Platinum Jubilee

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Symposium on "Meteoroids, Meteors and Meteorites: Messengers from Space"

Programme

30th November, Tuesday

Session-4: Atmosphere and Meteors

Session Chairs: Amit K. Patra & Varun Sheel

Abstract #	Time	Speaker	Title
Invited	10:40-10:55	K. Kishore Kumar	Overview of atmosphere and Meteors
S4-01	10:55-11:10	G. Kishore Kumar	Tropical Mesospheric Semi-annual Oscillation using Meteor radar observations
S4-02	11:10- 11:20	Keshav Tripathi	V0 layer in the Venus ionosphere: is it of meteoric origin?
S4-03	11:20-11:30	M. Pramitha	Meteor Radar Estimations of Gravity Wave Momentum Fluxes in the Mesosphere –Lower Thermosphere and their source spectra characterisation using Ray tracing modelling
S4-04	111:30-11:40	N. Koushik	Tropical Signatures of Sudden Stratospheric Warming Events as Observed by Meteor Wind Radars
S4-05	11:40 - 11:48	Masoom Jethwa *	Study of meteor induced metallic ions in the Martian atmosphere

Tropical Mesospheric Semi-annual Oscillation using Meteor radar observations

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Two long-period oscillations dominate Earth's equatorial atmosphere, viz., Quasi-biennial and semi-annual oscillations (QBO and SAO) in the stratosphere as well as the mesosphere. These two prominent oscillations have modulated many equatorial atmospheric processes. Among QBO and SAO, the latter is relatively less explored. The SAO is clearly observed in zonal winds and temperature with peaks in the stratosphere and mesosphere. The Mesospheric SAO (MSAO) is in the opposite phase with stratospheric SAO (SSAO). Besides the winds and temperature, the SAO signature is prominently observed in gravity wave (GW) activity and tidal activity. However, the SAO amplitudes obtained from different observations showed significant differences in amplitudes. This could be due to the differences in local time sampling. Most of the measurements in the middle atmosphere didn't comprise a full diurnal cycle. For example, the lidar measurements are limited to night-time, the MST radar observations are limited to daytime observations, and the rocket measurements are mostly limited to a selective time of the Day. In this study, we attempt to estimate the possible biases in the SAO amplitude due to the difference in the local time sampling by using the round-the-clock measurements of meteor radar observations. We estimated the semi-annual amplitudes in zonal winds for different local times in addition to the diurnal mean zonal winds. The differences between SAO amplitudes from a particular hour to a diurnal mean showed systematic differences. The significance of the present study lies in estimating the SAO amplitude as a function of local time and comparing the same with that obtained from diurnal mean winds. It is envisaged that the present results will address the differences in SAO amplitudes estimated using different observational platforms and will shed light on local time dependency in SAO forcing mechanism.

V_0 layer in the Venus ionosphere: is it of meteoric origin?

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Radio Occultation (RO) experiments are being conducted over Venus by the Akatsuki spacecraft since 2016. Total 34 electron density profiles of the Venus ionosphere have been obtained using this experiment among which six profiles show an enhancement in the electron density below 120 km altitude (below V1 base). This distinct layer below 120 km altitude has been named as V0 layer. The orbital geometry of spacecraft has enabled us to observe (1) the first V0 layers near the subsolar point (SZA = 5 degrees), (2) the first V0 layers well past the terminator (SZA=108 degrees), and (3) the first V0 layers at the equator.

The origin of V0 layer has traditionally been associated with the ablation of meteoric dust at a given altitude (Patzold et al 2009). Recent studies however suggest alternative origins for the enhancement in electron density profile at lower altitudes in the different planetary ionosphere, notable among them are :

1. Precipitation of solar energetic particles (SEP) can enhance the electron number density at lower altitudes by chemical reaction (charge exchange processes). Sheel et al., (2012) has modelled the SEP events and predicted that 50 MeV solar particles can penetrate the martian atmosphere up to 50 km altitude. Such an event can also be anticipated for the origin of V0 layer in the Venusian ionosphere.
2. Recent observations by MAVEN have demonstrated that the enhancement in transient electron density profile below 100 km altitude in the martian ionosphere (Mm layer) could be due to the occurrence of proton aurora (Crismani et al 2019). They suspect that such an enhancement could be the permanent feature of the planetary ionosphere.
3. Peter et. al. 2021 demonstrated that the enhancement in solar X-ray radiation (< 2 nm) can ionize the available NO molecules which will enhance the electron number density below 100 km altitude in the martian ionosphere (Mm Layer). Though there is no direct observation of NO molecules in the Venusian ionosphere, indirect evidence of meteor chemistry is ultraviolet night glow detection in which nitric oxide (NO) emissions were seen along with what might have been an extended meteor trail (Huestis & Slanger, 1993).

4. The local perturbation in the planetary atmosphere (internal gravity wave) can also enhance the electron density in the Earth ionosphere (Yiğit et al., 2016). Such enhancements are seen in the planetary ionosphere as well.

Due to the lack of supporting observations (other than RO investigation), we can not ignore the possibility of any of the above four reasons and ensure the meteoric origin of V0 layer. More details of all possibilities for the formation of V0 layer will be discussed during the presentation.

