

Spectral Datasets for Uranus's Atmosphere (UV-Visible and IR Ranges)

UV-Visible Datasets (300–1100 nm)

HST/STIS Hyperspectral Cubes (300–1020 nm): A premier source of calibrated UV-visible spectra for Uranus is the **HST/STIS “Uranus-STIS” dataset** ¹ ². This is a High-Level Science Product (HLSP) from Hubble Space Telescope programs in 2002, 2012, and 2015, providing hyperspectral image cubes of Uranus's disk. Each cube spans **300.4 nm to 1020.0 nm** with ~0.4 nm spectral sampling (≈ 1 nm resolution) ¹. The data are stored in multi-extension FITS files: the primary **SCI** cube gives calibrated spectral radiance in dimensionless I/F (reflectance), and a **WAVELENGTH** extension provides the wavelength scale in nm ³. Wavelength calibration metadata are included via FITS WCS headers and the wavelength table, ensuring each spectral pixel is accurately mapped ³. Each FITS also contains geometry information (planetographic latitudes, longitudes, etc.) for spatially resolved analysis ³. These STIS spectra are fully **calibrated** (flux converted to I/F) and suitable for extracting methane absorption bands or other spectral features for comparison with laboratory spectra of gases or aerosols.

Access & Download: The Uranus-STIS cubes are openly available from MAST. The HLSP page provides direct download links for the FITS files ² (one per epoch). For example, the 2002 cube can be downloaded as a FITS file (~150 MB) via the DOI link provided ⁴. Each file's header lists the constituent STIS exposure IDs and instrument settings used to produce the merged spectrum. To obtain similar HST spectra, one can search the Mikulski Archive for Space Telescopes (MAST) for **HST/STIS** observations of “Uranus.” The **HST HLSP** interface also allows filtering by target and instrument – selecting “Uranus-STIS” retrieves this curated dataset. Users can then download the calibrated spectral cubes in FITS format. If a disk-integrated spectrum is needed (for example, to compare with a 1-D lab spectrum), one can average the cube spatially (since the data are spatially resolved across Uranus's disk). The FITS files' README and an example IDL script are provided to guide users in reading the data and extracting spectra ³.

IUE UV Spectra (for <300 nm extension): *[Optional]* While outside the requested 300–1100 nm range, it's worth noting that the **International Ultraviolet Explorer (IUE)** captured Uranus's far-UV spectrum down to ~115 nm. IUE low-resolution spectra (115–335 nm, R~300) are available from MAST in FITS table format. These include the 250–335 nm near-UV region, overlapping the lower end of STIS. The IUE data (e.g. SWP and LWP camera exposures) are flux-calibrated ($\text{erg cm}^{-2} \text{s}^{-1} \text{\AA}^{-1}$) and could complement HST for UV emission/absorption features below 300 nm. To retrieve IUE spectra, use the MAST **IUE Archive** search by object name “Uranus.” Keep in mind the signal-to-noise is low for this faint target, and HST/STIS data above 300 nm supersede IUE in quality.

Infrared Datasets (1000–4000 cm⁻¹ / 2.5–10 μm)

ISO PHT-S Low-Resolution Spectra (2.5–11.6 μm): The **Infrared Space Observatory (ISO)** observed Uranus in the 2.5–10 μm range using its photometer-spectrometer **ISOPHOT-S (PHT-S)** ⁵. On 1997-05-08, ISO recorded multiple PHT-S spectral scans of Uranus's disk ⁶. PHT-S actually consists of two grating spectrometers: the short-wavelength channel covers **2.47–4.87 μm** and the long-wavelength channel covers **5.84–11.6 μm**, with spectral resolution ~0.05–0.1 μm ⁵. The combined data effectively span ~2.5–11 μm (with a small gap ~4.9–5.8 μm between the two segments). The Uranus PHT-S spectra are **calibrated in flux** (the ISO pipeline converts detector signals to absolute flux densities). Encrenaz et al. (2000) report that Uranus was clearly detected in reflected sunlight up to ~3.5 μm ⁷, with strong CH₄/CH₃D absorption bands in the 2.5–4 μm region ⁸. Beyond ~3.5 μm the reflected signal falls into the noise, but the PHT-S long-wavelength channel can capture thermal-emission features (if any) up to 10 μm. The PHT-S dataset was used to derive Uranus's **geometric albedo spectrum** in the 2.5–4.2 μm range ⁹ ⁷, making it suitable for comparing with lab spectra of methane, hydrogen, etc., in this near-IR region. The data files (available from the ISO archive) are typically in FITS or ASCII table format; they contain columns for wavelength (μm), flux (usually in Jy or W·m⁻²·μm⁻¹), and uncertainty. All requisite metadata – wavelength calibration, units, instrument settings – are included in the headers.

