EP 5: Near Earth Space

Time: Tuesday 16:15–18:45 Location: EP-H1

Invited Talk EP 5.1 Tue 16:15 EP-H1

Investigating Earth's atmosphere and ionosphere from space: How GNSS radio occultation measurements contribute to monitor the atmosphere in a high spatial resolution — •Christina Arras[1], Ankur Kepkar[1,2], and Jens Wickert[1,2] — [1]German Research Centre for Geosciences GFZ, Potsdam, Germany — [2]Technische Universität Berlin, Germany

The GNSS radio occultation (RO) technique has been established successfully during the previous two decades. It evolved into a valuable observation tool for precise atmospheric and ionospheric vertical profiling. Radio occultation measurements provide globally distributed precise profiles of the refractivity of the Earth's atmosphere that can be converted into profiles of temperature, pressure, and water vapor in the lower neutral atmosphere and into electron density values in the ionosphere. Until today, there are about 14 million RO recordings available.

GNSS RO signals are very sensitive to vertical electron density gradients in the Earth's ionosphere. This becomes visible as strong fluctuations in, e.g., signal-to-noise ratio recordings, which allow detecting ionospheric disturbances like sporadic E layers in the lower ionospheric E region and equatorial plasma bubbles in the F-layer.

In this presentation, we will give an overview on RO data availability. We will review the data analysis to derive information on ionospheric disturbances in the E and F layer. Further, we discuss the sporadic E and plasma bubble formations that result from complex coupling processes in the thermosphere-ionosphere-magnetosphere system.

EP 5.2 Tue 16:45 EP-H1

Measurements of cosmic rays by a mini neutron monitor aboard the German research vessel Polarstern — •M. Zoska[1], S. Banjac[1], S. Burmeister[1], H. Giese[1], B. Heber[1], K. Herbst[1], L. Romaneesen[1], C. Schwerdt[2], D. Strauss[3], C. Wallmann[1], and M. Walter[1] — [1]Christian-Albrechts-Universität Kiel, Germany — [2]Deutsches Elektronen-Synchrotron Zeuthen, Germany — [3]North West University, Potchefstroom, South Africa

Galactic cosmic rays (GCRs) are a direct sample of material from far beyond the solar system. Measurements by various particle detectors have shown that the intensity varies on different timescales, caused by the Sun's activity. Many studies on GCR intensity decreases are based on the analysis of ground-based neutron monitors. Their measurements depend on the geomagnetic position, and the processes in the Earth's atmosphere. In order to get a better understanding of the geomagnetic filter over the solar cycle, the above groups agreed on a continous monitoring of the GCR flux as a function of latitude, by installing a portable device aboard the German research vessel Polarstern in 2012. The vessel is ideally suited for this research campaign because it covers extensive geomagnetic latitudes (i.e. goes from the Arctic to the Antarctic) at least once per year. Here we present themeasurements for different latitude surveys including the solar maximum in 2014 and solar minimum in 2019.

The Kiel team received funding from the European Union Horizon 2020 programme under grant agreement No 870405. We thank the crew of the Polarstern and the AWI for supporting our research campaign.

EP 5.3 Tue 17:00 EP-H1

Utilizing Cosmic Ray data as input for neutron-based soil moisture measurement — •Hanna Giese[1], Bernd Heber[1], Konstantin Herbst[1], and Martin Schrön[2] — [1]Institut für Experimentelle und Angewandte Physik, Christian-Albrechts-Universität zu Kiel, Kiel, Germany — [2]UFZ Helmholtz Center for Environmental Research, Leipzig, Germany

Neutrons on Earth interact with the soil and are substantially moderated by hydrogen atoms. Since the reflected neutron flux is a function of the soil water content, cosmic-ray neutron measurements above the ground can be used to estimate the average field soil moisture. Thus, if the local incoming neutron flux and the abundance of nearby hydrogen pools are known, the reflected neutron flux could be modeled and compared to observed detector count rates. However, the incoming neutrons are secondaries produced by interacting energetic Galactic Cosmic Rays (GCRs) in the atmosphere. The total neutron flux on the ground depends on the solar modulation-dependent GCR flux, the geomagnetic position, and the altitude within the atmosphere. So far, measurements of either the Jungfraujoch neutron monitor (NM) or a NM of similar cutoff rigidity have been used and altered to estimate the neutron flux at the position of each neutron detector. In this contribution we present a new method based on the Dorman function to directly compute the local neutron flux using remote neutron monitor data.

We received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 870405

EP 5.4 Tue 17:15 EP-H1

Empirical modelling of SSUSI-derived auroral ionization rates — •Stefan Bender[1,2], Patrick Espy[1,2], and Larry Paxton[3] — [1]Norwegian University of Science and Technology, Trondheim, Norway — [2]Birkeland Centre for Space Science, Bergen, Norway — [3]APL, Johns Hopkins University, Laurel, Maryland, USA

Solar, auroral, and radiation belt electrons enter the atmosphere at polar regions leading to ionization and affecting its chemistry. Climate models usually parametrize this ionization and the related changes in chemistry based on satellite particle measurements. Precise measurements of the particle and energy influx into the upper atmosphere are difficult because they vary substantially in location and time. Widely used particle data are derived from the POES and GOES satellite measurements which provide in-situ electron and proton spectra.

