

Latest Assessment of Seismic Station Observations (LASSO)

Reference Guide and Tutorials

I. Introduction

[LASSO](#) is a software tool, developed by [Instrumental Software Technologies Inc.](#) in conjunction with IRIS Instrumentation Services, which utilizes data quality metrics produced by [MUSTANG](#). Metrics are calculated for standard broadband channels archived with IRIS Data Services and most major [virtual networks and networks](#) have complete metrics available now for standard broadband channels, and in the future LASSO will reflect added channels and metrics within MUSTANG. [Available metrics](#) can be identified through MUSTANG.

This software downloads and displays MUSTANG measurements entirely within your web-browser. Users should report on their experiences and suggest improvements to mustang-lasso@lists.ds.iris.edu. Please provide enough documentation such that any errors can be reproduced. This software was tested using Google Chrome. If a process stalls, send a bug report and refresh the page to begin using LASSO again.

This tutorial was developed using the most recent version (2.0.1) of LASSO. The following examples demonstrate to you, the user, how LASSO functions.

II. Basic Mode

The landing page for LASSO is its 'Basic' mode, which accesses grouped metrics to explore and evaluate key aspects of data quality for common seismic time series data:

- Derived Data Availability – Calculates the percentage of quality data for each channel by combining `percent_availability` and `dead_channel_gsn`
- Mass Positions – Derives output voltages for each seismometer using digitizer and instrument information.
- Noise Power – Returns the daily seismic noise level at seven selected periods.
- Signal Quality – Characterizes aspects of the seismic timeseries amplitude.
 - `calibration_signal` – flag a calibration signal if present, as this could be mistaken for a source signal
 - `sample_rms` – daily root-mean-square (RMS) variance of a time series, potentially indicating a dead channel or large number of calibration pulses
 - `sample_snr` – ratio of the RMS variance calculated for large teleseismic earthquakes, per earthquake
 - `pct_above_nhnm` – percentage of PDFs in a day exceeding the Peterson (1993) high noise model
- Metadata Validity – Provides information on the timing quality of the seismic channels.
 - `suspect_time_tag` – questionable clock quality if datalogger has not obtained a satellite lock since the system last powered up
 - `timing_quality` – daily average of timing quality based on the accuracy of a datalogger's sampling clock relative to an external reference, e.g. GPS
 - `timing_correction` – whether a timing correction has been applied
- Time Series Integrity – Demonstrates robustness of the archived data stream.
 - `num_gaps` – count for data gaps encountered
 - `num_overlaps` – count for data overlaps encountered, often indicates a time tear
 - `percent_availability` – percentage of data available
 - `max_gap` – length of largest gap encountered in seconds

View:

Metrics:

Search: By Virtual Network By Network

Virtual Network: Global Seismographic Network stations and arrays

Location(s):

Channel(s):

Ranking: Qualitative Quantitative

Display: Snapshot Mean Median

Time:

Show Counts:

The following input is required:

- Metric or Derived Metric grouping
- Virtual Network or Network
- Location(s) and Channel(s): Preloaded with common options or pairings
- Ranking¹: 'Qualitative' (logic-based) or 'Quantitative' (numeric)
- Table Type: 'Snapshot' displays metrics for only that day, while the 'Mean' and 'Median' calculate these values over the user-specified time range.
- Time: The user can set one date relative to another by clicking 'Set to' and choosing from the list of time frames or by entering the calendar dates in each field.
- Show Count: Checking this box adds another column for each metric, displaying the number of measurements in the time range and the number of rule-satisfying measurements.

¹This uses the status of each table entry metric to characterize an overall 'Rank' (second column) for each target row, i.e. 'good' is green, 'fair' is yellow, and 'bad' is red. For 'Qualitative', the worst result guides the 'Rank', so three 'good' and one 'bad' is overall 'bad'. For 'Quantitative', scores for 'good' (100), 'fair' (50), and 'bad' (0) are weighted and summed. Clicking the 'Rule' button in Rank column allows these parameters to be edited; change the values, click 'Save Changes', and the new values will be applied. If no edits have been made, unclick the button to return to the main page. Classifications for the individual metric rankings can be changed with the 'Rule' buttons (see below).

Tutorial A – Run LASSO!

To sample the output of LASSO, set the date in “Time:” to 2017-01-01 and click ‘Get Measurements’. The size of a query (# targets, duration) scales with the time needed to complete it. A progress bar will appear as measurements are requested. For some loads it will animate, filling from left to right as metrics load and disappearing when the process completes. It may take several minutes or more to query measurements in the following examples.

Derived Data Availability view of _GSN for 2017-01-01T00:00:00 requested at Tue Oct 15 2019 15:01:36 GMT-0400 (Eastern Daylight Time):

REQUESTING DATA...

Target	Rank	percent_availability <small>? Rule</small>	dead_channel_gsn <small>? Rule</small>	derived_data_avail <small>? Rule</small>
Averages:				
		Avg:	Avg:	Avg:

Each row in the table is labeled by its network, station, location (which is left blank for ‘--’), channel, and metric quality (usually shown by ‘M’, for ‘merged’), and has columns color-coded by ‘quality’; ‘good’ (green), ‘fair’ (yellow), and ‘bad’ (red). Those assignments are guided by the rules specific to each metric, which we will explore later. The columns of the table are sortable by clicking the up or down arrow in each one. If searching on a specific part of a target (e.g. IU, PASC, 10, BHZ) then enter it into the ‘Search’ field.

