

PDS4 Hayabusa NIRS Archive Overview

(urn:nasa:pds:hay.nirs)

February 2nd, 2022

Kristina Lopez, PDS Small Bodies Node, Asteroid/Dust Subnode

1. Introduction

Hayabusa was a JAXA mission to the near-Earth asteroid 25143 Itokawa. It was launched on May 9th 2003 and returned to Earth on June 13th 2010. During the mission the Hayabusa Near-Infrared Spectrometer (NIRS) returned 117,937 spectra, including over 80,000 of the asteroid Itokawa. This data set contains the raw and calibrated NIRS spectra from the entire mission.

In addition to the NIRS instrument the other Hayabusa instruments AMICA and LIDAR have also been archived in PDS, as well as higher level data. See the PDS4 Hayabusa Archive Overview in the Hayabusa Mission Information bundle (urn:nasa:pds:hay.mission) for details.

2. Archive Contents and History

In 2010, the Hayabusa NIRS instrument data were archived in PDS in the PDS3 archiving standard.

Table 1. PDS3 Hayabusa NIRS data sets included in this bundle

Data Description	PDS3 Data Set ID	Date archived	PDS node
NIRSRAW	HAY-A-NIRS-2-NIRSRAW-V1.0	2010-06-07	SBN
NIRSCAL	HAY-A-NIRS-3-NIRSCAL-V1.0	2011-03-21	SBN

During 2021-2022, the PDS3 Hayabusa NIRS holdings were migrated to the PDS4 archiving standard by the Small Bodies Node, using the On-Line Archiving Facility (OLAF) and the OLAF PDS4 migration tools. The data files are unchanged. This bundle contains both the Hayabusa NIRS raw data set as well as the Hayabusa NIRS calibrated data set, which were previously two separate PDS3 bundles.

Document and metadata changes made during the migration of the bundle include:

- No primary data files were modified.
- The PDS3 keyword HAY:STACK_COUNT was mapped into the new product labels as Spectral_Characteristics:Observation_Parameters:number_of_exposures
- Contents of PDS3 data/calib/ directory were moved to the new calibration_tables collection

- The PDS3 `cal_alignment` and `cal_detector` directories were moved from their original location in the `data_raw` collection into the new directory `calibration_obs`
- Mission description and spacecraft description documents have been included in the PDS4 Hayabusa Mission bundle and are not included in the NIRS bundle.
- Documentation was in some cases rearranged and updated to meet the needs of the PDS4 bundle.
- A new bundle overview (this document) was created to describe the NIRS bundle, incorporating information from the PDS3 data set catalog files and other documents.

3. Hayabusa NIRS Bundle Contents

The Hayabusa NIRS bundle contains a `data_raw` collection, a `data_calibrated` collection, a `calibration` collection, and a `document` collection:

The **`data_raw`** collection contains the raw NIRS spectra from the entire mission. The targets include the asteroid 25143 Itokawa as well as Earth, Moon, Mars, Jupiter, Saturn, stars. (See section 4).

The **`data_calibrated`** collection includes the calibrated spectra of asteroid 25143 Itokawa returned by the Near-Infrared Spectrometer (NIRS) instrument of the Hayabusa mission (See section 5).

The **`calibration`** collection contains the `.fits` calibration files and the the ASCII table files for the NIRS calibration procedure (See section 7).

The **`document`** collection contains the NIRS bundle overview (The document you are reading now), the LIDAR references document, the LIDAR instrument description and `nirscalpaper.pdf` which describes the calibration of the NIRS instrument. (See section 8).

4. The NIRS Raw Data

4.1 Data file types and contents

The NIRS `data_raw` collection contains eight directories. The data are organized into directories by target (**`earth`**, **`itokawa_ap`**, **`itokawa_gp`**, **`itokawa_hp`**, **`itokawa_td`**, **`jupiter`**, **`mars`**, **`moon`**, **`saturn`**), with the Itokawa data split into four directories by mission phase (Approach, Gatepoint, Home Position, and Touchdown). This data set includes the 117,937 raw spectra returned by the Near-Infrared Spectrometer (NIRS) of the Hayabusa mission.

NIRS data are taken by stacking a number of sequential sets of light and dark frames at a single spectral measurement. Dark subtraction and data averaging are carried out with the on-board software, and only the dark-subtracted average, standard deviation, minimum, and maximum values for each channel are returned via telemetry. These are included in the FITS spectral tables as four separate columns within a single FITS file.

