PDS Radio Science Data Viewer (PRSDV) User Manual
V2.2

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1. Introduction

The Planetary Data System (PDS) Radio Science Data Viewer (PRSDV) is an interactive application developed using MATLAB App Designer to provide quick-look functions to browse PDS4 TRK-2-34 formatted data. TRK-2-34 data, also known as Tracking and Navigation Files (TNFs), are the primary radiometric data type recorded at NASA's Deep Space Network for many interplanetary missions. The PDS4 standard in use at NASA's PDS utilizes Extensible Markup Language (XML) to label the files' metadata and is essential for use of the PRSDV (i.e., the PDS4 labels adjoining the TNFs are required for execution of the PRSDV).The app supports Linux, Mac OS, or Windows operating systems for non-MATLAB environments (i.e., PRSDV users do not require MATLAB software to run the app); however, the users need to install a compatible version of Runtime software on their local machines to run the app (details in section 1.2). The source code is also provided so that users can compile the APP to fit their operational environments. The current version (V1.0) provides functions to read PDS TRK-234 files, filter data with different configuration selections, plot the filtered data, and output the plotted data points into an ASCII file for further analysis. Future upgraded versions will be released at the NASA PDS GitHub.

1.1 PDS Transform Installation

The PRSDV app utilizes some functions of the PDS Transform Tool (https://nasa-pds.github.io/transform/index.html). Windows Users need to install the PDS Transform Tool and set up the configuration following the PDS tool instruction (https://nasa-pds.github.io/transform/install/index.html); section 1.2.1 also summarizes details of Windows environment settings for using the PRSDV tool. For Linux and Mac OS environments, the PDS Transform Tool is packed into the PRSDV app; users can run the app via Runtime.

1.2 PDS Transform Environment Setting

PDS Radio Science Data Viewer users should install or update their JAVA program (https://www.java.com/en/download/manual.jsp) to run the PDS transform functions in the PRSDV app.

1.2.1 Windows Users

Once the Windows users complete the JAVA installation or update, they need to create JAVA_HOME and PATH in the Windows Environment Variables via **Control Panel** > **System** > **Advanced System Settings** > **Environment Variables** (Figure 1-1 to Figure 1-3).

