HAPI Developments and a New Java Framework for HAPI Servers and Its Use at ESAC

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What I'll talk about

- the HAPI data transport protocol
- new features for HAPI this past year
- introduce a new Java framework for creating servers

The HAPI Protocol

- Many web sites have servers which send data. Each has its own protocol, and new client software is needed for each one.
- This means we're always coding, and writing code that works just well enough to get the job done.
- This also means code is buggy, and the service is only useful to those who can code. Interactions with the server staff are often required as well.
- The HAPI project started in 2016, where we hoped to create a single, simple API which time-series data providers could implement.
- We would also provide clients for common programming languages.

The HAPI Protocol

- HAPI (Heliophysics API) is a data discovery and access protocol.
- data is discovered using "catalog" and "info" requests:
  - https://vires.services/hapi/catalog → list of dataset ids
  - https://vires.services/hapi/info?id=CS_OPER_MAG → description of dataset and its parameters
- data is accessed using "data" requests:
  - https://vires.services/hapi/data?id=CS_OPER_MAG
    &start=2022-03-30T20:00Z
    &stop=2022-03-31T23:59Z
    &parameters=Timestamp,Latitude,Longitude,F → data file
- HAPI servers themselves are discovered using a registry at https://github.com/hapi-server/servers/blob/master/all.txt

The HAPI Protocol

- requests are REST-style queries
- responses are JSON and CSV (and optionally Binary)
- data responses are streamed to client,
  so that data can be transmitted as soon as it is read,
  and processed as it is received.
- JSON schemas on the responses constrain
  what is allowed, and x_* tags can be used to
  insert arbitrary metadata.

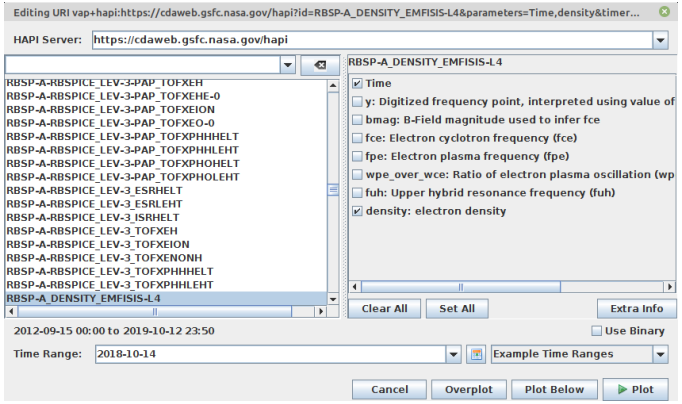
vires.services/hapi/info?id=CS_OPER_MAG

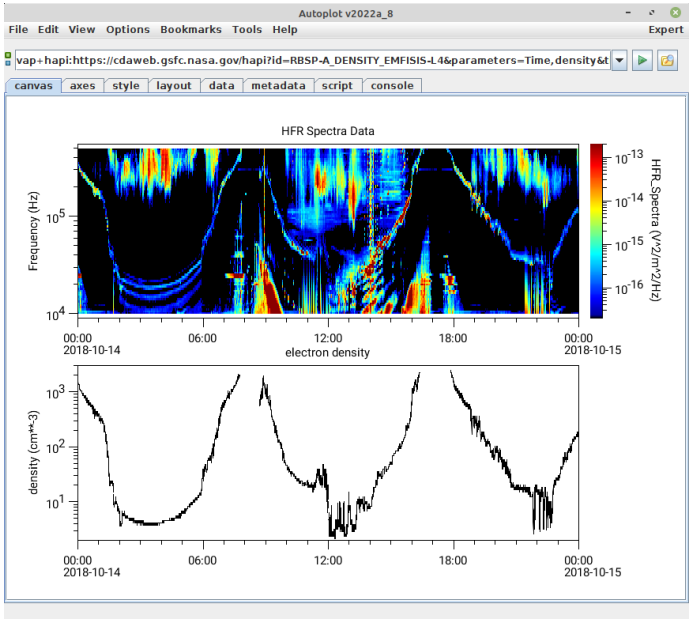
Apps timekeeping ihdea/agu fun ct project autoplot


```
{
  "HAPI": "3.0",
  "status": {
    "code": 1200,
    "message": "OK"
  },
  "x_dataset": "CS_OPER_MAG",
  "x_datasetType": "CS_MAG",
  "startDate": "2010-04-08T17:03:26.254008Z",
  "stopDate": "2022-03-31T23:59:52.266008Z",
  "cadence": "PT4S",
  "x_maxTimeSelection": "P20D",
  "modificationDate": "2022-05-19T09:21:03.928Z",
  "description": "Cryosat-2 Platform magnetometer measurements",
  "x_dataTerms": "This dataset is provided by the European Space Ag
  "resourceURL": "https://doi.org/10.1186/s40623-020-01171-9",
  "parameters": [
    {
      "name": "Timestamp",
      "description": "Time stamp",
      "units": "UTC",
      "type": "isotime",
      "length": 24,
      "x_standard": "UTC",
      "x_epoch": "1970-01-01T00:00:00Z",
      "x_unit": "ms",
      "x_type": "int64",
      "fill": null
    },
```

