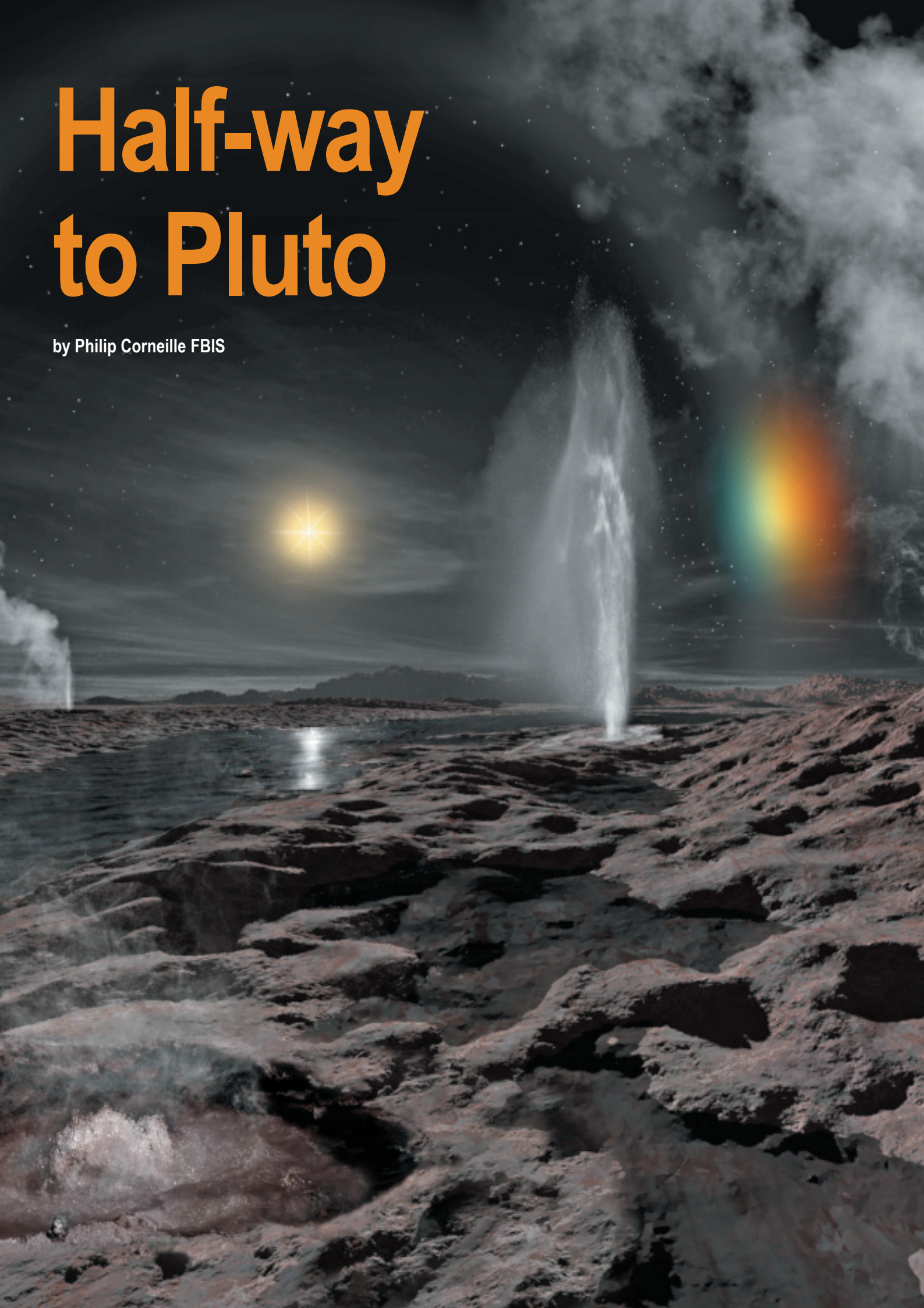


Half-way to Pluto

by Philip Corneille FBIS





Artist's concept of the New Horizons spacecraft as it approaches Pluto and its largest moon, Charon. Zipping through the outer solar system at nearly 1.5 million km per day, it will arrive at the dwarf planet by July 2015. The spacecraft's most prominent feature is the 2.1 m dish antenna, pointed towards a distant Earth at 7.5 billion km.

JHU-APL/SwRI

New Horizons, NASA's Pluto-bound spacecraft, was launched in January 2006 and got a gravity boost from the planet Jupiter in February 2007 toward its ultimate destination. In terms of distance the spacecraft was half-way in February 2010 but in terms of travel time New Horizons was halfway on 17 October 2010. Another half a decade wait before an exciting distant Pluto-Charon encounter in the Kuiper Belt by July 2015.