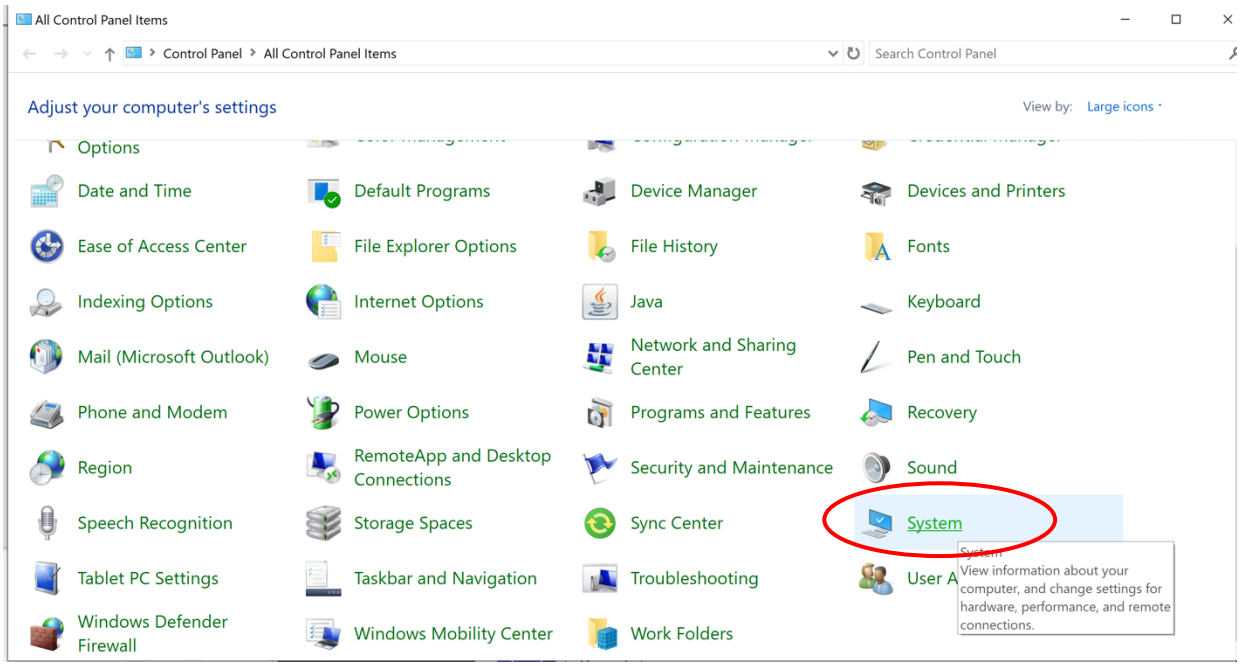

Figure 1-1

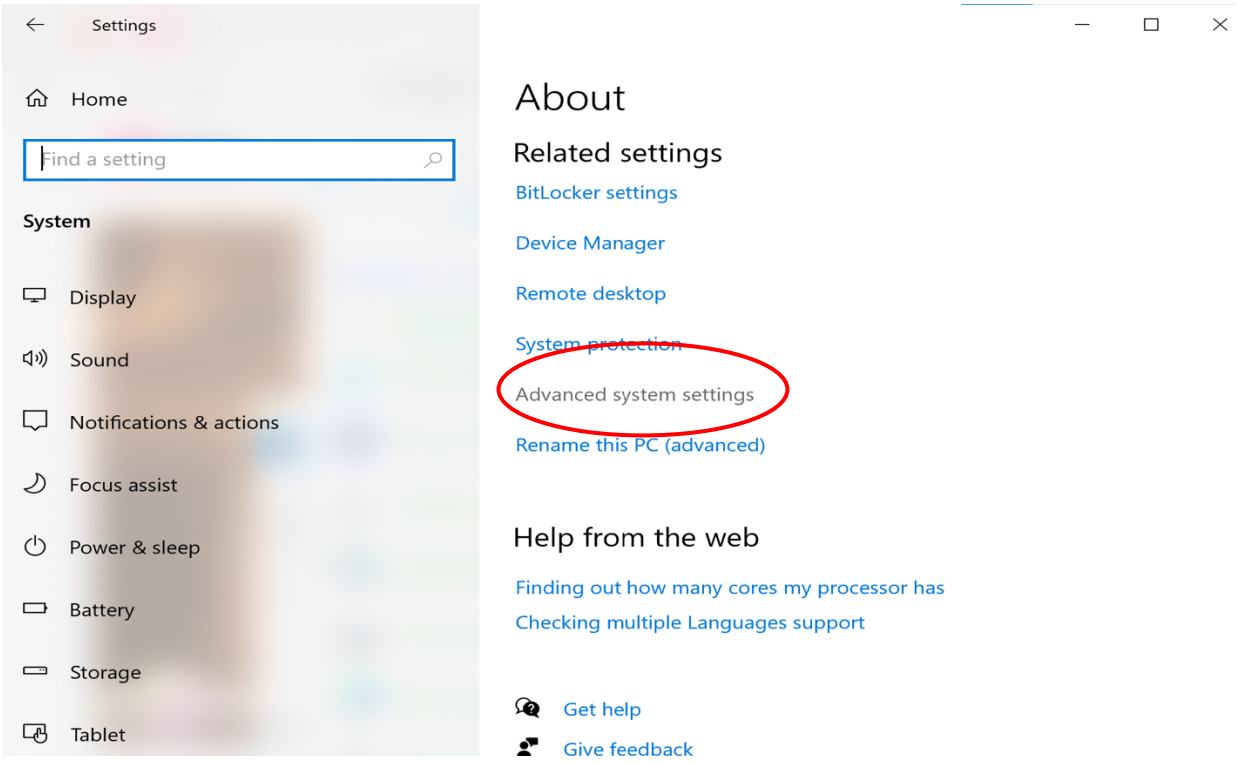

Figure 1-2

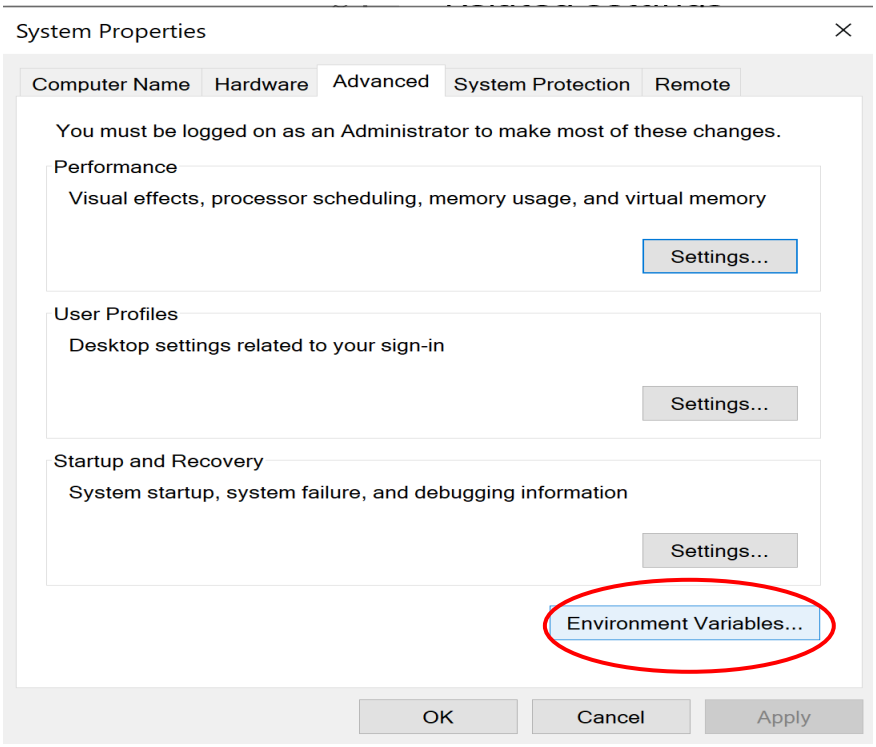

Figure 1-3

In the **Environment Variables**, users need to click New in the User Variable Panel and create/edit Variable name: JAVA_HOME and Variable value: C:\Program Files\Java\jre- 1.8 (or use the Browse Directory to select the JAVA program directory that users installed) as shown in **Figure 1-4 and Figure 1-5**.

