CASSINI: SCIENCE HIGHLIGHTS FROM THE EQUINOX AND SOLSTICE MISSIONS. L. J. Spilker[1], [1]Jet Propulsion Laboratory/California Institute of Technology, 4800 Oak Grove Dr., M/S 230-205, Pasadena, CA 91109, Linda.J.Spilker@jpl.nasa.gov.

Introduction: The Cassini-Huygens exploration of the Saturn system has returned a wealth of scientific data on Titan, Enceladus, and the other icy satellites, Saturn, the rings, and the magnetosphere. Cassini-Huygens arrived at Saturn in July 2004, roughly two years after the northern winter solstice, and has been in orbit around Saturn through spring equinox (August 2009), to date completing its Prime and Equinox Missions, and the first year of its Solstice Mission.

After more than seven years of close study, Cassini still unveils new scientific discoveries that continue to amaze us. Some highlights of recent discoveries are given below.

Vertical Structure in Saturn's Rings at Equinox: On Aug. 11, 2009 sunlight hit Saturn's rings exactly edge-on, making them all but disappear. For a few weeks around Saturn equinox, which occurs only once every 15 years, the Cassini's science instruments looked for vertically extended, three-dimensional structures in Saturn's rings caught in the low-angle lighting. Numerous vertically extended regions were discovered and the shadows of their undulations and ridges were used to measure their height and breadth. The heights of some of the newly discovered vertical formations are over 4 km. At the same time, the composite infrared spectrometer (CIRS) was measuring the rings' temperatures. During equinox, the rings cooled to the lowest temperature ever recorded.

Specular Reflection from Titan's Kraken Mare: On July 8, 2009 the visual and infrared mapping spectrometer (VIMS) detected the first specular reflection off a northern lake on Titan, confirming the presence of liquid on the part of the moon containing many large lakes. The extensive lake, called Kraken Mare, covers about 400,000 square kilometers, an area larger than the Caspian Sea, the largest lake on Earth. Titan's thick, hazy atmosphere blocks out reflections of sunlight in most wavelengths.

Titan Ice Volcano: Possible evidence for a Titan ice volcano was found in topography and surface composition data returned during a flyby of Titan. Most of the past flows observed on Titan could be explained using non-volcanic processes, such as rivers depositing sediment. For the 3-D radar map of Sotra Facula, however, cryovolcanism is the best explanation for two peaks more than 1,000 meters high with deep volcanic craters and finger-like flows (Fig. 1). Data from VIMS revealed the lobed flows have a composition different from the surrounding surface. There is no evidence of current activity at Sotra, but we plan to continue to monitor the area with Cassini.

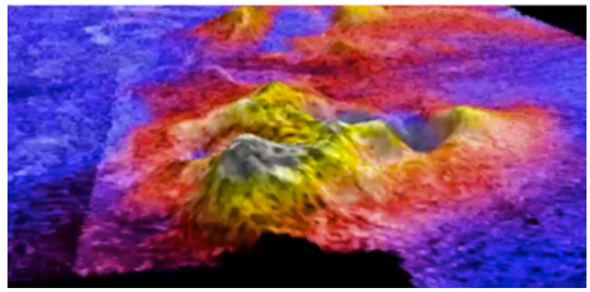

Fig. 1: Radar elevation map of Sotra region. White is highest elevation, blue is lowest elevation. The white regions are ~1 km above the blue regions.

Spring Brings Huge Saturn Storm: On Dec. 5, 2010, Cassini first detected a Saturn storm that raged for over eight months at ~35 degrees north latitude. Pictures from Cassini's imaging cameras showed the storm wrapping around the entire planet covering approximately 4 billion square kilometers, about eight times the surface area of Earth. Both professional and amateur astronomers also observed the storm, complementing Cassini data. The visible signs of the storm disappeared in July although a far infrared signature remains as the turbulent atmosphere equilibrates.

The sounds of the new storm's lightning strikes were analyzed using data from the radio and plasma wave science (RPWS) instrument which showed the lightning flash rate as much as 10 times more frequent than during other storms monitored since Cassini's arrival in 2004. At its most intense, the storm generated more than 10 lightning flashes per second.

Spring Rain Transforms Titan's Surface: Spring brought huge showers to Titan, soaking its surface. Methane rain fell in the equatorial deserts, and its effects were clearly seen in Cassini's images. Extensive rain from large cloud systems, spotted by Cassini's cameras in late 2010, darkened a portion of the equatorial region. The best explanation is these areas remained wet after methane rainstorms. These surface changes appear to be an effect of the changing seasons. Later observations show the surface drying out and returning to its earlier appearance.