Show entries Search:

Target	Rank	percent_availability <small>? Rule</small>	dead_channel_exp <small>? Rule</small>	data_availability <small>? Rule</small>
AU.MCQ..BHE.M <small>Data</small>	03,00,00	100.00	0.45	100.00
AU.MCQ..BHN.M <small>Data</small>	03,00,00	100.00	0.43	100.00
AU.MCQ..BHZ.M <small>Data</small>	03,00,00	100.00	0.51	100.00
BK.CMB.00.BHE.M <small>Data</small>	03,00,00	100.00	0.45	100.00
BK.CMB.00.BHN.M <small>Data</small>	03,00,00	100.00	0.42	100.00
BK.CMB.00.BHZ.M <small>Data</small>	03,00,00	100.00	0.54	100.00

Depending on the length of your LASSO query, clicking [Data] uses webservises to display up to 31 days of corresponding timeseries data that underlie the displayed metrics.

Above each metric column, [?] and [Rule] buttons are displayed. When clicked, these present additional information about the metrics selected.

- [?] provides the technical background for each corresponding metric. Unless otherwise stated, most MUSTANG metrics represent a single day of data.
- [Rule] shows a pop-up box with the parameters governing grading and colored coding of metric quality. Users can change the criteria by clicking “Edit” or exit the pop up by clicking “Rule” again.

Click ‘Target’ to sort the table alphabetically. Explore this view; you can see an example of how this derived metric works, adjusting (or not) the ‘percent availability’ term to be ‘derived data availability’ depending on the value of ‘dead_channel_gsn’. Sorting on ‘dead_channel_gsn’ and scrolling to IU.TIXI.00.BH1 shows an example of this adjustment when ‘dead_channel_gsn’ becomes unacceptably low. This derived metric may be further refined in the future to avoid potential false positives.

IU.TIXI.00.BH1.M <small>Data</small>	01,00,02	100.00	1.00	0.00
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Tutorial B – Examine an Expanded Basic View

Now that you have some familiarity with LASSO, we will extend this to a larger group of metrics for an entire year.

Change the following parameters:

View: Time Series Integrity

Channel(s): BH[3,Z]

Table Type: Mean

Start Time: 2016-01-01 00:00:00

End Time: 2017-01-01 00:00:00

Show Counts²:

² ‘Counts’ are shown as a fraction, where the denominator shows the number of measurements available (typically one per day) and the numerator represents the number of measurements that qualify as ‘good’.

Click ‘Get Measurements’.

Target	Rank	num_gaps		Count	num_overlaps		Count	percent_availability		Count	max_gap		Count
		? Performance Rule			? Performance Rule			? Performance Rule			? Performance Rule		
IC.LSA.10.BHZ.M	Data	00,00,01						0.00	0/315				
IC.MDJ.10.BHZ.M	Data	00,00,01						0.00	0/366				
II.TLY.00.BHZ.M	Data	00,00,01						0.00	0/366				
IU.KIEV.00.BHZ.M	Data	00,00,01						0.00	0/366				
IU.PTGA.00.BHZ.M	Data	00,00,01						0.00	0/366				
IU.TRIS.10.BHZ.M	Data	00,00,01						0.00	0/78				
MS.BTDF.01.BHZ.M	Data	00,00,01						0.00	0/366				
MS.BTDF.02.BHZ.M	Data	00,00,01						0.00	0/366				
II.ASCN.00.BHZ.M	Data	01,01,02	2.00	0/1	0.00	1/1	0.00	0/366	86398.32	0/1			
II.COCO.00.BHZ.M	Data	01,01,02	2.00	0/1	0.00	1/1	0.00	0/366	86398.32	0/1			
II.SACV.00.BHZ.M	Data	02,00,02	0.04	262/271	0.00	271/271	0.00	0/366	1111.17	267/271			
HK.HKPS.00.BHZ.M	Data	02,00,02	0.10	113/123	0.00	123/123	33.15	120/366	1180.90	113/123			
IU.TEIG.00.BHZ.M	Data	01,00,03	5.16	168/170	0.00	170/170	46.11	168/366	569.97	168/170			
IU.TEIG.10.BHZ.M	Data	02,00,02	0.03	166/170	0.00	170/170	46.12	168/366	556.34	166/170			
IU.SAML.00.BHZ.M	Data	01,00,03	8.19	127/274	0.00	274/274	52.05	134/366	20375.16	127/274			
II.NIL.00.BHZ.M	Data	02,00,02	0.91	172/271	0.00	271/271	53.20	174/366	6564.76	214/271			
II.NIL.10.BHZ.M	Data	02,00,02	0.91	170/272	0.00	272/272	54.27	179/366	5133.30	222/272			
IU.KOWA.00.BHZ.M	Data	02,00,02	0.64	165/209	0.00	209/209	54.53	192/366	3144.77	165/209			
IU.WCI.00.BHZ.M	Data	02,00,02	0.06	215/219	0.00	219/219	59.52	217/366	452.15	215/219			
IU.WCI.10.BHZ.M	Data	02,00,02	0.03	215/219	0.00	219/219	59.52	217/366	454.56	215/219			
IU.KNTN.00.BHZ.M	Data	02,00,02	0.06	218/228	0.00	228/228	61.58	223/366	977.26	219/228			
II.FFC.00.BHZ.M	Data	02,00,02	0.08	233/252	0.00	252/252	65.71	235/366	3250.14	236/252			
II.CMLA.10.BHZ.M	Data	02,00,02	0.09	338/362	0.00	362/362	65.78	238/366	1247.47	344/362			
II.FFC.10.BHZ.M	Data	02,00,02	0.73	201/253	0.00	253/253	66.31	236/366	2804.28	203/253			
IU.TRIS.00.BHZ.M	Data	02,01,01	0.79	143/284	0.00	284/284	75.04	270/366	2720.44	203/284			
IU.OTAV.00.BHZ.M	Data	02,02,00	0.01	285/287	0.00	287/287	78.36	286/366	59.52	286/287			
IU.OTAV.10.BHZ.M	Data	02,02,00	0.01	285/287	0.00	287/287	78.36	286/366	59.46	286/287			

Sort by ‘percent_availability’ (i.e. blue arrow on right-hand side is up) so that the lowest values appear at the top. A handful of the 274 channels recalled show unacceptably low ‘percent_availability’ during 2016. Scroll down to ‘IU.WCI.00.BHZ.M’, which should have a value of 59.52. Note that the box will become white when you hover your cursor over it, so that you know it is selected. Clicking will produce a pop-up with an x-y graph displaying the daily value for the selected period.

