ChatGPT

Spectral Datasets for Jupiter’s Atmosphere (UV–Visible and Infrared)

Multiple **space-based instruments** have captured calibrated spectra of Jupiter’s atmosphere across UV, visible, and IR wavelengths. Below we identify datasets covering **300–1100 nm (UV–visible)** and **1000–4000 cm^{-1} (2.5–10 μm, infrared)** ranges, focusing on Jupiter’s atmosphere (not moons/rings). All datasets listed are **calibrated or calibratable** and suitable for spectral line analysis, with metadata (wavelength calibration, units, etc.) included. Preferred formats (FITS or CSV) are noted, and guidance is given for accessing data and converting any specialized formats.

UV–Visible Datasets (300–1100 nm)

- **Cassini VIMS (Visual Channel)** – *Cassini’s Visual and Infrared Mapping Spectrometer* observed Jupiter during its 2000 flyby. The VIMS-VIS detector covers **0.35–1.05 μm** (350–1050 nm) in 96 spectral bands (≈7 nm sampling) [1]. By special commanding it could include wavelengths down to ~0.3 μm [2]. Data are stored as spectral image cubes (typically 64×64 spatial pixels × 96 bands) in the PDS. Each VIMS cube has an accompanying label that provides the wavelength for each band. The **PDS Imaging Node** archives these as volume **COVIMS_0002** (Jupiter flyby data) containing VIMS “QUBE” files and labels [3]. These are **raw cubes** (unitless instrument DN) but can be radiometrically calibrated to I/F or radiance using published calibration files [4]. *Format:* PDS binary cube (.qub with .lbl). *Metadata:* Wavelengths for all bands are in the label; observation geometry and timing are included. *Access:* Download via PDS (Imaging Atlas or OPUS search) by filtering for Cassini VIMS Jupiter data [3]. For example, the PDS index “Cassini VIMS Jupiter.csv” lists all Jupiter cube files and their paths. Each cube (e.g. `v1356977008_3.qub`) can be obtained from the PDS archive and opened with tools like **NASAView** [5] or converted to FITS (see **Format Conversion** below).

- **Hubble Space Telescope STIS** – *HST’s Space Telescope Imaging Spectrograph* provides UV–visible spectra of Jupiter with high calibration quality. STIS covers **115–1030 nm** in various modes [6]. In practice, one can obtain a continuous spectrum from **≈300 nm up to 1.0 μm** by combining STIS’s low-resolution gratings (e.g. G230LB, G430L, G750L). STIS data are **FITS** files from the MAST archive, with 1-D extracted spectra (wavelength vs flux) in calibrated units (e.g. ergs cm^{-2} s^{-1} Å^{-1}). For Jupiter, STIS observations are often spatially resolved (e.g. a long-slit across the disk), but one can sum the flux to get a disk-averaged spectrum. *Example:* Program observations of Jupiter’s reflected sunlight yield spectra across 300–1000 nm at ~1 nm resolution, useful for continuum and band analysis. *Format:* FITS (each `.fits` contains wavelength and flux arrays, plus header metadata for calibration). *Metadata:* Wavelength calibration (Å or nm) and flux units are in the FITS header. *Access:* Use **MAST** (HST archive) – search for target “Jupiter” and instrument “STIS”. For instance, a STIS dataset with G430L/G750L will appear in search results and can be downloaded as FITS. The data are fully calibrated (“*_x1d.fits” files for 1-D spectra).

- **Hubble WFC3 UVIS/IR (Spectral Scans)** – *HST WFC3* has grism modes that have been used for Jupiter as well. Notably, **WFC3/UVIS G280** (covering ~200–400 nm) and **WFC3/IR grisms G102 (0.8–1.15 μm)**

and G141 (1.07–1.7 μm) can produce spectra of Jupiter in those bands. For example, HST program WFC3/UVIS imaging of Jupiter's atmosphere is complemented by grism observations to retrieve regional spectra. These grism datasets are delivered as calibrated 2-D spectral images and extracted 1-D spectra in FITS from MAST. *Format:* FITS (with wavelength solution and flux). *Metadata:* Provided in FITS headers (wavelength dispersion, units, etc.). *Access:* Via MAST – e.g. search for "Jupiter WFC3 G141" to find observations (often taken to complement Juno ground tracks). Download the calibrated FITS which include the spectra. (If none are readily available in MAST, this indicates such observations are less common; STIS remains the primary HST spectrograph for Jupiter in UV/optical.)

