

# SuperMAG MATLAB Client 1.0

SuperMAG Web Service API MATLAB Client Documentation  
*MATLAB 2017 or later required*

## ◆ stations=fetchSuperMAG('inventory',userid,start,extent)

MATLAB function that retrieves an array of available stations for a given event.

**Parameters**  
**category** first parameter must be set to 'inventory' to return stations  
**userid** your supermag user id  
**start** start date of event, either in the format 'YYYY-MM-DDThhmm' or as an array [YYYY, MM, DD, hh, mm] (seconds are optional)  
**extent** extent or length of the event in seconds (3600= 1 hour, 86400 = 1 day)  
**noisy** (optional) If the keyword NOISY is supplied, the fetching routine will display the URL used and the first three rows of data, to help verify success to the user.

**Returns**  
Array of available stations. If there was an error, return is the error message.

**Example Usage**

```
mydata=fetchSuperMAG('inventory',userid,'2019-11-15T10:40',3600)
disp('Available Stations')
for i = 1:length(mydata)
    disp(mydata{i})
end
```

## ◆ sm\_data=fetchSuperMAG('data',userid,start,extent,flags,station)

MATLAB function that retrieves station magnetometer data for a given event and IAGA station code.

**Parameters**  
**category** first parameter must be set to 'data' to return stations  
**userid** your supermag user id  
**yr** start date of event, either in the format 'YYYY-MM-DDThhmm' or as an array [YYYY, MM, DD, hh, mm] (seconds are optional)  
**extent** extent or length of the event in seconds (3600= 1 hour, 86400 = 1 day)  
**station** IAGA code of the requested station  
**flags** list in string or array form of which data items to return and processing flags to use (see below). The full list of data items is either 'all' or 'mlt\_mag\_geo.decl.sza'. Flags can alternately be in array format, e.g. ['mlt' 'mag' 'geo' 'decl' 'sza']. Processing flags available are 'delta=start', 'baseline=None', 'baseline=yearly'. Flags are not case-sensitive

