

Influence of Event Definition Criteria (EDC) on IDC SHI products and possible approaches to optimize it

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INTRODUCTION AND MAIN RESULTS

We present results of our study on replicating the EDC criteria and applying it to the Late Event Bulletin (LEB). Accuracy of replication is 99.99%, enabling systematic analysis of the weights of the LEB events below the EDC threshold. 26.5% ($\pm 1\%$) of LEB events failed to meet EDC in the last 5 years. We propose an optimized EDC to include events fulfilling core requirements of IDC products – to include primary stations (at least 2 stations) and to account for quality of location.



Introduction

Event definition Criteria (EDC) control which events from the Late Event Bulletin (LEB) will become an event in the Reviewed Event Bulletin (REB) - the official SHI product of IDC. Developed in late 1990s, this criteria attempts to ‘... control the balance between the detection threshold and the quality and reliability of the event list or bulletin.’ as specified in the IDC operational manual. Current EDC criteria are :

- event to be located with at least 3 primary stations;
- Weight of the event should be >4.5, the weight of each phase is listed in the table below;
- Additional rules related to making specific phase time, azimuth or slowness defining are listed in IDC/OPS/SOP/301/Rev.1.

Increased number of SHI stations and development in SHI processing require a review of EDC parameters and adapting them to current conditions.

REB Event Definition Criteria					
Station Type		Phase Type	Phase Attribute		
			Time	Azimuth	Slowness
Seismic	Arrays	P type primary	1.0	0.4	0.4
		P type secondary	0.4	0	0
		S type regional	0.7	0.4	0.4
		S type teleseismic	0.7	0	0
	3C Station	P type primary	1.0	0.2	0.2
		P type secondary	0.4	0	0
		S type regional	0.7	0	0
		S type teleseismic	0.7	0	0
Hydroacoustic		Hydroacoustic H	1.54	0	0
Infrasound		Infrasound I	0.8	1.0	0

Table 1.

Current status

The IMS network has grown over time and reached 92% of SHI IMS network. Automatic infrasound processing has been in operations since 2010-2011, Global Association (GA) and NET-VISA (Network Processing Vertically Integrated Seismic Analysis) packages are currently in use at the CTBTO to build the automatic bulletins of Seismo-Acoustic (SHI) events. Plans are to promote NET-VISA as primary associator soon.

These changes have impacted the number of located events which grew from 24114(LEB) 23082(REB) in 2002 to 47553(LEB) 34849(REB) in 2024. The portion of LEB events not meeting EDC grew from 4.5% to ~26.5+/-1% for last 5 years. Figure 1 presents this tendency with the increase of the SHI stations by technology and type of technology/network.

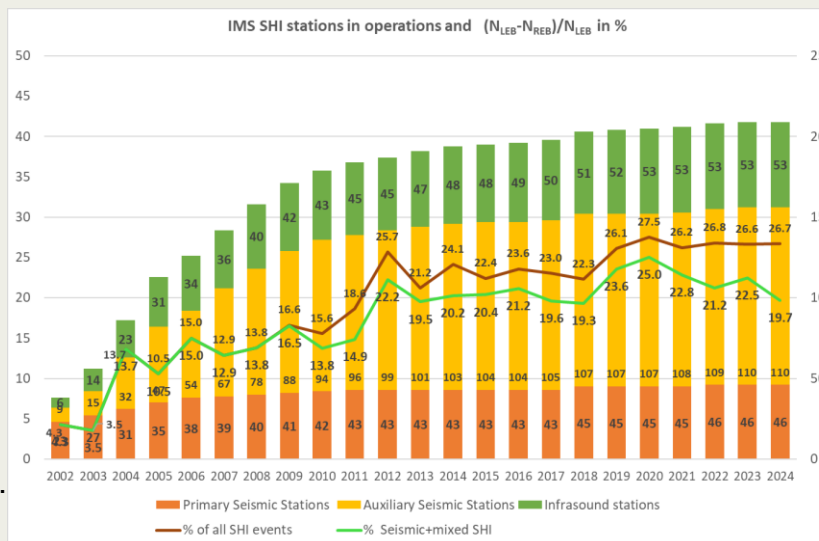


Figure 1.

