

Spectral Database Users Manual  
American Association of Variable Star Observers

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Version 1.4

## 1 | Introduction

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Welcome to the AAVSO Spectral Database! The aim of this database is to leverage the extensive Variable Star Index (VSX) to help foster a repository of quality 1-D spectra for use by the public, amateurs, and scientists. The database is accessed through an interface hosted on the AAVSO website.

AAVSO Users and the wider public may search, view, and download whole FITS-type observation files for their own use. Scientists too may use this tool to gather data for professional research, with due credit. We hope to provide the community with a treasure trove of useful data to further goals and projects world-wide.

We invite both new and veteran observers to contribute to the database. Observers must demonstrate a successful observation before they are able to contribute, simply by uploading a 1-D spectrum of a calibration star (for more info, see below). Once the observation has been validated, they will be able to upload observations freely. Uploaded observations are automatically checked for adherence to the requirements required by AAVSO, listed below.

We look forward to seeing your contributions soon!

For specific information and/or questions, please contact [avspec@aavso.org](mailto:avspec@aavso.org).

## 2 | Submitting an Observation

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In order to successfully upload a spectral observation, a user must first be registered with the AAVSO and have received an *obscode*. The obscode is the identification code used to denote users within AAVSO. For new observers, please register by clicking [here](#).

Secondly, a user must complete both the *equipment* and *site* information panels in their user profile.

**Equipment** – This database requires all observers to have and maintain records of the observation equipment. This includes information such as telescope model, camera or CCD, and spectroscopy details. The user packages a given equipment setup with a nickname. When any of the equipment are changed (I.e. a new telescope), a new record will be produced. Any old records should be deleted. If you have multiple equipment setups, we ask that you make multiple unique records. Since this information is sometimes impossible to check later, we ask that you pay close attention to your equipment record information. Spectroscopic equipment must have the “Spectroscopy” selected as the Observing Type, otherwise AVSpec will not recognize it as a valid equipment package. Furthermore, to submit echelle observations, your equipment package must have type “echelle” selected within the spectra information section.

**Site** – Similarly, AAVSO AVSpec requires all observers to have and maintain records of the observation site. Although the site will likely change less than equipment, it is invaluable to know the location (lat/long) and altitude of the observations for later corrections by data users. As above, if you have multiple sites, you must make multiple records. As well, this information is also sometimes impossible to check later, and we ask that you pay close attention to your site record information.

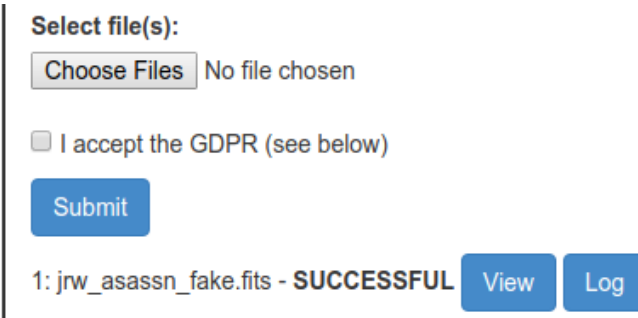
Once both records have been submitted, an observer can complete the observation submission form. Observation files be in FITS format, and must adhere to the requirements listed in Observation Requirements below. For more info on FITS type files, see the FITS Software section. As well as uploading a file (or multiple by ctrl+click), a user must specify the equipment and site used for that particular observation (or set of observations). Hence, multiple observations can be submitted simultaneously, but only for one pair of site and equipment.

The screenshot shows the 'New Submission' form in the AAVSO AVSpec interface. At the top, there is a navigation bar with links for 'Recent', 'Search', 'Submit', 'Forum', 'MyDB', and 'Help'. The main heading is 'New Submission'. Below the heading, the user is greeted with 'Hello, John! (WJOC)'. The form includes two dropdown menus: 'Equipment used:' with 'TEST\_EQUIP' selected, and 'Site used:' with 'TEST\_SITE' selected. There is a 'Select file(s):' section with a 'Choose Files' button and the text 'No file chosen'. Below this is a checkbox labeled 'I accept the GDPR (see below)'. At the bottom of the form is a blue 'Submit' button.

