REPORTS FROM THE 3RD BRAZILIAN SEISMOLOGY SYMPOSIUM

Marcelo Belentani de Bianchi,
Marcelo Sousa de Assumpção
& Carlos Alberto Moreno Chaves (org.)

Brazilian Seismology Symposium (3rd : 2019 : Vinhedo, SP)

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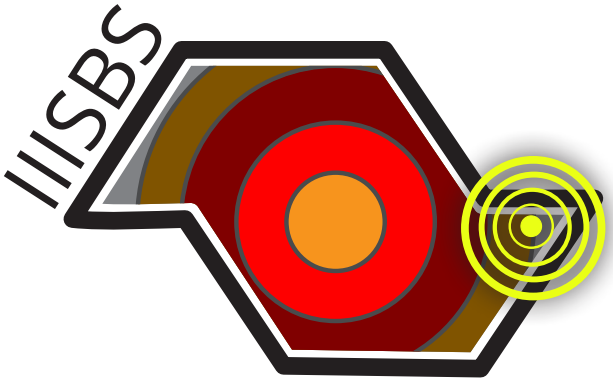

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Pre Symposium Courses & Mini Course:
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MOSTEIRO DE SÃO BENTO EM VINHEDO

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Summary

ORGANIZING COMMITTEE

Many different people worked to make this event possible. The team responsible for making this event a reality is listed below. Many others contributed, including all participants presenting papers at in our scientific program.

General Coordination

Marcelo Belentani de Bianchi (IAG/USP)
Marcelo Sousa de Assumpção (IAG/USP)
Carlos Moreno Chaves (IAG/USP)

Event Organization and Assistance

Luciana Hiromi Yamada da Silveira (IAG/USP)
Rosely Vieira de Sousa (IAG/USP)

Technical Infrastructure and Data Processing

Bruno de Barros Collaço (IEE/USP)

Infrastructure & Technical Support

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Lais Rodrigues (IAG/USP)
Felipe Proença Corral (IAG/USP)

PROGRAM SUMMARY

The total symposium program covered 9 days with a pre-symposium mini-course from 8th to 12th April, and mini-courses on 14th April. The scientific program covered two whole days, 15th and 16th April, and a half day, on 17th April.

During the evening, there were social activities. On 14th April there was an Ice Break reception. On 15th April we visited the OAM (Observatório Abraão de Morais in Vinhedo/SP) where we were received by Prof. Dr. Ramachrisna Teixeira for an Astronomical talk and had the opportunity to observe the sky from the building's roof. Finally, on 16th April there was a visit to one traditional Wine producer in the town area of Vinhedo/SP for tasting some wine and discover about the history of the city.

PRE SYMPOSIUM MINI-COURSE

During the week previous to the event, we offered a one week (30 hours) mini-course entitled “Signal Extraction from noise with polarization and correlation techniques: application to seismic tomography and crustal structure”. This course was held at the *Instituto de Astronomia, Geofísica e Ciências Atmosféricas* of the *University of São Paulo* (IAG/USP) from 8th to 12th April 2019. A total of 19 participants attended the course taught by Dr. Martin Schimmel (ICTJA/Spain).

The course program involved A) Noise auto/cross-correlations and stacking (phase coherence approach); A.1) Extracting Rayleigh waves using noise cross-correlations for different station pairs; A.2) Detecting P-wave reflections from the Moho using noise auto-correlations; A.3) Monitoring structural variation through decorrelation (e.g., deformation along a fault, volcano, mine); B) Noise characterization through polarization analysis; B.1) Characteristics of the noise wavefield: primary and secondary microseisms, main directions, seasonality, etc; B.2) Rayleigh wave ellipticity to constrain shallow structure (H/V); C) Introduction into ambient noise tomography; C.1) Group/phase velocity maps.

14th April MINI-COURSES

We offered two mini-courses on the afternoon of 14th April with a duration of 4 hours each. One was about Receiver Function analysis, by Dr. Fabio Dias from *Observatório Nacional* and another, about using the Seismic Analysis Code by Dr. Marcelo Bianchi from *IAG/USP*. Courses had 15 and 11 participants, each respectively. Participants brought their own laptop and training was done using Virtual Machines.

Receiver function course program included (1) Radial by Vertical deconvolution: what is the physical meaning of receiver functions, source signature and receiver

signature; (2) obtaining Ps and multiples phases travel-times. (3) effect of layer dipping. (4) joint inversion of Receiver Function and Surface Waves dispersion.

Seismic analysis code course program involved (1) Read and Write filename manipulation; (2) Basic pre-processing operations (cut, trend, taper decimation, interpolation and frequency filter); (3) Instrument removal, traces synchronization and component rotation; (4) Spectogram computation and waveforms correlations; (5) Seismic Sections; (6) Improving seismic data plotting; (7) SAC Macros.

INVITED SPEAKERS

The event had four invited lectures given by invited researchers. Theses talks were:

1. Dmitry Storchak (ISC/UK): *Recent and future ISC products: chances for international collaboration*.
2. Gerardo Sánchez (INPRES/Argentina): *Probabilistic seismic hazard assesment for Argentina*.
3. Lauren Waszek (NMSU/USA): *Global observations of reflectors in the mid-mantle with implications for mantle structure and dynamics*.
4. Martin Schimmel (ICTJA/Espanha): *Seismic noise-based imaging and monitoring with the phase coherence approach*.

SUMMARY

Program summary is presented on the next page. Each session is a block of two or more presentations under the specific subject. Main sessions names are:

TS-1: Tectonic Structure One
TS-2: Tectonic Structure Two
SS-1: Seismicity Studies One
SS-2: Seismicity Studies Two
SS-3/Signal: Seismicity Studies / Signal Processing
SS-4: Seismicity Studies Four
SS-5: Seismicity Studies Five
SS-6: Seismicity Studies Six / Probabilistic Seismic Hazard Analysis
FA-1: Field Advances One
LTSS: Lightining Talks Seismicity Studies
LTFA: Lightining Talks Field Advances
PP-1: Poster Session One (Monday - Tuesday)
PP-2: Poster Session Two (Tuesday - Weednesday

Time	Sun, Apr 14	Mon, April 15	Tue, April 16	Wed, April 17
07:00	Reception	Breakfast (1h)		
08:15		Welcome	**Invited Talk**	FA-1
08:30		**Invited Talk**		
08:45				
09:00				
09:15			SS-3/ Signal Processing	Poster (PP-2)
09:30		TS-1		
09:45				
10:00				
10:15		Coffee Break (30 Min)		
10:45		TS-2	SS-4	Check-out
11:00				
11:15				*Meetings*
11:30				
11:45				
12:00				
12:15				*Thank you !*
12:30		Lunch (1h30m)		
13:45		LTSS	LTFA	
13:50				
13:55				
14:00	**Minicursos:**			
14:15				
14:20	(1) Usando o SAC para processamento de sinais em sismologia de forma eficiente. Marcelo Bianchi / USP & (2) Função do Receptor: Entendendo a deconvolução, cálculos de espessura e Vp/Vs. Fábio Dias / ON ...	**Invited Talk**	SS-5	
14:25				
14:30				
14:45				
15:00				
15:15		SS-1	**Invited Talk**	
15:30				
15:45				
16:00				
16:15	Coffee Break (15 Min)			
16:30	**... Minicursos**	SS-2	SS-6/ PSHA	
16:45				
17:00				
17:15		Poster (PP-1)		
17:30				
17:45			Poster (PP-2)	
18:00				
19:15	Light Dinner			
20:30	Ice Break Reception	Social, Cultural & Sports Activities		

ABSTRACTS & PARTICIPANTS

Brazilian Seismology Symposium accepted simple abstracts containing a text resume and one optional figure. Abstracts submission were open from 1st October 2018 until 31st January 2019. In total, 101 abstracts were received: 101 were accepted; during the conference 95 were presented, including the four invited speakers.

Abstracts were presented in three different formats: Oral presentations with a total of 15 minutes, Poster presentations or Lightning talks, that are like Oral presentations but with a time limit of 5 minutes. All submitted abstracts were sorted into three different sessions: Field Advances, Network Operation and Technological Developments (FA), Tectonics & the Structure of the Crust and Upper Mantle (TS) and Local, Regional and Global Seismicity & Seismic Sources Studies (SS). Table 1 shows the number of abstracts distributed by session and presentation format.

Table 1: Number of presented works distributed by sessions and presentation format. Table does not count the invited talks (4). Total considered abstract adds up to 91 works.

Session/Format	Posters	Oral	Lightning	Total
FA	7	4	3	**14**
SS	22	27	3	**52**
TS	15	10	0	**25**

In terms of participants, the event counted with a total of 88 persons that were present, from a total of 94 registered participants. Contributions from different nationalities add up to 13 different countries listed below, together with the name of 37 institutions that were represented at the event.

Countries:

1. Brazil (74 participants)
2. Angola (1 participant)
3. Argentina (3 participants)
4. Australia (1 participant)
5. Bolivia (1 participant)
6. Spain (1 participant)
7. United Kingdom (2 participants)
8. Iran (1 participant)
9. Italy (1 participant)
10. Peru (2 participants)
11. Portugal (1 participant)
12. United States (1 participant)
13. Uruguay (5 participants)

Institutions:

1. Alta Resolução Geofísica

2. Australian National University / Australia
3. New Mexico State University / United States
4. Braskem (Chemical Industry)
5. Brown University / United States
6. Centro Regional de Sismología para América del Sur (CERESIS)
7. Consalt Consultoria
8. Coordenadoria Estadual de Defesa Civil do Ceará
9. Serviço Geológico do Brasil (CPRM)
10. Universidad de la República Oriental del Uruguay / Facultad de Ciencias (UDELAR) / Uruguay
11. Universidad Nacional de La Plata (Unlp) / Argentina
12. Observatorio Geofísico de Uruguay (OGU) / Uruguay
13. Faculdade de Engenharia da Universidade do Porto (FEUP) / Portugal
14. GeoOndas Ltda.
15. Guralp Systems Inc
16. Institute of Earth Sciences Jaume Almera (ICTJA/CSIC) / Spain
17. Instituto Nacional de Prevención Sísmica (INPRES) / Argentina
18. Instituto de Pesquisas Tecnológicas do Estado de São Paulo
19. International Seismological Center (ISC) / United Kingdom
20. Observatório Nacional
21. Observatório San Calixto (OSC) / Bolivia
22. Empresa Pública de Produção de Eletricidade (PRODEL) / Angola
23. Pontifícia Universidade Católica do Rio de Janeiro (PUC-Rio)
24. Rede Sismográfica Brasileira (RSBR)
25. SGGM Geologia & Mineração
26. Studio Mangoni Itália/Studio Mangoni Brasil
27. Trimble Inc.
28. Universidade Federal do Espírito Santo (UFES)
29. Universidade Estadual Paulista (UNESP)
30. Universidade Federal do Pampa (UNIPAMPA)
31. Universidade de Brasília (UnB)
32. Universidade de São Paulo (USP)
33. Universidade Estadual de Campinas (UNICAMP)
34. Universidade Federal de Mato Grosso do Sul (UFMS)
35. Universidade Federal do Ceará (UFC)
36. Universidade Federal do Rio Grande do Norte (UFRN)
37. Universidade Federal Fluminense (UFF

IMAGES OF THE EVENT

Below we present some images of the event showing most of the aspects of the symposium. Oral sessions were organized before and after lunch. During lunch we had lightning sessions and in the end of the day poster sessions. During the evening we arranged social activities where participants could better integrate.

"Resceiver Function minicourse" lectures given by Dr. Fabio Dias/ON.

Lightning talks. Presenters had 5 minutes, just after lunch to present their work.

Oral presentations. Speakers were given 15 minutes to present their work.

Poster presentations and discussions.

Main room used for Oral presentations, translating cabin was at the bottom of the room.

Visiting a local wine producer in the city of Vinhedo/SP as part of the evening activity.

MESSAGE TO ALL

The *Centro Regional de Sismologia para América del Sur* (CERESIS) is an intergovernmental institution created in 1966 by UNESCO and the Peruvian government to help the exchange of data and cooperation between many different countries in South America. During the conference, we had the opportunity to have with us Dra. Leda Sanchez Bettucci, president of the directive board, and Leandro Rodríguez the executive director. After the event, we received a letter that we would like to share with all the other participants (you) that show the importance and strength of our community. Thank you CERESIS and thank you ALL!

Centro Regional de Sismología para América del Sur

El Centro Regional de Sismología para América del Sur (CERESIS), felicita a la Comisión Organizadora del III Simposio Brasileiro de Sismología, por su excelente labor en la realización del mencionado evento. Logrando reunir a un buen número de científicos provenientes de diversos lugares, mostrando todo lo que avanza la investigación y el intercambio de conocimiento en pro del avance de la sismología a nivel mundial y en particular de América del Sur.

Sao Paulo, 16 de Abril de 2019

Dra. Leda Sánchez Bettucci
Presidenta del Consejo Directivo

Lic. Leandro Rodríguez V.
Director Ejecutivo

Image reproduction of the letter received by the organizing committee from the CERESIS representatives at the 3rd SBS.

Invited Talks

Global observations of reflectors in the mid-mantle with implications for mantle structure and dynamics

Lauren Waszek*[1]

[1] *New Mexico State University*

Abstract

Seismic tomography indicates that both up and downwelling flow is commonly deflected in the mid-mantle. However, without a candidate mineral phase change, causative mechanisms remain controversial. Deflection of flow has been linked to radial changes in viscosity and/or composition, but a lack of global observations precludes comprehensive tests by seismically detectable features. Using precursors to the mantle phases SS and PP, we perform a systematic global-scale interrogation of mid-mantle seismic reflectors with lateral size 500–2000 km and depths 800–1300 km. Reflectors are detected globally with variable depth, lateral extent and seismic polarity and identify three distinct seismic domains in the mid-mantle. Near-absence of reflectors in seismically fast regions may relate to dominantly subvertical heterogeneous slab material or small impedance contrasts. Seismically slow thermochemical piles beneath the Pacific generate numerous reflections. Large reflectors at multiple depths within neutral regions possibly signify a compositional or textural transition, potentially linked to long-term slab stagnation. This variety of reflector properties indicates widespread compositional heterogeneity at mid-mantle depths.

*Presenting Author.

Abstract ID: iiilau, *Contribution type:* Oral Presentation, *Session:* Invited Talk, *Submitted by:* Lauren Waszek (lauren.waszek@cantab.net).

Probabilistic Seismic Hazard Assesment For Argentina

Gerardo Sánchez Girino*[1]

[1] *Instituto Nacional de Prevención Sísmica y Universidad Nacional de San Juan (INPRES/UNSJ/Argentina)*

Abstract

The new seismic hazard map of Argentina is obtained through a Probabilistic Seismic Hazard Assessment using a complete catalog integrated by 6 databases: INPRES (Argentina National Network, S. I. S. R. A. catalog of CERESIS, The International Seismological Centre, GUC from National Seismological Centre from Chile, PDE from United States Seismological Service and Global CMT from Harvard University. The complete catalog was made homogeneous and non-independent seismic events were omitted using empirical equations for aftershock detection. The Seismic regionalization considered homogeneously distributed earthquakes and quaternary deformation structures compiled and published by the Argentine Mining Geological Service (SEGEMAR). Each of the 131 classified regions was computed considering it as a seismicity homogeneous volume depending on the seismic depths distribution mobile average. Gutenberg-Richter b-value and its standard deviation were obtained by a log-normal distribution of b-values calculated using Maximum Likelihood estimations varying the minimum magnitude and magnitude interval. Alternative algorithms such as Kijko and Smith (2012), and Ordaz and Guirado (2017) were used to confirm calculations and in the Logic Tree. Rupture dimensions were calculated using Wells and Coppersmith (1994) equations. Strong motion Attenuation were selected from the analysis of local data compared to several published model including NGA and GMPE attenuation models. PSHA results for Argentina were calculated for return periods of 145, 475, 975, 2475, 4975 and 9975 years and spectral periods of 0.01, 0.02, 0.03, 0.04, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 1, 2, 3, 4, 5, 10 seconds. Disaggregation chart analysis helped to identified main seismic hazard sources for places of especial interest as hydroelectric dams. Then, a Deterministic Seismic Hazard Analysis was realized to evaluate worst case scenario.

*Presenting Author.

Abstract ID: iiigrs, *Contribution type:* Oral Presentation, *Session:* Invited Talk, *Submitted by:* Gerardo Sánchez Girino (grsmath@gmail.com).

Recent and future ISC products: chances for international collaboration

Dmitry Storchak*[1]

[1] *International Seismological Centre*

Abstract

The International Seismological Centre (ISC) was set up in 1964 with the assistance of UNESCO as a successor to the International Seismological Summary (ISS) in collecting, archiving and processing seismic station and network bulletins and preparing and distributing the definitive summary of world seismicity. The Centre is now not only the repository of past data but is becoming more involved in international seismological projects and contributing to the development of seismology at all levels. The ISC provides tools for efficient research, in the form of a definitive, global, and long-term summaries of Earth's seismicity. These tools consist of a catalog of homogeneous events for seismic hazard and risk assessment, a reference list of events which are located with high accuracy, a catalog of relocated, well-constrained events for seismic tomography purposes. Also, the ISC is one of the main responsible for setting international standards for nomenclature, phase lists, and magnitudes. The aim of the ISC for the next years is to extend its bulletin, including additional data of permanent and temporary networks to build a more complete, and better-constrained catalog. Thus, the cooperation between Brazil and the ISC is fundamental to this aim. This cooperation has increased in the last years owing to the deployment of the Brazilian Seismographic Network (RSBR), a new permanent array of stations, which has allowed to fill a gap in the previous station distribution in South America and enhance the data available to monitor the seismicity in Brazil and neighboring countries. In this talk, I will update the current status of this cooperation showing how the data recorded by the RSBR improved the ISC tools in this part of the globe.

*Presenting Author.

Abstract ID: iiidmi, *Contribution type:* Oral Presentation, *Session:* Invited Talk, *Submitted by:* Dmitry Storchak (dmitry@isc.ac.uk).

Seismic noise-based imaging and monitoring with the phase coherence approach

Martin Schimmel*[1]

[1] *Instituto de Ciências da Terra Jaume Almera-CSIC*

Abstract

In the past 15 yr, seismic ambient noise studies for structural monitoring and imaging purposes have gained increasing importance in seismology and surrounding research fields. This is mainly due to the ubiquity of noise sources and recent advances on how to use the seismic noise wave field. All of these noise studies are based on interferometric principles in which empirical Green functions (EGFs) or robust seismic noise responses are extracted based on different signal processing strategies. These strategies mainly employ noise cross-correlations and subsequent correlogram stacking. Phase cross-correlations and phase weighted stacks, both based on the instantaneous phase coherence of analytic signals can be used in full analogy for an efficient signal extraction from ambient noise. During this presentation we will shortly revisit the phase coherence approach (phase weighted stacking and phase cross-correlation) to then discuss noise-based imaging and monitoring examples. We show that the phase auto/cross-correlation can robustly extract body waves, Rayleigh waves and normal modes because it is not biased by large amplitude signals (e.g., earthquakes). This is convenient because no data preprocessing (data selection or amplitude clipping) is required as usually employed for classical approaches. It also implies that the phase coherence approach takes advantage of the full data set and waveform information to achieve a high signal extraction convergence. The approach thus permits using small time windows to improve time resolution in monitoring studies. Among the examples, we show how we use noise autocorrelations to achieve an approximation of the zero-offset reflection response of the structure beneath seismic stations to finally map the Paleozoic basement of the Ebro Basin (North Spain), and how we detect structural variability before and during volcanic intrusions.

*Presenting Author.

Abstract ID: iiimat, *Contribution type:* Oral Presentation, *Session:* Invited Talk, *Submitted by:* Martin Schimmel (schimmel@ictja.csic.es).

Session SS

Local, Regional and Global Seismicity & Seismic Sources Studies

Oral Presentations

A New seismic zone in Porto dos Gaúchos - MT

Lucas V. Barros*[1], Marcelo Assumpção[2], and Juraci Carvalho[1]

[1] *Universidade de Brasília (UnB)*
[2] *Universidade de São Paulo (USP)*

Abstract

The biggest earthquake ever observed in all Stable Continental Interior of the South American plate occurred in Serra do Tombador (ST)/MT, in 1955. After that no other earthquake has been located close to ST. However, 100km to northeast of ST, in Porto dos Gaúchos (PG) a recurrent seismicity has been observed since 1959, when it arrived the first inhabitants to the region. Earthquakes continues to be detected in this area with the installation of the first seismic stations in the Amazon region in the end of 1970 decade. Two magnitudes 5 earthquakes occurred in 1998 and 2005 with intensities up to VI and V, respectively. These two main shocks were followed by aftershock sequences, both studied by local seismic networks lasting up today. Both sequences occurred in the same WSW-ENE oriented fault zone with right-lateral strike-slip mechanisms. Recently, on January 26 of 2015 we detected, 16km away from the PG seismic zone, another seismic activity with a main shock of magnitude 4.0. The new seismic area, is parallel to PG fault, with similar Focal Mechanism to the 1998 and 2005 seismic sequences. The graben and horst system in Parecis basin are perpendicular to the seismogenic faults. So, the seismicity in the north of Parecis Basin seems not to be related with stressed crust. Caiabis graben are located distant to the PG. Therefore, it is not responsible for the PG seismicity. Then, there is no relation between seismicity and geological lineaments. In light of new studies on Intraplate seismicity (e.g. Calais and Stein, 2009; Stein at al. 2009; Stein and Liu, 2009; Calais at al. 2016), it seems that the seismicity observed in north of Parecis Basin are interconnected: Serra do Tombador earthquake of 1955 Triggered Porto dos Gaúchos (PG) earthquakes and PG Triggered the seismicity of the new seismic zone. This work presents results of studies that has been made about this new seismic zone.

*Presenting Author.

Abstract ID: 7ce63d, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Lucas Vieira Barros (lucas.v.barros@gmail.com).

