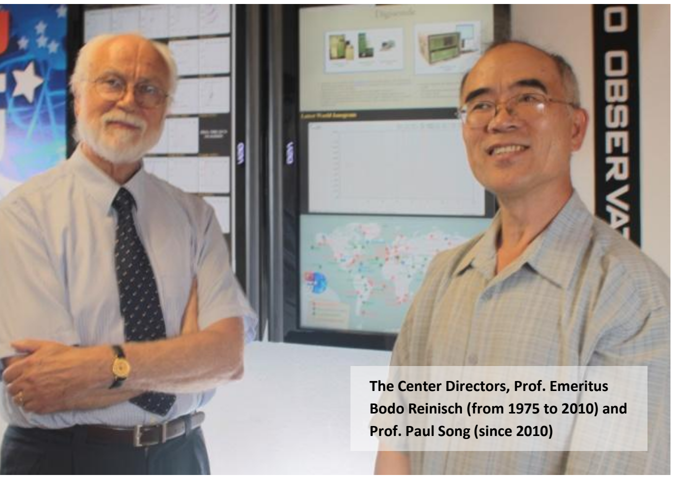


The Center Directors, Prof. Emeritus Bodo Reinisch (from 1975 to 2010) and Prof. Paul Song (since 2010)

Center for Atmospheric Research

Space Physics: Science and Technology

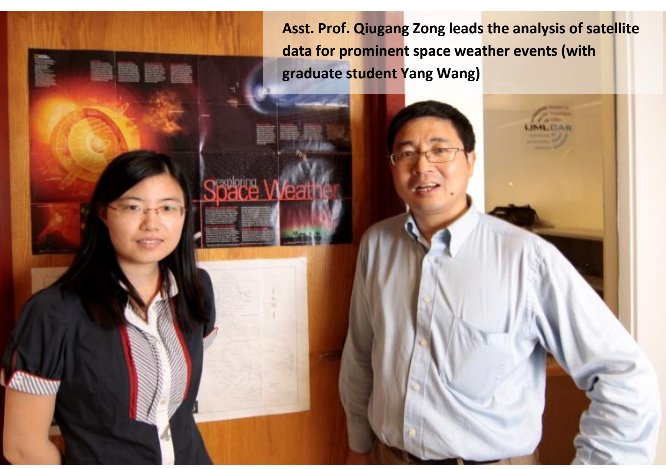
Founded in 1975, Center for Atmospheric Research excels at scientific investigations in Space Weather, Magnetospheric Physics, Ionospheric Physics, and Radio Science. Through research grants from NASA and US Air Force, the Center has developed strong engineering expertise for design of autonomous remote sensing systems for spacecraft platforms. Computer scientists at the Center build intelligent systems for automatic interpretation of acquired data. The Center operates Global Ionospheric Radio Observatory (GIRO), a worldwide network of instruments bearing the university logo since 1969.

ulcar.uml.edu

Active Space Research Projects

Solar wind – magnetosphere interaction modeling
Magnetosphere-ionosphere-thermosphere coupling
Plasmasphere sounding and modeling
Plasmasphere depletion and refilling processes
Ionosphere sounding and modeling
Real-time data assimilation
Radiation belt wave-particle interactions
Antenna-plasma interaction
Antenna radiation theory and experiments
Whistler-mode wave propagation
Solar coronal heating problem

Plasma modeling and simulation group: Asst. Prof. Jiannan Tu (project lead), Dr. Patrick Nsumei, and doctoral candidate Pavel Ozhogin.