First time users will be able to submit a single spectrum, while selecting a standard star used for the observation. For first time users, observation of a standard star enables us to ensure that the FITS file header information is compatible with the information under the user's profile, and to help diagnose any problems which emerge with the software and data processing. Validation may take a few days, please be patient. When the spectrum is validated (i.e. deemed successful), the corresponding observation will be included in the database, and the observer will have permission to upload observations to the AAVSO AVSpec. They will then be able to upload observations freely, and those observations will be routinely checked by our spectra validation team. If there is a problem with the spectrum, a member of our validation team will provide the user with information to help correct their observation.

**PLEASE NOTE:** You must agree to abide by the General Data Protection Regulation (GDPR) before submitting any observation to the AAVSO. The GDPR is an initiative by the European Union to better protect personal data. To comply with the GDPR, the AAVSO will permanently delete any personal data upon request. This includes observation, site, and equipment records. To find out more, please visit <https://eugdpr.org/>

Upon upload, the FITS file will be opened and carefully checked by an automated system. Please be patient as this may take up to a minute, especially for large files. The file status will then be returned on the screen with further information. Each file may only contain a single observation corresponding to a single star. Although multi-dimensional files are **not** accepted, more than one file can be uploaded at the same time.



The screenshot shows a web interface for uploading a FITS file. At the top, it says "Select file(s):" followed by a "Choose Files" button and the text "No file chosen". Below this is a checkbox labeled "I accept the GDPR (see below)". A blue "Submit" button is positioned below the checkbox. At the bottom of the interface, the upload status is shown as "1: jrw\_asassn\_fake.fits - SUCCESSFUL", with two blue buttons labeled "View" and "Log" to the right.

If a file is returned as **SUCCESSFUL**, then it has been successfully uploaded and submitted to the database. The user can click on the [View](#) button to view the details of the observation, as well as the spectrum itself. Any errors realized at this point should be immediately reported to [avspec@aaavso.org](mailto:avspec@aaavso.org). If a user would like to learn more about the checking process, they may download the detailed logfile via the [Log](#) button.

If a file is returned as a **DUPLICATE**, then the system believes the observation has already been submitted. The criteria for duplication is for a given observer, equipment, and site observing the same star with a mid-observation Julian Date (JD) which is rounded equal to the JD of the pre-existing observation. This is done by rounding to the greatest precision of the pair, and comparing. If a user believes there is an error, please contact [avspec@aaavso.org](mailto:avspec@aaavso.org).

If a file is returned as an **ERROR**, then the system has found one or more problems with the observation. Feedback on these errors will be returned to the user immediately. The most useful tool for error checking is to examine the log which accompanies the returned file. Please see the Error Checking section for more information. If issues persist, please contact [avspec@aaavso.org](mailto:avspec@aaavso.org) for assistance.

Select file(s):

No file chosen

I accept the GDPR (see below)

1: jrj\_hr7596\_fake.fits - **UNSUCCESSFUL**

Star not in database

Site latitude does not match record

Site longitude does not match record

If you believe to have found an error on any published AVSpec record pages, please send a report to [aasvo@aavso.org](mailto:aasvo@aavso.org). Please include "AVSpec Error Report" in your subject title. Your report should contain the following:

\* Record ID (if known)

-OR-

\* Obscode (if registered)

\* Star name

\* Observation date (or JD)

\* Observer (if listed)

and any other information which may be useful.

### 3 | Observation Requirements

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In order to submit to AVSpec, data must be reduced as a 1-D spectrum. AAVSO requests a data reduction process by which the raw spectral image is dark-subtracted. Bias and flat subtraction are optional, but **strongly** recommended. In addition, the spectrum **must** be wavelength calibrated. Otherwise the spectral lines cannot be identified. Although we do not explicitly require documentation of this procedure in the FITS header (although it is encouraged), we do require a wavelength unit of the data to be “Angstrom”. More on this below.

