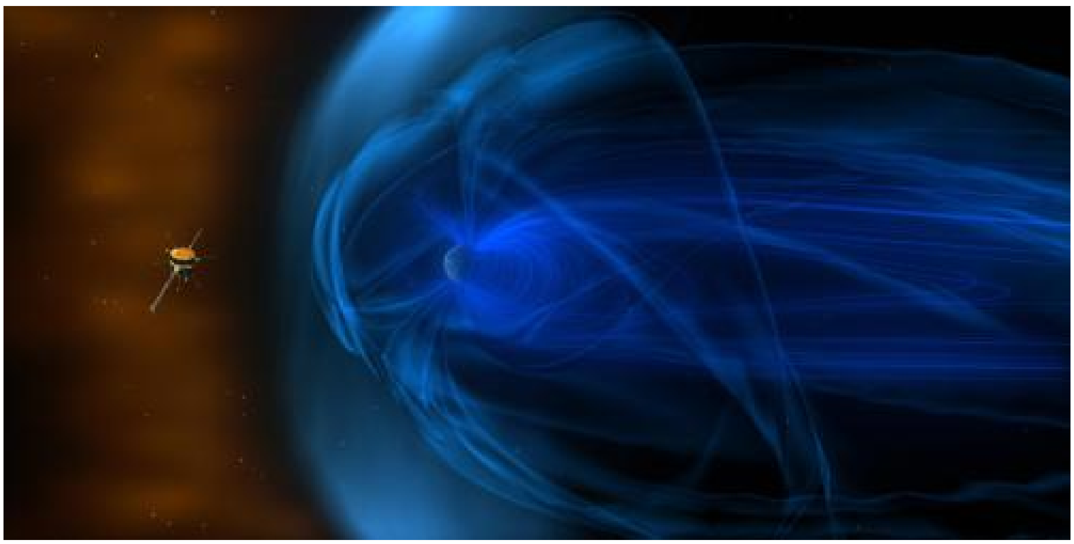
A solar wind workhorse marks 20 years of science discoveries

December 30 2014, by Karen C. Fox



The Wind spacecraft has spent much of its 20 years in space out in front of the magnetic fields – the magnetosphere – that surrounds Earth, observing the constant stream of particles flowing by from the solar wind. Credit: NASA

The end of 2014 marks two decades of data from a NASA mission called Wind. Wind—along with 17 other missions – is part of what's called the Heliophysics Systems Observatory, a fleet of spacecraft dedicated to understanding how the sun and its giant explosions affect Earth, the planets and beyond.

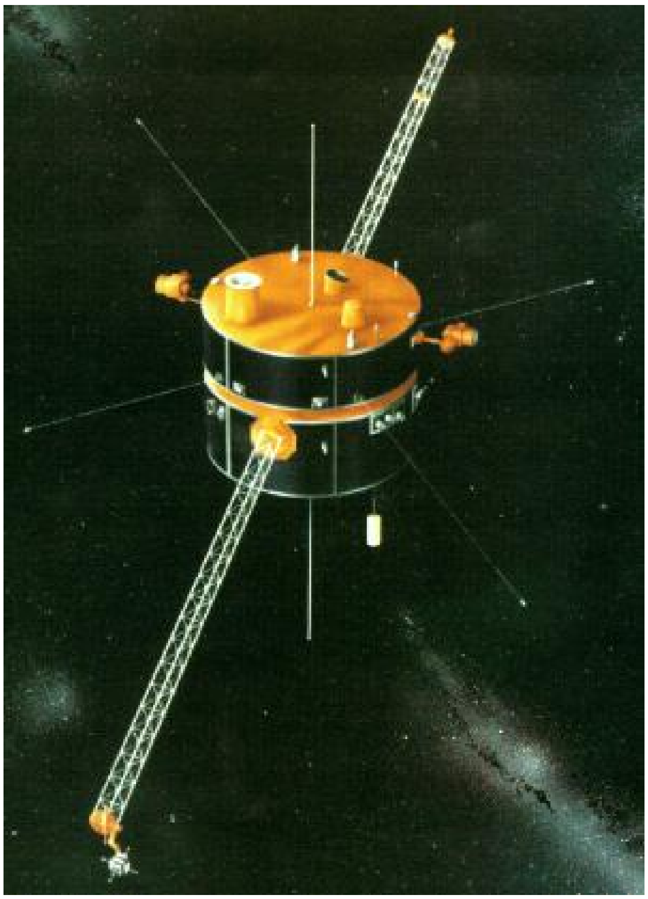
Wind launched on Nov. 1, 1994, with the goal of characterizing the constant stream of particles from the sun called the solar wind. With particle observations once every 3 seconds, and 11 magnetic measurements every second, Wind measurements were – and still are – the highest cadence solar wind observations for any near-Earth spacecraft.

