MLT Poster Session

Stadium Club
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Poster Abstract Booklet

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MLT-COUP-01 Mesospheric wave activities during 2006 sudden stratospheric warming - by Tao Li

Status of First Author: Non-student PhD

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Abstract: The activities of planetary waves, tides, and gravity waves in the mesosphere during the sudden stratospheric warming were studied with lidar and radars in the lower and higher latitudes: Rayleigh lidar at Mauna Loa Observatory (19.5°N, 195.6°W), Hawaii, MF radar at Kauai (22°N, 200.2°W), Hawaii, and meteor radars in the Tromsø (69°N, 19°E) and Svalbard (78°N, 16°E). We found that a strong planetary wave with period of ~10 days and amplitude of ~20m/s was observed over Hawaii and then started to decay in the early January and almost varnished during the 2006 sudden stratospheric warming on January 21, 2006, while the amplitude of ~15-day wave was observed to increase over Tromsø and Svalbard during the warming. The significant enhancement of mesospheric gravity wave activities was also revealed before the major warming followed by the decrease of activity during and after the warming over Hawaii. However, the meteor radar observations in both Tromsø and Svalbard suggested the reduced activities before warming and enhanced during and after warming. The significant variability of diurnal and semidiurnal tides was also observed during the warming event.

MLT-COUP-02 Observations and Climatology of Polar Middle Atmosphere disturbances related to Sudden Stratospheric Warmings - by Katelynn Greer

Status of First Author: Student IN poster competition

Authors: Katelynn Greer and Jeffrey P. Thayer

Abstract: Synoptic-scale disturbances in the arctic wintertime middle atmosphere are investigated using NASA TIMED/SABER observations and UK Meteorological Office (MetO) assimilated stratospheric data. Upper stratosphere lower mesosphere(USLM) disturbances observed between 1991-2010 for winter seasons in both the northern and southern hemispheres are identified. The observed strong vertical and horizontal thermal gradients in the arctic winter upper stratosphere and mesosphere are evocative of front-like behavior in the troposphere. The observations from the SABER instrument and the MetO data of temperature and geopotential suggest baroclinic instability is a process involved in enhancing the disturbance. The observations suggest that through planetary wave action the middle atmosphere becomes highly baroclinic and can promote baroclinic instability that can enhance temperatures to extreme levels (in excess of 290 K in the upper stratosphere and less than 200 K in the lower mesosphere) characteristic of these disturbances in the middle atmosphere. The repeatable nature of anomalous temperatures at the low stratopause height near 2 hPa enable a search criterion to identify these type of middle atmospheric events in SABER and MetO stratosphere data records. The collection of events from 1991-2010 demonstrate USLM thermal disturbances exhibit a strong preference for their position to lie to the east relative to the polar vortex core, supporting the dynamical implication of baroclinic instability. The frequency of these disturbances, and their relative occurrence with respective to major sudden stratospheric warming (SSW) events, is presented to describe the degree to which the middle atmosphere is disturbed in a given season and the precursor nature of USLM disturbances to SSW events. Lastly, while the extreme temperatures on the east side of the polar vortex are most easily identifiable, thermal characteristics on the west side of the polar vortex are presented to illustrate the effectsof the expected ageostrophic flow circulation across the vortex.

MLT-COUP-03 Correlation of stratopause and mesopause, and temperatures at different altitudes by Bo Tan

Status of First Author: Student IN poster competition

Authors: Bo Tan1, Xinzhao Chu1 and Chihoko Yamashita1
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Abstract: SABER data from 2002 to 2008 are used here to identify the stratopause and mesopause and to analyze the correlation of atmosphere temperatures at different altitudes. At latitudes higher than 50 deg, mesopause temperature, mesopause altitude and stratopause temperature have high correlations with each other (correlation coefficients above 0.9), while the correlations of stratopause altitude with them are small (correlation coefficient below 0.4). The high correlations among mesopause temperature, mesopause altitude and stratopause temperature only exist at high latitudes and the correlations decrease toward equator. In addition, the temperature correlations of different altitudes have clear latitudinal dependence and hemispheric asymmetry. The temperature of two layers far from each other can have large correlation or anti-correlation, such as 80 km and 40 km. The QBO, AO, SAO are extracted and the contributions to correlations from each oscillation are analyzed.