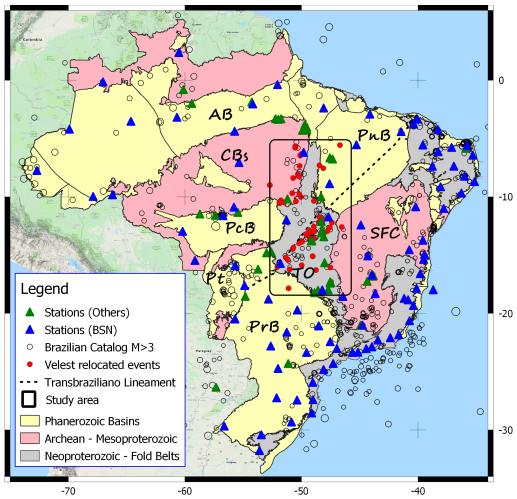
An improved velocity model for routine hypocenter location in Central Brazil

Juraci Carvalho*[1], Edi Kissling[2], Lucas Barros[1], Marcelo Assumpção[3], and Marcelo Rocha[1]

[1] *Seismological Observatory of the University of Brasilia*
[2] *Institute of Geophysics, ETH Zürich, Switzerland*
[3] *Seismology Center, IAG, University of São Paulo, São Paulo*

Abstract

Brazil is located in the stable continental interior of the South American plate. The seismicity distribution is not uniform and, with few exceptions, it is characterized by low seismicity (M<3.5). In the last century occurred only two dozen events of magnitudes greater than or equal to 5, two of which with magnitude larger than 6. The Brazilian Seismic Catalog - BSC (Fig. 1 - grey circles) was initially compiled by Berrocal et al. (1984) and it is maintained by a pool of institutions SIS-UnB, IAG-USP, UFRN, CPRM and ON. The BSC is very heterogeneous and the location quality for some events is unknown. A better and more uniform monitoring started after the establishment of the Brazilian Seismograph Network (RSBR) composed by 84 broad band stations completed in 2014. With the RSBR (Fig. 1-blue triangles), the detection threshold in the Amazon region dropped from M4.5 to M3.5. For the BSC earthquake location we use the generic model NewBR developed by Assumpção et al. (2010). In this study, we propose a new 1D velocity model with station delays specifically calculated for the central Brazil region (Fig. 1 – black line polygon) including most of the Tocantins Province and adjacent parts of the surrounding provinces. From a data set of 128 events listed in the BSC, we have selected, for quality reasons, 77 well-locatable events with a total of 812 P wave observations from 57 stations from RSBR and other projects. A series of coupled hypocenter-velocity-model non-linear inversions were performed with the code VELEST to search the model space for best performing results. The 77 relocated events are grouped in three regions, one in the North and one in the South with scattered epicenters and the largest event group along a SW-NE striking zone aligned with the Transbraziliano Lineament (Fig. 1). While, previously the seismicity exclusively was located at very shallow crustal levels, with the new model we do find evidence for some hypocenters located down to 20km depth.



*Presenting Author.

Abstract ID: 61cadd, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Juraci Mario De Carvalho (juraci-br@hotmail.com).

Attenuation of MM intensities for intraplate earthquakes in Brazil: Application to evaluate historical seismicity

Lúcio Quadros*[1], Marcelo Assumpção[1], and Ana Paula Trindade de Souza[1]

[1] *Institute of Astronomy, Geophysics and Atmospheric Sciences; University of São Paulo; São Paulo, SP, 05508-090, Brazil*

Abstract

Intensity data is a qualitative description of the effects observed from an earthquake, usually ranked in terms of how strong it was felt and the amount of damage. Despite its qualitative nature, intensity data is important to study both historical and recent earthquakes, such as in earthquake hazard studies. Magnitude of historical earthquakes in Brazil have so far been determined with magnitude x felt area relations. Intensity attenuation equations (decay of intensity as a function of magnitude and distance) have been determined in several portions of the world as they are intrinsically dependent on the crustal tectonic characteristics. Two approaches are commonly used: equations that fit the raw intensity values, or equations that fit the average isoseismal radius. We determined by least squares an equation fitting raw intensity data from 20 earthquakes in Brazil and neighboring intraplate areas, in the magnitude range 3.5 to 6.2 mb and hypocentral distances up to 720 km.

The best attenuation model (rms residual of 0.82) was I=1.11M-1.63logR-0.00104R+1.71 where M is the magnitude (mb) and R the hypocentral distance. The preliminary uncertainties estimated for the epicenter and magnitude are, respectively, around ±50 km and ±0.5 mb for events with 30 or more intensity points.

We tested the new equation with intensity data from the Venezuela earthquake of 2018-08-21 21:31:40 UTM with teleseismic short-period magnitude of 6.9 mb (USGS/ISC). The fit was reasonable (standard deviation of 0.73), especially considering that the event was felt to distances up to 3450 km and had a magnitude higher than the ones used to determinate the equation. Further tests of the equation will be presented. We also plan to re-evaluate the epicenter and magnitude of Brazilian historical events.

*Presenting Author.

Abstract ID: 03b46e, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Lúcio Quadros de Souza (lucio.souza@usp.br).

Brumadinho tailings dam failure through the USP Seismological Center perspective

Bruno Collaço*[1] and Marcelo Assumpção[1]

[1] *Centro de Sismologia da USP*

Abstract

A tailings dam at an iron ore mine in Brumadinho, SE Brazil, suffered a catastrophic failure on 25 January 2019. The collapsed dam released mudflow down the Córrego do Feijão resulting in more than 80 fatalities and more than 200 people missing.

The dam failure happened three years after the Fundão dam disaster near Mariana. At that time, a small-magnitude seismic sequence preceded the accident and was recorded by the Brazilian Seismographic Network (RSBR). The Seismological Center suggested that the small earthquakes could have been a contributing factor for the dam collapse (Detzel et al. 2016). This hypothesis was discarded by an international expert review panel.

Probably because of this earlier experience, there were many news (in the internet and even in major newspapers) suggesting that Brumadinho Dam also collapsed because of small earthquakes. However, no evidence of natural earthquakes near Brumadinho was found. RSBR seismograms showed a different thing: the seismic signals generated by the mudflow recorded on RSBR stations located up to 200 km away and over 5 minutes long, contributing to a better analysis of the aspect of the accident.

There was no natural events that preceded the arrival of the mudflow noise in our stations. We will present polarization analyses of the mudflow noise to confirm its origin and mode of propagation.

Brazilian authorities and the mine company are working to determine the causes of the dam failure. From a seismological point of view, earthquake related causes are discarded. The seismological contributions to natural disasters like this one could justify a seismic network in Brazil and proper funding to maintain and improve RSBR. Running the Brazilian Seismographic Network is important not only to detect and study natural earthquakes but also to contribute to studies of other uncommon types of events.

*Presenting Author.

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Capivara Reservoir, Sp, 42 Years Of Induced Seismicity

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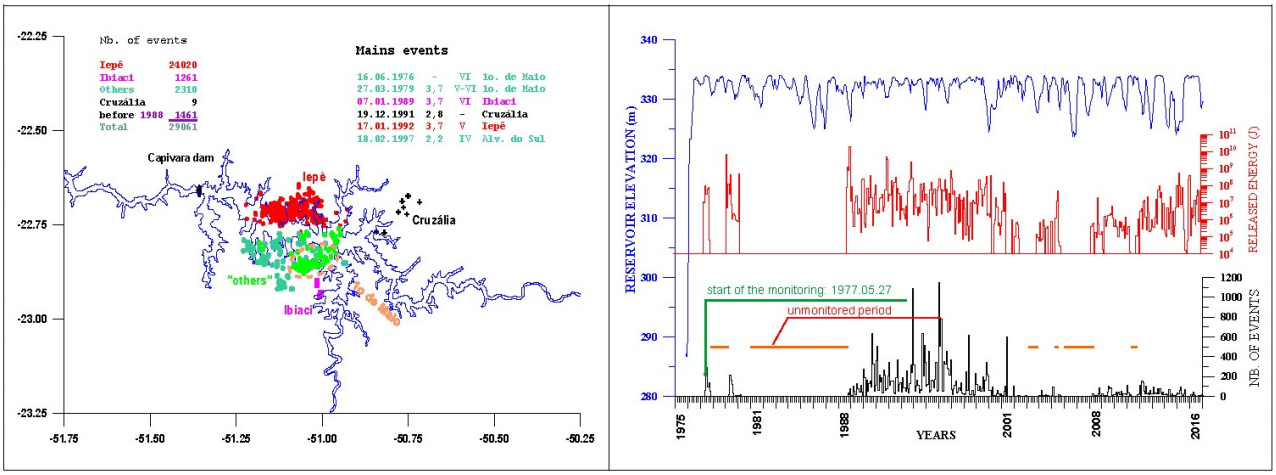
Abstract

The Capivara Reservoir, (22.66 S and 51.36 W) in the Paranapanema River, SP/PR, covers the Serra Geral basalts and the Bauru sandstones. At its normal operating level the reservoir has 576 km2, 10.5 km3, 85 km of extension and 55 m of maximum depth. It was filled in the first half of 1976. The induced seismicity showed the following characteristics: • no earthquakes were known in the area before the filling; • 3 months after the filling, earthquakes were felt in the vicinity of the Tibagi River mouth (at the towns of Primeiro de Maio, PR, and Iepê, SP); • epicenters are distributed in three areas: Iepê (large concentration), Primeiro de Maio, Others; • the area of Ibiaci and Cruzália had some seismicity for a certain period; • the seismic areas are 40 km from the axis of the dam and not in the deepest part of the lake; • epicenters are mostly outside the reservoir, with some near the margin; • the focal depths reached up to 3 km, with a predominance of depths < 1 km, probably in the basalts or in the immediately underlying sediments; • the earthquakes generally occurred in the form of "swarms", with up to 1100 earthquakes in a month; • between 1982 and 1988, according to local residents, small earthquakes continued to occur in the area of Iepê; • seismicity showed an expansion towards the West, in the direction of Alvorada do Sul, PR, since 1996; • the area of Primeiro de Maio resumed its seismicity in recent years; • studies conducted between 1991-1995 showed that the distribution of epicenters are consistent with fractures in basaltic and sedimentary rocks; • seismicity continues still today, although there has been a decrease in the number of earthquakes and magnitude. Earthquakes have magnitudes predominantly < 1.5 mR; • the induced seismicity can be classified as being of the combined type, that is, rapid or initial and delayed afterwards.



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Characteristics of the ongoing seasonally rain-induced seismicity in Jurupema, SP

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Abstract

We report on the ongoing rainwater induced seismicity in Jurupema, located the interior of the state of São Paulo, where we have been monitoring the seasonality of this phenomenon since 2016. The seasonal precipitation increase precedes the onset and increment of seismicity, as the induced seismicity fluctuates from averaging about 130 events per month with magnitudes between -0.2 to 2 Mw during the heavy rain season, to the absence of seismic events during the "dry" months.

Of the more than 1500 seismic events underneath an area of 20 kmˆ2 between 2016 and the beginning of 2019, we follow the seismicity variations and perform full moment tensor analysis when possible. We identify two main regions where events are more frequently occurring and have mostly prevalent sub-horizontal dipping planes, the very shallow events between 100 and 200 m and from 600 to 700 m depth. They suggest that the confined aquifer characteristics of intermittent sandstone layers and fractured basalt rocks condition the characteristics of the seismicity occurring underneath Jurupema.

The facilitating factor of uncased water wells that support the transport of water from upper to lower aquifers, and their location in the area of persistent seismicity, promote that the stress conditions of the fractured basaltic rock inside the shallow confined aquifers can be affected by the intrusion and percolation of significant amounts of rainwater, thus affecting the pore-pressure conditions.

The notable similarities of the seismicity to that of the previously recorded earthquake sequences in Bebedouro, 50 km away from Jurupema, correlate both to the seasonal precipitation changes and the location of water wells used for irrigation drilled contemporary to the onset of seismicity. We see this induced seismicity as a phenomenon that could be more commonly occurring in other regions under similar weather conditions and aquifer and host rock characteristics, such as the Parana basin.

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Characterization of soil layers and sediments in sedimentary basins by the H / V spectral ratio method of natural noise in seismographic stations

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Abstract

The H/V method, also called Nakamura's method (Nakamura 1989), is a relatively simple procedure to estimate the thickness of surface layers through the propagation of seismic waves. Analyzing the natural seismic noise of a station, and calculating the ratio between the horizontal (H) and vertical (V) amplitudes of the ambient noises' Fourier spectrum. This spectral ratio identifies the surface waves' resonance frequency (fo) that depends on the average layer thickness and S wave velocity. Using the appropriate inversions with this method, it is possible to infer the subsurface's physical properties with good precision and low cost. In this research, the sediment layer thicknesses of several stations of the IAG-USP seismographic network located at the Chaco Basin were estimated. The Geopsy free software along with Dinver (Wathelet 2006) was used to process the data and inversion, filtering out trends of instrumental origin and high-frequency urban noise. The curves of the H/V spectral ratio are obtained for several different days and for different times of the year to investigate the consistency and robustness of the fo peaks. Using empirical relationships between fo and sediment thicknesses, thicknesses ranging from 1.6 to 3.2 km were estimated in the Chaco Basin, Argentina, and 4.5 to 3 km in the Chaco Basin, Paraguay. In Taquaritinga, SP, it was not possible to obtain the resonance peak of the Paraná Basin, but only the soil layer, estimated between 3 and 9 meters. In this project, it is expected to obtain other important information about sedimentary basin thicknesses and to develop a joint inversion of the H/V curve with the High Frequency Receiver Function. References: Nakamura,Y., 1989. A method for Dynamic Characteristics Estimation of Subsurface using Microtremor on the Ground Surface. Quaterly Report of Railway Technical Research Institute. Tokyo, Japan, Issue 1, p. 25-33. Wathelet, M. 2006, Geopsy version 5.7.1, Computer Software, Geopsy Team.

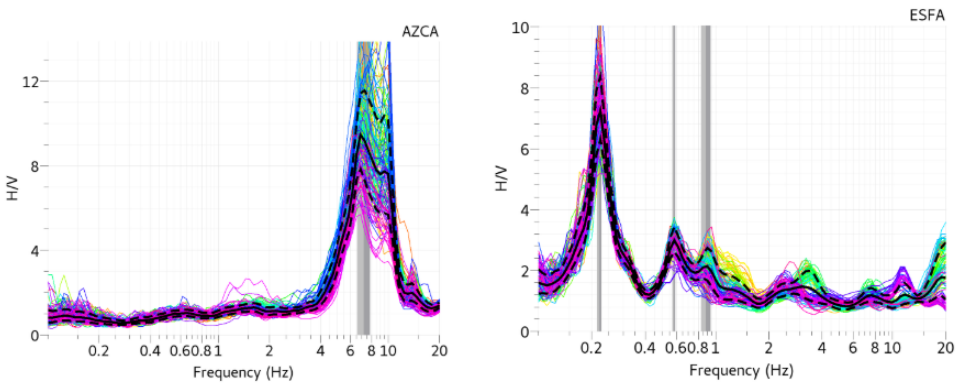

Figure 1. Ressonance peaks found at stations XC.AZCA (left) and XC.ESFA(right).

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Comparison in attenuation among ground motion prediction equations focus on brazilian stable continental region

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Abstract

An important parameter in the seismic hazard assessment is the definition of existent or suitable ground motion prediction equations (GMPE) for the study region. This work presents a comparison of the main characteristic of specific GMPEs for stable continental regions (SCR) that could better represent the Brazilian intraplate region, which is one of the least seismically active SCR in the world. Several models have been proposed, described and compared by means of charts that relate some model variables for the evaluation of the prediction parameter in terms of spectral acceleration in a given site as a result of different scenarios. In this context, hard rock and B/C site conditions were analyzed. As final results, we recommended four models to be adopted in logic trees in Brazilian seismic hazard studies, in order to provide a more coherent representation of its seismic activity. A discussion of the selection criteria on GMPEs adopted is also done.

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Distant earthquakes felt in Brazil.

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Abstract

Since 1922, 80 earthquakes have been felt in Brazilian cities due to the oscillations of high-rise buildings even if thousands of kilometers away from the epicenter,. Because of the increase of the number of skyscrapers in big cities, long-distance effects are becoming more frequent. We present a study on the characteristics of the earthquakes most likely to cause these oscillations and the cities where high-rise buildings are more susceptible to oscillations. Most earthquakes that occur at large depths and those with magnitudes larger or equal than 6.0 Mw, such as in the Jujuy and Santiago del Estero regions of northern Argentina, have caused long distance macroseismic effects. Most affected cities lie in sedimentary basins, such as São Paulo and Manaus, which can amplify the ground motions through basin resonance.

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Earthquake relocation, focal mechanisms and stress field in central Brazil

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Abstract

In this work, we perform seismological investigation in the Brazil central region. This large area (910.000 km2) includes several geological provinces: Eastern Amazon craton; southwestern Parnaíba basin; western São Francisco craton; northern Paraná basin; Tocantins province and Transbrasiliano lineament, a continental scale discontinuity. In the study area two seismic zones can be distinguished: (i) the Goiás Tocantins Seismic Zone (GTSZ) and, (ii) a seismic range following the eastern border of the Amazon craton (Seismic Zone of the Amazon Craton East - SZACE). The whole area is called Seismic Zone of Brazil Central (SZBC), is characterized mainly, by low magnitude events (M $<$ 3.5) recorded by the Brazilian Seismographic Network (RSBR) and stations from other projects. In this work, 128 events are analyzed. Most of the events are too weak to have their Focal Mechanisms (FM) determined by the traditional method of P-wave polarities. To overcome this limitation, we used waveform inversion (ISOLA code), Cyclic Scanning of the Polarity Solutions (CSPS code), and inversion of waveform envelopes (ENV code). The work was divided in three parts. (i) Events were relocated with the iLoc code and velocity model RSTT (Regional Seismic Travel Time). With epicentral error of about 10 km, making possible the correlation of the seismicity with the known geological structures; (ii) Determination of focal mechanisms of 10 events; (iii) Inversion of FMs for stress field. The main results show that the seismicity of the SZBC is concentrated in two relatively narrow belts (GTSZ and SZACE) and that the principal compressional stress axis of the whole zone is well resolved, featuring azimuth $\sim$148° and plunge $\sim$5°. To study events of small magnitudes in such a huge area, installation of additional seismic stations in the identified zones is needed, as well as more studies of aftershocks.

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Effects on the structure of the Tucuruí Dam axis due to the machinery stoppage on the blackout of March 21, 2018 in North and Northeast regions

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[2] *Centrais Elétricas do Norte do Brasil SA - ELETRONORTE*
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Abstract

On March 21 of 2018 at 18:48 (UTC) an anomalous event occurred in the power distribution lines causing a sudden interruption in all power generation machines in the Tucuruí hydroelectric power plant (HPP). A great vibration was caused in the dam structure that was detected by the three accelerographic stations installed in the dam structure and by two seismographic stations located up to 50km away from the dam axis. The Tucuruí Reservoir has a length of 240 km, a flooded area of 3200 km2, volume of 56.1 km3 and a height of 106 m, generating 8300 MW, 8% of all energy consumed in the country, besides that it is a seismic reservoir with Reservoir Triggered Seismicity (RTS), 3.2M on November 2, 1985. According to the National System Operator (ONS) a problem due to a failure in the circuit breaker at the Xingu substation, part of the Belo Monte – PA transmission system has caused a sudden shutdown of all the machines of the Tucuruí HPP, stages one and two (Folha de São Paulo, edition of April 6, 2018). The effects of the machines shutdown were so strong and frightening that the plant management decided to evacuate all operating personnel. Complete recovery occurred only 6 hours later and left about 70,000 people without energy. In this work we analyze, discuss, and interpret the recorders made by the accelerographic and seismographic networks from the point of view of dam safety.

*Presenting Author.

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Extracting optimum inter-station empirical Green's function in west-central Brazil

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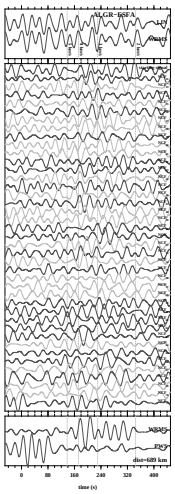
Abstract

The basic idea for retrieving inter-station empirical Green's functions (EGFs) using ambient seismic noise is well described in a homogeneous distribution of energy and/or sources in the study area. Several researchers considered the effect of inhomogeneous noise sources distributions on the extracted EGFs. For this purpose, some studies suggest the singular value decomposition (SVD) technique for obtaining inter-event EGF signals. However, the other ones calculated the error of calculated velocity with homogeneous in comparison of inhomogeneous noise source distributions in a ray-theoretical derivation/framework for far-field surface waves. Although many researchers apply the average of causal and acausal cross-correlation functions (CCFs) over a long time spans to obtain stable inter-station EGFs, this constraint is not enough to retrieve stable EGFs even for the inhomogeneous noise sources within the stationary zone. In this study, we considered estimating the effect of the noise source distributions on retrieved inter-station EGF signals within west-central Brazil. For this purpose, we computed CCFs from synthetic ambient seismic noise on the assumption of homogeneous and inhomogeneous distribution of noise sources' energy. Afterward, the inter-station EGF is retrieved using different stacking methods (e.g., linear, phase weighted stacking etc.) and then some critical constraints are obtained by comparison between the true and calculated EGF signal. These constraints are summarized as separating CCFs emanated by stationary sources (using the signal-to-noise ratio > 1, signal-to-zero-lag ratio >1), control the repetition of sources (by counting energy's packages), normalization of the energy of each source and stacking coherent CCFs. Finally, the possibility of extraction optimum EGF is considered in presence of these constraints on the dataset recorded in west-central Brazil. This dataset collected from five sub-networks.



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Improving ambient noise correlograms using an adequate processing flow

David Wendel Tomaz da Silva[1], Aderson Farias do Nascimento*[1], and Flavio Lemos de Santana[1]

[1] *UFRN*

Abstract

The retrieved Green's Function from ambient seismic noise correlation may exhibit several spurious events that may arise due to the non-cancellation of the crossed terms, the source distribution, and the presence of back scaterring. Therefore, post-processing of the retrieved correlograms obtained through the seismic interferometry is necessary. We apply a processing flow to improve the signal-to-noise ratio of the correlograms and determining the characteristics of the retrieved wave. The processing flow consists of frequency analysis, filter application (frequency filter, FK filter and surface wave noise attenuation), linear move out and trace stacking. We improved the signal-to-noise ratio on passive seismic data, determined the velocity of the recovered wave, removed spurious events. The present results highlight the importance of performing a passive seismic data processing after the Green's Function retrieval.

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Abstract ID: 1bb08b, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Aderson Farias do Nascimento (aderson@geofisica.ufrn.br).

Investigating Deep-Focus Earthquakes Along the Perú-Brazil Border (Acre) Region

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[2] *Universidade Federal do Acre (UFAC)*
[3] *Universidad Nacional de Colombia (UNAL)*

Abstract

The occurrence of earthquakes near the Earth's surface (h<60 km) is easily understood through the brittle rheology of rocks making the Earth's crust, because of progressive accumulation of shear stresses in areas of pre-existing fracture that overcome resistance (friction) to failure. The occurrence of deep earthquakes (h > 60 km), on the other hand, is harder to understand because they happen in parts of the globe where brittle fracture is physically impossible. Several mechanisms have been proposed to explain why these earthquakes occur. For intermediate-depth earthquakes (60<h<300 km), it is believed that fluids in the subducting plate released in metamorphic reactions could increase the pore pressure and enable brittle fracture in pre-existing fractures (dehydration embrittlement); for deep-focus earthquakes (h>300 km), it is believed that shear stresses are capable of inducing a local phase transformation in the (metastable) olivine inside the plate and form fractures with high effective pore pressure caused by its filling with small grains of the high-pressure phase (transformational faulting). In both cases, partial melt induced by shearing can result in an added positive feedback mechanism to the failure process. The Amazon region of Brazil (Acre) hosts one of the 12 zones of deep-focus (h>300 km) earthquakes in the planet and, since 2014, seismic stations belonging to the Brazilian Seismographic Network (RSBR) in the states of Acre, Rondônia and Amazonas have been producing recordings of those deep-focus events. Here, we report on initial progress on the analysis of 31 deep-focus earthquakes (magnitude $\geq$ 4.0 Mw) located in the Acre region since the deployment of the RSBR stations, as part of a research effort recently funded by the Conselho de Desenvolvimento Científico e Tecnológico (CNPq) that involves installation of additional seismic stations in the Amazon region and international, multi-institutional and multi-disciplinary collaboration.

