Anticipated Data Products from the Europa Imaging System (EIS) on Europa Clipper

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1. Europa Clipper is a NASA mission to understand the of habitability Jupiter's moon and ocean world Europa [1]. The Europa Imaging System (EIS) accounts for two of the 10 science instruments . The spacecraft orbits Jupiter, making more than 40 close passes of Europa, so the viewing and illumination geometry varies widely, and data products are complex.

2. EIS Overview

EIS combines narrow- and wide-angle cameras (Fig. 1), each with framing and pushbroom imaging capability. EIS data will constrain formation processes of landforms by characterizing geologic structures, units, and global cross-cutting relationships [2], to:

- identify relationships to subsurface structures and potential near-surface water [*e.g.*, 3] detected by ice-penetrating radar [4]
- Search for evidence of recent or current activity, including potential erupting plumes [*e.g.*, 5-8]
- Constrain ice-shell thickness,
- Characterize surface clutter to aid interpretation of deep and shallow radar sounding [4],
- Characterize the nature of the surface at meter scales (Fig. 2)

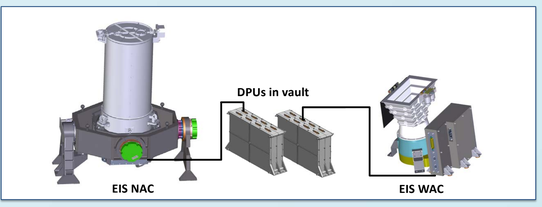

Fig. 1: (Left) NAC mounted on 2-axis gimbal, (right) WAC, and (middle) Digital Processing Units (DPUs) in spacecraft vault.

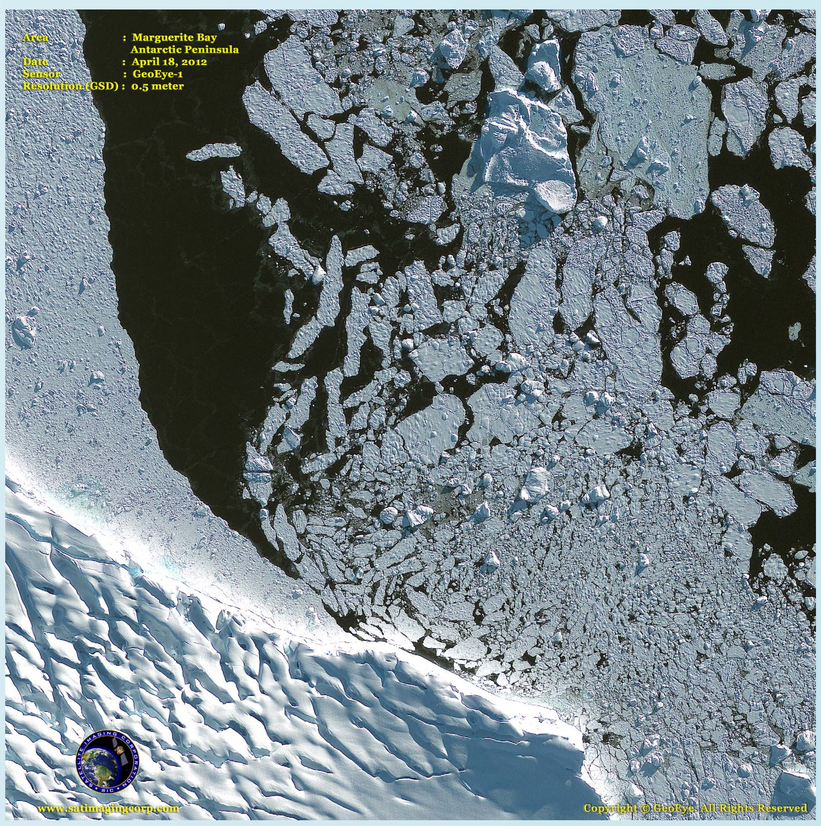

Fig. 2: Marguerite Bay, Antarctica at scales similar to EIS high-res imaging: GeoEye-1 image at 0.5 m/pixel
(http://www.satimagingcorp.com/gallery/geoeye-1/geoeye-1-antarctic-peninsula/)

3. EIS Narrow-Angle Camera (NAC)

- 2.3° cross-track x 1.2° along-track field of view (FOV) and 10-µrad instantaneous FOV (IFOV) achieves 0.5-m pixel scale over 2-km-wide swath at 50-km altitude.
- 2-axis ±30° gimbal for targeting independent of spacecraft orientation.

4. Wide-Angle Camera (WAC)

- 48° cross-track x 24° along-track FOV and 218-µrad IFOV achieve 11-m pixel scale over a 44-km-wide swath from 50-km altitude.
- Designed to acquire 3-line pushbroom stereo along flyby ground-tracks (Fig. 4), generating DTMs with 32-m spatial scale and 4-m vertical precision from 50-km altitude.

