

Disclaimer

The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

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Introduction

Background

The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) has been developing and testing NET-VISA, a software package which builds seismic, hydro-acoustic and infrasound events through a Bayesian inference method.

Tests show that NET-VISA has better performance than CTBTO's current association program (GA) (see "NET-VISA performance" section below). Analyst tests of NET-VISA have been limited to a few days of data. In addition, analysts, after having had some initial exposure to the results of NET-VISA, have requested to use it operationally as soon as it is practical. Through this module, we are providing access in a non-invasive way.

The goal of this work

Based on the above background, the following environment has been designed, to allow analysts to make use of NET-VISA benefits in addition to the event bulletin provided by the current association:

- (1) As before, the results of the current associator form the basis of analyst work.
- (2) Additional events produced by NET-VISA can be added if requested by analysts.

To achieve this objective, we have developed a module which provides analysts with NET-VISA results in their interactive analysis software.

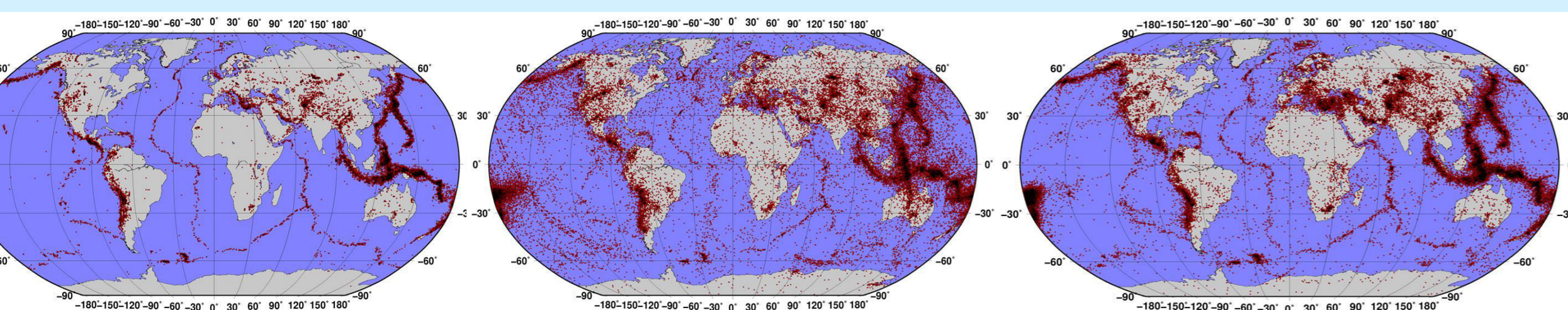
We have also undertaken a performance test of the module with operational data on our testing environment.

NET-VISA performance

The chart to the left compares bulletins produced by NET-VISA and, respectively, by the current associator (SEL3) in terms of *overlap* and *inconsistency* with respect to the analysts' reviewed bulletin (LEB).

In the both indices, NET-VISA shows better performance than the conventional.

- Overlap:** Events in both reviewed and automated detection systems
- Inconsistency:** Events wrongly detected.