Pluto was discovered by the American astronomer Clyde Tombaugh (1906-1997) at the Lowell observatory (Flagstaff, Arizona) in February 1930 after an extensive search during which he compared photographic plates. Planets and asteroids appear in a different position against the background of stars on two different photo plates taken days apart.

The name chosen for the ninth planet was that of the Roman god of the underworld but it was also intended to evoke the initials of astronomer Percival Lowell (1855-1916), who predicted that a planet would be found beyond Neptune. Pluto has an orbital period of 248 years and its diameter of 2300 km

means it is smaller than Earth's moon.

In 1978, American astronomers James Christy and Robert Harrington discovered that Pluto has a satellite, which they named Charon. This moon, named after the ferryman of the underworld, is about half the size of Pluto and orbits the planet every 6.4 days. Given the rough similarity of Pluto's size to Charon, planetary scientists referred to Pluto-Charon as a double, or binary, planet.

In the late 1980s, Pluto and Charon underwent a set of mutual eclipses during which each body passed in front of the other repeatedly for several years. Based on data from these eclipses, computer models were able to make crude maps of each body,

Space artist Ron Miller's concept of hypothetical geysers and sundogs on Pluto. Astronomers discovered Pluto's molecular nitrogen atmosphere by observing the gradual dimming starlight during stellar occultations by the dwarf planet.
Ron Miller

New Horizons spacecraft passes milestone

which revealed that Pluto has polar caps and dark spots near its equator.

The first images of Pluto's surface were taken in July 1996 by the Hubble Space Telescope (HST). In 2005, new HST images lead to the discovery of two additional moons, provisionally designed S/2005 P1 and S/2005 P2. In June 2006, these moons were named by the International Astronomical Union (IAU) as Nix (Greek Goddess of darkness) and Hydra (Nine-headed serpent guarding the underworld) so their initials were these of the New Horizons probe, which was launched in January 2006.

After a decade of lobbying by Dr Alan Stern of the Southwest Research Institute (SwRI), NASA gave the go-ahead for the New Horizons mission in November 2001. The first decadal survey in the new millennium by the US National Research Council had also placed a high priority on a mission to Pluto and beyond.

The unmanned 478 kg New Horizons spacecraft is a dual stabilisation mode probe, so it can operate in three axis — or spin-stabilized attitude control mode, a common feature for outer planet missions. The triangular 'thermos bottle' design of the space bus allows it to maintain safe operating temperatures in deep space.

The spacecraft is powered by Radio-isotope Thermoelectric Generators (RTG) mounted on an extended boom to minimise effects on the science suite. The RTGs convert heat from the radioactive decay of Plutonium-238 into electricity providing a power output of 200 Watts. RTGs provide continuous power in regions of space where the use of solar power is not feasible.

New Horizons carries backup devices for major electronics, star-tracking navigation cameras and data recorders. The probe has seven science instruments; Ralph and Alice are respectively visible/infrared and ultraviolet imaging spectrometers, a radio science experiment (REX) for atmospheric measurements, a solar wind and plasma spectrometer (SWAP), Pluto energetic particle spectrometer (PEPPSI), a long range reconnaissance telescopic imager (LORRI) and a student dust collector (SDC) to measure dust particles during the complete voyage across the solar system (*Spaceflight*, March 2006, p93 and June 2007, p222).

The total cost of the mission, including launch vehicle and a decade of science operations through the Pluto-Charon encounter is US\$700 million.

Status dispute

During the first decade of the 21st century,

Pluto's status as a planet came under dispute as a wave of 'icy object' discoveries in the Kuiper Belt was made thanks to systematic automated surveys by ground-based observatories.

Caltech astronomers Michael Brown, David Rabinowitz and Chad Trujillo had located several frozen Pluto-like worlds beyond the orbit of Neptune; Quaoar (2002 LM60), Sedna (2003 VB12) and Eris (2003 UB313).

As the latter was even larger than Pluto, the IAU adopted a new definition of 'planet' and both Pluto and Eris became a 'dwarf planet'. A so-called dwarf planet is defined as a celestial body that (a) is in orbit around the Sun, (b) has sufficient mass for its self-gravity to overcome rigid body forces so that it assumes a hydrostatic equilibrium (nearly round) shape, (c) has not cleared the neighbourhood around its orbit, and (d) is not a satellite.

Since August 2006, the new view of the solar system is four terrestrial planets, the asteroid belt, four gas giants and hundreds of 'Plutoids', the IAU name for dwarf planets in the outskirts of the solar system.

