PRISM: PROCESSING AND REVIEW INTERFACE FOR STRONG MOTION DATA SOFTWARE

Jeanne Jones, Erol Kalkan, Christopher Stephens and Peter Ng

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ACKNOWLEDGMENTS

* Members of the NSMP Working Group,
* David Boore, for sharing his Fortran codes
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* NSMP technicians who install and maintain the strong-motion network, and those involved in collecting and vetting data

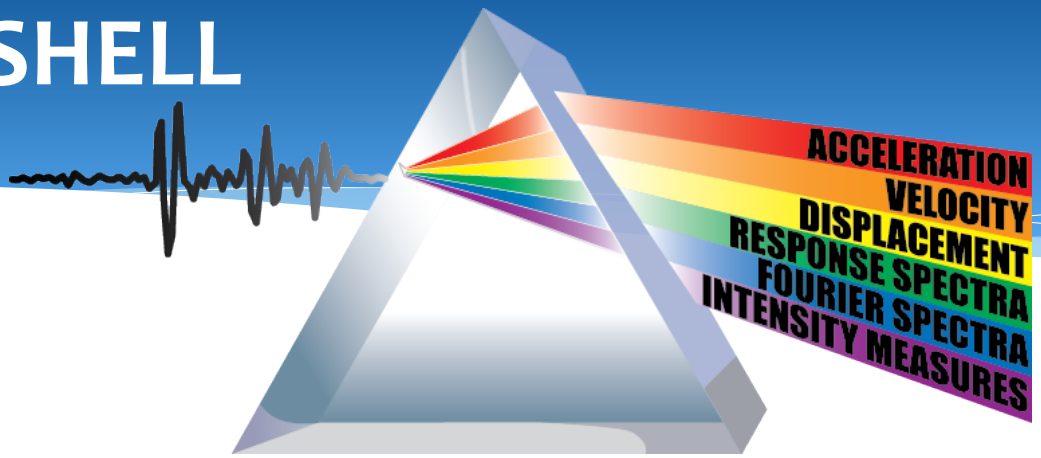
OUTLINE

* Motivation for **PRISM**
* **PRISM** in a nut shell
* Market comparison
* **PRISM** & AQMS
* Data format
* **PRISM** processing engine
* Testing
* **PRISM** GUI
* Documentation
* How to run **PRISM** processing engine
* Updates & Concluding remarks

MOTIVATION FOR PRISM

* Automatic strong-motion record processing is crucial to meet the demand for rapid preliminary processing of the increasing number of records being acquired
* Expert review should be limited to selected significant events, or to records identified as being problematic during automatic processing
* The venerable processing software BAP (Basic Strong-Motion Accelerogram Processing Software) (Converse and Brady, 1992) is outmoded

IN A NUT SHELL



Product Distribution

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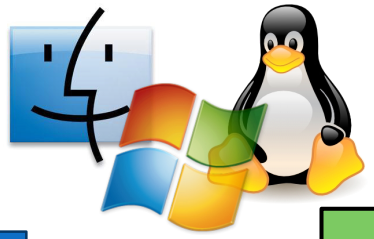
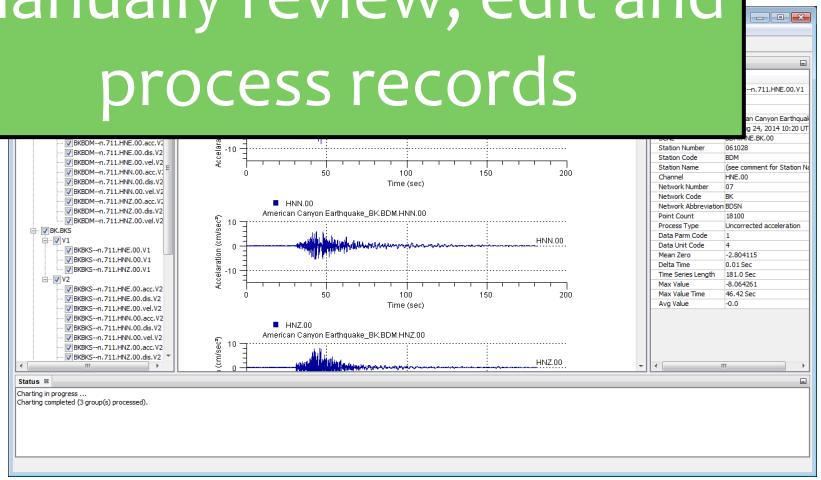


a module-based batch processing engine

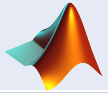
a review tool—graphical user interface (GUI)—to manually review, edit and process records

PRISM (both its processing engine and review tool) is easy to install and run as a stand-alone system



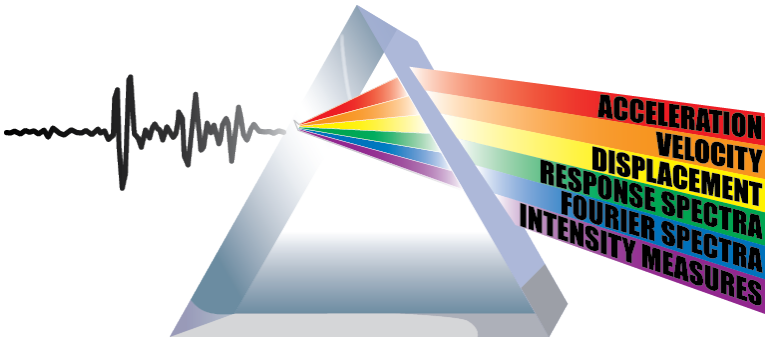
MARKET COMPARISON

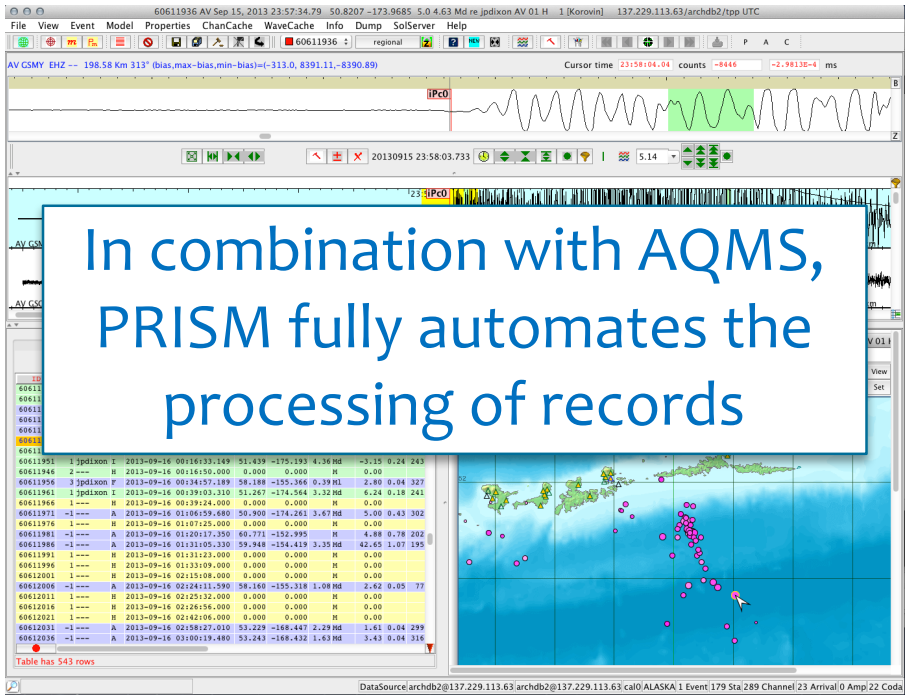
PRISM joins a suite of tools also used by other processing software even though PRISM certainly has features not present in others.

	PRISM	BAP	SEISMO SIGNAL	SEISGRAM 2K	PROSCHEMA
FREE	✓	✓	✗	✓	✓
OPEN SOURCE	✓	✓	✗	✗	✓
BATCH PROC.	✓	✗	✗	✓	✗
GUI	✓	✗	✓	✓	✓
PHASE PICKING	✓	✗	✗	✓	✗
OS PLATFORM					
UPDATE / SUPPORT	✓	✗	✓	✓	✗

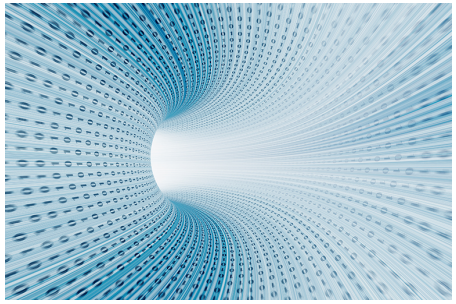
INTEGRATION OF PRISM WITH AQMS

AQMS is a real-time and post-processing wrapper around the Earthworm automated earthquake detection system that is in use by the USGS





PRISM USES STANDARD COSMOS DATA FORMAT



COSMOS www.cosmos-eq.org
Consortium of Organizations for Strong Motion Observation Systems

VOL-1 (V1): Uncorrected acceleration

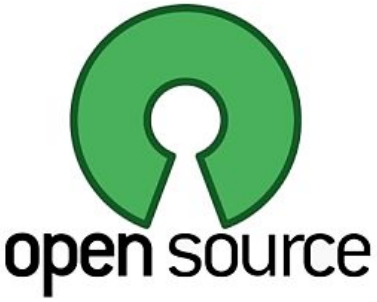
VOL-2 (V2): Corrected acceleration, velocity and displacement

VOL-3 (V3): Response spectrum, Fourier amplitude spectrum, and engineering intensity parameters

PRISM PROCESSING ENGINE

Java™ POWERED

KEY FEATURES

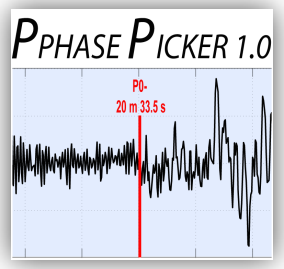


* Fully automated,
* Platform-independent, modular, extensible and open-source
* Does not dependent on any closed-source or proprietary software

* Processing engine implements application-programming interface (API) to allow incorporation of alternative implementations of each step

KEY FEATURES (cont.)

* Processing parameters are customizable with a configuration file (XML)



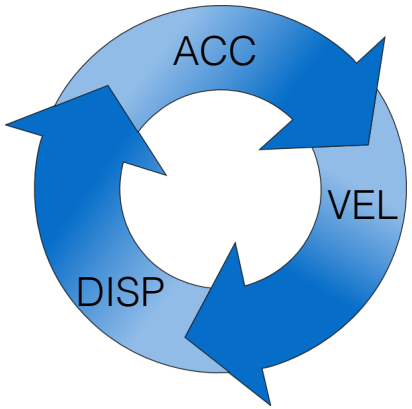
* Phase-time [PphasePicker (Kalkan, 2016) and AIC picker (Maeda, 1985)] and max. amplitude picking

* Time-domain mean-removal, integration and differentiation

KEY FEATURES (cont.)

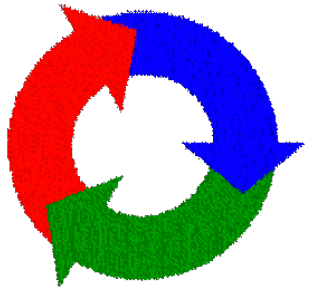
* Frequency-domain zero-padding resampling
* Acausal bandpass (Butterworth) filtering
* Filtering performed on acceleration time series in time domain

KEY FEATURES (cont.)



