MESSENGER
MErcury Surface, Space ENvironment, GEochemistry, and Ranging

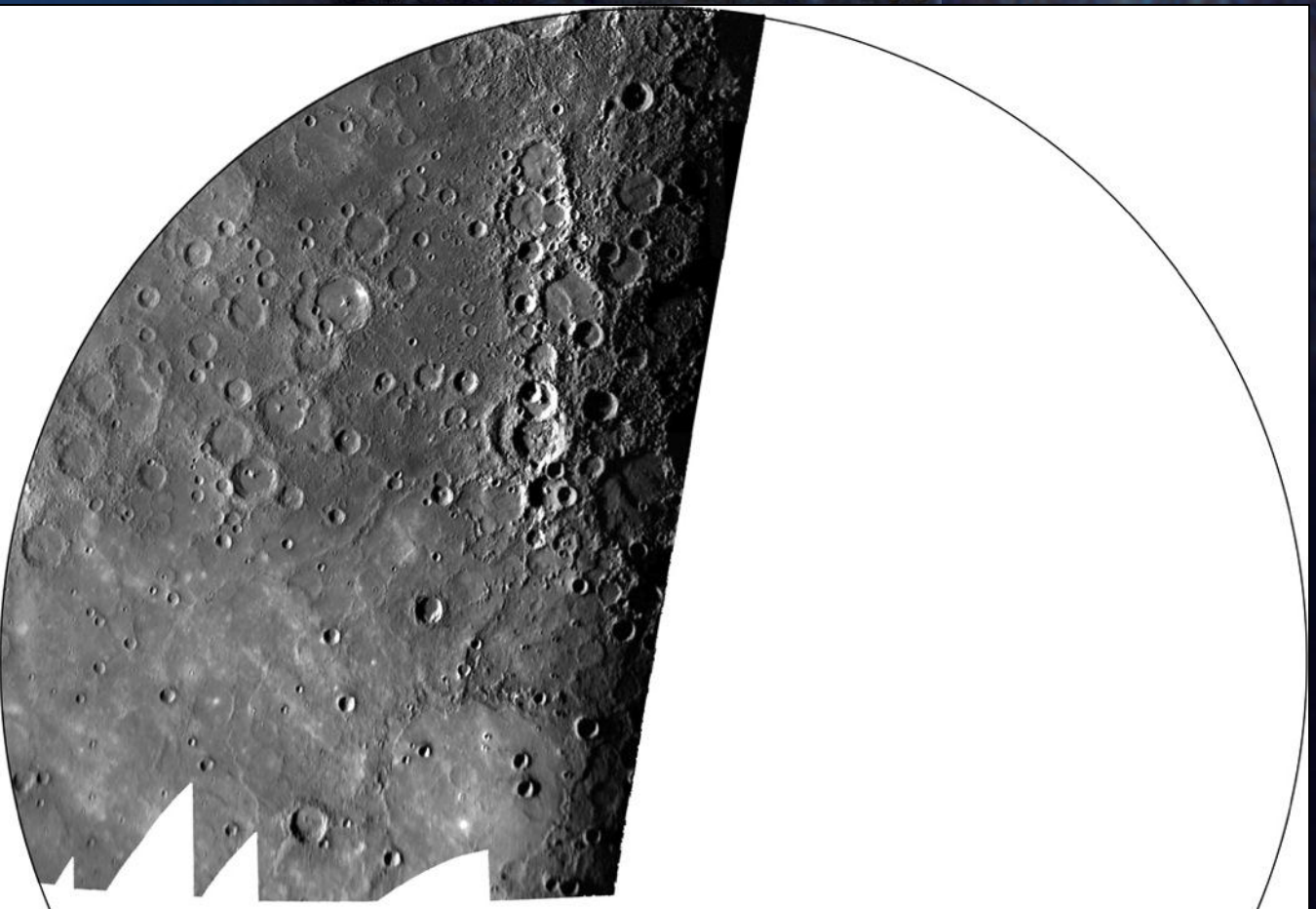
Having a Wonderful Time, Wish You Were Here!

NASA Challenge of Discovery Educator Workshop

April 6, 2013

Alice Berman

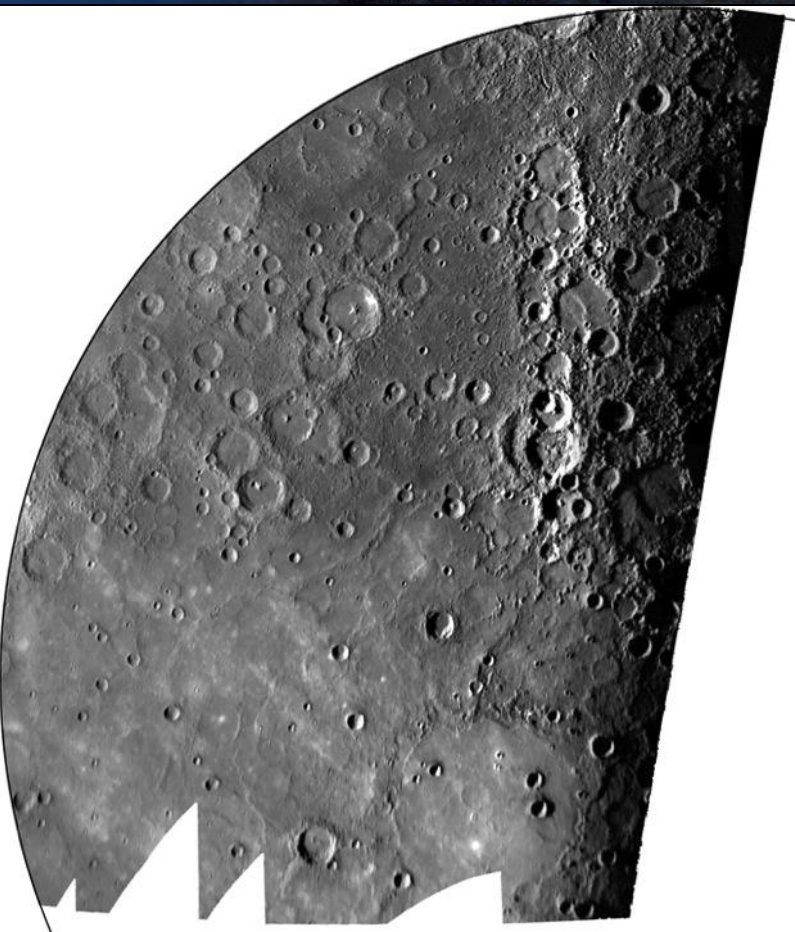
Nancy Chabot



Mercury's North Polar Region

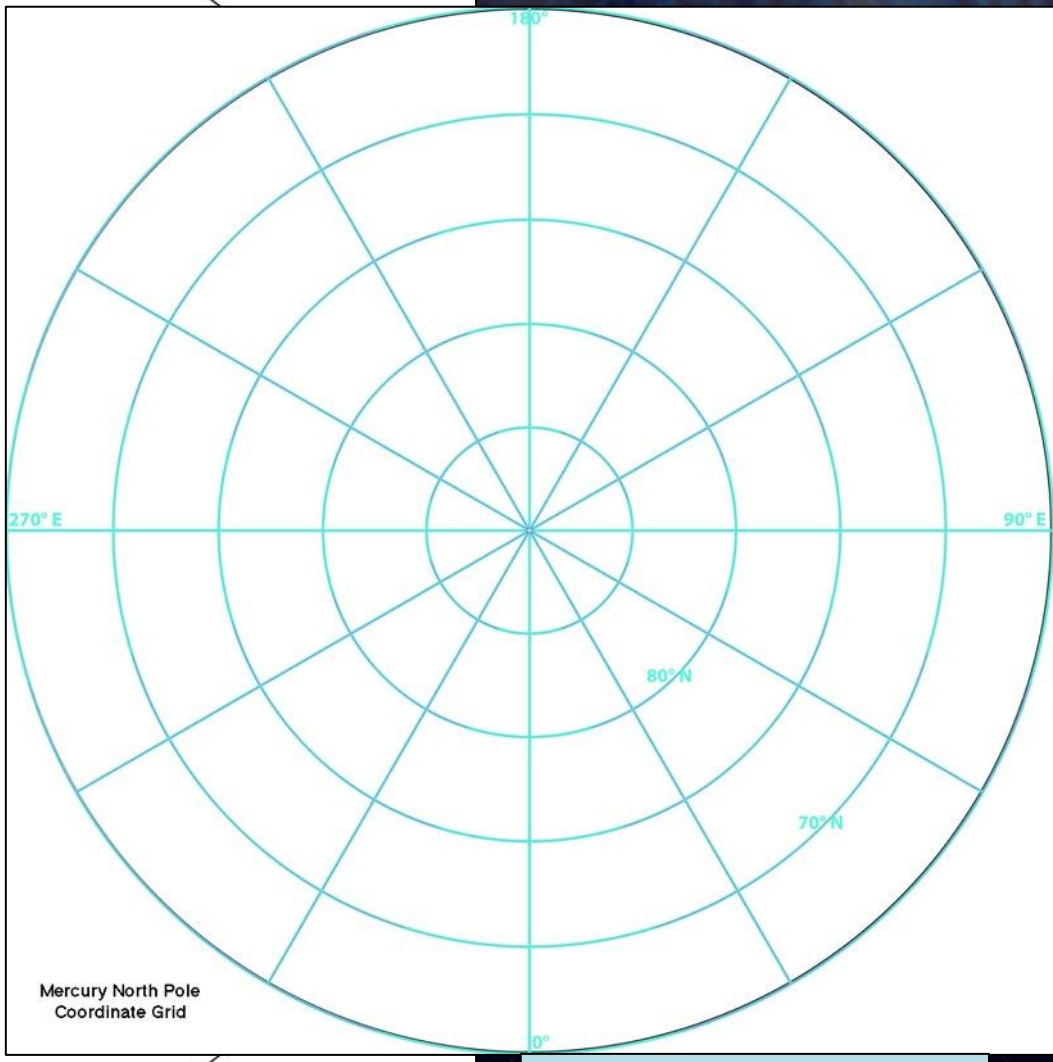
Mariner 10 Flyby Images

Prior to MESSENGER, Mariner 10 (1974-75) was the only spacecraft to visit Mercury