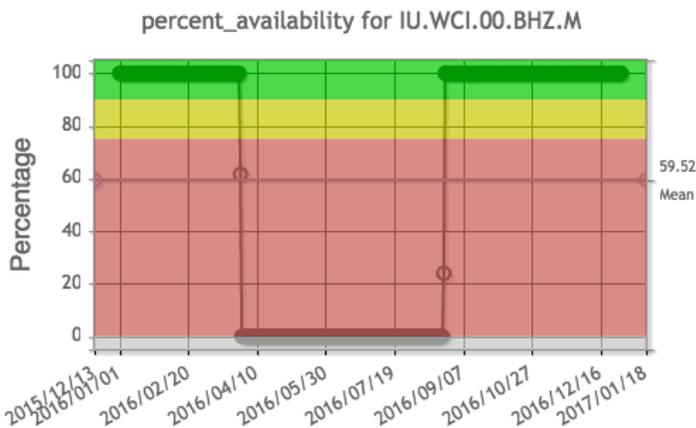
The mean percent availability for this period is plotted as a line and the value is noted on the right of the graph. The period of time when no data are available can be clearly seen. Clicking [View Plot As Image Below] creates a PNG-format image that can be dragged to the Desktop or saved by right-clicking. You can also open the plot in a separate tab/window by clicking on ‘Link to this plot’ in most browsers; this link can be shared as needed.

IU.WCI.00.BHZ.M



2016-01-01T00:00:00 to 2017-01-01T00:00:00

percent_availability



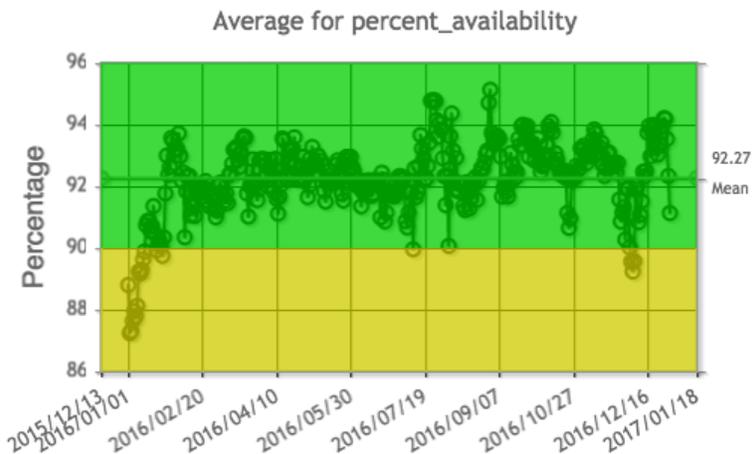
View Plot As Image Below (may need to scroll it into view)

Download Data (.csv) [Link to this plot](#)

Finally, should you want to work with this data outside of LASSO, click 'Export Data as CSV' to open a separate tab listing these measurements. Clicking outside of the pop-up returns you to the original view. If you click on the station name in the 'Target' column', it yields plots of all metrics in one pop up. Take a moment to explore these options.

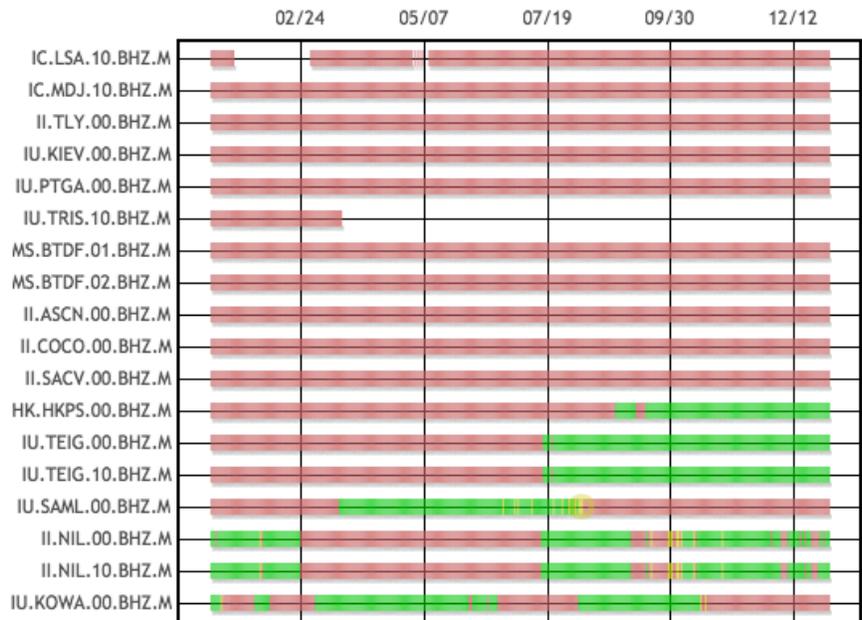
If you scroll to the bottom of the table, you will see the averages for each column. Clicking on these cells will display corresponding graphs. These represent the overall network performance for the year. A daily mean is calculated for the targets available for each day and then averaged over the duration of measurements. This avoids weighting the value towards one target more than others.

