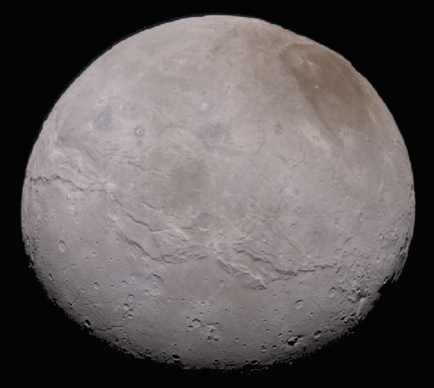
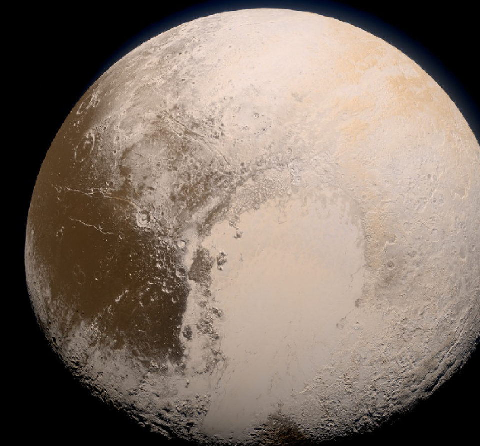


A Consensus Crater Catalog of Pluto, Charon, Nix, and Hydra



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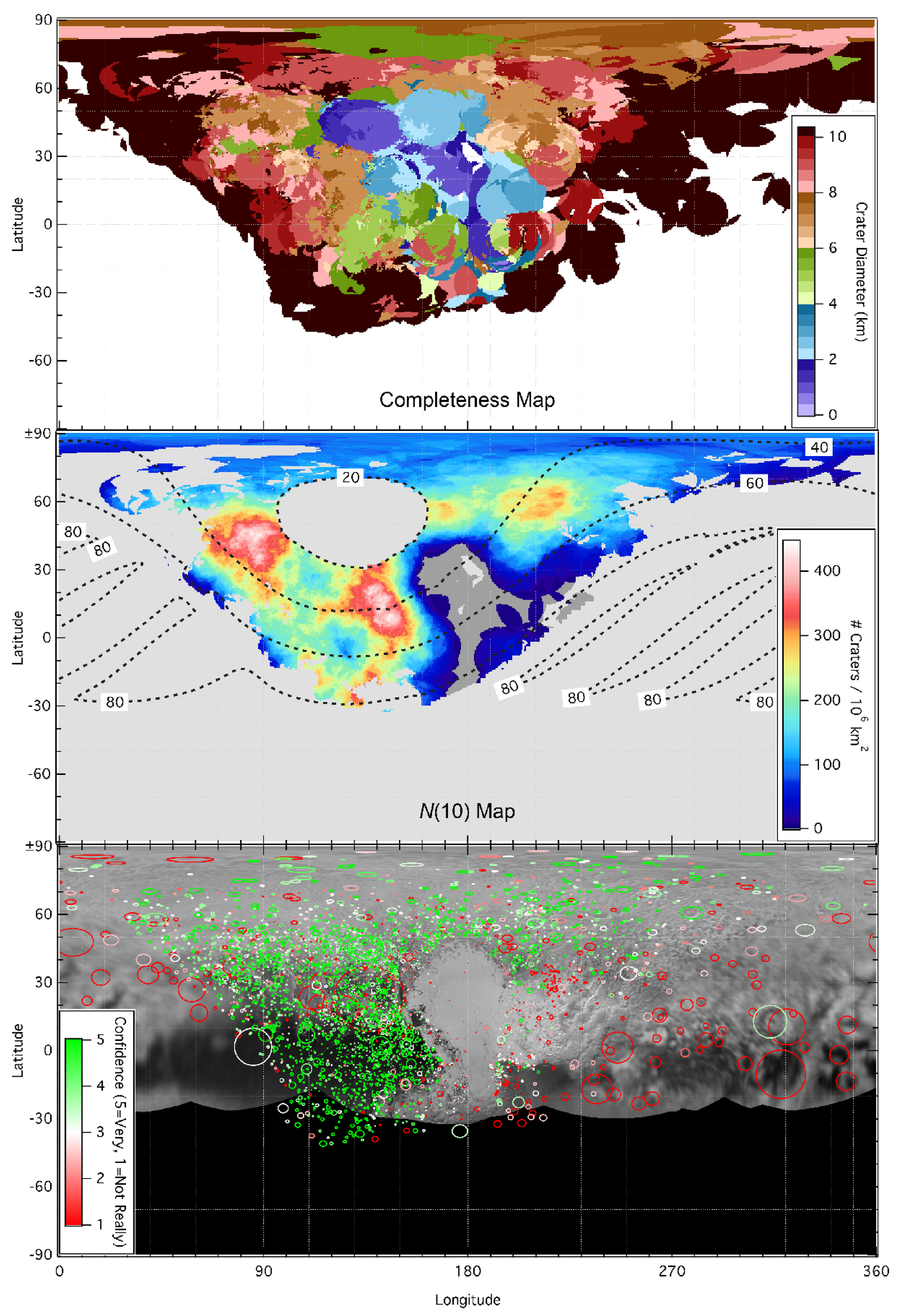
Abstract