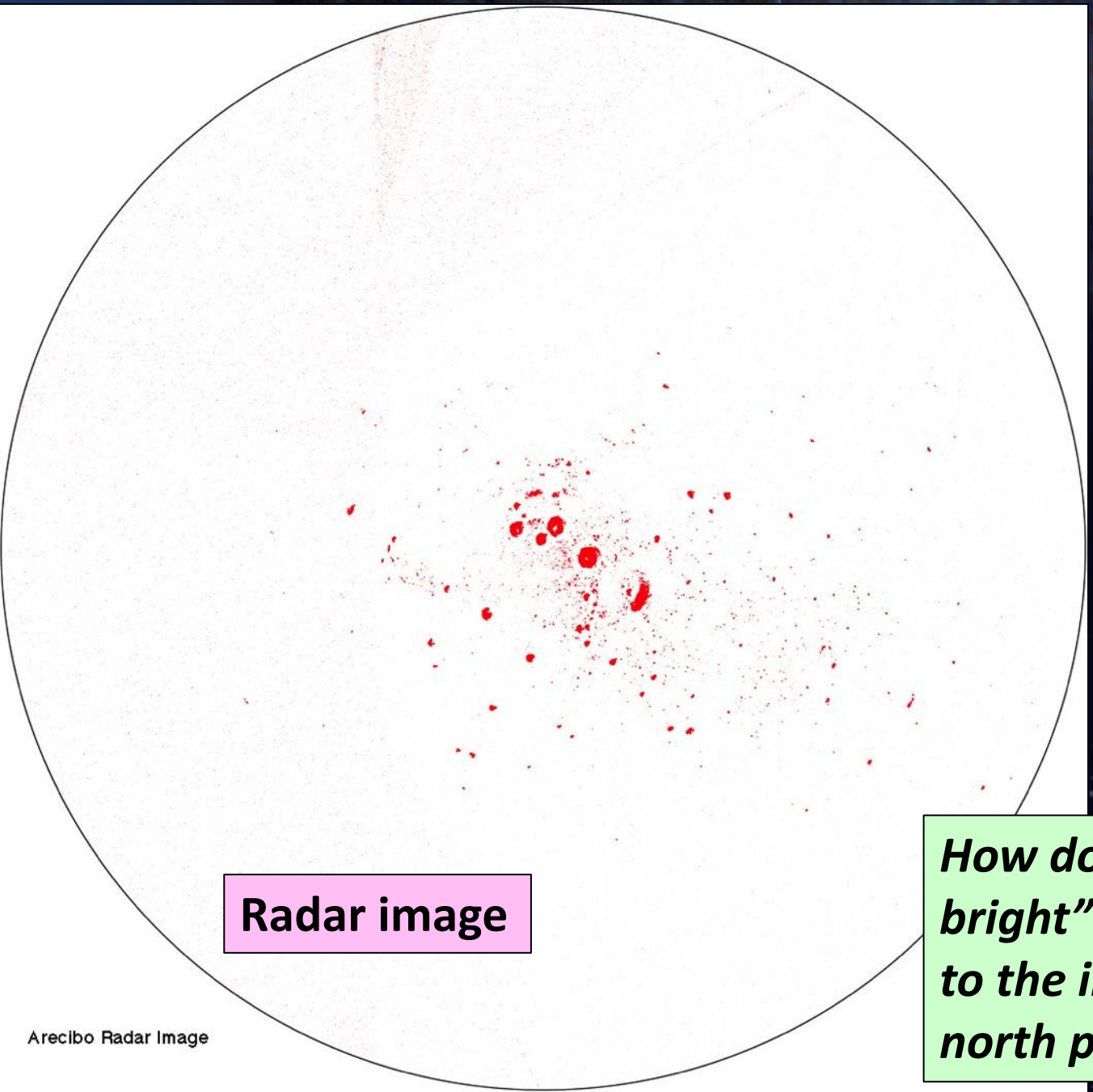


Mariner 10 Flyby Images

Mercury's North Polar Region



Coordinate Grid

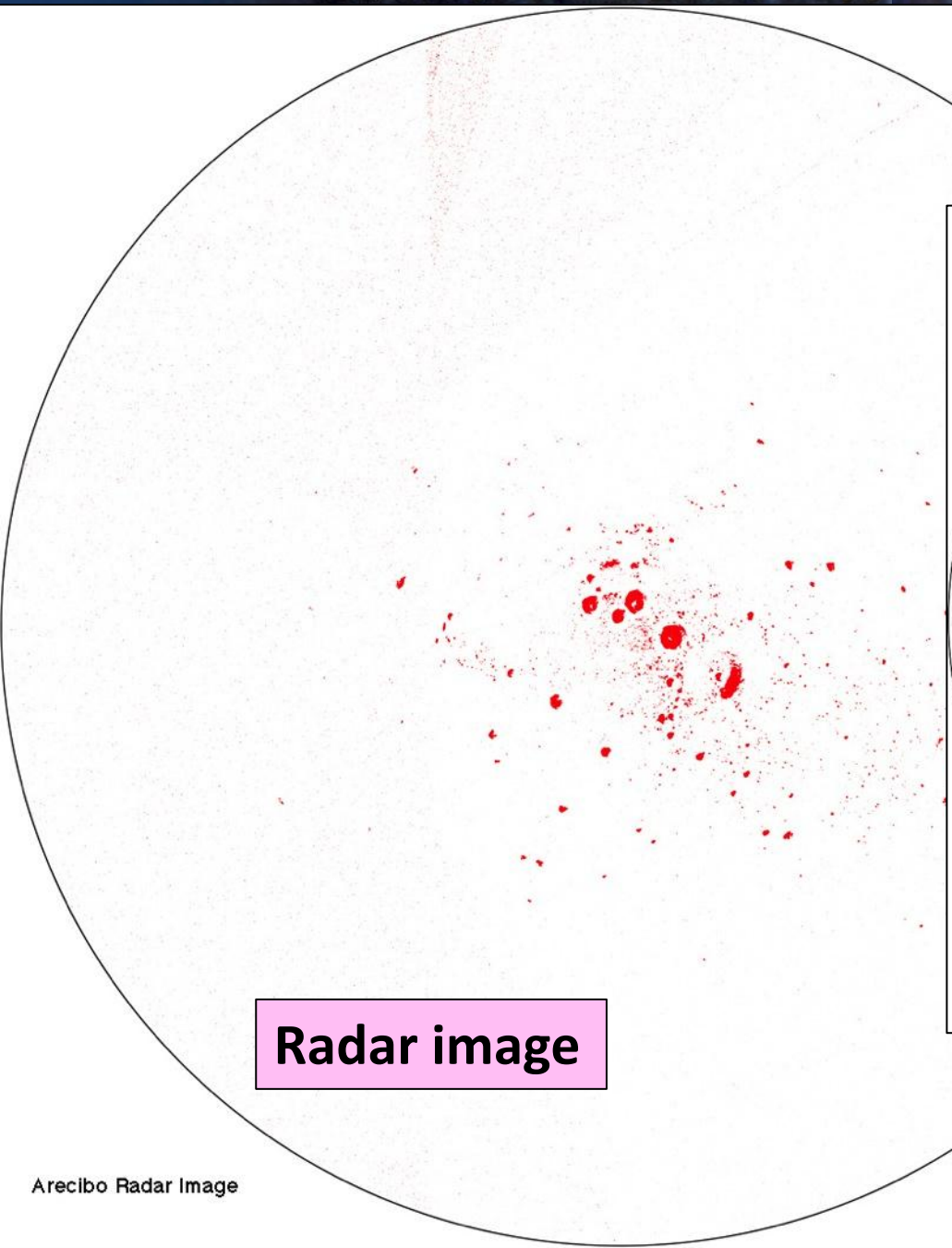


Arecibo Radar Image

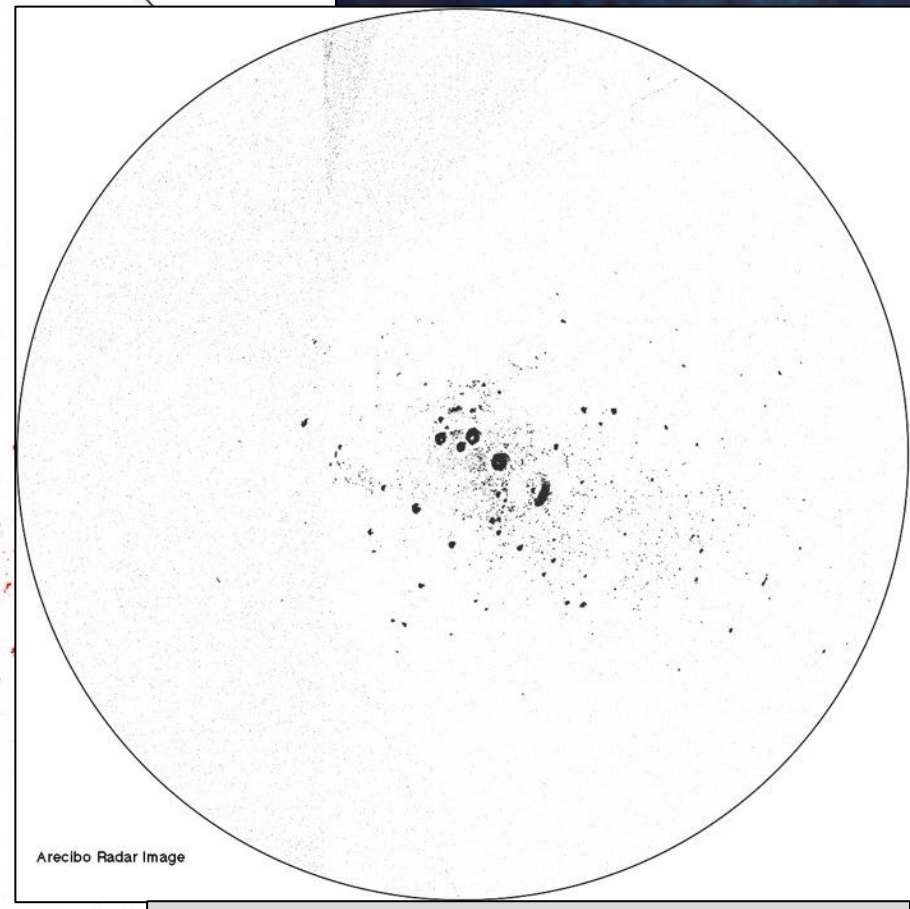
Radar image

In 1992, radar observations from Earth-based telescopes discovered bright features near Mercury's poles that resembled water ice

How do these "radar-bright" features compare to the image of Mercury's north polar region?