IU.YAK.00.BHZ.M	Data	04.00.00	0.00	365/366	0.00	366/366	100.00	366/366	0.90	365/366
IU.YSS.00.BHZ.M	Data	04.00.00	0.04	356/366	0.00	366/366	100.00	366/366	7.48	356/366
Averages:			Avg: 0.30		Avg: 0.00		Avg: 92.27		Avg: 546.29	



Scroll back up and note the [Performance] button that now appears at the top of each metric column. Clicking this will load a pop-up graph showing that metric's performance (assigned quality per day) during the time period displayed for the stations available. The plot can be similarly accessed in a separate window and shared. These plots are currently not available for derived or specialized metrics (mass positions, derived_data_avail, noise power).

Performance of percent_availability ×
 2016-01-01T00:00:00 to 2017-01-01T00:00:00
 IU.SAML.00.BHZ.M, 2016-08-08T00:00:00 thru 2016-08-08T23:59:59: **77.83**



Clicking on 'Download Table (.csv)' (below the request form and above 'Time Series Integrity view...') will export the table of results as comma-separated values. Here you will see the results ordered the same as how they are sorted on screen. This option will only appear when the query has successfully completed.

```

II.ASCN.00.BHZ.M,"01,01,02",2.00,0/1,0.00,1/1,0.00,0/366,86398.32,0/1
II.COCO.00.BHZ.M,"01,01,02",2.00,0/1,0.00,1/1,0.00,0/366,86398.32,0/1
II.SACV.00.BHZ.M,"02,00,02",0.04,262/271,0.00,271/271,0.00,0/366,1111.17,267/271
HK.HKPS.00.BHZ.M,"02,00,02",0.10,113/123,0.00,123/123,33.15,120/366,1180.90,113/123
IU.TEIG.00.BHZ.M,"01,00,03",5.16,168/170,0.00,170/170,46.11,168/366,569.97,168/170
IU.TEIG.10.BHZ.M,"02,00,02",0.05,166/170,0.00,170/170,46.12,168/366,556.34,166/170
IU.SAML.00.BHZ.M,"01,00,03",8.19,127/274,0.00,274/274,52.05,134/366,20375.16,127/274
II.NIL.00.BHZ.M,"02,00,02",0.91,172/271,0.00,271/271,53.20,174/366,6564.76,214/271
II.NIL.10.BHZ.M,"02,00,02",0.91,170/272,0.00,272/272,54.27,179/366,5133.30,222/272
IU.KOWA.00.BHZ.M,"02,00,02",0.64,165/209,0.00,209/209,54.53,192/366,3144.77,165/209
IU.WCI.00.BHZ.M,"02,00,02",0.06,215/219,0.00,219/219,59.52,217/366,452.15,215/219
IU.WCI.10.BHZ.M,"02,00,02",0.03,215/219,0.00,219/219,59.52,217/366,454.56,215/219
IU.KNTN.00.BHZ.M,"02,00,02",0.06,218/228,0.00,228/228,61.58,223/366,977.26,219/228
II.FFC.00.BHZ.M,"02,00,02",0.08,233/252,0.00,252/252,65.71,235/366,3250.14,236/252
II.CMLA.10.BHZ.M,"02,00,02",0.09,338/362,0.00,362/362,65.78,238/366,1247.47,344/362
II.FFC.10.BHZ.M,"02,00,02",0.73,201/253,0.00,253/253,66.31,236/366,2804.28,203/253
  
```

Tutorial C – Investigate Mass Positions, Modify and Save Settings

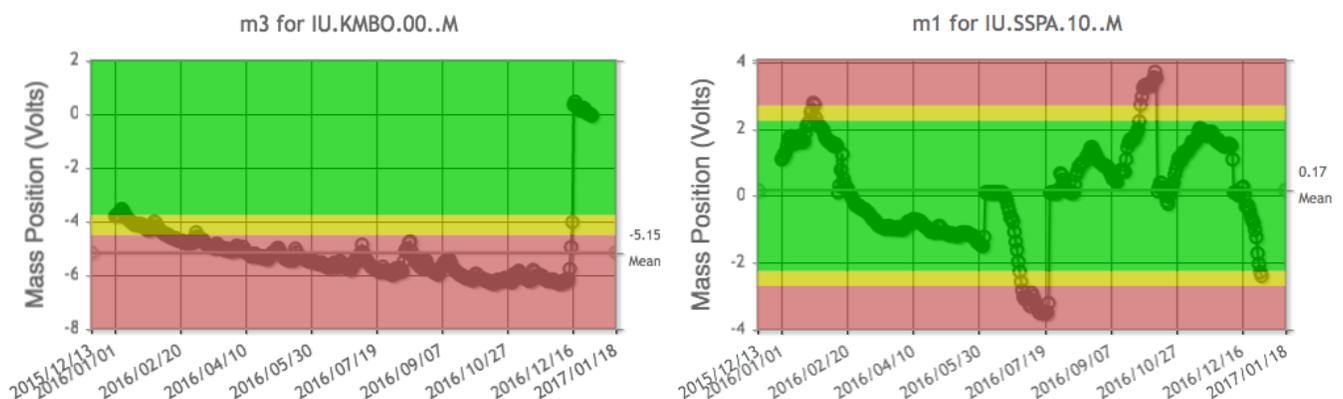
We can shift over to examine the ‘Mass Positions’ derived metrics, which allows the user to explore a how the voltage levels of a seismometer vary over time.

Change the following parameters:
View: Mass Positions

Click ‘Get Measurements’. The average voltages of each seismometer’s mass positions (m1, m2, m3) will load. Unusually high or low voltages may indicate a malfunctioning or tilted instrument. The ‘quality’ for each mass position is determined by comparison with the voltage limits expected for the type of corresponding seismometer and datalogger settings, information that is derived by LASSO from the station’s metadata. Cells marked green are within 75% of the voltage limits, yellow are 75-90%, and red exceed 90%. Sort the table by ‘Rank’ to see which instruments did not satisfy the default rule criteria for one or more masses.