The HAPI Protocol

- many clients exist already
  - Java
  - IDL
  - Matlab
  - Python
  - JavaScript
- use in applications
  - Autoplot
  - SPEDAS
  - LASP Space Weather Portal
  - ViRES server
  - Python client used in ad-hoc analyses
  - wget/curl ("read my data" feature)

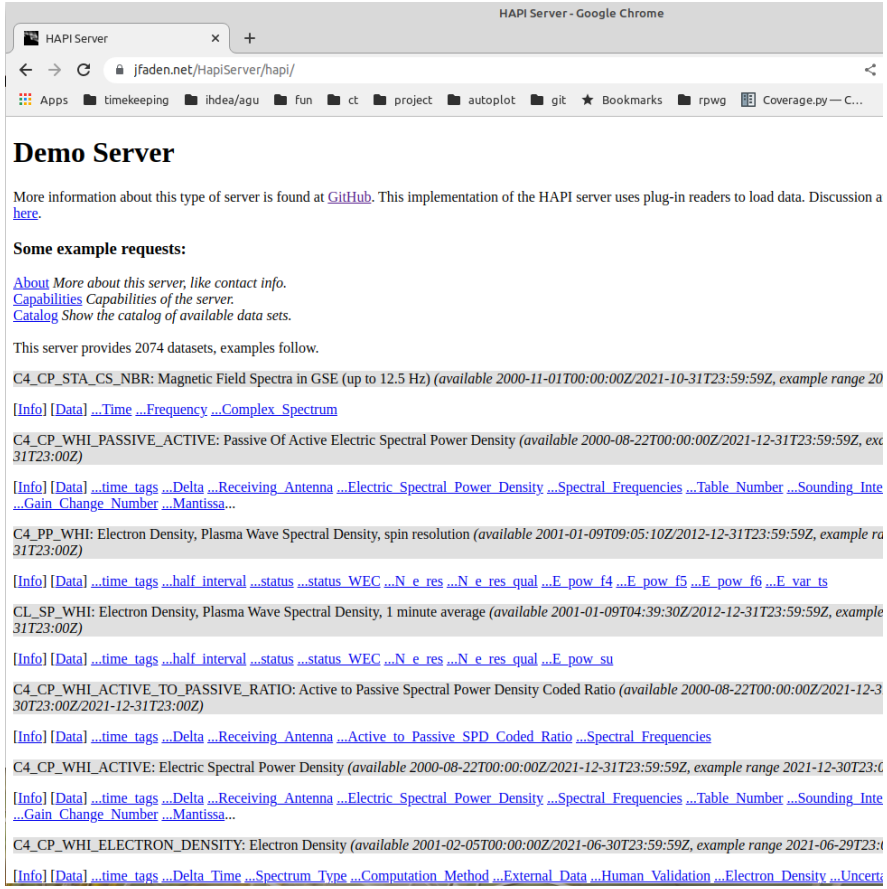




A Python script that uses a HAPI server works anywhere, unlike with data from downloaded files. This makes communication with collaborators easier.

