DESIS: Frequently Asked Questions

Sensor Information

1. What is DESIS?

The DLR Earth Sensing Imaging Spectrometer (DESIS) is a pushbroom hyperspectral sensor currently operating in the Multi-User System for Earth Sensing (MUSES) platform on the International Space Station (ISS). DESIS was developed and built by DLR and is operated commercially by Teledyne Brown Engineering. DESIS was launched on June 29, 2018, and achieved initial operating capability on November 21, 2018. DESIS data is available for ordering and purchase via the TCloud web interface (https://teledyne.tcloudhost.com).

2. What are the spectral bands and sampling?

The DESIS hyperspectral sensor operates in the 402 – 1000 nm spectral range. At full resolution, DESIS has 235 bands with 2.55 nm sampling with a nominal full-width at half maximum (FWHM) of 3.5 nm. DESIS data may also be binned to 5.1 nm sampling (118 bands, FHWM ~ 5 nm), or to 10.2 nm sampling (60 bands, FWHM ~10.0 nm). Initially, only the binned 10.2 nm data will be available for ordering.

3. What is the DESIS ground sample distance?

DESIS acquires data with a 30-m ground sample distance at the nominal ISS orbital altitude of 405 km.

4. How big is a DESIS image?

DESIS imagery is typically acquired in long strips of varying length, and then broken into tiles. Each tile is 1024 x 1024 pixels, or approximately 30 km x 30 km in size.

Acquisition Information

5. How far off angle can DESIS point?

DESIS across-track pointing is controlled by the MUSES platform, and ranges from -45° to 5°. In the along-track direction, MUSES allows for pointing up to ±25°. To enable stereo and BRDF acquisitions, the DESIS sensor also allows for along track pointing up to ±15°, independent of MUSES.

6. What are the DESIS acquisition modes?

DESIS can be acquired data in two different modes. Image strip mode acquires one or more tiles. In image stereo mode, up to three images of the same ground target area are acquired in a single orbital pass for stereo or BRDF (bi-directional reflectance distribution function) evaluations.

7. What size area can be acquired?

Standard images are 30km by 30km, but longer strips may be acquired pending ISS operations.

8. How does the ISS orbit affect DESIS acquisitions?

Rather than having a polar orbit with a standard equatorial crossing time, the shallower orbit of the ISS (51.6°) leads to more variability in image acquisition. DESIS can acquire data during either the Ascending or Descending side of the orbit. Data acquisitions can occur over a larger time period during the day, leading to a bigger range of solar zenith angles during acquisition. However, due to the ISS orbit, DESIS cannot acquire data further north than 55° N or further south than 52° S. The orbital altitude of the ISS also varies approximately ±5 km from the nominal 405 km.

9. What is the average revisit time?

The average revisit time differs by latitude and solar/sensor zenith angle restrictions. In general, at higher latitudes (North or South), there may be many grouped opportunities with large breaks in between. At the middle latitudes, the revisit opportunities will be more evenly spaced but less frequent. For example, at 30° latitude, with sensor zenith angles up to 25°, the average revisit time is 10 days, while at 15° latitude, with sensor zenith angles up to 25°, the average revisit time is 12 days.

Product/Delivery Information

10. What are the available products?

Initially, only L1B (top-of-atmosphere radiance) and L1C (orthorectified radiance) products will be available for ordering. These data sets will be spectrally binned to ~10.2 nm spectral resolution with 10 nm bandwidth.

L2A (surface reflectance) is expected to be made available during Q2 2019. Additionally, higher spectral resolution data (2.55 nm and 5.1 nm spectral resolution) is expected to be made available after Department of Commerce approval.

11. What information is included with each data product?

Each hyperspectral image is provided with a metadata file, a quick look (RGB) file, and a quality file, which provides quality information about every pixel in each band in the spectral image.

12. What is included in the metadata file?

The metadata file includes important information about the sensor, acquisition and processing. Image corner coordinates, acquisition times and sun and sensor geometry at the time of acquisition are provided. Center wavelengths, spectral band information, and scale factors (gains and offsets) are provided for each band. Information relating to the image orthorectification is also included for L1C and higher products.

13. How are the data products provided (file types)?

Spectral image data is provided in 16-bit tif format. Quality information is provided for each spectral band in a separate 8-bit tif file. A quick-look image (3 bands, RGB) is also provided as an 8-bit tif file. Image metadata is provided in xml format.

