DEPTH AND FOCAL MECHANIMS OF RECENT EARTHQUAKES IN BRAZIL USING TELESEISMIC P-WAVE MODELING AND STRESS FIELD IMPLICATIONS

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ABSTRACT

We determine the focal mechanism (FM) and depth of three moderate, shallow depth events (magnitudes between 4.8 and 5.0 m_b) occurred in Brazil with teleseismic P-wave modeling. Two of these events are located in the interior of Brazil and one in the Amazonic river fan. The modeling was made using seismogram stacks of several teleseismic stations ($\Delta > 30°$) grouped according to distance and azimuth. For Brazil interior events, we find a good agreement between our FM results and local/regional network station first-motion FM. We also noted that good azimuth coverage was necessary to constrain the focal depth. FMs found for Brazil interior indicate a compressive stress regime in agreement with regional theoretical models (Richardson & Coblentz, 1996). The Amazonic Fan event shows a strike-slip mechanism which agrees with flexural stress model due to sedimentary load in the fan (Watts et al., 2009).

INTRODUCTION

In June 15th, 2009, a 4.8 m_b earthquake occurred in Pantanal Basin, 50 km west of Coxim. This event had an MMI VI intensity and damaged a few local houses. At least two aftershocks were felt in the epicentral area. Studies using P-wave first motions (Facincani et al., 2011) indicate that the event has a reverse mechanism with NE-SW P axis. However the focal depth is not very well determined.

Mara Rosa event occurred in October 8th, 2010 in north of Goiás State. With magnitude 5.0 m_b (MMI VI) this event is the biggest recorded in the region and caused the evacuation of some buildings. According to Barros et al. (2011), 8 minutes later, another 4.2 m_b earthquake occurred. Between 19/10/2010 and 09/01/2011 local stations detected up to 300 events. The event also shows a reverse mechanism with NW-SE compression.

A 4.8 m_b earthquake occurred in the Amazon Fan in 2006. The initial focal mechanism (Harvard CMT) shows a strike-slip movement and a focal depth of 0.

In all cases, it was not possible to clearly identify the pP and sP phases indicating that all these events are shallow. The earthquake epicenters are shown in Figure 1.

METHODOLOGY

In all cases, we used the SOD (Owens et al., 2004) program to get teleseismic stations seismograms from the IRIS database. Every single record was visually inspected and those with a good signal/noise ratio (SNR) were grouped in latitude-longitude windows of ten degrees and stacked. We usually consider groups with at least two stations, but, in some cases a good record of single station with different azimuth was also used to constrain the focal depth.

The P, pP, sP wavetrains of the stacked signals were modelled using the *hudson96* program of Herrman seismology package (Herrman, 2002), based on Hudson (1969). This program allows different models for the station, path and receiver. We use local models for each event and the *ak135* model for the path and receiver.

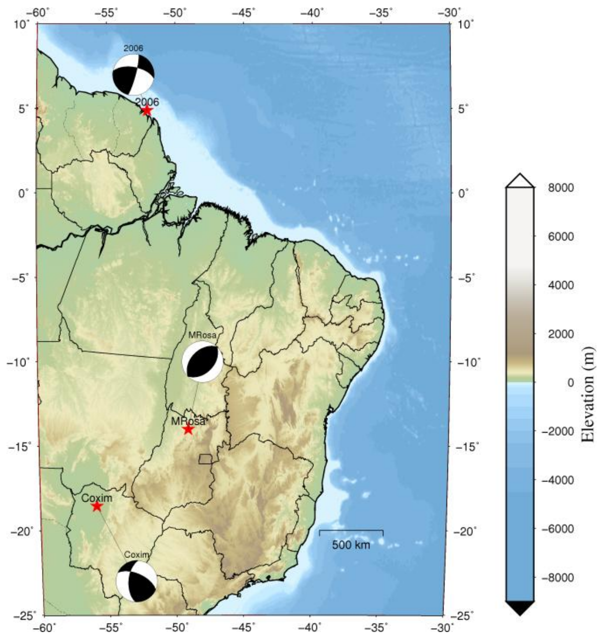

Figure 1: Events used in this study and initial focal mechanism from first P-wave motions

RESULTS

2009 – COXIM 4.8 m_b EVENT

An interesting example of how a good azimuthal coverage is needed to constrain the focal depth is shown by the Coxim event. Initially, only groups located in the US had more than one station and good SNR and with only these groups were not able to obtain the focal depth accurately. So, we include TAM station in Africa and the earthquake focal depth was confirmed at 6 km. The FM agrees with the results of Facincani et al. (2011): a reverse mechanism with a strike-slip component (strike=300, dip=55, rake=45) and NE-SW compression. The figures below illustrate the process.