MLT - Irregularities of the Ionosphere or Atmosphere

MLT-IRRI-01 Active Perturbation effects on irregularities associated with charged dust in the Earth's mesosphere (computational model and experimental data) - by Alireza Mahmoudian

Status of First Author: Student IN poster competition PhD

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Abstract: Polar Mesospheric Summer Echoes (PMSE) are strong echoes that have been typically observed in the frequency range from 50MHz to 1.3GHz and in the altitude about 85Km. The PMSE is produced by scattering from electron irregularities due to electron charging on the irregular subvisible mesospheric dust layer. The radar echoes occur at half the radar wavelength therefore the wavelength of the irregularities are roughly in the range of 10cm to 10m. In recent experiments, the EISCAT ground based ionospheric heating facility was used to produce an artificial enhancement in electron temperature in dust layer. Important information can be obtained from temporal behavior of the electron irregularities during turn on or turn off the radio wave heating. Considering the temporal behavior of electron irregularities during heating process provides diagnostic information about dust layer. The goal is to compare the experimental data with computational result to get some diagnostic information about the dust radius, amount of electron temperature increase and dust density at mesosphere altitude.
In the first part of the presentation, the radar data obtained during an experimental campaign at the European Incoherent Scatter Scientific Association (EISCAT) facility in Tromso, Norway in July 2009 is discussed. The measurement was set up with 3 minutes heating cycle in which the heater is on for 40 seconds to increase electron temperature in the specific area in the ionosphere and after 40 seconds, the heater is turned off. At the same time the scatter radar signal also is recorded to analyze temporal behavior during turn on and turn off of the heater. Radar scattering at 224 MHz (VHF) and 7.953 MHz (HF) frequency bands was observed. Modulation in the PMSE is observed.
In the second part of the presentation, a computational model is used to provide interpretation of the data. A one dimensional computational model is used to study PMSE during radio wave heating. There are different parameters which vary with temperature such electron-neutral collision frequency, recombination coefficient and dust charging process. The model includes ions, electrons and dust. The ions and electrons are treated as fluid and the dust with particle-in-cell method. In the computational model, the variation of different parameters such as electron temperature increase, dust radius, dust density and radar frequency is investigated to observe their effect on temporal behavior of electron irregularities as observed in the experimental measurements. The effect of these parameters on diffusion and charging time scales will be

discussed to show that why the turn on overshoot at longer wavelengths or turn off overshoot at shorter wavelengths is expected to see for electron irregularities amplitude or radar scattered power.

MLT - Equatorial Ionosphere or Thermosphere

MLT-EQIT-01 Coordinated observations of sporadic E layer using Chung-Li 30 MHz radar, ionosonde and FORMOSAT-3/COSMIC satellites - by Yen-Chieh Lin

Status of First Author: Student IN poster competition

Author: Yen-Chieh Lin

Abstract: A nighttime sporadic E (Es) layer that was responsible for range spread Es trace in ionogram and quasi-periodic echoes scattered from 5-m field-aligned electron density irregularities (FAIs) is investigated. A comparison shows a positive correlation between the 30 MHz radar backscatter and critical frequency foEs of the Es trace, which are consistent with earlier observational results. Interferometry measurement indicates that the spatial structures of the FAI echo patterns were in patchy form with vertical extent of about a few kilometers and horizontal dimensions of about 10-20 km. The echo structures experienced quasi-periodic oscillations not only in vertical but also in horizontal directions with periods within 5-6 minutes. Observed Doppler velocities of the FAIs also exhibit quasi-periodic oscillations with the same period. From their downward phase movement, these oscillations are very likely attributed to the modulations of upward propagating gravity waves with vertical wavelengths of about 10-20 km. In addition, vertical shears of the FAI Doppler velocity were observed, which are believed to result from the change in the phase of gravity wave with height. A physical process is proposed in this article to account for the relation between the gravity wave and FAI Doppler velocity. It is believed that the oscillations in the Doppler velocity are associated with the wave-induced polarization electric fields in a finite plasma structure in the azimuth direction.