*Presenting Author.

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Maranhão aftershocks activity studies with local seismic network for getting the main shock as a GT5 event

Lucas Vieira Barros*[1], Marcelo Assumpção[2], Marcelo Rocha[3], George Sand[3], and Juraci Carvalho[3]

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[3] *Universidade de Brasília (UnB)*

Abstract

The low Brazilian seismicity, with only three continental earthquakes of magnitude five in the last three decades and, until recently, the low number of seismic stations, explain why it is very difficult to detect events at regional distances that can be classed as Ground True 5 (GT5). In the first PTS - CTBTO RSTT meeting (in Vienna June, 2012) seismologists from the South and Central Americas were encouraged to cooperate in identifying GTx events. With the deployment of the Brazilian Seismographic Network (RSBR) and using aftershock sequences well recorded by local and regional stations as reference events, it was possible to relocate the Maranhão mainshocks suitable for GT5 events. In Brazil, the expected variations in P and S-wave velocities, due to structural variations in the upper mantle, on the order of ± 4-5%, not taken into account by 1D velocity models, can cause epicenter mislocation on the order of 10 - 30 km. Epicenter mislocation has a negative effect in studies of seismic risk currently done in Brazil. Using a local network, we studied the aftershock activity after a 4.6 mb mainshock (MMI V-VI) on January 3, 2017. This event was registered by 25 regional stations of the RSBR with the nearest station located about 40 km from the epicenter. The focal mechanism solution indicates a strike slip fault with compression parallel to the coast line, in agreement with previous studies. For hypocentral location an accurate velocity model determined using phase conversion in the interface sediment-basement (P to S – Ps, and S to P, Sp) and Wadati diagram, was used. A local seismic network, with 4 stations, together with the ROSB station of the regional network permitted the Maranhão main shock earthquake to be relocated with an accuracy of a GT5 event.

*Presenting Author.

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Modified Mercalli Intensity Values due to different interpreters: an automatic approach

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[1] *University of São Paulo (USP)*

Abstract

The Sentiu Aí? system was implemented in 2015 by the USP's Seismology Center and has already received more than 1000 reports of possible felt earthquakes. Like others, it consists of a questionnaire based on the Modified Mercalli Intensity Scale of 1931. Since 2016 a method to automatically estimate the intensity of earthquakes has been developed and intensities were estimated for significant earthquakes felt in Brazil, like Maranhão (Jan/2017), Tupã/SP (Jul/2018) and Venezuela (Aug/2018). The methodology consists of assigning one probability reference histogram to each alternative of the 13 multiple-choice questions used by the system. Reference histograms are the interpretation of the scale and encode the most probable intensity associated with the answer. The final intensity is the result of stacking all considered answered histograms. This process is done automatically by a program and helps to understand the earthquake impact quickly. In attempting to evaluate the uncertainty of the assigned intensity and the influence of each question we used two methods: (1) a random selection of 10 reference histograms to calculate the intensity and (2) random perturbations on the values of the reference histograms (between ±20% of the original value). The results of (1) showed that the intensity calculated by the program was the same in the majority of cases. The highest difference observed was of one unit on the MMI scale. Also after thousands of combinations using different values to the reference histograms, the final intensity was the same as using the original probabilities. These results lead us to conclude that even if the user chooses an answer that can super estimate or underestimate the intensity, the use of this wrong answer alone is attenuated by the correct ones. We can also state that a possible variation of ±20% on the reference values assigned by the interpreter, while creating the reference histogram, don't deviate the current estimate.

*Presenting Author.

Abstract ID: 0f71de, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Mariana Maia Lion (mariana.lion@usp.br).

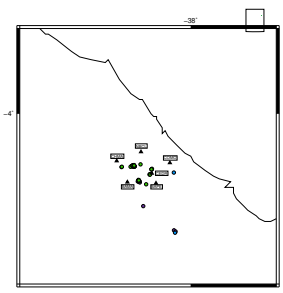
Recent seismicity in Cascavel-CE (2017)

José Augusto Silva da Fonsêca*[1], Joaquim Mendes Ferreira[1], Aderson Farias do Nascimento[1], Eduardo Alexandre de Menezes[1], and Heleno Carlos de Lima Neto[2]

[1] *Universidade Federal do Rio Grande do Norte (UFRN)*
[2] *Universidade Potiguar (UnP)*

Abstract

Northeast Brazil is characterized by being one of the regions with the largest seismic activity in the country. The Cascavel area, located in Ceará state, has turned to be famous in 1980 year, when it occurred the bigger earthquake of Northeast Brazil, with magnitude 5.2 mb. In addition, seismic activity was relatively significant since then. Seismicity in Cascavel region returned to be relevant in 2017 year, with events of magnitude greater than 3 mR. Thus, this work aims is to present an analyze of events that occurred from 24/03/2017 to 11/12/2017 period, recorded by a local network composed by 5 short-period stations and 1 broad-band station belonging to the Laboratório Sismológico/UFRN (LabSis/UFRN). This data will be used for determining the hypocentral parameters and elaborating composite focal mechanism. Preliminary results show that in total 980 earthquakes were identified. However, only 315 were recorded in at least 3 stations, minimum number to calculate the hypocentral location. Up to moment of submission of this abstract, the arrival times of the P and S waves of 89 earthquakes referring to the months of March, April and May were marked using SEISAN seismic analysis software. Using a VP/VS ratio value of 1.72 and velocity model of 6.15 km/s, considering a one-layer crust model over an infinite half-space, it was possible to calculate the preliminary hypocenters by using the HYPO71 program, figure in appendix. These events focused on approximately 3 clusters aligned in the E-W, NW-SE and NE-SW directions. The depths obtained are typically in the range of 6 to 12 km. It is intended to elaborate the focal mechanisms considering the localized events associated to the whole period of analysis, and this way contribute to a better understanding the seismotectonic and the stress field of this region.



*Presenting Author.

Abstract ID: a25434, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* José Augusto Silva da Fonsêca (augustofonseca.ja@gmail.com).

Rupture Lengths of Brazilian Earthquakes from Relative Location of Aftershocks: Evidence for Depth Dependence of Stress Drops

Marcelo Assumpção*[1] and Caio Ciardelli[1]

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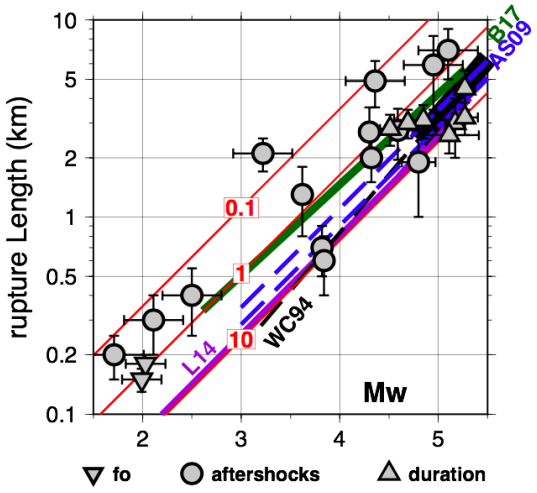
Abstract

Whether intraplate earthquakes have different average source properties, compared to interplate events, has been long debated. It has been proposed that intraplate events tend to rupture smaller areas with higher stress drops, compared to the average interplate earthquake. Here we estimate the rupture lengths of several Brazilian earthquakes by accurately locating their immediate aftershocks. The sparsity of stations in low-seismicity regions, such as Brazil, hinders accurate epicentral determination. We use cross-correlation of P-, S- and Lg waves to accurately locate the aftershocks relative to a reference event. In several cases, it was possible to infer the rupture length by the distribution of the early aftershocks; with the later aftershocks tending to span a larger area. We studied six different aftershock sequences using regional stations up to several hundred km distance. The mainshock occurs close to the foreshocks, which act as triggers to the main rupture. The immediate aftershocks tend to occur in a circle around a central (presumably stress-free) zone, which we interpret as the rupture of the mainshock. Published data from other events, based mainly on local networks, were added to provide an empirical relationship between rupture length and magnitude. These data suggest that stress-drops in Brazil vary mostly between 0.1 and 10 MPa, a similar range to many other studies worldwide. However, the mean stress drop (about 1 MPa) is smaller than the mean values of both interplate and intraplate events globally (mostly between 2 and 10 MPa). A possible dependence of stress drops with hypocentral depth may explain this difference: Brazilian intraplate earthquakes tend to be shallower than most other mid plate regions giving rise to smaller stress drops, on average. This result has important implications for seismic hazard estimation when GMPE equations from other intraplate regions are used in Brazil.



*Presenting Author.

Abstract ID: 783ade, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Marcelo Assumpção (marcelo.assumpcao@iag.usp.br).

Seismic and Infrasound Signal Analysis in the Discrimination of Natural and Artificial Events

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Abstract

A network of seismic, infrasound, hydroacoustic and radionuclide stations was created after the 1996 Geneva Disarmament Conference. The data of this network are useful to attest to the effectiveness of the Comprehensive Nuclear- Test-Ban Treaty (CTBT). In this context, Brazil has 3 stations of different technologies that contribute to the International Monitoring System (IMS). In Rio de Janeiro there is a Radionuclide Station and within the National Park of Brasília there are two other stations, one seismic and the other infrasound, PS07 and IS09, respectively, which are used in this project. One of the challenges of seismic monitoring is the distinction of natural events and events associated with anthropogenic action. The network created to detect events whose origin is the nuclear explosions detects also several sources of signals with the continuous monitoring of the stations. The PS07 station is able to detect natural seismic events such as earthquakes, landslides and artificial events, such as blasting mining companies' activities, and others. The IS09 infrasound station records natural phenomena such as severe rains, volcanic explosions, landslides, great earthquakes, meteorites and chemical explosions, and artificial events such as that caused by supersonic aircrafts, industrial activities, and others. This work is based on the signal analysis of seismic and infrasonic events that identify periodic patterns, useful in discriminating the nature of seismic events.

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Seismic evaluation of structural systems: a probabilistic approach

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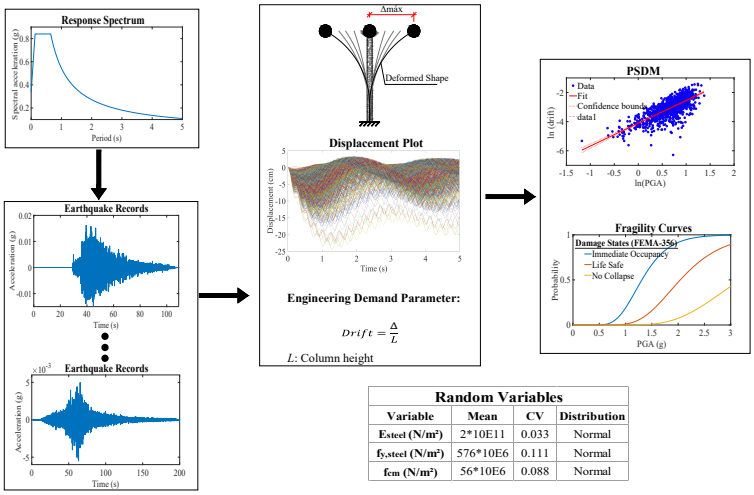
Abstract

The conception of a structural system includes aleatoric uncertainties since its design phase until its construction. The random oscillatory behaviour of ground motions associated with these aleatoric uncertainties leads to the necessity of using a probabilistic seismic structural evaluation; the approach presented herein aims to evaluate the probability of the seismic demand exceeding a structural system capacity. Hence, this methodology probabilistically evaluates a structural systems response once it is located in a seismically active region. A simple single degree of freedom structural system is considered, while a dynamic analysis is performed applying scaled ground motion records obtained from Pacific Earthquake Engineering Research (PEER) database that are compatible with the Brazilian acceleration spectrum. The variability associated to structural parameters are considered based on the results of a Monte Carlo (MC) analysis, which, by means of a linear regression in logarithmic space, is a Probabilistic Seismic Demand Model (PSDM). Structural capacity is determined based on a non-linear static analysis, Pushover Analysis (PA), according to Eurocode 8 provisions also based on a MC analysis; PA results are used to establish the structural limit states variability. Fragility curves depict the probability that the structural system reaches a certain damage state; herein, damage states are defined from slight to severe, given that both demand and capacity curves follow a log-normal distribution. Note that fragility curves are essential to informed decision making of risk mitigation strategies, such as: structural retrofit and improvement of design provisions.



Random Variables			
Variable	**Mean**	**CV**	**Distribution**
Esteel (N/m²)	2*10E11	0.033	Normal
fy,steel (N/m²)	576*10E6	0.111	Normal
fcm (N/m²)	56*10E6	0.088	Normal

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Seismic Hazard Evaluation for a Site near Cubatão, Serra do Mar, SE Brazil: Comparison with the Preliminary PSHA Map for Brazil

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Abstract

A Probabilistic Seismic Hazard Analysis was carried out for a site near Cubatão (SP), in the Serra do Mar ranges. The analysis involved 1) declustering the seismic catalog to remove precursors and aftershocks, using the Reasenberg (1985) method, 2) estimation of the limits of completeness of the final catalog, 3) proposal of three different models (scenarios) for the seismogenic zones, 4) estimation of the Gutenberg-Richter frequency-magnitude relation for each seismic zone, using the Weichert (1980) maximum likelihood method, 5) choice of three ground motion prediction equations (GMPE) typical of intraplate regions, for rock outcrop, 6) construction of a logical tree with nine branches (three scenarios of seismic zone models x 3 GMPEs), 7) calculation of the spectral acceleration levels corresponding to several return periods between 100 and 10,000 years. The R-CRISIS Ver. 18.4 program was used for this calculation. Seismotectonic studies in SE Brazil indicate that the Serra do Mar ranges have lower seismicity than both the continental shelf and souther Minas Gerais (Mantiqueira ranges). The possible seismic zone models, however, include the possibility of Cubatão being part of the more active seismic zone of the continental shelf. The peak ground acceleration (PGA) with probabilities of 10% and 2% exceedance in 50 years were estimated at 0.0079g and 0.026g, respectively. These values agree perfectly well with those calculated by Almeida et al. (2018) for Angra dos Reis, RJ, (0.0075g and 0.028g for the same probabilities of 10% and 2% in 50 years), a region very similar to Cubatão, in seismotectonic terms. However, the preliminary seismic hazard map presented by Assumpção et al. (2016) indicates for Cubatão values of 0.03g and 0.10g, respectively, four times higher than those obtained here. This could indicate that the preliminary seismic hazard map of Brazil (Assumpção et al., 2016) may be overestimating the hazard in regions of low seismicity.

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Seismic Monitoring of the Pantanal Sedimentary Basin and Adjacencies

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[2] *Universidade de São Paulo*

Abstract

The Pantanal is a tectonically active sedimentary basin of quaternary age, located in the Upper Paraguay Basin (BAP), located in the Center-West region of Brazil. The basin is considered to be one of the seismic regions of Brazil, where there are significant records of earthquakes due to faults of reverse type, transcurrent (transverse) component with focal depth in the order of 5 km. There have already been four significant earthquakes such as the ones in Corumbá (June 1, 1919, with magnitude 5.0), in Miranda (February 13, 1964, with magnitude 5.4), in the Region of Coxim, 100 km to W inside the Pantanal (June 15, 2009, with magnitude 4.8) and Aquidauana (November 6, 2015 with magnitude 4.0). This monitoring aimed at collecting data for the mapping of seismic hazard of the Pantanal Sedimentary Basin (BSP) and its adjacencies, through the study made possible the understanding of the dynamics of the seismic activities and the understanding of the structure of the lithosphere. Currently, the State of Mato Grosso do Sul has 10 seismographic stations: Amambai (AMBA), Antônio João (ANTJ), Aquidauana (AQDB), Bodoquena (BDQN), Chapadão do Sul (C2SB), Porto Murtinho, Pantanal/Corumbá), Sonora (PP1B), Ribas do Rio Pardo (RPRD) and Rio Verde (RVDE). The records of local, regional and distant events were identified through analysis of seismic records. For local and regional events readings of the arrival times of the "P" and "S" waves and their amplitudes were made. In addition to epicentral determinations and magnitudes, using the programs SAC, SeisGram and SeisComp3.

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Shallow Rupture in Very Large and tsunami earthquakes evidenced by their High Frequency Energy Release Rate and its use for rapid assessment of enhanced tsunami potential

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[2] *Georgia Institute of Technology*

Abstract

From the perspective of the radiated seismic energy from large earthquakes, we produce a robust high-frequency energy growth-rate discriminant for earthquakes that feature enhanced tsunami potential, using information gathered during only the initial P-wave arrival at teleseismic stations. We apply this to global earthquakes with moment magnitudes larger than 7 between 2000 and 2018, to identify that the scaling of high-frequency energy release rate directly relates to the total radiated broadband seismic energy for most events.

Earthquakes outside this scaling fall in two classes, deep earthquakes, which radiate energy up to 10× more rapidly, and most tsunamigenic earthquakes which radiate energy up to 10× more slowly. This second group includes MW 7.6-7.8 near-trench-rupturing tsunami earthquakes, and the two "total megathrust rupture" recent events; the MW 9+ Sumatra 2004 and Tohoku-Oki 2011 earthquakes. All of these tsunamigenic events rupture either partially, or entirely in the near-trench region, which slows rupture, reducing the overall energy-rate.

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Signal Denoising and Microseismic Event Location Improvement Using Adaptive Filtering in hydrofracking operations

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Abstract

In this work we show how adaptive filtering noise suppression improves the effectiveness of the Source Scanning Algorithm (SSA; Kao & Shan, 2004) in microseism location in fracking operations. The SSA discretizes the time and region of interest in a 4D vector and, for each grid point and origin time, a brightness value (seismogram stacking) is calculated. For a given set of velocity model parameters, when origin time and hypocenter of the seismic event are correct, a maximum value for coherence (or brightness) is achieved. The result is displayed on brightness maps for each origin time. Location methods such as SSA are most effective when the noise present in the seismograms is incoherent, however, the method may present false positives when the noise present in the data is coherent as it occurs in fracking operations. To remove the coherent noise present in the recorded data from the pumps and engines used in the operation, we use an adaptive filter (https://github.com/Wramberg/adaptfilt). As the noise reference, we use the seismogram recorded at the station closest to the machinery employed. Our methodology was tested on semi-synthetic data and real data recorded in a fracking operation. For semi-synthetic data, the microseismic was represented by Ricker pulses (with central frequency of 30 Hz), and to simulate real seismograms on a surface microseismic monitoring situation, we added real noise recorded in a fracking operation to these synthetics seismograms. The results show that after the filtering of the seismograms, we were able to improve our detection threshold and to achieve a better resolution on the brightness maps of the located events.

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The blog Sismos do Nordeste: an experience in the dissemination of seismic events

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Abstract

At the end of 2010 and early 2011, the Pedra Preta earthquakes and the tsunami in Japan generated a situation that demanded a great demand for clarification from the Seismological Laboratory. In order to minimize this problem, the Sismos do Nordeste blog was created where information would be published and disseminated via e-mail, tweeter and facebook, which began to be published on March 14, 2011. Since then, about 650 posts have been made which were accessed approximately 385,000 times. This paper will discuss the difficulties and successes in this type of dissemination.

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The Phases Of Civil Defence Applied To Living With The Seismic Shocks In The State Of Ceará

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Abstract

Considering the seismic risk to which the people of Ceará are subjected, it is natural that the security authorities adopt measures that aim at the protection and safety of people. Disaster Risk Management (DRM) should be defined as a social policy oriented toward the conceive, implementation, monitoring, follow and evaluation of public politcs for natural or non-natural disasters. Brazil is located in the interior of a stable continental plate, earthquakes are less frequent and of smaller magnitudes. However, the intensities are high because of the low attenuation of the seismic waves. It is common to observe the intensities VI and VII for earthquakes of small magnitudes. Several earthquakes were recorded in Pereiro, Baturité, Pacajus, Palhano, Irauçuba and Meruoca, with magnitudes around 4, with intensities VI to VII (MM). In the State of Ceará, 52 municipalities have already been affected by seismic shocks of varying magnitudes and intensity up to VII (MM), which is the maximum intensity observed in Brazil. The civil defense actions have been adopted, permeating as phases of: prevention, mitigation, preparation, response and recovery. This scope has been studied and debated in treaties sponsored by the United Nations – ONU, through the International Strategy for Disaster Risk– EIRD, and ratified by the Brazilian government, Law 12,608 of 2012, consecrating the new National Policy of Protection and Civil Defense – SINPDEC. Combining efforts to mitigate the effect of disasters is indisputable, bearing in mind that everyone has to contribute to this goal. The Academy, the School, the Government and the community itself are responsible for balancing this situation.

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Abstract ID: 0b3370, *Contribution type:* Oral Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* FRANCISCO DAS CHAGAS BRANDÃO MELO (fco.brandao@gmail.com).

Using a physics-based, coupled model to constrain the 2018 Sulawesi earthquake source and determine the cause of the subsequent tsunami

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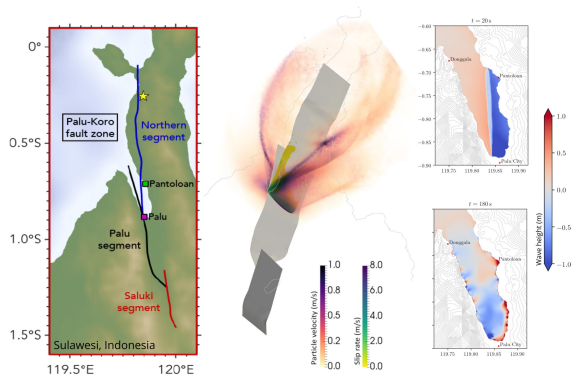
Abstract

The September 2018 Mw 7.5 Sulawesi earthquake began on land, propagated south through Palu Bay, and then ruptured back on land farther south through the city of Palu. Following the rupture, a tsunami inundated the Bay coasts. Strike-slip earthquakes like this one rarely cause tsunamis, but rupture through such a narrow bay makes a rupture-related source possible. The event's geologic setting is not unique: large strike-slip faults in California and Turkey run through elongate bays and across coastlines, and the 2016 Mw 7.8 Kaikōura earthquake rupture crossed off-shore, triggering a local tsunami. Thus, understanding the source of this devastating tsunami is critical to global hazard mitigation. We present a coupled earthquake-tsunami model that captures earthquake rupture dynamics, seismic wave propagation, tsunami propagation, and tsunami inundation. The earthquake model includes a 3D velocity model and high-resolution topography and bathymetry. The 3D faults are built from traces delineated by satellite data, in accordance with the fault plane solution, and with information from local field studies. They are loaded by a tectonic stress regime in agreement with regional transtension. The model results match the observed moment magnitude, overall duration, and horizontal ground deformation. Widespread supershear rupture velocity is required to reproduce the teleseismic waveforms and moment-rate function. The resulting time-dependent surface displacements are used as input for the tsunami simulation. The results suggest that the earthquake displacements could directly source the tsunami by producing reasonable wave amplitudes at the site of the Pantaloan wave gauge and maximum run-up heights around the Bay in agreement with data. Sourcing a tsunami model through direct coupling with a well-constrained, dynamic earthquake rupture provides critical insight into this rare earthquake-tsunami hazard.



