ICON at AGU 2023 Fall Meeting

AGU Fall Meeting – San Francisco and online everywhere 11-15 December 2023.
Theme: Wide. Open. Science.

Monday 11 December

Presentations

SA11A-06 Sources and Propagations of Large-Scale Waves using ICON/MIGHTI and SD-WACCMX
Chihoko Y Cullens
09:45 – 10:00
208 – South (Level 2, South, MC)

Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) instrument on the Ionospheric Connection Explorer (ICON) has been frequently observing large-scale waves with wavelength around 1000-5000 km from 2019 to 2022 in the altitude range of 94 km to 250 km. Large-scale waves observed from MIGHTI winds and temperature have semi-annual variations in the mesosphere and the lower thermosphere (MLT) region and annual variations at higher altitudes.

SD-WACCMX nudged by GEOS-5 (with horizontal resolutions of ~0.9 degree) also show similar climatology of waves with horizontal wavelengths of 1000-5000 km. In this work, we investigate causes of semi-annual variations in the MLT region and annual variations at higher altitudes focusing on sources of large-scale waves and background wind conditions using SD-WACCMX. Along with climatology study, short-term variations of large-scale waves related to stratospheric sudden warming (SSW) will be presented using both MIGHTI and SD-WACCMX.

Tues 12 December

Posters

SA21B-2678 Comparison of ICON/MIGHTI Observations With Astronomical Sky Spectra
Konstantinos S. Kalogerakis
8:30 AM – 12:50 PM PST
Location: MC, Poster Hall A-C – South

The objective of the Michelson Interferometer for Global High-Resolution Thermospheric Imaging (MIGHTI) instrument aboard NASA's Ionospheric Connection Explorer (ICON) satellite was to determine the altitude profiles of the wind and temperature in the Earth's upper atmosphere. The winds were obtained from the Doppler shifts of the measured atomic oxygen green and red line emissions at 557.7 nm and 630.0 nm [2], and the temperatures were derived from the measured molecular oxygen Atmospheric band emission [3].

The goals of our study are to broaden the scientific impact of the MIGHTI instrument, advance knowledge of the nightglow emissions, and improve retrievals of nighttime atomic oxygen by using the intensities of the emissions measured by MIGHTI. Accurate nighttime O-atom densities are required for modeling the chemistry and energy budget of the upper atmosphere. Just as important, a detailed understanding of the relationship between atmospheric composition and the intensity of observed nightglow emissions is essential for modeling and understanding gravity wave propagation and dissipation.

We report on our progress to evaluate the absolute intensities from ICON/MIGHTI by comparing them to flux-calibrated measurements of the same emissions from the ground-based instruments. This work is supported by the NASA GOLD-ICON Guest Investigators Program Grant 80NSSC22K0172 and by NASA Heliophysics (LNAPP) Program Grant 80NSSC20K0915.

<u>SA21C-2696 Climatology of upper E-Region shear layers from the MIGHTI wind instrument</u>
Kenneth Marr
8:30 AM – 12:50 PM PST
MC, Poster Hall A-C – South

The MIGHTI instrument on the Ionospheric Connection (ICON) Explorer mission measures horizontal wind profiles at altitudes from 90 to 300 km with a vertical resolution of ~2.5 km. Often, these profiles exhibit strong shear regions between 100 – 130 km and weaker shear regions above 130 km. The strong shear regions have been linked to the lower daytime sporadic E-layer formation, most recently by Yamazaki (2021), through comparisons with COSMIC-2 data and GAIA modeling. In this presentation we examine the climatology of very strong, extended, lower daytime shear layers and also the seasonal and local time dependence of the weaker upper shear layers. The lower shear layer shows no obvious dependence on latitude or longitude, but a preference for local solar times (LSTs) before noon. These shear profiles are also seen to lower in altitude with increasing LST, a motion often associated with DW1 tidal modes. Among other trends, the upper shear, which usually spans over 20 km in altitude, shows a seasonal altitude dependence and a four-mode longitudinal dependence.

