Online material for:

Residual analysis of large strong-motion flatfiles as a tool for detecting data error

and anomalies

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<u>AIM:</u> to propose a semi-automatic procedure for the consistency check of large strong-motion datasets, classifying the anomalies observed on the residuals analysis and identifying the possible causes.

TARGET: ITACA 3.1 Flatfile (D'Amico et al., 2020 - Italian Accelerometric Archive v3.1 - http://itaca.mi.ingv.it/ItacaNet_31/#/home)

METHOD:

(1) The proposed procedure is based on the **residual distributions** obtained **from ad-hoc ground motion models** for the ordinates of the 5% damped acceleration response spectra. The total residuals, computed as logarithm difference between observations and predictions, are decomposed in between-event, between-station and event-and-station corrected residuals by applying a mixed-effect regression (Bates et al., 2015). For the residual analysis of the **ITACA Flatfile**, since we focus on the active shallow crust events in Italy, we consider the ITA18 ground motion model (Lanzano et al., 2019) as reference.

(2) The residual components and their variabilities are analyzed to **raise a warning** in case **predicted values** significantly **deviate** from **observations**, due to metadata errors or peculiar behavior, worthy of further investigations.

(3) Based on the raised warnings, a classification is developed to identify the common anomaly sources. The procedure provides a **list of earthquakes**, **stations**, and **records** to be manually reviewed, indicating the incorrect metadata or peculiar features.

Terminology adopted for residual components and corresponding standard deviations

(modified after Al-Atik et al. 2010)

Definition	Residual component	Standard Deviation
Total	Res	σ
Between-event	δB _e	τ
Within-event	δW _{es}	φ
Site-to-site	δS2Ss	Фs2s
Event- and site- corrected	δWo,es	Φss
Event- and site- corrected at single-site	-	Φss,s

In the following we report some <u>ILLUSTRATIVE CASES</u> for the main causes of anomaly identified:

- **1. Event Cause** e.g., erroneous attribution of the tectonic regime, inaccurate or preliminary localization (events abroad, along the Italian border, along the coast, or offshore), inaccurate magnitude estimate, etc.
- **2.** *Site Cause e.g., erroneous site classification, peculiar site-effect not reproduced by the ground motion model, etc.*
- **3.** Acquisition Parameters e.g., erroneous acquisition parameters like amplitude gain
- **4. Anomalous Record** e.g., directivity, near-source effects, directional site amplification, etc.

EVENT CAUSE



ITACA DATABASE (http://itaca.mi.ingv.it/ItacaNet 31/#/home)

Event data

	Date	Latitude [°]	Longitude [°]	Depth [Km]	Reference	Location
*	2012-06-09 02:04:56	46.18030	12.48820	6.9	INGV-CNT Seismic Bulletin	Reviewed

Magnitude

	Value	Туре	Method	Reference
*	4.4	ML	unknown	INGV-CNT Seismic Bulletin
*	4	Mw	unknown	INGV-webservice









Event: EMSC-20120609_0000005 Ev. type: Active Shallow Crust M: 4.00; depth: 6.90 km; R: 178.03 km

Network: TV **Staz:** MIR08 **Vs₃₀:** 270 m/s Can be fixed adding more data!

<u>SITE CAUSE</u>

IT.BCN – Buccino (Italy)

- Measured $V_{S,30}$ NOT AVAILABLE
- $V_{S,30}$ is estimated from proxies (surface geology – map 1:100:000)

 \implies SOIL CLASS C

- No site-effects on $\delta S2S$ and HVSR curves
- Located at the border with a Limestone
 formation SOIL CLASS A



ITACA DATABASE (http://itaca.mi.ingv.it/ItacaNet 31/#/home)



Event: IT-2013-0093 Ev. type: Active Shallow Crust M: 3.30; depth: 13.30 km; R: 41.21 km

Network: IT Staz: BCN Vs₃₀: 270 m/s Can be fixed changing the soil category!



ITACA DATABASE (http://itaca.mi.ingv.it/ItacaNet 31/#/home)





Event: EMSC-20140912_0000057 Ev. type: Active Shallow Crust M: 3.40; depth: 16.39 km; R: 92.56 km

Network: FR Staz: ESCA Vs₃₀: 1000 m/s

To be discarded!

<u>ANOMALOUS</u> <u>RECORD</u>



• Fault rapture directivity

• Normal faulting



Focal mechanism







Physical

effect!

Event: EMSC-20161030_0000130 Ev. type: Active Shallow Crust M: 4.00; depth: 9.80 km; R: 30.42 km

Network: 3A Staz: MZ11 Vs₃₀: 1156 m/s



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