* Products include compatible acceleration, velocity and displacement time series, response spectra, Fourier amplitude spectra, and standard earthquake-engineering intensity measures
* Compatible data products include the initial values required, which are stored in V2 file, to reliably reproduce all products using the released acceleration and without the need to pad the time series

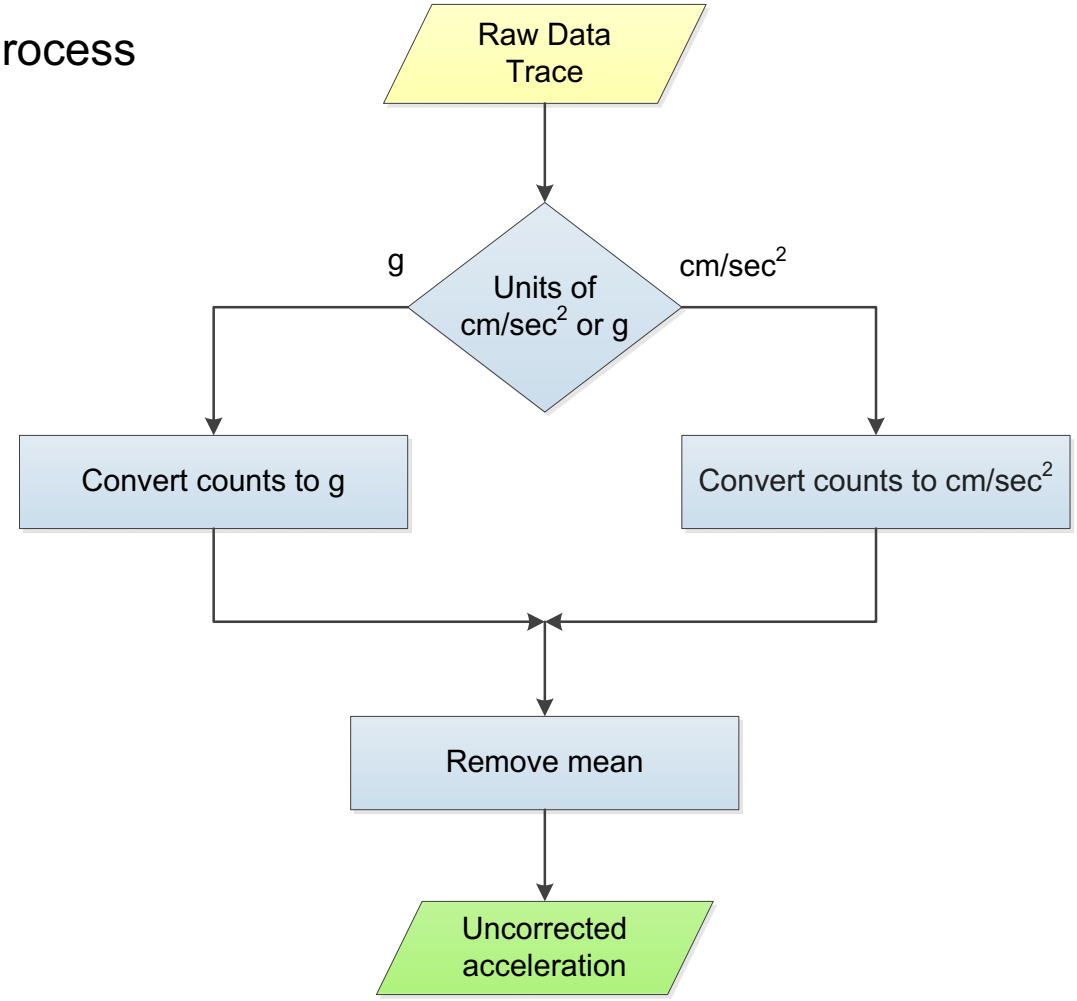
KEY FEATURES (cont.)



* Log files for quality control and reproducibility
* For input, currently uses COSMOS V0 input format with metadata in COSMOS headers (COSMOS Strong Motion Data Format, 2001)
* Products in COSMOS data format (V1, V2 and V3)

VOL-1 PROCESSING

V1 Process



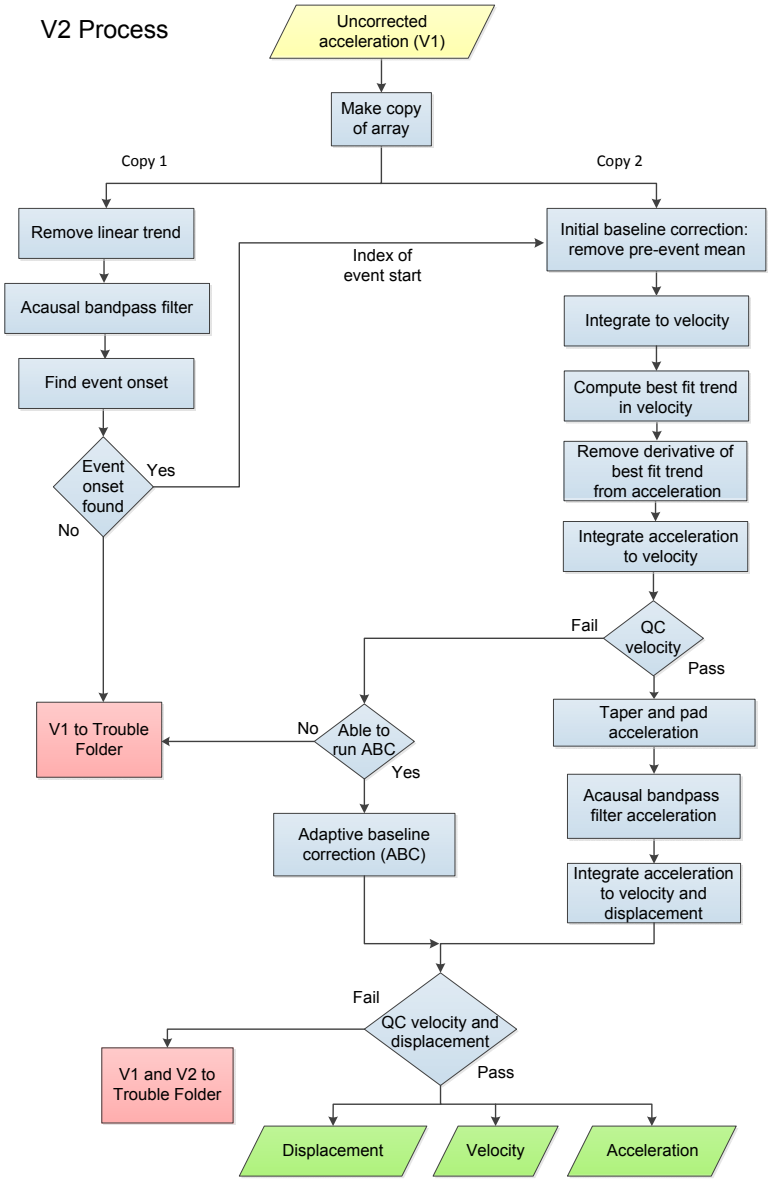
Step - 1: Unit conversion

Step - 2: Mean removal

Instrument response correction is not applied because the cutoff frequency of the low-pass filter is lower than that of the natural frequency of an accelerometer (>50 Hz)

PRISM is not intended to process records with a lower natural frequency (< 50 Hz)

VOL-2 PROCESSING



Step - 1: Resampling to 200 sps (if needed)

Step - 2: Event onset detection

Step - 3: Pre-event mean removal

Step - 4: Baseline correction (1st or 2nd order polynomial fit to velocity)

Step - 5: QC

Step - 6a: Bandpass filter with acausal (zero-phase distortion) filter (acc. domain)

Step - 6b: Adaptive baseline correction

Step - 7: Compute acc., vel. and disp.

VOL-3 PROCESSING

Step - 1: Compute pseudo acceleration, velocity and displacement spectra for 2, 5, 10 and 20% damping

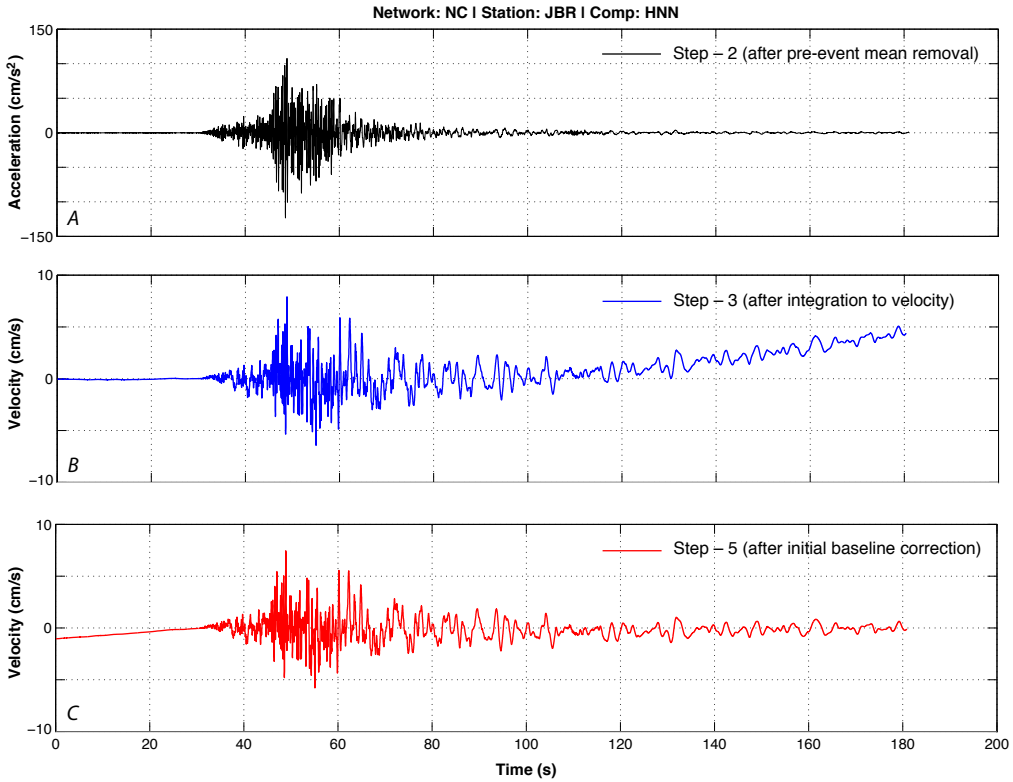
Step - 2: Compute Fourier amplitude spectrum

Step - 3: Compute earthquake-engineering intensity parameters:

i. Arias intensity
ii. Bracketed duration (seconds over 5% g)
iii. Duration interval (seconds over 5-95% of total energy)
iv. Response spectrum intensity (area under PSV spectrum between 0.1 s and 2.5 s)
v. RMS acceleration
vi. Cumulative absolute velocity

ADAPTIVE BASELINE CORRECTION

* Records may have spikes or step-like offsets in the baseline, or they may be contaminated by rotational or gravitational effects
* PRISM's regular processing may not be sufficient to correct for complex baseline distortions



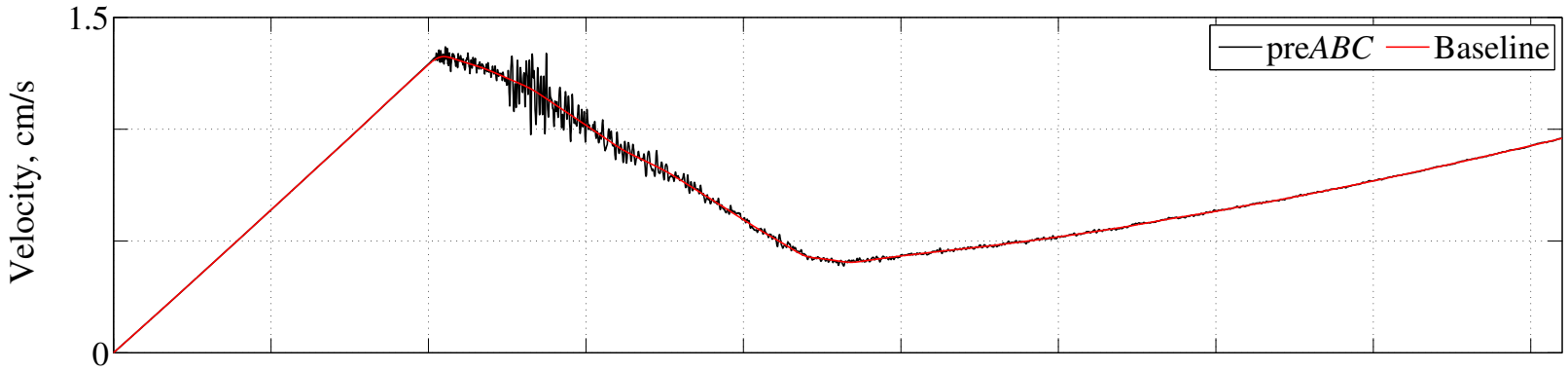
Pre-event mean removed from acceleration

Integrated to velocity

Apply initial baseline correction to velocity

ADAPTIVE BASELINE CORRECTION (cont.)