<u>ED21D-0793 How the Plasma Drifts: Improving ICON/IVM Data Quality</u>
Mateo Cardona Serrano
08:30 – 12:50
Poster Hall A-C - South (Exhibition Level, South, MC)

The ionosphere, the boundary between Earth and space, is formed via ionization from solar ultra-violet radiation. Here, neutral air and plasma (free ions and electrons) interact, generating electric fields which then further affect the plasma's motion. Changes in the plasma’s distribution can alter signals passing through the ionosphere, disrupting radio propagation and Global Positioning System (GPS) technology; it is necessary to improve our current models of the ionosphere to predict and prevent these disruptions in the future. NASA’s Ionospheric Connection Explorer (ICON) satellite was launched in 2019 to trace how energy moves through the ionosphere by studying the relationship between ionospheric plasma and neutral air. ICON is equipped with a state-of-the-art Ion Velocity Meter (IVM) which measures plasma density, temperature, and drifts. In this study, we analyze three years of IVM zonal, meridional, and field-aligned ion drift data products. By observing daily averages and standard deviations over the duration of the mission, we have identified and begun to classify anomalous drift measurements. Notably, we have identified instances of uncharacteristically large drifts without clear ionospheric causes, as well as a significant change in long-term drift behavior following January 2022. Our study aims to distinguish these anomalous behaviors as either a result of physical effects from the ionosphere or instrumental effects from the IVM. This work will enhance the integrity of the IVM drift data, allowing future studies to interpret the data with greater confidence and precision. Moreover, our findings will facilitate refinement of current ionospheric models, improving the ability to anticipate and mitigate disruptions to critical technologies reliant on the ionosphere, such as radio communications and GPS systems.

<u>SA23B-2714 Evening Solar Terminator Waves Observed in ICON/MIGHTI Data in Comparison with HIAMCM Simulations</u>
Claire Gasque
2:10 - 6:30
Poster Hall A-C - South (Exhibition Level, South, MC)

Every night, the evening solar terminator (EST) sweeps across Earth, plunging it into darkness and interrupting the solar radiation which plays a crucial role in heating the upper atmosphere and producing ionospheric plasma. The resulting temperature gradients generate disturbances, broadly known as solar terminator waves (STWs). Despite theoretically occurring every night, STWs remain poorly understood, partially due to the challenges of making reliable observations amidst the rapidly changing conditions during the passage of the EST. Only two previous studies have identified STWs in thermospheric winds and density (Forbes et al., 2008; Liu et al., 2009), and numerous questions remain unanswered. In this work, we identify altitudinally-resolved neutral wind signatures of STWs for the first time using the Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) neutral wind sensor on board NASA's Ionospheric Connection Explorer (ICON) observatory. In comparison with simulations from the High Altitude Mechanistic General Circulation Model (HIAMCM), we examine the characteristics of these waves, including their magnitude, orientation with respect to the EST, and seasonal dependence. If these waves are as large as model simulations suggest, they may play an under-recognized role in the daily variability of the thermosphere-ionosphere system, warranting further study.

<u>SA23B-2707 Validating Ohm’s Law in the ionosphere: Comparison of ionospheric currents derived from ICON’s wind and electric field measurements and Swarm’s magnetic field data</u>
Yen-Jung Joanne Wu
2:10 - 6:30
Poster Hall A-C - South (Exhibition Level, South, MC)

The equatorial ionosphere experiences notable daily variations, influenced in part by lower thermospheric neutral winds that generate currents, a process known as the neutral wind dynamo. ICON, NASA's Ionospheric CONnection Explorer, enables simultaneous space-based observations of thermospheric neutral winds and ionospheric electric fields through in situ plasma drift measurements near the magnetic equator. By combining the altitude-integrated conductivity weighted wind and electric field, the ionospheric current can be calculated. During conjunctions with the European Space Agency's Swarm satellites, magnetic signatures of ionospheric currents are measured by Swarm, revealing a strong correlation (r ~ 0.7) between the zonal currents derived from ICON and the eastward component of the Sq current system from Swarm's magnetic measurements near midday. This significant correlation suggests a substantial contribution from the local neutral wind dynamo to the Sq current system. However, a puzzling observation arises as the current derived from ICON is nearly three times larger than the current derived from Swarm, despite their strong correlation. This discrepancy persists even when considering extreme uncertainties in ICON's measurements. The situation becomes further intriguing as the magnitude of Swarm's derived current aligns more closely with the data obtained from ground-based magnetometers. Preliminary results suggest that the discrepancy could be due to the small-scale spatial structure of the ionospheric current, beyond the satellite's measurement capabilities. This speculation will be evaluated by deriving the current using ICON and Swarm's method with "synthetic measurements" provided by the high-resolution WACCM-X.