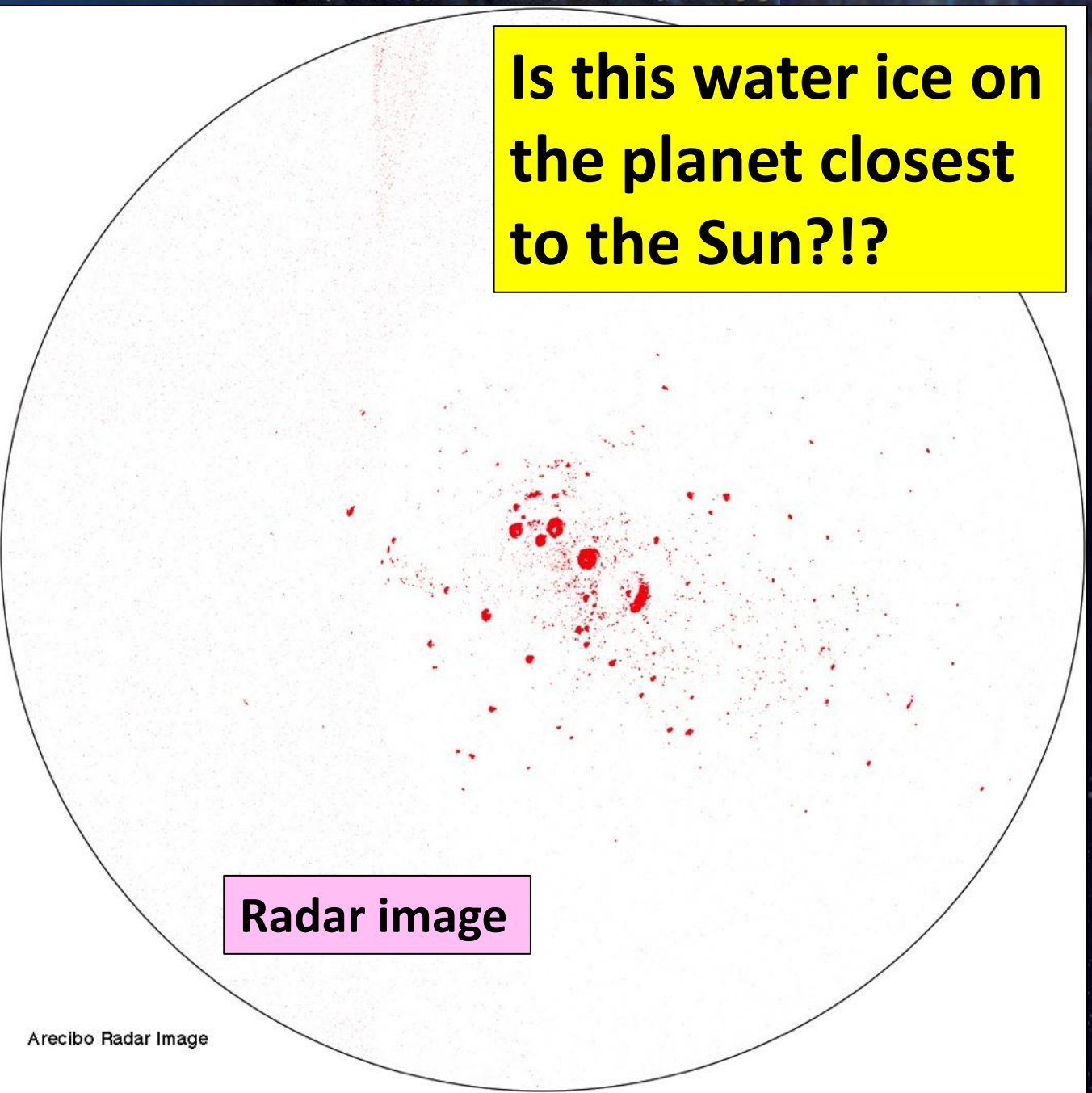


Radar image



Same radar image in black

Is this water ice on the planet closest to the Sun?!?



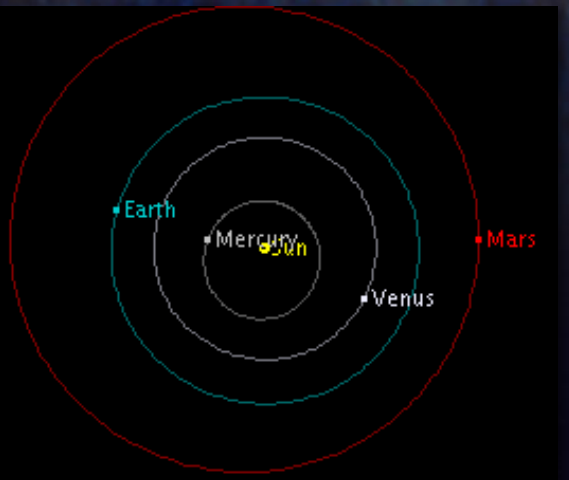
Radar image

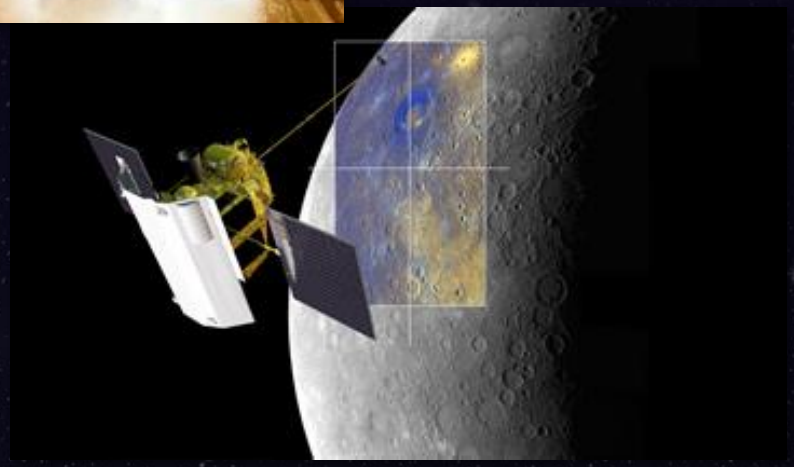
Arecibo Radar Image

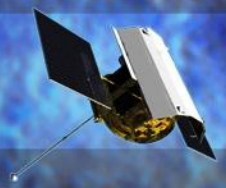
In 1992, radar observations from Earth-based telescopes discovered bright features near Mercury's poles that resembled water ice

To send a spacecraft to orbit Mercury, it must:

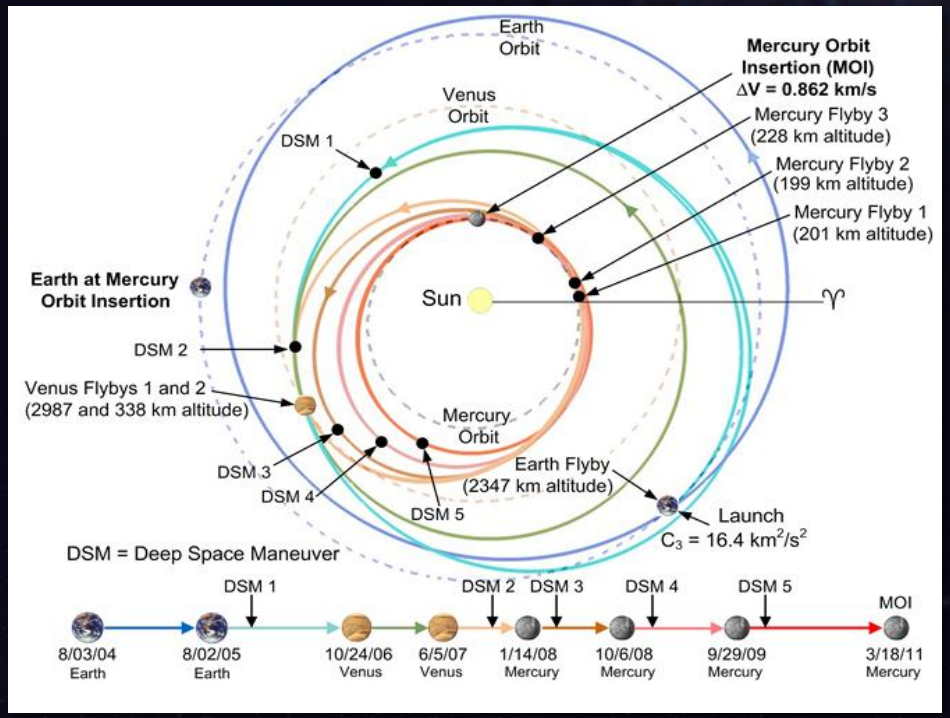
- Leave the ground and escape Earth's gravity.
- Carry enough propellant to:
  - Decelerate to travel to the inner Solar System.
  - Execute course corrections along the way.
  - Slow down to be captured by Mercury's gravity → "orbit insertion".
- Generate and store power from the Sun to operate its instruments and systems.
- Keep its components at the proper temperature. Report any problems.
- Take science images and data and send them to us.
- Communicate with us.



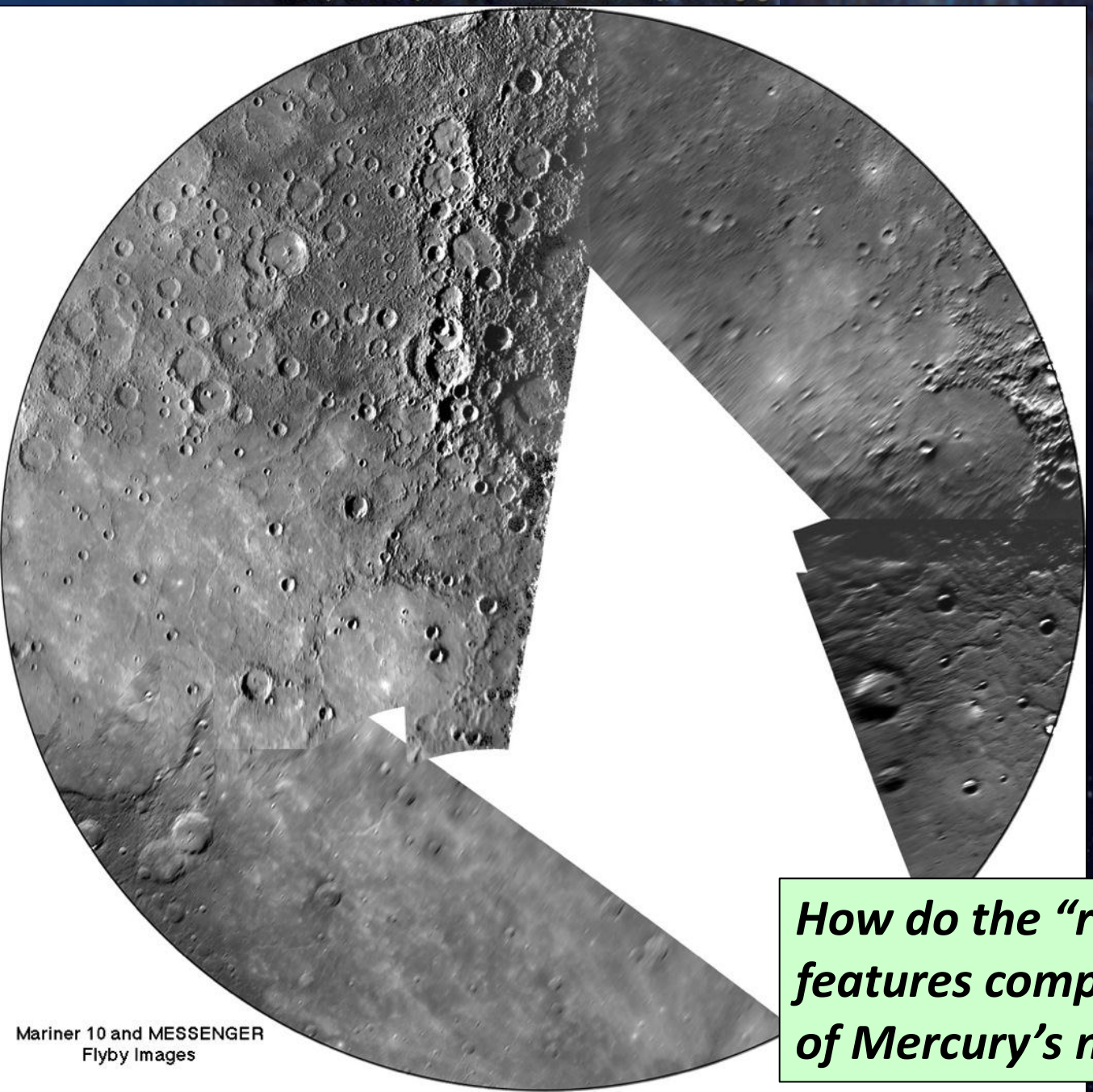




Our Trip Statistics



- 6.5 years in duration.
- 4.9 billion miles (7.9 billion km) spiraling in – not a straight line.
- Planetary flybys: Earth (once), Venus (twice), **Mercury (3x).**
  - Help us modify trajectory with less fuel.
  - Mercury flybys provided new views of planet but…
- 5 Deep Space Maneuvers (course corrections).
- Top speed during cruise ~140,000 mph (225,300 km/hr).

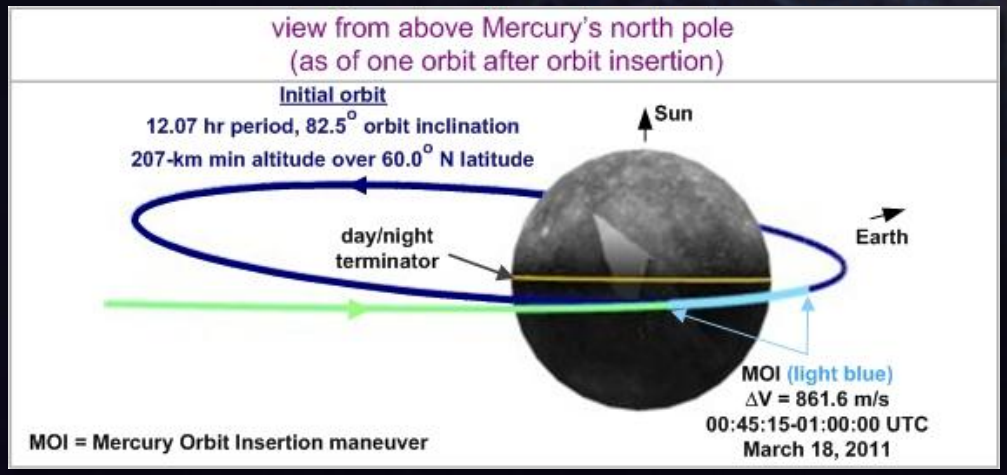


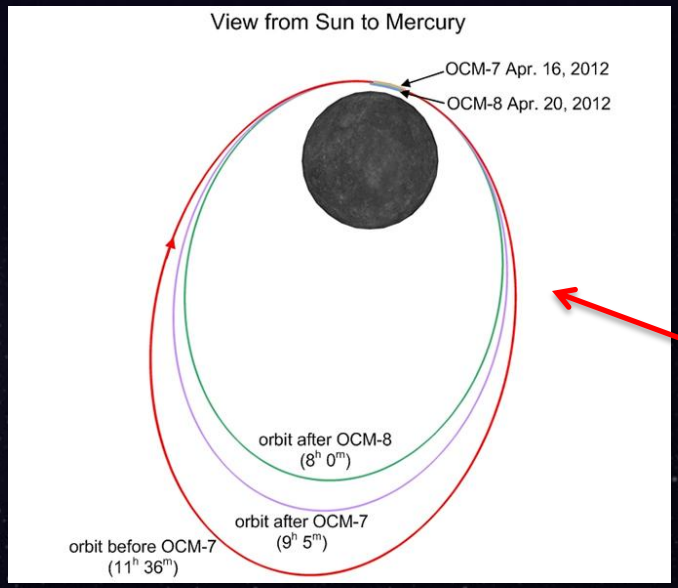
Mariner 10 and MESSENGER Flyby Images

MESSENGER's three flybys provided new images of Mercury, but the equatorial flybys did not provide good image coverage of the polar regions.

