

# Package ‘IRISMustangMetrics’

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**Type** Package

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**Title** Statistics and Metrics for Seismic Data

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stats, dplyr (>= 0.4.3)

**Collate** Class-Metric.R BSSUtils.R ISPAQUtils.R basicStatsMetric.R  
correlationMetric.R crossCorrelationMetric.R  
dailyDCOffsetMetric.R DCOffsetTimesMetric.R gapsMetric.R  
PSDMetric.R SNRMetric.R spikesMetric.R STALTAMetric.R  
stateOfHealthMetric.R upDownTimesMetric.R  
transferFunctionMetric.R

**Description** Classes and functions for metrics calculation as part of the  
'IRIS DMC MUSTANG' project. The functionality in this package  
builds upon the base classes of the 'IRISseismic' package.  
Metrics include basic statistics as well as higher level  
'health' metrics that can help identify problematic seismometers.

**License** GPL (>= 2)

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## R topics documented:

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IRISMustangMetrics-package

*Utilities for calculating seismic metrics from IRIS DMC data*

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## Description

This package provides S4 classes and functions for calculating metrics from seismological data available from the IRIS Data Management Center (DMC) (<http://www.iris.edu/dms/nodes/dmc/>). This package is part of the MUSTANG project and is intended for DMC internal use only.

## Introduction

The **IRISMustangMetrics** package depends upon the **IRISSeismic** package which defines new S4 classes and methods for manipulating seismic data. Please see the "seismic-intro" vignette for introductory examples on using **IRISSeismic**.

## History

### version 2.1.3

- fixed bug related to `getGeneralValueMetrics`, `getMustangMetrics` error handling
- added `pdf_aggregator` to `ISPAQUtils.R`, for multi-day pdf plotting within `ISPAQ`

### version 2.1.2

- version 2.1.1 unintentionally removed the `pct_above_nhnm` metric. This version restores it.
- made sample rate sanity rate check consistent between `correlationMetric` and `crossCorrelationMetric`

### version 2.1.1

- fixed bug in `PSDMetrics` that affected `dead_channel_gsn` results

### version 2.1.0

- `transfer_function` requires sample rates to be within a factor of 10 to avoid decimation effects on amplitude
- `transfer_function` uses 7 order Chebyshev filter in the `decimate` function, to correct 1% error occurring with default 8 order Chebyshev
- fixed bug in `transfer_function` trace start and end time comparisons
- `transfer_function` when determining if sample rate < 1, round to 5 digits first
- `getGeneralValueMetrics` added `metric_error`, `ts_channel_continuity`, `ts_channel_up_time`, `ts_gap_length`, `ts_gap_length_total`, `ts_max_gap`, `ts_max_gap_total`, `ts_num_gaps`, `ts_num_gaps_total`, `ts_percent_availability`, `ts_percent_availability` metrics
- aliased the `getGeneralValueMetrics` function to `getMustangMetrics`
- `dailyDCOffsetMetric` now returns error when result is NaN or NA

### version 2.0.9

- removed dependency on `pracma` package
- removed channel restrictions for `pct_above_nhnm`, `pct_below_nlm`
- cross correlation sampling rates of < 1 will round to 2 digits
- `getGeneralValueMetrics` better handles case of no targets found
- improved error handling in `spikesMetric.R`

### version 2.0.8

- minor bug fix to `ISPAQUtils.R`, `spikes=numSpikes`

### version 2.0.7

- fixed bug in `getGeneralValueMetrics` that didn't return measurements if there was more than one for any day
- `crossCorrelationMetric` filter now defaults to a butterworth 2 pole 0.1Hz (10 second) low pass filter

## version 2.0.6

- fixed bug related to NA -> NULL replacement in Class-Metric

## version 2.0.5

- fixed dplyr version dependencies

## version 2.0.4

- adds additional sanity check to `getGeneralValueMetrics()`
- `createBssUrl()` adds "&nodata=404" to url

## version 2.0.2

- updates to ISPAQUtils.R

## version 2.0.1

- removed dependency on tidy package

## version 2.0.0 – GeneralValueMetrics

- `GeneralValueMetric` class introduced, `SingleValueMetric` class deprecated. All metrics that previously returned `SingleValueMetric` now return `GeneralValueMetric`
- `getGeneralValueMetrics()` function added. Retrieves metrics measurements from BSS database
- `crossCorrelationMetric()` does not return `timing_drift`. The metric proved unreliable
- users can now supply instrument response information in the form of frequency, amplitude, phase to the function `PSDMetric`, in place of the `getEvalresp` webservice call

## version 1.3.1 – PSDs

- `getPsdMetrics` reworked

## version 1.3.0 – latency

- `getLatencyValuesXML()` removed from package.
- documentation improvements.
- additional error checking for `getSingleValueMetrics()`.

## version 1.2.7 – PSDs

- `PSDMetrics()` metrics `percent_above_nhnm` and `percent_below_nlnm` limited to frequencies less than `nyquist/1.5`.

## version 1.2.6 – PSDs

- Depends on **IRISseismic** ( $\geq 1.3.0$ ).
- `dead_channel_exp` and `dead_channel_lin` metrics will only return values for station channel codes matching "BH1HH".

## version 1.2.5 – ISPAQUtils

- ISPAQUtils.R contains functions for use with the ISPAQ standalone metrics system.

version 1.2.4 – package version dependencies

- Depends on **IRISSeismic** ( $\geq 1.2.3$ ). Imports **seismicRoll** ( $\geq 1.1.2$ ).

version 1.2.2 – correlationMetric tweak

- correlationMetric() allows trace sample lengths to differ by 2 samples without stopping.

version 1.2.1 – PSDs

- Better fix to very low powers issue in PSDMetrics() dead\_channel\_gsn metric.
- PSDMetrics() shifts PDF bin centers by 0.5 dB.

version 1.2.0 – PSDs

- PSDMetric() returns corrected PSD and PDF dataframes in addition to uncorrected PSDs and PSD derived metrics.
- Depends on R ( $\geq 3.2.0$ ) and **IRISSeismic** ( $\geq 1.1.7$ ).
- Imports **tidyr**, **dplyr**.

version 1.1.3 – bug fix, import version increased

- Fixes typo in SNRMetric() function windowSecs argument default value.
- Imports **seismicRoll** ( $\geq 1.1.1$ )

version 1.1.2 – modifications

- Improves error handling messages.
- dailyDCOffsetMetric() removes unused selectivity argument and adds argument controlling output type.
- Fixes bug in dailyDCOffsetMetrics() related to outlier removal and vector length.
- Fixes bug in PSDMetrics() dead\_channel\_gsn metric related to very low power values.
- PSDMetrics() only returns metrics that generate numeric values.

version 1.1.1 – bug fix

- crossCorrelationMetric() exits if either input trace is flatlined (all values equal).

version 1.1.0 – updates package dependencies

- Depends on **IRISSeismic** ( $\geq 1.1.0$ ).

version 1.0.8 – new metric and bug fix

- Improves error handling messages.
- Adds new dead\_channel\_gsn metric to PSDMetric() function output.
- Fixes bug in STALTMetric() involving required trace length.

version 1.0.7 – bug fix

- Fixes issue with spikesMetric() passing argument values to findOutliers.

version 1.0.6 – function argument changes

- Changes `spikesMetric()` default argument values `thresholdMin=10`, `selectivity=NA`, `fixedThreshold=TRUE`.
- `transferFunctionMetric()` now requires input of `evalresp` fap spectra, new arguments `evalresp1` and `evalresp2`.
- Additional sanity checks for `transferFunctionMetric()` and `PSDMetric()`.
- Depends on **IRISseismic** ( $\geq 1.0.10$ ). Imports **seismicRoll** ( $\geq 1.1.0$ ). Imports **stats**.

version 1.0.5 – new PSD metric

- Changes URL syntax for MUSTANG web services to use "format=..." instead of "output=...".
- Adds new `sample_unique` metric to `PSDMetric()` output.

version 1.0.3 – new functionality and bug fixes

- Adds new `metricList2DF()` function.
- Adds new `dead_channel_lin` metric to `PSDMetric()` output.
- Fixes typo in `Class-Metric.R` value string format.

version 1.0.0 – First Public Release

### Author(s)

Jonathan Callahan <jonathan@mazamascience..com>

### References

IRIS DMC web services: <http://service.iris.edu/>

### Examples

```
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient", debug=TRUE)

# Get the seismic data
starttime <- as.POSIXct("2010-02-27 06:45:00", tz="GMT")
endtime <- as.POSIXct("2010-02-27 07:45:00", tz="GMT")
st <- getDataselect(iris, "IU", "ANMO", "00", "BHZ", starttime, endtime)

# Apply a metric and show the results
metricList <- basicStatsMetric(st)
dummy <- lapply(metricList, show)
```

---

basicStatsMetric	<i>Min, median, mean, rms variance, max, and number of unique values of a signal</i>
------------------	--

---

### Description

The basicStatsMetric() function calculates the min, median, mean, max, rmsVariance and number of unique values for the input seismic signal.