SA23B-2709 Large-Scale Gravity Waves in ICON-MIGHTI Data
Colin Charles Triplett
2:10 - 6:30
Poster Hall A-C - South (Exhibition Level, South, MC)

In a recent paper, large-scale (~ 3000 km horizontal wavelength) gravity waves were shown in the Ionospheric Connection Explorer (ICON) Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) instrument for the year of 2020. These large-scale waves are seen every day and appear to have a relation to known gravity wave hotspots in the lower atmosphere. As gravity waves carry energy and momentum throughout the atmosphere, understanding the large-scale waves seen by ICON-MIGHTI is critical to understand the mesosphere/thermosphere/ionosphere system. These waves are seen in the volume emission rates of the 557 nm (green) airglow layer, the zonal winds, and temperatures. Here we extend the recent study to include all dates for the ICON mission (December 2019 to November 2022), the 630 nm (red) airglow layer, the nighttime data, meridional winds, and use the more accurate version 5 MIGHTI data. Statistics between years, local times, geographic locations are shown. Also, an estimation of wave parameters is discussed.

SA23C - Dynamics of the Thermosphere and Ionosphere System at Low and Middle Latitudes During Varying Internal and External Conditions IV Poster
Yen-Jung Joanne Wu
2:10 - 6:30
Poster Hall A-C - South (Exhibition Level, South, MC)

Over the past three years, our knowledge of dynamics and energetics of the thermosphere and ionosphere system has been advanced by the GOLD, COSMIC-2, and ICON missions, along with existing ground-based observations, as well as the advent of numerical modeling capabilities. Topics of interest include, but are not limited to, changes in the thermospheric winds, composition, thermal structure and ionospheric electric field and electron density due to geomagnetic activity, various waves arising from the lower atmosphere, and polar vortex activity, etc. This session solicits research papers that employ the data from satellite missions, ground-based observations, and the state-of-the-art general circulation models to address compelling scientific questions regarding variability of various scales in the low and middle-latitude thermosphere and ionosphere.

SA23C-2736 O^+ density profiles provided by the ultraviolet imagers onboard ICON: comparison with radio-based observations and role of the equatorial ionization anomaly
Benoît A Hubert
14:10 - 18:30 PST
MC, Poster Hall A-C – South

The NASA-ICON mission was dedicated to the observation of the terrestrial equatorial ionosphere between November 2019 and November 2022 from a circular orbit at about 600 km altitude. The scientific payload encompasses two ultraviolet imagers: the Far Ultraviolet Imaging Spectrograph (FUV) and the Extreme Ultra Violet (EUV) spectrograph. FUV observes the emission of the atomic oxygen doublet at 135.6 nm as well as the Lyman-Birge-Hopfield (LBH) band of N2 near 157 nm while the EUV spectrograph records daytime limb altitude profiles of terrestrial emissions in the extreme ultraviolet spectrum from 54 to 88 nm. Every 12s, based on the 135.6 nm emission for FUV and on the OII–61.7 nm and 83.4 nm emissions for EUV, both instruments provide O+ density profiles for nighttime and daytime conditions, respectively.

Besides, the GNSS radio-occultation mission COSMIC-2 daily provides, since 2019, several thousands of electron density profiles above low and mid-latitudes, in addition to ground-based ionosondes delivering high-quality observations at a regular cadence. For FUV, the peak density and height are, on average, similar to radio-based observations by about 10% in density and 7 km in altitude. The EUV spectrograph provides peak density values smaller than that from other techniques by 50 to 60%, while the altitude of the peak is retrieved with a slight bias of 10 to 20 km on average. While the equatorial ionization anomaly does not have a significant influence on the EUV comparisons, it is found that the largest density differences between FUV and C2/ionosonde data are related to the ionization crests where their large density gradients and specific geometry break the spherical symmetry assumed by the inverse Abel transform to retrieve the O+ density profile. We perform a dedicated analysis of these particular cases using GNSS-TEC maps to identify the problems arising when considering multi-sensor data fusion at low-latitudes.

