JunoCam at PJ57: Part I: Io

John Rogers (BAA) (2024 Jan.30)

Juno's 57th perijove was on 2023 Dec.30, shortly preceded by its first really close flyby of Io, at an altitude of 1500 km. Thus JunoCam was able to take the first closeup views of the volcanic moon for 22 years, since the last successful Galileo Orbiter flyby in 2001 Oct.

There was much anxiety about PJ57 because at PJ56 (Nov.22), JunoCam developed a serious problem with the camera: intense streaky noise appeared all across the images. It was feared that this could be a permanent problem which would impair subsequent imaging, including of Io. However, the JunoCam team (particularly Malin Space Science Systems) managed to cure the problem by heating the camera:

> "After Juno's last close pass by Jupiter in November, JunoCam's performance was severely degraded by radiation damage. Using its built-in heater, the camera was warmed to a temperature of about 65ºC for several weeks in December, a process called "annealing", and this treatment has restored camera function, at least for this pass." (-- NASA post quoted by Jamie Carter and Mike Caplinger).

The PJ57 images appear to be perfect. Full-quality images of Io have been posted on https://www.missionjuno.swri.edu/junocam/processing and www.unmannedspaceflight.com and Io expert Jason Perry has posted informative comments on those forums.

Juno came in over Io's dark side, and imaging began as it passed onto the sunlit side over Io's north polar region. So the first, highest-resolution image covered the north pole, and the subsequent images covered more of Io's northern hemisphere as Juno rapidly moved away towards its pass over the north pole of Jupiter (Figure 1). Moreover, most of the "dark side" in these images was well illuminated by light reflected from the planet. Much of the area shown had not been mapped by previous missions. So JunoCam completed the mapping of Io's north polar region, partly at high resolution in sunshine and partly at low resolution by Jupiter-shine (Figure 2). Notably, it obtained the first good images of several impressive high mountains that had never been properly resolved before, and discovered one mountain very close to the north pole, at 85ºN. As is common on Io, some of these mountains have volcanic calderas alongside them. All the labelled calderas were hot spots in recent JIRAM images (e.g. PJ47; Figure 3A). Vivasvant, at 75ºN, may be the furthest-north caldera known on Io, although the PJ47 JIRAM image showed a faint hotspot very close to the pole (Figure 3A). Closeups of these high northern mountains and calderas are shown in Figure 3B.

A global map from the PJ57 images is in Figure 4. The images are also very useful for mapping topography at lower latitudes, as previous missions rarely got extensive hi-res images near the terminator, so a lot of mountainous features were poorly known. The PJ57 map shows the relationships of mountains and volcanoes much better than the Voyager or Galileo maps (Figure 5), even for features which JunoCam observed near the limb, notably Ra with its radial bright lava flows.

No volcanic plumes were visible in the images (Prometheus and Pele were not in view), and there were no large changes since the Voyager and Galileo mapping. However, IR imaging from ground-based telescopes, from the Galileo Orbiter, and from Juno's JIRAM has shown that Io has ~100 "hot spots" (volcanic calderas or active lava flows), and the PJ57 images showed local changes around some of these, including the following (Figures 2 & 3A):

Chors is a dark caldera and a hot spot, shown here to have deep red streaks emanating from its edge. (This reddening was already noted by Jason Perry in the lo-res images at PJ49.)

Tonatiuh is at ~55ºN, 70ºW in Chalybes Regio, pointed out by Jason Perry on the Jupiter-lit dark side. He says: “This is Tonatiuh, a 500-km long lava flow that wasn't there 15 years ago, at all. This is also the site of that plume that JunoCam saw at the end of 2018 [PJ17 & PJ18].”

Loki is a uniquely large volcanic complex, including a huge 200-km-diameter caldera, which is always very dark and warm and frequently resurfaced by lava flows; on average it emits more heat than any other hot spot on Io. JunoCam’s images of it are the best since Voyager 1 in 1979, although Galileo observed it from larger distances up to 2001 (Figure 5). There are no changes since 1979 in the shapes of the Loki caldera or the large and small “islands” within it. The complex stripy area NE of the caldera, vigorously erupting in 1979, shows little if any change since 2001; lava may have flowing here in 1979 and then cooled and faded.