Target	Rank	m1	Count	m2	Count	m3	Count
		? Rule		? Rule		? Rule	
IU.QSPA.80..M	00,01,00					-4.39	3/366
IU.HKT.00..M	01,00,02	5.45	127/344	-4.81	126/344	-0.40	344/344
IU.SNZO.00..M	01,02,00	0.35	366/366	4.27	0/366	4.10	0/366
II.CMLA.00..M	02,00,01	0.10	325/325	0.16	325/325	4.50	0/325
II.EFI.00..M	02,00,01	0.09	364/364	0.17	364/364	-6.60	0/364
II.KAPI.00..M	02,00,01	0.40	363/363	0.30	363/363	-7.30	0/363
II.KDAK.00..M	02,00,01	-0.30	344/344	0.10	344/344	-8.00	0/344
II.MBAR.00..M	02,00,01	0.16	366/366	-0.17	366/366	-5.40	0/366
II.MSEY.00..M	02,00,01	0.23	358/358	0.40	358/358	-9.45	0/358
II.MSEY.10..M	02,00,01	-1.47	65/65	-8.02	0/65	-0.07	295/295
II.MSVF.00..M	02,00,01	-0.30	350/350	0.18	350/350	-8.70	0/350
II.NIL.00..M	02,00,01	0.10	305/305	0.14	305/305	-5.00	0/305
II.PALK.00..M	02,00,01	0.06	366/366	0.10	366/366	-5.70	0/366
II.SHEL.00..M	02,00,01	0.10	366/366	0.10	366/366	-6.10	0/366

Clicking on any of the entries near the top shows the behavior of masses for several questionable seismometers. For example, the ‘m3’ field for IU.KMBO.00.M shows a mean of -5.15. Clicking on this shows a steady drift of the mass voltage that is not corrected until near the end of 2016, resulting in only 21/366 ‘good’ measurements and an expectedly ‘bad’ average. In contrast, scroll to IU.SSPA.10 and click on ‘m1’, which has 319/362 ‘good’ measurements for the period. Closer inspection shows that although the overall value was good, the seismometer required several recenterings to keep the mass within specification. Clicking on IU.SSPA.00 shows plots for ‘m1’, ‘m2’, and ‘m3’ and allows the user to see how voltages of the mass positions often correlate.



Now, we will explore how the parameters for rules can be changed and retained. Click the ‘Edit’ button for ‘m1’. A pop-up shows the “Rule editor” with editable fields. Here, you can change the threshold

percentages by which 'm1' is assessed. Change 0.75 and -0.75 to 0.25 and -0.25 respectively. In this case, we have decreased the tolerance for mass positions, making it more likely for a voltage to be classified as 'fair' instead of 'good'. This changes the coloring of individual fields once you leave the editor, but you must click 'Get Measurements' again to redo ranks and counts.

Mass Positions view of _GSN thru 2017-01-01

Show All

Target	m1	Count
IU.QSPA.80..M	5.45	02,00,01
IU.HKT.00..M	0.35	
IU.SNZO.00..M	-0.47	
IU.QSPA.00..M	-2.05	
IU.PMSA.00..M		

m1 Rules

- bad >= fix(-Infinity)
- fair >= fix(-0.900)
- good >= fix(-0.750)
- fair >= fix(0.750)
- bad >= fix(0.900)

Edit

Rule editor for metric 'm1'

- bad >= -Infinity
- fair >= -0.900
- good >= -0.750
- fair >= 0.750
- bad >= 0.900

Add Line

m1 Rules

- bad >= fix(-Infinity)
- fair >= fix(-0.900)
- good >= fix(-0.250)
- fair >= fix(0.250)
- bad >= fix(0.900)

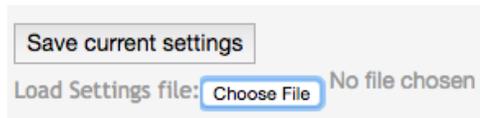
Edit

Target	Rank	m1	Count	m2	Count	m3	Count
IU.QSPA.80..M	00,01,00		?/undefined			-4.39	3/366
IU.RAO.00..M	03,00,00	-4.46	?/365	1.69	365/365	-0.74	365/365
II.RPN.00..M	03,00,00	-3.67	?/358	1.54	358/358	0.22	358/358
IU.GUMO.10..M	03,00,00	-3.09	?/366	-1.72	366/366	0.13	366/366
IU.KMBO.00..M	02,00,01	-2.93	?/366	-1.18	366/366	-5.15	21/366
IU.SDV.10..M	03,00,00	-2.76	?/75	2.17	75/75	0.39	75/75
IU.RAR.10..M	03,00,00	-2.56	?/366	1.12	366/366	2.79	366/366
IC.XAN.10..M	03,00,00	-2.55	?/355	-1.99	355/355	3.11	355/355
IU.TUC.00..M	03,00,00	-2.47	?/366	1.05	366/366	-1.88	197/366

Now, do the same for m2 and m3, and click 'Get Measurements' once again. We can see how this has changed the overall assessment of mass position quality.

Target	Rank	m1	Count	m2	Count	m3	Count
IU.QSPA.80..M	00,01,00					-4.39	0/366
II.COCO.00..M	00,03,00	1.63	102/361	1.67	102/361	1.61	102/361
IU.ANMO.10..M	00,03,00	1.85	30/365	1.82	30/365	1.87	30/365
IU.DAV.10..M	00,03,00	-0.82	145/366	-0.98	130/366	-1.02	121/366
IU.FUNA.10..M	00,03,00	-0.91	137/366	-0.93	162/366	-0.76	172/366
IU.GRFO...M	00,03,00	2.00	0/366	2.00	0/366	2.00	0/366
IU.KBS.00..M	00,03,00	1.74	77/366	-2.13	147/366	2.32	105/366
IU.RAR.00..M	00,03,00	-1.40	2/366	1.30	2/366	-2.91	2/366
IU.SSPA.00..M	00,03,00	2.00	0/362	2.00	0/362	2.00	0/362
IU.WVT.00..M	00,03,00	1.47	160/366	2.24	116/366	3.32	52/366
IU.HKT.00..M	01,00,02	5.45	44/344	-4.81	59/344	-0.40	344/344
II.MSEY.10..M	01,01,01	-1.47	0/65	-8.02	0/65	-0.07	295/295

Changes to rules will be lost if you restart LASSO. If you wish to avoid this, click 'Save Current Settings' at the bottom of the page. This will export lassoSettings.txt to your Desktop. This file can be modified locally and renamed as needed. Simply load the file using the 'Choose File' option if you need to use it in a future session.



