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¹Affiliation not available

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Making Heliophysics Data Easier to Use: Updates on the HAPI Specification

Making Heliophysics Data Easier to Use: Updates on the HAPI Specification
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Basics of Data Interoperability

Without a common interface, systems from data center require custom software, which can be time consuming to write and maintain.

With the addition to a standard system architecture (and a replacement) analysis software for one data source is reusable for all the other data sources that support the standard.

What data is available now with HAPI?

What is HAPI?

HAPI is a data access standard based on a standard system architecture approach to data access across all data source data systems.

It defines endpoints that a server must implement, 4 of these provide metadata, and one is for the interface for requesting data. The response is a data object in a common format of the data, not data in files, or bits of files. The streaming format is very simple.

For a request an:

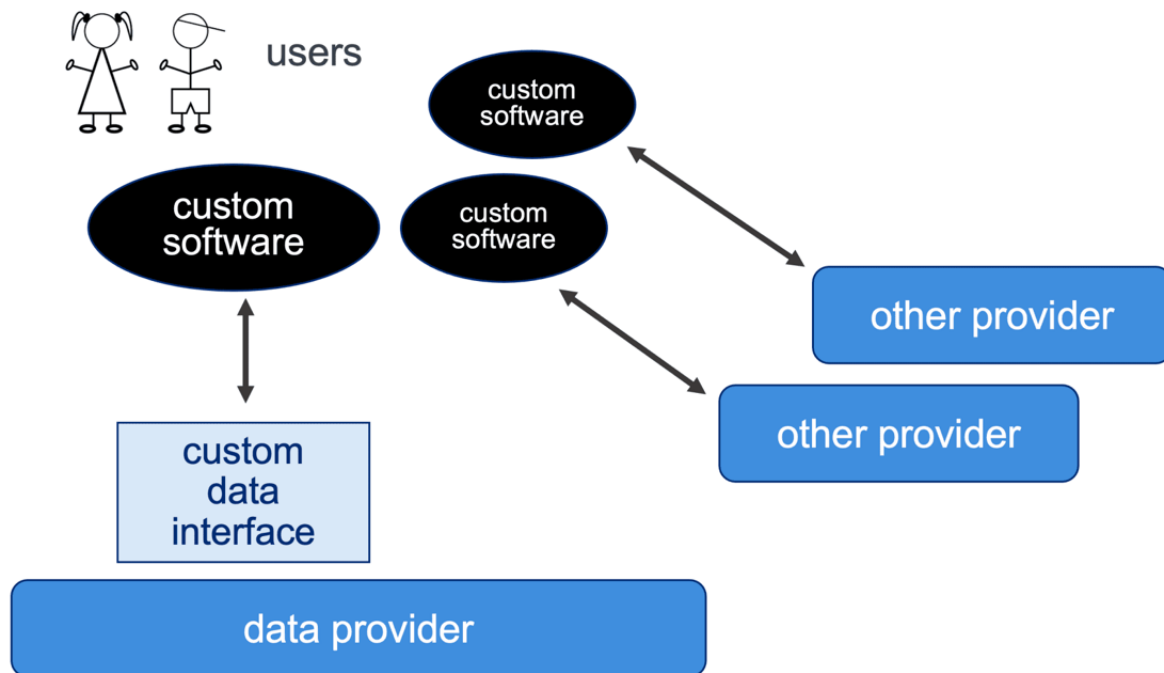
<http://example.com/hapi/health>
<http://example.com/hapi/metadata>
<http://example.com/hapi/endpoint>
<http://example.com/hapi/data>