How do the "radar-bright" features compare to this image of Mercury's north polar region?

Getting into Mercury Orbit

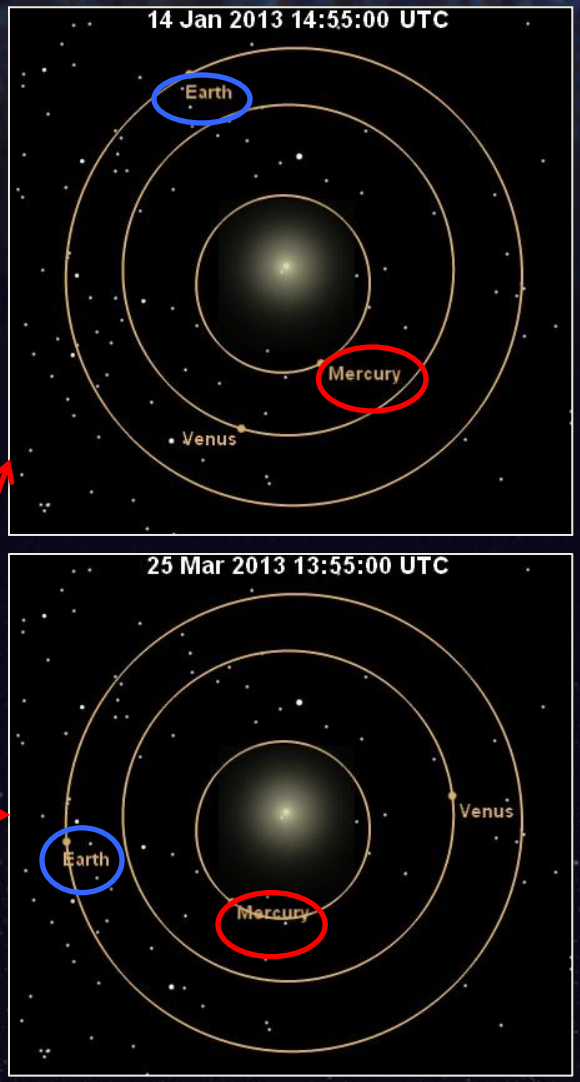




- March 18, 2011
- 30% of total onboard propellant was used to put MESSENGER in orbit around Mercury.
- Had to slow down by ~830 m/s (1,856 mph).
- 12-hour elliptical orbit:
  - Closest point: 200 km (124 mi)
  - Farthest point: 15,000 km (9,320 mi)
- Maneuvers to change to 8-hour period March 2012.

Operating in Mercury Orbit

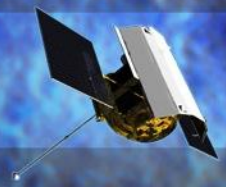
- New challenges:
  - Temperature: hot!
  - Power: some orbits have eclipse – no Sun on solar panels.
  - Spacecraft pointing: cannot point towards Sun.
  - Science priorities: many, and can change over time.
  - High command and data volume.
  - Orbital Correction Maneuvers
  - Variable data acquisition and downlink rates, depending on position of Earth and Mercury.



Solar Conjunction; no communication when Mercury within ~3 deg of Sun.

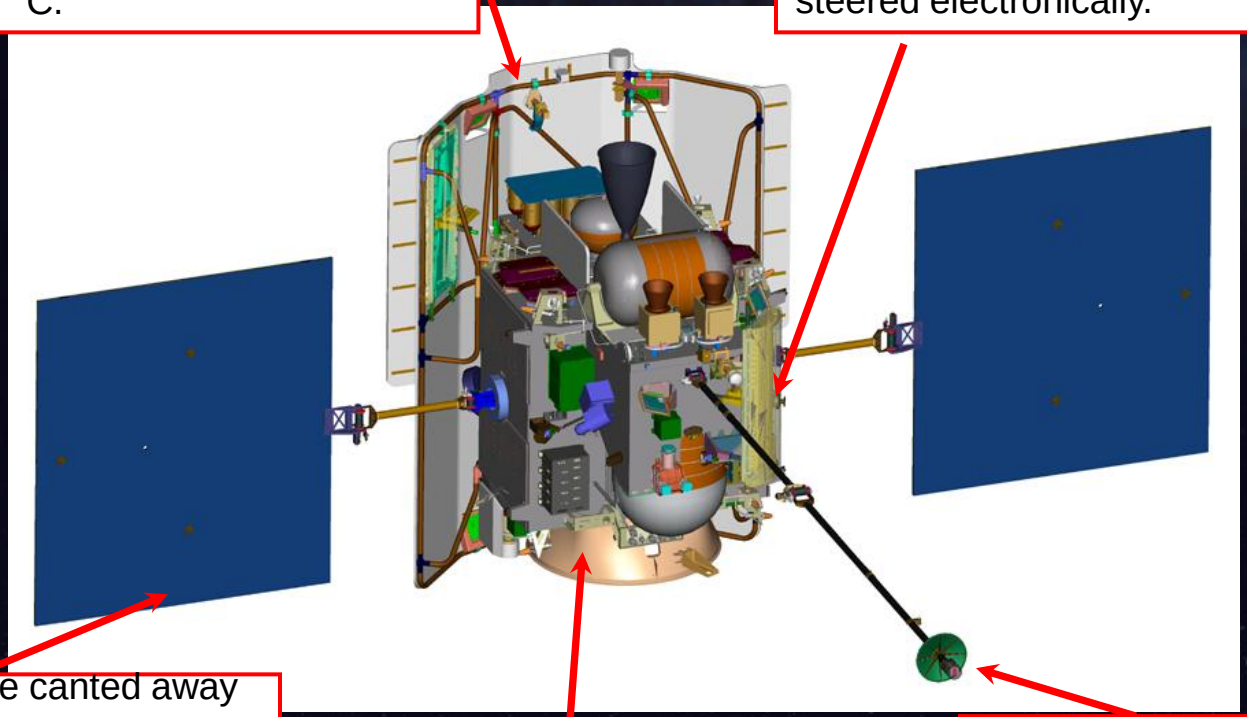
Mercury and Earth relatively close together; excellent communication uplink and downlink rates.

Spacecraft



Sunshade protects the spacecraft and instruments. Its temperature will rise to over 300° C while the spacecraft interior is maintained at 20° C.

2 high-gain antennas are located on the sun and anti-sun sides of the spacecraft. Both steered electronically.

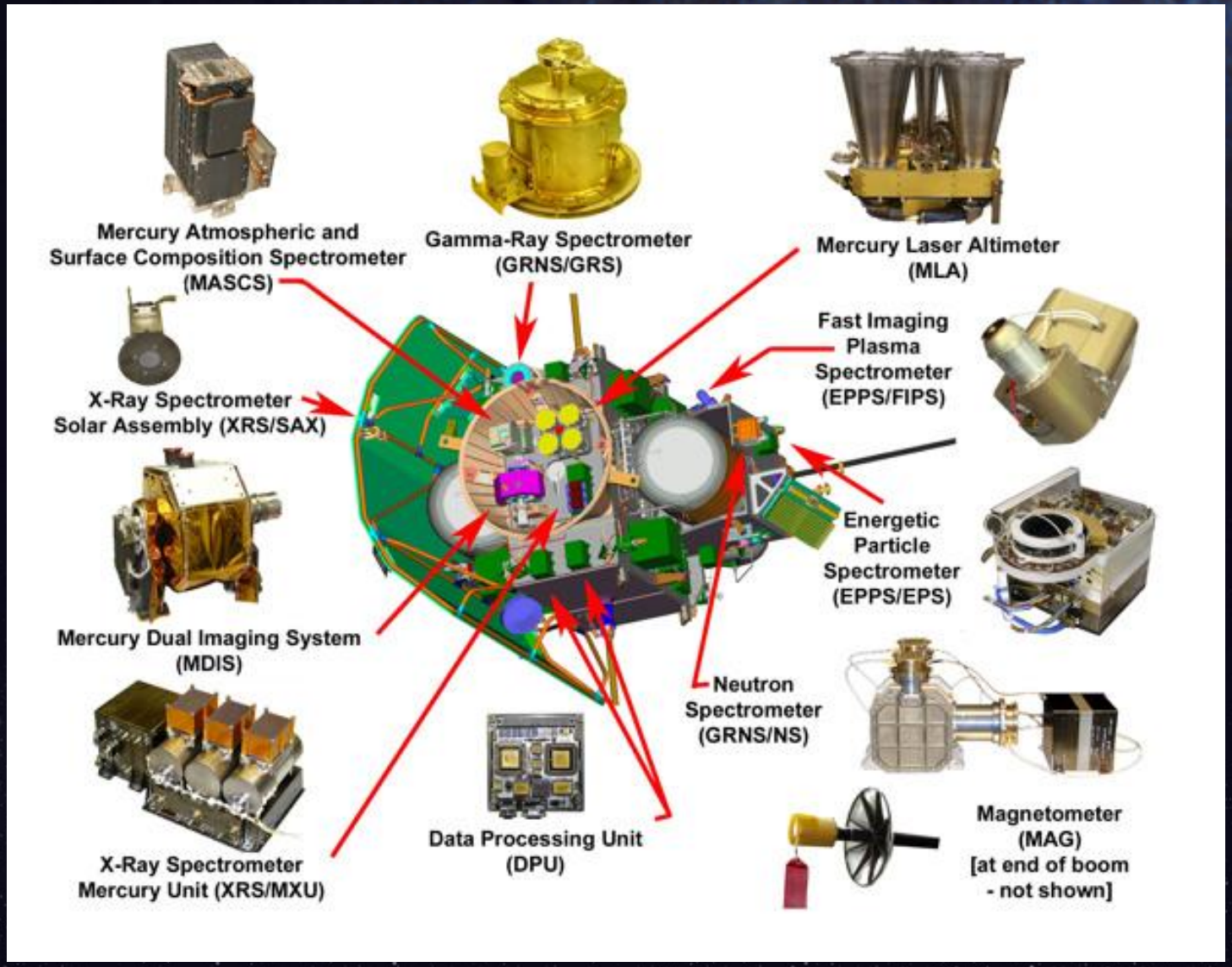


Solar arrays are canted away from the Sun at close distances. They can operate to 150° C but will reach 270° C at perihelion if left facing the Sun.