- **International Ultraviolet Explorer (IUE)** – *IUE* observed Jupiter in the far-UV to near-UV. IUE's two spectrographs covered **1150–1950 Å and 1900–3200 Å** (115–320 nm) [7] with low resolution (~6 Å) and high-resolution modes. Many IUE spectra of Jupiter (e.g. auroral UV emissions, albedo in 200–300 nm range) are available. Key datasets include IUE observations during the **SL9 comet impact** in 1994, which were archived in the PDS (raw image files with labels) [8] [9]. For general use, the **IUE Final Archive** (accessible via MAST) provides **calibrated** 1-D spectra (flux vs wavelength) for Jupiter in FITS or text format. *Format:* FITS (for extracted spectra) or PDS (.lbl+.dat for some archives). *Metadata:* Wavelength (Å) and flux (erg cm^{-2} s^{-1} $Å^{-1}$) with calibration info in file header. *Access:* Use **MAST IUE Search** – enter object "Jupiter" to retrieve a list of exposures (SWP or LWP camera). Download the "MXLO" FITS files for fully calibrated spectra. Alternatively, PDS Atmospheres Node provides specific Jupiter IUE datasets (e.g. **IUE-J-LWP-...SL9** data set) via its catalog [10] (these may require manual calibration if raw).

Infrared Datasets (1000–4000 cm^{-1}, 2.5–10 μm)

- **Cassini VIMS (Infrared Channel)** – The Cassini VIMS IR detector spans **0.85–5.1 μm** (approximately 1960–11760 cm^{-1}) with 256 bands [11]. Jupiter spectra in this range were obtained during Cassini's flyby, often combined with the VIS channel into one cube. The VIMS IR data overlap the **2.5–5.1 μm** portion of the requested IR range. Key atmospheric spectral features (e.g. CH_4, NH_3 bands, H_2-H_3^+ continuum in the 3–5 μm window) are captured. The data are in the same **PDS cube format** as described above (one cube covers 0.85–5.1 μm continuous). *Format/Metadata:* See Cassini VIMS entry above (wavelengths listed in label; needs calibration to I/F using provided files). *Access:* Via PDS (Cassini VIMS Volume 2) [3] or OPUS. By selecting Jupiter and an IR observation time (e.g. late 2000), one can download cubes that include the full VIMS IR spectrum. Once calibrated, these cubes yield spectra suitable for comparison to lab spectra (e.g. identifying CH_4 absorption lines).

- **Galileo NIMS** – *Galileo's Near-Infrared Mapping Spectrometer* observed Jupiter from orbit (1996–2000) in the **0.7–5.2 μm** range with ~0.025 μm resolution (spectral sampling ~25 nm). NIMS, like VIMS, produced spectral cubes (though with varying geometry and less spectral coverage per cube segment). NIMS data include global maps and spot spectra of Jupiter's atmosphere. This extends over **2.5–5 μm IR** similar to Cassini VIMS, and being an orbiter, Galileo obtained many spectra at different locations and phase angles. *Format:* PDS (often .img with .lbl, or older "cube" format). *Metadata:* PDS labels include band wavelengths and units (Galileo NIMS calibrated data are typically in radiance or I/F). *Access:* The PDS Imaging Node houses NIMS datasets (e.g. **GO-J-NIMS-3-TUBE-V1.0**). Users can search the PDS for Galileo NIMS Jupiter observations or use the **PDS Cart** to filter by mission=Galileo, instrument=NIMS, target=Jupiter. After download, calibration files (for instrument response) can be applied if not already calibrated. **Note:** Galileo NIMS and Cassini VIMS together provide a consistent near-IR reflectance spectral library for 0.7–5.2 µm, but both are in specialized formats (see *Conversion* section).