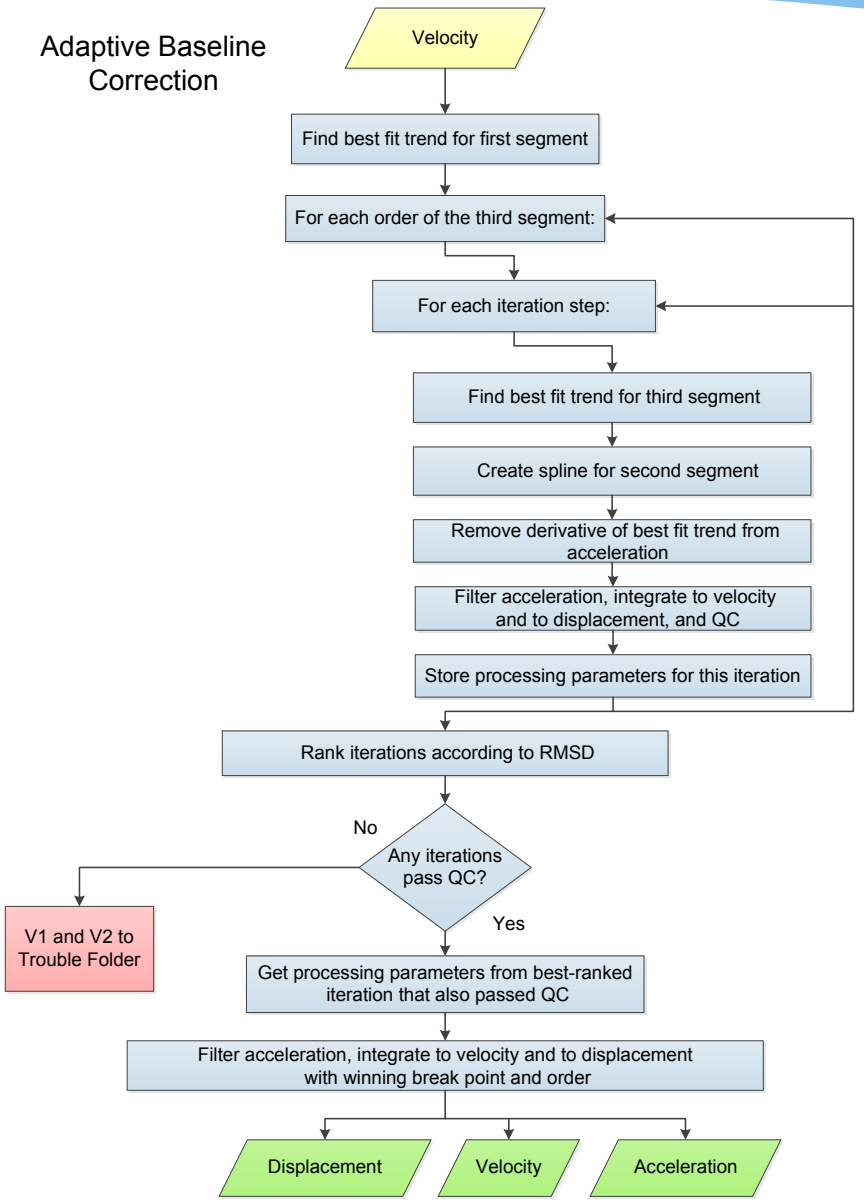
* Correction may require segmental baseline fit (e.g., Graizer, 1979; Iwan et al., 1985; Boore, 2001)

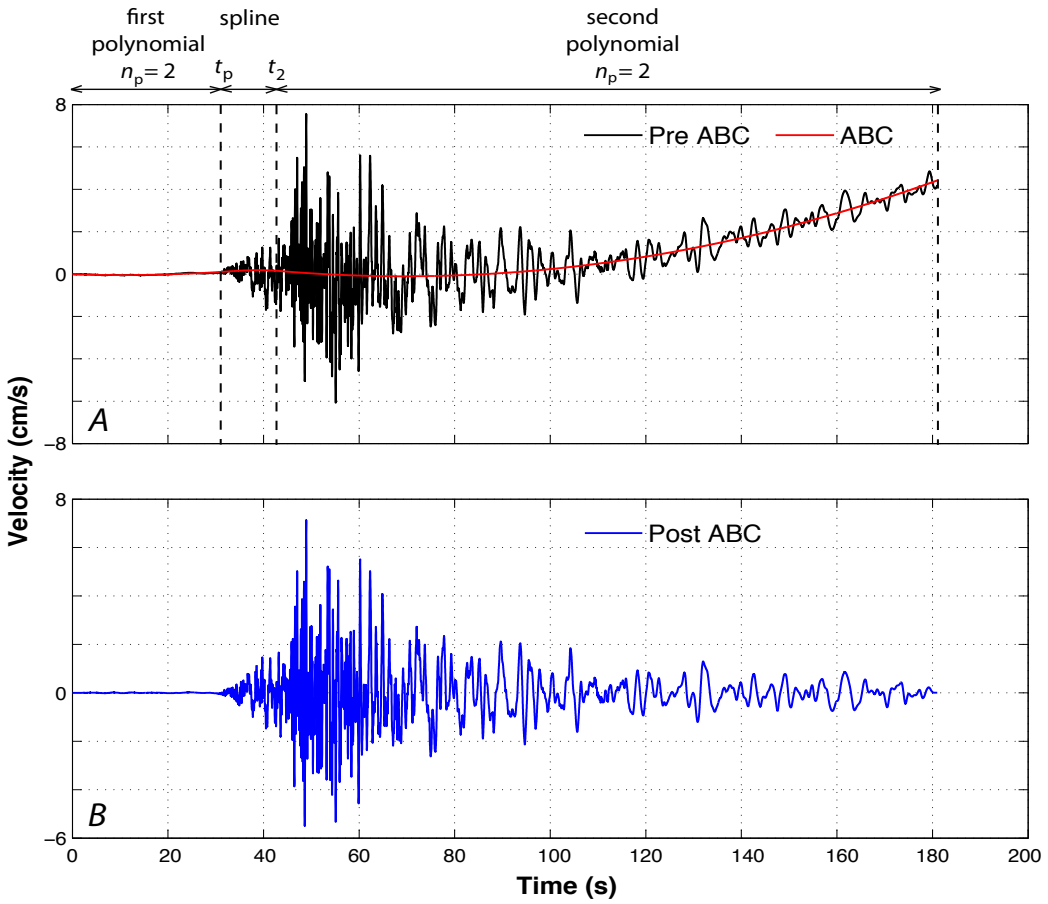


* Adaptive Baseline Correction (ABC) was developed following Iwan et al. (1985)
* In ABC processing , nth order polynomial is fitted to the initial and final segments since the ground velocity physically begins at zero and ends at zero. These two n^{th} order polynomials are connected by a cubic-spline (Ivan et al., 1985)

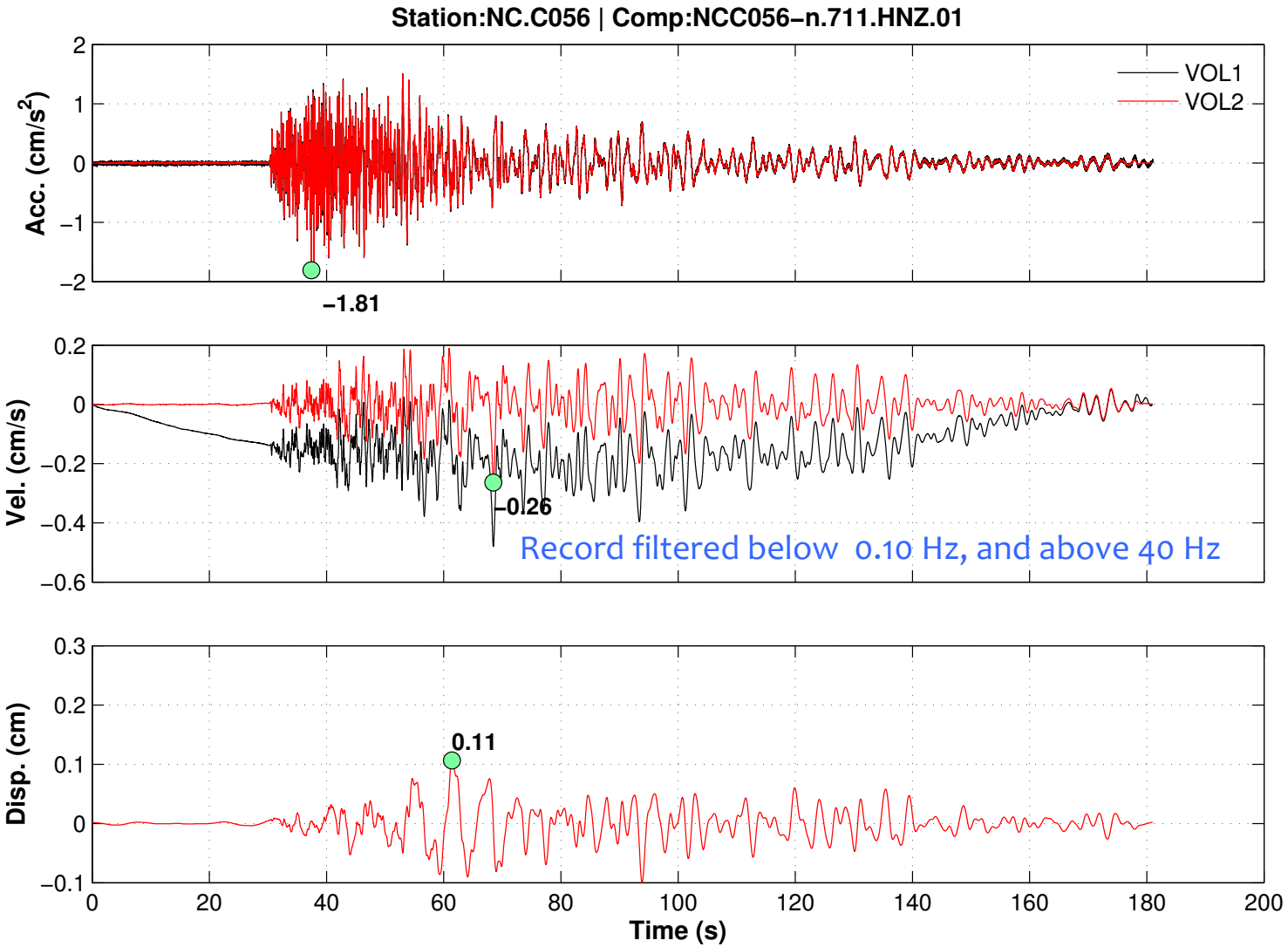
ADAPTIVE BASELINE CORRECTION (cont.)

