2022 Workshop: Interhemispheric asymmetries & high latitude forcing

Long title
GC: Interhemispheric asymmetries (IHA) in the I-T system: generated by the high-latitude forcing
Grand Challenge
Conveners
Yue Deng
Qingyu Zhu
Yun-Ju Chen
Astrid Maute
Rich Collins
Aaron Ridley
Daniel Welling
Hyomin Kim
yuedeng@uta.edu
Description

The state of ionosphere-thermosphere (IT) is hardly ever a mirror image of the other hemisphere even when considering differences due to season and Earth's magnetic field. Among others, neutral wind and density, composition, ion drift, and plasma distribution, exhibit interhemispheric asymmetries (IHA) on temporal scales from hours to seasonal. Forcing from the magnetosphere-ionosphere (MI) coupling can contribute to IHA but it is still not well understood what constitutes a significant asymmetry and their cause. In addition, the effect of the strong high latitude energy deposition on the IT system can be modulated by the background atmospheric state which is strongly affected by the vertical coupling to the lower atmosphere. In this workshop we will discuss causes and effects of IHA in the high-latitude region and the role of the background atmosphere. We solicit contributions examining IHA in the upper atmosphere including high latitude forcing being IHA and/or leading to IHA in I-T system.

Agenda

Onyx Ballroom, 10 am CDT, Wed, 06/22/2022

10:02~10:12

Gang Lu: Interhemispheric Asymmetries in the IT System: A multifaceted process

10:12~10:22

Marc Hairston: Preliminary results of penetration electric field asymmetry on the duskside during the 2015 St Patrick’s Day storm

10:22~10:32

Sheng Tian (by Sneha Yadav): Simultaneous observation of auroral streamers in conjugate hemispheres and the associated in-situ observations

10:32~10:42

Aaron Ridley: The Magnetospheric Auroral Asymmetry eXplorer

10:42~10:52

Naomi Maruyama: Impact of the hemispheric asymmetry of Superthermal Electrons on the coupled Magnetosphere-Ionosphere-Thermosphere (M-I-T) system

10:52~11:02

Qingyu Zhu: Interhemispheric asymmetries in the ionospheric response during the 2013 St Patrick’s Day geomagnetic storm

11:02~11:12

Yu Hong: Inter-hemispheric Asymmetry of Ion Convection and its Impacts on the Ionosphere-Thermosphere System During the 08-10 October 2012 Geomagnetic Storm

11:12~11:22

Delores Knipp

Inter-hemispheric asymmetries in Poynting flux: A perspective from different space-based platforms (Virtual)

11:22~11:32

Yongliang Zhang: Sources for Hemispheric Asymmetry in Storm-time O/N2 Depletion (Virtual)

11:32~12:00

All attendees: Discussion

(Virtual option)

Through the livestream used for the plenary session

Justification

(1) Introduction
The nature of I-T system can be highly asymmetric due to internal processes, e.g., the effects of the offset, tilted dipole and seasonal variability, but also due to asymmetric driving stemming from the IMF and solar wind conditions. While the interhemispheric Asymmetries (IHA) have been acknowledged widely in the community, due to the limited data coverage, it has been typically ignored in the data analysis and the data from two hemispheres have been binned together. Meanwhile, numerical models often fail to account for these effects, limiting their use when asymmetries are expected. Owing to recent advances in global simulations and an increasing amount and coverage of observations, the community has gained an appreciable level of understanding IHA in high-latitude forcing and their impacts on the I-T system.

(2) Justification for GC workshop
In the I-T system, interhemispheric Asymmetries (IHA) take many forms. Observations have revealed that IHA manifested via particle precipitation and conductivity, auroral patterns, substorm occurrence and locations, field-aligned currents, ionospheric electric potentials, magnetic field geometries, and ionospheric and thermospheric neutral and plasma characteristics. For example, a simultaneous observation of global aurora activities in both hemispheres by IMAGE and Polar satellites show that the aurora and polar cap were strongly asymmetric in the two

hemispheres. Field-aligned currents (FACs) from AMPERE and Poynting flux estimation from DMSP also show strong IHA. Understanding IHA is critical for understanding the magnetosphere-ionosphere-thermosphere (M-I-T) response to solar wind drivers and internal Earth conditions.