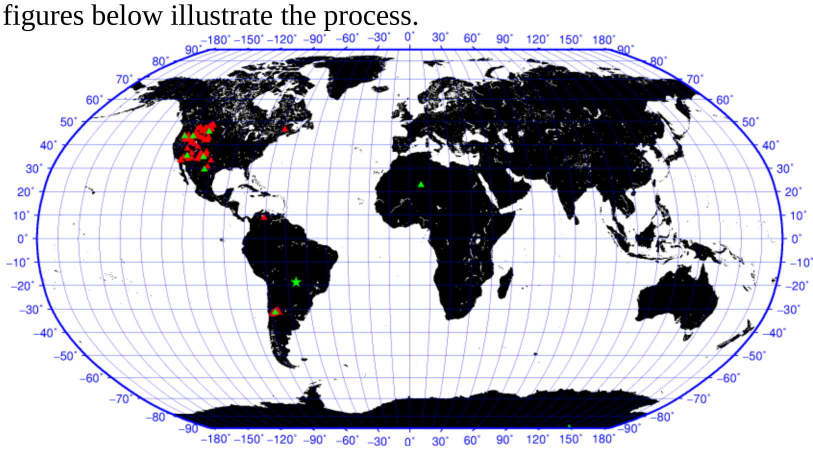

Figure 2a: Groups for Coxim event (star). Red triangles are the stations and green are the “mean” station.

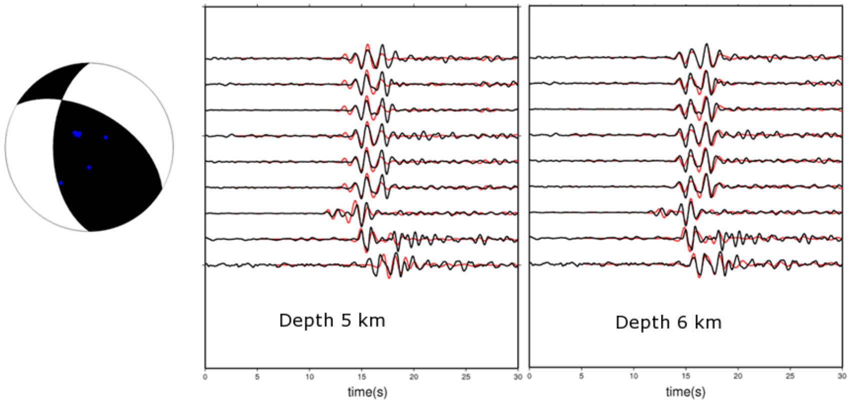

Figure 2b: Coxim modeling. Focal mechanism fixed form Facincani et al.(2011), reverse fault with strike-slip component. Black traces are recorded seismogram and red are the synthetic. Note that with 5 km depth the TAM station in Africa (last trace) is not fit very well; with 6 km depth we have good agreement for all stations.

2010 – MARA ROSA 5.0 mb EVENT

Mara Rosa event was modeled with 14 groups (Figure 3). We constrain the FM obtained by Barros (2012, personal communication), strike=220, dip=50, rake=70, and NW-SE P axis. The focal depth was modeled at 0.9 km.

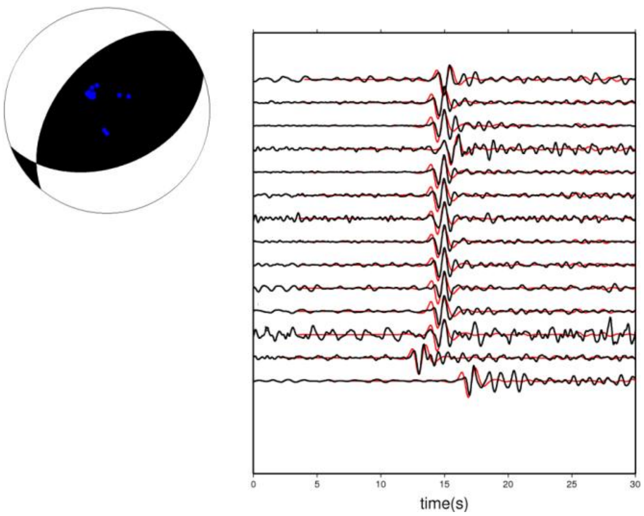

Figure 3: Mara Rosa modeling. The legend is same of 2b figure.

2006 – FAN AMAZON 4.8 m_b EVENT

We compared the Harvard CMT result (strike=273, dip=72, rake=-102) with the station first-motion polarities. Several polarities are close to the nodal planes and cannot be used to improve the FM. We use 16 groups in the modelling and we obtained a strike-slip mechanism with a small reverse motion component (strike=280, dip=60, rake=170) with a focal depth of 2 km.

