Measurement of Io's Thermal Output With Galileo NIMS

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Io is

- Hot ✔
- Cold ✔
- Warm ✔
- All of the above ✔

- Hotspots are defined as local maxima
- Cold is below the NIMS detection limit
- The mean temperature of the largest areas dominates the measurements.

Calculation of power output

- Determine the color temperature for by fitting a Planck function (using least squares with a single temperature and a scale factor as independent variables)
- Determine area from scale factor and resolution
- Estimate the total power radiated at each pixel as $W = A\sigma T^4$

Notes (I)

- The area subtended by pixel is not isothermal. Two-temperature fits can reduce the apparent mean temperature by about 20-50 degrees
- The current model assumes unit emissivity
- Hotspots of very small area not detected
- Areas cooler than 180K are not detected

Notes (II)

- The areas of hotspots are inversely related to temperature. As a result, maps of temperature, area, and power for a given area can have very different relative amplitudes.
- A significant amount of power is emitted from areas with temperatures below the detection limits of NIMS.
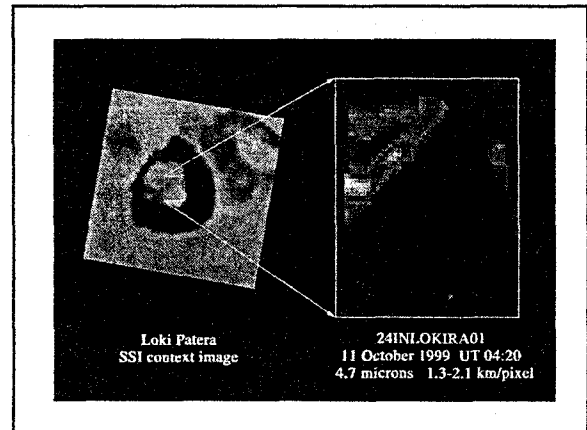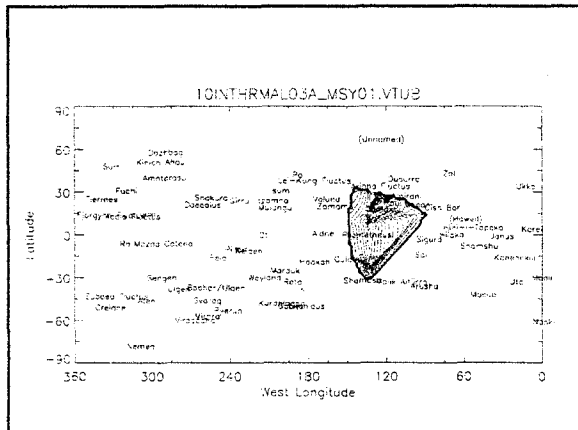

Observations of Io

- About 100 NIMS observations of Io during the Galileo prime mission
- Resolution ranged from 160 to 320 km/pix
- The majority of these observations have dayside areas
- The data used for these maps are from nightside observations

Application

- Constraints on heat deposition models
- Discrimination of (very adjacent) hotspots
- Temporal variability of global output
- Temporal variablity and classification of regional output

Galileo-NIMS
Thermal Characteristics

- Wavelength range 0.7 to 5.2μ
- Dynamic range ~ 1000, autogain beyond 4.4μ gives range of about 40000
- Minimum detectable temperature (fully filled pixel) ~180K
- Saturation temperature (fully filled pixel) ~600K

IOINTHRMALOSA_MSY01.VTUB

Loki Patera
SSI context image

24INLOKIRA01
11 October 1999 UT 04:20
4.7 microns 1.3-2.1 km/pixel

Guide to the Pictures

- **Global View**
  - Observations with spatial resolution ranging from 60-300 km map numerous hotspots.
  - There is a considerable difference in appearance between maps of temperature and power. Power output is the product of area and the fourth power of temperature. The peaks showing high temperature often are subdued in the maps of power, because the areas of high temperature features is often very small
  - There is frequently good evidence for multiple hotspots in pixels, based on the distribution of temperatures and sub-pixel mapping

- **Regional View**
  - The NIMS I24 observation of Loki provides a view of the complexity of the thermal activity inside of the pixels analysed in the global view. The spatial resolution is 1.3-2.1 km. The observation was taken at night.
  - The "island" in Loki has is distinctly different thermally, from the surrounding dark surface. The dark area is nearly homogeneous in temperature, has a relatively low temperature, and has a high thermal output (large area). The "island" has apparent high temperature features with small area. The area surrounding these features has temperature below the detection limits for NIMS.

## Global Maps

- Three power output maps are shown
- 1. G1 observations centered about 100 longitude
- 2. G7 observations centered about 270 degrees longitude
- 3. A combined map for (most) prime mission nightside observations.

