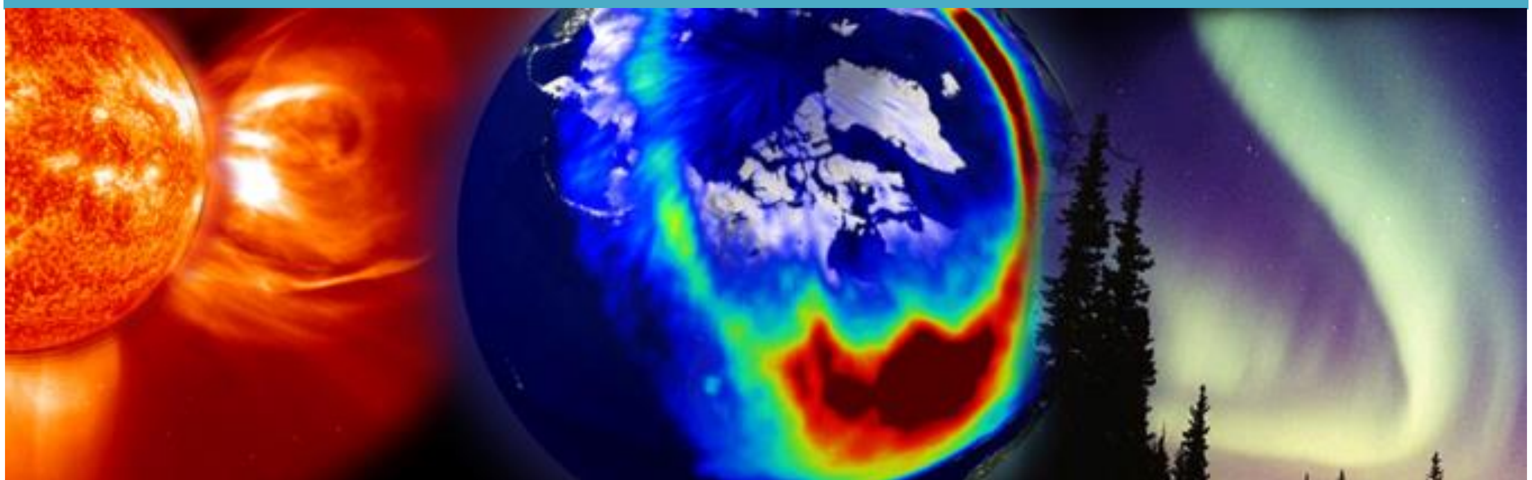
Joint Space Weather Summer Camp
Program



July 22 - August 18, 2013

The University of Alabama in Huntsville
German Aerospace Center (DLR)
The University of Rostock

CSPAR
CENTER FOR SPACE PLASMA AND AERONOMIC RESEARCH

DLR

LEIBNIZ-INSTITUT FÜR ATMOSPHÄREN PHYSIK IAP

Universität Rostock

Traditio et Innovatio

THE UNIVERSITY OF ALABAMA IN HUNTSVILLE

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Welcome to the Joint Space Weather Summer Camp 2013

The Joint Space Weather Summer Camp is a partnership between UAHuntsville, the DLR and the University of Rostock. Because of the considerable historical ties between Huntsville and the state of Mecklenburg Vorpommern (Germany) in the development of rockets, missiles, and eventually manned space flight, the Joint Space Weather Summer Camp was created to forge ties and develop communication between these two regions that have had such an impact on the 20th century.

During the 4 week series of lectures, hands-on projects, experiments, and excursions you will be given an understanding of both the theoretical underpinnings and practical applications of Space Weather and solar and space physics.
During the first two weeks in Huntsville, we begin by focusing on the Sun as the primary cause of space weather in the entire solar system, and discuss fundamental processes in plasma physics, the solar wind and the interaction processes between the solar wind and Earth's upper atmosphere.There will also be the opportunity to participate in either data or practical-based project work, enabling you to gain a practical understanding of the topics that will be discussed in the lectures both in Huntsville and in Germany. During the last two weeks in Northern Germany we will focus on the upper atmosphere and ionosphere.Besides the lectures there will also be practical project work and we will visit the University of Rostock and the Leibniz-Institute of Atmospheric Physics e.V. at the University of Rostock (IAP) in Kühlungsborn.

The Joint Space Weather Summer Camp is much more than just lectures, projects and experiments. It also provides a wonderful opportunity for cultural exchanges between the US and Germany in an academic setting. The visit of the 'Historical Technical Museum in Peenemünde' in the Northeast of Germany or the visit of the US Space and Rocket Center in Huntsville, USA, are just two further examples of a program that goes beyond.

We hope that the Joint Space Weather Summer Camp will be an interesting introduction to the theoretical and practical aspects of Space Weather combined with a cultural exchange between the US and Germany!

The Joint Space Weather Summer Camp 2013 Committee

	Mon, July 22	Tue, July 23	Wed, July 24	Thu, July 25	Fri, July 26	Sat, July 27	Sun, July 28
Time	Huntsville	Huntsville	Huntsville	Huntsville	Oak Ridge	Atlanta	Huntsville
	Room 2096	Room 2096	Room 2096	Room 2096			
8.30 - 9.00		Breakfast	Breakfast	Breakfast	Breakfast		
9.00 - 9.50	9.00 - 9.30 Breakfast 9.30 - 9.50 Introduction (Melanie Leonard, Alexander Dosch, Brian Swan)	- V. Florinski - Cosmic Rays throughout the Heliosphere	- J. Adams - Radiation Hazards	- J. Minow - Spacecraft Charging	Tour at Oak Ridge National Laboratories		Departure for Huntsville
9.50 - 10.40	- J. LeRoux - Universal basic processes in plasma physics	- G. Zank - Origin of fast and slow Solar Wind	- K. Wright - Perspectives on building laboratory and flight instrumentation for plasma measurements	- J. Minow - Missions Operations	Visit of the Supercomputer Center, Spallation Neutron Source and Historic Graphite Reactor	10.00 Museum of Natural History	
10.40 - 10.55	Break	Break	Break	Break	Break		
10.55 - 11.45	- ST Wu - Modeling of Magnetic Non-Potentiality of an Active Region using a Three-Dimensional, Data Driven Active Region Evolution Model	- G. Zank - Particle Acceleration and Transport Theory	- M. Sterrett - Grazing Incidence X-Ray Spectrometry	- V. Coffey - In-Situ Charged Particle Instrumentation used for Space Weather Measurements	Tour at Oak Ridge National Laboratories	Free Time	
11.45 - 12.35	- G. Li - Particle Acceleration in large SEP events - modeling extreme SEP events	- J. Spann - Space Instrumentation	- K. Kobayashi - Techniques for Measuring the Magnetic Field in the Solar Corona	- V. Coffey - Lab Tour	Tour at Oak Ridge National Laboratories		
12.35 - 2.00	Lunch	Lunch	Lunch	Lunch	Lunch		
2.00 - 5.00	Introduction to Projects 3.00 Project Work	Tour Space & Rocket Center	Project Work	Departure for Oak Ridge	Departure for Atlanta		

	Mon, July 29	Tue, July 30	Wed, July 31	Thu, Aug 1	Fri, Aug 2	Sat, Aug 3	Sun, Aug 4
Time	Huntsville	Huntsville	Huntsville	Huntsville	Huntsville	Huntsville	Berlin
	Room 2096	Room 2096	Room 2096	Room 2096	Room 2096		
8.30 - 9.00	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast		
9.00 - 9.50	- D. Gallagher - Geospace Overview	- M. Briggs - Gamma-ray signatures of solar flares	- A. Winebarger - Unlocking the secrets of the Sun	- R. Burrows - Electron kinetic scale simulations	- Ed Buckbee - Remembering the REAL Space Cowboys	Departure to Germany	Arrival in Germany
9.50 - 10.40	- D. Gallagher - Inner Magnetosphere Processes and Coupling	- V. Connaughton - Terrestrial Gamma-Ray flashes	- R. Moore - Explosive Solar Magnetic Fields and Space Weather	- S. Borovikov - Visualization of Scientific Data	- Owen Garriott - Space Weather		
10.40 - 10.55	Break	Break	Break	Break	Break		
10.55 - 11.45	- L. Krause - Ionospheric Radio Science	- D. Hathaway - An Introduction to Solar Physics	- Q. Hu - Reconstruction of Magnetic clouds from In-Situ Spacecraft Measurements	- N. Pogorelov - Large-scale simulations of the time dependent heliosphere	- Final Presentation -		
11.45 - 12.35	- S. Savage - Solar Flares as a Source of Energy in the Earth's Magnetotail	- D. Hathaway - Photospheric Magnetic Field Evolution - The inner boundary condition for the Heliosphere	- D. Falconer - Flare and CME Driven Space Weather Effects and Forecasting	- J. Heerikhuisen, E. Zirnstein - Looking to the interstellar boundary with IBEX	- Final Presentation -		
12.35 - 2.00	Lunch	Lunch	Lunch	Lunch (Rm 1010)			
2.00 - 5.00	Project Work	Project Work	Project Work	Project Work	- Veronica Belser - Pool Party		
5.00		- Gary Zank - Dinner					