HAPI Servers and Clients

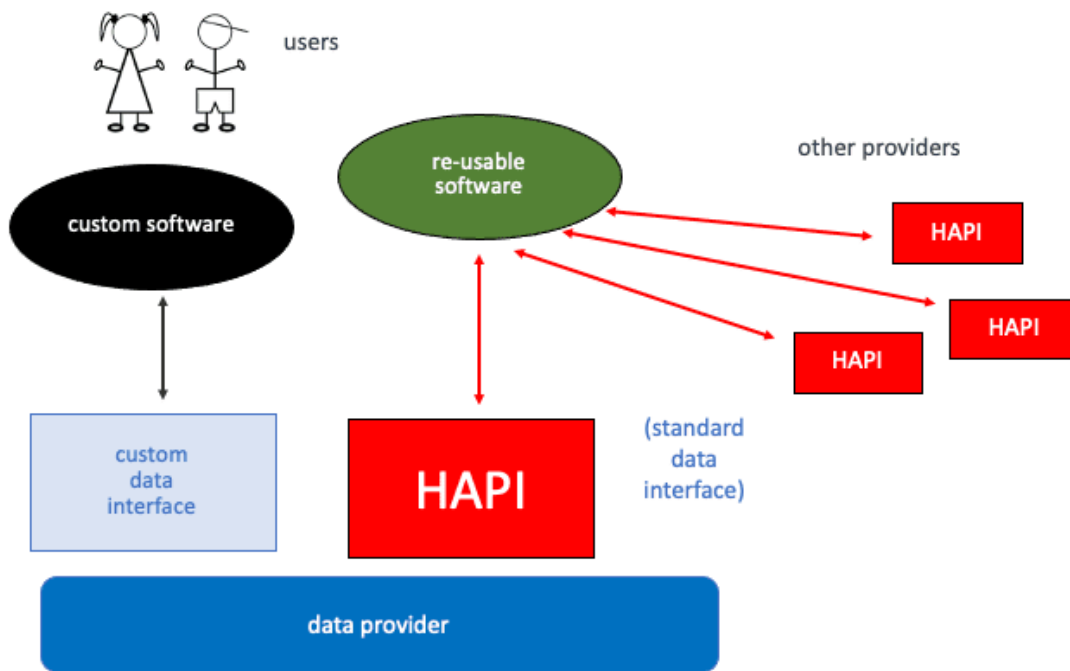
Here is an example of the HAPI client showing results from 2 different HAPI servers.