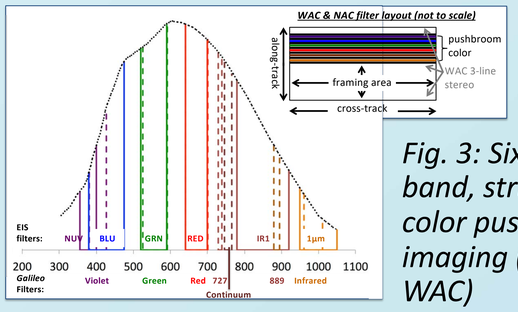

Fig. 3: Six, broad-band, stripe filters for color pushbroom imaging (NAC and WAC)

5. Detectors and Electronics

- Identical radiation-hard 4k x 2k CMOS detectors [9] with rapid readout for fast flybys and to minimize radiation-induced noise
- Framing and pushbroom imaging modes
- Both cameras have color stripe filters (Fig. 3) mounted in front of detectors
- APL radiation-hard data processing units (DPUs)

6. EIS Data products

EIS will produce a variety of data products for archival in the Planetary data System (PDS). These include:

1. Uncompressed raw images
2. Radiometrically calibrated, geometrically corrected, and map-projected images
3. A variety of mosaics, described in box 8.
4. Digital Terrain Models (DTMs) derived from stereo pair or triplets (Fig. 4)
5. Joint products with other Europa Clipper instruments
6. Specialized data products such as geologic maps; color, and photometric data products; a database of plume-search observations; global shape models derived from limb fits; and a geodetic control network tied to radar altimetry.
7. Reduced scale jpeg versions of all image products, linked in a catalog to easily find the desired products.

7. WAC Pushbroom Image Segmentation

The WAC will acquire continuous image swaths ranging in scale from 5 to 500 m/pixel. If the entire swath is map-projected at uniform scale, then the low-resolution data is greatly oversampled and/or the high-resolution data is degraded. The solution is segment it into standard scales of 5, 10, 20, 40, 80, 160, and 320 m/pixel.

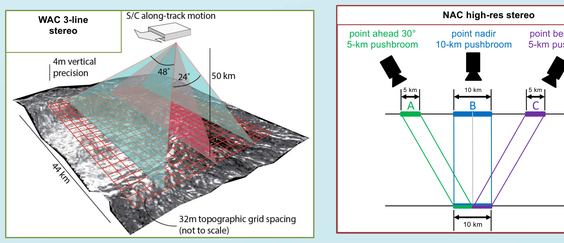

Fig. 4: (Left) WAC acquires 3-line pushbroom stereo (see detector layout in Fig. 3). (Right) NAC acquires high-resolution stereo using the gimbal below 100-km altitude.

8. EIS Mosaics

The NAC gimbal allows nearly global coverage at moderate resolution (<100 m/pixel), as shown in Figure 6. Furthermore, there will be full-disk color scans at ~350 m/pixel acquired during approach and departure of each encounter, at a range of phase angles, for a global color photometry dataset. EIS mosaic products will include:

1. 50 m/pixel global B&W mosaic
2. Global 300 m/pixel 6-color mosaic
3. Merge 1 and 2 above for 50 m/pixel color
4. Regional and local B&W mosaics at <50 m/pixel
5. Mosaics of digital terrain models

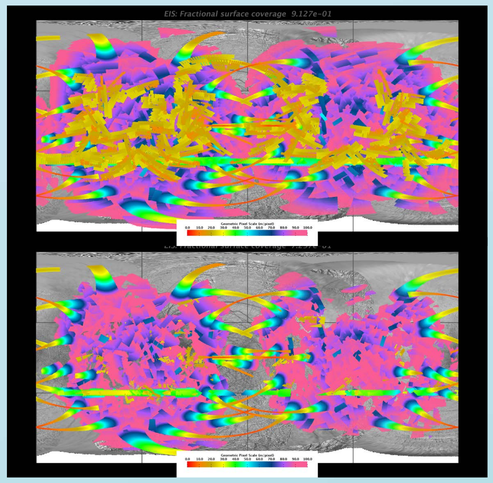

Fig. 5: (Top) NAC and WAC global mapping covers >90% of Europa at ≤100-m pixel scale for tour 17F12; NAC is primarily framing and WAC is primarily pushbroom imaging. (Bottom) NAC and WAC stereo imaging can cover >70% of Europa for tour 17F12, depending on downlink.

9. Multi-Instrument Data products

A variety of data products are possible by merging EIS products with those from other remote-sensing experiments on Europa Clipper:

1. Multispectral UV-visible-infrared data products: Co-register and combine data from the Europa-UVS spectrograph, EIS WAC with 6 colors, MISE with hundreds of wavelengths in the near-IR, and E-THEMIS with 3 bands in the thermal-IR. All of these datasets acquire data at about the same pixel scale and all are expected to acquire data simultaneously.
2. Bolometric hemispheric albedo map, by combining EIS and MISE data and photometric modeling. This product maps how much incident energy from the sun is reflected in all directions, and how much of that energy must be absorbed, raising surface temperatures. Any temperatures clearly above this value (measured by E-THEMIS), accounting for thermal inertia, must have an endogenic origin; such locations are of special interest.

10. Pipeline Data Processing

Automatic pipelines will be used to rapidly produce as many of the data products as possible. This includes the calibrated and map-projected individual image products and the WAC DTMs.

References

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Public outreach products will include full-disk color images, stereo anaglyphs, and color and high-resolution flyover movies.