Access & Download: ISO PHT-S Uranus observations can be obtained via the **ESA ISO Data Archive**. Using the archive's interface (now available through ESA's online GUI), search for target **"Uranus"** and select instrument **PHT-S** (observation date May 8, 1997). The archive will list the observation details (RA/Dec, wavelength coverage, integration time, etc.). Users should register for an ESA archive account (required to retrieve ISO data). Once logged in, you can request the **processed data** – the archive will generate the latest-pipeline products (often called Auto-Analysis Results) for download. The delivered package typically includes FITS files for the **short- and long-channel spectra** and calibration information. For scientific use, choose data with (pipeline-processed science products) ¹⁰ ¹¹. After your data request is prepared (you'll receive an email), download the spectra (FITS) from the provided ESA FTP link. These FITS files will contain the calibrated spectrum of Uranus's atmosphere in the 2.5–4.8 μm and 5.8–11.6 μm ranges. *Tip:* Ensure to subtract the sky background (ISO's observing sequence included off-source measurements ⁶) – the published analysis subtracted a nearby sky spectrum to isolate Uranus's flux ⁶. The result is a calibrated spectrum suitable for identifying spectral lines (e.g. CH₄ features) or continuum shape for model comparison.

ISO/SWS High-Resolution Segment (3.3 μm H₃⁺ lines): In addition to the broad PHT-S survey, ISO's **Short Wavelength Spectrometer (SWS)** captured **high-resolution** spectra of Uranus in a narrow interval around 3.3 μm. Two SWS AOT02 observations in April–May 1998 targeted the 3.295–3.335 μm region at **R≈1950** ¹². These spectra revealed four discrete emission lines of the H₃⁺ ion in Uranus's thermosphere ¹³ ¹². If your research involves spectral line identification or comparison to lab spectra (for example, H₃⁺ transition frequencies), these SWS datasets are invaluable. The SWS data are stored in FITS format and include the wavelength grid (high-resolution, in μm or cm⁻¹) and calibrated radiance (the ISO SWS pipeline provides flux in Jy or W·m⁻²·μm⁻¹ with known uncertainty). **Access:** These observations can also be found in the ISO Archive by searching for Uranus with instrument **SWS** (look for AOT02 mode around the dates 1998-04-07 and 1998-05-15, just before ISO's cryogen depletion). The archive will provide the FITS spectral files (or an option to reprocess and download). Ensure to select the **SWS full-scan or line mode** products; for AOT02,

the pipeline outputs a high-res spectral segment. The metadata will confirm the wavelength calibration and resolution. With these files, one can directly measure the H_3 line positions and strengths and compare them to laboratory frequency standards.

Spitzer/IRS Moderate-Resolution Spectra (5–21 μm): Although not listed in the prompt’s examples, the **Spitzer Space Telescope’s Infrared Spectrograph (IRS)** also provided spectral data on Uranus in the mid-IR. Spitzer observed Uranus in **staring mode** with both low-resolution (R~60–120) and high-resolution (R~600) modules, covering **5.2–21.5 μm** (low-res) and **10–36 μm** (high-res). These spectra are fully calibrated (flux vs. wavelength) and archived at the NASA/IPAC Infrared Science Archive. In particular, Spitzer IRS data enabled detection of very faint atmospheric features – for example, **collision-induced H_2 absorption around 10 μm** that is too weak to detect from the ground ¹⁴, and new hydrocarbon emissions (C_2H_6 , C_3H_4 , C_4H_2) in the 10–20 μm range ¹⁵. For the 2.5–10 μm window, Spitzer’s coverage overlaps the **5–10 μm portion** with higher signal-to-noise than the ISO PHT-S long-channel. Thus, if your interest extends toward 7–10 μm spectral features (e.g. the 7.7 μm CH_4 band or 8–13 μm continuum), the Spitzer IRS data would be the *best* calibrated source.