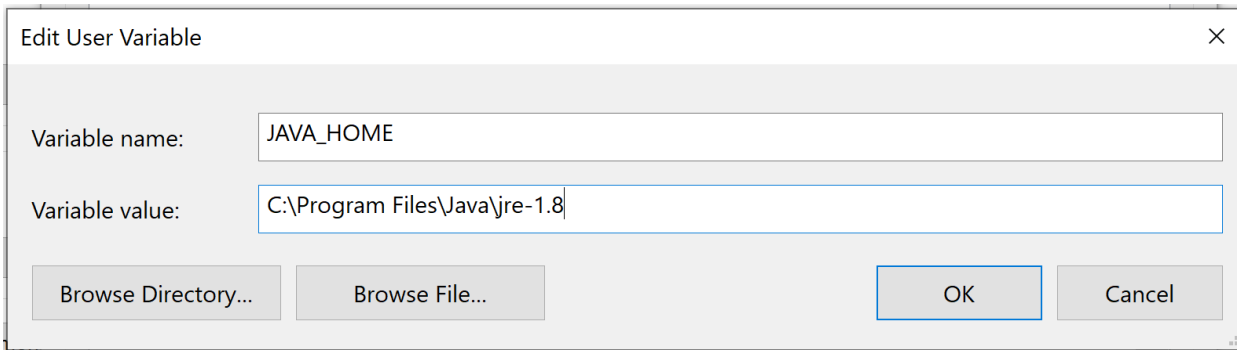

Figure 1-4 JAVA_HOME directory setting.

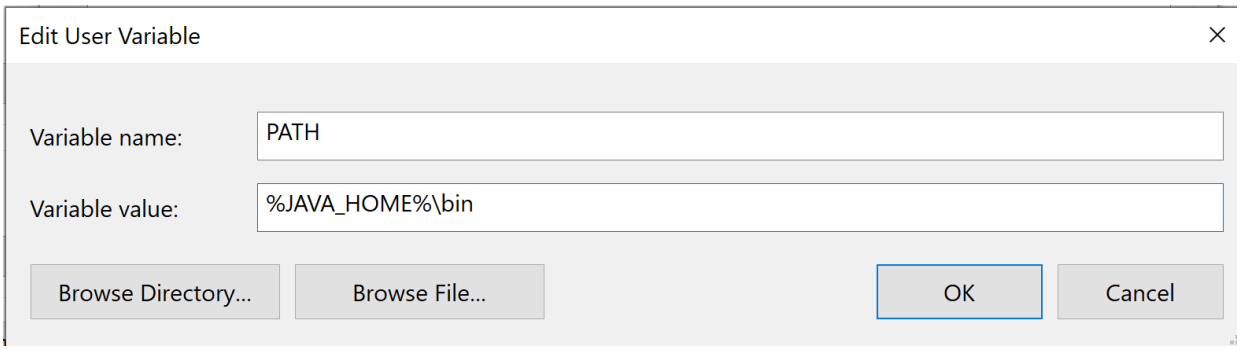

Figure 1-5 JAVA_PATH setting.

1.2.2 Linux and Mac OS Users

For Linux and Mac OS users, the standalone PRSDV app packs the required PDS transform functions in the sub-directory (/bin) of the software package. PDS Radio Science Data Viewer users might need to update their JAVA program; please check the website for details (https://www.java.com/en/download/manual.jsp).

