HEPPA 2009

HIGH ENERGY PARTICLE PRECIPITATION IN THE ATMOSPHERE

Meeting Report for the 2nd International HEPPA Workshop

6-8 October 2009

URL: http://www.acd.ucar.edu/Events/Meetings/HEPPA/.

General Information

In recent years, many new satellite instruments capable of polar region observations have been launched. This has provided unique opportunities to study effects of energetic particle precipitation (EPP) on the atmosphere. The Finnish Meteorological Institute organized the 1st International High Energy Particle Precipitation in the Atmosphere (HEPPA) Workshop, which was held 28-30 May, 2008. That workshop was so successful that we organized and held the 2nd International HEPPA Workshop on 6-8 October 2009 (HEPPA-2009). Like the first workshop, HEPPA-2009 focused on observational and modeling studies of atmospheric and ionospheric changes caused by EPP. It was held at the National Center for Atmospheric Research in Boulder, Colorado, USA, and was jointly sponsored by NCAR, the University of Colorado, IAGA, and NASA Living With A Star (LWS).

Participants and Presentations

HEPPA-2009 brought together 63 participants from Australia, Canada, Finland, France, Italy, Germany, New Zealand, Norway, Spain, Sweden, Switzerland, UK, and USA (see Figure 1). The workshop consisted of invited tutorials that were targeted at a level to bring together people from various disciplines, as well as invited talks, contributed talks, and contributed posters. A total of 42 oral and 17 poster presentations were given.

Sessions were arranged as follows:

- Tutorials
- Precipitating Particle Sources
- EPP effects on the Thermosphere & Ionosphere
- Direct EPP effects on the middle and lower atmosphere
- Indirect EPP effects and atmospheric coupling, including climate effects
- Future measurements and aviation hazards
- Second HEPPA model/measurement comparison workshop

Scientific Highlights

Tutorials were presented on topics including the earth's radiation belts, solar and galactic sources of energetic particles, satellite measurements of energetic particles, riometer measurements of energetic particles, effects of EPP on the thermosphere/ionosphere, mesosphere and stratosphere, and processes that govern vertical coupling in the atmosphere. All of the tutorials were presented at a graduate student level so that meeting attendees from various disciplines could assimilate the information, with a goal of facilitating more interdisciplinary work in the future.

Measurement capabilities continue to improve. The Antarctic Arctic Radiation Belt (Dynamic) Deposition VLF Atmospheric Research Konsortia (AARDDVARK) is a prime example of improved

sensing of the thermosphere. AARDDVARK is a new network of ground-based sensors that provide continuous, long-range observations of the lower ionosphere primarily in the polar regions; ultimately AARDDVARK will provide continuous, high temporal resolution, global coverage. EISCAT-3D is a design concept for a new generation, large-scale incoherent scatter radar facility in northern Scandinavia. When realized, EISCAT-3D will provide fundamental data on topics ranging from energy input from the solar wind to dust and aerosols in the upper atmosphere. Several different techniques for measuring polar night nitric oxide, an important constituent in EPP/atmosphere interactions, were discussed, including visible and infrared limb emission and UV stellar occultation.

Improvements in modeling capabilities were also highlighted at HEPPA-2009. New parameterizations are being developed that will enable atmospheric models to more easily incorporate ion chemistry. It is also becoming increasingly common to include ionization by both protons and electrons. Global chemistry-climate and chemical transport models that incorporate particle precipitation effects are now being used to simulate specific particle events, and results are validated against recently available satellite measurements. Such models are also being applied to investigations of historical events, including the Carrington Event of 1859.

Particularly impressive are the comparisons between models and measurements from the MIPAS instrument, which has an advantage over other instruments for these types of investigations because of its polar night coverage and measurement of so many chemical constituents. To prepare for the second HEPPA Model Measurement Workshop, nine different models were run with similar prescriptions for ionization rates, for the time period of the 2003 "Halloween" storms from 26 October to 30 November 2003. Temperatures and simulations of 14 chemical constituents were compared to MIPAS measurements during that time period. This type of coordinated, international study is proving to be an effective means of evaluating the models and our overall understanding of EPP effects on the atmosphere. While simulations of some parameters are robust, questions remain in many areas, including ionization rates, horizontal and vertical transport, and some fundamental NO_y chemical reactions.

An exciting aspect of HEPPA-2009 was a strong emphasis on atmospheric coupling. Presentations were given by scientists who previously had not been heavily involved in EPP investigations, but whose research is directly relevant to the pathways by which EPP effects are communicated throughout the atmosphere. This includes such topics as the polar vortex, mean residual circulation, and gravity waves. One very interesting report was that models and measurements agree that the mean circulation corresponds to rising motion above ~90-95 km in winter, suggesting that it is not responsible for transport of NO produced by EPP into the middle atmosphere.

An issue that arose repeatedly was the presence of short-duration periodicities in geomagnetic activity and related effects, with periods that are factors of the 27-day solar rotation period. For instance, 9-day periodicities have been observed in the solar wind velocity, global electron and ion power, interplanetary magnetic field |B|, thermospheric neutral density, outer radiation belt electrons, Kp index, and infrared NO and CO_2 cooling in the thermosphere. It is becoming more clear now that high speed solar wind streams play a fundamental role in controlling the effects of energetic particles on the atmosphere, at least during the declining phase of the solar cycle.

New this year was a short session on aviation hazards; in a recent turn-around, it appears that investigators are now beginning to converge in their findings that energetic particle activity does not pose a significant radiation hazard to the general public.

We ended the workshop with a discussion of outstanding issues. Very briefly, the main issues are:

- Separate quantification of medium and high energy electron precipitation information
- Incomplete understanding of chemistry related to EPP, especially with regard to HNO_3, N_2O_5, $ClONO_2$, ClO, N_2O, CO, H_2O_2, CH_4, HNO_4, OH and HO_2
- Incomplete understanding of dynamics related to EPP with regard to direct and indirect effects on temperatures and winds
- Mechanistic interpretation of possible correlations between geomagnetic activity and surface air temperatures
- Transport of thermospheric NO to the middle atmosphere
- Mechanistic interpretation of nitrates in polar ice after solar proton events
- Resolution of model-model disagreement in energy deposition computations

Figure 1. HEPPA-2009 participants at NCAR in Boulder, CO.

Next HEPPA workshop

Based on the success of these first two HEPPA workshops, we are planning a third workshop to be held in Granada, Spain in May, 2011.

Thanks to our sponsors!

IAGA

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LABORATORY FOR ATMOSPHERIC AND SPACE PHYSICS
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