New Horizons was the first mission to explore the last of the classical planets and objects in the third region of the solar system: The Kuiper Belt. The Pluto-Charon system is embedded within the inner edge of the Kuiper Belt, and so it is impacted by a distinct population of bodies that we cannot probe from gas giant planet moons, and detection technology from Earth can only probe the largest impactors. Therefore, the crater population of Pluto and Charon is an important probe into not only the impactor population, but also geologic processes occurring on both bodies. Here, we present a consensus crater database of these bodies and several observations from the database.

Pluto

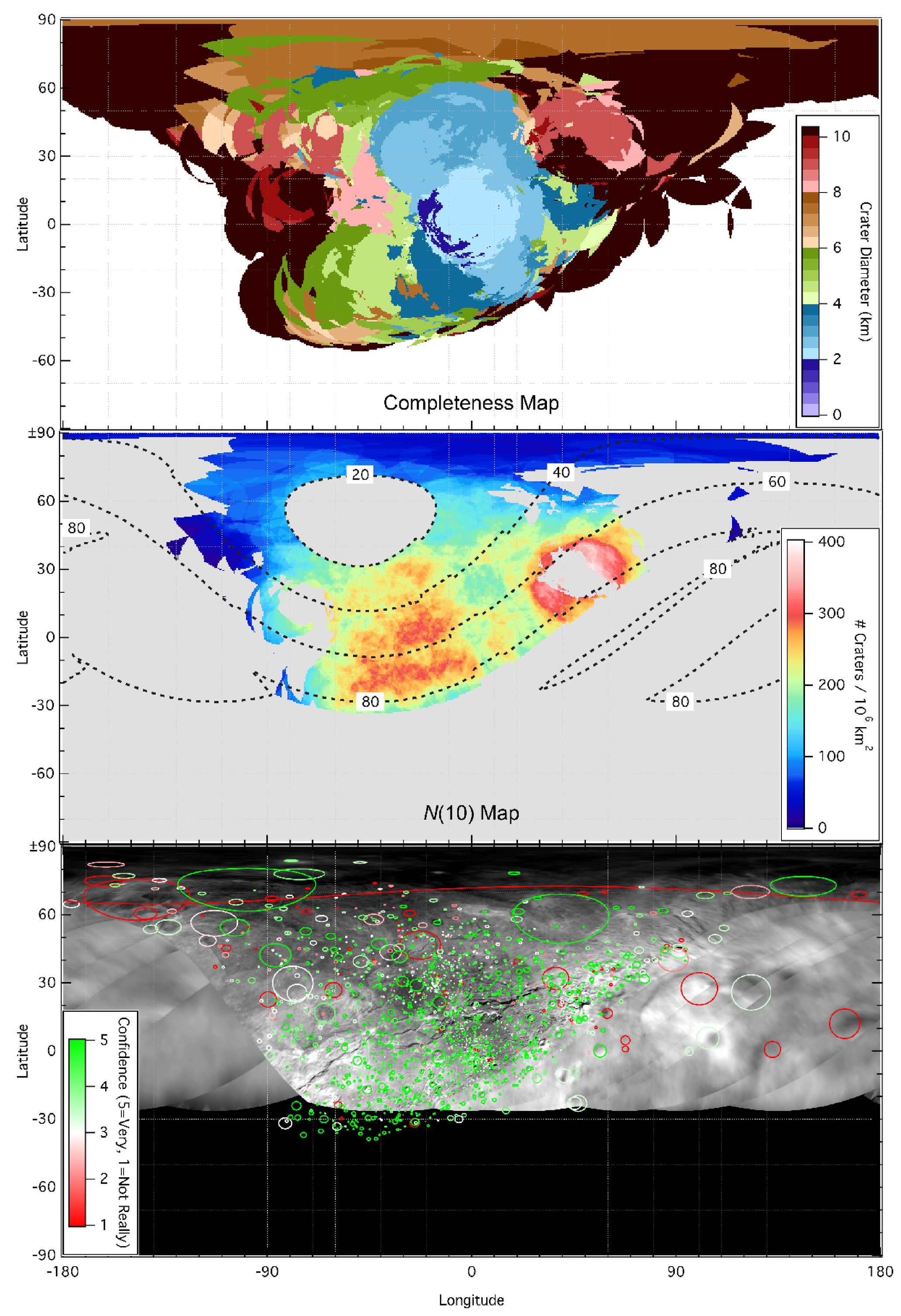


Estimate of completeness, where we assume crater number increases with decreasing diameter such that a decrease (from large to small diameters) indicates failure to identify craters. Size-frequency distributions for craters within 207 km of each grid point (10° at Pluto's equator, 20° at Charon's) are created and the diameter of the rollover is saved and graphed here. Plots are color-coded based on that diameter. All craters in our catalog are included in this analysis.