Please note that AAVSO requests that submitted spectra are **not** corrected for heliocentric or doppler velocities. Telluric features should remain too, as this may help correcting possibly ambiguous spectra.

Due to the accuracy and detail required by scientific projects, each observation must be accompanied by a set of parameters detailing the conditions under which the observation was taken. Please use the guide below in constructing your FITS file headers.

#### Mandatory Keywords

Below is a list of mandatory keywords required for all observations. Alternative keywords, listed on the right, will be mapped to the standard keyword chosen by AAVSO in compliance with IAU standard keywords. FITS headers compliant with the BESS database are immediately compliant with the AAVSO requirements, and will be accepted if the user registers their BESS alias with AVSpec.

SIMPLE	Fits standard	
BITPIX	Bits per pixel	
NAXIS	Number of data axes	
NAXIS1	Length of data axis 1	
CRVAL1	Coordinate at ref pixel	
CDELTA1	Coordinate increment	
OBJNAME	Object name <sup>[1]</sup>	OBJECT
DATE-OBS	Date of observation start <sup>[2]</sup>	
DATE-END	Date of observation end <sup>[2]</sup>	
EXPTIME	Total exposure time <sup>[2]</sup>	
CUNIT1	Wavelength unit <sup>[3]</sup>	
CTYPE1	Axis type	

CRPIX1	Reference Pixel	
OBSERVER	Obscode <sup>[4]</sup>	
AAV_ORD	Echelle Order Number <sup>[5]</sup>	BSS_ORD <sup>[6]</sup>

Notes:

- [1] Object name must be recognized by the Variable Star Index (VSX).
- [2] Must have ISOT format, with at least 2/3 specified (see section on Denoting Time).
- [3] Must be "Angstrom".
- [4] Must match user login obscode.
- [5] Only required if uploading echelle spectra
- [6] Note that the AAV\_ORD keyword is not the same as the BSS\_ORD keyword. The system will transform the BSS\_ORD keyword appropriately, but they are not interchangeable.

**Recommended Keywords**

Other keywords are particularly useful to include for further use of the data. If possible, please include them.

Please note that unless site and instrument are explicitly specified in the FITS header, they will be adopted from those selected in the upload form. For this reason it is extremely useful to include them directly in the FITS header. No cross checking is performed at this time.

EXPTIME2	Exposure decomposition	
JD	Julian date mid exposure	
AAV_INST	Instrument <sup>[5]</sup>	BSS_INST, INSTRUME
AAV_SITE	Site <sup>[6]</sup>	BSS_SITE, SITE
AAV_ITRP	Resolving power	BSS_ITRP, ITRP
VERSION	Software	SWCREATE

Notes:

- [5] Instrument name should match equipment package nickname.
- [6] Site name should match site nickname.

**Denoting Time**

Observation dates included in the header must be in ISOT format (2017-01-01T00:00:00.000). Other formats will be rejected. In addition, a header must contain *at least* two of the three main time keywords (DATE-OBS, DATE-END, and EXPTIME). This will allow the automated system to calculate the remaining date, if not already supplied.

Please note that the JD keyword should be supplied with the *mid-exposure* JD, and not the start JD. If a JD is not provided, it will be calculated from DATE-OBS and DATE-END. No JD cross checking is performed at this time.

### **Accepted File Types**

Individual spectra should be uploaded in FITS format with the information described below. Echelle observations should be uploaded as a series of .FITS files, one per order, inside a .zip file. The zip file must contain only .fits files and must only contain the orders from a single observation. .zip files should **only** be used for echelle observations. .zip files containing multiple non echelle observations will be rejected.



## 4 | Error Checking

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Upon receiving an ERROR response to an observation upload, an error summary will be provided. All errors must be eliminated before an upload can be successful. Please note one error may be a result of another.

If in need of further details, please download and review the log file which accompanies the response. The file is automatically generated by the checking system and details each step taken to review the FITS header and data to ensure compliance with the AVSpec requirements.