Adaptive Baseline Correction





EXAMPLE (WEAK-MOTION) FROM SOUTH NAPA EQ.



RUN TIME PERFORMANCE

RUNTIME STATISTICS FOR THREE RECENT EARTHQUAKES

Test machine: 2.6 GHz CPU and 16 GB RAM

	South Napa	South Dos Palos	Greenfield
Moment magnitude	6.0	4.4	4.4
Number of channels	720	102	105
Pass rate	99 %	100 %	100 %
Number of products	4,312	608	630
Average processing time (second/channel)	0.84	0.48	0.43
Need ABC	105	10	4

COMPARING PRISM WITH BAP AND CSMIP

COMPARISONS AMONG PRISM, BAP AND CSMIP PROCESSING

* A series of benchmark tests (Kalkan and Stephens, 2017) was run by comparing results of PRISM to BAP and to California Strong Motion Instrumentation Program (CSMIP) processing (Shakal et al., 2003, 2004)

* These tests were performed by using the MatLAB implementation of PRISM, which is equivalent to its public release version

KEY DIFFERENCE BETWEEN PRISM AND CSMIP PROCESSING

* In CSMIP processing, an initial long-period filter is applied to the instrument-corrected acceleration. Velocity and displacement are subsequently computed by integrating the acceleration and then filtered again by using the same long-period filter (Shakal et al., 2003)
* In contrast, PRISM applies filtering to corrected acceleration only, and velocity and displacement are obtained by integrating the filtered acceleration

COMPARISONS AMONG PRISM, BAP AND CSMIP PROCESSING (cont.)

Similarities among time series processed using PRISM, BAP and CSMIP were measured by:

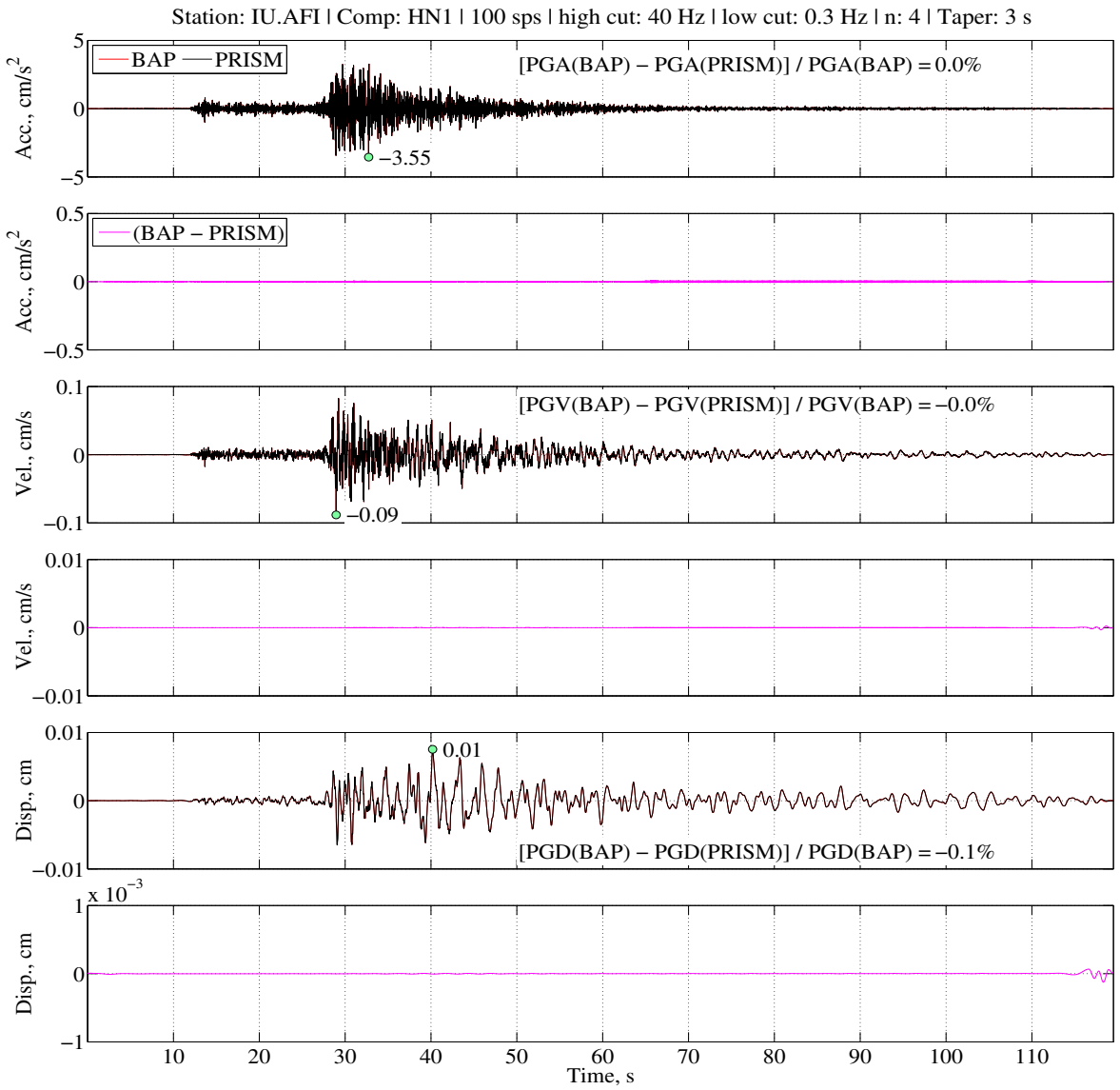
* comparing PGA, PGV and PGD of time series
* computing coherence, cross-spectrum phase and cross correlation of the time series
* comparing Fourier amplitude spectrum of acc., vel., disp. time series
* computing and comparing spectrograms of power spectra of acc., vel. and disp. time series

PRISM VS. BAP PROCESSING (EXAMPLE)

2015 mb5.0 earthquake in Afiamalu, Samoa.

Except in the final few seconds of the processed records, the differences are very small.

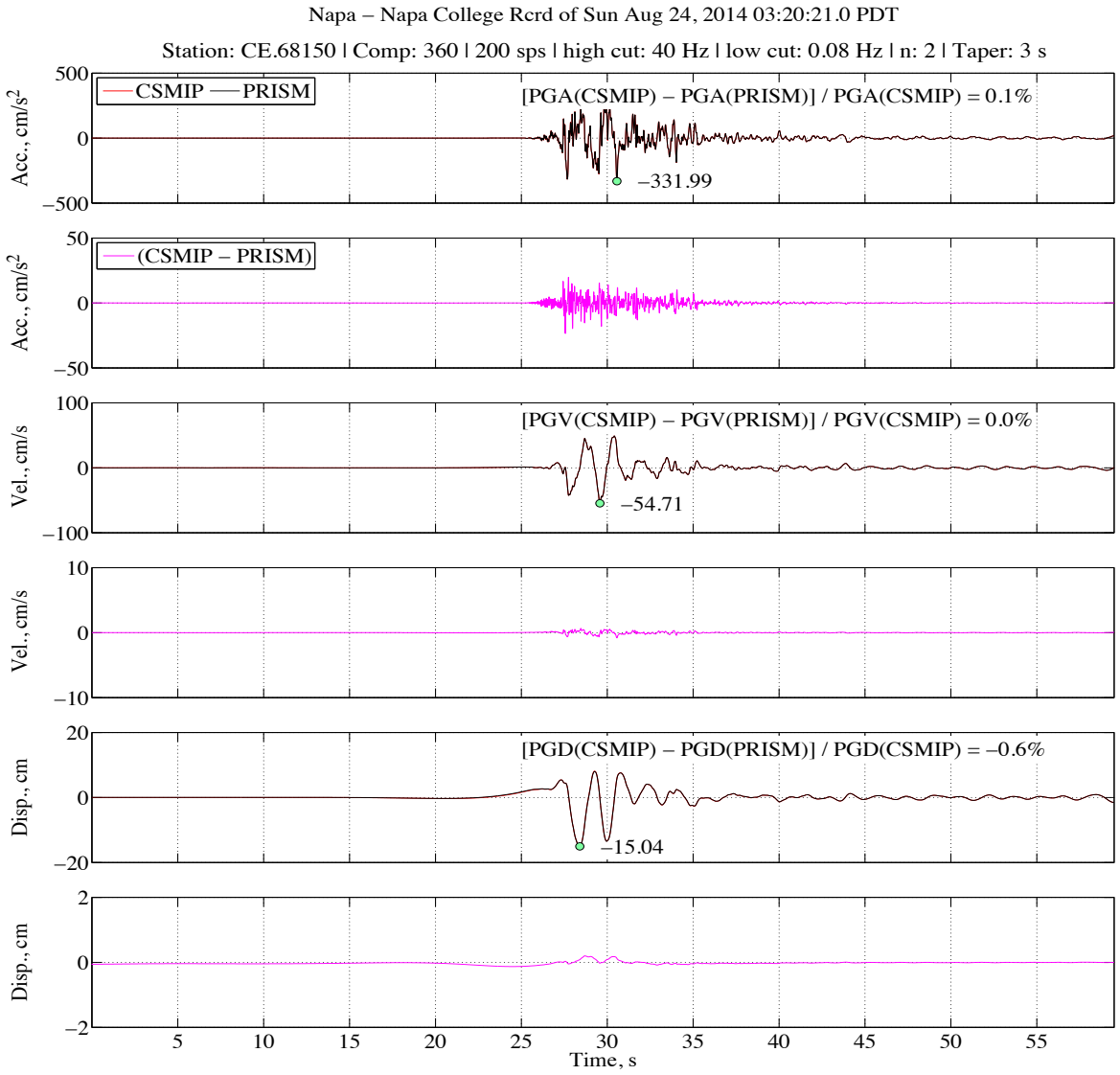
There is no difference in PGA and PGV, and the difference in PGD is 0.1%.



PRISM VS. CSMIP PROCESSING (EXAMPLE)

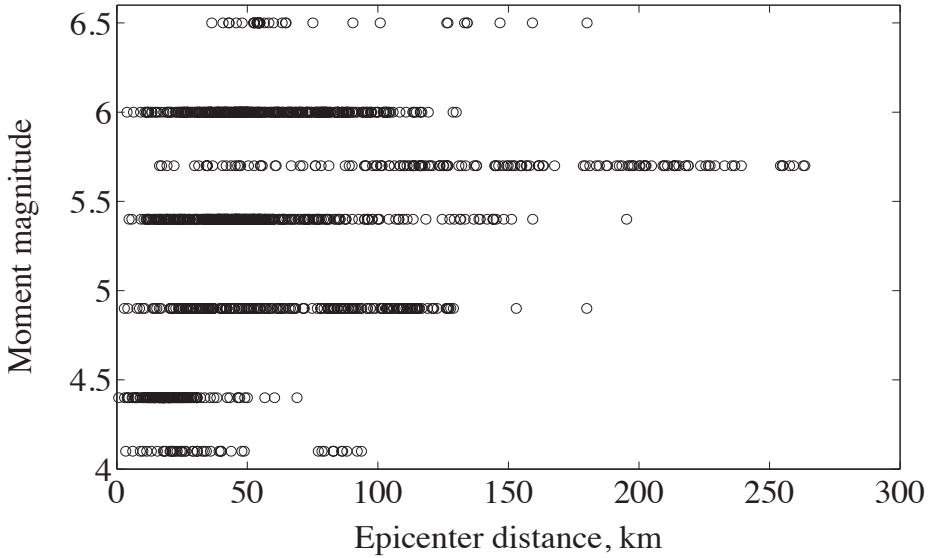
Despite any differences between PRISM and CSMIP processing, the resultant waveforms generally match well