Spatial density of craters $D \geq 10$ km ($N(10)$) with the same smoothing radius (207 km). Only features we were ≥50% certain are impact craters are included in this plot. Dark grey indicates no craters were mapped. Light grey has been masked due to: incidence angles not in the range $20° < i < 85°$, the best image coverage >1 km/px, and/or completeness (top plot) is ≥10 km.

Idealized circle outlines of every candidate impact crater in our databases overlaid on the most recent panchromatic global basemaps (these do not include some of the images upon which we mapped craters, and they are cut off for near-terminator incidence, so numerous features are off the basemap). These features are color-coded based on subjective confidence the feature is a real impact crater.

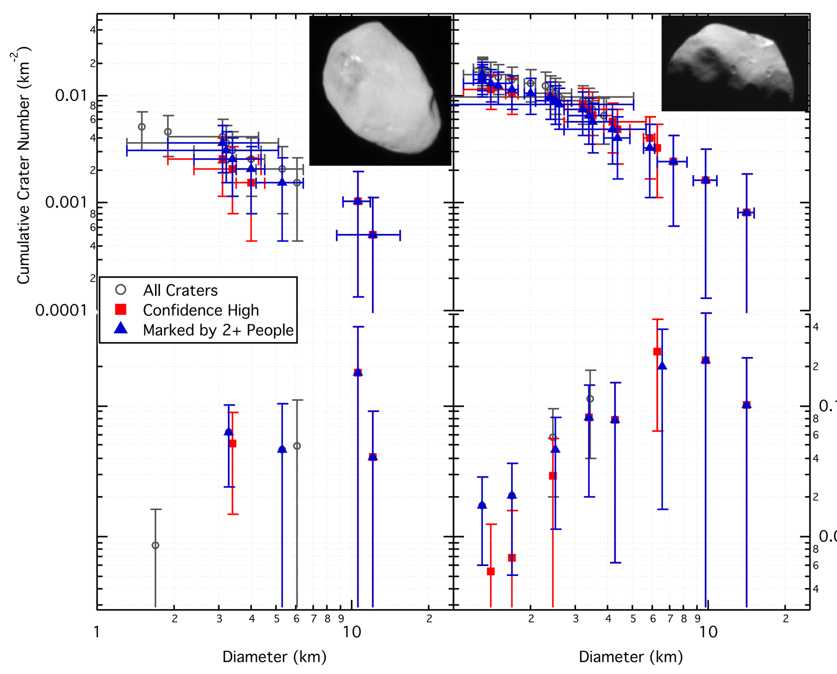
Charon

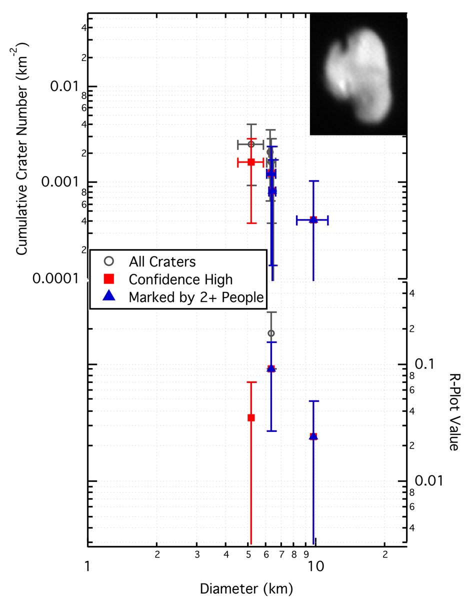


Nix and Hydra

The Nix crater population from two different images; left image data are an under-representation due to the near-noon sun; right image is more reliable.

Vertical uncertainty has been increased by 30% to represent surface area uncertainty, and horizontal error bars indicate crater diameter uncertainty.