Figures *[see small copies on following pages]:*

Figure 1. All the PJ57 Io images, to scale (processed by Brian Swift).

Figure 2. The first image at full size (processed by Gerald Eichstädt) with the dark side enhanced, & notable calderas/hot spots labelled. The white circle indicates the approximate position of the north pole.

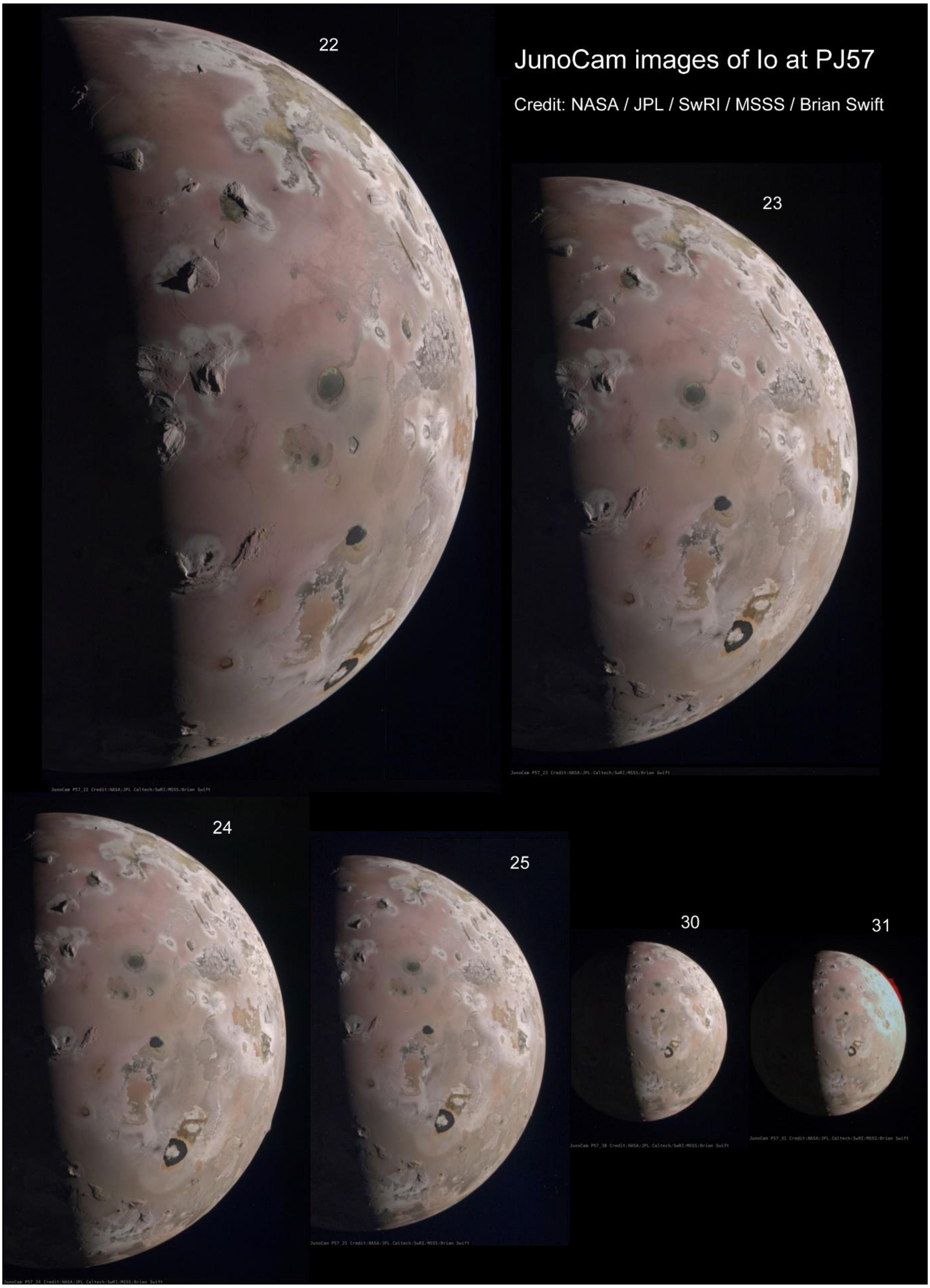
Figure 3A. Thermal infrared view of Io showing numerous hot spots, from Juno’s JIRAM at PJ47, overlaid on a synthetic image from incomplete Galileo USGS data (composite by Jason Perry). The view is similar to Fig.2 though more distant. The calderas labelled in Fig.2 are all hot spots and are labelled by initials here, along with Tonatiuh (T) and Zal (Z); all these were similar from PJ41 to PJ47. The circle indicates the faint hot spot very close to the north pole. The hot spots are slightly streaked because the JIRAM instrument’s spin-compensation mirror had been stuck since PJ44.

