New NASA Van Allen Probes observations helping to improve space weather models

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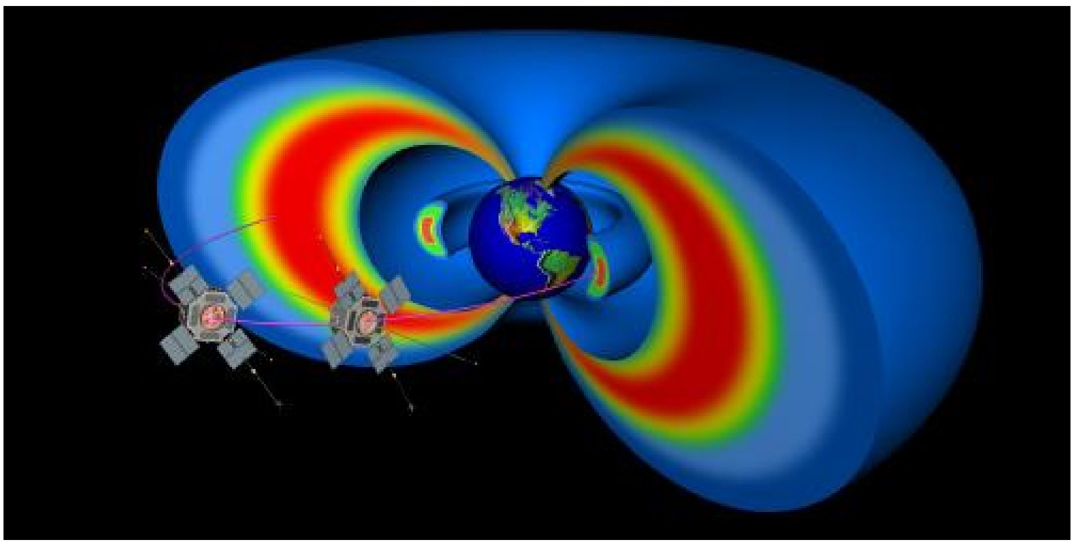


NASA's Van Allen Probes orbit through two giant radiation belts that surround Earth. Their observations help improve computer simulations of events in the belts that can affect technology in space. Credit: John Hopkins University Applied Physics Laboratory/NASA

(Phys.org) —Using data from NASA's Van Allen Probes, researchers have tested and improved a model to help forecast what's happening in the radiation environment of near-Earth space—a place seething with fast-moving particles and a space weather system that varies in response to incoming energy and particles from the sun.

When events in the two giant doughnuts of radiation around Earth –

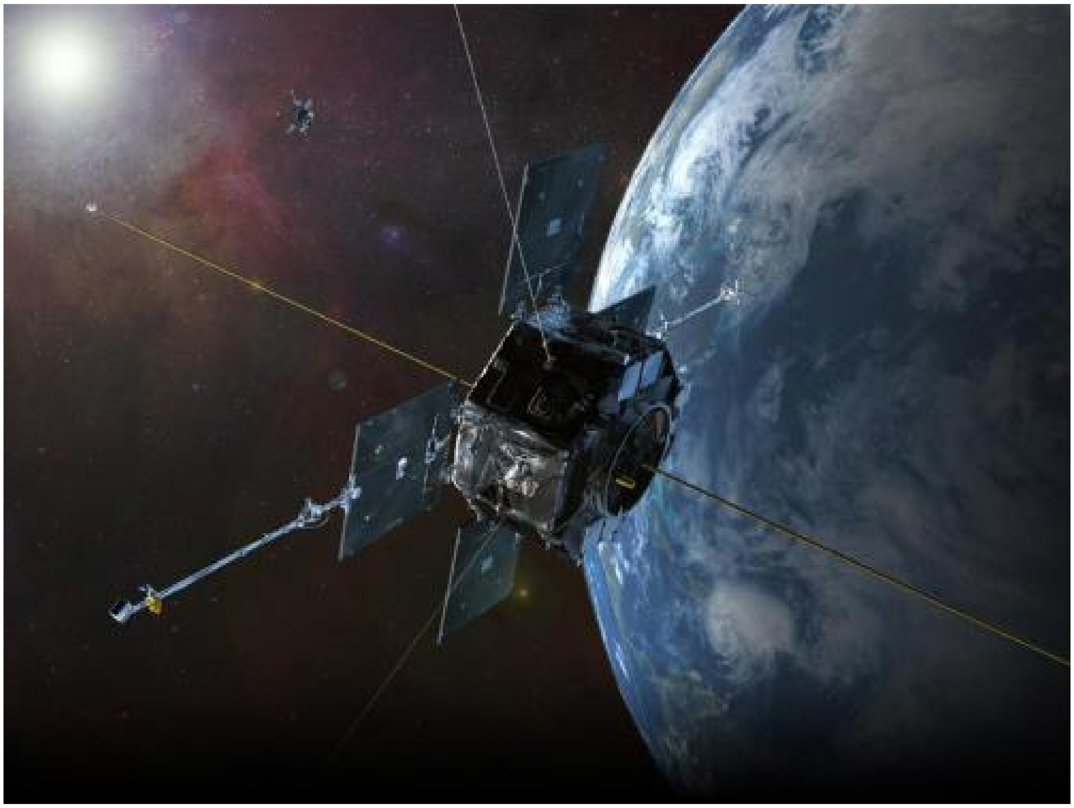
called the Van Allen radiation belts—cause the belts to swell and electrons to accelerate to 99 percent the speed of light, nearby satellites can feel the effects. Scientists ultimately want to be able to predict these changes, which requires understanding of what causes them.