1.3 Runtime Installation

To run the standalone PRSDV MATLAB app in an environment without MATLAB, users must install MATLAB Runtime. The MATLAB Runtime version (shown in the following **Figure 1-6**) needs to be compatible with the MATLAB version that is used to compile and pack the standalone application. MATLAB Runtime may be downloaded and installed from the website: https://www.mathworks.com/products/compiler/matlab-runtime.html. The current PRSDV app is compatible with the R2023a (9.14) version of MATLAB.

Release (MATLAB Runtime Version#)	Windows	Linux	Mac
R2024b (24.2)	64-bit	64-bit	Intel 64-bit / arm64
R2024a (24.1)	64-bit	64-bit	Intel 64-bit / arm64
R2023b (23.2)	64-bit	64-bit	Intel 64-bit / arm64
R2023a (9.14)	64-bit	64-bit	Intel 64-bit
R2022b (9.13)	64-bit	64-bit	Intel 64-bit
R2022a (9.12)	64-bit	64-bit	Intel 64-bit
R2021b (9.11)	64-bit	64-bit	Intel 64-bit
R2021a (9.10)	64-bit	64-bit	Intel 64-bit
R2020b (9.9)	64-bit	64-bit	Intel 64-bit
R2020a (9.8)	64-bit	64-bit	Intel 64-bit
R2019b (9.7)	64-bit	64-bit	Intel 64-bit
R2019a (9.6)	64-bit	64-bit	Intel 64-bit
R2018b (9.5)	64-bit	64-bit	Intel 64-bit
R2018a (9.4)	64-bit	64-bit	Intel 64-bit
R2017b (9.3)	64-bit	64-bit	Intel 64-bit

Figure 1-6 The Runtime Versions for Linux, Mac, and Windows.

2. PDS Radio Science Data Viewer (PRSDV) App

The standalone PRSDV app visualizes data types and fields archived as PDS4 format files. **Figure 2-1** shows the function block diagram of the PRSDV software; PRSDV app users can input a PDS4 header file (*.xml) to read and select the data types and fields for visualization. The standalone PRSDV app is compatible with Linux, Mac OS, and Windows operating systems without MATLAB software.

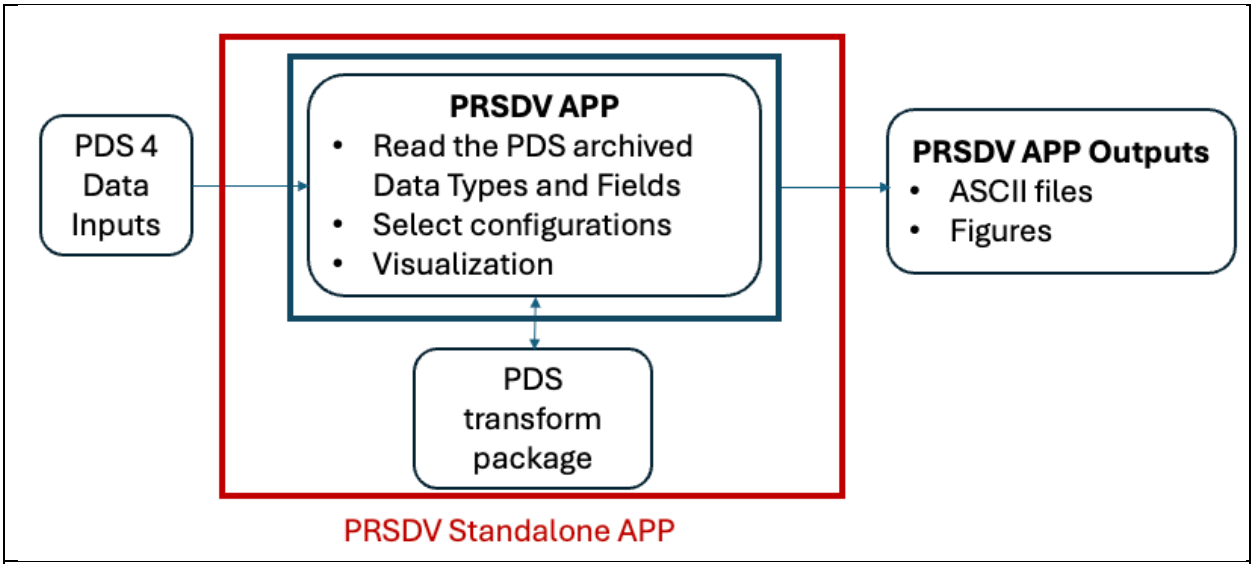

Figure 2-1 Block diagram of the PRSDV software

2.1 PDS4 data inputs

The PRSDV app is only compatible with the PDS4 format label (*.xml) and data files). Table 1 contains a list of PDS4-format Tracking and Navigation Files available at the time of this edition. More PDS4 datasets are expected to become available as they are migrated from the PDS3 format.

