2015 Workshop: CEDAR Lidar Workshop

Long title
Lidar Workshop: Space-Atmosphere Interaction, Wave Dynamics and Cosmic Dust Studies with Lidar Technology Transformation
Conveners
Xinzao Chu
Titus Yuan
Description

Recent years several lidar-centered observational campaigns or lidar-involved multi-instrument observational campaigns have been conducted or are still ongoing worldwide. Plus many other lidar observations being continued by CEDAR researchers on regular basis, resonance and Rayleigh lidars are providing new and exciting data to the CEDAR science community. Numerical models of meteoric metal layers, turbulence, and general circulation models are being developed with promising results produced. In the meantime, new development in CEDAR lidars has been ongoing by many talented researchers and students. The dramatic improvements of resonance fluorescence 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 intereferometer, ionosonde, magnetometer, riometer, etc. and with satellite measurements have provided new potentials for multi-dimensional studies of the global upper atmosphere. Furthermore, the Consortium of Resonance and Rayleigh Lidars (CRRL) are enhancing the coordinated community effort for lidar technology innovation and science advancement, and the lidar workshop is part of the CRRL efforts.

This workshop will consist of two parts. One is to 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. Another is to share the newest technology progresses and provide a forum to identify the science observational needs and how possible technology improvement helps transform CEDAR science research. We encourage presentations on topics related to CEDAR research, including but not limited to

neutral-plasma coupling, neutral and ion chemistry, gravity, tidal and planetary waves, wave dynamics, sources and impacts, coupling among different atmospheric regions, and lidar technology advancement and new ideas. Both observations and numerical simulations are welcome to this workshop.

Agenda

1. Cao Chen: Lidar observation of persistent inertia-gravity waves with periods of 3-10 h in the Antarctic middle and upper atmosphere

2. Rich Collins: Ageostrophic generation of gravity waves inferred from lidar measurements and nonlinear balance calculation

3. Yucheng Zhao: Na lidar gravity wave momentum flux and the associated wave forcing

4. Xian Lu: High to medium frequency mesoscale gravity waves in vertical winds and temperature over the central US using CRRL Na lidars and USU temperature mapper

5. Tao Yuan: Evidence of spectrally broad gravity wave packet propagation and dispersion

6. Biff Williams: New lidar observations in DEEPWAVE and WADIS-2 campaigns

7. Yen-Chieh Lin: Model simulation of sporadic E layers in the low- and mid-latitudes

8. Xuguang Cai: Model investigation of Na neutralization within the sporadic E layer

9. Weichun Fong: Antarctic winter temperature tides - plasma-neutral atmosphere interaction in the lower thermosphere

Justification

Challenges:

1) What are the roles of neutral-plasma 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 their impacts on the Earth’s atmosphere?

3) How do we advance lidar technologies to next-generations to transform the CEDAR research on space-atmosphere interactions and whole atmosphere?

4) What new aspect of the propagation and dissipation schemes of the atmospheric wave can be revealed by the collaborative studies with multiple lidars and other instruments?

Significance and fit with the decadal survey or strategic plan:

The plasma-neutral coupling between the 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 lidar 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 lidar workshop will also stimulate technology innovations to push lidar technologies to next generations that will transform the CEDAR research.

The principal scientific goals of this Workshop are consistent with the goals and recommendations of recent community scientific surveys and strategic plans.

National Research Council 2013-2022 Decadal Strategy for Solar and Space Physics; A Science for a Technological Society The Workshop helps address three of the four key scientific goals articulated in the NRC report. They are:

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?

CEDAR: The New Dimension, Strategic Vision for the NSF Program on Coupling, Energetics and Dynamics of Atmospheric Regions [May 2011] The Workshop is highly relevant to the NSF Coupling Energetics and Dynamics of Atmospheric Regions (CEDAR) program. The new CEDAR strategic vision, released in 2011, focused on the science of the space-atmosphere-interaction region and advocated the development of a systems perspective to study this region. The Workshop contributes directly to the first four of the CEDAR Strategic Thrusts.

Strategic Thrust 1. Encourage and undertake a systems perspective of geospace to understand global connectivities and causal relationships involving the SAIR and to determine their influences on the interaction region and the whole Earth system.

Strategic Thrust 2. Explore exchange processes at boundaries and transitions in geospace to understand the transformation and exchange of mass, momentum and energy at transitions within the ITM and through boundaries that connect with the lower atmosphere and the magnetosphere.

Strategic Thrust 3. Explore processes related to geospace evolution to understand and predict evolutionary change in the geospace system and the implications for

Earth and other planetary systems.

Strategic Thrust 4. Develop observational and instrumentation strategies for geospace system studies capable of measuring system properties necessary to examine the coupling mechanisms and complexity within the SAIR.

How the questions will be addressed?

1) Lidar observations and data analyses with unprecedented capabilities;

2) Coordinated observations with multiple instruments;

3) Coordinated studies of numerical simulations with data analyses and observations;

4) Lidar technology innovation and development.

What resources exist, are planned, or are needed?

Recent years several lidar-centered observational campaigns or lidar-involved multi-instrument observational campaigns have been conducted or are still ongoing worldwide. Excellent data have emerged or are emerging. Numerical modeling of meteoric metal layers and general circulation models are being developed with promising results produced. New lidar technologies are being actively pursued with some breakthroughs, and more ideas are emerging.

Analyzing these lidar and complementary observation data creatively, collaborating with numerical modeling to address these topics, and pushing lidar technologies further forward are desperately needed.

How progress is to be measured?

Progress will be measured by:

1) Analyzing existing and new lidar data along with complementary data together and turning the data into meaningful science results for these topics;

2) Publishing new science findings and understandings into journal papers;

3) Sharing new ideas of lidar technologies and producing new capabilities of existing and new lidars;

4) Planning observing campaigns and developing new strategies to advance this area of research.

View PDF