During its more than 20 years in space, Wind has taken up position at various spots around our planet to help determine how near-Earth space interacts with incoming energy and particles from the sun. Assessing the complex variations of the charged particles making up the solar wind cannot be done from a single point in space. That would be like trying to understand the entire Earth's weather system from a single collection station in Washington, D.C. So, Wind was part of a game changing idea: launch several missions to work in tandem to understand how the dynamic magnetosphere surrounding Earth reacts to the sun. Sitting at a point between Earth and the sun, Wind was the vanguard, observing the solar wind.

"We had a fairly simple original objective," said Adam Szabo, the project scientist for Wind at NASA's Goddard Space Flight Center in Greenbelt, Maryland. "The number one question was to find out how the solar wind was driving changes in the magnetosphere."

The original flotilla, named the Global Geospace Science (GGS) campaign, was composed of the Polar spacecraft observing Earth's magnetosphere in high latitudes, Equator-S making equatorial magnetospheric measurements, and the Japanese Geotail patrolling the elongated magnetotail —the long ribbon of magnetosphere that trails behind Earth, away from the sun. The original GGS program was rapidly extended with additional missions to form the International Solar Terrestrial Program, or ISTP.

With its mandate to watch the frontlines, Wind was sent into orbit around what's called a Lagrangian point, a point that experiences balanced gravity from both the sun and Earth. Wind took up residence in an elliptical orbit around the first Langrangian point (L1), lying between Earth and the sun, some 932,000 miles away from Earth. While several satellites have since been in a similar orbit, Wind was only the second spacecraft ever to orbit L1.



Graphic of Wind spacecraft. Credit: NASA

In 1997, another solar wind monitor joined the L1 neighborhood. The Advanced Composition Explorer, or ACE, was designed both to measure properties of the incoming solar wind, and to give scientists advanced notice of larger, more intense eruptions from the sun, such as coronal mass ejections, or CMEs. At their worst, CMEs can compress the magnetosphere so severely that satellites suddenly find themselves outside that protective bubble, exposed to harsh solar radiation. The compression can also set off vibrations in the magnetosphere that can induce electrical surges in power grids on Earth.

NASA decided to take advantage of having two spacecraft monitoring the solar wind by moving Wind to the second Lagrange point (L2), a point on the other side of Earth from the sun. L2 is some 1.1 million miles down the magnetotail, four times the distance to the moon. From this new location, Wind was able to provide measurements from deeper in the magnetotail than any other missions have done.

Working together, ACE and Wind unraveled even more mysteries about the solar wind, helping answer questions such as, did the observations on one side correlate to what was happening on the other? Did any particular occurrence stay coherent over long distances or did they change as they moved?

During this time frame, the ISTP missions helped scientists understand more about the size of events in the magnetosphere. At a distance of under 90,000 miles, what one satellite observed could be correlated to measurements from the other. That means that knowing what one satellite saw could perhaps be used to predict what might be seen elsewhere in the magnetosphere, as long as it was less than 90,000 miles away. At greater distances, however, any given blast of energy or particles moving through the magnetosphere simply changed too much to be predictable.

From 2000-2003, Wind moved through a variety of positions, including off to the side of the magnetosphere, 1.5 million miles away from Earth, and a return trip to the magnetotail. In 2004, Wind was moved back to the L1 point permanently.

"In its position at L1, Wind has witnessed a handful of first ever sightings of different kinds of electromagnetic waves traveling by in the solar wind," said Lynn Wilson, deputy project scientist for Wind at Goddard. "In space where a particle could travel 100 million miles before hitting another one, these waves simply can't be working the same way sound or water waves do, pushing material along. It has opened up whole areas of research trying to understand these unexpected properties."

Wind continues to work with other spacecraft—and is even looking to the future. In 2018, NASA will launch a new mission called Solar Probe Plus that will go to within 3.8 million miles of the sun to explore what happens within the solar wind near the sun. One big mystery is the question of what keeps the solar wind heated. One would think that the solar wind would cool down as it expands and travels away from the sun, but it remains hotter than expected. Some intrinsic activity within the wind must continue to generate heat. It is known that magnetic reconnection – a process in which magnetic energy is converted into heat and acceleration of particles – is part of the process. In sync with this endeavor, Wind has searched for the signatures of magnetic reconnection closer to home.

"The question we had was whether magnetic reconnection could ever happen in the low density solar wind, where things are not as dynamic as in the sun's atmosphere," said Szabo. "Wind found signatures of reconnection, but they weren't violent reactions like what happens closer to the sun. These were subtle, lower energy events, and the signature were thin streams of particles accelerating outward, which we call reconnection jets."

These jets last for such short periods of time that the 3-second data collection on Wind is just barely fast enough to capture them – an example of how Wind's high cadence measurements still shine 20 years after launch, and how its mission continues to offer important data for scientists.

Despite having a planned mission of five years, Wind was built with the hope of lasting much longer. Wind has enough fuel to keep it in orbit around L1 until 2074, and every effort has been made to reduce stress on its instruments in order to maintain their longevity. At 20 years, it is still going strong and helping scientists understand the forces that buffet near-Earth space.

Provided by NASA

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