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Poster Presentations

Seismological Correlations in Laúca Dam

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Abstract

Inaugurated in August 2017, the Laúca Hydroelectric Plant located in the Malanje Province, has the highest dam in Angola, with 156 m, with about 166 km^2 of flooded area and accumulated volume about of 5,638 Hm^3 . This work discuss the reservoir triggered seismic of Laúca Hydroelectric plant. The study was based on review of Angola natural seismicity and triggered in the Kwanza Middle Region, analysis of the geotechnical article on Lauca Hydroelectric plant, and data from the last seismic events in the region. The research use all this information as well as the support of Seismic Analysis Code (SAC), geologic and tectonic data, Satellite Images from Landsat-8 and Digital Elevation Model from ALOS 12,5. The region of the dam have faults zones with a preferential main direction of NW-SE. About 103 events that occurred in 2018 have been analyzed. Studies about triggered seismic are important to understand the risks that compromise the safety of a dam and prevent disasters.

*Presenting Author.

Abstract ID: 7ac9bb, *Contribution type:* Poster Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Joanne Magalhães Borges (joannemaborges@gmail.com).

A comparison of NBR15421:2006 seismic analysis methods on a three story shear building

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Abstract

Seismic analysis of a three story shear building subjected to base ground motion excitation based on methods described in the Brazilian design code NBR15421:2006 is shown in this study. Seismic zone 4 and soil type Rock was defined to run the analysis. The methods used are the Simplified Method, Equivalent static method (or lateral forces method), seismic modal analysis by response spectra and seismic response by time-history analysis, in order to calculate the total shear force at the base of the building and its maximum displacement. The response spectra analysis method was used considering the first three vibration modes, and the responses based on the response spectra described on the Brazilian design code was combined by the SRSS method. For the time-history analysis, an artificial accelerogram was generated and adapted to be compatible with the response spectrum of the NBR15421:2006 design code and used the Newmark Method with linear acceleration to perform the direct integration of the accelerogram. From the results it is possible to compare the proposed methods of analysis, showing that the simplified method results in the lowest shear base value in the base of the building, but it can only be used in structures located in seismic zones 0 or 1. The Equivalent static method was the most conservative method, with the highest horizontal force value at the base of the building, followed by the Modal Spectral Method and finally the time-history analysis. In these last two methods, the results obtained was very similar. The objective of this study was to present the concepts of seismic analysis in a low complexity building to raise interest and facilitate the understanding of engineers for more complex structures when subjected to earthquakes.

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Abstract ID: 5624ab, *Contribution type:* Poster Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Laís De Bortoli Lecchi (laislecchi@gmail.com).

A comparison of the Brazilian regional magnitude, mR, with the teleseismic mb for intraplate sub-Andean earthquakes

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Abstract

Intraplate earthquakes in Brazil are often measured with the P-wave regional magnitude mR, a scale developed for the attenuation characteristics of the Brazilian stable cratonic lithosphere. In the range 3.5 to 5.5, the regional magnitude compares well with the short-period P-wave teleseismic magnitude mb. Many crustal earthquakes in the sub-Andean region are recorded by the Brazilian Seismic Network (RSBR) with paths crossing mostly the stable continental interior. We compared the regional magnitudes mR of sub-Andean events, measured by RSBR, with the teleseismic mb to see if mR would be applicable to sub-Andean events. The RSBR mR magnitudes tend to be 0.5 units lower than the ISC mb values. This may imply that the upper mantle beneath the sub-Andean region attenuates P waves more strongly than the Brazilian lithosphere.

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Determination of the Probability Increase in Time (Alarm Times, TIP) for the occurrence of large earthquakes in South America (application of Algorithm M8)

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Abstract

In the present study, the intermediate-term earthquake forecasting method known as M8 was applied to the western edge of South America in order to estimate the occurrence of earthquakes with magnitudes of 7.0+ to 8.0+ Mw. The method allows to evaluate the Probability Increments in Time (Alarm Times, TIP) before the occurrence of large earthquakes and for its application, the seismic catalog of the National Earthquake Information Center (NEIC) has been used. The retroactive application of the method confirmed the occurrence of the last two earthquakes in Peru (2001 and 2007, Mw≥8.0) and Chile (2010 and 2014, Mw≥8.0). In the prospective analysis, the presence of two Alarm Times (TIP'S) was identified for the 2015-2020 time period; the first considers a circular area of 660km radius with center at -30.0 ° S, -71.5 ° W and the second with a similar area around the point: -33.0 ° S, -72.5 ° W. Both areas consider central and southern Chile (from Antofagasta to Concepción) In the retroactive analysis for earthquakes of 7.0 Mw, the alarm time for the earthquake occurred in Peru in 2013 (Ica) was identified and in the prospective analysis, identifies the presence of a TIP in the central zone of Chile within the circular area of 380km radius around the point: -27.00 ° S and -70.87 ° W, from Antofagasta to Coquimbo, valid for the period of time 2015-2020.

Note:

The results:

An earthquake occurred in Chile of magnitude 8.2 Mw at coordinates -31.57 -71.67, 22 km depth on September 16, 2015, confirming the forecast.

An earthquake in Chile of magnitude 7.0 Mw occurred at coordinates -30.07 -71.04, 53 km deep on January 19, 2019, confirming the forecast.

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Focal Mecanism Database for South America

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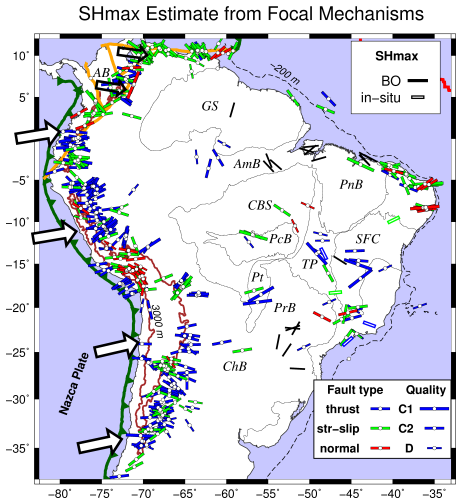
Abstract

This works aims the compilate of earthquake focal mechanisms and other stress indicators in Brazil and the sub-Andean region. Most events in the sub-Andes show reverse or strike-slip mechanisms.

Focal mechanisms in Brazil are reverse, strike-slip and normal faulting. Groups of focal mechanisms for nearby events were inverted for the stress tensor. In the sub-Andes, stresses are compressional with the principal major compression (S1) E-W, on average.

A slight rotation of S1 is observed, controlled by the orientation of the Andean plateau. In the sub-Andes the intermediate principal stress (S2) is also compressional, a feature not always reproduced in numerical models in the literature. In mid-plate S. America stresses vary in nature and direction. In SE Brazil and near the Chaco-Pantanal basins, S1 is oriented roughly E-W with S2 approximately equal to S3. This stress pattern changes to purely compressional (compressional SHmax and Shmin) in the São Francisco craton.

A rotation of SHmax from E-W to SE-NW is suggested towards the Amazon region. Along the Atlantic margin, the regional stresses are affected by coastal effects (due to continent/ocean spreading stresses as well as flexural effects from sediment load at the continental shelf). This coastal effect tends to make SHmax parallel to the coastline and Shmin (usually S3, extensional) perpendicular to the coastline. Few breakout data and in-situ measurements are available in Brazil and are generally consistent with the pattern derived from the earthquake focal mechanisms.



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Focal Mechanism in Mid-Ocean Ridges and Transform Faults

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[1] *UNIVERSIDADE FEDERAL DO CEARÁ*

Abstract

Earthquakes are frequent in the oceanic crust, however, they concentrate along the ridge and along the transform faults. The analysis of the focal mechanisms of these seismic events shows us that those that occurred along the ridge were produced by a set of maximum principal stresses organized so that the sigma1 is vertical, while in those occurring along the transform faults, have your sigma1 positioned horizontally forming an angle of 45° with the plane of the transform faults. We have here three concerns: the first one relates to the sigma1 vertical (P actually). The idea of vertical P positioning stems from the interpretation that the oceanic crust is a basin – it is not – and that it was believed that the gravitational force was the principal force of all crustal deformations – the geossinclinal theory. The mid-ocean ridge have in the "Sheeted dykes" its greatest characterization. These dikes – placed side by side – are the result of the magmatic filling of vertical extensional fractures produced by sigma1H>sigma2v>sigma3H. The geometry of the mid-Atlantic ridge suggests sigma1 horizontal, N-S trend and sigma3H E-W, horizontal trend. Extension fractures are characteristically "en échelon". Each segment of the fracture has its own development. The lateral displacement caused by sequential injections of magmas (sigma3), produces lateral ramps – transforms faults- along which the ocean crustal segments are moving. The movement along these ramps causes earthquakes – our 2nd concern – whose focal mechanisms suggest Transcurrence – is not. The third concern is related to the depth of earthquakes. It is established in 10km.

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Focal mechanisms of Brazilian earthquakes from waveform and envelope inversion

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[2] *Observatório Nacional (ON)*

Abstract

Focal mechanism (FM) is an important tool to understand crust deformation and dynamics of Earth. It also helps to obtain the stress directions that work on the lithospheric plates, thus we can estimate areas prone to earthquakes occurrence. In our work, we seek to increase the number of events with FM determined in Brazilian events to help future studies. We are studying the FMs which have been previously estimated aiming to explore different methodologies to determine them. There are several ways to recover the focal solution, the applied technique heavily depends on the available data. Currently, we are working with two inversion methods, the first is the waveform inversion method standard and second is the envelope inversion method. Both with dispersion velocity models and carried out with the ISOLA software with P-wave first motion polarity check, exploring their advantages and disadvantages.

As preliminary resulties, we have found the Mara Rosa earthquake FM (2010), Cajati earthquake (2015) and Maranhão earthquake (2017) using both methods, making us able to compare them with the ones that have been made before. In Mara Rosa and Maranhão events, we used the same stations than the references. For these two events, we had a good answer on waveform inversion, but the envelope inversion did not give us a reliable FM, since it was very different from what we expected. The Cajati event was made with one station (TIJ01) more than in the FM we used as the reference, we found the same focal solutions like the one before. We conclude that the methodology we have used works to retrieve FM, once we found similar results to the ones used as reference, but we have to better explore envelope inversion. This will be useful to retrive FM of future events in Brazil.

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Geiger's modified method: Inversion for hypocentral location andseismic velocity

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Abstract

Geiger's method is a nonlinear optimization scheme that allows for the determination of the origin time and hypocentral location of an earthquake from the arrival times of P and/or S waves. For the method to be effective, it is necessary to assume a velocity of propagation for the seismic waves, which is usually obtained from multiple inversion attempts and the analysis of the root-mean-square curve as a function of seismic velocity. The current work aims at modifying Geiger's algorithm to simultaneously determine the source parameters and the seismic velocity of the medium in a single inversion. To achieve this goal, Geiger's method isalteredto account for arrival times from multiple events, and to simultaneously determine theirhypocentral coordinates and a propagation velocitycommon to all of them. The new algorithm is tested with synthetic data, with and without noise, in which two situations are simulated: one in which a network of 5 stations is centered around a target earthquake, and another one in which 5 stations are surrounding several earthquakes distributed randomly. Both methodologies, traditional and modified, retrieve the true focal parameters with similar accuracy, demonstrating that constraining theseismic velocityof the medium is possible and that simultaneous inversion of multiple events is straightforward. The modified algorithm is also tested with data collected by a local aftershock network in Irauçuba/CE that operated from September 2015 to March 2016. The network consisted of 7 seismic stations that recorded continuously during the time of operation,identifying up to 22 local events. Our results demonstrate that the source parameters and the propagating wave speed can be accurately and efficientlyrecovered through the modified Geiger's scheme here proposed.

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Historical And Cartographic Survey In The Analysis Of Seismic Activity In West-Central Brazil: Emphasis In The Pantanal Sedimentary Basin

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Abstract

The construction of the country's seismic history was based on three research sources: a) paleossismic or geological studies that search for evidence of earthquakes occurred in the last ten thousand years approximately, a period of time that corresponds to the geological time called Holocene; b) instrumental records, which provide more reliable data, since they come from seismographic stations and c) historical information that are considered as a tool to deepen the knowledge of Brazilian seismicity, researching what happened in the past, that is, searching for information about earthquakes which were not recorded: the "historical earthquakes". The present study consisted of a historical survey of the seismic activities of the West-Central Brazil, with emphasis on the Pantanal Sedimentary Basin during the period from 1744 to 1981. The sources of research used were: printed newspapers provided by the National Library of Rio de Janeiro and the Correio do Estado - MS. Among the surveys, 27 historical records were highlighted, 26 of which belong to the West-Central Brazil, 19 unpublished and 7 with additional information to those already listed in the book Seismicity of Brazil (1984), highlighting that 9 of these records occurred in the Pantanal Sedimentary Basin. Considering that the Brazilian Seismic Bulletin needs constant corrections of the data already obtained, especially those previous to the installations of seismographic stations, the incorporation of new information, mainly regarding the temporal and spatial analysis, allowed the enrichment of the Brazilian Seismic Catalog. In addition to this contribution, the macroseismic data of the earthquake occurred in Coxim in 2009 could be compared to the attenuation equation of Brazilian intensities, allowing a new epicentral location and magnitude.

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Hydraulic fracturing noise observations and characterization in a oil field

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Abstract

The presence of unwanted noise in the field of study may make it difficult to recover signals of interest. Thus, the separation between the portion of interest (signal) of the noise present in the recorded data is relevant for microseismic detection, denoising design, and wave velocity estimations on the shallow portions of the oil field. Using FK beamforming of the recorded data, we have shown that noise from the well head contributes to nearly all of the monochromatic noise. Noise in the data from the electromagnetic induction of the power lines that were present in the oil field are also present. We also locate the sources of the seismic noise and estimated the propagation velocities of these vibrations in the geological environment and we found that ground-roll obliterate the events arising from subsurface induced microseismicity. We anticipate that adaptive noise filtering techniques which eliminate both the monochromatic frequencies and ground-roll are good candidates to suppress noise and detect microseismic activity in this experiment.

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Identification of Earthquakes in the city of Londrina/Paraná through cross correlation

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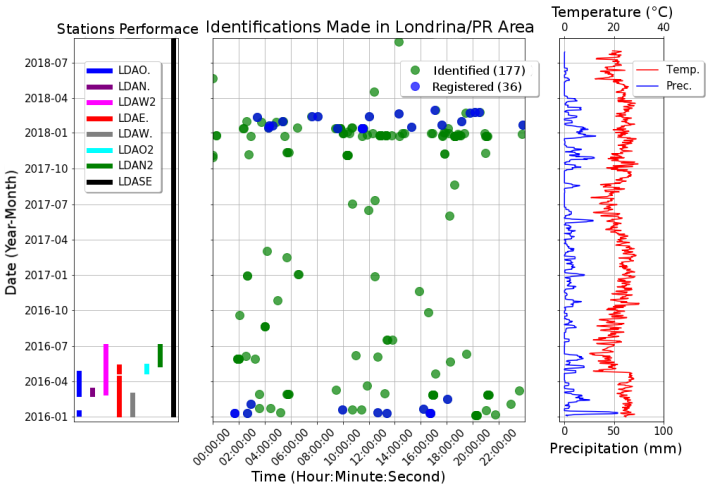
Abstract

Since 2016 city of Londrina/PR has observed recurrent seismicity, being composed of 36 known events recorded by a local network, that operated for only a few months, and a permanent station (LDASE). In comparison to Taquaritinga and Bebedouro areas, Londrina seismicity presents a smaller number of events and lower magnitudes that raises two different hypotheses: (1) There is a significant difference between geologies between Londrina and Bebedouro/Taquaritinga, that would cause the observed differences; (2) There are many earthquakes still not identified in Londrina due to the observed small magnitudes and noise records. To address these hypotheses, we try to identify new events in the region taking the 36 know events as templates in an automatic procedure. The work developed included: (1) Manual interpretation of know events phases; (2) Automatic classification of know events into families of similar waveforms using a self-developed program; (3) Search the continuous records of LDASE station using the cross-correlation of already classified families and (4) comparison with the amount of rain near the area. The 36 earthquakes resulted in 31 distinct families with a minimum similarity of 80% between elements. Those Families have identify another 177 possible tremors, 160 of undetermined origin, 15 possible earthquakes and two confirmed earthquakes through a localization routine using Hypo71 software in conjunction with the NewBR model. As observed in other areas a comparison with the amount of rain in the period indicate that all signals are temporal related to an increasing amount of rain close to the region. Considering the number of new events identified most probably the recurrent seismicity in the city of Londrina is caused by a slightly different mechanism than those in Bebedouro and Taquaritinga. Smaller magnitudes, lower number of events and the small delay with the rainy periods favors shallower than Bebedouro/Taquaritinga seismicity in the area.



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Illustrating the power of Bayesian inversion of receiver functions and surface wave dispersion curves within lithosphere and asthenosphere of iconic Alaska provinces

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Abstract

To provide new constraints on the structure of the crust and upper mantle in the state of Alaska, US, we are jointly inverting scattered body wave phases and Rayleigh wave phase velocities using a transdimensional hierarchical Bayesian approach. We are applying this approach to data recorded by tens of permanent and temporary stations in Alaska. Our goal is to shed light on how subduction has affected the upper plate lithosphere on distinct terrains and how this modification relates to patterns of geodetically observed surface deformation. Sp and Ps converted phases enhance resolution of the velocity gradients at the Moho and the lithosphere-asthenosphere boundary, while Rayleigh waves provide information about absolute shear velocities. The combination of these data infers influences of temperature, composition, and partial melt. To capture lateral variations in crust and mantle scattering, we calculate Sp and Ps receiver functions in 30° back-azimuth bins. We employ time domain deconvolution and use cluster analysis to improve receiver function stack signal-to-noise ratios. At stations in the Alaskan interior, near or beyond the edges of the subducting lithosphere, preliminary results show a strong negative velocity gradient at depths consistent with the base of the upper plate lithosphere. Closer to the volcanic arc, changes in velocities are less distinct, likely because the subducting lithosphere lies close to the base of the upper plate. At some stations in northernmost Alaska, we observe strong, shallow negative velocity gradients in the mantle, consistent with the view that lithosphere in this region is not uniformly thick and strong. This technique has been able to capture velocity gradients within and at the base of the lithosphere while maintaining smoothness of Earth models. These models will be integrated with geodynamic modeling to infer upper plate rheology and understand the driving forces of surface deformation in Alaska.

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Implementation Of An Automatic Filtering Method For The Signals Of The Seismographic Station (Aquidauana - Aqdb, Ms) In A Real-Time Seismic Monitoring Software

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Abstract

The objective of this work was to implement an automatic filtering method previously calculated in a real-time monitoring system (SeisComP3) for the signal coming from the seismographic station Aquidauana (AQDB) in the state of Mato Grosso do Sul, to evaluate the relevance of the treated signal of local, regional or distant seisms (teleseisms). SeisComP3 is a software for the acquisition of real-time seismic data, being of high standard divided into graphical partitions. Some of them, such as the scrttv, that constantly show the waves recorded by the stations and the markings made by the system. The graphical partition scesv presents a map with the pre-location of each earthquake and their information (magnitude, depth, graphical location, date, number of stations that recorded the event, among others), besides that, the scconfig can be used to set up the SeisComP3. In order to separate the seismic event from pre- existing noises, filter values were inserted in the SixSpanP3 through the graphic partition "scconfig" (processing >> scautopick), where the filter value was added to the filter. Then, the sub-module "bindings" was used to apply the new filter patterns in the AQDB station. After the modification of the default settings and the implementation of the SeisComP3 filter values, a total of 151 events were recorded from diverse regions, identified from 18/03/2017 to 23/08/2017. The applied test system obtained a minimum use of 77% of the events recorded and calculated. The number of events detected could be much greater, but in this sense, events that occured in South America were preferred, limited to 15 degrees of distance (1650km). This configuration allowed the system to record only events occurring in the region of interest, facilitating the pre-processing of data and post-analysis of this material.

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Joint inversion of high-frequency receiver functions and high-frequency phase and group dispersion curves for sedimentary structure: Case study in the Parnaíba Basin of NE Brazil

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Abstract

We assess the performance of the joint inversion of receiver functions (RF) and surface wave dispersion in the characterization of the sedimentary package making the Parnaíba Basin of NE Brazil. This procedure is routinely utilized in passive-source crustal studies and has seldom been used with high-frequency datasets. The Parnaíba Basin is a wide, circularly shaped intracratonic basin that developed in Paleozoic times. It is composed of up to 5 supersequences accumulating ∼3.5 km of sediments interbedded by Late Cretaceous diabase sills. Our dataset was acquired between 2015 and 2017 through deployment of 10 short-period and 1 broadband seismic stations distributed along an approximately 100 km-long linear array in the center of the basin. The deployment was carried out under the Parnaíba Basin Analysis Project (PBAP), an effort funded by BP Energy do Brasil aimed at improving our current understanding of the origin and evolution of this basin. High-frequency RFs (f < 2.4 Hz and f < 4.8 Hz) were calculated from time-domain deconvolution of teleseismic P-waveforms (30o < Δ < 90o). High-frequency phase and group dispersion curves (0.25 - 1 Hz) were obtained from empirical Green's functions (EGFs) emerging from cross-correlation (ZZ component) and stacking (6 months) of time-frequency-normalized ambient seismic noise recordings. Preliminary S-wave velocity-depth profiles down to ∼5 km depth were developed through an iterative, linearized joint inversion approach that minimizes the root-mean-square norm between observations and predictions. The inverted velocity models reveal prominent high-velocity zones within the sedimentary package at depths approximately coinciding with those expected for the Late Cretaceous sills, demonstrating the ability of high-frequency data to resolve fine structural details within the sedimentary package.

