tool for dam safety.

Lecture 3: DATA ANALYSIS OF THE CARTAGO, COSTA RICA EARTHQUAKE OF MAY 4, 1910 AND ITS POSSIBLE RELATION TO CURRENT SEISMIC ACTIVITY
Historically, the city of Cartago and its neighborhood have been severely affected by superficial seismic events of moderate to strong magnitude ($5.0 \leq mb \leq 6.2$), which have caused severe damage to the population and infrastructure in the area. One of these historical earthquakes, is the Santa Monica earthquake of May 4, 1910, registered at the seismic station located at the National Institute in San José at 06:47:35 (local time).

The Agua Caliente fault, located about 10 km south-southwest of Cartago city, has been considered by some authors as the cause of the 1910 Santa Mónica earthquake. However, the current seismicity registered by the OVSICORI-UNA seismic network shows seismic activity in the west and central part of the city; therefore, another source that generated the 1910 earthquake and closer to the city cannot be discarted as a possible source of the 1910 earthquake.

The data recorded by the Seismographic Network of the Volcanological and Seismological Observatory of Costa Rica (OVSICORI-UNA) and the epicentral locations of cortical earthquakes located east of the Costa Rica, Central Valley show seismic activity below the city of Cartago, such as the event seismic presented of 07/26/2014, recorded at 05:49:50 (UTC), Ml 4.4, located in Taras de Cartago and which, according to the waveform modeling analysis for the moment tensor, shows as possible origin a left lateral, vertical and SW subducting fault, with strike/dip/rake parameters of 230° / 85° / -8° and located ~2 km west of the city center or a right-lateral strike slip fault with NW direction, vertical and striking NW to SE going through the city and with strihe/dip/rake parameters of 321° / 82° / -175°.

The above mentioned earthquake has been the largest recorded by OVSICORI-UNA in the center of the city of Cartago, during the time t been in operation and its location agrees with one of the main direction indicated by Pedro Nolazco Gutiérrez in the seismogram of the earthquake of May 4, 1910; coinciding with firsts arrivals.

The epicenter of the earthquake of 07/26/2014 at 05:49:50 (UTC), Ml 4.4, which indicates the presence of active vertical and lateral shift faults with NW or SW direction and the location of cortical seismicity to the west and in the center of the city of Cartago, cannot discarded such fault as the origin of Santa Monica Earthquake of May 4, 1910, which destroyed Cartago, the capital of the country at that time.

Knowing that with the 1910 earthquake intensities in the Modified Mercalli Scale of IX in Cartago were reached and that many physical conditions in the central area of the country are preserved, as evidenced the Cinchona Earthquake of January 8, 2009 (Mw 6.1), located some ~ 55 km from the city of Cartago and which produced similar effects and intensities of historical earthquakes in that epicentral zone; they locate the city with a high degree of seismic risk.

Lecture 4: South America High-Resolution Waveform Tomography

The South American continent is composed of several geological units, from its former Precambrian platform to the current orogenic strip of the Andes. However, the structure of its lithosphere and its dynamics of interaction with the mantle is widely debated, and are not yet fully understood. The waveform tomography method has the power to solve the 3D distribution of velocities of the S wave, which are sensitive to temperature and composition of the crust and upper mantle. However, until recently, the distribution of seismic data was sparse and uneven.

The recent growth in the distribution of broadband seismic stations around the whole continent, allows us to resolve from large scale structures to regional-scale structures, such as the subduction of the Nazca Plate and the limits between nearby cratons. We gathered all the data available on the continent in the open database of IRIS, and included stations from the Brazilian Seismology Network and stations from the Pantanal and Paraná-Chaco basins that are part of FAPESP's “3 Basins Thematic Project”. We complement this data with our global waveform data set, which maximizes data

sampling over a wide range of frequencies, and makes it possible to obtain detailed structural information from the crust to the transition zone.

The S velocity tomography model used is solved with the adjustment information of the vertical wave component, calculated using the "Automated Multimode Inversion" (AMI) method of surface waves, S- and multiple S. Each wave adjustment provides a set of linear equations that describe the 1D average of velocity disturbances about a 3D model of reference velocities within the sensitivity volume of the source-receiver path. All equations are then combined into a large system of linear equations and inverted together for an isotropic S and P wave model, and azimuth anisotropy. In this work, we combine the S wave velocity maps with geology information, kimberlite location, transition zone thickness from the receiver function, and seismicity. In this way, we obtain new information about the structure and evolution of the lithosphere, including cratons, intra-cratonic basins, and the Andes region and its dynamics with the asthenosphere.

Lecture 5: History of the Pacajus earthquake, effects, and consequences

The State of Ceará today has 62 (sixty-two) municipalities affected by earthquakes, of different magnitudes and intensities. The "Pacajus Earthquake", of 11/20/1980, cataloged as the biggest earthquake in Northeast Brazil 40 years ago. Since then, much has been studied and much has been learned, there were several ways in which we came to live with this phenomenon since it is not possible to forecast these adverse events. In one way or another, there is preparation for living with them. Are common the earthquakes in Ceará? Keeping the proper proportions, and making a comparison with what happens in Japan or Chile, for example, there is a big difference. But, even so, we must not to stop being careful when facing this disaster. The magnitude of this earthquake was 5.2 on the Richter Scale and the intensity reached VII on the Modified Mercalli Scale, which ranges from I to XII. Several were the victims and material damages, only there was no death. In the epicentral region, 488 houses were rebuilt. There is concern about population growth, as during that time the number of inhabitants has doubled. In these 40 (forty) years, also following this evolution, we had house construction in the epicentral area without obeying any resistant earthquake norms. Another important aspect is that this event took place in the great Fortaleza, as the metropolitan region of the capital of Ceará is composed of 19 (nineteen) municipalities, among them Pacajus, where, according to IBGE, approximately 4.5 million inhabitants live.