MLT-EQIT-02 Examination of FORMOSAT-3/COSMIC-retrieved electron density in Ionospheric E Region - by Kang-Hung Wu

Status of First Author: Student IN poster competition PhD

Author: Kang-Hung Wu

Abstract: In this article, on the basis of globally distributed ionosonde measurements, we examine the morphology of the E region electron density retrieved by FORMOSAT-3/COSMIC satellites in accordance with radio occultation technique. The results show that the latitudinal and seasonal variations of the COSMIC-retrieved E region electron density in the region with geomagnetic latitude greater than +-35 degree are in good agreement with those of the ionosonde measurements, which are generally in accord with the predictions of the Chapman layer theory. However, the quasi-equatorial anomaly structures of COSMIC-retrieved E region electron density in geomagnetic latitude regions +-15-35 degree are absent in the ionosonde measurements, suggesting that they are very likely the result of retrieval error from the contamination of F region electron density structures in GPS radio occultation process. A comparison further indicates that the mean values of the COSMIC-retrieved E region peak electron density NmE are consistently larger than those of the ionosonde-measured NmE by a factor ranging from 10% to 200%, depending on season, local time and latitudinal zone. In addition, we also show in this article that the accuracy and uncertainty of the COSMIC-retrieved E region electron densities are significantly affected by the F region equatorial anomaly structure. However, the semi-annual variation in the COSMIC-retrieved NmE over geomagnetic equator seems to be a real phenomenon and not seriously affected by the F region electron density structure. After carefully removing photochemical component of the latitudinal variation in the monthly median NmE from the global ionosonde measurements, which is governed by the solar zenith angle and can be modeled by the Chapman layer theory, we find that the residual NmE tend to systematically enhance in geomagnetic latitude region 30N-30S. This feature seems to suggest that certain non-photochemical processes are responsible for the enhancement of the daytime E region electron density in low and equatorial latitude region.

MLT - Instruments or Techniques for Middle Atmospheric Observation

MLT-ITMA-01 The effect of ground reflection plane on the VHF radar beam pattern in the remote sensing of low and middle atmosphere - by Ching-Lun Su

Status of First Author: Non-student

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Abstract: Successful achievement has been made through the intensive observation and study of the precipitation by the Chung-Li VHF radar. The basic radar antenna system is an array configuration which is designed to perform the precipitation observation. It is found that the dielectric constant and conductivity of the ground reflection plane may significantly affect the antenna beam pattern, which is susceptible to precipitation on the ground. In this article, we calculate the theoretical antenna beam pattern in the precipitation environment. A method is developed to use vertical and oblique precipitation echo power profiles to calibrate the half power beam width. It is shown that the half power beam width of the vertical beam is 0.6 degree less then that of the tilted beam under precipitation condition. The mean precipitation echo power is 6.4 dB higher than that from ice particles. The error analyses of the terminal velocity of the rain drop and the wind velocity affected by the incorrect antenna beam pattern are also made and discussed in this report.

MLT-ITMA-02 GPS Receiver Bias Temperature Dependence and its Implications for the Murchison Widefield Array (MWA) - by Jennifer Williams

Status of First Author: Student IN poster competition

Authors: Jennifer Williams, A Coster, D Herne, P Erickson, A Weatherwax, D Oberoi, Keith Groves, C Carrano

Abstract: The Murchison Widefield Array (MWA) in Western Australia offers a tremendous new opportunity for ionospheric science. The MWA is a new low frequency array being built with funds from the US National Science Foundation (NSF), Air Force Office of Scientific Research (AFOSR), and other organizations to develop powerful new capabilities for radio astronomy and heliospheric science at frequencies from 80 to 300 MHz. Of particular interest to MWA applications are the propagation of TIDs over the MWA. Using observations collected from three specially designed GPS receivers at the MWA site which can measure L-band scintillation statistics, we will discuss multiple observations of TIDs over these arrays. These receivers were provided by Dr. Keith Groves (AFOSR) and have been intermittently operational at the site. GPS TEC data from these receivers, when combined with data from a large number of recently deployed GPS receivers on the Australian continent, will provide important contextual information about the regional distribution of TEC around the MWA site.