Trans-Neptunian objects

Between May and August 2006, New Horizons passed the asteroid belt, a concentration of small rocky celestial bodies between the orbits of Mars and Jupiter, extending from 2.1 to 3.3 Astronomical Units (AU) from the Sun (1 AU, the mean distance between the Earth and the Sun, is 150 million km).

Since 1801, many thousands of asteroids have been catalogued, each with a name and number representing the order in which they were discovered. Asteroids come in many shapes and sizes but the sizes drop rapidly, with the largest asteroid 1 Ceres (975 km diameter) being twice as large as the next largest 4 Vesta (575 km diameter).

Moreover, the largest asteroid Ceres is now considered a dwarf planet and some astronomers even suggested it might be an interloper of the Kuiper Belt, a ring shaped region extending from the orbit of Neptune (30 AU) out to 50 AU.

Dutch-American planetary scientist Gerard Kuiper (1905-1973) predicted the existence of this region as the place of origin for short period comets. The first observational evidence for this icy torus (doughnut shape) was the discovery of a faint object designated 1992 QB1 by astronomers David Jewitt and Jane Luu in August 1992. Since then, hundreds of Kuiper Belt Objects (KBO) have been detected.



Painting by Ed Hengeveld showing the New Horizons spacecraft during its July 2015 flyby of Pluto and its three moons. Radio signals will take 4.5 hours to reach Earth.

First glimpse

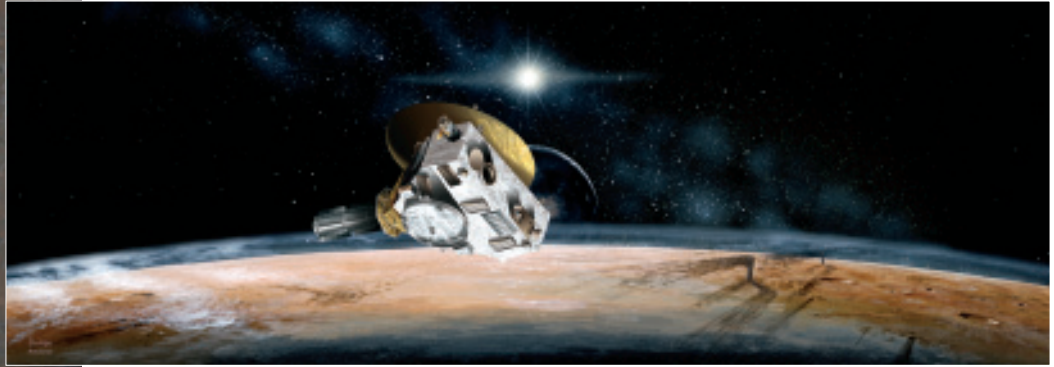
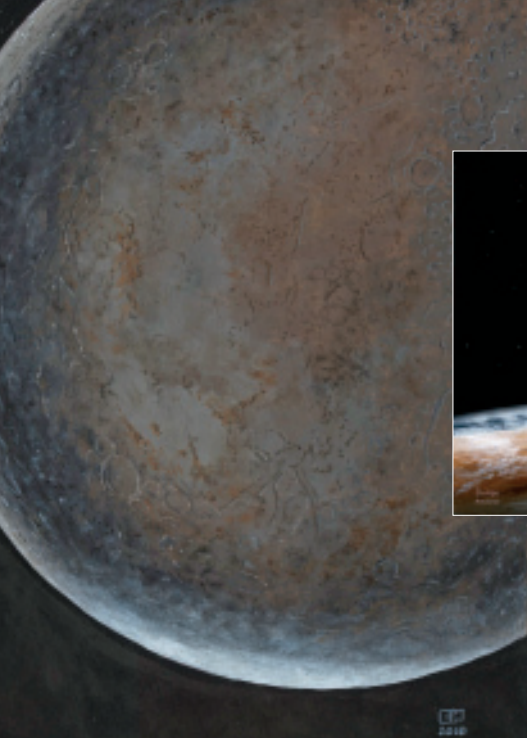
By September 2006, New Horizons' LORRI camera spotted the very first glimpse of Pluto during an optical navigation test, demonstrating that it can find distant targets, a critical capability the team will use to navigate toward the dwarf planet and other KBOs.

The spacecraft also performed flawlessly in February 2007, when it zoomed within 2.3 million km of the planet Jupiter to use the giant planet's gravity to speed toward the outer edge of the solar system.

