Status of Seismon

Nikhil Mukund, Michael Coughlin, Jan Harms, Nicolas Arnaud, David Barker, Sebastien Biscans, Eric Coughlin, Fred Donovan, Paul S Earle, Jeremy Fee, Irene Fiori, Hunter Gabbard, Michelle R Guy, Brian Lantz, Richard Mittleman, Arnaud Pele, Hugh Radkins, Bas Swinkels, Keith Thorne, Jim Warner

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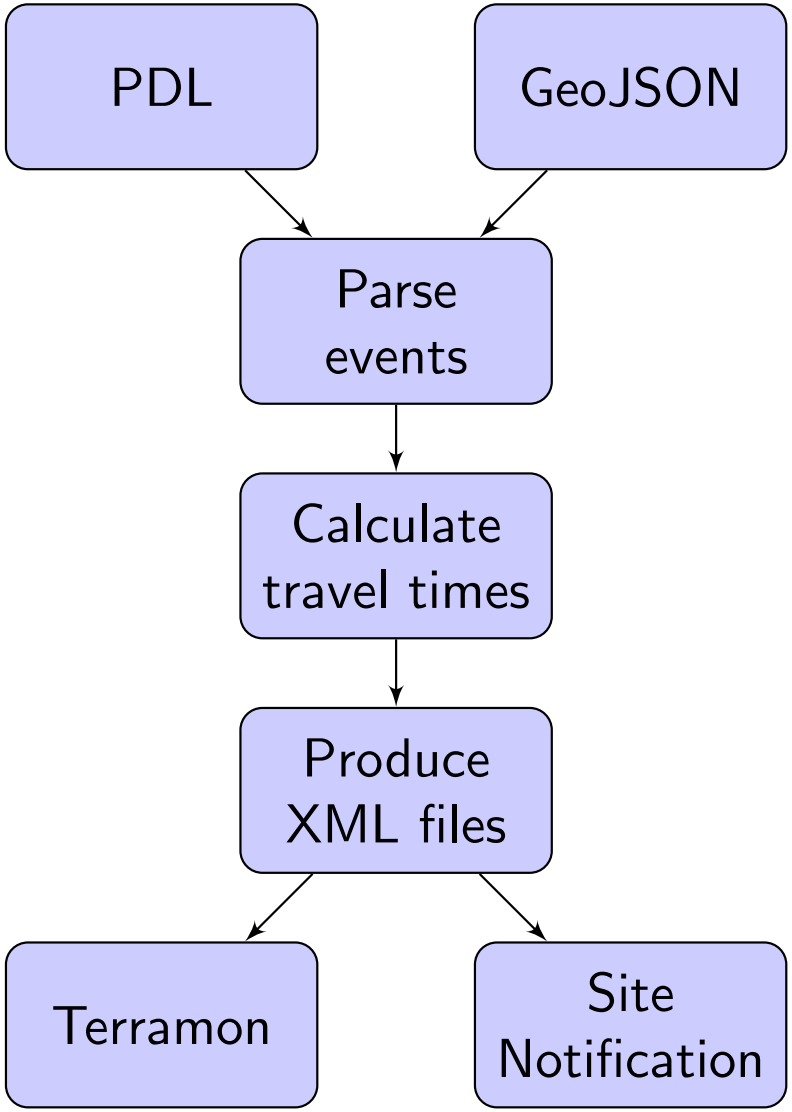
Introduction

1. The detectors are susceptible to teleseismic events, which can significantly impact a detector's duty cycle.
2. During O1 and O2, we used *Seismon*, an early-warning system for gravitational-wave observatories, which relies on near real-time earthquake alerts provided by the U.S. Geological Survey (USGS) and the National Oceanic and Atmospheric Administration (NOAA).
3. It had three methods for internal alert consumption: a Java applet written by Jan Harms (QuakeAlarm), a webpage designed by Hunter Gabbard (Terramon), and an EPICs client written by Keith Thorne and maintained by Sebastien Biscans, Jim Warner, and others.