Despite the now-known importance and ubiquity of IHA in the high-latitude forcing, their properties have not been thoroughly examined or documented. The lack of IHA input to models has prevented simulations from testing their impact on the global I-T system. Also simulation capabilities for handling IHA are significantly limited. Furthermore, impacts of IHA have not been quantified or reproduced. This workshop focuses on quantifying interhemispheric differences observed in the I-T system and understanding their causes and importance for the upper atmosphere. With the available observations and sophisticated numerical modeling capabilities we are in a better position now to study the effects of high latitude forcing in a system approach in understanding IHA. Specifically, the Center for the Unified Study of Interhemispheric Asymmetries (CUSIA), a phase-1 NASA DRIVE center, enhances numerical simulation-based data products, and is working to identify and address model shortcomings to provide more accurate results that account for asymmetries. Meanwhile, this workshop is complementary to the NASA 2020 LWS FST on “Caused and Consequences of Hemispherical Asymmetries in the M-I-T system”. This research is also timely in preparation for the upcoming Geospace Dynamic Constellation (GDC) mission. The proposed activities will be coordinated with NSF GEM focus group on “Interhemispheric Approaches to Understand M-I coupling (IHMIC)” by bringing their knowledge and holding joint campaigns.

This Grand Challenge Workshop calls for collaborative studies, which will go beyond the current paradigm of identifying IHA across the magnetosphere-ionosphere-thermosphere (M-I-T) system to assess the impact of these phenomena on system dynamics, both through data analysis and physics-based models in the growing M-I-T observational system, data science, and model development to effectively connect the individual resources.

(3) Proposed challenge questions

Our overarching goal is to understand IHA in the high-latitude forcing and their impacts in the global I-T system. Specifically, we propose to focus on the questions below:

(a) What are the difficulties to measure IHA and how could these gaps be closed? When are IHA significant?

(b) Where and under what solar wind conditions occur IHA at high latitudes? What

are the spatial and temporal characteristics of these IHA?
(c) How large are IHA in the MI coupling during quiescent and disturbed conditions? Do these IHA contribute to the asymmetries in the IT system and how?

(4) How the questions will be addressed
Recently many of the CEDAR sessions are filled with small presentations. We are concerned that these make it difficult to organize community-wide discussions to address challenges. We propose to dedicate one of the sessions each year for discussions with the audience on focused topic. Focused topics will be introduced by a few scene-setting talks, and most of time will be used for open discussions to collect ideas and thoughts to attack the topics and to seek out collaborations. The second session will be used for half presentations and discussions. We will also set up working groups to lead key collaboration activities. Such discussion-oriented sessions have been proved effective for bringing thoughts in the community and discuss strategies toward future steps. The team members also have experience in organizing CEDAR and CEDAR-GEM sessions.

(5) What resources exist, are planned, or are needed
Growing networks of ground and satellite instruments will be heavily utilized for this activity. SuperDARN and DMSP/SSUSI can provide large-scale convection and aurora. Other key networks include, imagers, GNSS, Fabry–Perot interferometers (FPIs), radars, magnetometers (including SuperMAG) and low/high altitude satellites such as DMSP, AMPERE, CHAMP, and GOCE. Ionospheric Connection Explorer (ICON), Global-scale Observations of the Limb and Disk (GOLD), and Constellation Observing System for Meteorology, Ionosphere, and Climate (COSMIC)-II will provide insights on how the equatorial I-T system responds to polar-equatorial interactions.
We will discuss the use of the available data for building science knowledge of IHA, quantifying control parameters and test ability of forecasting by data assimilation, and combine those with numerical simulations for physics understanding.

(6) How progress should be measured
(a) Identify science goals that have high impacts on I-T research, and scientific and technical gaps to reach these goals.
(b) Identify pathways to address these through discussions and collaborations.
(c) Plan and conduct data analysis and modeling campaigns.
(d) Enable improved and newly developed models and data technologies to feedback for community-wide benefit
(e) Report updates and discuss strategies to fill gaps to reach the goals.

Related to CEDAR Science Thrusts:

Encourage and undertake a systems perspective of geospace

Fuse the knowledge base across disciplines in the geosciences

Keywords

Interhemispheric asymmetries; high-latitude forcing; global I-T system response; M-I-T coupling

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