MLT-ITMA-03 Lower Hybrid Instabilities Associated with Artificially Created Dusty Plasmas in the near Earth Space Environment - by Maitrayee Ranade Bordikar

Status of First Author: Student IN poster competition

Authors: Maitrayee Bordikar and Wayne Scales, Bradley Department of Electrical and Computer Engineering, Virginia Tech, USA, maitrayee@vt.edu

Abstract: Abstract: A natural dust layer formed by tons of meteoric dust spans the altitude range between 80 and 100 kilometers of the earth's upper mesosphere and lower thermosphere. This dust layer forms Noctilucent Clouds NLCs. These dust layers are charged due to collection of electrons and ions from the earth's ionosphere. Polar Mesospheric Summer Echoes are radar echoes which result from scattering from the irregularities in the electron density above the NLC altitude. An alternate approach to understanding natural dust layers is to perform active space experiments in which a dust cloud is artificially created in a controlled manner in the upper atmosphere. The goal of Charged Aerosol Release Experiment (CARE) is to investigate similarity in plasma irregularity associated with natural and artificial dust layers. This poster will address some of the physical processes expected to be important during the early time and later time phase after creation of an artificial dust cloud in the earth's ionosphere. Of major importance will be the production of plasma

irregularities which may lead to radar echoes and the possibility of their relationship to PMSEs observed from natural dusty space plasmas.

The objective is to investigate early time evolution of shear driven lower hybrid instability due to growth of plasma instabilities driven by inhomogeneities in the boundary between the background plasma and the expanding charged dust layer and later time evolution of lower hybrid instability due to streaming charged cold dust particles. First, a two dimensional plasma simulation model will be described that may be used for examining early time and later time evolution after expansion of an artificial dust cloud across the magnetic field in the ionosphere. The model considers a three species system with fluid electrons and ions and Particle-In-Cell PIC charged dust grains in which the dust charge on the grains varies in time according to the standard charging model. The electrons are magnetized and the algorithm incorporates the parallel electron dynamics while the ions are assumed to be unmagnetized. Simulations runs were made to study shear driven and streaming lower hybrid instabilities with different inclination angle of magnetic field with respect to dust expansion direction.

MLT-ITMA-04 **Development and Initial Measurements of a Digital Receiver for Networked Meteor Radar Applications** - by Cody Vaudrin

Status of First Author: Student NOT in poster competition PhD

Authors: Cody Vaudrin and Scott Palo

Abstract: Defined by a minimal RF front-end followed by an analog-to-digital converter (ADC) controlled by a reconfigurable logic device (FPGA), the digital receiver will replace conventional heterodyning analog receivers currently in use by the COBRA meteor radar. A basic hardware overview touches on the major digital receiver components, theory of operation and data handling strategies. We address concerns within the community regarding the implementation of digital receivers in small-scale scientific radars, and outline the numerous benefits with a focus on reconfigurability. From a remote sensing viewpoint, having complete visibility into a band of the EM spectrum allows an experiment designer to focus on parameter estimation rather then hardware limitations. Finally, we show some basic multistatic receiver configurations enabled through GPS time synchronization.

MLT-ITMA-05 **Firefly: A CubeSat mission to study terrestrial gamma-ray flashes** - by Jeff Klenzing

Status of First Author: Non-student

Authors: JH Klenzing (1), DE Rowland (1) J Hill (2), AT Weatherwax (3), J Kujawski (3), P Uribe (1), S Kholdebarin (2), L Ramsey (2), R Carrol (3), J Williams (3), J DeMatteo (3)
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3: Department of Physics and Astronomy, Siena College, Loudonville, NY, USA

Abstract: Firefly is a small satellite mission to investigate the link between atmospheric lightning and terrestrial gamma-ray flashes scheduled to launch in April 2011. The instrumentation includes a Gamma-Ray Detector (GRD), VLF receiver, and photometer. GRD will measure the energy and arrival time of x-ray and gamma-ray photons, as well as the energetic electron flux by using a phoswitch-style layered scintillator. The current status of the instrumentation will be discussed, including laboratory tests and simulations of the GRD. Firefly is funded by the NSF, the second in a new series of scientific small satellites.

MLT-ITMA-06 **Modern phase-based ionosonde as a thermospheric neutral wind profiler** - by Nikolay Zabotin

Status of First Author: Non-student

Authors: N. Zabotin (University of Colorado at Boulder), S. Vadas (NWRA/CoRA)

Abstract: New 3-D plasma density inversion scheme for Dynasonde data, NeXtYZ, allows to reveal wave structures (TIDs) caused by gravity wave (GW) propagation. Both vertical and horizontal wavenumbers, as well as the amplitude and the frequency characterizing the GW packet, all as functions of the altitude, can be deduced. Based on these parameters, the background, horizontal neutral winds along the GW propagation direction can be calculated in the thermosphere using the GW dissipative theory. Application of this technique to Dynasonde data provides a possibility to monitor the background, horizontal neutral wind characteristics up to the F layer peak height.