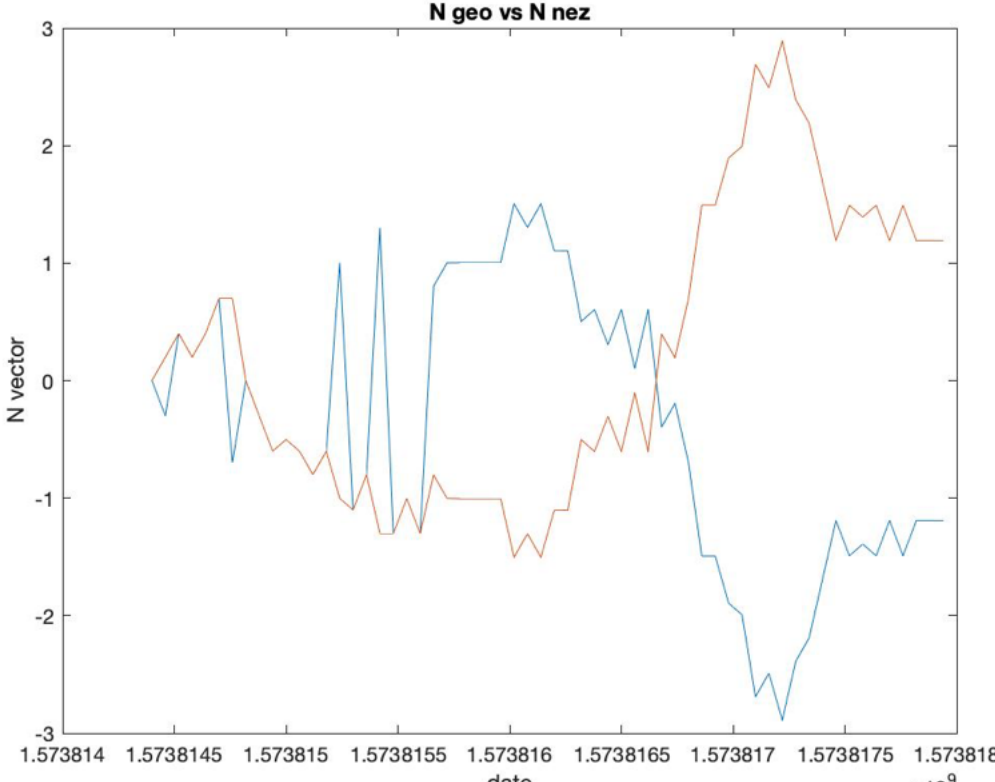
<b>MLT</b>	(optional) If supplied, The MLT/MCOLAT of the station will be returned in the two dimensional array of length extent/60 specified by MLT.						
<b>MAG</b>	(optional) If supplied, The Magnetic coordinates of the station will be returned in the two dimensional array of length extent/60 specified by MAG.						
<b>GEO</b>	(optional) If supplied, The Geographic coordinates of the station will be returned in the two dimensional array of length extent/60 specified by GEO.						
<b>DECL</b>	(optional) If supplied, The Declination from IGRF Model will be returned in the array of length extent/60 specified by DECL.						
<b>SZA</b>	(optional) If supplied, The solar zenith angle will be returned in the array of length extent/60 specified by SZA.						
<b>DELTA</b>	(optional) If the keyword DELTA is supplied, The baseline NEZ vector start values will be subtracted from the NEZ vector components in the resulting n, e, and z arrays.						
<b>BASELINE</b>	(optional) If BASELINE is specified, It must be set to one of three values: <table border="1"><tr><td>"baseline='all'" (default)</td><td>Subtract both the daily and yearly NEZ baselines</td></tr><tr><td>"baseline='yearly'"</td><td>Subtract the yearly NEZ baseline, but do not subtract the daily NEZ baseline</td></tr><tr><td>"baseline='none'"</td><td>Do not subtract either the yearly or the daily NEZ baseline</td></tr></table>	"baseline='all'" (default)	Subtract both the daily and yearly NEZ baselines	"baseline='yearly'"	Subtract the yearly NEZ baseline, but do not subtract the daily NEZ baseline	"baseline='none'"	Do not subtract either the yearly or the daily NEZ baseline
"baseline='all'" (default)	Subtract both the daily and yearly NEZ baselines						
"baseline='yearly'"	Subtract the yearly NEZ baseline, but do not subtract the daily NEZ baseline						
"baseline='none'"	Do not subtract either the yearly or the daily NEZ baseline						
<b>noisy</b>	(optional) If the keyword NOISY is supplied, the fetching routine will display the URL used and the first three rows of data, to help verify success to the user.						

**Returns**  
Structure with all return data. If there was an error, return is the error message. The format of the returns is as follows.

**tval** The time of the samples is returned as the structure element tval. The time array is an array of double precision numbers giving the time since 1970-01-01 0:00UTC (This is a standard representation of time on computer systems).  
**ext** The binned duration for each sample is returned, typically '60' representing the 1-minute bins of standard SuperMAG data  
**iaga** The 3-letter station code provided is returned in the structure, useful for identification when you have multiple sets of data.  
**N** The N vector component is returned in the two structure element arrays of length extent/60 specified by N. The second dimension refers to the coordinate system, so 'N.nez' contains the component of the vector in the standard NEZ coordinates. 'N.geo' contains the geographic mapping of the N vector component.  
**E** The E vector component is returned in the two structure element arrays of length extent/60 specified by E. The second dimension refers to the coordinate system, so 'E.nez' contains the component of the vector in the standard NEZ coordinates. 'E.geo' contains the geographic mapping of the E vector component.  
**Z** The A vector component is returned in the two structure element arrays of length extent/60 specified by Z. The second dimension refers to the coordinate system, so 'Z.nez' contains the component of the vector in the standard NEZ coordinates. 'Z.geo' contains the geographic mapping of the Z vector component.  
**mlt** (optional) If supplied, The MLT/MCOLAT of the station will be returned in the two structure element arrays 'mlt' and 'mcolat' of length extent/60 specified by MLT.  
**mag** (optional) If supplied, The Magnetic coordinates of the station will be returned in the two structure element arrays 'mlat' and 'mlon' of length extent/60 specified by MAG.  
**geo** (optional) If supplied, The Geographic coordinates of the station will be returned in the two structure element arrays 'glon' and 'glat' of length extent/60 specified by GEO.  
**decl** (optional) If supplied, The Declination from IGRF Model will be returned as a structure element array 'decl' of length extent/60 specified by DECL.  
**sza** (optional) If supplied, The solar zenith angle will be returned as a structure element array 'sza' of length extent/60 specified by SZA.

