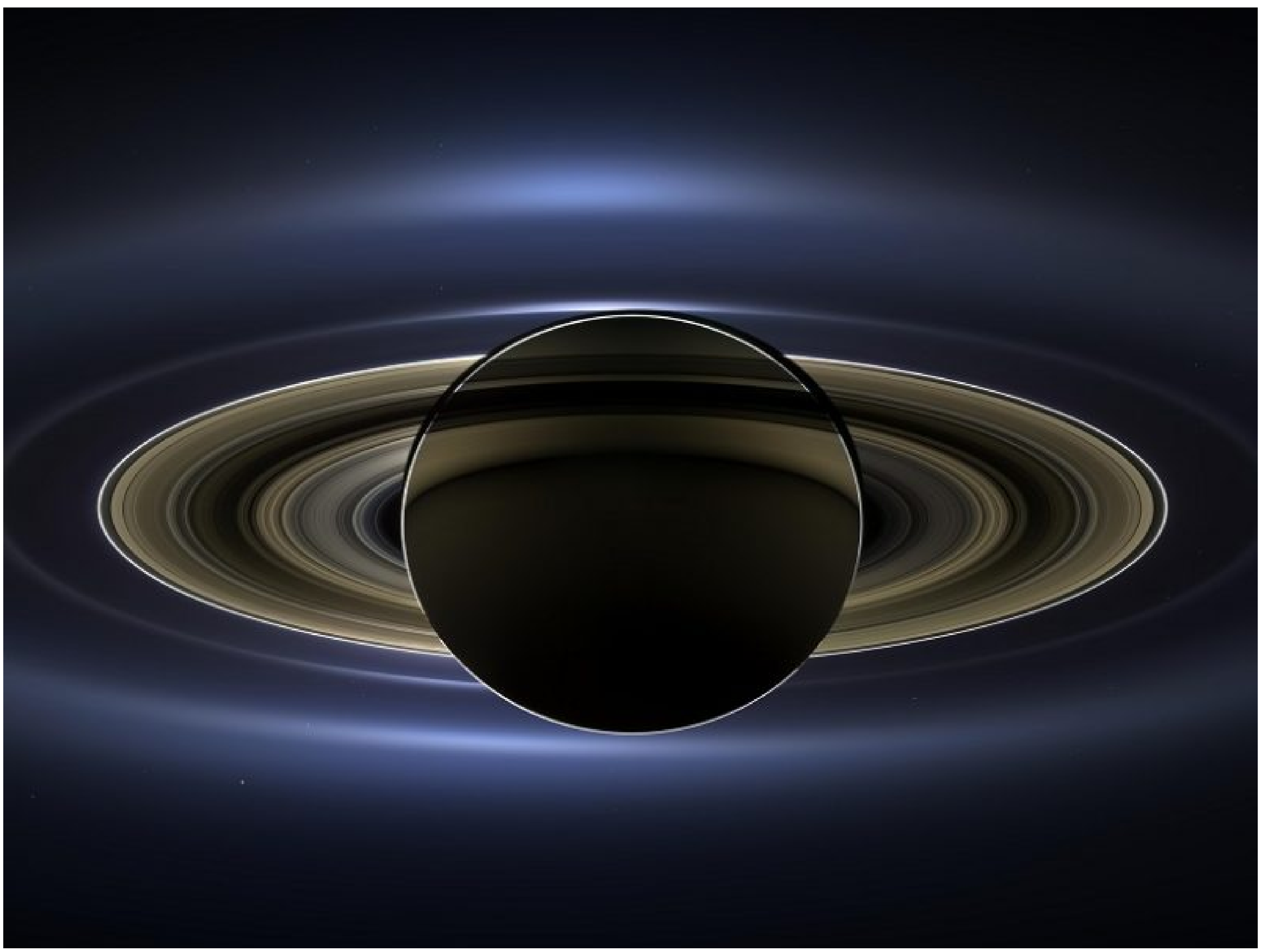
Editors' Vox

Perspectives on Earth and space science: A blog from AGU's journal editors

Cassini's Legacy in Print

With over 750 papers published in AGU journals based on Cassini-Huygens mission data, three editors select some of the most noteworthy.



