Data Introduction: New Horizons Spacecraft, LEISA Instrument

This is an abbreviated guide to the main elements of this NH LEISA PDS data set to provide an overview and a quick path to viewing the data. Many details and subtleties regarding these data have been excluded here for the sake of brevity and clarity; those who plan to perform scientific analysis on these data must read the documentation referenced by or provided in this data set.

Science Goals

1) <10 km/pixel hemispheric near-infrared spectral maps; 2) <10 km/pixel hemispheric distributions of N2, CO, and CH4; 3) Surface temperature mapping; 4) Phase-angle-dependent spectral maps.

Instrument

The Linear Etalon Imaging Spectral Array (LEISA), part of the RALPH instrument package, is a wedged etalon infra-red spectral imager that operates in a push-broom mode. The columns are spatial and the rows are spectral-spatial; each row of detector pixels receives light of only a particular wavelength.

LEISA has two bonded segments. The first segment, with high spectral resolution ($\lambda/d\lambda = 560$), covers a range from 2100 to 2250 nm. The second segment, with a lower spectral resolution ($\lambda/d\lambda = 240$), covers a wider range, from 1250 to 2500 nm. Though overlapping spectrally, the two segments are separate and adjacent spatially. The number of pixel-limited spectral channels is the number of rows of the detector, excluding a number of rows (4) obscured by opaque adhesive at the bond joint between the two filter segments.

Operations

LEISA forms a spectral map by sweeping the instrument FOV across a scene, sequentially sampling each point in the scene at each wavelength. Wavelengths vary along the scan direction. The frame rate is synchronized to the rate of the scan, and the entire frame is read each time the image moves by the single pixel IFOV (Instrument Field-Of-View). The geometry is similar to the method of the MVIC Time Delay and Integration (TDI) detectors, except the entire LEISA detector is read out each IFOV of movement so there is no integration across multiple lines as in TDI. LEISA is essentially 256 line arrays generating 256 line images at 256 different wavelengths.

Windowing

LEISA also uses two kinds of windowing: fixed windows and sliding windows. Fixed windows are in the same location and have the same size in every frame. Sliding windows have the same size in each frame, but their location moves across the 256x256 detector between frames. After March, 2016, the DOCUMENT/ directory of each LEISA data set contains a LEISA_WINDOW_<missionphase> table defining the location and extent of all windows (fixed and sliding) in each frame of LEISA data.

Directory- and file-names: YYYYMMDD_METMET/lsb_metmetmetm_0xaaa_ttt.sfx

The data are all stored as file pairs of one detached PDS label and one FITS file per exposure. The directory and file names are delimited by underscores and slashes as demonstrated above: ***YYYYMMDD*** is year, month and day-of-month; ***METMET*** is the first six digits of the ten-digit MET clock (Mission Elapsed Time; ~spacecraft seconds since launch); ***lsb*** is the prefix for LEISA SuBtracted data; ***metmetmetm*** is the full ten-digit MET of the image; ***0xaaa*** is the Application (Process) Identifier (ApID) for the telemetry data packet type; ***ttt*** is either ***eng*** or ***sci*** for EDR (Engineering Data Record) or RDR (Reduced Data Record) data, respectively; ***sfx*** is ***fit*** or ***lbl*** for the FITS or PDS label file, respectively.

Searching for data

There is a brief summary of the types of observations in the data set catalog (***catalog/dataset.cat)***. There is also a table of the sequences in the data set documentation (***document/seq_leisa_...)***. Each row in that table provides 1) a sequence ID that matches NEW_HORIZONS:SEQUENCE_ID keywords in data product PDS labels, 2) a time, in UTC & SCLK, just before all observations of that sequence, 3) a brief prose description of the observations. Refer to the sequence table label (***document/seq_leisa_*.lbl)*** for more detail.

Data file contents

Each EDR (raw) product comprises two data objects in the FITS file, described by its detached PDS label. The first data object (PDU; Primary Data Unit) is the raw image, with the 12-bit data stored in 16-bit integers. Each PDU image is 256 pixels wide by 256 pixel high, with N bands or planes (BANDS in the PDS label; NAXIS3 in the FITS header) holding spectral data, where N is the number of data frames in the observation. The second data object

contains RALPH housekeeping information as a 115 by S binary table, where S is roughly the observation duration in seconds.

Each RDR (calibrated) product comprises nine data objects in the FITS file, described by its PDS label. The first data object (PDU) is the radiometrically calibrated image with data stored in 32-bit floating point format. The PDU image is 256 pixels wide by 256 pixel high, with a variable number of bands (NAXIS3; BANDS) holding data in radiance units of ergs/sec/cm**2/angstrom/sr for extended sources or ergs/sec/cm**2/angstrom for point sources.

The rest of the file comprises six image (256x256) or image cube (256x256xN) maps of varying depths (N) and data types, one object of 5 per-frame properties (5xN), and one object that is a duplicate of the housekeeping data from the EDR product. Each value in each 256x256 plane of the maps applies to the corresponding pixels in each 256x256 plane of the PDU image. EDU 1 (Extension Data Unit) is a center wavelength and filter width (256x256x2 32-bit floating point). EDU 2 is a cartesian coordinate pointing vector in the LEISA SPICE reference frame (256x256x3, 64-bit floating point). EDU 3 is a flat field correction map (256x256 32-bit floating point). EDU 4 provides the radiometric gains and offsets (256x256x2 32-bit floating point). EDU 5 provides estimates of error (256x256xN 32-bit floating point). EDU 6 provides data quality control flags (256x256xN 16-bit integer), where each integer bit represents a pixel property (bad pixel, defect in calibration file, etc.) and an integer value of zero indicates a good pixel. EDU 7 contains ephemeris time and quaternion for each frame (5xN 64-bit floating point). EDU 8 is the RALPH housekeeping data from the EDR product (115xS 8-bit bytes).

N.B. Refer to the ICD (SOC to Instrument Interface Control Document) for more detail e.g. unit conversion, data quality bit definitions, etc.

Calibration

Image calibration comprises six processing steps: digital image validation; raw mode data preprocessing; A/D rollover pixel processing; conversion to radiometrically calibrated image radiance or irradiance values; pointing data computation; construction of the FITS file. Refer to the ICD for more detail.

Reading the data

Various tools are available to read these data. In the IDL environment, the READPDS.PRO package from PDS-SBN can read the data using the PDS label to access the accompanying FITS file. To use the FITS file directly, the NASA FITS Office has utilities and libraries in multiple languages and environments (from C to R and beyond). Refer to the documentation provided and referenced at those web sites for support.

N.B. Some utilities and libraries refer to the PDU as if it were EDU 0.