PGA, PGV and PGD values are very similar between the two processing procedures, with the largest observed discrepancy on the order of 1%



PRISM VS. CSMIP PROCESSING (STATISTICAL EVALUATION)

We processed more than 1,800 V1 records obtained from the CESMD website for eight earthquakes that occurred between 2005-2016 in California and then compared V2 products from PRISM and CSMIP processing



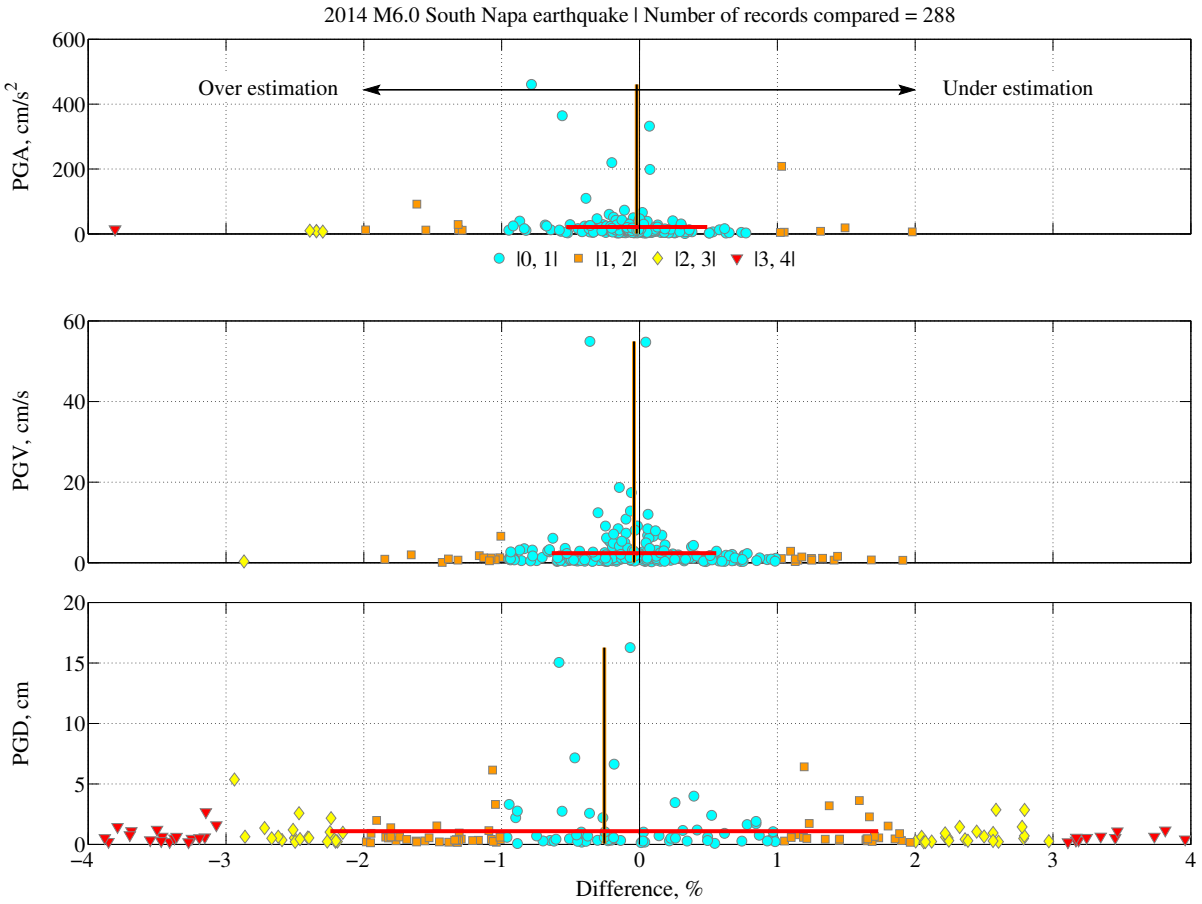
We computed misfit between two time series by comparing:

- PGA, PGV and PGD
- normalized Euclidian distance (L2 norm) between acc., vel. and disp. time series
- moving window RMS levels of acc., vel. and disp. time series

DIFFERENCES IN PGA, PGV AND PGD FROM PRISM AND CSMIP PROCESSING (EXAMPLE)

288 records of the 2014 **M**6.0 South Napa earthquake

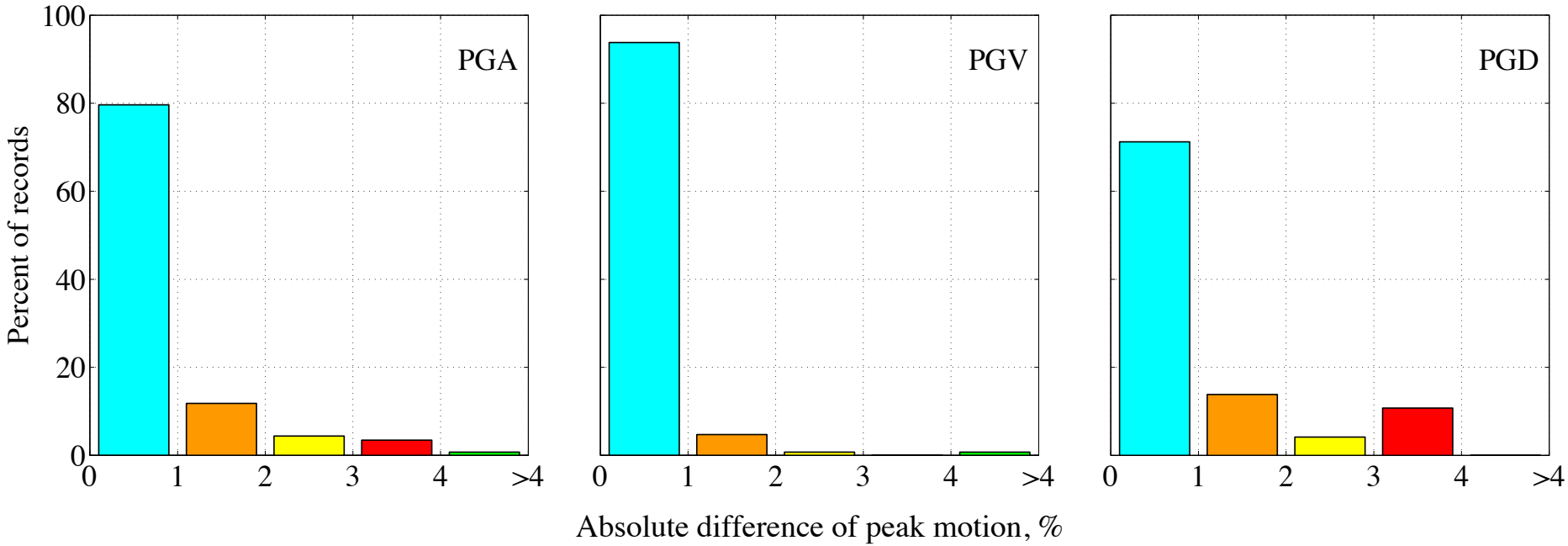
Median and standard deviation of differences are shown by horizontal and vertical thick lines, respectively



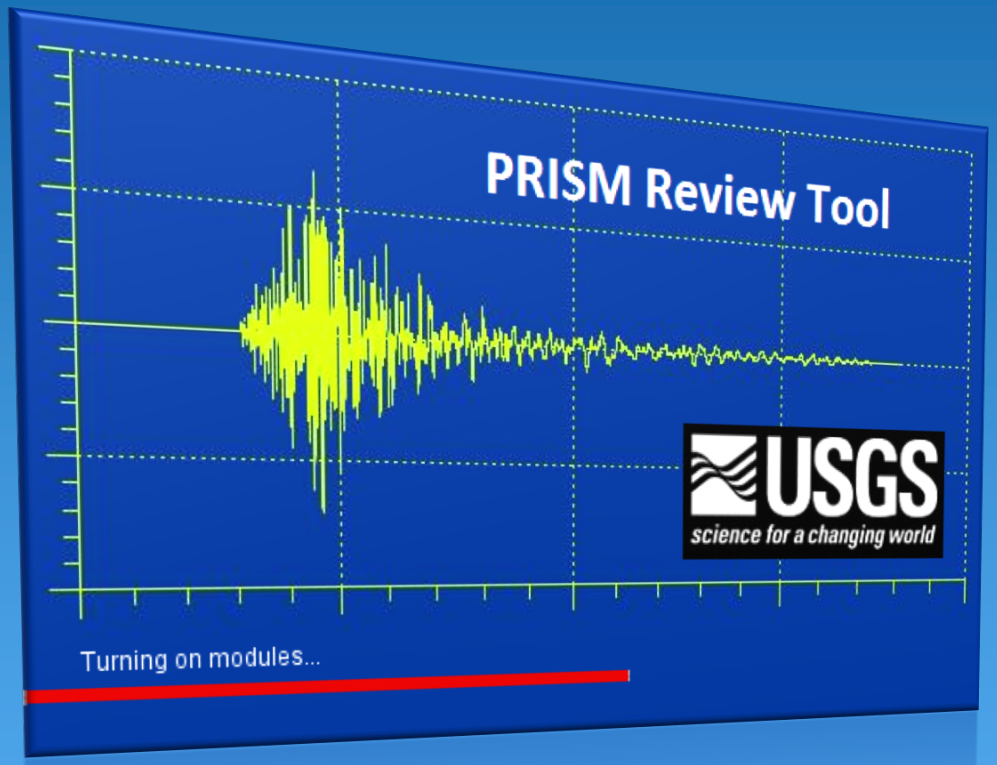
The differences are between 1-2% for majority of the records

PRISM VS CSMIP PROCESSING

Absolute differences in PGA, PGV and PGD in terms of percentage between PRISM and CSMIP processing



For 80% of records, PRISM provides peak values equal or less than 1% of CSMIP peak values