The HAPI Protocol

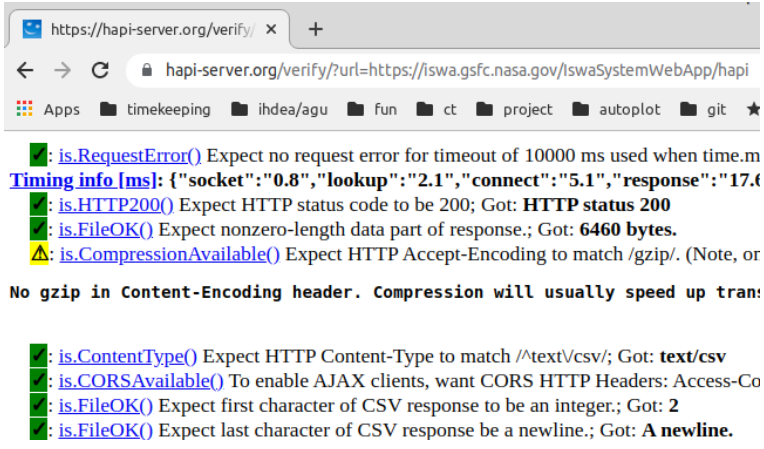
- many server codes exist already
  - Python
  - Node JavaScript
  - Scala
  - Java - several independently-written codes
- implementations include
  - CDAWeb https://cdaweb.gsfc.nasa.gov/hapi
  - SSCWeb http://hapi-server.org/servers/SSCWeb/hapi
  - University of Iowa http://planet.physics.uiowa.edu/das/das2Server/hapi
  - LASP http://lasp.colorado.edu/lisird/hapi
  - AMDA http://amda.irap.omp.eu/service/hapi
  - VirES https://vires.services/hapi
  - PDS-PPI https://pds-ppi.igpp.ucla.edu/hapi/
- Note that many of these simply convert an existing service to HAPI.



The HAPI Protocol

HAPI is a brand-name we want the scientists to recognize and know what it is, and for it to mean that there's a reliable service being offered.

- Validation
  - testing service which validates a server (https://hapi-server.org/verify/)
  - removes human biases gives a reference for what "HAPI" means
- Testing
  - hourly testing of all known servers ensures reliability (https://jfaden.net/jenkins/job/test-hapi-servers-2022/)
- Indexing
  - indexing of known servers is done weekly, capturing data sets offered and descriptions
  - https://github.com/hapi-server/servers/tree/master/index