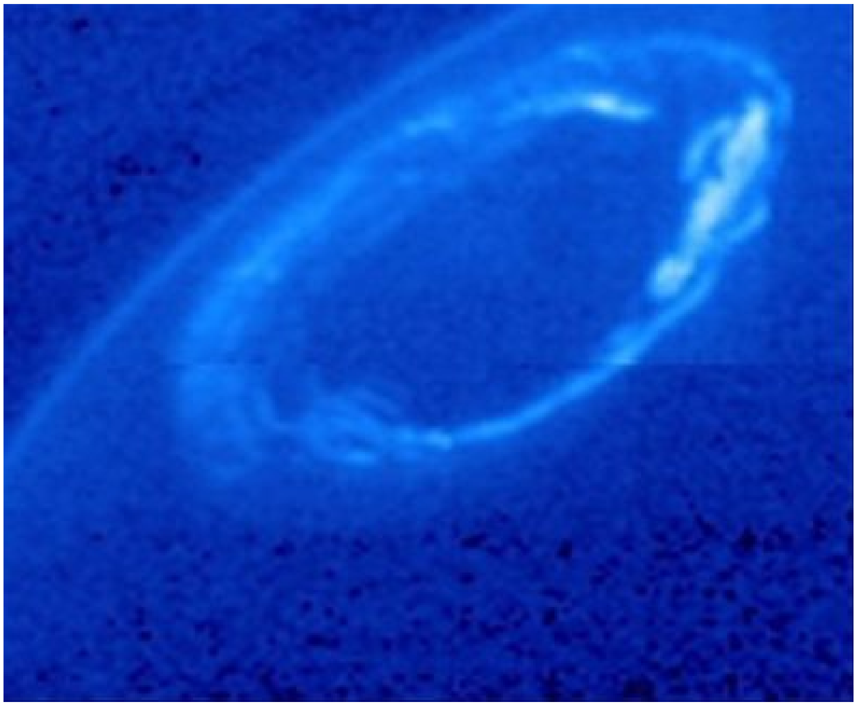
Cassini took 453,000 images, one of which was this spectacular perspective captured in 2013 when the spacecraft slipped into Saturn's shadow and turned to image the planet, seven of its moons, its inner rings and, in the background, Earth. Credit: NASA/JPL-Caltech/SSI

By Jenny Lunn, Mike Liemohn, Mark Moldwin, and Elizabeth P. Turtleon 20 September 2017

After two decades of incredible exploration, the Cassini Mission (https://www.nasa.gov/mission_pages/cassini/main/index.html) to Saturn is now over (https://eos.org/articles/cassini-plunges-into-saturn-ends-a-20-year-mission). The Cassini spacecraft has beamed back images and vast amounts of data, first from its flybys of Earth, Venus and Jupiter, then from 13 years spent circulating the ringed planet and its moons, as well as insights from landing the Huygens probe on the surface of Titan, the largest moon.

According to NASA, 3948 science papers have been published as a result of the mission. A search for papers in AGU journals with Cassini mentioned in the abstract published since the mission started in 1997 generated more than 750 results across 6 different journals. We are very proud that AGU has played a significant role in publishing some of the important findings from the mission. We invited some of the editors to reflect on papers published in their journals and how they have contributed to our scientific understanding. A special collection of all the papers highlighted below can be found here (http://agupubs.onlinelibrary.wiley.com/hub/issue/10.1002/(ISSN)2169-9402.CASSINI1/).

Mike Liemohn, Editor-in-Chief, *Journal of Geophysical Research: Space Physics*



An ultraviolet image captures an active aurora dancing around Saturn's north pole. Credit: NASA/JPL-Caltech/University of Colorado/Central Arizona College and NASA/ESA/University of Leicester and NASA/JPL-Caltech/University of Arizona/Lancaster University (https://photojournal.jpl.nasa.gov/catalog/PIA17900)

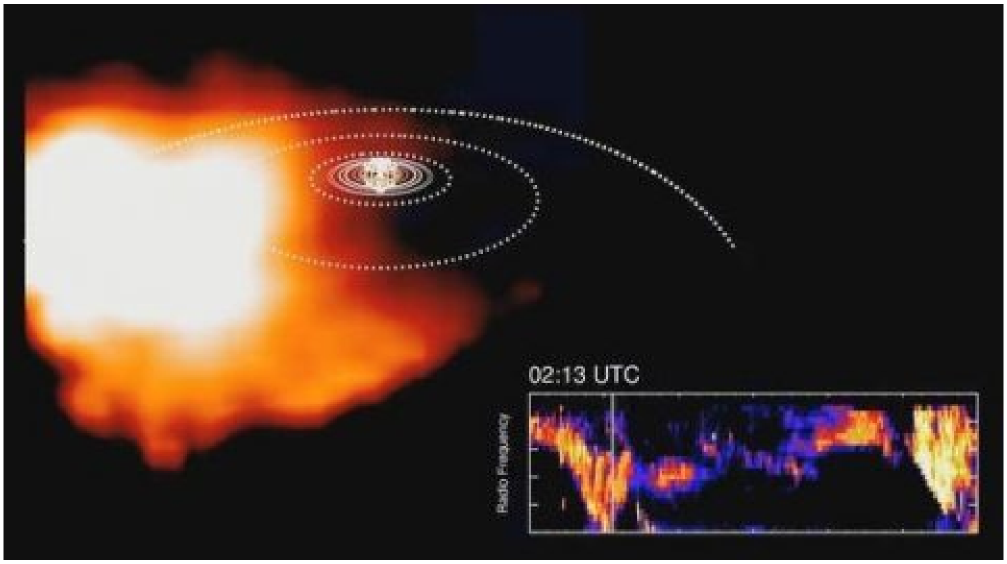
There are over 400 papers in *JGR: Space Physics* with Cassini mentioned in the abstract, so it is a rather difficult task to pick out just a few to highlight. Since one measure of impact is citations, here are a few reflections on the four most-cited Cassini papers.