Mimas thermal anomaly: A detailed temperature map of the small inner moon Mimas was obtained by CIRS during a February 2010 flyby. The temperature distribution was completely unexpected; the leading hemisphere has a higher thermal inertia (warms up more slowly during the day and cools off more slowly at night) than the trailing hemisphere, with a sharp, Vshaped boundary between them. We expected smoothly varying temperatures that peaked in the early afternoon near the equator. Instead, the warmest region was in the morning making a sharply defined Pac-man shape (Fig. 2). Retrograde energetic electrons interacting with the leading hemisphere are might increase the surface thermal inertia.

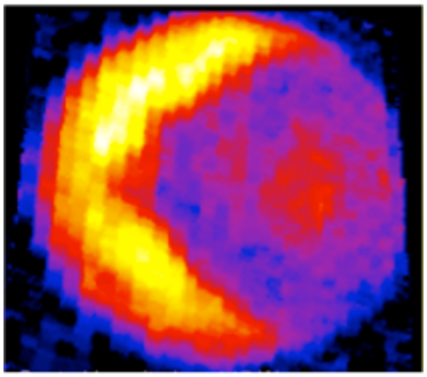

Fig. 2: Mimas thermal anomaly. Yellow is warm (~95K), blue is cool (~78 K).

Modulation Periods of Saturn Kilometeric Radiation in the Northern and Southern Hemispheres of Saturn: One interesting magnetospheric discovery in 2009 was the different and changing modulation periods of Saturn kilometric radiation (SKR) in the Northern and Southern hemispheres of Saturn. The SKR modulation was initially faster in the Northern hemisphere and slower in the Southern hemisphere. The differences in the radio wave periods are not caused by the two hemispheres physically rotating at different rates but more likely come from variations in high-altitude winds at high latitudes. The two SKR periods crossed over in March 2010 and the faster period is now in the Southern hemisphere. As the sun continues to climb in the south the period of the southern radio signals continues to decrease while the period of the northern radio signals is increasing. It is clear that the magnetic field external to the planet is not directly coupled to the interior and the external magnetosphere slips with respect to the internal rotation of the planet.

Ripples in the Rings: Revealing ripples in the rings of Saturn and Jupiter point to past collisions with cometary fragments dating back 10 years or more. For the Jovian rings, the ripple-producing agent was comet Shoemaker-Levy 9, whose debris cloud swept through the thin Jupiter ring system during its collision with the planet in July 1994. Saturn's ripples are attributed to a similar but unidentified object, likely another cloud of comet debris, that plunged through the inner rings in the second half of 1983.

Enceladus Ocean Spray: Using data from three Enceladus flybys in 2008 and 2009 the cosmic dust analyzer discovered the best evidence yet for a large-scale saltwater reservoir beneath the icy crust of Enceladus. The data came from direct analysis of salt-rich ice grains close to the jets ejected from the moon.

Data from CDA show the grains expelled from Enceladus' tiger stripes are relatively small and predominantly low in salt far away from the moon. But closer to the moon's surface, CDA found that relatively large grains rich with sodium and potassium dominate the plumes. The salt-rich particles have an "ocean-like" composition and indicate that most, if not all, of the expelled ice and water vapor comes from the evaporation of liquid salt water.

Solstice Mission: Cassini has now completed the first year of a seven-year phase called the Solstice Mission, which will return science in a hitherto unobserved seasonal phase from equinox to solstice. The Solstice Mission continues to provide new science; first, by observing seasonally and temporally dependent processes on Saturn, Titan, Enceladus and other icy satellites, and within the rings and magnetosphere; second, by addressing new questions that have arisen during the mission thus far, for example providing qualitatively new measurements of Enceladus and Titan which could not be accommodated in the earlier mission phases; and third, by conducting a close-in mission at Saturn that would provide a unique comparison to the Juno observations at Jupiter.

Proximal Orbits: The final 42 orbits of the Cassini Solstice mission will offer unique opportunities for new discoveries and groundbreaking science as well as further prospects to observe seasonal and temporal change. This Proximal orbit phase, proceeded by multiple orbits passing close to Saturn's F ring, is similar in many ways to the Juno mission at Jupiter. The final orbits are situated in between the innermost ring and the top of Saturn's atmosphere. This phase would end with the spacecraft ultimately vaporizing in Saturn's atmosphere in accord with anticipated planetary protection requirements.

These orbits enable unique science, including: determination of Saturn's internal structure, the higher order moments for both the gravity and magnetic fields, and possibly the internal rotation rate for Saturn; measurement of Saturn's ring mass, currently uncertain by about an order of magnitude; in situ measurements of Saturn's ionosphere, innermost radiation belts, and D ring, and possibly in situ measurements of Saturn's auroral acceleration region; highest resolution studies of the main rings; and high resolution Saturn atmospheric studies. The Cassini magnetometer would determine the higher order coefficients of the magnetic field which may allow a determination of the depth of Saturn's metallic core. This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with NASA. Government sponsorship acknowledged.