New Features this Year

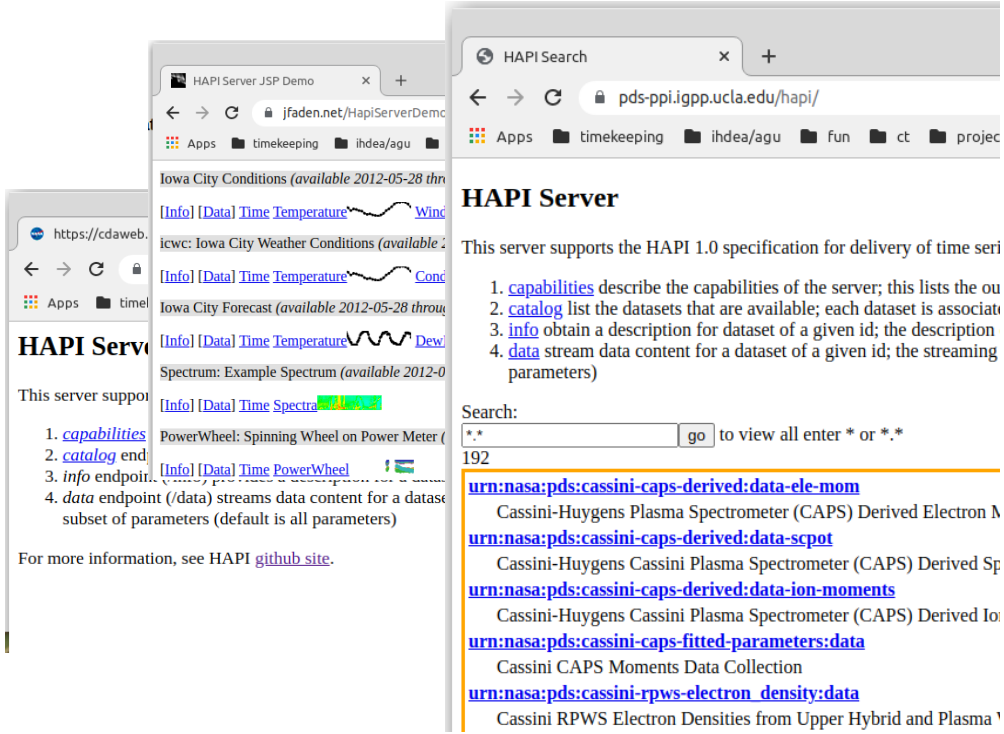
- Version 3.1 is about to be released
- trivial things like time.min→start, time.max→stop
  (Note this changes the API, version 4.0 will drop them)
- firm up the spec on IDs (recommendation that IDs should be a-z, A-Z, 0-9, [-._~] and up to 30 characters; but this is not required. Any Unicode characters are allowed, but will require URL escaping)
- maxRequestDuration allows servers to tell clients the size of a reasonable request, presumably "request too big" would be returned.
- units and units schemas, so that unit strings ("1/cm**3" vs "cm^-3" etc) are machine-ready.
- identifying coordinate frames in a machine-ready way. Vector quantities x,y,z or in theta,phi,radius or ...
- arbitrary metadata block of non-HAPI metadata (for example, all CDF metadata) with machine-ready schema identifier. For example, Autoplot understands CDF metadata, so now it can recognize and use it.
- and a new logo!

Help is available

- Help is available for teams wanting to set up servers.
- We have weekly Zoom meetings to discuss the technical details. ("Should ticket 141 be resolved for release 4.0?")
- Monthly Zoom community meetings to showcase new servers and to understand what's needed outside our group. ("Here's my new server, but my vector components don't have labels in Autoplot, why?")
- This is a very loose federation of institutions with common interests, and new people and ideas are welcome!

Server-Java

- Many Java implementations of HAPI servers exist already:
  - I have one which I use with Autoplot to test new HAPI features
  - CDAWeb
  - PDS-PPI planetary node at UCLA
- This confirms that the servers are easy enough to implement, but...



Server-Java

- I'd argue each is under-implemented
  - do bugs exist?
  - does it match performance goals of HAPI brand (response within 300ms, etc)?
  - does it provide all HAPI features (for example Binary as well as CSV)?
  - I have yet to see a server which completely validates with no warnings.
- There should be one common Java code for HAPI servers, and specific site's developer should only worry about the code to make their data available to the server.

Server-Java

- Server-Java is intended to be a framework with which new servers (specific-servers) are implemented.
- data providers will use its source code with their specific-server code to interface site data.
- it is configured to call into their specific-server code appropriately.
- Server-Java cleans up and validates responses from specific-server code, speeding up implementation.