### Usage

```
basicStatsMetric(st)
```

### Arguments

st                    a Stream object containing a seismic signal

### Details

This metric applies the min, median, mean and max methods of Stream objects to the st parameter to calculate the following metrics:

- sample\_min
- sample\_median
- sample\_mean
- sample\_max
- sample\_rms

It also calculates length(unique(stmerged@traces[[1]]@data)), where stmerged is the st parameter after mergeTraces is applied to it, for the following metric:

- sample\_unique

Any error messages generated in the process will pass through untrapped.

### Value

A list of SingleValueMetric objects is returned.

### Note

See the seismic package for documentation on Stream objects and the getDataselect method.

### Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

## Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime, inclusiveEnd=FALSE)

# Calculate some metrics and show the results
metricList <- basicStatsMetric(st)
dummy <- lapply(metricList, show)

## End(Not run)
```

---

convertBssErrors

*Generate Human Readable MUSTANG Errors*

---

## Description

The MUSTANG database is in charge of storing the results of metrics calculations and is accessed through a webservice API. The `convertBssErrors` function extracts pertinent error information from the HTML returned by MUSTANG on error conditions.

## Usage

```
convertBssErrors(err_msg)
```

## Arguments

`err_msg` error text received from the MUSTANG

## Value

A text string with the root cause extracted from the MUSTANG HTML Java error dump.

## Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

## See Also

[SingleValueMetric-class](#), [metricList2Xml](#), [getMetricsXml](#), [getBssMetricList](#),

---

correlationMetric	<i>Correlation between channels</i>
-------------------	-------------------------------------

---

**Description**

The correlationMetric() function calculates the correlation between two streams of seismic data.

**Usage**

```
correlationMetric(st1, st2)
```

**Arguments**

st1	a Stream object containing a seismic signal
st2	a Stream object containing a seismic signal

**Details**

The correlation returned is a value in the range [0-1]. This 'pearson r' correlation is a measure of the strength and direction of the linear relationship between two variables that is defined as the (sample) covariance of the variables divided by the product of their (sample) standard deviations.

Missing values are handled by casewise deletion with the following R code:

```
cor(x,y,use="na.or.complete")
```

**Value**

A list with a single SingleValueMetric object is returned. The metric name is cross\_talk.

**Note**

Seismic streams passed to correlationMetric must have the same network and station, must cover the same time range and must have the same sampling rate.

The metricList generated for this two-channel metric will have a SNCL code of the form: N.S.L1:L2.C1:C2.Q.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get seismic traces
starttime <- as.POSIXct("2013-03-01", tz="GMT")
endtime <- as.POSIXct("2013-03-02", tz="GMT")
```

```

stZ <- getDataselect(iris,"IU","ANMO","00","BHZ",starttime,endtime,inclusiveEnd=FALSE)
st1 <- getDataselect(iris,"IU","ANMO","00","BH1",starttime,endtime,inclusiveEnd=FALSE)
st2 <- getDataselect(iris,"IU","ANMO","00","BH2",starttime,endtime,inclusiveEnd=FALSE)

# Calculate correlationMetric
correlationMetric(stZ,st1)[[1]]
correlationMetric(stZ,st2)[[1]]
correlationMetric(st1,st2)[[1]]

## End(Not run)

```

---

createBssUrl

*Create URL to retrieve measurements from the MUSTANG BSS*


---

### Description

The createBssUrl method of the IrisClient returns a URL that can be used to make a request of the MUSTANG BSS (Backend Storage System).

### Usage

```

createBssUrl(obj, network, station, location, channel,
             starttime, endtime, metricName, ...)

```

### Arguments

obj	an IrisClient object
network	a character string with the two letter seismic network code
station	a character string with the station code
location	a character string with the location code
channel	a character string with the three letter channel code
starttime	a POSIXct class specifying the starttime (GMT)
endtime	a POSIXct class specifying the endtime (GMT)
metricName	a character string containing one or more comma separated metric names
...	optional arguments constraint a character string containing value constraints url optional url of the BSS measurements service

### Details

A blank location code should be specified as location="--"; Using location="" will return all location codes.

The default MUSTANG measurement service when url is not specified is:

<http://service.iris.edu/mustang/measurements/1/query?>

**Value**

A character string containing a BSS request URL

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[getSingleValueMetrics](#)

**Examples**

```
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2013-06-01", tz="GMT")
endtime <- starttime + 30*24*3600
metricName <- "sample_max,sample_min,sample_mean"

# Get the measurement dataframe
url <- createBssUrl(iris,"IU","ANMO","00","BHZ",
                  starttime,endtime,metricName)

# This URL can be pasted into a web browser to see the BSS return values
```

---

crossCorrelationMetric

*Correlation between channels*

---

**Description**

The `crossCorrelationMetric()` function calculates the maximum absolute correlation (`polarity_check`) and lag at maximum correlation (`timing_drift`) associated with two streams of seismic data.

**Usage**

```
crossCorrelationMetric(st1, st2, maxLagSecs=10, filter)
```

**Arguments**

<code>st1</code>	a Stream object containing a seismic signal
<code>st2</code>	a Stream object containing a seismic signal
<code>maxLagSecs</code>	maximum number of seconds of lag to use
<code>filter</code>	a <b>signal</b> package filter to be applied before cross-correlating, optional

## Details

Details of the algorithm are as follows:

- Both signals are demeaned and detrended
- If one signal has a higher sampling rate, it is decimated to the lower sampling rate using an IIR filter if it is a multiple of the lower sample rate. See `(signal::decimate)`.
- Both signals are filtered, by default with a Butterworth 2-pole low pass filter with a 0.1 Hz (10 second) corner frequency. See `(signal::filter)`.
- Signals are cross-correlated using the `stats::ccf()` function.

The maximum absolute correlation is saved as `polarity_check` while the lag at peak correlation is saved as `timing_drift`.

**Note:** For cross-correlation, seismic signals must not have any gaps – they must be contained in a single Trace object.

## Value

A list with one `GeneralValueMetric` object is returned. The metric names is `polarity_check`.

## Note

The `metricList` generated for this two-channel metric will have an additional `sncl2` attribute identifying the SNCL in `st2`.

## Author(s)

Jonathan Callahan <jonathan@mazamascience.com> (R code), Mary Templeton <met@iris.washington.edu> (algorithm)

## Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the same signal, shifted by 3 seconds
starttime <- as.POSIXct("2013-11-12 07:09:45",tz="GMT")
endtime <- starttime + 600
st1 <- getSNCL(iris,"NM.SLM.00.BHZ",starttime,endtime)
st2 <- getSNCL(iris,"NM.SLM.00.BHZ",starttime+3,endtime+3)

# Cross-correlate
crossCorrelationMetric(st1,st2)

## End(Not run)
```

---

dailyDCOffsetMetric    *DC Offset Detection*

---

### Description

The dailyDCOffsetMetric() function identifies days with a jump in the signal mean.

### Usage

```
dailyDCOffsetMetric(df,
                    offsetDays=5,
                    outlierWindow=7,
                    outlierThreshold=3.0,
                    outputType=1)
```

### Arguments

df	a dataframe containing sample_mean values obtained with getSingleValueMetrics()
offsetDays	number of days used in calculating weighting factors
outlierWindow	window size passed to findOutliers() function in the <b>seismic</b> package
outlierThreshold	detection threshold passed to findOutliers() function in the <b>seismic</b> package
outputType	if 1, return last day of valid values (index= length(index)-floor(outlierWindow/2)); if 0, return all valid values (indices= max(offsetDays, floor(outlierWindow/2)): length(index)-floor(outlierWindow/2))

### Details

This algorithm calculates lagged differences of the daily mean timeseries over a window of offsetDays days. Shifts in the mean that are persistent and larger than the typical standard deviation of daily means will generate higher metric values.

Details of the algorithm are as follows

