2023 Workshop: Gravity waves in the upper atmosphere and ionosphere

Long title
The role of gravity waves in the mesosphere, thermosphere and ionosphere cross-scale coupling and irregularities: Observations and numerical simulations
Grand Challenge
Conveners
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Description

Contributions to the upper atmospheric dynamics and the ionospheric irregularities by the ubiquitous gravity waves' modulations with various scales have been recognized and studied intensively over the past decades. The associated dynamical features, such as Kelvin-Helmholtz Instability (KHI), can further induce considerable variations in this region. Their horizontal scales have been found to vary from around a few tens of km to several thousand kilometers. The impacts of small-scale features, frequently observed in the mesosphere and lower thermosphere, are believed to be as significant as those of larger scale waves in the thermosphere and ionosphere, because of their fast phase speeds and the high momentum density they are carrying. The dynamical behaviors under atmospheric instability conditions, changing the laminar flow to turbulence flow, are especially important and enticing, when the energy and momentum transfer between them and the mean flow occurs, altering larger-scale dynamic features and potentially triggering some of the most significant ionospheric irregularities.

Various state-of-art ground-based, airborne and space borne experimental investigations have been dedicated to the investigations on this topic in the past decade, facilitated by many advanced regional and global numerical models. While considerable progress in understanding their contributions to the energy and momentum budget in the thermosphere ionosphere have been achieved, more and more unknown physics and dynamic processes have also been revealed in these observations. In addition, the lack of global coverage, and the limited observed gravity wave spectrum further limit the community's progress in the understanding of the Ionosphere-Thermosphere (IT) gravity wave coupling.
In this workshop, we will discuss the gaps, challenging problems and coordinated approaches of addressing the role of gravity waves in the mesosphere, thermosphere and ionosphere coupling.

Agenda

Planning GC

Monday 10:30 – 11:20

Introduction: Titus Yuan

General talk: Jonathan Snively: Gravity Wave Coupling Across Scales and Systems

Monday 13:30 – 15:30

Becker: Global scale GW simulations (15-min+3 min Q&A)

Sharon Vadas: Secondary and tertiary GW simulation in thermosphere (15-min+3 min Q&A)

Cesar Valladares.: Studies of TIDs and GWs using TEC and GOCE data (15-min+3 min Q&A)

Matthew Zettergren. IT modeling: Modeling Ionospheric Effects of TIDs Driven by Acoustic and Gravity waves (10-min+3 min Q&A)

Lynn Harvey: CIPS observations of GW activity at the edge of the polar vortices and coupling to the ionosphere. (10-min+3-min)

Jintai Li: First Simultaneous Observation of Secondary and Tertiary GWs by lidar and investigation with HIAMCM simulation (10-min+3 min Q&A)

Jorge L. Chau and Miguel Urco: Exploring MLT mesoscale dynamics with physics-informed Machine learing approaches. (10-min+3 min Q&A)

Nathaniel Frissell: Multi-instrument Observations and Modeling of MSTIDs, LSTID, and Stratospheric Polar Vortex: 2018-19 Case Study and 2010-2022 Climatology (5-min)

Tuesday

10:00 – 12:00

Jeffrey Forbes: AWE Mission Science (20-min+5 min Q&A)

Hanli Liu: WACCM GW simulations (15-min+3 min Q&A)

Jonathan Makela: Thermosphere GWs observation MANGO network. (15-min+3 min Q&A)

Dominique Pautet: Coincident neutral atmosphere and D-region gravity wave observations (10-min+3 min Q&A)

Fan Yang: Statistical signatures of shear-induced KHI and their radiated GWs: insights from Numerical simulations (5-min)

Wenjun Dong: A transformer-based maching learning method of simulating GW generation, propagation, breaking and secondary GW generation (5-min)

Open discussion

Justification

Introduction:
The gravity waves, mostly generated in the troposphere, can carry and transport tremendous amount of energy and momentum through the mesosphere into thermosphere and ionosphere. These waves’ breaking and dissipation processes deposit these energy and momentum in the IT system nonlinearly, inducing multi-scale local or global variations and irregularities, such as TID in the ionosphere.

So far, most of the associated individual studies, especially those involving observations, have been focusing on the regional scale, while the wave breaking induced background variations and their effects on the further behaviors of the waves are greatly simplified. General circulation models still rely on various parametrization schemes to account for the gravity waves body forcing on a global scale. The next few years are poised for significant advances in gravity-wave theory and observational studies: For example, numerical models such as HIAMCM are now able to directly simulate multi-step vertical coupling, observational datasets from ICON and ground-based imagers (e.g., MANGO) have expanded, and the NASA AWE mission is launching in 2023. This breadth of potential research requires a grassroots organizing forum such as the proposed GC workshop.

With the latest progress in the theory on the small-scale atmospheric dynamics, experimental observations, computing power and machine learning, the workshop will provide a community-wide platform for open discussions on the new coordinated investigations and campaigns to improve the understanding of these waves full contributions to the global IT system.

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