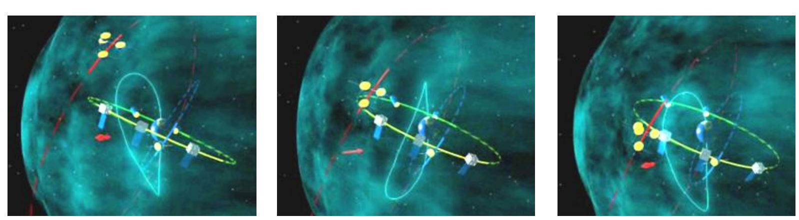
Asst. Prof. Qiugang Zong leads the analysis of satellite data for prominent space weather events (with graduate student Yang Wang)

Plasma Modeling and Simulation

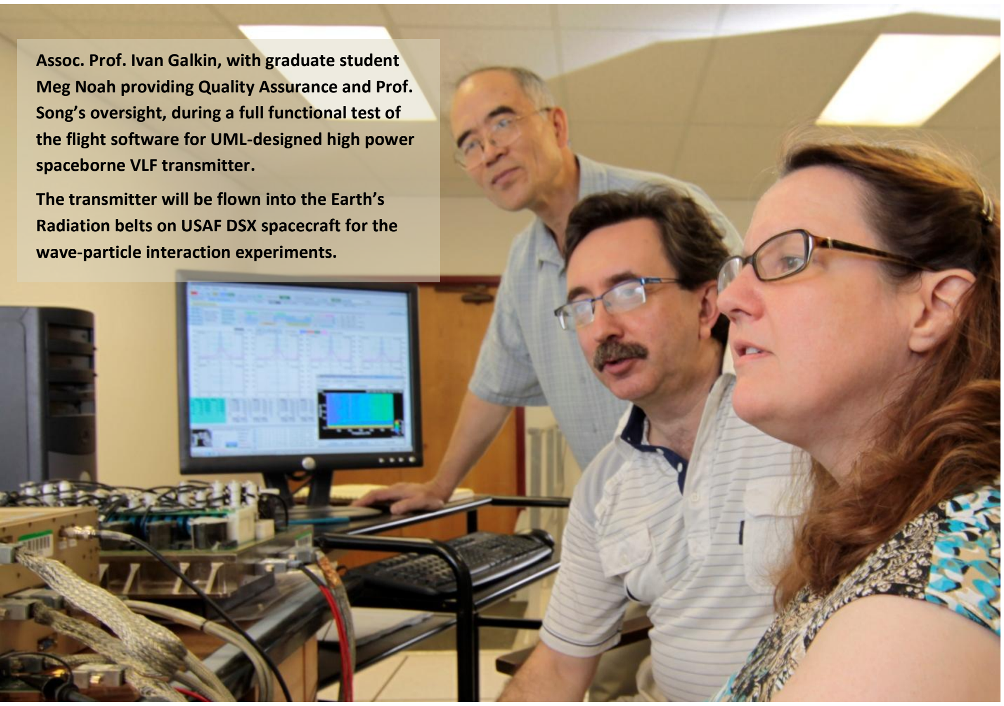
Ground-based and space-borne observations have established a global picture of the space plasma environment. The complicated and intriguing plasma processes and sparse observation coverage, however, hinder the deterministic understanding. The modeling and simulation, combined with observations, has been proved to be a powerful tool in providing understanding of physical and chemical processes in space plasma and in predicting space weather. The Center for Atmospheric Research has been actively undertaking empirical modeling and computer simulation of antenna-plasma interaction, magnetosphere-ionosphere-thermosphere coupling, ionosphere and magnetosphere density distribution, and plasmasphere depletion and refilling.

Killer Electrons

Featured at #37 in *Discover* magazine's "Top 100 Science Stories of 2007", discovery of the physical mechanism responsible for accelerating electrons trapped in the Earth's Radiation Belts to the 'killer' velocities as much as 94% of the speed of light has been credited to the UMLCAR scientists.



A slowly oscillating Pc5 wave of the Earth magnetic field with a period of ~10 minutes is responsible for accelerating electrons to the 'killer' energies posing a hazard to astronauts and damaging spacecraft in orbit (computer simulation)

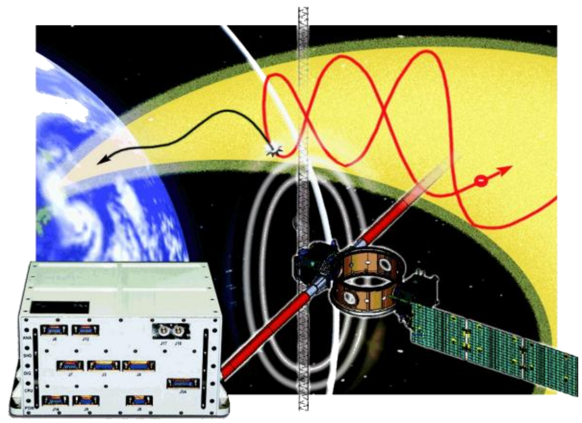


Assoc. Prof. Ivan Galkin, with graduate student Meg Noah providing Quality Assurance and Prof. Song's oversight, during a full functional test of the flight software for UML-designed high power spaceborne VLF transmitter.