### Example Usage

```
sm_data=fetchSuperMAG('data',userid,'2019-11-15T10:40',3600,'all,delta=start,baseline=yearly','HBK');
% simple plot of two nested structure elements
tval=[sm_data.tval]
% extract the N.geo and N.nez elements
N=[sm_data.N]
% plot the N.geo and N.nez elements
plot(tval, [N.geo])
hold on
plot(tval, [N.nez])
hold off
title('N geo vs N nez')
xlabel('date')
ylabel('N vector')
% Alternate way to extract a nested structure element such as sm_data.N.geo
N_geo = arrayfun(@(k) sm_data(k).N.geo, 1:numel(sm_data));
plot([sm_data.tval], N_geo)
% If you prefer everything as arrays instead of structures:
TVAL=sm_data.tval;
N_NEZ = arrayfun(@(k) sm_data(k).N.nez, 1:numel(sm_data));
E_NEZ = arrayfun(@(k) sm_data(k).E.nez, 1:numel(sm_data));
Z_NEZ = arrayfun(@(k) sm_data(k).Z.nez, 1:numel(sm_data));
MLT=[sm_data.mlt];
MCOLAT=[sm_data.mcolat];
MLON=[sm_data.mlon];
MLAT=[sm_data.mlat];
GLON=[sm_data.glon];
GLAT=[sm_data.glat];
SZA=[sm_data.sza];
```



## ◆ sm\_indices=fetchSuperMAG('indices',userid,start,extent,flags)

MATLAB function that retrieves a set of magnetic indices for a given event.

**Parameters**  
**category** first parameter must be set to 'data' to return stations  
**userid** your supermag user id  
**yr** start date of event, either in the format 'YYYY-MM-DDThhmm' or as an array [YYYY, MM, DD, hh, mm] (seconds are optional)  
**extent** extent or length of the event in seconds (3600= 1 hour, 86400 = 1 day)  
**flags** list in string or array form of which data items to return and processing flags to use (see below). The full list of data items is either 'all' or any subset, e.g. 'sme, sunsme, darksme'. Flags can alternately be in array format, e.g. ['sme' 'sunsme' 'darksme']. Several flags have alternative names which you are free to use (these are derived from the set of tags the SuperMAG web server uses natively.) Flags are not case-sensitive.

<b>SME</b>	(optional) If supplied, the SME indice will be returned in the structure array 'SME' (See definition of SME indice)
<b>SML</b>	(optional) If supplied, the SML indice will be returned in the structure array 'SML' (See definition of SML indice)
<b>SMU</b>	(optional) If supplied, the SMU indice will be returned in the structure array 'SMU' (See definition of SMU indice)
<b>NUM</b>	(optional) If supplied, the number of stations used to compute SME indices will be returned in the structure array 'SMEnum'
<b>(optional) the following options return additional data items, but only if SME, SML and/or SMU is set (for SME, returns both SMU and SML entries; for SMU, only SMU entries; for SML, only SML entries)</b>	
<b>MLAT</b>	(optional) If supplied, the magnetic latitude of the SME indice will be returned in the structure array 'SMLmlat' and 'SMUmlat'
<b>MLT</b>	(optional) If supplied, the magnetic local time of the SME indice will be returned in the structure array 'SMLmlt' and 'SMUmlt'
<b>GLAT</b>	(optional) If supplied, the geographic latitude of the SME indice will be returned in the structure array 'SMLglat' and 'SMUglat'
<b>GLON</b>	(optional) If supplied, the geographic longitude of the SME indice will be returned in the structure array 'SMLglon' and 'SMUglon'
<b>STID</b>	(optional) If supplied, the IAGA station codes of the stations used to compute the SME indices will be returned in the structure array 'SMLstid' and 'SMUstid'
<b>baseall</b>	(optional) If supplied, is the equivalent of the set of 'sme.sml.smu.mlat.mlt.glat.glon.stid.num'