```
# data0 = download requested daily means (in the 'df' dataframe), must be greater than max(offsetDays,
# data1 = remove outliers using MAD outlier detection with the 'outlier' arguments specified
# data2 = replace outliers with rolling median values using a default 7 day window, remove last floor(c
# weights = calculate absolute lagged differences with 1-N day lags, default N=5
# metric0 = multiply the lagged differences together and take the N'th root
# stddev0 = calculate the rolling standard deviation of data2 with a N-day window
# METRIC = divide metric0 by the median value of stddev0
```

### Value

A list is returned with a SingleValueMetric object for the last day-floor(outlierWindow/2) (default 3rd from last day) in the incoming dataframe if outputType=1 (one list element), otherwise the first+offsetDays to last day-floor(outlierWindow/2) (multiple list elements, one per day) if outputType=0.

**Note**

Prefer 60+ days of sample\_mean values to get a good estimate of the long term sample\_mean standard deviation. After initial testing on stations in the IU network, a metric value > 10 appears to be indicative of a DC offset shift (this may vary across stations or networks and larger values may be preferred as indications of a potential station issue).

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[getSingleValueMetrics](#)

---

DCOffsetTimesMetric    *DC Offset Detection*

---

**Description**

The DCOffsetTimesMetric() function returns times where a shift in the signal mean is detected.

**Usage**

```
DCOffsetTimesMetric(st, windowSecs, incrementSecs, threshold)
```

**Arguments**

st	a Stream object containing a seismic signal
windowSecs	chunk size (secs) used in DCOffset calculations (default=1800)
incrementSecs	increment (secs) for starttime of sequential chunks (default=windowSecs/2)
threshold	threshold used in the detection metric (default=0.9)

**Details**

Conceptually, this algorithm asserts: If the difference in means between sequential chunks of seismic signal is greater than the typical std dev of a chunk then this marks a DC offset shift.

Details of the algorithm are as follows

```
# Merge all traces in the time period, filling gaps with missing values
# Break up the signal into windowSecs chunks spaced incrementSecs apart
# For each chunk calculate:
#   signal mean, signal standard deviation
# Resulting mean and std dev arrays are of length 47 for 24 hours of signal
# Metric = abs(lagged difference of chunk means) / mean(chunk std devs)
# DC offset = times when Metric > threshold
```

**Value**

A list with a single MultipleTimeValueMetric object is returned.

**Note**

The denominator of this metric was tested with both `mean(chunk std devs)` and with `median(chunk std devs)` to identify a "typical" value for the chunk standard deviation. It was found that using `median` resulted false offset detects whenever there was a large seismic signal in an otherwise lo-noise signal.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get a signal with a DC offset problem
starttime <- as.POSIXct("2012-10-26",tz="GMT")
endtime <- starttime + 2*24*3600
st <- getDataselect(iris,"IU","TARA","00","BHZ",starttime,endtime)

# Calculate the metric
metricList <- DCOffsetTimesMetric(st)

# Extract values from the first element of the list
offsetTimes <- metricList[[1]]@values

# Plot the signal and mark locations where a DC offset was detected
plot(st)
abline(v=offsetTimes,col='red')

## End(Not run)
```

---

gapsMetric

*Gaps and overlaps in a signal*

---

**Description**

The `gapsMetric()` function calculates metrics associated with gaps and overlaps in a seismic signal, *i.e.* when `st` consists of more than one Trace.

**Usage**

```
gapsMetric(st)
```

**Arguments**

`st` a Stream object containing a seismic signal

**Details**

This function uses the output of the `getGaps` method of Stream objects to calculate the following metrics:

`num_gaps`: number of gaps found in `st`

`max_gap`: length of maximum gap (sec) found in `st`

`num_overlaps`: number of overlaps found in `st`

`max_overlap`: length of maximum overlap (sec) found in `st`

`percent_availability`: percentage of total requested time for which a signal is available

The `requestedStarttime` and `requestedEndtime` slots for the Stream are used to determine gaps before the start of the first or after the end of the last Trace in the Stream.

**Value**

A list of `SingleValueMetric` objects is returned.

**Note**

See the `seismic` package for documentation on Stream objects and the `getDataselect` method.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Calculate the gaps metrics and show the results
metricList <- gapsMetric(st)
dummy <- lapply(metricList, show)

## End(Not run)
```

---

GeneralValueMetric-class  
*Class "GeneralValueMetric"*

---

### Description

A container for metrics consisting of a vector of numeric values. This information is used to create XML that is then submitted to the MUSTANG Backend Storage System (BSS).

### Objects from the Class

Objects can be created by calls of the form:

```
new("GeneralValueMetric", snclq, starttime, endtime, metricName, elementNames, elementValues, valueS
```

Lists of GeneralValueMetric objects are returned by various metrics functions in this package.

### Slots

**snclq:** Object of class "character": SNCLQ identifier.

**starttime:** Object of class "POSIXct": Start time.

**endtime:** Object of class "POSIXct": End time.

**metricName:** Object of class "character": Name of the metric.

**elementNames:** Object of class "character": Names of the elements storing the metric values (default="x").

**elementValues:** Object of class "numeric": Numeric values.

**valueStrings:** Object of class "character": String representations of the numeric values.

**quality\_flag:** Object of class "numeric": Quality flag.

**quality\_flagString:** Object of class "character": String representation of quality flag.

### Methods

**show** signature(object = "GeneralValueMetric"): Prettyprints the information in the GeneralValueMetric

### Note

The *starttime* and *endtime* slots are typically associated with the *user requested* times which may not match up with the *starttime* associated with the first Trace and the *endtime* associated with last Trace in the Stream object being analyzed. This ensures that metrics results for a single time period but covering many stations or channels will have the same date range and improves performance of the BSS which expects XML of the following form:

```
<measurements>
  <date start='2012-02-10T00:00:00.000' end='2012-02-10T09:20:00.000'>
    <target snclq='N.S.L.C1.Q'>
      <EXAMPLE>
```

```

        <x value="1" />
        <x value="2" />
        <x value="3" />
        <x value="4" />
    </EXAMPLE>
</target>
</date>
</measurements>

```

The `quality_flag` is an optional value available for storing information related to the processing of a particular metric. Its meaning will vary from metric to metric.

### Author(s)

Jonathan Callahan <jonathan.s.callahan@gmail.com>

---

getBssMetricList	<i>Retrieve measurements XML from the MUSTANG BSS and convert them to a metricList</i>
------------------	--

---

### Description

The `getBssMetricList` method makes a request of the MUSTANG BSS (Backend Storage System) and returns a list of `_Metric` objects.

### Usage

```
getBssMetricList(obj, network, station, location, channel,
                 starttime, endtime, metricName, url)
```

### Arguments

<code>obj</code>	an <code>IrisClient</code> object
<code>network</code>	a character string with the two letter seismic network code
<code>station</code>	a character string with the station code
<code>location</code>	a character string with the location code
<code>channel</code>	a character string with the three letter channel code
<code>starttime</code>	a <code>POSIXct</code> class specifying the starttime (GMT)
<code>endtime</code>	a <code>POSIXct</code> class specifying the endtime (GMT)
<code>metricName</code>	a character string identifying the name of the metric stored in the BSS
<code>url</code>	optional url of the BSS measurements service



**Arguments**

obj	an IrisClient object
network	a character string with the two letter seismic network code
station	a character string with the station code
location	a character string with the location code, can be "" for wildcard all
channel	a character string with the three letter channel code, can be "" for wildcard all
starttime	a POSIXct class specifying the starttime (GMT)
endtime	a POSIXct class specifying the endtime (GMT)
metricName	a character string containing one or more comma separated metric names
...	optional arguments constraint a character string containing value constraints url optional url of the MUSTANG measurements service

**Details**

A blank location code should be specified as `location="--"`; Using `location=""` will return all location codes.

The default MUSTANG measurement service when `url` is not specified is:

`http://service.iris.edu/mustang/measurements/1/query?`

Data returned from MUSTANG are converted into an R dataframe.

The optional `constraint` parameter is used to add constraints to the query as defined in the [MUSTANG measurements web service documentation](#). Any string passed in with the `constraint` parameter will be appended to the request url following an ampersand.

Error returns from the BSS will stop evaluation and generate an error message.

**Value**

A dataframe with the following columns:

`~metricName~, value, additional values, snclq, starttime, endtime, loadtime`

The `loadtime` column contains the time at which this record was loaded into the database.

The dataframe rows will be sorted by `metricName` and increasing `starttime`.

**Author(s)**

Jonathan Callahan <jonathan.s.callahan@gmail.com>

**See Also**

[createBssUrl](#), [getPsdMetrics](#)

## Examples