The transmitter will be flown into the Earth's Radiation belts on USAF DSX spacecraft for the wave-particle interaction experiments.

Very Low Frequency in Space

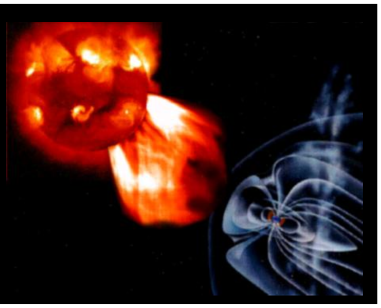
A self-tuning VLF transmitter will drive an 80-m dipole antenna with 5 kV onboard the USAF DSX satellite to study the effect of space plasma on the radiation process and the effect of the radiation on the trapped electron population. The center designed and delivered the power transmitter and a narrow-band receiver for the frequency range from 3 kHz to 750 kHz in cooperation with Southwest Research Institute and Stanford University. The transmit & receive system will measure the local plasma density and will automatically tune the antenna circuit for maximum radiation.



UMLCAR-designed VLF transmitter scheduled for launch in 2012

Solar Coronal Heating

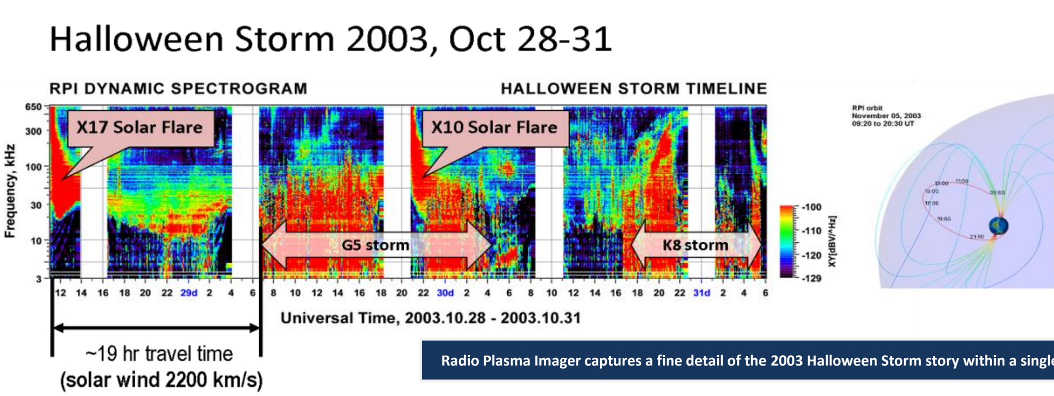
The surface temperature of the Sun is around 6000° K. However, about 70 years ago, observations showed that the temperature of the solar corona, the atmosphere of the Sun, is more than 2 million degrees. How can a heater of a lower temperature heat up the air to a temperature 100 times higher, apparently inconsistent with the second law of thermodynamics? This problem has puzzled physicists around the world since then. Any mechanism proposed to resolve the problem has been at least two orders of magnitude too small in the heating rate.



