



HATS (Hierarchical Adaptive Tiling Scheme) in IVOA Universe

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IVOA November ("Southern Spring") 2025 Interoperability meeting
Applications Session 1: November 14, 2025 - 11:00-12:30



LSST
Discovery
Alliance

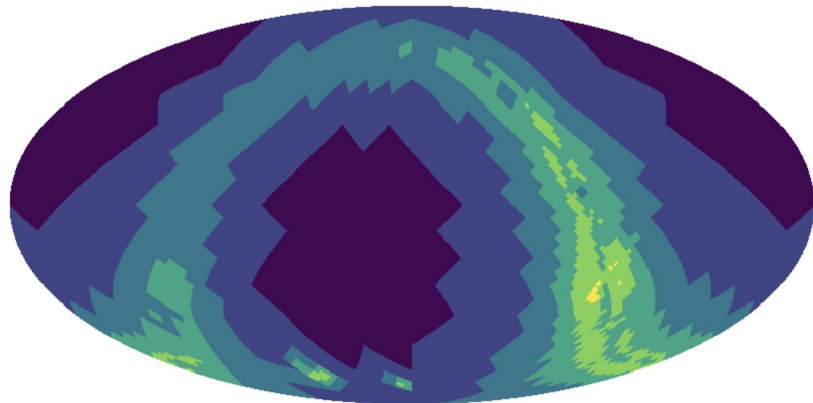
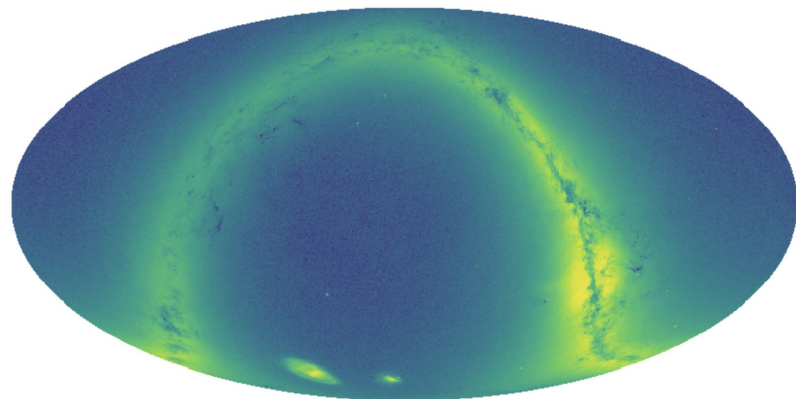


Schmidt Sciences



Short introduction of the format

- HATS (Hierarchical Adaptive Tiling Scheme):
 - Data is stored in a hierarchical data storage scheme, where the sky is split into HEALPix tiles until each tile has roughly a similar number of objects (rows).
 - These tiles are stored as Parquet files within a directory tree that encodes their location on the sky.





Progress since Maryland Meeting (last slide)

- Serving catalogs with CDS
- Further Collaboration
 - IPAC (ZTF, Euclid, Fornax)
 - Space Telescope (Roman, PanSTARRS, Fornax)
- Official status with Vera C. Rubin before LSST Data Release 1
- Using HATS for other types of astronomical data
 - Collaboration with HEASARC to provide Fermi data
 - Collaboration with NOIRLab and DESI to provide spectral data (and photometric redshifts)
- Collecting feedback and user experience with the goal of updating the note and towards IVOA standardization. Determining data discovery plan for HATS.



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Done or Solid progress

Slow progress



New or much-revised sections

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Service Capabilities

Currently available capabilities:

- Nearly trivial to serve HATS catalogs with plain HTTP file servers
 - This is **HTTP** capability
- Several providers want to perform server-side filtering based on user input
 - This is **ParamHTTP** capability
- The very same dataset can be accessed via S3 or HTTP URI
 - What kind of capability is that?