Pipeline


PDL
GeoJSON
Parse events
Calculate travel times
Produce XML files
Terramon
Site Notification

Notices

1. Warning system relies on the most preliminary notices of earthquakes currently available generated by worldwide networks of seismometers.
2. USGS provides preliminary estimates of the location providing latitude, longitude, and depth of each event.
3. These solutions are distributed through USGS's Product Distribution Layer (PDL), which has been configured to receive notifications for all located earthquakes worldwide.
4. They are also available at the USGS website in JSON files (and other formats).

Data products

Time-of-arrival predictions

1. P- and S- wave estimates given by Python version of iaspei-tau, which is based on 1-D Earth model.
2. R-wave estimates given by bounding box of [2, 5] km s, with best estimate at 3 km/s. (Rana also used a CNN based on picks that him and students did which he thinks did a bit better for R-wave arrivals... student project?).

Peak ground velocity estimates

1. Previously fit an empirical equation.
2. Now use a MLA using EQ parameters (discussed next) to make ground velocity predictions.

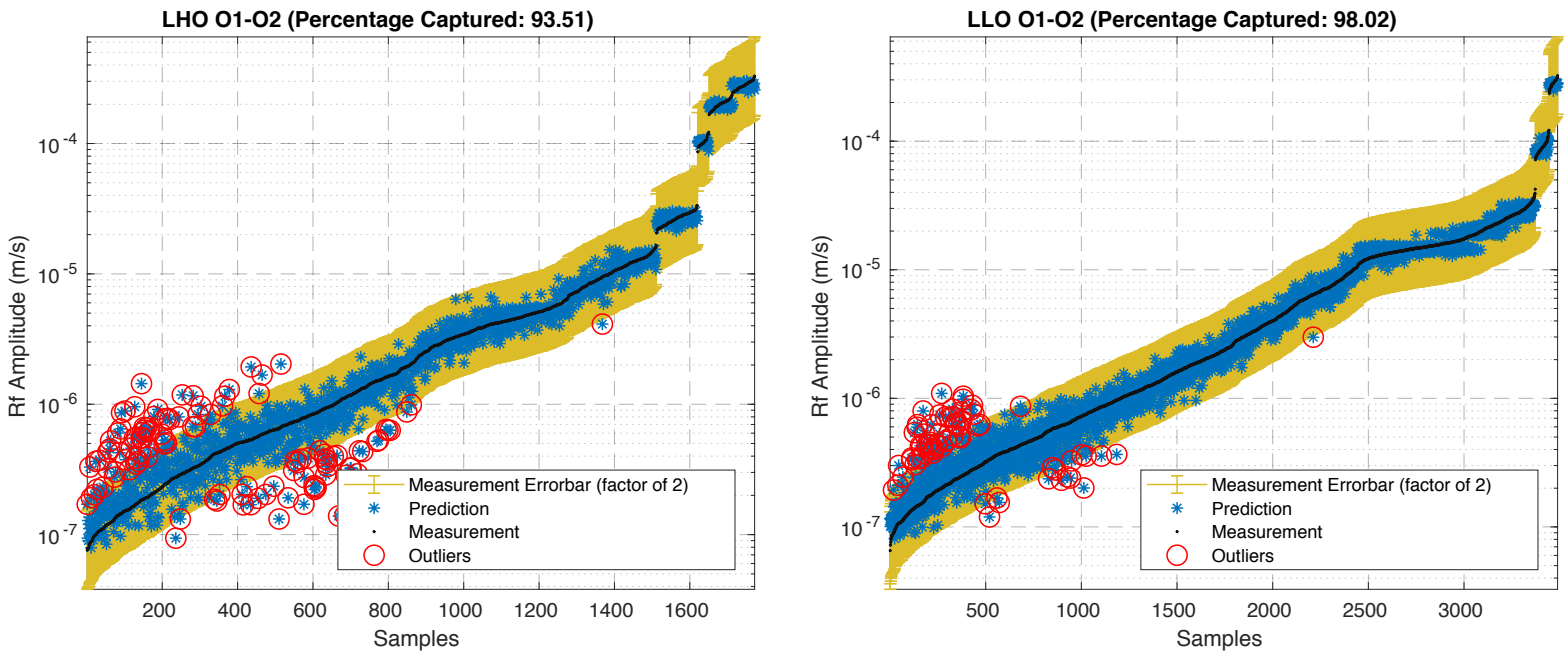
Lockloss predictions

1. Uses a MLA based on EQ parameters and ground velocity predictions to make lockloss predictions.

Data augmentation

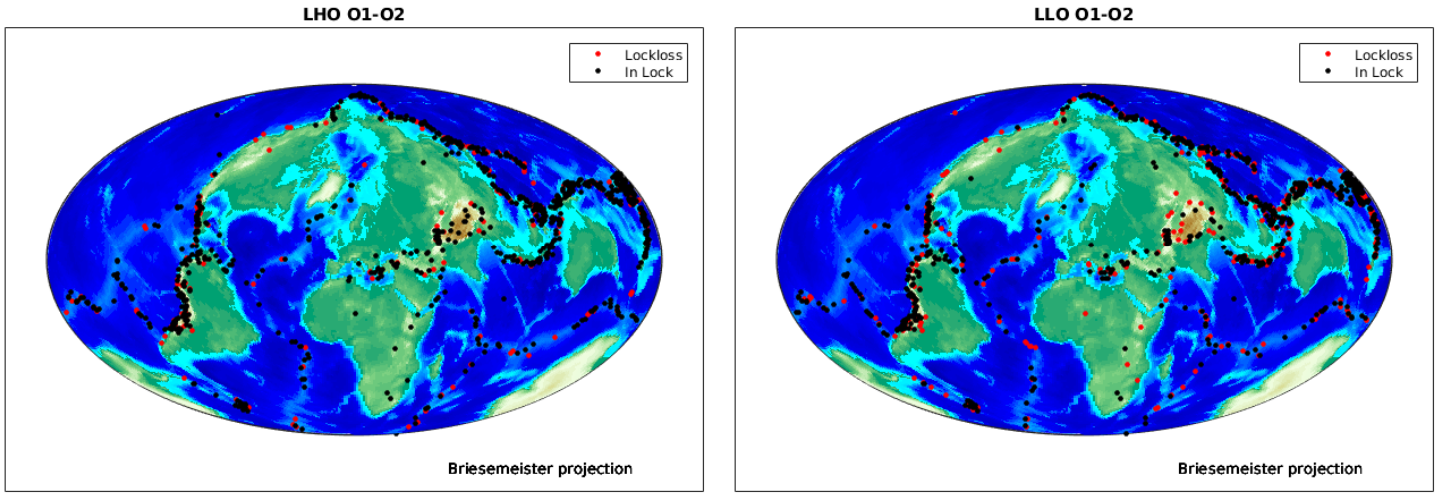
1. To improve the learning and prevent early stopping, we augment the data by artificially adding noise (or jitter) to the predictor and response variables in a controlled fashion.
2. We employ **S**ynthetic **M**inority **O**versampling **TE**chnique (SMOTE) to augment the data
3. The presence of noise enhances the ability of the MLA to better learn and generalize to the the underlying smooth nonlinear function.
4. New samples are generated from each of the original dataset by creating a gaussian jitter distribution centered around the parameter value followed by random draw of samples from these distributions.
5. Selective boosting is done so that the imbalances in the dataset are minimized.

Fit of peak velocities seen during O1-O2 at the interferometers.