Table 1. Available PDS4 TNF datasets

Mission	Website
Dawn	https://sbnarchive.psi.edu/pds4/dawn/gravity/dawn-rss-raw-ceres/data-tnf/2018/
InSight	https://pds-geosciences.wustl.edu/insight/urn-nasa-pds-insight_rise_raw/data_tnf/
Juno	https://atmos.nmsu.edu/PDS/data/jnogrv_1001/DATA/TNF/
Lucy	https://pdssbn.astro.umd.edu/holdings/pds4-lucy.rss-v1.0/data_dinkinesh_trk234/
MAVEN	https://pds-ppi.igpp.ucla.edu/collection/urn:nasa:pds:maven.rose.raw:data.tnf
Messenger	https://pds-ppi.igpp.ucla.edu/data/mess-rs-raw/data-tnf/
OSIRIS-REx	https://sbnarchive.psi.edu/pds4/orex/orex.radioscience/trk234_trknav/

2.2 Configuration Selection

Once users load a PDS file (.xml) via the Browse icon, the app will list all the data types in the dropdown box Available Data Types. Users can click to select the data type for visualization. Once users select the data type, the app will fill the Description and Records fields as well as the Available Fields dropdown menu in the Select Data Fields panel. Once the data field is selected, the app will populate the corresponding Configuration Selection in the GUI automatically

(shown in **Figure 2-2**). The current version supports the visualization of TRK-2-34 Data Type 1 – Downlink Carrier Phase, Data Type 9 – Ramp, and Data Type 16 – Carrier Observables. See Tables 2, 3, and 4, respectively, for listings of the available data fields and filtering options for each of these data types. **Figures 2-3, 2-4,** and **2-5** illustrate examples of the three selected data types for the Juno Gravity Science PDS data archive.

Table 2. Data fields and available filters for Data Type 1, Downlink Carrier Phase

Data Type1				
Downlink Carrier Phase				
Data Field Abbreviation	Item Name and Description	Unit : Precision	Filter Abbreviations	Filter Descriptions
pcn0	Pc/N0 Carrier Power to Noise Spectral Density Ratio.	dB-Hz : 0.1 dB-Hz Has a value of -300.0 if no signal or carrier is suppressed.	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink frequency band
			dl_chan_num)	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
system_noise_temp	System Noise Temperature	K (degrees Kelvin) : 0.1 K	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink frequency band
			dl_chan_num	Downlink Channel Number
			carr_lock_stat	Carrier lock status
			snt_flag	SNT measurement flag
dl_freq	Downlink Frequency	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink Frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
dop_resid	Doppler Residual	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
dop_noise	Doppler Noise (Averaged over 10 points in record)	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
prdx_freq_offset	Predicts Frequency Offset (Hz	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			dl_band	Downlink frequency band
			dl_chan_num	Downlink Channel Number

	added to predicted value)		prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status

Table 3. Data fields and available filters for Data Type 9, Ramps

Data Type 9				
Ramps				
Data Field Abbreviation	Item Name and Description	Unit : Precision	Filter Abbreviations	Filter Description
Ramp_freq	Ramp Frequency	Hz. Precision varies with band. A value of 0.0 indicates an invalid or unknown value.	ul_band	Uplink frequency band
			ul_dss_id	Uplink antenna number
Ramp_rate	Ramp Rate	Hz/sec : μHz/sec	ul_band	Uplink frequency band
			ul_dss_id	Uplink antenna number.

Table 4. Data fields and available filters for Data Type 16, Carrier Frequency Observable

Data Type 16				
Carrier Frequency Observable				
Data Field Abbreviation	Item Name and Description	Unit : Precision	Filter Abbreviations	Filter Description
Dop_noise	Doppler Noise.	Hz : 1 mHz Invalid indicated by value of -1.0	dl_dss_id	Downlink Antenna Number
			vld_dl_band	Validated downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
Rcv_sig_lvl	Received Signal Level. Carrier power or data power (if suppressed carrier tracking).	dBm : 0.1 dBm --300 indicates invalid	dl_dss_id	Downlink Antenna Number
			vld_dl_band	Validated downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
Rcv_carr_obs	Received Carrier Observable (aka sky frequency)	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			vld_dl_band	Validated downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.