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Macroseismic Intensity Data Online Publisher (MIDOP): Implementation for Brazilian earthquakes

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Abstract

When working with macroseimic intensity data one of the main issues is the lack of a common platform that unifies contributing and searching for this kind of data. It is common that each researcher compiles individually his/her dataset, possibly in different formats, and not always available in digital format.

To overcome such issues, the Archive of Historical Earthquake Data (AHEAD) coordinated at Istituto Nazionale di Geofisica e Vulcanologia - Sezione di Milano in Italy developed the first dedicated solution to publish macroseismic intensity data on the internet. The AHEAD team created MIDOP, a coding-free approach that allows users to create a secure and lightweight web interface capable of transforming raw macroseismic data tables in interactable intensity maps. That interface allows for easy search, download and upload of macroseismic information, that is accessible to any user on the internet.

The Seismology Center of the University of São Paulo reached out to the team in Italy and to implement MIDOP for use with Brazillian macroseismic data. We already compiled data from several historical earthquakes (most of the main events from the book of Berrocal et al.(1984)) that we plan to make available at the launch of the platform. We hope that MIDOP will allow further collaboration between researchers through standard formats and easy access to macroseismic intensity data in Brazil.

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O impacto do novo mapa de sismicidade brasileira na avaliação de vulnerabilidade das estruturas de concreto

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Abstract

Em determinados sismos, mesmo com elevadas magnitudes, a perda de vidas humanas pode ser mínima. Tais perdas são consequências dos danos estruturais. Em condições semelhantes de aceleração sísmica, determinados edifícios apresentam diferentes desempenhos sísmicos sendo o comportamento das estruturas diretamente relacionado às considerações de dimensionamento em projeto. Nos países onde a atividade sísmica é bastante intensa, os estudos das consequências dos terremotos nas construções já são bem desenvolvidos e levaram à publicação de documentos e normas de Engenharia que obrigam a consideração dos efeitos sísmicos nos projetos de novas edificações, bem como a verificação da vulnerabilidade de estruturas existentes. Embora o Brasil seja um país de baixa sismicidade, em 2006, foi publicada a norma sísmica brasileira, a NBR 15421. O mapa de sismicidade apresentado na norma divide o Brasil em cinco zonas sísmicas. Mesmo em países de baixa a moderada sismicidade, o estudo detalhado da ameaça e zoneamento sísmicos é justificado pelo elevado risco sísmico gerado muitas vezes pela alta vulnerabilidade das edificações e grande exposição de pessoas. Um método de avaliação de vulnerabilidade sísmica mundialmente reconhecido, o Método de Hirosawa, foi adaptado à realidade brasileira e aplicado em estruturas modelo considerando as características construtivas locais e a sismicidade de acordo com a NBR 15421. A avaliação dos registros sísmicos brasileiros, especialmente a partir da década de 80 do século passado, indica uma diferente configuração da ameaça sísmica no Brasil daquela apresentada no mapa da norma sísmica. Um novo mapa de ameaça sísmica brasileira está prestes a ser publicado. Neste trabalho, o Método de Hirosawa adaptado é aplicado considerando a nova sismicidade e são realizadas comparações entre os resultados encontrados e os resultados considerando a sismicidade da norma brasileira.

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Probabilistic Seismic Hazard Map for Bolivia

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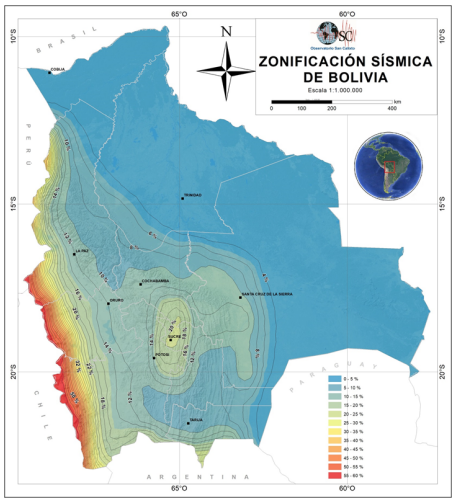
Abstract

Observatorio San Calixto presents a probabilistic seismic hazard map for Bolivia (PSHBO) taking into account seismic zones based on epicentral location, our zones includes shallow crustal, intra and inter slab seismicity. The geomorphological context and the stress regime studied by focal mechanism were also included into the new map, eleven seismic zones are defined to be analyzed. To reach our main goal we combined different seismic catalogs from national to international sources, the homogenization and declustering was done manually to get a final harmonized catalog, the well know procedure for hazard assessment was applied. Our new magnitude conversion from ML to Mw was done by ordinary least square method (OLS) regression, we took crustal, intra and inter slab seismic events. The Gutenberg – Richter laws were applied in order to have "a" and "b" variables which were included into the attenuation laws for each zone. Two attenuation laws were applied, "Boore and Atkinson 2008" for shallow crustal seismicity, "BCHydro" for intra and inter slab seismicity. CRISIS software was the main tool to get the probability calculation for 475 years and 10% of recurrence, GIS tools were applied to get a high quality map and iso acceleration curves. The results shows that at Western Cordillera has from 22 to 50 % of g taking into account seismicity from our neighbors Chile and Peru, the Altiplano goes from 14 to 20 % of g, the Eastern Cordillera where the Bolivian Orocline is present is around 18 to 20% of g, the Sub Andes has from 4 to 8 % of g. This study improves our knowledge of seismological hazards in Bolivia, furthermore this work can be applied to the new building code for our country.



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Quality Control Of Events Recorded By The Seismographic Station Of Chapadão Do Sul (C2Sb), Ms, Through The Seismogram Viewer Software (Seisgram2K)

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Abstract

The objective of this work was to analyze seismograms recorded by the seismographic station of Chapadão do Sul – MS (C2SB), corresponding to the period from 06/08/2012 to 12/31/2014, aiming at the quality control of the events reported globally (catalog of earthquakes located by the National Earthquake Information Center (NEIC) – USGS), recorded at the station and those actually confirmed after user analysis, considering teleseisms (> 1000 km), regional (101-1000 km) and local earthquakes (up to 100 km). Seismogram Viewer - Seisgram2K was used to quantify and to validate the results of seismographic analysis. Seismic data for the second half of 2012 were not used due to lack of time availability. For the years 2013 - 2014 there was a total of 2,316 events recorded, including teleseisms, regional and local seisms recorded by the C2SB station. For 2013, 763 earthquakes were recorded by the station, from which 288 were confirmed and in 2014 there was the confirmation of 1,377 of the 1,553 earthquakes recorded. With the confirmation of the data, a greater number of events were found in the State of Minas Gerais followed by the State of Rio Grande do Norte and Mato Grosso recorded by the Chapadão do Sul station (C2SB), establishing a significant result with the NEIC catalog for local and regional events. The seismographic station presents a mean percentage of complete data in the order of 63% of its operation, which is equivalent to the monitoring of 9,125 h or 730 days. The quality control of the events reported and recorded by the seismographic station of Chapadão do Sul (C2SB) has presented an increase of gradual reliability in the period from 06/08/2012 to 12/31/2014.

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Abstract ID: 0e80d9, *Contribution type:* Poster Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Edna Maria Facincani (edna_facincani@hotmail.com).

Seismic activity in Irauçuba, NE Brazil, from September 2015 until March 2016

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[2] *Escola de Engenharias e TI, UnP*

Abstract

We present the analysis of a set of 294 digitally recorded earthquakes during a campaign in the Irauçuba region, NE Brazil, from September 2016 until Februabry 2016. A 4.8 mb intraplate event has already been recorded in 1991 in the region, and up until recently, no earthquake with magnitude above 1.0 mb was recorded. From the data recorded in the 2016 campaign, 69 of them were used to determine the half-space model parameters Vp/Vs =1,69 and Vp = 6,20 km/s. From this model parameters the hypocentres were calculated using the HYPO71 programme, and 22 best located events where then used for focal mechanism inversion. These events define a seismogenic fault – Passarinho Fault – measuring nearly 2 km in length, with hypocentral depths ranging from 8 until 9 km. The fault kinetic parameters were obtained by least-square fitting a fault plane and using the FPFIT programme, yielding strike = 45 deg, dip = 53 deg and rake = -151 deg, thus characterizing a normal fault. The epicentres and focal mechanism were used to investigate if they they were associated with local mapped geological features on the surface. Although we do not observe a clear correlation between the Passarinho Fault and the Precambrian foliation, we do observe a correlation with the kind of fault and the compressive maximum direction between the Passarinho Fault and the seismicity recorded in 1991. In both cases the focal mechanisms indicate normal faulting and the maximum horizontal stress is roughly E-W.

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Abstract ID: faf787, *Contribution type:* Poster Presentation, *Session:* Local, Regional and Global Seismicity & Seismic Sources Studies, *Submitted by:* Aderson Farias do Nascimento (aderson@geofisica.ufrn.br).

Seismic risk and seismic vulnerability: why it's important to know the difference

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Abstract

Today, usually, people link an earthquake event and its knowledge to the effects, so normally various definitions are used with the same aim, such as seismic risk, seismic vulnerability, seismic hazard and so on, always linking the effects to a specific site. It's clear that this position isnt's completely corret and in countries as Brazil, this doesn't build a seismic culture in the field of new constructions and also in the retrofitting interventions. A scientific community recognize seismic risk as a combination of seismic hazard, exposition and vunerability of construction; we can't modifie a seismic hazard and the exposition, on the contrary we can reduce very much a vulnerability of the constructions, creating an appropriate common consciousness and a new category of engineers. This is particularly important in Brazil, defined as a low seismic site, where on the contrary low intensity earthquakes can generate construction effects very similar to those in countries with a larger seismicity, but with a better contest of seismic constructions. In the memory, after some general questions we present a european experience and position, on the definition of a seismic risk, particularly a italian position.

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Sismicidade do Estado do Ceará

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Abstract

Ceará is located in one of the most seismic regions of Brazil, where the largest northeast earthquake occurred and is the Brazilian state with the highest number of seismic sources. 52 municipalities in Ceará have already been hit by earthquakes. In addition, many VI and VII intensities have already been observed. Ceará is the state with the largest number of magnitudes goal or above 4.0 on the Richter scale; 10% of all Brazilian earthquakes with magnitudes >= 4.0mb occurred in Ceará. It is the Brazilian State with the greatest number of public power interventions in the reconstruction of residences due to the seismic occurrences, three times: Pacajus earthquake, of November 20, 1980, 5,2mb, 488 residences were reconstructed; Alcântara earthquake of magnitude 3.9mR, on May 21, 2008, 18 houses were reconstructed; Palhano earthquake, 4.3M, on August 28, 1989, several houses were reconstructed. The earthquakes in Ceará are located in the northern part of the state and, mainly are parallel to the coast. Focal mechanism studies indicate that distension stresses are perpendicular to the coast with compression parallel. Seismic monitoring began early in relation to North region. In 1980 the first station was installed at the uranium mine. This station resulted from a partnership between the Brazilian Nuclear Industries, the University of Brasília and the Government of the State of Ceará. Subsequently, the stations of Sobral, Aracoiaba and Beberibe were installed. All of them were analog, SP vertical. In 2002 was installed the station of Fortaleza, digital three components, which continues in operation up today. More recently, UFRN has installed the stations of the Brazilian Seismographic Network, four stations. Several studies of seismicity and focal mechanism were presented in theses, dissertations, congresses and articles. Particularly by researchers and students of UFRN. This work aims to presents a study of Ceará historical and instrumental seismicity.

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Teleseisms recorded by the Aquidauana station (AQDB) in 2015

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Abstract

The objective of this work was to carry out a quality control of the globally reported events recorded at the Aquidauana seismographic station (AQDB), with emphasis on regional events and teleseisms. Specifically, it was aimed to apply the basic concepts of Seismology, both in theoretical and practical aspects, based on the records collected by the Aquidauana seismographic station - AQDB, through the software Seisgram2k and Seismic Analysis Code - SAC. The steps of the work included the acquisition of the data, the visualization of the events, the identification of the events in the NEIC website and in the last step, the calculation of the events identified was performed, highlighting events whose waves are sufficiently clear and evident to confirm the existence of a seismic event. In this step we used the Python Obspy Earthquake Tools - POET script, using the command: $ python poet.py -b 2015-01-01 -e 2016-01-01 -m 6/10 -t 'BL.AQDB', comprising the period from 01/01/2015 to 12/31/2015. The seismic events recorded in this period corresponded to a total of 2299, and 70 of these events had a magnitude of 6.0 Mb or higher from the Andean region, with a special emphasis on Chile. The Aquidauana seismographic station (AQDB) presented a data completeness of 98.4% in 2015, meaning that of the 8760 possible monitoring hours in a year (365 days), the station monitored 8619 hours, or 359 days. This shows that the station has a high reliability index regarding the possibility of recording events, but a factor that should always be considered during data compilation is the aspect to be addressed. The purpose of this study was to verify the capacity of the station to record teleseismic events, whose scale was equal to or higher than 6.0 Richter, and in this context the station remains with good indices of effective record, evidencing that the reliability tends to decrease, without damaging the efficiency of the station.

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Lightning Presentations

Earthquakes are NOT fun

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Abstract

Earthquakes in Brazil that could cause damage to people or buildings occur very rarely. However, small events may happen every week in some part of the country. Even barely felt earthquakes can be perceived as stressful by some people. The major part of Brazilian population does not even know what an earthquake is, and that is why these events are associated with unfounded rumours, myths and religious causes — making people react strongly.

We seismologists know that earthquakes provide very rich opportunities to better understand our planet. So, it is normal to think about the last event as positive, but it is not appropriate to pass on this idea on an interview or social media posts. In the era of instant communication, any earthquake enthusiasm caught in wrong situation, could haunt one forever.

When a significant earthquake happens, people are initially more focused on the crisis than the science (Wein et al. 2016). Then, if we want to have success in communicating science, our messages need to include words of compassion, commitment and optimism. For the public, our credibility will arise from our capacity to connect to people's reality (Covello, 2011).

Coping with this matter since the Brazilian Seismographic Network (RSBR) started its deployments in 2011, our experience concludes that seismologists should provide scientific information in a compassionate way when people are under stress due to earthquakes. In a broader scenario, scientists in general should avoid taking on communication roles outside of their area of expertise or training. Our role is to investigate, present, and explain science about what is happening and what could follow, leaving to emergence managers the responsibility to communicate risks and hazards.

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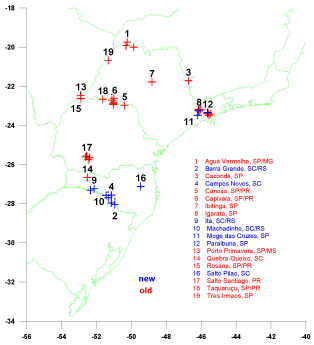
The Ipt And The Study Of Seismicity

Luis Carlos Ribotta*[1] and Patricia Del Gaudio Orlando[1]

[1] *IPT-SP*

Abstract

The IPT has been performing research and helping organizations in their projects requiring seismological expertise for almost 70 years. They began its activities evaluating earthquakes induced by deep groundwater extraction wells (1959, Fernando Prestes,SP) and reservoirs fillings (1975-1977, Capivara,SP/PR and Paraibuna,SP). In 1979 a team of researchers continued the studies on SIR with installation of seismological stations (Salto Santiago,PR) and started others related to nuclear plants (Itaorna,RJ). In 1980 started studies of natural seismicity and in 1981 the development of analysis of seismograms. Acting in the Engineering Geology area, its activities focus on Applied Seismology, considering the geological and tectonic elements, contemplating suggestions of the International Committee of Great Dams and the United States Nuclear Regulatory Commission. In the last 35 years, it has developed SIR studies in the State of São Paulo and the Southern region of Brazil. Its main projects which continue until today are: •1983: RSESP-reservoirs of CESP (until 1996), Capivara (until 2016) and Paraibuna (until today); •1999: RSIM, Itá-Machadinho,SC/RS; •1999: SPAT, Alto Tiete Producer System,SP; •2002-2007: Quebra-Queixo,SC (without SIR); •2003: RSBC-Barra Grande-Campos Novos,SC/RS; •2004-2005: seismological characterization of the reservoirs in the Tietê-Grande-Mogi and Paranapanema rivers; •2007: Salto Pilão,SC (without SIR, but with region's natural seismicity record); In 1992 a technical cooperation with IAG/USP, BLSP Project, allowed the IPT to acquire expertise to work with digital data. Based on this work, CPVR94 Project (IAG, IPT, CESP, ON/RJ) was developed (1994-1997) to study seismicity in Capivara. In 2013-2014, participating only in the initial phase of the PSHB Project (IAG, OB-SIS/UnB, UFRN, ON/RJ) to improve the seismic hazard map of the ABNT Standard NBR15421. Nowadays IPT operates in 7 areas with 10 seismological stations, studding SIR.



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The Seismic Zone of Southern Paraguay with a Revised Catalog: Another Example of Intraplate Activity in a Lithospheric Thin Spot?

Marcelo Assumpção*[1], Moises Gadea[2], Maxi Caballero[2], Daniel Portner[3], Emily Rodríguez[3], and Marcelo Rocha[4]

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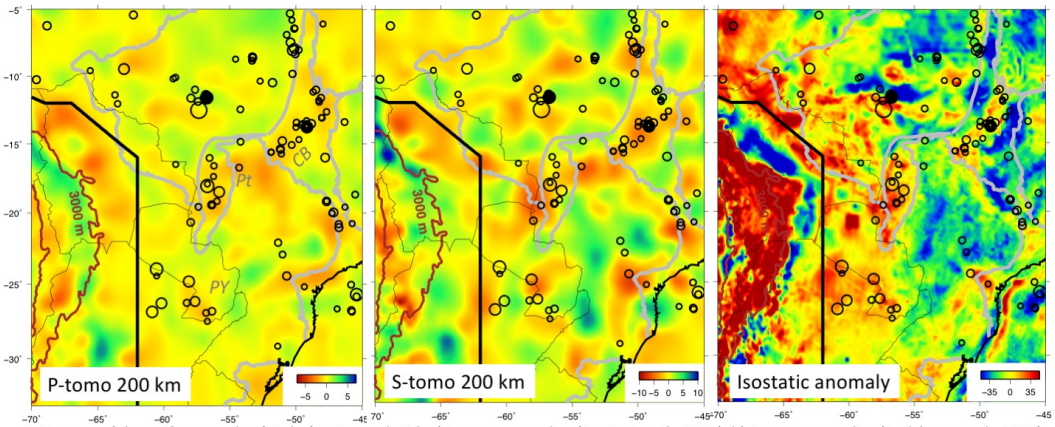
Abstract

The causes of intraplate seismicity are still a matter of debate and many hypotheses have been proposed to explain earthquake zones in stable continental interiors, such as different mechanisms of stress concentration and different definitions of weak zones. In central and western Brazil earthquakes generally occur above regions with low P- and S-wave velocities in the upper mantle. This has been used to explain the seismicity as due to stress concentration in areas of thin lithosphere. Alternatively, flexural stresses have also been proposed to explain the same seismic zones. A revised earthquake catalog for Paraguay (filtered for uniform distribution) shows a concentration of events in the southern part of the country, near the Argentinian border. Recent teleseismic P- and S-wave tomography results indicate low-velocities beneath southern Paraguay. Previous models of seismic zones had suggested that the seismicity in Paraguay could be part of the same seismic zone of the Pantanal Basin in western Brazil. The recent tomography results and the revised catalog indicate that the southern Paraguay seismicity is separated from the Pantanal zone by a high-velocity lithosphere. This suggests that the model of thin lithospheric spots, used to explain the seismicity in Central Brazil (Goiás-Tocantins seismic zone) and in the Pantanal Basin, may also be applicable to southern Paraguay. On the other hand, southern Paraguay is characterized by positive isostatic gravity anomalies. This means that a contribution from flexural stresses (similar to Central Brazil) could also help explain this new seismic zone.



Epicenters of the uniform catalog (circles) compared with a) P-wave anomalies (Portner et al., 2018), b) S-wave anomalies (Rodríguez et al., 2018), and c) isostatic gravity anomalies (Sá, 2004). Thick solid line is the limit of the earthquake catalog. Velocity anomalies in %, gravity in mGal. *PY* = Paraguay, *Pt* = Pantanal Basin; *CB* = Central Brazil. Gray lines are main geological provinces.

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Session TS

Tectonics & the Structure of the Crust and Upper Mantle

Oral Presentations

Azimuthal anisotropy in west-central Brazil using ambient seismic noise

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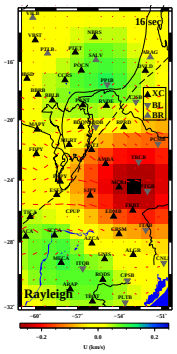
Abstract

Observed azimuthal anisotropy, which is obtained by surface waves, gives the most direct information on the crustal structure in the Pantanal, Chaco, and Parana basins as a part of west-central Brazil. It is generally believed that alignment of cracks, which are induced by the stress field, lead to seismic anisotropy observed in the crustal structure. The data used for the present study were recorded with 100 sps from January 2016 to September 2018 in the five individual sub-networks including (1) XC with 35 stations (from FAPESP project), (2) BL with 19 stations, (3) BR with 15 stations, (4) ON with two stations, and (5) GT one station. Initial data pre-processing follow the method of Bensen et al. (2007). So that, the mean and trend are removed, the bandpass filtering is applied in the range of 4 to 80 sec and normalization (in the time and frequency domains) is used. After using cross-correlation operator on all available inter-stations, the stacking procedure is done based on a homogeneous distribution of noise sources (WRMS method). After retrieving vertical component of empirical Green's function (EGF), dispersion curve is calculated for each inter-station signal. Based on calculated dispersion curves, 1388 and 1373 available ray paths are found to be usable on the inversion procedure in the periods of 16 and 40 sec. The resulted maps indicate that the azimuthal anisotropic fast directions in the middle and lower crust are consistent with both regional magmatic anomalies in the Parana basin. While this direction consists of regional tectonic trends in the Chaco, Pantanal basins.