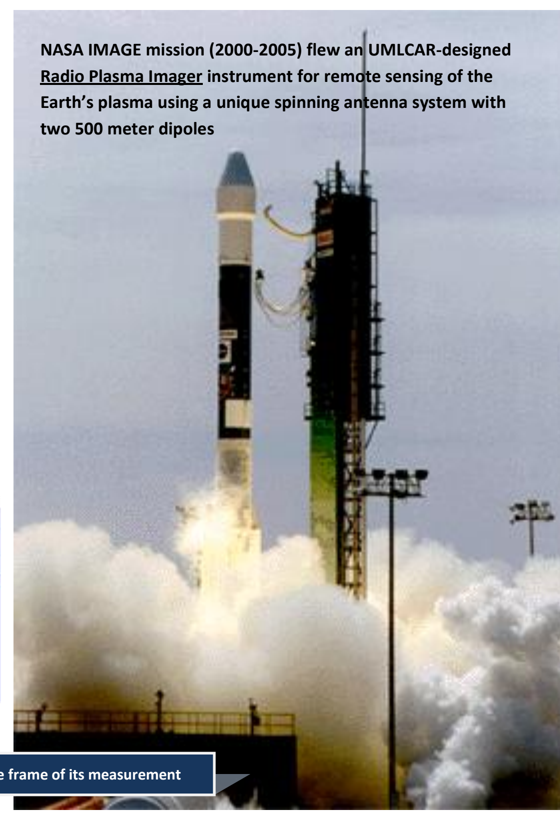
The scientists in the Center for Atmospheric Research have proposed new mechanism that for the first time is able to provide an adequate heating rate to explain the Solar coronal Heating problem

Space Weather

Space weather is an emerging field of research that applies the knowledge we gained in space physics and space plasma physics to forecast the conditions in space. Same as any forecast, space weather forecast needs to be reliable, timely, and economical. Over the last years, the United States has developed primitive capability to forecast major solar storm events. Constellations of satellites are being built to be launched to strategic locations in space and global computer simulation codes are being developed. The Center for Atmospheric Research has been actively participated in this exciting science endeavor and has developed models that are used in the National Space Weather Services.



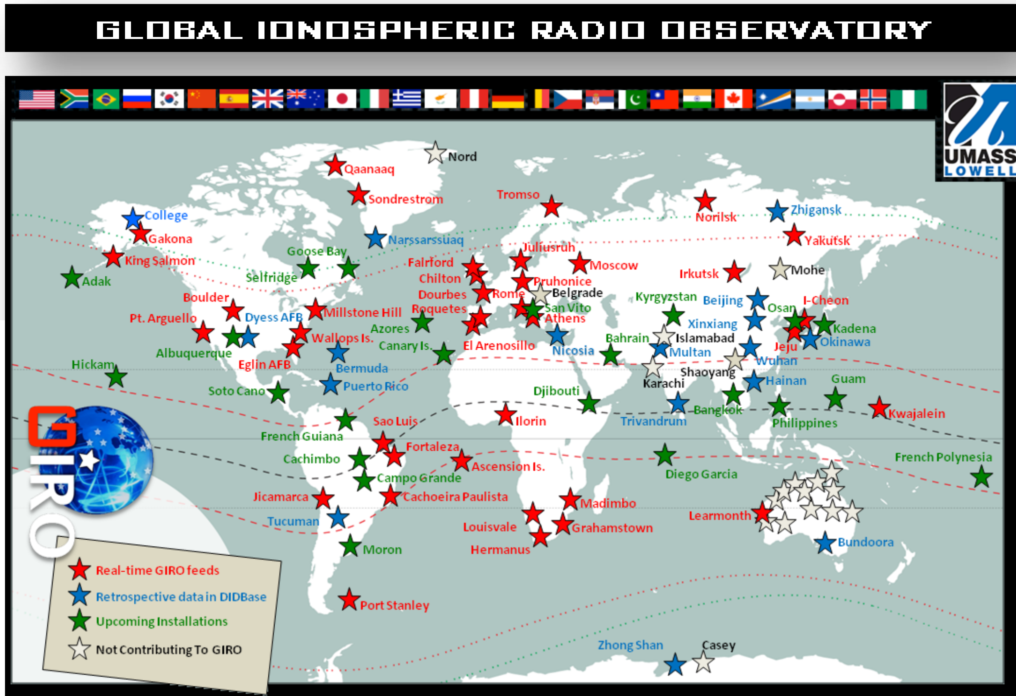
Radio Plasma Imager captures a fine detail of the 2003 Halloween Storm story within a single frame of its measurement