Figure 3B. Enlargements of mountains & calderas from the image in Fig.2. The mountains, like others on Io, have striated slopes and are flanked by broad “aprons” that may be rubble from landslides. They are also largely surrounded by diffuse white deposits, possibly SO_2 frost. It is not known whether these are from solid material that has slid down the mountains, or from vapour emissions around them.

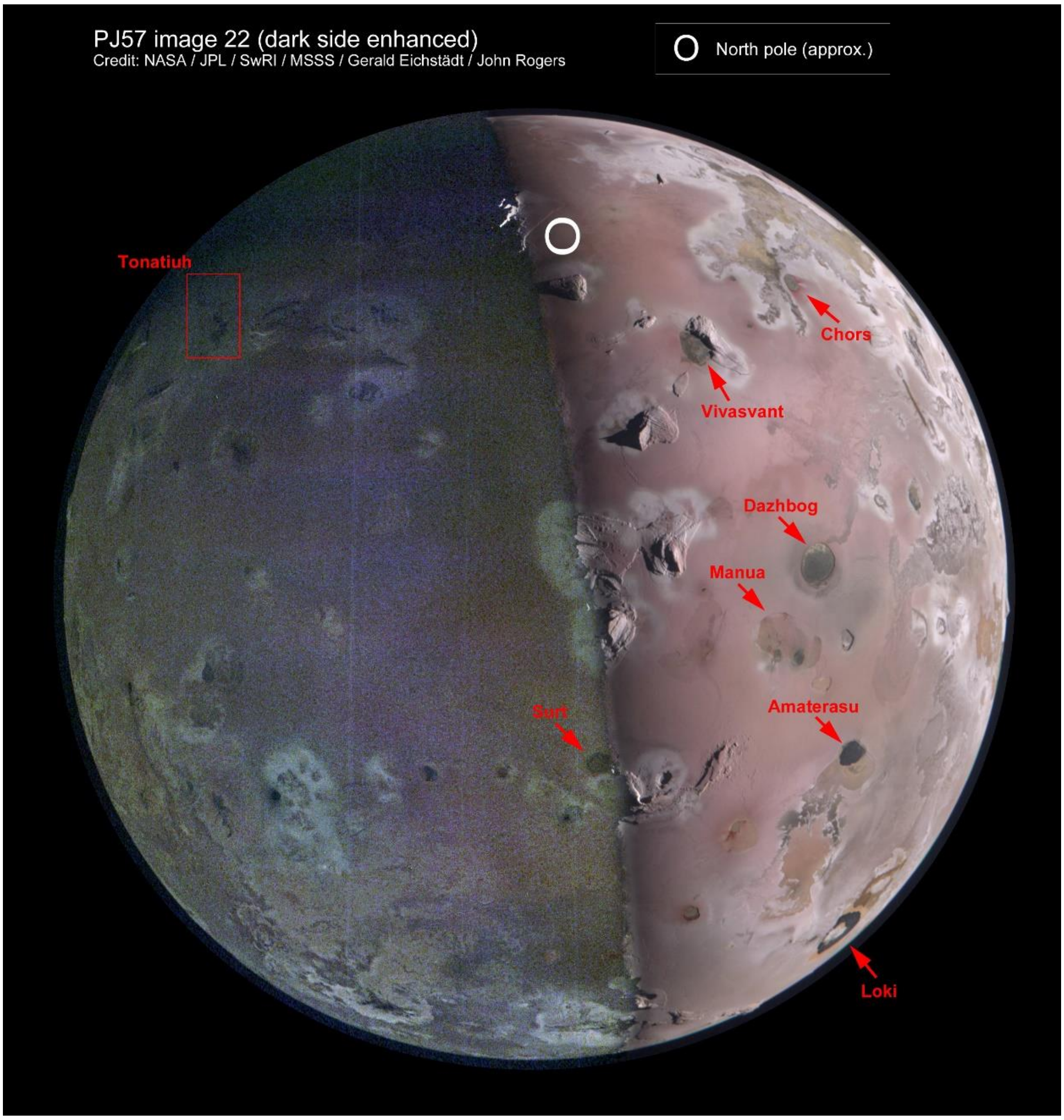
Figure 4. Complete map of the PJ57 images, by Jason Perry (cylindrical equirectangular projection). Compare with Voyager/Galileo maps of Io:
https://astrogeology.usgs.gov/maps/io-voyager-galileo-global-mosaics
https://britastro.org/jupiter/moonmaps.htm

