

Towards Focal Mechanisms in Poorly Known Velocity Models: Inverting Waveform Envelopes

Vargem Grande event example ($M \sim 4$)

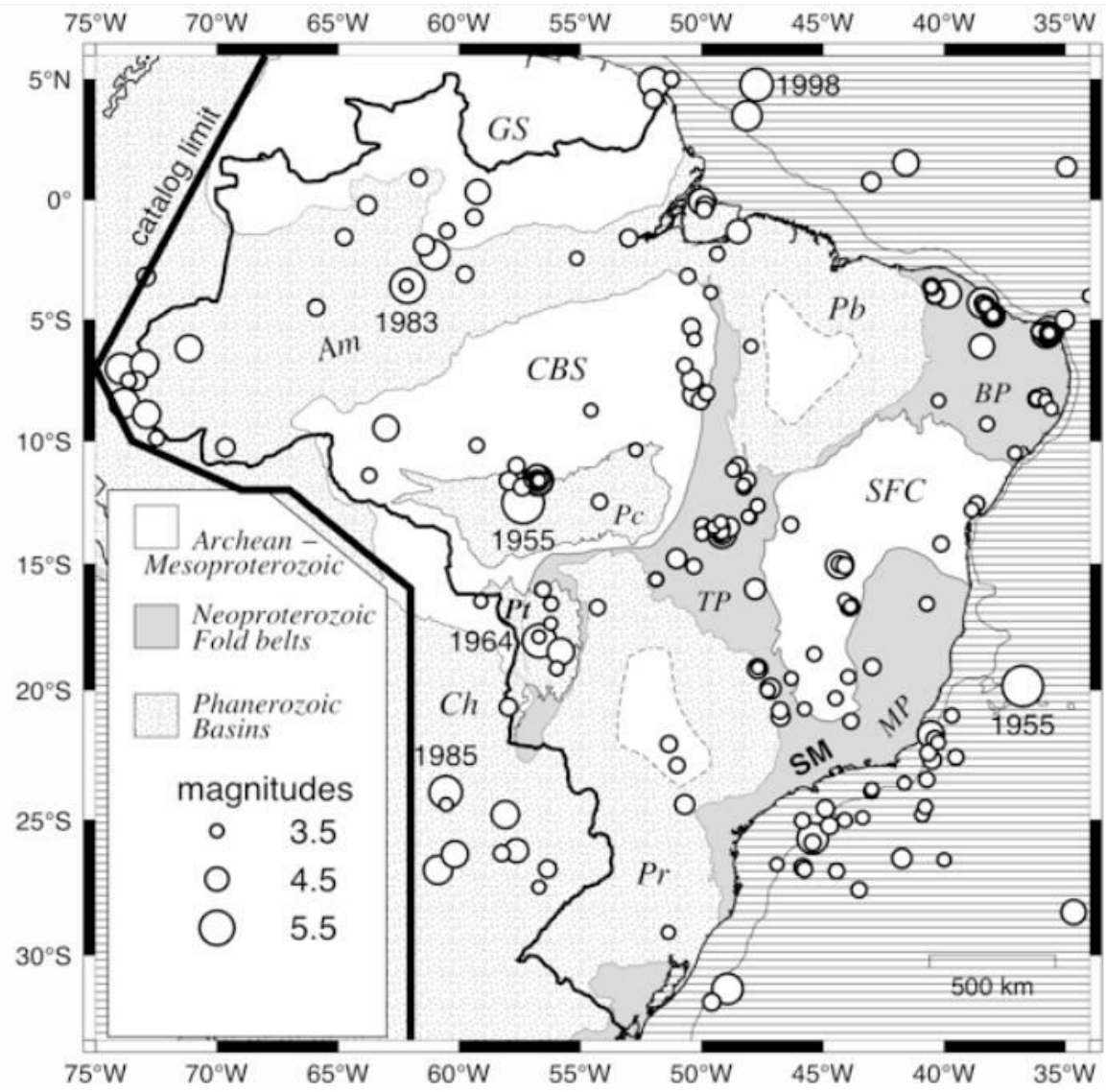
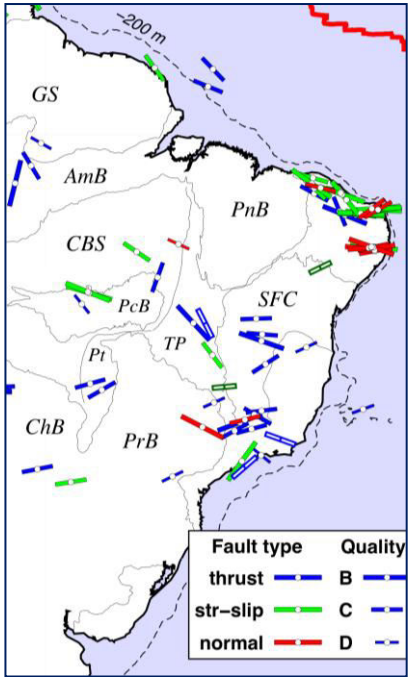
Juraci Carvalho¹, Lucas Vieira Barros¹, Jiří Zahradník²