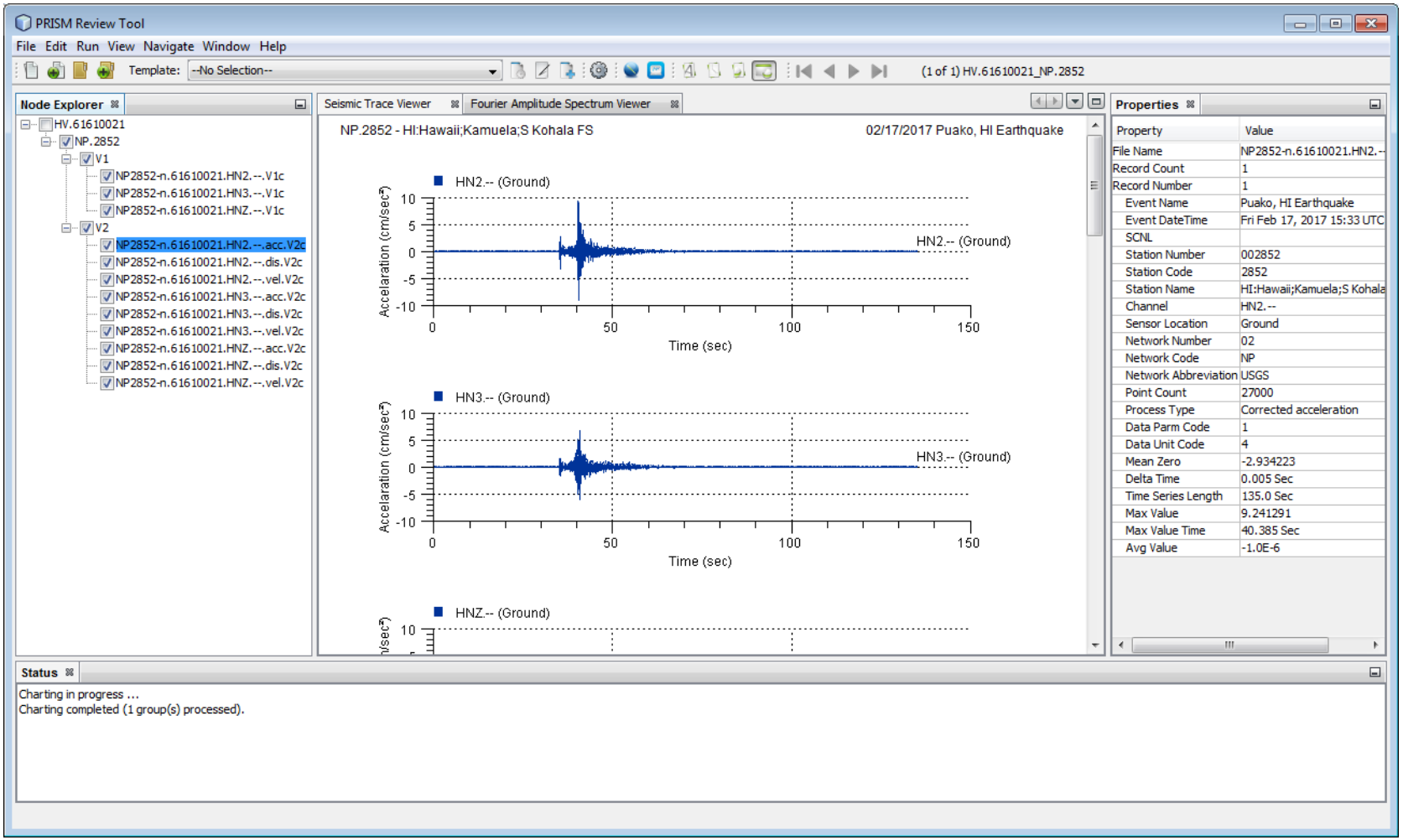
PRISM REVIEW TOOL

Java™ POWERED

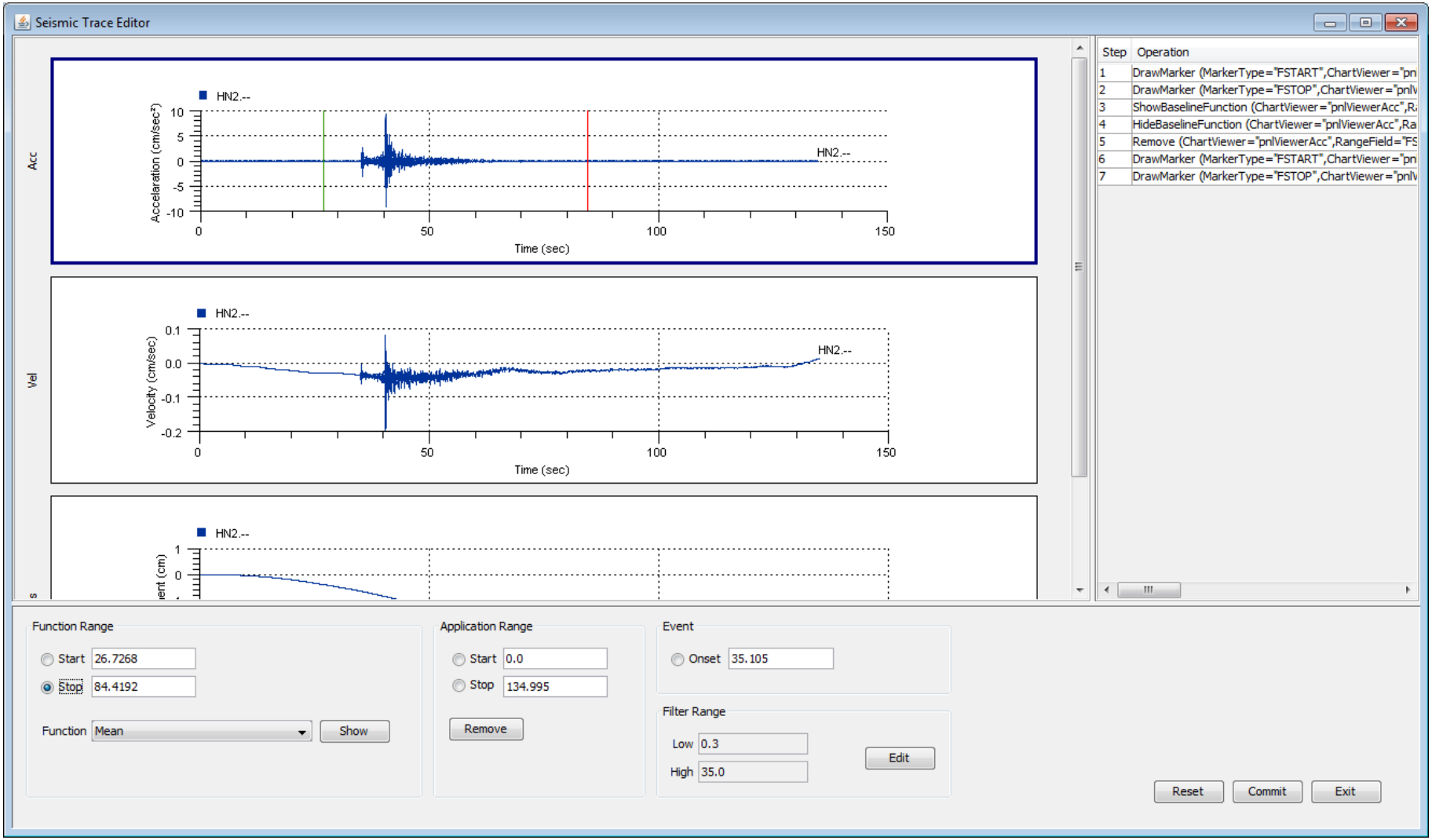
PRISM REVIEW TOOL

* **PRISM** desktop GUI application for manual review, editing, and processing of COSMOS datasets
* GUI utilizes processing engine API
* Multiple viewers and editors for handling seismic and spectral trace data
* Template processing
* GUI customization
* Platform independent

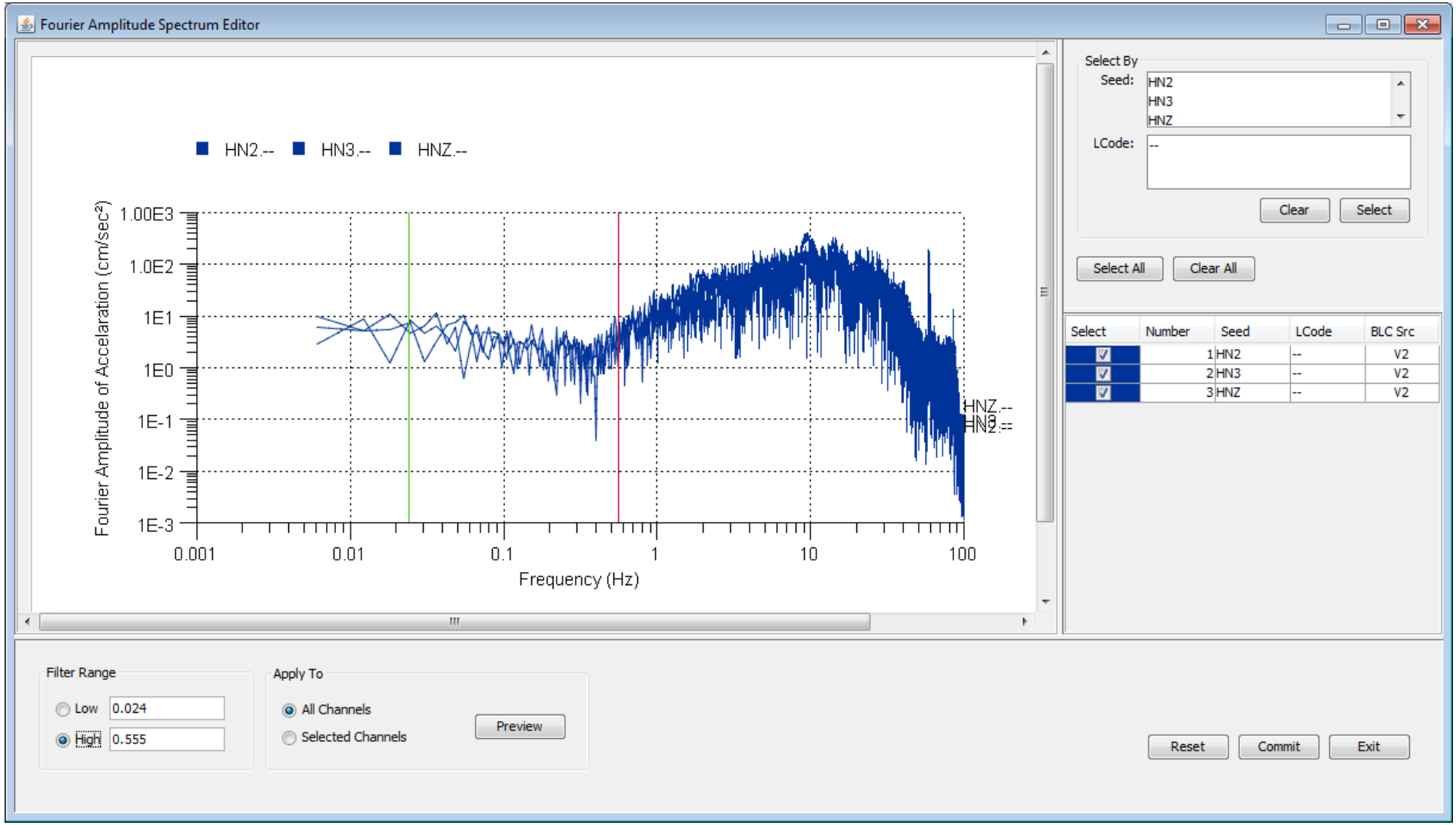
MAIN INTERFACE



SEISMIC EDITOR



SEISMIC EDITOR (cont.)



DOCUMENTATION

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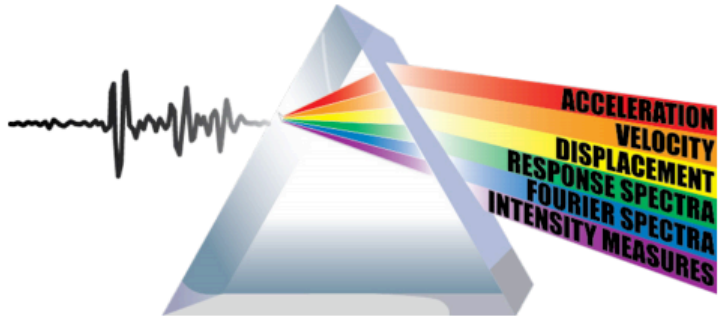
Processing and Review Interface for Strong Motion Data (PRISM) Software, Version 1.0.0—Methodology and Automated Processing

By Jeanne Jones, Erol Kalkan, and Christopher Stephens



Open-File Report 2017–1008

U.S. Department of the Interior
U.S. Geological Survey

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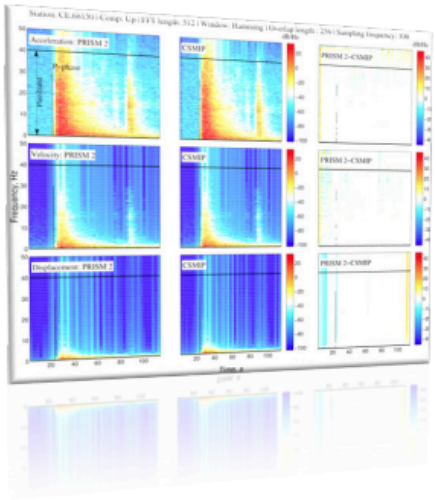
Systematic Comparisons Between PRISM Version 1.0.0, BAP, and CSMIP Ground-Motion Processing

By Erol Kalkan and Christopher Stephens



Open-File Report 2017–1020

U.S. Department of the Interior
U.S. Geological Survey

DOCUMENTATION (cont.)

