EP 3: Near-Earth Space I

Time: Tuesday 13:45–15:45 Location: ZHG005

Invited Talk EP 3.1 Tue 13:45 ZHG005

Atmospheric modelling from ground to lower thermosphere — •Claudia Stephan — Leibniz Institute of Atmospheric Physics at the University of Rostock, Kühlungsborn, Germany

The mesosphere and lower thermosphere (MLT) extend from an altitude of approximately 50 km to a few hundred kilometres. Highly dynamic physical processes in the MLT are driven by solar and magnetospheric forcing from above and by meteorological disturbances from below. The MLT layer is of increasing societal relevance as its weather directly affects the functionality of ground- and space-based communication and navigation systems. In addition, it hosts a growing number of satellites that monitor weather and climate or support critical technologies. Long-term trends in the MLT are mainly driven by increasing concentrations of anthropogenic carbon dioxide (CO2), which is responsible for large negative temperature trends of about -1.6 K/decade in the mesosphere. Atmospheric waves are associated with variability in winds, temperature and pressure on time scales of minutes to days. In particular, gravity waves are essential for coupling all atmospheric layers, from the troposphere to the thermosphere, but are difficult to treat in numerical models. Exascale computing allows global-scale simulations with horizontal grid spacings in the range of 1-10 km. In such models, resolved orography and non-orographic gravity wave sources provide a realistic wave forcing of the overlying atmosphere with explicitly simulated vertical energy and momentum transport. We extend these efforts to the MLT.

EP 3.2 Tue 14:15 ZHG005

A global picture of the ionosphere response to solar wind during equinox — •Claudia Borries — DLR, Institut für Solar-Terrestrische Physik

The ionosphere can change significantly with the solar wind conditions. Especially during storm conditions, e.g. the impact of an interplanetary coronal mass ejections, large deviations from quiet conditions can be observed in different ionospheric observables. Modelling and predictions of ionospheric storm conditions is a great challenge because of the large variability in the storm characteristics and so far, there is no global model, which is capable in reproducing ionosphere storm conditions. In our study, we analyse the Total Electron Content (TEC) with respect to its response to solar wind conditions with the goal to extract general characteristics for different regions, local times and delays to solar wind variability. Statistical analysis is applied on the TEC map data provided by the International GNSS Service for the period 2005-2023. We compare these general characteristics with a recent very strong storm in May 2024 to show, how well they agree with actual storm characteristics.

EP 3.3 Tue 14:30 ZHG005

Atmospheric impact of the extreme geomagnetic storm of May 10/11, 2024 — •Miriam Sinnhuber — Karlsruher Institute of Technology, Karlsruhe, Germany

On May 10-11, two CMEs arriving within few hours initiated a geomagnetic storm with a DST of around -400 nT in the main phase. With a Kp of 9 for several hours, the threshold for an *extreme* geomagnetic storm was reached for the first time since the Halloween storm in October/November 2003, and polar lights were clearly visible well into magnetic midlatitudes. Proton fluxes were enhanced for several days, reinforced by a third CME arriving on May 13; however, they were distinctly lower than for the Halloween SPE of October 2003, making this a fairly moderate solar proton event. Analyses of satellite datasets MLS/AURA and ACE-FTS/SCISAT show a moderate ozone loss in the high-latitude upper mesosphere, as well as increases of NO and N2O in the upper mesosphere at magnetic mid-to high latitudes. The spatial structure of the response is consistent with a moderate solar proton event, but it appears to be weaker than, e.g., the response to the much more moderate geomagnetic storm of April 2010. However, a direct comparison is difficult as the instruments used to assess the April 2010 or Halloween storms are inoperable now. This emphasizes on the one hand the large spread of possible impacts of geomagnetic storms, on the other hand the need for continuing global observations.

Invited Talk EP 3.4 Tue 14:45 ZHG005

Beauty and hazards created by the terrestrial magnetosphere — •Elena Kronberg — LMU, Munich, Germany

Space weather activity during the current solar cycle maximum draws our attention to striking phenomena, such as auroras seen at unusually low latitudes. It also raises concerns about whether modern technology is sufficiently protected from space hazards. In this talk I will discuss magnetospheric mechanisms that generate auroral features such as spirals. These mechanisms also make powerful particle accelerators. Energetic particles at 100s of keV are responsible for lost observation time in astrophysical X-ray missions such as XMM. They may damage observations from the prospective magnetospheric mission SMILE. Machine learning based models of the charged particle population are derived to mitigate such costly losses. Magnetospheric dynamics also leads to changes in the atmosphere, which in the long term may affect planetary habitability.

EP 3.5 Tue 15:15 ZHG005

Space Weather monitoring and research with new ground-based monitoring capabilities during the maximum of Solar Cycle 25 — •Jens Berdermann, Martin Kriegel, Daniela Banyś, Mainul Hoque, David Wenzel und Dmytro Vasylyev — Deutsches Zentrum für Luft- und Raumfahrt e.V., Kalkhorstweg 53, 17235 Neustrelitz, Germany

By reaching the maximum of solar cycle 25 the influence of space weather is becoming increasingly visible, with phenomena like radio bursts, solar flares and geomagnetic storms occurring more frequently and also with impact on technical systems. Therefore, we have set up a ground-based space weather observation system to continuously monitor the actual space weather situation and related conditions in the upper atmosphere. The system combines a CALLISTO receiver to track solar radio bursts in the frequency range from 10 to 1,600 MHz covering HF, VHF and L-band spectrums, a VLF GIFDS receiver for solar flare detection as well as a high rate GNSS receiver for monitoring ionospheric scintillations. The prototype system is being operated at the Multi-instrument Ionospheric Radio observation Array (MIRA), a measurement field at the DLR site in Neustrelitz, to conduct the final testing and performance analysis. The expansion to other locations in Europe and worldwide in cooperation with partner institutions is intended and it will further increase the coverage. In this presentation, we will show the system's benefits for space weather research and services based on the analysis of the latest events from the maximum of solar cycle 25.

EP 3.6 Tue 15:30 ZHG005

Simulations of the CHerenkov Atmospheric Observation System (CHAOS) — •Pierre Bornfleth, Hannes Ebeling, and Ava Pohley — Christian-Albrechts-Universität zu Kiel

The Earth is continuously exposed to high-energy charged particles, so-called Galactic Cosmic Rays (GCRs). When these particles hit the Earth's atmosphere, they create a cascade of secondary particles. CHAOS uses a new detector design developed at the Department of Extraterrestrial Physics at Kiel University by a team of students to measure the different particle species of the primary GCRs above the so-called Regener-Pfotzer Maximum. To perform these measurements a combination of multiple solid state detectors and a bismuth germanium oxide (BGO) scintillator is used to measure the energy depositions of the particles. The use of an additional Cherenkov aerogel scintillator allows to separate between electrons and protons. Because electrons are much lighter than ions, electrons with energies above $\sim 1.1\,\mathrm{MeV}$ will trigger the Cherenkov detector whereas ions with the same energy are much slower and will not trigger the Cherenkov detector. CHAOS flew on a stratospheric balloon as part of the BEXUS program in early Oktober 2024. In this talk I present a comparison between simulations of the detector and the measurements of the flight to identify which particles were measured and what energy they had.