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Crustal Structure Of The Pantanal Basin From Joint Inversion Of Receiver Functions And Rayleigh-Wave Dispersion

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[2] *Universidade de São Paulo (USP)*

Abstract

The understanding of the origin and evolution of the Pantanal basin, and its relationship to adjacent foreland basins and flexure of the South American plate, is still poorly understood due to the paucity of seismic data. To fill this gap, USP is leading a FAPESP-funded international, multi-institutional effort to investigate the deep structure under the Paraná, Pantanal, and Chaco basins with seismic data. Here, we analyze Moho P-to-S conversions in receiver functions for 41 stations in and around the Pantanal basin to determine crustal thickness and bulk Vp/Vs ratio, and jointly invert receiver functions with surface wave dispersion curves to develop S-wave velocity-depth profiles for the crust and uppermost mantle. We find average Moho depths of 36.1±1.8 km and average Vp/Vs ratios of 1.69±0.06 in the Pantanal basin, lower than those in adjacent areas; S-wave velocity models confirm the crust is thin under the Pantanal region and reveal a lower-crust with S-velocities ∼3.8 km/s, slower than in nearby regions. Existing geodynamic models suggest that the Pantanal basin formed at the top of a flexural bulge induced by the weight of the Andes on the western edge of the South American plate, causing extensional stresses in the upper crust of the bulge and reactivating pre-existing faults. We show that the Pantanal basin formed over a structurally weak stretch of the South American bulge characterized by thin and slow crust. We propose that crustal (and lithospheric) thinning facilitated the basin formation by stress concentration during the passage of the flexural bulge, while thicker crust prevented the formation of similar basins in other parts along the bulge. Projection of the Transbrasiliano Lineament (TBL) in the SW direction suggests it may extend under the Pantanal basin. If collisional processes triggered delamination that led to the TBL formation, we postulate that asthenospheric flow must have kept the lithosphere thin under the TBL after its formation.

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Crustal structure using ambient seismic noise in west-central Brazil

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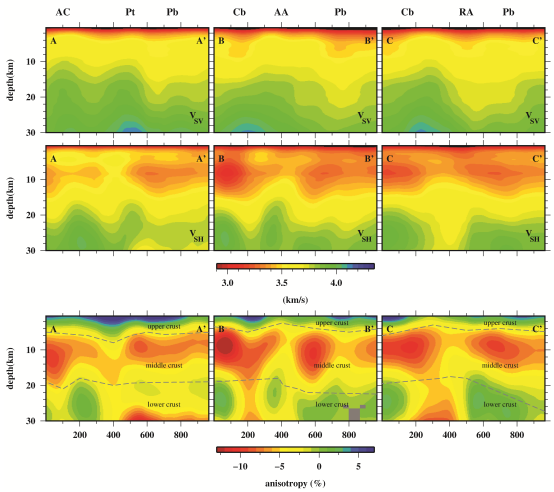
Abstract

Classical surface wave analysis provides important information about the crustal structure in west-central Brazil, but it is challenging to obtain reliable velocity models at this semi-aseismic region because of the lack of local earthquake records. However, a crustal structure obtained with teleseismic tomography are not usually robust enough to be used for interpretation of geological evolution. To alleviate this problem, a temporary deployment of seismic stations was installed as a FAPESP "3 Basins Project" to study the Pantanal, Paraná and Chaco basins using interferometry (e.g., ambient seismic noise) approach. Ambient seismic noise methods are now well-established and used in different period bands for different scales. Therefore, the continues recorded data in the five sub-network cross-correlate to retrieve inter-station empirical Green's function (EGF) signals. These sub-networks are including (1) XC with 35 stations (from FAPESP project), (2) BL with 19 stations, (3) BR with 15 stations, (4) ON with two stations, and (5) GT one station. Before cross-correlation, removing mean and trend, bandpass filtering (4 to 80 sec) and normalization (time and frequency domains) are necessary for single station preparation. Surface waves tomography indicate that the thin crust is appeared in the Pantanal basin, while thick crust becomes evident in Chaco and Paraná basins. Also, the discrepancy between shear wave velocity models, obtained from Love and Rayleigh waves, was generally used to calculate the presence of radial anisotropy. This model indicates the thickness of the upper crust, with relatively positive radial anisotropy, varies from subsurface to maximum depths of 8 km, while middle crust with relatively negative radial anisotropy extends to a maximum depth of 25km. Whereas, the lower crust has relatively positive radial anisotropy. Moreover, the middle crust beneath the Chaco-Paraná basin is thinner than the Paraná basin.



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Estrutura Crustal da Bacia do Pantanal por Tomografia de Ruído Ambiental

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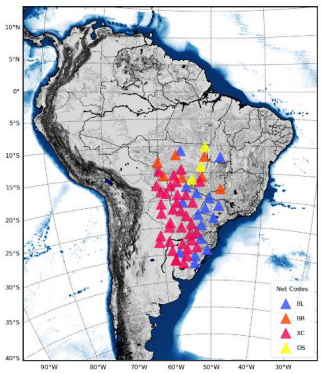
[2] *Universidade de São Paulo (USP)*

Abstract

A estrutura crustal da América do Sul é uma das menos compreendidas dentre as áreas continentais da Terra. Valores de espessura da crosta na América do Sul ainda apresentam problemas de resolução, pois as estimativas ou são bastantes escassas para o continente ou mal distribuídas (Assumpção et. Al, 2013). Para tentar diminuir este problema e identificar com maior precisão as estruturas crustais de área menores do continente, como a bacia do Pantanal, o uso da Tomografia de Ruído Ambiental (ANT) se mostra mais adequado por conseguir superar algumas limitações dos métodos convencionais baseados em terremotos. Assim, para o desenvolvimento deste trabalho estão sendo utilizados sismogramas contínuos de Mar-2016 e Dez-2018 de 62 estações sismográficas de banda-larga localizadas no Brasil e em países vizinhos como Paraguai, Uruguai, Bolívia e Argentina (figura 1). A base de dados e o processamento serão organizados de acordo com BENSEN, et al (2007) da seguinte forma: (1) preparação individual dos dados das estações, (2) correlação cruzada e empilhamento temporal ("stacking", obtido com aproximadamente dois anos de dados contínuos), (3) medidas de curvas de dispersão para períodos de 5 a 100s, com controle de qualidade, avaliação de erros e seleção de dados com medidas confiáveis, (4) inversão lateral dos dados obtidos com as curvas de dispersão geradas e (5) inversão em profundidade para gerar mapas de espessura. Desta forma, utilizando a técnica da ANT esperamos conseguir imagear com uma boa resolução as estruturas crustais sob a bacia do Pantanal e colaborar com o conhecimento sobre a mesma, a fim de solucionar as dúvidas sobre a evolução da crosta do continente sul-americano.

Figura 9 - Estações sismográficas que serão utilizadas neste trabalho, separadas por rede. BL e BR fazem parte da Rede Sismográfica Brasileira (RSBR). As estações da rede XC foram recém instaladas pelo projeto FAPESP 2013/24214-e. A rede OS pertence à UNB e possui dados restritos ao público em geral



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Evaluating the ratio of S-wave to P-wave velocity variation in the lowermost mantle beneath the Central Pacific: Implications for thermochemical interpretations of D”

Carlos A. M. Chaves*[1], Paula Koelemeijer[2], and Jeroen Ritsema[3]

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[2] *University College London*
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Abstract

The large-low-velocity-provinces (LLVPs) are broad seismic anomalies in the lowermost mantle beneath Africa and the central Pacific Ocean. For these structures, the ratio R of S-wave and P-wave velocity perturbations appears to be higher than 2.5–3.0. This is one of several seismic characteristics used to infer that LLVPs are compositional distinct structures. Here, we evaluate the estimates of R for the Pacific LLVP based on traveltime delays of P-waves (dTP) and S-waves (dTS). We explore how well R can be resolved using dTS/dTP recorded in the same seismograms by using ray (RT) and finite-frequency theories (FF). Our calculations indicate that RT predicts a higher dTS/dTP than for FF with a strong epicentral distance-dependence when R varies with depth. On the other hand, FF predicts that dTS/dTP varies only weakly with epicentral distance in a global dataset. This indicates that dTS/dTP based on long-period traveltime data is determined by the average value of R in the lower mantle and that the radial structure of R, particularly in D”, cannot be constrained from these data alone. Waveform simulations show that the high dTS/dTP of the Pacific LLVP is also strongly affected by the velocity structure in the uppermost mantle. If R increases with depth in the mantle, dTP due to the high-velocity lithosphere beneath eastern North America and dTP due to the LLVP in the lower mantle are equally strong and of opposite sign, whereas the effect is small for dTS. Consequently, the high dTS/dTP recorded for the Pacific LLVP can be explained without invoking an anomalously high R-value.

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Moho Depth from S-wave Receiver Function in reverberating low-velocity sedimentary basin

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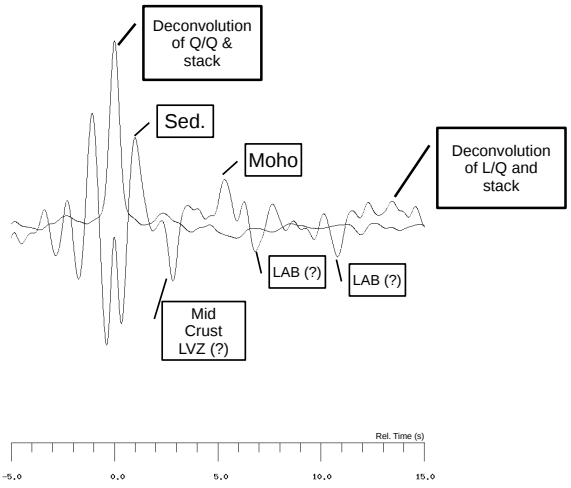
[2] *Universidade de São Paulo (USP)*

Abstract

Determining crustal thickness using P-wave receiver function on stations over thick and soft sediments is a remarkably complicated task due to difficulties with multiple phases interacting with the direct Moho Ps conversion. An alternative to P-wave receiver function is the use of S-wave receiver function that naturally isolates multiple conversions after the S-wave while S-to-p conversion would arrive earlier. One dilemma in using S-wave is the lack of suitable events (distances from 60-85 degrees and magnitudes greater than 6 mb) and the fact that S-waves have a lower spectral content due to higher attenuation. The station analyzed is part of INPRES seismic network and is in a region poorly sampled by seismic stations with a lack of crustal thickness estimates. It is located inside the city of Buenos Aires and presents a high noise level. P-wave receiver function on this station shows evident contamination with multiply reflected phases from the basin. We analyzed data from teleseismic earthquakes, applying LQT rotation based on theoretical values, deconvolution of L by Q components and stacking of moved-out records to obtain one stacked average trace with a higher signal-to-noise level. S-to-p times for the Moho and a shallow sediment conversion could be identified and measured. Sediment thickness was found to be 7 km while crustal thickness was found to be around 39 km. The obtained result shows that crustal thickness in the region is close to the expected average for the South American platform. Comparison with P-wave receiver function traces shows consistency.



*Presenting Author.

Abstract ID: 2f037c, *Contribution type:* Oral Presentation, *Session:* Tectonics & the Structure of the Crust and Upper Mantle, *Submitted by:* Marcelo Bianchi (m.bianchi@iag.usp.br).

Numerical modeling of intraplate stresses of the lithosphere focusing on topography and density heterogeneities - implications for seismicity in NE Brazil

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[1] *Universidade Federal do Rio Grande do Norte*

Abstract

The controlling factors of Intraplate Seismicity (IS) are a matter of scientific debate and many models have been proposed to explain it such as stress concentration and lithospheric zones of weakness. However, the detailed state of stress, the contribution of regional and topographic stress sources, and the role they play into geological features precludes better understanding of IS. IS in NE Brazil is characterized by a non-homogeneous distributed seismicity, not fully understood. Numerical stress modeling is a suitable tool to investigate IS as one can test different source scenarios for the stress field by comparing the results with observed stress data. We model the contribution of the stresses generated by the topography and density heterogeneities in the observed seismicity in NE Brazil, and the interplay between topography-generated and regional stresses. Our model consists of horizontally-layered plates above an inviscid fluid (the asthenosphere), where the surface load generated by the topography and bathymetry, and over the internal interfaces of the model (the internal loads) are calculated from the Bouguer anomalies, and the deviatoric flexural stresses are calculated in the Fourier domain. Modeled stresses seem to agree with the seismicity in the Pernambuco Lineament. However, some other areas with high stress concentrations are almost aseismic. The principal stress axes obtained from the modeling agrees with a normal faulting regime in the continent and thrust faulting in the ocean. Adding a regional E-W-oriented compression turns the stress regime in the continent to be strike-slip and matches the main stress directions derived from focal mechanisms. Hence, the combination of topography and large-scale density inhomogeneities are key in characterizing the observed stress field and seismicity. Geological structures and variations in elastic properties are critical and should be considered to improve the understanding of the observed data.

*Presenting Author.

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Tomography from Ambient Cross Correlation in Brazilian Southeast region: preliminary results

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[1] *Observatório Nacional (ON)*

Abstract

Brazilian southeast region has been poorly studied by seismic tomography. As an intraplate and aseismic region, the lack of strong events well recorded at seismograph stations jeopardizes the use of conventional tomography. In the literature, Brazilian southeast region appears in continental tomography inhibiting detailed study of this region. Aiming to better understand the geology of the region and along the continental margin, this present work uses the ambient cross-correlation noise tomography.

Data from stations appurtenant to Brazilian Seismographic Network and Brazilian Instrument Pool had been processed as follows. Firstly, the orientation accuracy for all stations through P-wave particle motion analyses of mb $>$ 6.0 events from the IRIS catalog. In this stage, six stations were identified as ill-oriented. The wrong orientation was confirmed by field trips.

The seismograms were converted to velocity and merged in days; excluding those with gaps was longer than 20 seconds. The data were one-bit normalized to attenuate the influence of earthquakes during the correlation. All the process was performed to vertical and horizontals components. Vertical component from all stations was cross-correlated among them as well as vertical components. After that step, horizontals components were rotated to radial and transversal according to the pairs of the stations.

The correlation-grams were stacked and the Love and Rayleigh group velocity surface wave dispersion was measured. The curves show dispersion between 7 s and 30 s. Shear velocity models derived from the dispersions curves and preliminary results from tomography inversion show correlations with local geology: low velocity in sedimentary basins and high velocities in more cratonic regions.

*Presenting Author.

Abstract ID: e96b13, *Contribution type:* Oral Presentation, *Session:* Tectonics & the Structure of the Crust and Upper Mantle, *Submitted by:* Fabio Dias (fabioludias@gmail.com).

Transition zone thickness and its correlation to the Nazca slab position in South America

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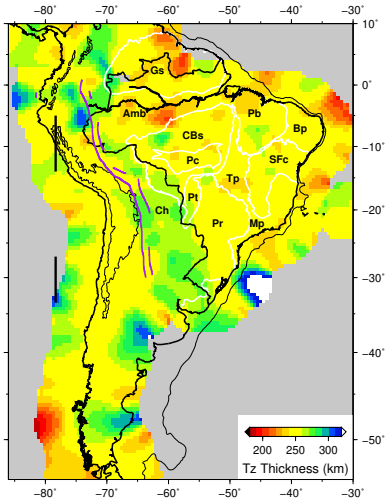
[2] *University of Arizona*

Abstract

Nazca subducted plate under stable South America (SA) influences the position and thickness of the transition zone (TZ) under the continent. TZ variations are associated with mantle temperature and also to mantle P- and S-waves velocities. TZ thickness is an indirect method to map Nazca slab position at greater depths. Recent tomography results show that Nazca plate is being held below TZ for latitudes around 20°S and longitudes between 70-55°W. We use a database of 63,809 LQT deconvolved P-wave receiver function traces (from 1,126 seismographic stations) to image the mantle TZ under different terranes. Dataset was automatically processed to obtain moved-out corrected, stacked P-wave receiver functions in boxes of 3x3 degrees every 1x1 degree. In total, we obtained 1,879 and 2,214 stacked receiver function traces that images the 410km and the 660km discontinuities respectively. An automatic extraction routine picked discontinuities times that were corrected using SL2013 global tomography model to obtain depths. In the end, we constructed IASP91 time residuals maps, maps of individual discontinuity depths and, a final map showing TZ thickness. The main result is a thickened TZ in a trend following the Andean cordillera where Nazca plate is. To the north of the latitude 18°S the TZ thickened zone has a map extension of ∼250km, to the south, we observed that the thickened zone reach up to a 1,100km width. This observation gives a clear indication that the Nazca slab flattens close to the TZ creating a perturbation in the mantle temperature and thickening the TZ. Looking at individual discontinuities depths, it looks like that 660km discontinuity is more affected than 410km favoring that the Nazca slab could flat below the TZ and not in the TZ. Individual discontinuities times indicates that upper mantle velocities are faster than IASP91 for cratonic areas and, slower than expected for the Altiplano as also mapped by local tomography.



*Presenting Author.

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Updated Crustal Thickness map of central South America Based on Receiver Function measurements in the Pantanal and Chaco basins, western Brazil

Julia Carolina Rivadeneyra Vera*[1] and Marcelo Belentani de Bianchi[1]

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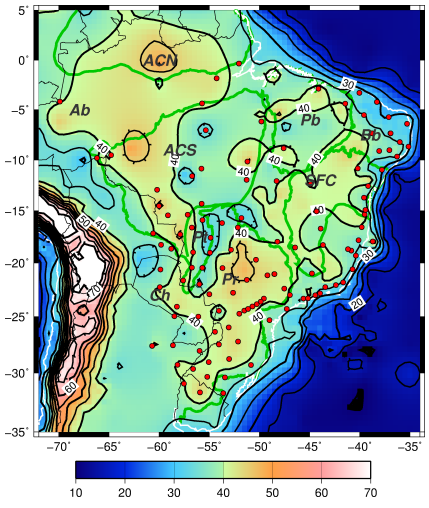
Abstract

Previous compilation of crustal structure in South America had large unsampled areas in the middle part of the continent, as the long belt of thin crust in the Sub-Andean lowlands that was mainly estimated indirectly by gravity data and the Amazon Craton that was sparsely sampled by seismic stations. A temporary deployment of 35 seismic stations in southwest Brazil and parts of Bolivia, Paraguay, Argentina and Uruguay filled a significant gap in crustal information in the stable platform. This experiment covers the Quaternary Pantanal Basin in west-center Brazil, the intracratonic Paraná Basin in southern Brazil and part of the Chaco-Paraná Basin in the northeast of Argentina and Paraguay. We estimated crustal thicknesses and Vp/Vs ratios with a modified H-k method by previously producing optimized traces with the three enhanced Moho conversions. This modified method yields lower uncertainties, given by bootstrap resamplings, and shows more regional consistency between adjacent stations. Using the temporary stations and the Brazilian permanent network (RSBR) we better characterized the crustal structure in the study area as follows. The intracratonic Paraná Basin has a thick crust (40-45 km) especially in the northern part and average Vp/Vs ratio (1.71-1.77), compared to the Chaco-Paraná further south with 35-40 km and higher Vp/Vs ratio. Those confirms the lack of widespread significant magmatic underplating in the Paraná Basin that could be related to the origin of the flood basalts during the South Atlantic opening. Our results confirmed a narrow belt of thin crust (30-35 km) with low Vp/Vs (<1.73) to the eastern edge of the Pantanal Basin. In the southern part of the Amazon Craton, to the Rio Apa block in the south, is observed a N-S belt of average to thick crust (40-45 km). The crustal information obtained in this experiment, together with a compilation of recently published data, was used to update the South America crustal thickness map.



*Presenting Author.

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Poster Presentations

Crustal thickness and Vp/Vs ratio for three stations in Uruguay using receiver function analysis: preliminary results

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Abstract

The aim of this study is to present the preliminary results of Moho depth and Vp/Vs ratio obtained by the study of teleseismic P receiver functions from stations ANCO, PSAL and TBOT in Uruguay. ANCO broadband three-component seismic station belongs to UY seismological network and is located in SW Uruguay. Meanwhile, PSAL and TBOT broadband three-component stations are located at NW and central Uruguay, respectively, and belongs to XC seismological network which is framed in the Pantanal-Chaco-Paraná basins (PCPB): crust and upper mantle seismic structure and evolution project. The teleseismic P receiver function method allows us to know the crustal and upper mantle structure under a seismic station by the study of P to S converted phases at sharp discontinuities (e.g. Moho) and the multiples or reverberations (PpPs, PsPs+PpSs). In this study the receiver functions are carried out by the iterative deconvolution technique and the estimation of crustal thickness and Vp/Vs ratio calculated using a H-k stacking algorithm. All teleseismic events used in this work had a minimum magnitude of 6.0 and the epicentral distances from the seismic station were comprised between 30 to 95 degrees. Seven receiver functions were computed for station ANCO yielding a Moho depth of 42.1 km and a Vp/Vs ratio of 1.716. For station PSAL eight receiver functions were used to calculate the crustal thickness and Vp/Vs ratio. The Moho depth under PSAL is 43.3 km while the Vp/Vs ratio is 1.723. Finally, eighteen receiver functions from station TBOT shows a Moho depth of 40.4 km and a Vp/Vs ratio of 1.789.

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Development of computational routines for travel time data processing for finite-frequency tomography in Brazil

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Abstract

We present a set of computational routines for retrieving, processing and management of seismological datasets based on the obspyDMT package. We retrieve three components seismograms for teleseismic distances recorded by Brazilian seismic stations from 1992 to 2018. Vertical component and horizontal components rotated to the transversal one are analyzed to identify P-waves (e.g., P, Pdiff, PP, PPP, PKP, PcP) and S-waves (S, Sdiff, SS, SSS, ScS, ScS2, SKS, SKKS). For each pair source-receiver in our database, we calculate synthetic waveforms for the Earth's reference model AK135 and the Harvard-CMT source parameters. Travel time anomalies for P-phases and S-phases are estimated by cross-correlating synthetic and recorded seismograms, which are band-pass filtered for different periods. We apply the criteria of Ritsema & Van Heijst (2002) and Zaroli et al. (2010) to identify unreliable travel time anomaly measurements. We correct our measurements for the effects of Earth's ellipticity and variations of the crustal velocity structure using the model CRUST1.0. Thus, we build a travel time anomalies table to derive new P-wave and S-wave seismic tomography models based on finite-frequency theory for Brazil. From here on, with this set of computational routines, we can easily update our travel time anomalies table for newly recorded seismograms and future seismic stations deployments in order to constantly obtain P and S velocity structure models beneath Brazil.

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Development of computational routines to compute a library of Fréchet kernels for finite frequency tomography in SE Brazil

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Abstract

We develop a set of computational tools (CT) to calculate a library of Fréchet sensitivity kernels (K) for finite-frequency tomography. The Frechét kernels are computed following the methodologies proposed by Zhao & Chevrot (2011) and Fuji et. al. (2012), which consist in the calculation of strain Green's tensors using the Direct Solution Method to solve the weak form of the elastic equation of motion in the frequency domain. Assuming that K varies insignificantly with the assumed moment tensor and velocity structure, the first module of our CT automates the generation of synthetic waveforms for the Earth's reference model AK135. We use the source parameters of the Global CMT for events 080596G (August 5, 1996; Tonga) for S-waves and 060994A (June 9, 1994; Bolivia) for P-waves and station azimuths of 90° when P- and S-wave radiation is strongest. To calculate K, with the second module of our CT, we graphically analyze synthetics low-pass filtered waveforms to determine a time window of length t2-t1, where t1 and t2 are the travel times picks around the target phase. The third module of our CT involves the filtering of the calculated sensitivity kernels for suppression of numerical noise and interference of phases arriving within the time window of the target phase. The computed library of K will be used to derive new P-wave and S-wave velocity models for the mantle beneath SE Brazil.