1. GSFC HAPI Server - Cluster 2/3/4/5/6/7/8/9/10/11/12/13/14/15/16/17/18/19/20/21/22/23/24/25/26/27/28/29/30/31/32/33/34/35/36/37/38/39/40/41/42/43/44/45/46/47/48/49/50/51/52/53/54/55/56/57/58/59/60/61/62/63/64/65/66/67/68/69/70/71/72/73/74/75/76/77/78/79/80/81/82/83/84/85/86/87/88/89/90/91/92/93/94/95/96/97/98/99/100/101/102/103/104/105/106/107/108/109/110/111/112/113/114/115/116/117/118/119/120/121/122/123/124/125/126/127/128/129/130/131/132/133/134/135/136/137/138/139/140/141/142/143/144/145/146/147/148/149/150/151/152/153/154/155/156/157/158/159/160/161/162/163/164/165/166/167/168/169/170/171/172/173/174/175/176/177/178/179/180/181/182/183/184/185/186/187/188/189/190/191/192/193/194/195/196/197/198/199/200/201/202/203/204/205/206/207/208/209/210/211/212/213/214/215/216/217/218/219/220/221/222/223/224/225/226/227/228/229/230/231/232/233/234/235/236/237/238/239/240/241/242/243/244/245/246/247/248/249/250/251/252/253/254/255/256/257/258/259/260/261/262/263/264/265/266/267/268/269/270/271/272/273/274/275/276/277/278/279/280/281/282/283/284/285/286/287/288/289/290/291/292/293/294/295/296/297/298/299/300/301/302/303/304/305/306/307/308/309/310/311/312/313/314/315/316/317/318/319/320/321/322/323/324/325/326/327/328/329/330/331/332/333/334/335/336/337/338/339/340/341/342/343/344/345/346/347/348/349/350/351/352/353/354/355/356/357/358/359/360/361/362/363/364/365/366/367/368/369/370/371/372/373/374/375/376/377/378/379/380/381/382/383/384/385/386/387/388/389/390/391/392/393/394/395/396/397/398/399/400/401/402/403/404/405/406/407/408/409/410/411/412/413/414/415/416/417/418/419/420/421/422/423/424/425/426/427/428/429/430/431/432/433/434/435/436/437/438/439/440/441/442/443/444/445/446/447/448/449/450/451/452/453/454/455/456/457/458/459/460/461/462/463/464/465/466/467/468/469/470/471/472/473/474/475/476/477/478/479/480/481/482/483/484/485/486/487/488/489/490/491/492/493/494/495/496/497/498/499/500/501/502/503/504/505/506/507/508/509/510/511/512/513/514/515/516/517/518/519/520/521/522/523/524/525/526/527/528/529/530/531/532/533/534/535/536/537/538/539/540/541/542/543/544/545/546/547/548/549/550/551/552/553/554/555/556/557/558/559/560/561/562/563/564/565/566/567/568/569/570/571/572/573/574/575/576/577/578/579/580/581/582/583/584/585/586/587/588/589/590/591/592/593/594/595/596/597/598/599/600/601/602/603/604/605/606/607/608/609/610/611/612/613/614/615/616/617/618/619/620/621/622/623/624/625/626/627/628/629/630/631/632/633/634/635/636/637/638/639/640/641/642/643/644/645/646/647/648/649/650/651/652/653/654/655/656/657/658/659/660/661/662/663/664/665/666/667/668/669/670/671/672/673/674/675/676/677/678/679/680/681/682/683/684/685/686/687/688/689/690/691/692/693/694/695/696/697/698/699/700/701/702/703/704/705/706/707/708/709/710/711/712/713/714/715/716/717/718/719/720/721/722/723/724/725/726/727/728/729/730/731/732/733/734/735/736/737/738/739/740/741/742/743/744/745/746/747/748/749/750/751/752/753/754/755/756/757/758/759/760/761/762/763/764/765/766/767/768/769/770/771/772/773/774/775/776/777/778/779/780/781/782/783/784/785/786/787/788/789/790/791/792/793/794/795/796/797/798/799/800/801/802/803/804/805/806/807/808/809/810/811/812/813/814/815/816/817/818/819/820/821/822/823/824/825/826/827/828/829/830/831/832/833/834/835/836/837/838/839/840/841/842/843/844/845/846/847/848/849/850/851/852/853/854/855/856/857/858/859/