2021 Workshop: AIM Coupling at Midlatitudes

Long title

AIM Coupling Studies at Midlatitudes Inspired with Lidar Observations

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Description

High-sensitivity Doppler lidar observations have recently discovered thermosphere-ionosphere Na (TINa) neutral layers in the E region (100-150 km) over Boulder, Colorado. These mid-latitude TINa layers occur regularly in various months and years with semidiurnal tidal phases near the dawn and dusk. Such regular occurrence of dawn/dusk layers is distinctively different from the TINa and TIFe (thermosphere-ionosphere Fe) layers observed in the polar regions and at low latitudes. Lidar data strongly suggest in-situ production of Boulder TINa layers via neutralization of converged TINa+ ion layers. Furthermore, one or more TINa layers sometimes occur across local midnight, which are likely related to phenomena such as travel ionospheric disturbances (TIDs) or midnight temperature maximum. Therefore, the Boulder TINa layers provide a natural laboratory to study the atmosphere-ionosphere-magnetosphere (AIM) coupling at mid-latitude regions. A possible application is to use the TINa layers as tracers to measure the neutral winds and temperatures as well as ion transport in the nighttime E region.

This workshop solicits presentations focusing on the mid-latitude electrodynamics and neutral dynamics that may help interpret the Boulder TINa layers. We welcome data showing driving forces either from below or above, like neutral tidal winds and gravity waves as well as ionospheric and magnetospheric observations (such as TIDs, airglow emission, and sporadic E layers, etc.). We also welcome numerical modeling that can help understand the behaviors of these thermosphere-ionosphere metal (TIMt) layers and the underlying AIM coupling processes.

Agenda

1. Dawn, dusk, and midnight TINa metal layers over Boulder (Yingfei Chen)

2. Observations of thermospheric metal layers at Yanqing Station (Guotao Yang)

3. Thermospheric metal layers over Arecibo (Shikha Raizada)

4. The first year of ICON-MIGHTI tidal analysis and HME results (Chihoko Cullens/Thomas Immel)

5. Relation between midnight TINa layers and midnight temperature maximum (Toshi Nishimura)

6. GNSS TEC observations of TIDs associated with TINa events in Boulder (Shunrong Zhang)

7. New results on the Midnight Temperature Maximum (Dustin Hickey/Carlos Martinis)

8. SAMI-3 simulations of Na+ over Boulder (Joe Huba)

9. Tidal and gravity wave impacts on the short-term ionospheric variability at low- and mid-latitudes using nudged TIEGCM (Xian Lu)

Justification

This workshop aims to bridge the neutral atmosphere communities with the ionosphere and magnetosphere communities to tackle some fundamental science questions and make new paths for the future.

Challenges:

1) How are Boulder TINa layers formed? What are the roles of AIM coupling and tidal winds in shaping the compositions and structures in the space-atmosphere-interaction region?

2) Are the midnight TINa layers at midlatitudes closely related to TIDs or midnight temperature maximum?

3) What new understandings of midlatitude electrodynamics and neutral dynamics can be gained through collaborative studies?

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

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. This CEDAR workshop will encourage the community to tackle these issues through making unprecedented ground-based and space-borne measurements and conducting multi-dimension studies.

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

The Workshop helps address two 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 three 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 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 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? • Cutting-edge observatories and modern facilities • 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 Lidar-centered observational campaigns, NASA satellite missions, magnetosphere-ionosphere observational chains including GPS, airglow imagers, and radars. 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 and more ideas are emerging.

Progress will be measured by: • Analyzing the existing and new observational data creatively, in collaboration with advanced numerical modeling • 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

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