1 - Observatório Sismológico – UnB, Brasília – DF, Brasil

2 - Faculty of Math and Physics – Charles University Prague, Czech Republic

Brazilian Seismicity (BSB Catalog)

- Historical data from 1764
- Instrumental data 1960
- Shallow events
- Mag. > 3.5
- 2 M>6; 22 M>5

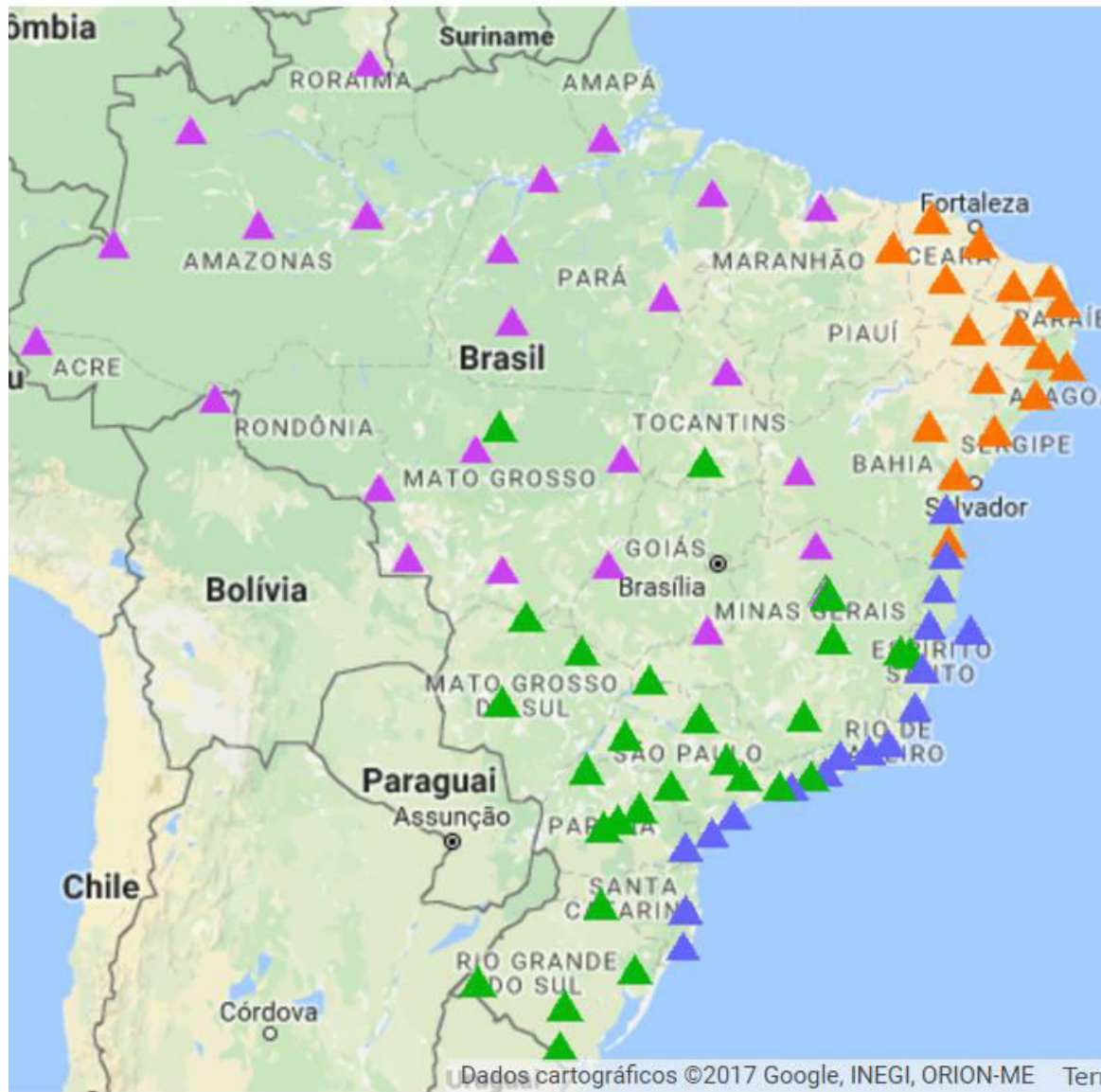


Focal mechanism data base (~100)

Brazilian Seismograph Network (RSBR),

Details about the BSN.....