Tutorial D – Assessing Noise Levels and Ranking Stations Quantitatively

The last type of view explores how noise levels vary across a network. Here we will examine how this can be diagnostic of station performance, as well as environmental conditions.

Change the following parameters:

- View: Noise Power³
- Channel(s): BH[1,2,N,E]
- Ranking: Quantitative
- Table Type: Median

Click 'Get Measurements'.

³ MUSTANG calculates power spectral density estimates for 47 continuous, overlapping, hour-long time segments per day. These measurements are used to form probability density functions for various durations of time, also stored in MUSTANG. The noise-mode-timeseries option displays the most common power (amplitude squared) observed for a specified period of the daily PDF of a station.

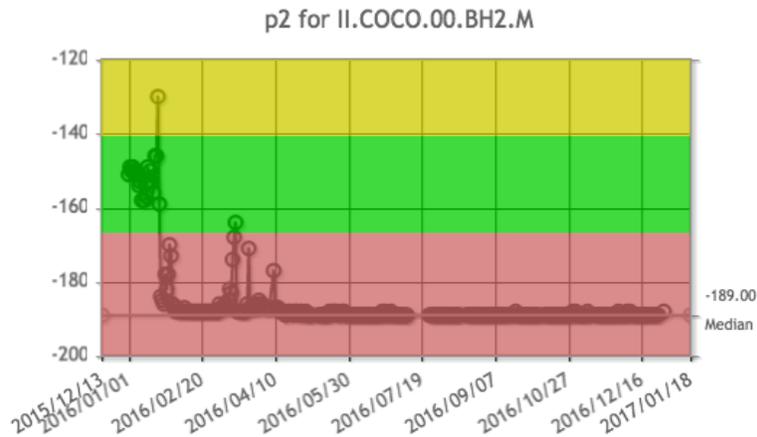
Target	Rank	p1	Count	p2	Count	p3	Count	p4	Count	p5	Count	p6	Count	p7	Count	
	Rule	? Rule		? Rule		? Rule		? Rule		? Rule		? Rule		? Rule		
AU.MCQ..BHE.M	Data	28.57	-111.00	1/365	-118.00	0/365	-103.00	0/365	-120.00	0/365	-127.00	0/365	-123.00	0/365		
AU.MCQ..BHN.M	Data	28.57	-112.00	14/365	-119.00	0/365	-105.00	0/365	-123.00	0/365	-133.00	1/365	-130.00	0/365		
BK.CMB.00.BHE.M	Data	78.57	-128.00	358/366	-154.00	366/366	-132.00	315/366	-142.00	215/366	-157.00	75/366	-149.00	56/366	-142.00	82/366
BK.CMB.00.BHN.M	Data	92.85	-129.00	359/366	-153.00	366/366	-130.00	259/366	-140.00	188/366	-166.00	336/366	-157.50	202/366	-143.00	176/366
CI.PASC.00.BHE.M	Data	71.43	-115.00	31/364	-141.00	196/364	-124.00	162/364	-136.00	123/364	-168.00	253/364	-161.00	231/364	-143.00	167/364
CI.PASC.00.BHN.M	Data	64.28	-111.00	3/364	-138.00	55/364	-121.00	107/364	-132.00	61/364	-169.00	315/364	-158.00	209/364	-138.00	76/364
CI.PASC.10.BHE.M	Data	64.28	-115.00	21/364	-141.00	188/364	-124.00	160/364	-136.00	123/364	-163.00	246/364	-155.00	164/364	-142.00	135/364
CI.PASC.10.BHN.M	Data	64.28	-116.00	30/364	-139.00	102/364	-123.00	144/364	-134.00	90/364	-167.00	316/364	-157.00	189/364	-140.00	105/364
CU.ANWB.00.BH1.M	Data	64.28	-136.00	364/366	-117.00	0/366	-127.00	207/366	-142.00	296/366	-142.00	29/366	-146.00	46/366	-133.00	0/366
CU.ANWB.00.BH2.M	Data	64.28	-136.00	363/366	-117.00	0/366	-126.00	203/366	-140.00	208/366	-143.00	12/366	-144.00	42/366	-132.00	0/366
CU.BBGH.00.BH1.M	Data	42.85	-121.00	26/366	-109.00	0/366	-118.00	18/366	-133.00	2/366	-156.00	83/366	-156.00	153/366	-138.00	5/366
CU.BBGH.00.BH2.M	Data	42.85	-118.00	3/366	-109.00	0/366	-117.00	4/366	-132.00	0/366	-153.00	30/366	-152.00	58/366	-140.00	11/366
CU.BCIP.00.BH1.M	Data	71.43	-130.00	290/366	-130.00	4/366	-132.00	319/366	-143.00	272/366	-154.00	20/366	-136.00	0/366	-115.00	0/366
CU.BCIP.00.BH2.M	Data	71.43	-128.00	257/366	-130.00	6/366	-132.00	330/366	-144.00	286/366	-157.00	113/366	-142.00	0/366	-118.00	0/366

Power measurements for the horizontal components fill the table. Smaller (more negative) values typically correspond to a seismometer with better data quality (lower background noise levels). LASSO displays the mode of the PDF at seven periods between approximately 10 Hz and, in some cases, 900 seconds. The values shown in the table are the medians of the modes for the time period selected. For more information, click on the '?' button at the top of any column.