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Evaluating the Effects of Finite-Frequency Theory on the Determination of the Mantle Transition Zone Thickness

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Abstract

Differential travel times between SS and its precursors (i.e., S410S and S660S) are frequently used to estimate the thickness of the mantle transition zone (MTZ) and the thermal state of the mantle. To understand how simplified traveltime corrections may affect these estimates, we compare ray-theoretical (RT) and finite-frequency theory (FF) traveltime corrections due to the heterogeneous mantle velocity structure in tomography model S40RTS. We apply these corrections to all waveforms in a new global SS waveform dataset before stacking. We present new MTZ thickness maps based on RT and FF traveltime corrections. Our preliminary results show that for a well-sampled region as the Pacific, the RT and FF estimates of the MTZ thickness differ by about 1-3 km. In other parts of the globe, the difference may be as much as 5 km.

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Evaluation Of Herglotz-Wiechert Inversion Using P Wave Travel Times From Brazilian Seismic Network Stations

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Abstract

The Herglotz-Wiechert method, developed in 1910 by Gustav Herglotz and Emile Wiechert, is based on the analytical solution of the inversion of seismic travel times to determine variations of seismic velocity with depth. Here, we present a computational code in Python that implements this inversion methodology, and assess its performance through measurement and inversion of P-wave travel times for 11 earthquakes recorded at 81 seismic stations of the Brazilian Seismographic Network (RSB). The efficiency of the code is assessed through two numerical experiments with synthetic "data", resulting in inverted v(r) functions that accurately match the ak135 global model utilized to generate the synthetic "dataset". The results obtained from the inversion of real data showed that, for depths up to 1000 km, the inverted v(r) functions are similar to those predicted in global Earth models, while for depths between 1000 and 2000 km they present large deviations. Those deviations seem to be dependent on the interpolation strategy utilized to homogenize the integration steps along the T-Δ curves. We conclude that the methodology allows to successfully estimate the variation of P-wave velocity with depth within the continental lithosphere and upper mantle of Brazil.

Keywords: Herglotz-Wiechert Inversion; Upper mantle; Brazilian Seismographic Network.

*Presenting Author.

Abstract ID: dc78dd, *Contribution type:* Poster Presentation, *Session:* Tectonics & the Structure of the Crust and Upper Mantle, *Submitted by:* THABITA SOFIA GOMES (thabita.sof@hotmail.com).

Natural Land And Geotechnical Structures Deformations Detected By Radarsat In The Platô Moeda Region, Itabirito-Quadrilátero Ferrífero

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[1] *SGGM Geologia & Mineração*
[2] *TELESPAZIO*

Abstract

A series of ruptures in the form of sink holes and reactivation and faults / fractures indicated a clear relation, in principle in terms of date and time; with the occurrence of earthquakes on April 5, 2014, in the region of Plateau Moeda in Itabirito. A series of surface ruptures, in natural terrain and geotechnical structures; with movement of faults and fractures systems occured subsequent and concomitant to the event of earthquake. In this work performed by the RADARSAT technique of double geometry, ascending and descending, the calculation and analysis of the progression of the deformation velocities indicated the same period of the earthquakes for a series of ruptures registered by the radar. Certainly the local natural fragility motivated by the existence of a karst system in the existing dolomite bodies provides a vulnerability to phenomena of depletion and displacement of the local base level. However, the direct relationship of the deformation of this natural environment caused by events of earthquakes indicates the need to know more deeply the reach of this geological conditioner and more broadly its occupation, whether by industrial, rural or urban activities; where the consequence will always be harmful. The radar records were either by sampling or by the correct generation of stable reference points for the deformation analysis were assertive in the correlation of seismic events. In this specific area the technique would have some application in the prevention of accidents; since from three to four months before the rupture occurred in one of the geotechnical structures the acceleration in the average velocities was clear and consistent in practically all PSP (persistent scatter pairs) evaluated.

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P-wave tomography sensibility test applied to the Chaco-Paraná, Paraná and Pantanal basins inversion

Israel Dragone*[1] and Marcelo Bianchi[1]

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Abstract

Travel time tomography proved to be an attractive tool to study the upper mantle and lithosphere. In the last decades, this technic has been applied to the whole Earth generating interesting results without any expensive computation infrastructure. We are applying it to a set of temporary stations that were deployed to study the Pantanal-Chaco basin located at southeast Brazil. Our database is composed of 66 seismic stations and 820 teleseismic events (between 30 and 95 degrees). To pick the arrivals we used a semi-automatic software marking extreme amplitudes in a window within the P-wave arrival since we are working with relative residuals. This approach is significantly faster than absolute picking and, in theory, remove the influence of structures outside of inversion region. Picking was performed in three fixed frequency bands: (1) 1.2-2.0 Hz; (2) 0.5-0.9 Hz and (3) 0.05-0.4 Hz, once the difference between the arrival time in the same seismogram for those frequencies was significant in several cases. We used a self-written code to filter events with the low correlation coefficient for different stations in one event. Inversion step was performed with two different codes and results were obtained for several depths and sections. Main, well know, features as the high-velocity anomaly under Parana basin, and the low-velocity anomaly under Pantanal basin are present in all models. Nevertheless, differences existed between the three used frequency bands. Ray covering and the synthetic test revealed better resolution deeper than 200 km since teleseismic rays arrive almost vertically generating few ray cross for shallower depths. Probably the only way to improve superficial resolution is adding local events, which we plan to do soon.

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S -Wave Velocity Model (1D) For The Lithosphere Of The Pantanal Basin

Estevão Vasconcello Campos Tadeu *[1] and Marcelo Assumpção[1]

[1] *Universidade de São Paulo (USP)*

Abstract

The Quaternary Pantanal sedimentary basin is tectonically active with earthquakes with magnitude up to 5.4. The upper mantle of this region presents low velocity in the propagation of the P and S seismic waves. To better understand the causes of this low-velocity anomaly of the S wave beneath the Pantanal Basin we analyzed surface-wave dispersion curves. We only use events of magnitude larger than or equal to 5.5 mb, with good azimuthal distribution. For the Rayleigh surface waves, we measured phase and group velocities for fundamental and first higher modes. For the Love waves, we only analyzed velocities of the fundamental mode. We intend to determine a new 1D velocity model of the S wave for the Pantanal Basin. Multiple Filtering techniques were used to measure the group velocities of the Rayleigh and Love waves were obtained. The filtered seismograms were stacked to obtain the phase velocities. The group and phase velocities were inverted with the Surf96 software, obtaining a preliminary S wave velocity model for the Pantanal Basin.

*Presenting Author.

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Seismic Anisotropy in Mid-Plate South America: an Updated Model Using Shear Wave Splitting Measurements and Waveform Tomography

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[2] *Universidade de Sao Paulo (USP)*

Abstract

Seismic anisotropy beneath stable continental regions yields important information on their tectonic history and patterns of upper mantle flow, in a way not achieved by other methods. We investigate the upper-mantle seismic anisotropy beneath South America using a suite of complementary data and models, including shear wave splitting (SWS) and the isotropic and azimuthally anisotropic shear-velocity distributions in the upper mantle from waveform tomography.

Previous studies of SWS in South America concentrated mainly along the Andes and in southeast Brazil. Here, we add extra measurements extending to the entire Brazilian territory, including the Amazon area, and the Pantanal and Parana-Chaco basins, as part of the FAPESP "3-Basins Thematic Project". The results from both temporary deployments and the Brazilian permanent network provide a more complete and robust anisotropy map of South America's stable core than available previously.

We observe, in general, little correlation of the anisotropy directions with geological trends and a better match with the absolute plate motion (APM) directions, mainly E-W. This indicates that the observed anisotropy is mainly due to the upper-mantle flow, with little contribution from frozen lithospheric anisotropy. Notable deviations from the APM directions appear to be due to flow surrounding cratonic nuclei: the keel of the São Francisco craton, a possible cratonic nucleus beneath the northern part of the Paraná Basin (the Paranapanema block) and, in the north, the Amazon Craton. Large delay times at the Pantanal Basin may indicate a stronger asthenospheric channel, a more coherent flow, or a thicker asthenosphere. Small delays beneath the northern Paraná Basin may indicate thinner anisotropic asthenosphere beneath the thick Paranapanema block or a reduction in the amount of SWS due to anisotropy with different fast azimuths in the asthenosphere and lithosphere.

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Shear wave velocity models for the Chaco-Paraná Basin from ambient seismic noise analysis: constraints on upper crustal structure

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Abstract

The seismic structure of the crust and uppermost mantle under the central and eastern region of South America is being a matter of study in recent years due to the installation of new temporary and permanent seismological stations. In this study, the upper structure of the crust beneath the Chaco-Paraná basin (CPB) was modeled in order to provide valuable information about the evolution and present geodynamics of the basin. The CPB is a Neopaleozoic intracratonic basin, formed by a complex history of different processes of subsidence.

For this purpose, Rayleigh-wave group velocity dispersion curves, obtained by the ambient seismic noise cross-correlation technique, were extracted using a time-frequency analysis. The observed group velocities were inverted considering a non-linear iterative damped least-squares inversion procedure and several 1-D shear wave velocity models of the upper crust were obtained. The final models fit reasonably well the measured group velocity curves, which indicate a high degree of robustness.

Dispersion curves estimations using ambient seismic noise allowed the estimation of Rayleigh wave velocities at periods lower than those achieved with earthquakes and, therefore, sensitive to shallower structures.

The data to perform this work was acquired from new seismological stations that have been installed since May 2016 in the CPB region, particularly in Misiones, Corrientes, Chaco and Formosa provinces in Argentina.

The results are in agreement to the major known surface and sub-surface geological and tectonic features recognized in the CPB area. This work is part of a main project (Pantanal-Chaco-Parana Basins: Crust and Upper Mantle Seismic Structure and Evolution) that will enhance the understanding of crustal structure in Southern Brazil and Eastern Argentina and is being carried out by IAG-USP (Brazil) in collaboration with FCAG-UNLP (Argentina) and INPRES (Argentina).

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Study of Chaco basin thickness with receiver function

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Abstract

The Chaco Basin is located in meridional region of South American plate and has coverage of few stations, what makes difficult studies about the geodynamic process that control its subsidence. The temporary stations SCCA, TICA, and VACA, in Argentina (already deactivated); FDPY and PAPY, in Paraguay and the ITQB, permanent in Rio Grande do Sul state, in Brazil, registered teleseismic events until 2018.

To determine the basin width under the stations, the present study is using the method of receiver function (RF) for P waves inversion, that is widely used for crustal studies. The selected events are of deep seisms (> 450 km). Gaussian filters of 5 Hz and 15 Hz are being used in deconvolution for high frequency RF obtaintion.

Preliminary results obtained by time difference between the P and Ps conversion arrives, considering vp = 3 km/s e vp/vs = 1.8, shows width of about 3 km under SCCA station, 3.7 km under ITQB and 5 km under PAPY, for example. The RF inversion, however, is not unique. Therefore, it is pretended to use these data during the year in a joint inversion with dispersion obtained by noise tomography.

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Study of physical and structural properties in the region of the Pantanal, Paraná and Chaco-Paraná Basins using joint inversion of gravimetric observations and surface waves velocity

Denise Silva de Moura*[1], Yára Regina Marangoni[1], and Carlos Alberto Moreno Chaves[1]

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Abstract

Gravimetric and seismological data will be used to derive 3D models of density and S-wave velocity for the Pantanal, Paraná and Chaco-Paraná basin regions, through the joint inversion of these two types of geophysical data. Initially, for the gravimetric case, we will combine satellite data (GOCE) with freshly collected terrestrial data in the Paraguay region to increase the resolution of the gravimetric model. The effects of topography, sediments and variation of the Moho topography on the gravitational field will be removed to isolate the density anomalies inside the crust and the upper mantle. Surface wave data will be processed for determination of group velocity curves for Rayleigh and Love waves, for each source-receiver pair, from seismograms recorded by the Brazilian Seismographic Network (RSBR) and the temporary arrangement of XC stations. In the beginning, density and velocity models will be obtained independently. Then, a joint inversion of the residual gravimetric data and the Rayleigh and Love dispersion curves will be performed. To integrate the gravity anomaly data with the seismic wave velocity in the joint inversion scheme, we will test empirical relationships suggested in the literature. The obtained models will be compared to evaluate the results consistency. Thus, we hope to contribute with new models of the crust and the upper mantle physical properties. It will help to provide new links about the current thermal and compositional state of these three basins and to understand their geodynamic evolution, emphasizing the poorly known region of the Pantanal basin.

*Presenting Author.

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The Pseudo Active Fault System Of 'Marinho Da Serra', Quadrilatero Ferrífero/mg, Brazil

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Abstract

The 'Marinho da Serra' Fault System (MSFS) is the set of structural lineaments / faults located in the southwest portion of the Iron Quadrangle (QFe) of the WNW-ESE trend. This system promotes the splitting of the Bonfim Metamorphic Complex (BMC); along rectilinear structures represented in the field by shear bands with at least two deformation phases marked by a pattern of intense fracturing and relief breaks, with crest displacement; in plans with high angle of deep. The MSFS has transcurrent movement characteristics along the main direction N110° and N020°. These structures cross the basement rock domain (BMC) cutting from the supracrustal rocks belonging to the Rio das Velhas and Minas Supergroups until recent coverings, originated in the Neogene, in the southern portion of the Serra da Moeda. These lineaments are persistent in the southern portion of the São Francisco Craton (CSF) and their associated structural fracture arrangement is compatible with the current stress field in this portion of the CSF, Assumpção et al. 2014. A series of dry slides characteristics can be observed along with the set of relief faults in the fault zones, which may represent the reactivation of pre-existing structures or even materialize new ruptures in the shallow lithosphere provoked / triggered by earthquakes. Similar situations in the surface geology, since the presence of the same zones of shear and also of the anomalies of relief and drainage; were observed from the vicinity of the 'Serra de Bom Sucesso' to the northwest border of the QFe where the MSFS is located. The nature of seismicity and ruptures in the lithosphere in the southwest portion of the QFe is associated with the loss of lithospheric thickness and other larger processes in the crust dynamics.

*Presenting Author.

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Underworld2 Code: Numerical Subduction Model

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Abstract

Mountain building at convergent margins is generally attributed to the collision of two continents or the accretion of continental ribbons, oceanic plateaus or arc terranes to the overriding plate of a subduction system. In this respect, subduction along the western margin of South America has been active since the Jurassic, but Andean orogeny started in the middle Cretaceous and was preceded by backarc extension in the Jurassic-Early Cretaceous. The timing and sequence of these events has remained unexplained. The episodic deformation and magmatism have been attributed to cyclic changes in the dip angle of the subducting slab, slab break-off and the penetration of the slab into the lower mantle; the role of plate tectonics remains unclear, owing to the extensive subduction of the Nazca–Farallon plate. This work aims to acquire expertice in the use of Underworld2 (UW2) code in containerized parallel High-Performance Computing (HPC) environment. UW2 is an open-source, particle-in-cell finite element code tuned for large-scale geodynamics simulations. For this, We take as reference the paper of Schellart, W. P. (2017). Here We present a dynamic, buoyancy-driven, whole-mantle numerical subduction model to test a hypothesis in which the formation of the Andes is mostly a consequence of the long-term (∼200 Myr) progressive evolution and large width (trench-parallel extent) of the subduction zone, focusing on the role of subduction-induced mantle flow in driving overriding plate deformation. The numerical experiment uses the code UW2 and builds on previous generic subduction models to simulate time-evolving subduction of a 6000 km wide (trench-parallel extent) oceanic plate below a continental plate in a very large three-dimensional layered wholemantle domain (comparable to the Nazca-South America subduction setting).

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Upper crustal velocity structure beneath Northern Peruvian Andes from ambient noise tomography

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Abstract

The structure of the crust in the northern region of Peru is a consequence of the convergence between the oceanic Nazca plate and the South American continent. Several studies have aimed to understand the structure and dynamics of the Peruvian crust. Despite this effort, many aspects remain poorly understood. In this study, we applied the technique of ambient noise seismic tomography (ANT) with the objective of studying the crust velocity structures under the study region. We use cross-correlations of ambient seismic noise at 26 broadband stations from national and international networks in northern Peru to image crustal structure. Rayleigh wave Green's functions were obtained after the frequency-domain normalization of the ambient noise recordings and stacking of 14 months of normalized data. Dispersion curves from phase velocity maps were inverted as a function of depth to obtain 2D shear wave velocity model of the upper crust. The preliminary results reveal features that correlate with surface geology. We observed a slow velocity zone under the Sub-Andes that may represent regions with mayor deformation caused by the isostatic compensation that correlates with the seismicity, crustal thickness model and Bouguer gravity values.

*Presenting Author.

Abstract ID: 4f0246, *Contribution type:* Poster Presentation, *Session:* Tectonics & the Structure of the Crust and Upper Mantle, *Submitted by:* Cristobal Condori (gfcristobalcq@gmail.com).

Session FA

Field Advances, Network Operation and Technological Developments

Oral Presentations

Improvements On Routine Seismic Data Processing

Gerardo Sánchez Girino*[1], Valeria Nicolia[2], and Marcelo Moreno[1]

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Abstract

We have developed a code in Bash (MAGI) that combined with SEISAN (Ottemöller et al., 2011) helps to increase the capability of earthquake location calculations, reduce uncertainty, locate low magnitude earthquakes and obtain reliable results automatically, even for regions with low coverage of seismological stations. The MAGI code is able to pick P and S waves from normal and noisy records using three different filters, locating earthquakes with data from at least three stations, applying quality and distance weighting, calculating ML and MW and also provides an estimation of intensities to help to analysts at data processing for fast and reliable results. The picking process shows results with average errors of 0.2 ± 0.1 seconds for P waves and 0.4 ± 0.2 seconds for S waves. It uses quality and distance weighting criteria to get the earthquake location more influenced by stations with closest epicentral distance. MAGI works with alternative logical algorithms to solve unusual and more difficult earthquake location procedures. The estimated intensities are obtained using the modified attenuation equations A15 (Atkinson, G., 2015) on Peak Ground Velocity (PGV) obtained in each station. Then, the estimated intensity for each point on the map is calculated using a weighted average between a North-South attenuation model and an East-West attenuation model. MAGI has its own data control system, generates a summary of the location analysis, and results are obtained in 25 to 45 seconds, depending on the number of channels available for processing. For Argentina, it can successfully solve more than 95% of cases when signals have P picks from an automatic or manual preprocessing, or it generally solves more than 70% when the signal package has no picks. The analysis of results shows that in most cases, location errors are less than 20 km compared to the location obtained through manual processes, the solutions improve as the coverage and density of stations increases.

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Ocean Bottom Seismometers: A short overview focusing on data processing

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Abstract

About 70 % of the Earth is covered by water mainly distributed among in the five oceans. This creates a natural barrier to conventional seismological data acquisition. In this context, the ocean bottom seismometers (OBS) are helping scientists to recover information from the ocean floor for both local and global studies.

Despite the recent developments of new technologies, working with OBSs is still a challenge which includes a considerable budget necessary to install them on the ocean, the duration of the battery and the lack of direct communication with the device after the deployment, i.e., it is like a "blind" acquisition: it is almost impossible to check whether the equipment is working correctly. Even if the OBSs have been fully recovered the data needs heavy pre-processing steps before been apt to be used.

This work will give a short view of the processing required to use the OBSs data. The first step is to locate the OBS on the ocean floor. The OBS final location is not the as same as the deployment and the retrieval. The final location can be done by using the time difference between acoustic signal release from the ship towards the OBS and vice versa assuming the P-wave velocity and the bathymetry are known.

Because there is no communication with GPS, time drift correction is a must, in one year the difference can reach more than 10 s. There are also the compliance and tilt corrections due to the ocean tides and seafloor currents adding a new channel unfamiliar to land seismologists: pressure. Azimuthal correction is also needed and it can be retrieved from Rayleigh wave polarization (from natural events or from Ambiental cross-correlation noise). Some corrections that also may be needed are one more time correction because of leap seconds and the removal of electronic glitch in the data.

Summarizing, OBS data requires much more effort to be used, however, is a must for a better understanding of the Earth and sea process.

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Seismology at the Federal University of Ceará

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Abstract

Recently, the Seismic Data Acquisition, Processing and Analysis System - SeisComp3, through which data from the Brazilian Seismographic Network (RSBR) is received and recorded, was installed at the Science Center of the Federal University of Ceará (UFC). The UFC Science Center is comprised of the departments of Geology, Physics, Mathematics, Geography and Statistics. The seismicity of the State of Ceará is one of the most significant in the context of Brazilian seismicity, especially in the seismic areas of Baturité, Maranguape, Aracati, Pereiro, Pacajus, Groaíras, Palhano, Irauçuba, Cascavel and Meruoca. In these areas, 10% of all Brazilian seismicity were registered, with magnitudes greater than or equal to 4.0, and the area of the State of Ceará represents less than 2% of Brazilian territory. There are even more than 40 other seismic areas in the Ceará state. One relevant fact concerns the locations of these areas in relation to urban centers and building qualities. Almost all are close to populated urban areas, with no observance of anti-seismic norm. This makes Ceará one of the Brazilian states of greater seismic hazard and risk. Therefore, justifying the need for a Seismology group in the State. The objectives of the Seismology nucleus of the UFC are: to analyze daily the RSBR data, especially of the stations located in Ceará, to identify and study the events located in the State; training of human resources in the area of seismology; contribute to the determination of the tectonic stresses in the NE, through studies of focal mechanisms, with local network in Ceará; maintain close collaboration with other Brazilian seismology centers; to work in partnership with the Civil Defense of Ceará, in the face of seismic shocks in the State of Ceará.

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USP Data Center: infrastructure supporting the Seismology Center

Jackson Calhau*[1], Bruno Collaço[2], Marcelo Bianchi[1], Marlon Pirchiner[1], and Marcelo Assumpção[1]

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Abstract

Traditionally, Brazilian seismology did not have a clear strategy for acquiring, evaluating, storing and sharing data with a long-term view. Without adequate infrastructure and effective management, the collection of seismological data may be lost or partially unusable (as it has happened many times in the past), resulting in non-uniform coverage, decreasing the chances of local and international collaboration, and making it difficult to extract scientific knowledge in the future.

Since 2009, efforts of four institutions have established the new Brazilian Seismographic Network (RSBR, Rede Sismográfica Brasileira), initially with resources from PETROBRAS to implement the network of 85 stations and adjustments in the infrastructure of these institutions, waxing in 2015. Since 2016 CPRM supports the maintenance of the Network.

The USP Seismology Center as a member of the RSBR receives in real time data from the 4 different networks (BL, BR, NB and ON), operated respectively by USP, UnB, UFRN and National Observatory. In addition, it distributes real-time and on-demand data to more than 20 sites around the world.