```
## Not run:
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2016-08-01", tz="GMT")
endtime <- starttime + 30*24*3600
metricName <- "sample_max,sample_mean,orientation_check"

# Get the measurement dataframe
juneStats <- getGeneralValueMetrics(iris,"IU","ANMO","", "BH[12Z]",
                                   starttime,endtime,metricName)

print(juneStats)

## End(Not run)
```

---

getMetricFunctionMetadata

*Return JSON Metadata for Metric Functions*

---

## Description

Returns a JSON formatted string with metric function metadata. This string is needed by the python-based ISPAQ command-line utility developed by IRIS DMC.

## Usage

```
getMetricFunctionMetadata()
```

## Value

JSON formatted string containing metric function metadata.

## Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

---

getMetricsXml	<i>Retrieve measurements XML from the MUSTANG BSS</i>
---------------	---

---

### Description

The `getMetricsXml` method makes a request of the MUSTANG BSS (Backend Storage System) and returns a character string with the response XML.

### Usage

```
getMetricsXml(obj, network, station, location, channel,  
             starttime, endtime, metricName, url)
```

### Arguments

<code>obj</code>	an <code>IrisClient</code> object
<code>network</code>	a character string with the two letter seismic network code
<code>station</code>	a character string with the station code
<code>location</code>	a character string with the location code
<code>channel</code>	a character string with the three letter channel code
<code>starttime</code>	a <code>POSIXct</code> class specifying the starttime (GMT)
<code>endtime</code>	a <code>POSIXct</code> class specifying the endtime (GMT)
<code>metricName</code>	a character string identifying the name of the metric stored in the BSS
<code>url</code>	optional url of the BSS measurements service

### Details

The default BSS measurement service when `url` is not specified is:

```
http://service.iris.edu/mustang/measurements/1/query?
```

This method returns raw XML which is not that useful by itself. Users should instead use the [getBssMetricList](#) method which calls this function and returns a list `_Metric` objects.

Error returns from the BSS will stop evaluation and throw an error message.

### Value

A character string with the XML response from the BSS is returned.

### Author(s)

Jonathan Callahan <[jonathan@mazamascience.com](mailto:jonathan@mazamascience.com)>

### See Also

[getBssMetricList](#)

**Examples**

```
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")

# Get the measurement XML
xml <- getMetricsXml(iris,"AK","PIN","", "BHZ",
                    starttime,endtime,metricName="sample_mean",
                    url="http://service.iris.edu/mustang/measurements/1/query?")
```

---

getMustangMetrics	<i>Retrieve measurements from the MUSTANG BSS</i>
-------------------	---

---

**Description**

The `getMustangMetrics` method of the `IrisClient` makes a request of the MUSTANG database and returns a dataframe containing metrics measurements. This function is an alias of the `getGeneralValueMetrics` function.

**Usage**

```
getMustangMetrics(obj, network, station, location, channel,
                 starttime, endtime, metricName, ...)
```

**Arguments**

<code>obj</code>	an <code>IrisClient</code> object
<code>network</code>	a character string with the two letter seismic network code
<code>station</code>	a character string with the station code
<code>location</code>	a character string with the location code, can be "" for wildcard all
<code>channel</code>	a character string with the three letter channel code, can be "" for wildcard all
<code>starttime</code>	a <code>POSIXct</code> class specifying the starttime (GMT)
<code>endtime</code>	a <code>POSIXct</code> class specifying the endtime (GMT)
<code>metricName</code>	a character string containing one or more comma separated metric names
<code>...</code>	optional arguments constraint a character string containing value constraints url optional url of the MUSTANG measurements service

**Details**

A blank location code should be specified as `location="--"`; Using `location=""` will return all location codes.

The default MUSTANG measurement service when `url` is not specified is:

```
http://service.iris.edu/mustang/measurements/1/query?
```

Data returned from MUSTANG are converted into an R dataframe.

The optional constraint parameter is used to add constraints to the query as defined in the [MUSTANG measurements web service documentation](#). Any string passed in with the constraint parameter will be appended to the request url following an ampersand.

Error returns from the BSS will stop evaluation and generate an error message.

**Value**

A dataframe with the following columns:

```
~metricName~, value, additional values, snclq, starttime, endtime, loadtime
```

The `loadtime` column contains the time at which this record was loaded into the database.

The dataframe rows will be sorted by `metricName` and increasing `starttime`.

**Note**

The database was originally populated with a version of this package that always assigned quality to be 'B'. Later versions obtained the quality from the miniSEED packet (typically 'M'). Because of this it is possible to have duplicate entries that only differ in the Q part of their `snclq`. To avoid double counting, when the webservice return contains two records whose only difference is the quality code portion of the of the `snclq`, only the record with the later `loaddate` will be used in the dataframe.

**Author(s)**

Jonathan Callahan <jonathan.s.callahan@gmail.com>

**See Also**

[createBssUrl](#), [getPsdMetrics](#)

**Examples**

```
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2016-08-01", tz="GMT")
endtime <- starttime + 30*24*3600
metricName <- "sample_max,sample_mean,orientation_check"

# Get the measurement dataframe
juneStats <- getMustangMetrics(iris,"IU","ANMO","","BH[12Z]",
```

```
starttime, endtime, metricName)  
  
print(juneStats)
```

---

getPsdMetrics      *Retrieve measurements from the MUSTANG BSS*

---

### Description

The getPsdMetrics method of the IrisClient makes a request of the MUSTANG BSS (Backend Storage System) and returns a dataframe containing instrument corrected Power Spectral Density (PSD) measurements.

### Usage

```
getPsdMetrics(obj, network, station, location, channel, starttime, endtime, url)
```

### Arguments

obj	an IrisClient object
network	a character string with the two letter seismic network code
station	a character string with the station code
location	a character string with the location code
channel	a character string with the three letter channel code
starttime	a POSIXct class specifying the starttime (GMT)
endtime	a POSIXct class specifying the endtime (GMT)
url	optional url of the BSS measurements service

### Details

The default BSS measurement service when url is not specified is:

<http://service.iris.edu/mustang/noise-psd/1/query?>

Data returned from the BSS are converted into an R dataframe.

Error returns from the BSS will stop evaluation and generate an error message.

### Value

A dataframe with the following columns:

```
target, starttime, endtime, frequency, power
```

### Author(s)

Jonathan Callahan <[jonathan@mazamascience.com](mailto:jonathan@mazamascience.com)>

**See Also**[getBssMetricList](#)**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")

# Get the measurement XML
psdDF <- getPsdMetrics(iris,"AK","PIN","", "BHZ", starttime,endtime)

## End(Not run)
```

---

getSingleValueMetrics *Retrieve measurements from the MUSTANG BSS*

---

**Description**

The `getSingleValueMetrics` method of the `IrisClient` makes a request of the MUSTANG database and returns a dataframe containing metrics that are stored as single values, e.g. `sample_max`, `sample_min`, etc..

**Usage**

```
getSingleValueMetrics(obj, network, station, location, channel,
                      starttime, endtime, metricName, constraint, url)
```

**Arguments**

<code>obj</code>	an <code>IrisClient</code> object
<code>network</code>	a character string with the two letter seismic network code
<code>station</code>	a character string with the station code
<code>location</code>	a character string with the location code
<code>channel</code>	a character string with the three letter channel code
<code>starttime</code>	a <code>POSIXct</code> class specifying the starttime (GMT)
<code>endtime</code>	a <code>POSIXct</code> class specifying the endtime (GMT)
<code>metricName</code>	a character string containing one or more comma separated metric names
<code>constraint</code>	a character string containing value constraints
<code>url</code>	optional url of the MUSTANG measurements service

## Details

A blank location code should be specified as `location="--"`; Using `location=""` will return all location codes.

The default MUSTANG measurement service when `url` is not specified is:

```
http://service.iris.edu/mustang/measurements/1/query?
```

Data returned from MUSTANG are converted into an R dataframe.

The optional `constraint` parameter is used to add constraints to the query as defined in the [MUSTANG measurements web service documentation](#). Any string passed in with the `constraint` parameter will be appended to the request url following an ampersand.

Error returns from the BSS will stop evaluation and generate an error message.

Most MUSTANG metrics are single valued and can be retrieved with `getSingleValueMetrics()`. Examples of multi-valued metrics that cannot be returned with this function include `"asl_coherence"`, `"orientation_check"`, and `"transfer_function"`.