<b>SUNSME (alt: smes)</b>	(optional) If supplied, the Sunlit SME indice will be returned in the structure array 'SMEs' (See definition of Sunlit SME indice)
<b>SUNSM (alt: smls)</b>	(optional) If supplied, the Sunlit SML indice will be returned in the structure array 'SMLs' (See definition of Sunlit SML indice)
<b>SUNSMU (alt: smus)</b>	(optional) If supplied, the Sunlit SMU indice will be returned in the structure array 'SMUs' (See definition of Sunlit SMU indice)
<b>SUNNUM (alt: numS)</b>	(optional) If supplied, the number of stations used to compute the Sunlit SME indices will be returned in the structure array 'sunnum'
<b>(optional) the following options return additional data items, but only if SMEs, SMLs and/or SMUs is set (for SMEs, returns both SMU and SMLs entries; for SMUs, only SMUs entries; for SMLs, only SMLs entries)</b>	
<b>SUNMLAT (alt: mlatS)</b>	(optional) If supplied, the magnetic latitude of the Sunlit SME indice will be returned in the structure array 'SMLsmlat' and 'SMUsmlat'
<b>SUNMLT (alt: mlts)</b>	(optional) If supplied, the magnetic local time of the Sunlit SME indice will be returned in the structure array 'SMLsmlt' and 'SMUsmlt'
<b>SUNGLAT (alt: glats)</b>	(optional) If supplied, the geographic latitude of the Sunlit SME indice will be returned in the structure array 'SMLsglat' and 'SMUsglat'
<b>SUNGLON (alt: glons)</b>	(optional) If supplied, the geographic longitude of the Sunlit SME indice will be returned in the structure array 'SMLsglon' and 'SMUsglon'
<b>SUNSTID (alt: stids)</b>	(optional) If supplied, the IAGA station codes of the stations used to compute the Sunlit SME indices will be returned in the structure array 'SMLstid' and 'SMUstid'
<b>sunall</b>	(optional) If supplied, is the equivalent of the set of 'smes.smls.smus.mlat.mlt.glat.glon.stids.numS'

<b>DARKSME (alt: smed)</b>	(optional) If supplied, the Dark SME indice will be returned in the structure array 'darksme' (See definition of Dark SME indice)
<b>DARKSML (alt: smld)</b>	(optional) If supplied, the Dark SML indice will be returned in the structure array 'darksm' (See definition of Dark SML indice)
<b>DARKSMU (alt: smud)</b>	(optional) If supplied, the Dark SMU indice will be returned in the structure array 'darksmu' (See definition of Dark SMU indice)
<b>DARKNUM (alt: numd)</b>	(optional) If supplied, the number of stations used to compute the Dark SME indices will be returned in the structure array 'darknum'
<b>(optional) the following options return additional data items, but only if SMed, SMLd and/or SMUd is set (for SMed, returns both SMUd and SMLd entries; for SMUd, only SMUd entries; for SMLd, only SMLd entries)</b>	
<b>DARKMLAT (alt: mlatd)</b>	(optional) If supplied, the magnetic latitude of the Dark SME indice will be returned in the structure array 'SMLdmlat' and 'SMUdmlat'
<b>DARKMLT (alt: mltd)</b>	(optional) If supplied, the magnetic local time of the Dark SME indice will be returned in the structure array 'SMLdmlt' and 'SMUdmlt'
<b>DARKGLAT (alt: glatd)</b>	(optional) If supplied, the geographic latitude of the Dark SME indice will be returned in the structure array 'SMLdglat' and 'SMUdglat'
<b>DARKGLON (alt: glond)</b>	(optional) If supplied, the geographic longitude of the Dark SME indice will be returned in the structure array 'SMLdglon' and 'SMUdglon'
<b>DARKSTID (alt: stidd)</b>	(optional) If supplied, the IAGA station codes of the stations used to compute the Dark SME indices will be returned in the structure array 'SMLdtd' and 'SMUdtd'
<b>darkall</b>	(optional) If supplied, is the equivalent of the set of 'smed.smld.smud.mlat.mlt.glat.glon.stidd.numd'