- 4 Networks
 - ON (18) → ON
 - USP (26) → BL
 - UnB (24) → BR
 - UFRN (16) → NB
- RSBR
 - Total of **84** BB stations



▲ USP-BRASILIS
 ▲ UFRN-RSISNE
 ▲ UNB-RSCN

▲ ON-RSIS

<http://rsbr.gov.br/index.html>

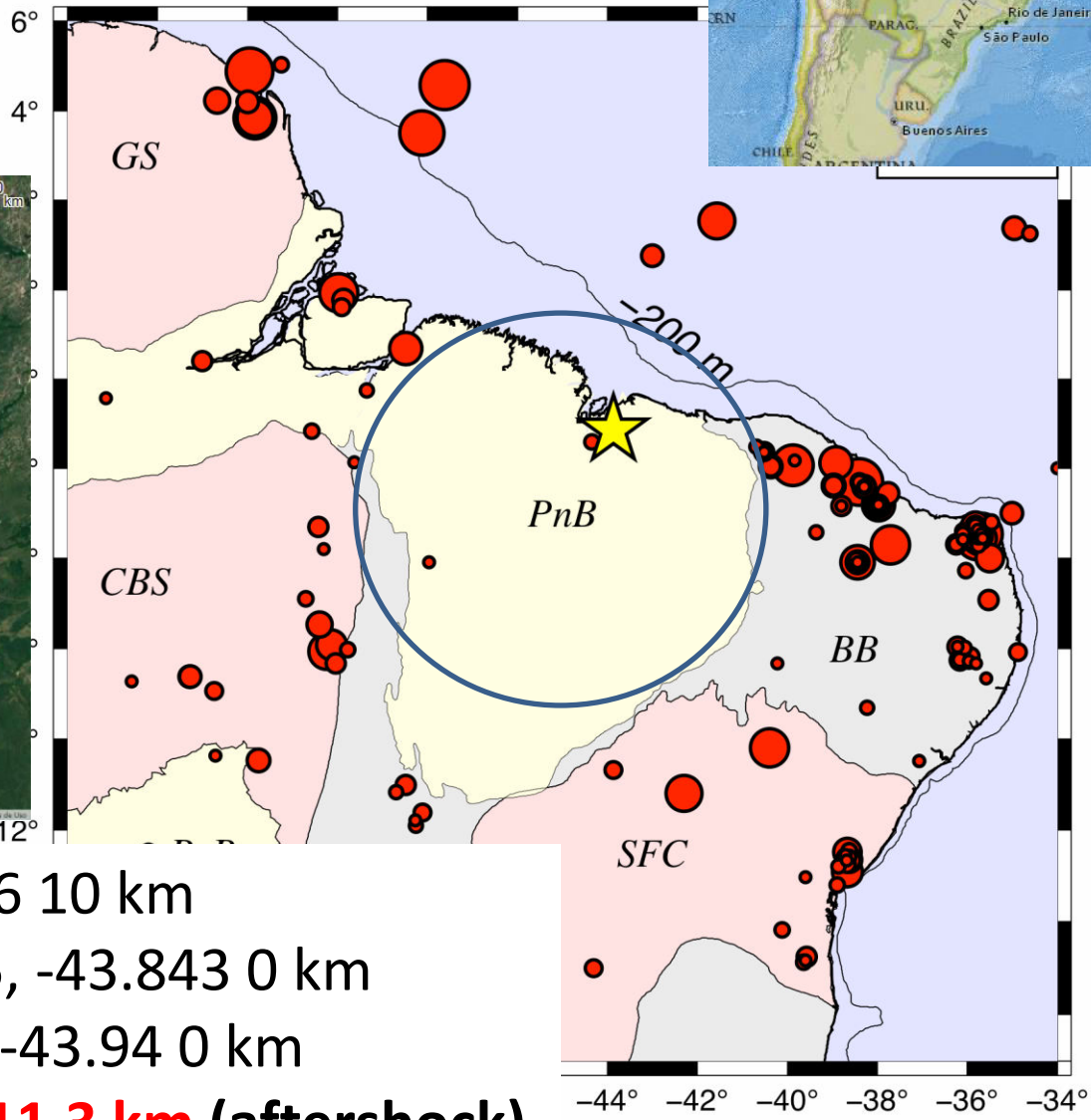
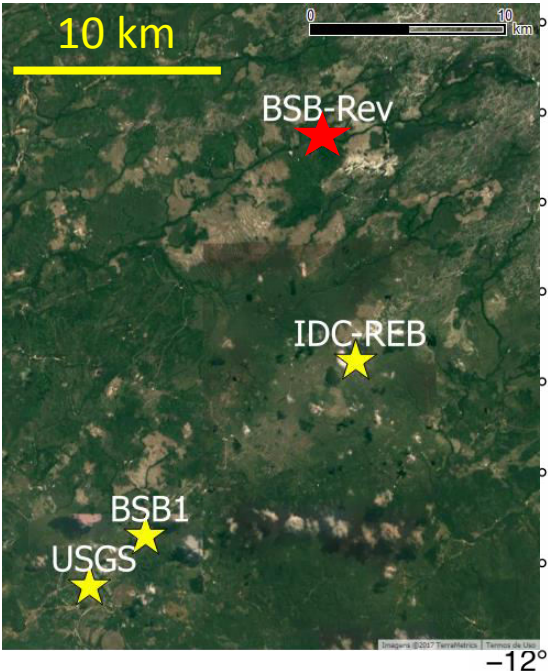
OPEN DATA

Motivation for a new methodology???