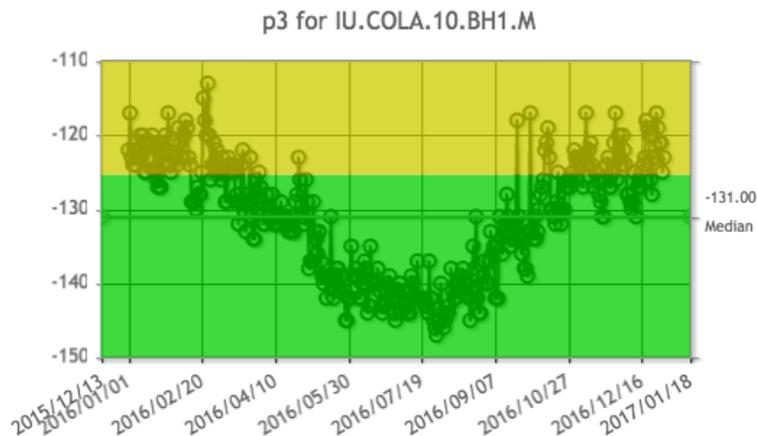
The default 'Rule' for power measurements is green if the mode of the power level at a specific frequency is less than the logarithmic mean of the global high and low noise models (Peterson, 1993), yellow if greater than the mean but less than the high noise model, and red if greater than the high noise model. Here we use the median power measurement for comparing targets. You can see that for any given station, BH1/BHN and BH2/BHE have similar values. This is also true for many IU and II stations with two sensors (locations 00 and 10), except sometimes for 'p1' (due to current instrumentation differences) or if one sensor is in need of replacement. As an example, sort 'p2' in descending order (i.e. click on header cell of 'p2' until the blue arrow is pointing down). This should

show IU.PTCN.00.BH1 (value of -101.00) at the top and II.COCO.00.BH2 (-189.00) at the bottom. For ~1 Hz, channels near the bottom are likely to yield more discernable teleseismic body wave arrivals because they have less average background noise than channels near the top.

Note that II.COCO is marked as 'bad', despite being 'low' noise. Clicking on the measurement for 'p1' shows that the noise level suddenly lapsed into very low noise levels. Noise levels considerably below the low noise model are indicative of instrument failure, and this mode of LASSO is designed to flag that.



For an example of how environmental conditions influence noise levels, click on 'p3' for IU.COLA.00.BH1. This station is located in central Alaska, where noise levels strongly relate to the strength of the microseismic signal at this period with higher noise levels during the winter.



III. Advanced Mode

Clicking next to the 'Basic' tab brings you to the 'Advanced' page. This provides the ability to create a customized view of MUSTANG metrics and channels for a network or more closely examine a specific station. 'Advanced' includes all of the search parameters as the 'Basic' tab, and options to specify 'Quality' and easily wildcard input. This makes it easy to query additional channels for a station.

Metrics can be cherry-picked or selected broadly from the automatically populated list. Clicking 'Expand metric list' will show all the available metrics. To grab all metrics in the list, click the first metric and drag the cursor all the way to the bottom. To be more selective, hold either Command (Mac) or Control (PC/Linux) and click the cursor on the specific metrics. Additionally, users can click the radio button for Derived Metrics, including m1, m2, or m3 (seismometer mass positions) and derived_data_avail to be displayed.

Metric(s): Metrics Derived Metrics
 Click to select metric(s) to display.

Hold [control] (PC) or [command] (Apple) to make multiple selections or hold [shift] (any platform) to select metrics en masse.

Search: By Network and Station By Virtual Network By Network

Network(s): Enter "*" for all or use single network code, e.g. "II".
 "*" not recommended due to size of potential return

Station(s): Enter "*" for all or station code, e.g. "BORG".

Location(s): Enter "*" or location code, e.g. "00".

Channel(s): Enter "*" or wildcard with "?", e.g. "VM?".

Quality: Enter "*" for all; "M" is highly recommend.

Ranking: Qualitative Quantitative

Display: Snapshot Mean Median

Time:

Show Counts:

In addition, this view has been customized to handle multi-value output from certain MUSTANG metrics:

- asl_coherence (PB4to8sec, PB18to22sec, PB90to110sec, PB200to500sec)
- m2_tides⁴ (gain_ratio, phase_diff, rms_residual_obs, rms_residual_syn)
- orientation_check (azimuth_Y_obs, azimuth_X_obs, azimuth_Y_meta, azimuth_X_meta)
- polarity check (cross_corr_max, ref_station)
- transfer_function (gain_ratio, phase_diff, ms_coherence)

Finally, several MUSTANG metrics require special input, which can be parameterized directly or wildcarded:

- asl_coherence (Location1:Location2, ex. 00:10)
- cross_talk (Channel1:Channel2, ex. BH1:BH2)
- pressure_effects (BarometerLocation:SeismometerLongPeriodLocation, BarometerChannel:SeismometerLongPeriodChannel, ex. 31:00.LDO.LHZ)

⁴ This metric is not yet deployed.

Tutorial E - Advanced

Enter the following parameters:

Metric(s): Select all

Search: By Network and Station

Network(s): IU

Station(s): TUC

Location(s): *⁵

Channel(s): *

Quality: M

Ranking: Qualitative

Table Type: Mean

Start Time: 2016-01-01 00:00:00

End Time: 2017-01-01 00:00:00

Show Counts:

⁵ * is a global wildcard which enables all potential returns. Certain uses may result in long or failed grabs due to the large demand placed on MUSTANG.

Click 'Get Measurements'. Again, particularly large requests like this may produce a slight delay in loading.