MLT-ITMA-07 **Analysis of the Uncertainties in the PMC Parameter Retrieval from a CIPS Scattering Profile** - by Carstens Neal Justin

Status of First Author: Student IN poster competition PhD

Authors: Justin Carstens, Scott Bailey, Jerry Lumpe, Cora Randall

Abstract: The Cloud Imaging and Particle Size (CIPS) experiment on the Aeronomy of Ice in the Mesosphere (AIM) satellite is a nadir imager with an approximately 2000 km along track by 1000 km cross track field of view. CIPS observes at the UV wavelength of 265nm with a spatial resolution of 1km by 2km. One of the key goals for CIPS is to determine Polar Mesospheric Cloud (PMC) ice particle sizes. The scattering "profile" is the approximately 7 albedo measurements obtained by CIPS as AIM passes over each cloud parcel. These are each made at different viewing geometries and thus over a range of scattering angles.

The scattering profile is composed of a Rayleigh background signal and a PMC ice phase function signal. The Rayleigh albedo is controlled by the ozone column density above ~50km as well as the vertical ozone structure in this altitude region. The PMC particle size information is in the PMC phase function. In order to isolate the PMC phase function, we must remove the Rayleigh background albedo. Using an analysis where we decompose the signal into orthogonal components, we will attempt to quantify the degree to which this decomposition is unique. Additionally, we will address how several types of errors, systematic and random, propagate into errors in retrieved PMC parameters.
A key result is that a large component of the PMC signal can be described in terms of a Rayleigh-like background signal. The principal (but not only) difference between the PMC signals for differing particle sizes is the relative amount (or power) of this Rayleigh-like component in the PMC signal. This means that an error in the amount of Rayleigh background signal removed will translate almost directly into an error in retrieved particle size.

MLT-ITMA-08 **Doppler Rayleigh lidar for wind and temperature measurements in the middle atmosphere up to 80km** - by Gerd Baumgarten

Status of First Author: Non-student PhD

Authors: G. Baumgarten, J. Fiedler, J. Hildebrand

Abstract: The ALOMAR Rayleigh/Mie/Raman lidar (69° N, 16° E) was recently upgraded for measuring wind speed by direct detection of the Doppler shift in the middle atmosphere up to 80 km with 2 hours time resolution. The statistical uncertainty of the line of sight wind is about 1 m/s at 50 km and 10 m/s 80 km altitude. We use a Doppler Rayleigh Iodine Spectrometer (DoRIS) at the iodine line 1109 (~532.260 nm) whichs allows to detect a Doppler shift of dl/l=10E-8 by measuring a signal ratio with a precision of dS/S=1E-3. DoRIS uses two branches of intensity cascaded channels to cover the dynamic range of about 8 orders of magnitude from 10 to 100 km altitude.

The wind system was integrated in the system to extend existing multi-color observations of aerosol and temperature. The upper altitude limit is reached by using two lasers with a mean power of 14 W at 532 nm each and two 1.8 m diameter tiltable telescopes. Below about 50 km altitude the accuracy and time resolution is limited by the maximum count rate of the detectors used and not by the number photons available. We report about the first simultaneous Rayleigh temperature and wind measurements by lidar in the strato- and mesosphere on January 17 and January 23, 2009.

MLT - Long-Term Variations of the Upper Atmosphere

MLT-LTRV-01 Long term variations of atmospheric waves in the OH (6,2) and O2 (0,1) emission layers due to the solar cycle - by Ryan Matthew Agner

Status of First Author: Student IN poster competition

Authors: Ryan Agner agner583@hotmail.com

Abstract: This study investigates the long term variation of Atmospheric Wave amplitude and phases at the Mesopause and in the Upper Mesosphere, Lower Thermosphere (MLT) region due to the previous decline into solar minimum. The temperatures for the OH (6,2) and O2 (0,1) emission layers are derived using a CCD Spectrometer operating nightly in Adelaide, Australia (34°52'S 138°30'E) from January 2002 till April 2006. The OH (6,2) layer, located at 87 km, and the O2 (0,1) layer, located at 93 km, were chosen due to their relative brightness in the nighttime airglow and due to the fact that we are able to observe both bands simultaneously. Hourly averages of the temperatures are then analyzed to find periodicities and amplitudes of the waves using a Lomb-Scargle transform to derive the periodicities and a least squares fit to derive the amplitudes. Hourly averages are used so that only long term variations of the wave activity are analyzed. Some relevant results are then presented here.