860/861/862/863/864/865/866/867/868/869/870/871/872/873/874/875/876/877/878/879/880/881/882/883/884/885/886/887/888/889/890/891/892/893/894/895/896/897/898/899/900/901/902/903/904/905/906/907/908/909/910/911/912/913/914/915/916/917/918/919/920/921/922/923/924/925/926/927/928/929/930/931/932/933/934/935/936/937/938/939/940/941/942/943/944/945/946/947/948/949/950/951/952/953/954/955/956/957/958/959/960/961/962/963/964/965/966/967/968/969/970/971/972/973/974/975/976/977/978/979/980/981/982/983/984/985/986/987/988/989/990/991/992/993/994/995/996/997/998/999/1000/1001/1002/1003/1004/1005/1006/1007/1008/1009/1010/1011/1012/1013/1014/1015/1016/1017/1018/1019/1020/1021/1022/1023/1024/1025/1026/1027/1028/1029/1030/1031/1032/1033/1034/1035/1036/1037/1038/1039/1040/1041/1042/1043/1044/1045/1046/1047/1048/1049/1050/1051/1052/1053/1054/1055/1056/1057/1058/1059/1060/1061/1062/1063/1064/1065/1066/1067/1068/1069/1070/1071/1072/1073/1074/1075/1076/1077/1078/1079/1080/1081/1082/1083/1084/1085/1086/1087/1088/1089/1090/1091/1092/1093/1094/1095/1096/1097/1098/1099/1100/1101/1102/1103/1104/1105/1106/1107/1108/1109/1110/1111/1112/1113/1114/1115/1116/1117/1118/1119/1120/1121/1122/1123/1124/1125/1126/1127/1128/1129/1130/1131/1132/1133/1134/1135/1136/1137/1138/1139/1140/1141/1142/1143/1144/1145/1146/1147/1148/1149/1150/1151/1152/1153/1154/1155/1156/1157/1158/1159/1160/1161/1162/1163/1164/1165/1166/1167/1168/1169/1170/1171/1172/1173/1174/1175/1176/1177/1178/1179/1180/1181/1182/1183/1184/1185/1186/1187/1188/1189/1190/1191/1192/1193/1194/1195/1196/1197/1198/1199/1200/1201/1202/1203/1204/1205/1206/1207/1208/1209/1210/1211/1212/1213/1214/1215/1216/1217/1218/1219/1220/1221/1222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/2223/2224/2225/2226/2227/2228/2229/2230/2231/2232/2233/2234/2235/2236/2237/2238/2239/2240/2241/2242/2243/2244/2245/2246/2247/2248/2249/2250/2251/2252/2253/2254/2255/2256/2257/2258/2259/2260/2261/2262/2263/2264/2265/2266/2267/2268/2269/2270/2271/2272/2273/2274/2275/2276/2277/2278/2279/2280/2281/2282/2283/2284/2285/2286/2287/2288/2289/2290/2291/2292/2293/2294/2295/2296/2297/2298/2299/2300/2301/2302/2303/2304/2305/2306/2307/2308/2309/2310/2311/2312/2313/2314/2315/2316/2317/2318/2319/2320/2321/2322/2323/2324/2325/2326/2327/2328/2329/2330/2331/2332/2333/2334/2335/2336/2337/2338/2339/2340/2341/2342/2343/2344/2345/2346/2347/2348/2349/2350/2351/2352/2353/2354/2355/2356/2357/2358/2359/2360/2361/2362/2363/2364/2365/2366/2367/2368/2369/2370/2371/2372/2373/2374/2375/2376/2377/2378/2379/2380/2381/2382/2383/2384/2385/2386/2387/2388/2389/2390/2391/2392/2393/2394/2395/2396/2397/2398/2399/2400/2401/2402/2403/2404/2405/2406/2407/2408/2409/2410/2411/2412/2413/2414/2415/2416/2417/2418/2419/2420/2421/2422/2423/2424/2425/2426/2427/2428/2429/2430/2431/2432/2433/2434/2435/2436/2437/2438/2439/2440/2441/2442/2443/2444/2445/2446/2447/2448/2449/2450/2451/2452/2453/2454/2455/2456/2457/2458/2459/2460/2461/2462/2463/2464/2465/2466/2467/2468/2469/2470/2471/2472/2473/2474/2475/2476/2477/2478/2479/2480/2481/2482/2483/2484/2485/2486/2487/2488/2489/2490/2491/2492/2493/2494/2495/2496/2497/2498/2499/2500/2501/2502/2503/2504/2505/2506/2507/2508/2509/2510/2511/2512/2513/2514/2515/2516/2517/2518/2519/2520/2521/2522/2523/2524/2525/2526/2527/2528/2529/2530/2531/2532/2533/2534/2535/2536/2537/2538/2539/2540/2541/2542/2543/2544/2545/2546/2547/25