The Hydra crater population, mapped on the best image at ≈1.4 km/px. There were no other views of Hydra suitable for mapping impact craters.

We mapped six different features that are possible impact structures, rendering a large uncertainty in the number of features at any given diameter.

Hydra was on the opposite side of the system as the spacecraft, so solutions for the size of the body are prone to ±10 km uncertainty; combined with the uncertainty of the amount of the body imaged, we increased vertical error bars by 55%.

Observations

- Different researchers mapping craters on lossless images found very similar size-frequency distributions of crater data, though some found different spatial densities due to different thresholds of considering a feature an impact crater.
- 1σ spread in crater diameters averaged ±10%·D.
- The global crater population of Pluto is among the most non-uniform in the solar system, similar only to Mars, Enceladus, and Ganymede.
- The most densely cratered area of Pluto we can map is just west of Sputnik Planum. However, the peak $N(5)$ density is only ≈60% the peak $N(5)$ density of Charon. The peak $N(5)$ of Charon is only ~35% the $N(5)$ of Nix after gravity scaling is accounted for (2.6× decrease due to material properties on Nix).
- Differential SFD slope averaged over Pluto is –2.88±0.04. However, over small diameters (D=2–10 km), it is –1.0±0.1 in several areas, while at larger diameters (D=2–10 km), we find a slope of –3.2±0.2 (2σ uncertainties).
- Differential SFD slope averaged over Charon is –2.93±0.07 (2σ uncertainty).
- Largest possible crater observed on Pluto is the basin under Sputnik Planum‡ (D≈800 km); if Sputnik Planum is not a basin, Simonelli crater‡ (≈297±7 km) is the largest.
- Largest possible crater observed on Charon is Mordor Macula‡ (D≈450 km) but this is likely an arcuate scarp; therefore, Dorothy Gale crater‡ (≈231±7 km) is likely the largest observed.

Mapping Craters

Our database is combined from annotations by Robbins, Singer, Bray, Runyon, and Weaver, who marked craters on a variety of images on the four bodies. These were mostly manually matched and markings of the same feature were averaged together to create the final feature.

Several of the persons involved included a subjective confidence that the feature was a real impact crater; these were re-scaled to be on the same scale as Robbins and averaged together, as well (shown in the middle panel of this poster as red to green crater outlines).

Pluto: 5287 features, 4030 have confidence ≥3 (50/50 chance the feature is a real impact crater, or better).

Charon: 2287 features, 2022 have confidence ≥3.

Nix and Hydra: 35 and 6 features, respectively.

New Horizons Mission Profile

Trajectory:

1) The *New Horizons* spacecraft passed between the orbits of Pluto and Charon, but it was while Charon was on the other side of the system.
2) Closest approach to Pluto was a distance of 12,500 km, and the best images have a pixel scale of 80 m/px.
3) Closest approach to Charon was a distance of 30,000 km, and the best images have a pixel scale of 150 m/px.
4) Of the small satellites, only Nix was on the same side of the system as New Horizons, providing a pixel scale 300 m/px.

Imaging Pluto:

6) The non-encounter hemisphere has 20 km/px at best.
7) The encounter hemisphere was fully imaged at up to 300 m/px by MVIC*.
8) Sputnik Planum‡ was imaged at 360-400 m/px for inclusion in a stereo sequence.
9) Three ribbons of imaging at up to 80 m/px were included through or near Sputnik Planum as LORRI* ride-alongs.

Imaging Charon:

10) A similar imaging sequence was conducted for Charon: up to 20 km/px for the non-encounter hemisphere, full-disk encounter hemisphere imaging at up to 400 m/px, and there was one ride-along at 150 m/px that provided a swath through the middle of the non-encounter hemisphere.

Imaging Small Satellites:

11) Nix was the closest small satellite to the spacecraft trajectory, and images at up to 310 m/px were obtained.
12) Kerberos, Styx, and Hydra were all imaged at pixel scales >1 km/px.

References, Acknowledgments, & Notes

[1] Reuter, D.C. *et al.* (2008) *Ralph: A Visible/Infrared Imager for the New Horizons Pluto/Kuiper Belt Mission.* Space Sci. Rev. **140**, 129-154. doi: 10.1007/s11214-008-9375-7.

[2] Cheng, A.F. *et al.* (2008) *Long-Range Reconnaissance Imager on New Horizons.* Space Sci. Rev. **140**, 187-215. doi: 10.1007/s11214-007-9271-6.

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*MVIC is Multi-spectral Visible Imaging Camera [1], and LORRI is LOng-Range Reconnaissance Imager [2].

‡All region/feature names are informal and used here only meant for convenience.

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