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Meteor Radar Estimations of Gravity Wave Momentum Fluxes in the Mesosphere –Lower Thermosphere and their source spectra characterisation using Ray tracing modelling

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Atmospheric gravity waves play a vital role in coupling the various layers of the atmosphere. Meteor radars are widely used to study gravity wave (GW) variances and their momentum fluxes at the altitudes where meteor counts are sufficient to yield good statistical fits to the data (Mesosphere-Lower Thermosphere). Hocking's matrix inversion method is widely used for obtaining GW momentum flux from meteor radar, but in this method GW perturbation obtained after the removal of background winds are contributed by tides and planetary waves.So, a modified composite day (MCD) analysis of Hocking Method is adopted to estimate the GW momentum fluxes, which accounts for the tidal and planetary wave contributions.The present study evaluates the meteor radar observations of GW momentum fluxes obtained from Thumba (8.5°N, 77°E; 2006–2015), Kototabang (0.2°S, 100.3°E; 2002–2017), and Tirupati (13.63°N, 79.4°E; 2013–2018) using three-dimensional wind field simulations, which include specified tidal, planetary and GW fields in MCD analysis. The results showed that the retrieved and specified GW momentum fluxes agree very well over Tirupati followed by Thumba and Kototabang which is depend on the number of meteor detections used in the analysis.

Being a sub-grid process, the gravity waves are parameterized in the global atmospheric models. One of the important aspects of the gravity wave parameterisation is to identify the source spectrum in the lower atmosphere. Earlier studies employed the GROGRAT (Gravity-wave Regional Or Global Ray Tracer) model to fine tune the source spectrum by comparing model results with the observations. An attempt is made in the present study to identify the best fit source spectra for the gravity waves which are observed at mesospheric altitude using GROGRAT model and meteor radar located at Tirupati. In this regard, monthly mean climatologies of background atmosphere are developed (using SD-WACCM,TIMED/SABER & Radiosonde) in and around $\pm 5^0$ at Tirupati. Considering this as background atmosphere for GROGRAT model and by considering different source spectra (isotropic as well as anisotropic, symmetric as well as antisymmetric) with various combinations of spectral width, horizontal wavelength, spectral amplitude, model runs were carried out at different altitudes and zonal momentum fluxes are obtained. These simulated fluxes are compared with that of the meteor radar observed monthly mean gravity wave momentum flux to get the best fit source spectra at Tirupati. The significance of the present study lies in identifying the best fit source spectra of gravity waves by tuning it with gravity wave momentum flux observations from meteor radar in the mesosphere and lower thermosphere region.

Tropical Signatures of Sudden Stratospheric Warming Events as Observed by Meteor Wind Radars

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Spectacular meteorological phenomena in the winter polar stratosphere called Sudden Stratospheric Warming (SSW) events are found to exhibit coupling across a wide range of spatial and temporal scales. In high and midlatitudes, these events often result in severe weather episodes at the surface in weeks or months to follow. In the low latitudes, SSW events are found to cause significant day to day variabilities in the upper atmosphere/ionosphere. Key to understanding there variabilities are the processes taking place in the Mesosphere Lower Thermosphere (MLT) region which acts as a gateway between the neutral atmosphere below and the ionosphere above. Meteor Wind Radars serve as one of the most versatile tools for probing the MLT region with high temporal and spatial resolution. In this study, we use meteor wind radars to understand the dynamics of the MLT region in association with SSW events in terms of mean winds, tidal and planetary wave variability. Significant enhancements in solar semidiurnal tides and quasi-two day waves are observed in the tropical MLT during major SSW events. Apart from this, certain events exhibited enhancements in lunar semidiurnal tides which are purely gravitational in original. This observation is further discussed in the light of planetary wave-tidal interactions, wherein lunar tidal amplitudes can be potentially contaminated by secondary tidal components resulting from the interaction of solar semidiurnal tides and the quasi-16 day planetary waves. We present classical examples for atmosphere-ionosphere coupling present in the low latitudes through lunar tidal signatures in the Equatorial Electrojet (EEJ) intensities. Further, we provide evidences for the equatorward propagation of secondary planetary waves in the mid/high latitude MLT following SSW events. These results highlight the importance of using state of the art meteor wind radars to study short term variabilities in the middle atmosphere.

Study of meteor induced metallic ions in the Martian atmosphere

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Abstract:

The primary source of metallic species in the Martian atmosphere is an influx from meteors. The assessment of metallic ion/neutral species, their chemistry and physics of the upper and middle atmosphere amalgamates meteoric and atmospheric research. This work aims to study the impact of meteoroid influx in the ionospheric of Mars [1]. Recent prediction of cosmic dust particles mass input is approximately two tons per day for Mars [2]. We present evidence of the metallic ion layer produced by meteoric ablation in the upper atmosphere using Neutral Gas and Ion Mass Spectrometer (NGIMS) onboard MAVEN spacecraft [3]. We report observations that span more than an Earth year, showing enhancement of metallic ions during the predicted meteor showers, at least by a factor of two. This work will help us validate/improve densities from PRL Neutral & Ion Reactivities Upon Atmospheric Meteoroid Ablation (NIRUPAMA) model. In future, there is a scope to model the airglow emissions from the metallic ions [4].

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