	Sun, 04.08.2013	Mon, 05.08.2013	Tue, 06.08.2013	Wed, 07.08.2013	Thu, 08.08.2013	Fri, 09.08.2013	Sat, 10.08.2013
Time	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Rostock**	**Kühlungsborn**	**Neustrelitz**	**Neustrelitz**
08:45-09:00	Arrival in Neustrelitz / Welcome and check-in	Free time	Reception	Transfer to Rostock	Reception	Reception	Free time
09:00-09:20			*H. Maass* Welcome to the Summer Camp		*Prof. Fr-J Lübken* Welcome / Introduction to atmospheric science at IAP	*Dr. M. Rietveld* Incoherent Scatter Radars to Study the High Latitude Ionosphere	
09:20-10:00			*Dr. N. Jakowski* Introduction and History of Ionospheric Research at DLR				
10:00-10:15			*H.-J-.Stottke* Visit of DLR site Neustrelitz	*A. Becker, R. Püstow* Progress in warm dense matter and planetary physics	*Coffee Break*	*Coffee Break*	
10:15-10:30					*Dr. M. Gerding, A. Schneider* Start of a balloon	*Graf zu Eulenburg* SWE impact on GNSS	
10:30-10:45			*Coffee Break*				
10:45-10:55			*A. Dosch* About the UAH				
10:55-11:05			*Dr. B. Opperman* About SANSA				
11:05-11:15			*Dr. B. Opperman* Satellite orbital mechanics and its relevance to space weather				
11:15-12:05					*Dr. G. Stober* Mesopheric dynamics as observed by radars	*Dr. K. Scherer* Ionization processes in the heliosphere	
12:05-12:15			Introduction to project work				
12:15-13:45			*Lunch*	*Lunch*	*Lunch*	*Lunch*	
13:45-14:45			Project work: - Modelling - SOFIE - Scintillations	visit lab	Visit of IAP labs - Lidars: *Dr. M. Gerding* Calibration lab for sounding rockets *Dr. Boris Strelnikov* Radar + computer	*Prof. G. Mann* Radio observations of the sun with LOFAR	
14:45-15:00					*Coffee Break*	*Coffee Break*	
15:00-16:00		Visit of town 3:00 pm			*Prof. E. Becker* Theoretical concepts of atmospheric dynamics	Project work: - SOFIE Visit of local School	
16:00-17:00		Dinner at Orangerie 5:30 pm		Transfer to Kühlungsborn	*Prof. Fr.-J. Lübken* Concluding discussion		
				Beachparty 6 pm Hotel Polarstern, Garden Lounge	Transfer to Neustrelitz		
Night	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Kühlungsborn**	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**

	Sun, 11.08.2013	Mon, 12.08.2013	Tue, 13.08.2013	Wed, 14.08.2013	Thu, 15.08.2013	Fri, 16.08.2013	Sat, 17.08.2013
Time	**Peenemünde**	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Berlin**	**Berlin/Departure**
08:45-09:00	Transfer to Peenemünde 8:00 am	Reception	Reception	Reception	Reception		Berlin
09:00-9:45		*Prof. Heber* Cosmic rays on their route through the magnetosphere and atmosphere – Theory and Experiment	*Prof. Heber* Cosmic rays on their route through the magnetosphere and atmosphere – Theory and Experiment	*Prof. E. Flückiger* Cosmic rays Rays - Fundamentals and Space Weather Effects	*K.de Jong* Offshore GNSS positioning	Transfer to Berlin 9:00 am	
09:45-10:00		*Dr. D. Stiefs* DLR_School_Lab: Out of the classroom - into the lab!					
10:00-10:15	11:00 Historical Technical Museum Peenemünde		*Coffee Break*			Visit of Town	
10:15-10:30			*Prof. H. Lühr* Geomagnetic variations, activity indices, and thermospheric response to magnetic storms				
10:30-10:45		*Coffee Break*		*Coffee Break*	*Coffee Break*		
10:45-11:15		*Prof. K. Schlegel* History of ionospheric research		*Dr. G. Reitz* Radiation Exposure in Space and at Aviation Altitudes	*Dr. St. Metzger* Impacts of Space Weather on Satellites		
11:15-11:30			*Prof. Chr. Jacobi* Neutral atmosphere signature seen in ionospheric variability				
11:30-12:15		*Prof. K. Schlegel* Ionospheric Resonse to Space Weather					
12:15-13:45		*Lunch*	*Lunch*	*Lunch*	*Lunch*		**Sun, 18.08.2013**
13:45-14:30		**Project work:** - **Modelling** - **SOFIE** - **Scintillations**	School_Lab + geocaching + barbecue + volleyball + etc.	**Project work:** **Aviation Dosimetry**	Result of project work		Departure
14:30-15:15							
15:15-15:30					*Coffee Break*		
15:30-16:15					*D. Wenzel* *Dr. A. Dosch* Summary	Evening: Dinner 7:30 pm	
16:15-17:00	Transfer to Neustrelitz						
Night	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Neustrelitz**	**Berlin**	

Monday, July 22

Universal Basic Processes in Plasma Physics

Jakobus LeRoux
CSPAR,
The University of Alabama in Huntsville

The basic description of a plasma system will be introduced, starting from a kinetic description and culminating in the magnetohydrodynamic (MHD) description. On the basis of both kinetic and MHD models, we will discuss the following four universal plasma physical processes at an introductory level:

1) Small amplitude waves and fluctuations in a plasma;
2) Nonlinear behavior of fluctuations and dissipation and MHD turbulence;
3) Shock waves, considering both a basic MHD description and a more refined kinetic description;
4) Reconnection, described by MHD and the important role of kinetic processes.

The important process of particle acceleration at shock waves is relegated to a separate presentation.

Modeling of Magnetic Non-Potentiality of an Active Region Using a Three-Dimensional, Data Driven Active Region Evolution Model

S. T. Wu
CSPAR
The University of Alabama in Huntsville

One of the major interesting problems for space weather forecasting is to have the capability of predicting solar eruptive events. To achieve this goal, we must investigate the evolution of an Active Region. In this presentation, we will present an analysis of magnetic field structures of the productive AR10720 of January 15, 2005 AND AR11283 of September 6, 2011 using a data-driven 3D MHD model. The measured magnetic field from Big Bear Solar Observatory (BBSO) digital vector magnetogram (DGVM) for AR 10720 and the SDO/HMI measurements for AR 11283 are used to model the non-potential magnetic field changes. The numerical results include the change of magnetic flux, the net electric current, the length of magnetic shear of the main neutral line, and the flux normalized measure of the field twist. From these results we found the above four non-potential magnetic parameters increase and decrease before and after solar eruption. In other words, these four parameters are necessary conditions for solar eruption. Then we reveal a particular feature: "the fragmented strong shear along the neutral line". This feature could be interpreted as the variability of the shear angle (angle between the observed and potential horizontal field) along the neutral line. It may be an additional condition for eruption. This suggests that the active region probability of producing an eruption is not only dependent on active region free energy but also on the variability of the shear angle which appears to correspond to the fragmented strong shear along the neutral line.

Particle Acceleration in Large SEP Events-modeling extreme SEP events

Gang Li
CSPAR,
The University of Alabama in Huntsville

In extreme Solar Energetic Particle (SEP) events, such as GLE events, protons are often accelerated to GeV/nucleon. Understanding the underlying particle acceleration mechanism in these events is a major goal for space weather/climate studies.

In Solar Cycle 23, a total of 16 GLEs have been identified. Most of them have preceding CMEs and in-situ energetic particle observations show some of them are enhanced in ICME or flare-like material. Motivated by this observation, we proposed a "twin-CME" scenario for GLE events. In this scenario, two CMEs erupt in sequence during a short period of time from the same Active Region (AR) with a pseudo-streamer-like pre-eruption magnetic field configuration.

The first CME is narrower and slower and the second CME is wider and faster. We show that the magnetic field configuration in our proposed scenario can lead to magnetic reconnection between the open and closed field lines that drape and enclose the first CME and its driven shock. The combined effect of the presence of the first shock and the existence of the open close reconnection is that when the second CME erupts and drives a second shock, one finds both an excess of seed population and an enhanced turbulence level at the front of the second shock than the case of a single CME-driven shock. Therefore, a more efficient particle acceleration will occur. In the context of the "twin-CME" scenario, I will discuss in detail, an examination of the single GLE event in solar cycle 24, the May 17 2012 event. I will also discuss some statistical studies of other large SEP events in solar cycle 23.

Tuesday, July 23

Cosmic Rays thoughout the Heliosphere

Vladimir Florinski
CSPAR,
The University of Alabama in Huntsville

This year marks a one hundred and first anniversary of the discovery of cosmic ionizing radiation. Initially though to be gamma-rays (hence the name), cosmic rays turned out to be energetic charged particles (atomic nuclei and electrons) that permeate the Galaxy. Because of their large Larmor radius, cosmic rays are capable of entering the heliosphere and are routinely detected on Earth and in interplanetary space. They are a valuable tool to learn about the properties of the plasma in those parts of the solar system that are too distant to be directly explored by spacecraft. This tutorial is an introduction to the physics of low energy cosmic-ray transport within our solar system, including the solar wind and the heliosheath. I will introduce the famous Parker equation that describes the process of cosmic-ray diffusion in turbulent space plasmas. Simple applications of Parker equation to cosmic ray transport in the expanding solar wind will be discussed. I will also give an update on the latest results from the Voyager mission that may have recently crossed the boundary of the solar system.

The Origin of the Fast and Slow Solar Wind

Gary P. Zank
CSPAR
The University of Alabama in Huntsville

The basic description of expanding flows in a nozzle will be discussed as a basis for understanding the solar wind flow. The Parker model and early observations of the solar wind will be presented. From this, we will infer the structure of the interplanetary magnetic field and the "Parker spiral." The basic properties of the slow solar wind and fast wind will be discussed, and from this the difficulties of the Parker model will be identified. Subsequent refinements of the fast solar wind model will be described, and the need for a hot corona and the segregation of the wind by coronal holes will be addressed. We will conclude with a brief introduction to two modern models for heating the solar corona and driving a fast wind.