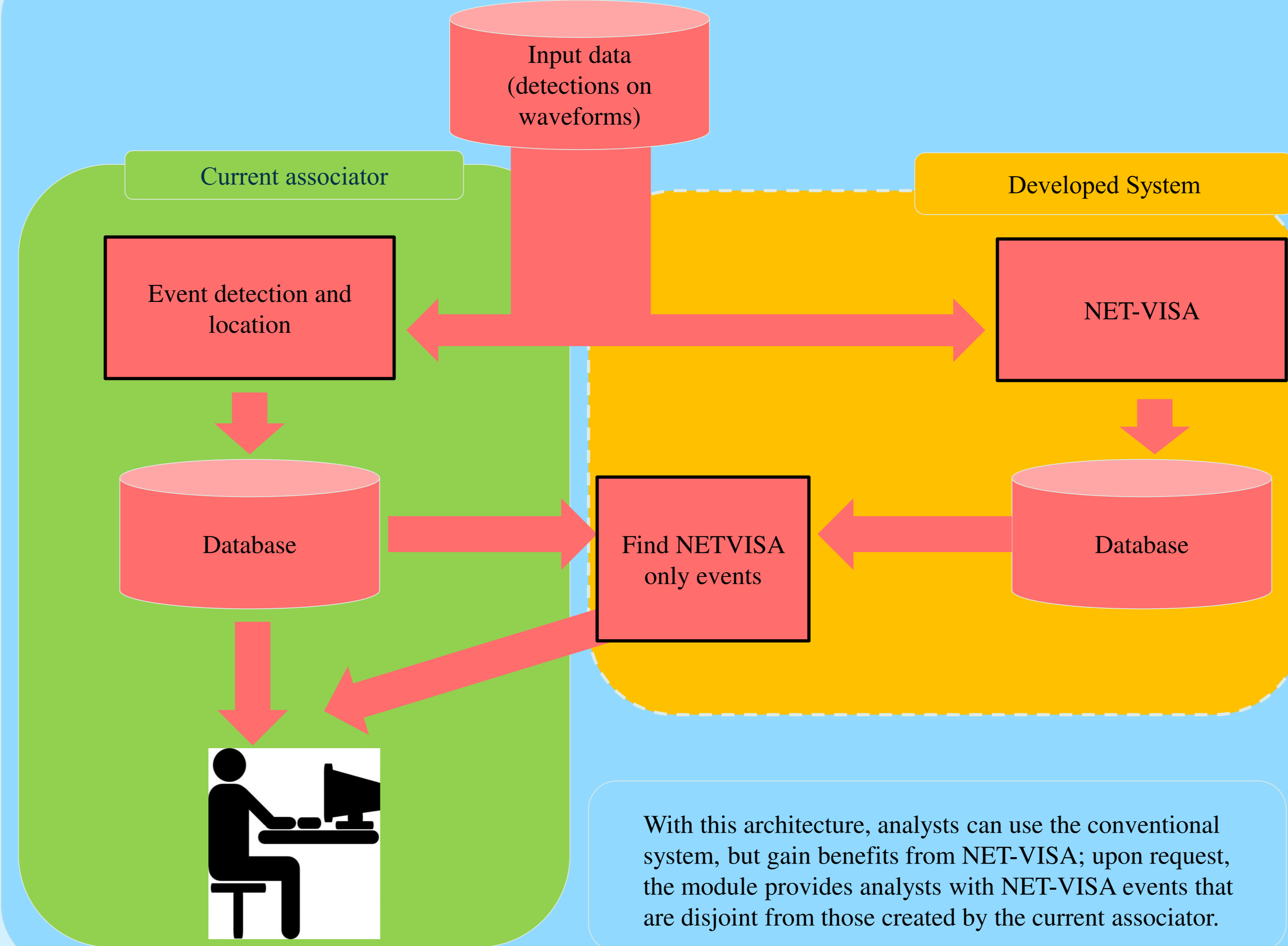


Analysts reviewed 2013: 42,782 events
 BASE 2013: 54,327 events
 NET-VISA 2013: 61,441 events

NET-VISA events match analyst reviewed events better and show less scatter than those produced by the current associator.