Service Capabilities - Edge cases

- Data mirrors or partial mirrors
 - How can a user pick the right mirror? How are we helping them do it?
- S3 might allow anonymous access
 - How to indicate that?
- Similar data mirrored on S3 and GCS and hugging face
 - How to represent other connections?
- Others ...



HATS + VOTable Metadata Maturity

- **Quick VOParquet Overview**

- Embed VOTable metadata inside parquet files
 - When reading the parquet file, use the VOTable blob for TABLE metadata and the parquet row groups for DATA
 - Supported in astropy.io
-
- For now (and for some catalogs), VOTABLE XML blob lives in `_common_metadata` file (key `IVOA.VOTable-Parquet.content`)
 - Co-working in October found several compatibility issues in astropy.io
 - round-trip parsing
 - additional support for "nested" representation of data inside parquet files
 - Issues (updated, created) at <https://github.com/astropy/astropy>: [#18729](https://github.com/astropy/astropy/issues/18729), [#18737](https://github.com/astropy/astropy/issues/18737), [#18738](https://github.com/astropy/astropy/issues/18738)



Using VOTABLE GROUP??

Want to represent "nested" data in VOTable metadata.

e.g. Arrays for light curve data embedded in the same single row as the object-level data.
GROUP unused to-date. Seems the right fit for this use case.

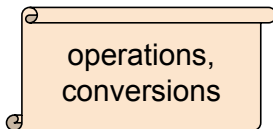
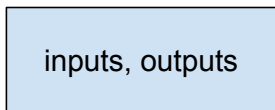
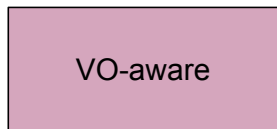
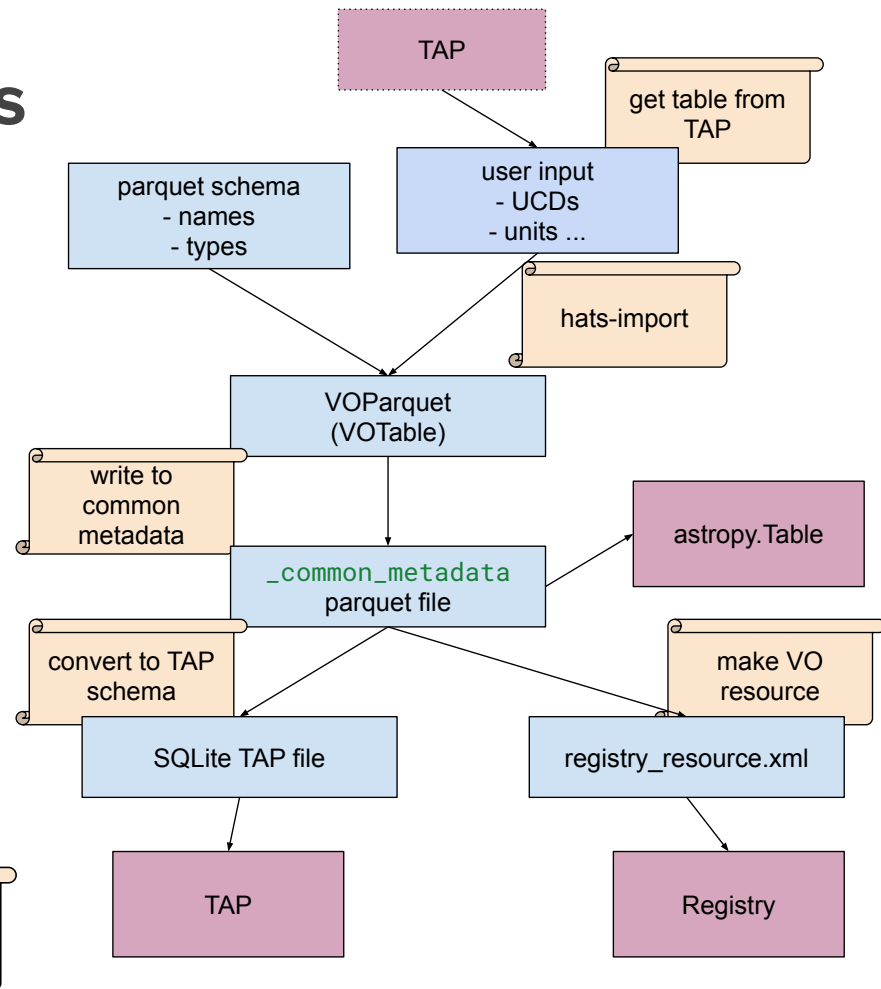
```
<VOTABLE version="1.4" xmlns="http://www.ivoa.net/xml/VOTable/v1.3">
  <RESOURCE>
    <TABLE name="DIA Object">
      <DESCRIPTION>Rubin DP1 DIA Object table with nested Source and Force Source tables</DESCRIPTION>
      <PARAM name="author" datatype="char" arraysize="*" value="Vera C. Rubin Observatory"/>
      <FIELD datatype="double" name="ra" ucd="pos.eq.ra" unit="deg">
        <DESCRIPTION>DIA Object ICRS Right Ascension</DESCRIPTION>
      </FIELD>
      <FIELD datatype="double" name="dec" ucd="pos.eq.dec" unit="deg">
        <DESCRIPTION>ICRS Declination</DESCRIPTION>
      </FIELD>
      <GROUP name="diaSource">
        <DESCRIPTION>Properties of transient-object detections on the single-epoch difference
        <PARAM name="is_nested_column" datatype="boolean" value="t"/>
        <FIELDref ref="diaSource.band"/>
        <FIELDref ref="diaSource.midpointMjdTai"/>
        <FIELDref ref="diaSource.psfFlux"/>
        <FIELDref ref="diaSource.psfFlux_flag"/>
      </GROUP>
      <!-- It is actually "double-nested", because single band is an array of unicode chars,
      and here we have an array of bands-->
      <FIELD datatype="unicodeChar" name="diaSource.band">
        <DESCRIPTION>Band used to take this observation</DESCRIPTION>
      </FIELD>
      <FIELD datatype="double" name="diaSource.midpointMjdTai">
        <DESCRIPTION>Midpoint time for exposure at the fiducial center of the focal plane arra
      </FIELD>
    </TABLE>
  </RESOURCE>
</VOTABLE>
```