Particle Acceleration and Transport Theory

Gary P. Zank
CSPAR
The University of Alabama in Huntsville

A fundamental plasma process in space and astrophysical plasmas is that of energetic particle transport and particle energization at shock waves. The basic description, both physical and mathematical, for energetic particles propagating in a magnetically turbulent environment will be presented. The interaction of cosmic rays with expanding flows such as the solar wind will be discussed briefly. The main focus of the lecture will be on the application of the basic description of energetic particle scattering and transport at a shock wave. We will show that particles can be accelerated at a shock wave via the process of diffusive shock acceleration and that quite remarkably a power law distribution in momentum independent of the details of the diffusive scattering emerges. We will discuss some applications of the theory of diffusive shock acceleration.

Space Weather Instrumentation

James Spann
NASA Marshall Space Flight Center

The value of space weather operations and products are only as good as their accuracy. Our understanding of the dynamic space environment and knowledge of its impacts on systems enables accuracy. Therefore, it is imperative that accurate models and sound theories associated with the physics of space weather are developed. Observations of key space environment parameters motivate and guide theories and models. In turn, theories and models point to key observations that should be measured. This is an iterative process.
This talk will (1) develop the interactive nature of theory/models with observations/ instruments, (2) provide an overview of the types of observations associated with space weather including remote and in situ sensing, and (3) show and example of what is involved in developing space instrumentation.

Wednesday, July 24

Radiation Hazards

Jim Adams
CSPAR,
The University of Alabama in Huntsville

The ionizing radiation environment in space poses a hazard for space crews and also affects space systems, especially electronics. This lecture will cover the health hazards posed by space radiation and how these hazards are managed. The effects of space radiation on spacecraft will also be discussed. The focus will be mainly on radiation effects on electronics. The various effects will be described and the techniques for estimating the vulnerability of electronic parts will be discussed. Also techniques or radiation hardening spacecraft will be reviewed.

Perspectives on Building Laboratory and Flight Instrumentation for Plasma measurements

Kenneth. H. Wright
CSPAR
The University of Alabama in Huntsville

Development of a laboratory instrument to diagnose plasma wakes and the evolution of its design through different flight versions will be discussed. Data from laboratory experiments and from space flight missions will also be presented. The author will review guiding principles for space instrument/mission development and, lastly, discuss his recent experience with the International Space Station concerning its interaction with the ionosphere.

Grazing Incidence X-Ray Spectrometry

Mark Sterrett
CSPAR,
The University of Alabama in Huntsville

MaGIXS is comprised of a Wolter I telescope, a slit, a pair of parabolic mirrors, a plano variable line-spaced grating and a CCD detector. This design and layout have been optimized to produce an optical system with peak effective area of 5 mm^2, a wavelength range of 0.6-2.4 nm, spectral resolution of 2.0 pm, and spatial pixels of 2.5 arcsec along a 5 arcminute slit. The resulting instrument will resolve the solar spectrum for features in the solar corona with a two orders of magnitude increase over previous soft x-ray spectrographs in spatial and spectral resolution.

Techniques for Measuring the Magnetic Field in the Solar Corona

Ken Kobayashi
CSPAR,
The University of Alabama in Huntsville

Magnetic fields play a key role in the dynamics and energy transfer of the solar atmosphere, from the chromosphere to the corona and beyond. Energetic events such as flares and coronal mass ejections (CMEs) are believed to be powered by energy stored in, and transported by, magnetic fields. Yet our understanding of the magnetic field in the chromosphere and corona are based on indirect measurements, such as extrapolation from

the sun's photosphere and field lines inferred from imaging observations. Direct measurements are still very much experimental.
The talk will review the primary means of measuring magnetic magneticfields remotely, i.e. Zeeman effect and Hanle effect. The solar physics group at NASA MSFC / UAHuntsville have developed two sounding rocket experiments that attempt to measure these effects in the sun's chromosphere. The instrument principles and designs will be discussed.

Thursday, July 25

Spacecraft Charging

Joseph I. Minow
NASA, Marshall Space Flight Center

Spacecraft charging is the accumulation of a net charge density on spacecraft surfaces (surface charging) or in spacecraft materials (internal or deep dielectric charging). Charging is a fundamental physical process for materials exposed to the space plasma and radiation environment resulting in a net electric potential relative to the space plasma environment. Charging can also be a potential threat to space systems requiring evaluation of charging effects both at the design and operational phase of space programs. This presentation provides an overview of the physical processes involved in the spacecraft charging process, techniques used to model spacecraft charging, and provides examples of the impact of charging on satellite operations and charged particle measurements in the space environment.

Space Weather and Mission Operations

Joseph I. Minow
NASA, Marshall Space Flight Center

Space weather can impact all phases of space mission operations starting with launch decisions, through the on-orbit operations period, and during the final phase of satellite decommissioning. Mission operations teams use space weather data from a variety of sources to characterize the environment for space situational awareness, to determine if current conditions are within operational constraints, for scheduling science and engineering operations to minimize impact of the space environment, and for specifying the operational environment during anomaly investigations. The data requirements are variable and typically unique to a specific mission. This presentation will highlight examples of space weather impacts on space missions, real time sources of data for monitoring the space environment, and practical strategies for incorporating space weather data into mitigation schemes used to minimize the detrimental effects of space weather.

In-Situ Charged Particle Instrumentation used for Space Weather Measurements

Victoria N. Coffey
NASA, Space Science Department

Experimentally, the measurements taken for Space Weather are largely pursued through different types of instrumentation to study the properties and physical processes in our space environments that are permeated by waves, particles, photons, electric and magnetic fields. This science is largely pursued through in-situ charged particle instrumentation that can be utilized in either earth, planetary, or heliospheric missions (e.g., ionospheric or magnetospheric environments). We will discuss the main types of charged particle instruments, how their measurements are made, and how these measurements broaden our understanding. Examples of specific instruments and their components will be presented. Advantages and disadvantages of each will be further discussed along with a tour of the Low Energy Electron and Ion Facility (LEEIF) that has been used to develop, test, and calibrate these instruments for sounding rocket and satellite missions.

Monday, July 29

Geospace Overview

James Spann, ***Dennis L. Gallagher***
NASA Marshall Space Flight Center

Space weather has its origins beyond the Earth, almost entirely at the Sun. However, the impacts of space weather on our society occur within the near-Earth space environment called Geospace. Geospace is the region around the Earth that begins at ~80 km altitude where the neutral atmosphere and ionized ionosphere/thermosphere begin to interact, and extends out to the far limits of where its magnetic field impacts the impinging solar wind. With few exceptions, all the space assets that exist are in Geospace. Therefore to understand space weather and its impact on society it is required that we comprehend how Geospace filters, converts and dissipates the energy and mass from the Sun and heliosphere as it traverses down to the Earth. This session will provide an overview of what Geospace is and what its role is in the solar-terrestrial system. This includes how Geospace screens the solar wind, responds to external drivers, and generates its own space weather that impact space assets and ground-based systems. We will explore the fact that Geospace is not a passive recipient of solar variability, but an active participant in space weather.

Inner Magnetosphere Processes and Coupling

Dennis L. Gallagher
NASA, Space Plasma Physics Group
Marshall Space Flight Center

The inner magnetosphere is loosely defined to be the region of space threaded by terrestrial magnetic field lines from geosynchronous orbit inward. The dominant sources of energy in this region are the radiation belts and the ring current. The dominant mass in the region is the plasmasphere, which is an extension of the ionosphere. The region is characterized by the transport of plasma and energy both inward driven by the solar wind magnetosphere interaction and outward driven by ionization of the upper atmosphere and by plasma heating. The physical processes involved depend on particle-particle and wave-particle processes and on electric currents driven by energetic plasma through the resistive ionosphere. Plasma dynamics throughout the inner magnetosphere are highly coupled with that in the ionosphere and thermosphere as a consequence of these processes. An overview of these interactions and their consequences will be discussed.

Ionospheric Radio Science

Linda Krause
NASA, Marshall Space Flight Center

"Houston, we have a problem!" The iconic declaration heralds a well-known story of technical heroism that would make any geek proud, one in which scientists and engineers worked around the clock to save the lives of the three astronauts aboard the crippled Apollo 13 until it could safely hobble home. But what if those communication signals never reached Mission Control back on Earth because of a space weather storm? This talk will provide a survey of topics related to ionospheric radio science, including communication and GPS navigation outages resulting from solar and geomagnetic storms. Generally, the Earth's magnetic field protects us from the harmful solar particles streaming toward us at supersonic speeds. However, sometimes there are vast explosions of solar material sending large blobs of plasma hurling through space toward Earth. These blobs slam into the Earth's magnetic field, compressing it on the day side and causing many complex reactions on the nightside, some of which result in aurora. The problems arise when this reorganization of magnetic field energies our Earth's plasma environment in a complex way, often resulting in plasma "bubbles" that scramble radio transmissions similar to the distortion of an underwater image in front of Jacuzzi bubbles. With this talk, we will discuss ionospheric structures, plasma instabilities, solar drivers, diagnostics, and forecasting systems. We'll take a look at one case study, and conclude with some thoughts about opportunities for student research in this field.