We knew so little about Saturn's magnetosphere before Cassini that the initial papers published soon after orbit insertion were all "discovery studies" of never-before-seen phenomena. Only one of those initial papers makes the list, though; the other three came a few years later, when the first statistical analyses could be conducted.

In poll position, the most-cited paper is Schippers et al. [2008] (http://onlinelibrary.wiley.com/doi/10.1029/2008JA013098/abstract), who presented an analysis of the electrons seen by several instruments. A complementary study of the ion populations in Saturn's magnetosphere, second on the most-cited list, was conducted by Thomsen et al. [2010] (http://onlinelibrary.wiley.com/doi/10.1029/2010JA015267/abstract). In addition to the survey results describing the charged particles environment around Saturn, these studies also include detailed methodologies for handling tricky instrumentation obstacles: sensor intercalibration in the first case and moments calculations in the second.

The third most-cited paper, also related to the plasma environment of Saturn, is Cowley et al. [2005] (http://onlinelibrary.wiley.com/doi/10.1029/2004JA010796/abstract), who examined Cassini measurements in the magnetosphere in relation to Hubble Space Telescope observations of Saturn's aurora. It is an elegant explanation of spiral auroral structures being related to magnetic reconnection behind the planet in the magnetotail and the subsequent convection due to Saturn's fast rotation. It also demonstrated that solar wind dynamic pressure controls this magnetotail reconnection, rather than the direction of the interplanetary magnetic field, as is the case at Earth.

The fourth most-cited Cassini paper in the journal is about the famous question of the planetary rotational period [Kurth et al., 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2007JA012861/abstract)]. Much of the sphere that we call Saturn is a fluid, not a solid, and the "surface" that we see is really just the top of a particular cloud layer. This allows for something called differential rotation, in which different latitudes rotate at different rates, making it very difficult to determine a definitive and single planetary rotation rate.



Plasma swirling around Saturn is correlated to bursts of radio waves emanating from the planet. The image on the left was obtained by the ion and neutral camera, part of the magnetospheric imaging instrument, and the data on the right from Cassini's radio and plasma wave subsystem.
Credit: NASA/JPL/JHUAPL/University of Iowa (https://photojournal.jpl.nasa.gov/catalog/PIA13698)

One manifestation of this is in radio emissions from the auroral regions of Saturn, which exhibit a large-scale amplitude modulation that is very close to the nominal rotation period of 10.7 hours. This "daily" wax and wane of the radio emission slowly varies with time, and even more mysteriously, has different periods in the northern and southern auroral regions. This paper defines a Saturn longitude system timed with the radio emission modulations.

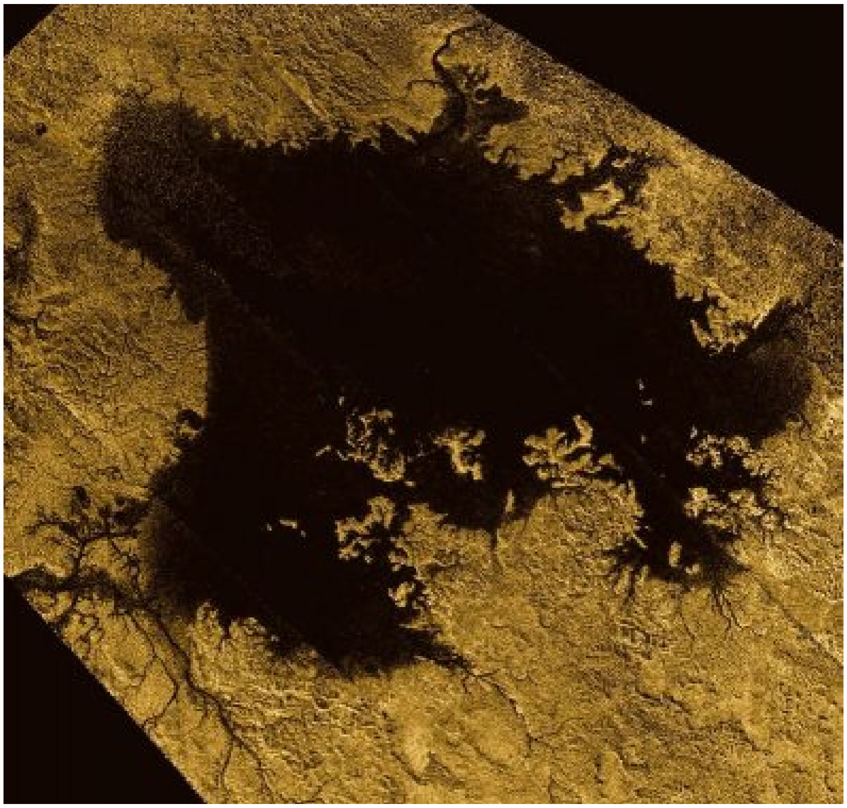
Mark Moldwin, Editor-in-Chief, ***Reviews of Geophysics***