Implementation

System architecture



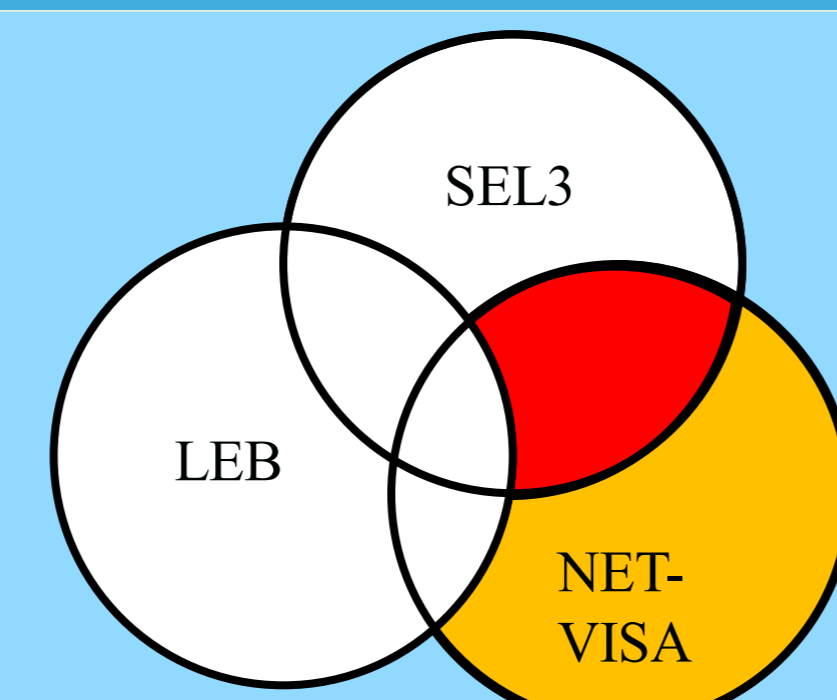
Finding NET-VISA exclusive events

Because the current associator and NET-VISA process the same input detections independently, finding identical (common) events between them is not straightforward.

- We employed the following rules to find determine events considered "common" between the two associators;
- (1) If an event in the conventional system, and one in NETVISA share 2 or more arrivals, they are considered "common".
 - (2) If there are 2 or more events that satisfy the above condition, the event which has the most common arrivals is considered to be the best match.
 - (3) If a stronger condition is needed, analysts can additionally limit the distance of the two events being matched, e.g. by requesting that the epicenters of events that are common are within a certain distance (60km in this study). This condition can be added interactively and the distance criteria can be changeable.

This detection of common events is done by a Python script that executes in a few seconds for a 1 hour time block. Therefore, the performance is well within the tolerance for interactive analysis.

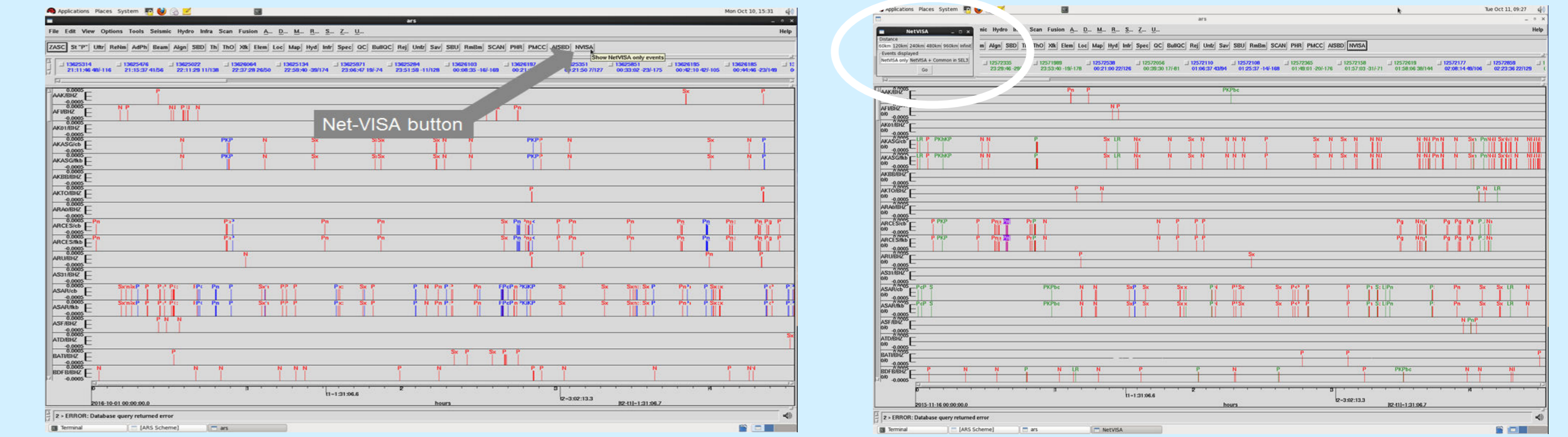
Sets of loading events



The basic idea of the module is to provide analysts with NET-VISA exclusive events, to complement analysts. In this context, the orange part of the Venn diagram should be extracted.