			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status
Carr_prefit_resid	Received carrier pre-fit residual (aka pseudo-residual). Observed minus predicted	Hz : 1 mHz	dl_dss_id	Downlink Antenna Number
			vld_dl_band	Validated downlink frequency band
			dl_chan_num	Downlink Channel Number
			prdx_mode	Predicts mode.
			ul_prdx_stn	Uplink station used for predicts.
			ul_band_dl	Uplink band assumed by downlink.
			carr_lock_stat	Carrier lock status

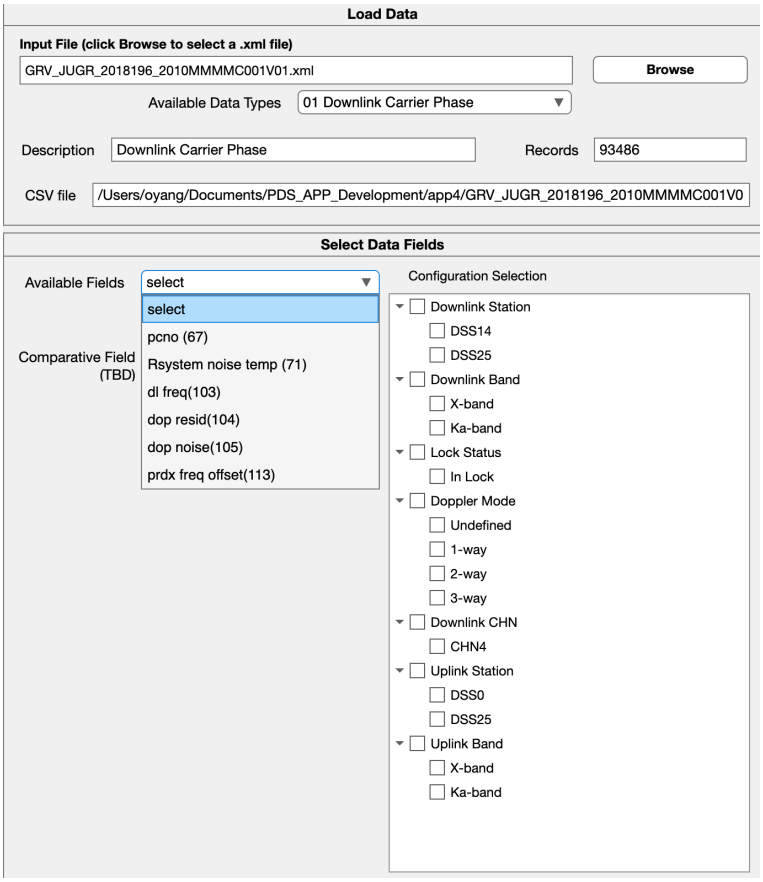

Figure 2-2 Select and load a PDS file (.xml). The bottom panel shows the Data Type 1 available fields for the Juno Gravity Science PDS TRK-2-34 data archive.

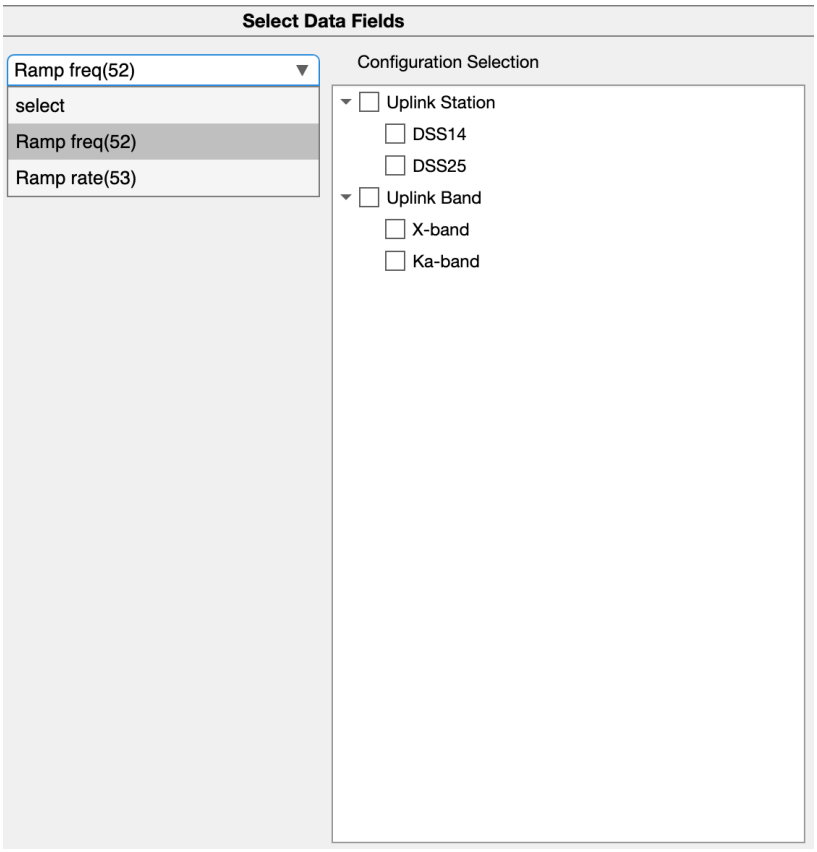

Figure 2-3 Data Type 9 (Ramps) for the Juno Gravity Science PDS TRK-2-34 data archive.