Now, two sets of related research published in the *Geophysical Research Letters* improve on these goals. By combining new data from the Van Allen Probes with a high-powered computer model, the new research provides a robust way to simulate events in the Van Allen belts.

"The Van Allen Probes are gathering great measurements, but they can't tell you what is happening everywhere at the same time," said Geoff Reeves, a space scientist at Los Alamos National Laboratory, or LANL, in Los Alamos, N.M., a co-author on both of the recent papers. "We need models to provide a context, to describe the whole system, based on the Van Allen Probe observations."

Prior to the launch of the Van Allen Probes in August 2012, there were no operating spacecraft designed to collect real-time information in the radiation belts. Understanding of what might be happening in any locale was forced to rely mainly on interpreting historical data, particularly those from the early 1990s gathered by the Combined Release and Radiation Effects Satellite, or CRRES.

Imagine if meteorologists wanted to predict the temperature on March 5, 2014, in Washington, D.C. but the only information available was from a handful of measurements made in March over the last seven years up and down the East Coast. That's not exactly enough information to decide whether or not you need to wear your hat and gloves on any given day in the nation's capital.



Artist's rendition of the Van Allen Probes in orbit. Credit: NASA

Thankfully, we have much more historical information, models that help us predict the weather and, of course, innumerable thermometers in any given city to measure temperature in real time. The Van Allen Probes are one step toward gathering more information about space weather in the radiation belts, but they do not have the ability to observe events everywhere at once. So scientists use the data they now have available to build computer simulations that fill in the gaps.

The recent work centers around using Van Allen Probes data to improve a three-dimensional model created by scientists at LANL, called DREAM3D, which stands for Dynamic Radiation Environment Assimilation Model in 3 Dimensions. Until now the model relied heavily on the averaged data from the CRRES mission.

One of the recent papers, published Feb. 7, 2014, provides a technique for gathering real-time global measurements of chorus waves, which are crucial in providing energy to electrons in the radiation belts. The team compared Van Allen Probes data of chorus wave behavior in the belts to data from the National Oceanic and Atmospheric Administration's Polar-orbiting Operational Environmental Satellites, or POES, flying below the belts at low altitude. Using this data and some other historical examples, they correlated the low-energy electrons falling out of the belts to what was happening directly in the belts.

"Once we established the relationship between the chorus waves and the precipitating electrons, we can use the POES satellite constellation – which has quite a few satellites orbiting Earth and get really good coverage of the electrons coming out of the belts," said Los Alamos scientist Yue Chen, first author of the chorus waves paper. "Combining that data with a few wave measurements from a single satellite, we can remotely sense what's happening with the chorus waves throughout the whole belt."

The relationship between the precipitating electrons and the chorus waves does not have a one-to-one precision, but it does provide a much narrower range of possibilities for what's happening in the belts. In the metaphor of trying to find the temperature for Washington on March 5, it's as if you still didn't have a thermometer in the city itself, but can make a better estimate of the temperature because you have measurements of the dewpoint and humidity in a nearby suburb.

The second paper describes a process of augmenting the DREAM3D model with data from the chorus wave technique, from the Van Allen Probes, and from NASA's Advanced Composition Explorer, or ACE, which measures particles from the solar wind. Los Alamos researchers compared simulations from their model – which now was able to incorporate real-time information for the first time – to a solar storm from October 2012.

"This was a remarkable and dynamic storm," said lead author Weichao Tu at Los Alamos. "Activity peaked twice over the course of the storm. The first time the fast electrons were completely wiped out – it was a fast drop out. The second time many electrons were accelerated substantially. There were a thousand times more high-energy electrons within a few hours."

Tu and her team ran the DREAM3D model using the chorus wave information and by including observations from the Van Allen Probes and ACE. The scientists found that their computer simulation made by their model recreated an event very similar to the October 2012 storm.

What's more the model helped explain the different effects of the different peaks. During the first peak, there simply were fewer electrons around to be accelerated.

However, during the early parts of the storm the solar wind funneled electrons into the belts. So, during the second peak, there were more electrons to accelerate.

"That gives us some confidence in our model," said Reeves. "And, more importantly, it gives us confidence that we are starting to understand what's going on in the radiation belts."

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