Target	Rank	amplifier_saturation	Count	asl_coherence (PB4to8sec)	Count	asl_coherence (PB18to22sec)	Count	asl_coherence (PB90to110sec)	Count	asl_coherence (PB200to500sec)	Count	calibration_signal	Count
IU.TUC.00.BH1.M	08,01,03	0.00	0/366									32.46	362/366
IU.TUC.00.BH1:BH2.M	00,00,00												
IU.TUC.00.BH1:BHZ.M	00,00,00												
IU.TUC.00.BH2.M	07,03,02	0.00	0/366									32.11	362/366
IU.TUC.00.BH2:BHZ.M	00,00,00												
IU.TUC.00.BHZ.M	08,02,02	0.00	0/366									34.11	362/366
IU.TUC.00.LH1.M	07,02,02	0.00	0/366									2.05	362/366
IU.TUC.00.LH2.M	07,02,02	0.00	0/366									2.06	362/366
IU.TUC.00.LHZ.M	07,02,02	0.00	0/366									2.07	362/366
IU.TUC.00.VM1.M	08,00,01	0.00	0/366									0.00	366/366
IU.TUC.00.VM2.M	08,00,01	0.00	0/366									0.00	366/366
IU.TUC.00.VMZ.M	08,00,01	0.00	0/366									0.00	366/366
IU.TUC.10.BH1.M	08,01,03	0.00	0/366									18.89	364/366
IU.TUC.10.BH1:BH2.M	00,00,00												
IU.TUC.10.BH1:BHZ.M	00,00,00												
IU.TUC.10.BH2.M	08,02,02	0.00	0/366									19.26	364/366
IU.TUC.10.BH2:BHZ.M	00,00,00												
IU.TUC.10.BHZ.M	06,04,02	0.00	0/366									37.56	364/366
IU.TUC.10.HH1.M	08,01,03	0.00	0/340									0.27	339/340

IU.TUC is a GSN station and contains several sensors as well as channels with different sampling rates (LH, HH, etc.). Over time, MUSTANG is likely to increase the number of channels it includes for its metrics. There should be 91 entries total, and you can scroll down these rows to see not only channels, but also paired entries for metrics like cross_talk or pressure_effects. Moving from right to left, you will see columns that are mostly blank where metrics have not yet been added (e.g. asl_coherence) or are not relevant to the channels listed. Most metrics in LASSO do not have default rules associated with them for the 'Basic' view, and thus are colored grey. Rules for these can be added as demonstrated in Tutorial C.

Scroll from left to right to view all the displayed columns of metrics. The table features are the same as under the 'Basic' view, and measurements can be sorted, accessed, and exported as needed. The

'Rank' feature under 'Advanced' works loosely, accounting for metrics with existing rules. Adding rules will cause the ranks to be reset.

The search feature positioned to the top-right of the table allows for selecting a subset of the rows to be displayed in the table. Type 'VM' into the 'Search' field. The rows of the table are automatically reduced to only those containing 'VM'. This example has limited the view to the three output voltage channels (e.g. VM[1,2,Z]) per seismometer at TUC.

Tutorial F - Advanced

The '?' wildcard can make LASSO more efficient at querying targets in surgical manner.

Enter the following parameters:

Metric(s): Select all metrics beginning with 'sample'

Search: By Virtual Network

Virtual Network: _CASCADIA-TA

Location(s): ⁶

Channel(s): ?N?⁷

Quality: M

Ranking: Qualitative

Display: Snapshot

Time: 2013-01-01 00:00:00

⁶ Leaving this empty represents a '—' (blank) location code typical of TA and other network metadata where a station has only one seismometer.

⁷ Time series channels for strong motion sensors.

Click 'Get Measurements'.

Target	Rank	sample_max	sample_mean	sample_median	sample_min	sample_rms	sample_snr	sample_unique
		? Rule	? Rule	? Rule	? Rule	? Rule	? Rule	? Rule
TA.A04D..HNE.M <small>Data</small>	01,00,00	-35930.00	-36346.60	-36434.00	-36608.00	138.96		
TA.A04D..HNN.M <small>Data</small>	01,00,00	3154.00	2695.20	2710.00	2297.00	100.04		
TA.A04D..HNZ.M <small>Data</small>	01,00,00	-71214.00	-71789.50	-71850.00	-72125.00	155.07		
TA.A04D..LNE.M <small>Data</small>	01,00,00	-36047.00	-36343.80	-36431.00	-36448.00	138.90		
TA.A04D..LNN.M <small>Data</small>	01,00,00	3052.00	2694.90	2710.00	2427.00	97.44		
TA.A04D..LNZ.M <small>Data</small>	01,00,00	-71464.00	-71783.80	-71844.00	-71927.00	155.00		
TA.B05D..HNE.M <small>Data</small>	01,00,00	49434.00	49360.40	49351.00	49326.00	21.12		
TA.B05D..HNN.M <small>Data</small>	01,00,00	-54128.00	-54185.10	-54189.00	-54226.00	11.27		
TA.B05D..HNZ.M <small>Data</small>	01,00,00	-32491.00	-32887.20	-32967.00	-33017.00	150.37		
TA.B05D..LNE.M <small>Data</small>	01,00,00	49409.00	49356.50	49347.00	49329.00	21.06		
TA.B05D..LNN.M <small>Data</small>	01,00,00	-54147.00	-54180.80	-54185.00	-54196.00	11.16		
TA.B05D..LNZ.M <small>Data</small>	01,00,00	-32509.00	-32884.60	-32965.00	-32983.00	150.35		

This obtains the selected metrics for all ?N? channels (LNE, LNN, LNZ, HNE, HNN, HNZ) for the entire virtual network. Metrics calculated for LN? and HN? show similar results for corresponding channels and in most cases are redundant, suggesting that a future request could be refined further to focus on just 'LN?' or 'HN?'.