Most of the **science instruments** are located or alongside the launch vehicle adaptor.

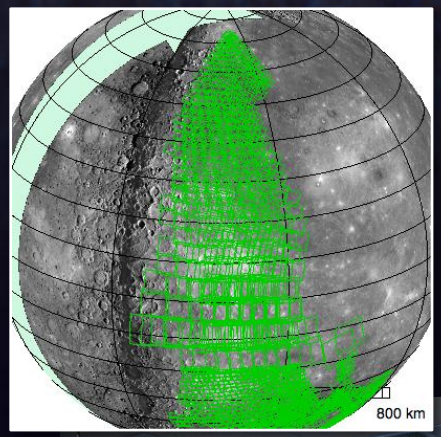
The **magnetometer** is on a boom to minimize interference from the spacecraft.

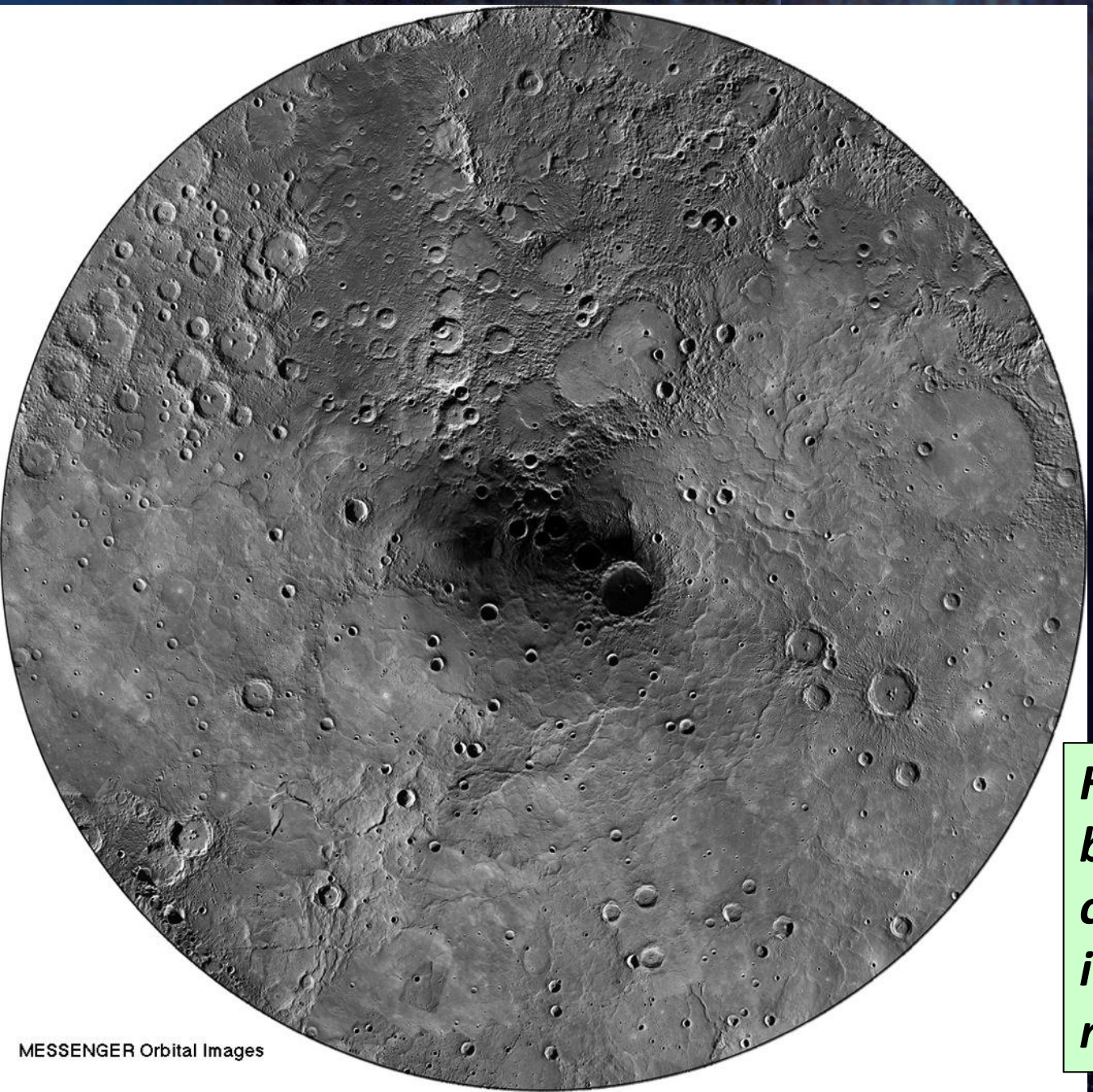
Science Instruments



Typical Planning Week

- What are the science priorities this week?
- How many images to take?
- How many commands to upload?
- What kinds of observations are we doing?
- What kinds of spacecraft activities?
- Any power/thermal issues?
- How much data volume?
- How many contacts with spacecraft?
- What meetings do we need to hold?