- **Cassini CIRS** – *Cassini's Composite Infrared Spectrometer* is a Fourier-transform spectrometer that covers mid-IR wavelengths. For Jupiter, CIRS data span **≈600–1400 cm^{-1}** (≈7–17 µm) in two mid-IR channels [12]. This includes the **1000–1400 cm^{-1}** interval (10–7.14 µm) of interest. During the 2000 flyby, Cassini CIRS recorded Jupiter's thermal emission spectra, capturing key atmospheric emission lines (e.g. tropospheric NH_3 at ~10 µm, stratospheric C_2H_2, C_2H_4 emissions in the 13 µm region, etc.). The CIRS Jupiter data are archived in the PDS Atmospheres Node (volumes **COCIRS_0011** through **COCIRS_0101** contain Jupiter encounter data) [12]. These archives include interferogram products and calibrated spectra. The **spectral resolution** is adjustable; for Jupiter, moderate resolution (0.5–1.0 cm^{-1}) was used to resolve gas features. *Format:* PDS tables (PDS3 labeled binary tables or PDS4 products) rather than FITS, typically. Each CIRS spectral file has columns for wavenumber, radiance, and uncertainty. *Metadata:* Wavenumber calibration (cm^{-1}) is precise and included; radiance units (e.g. W cm^{-2} sr^{-1} cm^{-1}) or brightness temperature are given in labels. *Access:* Via PDS – one can navigate to the Atmospheres Node Jupiter catalog [13] [14] and find CIRS data, or use the PDS search filtering Cassini CIRS + Jupiter. The PDS provides index tables (e.g. a "Jupiter CIRS index") listing each observation's file name. Download the desired spectral files (e.g. `.TAB` with .LBL). These can be opened in tools like NASAView [5] or converted to text/CSV. CIRS data are **calibrated** – no further instrument response correction is needed, so one can directly analyze spectral lines.

- **Voyager 1 & 2 IRIS** – *Voyager's Infrared Interferometer Spectrometer* obtained broadband IR spectra of Jupiter during 1979 flybys. IRIS covered roughly **200–2500 cm^{-1}** (4–50 µm) at ~4.3 cm^{-1} resolution, which fully includes the 1000–4000 cm^{-1} (2.5–10 µm) range. Key absorption/emission features of CH_4, NH_3, PH_3, etc., in Jupiter's stratosphere and troposphere were observed. The IRIS datasets are archived at the PDS Atmospheres Node [15]. They provide calibrated spectra (often expressed as brightness temperatures vs wavenumber, or as radiance). *Format:* PDS binary tables (Voyager era data; not in FITS by default). Each spectrum may be a table of radiance vs wavenumber. *Metadata:* Included in PDS labels (target, geometry, calibration info). *Access:* Use the PDS search (mission=Voyager, instrument=IRIS, target=Jupiter) or the Jupiter Atmosphere Archive page [15] to locate Voyager IRIS files. After downloading, these can be read with PDS tools or custom scripts. **Note:** Despite age, Voyager IRIS spectra remain a valuable calibrated reference for mid-IR comparisons (e.g. for 5–10 µm region not covered by Cassini VIMS). The data are already in physical units, requiring no additional calibration.