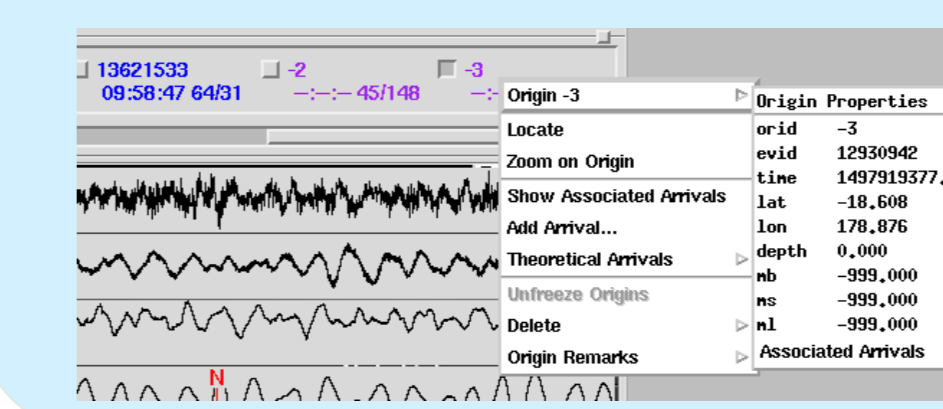
At the same time, our preliminary test results show that NET-VISA associates more detections with each event than the current associator does. This behavior is considered to be preferable and helps analysis. Thus, we also have the option to provide analysts with events common to SEL3 and NET-VISA (red part in the diagram), upon their requests.

Screenshots



Newly introduced button, which loads NET-VISA data onto our interactive analysis software

The window which provides the selection of distance criteria and set of loading events



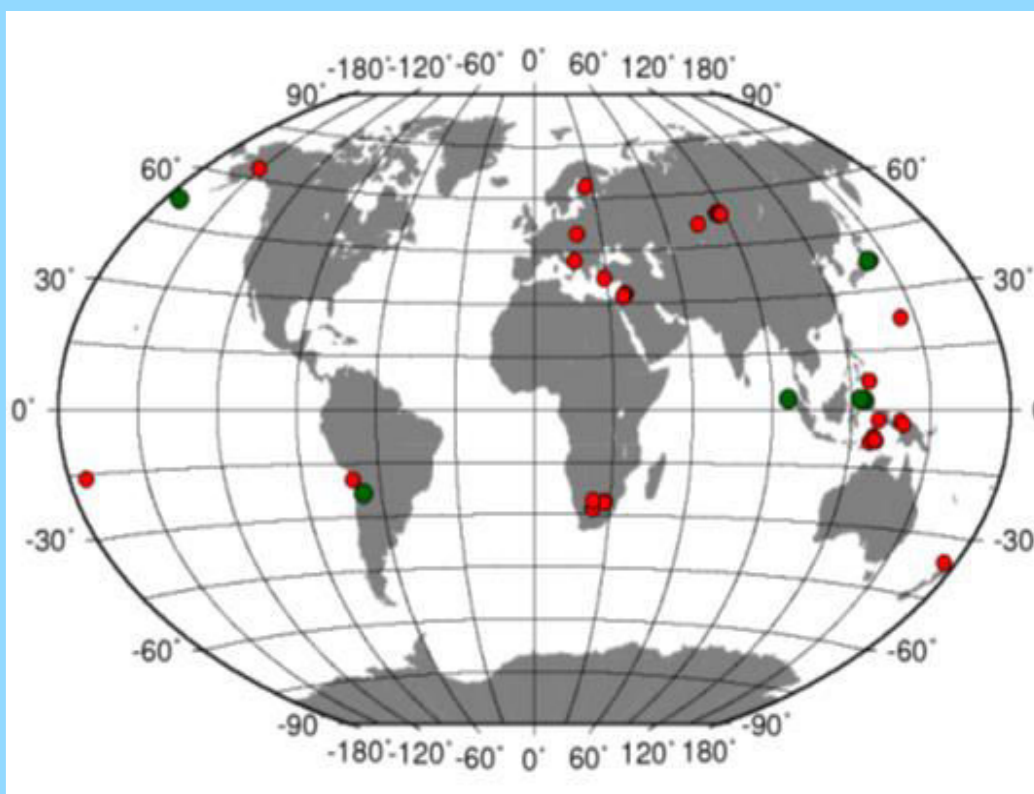
Origin ID (*orid*) "-2" and "-3" are presented to the analyst. Negative values in ID indicate that they are not created by the current associator. The interactive analysis software will assign new values after analysis. On the other hand, Event ID (*evid*) is consistent throughout the process, and one can track the history of events using *evid*, and thus, be able to determine the provenance of analyzed events.