Scientists noted a less turbulent equatorial region compared with older photos of Jupiter taken during the six previous encounters; Pioneer 10 (December 1973), Pioneer 11 (December 1974), Voyager 1 (March 1979), Voyager 2 (July 1979), Galileo (December 1995) and Cassini-Huygens (November 2000).

In June 2008, New Horizons passed the orbit of Saturn and the spacecraft performed a short but important course-correction manoeuvre in July 2010 to keep it on track. The next milestones will be the crossing of Uranus' orbit on 18 March 2011 and Neptune's orbit on 24 August 2014. Closest encounter operations with Pluto-Charon will begin in April 2015.

The New Horizons spacecraft has five major science objectives — (1) map the surface composition of Pluto and Charon, (2) map the temperatures, (3) characterise geology and morphology of Pluto-Charon, (4) study the atmosphere of Pluto, and (5) search for rings and additional satellites around Pluto.



Artist's impression of New Horizons' flyby of Pluto. The craft will characterise the global geology and geomorphology of the Pluto-Charon system, map surface compositions and temperatures, and examine Pluto's atmosphere in detail.

JHU-APL/SwRI

Furthermore, the spacecraft is to conduct similar investigations of one or several KBOs as the power output of the RTG will keep it working for about 10 years after the 2015 Pluto flyby.

The busiest part of the Pluto-Charon encounter will last a full Earth day, on 14 July 2015, from 12 hours before closest approach to a half-day after.

Inbound to the binary KBO, New Horizons will check ultraviolet emission from Pluto's atmosphere and make global maps of the planet and its satellite in red, green, blue and a special wavelength sensitive to methane frost on the surface.

During the half-hour when the space probe will be closest to Pluto, it will take close-up pictures in both visible and near-infrared wavelengths. The best pictures should depict surface features of 60 m across.

When the spacecraft has passed Pluto-Charon, it will look back to spot haze in the atmosphere, conduct radio occultation

experiments and look for rings. New Horizons could then be retargeted for an encounter with yet another KBO.

Planetary scientists and astronomers expect that the very first voyage to the farthest zone of the solar system could confirm Pluto as a prototype for a class of Trans-Neptunian Objects (TNO).

Almost 20 years after the first observational evidence of TNOs, astronomers have divided these objects in two subpopulations; (1) KBO between 30-50 AU and (2) Scattered Disc Objects (SDO) between 50 and beyond 100 AU. The latter is a dynamic environment as SDOs are scattered into inclined orbits above/below the ecliptic plane by gravitational interactions with Neptune and the other gas giants.

The orbit of Eris (2003 UB313), the largest dwarf planet known in the solar system, lays between 37 to 97 AU with an inclination of 44 degrees to the solar system's main plane. Eris was classified as an SDO with an orbital period of 557 years.

The most distant object known in the solar system, Sedna (2003 VB12), orbits the Sun between 76 and 960 AU with an orbital period of 12,000 years and was described as

the first observed body of the inner Oort cloud.

Dutch astronomer Jan Oort (1900-1992) proposed that our Sun is surrounded by a distant swarm of deep frozen bodies, which could be the place of origin for long-period comets. Although there's no direct observational evidence of this hypothetical spherical shell of 'dirty snowballs', astronomers consider it as a third reservoir of TNOs. The Oort cloud is estimated to occupy the space between 2000 and 50000 AU, although some astronomers estimate the outer edge to about one light year (63240 AU) or beyond 100000 AU.

New dawn

Next year, NASA's Dawn mission, which was launched in September 2007, will rendezvous with 4 Vesta, the brightest object in the asteroid belt.

After the encounter with Vesta, Dawn will continue toward 1 Ceres, the largest and most massive body in the asteroid belt. Due to the new IAU definition, Ceres is regarded as the only dwarf planet in the asteroid belt and the smallest of the lot (Eris, Pluto, Haumea and MakeMake are KBO-dwarf planets).

Dawn is planned to arrive at Ceres in February 2015 to study this embryonic planet with a rocky core and a mantle of water ice.

Both Dawn and New Horizons, in combination with ground-based surveys, will help astronomers better understand the rocky planet formation process by accretion (collisional and gravitational accumulation) and get a broader view in the universe's planet-forming menagerie.

By 2015, Pluto will be once more in the spotlight as a harbinger of the mysteries that await on the far edge of the solar system. For now, Pluto is the only known KBO with multiple moons, but as history indicates, it is likely to be just our first glimpse of other incredible scientific finds on the planetary frontier.

The 120 degrees tilt in Pluto's rotational axis creates very large seasonal variations. As surface ices melt in the migrating sunlight, their gases are transported and redeposited in dark, cold surface regions as frost.

Ron Miller