- **ISO/SWS (Infrared Space Observatory)** – ESA's ISO mission (1995–1998) observed Jupiter in the mid-IR with the **SWS spectrometer**. Notably, high-resolution spectra in the **7–13 µm** range were obtained, targeting Jupiter's auroral regions [16] [17]. ISO was the first to **accurately measure Jupiter's spectrum around 7–8 µm** (which is largely inaccessible from ground due to atmospheric absorption) [18] [17]. For example, Drossart et al. (1998) recorded Jupiter's CH_4 ν_4 band at 7.7 µm and C_2H_2 ν_5 at 13.6 µm, which revealed how auroral energy is radiated in the IR [16] [17]. The SWS data have very fine spectral resolution (R~1000–2000) ideal for line identification. *Format:* FITS (ISO pipeline products). *Metadata:* Each FITS contains the wavelength (in µm or cm^{-1}) and flux (usually in W cm^{-2} sr^{-1} µm^{-1} or Jy) with calibration applied. *Access:* The ISO Data Archive (accessible through ESA) provides these datasets. For instance, the dataset **"Spectroscopy of the auroral regions of Jupiter"** has DOI:10.5270/esa-pntdaxy and can be retrieved via the ISO archive interface [19]. By inputting the observation number or DOI, one can download the FITS spectral files. These are fully calibrated. *Note:* ISO's Jupiter spectra complement Cassini/ Galileo by covering **5–12 μm**, filling the gap beyond 5 μm that those missions couldn't observe [20] [21]. If a continuous 2.5–10 μm spectrum is needed, ISO data (for ~5–8 μm) can be combined with VIMS or ground-based data to bridge the interval where other space instruments have no coverage [22].

Summary of File Contents: Each dataset above includes necessary metadata for interpretation. For imaging spectrometer "cube" data (Cassini VIMS, Galileo NIMS), the file or its label provides the list of band center wavelengths (in nm or μm) and typically the radiometric units (raw DN or I/F). For spectrograph 1-D spectra (HST STIS/WFC3, IUE, ISO, CIRS, IRIS), the files contain arrays of wavelength (or frequency) and flux, plus headers with calibration info (e.g. flux units, any slit size or spatial scaling to convert to e.g. $arcsec^2$ units). All of these datasets, once downloaded, can be directly used to extract spectral line profiles or continuum shapes for comparison with laboratory spectra. For example, STIS and IUE UV spectra list flux in erg s^{-1} cm^{-2} $Å^{-1}$ [23], and the planetary spectra in the STScI archive are given as surface brightness (per $arcsec^2$) to ease comparing extended sources [24]. Cassini CIRS and Voyager IRIS data provide either radiance or brightness temperature per wavenumber interval, which can be converted to radiance units if needed for line-by-line comparison. The **wavelength calibration** is explicitly included in all cases (either as column values or as keywords for start/spacing), so spectral lines can be identified at the correct frequencies.

Access and Download Instructions

To obtain additional spectra of similar type, follow these general **step-by-step instructions**:

1. **Via NASA PDS (Planetary Data System):** Use the PDS **Data Search** interface [25]. Go to **pds.nasa.gov/datasearch/** and filter by *Target* = Jupiter, then select the relevant *Mission/Instrument*. For example, to find **Cassini VIMS Jupiter cubes**, filter Mission = "Cassini" and Instrument = "VIMS", and Target = "Jupiter". The search results will list data products; you can add them to your cart and download the files (PDS often provides both data and label together). Similarly, to get **Cassini CIRS** spectra, filter Instrument = "CIRS". The PDS search tool will also find **Voyager IRIS** data by selecting Mission = "Voyager" and Instrument = "IRIS". Once the desired products are in your cart, choose "Download All" to get the data. *Tip:* Many PDS datasets are organized in volumes by time; you can also navigate via the node websites (e.g. the PDS Atmospheres Jupiter page) which often have direct volume links or indices for each mission (for instance, an index of all Cassini Jupiter VIMS cubes is available in CSV form [26] [27]).

2. **Via PDS Node Portals:** Some PDS nodes offer search portals tailored to certain instruments. For Cassini rings and remote sensing data, the **OPUS tool (Outer Planets Unified Search)** can be very helpful. Go to the OPUS interface and enter constraints (e.g. Instrument = Cassini VIMS, Target = Jupiter) to browse thumbnails of data [28]. You can then select specific observations and download them (OPUS will provide all relevant files, e.g. `.qub` and `.lbl`). This approach is useful for imaging spectrometer data where you might want to preview which part of Jupiter was observed. The PDS **Imaging Atlas** is another option for VIMS; it allows parameter search and will retrieve the raw cube files [29] [30].