Technology impact

Figure 2 shows total LEB events by technology and percentage not meeting EDC. We present also separately SHI mixed events showing the best performance from all (seismic, infrasound, hydro) indicating the importance of integrated approach in processing and analyses. The 3 primary stations requirement is difficult to meet for purely infrasound often and hydroacoustic events as the propagation of signal may depend on various external conditions.

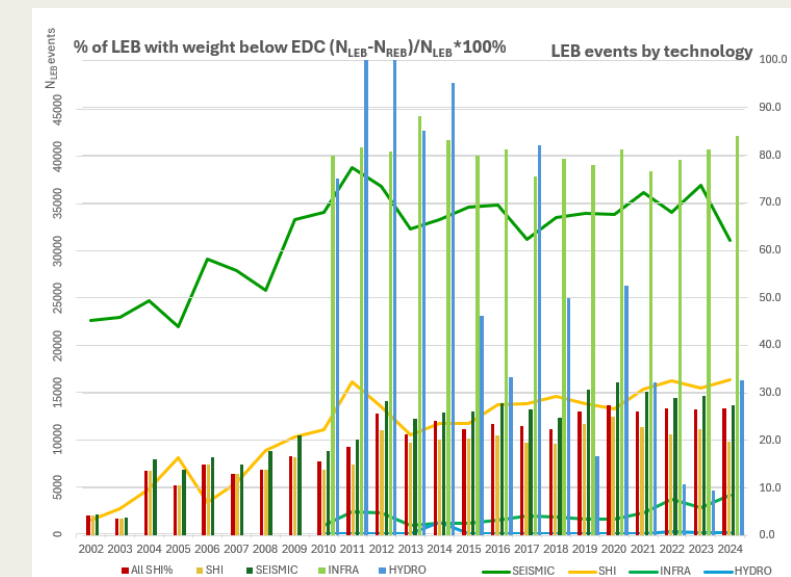


Figure.2





Approach to EDC replication and results

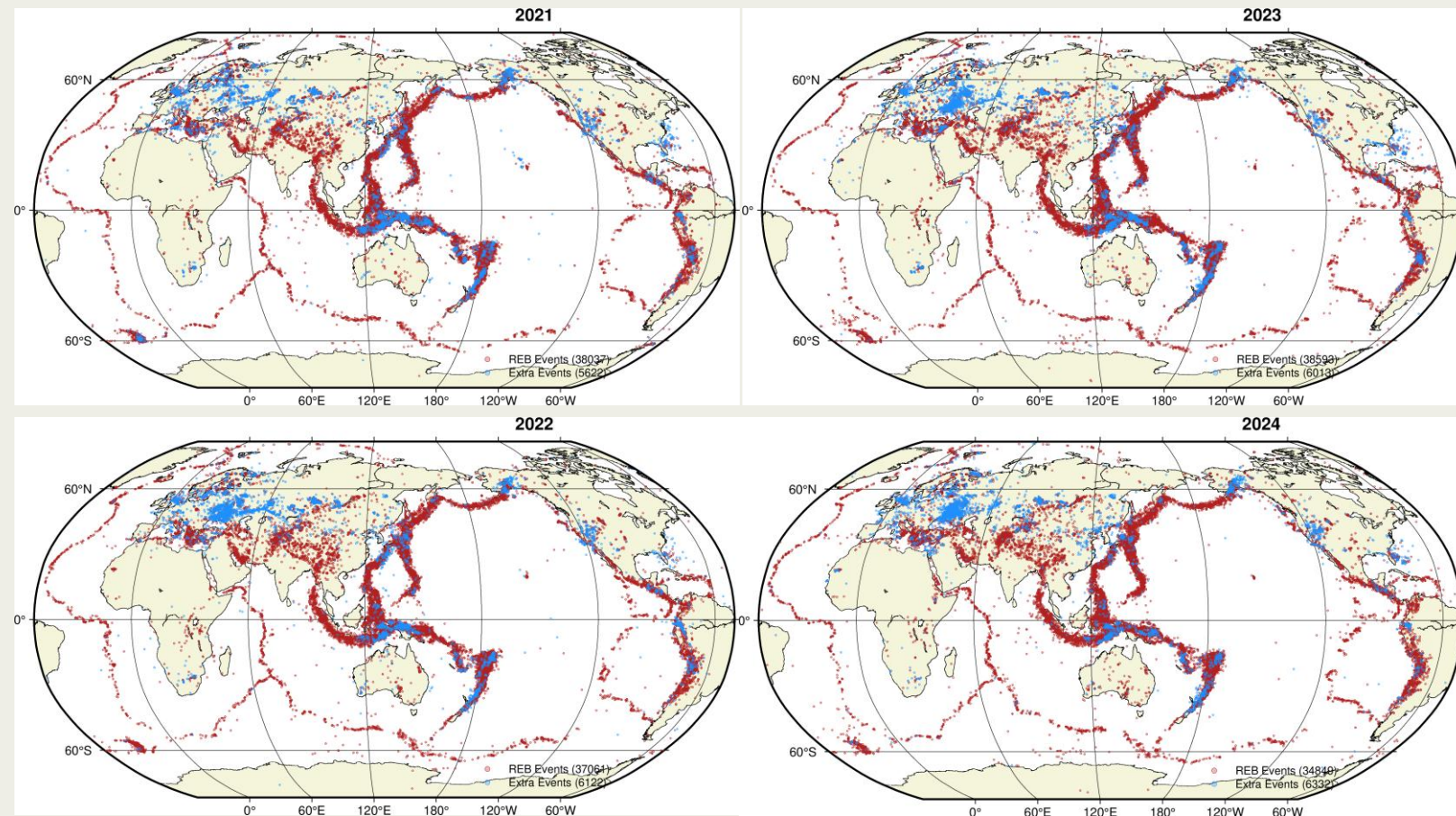
We focused on 2015 - 2024 as most representative of the current network status and main components of the processing software. A query to replicate REB was developed; it calculates weight of events according static.weight table in IDC DB and accounts for stations of different technologies and phases and their use in event location. Results were stored in new table in the DB.