Solar Flares as a Source of Energy in the Earth's Magnetotail

Sabrina Savage
NASA, Research Astrophysicist

Flares on the solar surface propagate energy into the solar system which in turn affect the Earth's magnetosphere. Coronal mass ejections (CMEs) are a notable consequence of solar eruptive events and are the result of magnetic field reconfiguration. Interesting sunward-flowing voids are now an expected consequence resulting from the passage of CMEs from solar flaring regions. Recent observations made using the extreme-ultraviolet (EUV) imagers aboard SDO/AIA have highlighted their association to magnetic reconnection, which is in turn associated with continual energy release following flare initiation. I will discuss how these flows propagate, their connection to flare energy release, and tie them back to potentially analogous events in the magnetotail.

Tuesday, July 30

Gamma-ray Signatures of Solar Flares

Michael Briggs
CSPAR,
The University of Alabama in Huntsville

Energetic processes that occur in solar flares can create gamma-ray signatures. Accelerated

ions can create radioactive isotopes, some of which emit gamma-ray lines from approximately 1 to 6 MeV.
Hundred-MeV protons can create pions. Neutral pions decay into gamma-rays. Positrons are produced from charged pions and by some radioisotopes; from positron annihilation we observe a signature 511 keV line.
Neutrons combine with protons, emitting a characteristic 2.2 MeV line. The nuclear gamma-ray lines are especially useful as diagnostic of the energy of the particles that created the radioisotopes.
I shall use Fermi observations of the M2 solar flare of 2010 June 12 as an example.

Terrestrial Gamma-ray Flashes: Gamma rays Electrons, Radio Discharges and Antimatter Signals from Thunderstorms

Valerie Connaughton
CSPAR
The University of Alabama in Huntsville

Terrestrial Gamma-ray Flashes (TGFs) have become an unexpectedly rich area of scientific discovery for the Fermi Gamma-ray Space Telescope, an astrophysical space mission launched in June 2008. TGFs seen by GBM are detected through their gamma-ray or electron-positron signals depending on the position of Fermi relative to the initiation point. I will discuss the population of TGFs observed by GBM, focusing on their temporal properties and their very close relationship to the associated radio signals detected by the World Wide Lightning Location Network (WWLLN).

An Introduction to Solar Physics

David H. Hathaway
NASA, MSFC

The key scientific questions for Solar Physics – the scientific study of the Sun – have evolved over the last century from questions concerning the source of the Sun’s energy (nuclear fusion) to three space weather related questions: 1) How is the sunspot cycle produced? 2) How is the corona heated/solar wind driven? And 3) How are solar flares and coronal mass ejections produced? This introduction to Solar Physics will describe the nature of these problems and current avenues for exploring solutions.

Photospheric Magnetic Field Evolution

The Inner Boundary Condition for the Heliosphere

David H. Hathaway
NASA, MSFC

Intense magnetic fields loop outward from the solar interior in the sunspot zones through the sunspots themselves. The turbulent motions at the surface of the Sun shred these fields and spread them out across the surface where they get caught up in the global flows – differential rotation (faster than average rotation at the equator and slower than average near the poles) and meridional flow (flow along meridian lines from the equator to the poles). In this talk the evolution of the magnetic field at the surface of the Sun will be described along with its use as the inner boundary condition for the structure and evolution of the heliosphere.

Wednesday, July 31

Unlocking the Secrets of the Sun

Amy R. Winebarger
NASA, Marshall Space Flight Center

The recent launch of the High-Resolution Coronal Imager (Hi-C) as a sounding rocket has offered a new, different view of the Sun. With ~ 0.2" resolution and 5 second cadence, Hi-C reveals dynamic, small-scale structure within a complicated active region, including coronal braiding, reconnection regions, cool, evolving structures, and flows along active region fans. By combining the Hi-C data with other available data, we have compiled a rich data set which can be used to address many outstanding questions in solar physics. Though the Hi-C rocket flight was short (only 5 minutes), the added insight of the small-scale structure gained from the Hi-C data allows us to look at this active region (+-1 day of flight) and other active regions with new understanding. The results from the Hi-C sounding rocket were recently published in Nature and have inspired more than 150 media reports. In this talk, I will show some the first results from the Hi-C sounding rocket and explain how they help us advance problems that have stymied the astrophysical community for almost 100 years.

Explosive Solar Magnetic Fields and Space Weather

Ron Moore
NASA, Marshall Space Flight Center

An overview is given of the explosions of magnetic arcades on the Sun, explosions of closed bipolar fields that range in size from as large as the solar radius to as little as a thousand times smaller. Typical observed explosions are shown in solar images and explained with cartoons of the form and action of the magnetic field. The take-home points are:

- All space weather is made or modulated by the Sun's magnetic activity.
- All magnetic fields on the Sun are made from Ω-loop bipoles that are 10 to 1000 times smaller than the Sun when they emerge.
- The field in an emerged bipole often has free energy that it releases by exploding.
- The greatest explosions of the big bipoles are gigantic CME/flare eruptions that blast out into the solar wind and make the most violent space weather.
- Explosions of the smallest bipoles possibly power the quiet corona and steady solar wind of normal space weather.
- Each explosion, large or small, is an explosion of stressed magnetic field unleashed by reconnection.

Reconstruction of Magnetic Clouds from In-Situ Spacecraft Measurements

Qiang Hu
CSPAR,
The University of Alabama in Huntsville

Coronal Mass Ejections (CMEs) are explosive events that originate, propagate away from the Sun, and carry along solar material with embedded solar magnetic field. Some are accompanied by prominence eruptions. The entire process can be observed by multiple instrumentations on-board several on-going spacecraft missions. The interplanetary counterparts of CMEs (ICMEs) are often detected in-situ by spacecraft ACE and Wind, which provide both magnetic field and plasma measurements sampled along the spacecraft path across the ICME structure. All these remote-sensing and in-situ measurements make it possible to perform the intercomparison between the (I)CMEs and their source regions at the Sun. In particular, a subset of ICMEs, so-called Magnetic Clouds (MCs) can be characterized by magnetic flux-rope structures. We will apply the Grad-Shafranov reconstruction technique to examine the configuration of MCs and to derive relevant physical quantities. We will select recent events during the rising phase of enhanced solar activity, and utilize additional observations from the most recent spacecraft missions, such as the STEREO and SDO spacecraft. Both observational analyses of solar source region characteristics including flaring and dimming, and the corresponding MC structures will be presented.

Flare and CME Driven Space Weather Effects and Forecasting

David Falconer
CSPAR,
The University of Alabama in Huntsville

Solar flares and Coronal Mass Ejections (CMEs) are the drivers of the most severe forms of space weather. Space weather can create benign effects such as the Northern Lights, but it can also interfere with GPS, apply unexpected voltages to power transmission lines, and harm satellites and astronauts. NOAA is in charge of monitoring and forecasting space weather for the nation. While forecasting when the next flare or CME will occur is beyond current capabilities, forecasting the probability of an event in the future is possible. One method that is being developed uses a free-energy proxy and empirically-derived event rates. This work is presently being done here at UAH and MSFC and will be reviewed in this talk. In addition, we will present other forecasting methods and their efficacy, as well as the process of research to operation (R2O).

Thursday, August 1

Electron Kinetic Scale Simulations

Ross Burrow
CSPAR,
The University of Alabama in Huntsville

Particle in cell (PIC) code is a numerical method for implicitly solving the Vlasov equation for collisionless plasmas. Theoretically and conceptually the PIC method is simple and works by brute force, solving particle motion via the Lorentz force equation and the electromagnetic fields directly through Maxwell's equations. If computer resources were not an issue PIC code would, in principle, able to resolve the relevant physics for large (AU scale) as well as small (Debye) scale astrophysical simulations, but in reality PIC is limited by the fact that it is a very computer-resource expensive, plasma simulation method. Thus PIC simulations are typically employed for electron kinetic (fine) scale plasma simulations.

We discuss the construction of a 1D PIC code and present some simulation results including the evolution of a two-stream instability due to counter-streaming electrons, as well as the evolution of an ion ring-beam in the presence of electrostatic fluctuations. We also discuss the development of a new type of hybrid code, which promises gains in computational efficiency by using PIC methods to couple energetic ion populations with the hydromagnetic, multifluid equations, with coupling via the pressure tensor.

Numerical Simulations

Sergey Borovikov
CSPAR,
The University of Alabama in Huntsville

Numerical simulations may produce gigabytes of data, which are values of some physical quantities. Although these data are self-sufficient, it is nearly impossible to analyze them by looking at the numbers. In this talk, we will look how visualization techniques help researches to understand physical phenomena. We will examine different types of plots, discuss best practices in the visualization, and speak about software/hardware aspects of the visualization.

Large-Scale Simulations of the time Dependent Heliosphere

N. Pogorelov
CSPAR,
The University of Alabama in Huntsville

Solar cycle has a profound influence on the solar wind (SW) interaction with the local interstellar medium (LISM) on more than one time scale. Also, there are substantial differences in individual solar cycle lengths and SW behavior within them. The presence of a slow SW belt, with a variable latitudinal extent changing within each solar cycle from rather small angles to 90 degrees, separated from the fast wind that originates at coronal holes substantially affects plasma at the heliospheric interface, in the compressed plasma layers ahead of and behind the heliopause. The solar cycle may be the reason of the complicated flow structure being observed in the inner heliosheath by Voyager 1. We present the results of the solar cycle simulations based on different numerical models, including the model with the SW boundary conditions derived from Ulysses measurements, and demonstrate how they can explain the observations of small to negative SW radial velocity components at Voyager 1, as well as an abrupt decrease in the ACR flux. The possibility of using observational data as boundary conditions for the SW simulations is discussed.