## Value

A dataframe with the following columns:

```
~metricName~, value, snclq, starttime, endtime, loadtime
```

The `loadtime` column contains the time at which this record was loaded into the database.

The dataframe rows will be sorted by increasing `starttime`.

The structure of this dataframe is appropriate for use with the **ggplot2** plotting package.

## Note

The database was originally populated with a version of this package that always assigned quality to be 'B'. Later versions obtained the quality from the miniSEED packet (typically 'M'). Because of this it is possible to have duplicate entries that only differ in the Q part of their `snclq`. To avoid double counting, when the webservice return contains two records whose only difference is the quality code portion of the of the `snclq`, only the record with the later `loaddate` will be used in the dataframe.

## Author(s)

Jonathan Callahan <[jonathan@mazamascience.com](mailto:jonathan@mazamascience.com)>

## See Also

[createBssUrl](#), [getPsdMetrics](#)

**Examples**

```

## Not run:
# Open a connection to IRIS DMC webservices (including the BSS)
iris <- new("IrisClient", debug=TRUE)

starttime <- as.POSIXct("2013-06-01", tz="GMT")
endtime <- starttime + 30*24*3600
metricName <- "sample_max,sample_min,sample_mean"

# Get the measurement dataframe
juneStats <- getSingleValueMetrics(iris,"IU","ANMO","00","BHZ",
                                   starttime,endtime,metricName)

head(juneStats)

# Simple ggplot2 plot
#library(ggplot2)
#p <- ggplot(juneStats, aes(x=starttime,y=value, color=as.factor(metricName))) +
#  geom_step()

#print(p)

## End(Not run)

```

---

metricList2DF

*Convert a MetricList into a Tidy Dataframe*


---

**Description**

The metricList2DF function converts a list of SingleValueMetrics into a "tidy" dataframe with one value per row..

**Usage**

```
metricList2DF(metricList)
```

**Arguments**

metricList      a list of SingleValueMetric objects

**Details**

Metrics functions return lists of SingleValueMetric objects. A long metricList may be built up by appending the results of different metrics functions or the same metrics function operating on different seismic signals. A metricList generated by any of the MUSTANG Rscripts can be stored as an .RData file and reloaded for examination.

A metricList may contain values for many different metrics. This function creates a single "tidy" dataframe with the following columns: metricName, value, snclq, starttime, endtime, qualityFlag.

**Value**

A dataframe with one row per metric measurement.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[SingleValueMetric-class](#), [metricList2Xml](#)

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
client <- new("IrisClient")

# Get the waveforms
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st1 <- getDataselect(client,"AK","PIN","", "BHE",starttime,endtime)
st2 <- getDataselect(client,"AK","PIN","", "BHN",starttime,endtime)
st3 <- getDataselect(client,"AK","PIN","", "BHZ",starttime,endtime)

# Calculate metrics and append them to the metricList
metricList <- stateOfHealthMetric(st1)
metricList <- append(metricList, basicStatsMetric(st1))
metricList <- append(metricList, basicStatsMetric(st2))
metricList <- append(metricList, basicStatsMetric(st3))

# Create dataframe
metricDF <- metricList2DF(metricList)
head(metricDF)

## End(Not run)
```

---

metricList2DFList

*Conver a metricList into a list of dataframes*

---

**Description**

The `metricList2DFList` function converts a list of `SingleValueMetrics` into a list of dataframes, one per named metric.

**Usage**

```
metricList2DFList(metricList)
```

**Arguments**

metricList      a list of SingleValueMetric objects

**Details**

Metrics functions return lists of SingleValueMetric objects. A long metricList may be built up by appending the results of different metrics functions or the same metrics function operating on different seismic signals. A metricList generated by any of the MUSTANG Rscripts can be stored as an .RData file and reloaded for examination.

A metricList may contain values for many different metrics. This function creates a separate dataframe for each metricName found in the metricList. As each dataframe is created, values associated with that metric are stored in a column named after the metric. Individual dataframes are stored in the returned list with their own name: metricName\_DF.

**Value**

A character string with BSS formatted XML is returned.

**Note**

metricList2DFList is deprecated. Please use metricList2DF.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[SingleValueMetric-class](#), [metricList2DF](#), [metricList2Xml](#)

---

metricList2Xml      *Create XML for the BSS*

---

**Description**

The metricList2Xml function converts a list of SingleValueMetrics or GeneralValueMetric into an XML structure appropriate for submitting to the MUSTANG Backend Storage System (BSS).

**Usage**

```
metricList2Xml(metricList)
```

**Arguments**

metricList      a list of SingleValueMetric or GeneralValueMetric objects.

**Details**

Metrics functions return lists of `SingleValueMetric` or `GeneralValueMetric` objects. A long `metricList` may be built up by appending the results of different metrics functions or the same metrics function operating on different seismic signals. The list may only contain a single class (`SingleValueMetric` cannot be mixed with `GeneralValueMetric` objects). These metrics can be submitted to the BSS in a standardized XML format. (see [SingleValueMetric-class](#))

**Value**

A character string with BSS formatted XML is returned.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ", starttime, endtime)

# Apply a metric and show the results
metricList <- stateOfHealthMetric(st)
metricList <- append(metricList, basicStatsMetric(st))
bssXml <- metricList2Xml(metricList)

## End(Not run)
```

---

MultipleTimeValueMetric-class

*Class "MultipleTimeValueMetric"*

---

**Description**

A container for metrics consisting of a vector of `POSIXct` datetimes. This information is used to create XML that is then submitted to the MUSTANG Backend Storage System (BSS).

**Objects from the Class**

Objects can be created by calls of the form:

```
new("MultipleTimeValueMetric", snclq, starttime, endtime, metricName, values)
```

Lists of `MultipleTimeValueMetric` objects are returned by various metrics functions in this package.

**Slots**

**snclq:** Object of class "character": SNCLQ identifier.  
**metricName:** Object of class "character": Name of the metric.  
**elementName:** Object of class "character": Name of the datetime element (default="t").  
**starttime:** Object of class "POSIXct": Start time.  
**endtime:** Object of class "POSIXct": End time.  
**values:** Object of class "POSIXct": Datetime values.  
**valueStrings:** Object of class "character": String representations of the datetime values.  
**quality\_flag:** Object of class "numeric": Quality flag.  
**quality\_flagString:** Object of class "character": String representation of quality flag.

**Methods**

**show signature(object = "MultipleTimeValueMetric"):** Prettyprints the information in the MultipleTimeValueMetric

**Note**

The `starttime` and `endtime` slots are typically associated with the *user requested* times which may not match up with the `starttime` associated with the first Trace and the `endtime` associated with last Trace in the Stream object being analyzed. This ensures that metrics results for a single time period but covering many stations or channels will have the same date range and improves performance of the BSS which expects XML of the following form:

```

<measurements>
  <date start='2012-02-10T00:00:00.000' end='2012-02-10T09:20:00.000'>
    <target snclq='N.S.L.C1.Q'>
      <up_down_times>
        <t value="2012-02-10T00:00:00.000"/>
        <t value="2012-02-10T00:01:00.000"/>
        <t value="2012-02-10T00:02:00.000"/>
        <t value="2012-02-10T00:03:00.000"/>
      </up_down_times>
    </target>
  </date>
</measurements>
  
```

The `quality_flag` is an optional value available for storing information related to the processing of a particular metric. Its meaning will vary from metric to metric.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[upDownTimesMetric](#)

**Examples**

```

## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Make sure we're working with a single snclq
unique_ids <- uniqueIds(st)
if (length(unique_ids) > 1) {
  stop(paste("meanMetric: Stream has",unique_ids,"unique identifiers"))
}
snclq <- unique_ids[1]

# get the upDownTimes with a minimum signal length and minimum gap (secs)
upDownTimes <- getUpDownTimes(st, min_signal=30, min_gap=60)

# Create and return a MultipleTimeValue metric from the upDownTimes
m <- new("MultipleTimeValueMetric", snclq=snclq,
        starttime=starttime, endtime=endtime,
        metricName="up_down_times", values=upDownTimes)

# Show the results
show(m)

## End(Not run)

```

---

PSDMetric

*Power Spectral Density of a signal*


---

**Description**

The PSDMetric() function performs spectral analysis on a seismic signal and returns 'PSD' metrics with discretized spectral components as well as other metrics based on PSDs.