MLT - Midlatitude Ionosphere or Thermosphere

MLT-MDIT-01 Midlatitude D region ionosphere remote sensing by broadband sferics - by Feng Han

Status of First Author: Student IN poster competition PhD

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Abstract: Broadband very low frequency (VLF) sensors located near Duke University have being operating with the aim of studying the variability of the midlatitude ionospheric D region. Significant temporal variability of the D region is well known, and we aim to study the time scales and possible sources of that variability in this work. We probe the D region ionosphere by measuring the high power, broadband signals launched by lightning (sferics) and that propagate in the Earth-Ionosphere Waveguide. We analyzed both nighttime and daytime sferics data of July and August, 2005 recorded by our sensors by comparing measured sferic spectra to model results and extracted the height of the two-parameter exponential electron density profile for each measurement. The measured nighttime D region electron density profile heights showed large variations on some nights and relatively stable behaviors on others. The spatial variability was also observed. Possible reasons accounting for the nighttime temporal variations are analyzed in the context of those measurements. The measured daytime profile height dependence on the solar zenith angle and solar flare X-ray flux is studied. And we also found the daytime spatial variability beyond the solar radiation.

MLT - Meteor Science other than Wind Observations

MLT-METR-01 Metero Head-echo Observations with PFISR Operated in Interferome Mode by Jonathan Sparks

Status of First Author: Student IN poster competition

Authors: *Joanthan J. Sparks 1,2; Diego Janches 2; Craig H. Heinselman ; Michael J. Nicolls 3
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3) SRI International, Menlo Park CA USA

Abstract: In the past decade meteor head-echo observations with High Power and Large Aperture (HPLA) radars have became crucial measurements for meteor science. These highly resolved, in time and space, detections provide invaluable information for the understanding of the origin and impact of small extraterrestrial particle flux into the upper atmosphere. One important limitation that many of the HPLA systems have is the inability to determine the traveling direction of the

particle while crosses the radar beam which would allow for the calculation of its absolute velocity. Radars designed as array configuration such as the 50 MHz Jicamarca Radio Observatory in Peru and the 46 MHz MU radar in Japan can be efficiently operated as interferometers by simultaneously receiving single meteor events with different sections of the array. This technique provides ideal data to address a number of issues that range from the astronomical origin because it allows for precise orbital determination to plasma, ablation and radar detection issues because it permits to model precisely the interaction of the meteor with the particular instrument. In this poster we present results from the first successful attempt to operate the Poker Flat Incoherent Scatter Radar (PFISR) in intrferometer mode. The observations discussed here were performed during a six hour period (07:00 to 13:PM AKLT) on the morning of July 9th , 2007. The observational setup included a 90 microseconds pulse transmitted vertically utilizing the full PFISR phase. The meteor detection was performed by using three receiving channels each connected to eight panels located in three of the four corners. This setup was intended to maximize the baseline distance between receivers. We discuss the methodology and present the initial results.

MLT-METR-02 Spatial and Numerical Mass Distributions of Meteoroids from Observations at the Jicamarca Radio Observatory - by Elizabeth Bass

Status of First Author: Student IN poster competition

Authors: Elizabeth Bass (enb@bu.edu), Meers Oppenheim, Jorge Chau

Abstract: High-power, large-aperture (HPLA) radars are used to provide accurate measurements of meteoroid trajectories and velocities. From these we can calculate their points of origin as well as estimate their masses. Chau et al. (2006) demonstrated that the points of origin of the sporadic meteor population detected using HPLA radars closely resembles that found by specular radars when examining meteors observed below 100 km but differs dramatically for those above 100 km. Here, we look at how the spatial distribution of meteoroids changes with meteoroid mass, using data comprised of 89,000 head echoes from the Jicamarca Radio Observatory (JRO). When looking at the smallest particles, the Apex sources dominate, and few meteoroids are seen from other sources. However, when examining the larger mass particles (mass of a μg or higher), six sources are clearly seen and the resulting map of meteoroid sources is similar to specular radar observations. We also use the JRO data to estimate the overall mass distribution. We see that the number of meteoroids vs. their masses follows a simple power law for meteoroids ranging from .01 to 1000 μg. The slope of this power-law is called the mass index. We compare mass indices for a number of JRO data sets and a range of mass estimation methods. We will also compare these results to previously published values derived from optical and radar data.