4.2 NIRS data_raw Calibration Information

The NIRS calibration procedure uses the ASCII table files (*nirs_vol2rad_pls.tab* for point light source and *nirs_vol2rad_als.tab* for area light source) to convert from raw NIRS output (Voltage) to radiance and the file *nirs_solar_spc.tab* to convert to I/F. These files are located in the *hay.nirs:calibration_tables* directory.

For additional information about the NIRS raw data, see Abe et al. (2006) and Kitazato et al. (2008).

4.3 Confidence Level Overview

Because Itokawa has a very irregular shape, the NIRS spectral data were acquired under widely varying viewing geometries and lighting conditions. Before comparison with one another, the observed spectra must be photometrically corrected to a common viewing geometry using an accurate photometric function. Otherwise, photometric effects such as phase reddening could be interpreted as spectral variations

5. The NIRS Data Calibrated

5.1 Data file types and contents

The *data_calibrated* collection contains one directory and one parameters file:

The **spectra** directory data are organized into directories by mission phase (Approach, Gatepoint, Home Position, and Touchdown) and sub directories are organized by date. This directory contains the calibrated spectra of Itokawa. The filenames follow the convention *nnnnnnnnnn_lv13_0.fit*, where *nnnnnnnnnn* is the spacecraft time of the image, and *lv13* indicates calibrated data with footprint information.

The **nirsparams.tab** is the parameters table file that lists geometry and illumination parameters for those NIRS spectra for which they are available.

5.2 NIRS data_calibrated calibration information

The NIRS calibration procedure uses the ASCII table files (*nirs_vol2rad_pls.tab* for point light source and *nirs_vol2rad_als.tab* for area light source) to convert from raw NIRS

output (Voltage) to radiance and the file *nirs_solar_spc.tab* to convert to I/F. These files are located in the *hay.nirs:calibration_tables* directory.

For further information about the NIRS instrument and its calibration, see Abe et al. (Unpublished). For a complete description of the processing of the calibrated spectra, see Kitazato et al. (2008).

5.3 Confidence Level Overview

The highest quality spectra in this data set are those taken during the Gate Position phase of September 12-29, 2005, in which the accuracy of the NIRS footprint estimate is relatively high.

6. Calibration collection

The calibration_tables collection contains two data collections:

The subdirectory **conversion tables** contains the ASCII table files (nirs_vol2rad_pls.tab for point light source and nirs_vol2rad_als.tab for area light source) were used to convert from raw NIRS output (Voltage) to radiance and the file nirs_solar_spc.tab to convert to I/F.

Within the **in_flight** subdirectory there are two collections cal_alignment, and cal_detector. The filenames follow the convention nnnnnnnnnn_lv1_0.fit, where nnnnnnnnnn is the spacecraft time of the image, and lv1 indicates raw (level-1) data. The files contain the Hayabusa NIRS raw spectrum files which provide The four columns of the table give the average, standard deviation, maximum, and minimum over the stacked spectra.

7. The Hayabusa NIRS Document Collection

The document collection contains four documents:

The document you are reading now, the **NIRS_Bundle_Overview.pdf** describes the contents of the hay.nirs bundle.

The **NIRS_Instrument_Description.txt** describes the NIRS instrument.

The **NIRS_References.txt** lists all the references for the Hayabusa NIRS bundle.

The **nirscalpaper.pdf** is the unpublished paper, entitled 'Instrument calibration of the Hayabusa near-infrared spectrometer' and authored by Masanao Abe, Yasuhiko Takagi, Shinsuke Abe, and Kohei Kitazato, which was provided to the PDS on March 18, 2010.

8. References

Abe, M., Y. Takagi, K. Kitazato, S. Abe, T. Hiroi, F. Vilas, B.E. Clark, P.A. Abell, S.M. Lederer, K.S. Jarvis, T. Nimura, Y. Ueda, and A. Fujiwara, Near-infrared spectral results of asteroid Itokawa from the Hayabusa spacecraft, Science 312, 1334-1338, 2006.

Kitazato, K., B.E. Clark, M. Abe, S. Abe, Y. Takagi, T. Hiroi, O.S. Barnouin-Jha, P.A. Abell, S.M. Lederer, and F. Vilas, Near-infrared spectrophotometry of asteroid 25143 Itokawa from NIRS on the Hayabusa spacecraft, *Icarus* 194, 137-145, 2008.

Abe, M., Y. Takagi, S. Abe, and K. Kitazato, Instrument calibration of the Hayabusa near-infrared spectrometer, Unpublished. (Included in the document directory of this data set.)