Looking to the interstellar boundary with IBEX

J. Heerikhuisen, E. Zirnstein
CSPAR,
The University of Alabama in Huntsville

The IBEX spacecraft has two neutral atom detectors (IBEX-Hi and -Lo) that sample each direction of the sky at least once every six months, allowing it to produce all-sky maps of energetic neutral atom (ENA) flux at a range of energies. Since neutrals are not affected by magnetic fields, and since collisions are very infrequent, IBEX is able to detect ENAs that traveled from the boundary region between the heliosphere and the local interstellar medium (LISM). In this talk we introduce the IBEX spacecraft and some of its capabilities. We will then show results of simulating Hydrogen (H) ENA and interstellar H flux measurements at the IBEX spacecraft position, while including the Compton-Getting (CG) effect. The CG effect arises when measurements of particle flux are made in a frame moving with respect to the frame of the emission source. In this case, measurements made in the IBEX spacecraft frame, which moves ~30 km/s circularly along the ecliptic plane, produce different results than those measured in the solar inertial frame. We will first show results from simulating high energy H atom fluxes relevant to IBEX-Hi measurements, particularly that of the IBEX ribbon. Then we will show results from simulating low energy H atom fluxes relevant to IBEX-Lo measurements. The CG effect becomes increasingly important at lower particle energies, particularly when including radiation pressure and gravitational effects.

Friday, August 2

Remembering the Real Space Cowboys

The Soul Of An Explorer Lives In Us All!

Ed Buckbee
U.S. Space & Rocket Center

"As far as returning to normal life, I don't think any of us ever returned to normal life. I don't think any us were normal people to began with."
Mercury Astronaut Alan B. Shepard, Jr.

Fifty-two years ago, Alan Shepard climbed aboard a Huntsville-developed Mercury Redstone rocket and blasted off from Cape Canaveral to became the first American to ride a rocket. That was the beginning for U.S. manned space flight. He had been selected to train with America's first astronauts—John Glenn, Wally Schirra, Gordon Cooper, Gus Grissom, Scott Carpenter and Deke Slayton- - who accepted their country's call to service and would become known as the Mercury 7. These men who had jockeyed for the best flying jobs in the military, began competing for rides on rockets. Most would eventually vie for the ultimate ride to the moon. This was the dream—a chance to ascend to the top of the pyramid—a lion-hearted pilot's deepest desire. Ed Buckbee, who has enjoyed a 50 + year association with the U.S. space program, follows these brave pioneers. From Alan Shepard's sub-orbital flight to the last man to walk on the moon, Gene Cernan, Buckbee covers all the manned missions of that era. Through time and personal friendships, he captures their dreams of flying higher, faster and farther than anyone in the known universe. You are taken behind the scenes to witness the competition between chimpanzees and astronauts and the conflict between NASA engineers designing capsules and those who would pilot them. They were our first astronauts. The path they blazed now shines for others; on a voyage that is a measure of the best in us all. The Mercury 7 astronauts were the first, the bold, the brave. They had the right stuff. They were *The REAL Space Cowboys*.

Space Weather

Owen Garriott
U.S. Space & Rocket Center

Forecast: Lot's of sun (except at "night"). Cloud free (above the horizon).
No precipitation (except in case of propellant leak!)
Be sure to prepare for extensive UV, EUV and even Xray exposure if you expect to take a stroll outside.
(As an extraordinary requirement when strolling, bring along your own breathing atmosphere as well!)

For the rest of the week (and even longer) expect no major changes for a long time.

Our observation post? Skylab, the US first space station, orbited precisely 40 years ago in 1973.

Skylab was flown in 3 missions of about 1, 2 and 3 months duration, all world records at the time.

Although there were many experiments in multiple fields conducted, we will talk mostly about research done on the Sun at wavelengths which cannot penetrate the earth's atmosphere. Secondly we discuss the many life science experiments conducted to better understand how the human body adapts to weightlessness and then readapts when one comes back to a normal gravitational environment

Project work in Huntsville

Project 1

SOFIE – Solar Flares Detected by Ionospheric Effects

Daniela Wenzel
German Aerospace Center (DLR), Neustrelitz

SOFIE is an educational project developed by the DLR_Project_Lab in Neustrelitz / Germany. It aims to develop a network of stations and is intended for long-term studies. The project is concerned with the observation of radio bursts emitted by the sun (so-called solar flares).

These flares may be detected via measurements of the resulting amplitude of signals emitted by VLF transmitters (3-30 kHz). Whenever a flare hits earth's atmosphere, X-rays cause an increase of electron density in the lower ionosphere. By this, conditions for propagation of terrestrial radio signals are altered, enabling a detection of the causes.

During the camp a receiver will be set up. This requires building an antenna. Afterwards data analysis and signal processing are discussed. Implementations are going to be done in Python; a short introduction into that language will be given. The ground-based data is compared to satellite data (GOES). We will experience a couple of filters and first comparisons in strength and time delay of solar flares' maxima.

Project 2

Grad-Shafranov Reconstruction of Magnetic Flux Ropes

Qiang Hu1[1], Christian Möstl[2], Chales J. Farrugia[3]
[1] CSPAR, The University of Alabama in Huntsville
[2] Space Research Institute, Graz, Austria
[3] University of New Hampshire, Durham

The Grad-Shafranov (GS) reconstruction method has recently become widely used in the space physics community in different contexts. It has been often used on structures in space plasmas which can be described by the approximation of magneto-hydrostatics such as the magnetopause, flux transfer events, flux ropes in the Earth's magnetotail, as well as magnetic flux ropes/magnetic clouds in the solar wind. The method is capable of deriving a cross section of a cylindrical structure (non-axisymmetric) from single-spacecraft data along a line across the structure.

In this project, a program package written in MATLAB (courtesy of Christian Möstl) will be utilized for learning the method and analyzing real in-situ spacecraft measurements of magnetic flux ropes/magnetic clouds. These programs are based on those developed by Qiang Hu in his 2002 JGR paper. They were extended by Christian Möstl (Space Research Institute, Graz, Austria) during his PhD thesis (finished in 2009) to include a graphical user interface (GUI), which makes it easy to apply the reconstruction method for a single event after the satellite data have been put into a proper format. Knowledge of and experience with MATLAB is not required, but would be helpful. The goal of this project is to go through the process of data acquisition, interval selection, pre-processing, final reconstruction and visualization of the result. The evaluation of the project will be based on the execution of the program, the correct and coherent analysis of the data, and the interpretation of the final results. Bonus points will be awarded if the team could succeed in 3D visualization of the result and deriving additional physical quantities associated with a magnetic flux rope.

Project 3

Numerical Simulation of Ring-Current particles

Jacob Heerikhuisen
CSPAR
The University of Alabama in Huntsville

The Earth's magnetic field is approximately a dipole. Particles in a dipole field are initially confined to field lines and so move up or down toward a pole. Near the pole, however, field lines converge and particles are reflected by the conservation of magnetic moment. This results in particles "bouncing" on field lines between the north and south poles. Additionally particle drift around the earth, thereby creating the rind-current, due to the curvature of the field-lines. We will simulate the ring current by assuming a simple form the the Earth's magnetic field, and numerically computing the trajectory of charged particles.

Project 4

Scientific Visualization of Space Environment Data

Linda Krause
NASA, Marshall Space Flight Center

This project will teach students how to develop 3D surface model of space environment structures from 3D gridded vector data sets. For example, it is one thing to have magnetic field vector data on a 3D grid, and quite another to construct magnetic field lines from those data. The students will learn an open source tool called VisIt. They will use VisIt to visualize magnetic field lines, isosurfaces, and particles using space environment data that will be provided to them. Time permitting, the student may learn how to animate the 3D surface models.

Tuesday, August 6

Welcome and Visit DLR Neustrelitz

Holger Maass, Hans-Joachim Stottke
German Aerospace Center (DLR), Neustrelitz

The Neustrelitz site of the German Aerospace Center (DLR) is located in Mecklenburg-Vorpommern, approximately 100 km north of Berlin. More than 60 employees are working in three institutes the

- Earth Observation Centre
- Institute for Communications and Navigation
- Institute for Remote-sensing Methods

and the Technology Marketing section. In addition a school-lab is just established for educating students in space sciences and related innovative technologies. DLR Neustrelitz site has access to modern technological systems suitable for the demands of a real-time data centre for GMES and Galileo related research tasks.

The national ground segment is a department of the Earth observation center (EOC) and takes care for reception of numerous remote sensing and scientific satellites. Thus, DLR Neustrelitz, as one of the four stations belonging to the Real Time Solar Wind (RTSW) network of NOAA, contributes essentially to the permanent availability of solar wind data measured onboard NASA's ACE satellite. Huge remote sensing data volume is successfully managed in the EOC by using the Data Information Management System (DIMS).

Research activities in the Institute for Remote sensing Methods focus on studying scattering and radiative transfer in the Earth's atmosphere for improving atmospheric corrections of remote sensing data.

In the field of satellite navigation, the research is focused on developing algorithms for precise and safe navigation in particular in the maritime application sector. Thus, technological developments have been carried out for the Rostock Research Harbour.

To correct and the impact of space weather effects on GNSS applications, the ionosphere is permanently monitored and modelled in near real time. Research activities focus on developing methods to detect, forecast and mitigate ionospheric perturbations having the capability to degrade GNSS systems. Derived Data products are disseminated via the Space Weather Application Center Ionosphere (SWACI), a project which is essentially supported by the state government of Mecklenburg Vorpommern.

Introduction and History of Ionospheric Research at DLR

Norbert Jakowski
German Aerospace Center (DLR), Neustrelitz

The Neustrelitz site of the German Aerospace Center (DLR) has a nearly 100 years old history of space weather related observations and research. Activities were always focussed on observations of the propagation characteristics of radio waves and studies of the ionospheric impact. After the launch of the first satellite, Sputnik 1, in 1957 the focus shifted rapidly from terrestrial HF to transionospheric radio wave propagation.