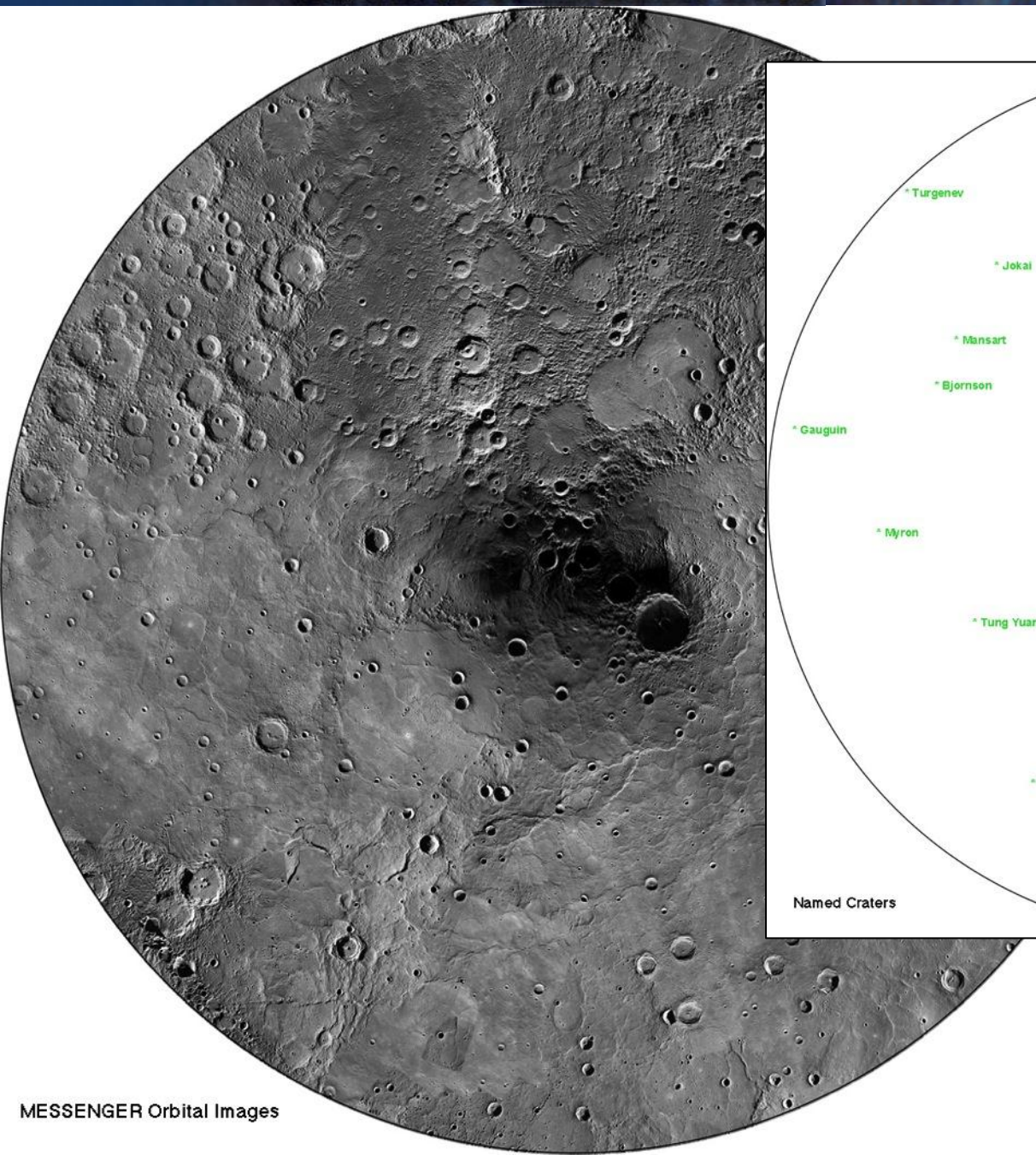


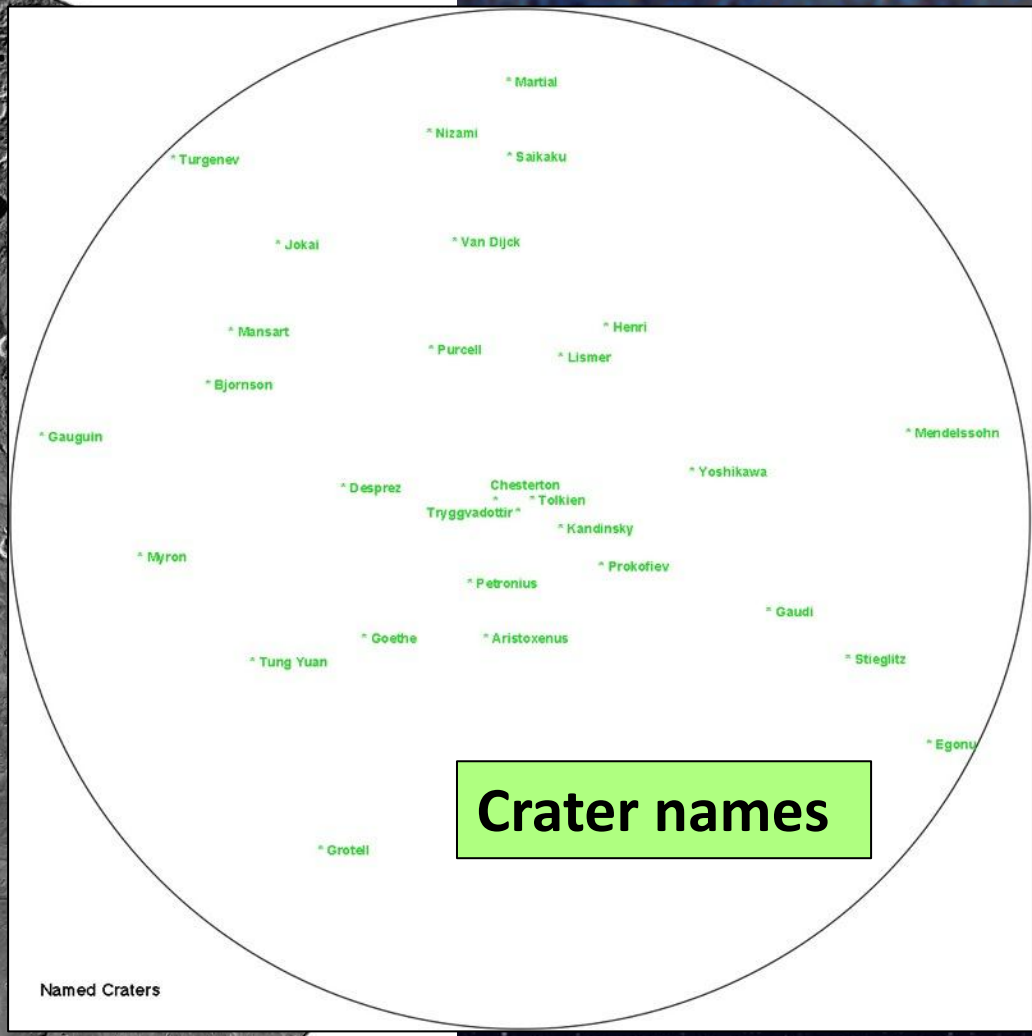


MESSENGER Orbital Images

MESSENGER orbital imaging provides a complete and detailed view of Mercury's north polar region for the first time.

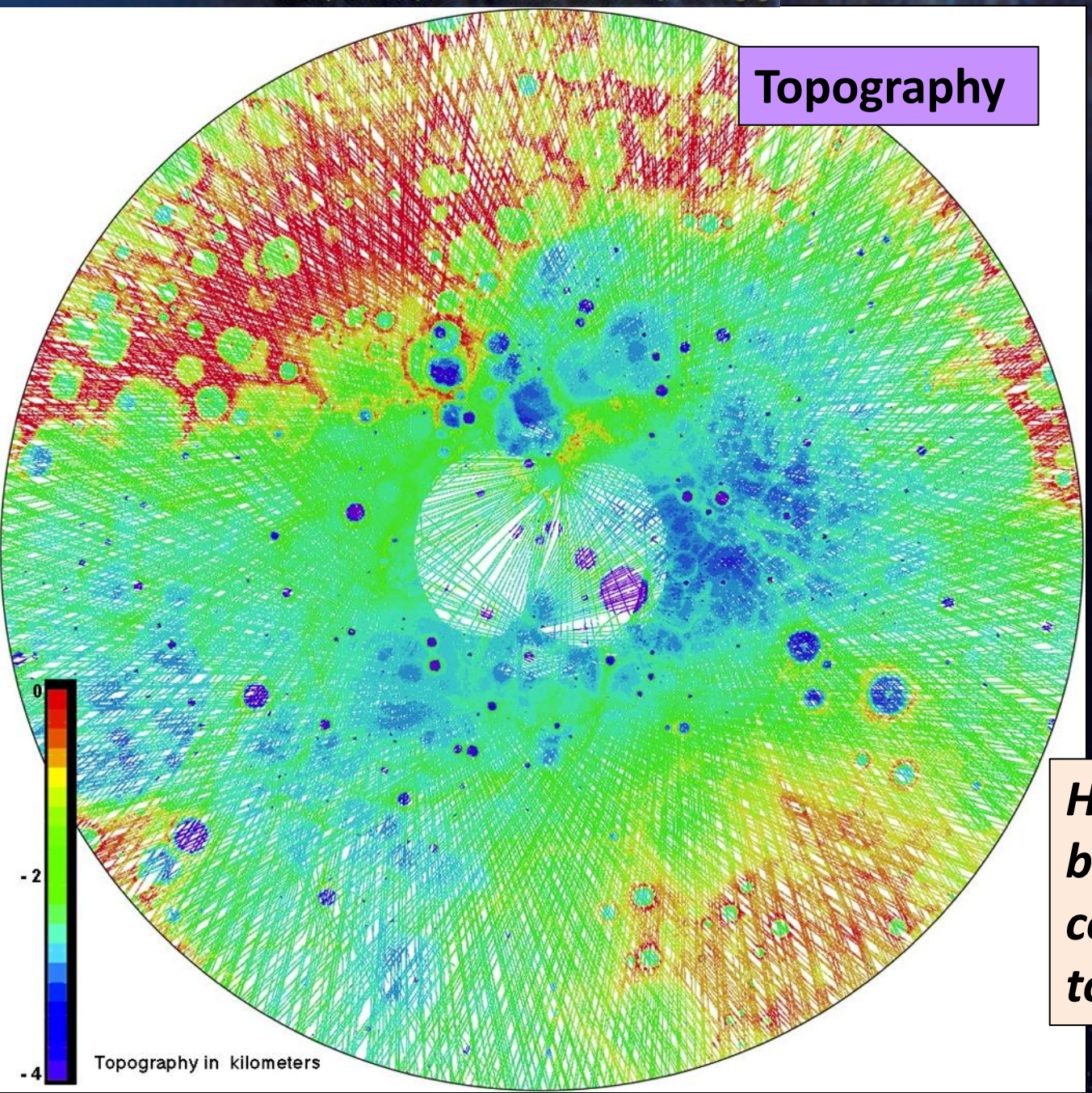
How do the "radar-bright" features compare to this image of Mercury's north polar region?





Crater names

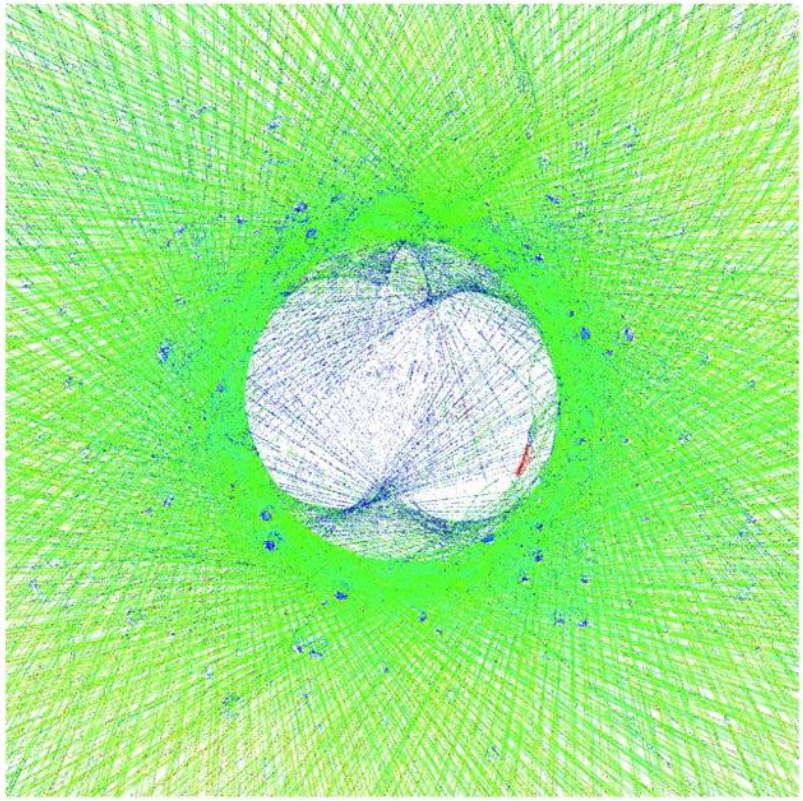
MESSENGER Orbital Images



In orbit, MESSENGER obtains measurements from other instruments, in addition to the images

How do the "radar-bright" features compare to the topography?