The file checking routine given by the log file is detailed in the next section. In brief, the system will list the description of which header keyword it is looking for, and whether it was found. The system will also try to open the data and perform elementary checks to ensure the data is valid. An upload report at the end of the document identifies the success or failure of the submission, and if the later, which errors must be addressed.

If an observation is still unable to be uploaded after a thorough attempt at correcting all errors, please contact [avspec@aavso.org](mailto:avspec@aavso.org). In your message, please include the error log, as well as the file itself. This will help us identify any potential issues so that we may get back to you with suggestions.

## 5 | Development-side Technical Information

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This section is not intended for use by the typical observer, and is provided for those who wish to understand how the system works internally.

The file checking system uses a Python-based script to automate FITS header parsing and data validation. It does this by using *Numpy* and *Astropy* based subroutines to identify correct keywords and data types with the greatest flexibility possible.

The script is designed to host a set of keywords. Each keyword is noted as either mandatory or optional. Optional keywords will still be searched for and logged, but will not generate an error if not found. Mandatory keywords will generate critical errors. Keywords are assigned a description to be used as a comment card in the FITS header. In addition, all acceptable alias keywords are included. Variable type checks are also implemented. This is a flexible system designed for easy access.

The first objective for the script is to open the FITS file. This is done through the *Astropy* `fits.open()` function. If there is an exception, an error will be generated and logged. The length of the file is determined and logged. Although multi-dimensional files are not accepted, they will be checked in hope of generating error reports to reduce unnecessary upload attempts.

Next, the system will attempt to open the header. If the header cannot be opened, it will generate a fatal error which will terminate the check. If opened successfully, the script will begin looking for keywords corresponding to the aforementioned set. All secondary keywords are then looped through until an acceptable keyword and value is found. For example, if the system does not find the observation site under `AAV_SITE`, it will try `BSS_SITE`, and so on. Finding a valid keyword will terminate the search for that keyword. It does this in a generic for-loop, only using specific keyword names to introduce additional checks. This allows the set of keywords to be changed when needed without requiring significant changes to the structure of the script.

If a keyword is found under an alias, it will be standardized in the header by replacing the old keyword with the AAVSO standard keyword. A corresponding history comment will be written to the header beneath the pre-existing sections. This change is imposed to standardize all AVSpec observations to ensure further data analysis can be done in a consistent way.

All identified keywords are checked for variable type (i.e. string, integer, or floating-point number). Beyond this, additional checks include time ISOT format, wavelength unit of angstroms, and VSX cross-matching. An API connection to VSX will be opened when the object name is found. Obscode, Site, and Equipment values are also cross-checked from the upload form. If either Site or Equipment is not specified, the script will adopt the value from the upload form and add it to the header. A history comment will be included.

The time values are tricky. AVSpec requires observation headers to include two of the three main time keywords (`DATE-OBS`, `DATE-END`, and `EXPTIME`). This allows the calculation of the remaining value. As well, a mid-observation JD is calculated if not supplied.

If the JD is acceptable, then the system checks that the airmass at the object coordinates and JD for the supplied site location is between 1 and 5. Any observation found with an airmass outside this range will be

considered problematic, and will raise an error. In the event that the JD is unreliable or that the site information cannot be accessed, this check will not be done, and an error will not be raised.

If at this point the header is found to be in good standing, the script will use the API connection to VSX to download details about the object relevant to variable star studies. This includes the location (RA/Dec), variability type, and period of the star/object. This information is also added to the header for quick access. It may also serve as a red flag to users if the information does not match up. AVSpec does not require this information to be explicitly included in the header upon submission, and therefore does not cross-check at this time.

If the check of the VSX data raises an error, AAVSO should be contacted at [avspec@aavso.org](mailto:avspec@aavso.org). It is likely due to an issue within VSX, as opposed to the observation file, and thus cannot be fixed by the external observer. Hence, critical errors are not generated from this section of the script. However, they are noted in the log file and forwarded to the user in the upload response.