**Usage**

```

PSDMetric(st,
          expLoPeriod=4/(st@traces[[1]]@stats@sampling_rate),
          expHiPeriod=100,
          linLoPeriod=4/(st@traces[[1]]@stats@sampling_rate),
          linHiPeriod=100,
          evalresp=NULL)

```

### Arguments

st	a Stream object containing a seismic signal
expLoPeriod	low end of the period band use for calculating the exponential dead channel metric
expHiPeriod	high end of the period band use for calculating the exponential dead channel metric
linLoPeriod	low end of the period band use for calculating the linear dead channel metric
linHiPeriod	high end of the period band use for calculating the linear dead channel metric
evalresp	dataframe of freq, amp, phase information matching output of getEvalresp, optional

### Details

This function calculates average power spectra for a seismic signal as described in the McNamara paper. See the McNamaraPSD method of Stream objects in the **IRISSeismic** package for details.

If optional evalresp dataframe is not supplied, the code will call getEvalresp to obtain response information from webservices.

*Uncorrected* spectral density values are returned in spectrumMetricList in units of dB.

*Instrument response corrected* spectral density values are returned in correctedPsdDF in units of dB.

Probability Density Function (PDF) histogram values are returned in pdfDF.

Other metrics calculated from the PSDs are returned in svMetricList. These metrics are:

**pct\_above\_nhnm – "percent above New High Noise Model"** Percentage of PSD values that are above the New High Noise Model for their frequency. Only frequencies less than the sample\_rate/3 are considered to avoid instrument response effects as you approach the nyquist frequency. This value is calculated over the entire time period.

**pct\_below\_nlnm – "percent below New Low Noise Model"** Percentage of PSD values that are below the New Low Noise Model for their frequency. Only frequencies less than the sample\_rate/3 are considered to avoid instrument response effects as you approach the nyquist frequency. This value is calculated over the entire time period.

**dead\_channel\_exp – "dead channel metric - exponential fit"** A "dead channel" metric is calculated from the mean of all the PSDs generated. (Typically 47 for a 24 hour period.) Values of the PSD mean line over the band (expLoPeriod:expHiPeriod) are fit to an exponential. The dead\_channel\_exp metric is the standard deviation of the fit residuals. Lower numbers indicate a better fit and a higher likelihood that the mean PSD is exponential – an indication of a "dead channel".

**dead\_channel\_lin – "dead channel metric - linear fit"** A "dead channel" metric is calculated from the mean of all the PSDs generated. (Typically 47 for a 24 hour period.) Values of the PSD mean line over the band (linLoPeriod:linHiPeriod) are fit to a line. The dead\_channel\_lin metric is the standard deviation of the fit residuals. Lower numbers indicate a better fit and a higher likelihood that the mean PSD is linear – an indication of a "dead channel".

**Value**

A list of lists is returned containing:

- spectrumMetricList = list of SpectrumMetric objects
- correctedPsdDF = dataframe of starttime, endtime, frequency (Hz), power (dB) values
- pdfDF = dataframe of frequency (Hz), power (dB), hits (count) values
- svMetricList = list of SingleValueMetric objects:
  - pct\_above\_nhnm
  - pct\_below\_nlnm
  - dead\_channel\_exp
  - dead\_channel\_lin

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**References**

[Seismic Noise Analysis System Using Power Spectral Density Probability Density Functions](#) (McNamara and Boaz 2005)

[Observations and Modeling of Seismic Background Noise](#) (Peterson 1993).

**See Also**

[SpectrumMetric SingleValueMetric](#)

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# NOTE: The following trace has 1.728 million points.
# NOTE: Downloading and calculating PSD may take a few seconds.
starttime <- as.POSIXct("2010-02-27",tz="GMT")
endtime <- as.POSIXct("2010-02-28",tz="GMT")

# Get the waveform
st <- getDataselect(iris,"IU","ANM0","00","BHZ",starttime,endtime)

# Calculate the PSD metric and show the SingleValueMetric results
listOfLists <- PSDMetric(st)
svMetricList <- listOfLists[['svMetricList']]

dummy <- lapply(svMetricList, show)

## End(Not run)
```

---

saveMetricList	<i>Save a MetricList as RData or XML</i>
----------------	--

---

### Description

The saveMetricList() function allows metrics to be saved as either .RData files or as XML. The XML format is the same as that used by the IRIS DMC MUSTANG database for metric submission.

### Usage

```
saveMetricList(metricList, id=Sys.getpid(), rdata=FALSE)
```

### Arguments

metricList	list of SingleValueMetric objects
id	ID to be used when generating output files
rdata	optional flag to save the incoming metricList as a .RData file

### Details

The saveMetricList function saves a list of SingleValueMetrics as a .RData binary file or converts the list into the XML format expected by the MUSTANG database submission process. This XML format is human readable and can be used to spot check results of metrics calculations.

### Value

The automatically generated filename is returned invisibly.

### Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

### See Also

[SingleValueMetric-class](#), [metricList2Xml](#), [getMetricsXml](#), [getBssMetricList](#),

### Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Apply a metric and show the results
```

```
metricList <- stateOfHealthMetric(st)
metricList <- append(metricList, basicStatsMetric(st))
saveMetricList(metricList, id='AK.PIN..BHZ')

## End(Not run)
```

---

SingleValueMetric-class

*Class "SingleValueMetric"*

---

### Description

A container for metrics results and associated metadata. This information is used to create XML that is then submitted to the MUSTANG Backend Storage System (BSS). This has been superseded by GeneralValueMetric and is no longer in use.

### Objects from the Class

Objects can be created by calls of the form:

```
new("SingleValueMetric", snclq, starttime, endtime, metricName, value)
```

Lists of SingleValueMetric objects are returned by various metrics functions in this package.

### Slots

**snclq:** Object of class "character": SNCLQ identifier.

**metricName:** Object of class "character": Name of the metric.

**starttime:** Object of class "POSIXct": Start time.

**endtime:** Object of class "POSIXct": End time.

**valueName:** Object of class "character": Name of the XML value identifier (default="value").

**value:** Object of class "numeric": Metric value.

**valueString:** Object of class "character": String representation of the metric value.

**quality\_flag:** Object of class "numeric": Quality flag.

**quality\_flagString:** Object of class "character": String representation of quality flag.

**attributeName:** Object of class "character": Name of one or more optional attributes.

**attributeValueString:** Object of class "character": String representation of one or more attribute values.

### Methods

**show** signature(object = "SingleValueMetric"): Prettyprints the information in the SingleValueMetric

**Note**

The starttime and endtime slots are typically associated with the *user requested* times which may not match up with the starttime associated with the first Trace and the endtime associated with last Trace in the Stream object being analyzed. This ensures that metrics results for a single time period but covering many stations or channels will have the same date range and improves performance of the BSS which expects XML of the following form:

```
<measurements>
  <date start='2012-02-10T00:00:00.000' end='2012-02-10T09:20:00.000'>
    <target snclq='N.S.L.C1.Q'>
      <example value='1.0' />
    </target>
    <target snclq='N.S.L.C2.Q'>
      <example value='2.0' />
    </target>
    <target snclq='N.S.L.C3.Q'>
      <example value='3.0' />
    </target>
  </date>
</date>
</measurements>
```

The quality\_flag is an optional value available for storing information related to the processing of a particular metric. Its meaning will vary from metric to metric.

For an IRIS/DMC specific example, the station\_completeness metric obtains a list of available channels for a station from the availability web service and compares this list with the list of percent\_availability metrics for this station stored in the MUSTANG BSS. In the case of the station\_completeness metric, the quality\_flag is set to the number of channels that should be available but for whom no percent\_availability measure is obtained from the BSS.

The attributeName and attributeValueString slots can be used to store additional attributes associated with a metric values. For example, the max\_stalta value for a seismic trace can be calculated and a metric can be created that contains this value and another attribute with a string representation of the time at which this maximum occurred.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris, "AK", "PIN", "", "BHZ", starttime, endtime)
```

```
# Apply a metric and show the results
metricList <- basicStatsMetric(st)
show(metricList[[1]])

## End(Not run)
```

---

SNRMetric	<i>Signal to Noise Ratio</i>
-----------	------------------------------

---

### Description

The SNRMetric() function calculates the Signal-to-Noise Ratio of a seismic trace by one of several named algorithms.

### Usage

```
SNRMetric(st, algorithm, windowSecs)
```

### Arguments

st	a Stream object containing a seismic signal
algorithm	a named algorithm to use for calculating SNR (default="splitWindow")
windowSecs	width (seconds) of the full window used in SNR calculations (default=60)

### Details

Seismic signals in the Stream must be without gaps, *i.e.* contained within a single Trace.