PRISM Software: Processing and Review Interface for Strong-Motion Data

by Jeanne Jones, Erol Kalkan, Christopher Stephens, and Peter Ng

ABSTRACT

A continually increasing number of high-quality digital strong-motion records from stations of the National Strong Motion Project (NSMP) of the U.S. Geological Survey, as well as data from regional seismic networks within the United States, calls for automated processing of strong-motion records with human review limited to selected significant or flagged records. The NSMP has developed the Processing and Review Interface for Strong Motion data (PRISM) software to meet this need. In combination with the Advanced National Seismic System Quake Monitoring System (AQMS), PRISM automates the processing of strong-motion records. When used without AQMS, PRISM provides batch-processing capabilities. The PRISM software is platform independent (coded in Java), open source, and does not depend on any closed-source or proprietary software. The software consists of two major components: a record processing engine composed of modules for each processing step, and a review tool, which is a graphical user interface for manual review, edit, and processing. To facilitate use by non-NSMP earthquake engineers and scientists, PRISM (both its processing engine and review tool) is easy to install and run as a stand-alone system on common operating systems such as Linux, OS X, and Windows. PRISM was designed to be flexible and extensible to accommodate implementation of new processing techniques. All the computing features have been thoroughly tested.

INTRODUCTION

A continually increasing number of high-quality digital strong-motion records acquired from stations of the National Strong Motion Project (NSMP) of the U.S. Geological Survey (USGS), as well as data from regional seismic networks within the United States, calls for automated processing of strong-motion records with human review limited to selected significant events or to events identified as being problematic during automatic processing. The NSMP has developed the Processing and Review Interface for Strong Motion data (PRISM) software to meet this need, and to replace the outdated software program BAP (Basic Strong-Motion Accelerogram Processing; Converse and Brady, 1992) developed and used by the NSMP to process earthquake strong-motion records.

The PRISM software consists of two major components: a module-based record processing engine, and a review tool—a graphical user interface (GUI)—to manually review, edit, and process records. NSMP implements PRISM in a structured workflow environment that includes an instance of the Advanced National Seismic System Quake Monitoring System (AQMS) to automatically acquire and process strong-motion records. PRISM can also operate in a batch-processing mode. The PRISM software is platform independent (coded in Java), open source, and does not depend on any closed-source or proprietary software. To facilitate use by earthquake engineers and scientists, the PRISM processing engine and review tool are easy to install and run as a stand-alone system on common operating systems such as Linux, OS X, and Windows. PRISM was designed to be flexible and extensible to accommodate implementation of new processing techniques. The processing engine implements each processing step according to a well-defined application-programming interface (API) to allow incorporation of alternative implementations of each step.

Input to PRISM is currently limited to data files in Consortium of Organizations for Strong Motion Observation Systems (COSMOS) V0 format (COSMOS, 2001), so that all acceleration input time series need to be converted to this format. COSMOS V0 files contain raw acceleration time-series data in digital counts. All associated metadata, and particularly instrument response parameters, should be in the COSMOS V0 headers. In addition, earthquake magnitude is required for selecting appropriate band-pass filter corners. Output products include files in COSMOS V1 (raw acceleration time series in physical units with mean removed), V2 (baseline-corrected and filtered acceleration, velocity, and displacement time series), and V3 (response spectra, Fourier amplitude spectra [FAS], and common earthquake-engineering intensity measures [IMs]) formats.

PRISM joins a suite of tools also used by other ground-motion processing software (e.g., BAP, Converse and Brady, 1992, SeismoSignal, SeismoSoft, 2016), even though this software certainly has features not present in others. This article presents an overview of PRISM 1.0.0, including the processing engine and the review tool; updated PRISM versions will follow a sequenced-base major.minor.patch version identifier. All the computing features of PRISM have been thoroughly tested. Details of PRISM, including the configuration file format, how to run PRISM, output log files, and a performance assessment, can be found in Jones *et al.* (2017).

The complete list of abbreviations and symbols used throughout this article is given in Table 1.

doi: 10.1785/0220160200

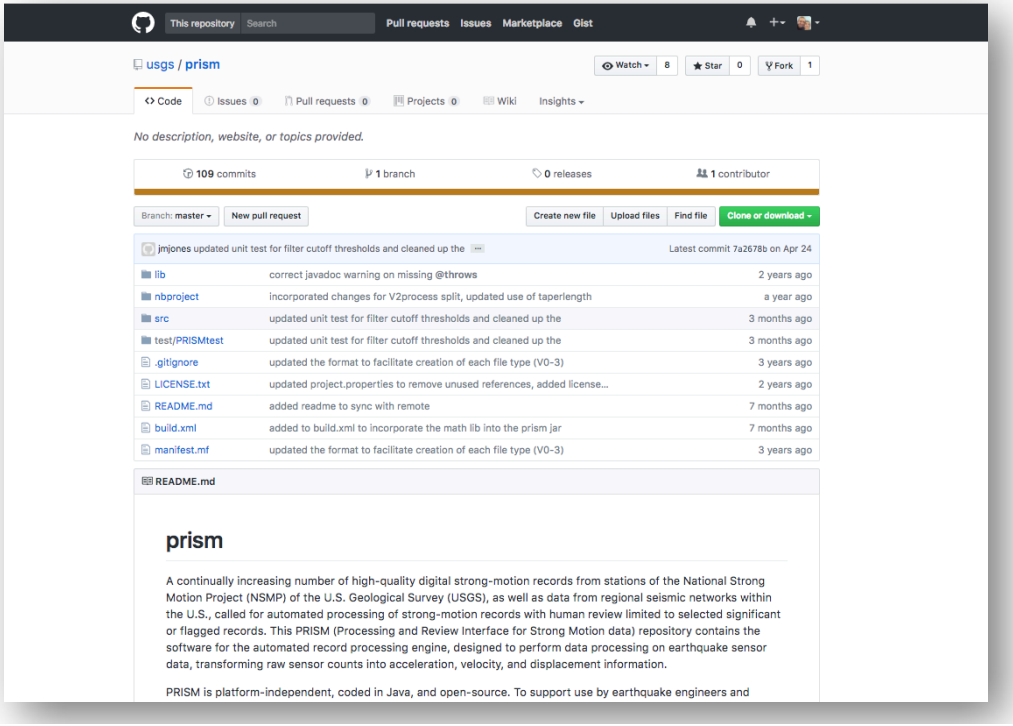
Jones, J., Kalkan, E., Stephens, C. and Ng, P. (2017). PRISM Software: Processing and Review Interface for Strong-Motion Data, *Seismological Research Letters*, doi:10.1785/0220160200

PRISM @ GitHub

PRISM processing-engine source code is at

GitHub

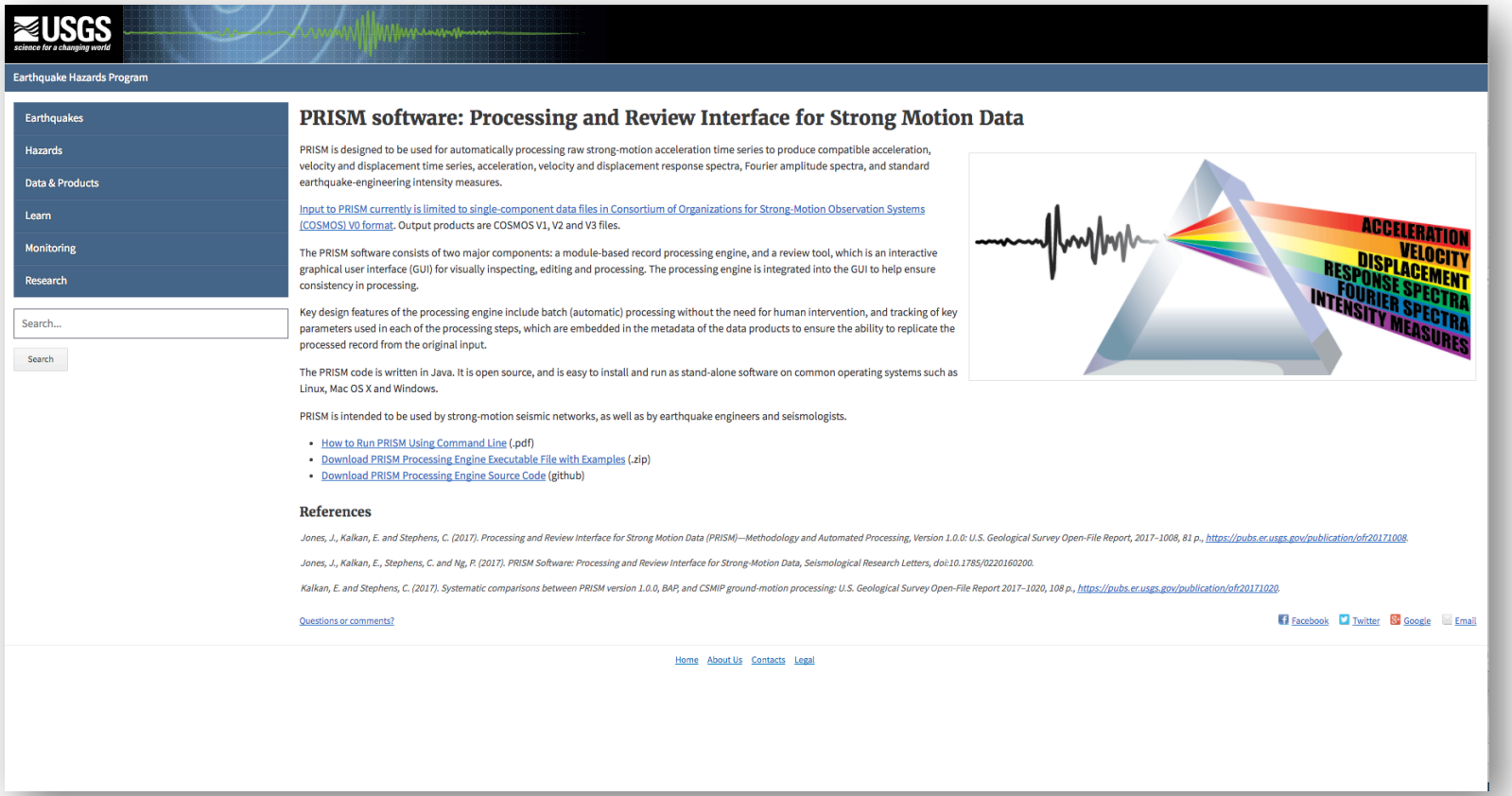
https://github.com/usgs/prism



PRISM @ USGS SOFTWARE WEBSITE

PRISM documentation and GitHub links are available at

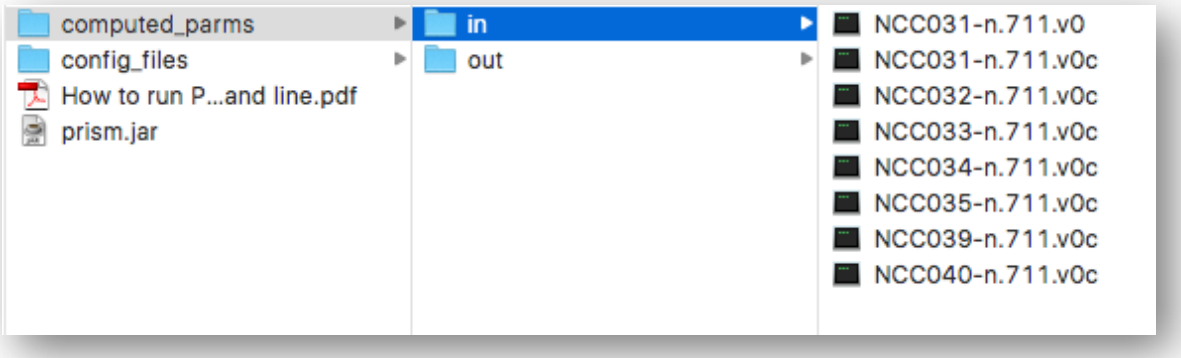
https://earthquake.usgs.gov/research/software/#prism



HOW TO RUN PRISM PROCESSING ENGINE

Simple four-step procedure with example data set is @ https://earthquake.usgs.gov/research/software/#prism

- How to Run PRISM Using Command Line (.pdf)
- Download PRISM Processing Engine Executable File with Examples (.zip)
- Download PRISM Processing Engine Source Code (github)



How to run PRISM 1.0.0 using command line
(simple four step procedure for WINDOWS/MAC/LINUX)

1. Make sure that you have Java installed, and the version should be 8.0 or higher. If you don't have Java you can download it freely from

   http://www.oracle.com/technetwork/java/javase/downloads/index-jsp-138363.html

2. Extract "PRISM 1.0.0.zip"file. The directory/folder "PRISM 1.0.0" will have the "prism.jar" file and sample V0 files under "/computed_params/" in folder and the sample configuration file under "/config_files/" folder.