<b>REGIONALSME (alt: smer)</b>	(optional) If supplied, the Regional SME indice will be returned in the structure array 'SMEr' (See definition of Regional SME indice)
<b>REGIONALSML (alt: smlr)</b>	(optional) If supplied, the Regional SML indice will be returned in the structure array 'SMLr' (See definition of Regional SML indice)
<b>REGIONALSMU (alt: smur)</b>	(optional) If supplied, the Regional SMU indice will be returned in the structure array 'SMUr' (See definition of Regional SMU indice)
<b>REGIONALNUM (alt: numr)</b>	(optional) If supplied, the number of stations used to compute the Regional SME indices will be returned in the structure array 'SMErnum'
<b>(optional) the following options return additional data items, but only if SMER, SMLr and/or SMUr is set (for SMER, returns both SMUr and SMLr entries; for SMUr, only SMUr entries; for SMLr, only SMLr entries)</b>	
<b>REGIONALMLAT (alt: mlatr)</b>	(optional) If supplied, the magnetic latitude of the Regional SME indice will be returned in the structure array 'SMLrmlat' and 'SMUrmlat'
<b>REGIONALMLT (alt: mltr)</b>	(optional) If supplied, the magnetic local time of the Regional SME indice will be returned in the structure array 'SMLrmlt' and 'SMUrmlt'
<b>REGIONALGLAT (alt: glatr)</b>	(optional) If supplied, the geographic latitude of the Regional SME indice will be returned in the structure array 'SMLrglat' and 'SMUrglat'
<b>REGIONALGLON (alt: glonr)</b>	(optional) If supplied, the geographic longitude of the Regional SME indice will be returned in the structure array 'SMLrglon' and 'SMUrglon'
<b>REGIONALSTID (alt: stidr)</b>	(optional) If supplied, the IAGA station codes of the stations used to compute the Regional SME indices will be returned in the structure array 'SMLrtd' and 'SMUrtd'
<b>regall</b>	(optional) If supplied, is the equivalent of the set of 'sme.sml.smu.mlat.mlt.glat.glon.stid.num'

<b>SMR</b>	(optional) If supplied, the SMR indice will be returned in the structure array 'smr' (See definition of SMR indice)
<b>LTSMR</b>	(optional) If supplied, the SMR LT indice will be returned in the structure arrays 'smr00','smr06','smr12','smr18' (See definition of SMR LT indice)
<b>LTNUM</b>	(optional) If supplied, the number of stations used to compute the SMR LTN indice will be returned in the structure arrays 'smrnum00','smrnum06','smrnum12','smrnum18'
<b>NSMR</b>	(optional) If supplied, the number of stations used to compute the SMR indices will be returned in the structure array 'nsmr'
<b>plusall</b>	(optional) If supplied, is the equivalent of the set of 'sme.sml.smu.mlat.mlt.glat.glon.stid.num'

**all** (optional) If supplied, is the equivalent to all the above, 'baseall,small,darkall,regall,plusall' (but not the swi and imf keys below)