Tuesday 12 December

Presentations

SA21A - Dynamics of the Thermosphere and Ionosphere System at Low and Middle Latitudes During Varying Internal and External Conditions I Oral
Convener: Yen-Jung Joanne Wu et al
08:52 - 09:02
207 - South (Level 2, South, MC)

Over the past three years, our knowledge of dynamics and energetics of the thermosphere and ionosphere system has been advanced by the GOLD, COSMIC-2, and ICON missions, along with existing ground-based observations, as well as the advent of numerical modeling capabilities. Topics of interest include, but are not limited to, changes in the thermospheric winds, composition, thermal structure and ionospheric electric field and electron density due to geomagnetic activity, various waves arising from the lower atmosphere, and polar vortex activity, etc. This session solicits research papers that employ the data from satellite missions, ground-based observations, and the state-of-the-art general circulation models to address compelling scientific questions regarding variability of various scales in the low and middle-latitude thermosphere and ionosphere.

SA21A-03 The Effects of a Small Geomagnetic Storm on Earth's Thermosphere and Ionosphere: 25 January, 2021
Thomas Immel
08:52 - 09:02
207 - South (Level 2, South, MC)

Isolated geomagnetic storms during solar minimum offer the opportunity to observe the effects of solar wind on Earth's atmosphere without interference from other background changes in the ionosphere-thermosphere system. Here, we observe the effects of a minor storm on the ionosphere at middle and low latitudes, where disturbances in thermospheric winds and composition can produce storm-time changes in ionospheric densities. Using data from the NASA Ionospheric Connection Explorer (ICON), we investigate the competing effects of composition changes and neutral wind disturbances in modifying the ionosphere during the 25 Jan. 2021 storm, characterized by only a 30 nT drop in Dst. Large enhancements in plasma densities are seen across the dayside late on 25 Jan., associated with large changes in meridional winds and significant high-latitude electric current enhancements as measured by the auroral electrojet index. At the same time, we find evidence of rapid transport of heated air from the southern auroral zone to the equator in the East-Asian sector with the appearance of deeply reduced O/N$_2$ in the morning sector and storm-time northward winds prior to its appearance. We observe significant, rapid erosion of the high plasma densities in the sector where thermospheric disturbance appears over 5 hours of observations. The noon-time plasma density enhancements are short-lived and we observe no westward perturbation in the low-middle latitude, dayside zonal winds over a 5-day period including the storm. Thus, we attribute the ionospheric changes to prompt penetration and meridional wind forcing, while ruling out the presence of a storm-time disturbance dynamo and its related ionospheric effects.

<u>SA22A - Dynamics of the Thermosphere and Ionosphere System at Low and Middle Latitudes During Varying Internal and External Conditions II Oral</u>
Convener: Yen-Jung Joanne Wu et al
10:20 - 11:50
207 - South (Level 2, South, MC)

Over the past three years, our knowledge of dynamics and energetics of the thermosphere and ionosphere system has been advanced by the GOLD, COSMIC-2, and ICON missions, along with existing ground-based observations, as well as the advent of numerical modeling capabilities. Topics of interest include, but are not limited to, changes in the thermospheric winds, composition, thermal structure and ionospheric electric field and electron density due to geomagnetic activity, various waves arising from the lower atmosphere, and polar vortex activity, etc. This session solicits research papers that employ the data from satellite missions, ground-based observations, and the state-of-the-art general circulation models to address compelling scientific questions regarding variability of various scales in the low and middle-latitude thermosphere and ionosphere.