Validation. After applying EDC thresholds (N primary stations ≥ 3 and weight > 4.5) it was possible to replicate IDC results with accuracy 99.9996% over this period (13 more events to 363133 REB events in our REB bulletin). This enabled detail investigation of weight distribution of weights below current EDC and to search for threshold that allows more quality LEB events to pass EDC. The distribution of LEB events with weight ≥ 3.5 are in table 2.

Weight range	Events	Percentage
3.6-3.7	59389	70%
3.9-4.0	15665	18.5
All other	9771	11.5

Table2. Weight analysis.

Figure 3: Potential REB events under proposed EDC (weight > 3.5 , ≥ 2 primary stations, error ellipse $< 10,000 \text{ km}^2$).





Conclusions

One of the criteria for quality of SHI events is area of the location error ellipse. These parameters are calculated for all SHI events but are not considered in EDC. We propose to set this as one criteria in EDC. Figure 3 presents potential REB events if new proposed EDC (>3.5 , at least 2 primary stations is applied). We additionally set maximum error ellipse $<10,000 \text{ km}^2$. With these parameters the number of REB events will grow with $\sim 10\text{-}17\%$ and will provide more information to the member states about SHI events in the world.

Proposed Quality Controls:

- Error ellipse area $<10,000 \text{ km}^2$ (can be further elaborated) ;
- Eccentricity constraints for location reliability.

Proposed new EDC:

- ≥ 2 primary stations (accommodating infrasound/hydroacoustic limitations);
- Weight >3.5 (recovering 70% of excluded events in 3.6-3.7 range) ;
- Location quality controls (error ellipse area and eccentricity) .

Technological Impact: Location of infrasound and hydroacoustic events is frequently limited to 2-station detection due to atmospheric/oceanic propagation physics, not signal quality. Current 3-station requirement systematically excludes otherwise real events from these technologies.

Conclusions

- There is a clear trend of an increasing number of LEB events not qualifying for the CTBTO final product REB (reaching $26.5\% \pm 1\%$ of LEB events over last 5 years). It is result of increased number of contributing stations and IDC processing. All LEB events have been reviewed by expert analysts which ensures the quality of locations.
- Further reliance on NET-VISA software for building automatic bulletins may further increase this discrepancy as the software makes greater use of auxiliary seismic stations (Nippres, 2023)
- **Recommendation:** EDC review should decrease excluded LEB proportion by applying location quality criteria and accounting for technology-specific propagation constraints, bringing $\sim 10\%$ more quality events into official IDC products."

References

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