<b>BGSE</b>	(optional) If supplied, the Solar Wind B field (GSE) parameter will be returned in the structure array 'bgse'
<b>BGSM</b>	(optional) If supplied, the Solar Wind B field (GSM) parameter will be returned in the structure array 'bgsm'
<b>VGSE</b>	(optional) If supplied, the Solar Wind V (GSE) parameter will be returned in the structure array 'vgse'
<b>VGSM</b>	(optional) If supplied, the Solar Wind V (GSM) parameter will be returned in the structure array 'vgsm'
<b>imfall</b>	(optional) If supplied, is the equivalent of the set of 'sme.sml.smu.mlat.mlt.glat.glon.stid.num'

<b>PDYN</b>	(optional) If supplied, the Solar Wind Dynamic Pressure parameter will be returned in the structure array 'pdyn'
<b>EPSILON</b>	(optional) If supplied, the Solar Wind E Parameter parameter will be returned in the structure array 'epsilon'
<b>NEWELL</b>	(optional) If supplied, the Solar Wind Newell parameter will be returned in the structure array 'newell'
<b>CLOCKGSE</b>	(optional) If supplied, the IMF Clock Angle (GSE) parameter will be returned in the structure array 'clockgse'
<b>CLOCKGSM</b>	(optional) If supplied, the IMF Clock Angle (GSM) parameter will be returned in the structure array 'clockgsm'
<b>DENSITY</b>	(optional) If supplied, the Solar Wind Plasma Density parameter will be returned in the structure array 'density'
<b>swi</b>	(optional) If supplied, is the equivalent of the set of 'sme.sml.smu.mlat.mlt.glat.glon.stid.num'

**noisy** (optional) If the keyword NOISY is supplied, the fetching routine will display the URL used and the first three rows of data, to help verify success to the user.

**Returns**  
Structure with all return data. If there was an error, return is the error message. The format of the returns is as follows.

The following data structure arrays are returned, dependent on which optional flags you requested. Note that no data is returned unless flags are specified, there is no 'default dataset'.

**tval** The time of the samples is returned as the structure element tval. The time array is an array of double precision numbers giving the time since 1970-01-01 0:00UTC (This is a standard representation of time on computer systems).  
**decl** (optional) If supplied, The Declination from IGRF Model will be returned as a structure element array 'decl' of length extent/60 specified by DECL.  
**base data:** Structure elements as defined above and named: SME, SML, SMLmlat, SMLmlt, SMLglat, SMLglon, SMLstid, SMU, SMUmlat, SMUmlt, SMUglat, SMUglon, SMUstid, SMEnum  
**Sunlit data:** Structure elements as defined above and named: SMEs, SMLs, SMLsmlat, SMLsmlt, SMLsglat, SMLsglon, SMLsstd, SMUs, SMUsmlat, SMUsmlt, SMUsglat, SMUsglon, SMUsstd, SMEdnum  
**Dark data:** Structure elements as defined above and named: SMed, SMLd, SMLdmlat, SMLdmlt, SMLdglat, SMLdglon, SMLdstd, SMUd, SMUdmlat, SMUdmlt, SMUdglat, SMUdglon, SMUdstd, SMednum  
**Regional data:** Structure elements as defined above and named: SMER, SMLr, SMLrmlat, SMLrmlt, SMLrglat, SMLrglon, SMLrstd, SMUr, SMUrmlat, SMUrmlt, SMUrglat, SMUrglon, SMUrstd, SMERnum  
**IMF data:** Structure elements as defined above and named: smr, smrnum00, smrnum06, smrnum12, smrnum18  
**SWI data:** Structure elements as defined above and named: clockgse, clockgsm, density, dynpres, epsilon, newell

### Example Usage

```
sm_data=fetchSuperMAG('indices',userid,'2019-11-15T10:40',3600,'all');
% plot time vs a data item
plot([sm_data.tval], [sm_data.SMEs])
hold on
plot([sm_data.tval], [sm_data.SMLs])
hold off
% plot time vs a multi-dimensional data item
tval=[sm_data.tval];
y=[sm_data.SMLr];
nrows = length(tval);
hours = 0:23;
for i=1 : nrows
    plot( hours, y(:,i) )
    hold on
end
hold off
title('Sample Plot, SMLr vs Hour across multiple days');
```