<u>SA22A-01 Forecasting equatorial F-region convective instability with ICON</u>
David L. Hysall
10:20-10:30
207 - South (Level 2, South, MC)

Measurements from the Ionospheric Connections Explorer satellite (ICON) form the basis of direct numerical forecast simulations of plasma convective instability in the postsunset equatorial F region ionosphere. ICON data from 2022 have been selected and used to initialize and force simulations and then to assess the results when the satellite revisits the same longitude in the next orbit. Data from the IVM plasma density and drifts instrument and the MIGHTI red-line thermospheric winds instrument are used to force the simulation. Data from IVM are also used to test for irregularities. The numerical simulations have been able to reproduce the observed phenomenology with respect to the detection or non-detection of ionospheric irregularities in most cases, although false alarms and missed detections occur. Possible reasons for model/data discrepancies will be presented.

SA22A-03 Effects of upward propagating tides on the thermosphere ionosphere as captured by TIEGCM-ICON
Astrid I Maute
10:40-10:50
207 - South (Level 2, South, MC)

The vertical coupling of the lower and upper atmosphere via atmospheric solar tides is very variable and affects the dynamics, composition and electrodynamics of thermosphere - ionosphere (TI) system. In addition, complex magnetosphere-ionospheric coupling at high latitude is always present and its influences on the TI is not limited to the high latitude but connects to mid- and low latitude region. The Ionospheric Connection (ICON) explorer mission provides almost 3 year of data and an opportunity to examine the variation in the TI due to lower atmospheric and MI forcing. This is facilitated by the ICON Level4 product, the thermosphere-ionosphere-electrodynamics general circulation model (TIEGCM) driven by tides fitted to ICON observations via the Hough Mode Extension (HME) method. The effect of the upward propagating tides can be isolated by examining the difference between two TIEGCM simulations with and without tidal HME forcing at the model lower boundary.

In this presentation we use the over 2 years of TIEGCM-ICON simulations to evaluate the model by comparing primarily to ICON observations as well as examine the captured TI variations. A special focus in our comparison will be on the daytime neutral wind driving the ionospheric electrodynamics, influencing the ion drift, and the plasma distribution. We will delineate during specific time periods the contributions due to lower atmospheric tidal forcing from the one due to solar and magnetospheric forcing and quantify the effect on the neutral wind, ion drift, and plasma variation.

SA22A-04 Impact of the 2020/2021 Major Sudden Stratospheric Warming on the Low-latitude Thermospheric Winds and Temperature as observed by ICON and GOLD Satellites
Erdal Yiğit
10:50 - 11:00
207 - South (Level 2, South, MC)

We study the response of the thermospheric daytime horizontal winds and neutral temperature to the 2020/2021 major sudden stratospheric warming (SSW) at low- to middle latitudes, using measurement by NASA’s ICON and GOLD satellites. We compare the SSW-induced changes in winds and temperature with the associated wind and temperature variations during the non-SSW winter of 2019/2020 and the pre-SSW period (December 2020), which clearly demonstrates the impact of the major SSW on thermospheric winds and temperature. The northward and westward thermospheric winds are enhanced during the warming, while thermospheric temperature around 150 km drops by about 50 K compared to the pre-SSW phase. SSW-induced thermal and dynamical changes in the thermosphere are intimately connected. The observed thermospheric temperature drop is likely caused by adiabatic cooling at low-latitudes associated with changes in the large-scale horizontal circulation, which can generate upwelling at low-latitudes during SSWs. The observed changes during the major SSW are a manifestation of long-range vertical coupling in the atmosphere.

SA23A-02: Lessons from 3 years of neutral winds and temperature observations in the E-region from ICON (Invited)
Scott England
2:25 – 2:40 PST
MC, 207 – South

The E-region is in near photochemical equilibrium, and thus is highly coupled to the local atmosphere. The neutral atmosphere at E-region altitudes is highly dynamic, with large amplitude waves producing variability and gradients on a variety of scales. The ICON mission observed of the neutral atmosphere throughout the E-region, allowing it to identify the role the neutral atmosphere plays in processes such as the E-region dynamo. Key observations from this region have provided new insight into the dynamics during geomagnetically quiet to moderation conditions. This talk will present results from the 3-years of ICON observations, highlighting the observations of wind shears – their occurrence, spatial scales, apparent organization and their possible role in forming sporadic-E layers; small-scale variability associated with atmospheric waves – its variation with season and altitude; characteristic wave scales seen; variation in neutral compositional throughout the E-region; the impact of neutral winds on currents flowing in the E-region and the impact of moderate high latitude forcing on the dynamics at E-region altitudes.