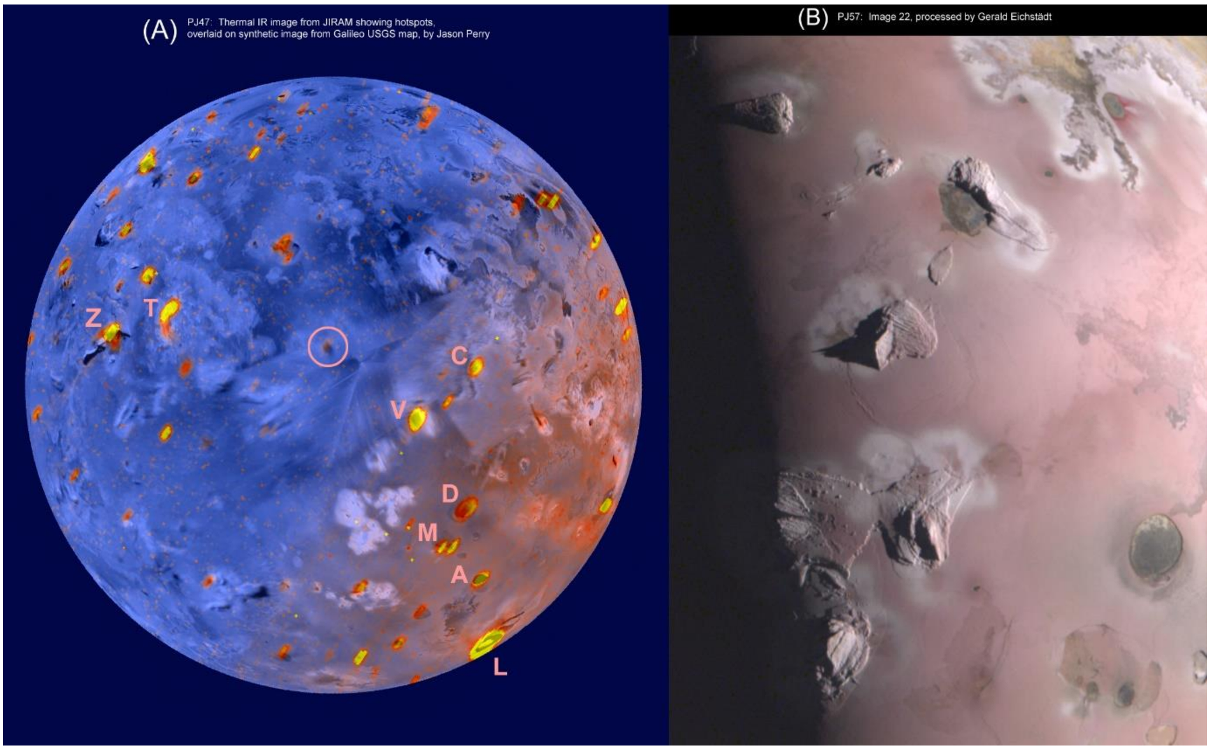
Figure 5. Excerpts from cylindrical maps of Io by Voyager, Galileo, & Juno at PJ57, including the well-known volcanoes Loki & Ra. Some changes can be seen around these two. But note that the colour and brightness of surfaces on Io can vary greatly with the lighting and viewing angles, and with the camera filters used, so many apparent differences are likely due to these factors.