Reflectivity

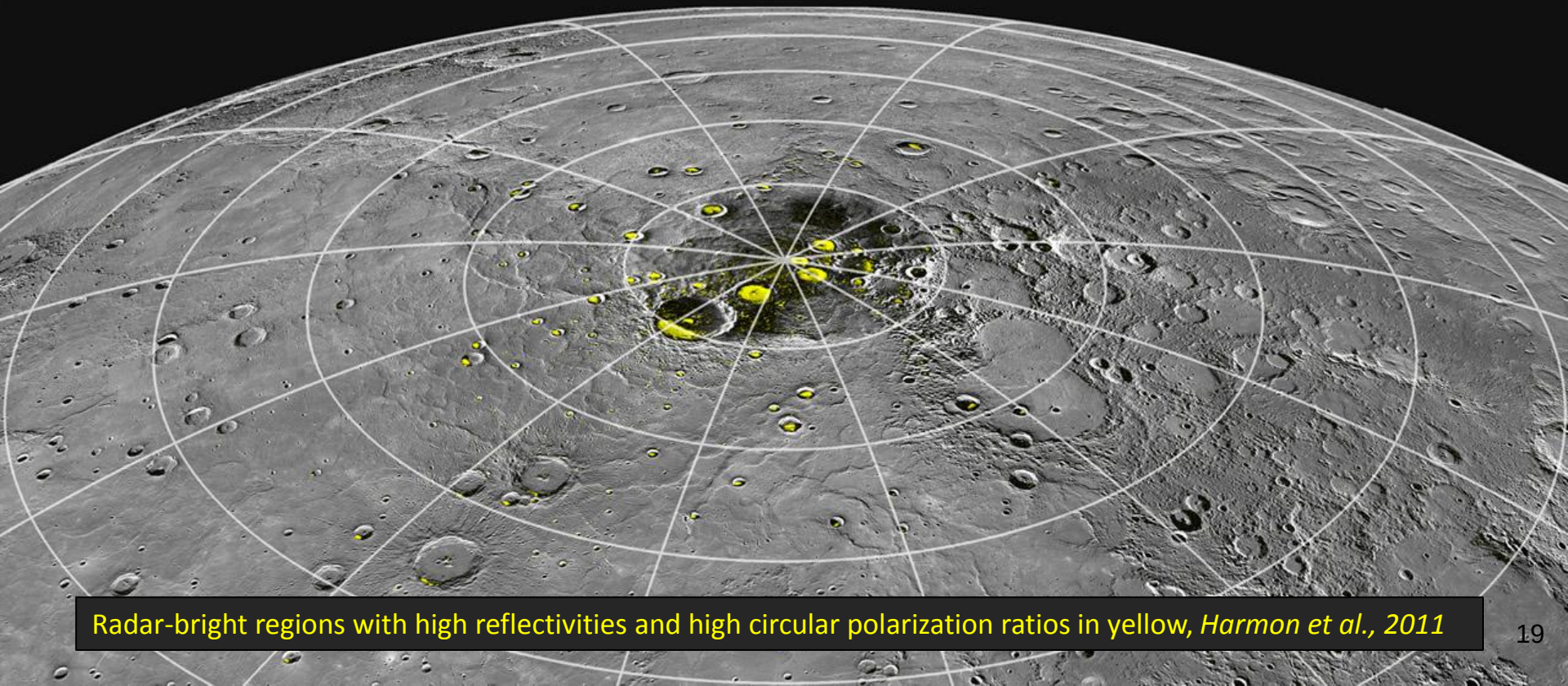


In orbit, MESSENGER obtains measurements from other instruments, in addition to the images

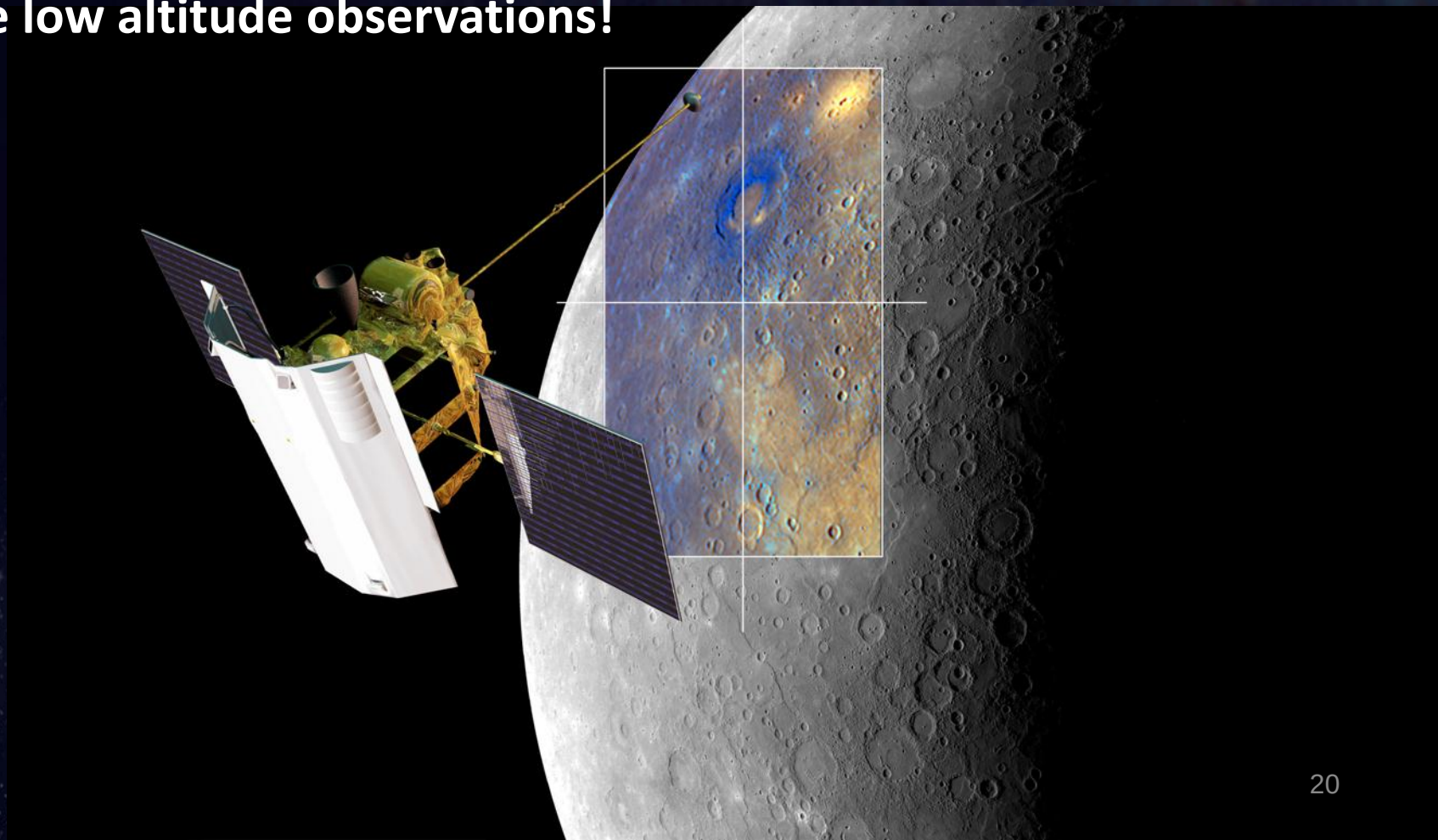
How do the "radar-bright" features compare to the surface reflectance?

Evidence for Water Ice at Mercury's Polar Regions

- **Earth-based radar shows "radar-bright" regions** (e.g. Harmon et al., 2011)
- **Radar-bright regions are shadowed** (e.g. Chabot et al., 2013)
- **Neutron spectrometry indicates H-rich material** (Lawrence et al., 2013)
- **Reflectance at 1064 nm shows bright & dark deposits** (Neumann et al., 2013)
- **Thermal models support the presence of water ice** (Paige et al., 2013)



Radar-bright regions with high reflectivities and high circular polarization ratios in yellow, *Harmon et al., 2011*

What Is MESSENGER Doing Now to Explore Mercury's Ice?

- Recent campaign to image the ice-bearing regions!
- More reflectivity measurements for more craters!
- Improved topography for thermal modeling!
- Future low altitude observations!