MLT-METR-03 Turbulent Effects in Specular Meteor Echoes - by Eli Hibit

Status of First Author: Student IN poster competition

Authors: Julio V. Urbina (jvu1@psu.edu) and Lars P. Dyrud

Abstract: We present results from a comparison between specular trail echoes modeled with a new numeric model designed to incorporate both radar geometry and atmospheric parameters. This is compared with observations from Fort Macon, North Carolina in 1999 and 2001 to determine the role which turbulence plays in the evolution of these plasma trails echoes.

MLT-METR-04 V/UHF Radar Meteors at Arecibo: The Usual Suspects plus some Bolides by Jonathan Ore

Status of First Author: Student IN poster competition Undergraduate

Authors: Jonathan Ore, Radar Space Sciences Lab, Penn State University, jpo149@psu.edu

Abstract: Radar meteors are observed at Arecibo Observatory using both the 430 MHz and at 46.8 MHz radars. These meteor events, viewed at RTI (Range-Time-Intensity) images, often exhibit very complex structure. This complex "head-echo" structure is consistent with multiple close-formation fragments that each produces a head-echo that interferes with the other head-echoes thus producing the complex echo structure. This interpretation is confirmed by viewing events at both radar frequencies and by noting that trail-echoes are often produced at VHF. We show a "zoo" of such results. Additionally, we show unusual events that we interpret as being "fossil" radar bolide (fireball) events.

MLT-METR-05 Estimation of the Orbital Parameters and Meteoroid Properties of Meteoroids Detected by the ALTAIR Radar System - by Steven Pifko

Status of First Author: Student IN poster competition PhD

Authors: Steven Pifko, spifko@stanford.edu and Sigrid Close, sigridc@stanford.edu
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Abstract: The Earth's atmosphere is constantly being bombarded by meteoroids. These small, "dust-sized" objects strike the atmosphere at high speeds (namely 30-60 km/s), where they ablate and form plasma between approximately 140 and 70 km altitude. Radar systems, such as the ARPA Long-Range Tracking and Instrumentation Radar (ALTAIR), can detect the plasma head echoes (the radar return from the plasma immediately surrounding and moving with the meteoroid). ALTAIR is particularly suited for precise measurements at long ranges and can be used to give the meteoroid's 3-D position and velocity, allowing for the calculation of the meteoroid's orbital parameters. Analysis of the orbital parameters provides information about the sources of meteoroids and the flux associated with these sources. This knowledge provides improved estimates of the meteoroid's composition and density, which are used to estimate mass and size.
Meteoroids are a prominent component of space weather that can influence the performance and reliability of space-based technological systems. Spacecraft designers and engineers must be aware of the potential threat to space missions due to meteoroid impacts. In addition to mechanical damage from an impact, the plasma associated with meteoroids can have significant effects on the communications and electrical systems of satellites. The determination of meteoroid properties, such as the orbital parameters and density, will lead to a better assessment of the risk associated with meteoroid impacts, and consequently, improved risk models and mitigation techniques during the spacecraft design and operations phases.

MLT-METR-06 Cognitive Radar Detection of Specular and Nonspecular Trails - by Siming Zhao

Status of First Author: Student IN poster competition Masters

Author: Siming Zhao

Abstract: Meteor data are continuously collected by radars operating year round. This fast growing large data set requires efficient and reliable detection routines. Current meteor echo detection routines are capable to pick up underdense meteor echoes but discard overdense and usually fail on nonspecular trail reflections. In this poster, a cognitive radar detection algorithm is proposed to not only detect but also correctly identify different types of meteor trail reflections. The whole detection process has two parts. The first part is based on the time-frequency detector developed by Kang and Palo. By choosing a low threshold, the detector can detect all types of radar echoes with a very high probability of detection at the cost of a high probability of false alarm as expected. Then several features were extracted from the detected signals and a support vector classifier was constructed using LibSVM to separate each type of meteor and non-meteor echoes. The whole detection program was tested over data collected from a 50MHz radar near Salinas Puerto Rico during the Coqui 2 campaign in 1998, with 265 detected signals labeled including strong and weak underdense, overdense, nonspecular, QP/TIL, and noises. The best classification rate achieved were above 85% for unseen data. Details about the implementation, features extracted, and data visualization are presented.