- It must be remembered that nearly all of the hotspots are sub-pixel in size. The apparent thermal gradients are an artifact of the presentation technique (contouring).

Regional Maps
Discussion and conclusions

- The "lake" has high thermal output at about 350 K
- The "cracks" are not related thermally to the lake (in fact, they look a lot like the "island")
- The "island" appears to have numerous small hot spots (greater than 600 K) having very little area (10-100 m^2). The temperatures range from 300 to 1500 K. The distribution appears gaussian and is centered about 800 K.
- The thermal structure of the island is consistent with a picture surface that has numerous small skylights or breakouts.
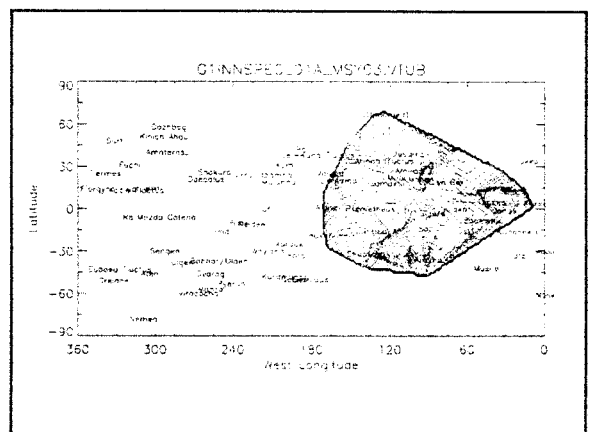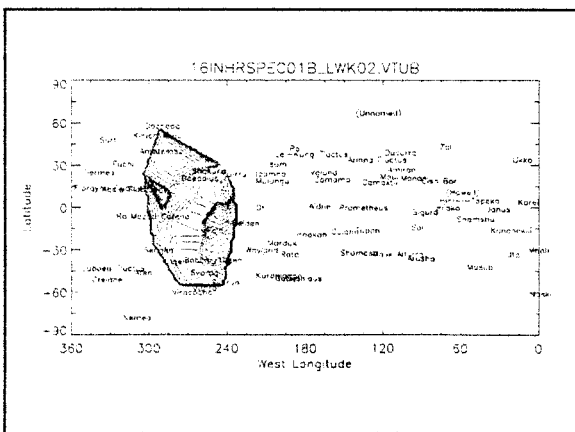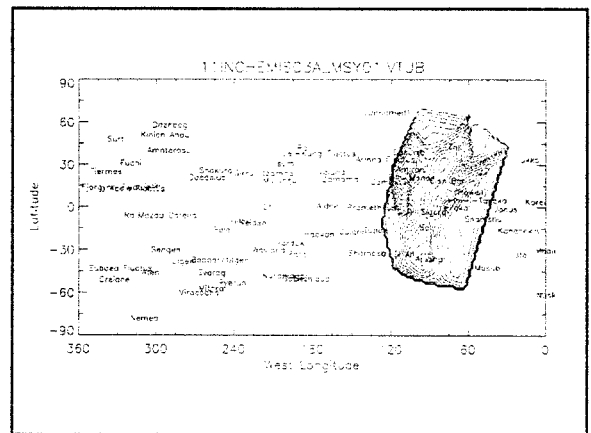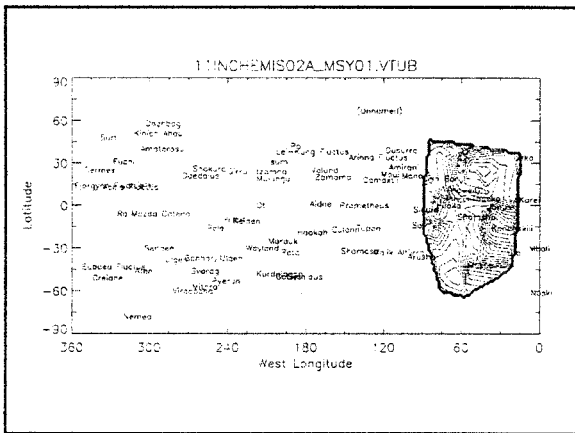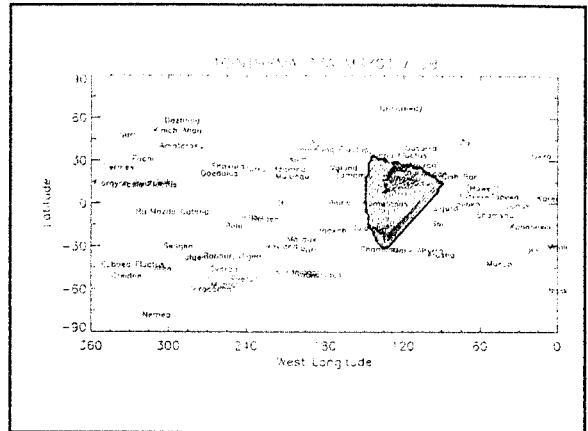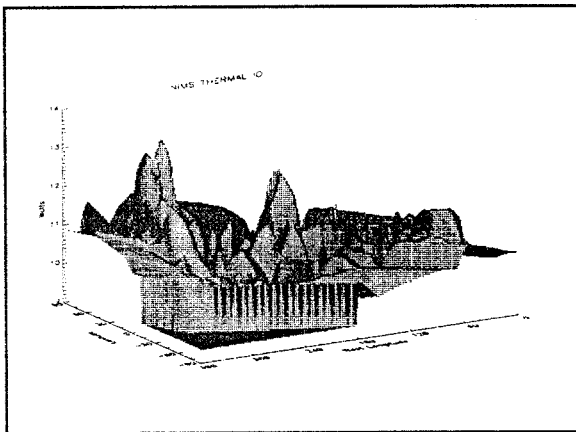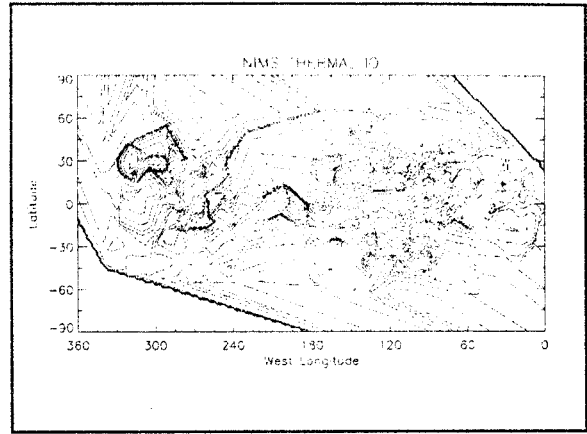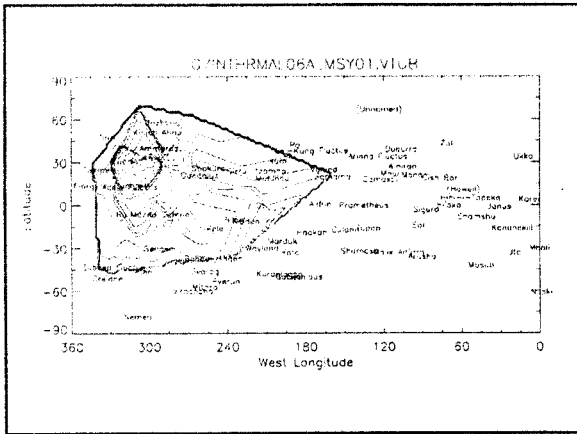
Regional Areas