3. Open a terminal window, and Change directory (cd) into the PRISM 1.0.0 directory/folder where the prism.jar file is located.

4. Type

   java -jar prism.jar ./computed_parms/in ./computed_parms/out ./config_files/prism_config.xml

   Any error messages that occur while prism is running will be written to the terminal window. The logs are located in the output directory <./computed_parms/out> along with the processed V1-V3 files. Copies of the original V0 files are also written here.

In 4. above, one can replace <./computed_parms/in> with the full path name of the directory where the sample test V0 files are located. Replace <./computed_parms/out> with the full path name of the directory where you want the results to be written. Replace <./config_files/prism_config.xml> with the full path name, ***including file name***, of the configuration file that you downloaded.

PRISM 2.0

Proposed updates:

* Pre-screening of V0 files by computing signal-to-noise ratio (SNR) [Reject V0 files if SNR < 3]
* Automatic computation of filter corner frequencies for V2 processing based on frequency content [Replace current magnitude dependent look up table]

PRISM 2.0 (cont.)

Proposed updates:

* Implement frequency domain decimation algorithm [decimate records after V2 processing to original sampling rate]
* Implement frequency domain integration and differentiation
* Develop conversion tools for broader use

PRISM 3.0: CLOUD COMPUTING

CONCLUDING REMARKS

* A robust automated data processing procedure is essential to ensure high-quality products for immediate use in engineering applications and for seismological studies
* Although there are no unique procedures for processing, PRISM utilizes widely accepted methods (e.g., Shakal et al., 2003, 2004; Stephens and Boore, 2004; Boore and Bommer, 2005; COSMOS, 2005) that are designed to remove low- and high-frequency noise in order to provide reliable estimates of velocity and displacement time series
* All of the essential steps applied in PRISM, whether automatic or manual, are documented in the ASCII file headers of the processed time series so that users can evaluate the suitability of the data for their intended application

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CREDITS FOR LOGOS

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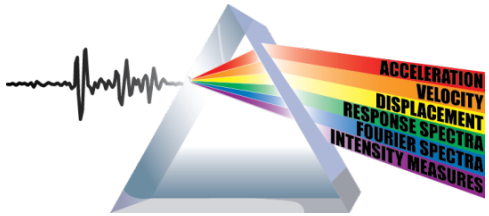
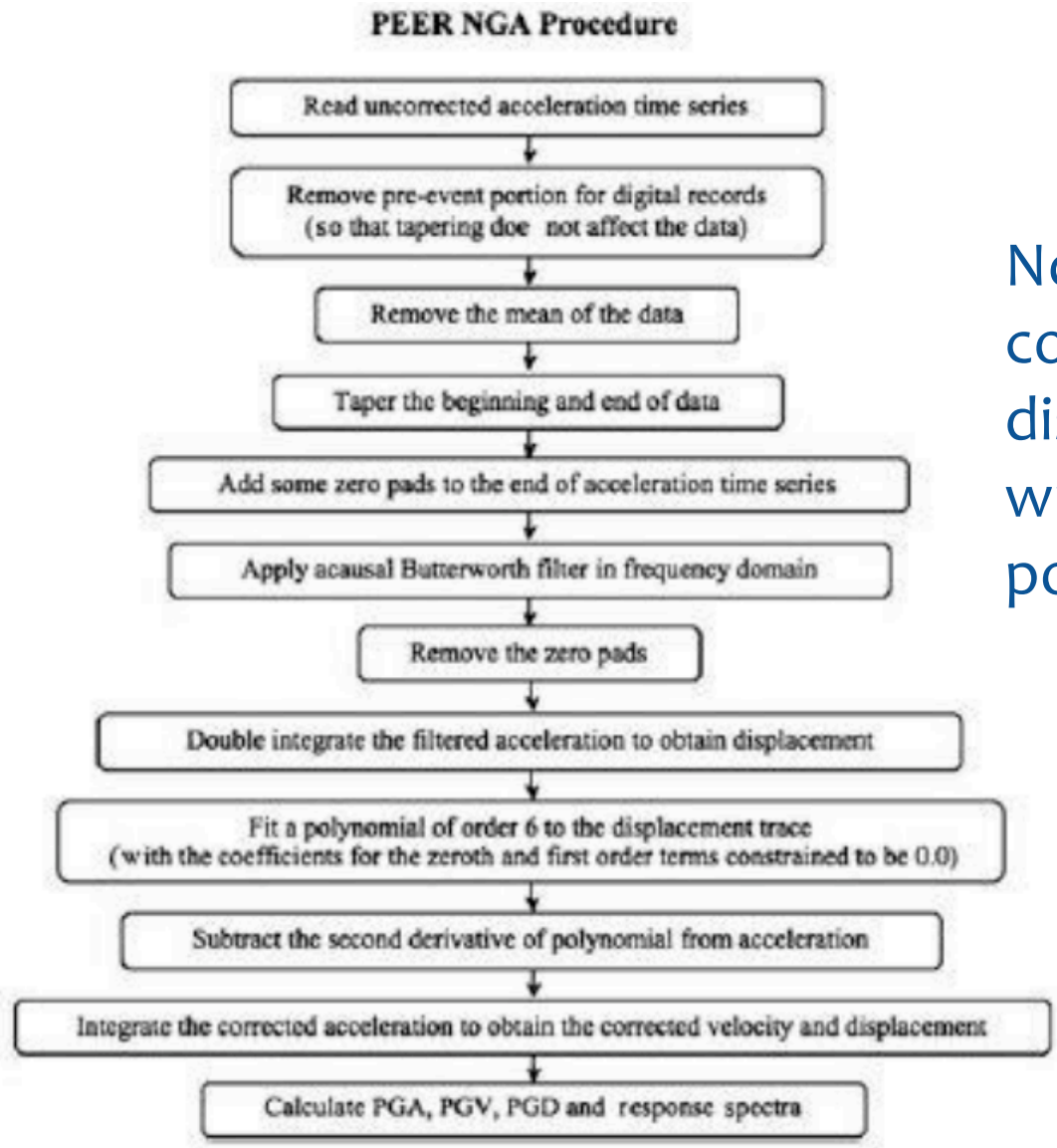
http://www.coolheadtech.com/blog/cloud-computing-pros-and-cons

THANK YOU FOR YOUR TIME & ATTENTION!!!



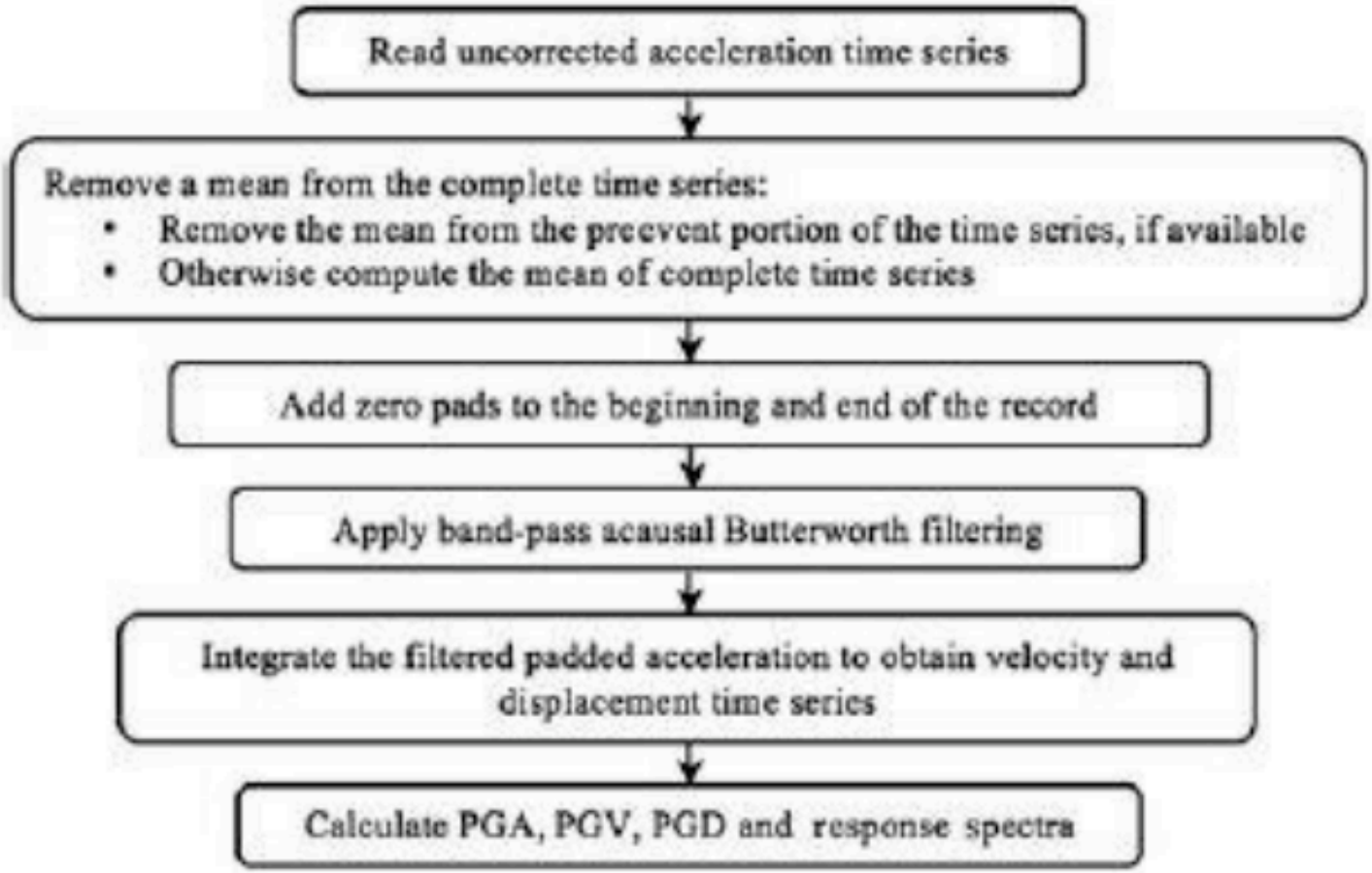
EXTRA: PEER NGA PROCESSING



Note: baseline correction done at displacement level with 6th order polynomial

Adapted from Boore et al. (2012)

EXTRA: ITACA PROCESSING



Adapted from
Boore et al. (2012)

Note: no baseline correction