Access: To retrieve Spitzer Uranus spectra, use the **Spitzer Heritage Archive (SHA)** at IRSA. In the SHA web interface, use *Target Search* with “Uranus” (as a moving target – Spitzer observations of planets are indexed by target name). You may refine by instrument = IRS and observation type = Staring. The search will return datasets such as program IDs 548 (Thermal emission spectroscopy of Uranus by Orton et al.). You can then download the **pipeline-processed spectra** (for IRS low-res, these are often delivered as tabulated spectra in FITS or ASCII format, with columns for wavelength (μm), flux (Jy), and uncertainty). The Spitzer data include headers with the calibration version, units, and any applicable corrections. **Note:** Spitzer spectra beyond 10 μm go outside the requested range, but they seamlessly cover 5–10 μm , which can augment the ISO results. For additional similar data, one can also search IRSA’s general catalog of IRS observations for **Neptune or other planets** to compare Uranus’s spectrum with those bodies.

Additional Notes and Closest Alternatives

If **exact-format datasets** are not available for a segment of the spectrum, consider conversions or related products:

- **Voyager 2** observations are not directly in the 300–1100 nm or 2.5–10 μm ranges. Voyager’s UV Spectrometer covered far-UV wavelengths (primarily <170 nm, well below 300 nm), and the **Voyager IRIS** infrared spectrometer focused on thermal far-IR emission (nominal range 180–2500 cm^{-1}) with Uranus data emphasized in the 200–400 cm^{-1} (25–50 μm) region ¹⁶. These do not overlap the UV-visible or 2.5–10 μm reflected-sunlight region of interest. Moreover, Voyager IRIS data in NASA PDS archives are stored in old formats (.QUB), requiring conversion to use. For the purposes of Uranus’s reflected/near-IR spectrum, the ISO and Spitzer datasets described above are far more suitable and already calibrated.
- If a **format conversion** is needed (e.g. ISO archive yields data in proprietary format), tools like the ISO Spectral Analysis Package or PDS4 conversion utilities can translate them to CSV or simple tables. Fortunately, ISO pipeline products and HST/Spitzer archives generally provide data in **FITS**

tables or **ASCII tables** that can be opened with common software (Python `astropy`, IDL, etc.) and saved as CSV if required.

Downloading Similar Spectra – Step-by-Step

To obtain **additional spectra of similar type** or for other targets (e.g. Neptune or different epochs):

- **HST Spectra:** Use the MAST **HST Search** or DOI links for published HLSPs. For Uranus, the Uranus-STIS HLSP is already identified (DOI: 10.17909/T9KQ4N) ⁴. For other HST instruments (e.g. WFC3 UVIS/IR grism spectra of Uranus, or older FOS data), you can search MAST by target = “Uranus” and filter by instrument. The interface will list available datasets. Select the desired exposures and download the calibrated `*_x1d.fits` (1D extracted spectra) or high-level combined products if available. For example, to find any **WFC3** spectral scans, search HST -> WFC3 -> Uranus (though HST/WFC3 observations of Uranus are mostly imaging, not spectral).
- **ISO Spectra:** Register at ESA's ISO archive (if you haven't already). Through the archive query form, input the **target name** or coordinates for Uranus (or another planet) and specify instrument (PHT-S for low-res 2.5–11 μm , SWS for higher-res 2.4–45 μm , or LWS for 45–197 μm far-IR spectra). For Uranus, you may find multiple observations: e.g., **PHT-S** in 1997, **SWS** in 1998 (H₃ lines), and possibly calibration observations with **LWS** (Uranus was used as a far-IR calibrator ¹⁷). Select the observations of interest and add them to your download basket. After submitting the request, you'll get an email with links to the data (FITS files). Download those to retrieve the spectra. For ISO data on **other planets (Neptune, Jupiter, etc.)**, follow the same steps – e.g. search “Neptune” + PHT-S to get Neptune's 2.5–5 μm spectrum (similar data exist from the same program ⁷). The ISO archive's *Observation Log* or catalogs (e.g. VizieR ISO log VI/111) can also be consulted to find observation IDs (TDT numbers) for specific targets, which you can plug into the search.
- **Spitzer IRS Spectra:** Go to IRSA's **Spitzer Heritage Archive** and use the *Advanced Search*. Under *Targets*, enter the object name (for planets use the moving target option; “Uranus” is recognized). Specify instrument = IRS and select the wavelength range or mode if needed. The archive will return all IRS observations for that target. You can then download the **Level 2 spectral products** (typically FITS tables of extracted spectra). For Uranus, you might retrieve multiple segments (e.g. SL1, SL2, SH modules covering different parts of 5–21 μm). Ensure to download the accompanying metadata if available (Spitzer will provide a README with units and calibration notes). Similarly, to get spectra for **Neptune or other outer planets**, just change the target name and repeat the search.
- **Other Archives:** The **Planetary Data System (PDS)** hosts historical spacecraft data. For Uranus's atmosphere, you might find relevant data in the **PDS Atmospheres Node** (e.g. Voyager UVS stellar occultation data for Uranus's upper atmosphere, or ground-based telescopic spectral atlases). However, these are often in older formats. If needed, consult the PDS Atmospheres Uranus page for guidance. Given your preferences (FITS/CSV), sticking to HST, ISO, and Spitzer archives (which yield modern formats) will minimize conversion work.