Nowadays, when considering modern space based radio systems of telecommunication, navigation and remote sensing, our modern society depends strongly on reliability of used transionospheric signals. This is a strong motivation to study the ionosphere and associated space weather phenomena. Fortunately, dual frequency signals of Global Navigation Satellite Systems (GNSS) such as GPS or Glonass can effectively be used for monitoring and modelling the ionosphere for research and establishing ionospheric services which provide crucial information and data to customers to warn them or to enable ionospheric corrections/mitigation of erroneous radio signals.

DLR Neustrelitz has a long-term experience in monitoring, studying and modelling the ionosphere.

The strong relationship of ionospheric behaviour with space weather phenomena is the basis for our interest in organizing the Space Weather Summer Camp in close cooperation with the University of Alabama Huntsville. A short overview on the summer school programme in Germany will be given.

Introduction to Satellite Orbital Mechanics for Space Weather Applications

Ben Opperman
SANSA Space Science

Satellite-borne measurements of space weather phenomena significantly enhance our understanding of, and modelling capability for predicting space weather processes and events. Specific space weather satellite missions however require specialised orbits to achieve its mission objects and orbits may differ from one mission to another. Knowledge and understanding of satellite orbit characteristics and dynamics is subsequently required in the design of relevant orbits for specific space weather satellite missions. The objective of the lecture is to supply necessary background on orbit dynamics and design with emphasis on space weather missions. The content will cover basic dynamics derived from Kepler and Newton’s laws; various orbit types; the application of perturbations to orbit design and the importance and characteristics of Lagrangian points. The orbit characteristics of ACE, GOES, SOHO, STEREO and other satellites will be discussed. Basic software for demonstrating orbit propagation and design will be introduced.

Progress in Warm Dense Matter and Planetary Physics

Andreas Becker, Winfried Lorenzen, Robert Püstow, Ronald Redmer
University of Rostock

The behavior of matter under extreme conditions (megabar pressures, temperatures of several 1000 K up to about 100.000 K) is important for interior models of giant planets. Surprisingly, the high-pressure phase diagram of even the simplest and most abundant elements hydrogen and helium is not well known (Jupiter, Saturn). Interesting phenomena such as proton conduction and demixing are expected when studying the behaviour of oxygen, carbon, nitrogen, their hydrides and mixtures at high pressures (Uranus, Neptune). A large number of planets has been found around other stars since 1995 which show a strong variation in mass, chemical composition, and distance to their parent star so that solar and extrasolar giant planets are perfect laboratories for the study of matter under extreme conditions. In the first part we will review the main properties of the solar planets and introduce detection methods for extrasolar planets and their properties.

In the second part we will give an introduction into the physics of matter under extreme conditions. Because simple plasma models based on perturbation theory fail to describe strongly correlated systems, ab initio methods have been applied to derive physical properties. For instance, molecular dynamics simulations based on finite-temperature density functional theory were used to calculate the equation of state, the electrical and thermal conductivity of H, He, their mixtures, and of molecular systems such as H2O for a wide range of densities and temperatures. Most interestingly, the equation of state data for hydrogen predict a first-order liquid-liquid phase transition with a critical point at 1400 K, 1.32 Mbar and 0.79 g/cm3 which is connected with a nonmetal-to-metal transition [1,2]. The behavior of the electrical and thermal conductivity and of their ratio (Lorenz number) is analyzed along this transition, especially the deviations from the well-known Wiedemann-Franz relation [3] which might be important for the operation of planetary dynamos. Furthermore, we have identified the parameters for demixing of helium from hydrogen [4,5] which match the conditions in the interior of Saturn as long has been predicted. Finally, we have calculated the interior structure and composition of solar [6] and some extrasolar planets (GJ 436b [7], GJ 1214b [8]) within three-layer models. We will give exemplary results for the density and temperature profile, the metallicity and size of the planetary cores, and for the slope of the material properties along planetary isentropes [9,10].

[1] W. Lorenzen, B. Holst, R. Redmer, Phys. Rev. B 82, 195107 (2010).
[2] M.A. Morales et al., PNAS 107, 12799 (2010).
[3] B. Holst, M. French, R. Redmer, Phys. Rev. B 83, 235120 (2011).
[4] W. Lorenzen, B. Holst, R. Redmer, Phys. Rev. Lett. 102, 115701 (2009).
[5] M.A. Morales et al., PNAS 106, 1324 (2009).
[6] J.J. Fortney, N. Nettelmann, Space Sci. Rev. 152, 423 (2010).
[7] N. Nettelmann et al., Astron. &Astrophys.523, A26 (2010).
[8] N. Nettelmann et al., Astrophys. J. 733, 2 (2011).
[9] N. Nettelmann, A. Becker, B. Holst, R. Redmer, Astrophys. J. 750, 52 (2012).
[10] M. French et al., Astrophys. J. Suppl. Ser. 202, 5 (2012).

Thursday, August 8

Welcome/Introduction to Atmospheric Science at IAP

Franz-Josef Lübken
Leibniz-Institute of Atmospheric Physics (IAP), Kühlungsborn, Germany

The major task of the IAP is the experimental and theoretical exploration of the atmosphere from the ground to the lower thermosphere (≈10 – 120 km). The focus of the activities is on the thermal and dynamical state of the mesosphere (50-100 km) at middle and polar latitudes, the coupling between various atmospheric layers, and long-term changes in the upper atmosphere. Experimental studies at IAP concentrate on highly sophisticated observations of temperatures and winds by ground based lidars and radars, and on measurements of turbulence and meteoric smoke particles on sounding rockets. More recently, turbulence detection on balloons in the stratosphere and ground based measurements of water vapor by microwave technique have been developed. Theoretical investigations include the role of dynamical processes (gravity waves, turbulence etc.) for the energy and momentum budget of the atmosphere, as well as the role of ice layers (noctilucent clouds, NLC) at≈83 km for the detection of climate change. Our understanding of the middle atmosphere is still rudimentary which is partly caused by the fact that this region is experimentally difficult to access and that the theoretical description of the most relevant physical processes changes fundamentally in the upper mesosphere/lower thermosphere. Some worldwide unique experimental and theoretical expertise has been developed at IAP to fill this gap. The activities of IAP concentrate on the headquarter in Kühlungsborn (54°N) and on the ALOMAR observatory (Arctic Lidar Observatory for Middle Atmosphere Research) being located at 69°N in Northern Norway. Furthermore, IAP runs a mobile lidar which is currently located in Davis, Antarctica. The IAP is member of the Leibniz-Society and has 80-90 employees. The institute is funded by the local government of Mecklenburg-Vorpommern, by the federal government in Berlin, and by research grants from various organizations.

Mesospheric Dynamics as Observed by Radars

Gunter Stober, Ralph Latteck, ManjaPlacke, Vivien Matthias, Peter Hoffmann and Marius Zecha
Leibniz-Institute of Atmospheric Physics (IAP), Kühlungsborn

Radar remote sensing is a key element investigating atmospheric dynamics in the troposphere/lower stratosphere and in the mesosphere. In particular, the mesosphere is characterized by its high dynamic variability due to tides, planetary waves, gravity waves and turbulence. In this lecture we present an overview of different radars and techniques to investigate the dynamic situation at various spatial and temporal scales. Further, the lecture provides a short overview of the physics of the related scattering processes to obtain the atmospheric information. This includes also an introduction to special mesospheric phenomena like e.g. polar mesospheric summer echoes, mesospheric echoes and meteors. As highlight a short introduction in the IAP student paper rocket program is given.

Friday, August 9

Incoherent Scatter Radars to Study the High Latitude Ionosphere

Michael Rietveld
EISCAT Scientific Association,
Ramfjordmoen, Norway

Incoherent Scatter Radars (ISR) are powerful radars with large antennas operating in the VHF and UHF bands with the ability to provide detailed ionospheric parameters from altitudes as low as 50 km to over 1000 km. The principles of their operation, some of the background theory, and the resulting measurements will be described. The two EISCAT radars (at 224 and 931 MHz) operating in northern Scandinavia and a third (at 500 MHz) operating on Svalbard will be used as primary examples but newer radar systems in Alaska and Canada will also be described. Although primarily used to study the natural ionosphere and upper atmosphere, they can also be used to study the effects of artificial perturbations (often similar to space weather effects) produced by radio-wave heating from specialized powerful HF transmitters, which will also be illustrated using the HF-facility operated by EISCAT.

The limitations of the present second-generation 20 to 30 year old radars, particularly in the inability to observe different directions of the sky simultaneously, and the difficulties associated with running these radars continuously, have led to proposals to build new types of radar based on phased-array antennas instead of the traditional dish antennas. In north America some radars based on this technology (AMISR) are now operating in the auroral zone and polar cap. In northern Europe a more advanced, more powerful radar with remote stations will be built. The new radar, with thousands of small antennas and transmitters, called EISCAT_3D is a three-dimensional imaging radar. It will make continuous measurements of the geospace environment and its coupling to the Earth's atmosphere from its location in the auroral zone at the southern edge of the northern polar vortex.

SWE Impact on GNSS

Botho Graf zu Eulenburg
AXIO-NET GmbH, Germany

Precise GNSS measurements with cm accuracy rely on resolving phase ambiguities of satellites signals received. The speed and reliability of achieving a so called “fixed solution” or “RTK solution” strongly depends on ionospheric conditions.