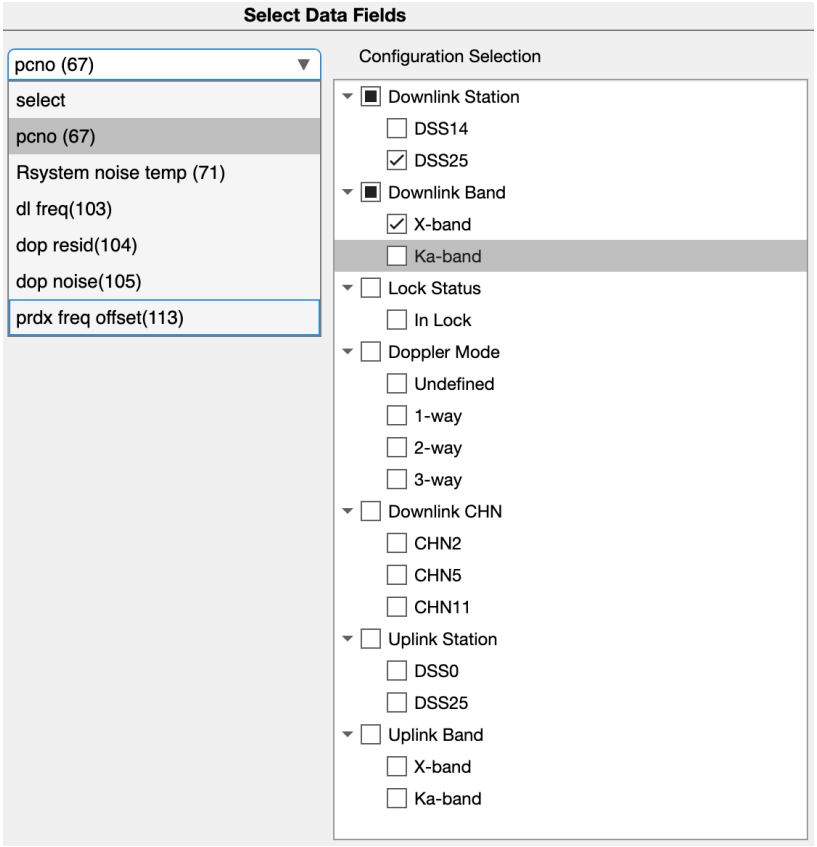

Figure 2-4 Data Type 16 (Carrier Observables) for the Juno Gravity Science PDS TRK-2-34 data archive.

2.3 Data Field Filtering

Users can check options in the configuration list to visualize the selected data points. The selected configuration data points (S) are defined as:

$$S = \bigcup_{i=1}^{n} A_i,$$

where $A_i = \bigcap_{k=1}^{m} B_k$ and B_k $(k = 1, \ldots, m)$ are the selected subsets of each configuration option (A_i $(i = 1, \ldots, n)$) such as downlink station, downlink band, and uplink station shown in **Figure 2-4**. For example, users can filter out data points for the downlink station DSS-25 and downlink band X by checking the corresponding boxes in the configuration list (**Figure 2-4**). Once users check the configuration options for data visualization, they can click the Select icon to execute the filtering function (the indicator light will turn from red to the green). All subset data points will be selected if users don't check any subset boxes. For example: if users only check the downlink station DSS-14, the filtering function will pick up all the downlink station DSS-14 data points with configuration options for all uplink stations, all Doppler modes, and all uplink/downlink bands. See Table 5 for a listing of the available values for the data filtering fields in data types 1, 9, and 16.

Table 5. Data Filtering Key

Filter Abbreviation	Filter Description	Values
carr_lock_stat	Carrier lock status	0 => Off 1 => Open (only using predicts) 2 => Acquiring, FFT Search 3 => Acquiring, Waiting for Lock Decision 4 => In Lock 5 => Out of Lock
dl_band	Downlink frequency band	Downlink frequency band. 0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band (Deep Space) 4 => K-band (Near Earth) 5 => L-band
dl_chan_num	Downlink Channel Number	1 to 24
dl_dss_id	Downlink Antenna Number	0 to 255
prdx_mode	Predicts mode. Predicts subset used by downlink channel.	0 => No Predicts 1 => One-way 2 => Two-way 3 => Three-way
snt_flag	SNT measurement flag	0 => SNT value is the predicted value 1 => SNT value is the measured value
ul_band	Uplink frequency band	0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band (Deep Space) 4 => K-band (Near Earth) 5 => L-band
ul_band_dl	Uplink band assumed by downlink.	0 => Unknown or not applicable 1 => S-band 2 => X-band 3 => Ka-band (Deep Space) 4 => K-band (Near Earth) 5 => L-band
ul_dss_id	Uplink antenna number	0 to 255
ul_prdx_stn	Uplink station used for predicts. Valid only if prdx_mode is 2 or 3.	0 to 255 A value of 0 means that the number is unknown or not valid (e.g., no uplink).
vld_dl_band	Validated downlink frequency band	0 => Unknown 1 => S-band 2 => X-band 3 => Ka-band (Deep Space) 4 => K-band (Near Earth) 5 => L-band 6 => S or X band (26m stations)