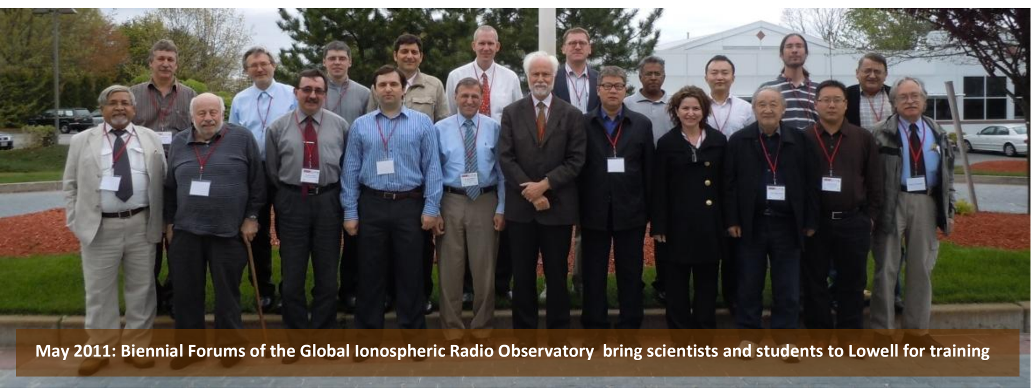


NASA IMAGE mission (2000-2005) flew an UMLCAR-designed Radio Plasma Imager instrument for remote sensing of the Earth's plasma using a unique spinning antenna system with two 500 meter dipoles

GIRO

Since 1969, UMLCAR has designed and built 130 HF radar sensing instruments, "Digisondes", to conduct radio wave experiments in Earth's ionosphere. The Global Ionospheric Radio Observatory (GIRO) comprises Digisonde installations in 27 countries with real-time access to observational data from 42 locations, and the UMLCAR DIDBase and ionospheric Drift databases with cumulative 30M records.





May 2011: Biennial Forums of the Global Ionospheric Radio Observatory bring scientists and students to Lowell for training

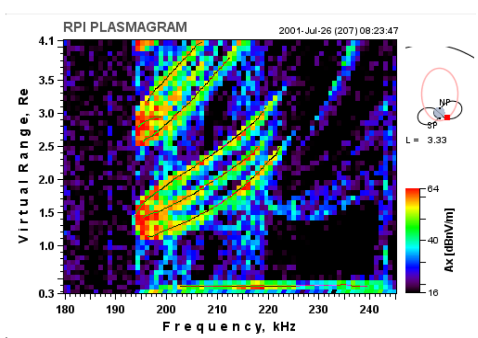
Graduate students Yan Wang and Richard Reddy observing 24-hour data animations at GIRO Real-Time Monitor wall

Neural Computing Research

CORPRAL, a computer replica of the pre-attentive vision system in humans uses a recurrent neural network to locate the most interesting examples among the otherwise unfathomable archive of images of remote radio sounding in the Earth's magnetosphere.

The Intelligent System research at the Center aims at development of the bio-plausible mathematical models to approach data analysis problems that are traditionally regarded as "machine-hard" due to their strong intelligent component that resists formalization. First software solutions for intelligent visual data interpretation problems were developed in late 1970s.

INTELLIGENT IMAGE PROSPECTING



CORPRAL software has parsed 1.2 million images looking for spectacular examples like this "*Mars Attacks!*" plasmagram showing echoes of RPI signal travelled 50,000+ km in space

NASA Virtual Wave Observatory (VWO)

The Center operates three multi-million image repositories with online access for interactive derivation of secondary products and expert annotation of physical wave phenomena. The data annotation capability has attracted attention of the NASA Virtual Wave Observatory (VWO) and SPASE Consortium for the space physics data exchange.

Nuggets of the expert knowledge are accumulated, systematized, and preserved by the Center databases for posterity. Data annotation opens possibility for data search by phenomena type, rather than simply by time or by measurement context. Software solutions developed at the Center will make the wealth of wave data more understandable, searchable, and useable by the Heliophysics community.