BASICS OF DATA INTEROPERABILITY



Without a common interface, access to each data center requires custom software, which can be time consuming to write and maintain.



With the addition of a standard access mechanism (not a replacement), analysis software for one data source is reusable for all the other data sources that support the standard.

What data is available now with HAPI?

Both US and European data centers are adopting HAPI.

Institution	Server	Type of Data	Number of Datasets
	CDAWeb	Heliophysics	2800
	<u>SSCWeb</u>	Ephemeris	250
	CCMC	Space Weather	250
	AMDA	Heliophysics and Planetary Data and Ephemeris	500
University of Iowa	Das2 Server	<u>Helio.</u> & Planetary	30
	LISIRD	Solar Irradiance	40
SWARM Mission	<u>ViRES</u> Data Server	Space Mag Data	14

These data sources are planning or thinking about using HAPI:

Institution	Server	Type of Data	Number of Datasets
	ESAC	Heliophysics	2073
JHU / APL	<u>SuperMAG</u>	global ground mag	~500
JHU / APL	TIMED / GUVI	ionospheric images	~10
Royal Netherlands Meteorological Institute	Royal Netherlands Meteorological Institute	Space Weather	few dozen
Eventually			
	PDS PPI Node	Planetary Plasma, Particle, and Fields	~1000
CEDAR / NSF	Madrigal	Space Weather	1000+ (??)

WHAT IS HAPI?

HAPI is a protocol for serving data.

HAPI is a data access standard focused on a lowest common denominator approach to data access across all time series data servers.

It defines 5 endpoints that a server must implement. 4 of these provide metadata, and one is the key interface for requesting data. The response to a data request is a stream of the data, not links to files, or lists of files. The streaming format is very simple.

The 5 endpoints are:

`http://example.com/hapi/about`

`http://example.com/hapi/capabilities`

describes options implemented by the server

`http://example.com/hapi/catalog`

list of datasets at the server

`http://example.com/hapi/info`

show metadata for one dataset at a time (data header)

`http://example.com/hapi/data`

retrieve a stream of data content for one dataset over a specific time range

This is a sample request:

`http://server.org/hapi/data?dataset=ACE_MAG&start=2004-183T00:00Z&stop=2004-184T00:00Z`

And the CSV response (binary and JSON are supported but optional)

2004-183T00:00:03.403Z, 1.0724e+02, -6.8993e+01, -5.1978e+02

2004-183T00:00:07.153Z, 1.0842e+02, -6.8956e+01, -5.1962e+02

2004-183T00:00:10.907Z, 1.0855e+02, -6.9063e+01, -5.2084e+02

2004-183T00:00:14.653Z, 1.0852e+02, -6.9049e+01, -5.2085e+02

2004-183T00:00:18.403Z, 1.0849e+02, -6.9035e+01, -5.2085e+02

2004-183T00:00:22.153Z, 1.0862e+02, -6.9142e+01, -5.2207e+02

2004-183T00:00:25.903Z, 1.0859e+02, -6.9128e+01, -5.2208e+02

Where to find more info:

<http://hapi-server.org>

one-page summary, video intro, links to Github repos, mailing lists, etc

The HAPI Specification

Version 3.0 <https://doi.org/10.5281/zenodo.4757597>

The development location for the latest spec and drafts and open issues, etc:

<https://github.com/hapi-server/data-specification>

JGR Space Physics Paper:

R. Weigel et al, HAPI: An API Standard for Accessing Heliophysics Time Series Data

<https://doi.org/10.1029/2021JA029534>

Lots of other HAPI projects:

<https://github.com/hapi-server>

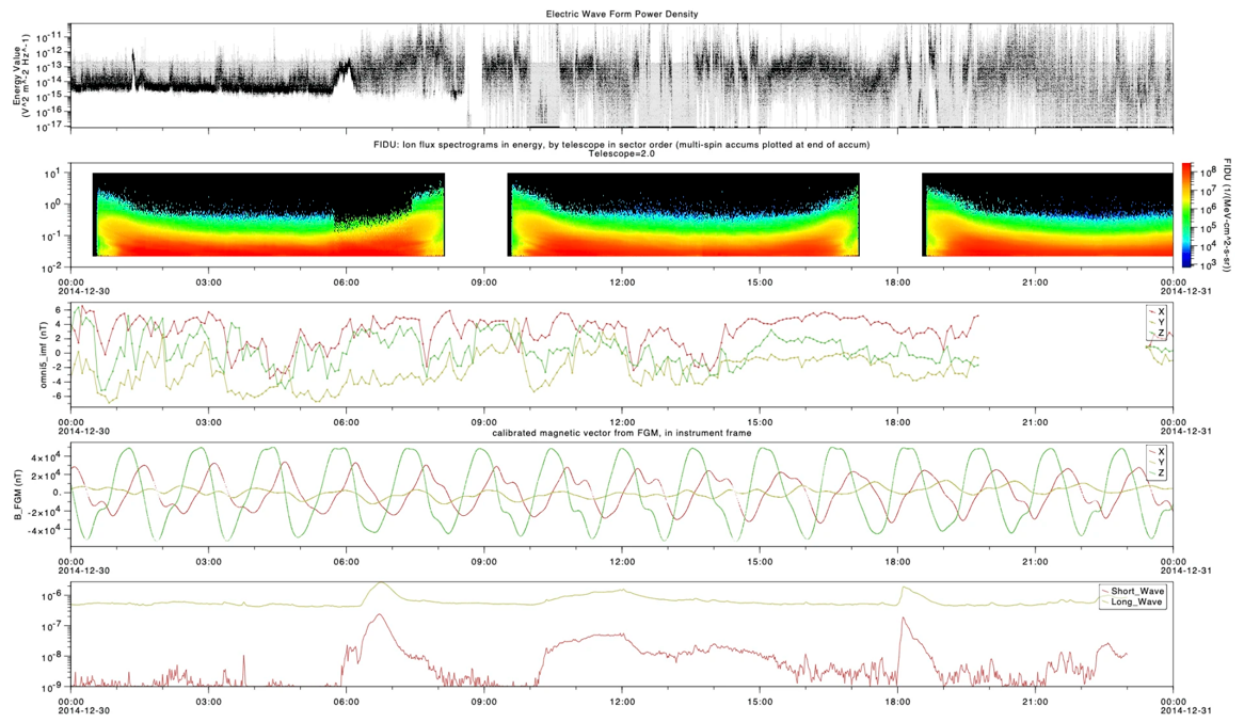
Try it out with this interactive way to explore known HAPI servers!

<http://hapi-server.org/servers/>

Tutorial Notebooks for using HAPI in Python:

<https://github.com/heliophysicsPy/summer-school/tree/main/hapi-tutorial>

HAPI SERVERS AND CLIENTS



Here is an example of the Autoplot client showing panels from 5 different HAPI servers.

1. ESAC HAPI Server: Cluster-3 Electric Wave Form Power Density
2. CDAWeb HAPI Server - Van Allen Probes, RBSPICE Ion Energy Spectrogram
3. AMDA HAPI Server - Omni MAG data
4. ViRES HAPI Server - GRACE-A MAG Data
5. CCMC ISWAT HAPI Server - GOES X-ray flux

Clients

For analyzing data from HAPI servers, there are HAPI clients available in Python, Java, IDL, Matlab, and R. These are designed to facilitate individual analysis.

For an extensive tutorial on the Python client, see this github repo:

<https://github.com/heliophysicsPy/summer-school/tree/main/hapi-tutorial>

Servers

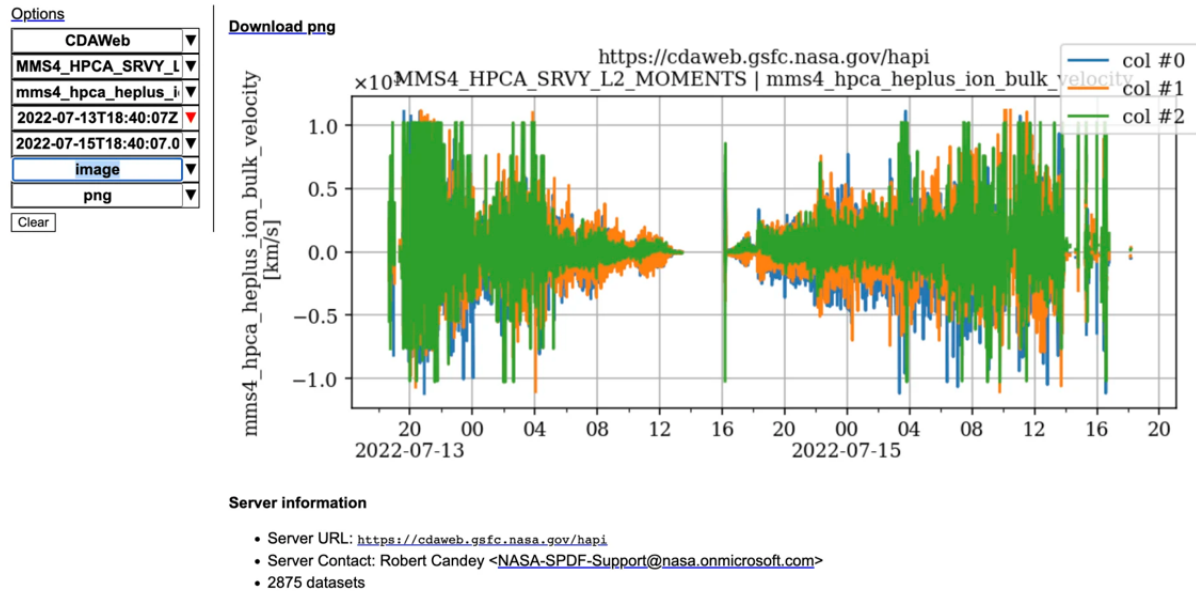
There are HAPI servers available in Python, Java, and node.js. See this Github page for a list of HAPI projects:

<https://github.com/hapi-server>

Exploring existing Servers

Use this page to interact with HAPI servers and data (a kind of browsing capability):

<http://hapi-server.org/servers/>



This page can also provide code stubes for accessing the data you are viewing.



NEW FEATURES IN HAPI 3.1

HAPI 3.1 is now released.

It includes the following new features:

1. Ability to include large blocks of additional, arbitrary (non-HAPI) metadata in a separate name space. This can be a reference URL to other metadata, a set of keyword-value pairs, or a hierarchical JSON object.

```
{ "additionalMetadata" : [

  { "name" : "SPASE",

    "contentURL": "https://hpde.io/NASA/DisplayData/ACE/MAG/27-Day.xml",

    "aboutURL": "http://spase-group.org"

  },

  { "name" : "FITS",

    "content": { "fits_header_keyword1":"value1", "fits_keyword2":"value2" },

    "aboutURL": "http://fits.gsfc.nasa.gov"

  },

  { "name" : "ISTP",

    "content": { "json object (not shown) of ISTP keyword-value pairs" },

    "aboutURL": "https://spdf.gsfc.nasa.gov/istp_guide/variables.html"

  }

]

}
```

2. The ability to specify coordinate system information for vector quantities.

```
{  "parameters": [

    { "name": "spacecraftLocationXYZ",

      "description": "S/C location in X,Y,Z; vector from Earth to s/c",

      "size": [ 3 ], "units": "km",

      "coordinateSystemName": "GSM",

      "vectorComponents": [ "x", "y", "z" ] },

    {

      "name": "magneticField",

      "description": "mag vector as R, MLT and magnetic latitude",

      "size": [3],  "units": [ "Re", "hours", "degrees" ],

      "coordinateSystemName": "GSM",

      "vectorComponents": [ "r", "longitude", "latitude" ]  }

  ]

}
```

ABSTRACT

The Heliophysics Application Programmer's Interface (HAPI) offers a standard way to access time series data in a content-neutral fashion, and its growing adoption across multiple data centers in the US and Europe is helping make more datasets interoperable. HAPI can help scientists fulfill the open data requirements from NASA. We present recent updates offered in backwards-compatible HAPI 3.1 that are aimed at keeping the specification simple, but also allowing it to capture relevant science details needed for analyzing data. New features include the ability to indicate the coordinate system for data with vector quantities, a way to include other (non-HAPI) metadata, and a way for servers to specify a time range limit on data requests. In addition, the HAPI ecosystem has generic servers with recent improvements, a more robust Python client, and newly available tutorial materials focused on how scientists can use HAPI for analysis. Finally, we offer reminders of available connections to the HAPI community: a monthly forum for learning about new developments, and a HAPI developer team able and willing to help new adopters. More info is available at <http://hapi-server.org> (<http://hapi-server.org/>).

