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50 years of CDS, 30 years of Aladin project: status and perspectives of the HiPS ecosystem

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Abstract. CDS (Centre de Données astronomiques de Strasbourg, Strasbourg astronomical Data Center) celebrates in 2022 the 50th anniversary of its creation. 2022 also marks the 30th anniversary of the start of the Aladin project. The original mission of the project - a sky atlas providing access to reference image surveys, enabling comparison of multi-wavelength data, cross-identification of sources - still holds strong. It is now fully supported by the HiPS (Hierarchical Progressive Survey) format. We want to take the opportunity of this 30th anniversary to provide with a comprehensive summary of the HiPS ecosystem that CDS and its close partners (ESO, ESA, STScI) have built in the last decade, and which allows the creation, publication, visualisation and scientific exploitation of HiPS datasets.

1. The HiPS format

HiPS stands for Hierarchical Progressive Surveys. It started as CDS implementation of slippy maps, suited for astronomy. It is based on the HEALPix (Górski et al. 2005) tessellation, with the benefits of minimizing deformation overall and preventing singularity at poles. It also preserves the dynamic range of the original data.

The HiPS format, originally described in (Fernique et al. 2015), is a Virtual Observatory standard since 2017 (Fernique et al. 2017).

HiPS is a FAIR (Findable, Accessible, Interoperable, Reusable) product: the HiPS protocol has been endorsed by the IVOA (International Virtual Observatory Alliance) and relies on proven existing standards (FITS, WCS, HEALPix). Individual HiPS are findable as resources in VO registries.

The HiPS format itself has proven to be quite efficient and resilient to high load: in the hours following the release of the first JWST images, CDS servers have recorded

more than 30 million requests on average (coming from 100,000 different IPs) with peaks at 1,500 requests per second.

2. HiPS datasets

2.1. A versatile data container

While the majority of available HiPS consist in images datasets, HiPS is a container not only for pixel data. It is used to serve efficiently:

- sky images HiPS.
- cubes: both radio cubes and IFU.
- catalogues HiPS: large catalogues, as the recent Gaia DR3 main table, are available in HiPs format.
- planetary surfaces.
- quantity maps: gravitational waves probability maps (LIGO/VIRGO), fluxes maps, density maps for Vizier catalogues.

2.2. Available HiPS image data products

Available HiPS are quite diverse, going from all-sky surveys (AllWISE, Integral, DSS, ...) to pointed observations (XMM-Newton, HST, HSC, Spitzer, ...), covering the whole electromagnetic spectrum and with a large variety of angular resolution. This is depicted in figure 1.

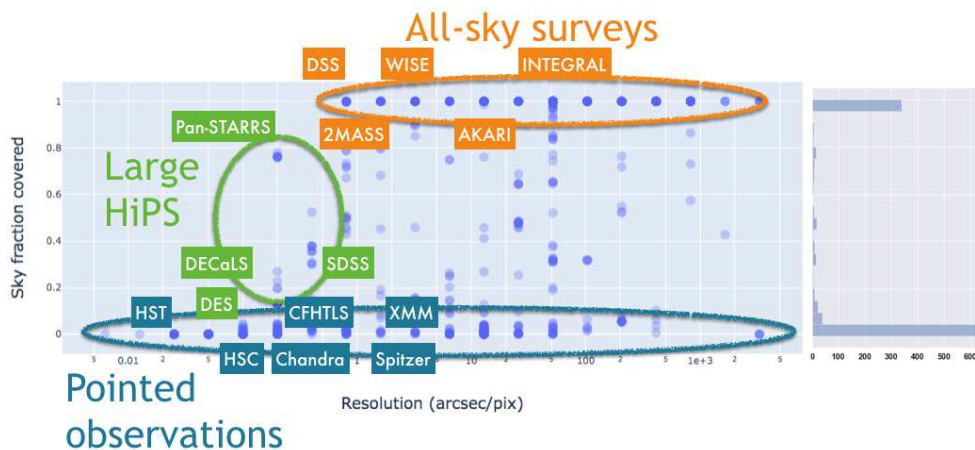


Figure 1. Available images HiPS, displayed on a sky coverage vs. resolution plot

3. The HiPS network

As of November 1st 2022, the HiPS network is serving more than 1,200 HiPs, created by 21 data producers, with a total volume of 430TB and 360,000 billion pixels.

Figure 2 shows the 24 HiPS nodes making up the HiPS network, ensuring redundancy and good access time around the world.

