MRD 544- Rotationally resolved thermal inertia

Data Product Overview

Executive Descripton

The rotationally resolved thermal inertia product will be a list of whole-disk thermal inertia values of Bennu linked to the rotational phase, analogous to the thermal inertia values derived from Spitzer data.

Overview

Rotationally resolved thermal inertias will be produced and stored as a data table that lists rotational phase and the whole disk thermal inertia derived for that rotational phase. The file will include input parameters (e.g., info on the asteroid shape and Bond albedo) as well as derived intermediate products (e.g., estimate of RMS surface roughness).

The product measures the average thermal inertia of the hemisphere facing the spacecraft during the observation, as a function of rotational phase. Thermal inertia is a measure of the response of the surface to changes in temperature.

Rotationally resolved thermal inertias will be derived from full disk observations during Approach Phase. The primary observations required are OTES thermal flux observations covering an entire rotation of Bennu. These observations are currently scheduled in the DRM when the spacecraft is at a range of 231 km with an OTES spot size of 1.848 km. There are currently 7940 OTES spectra scheduled to be taken at a frequency of 0.5 Hz over 4.3 hours, plus 100 space calibration observations before and after. Basic information on spacecraft and asteroid position is also required.

Supplemental information that will be included if available is any update to the shape, spin-state, or albedo of Bennu from approach observations. These are not critical, and if not available, the existing information from ground-based observations will be used.

The model currently in use takes ~1 hr to derive thermal inertia from a disk-integrated thermal flux spectrum, using the radar shape model (~2500 surface facets). If we fit every 1 degree of rotation, the total time would be 1hr x 360 = 360hr = 15 days. Part of the goal of algorithm development will be to make this process more efficient, perhaps utilizing look-up tables. Our estimates are that with look-up tables, the processing time could be cut to a few minutes per disk-integrated spectrum, so that the production time would be cut to 1 to 3 days.

Rotationally resolved thermal inertias are used for long term science and as inputs to temperature predictions for subsequent mission phases.

Data Product Structure and Organization

Rotationally resolved thermal inertias will most likely be stored as a table in an ascii file. There will be a single file, as this product only applies to the Approach Phase OTES observations.

Data Format Descriptions

Header data (metadata) to be included:

- Start/end time of OTES observations
- Version/calibration set of OTES observations
- Bennu position relative to the Sun (distance, ecliptic longitude and latitude)
- Bennu position relative to the spacecraft (distance, ecliptic longitude and latitude)
- Bennu rotational state (ecliptic coordinats of spin-pole, rotation period)
- Name/location of shape file used in model
- Name/version of thermal model used
- Average Bond albedo used for model, or name/location of Bond albedo map
- Bolometric emissivity used for model

Detailed Description of Data Format:

- Data type – ascii table
- Field 1: Rotational phase (0 to 1), floating point, precision of 1e-6
- Field 2: Thermal inertia (0 to 2500), floating point, precision of 0.1
- Field 3: Uncertainties for derived thermal inertias, precision of 0.1
- Field 4: RMS surface tilt (0 to 70), floating point, precision of 0.1

Note: If the spacecraft motion is such that the position of Bennu relative to the Sun or spacecraft changes significantly during the 4.3 hrs of OTES observations, then the positions will also have to be table entries (6 additional fields).

Data Product Generation

Rotationally resolved thermal inertias are generated from OTES observations using a thermal model. Basically, thermal inertia is varied in the model to match the measured disk-integrated flux at each rotational phase.

Required inputs and formats are:

- OTES disk-integrated spectral fluxes
  - 3 x n_wavelength array of wavelengths, fluxes, and flux uncertainties
- Shape of Bennu
  - vector-facet format of shape model
- Spin state of Bennu
  - 3 floating point values: rotation period and ecliptic coords of spin pole
- Bennu position relative to Sun
  - 3 floating point values: distance, ecliptic longitude and latitude relative to the Sun

- Bennu position relative to spacecraft
    - 3 floating point values: distance, ecliptic longitude and latitude relative to the Sun
- Average Bond albedo or Bond albedo map (from SAWG)
    - single floating point value, or file of albedo for each facet in the shape model

Co-I Emery has been assigned to this product

Multiple versions of the product are not anticipated. The exception would be the case that knowledge of important input parameters improves significantly. For example, if the original derivation uses the ground-based radar shape model and rotation state, but later spacecraft observations reveal significant errors in those values, a new version of rotationally resolved thermal intertias would likely be generated. As this would not impact sampling, it would be done on a best-effort basis, possibly just for long-term science.

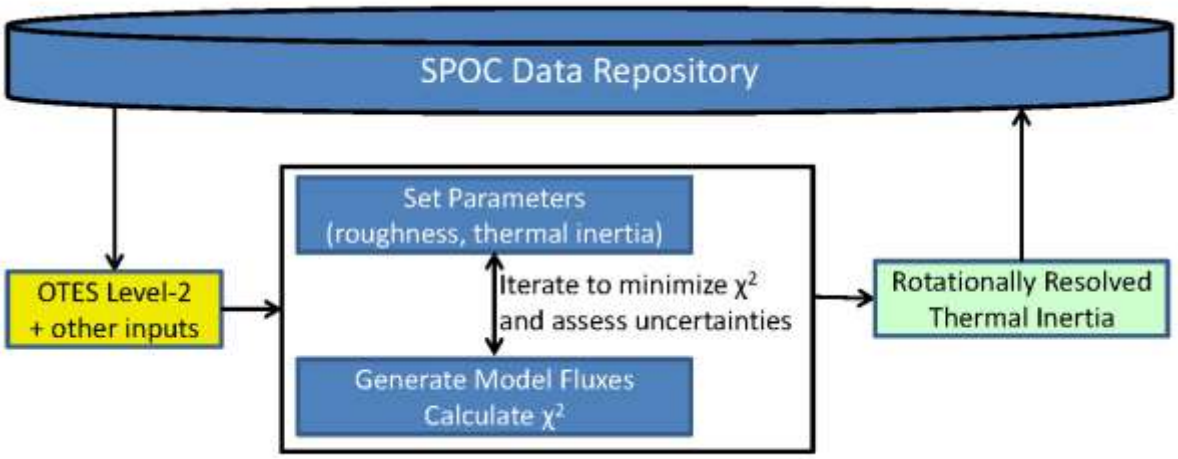
Data Product Validation

The file contents will be checked by eye to verify that the formats are correct and qualitatively make sense.

The approach phase results will be directly compared with thermal inertia estimates from the Spitzer Space Telescope.

Data Flow

Input data, including OTES flux spectra, will be read from the SPOC database. The thermal model will be run at each rotational phase to find the thermal inertia that best-fits the thermal flux spectrum at that location. The model will also determine confidence limits in order to establish uncertainties in the derived parameters.



Standards Used to Generate Data Product

- All time will be in UTC.
- Ecliptic coordinate system will be used for specifying Bennu's position relative to the Sun and spacecraft and for the orientation of the spin pole.
- Distance of Bennu from the Sun will be in Astronomical Units (AU).
- Distance of Bennu from the spacecraft will be in km.
- Rotational phase will be linked to mission-determined 0 deg longitude.

Data Product Storage

Final product will be stored as an ascii table.

The rotationally resolved thermal inertia product will be a list of whole-disk thermal inertia values of Bennu linked to the rotational phase, analogous to the thermal inertia values derived from Spitzer data.