The current prediction for ionospheric activity (Sunspot solar cycle) estimates a maximum in 2013. During the last solar cycle, in particular in 2002, a strong correlation could be observed between ionospheric activity and user performance in GNSS network operation. An RTK user needed a long time to get an RTK solution, and on some cases it was not possible to work with GNSS at high precision.

An unusually intense solar flare observed by NASA space observatory on 7 June 2011 could cause significant disruptions to satellite communications and power lines on the Earth so officials said (Space Weather Prediction Centre). In some German media (newspapers, TV) this got major publicity as a huge cloud of particles was released and was placed over an area of nearly half the size of the solar surface.

Solar flares can cause geomagnetic storms, including disturbances in satellite navigation. This is what an RTK service provider as AX-IO-NET is would like to know in advance or immediately when such an event occurs, in order to provide its customers with relevant information how to prevent irregular results from satellite navigation.

In fact there were no such influences seen as predicted.

Available forecasts currently are inaccurate with respect to the influence on GNSS-RTK. Possible effects are well known, but when does a solar flare significantly influence precise positioning applications with GNSS?

Reliable forecast products are needed for such Space Weather incidents. A growing user community (e.g. surveyors, construction and agriculture) is depending on reliable use of GNSS and on precise forecasts of Space Weather events.

Ionization Processes in the Heliosphere

Klaus Scherer
Copernicus Gesellschaft e.V., Germany

In the heliosphere, especially in the inner heliosheath, mass-, momentum-, and energy loading induced by the ionization of neutral interstellar species plays an important and for some species, especially He, an underestimated role. I discuss the implementation of charge exchange and electron impact processes for interstellar neutral Hydrogen and Helium and their implications for further modeling. Especially, the importance of electron impact and a more sophisticated numerical treatment of the charge exchange reactions will be discussed.

Radio Observations of the Sun with LOFAR

Gottfried Mann
Leibniz Institute for Astrophysics Potsdam (AIP), Potsdam

The Sun is an intense radio source in sky. The Sun is an active star, which manifest not only in the variation of Sun spots and flares, but also a virulent variation of its radio radiation. Bursts of the radio emission from the Sun are closely related to flares. Basically, flares are defined as a strong enhancement of the emission of electromagnetic waves covering from the radio up to the gamma-ray range. Thus, the observation of the Sun's radio emission is a sensitive tool for studying flare physics.
The new European radio telescope LOFAR (Low Frequency Array) is able to measure the Sun's radio radiation with a highly spatial and temporal resolution. Few examples of flares are presented to demonstrate the close relationship between the various flare phenomena with the Sun's radio radiation.

Monday, August 12

Cosmic Rays on Their Route Through the Magnetosphere and Atmosphere - Theory and Experiment

Bernd Heber
Institute for Experimental and Applied Physics, Christian-Albrechts-University of Kiel

On their way to Earth cosmic rays encounter after passing the galaxy and the heliosphere the Earth's magnetic field and, if they succeed

to go beyond, the atmosphere. The magnetic field is shaped by electric currents in the Earth's core and by the interaction with the solar wind. Cosmic rays coming from outside will due to the Lorentz force undergo complicated trajectories in the magnetic field and may even be prevented from getting access to the atmosphere. The DOSimetry Telescope orbits the Earth aboard the International Space Station in a height of about 400 km. Its functionality as well as typical data will be discussed. We will in addition show that the filtering by the magnetosphere gives us thus the possibility to derive the spectra and arrival directions of cosmic rays.
When the cosmic ray enters the Earth's atmosphere, it encounters atoms and molecules, especially nitrogen and oxygen. Collisions will create secondary particles of different energies. Of special interest to aircraft personal are neutrons. PING is a detector developed to measure neutrons with energies up to a few tenth of MeV. In a practical unit of the course we will take data with the instrument and discuss the outcome.
Some of the secondary particles in the atmosphere may reach the ground, where one can measure them by e.g. a neutron monitor. Despite their decades of tradition, ground based neutron monitors (NMs) remain the state-of-the-art instrumentation for measuring cosmic rays, and they play a key role as a research tool in the field of space physics, solar-terrestrial relations, and space weather applications. They are sensitive to cosmic rays penetrating the Earth's atmosphere with energies from about 0.5-20 GeV. In two projects, funded by the EU, SEPSErver and NMDB we will compare data from spacecraft with the one from neutron monitors.

Out of the classroom-Into the Lab!

Dirk Stiefs
DLR_School_Lab Bremen

The German Aerospace Center (DLR) invites students and their teachers to visit its high-tech student laboratories, the DLR_School_Labs. This is where young people and students have an opportunity to actively discover the fascinating world of research and technology. The special feature of our concept: in the authentic environment of a research institution the students themselves can carry out experiments which are specifically related to ongoing projects in the fields of aeronautics, space, transportation and energy. And so they experience in a relaxed way how exciting the natural sciences and research can be.
In DLR_School_Lab Neustrelitz and DLR_School_Lab Bremen the main topic of the experiments is space. A special focus of an experiment both school labs have in common is space weather. Mr. Stiefs will give a short overview about the concept of the DLR_School_Labs and space weather activities. Afterwards the audience can try some special selected hands on experiments.

History of Space Weather Observations and Research

Kristian Schlegel
Copernicus Gesellschaft e.V., Germany

Centuries ago, people were not aware of “space weather“, but observed two important related phenomena: Aurora and sunspots. Thus a history of space weather exploration starts with the history of such observations. In the 18th century scientists began to explore the geomagnetic field and realized a connection with aurora. It took more than 200 years to clarify and explain this relationship. Before, the fundamentals of electricity, had to be es-

tablished after the discovery of the electron in 1897. The discovery of the ionosphere at the beginning of the 20th century was another important step in understanding solar terrestrial relations. With the introduction of magnetic indices by Julius Bartels in 1938 space weather effects could be characterized quantitatively.
The first effects of space weather on technical systems were observed at the end of the 19th century: disturbances on telegraph lines. About hundred years later the first effects on power lines were reported.
A true breakthrough of space weather exploration occurred towards the end of the 20th century with observations from satellites and space probes carrying sophisticated instrumentation and cameras.
The presentation summarizes these steps and highlights important milestones.

Ionospheric Response to Space Weather

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After presenting basic facts of the terrestrial ionosphere, a flow chart of impacts of space weather on the ionosphere is used to review the most important related phenomena: particle precipitation and convection. They both intensify the current systems in the ionosphere. Besides magnetic disturbances measurable on the ground, the enhanced currents cause a heating of the ionosphere, which eventually leads to a heating of the neutral atmosphere. In addition, magnetospheric convection affects the high altitude wind system. Another effect related to particle precipitation are auroras, their formation will be briefly summarized. Precipitation of high-energy electrons and protons after solar flares affect the lower ionosphere and cause radio wave propagation and attenuation, similar as enhanced solar x-ray emissions.
Another important space weather effect is the excitation of plasma instabilities in the ionosphere causing density irregularities, which affect radio waves as well.
The above effects are mainly observed at high geographic latitudes. At mid latitudes so called positive and negative ionospheric storm effects cause an enhancement/de-pletion of electron density.

Tuesday, August 13

Geomagnetic Variations, Activity Indices, and Thermospheric Response to Magnetic storms

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Most space weather events are accompanied by rapid variations of the geomagnetic field. Strong electric currents in the ionosphere and the magnetosphere cause these changing fields. Particularly intense currents flow at auroral latitudes in connection with northern lights. There are a number of geomagnetic indices that help to quantify the degree of activity. The Dst index characterises the strength of a magnetic storm. At high latitudes there is the AE index quantifying the intensity of the auroralelectrojet. It is a measure for the substorm strength. The most widely used index is Kp. It reflects the gen-

eral degree of magnetic activity. In recent years researchers make preferably use of direct measurements in the solar wind and in the magnetosphere for modelling space weather phenomena, rather than using indices. Electric fields set up by the solar wind in the outer magnetosphere are mapped down along field lines and cause currents in the auroral ionosphere.
The electric currents cause besides the varying magnetic field also a significant heating of the upper atmosphere. As a consequence, air is uplifted and the mass density at given height is rising. This effect can causes a markedly enhanced air drag for spacecraft and thus a more rapid orbit decay. The response of the neutral thermosphere to magnetic activity will be presented.

Neutral Atmosphere Signature Seen in Ionospheric Variability

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Changes of the upper atmosphere/ionosphere system at different time scales are mainly due to solar and extraterrestrial variability. However, the ionosphere is also influenced by forcing from the neutral atmosphere below, which may, e.g., lead to additional uncertainty in navigation and communication systems. This forcing is mainly due to atmospheric waves at different temporal and spatial scales. Waves originating from the lower atmosphere may propagate to the upper atmosphere directly or indirectly.
An overview of neutral atmospheric waves – gravity waves, tides, and planetary waves – is presented, including their forcing mechanisms and climatology. Some of these waves cannot directly propagate to the ionosphere, and indirect mechanisms leading to the presence of their signature in the upper atmosphere are discussed. Examples of lower atmosphere wave signatures in the ionosphere are shown. Another source of upper atmosphere variability is long-term cooling due to changes of minor atmospheric constituents like carbon dioxide and ozone. Results of observations and modelling are presented.