Wednesday, 13 December

Posters

SA31C-2874 Day-to-day variability of the neutral wind dynamo: ICON's conjugate observations
Brian Harding
08:30 - 12:50
Poster Hall A-C - South (Exhibition Level, South, MC)

Results are presented from three years of conjugate maneuvers performed by the Ionospheric Connection Explorer (ICON) spacecraft. During these special maneuvers, ICON measures the plasma drift at the 600-km apex of a magnetic field line and the neutral wind profiles (90-300 km altitude) along both ends of that field line. This represents the first dataset capable of investigating interhemispheric wind dynamo forcing. Over 150 maneuvers have been performed, many 24 hours apart. The results suggest that about half of the day-to-day variance in the equatorial vertical and zonal drift is attributable to local wind driving. Zonal winds in both hemispheres are the dominant drivers, while meridional winds have smaller but significant contributions which differ between the hemispheres.

Presentations

SA31A-03 Ionosphere-Thermosphere Coupling via Global-Scale Waves: New Insights from Concurrent In-Situ and Remotely-Sensed Satellite Observations (Invited)
Federico Gasperini
08:50 - 09:00
207 - South (Level 2, South, MC)

Growing evidence indicates that a selected group of global-scale waves from the lower atmosphere constitute a significant source of ionosphere-thermosphere (IT, 100-600 km) variability. Due to the geometry of the magnetic field lines, this IT coupling occurs mainly at low latitudes (< 30) and is driven by waves originating in the tropical troposphere such as the diurnal eastward propagating tide with zonal wave number s = -3 (DE3) and the quasi-3-day ultra-fast Kelvin wave with s = -1 (UFKW1). In this work, over 2 years of simultaneous in situ ion densities from Ion Velocity Meters (IVMs) onboard the Ionospheric Connection Explorer (ICON) near 590 km and the Scintillation Observations and Response of the Ionosphere to Electrodynamics (SORTIE) CubeSat near 420 km, along with remotely-sensed lower (ca. 105 km) and middle (ca. 220 km) thermospheric horizontal winds from ICON's Michelson Interferometer for Global High-resolution Thermospheric Imaging (MIGHTI) are employed to demonstrate a rich spectrum of waves coupling these IT regions. Strong DE3 and UFKW1 topside ionospheric variations are traced to lower thermospheric zonal winds, while large diurnal s = 2 (DW2) and zonally symmetric (D0) variations are traced to middle thermospheric winds generated in situ. Analyses of diurnal tides from the Climatological Tidal Model of the Thermosphere (CTMT) reveal general agreement near 105 km, with larger discrepancies near 220 km due to in situ tidal generation not captured by CTMT. This study highlights the utility of simultaneous satellite measurements for studies of IT coupling via global-scale waves.

SA32A-01 Incorporating non-migrating tidal temperatures into the NRLMSIS®
Michael H Stevens
10:20 - 10:30
207 – South (Level 2, South, MC)
NRLMSIS® is an empirical atmospheric model that extends from the ground to the exobase and describes the average behavior of temperature, composition, and mass density, as a function of day of year, time, location, solar and geomagnetic activity. The MSIS model has recently been extensively upgraded, including the assimilation of a number of new data sets, reformulation to couple species densities to the entire temperature column, and the addition of nitric oxide to the species densities represented by the model. As part of a continuing effort to enhance NRLMSIS for scientific and space weather applications, we describe progress on the incorporation of non-migrating tidal variations of temperature into the MSIS framework. Non-migrating atmospheric tides have long been understood to play a major role in driving large-scale thermospheric and ionospheric variations, but are not currently included in MSIS. Specifically, we report on the formulation and fitting of the major diurnal and semidiurnal non-migrating tidal components, using output from the Climatological Tidal Model of the Thermosphere (CTMT) to provisionally tune the new MSIS parameters. We further present validation against new and independent temperature measurements from the Michelson Interferometer for Global High-Resolution Thermospheric Imaging (MIGHTI) instrument onboard the Ionospheric Connection Explorer (ICON).