Data resource pathways

Given some parquet file, and optionally curated VO metadata, want to create VO entities in various forms.

- We'll write conversions if we have to
- Would love to borrow existing conversions





Going together!!

This didn't happen overnight. And there's still a long way to go. Thank you for:

- Monthly demos and format discussion in HATS Americas meeting
- Monthly demos and format discussion in HATS @Europe meeting
- Weekly office hours and co-working
- Intensive busy week hosted by Space Telescope in Baltimore
 - IPAC: Brigitta Sipócz, Jaladh Singhal, Troy Raen
 - STScI: Tessa Dower, Tom Donaldson
 - LINCC Frameworks: Just about everyone
 - ESA: Enrique Utrilla
- CMU Human Computer Interaction Institute user study
- Users, tutorial attendees, hallway conversations, grad student projects, summer undergraduate interns, reviewer feedback,



Future

- Official status with Vera C. Rubin before LSST Data Release 1
- Using HATS for other types of astronomical data
 - Collaboration with HEASARC to provide Fermi data
 - Collaboration with NOIRLab and DESI to provide spectral data
- TAP/ADQL implementation
- Propagate registry entries for current HATS catalogs
- Updating the note and towards IVOA standardization

<https://docs.lsd.io/en/latest/contact.html>

Slack channel: [#lincc-frameworks-lsd](#)

[@discovery-alliance.slack.com](#)

Working group: [hats-wg@googlegroups.com](#)

10am Pacific, 3rd Friday of month

6am Pacific, 4th Thursday of month

Office hours:

[10am Pacific, every Friday](#)

[10am Pacific, every Thursday](#) (LINCC F.)

[IVOA note here](#)