In summary, multiple **space-based spectral datasets** meet the criteria:

- **HST/STIS UV-Visible cube (300–1020 nm)** – Calibrated I/F spectra with 0.4 nm sampling ¹ ³ , available as FITS (with wavelength & units metadata).
- **ISO PHT-S 2.5–4.8 μm & 5.8–11.6 μm spectra** – Calibrated flux spectra (Jy vs. μm) in FITS, covering the 2.5–10 μm range (low resolution) ⁵ .
- **ISO SWS 3.3 μm high-res segment** – Narrow-range, high-res FITS spectrum revealing H₃ lines ¹³ ¹² .
- **Spitzer IRS 5–10 μm spectra** – Moderate-res spectra in FITS table format, for improved S/N in the mid-IR ¹⁵ .

Each dataset includes the necessary **wavelength calibration and units** in its headers or documentation, ensuring they are immediately usable for line identification or comparison to laboratory spectra. By following the access steps above, you can download these datasets and even obtain similar spectra for other time periods or planetary targets, fully prepared for in-depth analysis of Uranus's atmospheric composition.

Sources:

- High-level STIS Uranus spectral data overview and access instructions ¹ ²
- STIS FITS content (wavelength and I/F calibration) ³
- ISO PHT-S instrument range and Uranus observation details ⁵ ⁷
- Detection of H₃ lines in ISO SWS 3.3 μm spectra ¹³ ¹²
- Spitzer IRS Uranus spectral findings (mid-IR features) ¹⁴ ¹⁵
- Voyager/IRIS spectral range (for context) ¹⁶
- MAST/ISO archive usage documentation ¹⁰ ¹¹

¹ ² ³ ⁴ Hyperspectral Images of Uranus

<https://archive.stsci.edu/prepds/uranus-stis/>

⁵ ⁶ ⁷ ⁸ ⁹ ¹² ¹³ 2300L83.DVI

http://www-personal.umich.edu/~atreya/Articles/2000_ISO_Spectra.pdf

¹⁰ ¹¹ How to use the ISO Data Archive

https://www.ipac.caltech.edu/iso/iso_archive/archive_instruct.html

¹⁴ Mid-infrared spectroscopy of Uranus from the Spitzer Infrared ...

<https://www.sciencedirect.com/science/article/abs/pii/S0019103514003765>

¹⁵ Detection of new hydrocarbons in Uranus' atmosphere by infrared ...

<https://www.sciencedirect.com/science/article/abs/pii/S001910350600203X>

¹⁶ Infrared Observations of the Uranian System - Science

<https://www.science.org/doi/10.1126/science.233.4759.70>

17 ISO LWS observations of planetary nebula fine-structure lines

<https://academic.oup.com/mnras/article/323/2/343/1243813>