Server-Java — configuration

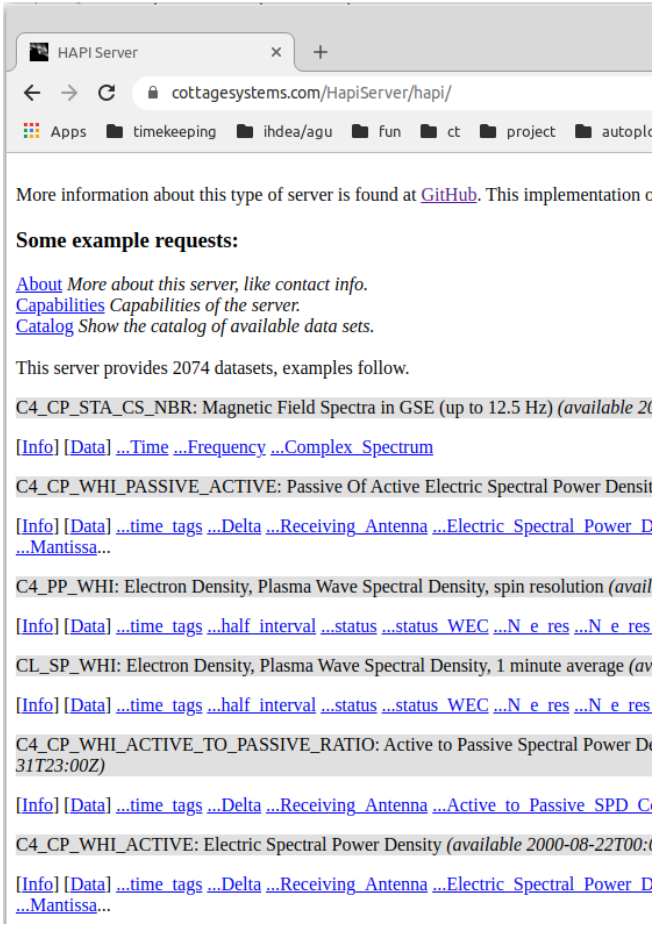
- For each data set, a configuration controls
  - identifies the "data reader", for example it should:
    - call into Java code (a special reader or adapter to existing API),
    - or execute a Unix command and read the output,
    - or read pre-formatted files,
    - or ... (we can extend the code as needed).
  - but also tells Server-Java how to call the data reader. Should it:
    - load all data set's parameters at once, or just load a subset of the parameters?
    - load all records in the requested interval, or break it up into granules of regular cadence (i.e. $Y-$m-$d for daily granules) and Server-Java will combine them? This allows a non-streaming legacy server to feed data into the streaming HAPI server.

Server-Java — configuration

- This means a data reader can be as simple as executing "cat my_formatted_file.csv" on Unix,
- and as complex as calling into a reader which opens each CDF file and extracts just the needed data.
- Servers are configured using .json files, which can contain the pre-formatted info responses, or they can specify a code to call which will output the info and catalog responses.

Use Case at ESAC

- Larry visited ESAC and set up a server with their service staff.
- The server-specific software interfaces with the existing TAP server.
- He wrote Java code which knows how to request data from the TAP server and provide it to server-java.
- The TAP responses are streaming, so server-specific code calls it once per data request. The TAP server responds with all parameters for a data set.
- The Server-Java code will trim the whole-day response to precisely the time range requested, and extract only the parameters which were requested by the scientist.
- The ESAC server should be available to the public soon.



What's Coming

- servers ought to be responsive, so caching will enable servers to cache responses. This will reduce server load at the expense of storage.
- right now the configuration is done with JSON and familiarity with HAPI is needed to form JSON HAPI responses, and a tool for generating responses is needed (interview form).
- we plan to implement new CDAWeb and SSCWeb servers using this framework in the next year.

Thanks!

https://hapi-server.org

https://github.com/hapi-server

https://github.com/hapi-server/data-specification (documentation for specification)

https://github.com/hapi-server/server-java (server-java code)

https://github.com/hapi-server/server-java/wiki (server-java documentation)

https://cottagesystems.com/HapiServer/hapi/ (temporary home for ESAC server, will change)

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Server-Java

actors and nouns

- data reader is the code which provides data
- parameter is an individual time series (Density or GSMPosition or FluxSpectrum)
- data id identifies a group of parameters with common time tags. (OMNI_HRO_5MIN)
- data request is a request for a set of parameters for a block of time.
- info response is the JSON response describing the parameters available and time span of a data id.
- data set is the data for a group of parameters for a block of time.
- server home directory is the directory containing configurations and cached data.
- json reader configs are the files which configure the server.
- server-java is the core part which is common to all server implementations.
- specific-server is a particular implementation, like ESAC or CDAWeb.
- scientist is the person receiving data.
- server developer is the person/people implementing the server.
- service staff are the people maintaining and adding data to the server.
- site data is the data which will be served to the public.