Figure 1:



Figures 2 & 3 *[on following page]:*


PJ57 image 22 (dark side enhanced)
Credit: NASA / JPL / SwRI / MSSS / Gerald Eichstädt / John Rogers
North pole (approx.)
Tonatiuh
Chors
Vivasvant
Dazhbog
Manua
Surt
Amaterasu
Loki


(A) PJ47: Thermal IR image from JIRAM showing hotspots, overlaid on synthetic image from Galileo USGS map, by Jason Perry
Z
T
C
V
D
M
A
L
(B) PJ57: Image 22, processed by Gerald Eichstädt

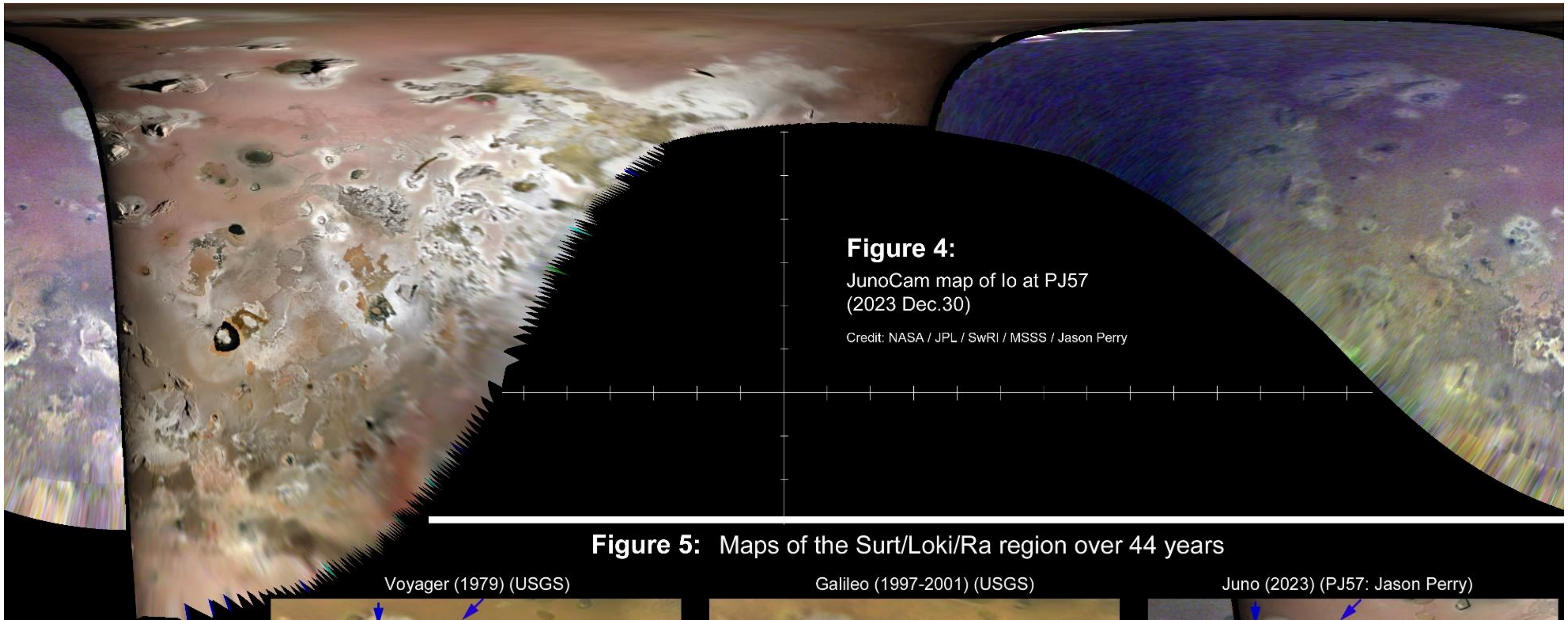


Figure 4:
JunoCam map of Io at PJ57
(2023 Dec.30)
Credit: NASA / JPL / SwRI / MSSS / Jason Perry

Figure 5: Maps of the Surt/Loki/Ra region over 44 years