Solar Storms: a communication problem
The same high-atmosphere disturbances that create the northern lights can also cause havoc for high-frequency radio.

Electrical storms in the ionosphere, the uppermost portion of the atmosphere, can have significant and detrimental effects on the systems most people depend on each day. It isn’t just the big dogs—the U.S. military and large corporations—who suffer when their high-powered communication systems and GPS satellites fail; everyday citizens are also affected by problems created by solar storms.

“Disturbances in the ionosphere have an effect on everything," said Robert Schunk, director of USU’s Center for Atmospheric and Space Sciences and member of the USTAR Space Weather team at USU. “Disruptions in GPS and high-frequency radio communications are just two very significant examples of the impacts that solar storms have on regular people.”

Ionosphere disturbances create a rapid fluctuation of electrons, which can disrupt satellite communications and cause random delays in communication signals. Additionally, these electrons in the ionosphere cause GPS receivers to lose signal lock or experience delays. Compromised GPS signals result in greater uncertainty and error for precision activities such as road grading, GPS-guided farming and emergency location tracking. Without a solution to mitigate the impacts created by ionospheric disturbances and their effects on construction, navigation, oil and gas exploration, agriculture and emergency response, average people will see impacts on their pocketbooks.

“An ionospheric disturbance can easily become an issue of national security,” said Schunk. “The U.S. military relies on space weather warnings to protect satellites and ground-based systems.” High-frequency communications, often used as a communication system for the U.S. military and a back-up for emergency response teams, may be interrupted as radio waves reflect off the disturbed ionosphere and reach sites over the horizon.
Mitigating the effects of space weather disturbances is a priority for the U.S. government and the Department of Defense, and the task comes with an annual price tag of $500 million each year.

Unexpected complications for these radio wave reflections can compromise the security of those in dangerous operative situations.

During Hurricane Katrina, for example, ionospheric disturbances could have severely impacted rescue efforts in New Orleans when a large solar flare on September 7, 2005 cut off HF radio communications, leaving disaster relief workers without a working backup communication system.

Mitigating the effects of space weather disturbances is a priority for the U.S. government and the Department of Defense, and the task comes with an annual price tag of $500 million each year. CASS and the USTAR Space Weather Center, established in 2008, have developed the Global Assimilation of the Ionospheric Measurements (GAIM) model, a complex forecasting system that compensates for these disturbances as they occur.

W. Kent Tobiska, who joined the team in fall 2009 as director of the USTAR Space Weather Center, says that understanding space weather and compensating for ionospheric disturbances can lead to improved communications and safety for emergency personnel.

"Operational space weather forecasting makes it possible to solve communication problems on earth by closing the loop between receiving raw satellite or ionosphere data and providing automated products to users that show what radio frequencies can be used based on space weather's current effects of the ionosphere," said Tobiska. "We are moving beyond the exploration of the technology and are now solving problems created by ionospheric disturbances."

Their GAIM model creates specifications and forecasts for global, regional and local distributions of ionospheric densities, temperatures and winds using total electron content and other measurements to forecast space weather. Through these complex measurements, the SWC and CASS can forecast space weather in real-time (with updates every 15 minutes). The GAIM model ingests over 10,000 measurements every 15 minutes and has the ability to compensate for ionospheric disturbances that negatively affect communication systems. Because of the complexity of the model, GAIM is available to specialized groups, like the U.S. military, on a subscription basis.

And because space weather disturbances affect communications for governments, corporations and consumers alike, in 2009, CASS and the USTAR Space Weather Center began commercializing technology for mainstream users. The recently launched iPhone application "Space Wx" (available through Apple for $1.99) visually shows users how space weather disturbances are affecting the ionosphere.

Using the application, corporations, such as those who own large oilrigs, are able to understand how high...
frequency radio communications and GPS accuracy are being affected by space weather in real-time. Farmers who rely on GPS technology and oil drillers can avoid costly mistakes—like over-fertilizing or under-watering crop sections or recording the wrong drilling location because GPS coordinates are off by as much as a football field.

The advancements in space weather forecasting and ionospheric disturbance mitigation at Utah State’s CASS and SWC aren’t surprising to Schunk. "USU is the long-time leader in space and upper atmospheric research, and this is our golden opportunity; we can have a tremendous impact on safety and security in the world."

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**Polar Flights and Space Weather**

The Global Assimilation of the Ionospheric Measurements model and other technologies being developed by the Center for Atmospheric and Space Sciences and the USTAR Space Weather Center will have impacts beyond radio and satellite communications. Using space weather technology to forecast solar storms, airplanes can fly over the Earth’s polar regions and maintain HF radio communication, an advancement that provides significant savings in fuel costs and results in shorter flight times. Forecasting solar storms before they happen is critical to polar flights, as disturbances require landing and refueling interruptions to compensate for the extra miles required in-air as the plane travels around, instead of through, the region—an interruption that costs airlines $100,000 or more per incident.

Mitigating solar storms’ impact on communication and GPS systems will allow more planes to be flown at one time, an advancement that will boost the aviation industry. "There are about 6,000 planes being flown in the U.S. each morning," said Schunk. "Using the GAIM model to alter incorrect GPS information, planes can be flown closer together—an advancement that will translate into a reduction in airport delays and can have an impact on international travel as countries around the globe establish better air traffic control systems," making travel safer, more economical and more efficient for the consumer."