Vargem Grande Event 2017-01-03, 4.6 mb

IMS-Network (Dist)

- RCBR (8)
- MDP (12)
- BDFB (13)
- SIV (21)
- PCRV (24)



- USGS: M4.5 -3.353 -43.966 10 km
- IDC: (REB) mb 4.0 -3.2495, -43.843 0 km
- BSB1: mR (~mb) 4.6 -3.33 -43.94 0 km
- **BSB-Rev: -3.145 -43.086 11.3 km (aftershock)**

Waveform inversion (Vargem Grande)

Velocity model general for Brazil NewBR (Assumpção 2010)

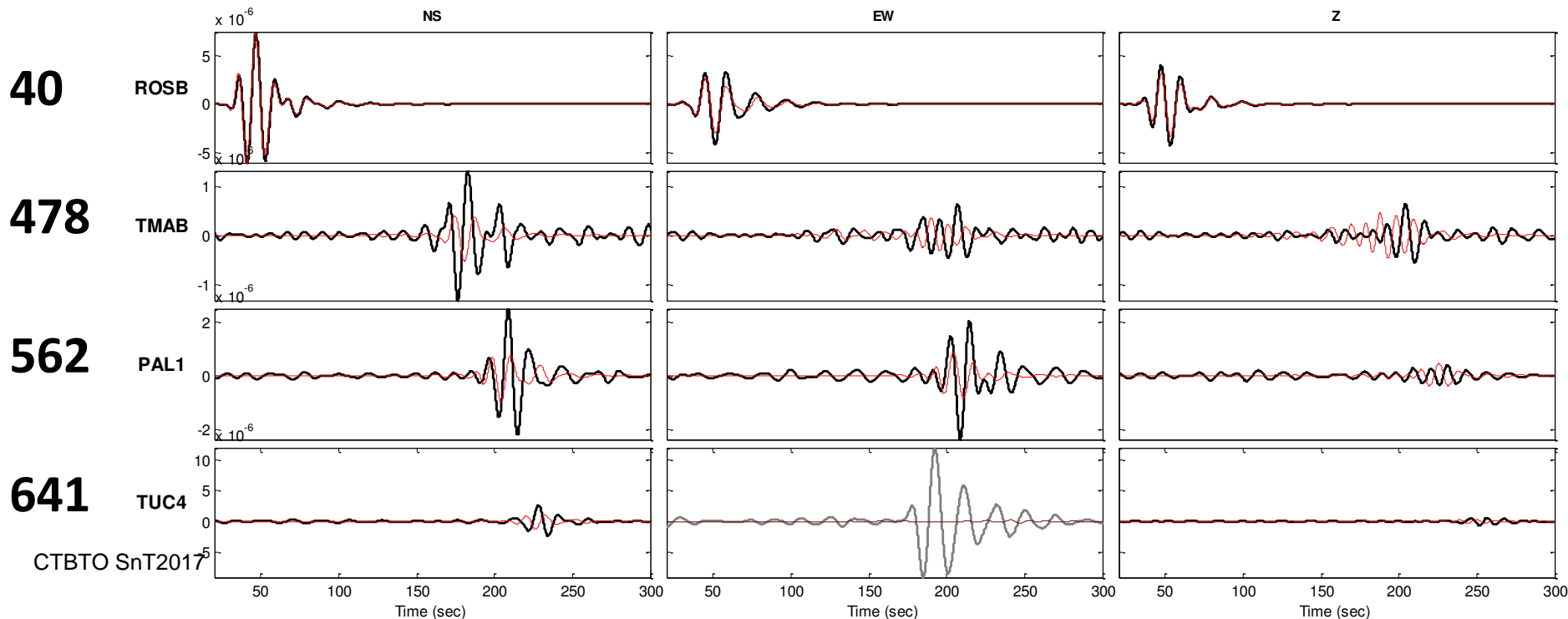
Frequency band 0.05-0.1 Hz

Fixed depth (7 km)