Wednesday, August 14

Cosmic Rays-Fundamentals and Space Weather Effects

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The energy input from cosmic rays into the system Earth is small, roughly the same as that of starlight. However, continuous galactic and sporadic solar cosmic rays have a multitude of effects on terrestrial, biological, and technological systems. In all scenarios for space weather services cosmic ray measurements are included as a monitoring instrument, as an additional forecasting tool, and as a provider of key input parameters for real time applications and post-event analysis. The first part of the review talk summarizes fundamentals of cosmic rays and of their interaction with the geospace environment. Emphasis is given to the role of cosmic ray measurements taken by the global network of ground-based detectors, such as neutron monitors. In the second part, after a general overview of cosmic ray space weather effects, the relevance of cosmic ray data within space weather programs is discussed. Real time ground based cosmic ray observations and advanced analysis methods

are significant as forecasting tools for geomagnetic storms, as an alert and monitoring instrument of the variability of particle radiation at the Earth, and as a key element in the assessment of the radiation do seat aircraft altitude during energetic solar particle events. This will be illustrated, based on selected examples.

Radiation Exposures in Space and Aviation Altitudes

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For long term human missions the main concerns are the human physiological responses to microgravity and radiation. For missions outside the magnetosphere ionising radiation is recognized as the key factor through its impact on crew health and performance. Of major concern is the exposure of humans by Galactic Cosmic Rays (GCR), because of the still in large parts unresolved questions about unique radiobiological aspects of irradiation by heavy ions, which results in high uncertainties of radiation risk estimates for late radiation effects, like cancer. Solar energetic particles released in coronal mass ejections are a further concern because exposures are possible which can be life threatening if no appropriate countermeasures are performed. In aviation altitudes the exposure is dominated by the secondary radiation produced in interactions of the incoming protons with the molecules of the atmosphere, such as neutrons, secondary protons, electrons and gamma rays.
On the ISS a huge set of radiation instruments is used to monitor the radiation environment for a fixed inclination in dependence on altitude, solar activity and shielding distribution. Besides environmental dosimetry also personal dosimetry for the astronauts is a mandatory part of the measurement program, which besides the physical characterisation of the radiation field has as main task provision of radiation protection measures for the astronaut. The measurements are completed by the use of phantoms (spherical and anthromorphic) to relate the quantities measured by environmental and personal dose meters to radiation protection quantitites. The ESA multiuser facility MATROSHKA was designed to provide accurate information on the radiation doses in human organs. The key part of MATROSHKA is a human phantom upper torso, equipped with numerous radiation detectors at the surface and inside the phantom. The facility therefore allows the determination of the empirical relations between measurable absorbed doses at the skin and the tissue absorbed doses in different depth inside the phantom.
Calculation of radiation risks in the ISS orbits is therefore based on quite reliable data. This is not the case for interplanetary missions where the exposure rates for planned future missions are mostly based on calculations so far. Most recently, the radiation assessment detector has provided first measurements on the cruise to Mars which no allow to benchmark calculations.
Whereas in space radiation exposures can approach or even exceed radiation limits set for radiation workers on Earth, in aviation altitudes we are far away from such limits, although civil aircrew is the highest exposed cohort at all. Exposures here are strongly depending on flight altitudes and latitudes and on the solar activity.
The presentation reviews the physical features of the radiation field as far as they relevant for radiation protection followed by an overview on exposure data gathered mainly on the ISS and with the Radiation Assessment Detector of the Mars Science Laboratory (MSL) together with calculations for future human missions. Finally, the unique features of heavy

ions will be described, radiobiological effects observed from space radiation and radiation risks for different mission profiles are shown.

Thursday, August 15

Offshore GNSS Positioning

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Fugro's mission is to be the world's leading service provider for the collection and interpretation of data relating to the Earth's surface and sub-surface, and for associated services and advice in support of infrastructure developments on land, along the coast and on the seabed. Fugro's activities are carried out across the world, both onshore and offshore, and are primarily aimed at the oil and gas industry, the construction industry and the mining sector. All these activities require precise and reliable positioning, usually in real-time. Fugro provides a number of GNSS (Global Navigation Satellite System) positioning services, mainly for use offshore. In the early 2000's it introduced the differential, carrier based HP service, followed by XP, a GPS only Precise Point Positioning (PPP) service, a few years later. In 2009 G2, based on integrated use of GPS and Glonass, became operational.
Current research at Fugro focuses on including the Chinese BeiDou and the European Galileo systems in its PPP services. Once these systems are operational, more than 100 satellites will be available for high precision positioning applications.
Precision can be further improved once the ambiguities of the GNSS carrier observations can be fixed to their integer values. Fugro has set up several test beds to investigate the feasibility of this concept, usually referred to as PPP RTK (Real-Time Kinematic) or PPP IAR (Integer Ambiguity Resolution).

Apart from the GNSS signals themselves, the services also rely on correction signals, broadcast e.g. by geostationary satellites, using frequency bands similar to GNSS.
A lot of Fugro's activities take place in areas at or near the geomagnetic equator, such as Brazil, West Africa and Southeast Asia. As a result, the GNSS and correction signals are often disturbed or even completely lost, due to e.g. ionospheric scintillations. Using more satellite systems, such as GPS, Glonass, Galileo and Compass, may help, but it would also be beneficial to be able to predict when the ionosphere will start behaving badly and which signals will be affected.
In this contribution, we will give an overview of Fugro's current positioning services and present initial results from including BeiDou and Galileo. We will also present results from PPP RTK, obtained from a test bed in the Gulf of Mexico. Next, we will give a description of the network monitoring activities. We will conclude with an overview of the activities related to ionospheric monitoring and prediction of scintillations.

Impact of Solar Activity on satellite Electronics

Stefan Metzger
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Space crafts are vulnerable to space weather through its influence on the space environment. During solar events like flares or coronal mass ejection the fluxes of high energetic particles in the earth radiation belts can increase several orders of magnitude. In addition the flux of galactic cosmic rays is modulated in antiphase with the 11-year solar cycle. As a result the space radiation environment depends strongly on the actual space weather.

The particles that compose the radiation environment produce a variety of effects including total dose, lattice displacement damage and single event effects (SEE) as well as noise in sensors. Examples of all the above effects will be given from observed spacecraft anomalies or on-board dosimetry and these demonstrate the need for increased understanding and prediction accuracy for space weather as well as the need for protection from the induced phenomena. The induced effects are often the origin of satellite anomalies which can at worst lead to the total loss of a satellite.

Project work in Neustrelitz

Project 1

SOFIE – Development and Test of a VLF-receiver for Monitoring Solar Flares

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DLR_Project_Lab, Neustrelitz

Natural disturbances of radio communication are known to be connected with space weather phenomena. Solar Flares can influence long waves (LW) over large distances. A simple VLF receiver allows continuous monitoring of signals from far distant transmitters. The analysis of the signal enables simultaneous investigation of different space weather related physical phenomena.

The DLR project lab offers participants to set up their own VLF receiver with professional guidance of a school lab supervisor. Participants learn about technical requirements for receiver and antenna. Each component of the receiver and its specific use will be presented in detail. One main point is the proper integration of single components to the printed circuit board (PC-board) of the receiver. The required solder techniques will be trained and applied. Afterwards all components will be balanced and the whole instrument is put into operation.

Finally, after the successful receiver set up, data management is emphasised. The participants learn how to deal with different data formats, the required software and data transfer issues. At the end of the project a regular operation is planned, where external users can access data records of a large amount of VLF-receiver at different positions.

Project 2

Ionospheric Modelling

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Single frequency users of Global Navigation Satellite Systems (GNSS) need to correct link related ionospheric range errors of up to 100m. Since this range error is proportional to the Total Electron Content (TEC) of the ionosphere, correction information can be provided by TEC maps deduced from corresponding GNSS measurements or by correction model values. In this project work, the students will learn about different ionospheric correction models such as the NeQuick, the NTCM (Neustrelitz TEC Model), the GPS Ionospheric Correction Algorithm (ICA) also known as the Klobuchar model and the International Reference Ionosphere (IRI) model as well as about TEC maps deduced from GNSS measurements at DLR Neustrelitz. The ionospheric parameters dependencies on solar activity level, their annual, semi-annual variation, local time variation and geomagnetic latitude variation will be studied in details. The students will compare TEC values derived from the Klobuchar model, the NeQuick model and the NTCM-GL global model with reconstructed TEC map values during daytime and nighttime in high and low solat activity periods.

Project 3

Scintillation Monitoring

Nikolai Hlubek
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Global Navigation Satellite Systems (GNSS) such as GPS, Galileo or Glonass can be heavily disturbed by space weather hazards. Severe temporal and spatial changes of the electron density in the ionosphere can lead to strong GNSS signal fluctuations in phase and amplitude – so-called scintillations. These scintillations can reduce the positioning accuracy significantly and in the worst cases lead to a receiver loosing lock of the satellite signal. The scintillation indices S4 and σ_ϕ provide a characteristic quantity that shows the strength of the scintillation. In this project work the students will learn how to derive and visualize said indices from real data sets using the Python programming language.

Project 4

Aviation Dosimetry

Nicole Santen
German Aerospace Center (DLR), Cologne

The determination of the radiation exposure of aircrew at aviation altitudes, generated by interactions of primary high-energetic particles of cosmic origin with atoms in upper layers of the Earth's atmosphere, has been part of the radiation protection standards in the EU for more than ten years. The corresponding radiation field is very complex in both particle composition and energy distribution. The corresponding intensity depends on altitude, geomagnetic latitude and solar activity. Furthermore, Solar Particle Events (SPEs) can temporarily lead to increased dose rates at aviation altitudes as well.

For the operational dose assessment of aircrew, computer programs are used, which are regularly verified and improved by concomitant measuring flights that allow spot checks of the calculated doses by measuring this cosmic radiation field with different types of detectors. This project work will give an insight into the field of radiation protection in aviation by evaluating such a measuring flight. The students learn which dosimetric quantities can be measured by various detectors and determine the relevant characteristics of the radiation field at cruising altitudes. Finally, the space weather situation during the flight is to be considered.