Due to the wide range of expected spectral shapes and wavelength ranges, data checking is kept to a minimum. An attempt is made to open the data section of the fits file. The shape of the data is calculated. A dataset without anything in it is noted as a critical error. Users are reminded to document their reduction technique in their header, where possible.

Finally, an upload report is provided, listing the final status of the header and data. This will indicate whether or not the observation has been accepted. If the header and data are bad, the report will list the errors incurred during the checking.

If successful, the FITS file, the VSX ID of the identified object, and the final result of the upload is then sent on to the database for storage.

## A.1 | Telluric Lines

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A list of telluric lines is used so that members of the validation team can easily check for good wavelength calibration. This list is as follows:

H2O near H $\alpha$	O2 B band	O2 A band	Other bandheads
6532.359	6867	7594	6278.3 (O2 a)
6543.907	6883.833	7620.996	7168 (H2O)
6548.622	6885.754	7623.288	8230 (H2O)
6552.629	6886.743	7624.500	8935 (H2O)
6557.171	6888.948	7627.054	9275 (H2O)
6572.072	6889.903	7628.225	
6574.847	6892.369	7631.016	
6580.786	6893.309	7632.168	
6586.596	6896.037	7635.192	
6559.324	6896.965	7636.328	
	6899.954	7639.585	
	6900.868	7640.707	
	6904.117	7644.200	
	6905.023	7645.312	
	6908.534	7649.035	
	6909.431	7650.135	
	6913.200	7654.094	
	6914.090	7655.182	
	6918.122	7659.370	
	6919.002	7660.454	
	6923.286	7664.872	
	6924.164	7665.944	
		7670.600	
		7671.670	
		7676.563	
		7677.618	
		7682.756	
		7683.800	
		7689.177	

		7690.217	
		7695.836	
		7696.868	

## A.2 | Web Interface Structure

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AVSpec is composed of several user interfaces. They are explained briefly below:

**Recent** – This is the landing page for AVSpec, and features the 10 most recent observations published on AVSpec. Each listing shows the object, time, and a bit about the observation.

**Search** – A basic search engine for navigating the database. Fields which are used in a search are combined “and”-style, and not treated as separate “or” search values.

**Submit** – This is the primary submission page, and allows users to upload their spectra of both calibration and variable stars. Live feedback is included, as well as any alerts about validation status, or spectra which have been rescinded.

**Forum** – Best place to go if you have questions about the database, or spectroscopy in general. This page is external to the database, but still contained within the forum pages maintained by the AAVSO. The community established here is eager to help out spectroscopic observers of all levels of experience.

**MyDB** – Your personal database scorecard and data access portal. From here you can get a snapshot of your contributions to the science of variable star spectroscopy, and search your observations. You must have submitted a standard star observation for this page to be visible.

**Help** – The help page, containing documentation and help guides for getting started with AVSpec.

**Records** – These pages are procedurally generated for each observation, and includes information about the observation, site, equipment, and star. It also includes a snapshot of the spectrum which can be interactively manipulated. Users also have the option to remove their own observations from the bottom of this page.

## A.3 | FITS Software

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Flexible Image Transport System or FITS files are the standard go-to file system choice for astrophysics. The reason for this is that FITS files are able to convey not only the data of the observation, but also potentially invaluable information about the observation target, conditions, etc in what is called the “header”.

FITS files cannot be accessed with a typeset or spreadsheet processing system like Word or Excel, respectively. They can however be accessed with prefabricated software or by using programming methods with languages such as Python, IDL, or FORTRAN.

We do not expect nor require users of AVSpec to be experts with FITS files. We do however ask that they are able to write out FITS files using a compatible software system of their choice.

The automatic header checking system employed by AVSpec has been made compatible with: ISIS, Mag-E, Vspec, MaximDL, and BASS.

If you use a different software and cannot successfully submit an observation, please contact [avspec@aavso.org](mailto:avspec@aavso.org) with information about your situation, and the software you use.