```
algorithm="splitWindow"
```

This algorithm uses the midpoint of the seismic signal as the border between noise to the left of the midpoint and signal to the right. The value for signal-to-noise is just the rmsVariance calculated for windowSecs/2 seconds of data to the right of the midpoint divided by the rmsVariance for windowSecs/2 seconds of data to the left of the midpoint.

No other algorithms have been vetted at this point.

### Value

A list with a single SingleValueMetric object is returned.

### Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get an hour long waveform centered on a big quake
starttime <- as.POSIXct("2010-02-27 06:16:15",tz="GMT")
endtime <- as.POSIXct("2010-02-27 07:16:15",tz="GMT")
st <- getDataselect(iris,"IU","ANMO","00","BHZ",starttime,endtime)
tr <- st@traces[[1]]

# Calculate the SNR metric and show the results
metricList <- SNRMetric(st)
dummy <- lapply(metricList, show)

## End(Not run)
```

---

SpectrumMetric-class    *Class "SpectrumMetric"*

---

**Description**

A container for metrics consisting of discrete spectra. This information is used to create XML that is then submitted to the MUSTANG Backend Storage System (BSS).

**Objects from the Class**

Objects can be created by calls of the form:

```
new("SpectrumMetric", snclq, starttime, endtime, metricName, freqs, amps, phases)
```

**Slots**

**snclq:** Object of class "character": SNCLQ identifier.

**metricName:** Object of class "character": Name of the metric.

**elementName:** Object of class "character": Name of the datetime element (default="t").

**starttime:** Object of class "POSIXct": Start time.

**endtime:** Object of class "POSIXct": End time.

**freqs:** Object of class "numeric": Frequency values.

**freqStrings:** Object of class "character": String representations of the frequency values.

**amps:** Object of class "numeric": Amplitude values.

**ampStrings:** Object of class "character": String representations of the amplitude values.

**phases:** Object of class "numeric": Phase values.

**phaseStrings:** Object of class "character": String representations of the phase values.

**quality\_flag:** Object of class "numeric": Quality flag.

**quality\_flagString:** Object of class "character": String representation of quality flag.

**Methods**

`show signature(object = "SpectrumMetric")`: Prettyprints the information in the SpectrumMetric

**Note**

The `quality_flag` is an optional value available for storing information related to the processing of a particular metric. Its meaning will vary from metric to metric.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

---

spectrumMetric2Xml      *Convert a SpectrumMetric into XML for the BSS*

---

**Description**

The `spectrumMetric2Xml` function converts a `SpectrumMetric` into an XML structure appropriate for submitting to the MUSTANG Backend Storage System (BSS).

**Usage**

```
spectrumMetric2Xml(metricList)
```

**Arguments**

`metricList`      a list of `SpectrumMetric` objects

**Value**

A character string with BSS formatted XML is returned.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# NOTE: The following trace has 1.728 million points.
# NOTE: Downloading and calculating PSD may take a while.
starttime <- as.POSIXct("2010-02-27",tz="GMT")
endtime <- as.POSIXct("2010-02-28",tz="GMT")

# Get the waveform
st <- getDataselect(iris,"IU","ANMO","00","BHZ",starttime,endtime)
```

```

# Make sure we're working with a single snclq
unique_ids <- uniqueIds(st)
if (length(unique_ids) > 1) {
  stop(paste("PSDMetric: Stream has",unique_ids,"unique identifiers"))
}
snclq <- unique_ids[1]

# Calculate and plot the Power Spectral Density
psdList <- psdList(st)

# Create a Spectrum metric list
spectrumMetricList <- list()
index <- 1
for (psd in psdList) {
  spectrumMetricList[[index]] <- new("SpectrumMetric", snclq=snclq,
                                     starttime=psd$starttime, endtime=psd$endtime,
                                     metricName="psd", freqs=psd$freq,
                                     amps=psd$spec, phases=psd$freq*0)

  index <- index + 1
}

# Show the XML version of the metric
bssXml <- spectrumMetric2Xml(spectrumMetricList)
cat(bssXml)

## End(Not run)

```

---

spikesMetric

*Find spikes using a rolling Hampel filter*


---

## Description

The `spikesMetric()` function determines the number of spikes in a seismic Stream.

## Usage

```
spikesMetric(st, windowSize=41, thresholdMin=10, selectivity=NA, fixedThreshold=TRUE)
```

## Arguments

<code>st</code>	a Stream object containing a seismic signal
<code>windowSize</code>	The window size to roll over (default=41)
<code>thresholdMin</code>	Initial value for outlier detection (default=10.0)
<code>selectivity</code>	Numeric factor [0-1] used in determining outliers, or NA if <code>fixedThreshold=TRUE</code> (default=NA)
<code>fixedThreshold</code>	TRUE or FALSE, set the <code>threshold=thresholdMin</code> and ignore <code>selectivity</code> (default=TRUE)

## Details

This function uses the output of the `findOutliers()` function in the **seismicRoll** package to calculate the number of 'spikes' containing outliers.

The `thresholdMin` level is similar to a sigma value for normally distributed data. Hampel filter values above 6.0 indicate a data value that is extremely unlikely to be part of a normal distribution (~ 1/500 million) and therefore very likely to be an outlier. By choosing a relatively large value for `thresholdMin` we make it less likely that we will generate false positives. False positives can include high frequency environmental noise.

The `selectivity` is a value between 0 and 1 and is used to generate an appropriate threshold for outlier detection based on the statistics of the incoming data. A lower value for `selectivity` will result in more outliers while a value closer to 1.0 will result in fewer. The code ignores `selectivity` if `fixedThreshold=TRUE`.

The `fixedThreshold` is a logical TRUE or FALSE. If TRUE, then the threshold is set to `thresholdMin`. If FALSE, then the threshold is set to maximum value of the `roll_hampel()` function output multiplied by the `selectivity`.

The total count of spikes reflects the number of outlier data points that are separated by at least one non-outlier data point. Each individual spike may contain more than one data point.

## Value

A list of `SingleValueMetric` objects is returned.

## Note

The `thresholdMin` parameter is sensitive to the data sampling rate. The default value of 10 seems to work well with sampling rates of 10 Hz or higher ('B.' or 'H.' channels). For 'L.' channels with a sampling rate of 1 Hz `thresholdMin=12.0` or larger may be more appropriate.

### **More testing of spiky signals at different resolutions is needed.**

See the **seismicRoll** package for documentation on the `findOutliers()` function.

## Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

## Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2013-01-03 15:00:00", tz="GMT")
endtime <- starttime + 3600 * 3
st <- getDataselect(iris,"IU","RA0","10","BHZ",starttime,endtime)

# Calculate the gaps metrics and show the results
metricList <- spikesMetric(st)
dummy <- show(metricList)
```

```
## End(Not run)
```

---

STALTA Metric                      *Maximum STA/LTA of a signal*

---

### Description

The STALTA Metric() function calculates the maximum of STA/LTA over the incoming seismic signal.

### Usage

```
STALTA Metric(st, staSecs, ltaSecs, increment, algorithm)
```

### Arguments

st	a Stream object containing a seismic signal
staSecs	length of the short term averaging window in seconds (default=3)
ltaSecs	length of the long term averaging window in seconds (default=30)
algorithm	algorithm to be used (default="classic_LR")
increment	increment used when sliding the averaging windows to the next location (default=1)

### Details

Currently supported algorithms include:

- "classic\_RR"
- "classic\_LR"
- "EarleAndShearer\_envelope"

This metric applies the STALTA method of Trace objects to every Trace in st with the following parameter settings:

- demean=TRUE
- detrend=TRUE
- taper=0.0

The final metric value is the maximum STALTA value found in any Trace in this Stream.

Further details are given in the documentation for STALTA.Trace().

### Value

A list with a single SingleValueMetric object is returned. The metric name is max\_stalta.