Friday 15 December

Posters

SA51B-2512: Observations of the Impact of an M-Class Solar Flare on the Global I-T System
Andrew W Stephan
8:30 AM – 12:50 PM PST
Moscone Center, South, Poster Hall A-C

On 13 June 2022 at 03 UT, sunspot AR3032 erupted into an M3-class solar flare that lasted nearly eight hours, causing increased ionization and temporary shortwave radio blackouts particularly over the direct-impact region in the Asian-Pacific sector. We have examined the detailed and comprehensive measurements of the Ionospheric Connections Explorer (ICON) sensor suite during this space weather event, including ion and neutral densities, winds, and plasma drifts, to identify the magnitude and extent of the impact of even such a moderate-strength flare on the ionosphere-thermosphere (I-T) system. We also have evaluated these measurements in the context of total electron content (TEC) maps generated at 15-minute cadence from Global Positioning Satellites (GPS), the NASA Global Observations of the Limb and Disk (GOLD) imagery, and radar measurements taken from Millstone Hill. While the effect on thermospheric composition is confined to the impulsive temporal and spatial window of the flare event, the ionosphere shows significant variability in both NmF2 and hmF2 consistent with traveling ionospheric disturbances (TIDs) that persist for more than 24 hours after the event, and extending to all longitudes around the globe. Equatorward of Millstone Hill, which was shadowed at the time of the flare event, significant ionospheric perturbations are reflected in both the ICON and GPS TEC measurements 10-15 hours after the event. Specifically, the ICON altitude-profile plasma density data show that increased TEC at low latitudes was caused by uplift of ionospheric plasma rather than an overall increase in number density, supporting the assumed connection to TIDs. We present these observations that demonstrate the level to which even moderate M-class flares can generate significant, enduring, and globally structured disruptions to ionospheric states.

SA51C-2514 Characterizing the Upward-Propagating Global-Scale Wave Spectrum for DYNAMIC Science Investigations
Federico Gasperini
8:30 AM – 12:50 PM PST
Moscone Center, South, Poster Hall A-C

The DYNAMIC mission aims to provide a comprehensive understanding of the variability in space weather driven by terrestrial weather. DYNAMIC will investigate the wave coupling of energy and momentum from the lower and middle atmosphere to the ionosphere, thermosphere, and mesosphere (ITM, 100-600 km) system. Recent studies have demonstrated that the quiet time ITM is characterized by significant day-to-day variability associated with a select group of global-scale atmospheric waves, including solar tides, ultra-fast Kelvin waves (UFKWs), and secondary waves due to wave-wave interactions. Day-to-day variability of diurnal tides generated in the lower and middle atmosphere is not well captured by previous space-borne ITM observations due to constraints in the orbital geometry. A two-spacecraft mission making identical observations in sufficiently separated orbital planes provides a critical dataset for characterizing the day-to-day variability of the major diurnal tides, and greatly advancing the ability to characterize short-term variability in semidiurnal tides.

In this work, a reanalysis-driven global circulation model containing realistic variability of the important global-scale wave components is used as a mock data set to estimate the veracity of tidal and UFKW fitting methods applied to asynoptic sampling from DYNAMIC. Output for a Specified Dynamic (SD) Whole Atmosphere Community Climate Model with thermosphere and ionosphere extension (WACCM-X) v2.1 simulation driven by Modern-Era Retrospective analysis for Research and Applications, version 2 (MERRA-2) reanalysis is used to quantify uncertainties on daily wave retrievals from a two-spacecraft DYNAMIC mission with varying local time separation. The focus is on some of the largest global-scale wave components in the ITM, including diurnal and semidiurnal tides and UFKWs. Results from this study are expected to provide needed observational constraints for the DYNAMIC mission design.