3. **Via MAST (Mikulski Archive for Space Telescopes):** For **HST** and **IUE** data, use the MAST Portal at **archive.stsci.edu**. In the search bar, enter "Jupiter" as the target and refine the mission/instrument (e.g. choose **HST** and then filter Instrument = STIS, or select **IUE**). MAST will list matching datasets.

You can click on a dataset to see details (observation date, modes, etc.), then click “Download Data” to retrieve the calibrated FITS files. For example, searching “Jupiter STIS” might show several entries with different gratings; select one that covers your wavelength range of interest. For IUE, after searching “Jupiter IUE”, you may get a list of SWP/LWP exposures – you can download the low-dispersion FITS which contain the spectrum. (If using the older MAST IUE search interface [31], input Jupiter and select “Low” resolution to get the combined spectra rather than raw image files.)

4. **Via ESA/Other Archives:** For specialized datasets like **ISO**, go to the ESA ISO Data Archive. You can search by target name “Jupiter” or by the DOI if known. For instance, entering the DOI from a publication (e.g. 10.5270/esa-pntdaxy for the ISO auroral spectrum) should give access to the data set. You can then download the spectral FITS file(s) from that interface. Similarly, if using **Juno** data (not explicitly requested but available), you would visit the PDS (Juno data are at the PDS Atmospheres and PPI nodes) and filter for Juno UVS or JIRAM with Jupiter. Those come in FITS format usually, and the PDS search would yield direct download links.

5. **High-Level Compilations:** As a convenience, the STScI has assembled some high-level spectral products. One such product is a **“Solar System Objects Spectra”** HLSP file for Jupiter, which compiles visible and mid-IR data into one spectrum [32] [33]. You can download `jupiter_solsys_surfbright_001.fits` from MAST HLSP if you need a quick combined spectrum. *However, be cautious:* as noted by STScI, **no real data exist between ~4–8 µm in this composite**, so they interpolated that region [22]. This file is found by searching the HLSP section for "Jupiter spectrum". If using this, rely on actual datasets for any analysis of the 4–8 µm region, since it’s an extrapolation [34].

Format Conversion and Alternatives

Not all datasets come in the ideal format (FITS/CSV), but they can be converted or have alternative versions:

- **Cassini VIMS & Galileo NIMS (.QUB/.IMG):** These are in old PDS formats. You can use **NASAView** (a free PDS tool) to open .lbl/.qub files and export the spectral data to ASCII or CSV [5]. Another powerful option is **USGS ISIS3** software, which has import routines for VIMS and NIMS. For example, use ISIS3’s `vims2isis` to read a Cassini VIMS cube, then `isis2std` or `isis2fits` to save it as a multi-band FITS. The PDS also provides a VIMS Software Interface Specification (SIS) and calibration files to help interpret raw cubes [35]. By applying the radiometric calibration (using the files from the 2018 calibration update [4]), you can convert DN to I/F (dimensionless reflectance) or radiance. After calibration, you may also sum spectra spatially and save as CSV (wavelength vs I/F). If working in Python, libraries like `pds3read` or `planetaryimage` can sometimes read PDS3 image cubes as NumPy arrays for manipulation.

- **Voyager IRIS & Cassini CIRS (PDS tables):** These typically come as tables of numbers in PDS label format. Each can be converted by reading the label for structure. For instance, a Voyager IRIS file might be read with a Python script (using `pds4_tools` if a PDS4 label is available, or manually parsing PDS3 label definitions) and then saved as CSV. The PDS Atmospheres Node provides some Voyager IRIS in more accessible forms (sometimes detached labels with ASCII tables). If you have the data in binary, NASAView can save it as text. Cassini CIRS data, if in PDS4, might be directly opened with `pds4_tools` into a Pandas dataframe, then saved as CSV. *Alternative:* Some researchers have produced **derived datasets** – for example, a published atlas of Jupiter's thermal spectra might be available in CSV from journal supplemental material. Always verify that units and calibration are preserved during conversion (the metadata will indicate if values are radiances or brightness temperatures).