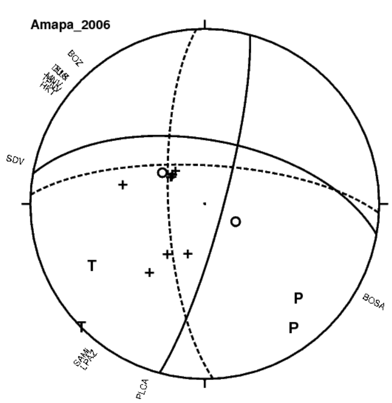

Figure 4a: Initial mechanism (HRVD, dashed line) and final result (modeled, solid line). The focal depth was improved from 0 km (IDC) to 2 km (this work).

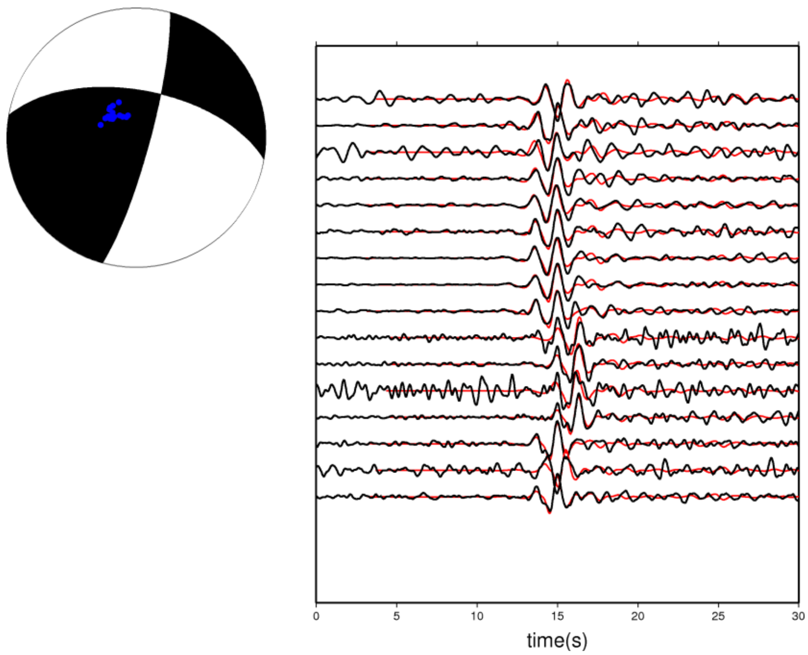

Figure 4b: Amapá modeling. The legend is the same of 2b figure.

DISCUSSION AND CONCLUSIONS

We now compare the FM results with the stress field in South America. For Coxim and Mara Rosa events, the reverse fault indicates that the region is under ~E-W compression. This result is in agreement with Coblentz & Richardson (1996) numerical model which predicts compression in the interior of South America. The Amazon Fan event has a T axis oriented NE-SW which agrees with flexural stress regime due local sediment load (Watts et al., 2009).

Modeling P-teleseismic waves we determined focal depths, showing that this technique is capable to recover focal depth from shallow events when P, pP, sP are difficult to identify. The FM constrain is also a good point of this technique. We are able to confirm the FM from local/regional first-motion P-wave and, in the Amazon Fan case, we are able to improve previously published FM.

REFERENCES

Coblentz, D.D. and Richardson, R.M. 1996. Analysis of the South America intraplate stress field. Journal of Geophysical Research 101: 8,643-8,657.

Barros, L. V., Chimpliganond, Cristiano N., Von Huelsen, M. G., Franca, G. S. L. A., Caixeta, Daniel F., Albuquerque, D. F. The Mara Rosa 5.0 mb Earthquake and Aftershock Activity In: XII International Congress of the Brazilian Geophysical Society, 2011, Rio de Janeiro.

Facincani, E. M, Assumpção M.S, Assine M.L & França, G.L. 2011. Sismicidade da Bacia do Pantanal Mato-Grossense. XIII Simpósio Nacional de Estudos Tectônicos (XIII SNET). Campinas-SP.

Herrmann, R. B. (2002). Computer programs in seismology, St. Louis University Earthquake Center, St. Louis, Missouri, www.eas.slu .edu/eqc/eqccps.html.

Hudson, J. A. (1969). A quantitative evaluation of seismic signals at teleseismic distances-II: Body waves and surface waves from an extended source, Geophys. J. Roy. Astr Soc. 18, 353–370, doi 10.1111/j.1365-246X.1969.tb03574.x

Owens, T. J., H. P. Crotwell, C. Groves, and P. Oliver-Paul (2004), SOD:Standing Order for Data, Seismol. Res. Lett., 75, 515–520, doi:10.1785/gssrl.75.4.515-a.

Watts, A. B., M. Rodger, C. Peirce, C. J. Greenroyd, and R. W. Hobbs (2009), Seismic structure, gravity anomalies, and flexure of the Amazon continental margin, NE Brazil, J. Geophys. Res., 114, B07103, doi:10.1029/2008JB006259.