Results

Three analyst tests were performed for this module under slightly different conditions, as described below. In Test1, 3 days of data were analysed (12/Nov/2015=>14/Nov/2015)

The events produced by the current associator are initially loaded in the analysis software. Events that are formed with the remaining arrivals (using the Scanner software) are also taken into consideration. NET-VISA events that are disjoint from both of these categories are loaded afterwards.

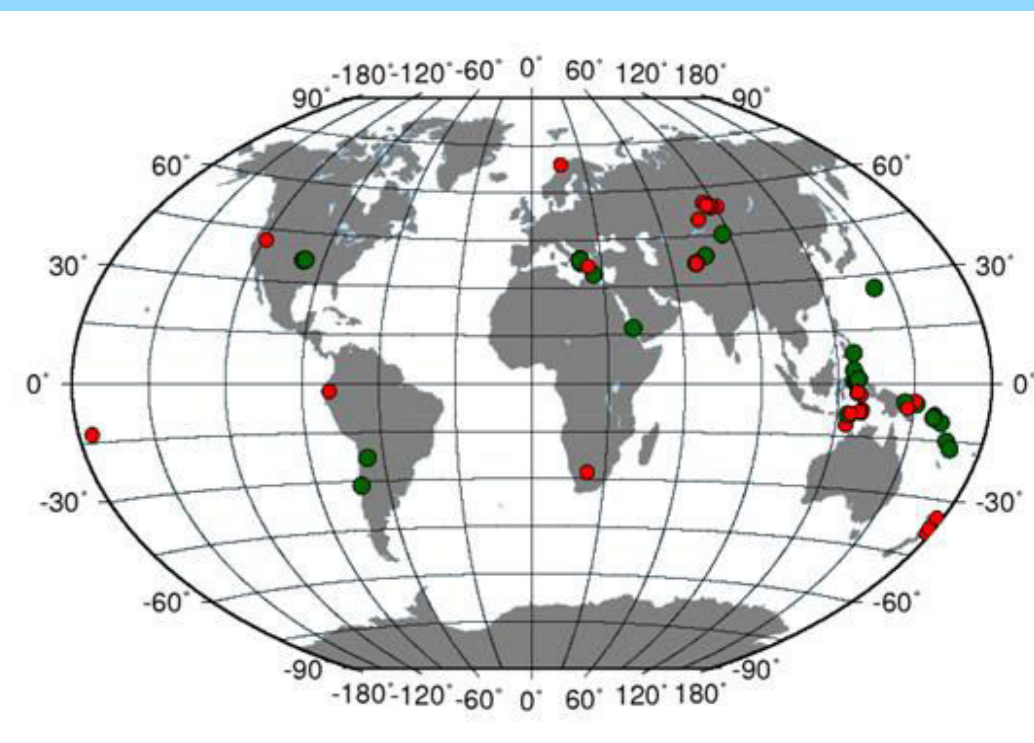
- 116 additional events produced by NET-VISA were presented to the analyst
- Of these 42 events (36%) were found to be valid LEB events
- 36 of the 42 events (shown in red on the map) events do not meet REB criteria
- 6 valid REB events in green on map



In Test2, 5 days of data were analysed. (16/Nov/2015=>20/Nov/2015)

In this case, NET-VISA events are presented that are disjoint from events produced by the current associator.

- 177 seed events produced by NET-VISA were presented to the analyst
- Of these 75 events (42%) were found to be valid LEB events
- 42 of the 75 events do not meet REB criteria (red on the map)
- 33 of the 75 events are valid REB events (green on the map)



LEB: Late Event Bulletin.
 REB: Reviewed Event Bulletin

Conclusion

We have developed a module which provides analysts with NET-VISA results as complementing information, upon request by the analyst. With this technology, analysts can continue analyzing the data produced by the current pipeline, but gain benefits from the newly developed associator based on Bayesian inference. Initial tests show very promising results, with NET-VISA proposing missed REB events even in addition to those built by analysts on the basis of SEL3 and after running the Scanner software which supplements GA.

Reference

Arora, N., Russell, S., and Sudderth, E., NET-VISA: Network Processing Vertically Integrated Seismic Analysis, 2013, Bull. Seismol. Soc. Am., 103, 709-729.