- **HST/IUE FITS:** These are already in FITS, but if CSV is needed, you can use astronomy tools (e.g. **ESA/STSci's FV or TOPCAT**) to open the FITS table and then save as CSV. The FITS headers will give the column meanings (e.g. `WAVELENGTH`, `FLUX`). For HST STIS, the x1d FITS contains multiple extensions (one per exposure); you might combine them if needed. MAST's interfaces sometimes allow direct CSV download of table data as well.

- **ISO SWS FITS:** ISO data comes as FITS with multiple spectral segments. You may need to concatenate segments (since SWS covered 7–8 μm in one scan and 12–14 μm in another, etc.). Tools like the **ISO Spectral Analysis Package** or the general **FITS I/O libraries** can be used. After reading the FITS (which has columns for wavelength and flux), you can output a CSV. The ISO archive documentation describes the product format if any conversion issues arise.

- **Addressing Gaps:** As mentioned, **no single instrument** covers 4–8 μm from space [22]. If your goal is a complete 2.5–10 μm spectrum, you'll need to **merge data** from multiple sources. For example, you can take Cassini VIMS up to 5.1 μm, then use a model or interpolate 5–7 μm (since neither VIMS nor CIRS covers 5–7 μm), and then attach Cassini CIRS or Voyager IRIS data from 7–10 μm. The STScI composite spectrum followed a procedure of extrapolating a curve to bridge 4–8 μm [34] – you can do similarly, but for rigorous analysis it's better to use actual data on either side of the gap and note the uncertainty in the interpolated region. If needed, laboratory spectra of Jupiter's atmospheric constituents (e.g. CH_4, NH_3 opacities) could inform an interpolation in the gap.

Closest Available Alternatives: If an exact dataset in FITS/CSV cannot be found, the above approaches will yield the **closest alternatives**. For instance, **Cassini VIMS** is the prime dataset for 0.3–5 μm even though it's in .QUB – converting it to FITS is straightforward with the right tools, and no equivalent already in CSV exists due to the volume of data. For the **5–10 μm range**, if you prefer not to handle Voyager IRIS binary files, you might use the **Cassini CIRS** spectra (7–10 μm) which are well-calibrated and then supplement with a **model or ground-based data** for 5–7 μm (ground-based telescopes like the IRTF have recorded Jupiter spectra up to ~5 μm, and some mid-IR filter photometry exists beyond). However, since the question emphasizes *space-based*, Cassini CIRS and ISO are the go-to sources for the mid-IR slice.

In summary, **working datasets** have been identified for both requested ranges: *HST/STIS* and *Cassini VIMS VIS* for 300–1100 nm, and *Cassini VIMS IR*, *Cassini CIRS*, *Voyager IRIS*, *ISO SWS* for 2.5–10 μm (with slight overlap gaps). All include necessary calibration metadata (wavelength scales, units, etc.), and with minor processing can be obtained in user-friendly formats. By following the retrieval steps for PDS and MAST, you can download additional Jupiter spectra of each type. And if formats like .IMG or .QUB are encountered, the conversion tips above will help transform them into FITS or CSV for easy analysis. Each of these datasets will enable extraction of spectral lines and direct comparison to laboratory spectra of Jupiter's atmospheric constituents, facilitating robust analysis of Jupiter's atmospheric composition.

Sources:

- Cassini VIMS instrument and data archive (PDS) [1] [3] [4]

- HST STIS capabilities (115–1030 nm) [6]
- IUE UV range and resolution [36]
- Cassini CIRS Jupiter data (PDS volumes) [12]
- Voyager IRIS/UVS Jupiter archive (PDS) [15]
- ISO Jupiter mid-IR observations and complement to Galileo [17] [21]
- STScI composite Jupiter spectrum (0.53–28.75 μm) and 4–8 μm gap note [22] [33]
- Tools for PDS data (NASAView, etc.) [5] [37]

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[1] [2] [4] [11] [28] [29] [30] [35] [37] Cassini VIMS: Visual and Infrared Mapping Spectrometer
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[5] [13] [14] [15] [25] Jupiter Data Archive
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