Here we use the electron energy and flux data products from the Special Sensor Ultraviolet Spectrographic Imager (SSUSI) instruments on board the Defense Meteorological Satellite Program (DMSP) satellites. The currently three operating satellites directly observe the auroral emissions in the UV from which electron energies and fluxes are inferred in the range from 2 keV to 20 keV. We use these observed electron energies and fluxes to calculate auroral ionization rates in the lower thermosphere (90–150 km). We present an empirical model of these ionization rates according to magnetic local time and geomagnetic latitude. The model is based on geomagnetic and solar flux indices and will be particularly targeted for use in climate models that include the upper atmosphere, such as WACCM-X or EDITh.

Invited Talk EP 5.5 Tue 17:30 EP-H1

Solar extreme events and their impact on the middle atmosphere — •Thomas Reddmann[1], Monali Borthakur[1], Miriam Sinnhuber[1], Ilya Usoskin[2], and Jan-Maik Wissing[3] — [1]Karlsruhe Institute of Technology, Germany — [2]University of Oulu, Finland — [3]University of Rostock, Germany

The Sun occasionally produces strong eruptions on its surface and in the corona. Within these strong eruptions, energetic particles are accelerated to high energies which hit the Earth within hours after the event. In addition, ejected plasma clouds can be accelerated towards the Earth causing severe geomagnetic disturbances which also cause particle precipitation. Here we study the impact of a one per millenium solar event on the atmosphere.

We use historical records and analyzed distributions of energy spectra to derive ionization rates for a combined extreme solar proton event and a geomagnetic storm which typically impact different parts of the atmosphere. The ionization rates for the extreme event are then used in simulations in the KASIMA and EMAC model which both include energetic particle induced chemistry. Their simplified production efficiency of NOx and HOx is compared to an ion chemistry model. We select specific dynamical situations for the event which represent a different vertical coupling in the atmosphere. Finally, we estimate the impact of the extreme event under those different dynamical situations on the chemical state in the atmosphere on the seasonal time scale in terms of ozone change and the global NOx budget together with the additional UV dose.

EP 5.6 Tue 18:00 EP-H1

Impact of chlorine ion chemistry on the ozone loss during very large solar proton events — •Monali Borthakur[1], Thomas Reddmann[1], Miriam Sinnhuber[1], Gabrielle Stiller[1], Thomas Von Clarmann[1], and Ilya Usoskin[2] — [1]Karlsruhe Institute of Technology, Karlsruhe, Germany — [2]University of Oulu, Oulu, Finland

Strong eruptions on the Sun can accelerate charged particles, mostly protons, to high energies, causing solar proton events (SPEs). Such energetic particles can precipitate upon the Earth's atmosphere, mostly in polar regions because of the geomagnetic shielding. SPE induced chlorine activation and its impact on stratospheric ozone in the polar northern atmosphere has been investigated using a 1D stacked-box model, of atmospheric ion and neutral composition, EXOTIC. Two SPEs were used as test fields: the Halloween SPE late October 2003 and an extreme event of 775 AD, which was derived from historical records of cosmogenic nuclides. We used observations of chlorine species and ozone from the Michelson Interferometer for Passive Atmospheric Sounding (MIPAS) on ENVISAT to evaluate model results for the Halloween event. Model experiments were carried out with full ion chemistry as well as with a common parameterisation scheme considering the formation of HOx and NOx. Additional ozone destruction due to the chlorine catalytic cycles was observed as well in the upper stratosphere and lower mesosphere. For the parameterised model runs, ozone depletion was observed to be the largest for full parameterisation.

EP 5.7 Tue 18:15 EP-H1

Ring current electron precipitation during storm events — •Alina Grishina[1,2], Yuri Shprits[1,2,3], Michael Wutzig[1], Hayley Allison[1], Nikita Aseev[1,2], Dedong Wang[1], and Matyas Szabo-Roberts[1,2] — [1]GFZ Potsdam, Potsdam, Germany — [2]University of Potsdam, Potsdam, Germany — [3]University of California, Los Angeles, Los Angeles, CA, USA

The particle flux in the near-Earth environment can increase by orders of magnitude during geomagnetically active periods. This leads to intensification of particle precipitation into Earth's atmosphere. The process potentially further affects atmospheric chemistry and temperature.

In this research, we concentrate on ring current electrons and investigate precipitation mechanisms on a short time scale using a numerical model based on the Fokker-Planck equation. We focus on understanding which kind of geomagnetic storm leads to stronger electron precipitation. For that, we considered two storms, corotating interaction region (CIR) and coronal mass ejection (CME) driven, and quantified impact on ring current. We validated results using observations made by POES satellite mission, low Earth orbiting meteorological satellites, and Van Allen Probes, and produced a dataset of precipitated fluxes that covers energy range from 1 keV to 1 MeV.

EP 5.8 Tue 18:30 EP-H1

Solar energetic particle event on 28 October 2021 as seen by the neutron monitor network — •Christian Steigies[1] and Rolf Bütikofer[2] — [1]Christian-Albrechts-Universität zu Kiel, Germany — [2]Universität Bern, Switzerland

The first solar energetic particle event during the current solar cycle 25 observed on ground, a so-called ground level enhancement (GLE), was detected on 28 October 2021 by a few neutron monitors of the worldwide network. At 16:09 UT the Athens GLE Alert system issued successfully an automatic alert. After the initial rapid increase in cosmic ray (CR) intensity, it slowly declined to background level within several hours. During times of raised CR intensities, the ionization rates in the atmosphere are increased and thereby radiation dose rates at aircraft altitudes may be enhanced depending on the location and the altitude. We present a first GLE analysis and assess the additional radiation doses that may be acquired on selected flight routes.