2.4 Visualization Functions

Once users the select the configuration, they can click the Plot button to visualize the data points. The app will automatically generate the plot title, data units, and axis legend corresponding to the selected data field and configurations. The entries for the title, axes, and units are pulled directly from those in the *.xml label. Users can also manually update the plot title and legends via typing the title and legends in the Manual Legend Update and clicking the Update Legend button (**Figure 2-5**).

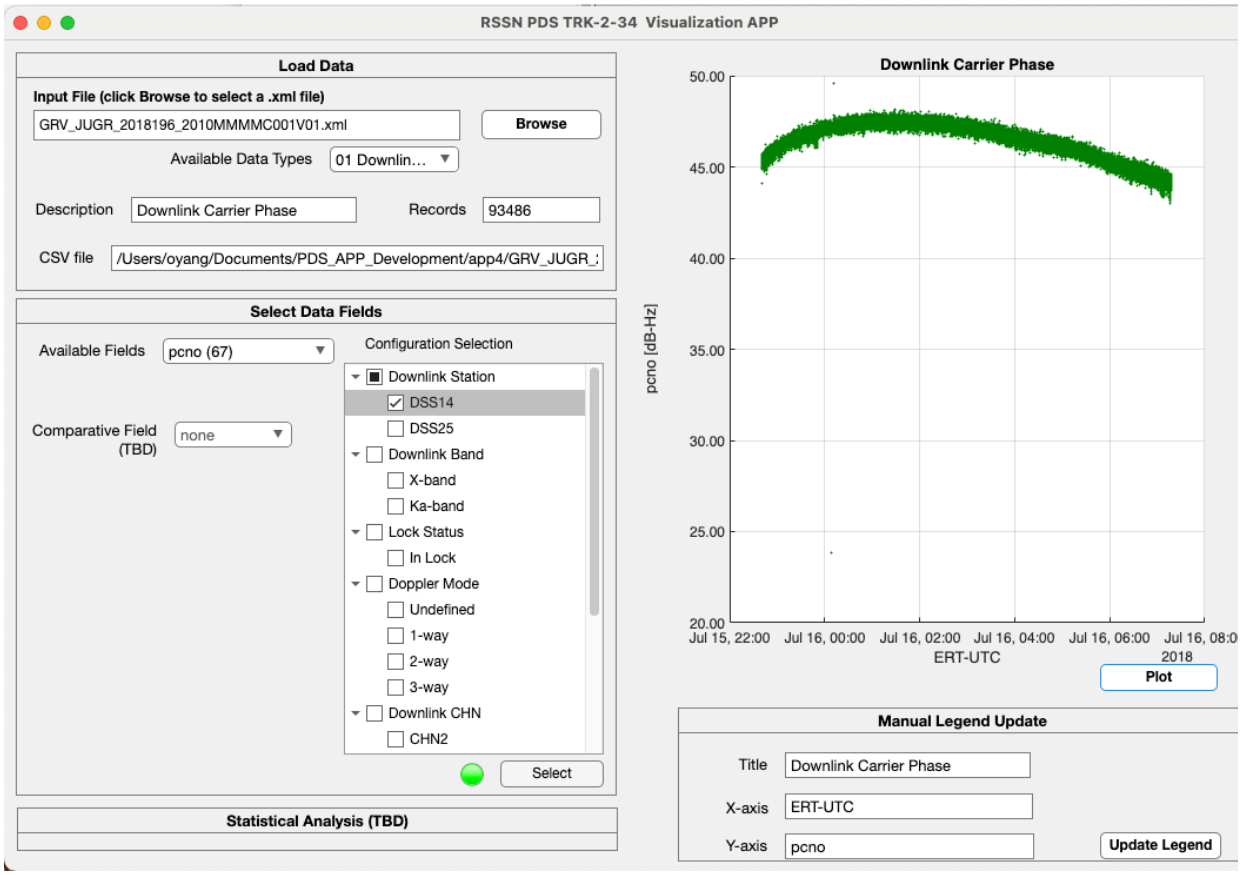

Figure 2-5 PRSDV APP Graphic User Interface panel.