2016 Workshop: Lidar workshop on AIM coupling

Long title
Exploration of the neutral atmosphere and its coupling with the ionosphere, magnetosphere and cosmic dust
CEDAR-GEM
Conveners
Xinzhao Chu
Zhonghua Xu
Tao Yuan
Alan Liu
Description

Recent years several lidar-centered observational campaigns, magnetosphere-ionosphere observational chains, and lidar-involved multi-instrument observational campaigns have been conducted or are ongoing worldwide including Antarctica. Plus many other observations being continued by CEDAR and GEM researchers on regular basis, new and exciting data are being provided to the CEDAR-GEM science community with unprecedented coverage, precision and resolution. For example, lidar measurements of the neutral atmosphere from the ground up to nearly 200 km open a new door to explore the space-atmosphere interactions, complementing radar and magnetometer observations of the plasma. Numerical models of meteoric metal layers, turbulence, and general circulations as well as the development of empirical geospace models provide good tools for CEDAR-GEM community to tackle science questions together. In the meantime, new development in lidars has been ongoing by many talented researchers and students. The dramatic improvements of resonance lidar efficiency have enabled new science inquires such as eddy flux measurements in the mesopause region and detection of tenuous metal layers in the thermosphere of 100-200 km. Collaborative studies among lidar groups and with co-located rocket, radar, airglow imager and Fabry-Perot interferometer, ionosonde, magnetometer, riometer, etc. and with satellite measurements have provided new potentials for multi-dimensional studies of the global upper atmosphere and space.

As part of the Consortium of Resonance and Rayleigh Lidars (CRRL) efforts, this workshop aims to bridge the lidar and neutral atmosphere communities with the

ionosphere and magnetosphere communities to address the following challenges:

1) What are the roles of neutral atmosphere-ionosphere-magnetosphere (AIM) coupling and wave dynamics in shaping the compositions and thermal structures in the space-atmosphere-interaction region and their responses to geomagnetic and solar activities?

2) What are the influx magnitude, velocity and mass distribution of the global cosmic dust and how does the cosmic dust impact the Earth’s atmosphere and space environment?

3) What new aspect of the source, propagation and dissipation schemes of the atmospheric waves can be revealed by collaborative studies with multiple instruments?

4) How to advance remote sensing technologies and numerical models to transform the CEDAR-GEM research on space-atmosphere interactions and the whole atmosphere?

This workshop will provide a platform for the newest observational and modeling results to be presented and discussed, stimulating new science collaborations among observations, data analysis and modeling, and seeking new science potentials and technology innovations. We encourage short presentations and discussions from both CEDAR and GEM communities to address the above science questions.

Agenda

) Bob Clauer — A Tutorial on "Solar Wind-Magnetosphere-Ionosphere Coupling"

2) Dan Weimer - Field Aligned Current Do Not Saturate

3) Xinzhao Chu — Thermospheric metal layers correlating with geomagnetic storms

4) Zhonghua Xu — A comparison of the ground magnetic responses during the 2013 and 2015 St. Patrick's Day storms

5) Titus Yuan — Gravity wave forcing in the mesopause region during autumnal equinox studied by lidar and WACCM

6) Katrina Bossart — Lidar/AMTM studies of small-scale gravity waves and instability in airglow

7) Cao Chen and Jian Zhao — Persistent gravity waves from the stratosphere to the lower thermosphere in Antarctica

8) Xian Lu — Planetary waves from the stratosphere to the lower thermosphere at McMurdo

Justification

Challenges: 1) What are the roles of neutral atmosphere-ionosphere-magnetosphere (AIM) coupling and wave dynamics in shaping the compositions and thermal structures in the space-atmosphere-interaction region and their responses to geomagnetic and solar activities? 2) What are the influx magnitude, velocity and mass distribution of the global cosmic dust and how does the cosmic dust impact the Earth's atmosphere and space environment? 3) What new aspect of the source, propagation and dissipation schemes of the atmospheric waves can be revealed by collaborative studies with multiple instruments? 4) How to advance remote sensing technologies and numerical models to transform the CEDAR-GEM research on space-atmosphere interactions and the whole atmosphere?

Significance and fit with the decadal survey and strategic plan: The coupling between the magnetosphere and ionosphere plasma and neutral thermosphere and mesosphere gas, and the wave coupling among different atmosphere/space regions lead to very complicated processes that govern the space-atmosphere-interaction region (SAIR). These processes and the states of SAIR are far from being sufficiently described and understood, but they are critical to fully understanding the whole atmosphere and to improving space weather and climate models. Two major roadblocks are the starvation of sufficient observations that measure the neutral gas and plasma properties in large ranges with adequate accuracy, resolution and overlap, and the lack of coordinated studies of observations with various instruments, data analyses and numerical modeling. Lidar measurements of neutral atmosphere winds, temperatures and species in the thermosphere, mesosphere and stratosphere are critically needed, but very challenging, to complement radar observations of the plasma. This joint CEDAR-GEM workshop will encourage the community to tackle these issues through making unprecedented measurements and through multi-dimension studies using model, data analysis and observation.

The principal scientific goals of this Workshop are consistent with the goals and recommendations of recent community scientific surveys and strategic plans. The Workshop is highly relevant to the NSF CEDAR and GEM programs, especially regarding the coupling and collaboration between the two programs. The Workshop helps address two of the four key scientific goals articulated in the National Research Council (NRC) 2013-2022 Decadal Strategy for Solar and Space Physics.

Key Science Goal 2. Determine the dynamics and coupling of Earth's magnetosphere, ionosphere, and atmosphere and their response to solar and terrestrial inputs.

Key Science Goal 4. Discover and characterize fundamental processes that occur both within the heliosphere and throughout the universe.

In addition, the Workshop goals are consistent with four of the scientific goals identified by the NRC Panel on Atmosphere-Ionosphere-Magnetosphere Interactions (AIMI). They are:

AIMI Science Goal 1. Global Behavior of the Ionosphere-Thermosphere: How does the IT system respond to, and regulate magnetospheric forcing over global, regional and local scales?

AIMI Science Goal 2. Meteorological Driving of the IT System: How does lower atmosphere variability affect geospace?

AIMI Science Goal 3. Ionosphere-Thermosphere-Magnetosphere Coupling: How do high-latitude electromagnetic energy and particle flows impact the geospace system? What are the origins of plasma and neutral populations within geospace?

AIMI Science Goal 4. Plasma Neutral Coupling in a Magnetic Field: How do neutrals and plasma interact to produce multiscale structures in the AIM system?

How the questions will be addressed?

Observations and data analyses with unprecedented capabilities

Coordinated observations with multiple instruments

Coordinated studies of numerical simulations and data analyses

Technology innovations to push the detection limits

What resources exist, are planned, or are needed?

Recent years several lidar-centered observational campaigns, magnetosphere-ionosphere observational chains, and lidar-involved multi-instrument observational campaigns have been conducted or are ongoing worldwide. Excellent data have emerged or are emerging. Numerical models and empirical models are being developed with promising results produced. New technologies are being actively pursued with some breakthroughs, and more ideas are emerging. Analyzing these observational data creatively, collaborating with numerical modeling to address these topics, and pushing detection technologies further forward are desperately needed.

Progress will be measured by: Analyzing existing and new observational data and turning the data into meaningful science results for these topics; Publishing new science findings and understandings into journal papers; Sharing new ideas of technologies and producing new observational capabilities; Planning observing campaigns and developing new strategies to advance this area of research.

View PDF