<u>SA53A-2526 Effects of Geomagnetic Storms on Plasma Bubbles over South America</u>
Gilda González
2:10 PM – 6:30 PM PST
Moscone Center, South, Poster Hall A-C

The generation and development of ionospheric irregularities is an important topic of study in space weather, particularly due to their adverse effects on navigation positioning systems and trans-ionospheric communications. To improve our prediction capabilities, a comprehensive understanding of their variability during different geomagnetic conditions is important. The purpose of this research is to analyze the generation or inhibition of ionospheric irregularities in the F region over South America during geomagnetic storms. To conduct the analysis, we use GOLD OI 135.6 nm radiance maps, ICON IVM ion density and vertical drift, ICON FUV data and ROTI maps. Additionally, we consider ICON MIGHTI wind data (red line emission) to study the role of the neutral wind. We examine the presence of irregularities during three storms: November 3, 2021; January 14, 2022, and February 3, 2022. Two of them (November and February) showed inhibition of plasma bubbles over the east of Brazil, whereas, during the January storm, generation of plasma bubbles was observed over the same region. The storm-time electric fields might play an important role in the development of irregularities. The potential drivers of the plasma bubbles variability during disturbed geomagnetic conditions will be examined using wind profiles provided by ICON MIGHTI.

Presentations

<u>SA51A-08 The effect of Planetary Waves on the day-to-day variability of equatorial plasma bubbles</u>
Jeff Klenzing et al
09:40 - 09:50
207 - South (Level 2, South, MC)

In the equatorial ionosphere, large persistent depletions in nighttime plasma density (sometimes referred to as “bubbles”) can arise when an unstable ionosphere is perturbed by wave activity. In this scenario, a seed perturbation (such as a gravity wave) on the bottomside of the ionosphere grows rapidly as a Rayleigh-Taylor Instability. Despite over 80 years of observations, prediction of these plasma bubbles and the resulting ionospheric scintillation remains an outstanding challenge for the Space Weather community because the terrestrial IT system is driven through multiple energy paths. This talk will discuss the geophysical drivers that can enhance or suppress this instability in the ionosphere — such as geomagnetic storms and planetary waves — which can influence whether a seed wave will grow into a bubble on a given night at a given location.

Previously, the day-to-day variability of the ionosphere due to lower atmospheric forcing was quantified by driving the SAMI3 model with the Whole Atmosphere Community Climate Model eXtended (WACCM-X) with the lower boundaries specified by the High Altitude Navy Global Environment Model (NAVGEM-HA) over an extended period of time. The variability levels of Total Electron Content from ground-based GPS measurements were found to be similar to those predicted by the model. Here we extend this analysis to investigate the day-to-day variability of the Rayleigh-Taylor Instability growth rate as calculated from SAMI3/WACCM-X/NAVGEM and its effect on the growth or suppression of plasma bubbles. We will compare with data to quantify the contribution of Planetary Waves and lower atmospheric forcing on bubbles and subsequent scintillation.

SA52A-04 Modeling Plasma Bubble Occurrence with *growin*

Jonathan Smith et al
10:50 - 11:00
207 - South (Level 2, South, MC)

Seasonal and zonal climatologies of Rayleigh-Taylor (RT) growth rates under geomagnetically quiet conditions during solar minimum and solar moderate conditions as a function of local time and altitude are calculated. This is achieved with an open science workflow using publicly available models and open-source scientific code that enhances the model output. It is under the action of the RT instability that plumes of depleted plasma, or plasma bubbles, are understood to develop in the bottomside of the equatorial ionosphere. The *growin* python module utilizes other Heliophysics python modules to calculate the flux tube integrated RT growth rate by collating and processing vertical plasma drift to drive the SAMI2 is Another Model of the Ionosphere (SAMI2) model using the open-source sami2py. Enhancements to the *growin* module allow SAMI3 to be used to calculate the flux tube integrated RT growth rate. Additional modifications in light of recent improvements to the growth rate calculation have also been incorporated. The RT growth rate is calculated using multiple runs of SAMI3 with different neutral atmosphere models as drivers. The growth rates from these different model conditions are compared to plasma bubble occurrence frequencies deter- mined from in-situ plasma density measurements from satellite missions.