The Center has a robust infrastructure composed of a Tier II Data Center, an own Satellite Central (VSAT, Very Small Aperture Terminal), two NOCs (Network Operations Center), two storage arrays, dozens of servers (physical and virtual) and a motivated specialist team.

With this, one of the challenges of the Seismology Center is to maintain, manage and expand the entire built infrastructure, always in a sustainable and scalable way, to provide reliable data to society and researchers in Brazil and worldwide.

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Poster Presentations

Evaluation of Capivara (SP) station orientation using teleseismic events

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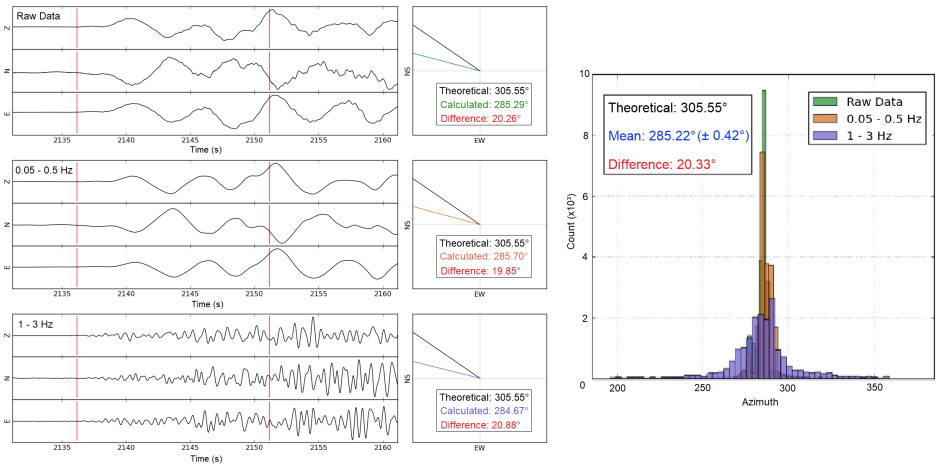
Abstract

The correct orientation of a triaxial seismographic station concerning the geographic North Pole is of great importance while recovering the accurate movement of the ground due to the arrival of the seismic waves and after that, calculating an earthquake epicenter location. Poor orientation of the station can occur for several reasons, among them: lack or incorrect magnetic declination of the compass; interference in the compass caused by magnetized rocks at the installation site; inaccuracy when transferring the compass north direction to the instrument pillar; or even caused by problems during the equipment's construction. Earthquakes recorded by the Capivara Seismographic Station in São Paulo are located using the time difference between P and S waves' arrivals (S-P) and their azimuths showed constant divergence in results compared to locations using travel times alone. To ascertain the station orientation, we applied a method of azimuthal estimation based on the polarities of the P waves from well-located teleseismic events. Earthquakes were chosen considering magnitudes greater than or equal to 5.5 and epicentral distances between 30° and 90°. Data were manually inspected and preprocessed to highlight features of interest. Azimuths were obtained by averaging the arctangent values of the North-South by East-West components corrected by the vertical. For each earthquake, three filters were applied in 15 different time windows, allowing the determination of uncertainty. Results indicate that the station's North-South component is oriented at the azimuth 339.04° ± 2.96°. Considering this new orientation, epicenters previously located using the azimuth and S-P time could be corrected, and significant earthquakes detected by the CAP12 station could be correctly located, such as the Curitiba earthquake (September 2017) which had its final epicenter determined at a distance of 33km from the epicenter determined by the Brazilian Seismographic Network.



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Güralp Systems; Aquarius, the future of ocean seismic research

Stuart Allardice*[1] and Phil Hill[1]

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Abstract

With 70% of the Earth covered in water, there is a significant gap in the seismic data catalogue which offshore datasets could refine to complement current surface research. Güralp Systems have understood this and have been developing broadband Ocean Bottom Seismometers (OBS) systems for over 25 years. Güralp have deployed systems in a range of ocean environments, from the Japan Trench in the Northern Pacific Ocean to the North Sea. Applications for Güralp's cabled and autonomous OBS systems include passive and active seismic surveys, ambient noise recording, real-time reservoir monitoring and ocean bottom observatories. We have taken our knowledge and success in OBS design and invested into developing the next generation of autonomous OBS; the Aquarius series. The Aquarius series of OBS allows researchers to download raw seismic data via acoustic communications, during any period of the deployment, without the requirement for cables to shore or other infrastructure. This capability provides unparalleled flexibility as it allows the scientist to visit the deployment location multiple times to download data from events of interest in order to further their research whilst the system is still deployed at depth and without disturbing the unit. The seismic community are highly motivated to perform transportable array style projects on land. Now Güralp can support the community with Aquarius; easily accessible, portable, off the shelf systems for a similar array of ocean based seismological research ventures. The Aquarius series of OBS bridges the gap between real-time and offline ocean bottom systems and continues the trend of Güralp supporting the research community and supplying innovative OBS designs to meet operational requirements.

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IoT in seismology: real-time transmission methods

Jackson Calhau*[1], Bruno Collaço[2], Marlon Pirchiner[1], Luis Galhardo[1], Felipe Neves[1], José Roberto Barbosa[1], Cleusa Barbosa[1], Emilia Brasilio[1], Marcelo Bianchi[1], and Marcelo Assumpção[1]

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[2] *Universidade de São Paulo (IEE/USP)*

Abstract

Nowadays the great challenge for specialists in communication networks and seismologists is to achieve an efficient data transmission in the adverse conditions where the seismographic stations are deployed.

The transmission (or telemetry) of seismological data is gaining more and more prominence in the world, since it is an essential point for the effectiveness of Earthquakes and Tsunamis Early Warning System, as Seiscomp3, the system used by the 5 groups (USP, UnB, UFRN, National Observatory and CPRM) that constitute the Brazilian Seismographic Network (RSBR, Rede Sismográfica Brasileira).

The RSBR has 85 seismographic stations, where many of them transmit data in real time and probably by the end of 2019, all stations will be online. USP Seismology Center manages 50 links (of 85), using three transmission methods: Very Small Aperture Terminal (VSAT/Satellite), 3G/2G (mobile), WISP (Wireless Internet Service Provider).

The definition of the best method for transmission is always a recurring topic of discussion. Finding metrics, evaluating available alternatives to the location, monitoring performance and budget adequacy are basic items for choosing the technology to be used for each station.

Another aspect to be emphasized when it comes to real-time transmission is the remote monitoring and management of equipment, reducing downtime, correcting problems of simple settings or adjustments, making the network or system of which the station is most effective.

The choice of the best transmission technology is essential to meet a basic premise of the RSBR and other projects of the Center, to have the highest availability of transmission links possible. Benefiting researchers in Brazil and in the world, besides society when there is a significant event, with the sharing of data in real-time.

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Numerical Simulation of an Optical Seismometer Based in Fiber Bragg Grating (FBG)

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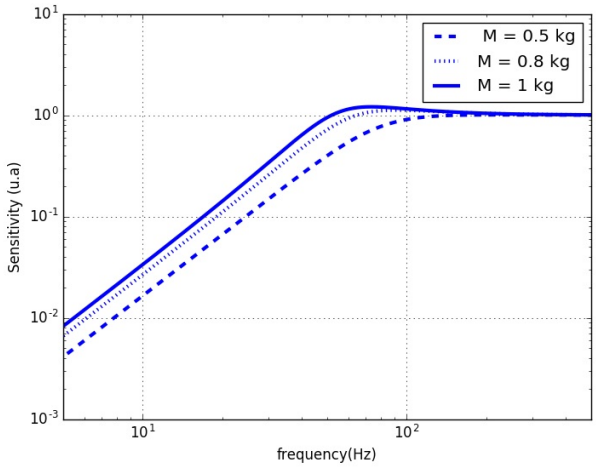
Abstract

In recent years fiber Bragg grating (FBG) sensors are being used for vibration and displacement monitoring, with high sensitivity, on the order of micrometers and less. Because these sensors are highly sensitive, a research area with FBGs has arisen for the development of optical seismometers. In this work we present a theoretical and numerical simulation of an optical seismometer based on FBG. Basically the seismometer to be simulated is a damped system formed by two parallel springs, one of which is a mechanical spring (k) and the other is an optical spring (FBG, K). The damper is a coil (L) and the mass (M) is a magnet. The damping occurs when the moving magnet, inside the coil, and in this acts a magnetic force that prevents the movement. In the mass M interact three forces, magnetic force, mechanical spring forces and optical spring force. All these forces that interact in the mass M, allow to formulate an equation by the second law of Newton, that when being solved numerically, we obtain the curves of sensitivity of the seismometer. Previous results of this simulation are shown in Figure 1. This figure shows three sensitivity curves for three masses, M = 0.5 kg, 0.8 kg and 1 kg. The magnetic field of the magnet is B = 1 T. From the curves we are interested in the flat region, and we see that for a mass of 1 kg the seismometer has a flat response from 50 Hz and in the case of the mass of 0.5 kg the flat region begins at 100 Hz. Therefore, this previous simulation shows us that as the optical seismometer is larger, that is, the mass is greater, the flat response of the seismometer is increasingly at lower frequencies. Acknowledgment to FAPESP (No Processo: 2015/22676-1) for the support and funding of this project.



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Quality control system in seismology

Emilia Brasilio*[1], Marcelo Bianchi[1], Jackson Calhau[1], Bruno Colaço[1], and Marcelo Assumpção[1]

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Abstract

USP Seismological Center developed a protocol for quality control (QC) of seismological data and stations operation status ensuring adequate performance of sensors and the best and most complete data archive. A set of variables acquired depending on the instruments used (Nanometrics, Guralp, Reftek on Knemetrics), are weekly monitored. Variables are chosen to guarantee the maximum uptime of stations, ensure the correct station configuration and optimization of onsite maintenance. Noise level is also monitored with the use of PQLX software (IRIS/PASSCAL), comparing changes to stations common probability density functions (PDF) over time. Collected information generate reports that are physically and digitally archived in a git repository and composes a rich set of information for field work planning. When any parameter change to a critical state, we open a git issue for a team member that will be responsible for verification and any needed correction. While the issue is open on the system, the QC operator accompanied it. On the data archive side, we compare the amount of stations link up-time with data completeness. Data collected during station maintenance builds up a duplicate archive that is usually most complete than real-time transmitted data. We also ensure that this archive is clean, with non redundant data. It is filled slowly with data from the real-time archive to form a final USP data archive. During the merge process, we label data extracted from the instrument using miniSeed flags that allows for later corrections that may be needed. Newly installed stations have its orientation verified using teleseismic data, and should not have an error greater than 5° concerning the North Geographic orientation. In the three years that the system is in operation more than 600 calls have been opened, being half for internal processing and the other half is divided into data transmission problems, power failure problems and problems with damaged or vandalized sensors.

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RSIS - REDE SISMOGRÁFICA DO SUL E SUDESTE DO BRASIL: Situação Atual e Projeções Futuras

Thiago Moeda[1], Ronaldo Carvalho[1], Giovanna Anacleto[1], Italo Mauricio[1], Sergio L. Fontes[1], and Fabio Dias*[1]

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Abstract

O Brasil implementou sua rede sismológica (RSBR) e este trabalho apresenta a sub-rede RSIS, operada pelo Observatório Nacional (ON) no Rio de Janeiro (www.rsis.on.br). Composta atualmente por 18 estações sismológicas banda larga de alto desempenho e operação contínua, a rede RSIS cobre a maior parte da costa sudeste do Brasil, sendo duas destas estações localizadas nas ilhas de Trindade e Abrolhos. As estação do RSIS possuwm sismógrafo STS 2 ou 2.5 e sistemas de aquisição Q330 Quanterra, operando com painéis solares. A maior parte das estações da rede RSIS transmitem seus dados em tempo real usando de links 3G ou satélite. Neste ano, ampliaremos a rede RSIS com mais 3 estações na Bahia e em Santa Catarina.

Uma nova parceria entre o ON, a Universidade Federal de Santa Catarina (UFSC) e a Petrobrás, será iniciado neste ano de 2019 o monitoramento SISMO-OCEANOGRÁFICO, integrando a sismologia e levantamentos sísmicos rasos à oceanografia , através da obtenção de sismógrafos de fundo oceânico (Ocean Bottom Seismometers-OBS), levantamentos geofísicos rasos e uma linha de fundeio oceanográfico, a serem instalados na Margem Sudeste do Brasil, Bacia de Campos.

O ON também é responsável por manter o Portal Web RSBR, onde todos os dados armazenados são disponibilizados. São fornecidas informações sobre cada estação, incluindo fotos da localidade, arquivos de metadados, completude, espectros de ruído e notícias sobre eventos sísmicos no Brasil. Todos os dados são mantidos em um servidor de banco de dados seguro e estão disponíveis para download. A rede RSBR foi implementada com recursos da Petrobras. Sua manutenção está garantida para este ano por meio de financiamento do Serviço Geológico do Brasil - CPRM.

*Presenting Author.

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Why should the community move towards digital sensors?

Stuart Allardice*[1] and Phil Hill[1]

[1] *Güralp Systems Ltd*

Abstract

Traditional seismic station setups include an analogue seismometer or accelerometer, digitizer and datalogger. Over time digitizers and dataloggers were incorporated into a single package, with the next step of instrument evolution being the seismometer and data acquisition function in one package. This has been an offering within the community for over 10 years now but, in both systems, sensor components and digitizer are still quite separate elements albeit housed in the one casing. Güralp's latest design in digital seismometers takes the digital instrument to the next level. By bringing digital functions into the feedback mechanism we have created a sensor component that can operate at any angle making deployments, quick, easy and efficient. With this next step at the digital forefront, the packages can host an abundance of ancillary sensors including temperature, humidity, magnetometer, MEMS accelerometer, pressure and many more state of health parameters. With the data from these ancillary sensors being so readily available to the user, further research can be done into aspects out-with the seismic realm. This creates an intelligent system dynamics which Güralp aims to base further developments on.

*Presenting Author.

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Lightning Presentations

Nova Estação Sismográfica SBB no Brasil

Luis Galhardo*[1], Marcelo S. Assumpção[1], Marcelo B. de Bianchi[1], and Jackson Calhau[1]

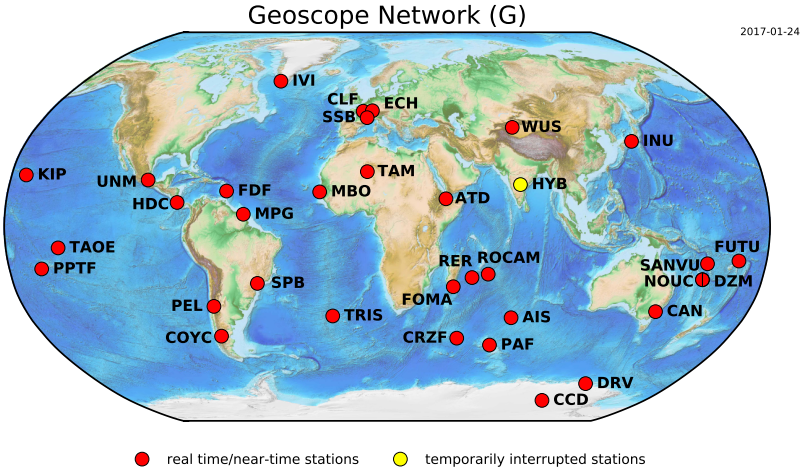
[1] *Universidade de São Paulo (USP)*

Abstract

Em junho de 1996 foi instalada a estação SPB, a primeira Estação Sismográfica da rede Global Francesa (RESIF) no Brasil, na cidade de Votorantim subdistrito da Cidade de Sorocaba-SP. O Local escolhido foi um túnel de acesso da mineração de calcário dentro da fabrica de cimento Votorantim. Instalada a 700m de distância da entrada do túnel e à 400m de profundidade dentro mina. Foi firmado o convenio entre o Observatório GEOSCOPE e o IAG-USP, para doação dos equipamentos e a cooperação de trabalhar nas instalações, realizar manutenções periódicas, operação da Estação e compartilhamento dos dados. Isto permitiu ao Brasil possuir a única estação com características de sensibilidade e largura de Super Banda Larga (SBB).

Hoje a rede RESIF tem 34 estações em 18 países, com seu data center dentro do IPGP, em Paris. No ano passado, durante a visita técnica de manutenção pelo grupo técnico do GEOSCOPE, fez-se a proposta para instalação de uma segunda Estação da rede, com as mesmas características, também dentro do Brasil.

Uma busca inicial de regiões apropriadas esta sendo realizada, inicialmente através de estudos teóricos considerando a distribuição atual da rede e visando melhorar a cobertura mundial implementada pelo GEOSCOPE. Dentro deste estudo buscamos o local mais indicado para as instalações que provavelmente se dará na região entre o norte do estado de Mato Grosso e a divisa com o estado do Amazonas.



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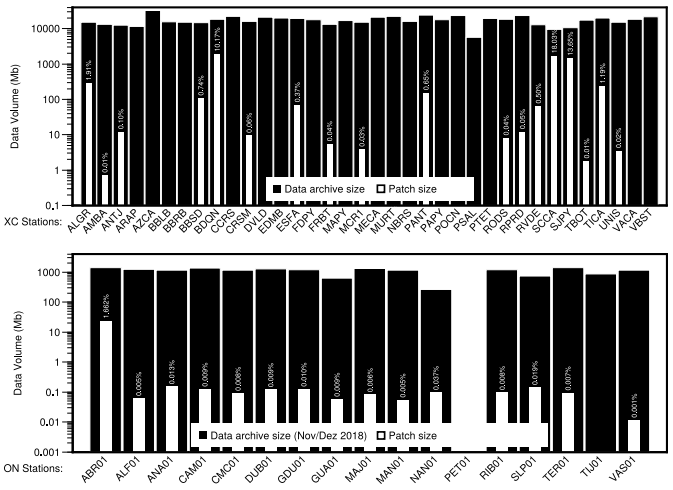
Pursuing data completeness in RSBR data archives

Marcelo Bianchi*[1], Fabio Dias[2], Thiago Moeda[2], and Giovanna Anacleto[2]

[1] *Universidade de São Paulo (USP)*
[2] *Observatório Nacional (ON)*

Abstract

Brazilian seismographic network (RSBR) is a well established distributed seismic network with one central archive (National Observatory/ON) and satellites archives in each node. Each node has its own procedure to acquire data that results in different data archives for the same data span and station. Real-time data is sometimes lost on the original node and can be found on a satellite node, the other way around is also true. This could indicate that SeedLink along with its archive tool is not guaranteeing data integrity. Using IRIS miniseed inspector (msi) we detected different issues that we do not understand the reason, but we could treat the symptom. A tool was implemented using PyRocko Python package and msi that can create a miniseed patch file from one archive to another. The patch is a file with data available from one archive that is not on the other. When ON and University of São Paulo (USP) archives were considered for data being acquired in the period of Nov-Dez/2018 some missing records could be observed. USP archive could contribute to a 24.7 Mb patch file to all 17 ON stations. It is worth mention that ABR01 station, which has shown the largest difference is acquired by USP. This value corresponds to a 0.148% of the total data volume (16.698 Mb) archived at the ON node for the ON stations in this period. When data recovered from instruments are considered a higher entropy is found, specially Nanometrics instruments have software issues that cannot recover all data stored in persistent storage. Again, the tool was tested with the XC temporary experiment operated by USP considering the transmitted and flash-disks-extracted data. A patch with 6.025 Mb was generated for 31 stations that had online transmission in the last 3 years. Again, the patch volume is small (∼1.7%) when compared to the total volume of 361.811 Mb of archived data for those stations, but we were able to fill gaps in the archive extracted from the instruments using transmitted data.



*Presenting Author.

Abstract ID: ecbeab, *Contribution type:* Lightining Presentation, *Session:* Field Advances, Network Operation and Technological Developments, *Submitted by:* Marcelo Bianchi (m.bianchi@iag.usp.br).

Rede Sismográfica de Carajás - PA (RSCK)

Bruno Collaço*[1], Marlon Pirchiner[1], Julia Prado[1], Camille Aguiar[1], Marcelo Assumpção[1], Dionísio Uendro[2], and Wanderson Pereira[2]

[1] *Centro de Sismologia da USP*
[2] *Vale SA (CTF, Nova Lima)*

Abstract

Uma rede de cinco estações de banda larga está sendo instalada na Floresta Nacional de Carajás - PA pela VALE SA, em um trabalho conjunto com o Centro de Sismologia da USP. O principal objetivo da implantação da rede é o monitoramento da sismicidade local e regional, sendo que os epicentros localizados pela RSCK poderão ser integrados ao banco de dados da Rede Sismográfica Brasileira (RSBR) mediante autorização prévia da mineradora.

Os sismômetros utilizados e o estilo de construção das estações serão semelhantes aos implementados pela Rede Sismográfica do Quadrilátero Ferrífero (RSQF) (Collaço et al. 2017). Serão utilizados sensores posthole instalados em poços tubulares de aço galvanizado com 6m de profundidade, cimentados à rocha.

Em uma etapa que precedeu a instalação da rede, foram realizados testes de ruído (utilizando-se um sensor de superfície), a fim de encontrar locais que minimizassem a interferência da atividade de mineração, pois não há a possibilidade da instalação das estações fora da área das minas da VALE SA — condição passada pela administração da própria mineradora.

As estações vão transmitir dados em tempo real a um sistema de aquisição mantido pela VALE SA e operado pelo Centro de Sismologia da USP, contribuindo com tempos de chegada (picks) para localização de tremores regionais também fora da área de Carajás. Além do monitoramento da sismicidade, a implantação da RCKS permitirá estudos da crosta e manto terrestre, ANT, e desenvolvimento de algoritmos de classificação de eventos sísmicos.

*Presenting Author.

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Using APA style:

Bianchi, M., Koch, C., Assumpção, M., & Beck, S. (2019); Transition Zone Thickness And Its Correlation To The Nazca Slab Position In South America. In: M. B. Bianchi, M. S. Assumpção & C. A. M. Chaves (Orgs.), Reports from the 3rd Brazilian Seismology Symposium (pp. 84), Vinhedo, SP: IAG-USP. ISBN: 978-85-85047-21-4. doi: 10.5281/zenodo.2656790.

Using ABNT style:

BIANCHI, M.; KOCH, C.; ASSUMPÇÃO, M., & BECK, S. Transition Zone Thickness And Its Correlation To The Nazca Slab Position In South America. In: BIANCHI, M. B.; ASSUMPÇÃO, M. S.;CHAVES, C. A. M. Chaves (Org.), Reports from the 3rd Brazilian Seismology Symposium. Vinhedo, SP: IAG-USP, 2019. p. 84. ISBN: 978-85-85047-21-4. doi: 10.5281/zenodo.2656790.

[1] Zenodo project is available at http://www.zenodo.org/

[2] Please note that some adjustments of format my be needed depending on the requested citation style of your work. Those are just examples of standard, well defined citation formats.

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