Waveform fit only at the nearest station

Failed

Dist. Km



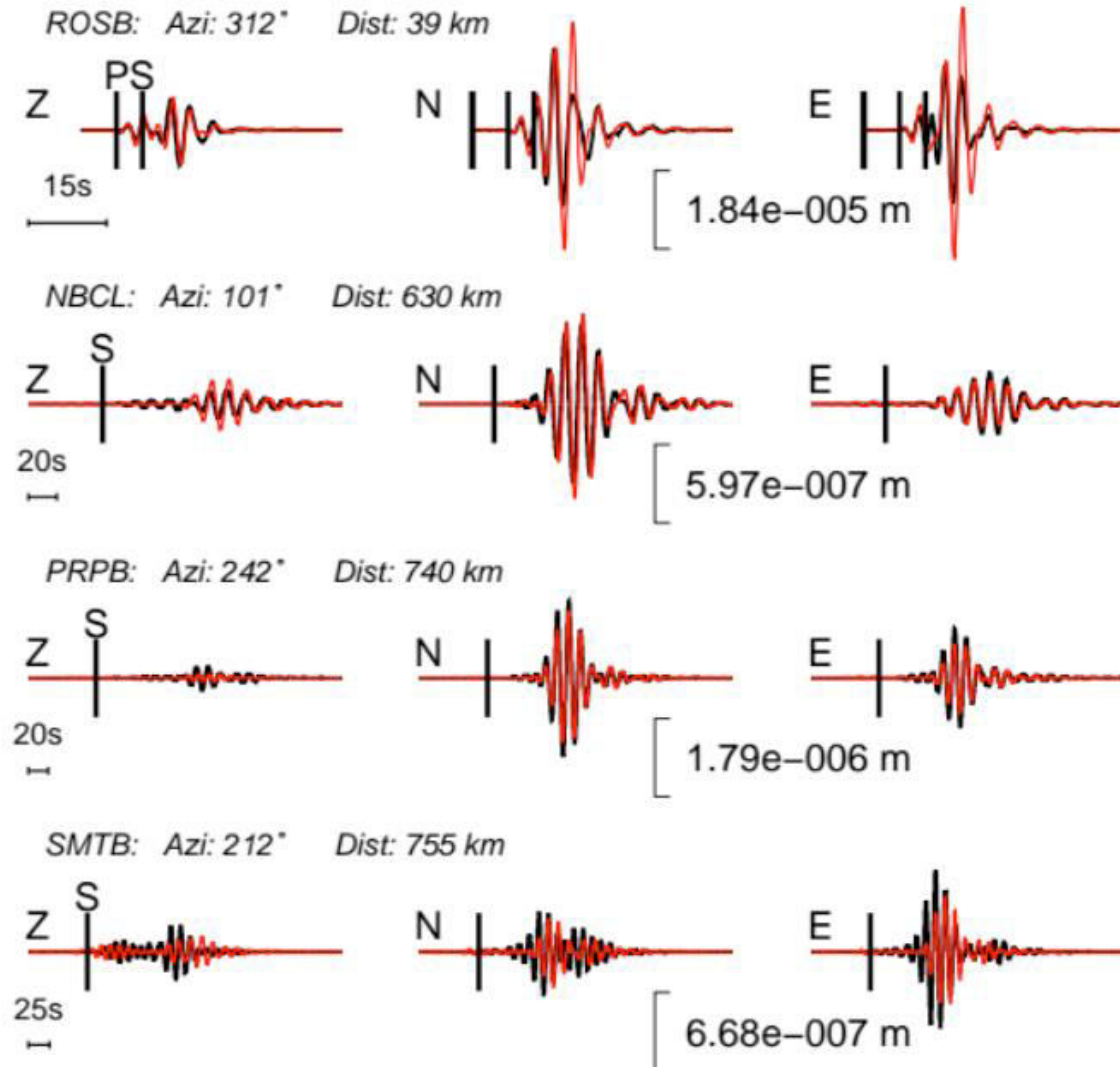
Waveform inversion specialized VM

Path specific velocity models derived from Love and Rayleigh wave group velocity dispersion (Dias et al. (2017))

ROSB=40 km
NBCL, PRPB and SMTB = 600-700
2.5 to 19.5 km time \pm 5 seconds



Mw: 4.32(4.29/4.32)
Depth: 7.0(5.5/12.0)km
MaxKagan: 11.41(3.61)*
VR: 0.76(0.69/0.76)
PF: 0.79(0.74/0.79)
NP1: 339/89/0
NP2: 249/89/179
FR: 0.200-0.400 Hz



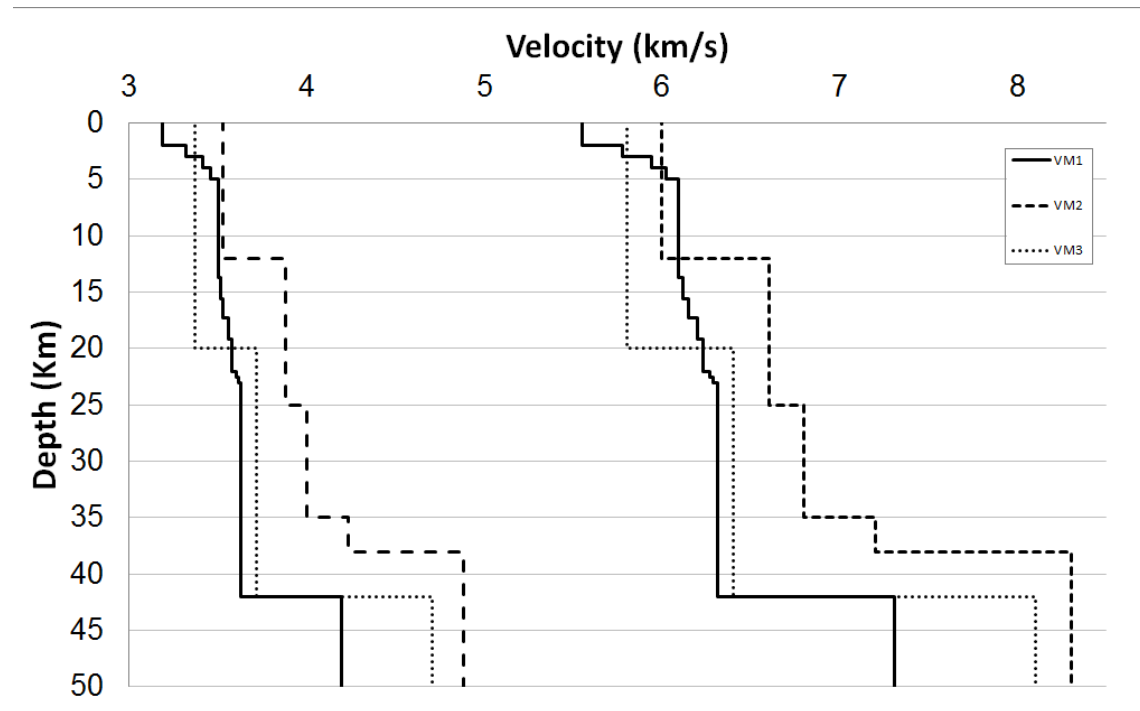
Waveform Envelope inversion method:

- Empirical method
- Time shifts allowed for better correlation (component)
- Amplitude normalization (station)
- DC fixed = 100%
- CT = not constrained (due to the option of free shifts)
- Used station components NEZ or RTZ
- Frequency band (tested): 0.05 to 0.1 Hz
- Green function calculated for fixed depth (Vargem event 7 km)
- Distances up to 650 km
- **Strike/dip/rake grid search + polarity check (P) (or constrain)**

Envelope inversion synthetic tests

Synthetic tests:

- Different VMs
 - VM1 ($V_p/V_s = 1.74$)
 - VM2 ($V_p/V_s = 1.70$)
 - VM3 ($V_p/V_s = 1.72$)
- 5 Elementary MTs
- Combination of 5 MTs



➤ Time shifts and

➤ Amplitude variation

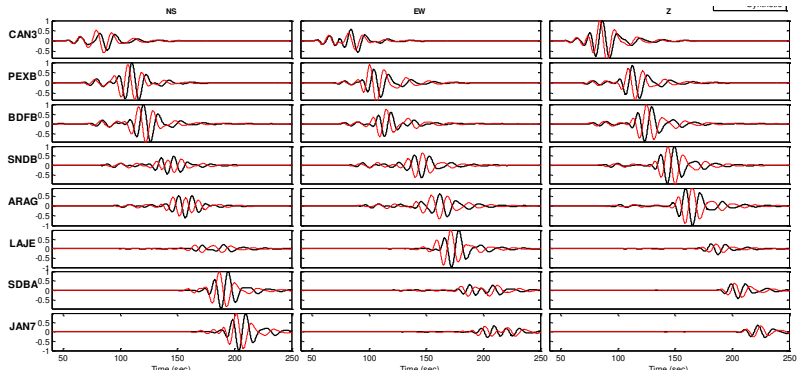
Solid lines VM1 surface waves dispersion (Dias 2016)

Dashed line (coarse), aftershocks study VM2 (Barros 2015)

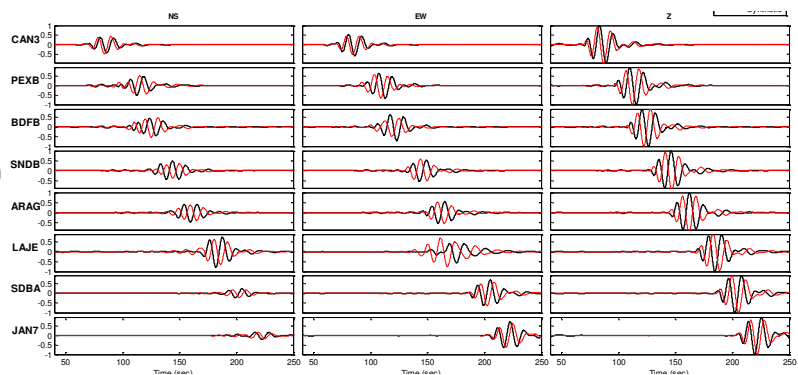
Dashed line VM3 (NewBR) Generic for Brazil (Assumpção 2010)