As mentioned above, one of the most interesting aspects of the magnetosphere of Saturn that the Cassini Mission observed was that there are modulations in charged particles, magnetic fields, energetic neutral atoms, radio emissions, motions of the plasma sheet and magnetopause and even in the rings with periodicities near the rotation period of the planet of about 10.7 hours. However, these periodicities change by about 1 per cent over time scales of a year or longer and are different in the northern and southern hemispheres. The highest-cited paper in *Reviews of Geophysics* related to Cassini is Carbary and Mitchell [2013] (http://onlinelibrary.wiley.com/doi/10.1002/rog.20006/abstract) who reviewed the observations and the many models that have struggled to explain these puzzling periodicities.

Elizabeth P. Turtle, Associate Editor, ***Journal of Geophysical Research: Planets***

In over 13 years of exploring the Saturnian system, the Cassini-Huygens mission has completely revolutionized our understanding of Saturn, its magnetosphere, rings, and moons large and small. Over 70 manuscripts published in *JGR-Planets* to date illustrate the remarkable breadth and depth of the scientific discoveries that Cassini-Huygens has made possible, covering topics from the winds and vortices of giant Saturn itself [Vasavada et al. 2006 (http://onlinelibrary.wiley.com/doi/10.1029/2005JE002563/full)] to diminutive Enceladus' powerful cryovolcanic eruptions [Howett et al. 2011 (http://onlinelibrary.wiley.com/doi/10.1029/2010JE003718/full)] and interior dynamics [Barr 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2008JE003114/full)].

Developments in our understanding of Titan have had particular impact. In fact, eighty percent of the twenty most-cited *JGR-Planets* papers related to Cassini-Huygens present Titan results. Some of these wide-ranging papers address the behavior of the atmosphere [Teanby et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2008JE003218/full), Yelle et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2007JE003031/full), Mueller-Wodarg et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2007JE003033/full), Cui et al. 2012 (http://onlinelibrary.wiley.com/doi/10.1029/2012JE004222/full)].



Radar images capture Ligeia Mare, the second largest known body of liquid on Titan, one of the many seas and lakes in the moon's north polar region. Credit: NASA/JPL-Caltech/ASI/Cornell (https://photojournal.jpl.nasa.gov/catalog/PIA17031)

Others examine the tremendous level of complexity in the chemistry occurring on Titan revealed by *in situ* compositional measurements by Huygens [Niemann et al. 2010 (http://onlinelibrary.wiley.com/doi/10.1029/2010JE003659/full)] and Cassini [Mandt et al. 2012 (http://onlinelibrary.wiley.com/doi/10.1029/2012JE004139/full), Westlake et al. 2012 (http://onlinelibrary.wiley.com/doi/10.1029/2011JE003883/full)], combined with modeling [Vuitton et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2007JE002997/full), Horst et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2008JE003135/full)].

They also trace the long-awaited unveiling of Titan's surface, documenting the diversity of its geological structures and processes [Barnes et al. 2007 (http://onlinelibrary.wiley.com/doi/10.1029/2007JE002932/full), Le Mouelic et al. 2008 (http://onlinelibrary.wiley.com/doi/10.1029/2007JE002965/full), Mitri et al. 2010 (http://onlinelibrary.wiley.com/doi/10.1029/2010JE003592/full)], materials [Clark et al. 2010 (http://onlinelibrary.wiley.com/doi/10.1029/2009JE003369/full)], methane lakes and seas [Hayes et al. 2010 (http://onlinelibrary.wiley.com/doi/10.1029/2009JE003557/full)], and potential subsurface exchange via cryovolcanism [Lopes et al. 2013 (http://onlinelibrary.wiley.com/doi/10.1002/jgre.20062/full)].

Although the Cassini-Huygens mission is at an end, the wealth of data it has gathered will continue to fuel research on the Saturnian system and broader comparative planetology studies for decades to come.

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