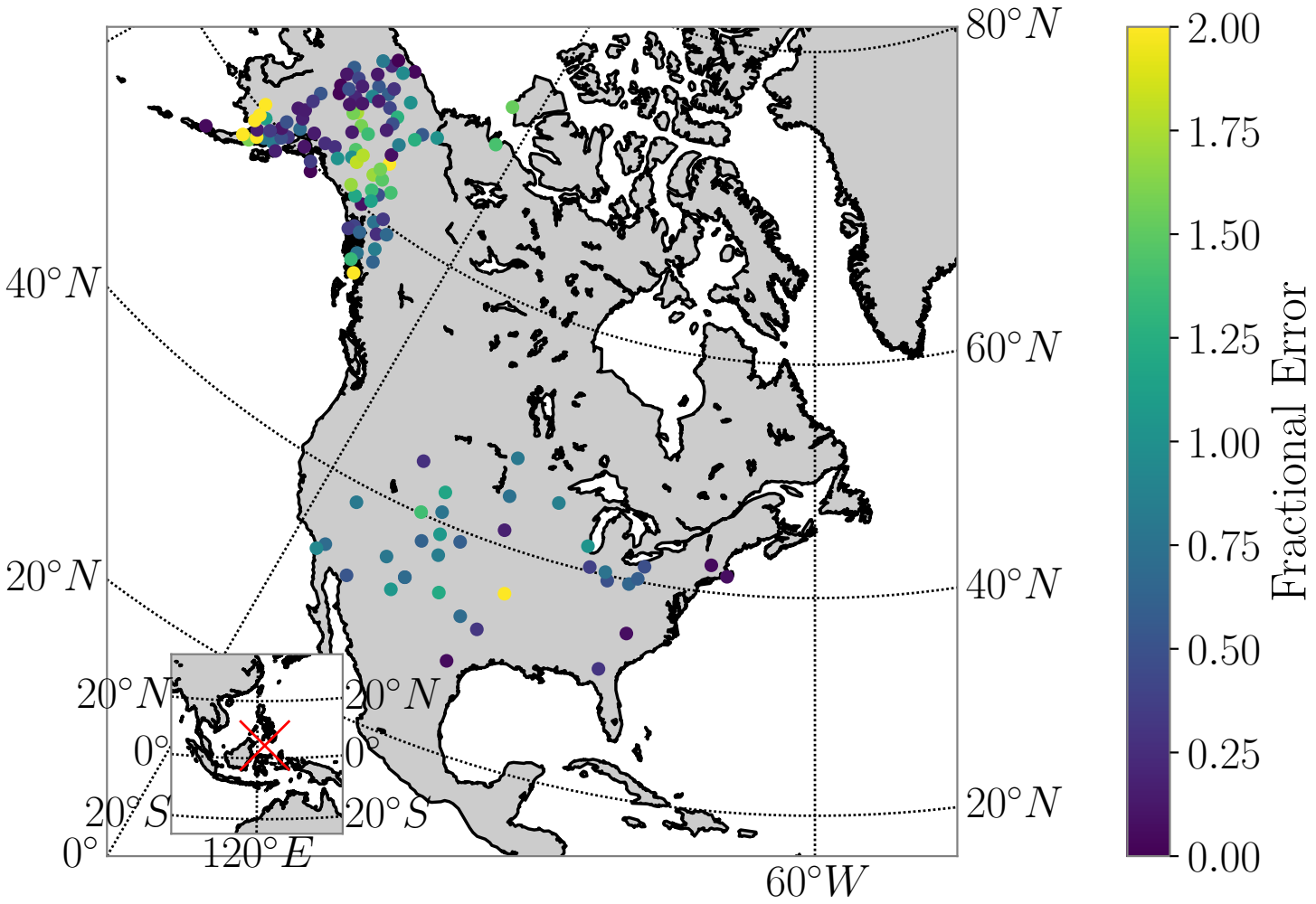
(a) Fit of peak velocities seen during O1-O2 at the interferometers (LHO and LLO) using Gaussian Process Regression. The events have been ordered by their measured peak ground velocity (in grey) and yellow error bar corresponds to a factor of 2 within the predicted value. About 90% of events are within a factor of 2 of the predicted value.

Impact of earthquakes happening worldwide on gravitational-wave Inteferometers.



(b) Impact of earthquakes happening worldwide on gravitational-wave Inteferometers.

Performance of prediction at other sites.



Conclusion

In conclusion,

1. *Seismon* is running reasonably well at LHO/LLO, with inputs to EPICs channels and the like.
2. Virgo has installed and is running the code, and there is some debate about how to best use the output there.
3. Ability to do add fake earthquakes exists for testing.

There is much to do going forward ...

1. Include updated ground velocity and lockloss predictions in *Seismon*.
2. Install updated code at the sites (including the new LHO dedicated computer).
3. Use IRIS data to make global fits (and improve those at LHO, LLO, and Virgo?).
4. Control configuration changes