**Note**

The STALTA method of Trace objects returns a numeric vector of STA/LTA values that has the same length as the signal data. This is a moderately time consuming operation. By comparison, finding the maximum value of this vector of STA/LTA values is very fast.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**References**

- [First break picking](#) (Wikipedia)
- [Automatic time-picking of first arrivals on noisy microseismic data](#) (Wong et. al. 2009)
- [Automatic first-breaks picking: New strategies and algorithms](#) (Sabbione and Velis 2010)

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-02-12",tz="GMT")
endtime <- as.POSIXct("2012-02-13",tz="GMT")
st <- getDataselect(iris,"AK","GHO","", "BHN",starttime,endtime)

# Calculate the STA/LTA metric and show the results
metricList <- STALTAMetric(st)
dummy <- lapply(metricList, show)

## End(Not run)
```

---

stateOfHealthMetric    *State of Health metrics*

---

**Description**

The stateOfHealthMetric function extracts accumulated miniSEED quality flags and a measure of timing quality associated with the incoming seismic signal.

**Usage**

```
stateOfHealthMetric(st)
```

**Arguments**

st                    a Stream object containing a seismic signal

## Details

The miniSEED flags and timing\_qual values are described in the SEED manual ([http://www.fdsn.org/seed\\_manual/SEEDManual\\_V2.4.pdf](http://www.fdsn.org/seed_manual/SEEDManual_V2.4.pdf)).

Each Stream object contains "accumulators" with counts of the number of times each bit flag was set during the parsing of a miniSEED file. Metrics are reported for a subset of these flags as show in the code snippet below:

```
# act_flags
calibration_signal <- st@act_flags[1]
timing_correction <- st@act_flags[2]
event_begin <- st@act_flags[3]
event_end <- st@act_flags[4]
event_in_progress <- st@act_flags[7]

# io_flags
clock_locked <- st@io_flags[6]

# dq_flags
amplifier_saturation <- st@dq_flags[1]
digitizer_clipping <- st@dq_flags[2]
spikes <- st@dq_flags[3]
glitches <- st@dq_flags[4]
missing_padded_data <- st@dq_flags[5]
telemetry_sync_error <- st@dq_flags[6]
digital_filter_charging <- st@dq_flags[7]
```

An additional "timing quality" metric gives the average value for the timing\_qual value associated with each block of miniSEED data.

## Value

A list of SingleValueMetric objects is returned.

## Author(s)

Jonathan Callahan <[jonathan@mazamascience.com](mailto:jonathan@mazamascience.com)>

## Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Generate State of Health metrics and show the results
```

```
metricList <- stateOfHealthMetric(st)
dummy <- lapply(metricList, show)

## End(Not run)
```

---

timesMetric2Xml      *Create XML for the BSS*

---

### Description

The timesMetric2Xml function converts a MultipleTimeValueMetric into an XML structure appropriate for submitting to the MUSTANG Backend Storage System (BSS).

### Usage

```
timesMetric2Xml(metric)
```

### Arguments

metric            a MultipleTimeValueMetric object

### Value

A character string with BSS formatted XML is returned.

### Author(s)

Jonathan Callahan <jonathan@mazamascience.com>

### Examples

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

# Get the waveform
starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Make sure we're working with a single snclq
unique_ids <- uniqueIds(st)
if (length(unique_ids) > 1) {
  stop(paste("meanMetric: Stream has",unique_ids,"unique identifiers"))
}
snclq <- unique_ids[1]

# get the upDownTimes with a minimum signal length and minimum gap (secs)
upDownTimes <- getUpDownTimes(st, min_signal=30, min_gap=60)
```

```
# Create and return a MultipleTimeValue metric from the upDownTimes
m <- new("MultipleTimeValueMetric", snclq=snclq, starttime=starttime,
        endtime=endtime, metricName="up_down_times", values=upDownTimes)

# Show the XML version of the metric
bssXml <- timesMetric2Xml(m)
cat(bssXml)

## End(Not run)
```

---

transferFunctionMetric

*Cross-spectral comparison*

---

## Description

The transferFunctionMetric() function calculates metrics that assess the relationship between two SNCLs with the same network, station and channel but separate locations. When seismometers are working properly, the transfer function amplitude and phase will match similar values calculated from the instrument responses.

This function calculates the transfer function from data in the incoming streams. Response information is then obtained from the [evalresp web service](#).

## Usage

```
transferFunctionMetric(st1, st2, evalresp1, evalresp2)
```

## Arguments

st1	a Stream object containing a seismic signal
st2	a Stream object containing a seismic signal
evalresp1	a data frame containing an amplitude and phase spectrum
evalresp2	a data frame containing an amplitude and phase spectrum

## Details

Details of the algorithm are as follows

```
# compute complex cross-spectrum of traces x and y ==> Pxx, Pxy, Pyy
# calculate transfer function values:
#   Txy(f) = Pxy(f) / Pxx(f)
#   dataGain <- Mod(Txy)
#   dataPhase <- Arg(Txy)
#
# calculate avgDataGain and avgDataPhase values for periods of 5-7s
#
# calculate the corresponding response amplitude ratio and phase difference:
```

```

#   request responses for x and y
#   respGain = respGainy(f) / respGainx(f)
#   respPhase = respPhasey(f) - respPhasex(f)
#
# calculate avgRespGain and avgRespPhase values for periods of 5-7s
#
# calculate metrics:
#   gain_ratio = avgDataGain / avgRespGain
#   hase_diff = avgDataPhase - avgRespPhase
#   ms_coherence = |Pxy|^2 / (Pxx*Pyy)

```

### Value

A list with a single SingleValueMetric object is returned. The metric name is `transfer_function` and it has three attributes:

- `gain_ratio` – reasonableness of cross-spectral amplitude between `st1` and `st2`
- `phase_diff` – reasonableness of cross-spectral phase between `st1` and `st2`
- `ms_coherence` – mean square coherence between `st1` and `st2`

These values can be interpreted as follows:

Whenever `ms_coherence`  $\approx$  1.0, properly functioning seismometers should have:

- `gain_ratio`  $\approx$  1.0
- `phase_diff` < 10.0 (degrees)

### Note

Seismic streams passed to `transferFunctionMetric()` must have the same network, station and channel and must cover the same time range. The two channels should also have values of azimuth and dip within five degrees of each other. If sampling rates differ and one is a multiple of the other, the stream with the higher sampling rate will be decimated to match the lower sampling rate.

The `metricList` generated for these two-channel metrics will have a SNCL code of the form: `N.S.L1:L2.C.Q.`

### Author(s)

Jonathan Callahan <jonathan@mazamascience.com> (R code), Mary Templeton <met@iris.washington.edu> (algorithm)

### Examples

```

## Not run:
# Create a new IrisClient
iris <- new("IrisClient", debug=TRUE)

# Get seismic data
starttime <- as.POSIXct("2011-05-01", tz="GMT")
endtime <- starttime + 3600
# These values are specific to two 40 sps channels
minfreq <- 0.005255603

```

```

maxfreq <- 19.7403
nfreq <- 96
units <- 'def'
output <- 'fap'

st1 <- getDataselect(iris,"CI","PASC","00","BHZ",starttime,endtime)
st2 <- getDataselect(iris,"CI","PASC","10","BHZ",starttime,endtime)
evalresp1 <- getEvalresp(iris, "CI", "PASC", "00", "BHZ", starttime,
                        minfreq, maxfreq, nfreq, units, output)
evalresp2 <- getEvalresp(iris, "CI", "PASC", "10", "BHZ", starttime,
                        minfreq, maxfreq, nfreq, units, output)

# Calculate metrics
metricList <- transferFunctionMetric(st1,st2,evalresp1,evalresp2)
print(metricList)

## End(Not run)

```

---

upDownTimesMetric      *Up/down times for a channel*

---

### Description

The upDownTimesMetric() function determines the times at which data collection starts and stops within a seismic Stream.

### Usage

```
upDownTimesMetric(st, min_signal, min_gap)
```

### Arguments

st	a Stream object containing a seismic signal
min_signal	minimum duration of a Trace in seconds (default=30)
min_gap	minimum gap in seconds (default=60)

### Details

This function uses the output of the getUpDownTimes method of Stream objects.

### Value

A list with a single MultipleTimeValueMetric object is returned.

### Note

See the seismic package for documentation on Stream objects and the getDataselect method.

**Author(s)**

Jonathan Callahan <jonathan@mazamascience.com>

**See Also**

[getUpDownTimes](#)

**Examples**

```
## Not run:
# Open a connection to IRIS DMC webservices
iris <- new("IrisClient")

starttime <- as.POSIXct("2012-01-24", tz="GMT")
endtime <- as.POSIXct("2012-01-25", tz="GMT")

# Get the waveform
st <- getDataselect(iris,"AK","PIN","", "BHZ",starttime,endtime)

# Create the upDownTimesMetric, ignoring Traces < 3 minutes and gaps of < 5 minutes
metricList <- upDownTimesMetric(st, min_signal=180, min_gap=300)

## End(Not run)
```

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