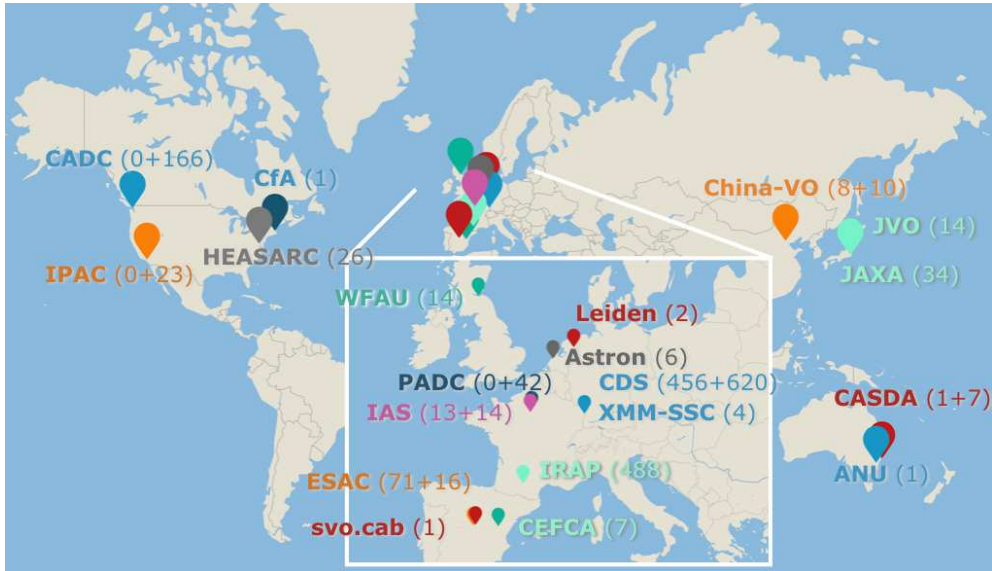


Figure 2. HiPS network, as of November 2022

4. HiPS generators

The large majority of the available HiPS images have been generated with the field-proven Hipsgen tool which was used notably to create HiPS for individual PanSTARRS bands (three quarter of the sky at 250mas/pixel resolution) in 16 days on a single server, for a total of 40 TB of FITS tiles.

The Montage toolkit, developed by IPAC, is also capable of generating HiPS individual tiles.

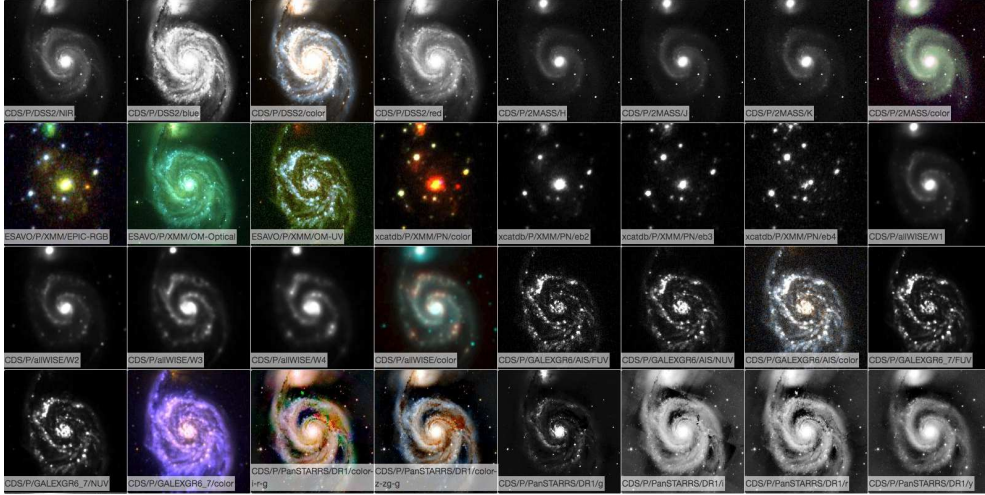
5. HiPS clients

HiPS data can be consumed by a dozen of existing clients: heavy clients (KStar, Stellarium, Aladin Desktop), web clients (Aladin Lite, World Wide Telescope, HscMap, Firefly) in various contexts: scientific purpose (with access to pixel real values), visualisation, amateur astronomy but also for EPO with the recent HiPS support in the Digistar planetarium control software.

Aladin Lite, developed at CDS, has been implemented in more than 50 professional astronomy websites and is being endorsed by ESA and ESO portals to explore and access their archival data. Version 3, currently in beta test, will offer all-sky projections, coordinates grid display, access to real pixel value (FITS tiles) and improved display thanks to GPU-based rendering.

6. Services on top of HiPS datasets

As the data are sampled in a common space grid, they can be easily composed and reused, as shows for instance the *hips2fits* service which provides arbitrary FITS cutouts for any published HiPS. Figure 6 shows cutouts extracted from different HiPS datasets for the galaxy Messier 51.



Recent prototype developments include access to HiPS and services related to large data cubes (in the context of SKA), generation of SED (Spectrum Energy Distribution) from photometric-calibrated HiPS, and extraction of light curves from image HiPS at different epochs.

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