14. What is the file naming convention?

Filenames are as follows:

DESIS-HSI-L<XX>-DT<nnnnnnnnnn>_<fff>-<yyyymmdd>T<hhmmss>-V<vvvv>-<file type>.<ext>

Where,

<XX> is the product level (1B, 1C or 2A)
<nnnnnnnnnn> is a unique identifier from the planning system
<fff> is the tile number of the image strip
<yyyymmdd> is the date in year, month, day format
<hhmmss> is the time in UTC (hour, minute, second)
<vvvv> is the image processor version number
<file type> is the type of file (SPECTRAL_IMAGE, QL_QUALITY, QL_IMAGE, or METADATA)
<ext> is the file extension (tif or xml)

15. How do I view the data?

Spectral image and quality data sets may be viewed in image processing software packages, including ENVI (Harris Geospatial). The data may also be imported and displayed in programming packages such as MATLAB.

The quick look image may be viewed in the above software or using standard photo viewing software including Windows Photo Viewer.

16. How are the data products delivered?

After ordering and processing via TCloud (https://teledyne.tcloudhost.com), each requested image tile is compressed into a zip file (along with the metadata, quality image and quick look files) and stored in an S3 bucket on Amazon Web Services. End users will receive an email with a link and instructions to download the data sets.

17. What are the data restrictions?

Data are currently restricted by NOAA to 10nm spectral resolution. Teledyne is working to get waivers for higher resolution data. End users will need to be screened against denied party lists.

Image Information

18. How do I convert the data to radiance or reflectance?

Data is converted from scaled image digital number (DN) to radiance or reflectance using the gains and offsets provided for each band in the METADATA.xml file that accompanies each image file (gainOfBand and offsetOfBand, respectively). These gains and offsets are specific to each image. Gains and offsets are applied pixel by pixel to the image data to calculate radiance (or reflectance) as follows:

$$L_{i,j,B} = G_B * DN_{i,j,B} + O_B$$

Where, L_B = Radiance (or reflectance) for pixel *i,j* per band, *B*
G = Gain per band, *B*
D_B = DN for pixel *i,j* per band, *B*
O_B = Offset per band, *B*

19. Are there any sensor artifacts?

DESIS has a known spectral smile, but the effect is small and it is corrected during radiometric processing. Keystone correction is not required for the sensor since the effect is far less than one pixel.

Other potential sensor artifacts, including noise, striping and fringing, are currently being corrected by the DLR.

20. How are defect pixels handled?

Defect or suspicious (radiance too high or low) pixels are identified on a per band basis in the quality file that accompanies each image.

Several spectral channels are affected by a manufacturing defect in the data acquired on the edge of the focal plane. Spectral bands affected by this manufacturing defect are the shorter wavelength bands (full resolution Bands 1 – 7; binned 10.2 nm Bands 1 – 2) and the last band (full resolution Band 235; binned 10.2 nm Band 60). These pixels are also identified in the quality image.

21. How is the quality image used?

A quality image is provided with each DESIS tile. Quality data is 8-bit, with one layer per DESIS band.

22. What is the geopositional accuracy of the data?

For L1C or L2A processing, the geometric accuracy of DESIS is ~20 m with ground control points (GCP) (with respected to global reference Landsat ETM+ Pan GSD 14m). Without GCPs, the geometric accuracy is ~300 – 400 m (water collects).

23. What is the SNR of the data at different radiance values?

The signal-to-noise ratio (SNR) of DESIS, define for 0.3 albedo at 550-nm is 195 (full-resolution) and 386 (10.2 nm binned). These values are based on the on-ground calibration of the sensor.

24. Is there a cloud cover percentage calculated for each tile?

Cloud cover is estimated for each tile during QA/QC when the tile is ingested into TCloud—Teledyne Cloud. This cloud cover value can be used to filter data sets within TCloud. Additionally, a more refined estimate of cloud cover is produced during L2A processing, and is included in the metadata delivered with that product.

25. What DEM is used to process L2A?

The Aster Global Digital Elevation Model (GDEM) version 2 is the default DEM used when generating L2A surface reflectance products.

26. Are there any acquisition constraints?

If a L2A product is being requested, there are some solar zenith angle restrictions:

SZA > 55° produces reduced quality L2A product
SZA > 65° produces low quality L2A product
SZA > 70° not processible to L2A