Lecture 6: Behavior in case of earthquakes, experience developed within the framework of the application of human security standards in institutions

The National University of Costa Rica has carried out in the last 10 years training efforts so that its collaborators are active actors in the actions of preparation and response to disasters, it is for this reason, that in 2020 we can present part of the advances that have been obtained in this management. This presentation will show the practices implemented in the structural, non-structural, and functional components to advance institutional resilience.

We will show the most recommended practices to be followed by the group in the face of seismic events of different magnitudes and we will be relating it to the importance of

the participation of all collaborators, our protocols, and incorporation into the ordinary work of the University.
A knowledgeable and prepared society is a vital link for disaster risk reduction; a more active society in the National Disaster Risk Management System favors social resilience and the National University is committed to this in the approach to Disaster Risk Management from the scope of preparations and response.

Lecture 7: Paleosismicity and historical seismicity in Northeastern Brazil: implications for seismic risk
In intra-plate regions, the recurrence of failures tends to be greater than the period monitored instrumentally. In this lecture, geological and historical evidence on seismicity in Northeast Brazil will be presented. Initially, examples of scientific reports and journalistic sources on seismicity in the region since 1808 will be shown. Then, geological evidence will be addressed. The South American Hazardous Faults map, recently released in the Journal of South American Earth Sciences (DOI: 10.1016 / j.jsames.2020.102837) will be discussed with an emphasis on the fault mapping methodology for seismic risk purposes, including examples of faults with and without slip-rate. The correlation between seismicity and geological faults will also be discussed. Finally, evidence of liquefaction will be presented. The lecture will conclude with an analysis of the seismic risk in the region and implications for Brazil.

Lecture 8: Northeastern Brazil: A Natural Laboratory for Intra-Plate Seismicity Studies
One of the most seismically active regions of Brazil, the Northeast has been studied for over 40 years and has the best record of the characteristics of Brazilian earthquakes: they occur in the first 10 km of the upper crust, usually under a regime of transient tensions of regional origin, and the most active areas are around the Potiguar Basin. It is the only region in Brazil where some old fault zones are clearly in reactivation, such as the Lineamento de Pernambuco. Despite the great progress made in the observation of earthquakes and the description of their characteristics, little progress has been made in understanding the fundamental causes of intra-plate seismicity, which is a worldwide challenge and not only in Brazil. The most common explanatory hypotheses involve some type of stress concentration in the upper crust due to lateral structure variation (thinning of the lithosphere, flexural stresses, etc.). But they are only general hypotheses yet to be confirmed and which cannot be used in the seismic threat projections.
These issues will be discussed for the elaboration of seismic threat maps of the Northeast.

Lecture 9: Book launch: Brazilian participation in the verification of the Comprehensive Nuclear-Test Ban-Treaty - CTBT
The Comprehensive Nuclear-Test-Ban Treaty (CTBT) prohibits the carrying out of nuclear explosions on a global level. The CTBT, although not yet in force, has an International Monitoring System (IMS) based on geophysical sensors, capable of globally detecting any nuclear test with a power equal to or greater than 1 kt (kiloton) of TNT. The sensors of the IMS worldwide network use four technologies: Seismic; Infrasonic; Hydroacoustics and Radionuclides. Data from the IMS network is transmitted to the International Data Center (International Data Center - IDC), located at the UN in Vienna - Austria, where they are processed, analyzed and interpreted to identify possible signals

related to clandestine nuclear explosions, as well as for issuing bulletins and reports on any events of interest to comply with the Treaty. Brazil, which has already signed and ratified the CTBT, contributes data from three technologies: Seismic, Infrasonic, and Radionuclides. The Seismological Observatory (SIS) of the University of Brasilia (UnB) contributes data from two stations, a primary seismic and an infrasonic, both installed inside the National Park of Brasília (PNB). The data from these stations are transmitted to the SIS - UnB, where they are recorded, analyzed, and retransmitted to the IDC in Vienna. The other IMS stations in Brazil are two auxiliary seismic stations, located in the states of Rio Grande do Norte and Amazonas; two radionuclide stations, located in Rio de Janeiro and Recife (planned), and a radionuclide laboratory, located at the Institute of Radioprotection and Dosimetry (IRD), also in the city of Rio de Janeiro. In this text, we briefly present the CTBT treaty, its verification system, and the Brazilian participation in its compliance and surveillance. And, to support the discussions that have been carried out on the implementation of the Brazilian NDC, we also present a description of an NDC, with definition, attributions, and requirements for assembly and operation. Finally, the results of the analysis of seismic and infrasonic signals from the last nuclear explosion carried out by North Korea, on September 3, 2017, and the accidental explosion that occurred in Beirut, on August 4, 2020, are presented.