5 Elementary MTs Synthetic waveforms

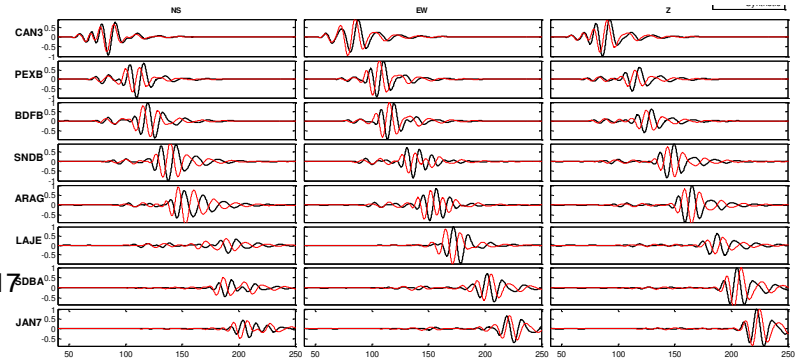
Black = VM1 and Red = VM2



00 90 00



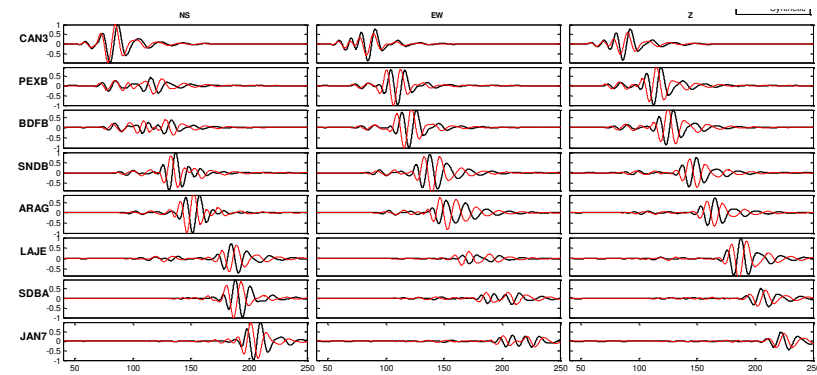
00 90 90



00 45 90



270 90 -90



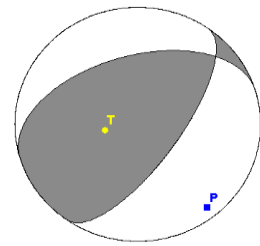
90 45 90



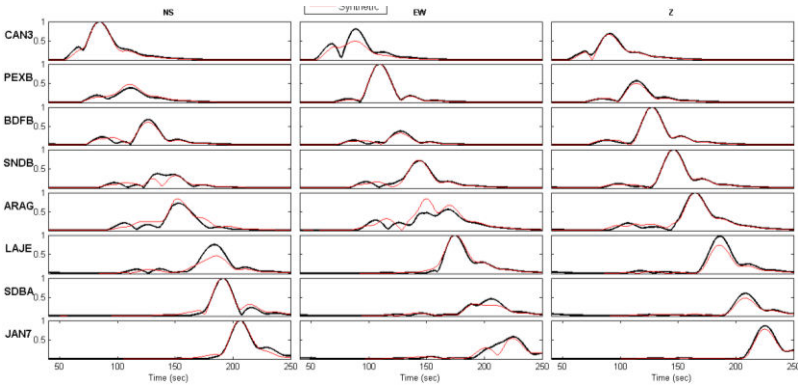
Envelope inversion of synthetic data

Synthetic data from VM1 (Ref.) inverted in:

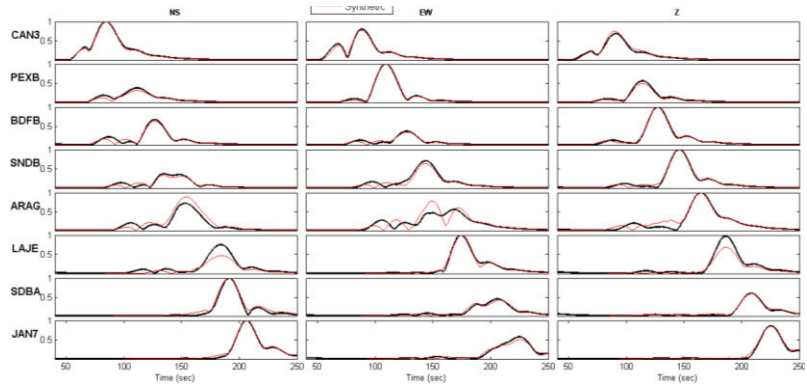
Reference:
 $S/D/R = 83/61/86$



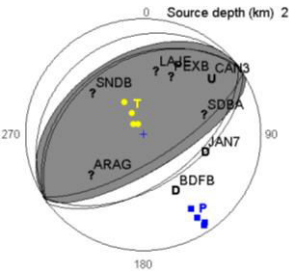
VM2 model



VM3 model

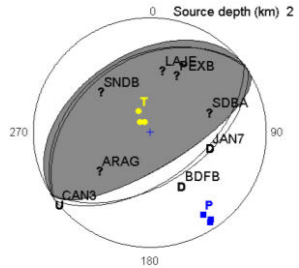


VM2



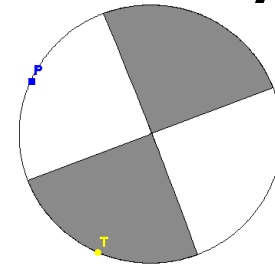
LF VM2	
Average	Optimum
7	5

VM3

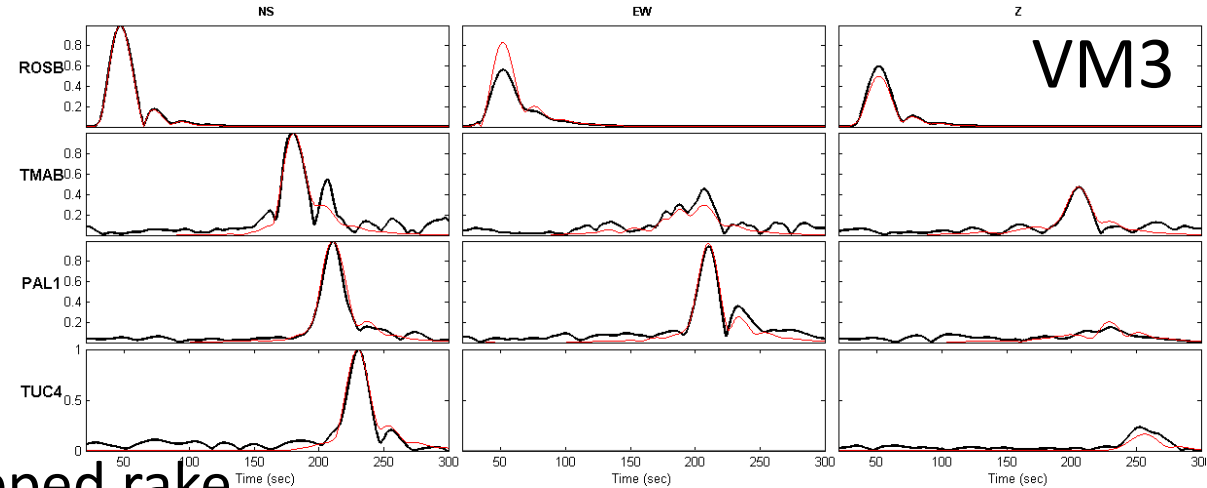
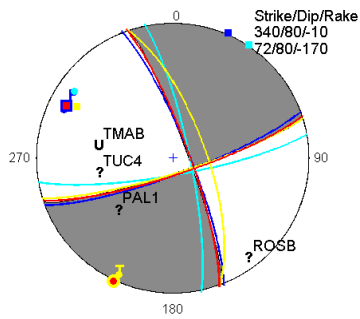
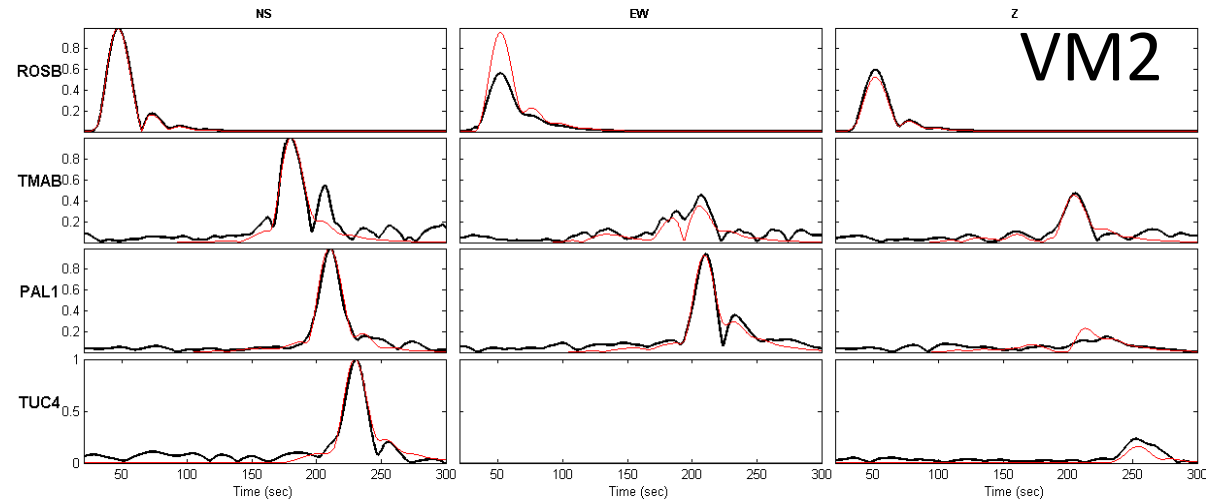
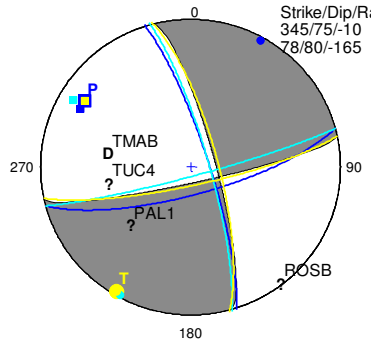


LF VM3	
Average	Optimum
6	5

Vargem Grande real data (envelope inversion)



Reference
(Dias et al. 2017)
 $S/D/R = 339/89/0$



- Goal is to work with low-magnitude events ($M \sim 4$)
- Using data from regional seismic stations (>300 km)
- Generic 1D velocity models
- **Test case:** Vargem event, Jan 2017, 4.6 mb
 - Waveform inversion 1D-VM failed to obtain the correct FM
 - Waveform inversion with specialized VM succeeded
- We learned that envelopes are less affected by poor VMs (1D)
 - DC fixed at 100% (grid search)
 - Centroid time not determined (shifts)
 - Fixed depth (no resolution using distant stations)
- Uncertainty is not well defined, but it is directly related to the set of data, station geometry, frequency band and VM
- **Envelope inversion in a generic 1D VM, pre-constrained 1 polarity, succeeded to retrieve the correct focal mechanism**

Thanks