- 1. View of Loki. Note apparent "crack" in "island" that looks similar to the "lake" area in the visible.
- 2. View of complete NIMS data set. The wiggles were obtained while slewing between observations.
- 3. Temperature map of the wiggles (note view is flipped l-r from (2))
- 4. Temperature map of the island
- 5. Surface map of temperature of island
- 6 Surface map of island power

- 7. Temperature on "lake" (blue wiggles in (3))
- 8. Temperature in "crack" on island. Note the temperature is higher. Thermal data shows that the dark stuff in the "crack" is not related (thermally) to the dark stuff in the "lake"
- 9. Temperature fit on light area of "island"
- 10. Radiance levels on cold area on far left side of (3) (off the island)
- 11. Responsivity of NIMS instrument

Pixel = 49, 31 Kelvin = 339.941

Pixel = 5, 6 Kelvin = 822.173

Pixel = 84, 45 Kelvin = 509.317

Pixel = 0, 43 Kelvin = 994.015

Pixel = 10, 43 Kelvin = 1144.35

Pixel = 14, 13 Kelvin = 1092.68

Pixel = 15, 50 Kelvin = 507.538

Pixel = 22, 38 Kelvin = 516.854

Pixel = 4, 38 Kelvin = 954.549

LOKI28: 0, 429; Tc = 405

LOKI28: 1, 363; Tc = 297

LOKI28: 2, 722; Tc = 297

LOKI28: 3, 706; Tc = 371

LOKI28: 3, 720; Tc = 328

LOKI28: 3, 720; Tc = 328

LOKI28: 11, 666; Tc = 623

LOKI28: 13, 749; Tc = 326

LOKI28: 13, 749; Tc = 326

LOKI28: 14, 635; Tc = 226