MLT-METR-07 Design and First Observations of the new meteor radar at Penn State - by Ryan Seal presented by Julio Urbina

Status of First Author: Student NOT in poster competition

Authors: J. Urbina and L. Dyrud

Abstract: Penn State has been developing advanced instruments and technologies for future meteor radars, with primary objectives of making such instruments more capable and more cost effective in order to study the basic properties of the global meteor flux, such as average mass, velocity, and chemical composition. Using low-cost field programmable gate arrays (FPGAs), combined with open source software tools, we describe a design methodology enabling one to develop state-of-the art radar instrumentation, by developing a generalized instrumentation core that can be customized using specialized output stage hardware. Furthermore, using object-oriented programming techniques and open-source tools, we

illustrate a technique to provide a cost-effective, generalized software framework to uniquely define an instrument's functionality through a customizable interface, implemented by the designer. The new instrument is intended to provide instantaneous profiles of atmospheric parameters and climatology on a daily basis throughout the year. The system uses a VHF coaxial-collinear antenna array, oriented perpendicular to the Earth's magnetic field lines. The instrument design concepts and some of the emerging technologies developed for this meteor radar will be discussed. We will also present first observational trends of specular, non-specular, and head-echoes collected with the new system.

MLT-METR-08 Meteoroid and Energetics Detection for Understanding Space Situational Awareness
by Nicolas Lee

Status of First Author: Student IN poster competition PhD

Authors: Nicolas Lee, Stanford University, nnlee@stanford.edu; Sigrid Close, Stanford University, sigridc@stanford.edu

Abstract: The Meteoroid and Energetics Detection for Understanding Space Situational Awareness (MEDUSSA) project proposes to fly a CubeSat in low-Earth orbit (LEO) to characterize electrical effects of meteoroid impact. The theory of plasma generation and electromagnetic pulse (EMP) formation is discussed, as well as an overview of the proposed sensor suite and spacecraft configuration.

MLT - Mesosphere and Lower Thermosphere Gravity Waves

MLT-MLTG-01 Gravity Wave Characteristics, Momentum Flux Observed by OH Imager at Maui and Cerro Pachon - by Zhenhua Li

Status of First Author: Student IN poster competition

Authors: Zhenhua Li,

Abstract: Gravity wave characteristics at Mesopause region are derived from UIUC OH Imager data collected at Maui (157 W, 21 N) from 2002 to 2007. Gravity wave momentum flux is also inferred using observed wave parameters with background wind measurement from UIUC Meteor Radar. The seasonal evolution of wave characteristics, momentum flux and its relationship with mean flow is analyzed.

From September 2009, UIUC OH Imager started observation at Cerro Pachon (71 W, 30 S). Wave characteristics from this site are derived and compared with those from Maui.

MLT-MLTG-02 Tidal modulation of gravity wave momentum fluxes in the mesosphere and lower thermosphere at Maui, Hawaii (20.7N, 156.3W) - by Xian Lu

Status of First Author: Student IN poster competition PhD

Authors: Zhenhua Li, Alan Z. Liu, Steven J. Franke, Gary R. Swenson

Abstract: Tidal modulation of gravity wave (GW) momentum fluxes in the mesosphere and lower thermosphere at Maui, Hawaii (20.7N, 156.3W) is studied using co-located OH imager and meteor radar. High-frequency GW momentum fluxes are obtained from the OH imager in the OH layer and tides are obtained from meteor radar. Tidal signatures are present in the high-frequency GW momentum fluxes for all seasons. The GW momentum direction is opposite to the tidal wind below the OH layer, suggesting a significant filtering effect of GWs by tides.

MLT-MLTG-03 The excitation of medium and large-scale secondary GWs from wave breaking near the mesopause and wave dissipation in the thermosphere using new compressible acoustic-gravity wave solutions - by Sharon Vadas

Status of First Author: Non-student

Author: Sharon Vadas

Abstract: In this poster, we describe our new f-plane, compressible acoustic and gravity wave solutions to horizontal body forcings that turn on and off smoothly over a finite interval in time. We then apply our solutions to 1) wave breaking near the mesopause, and 2) wave dissipation in the lower to mid thermosphere. We compare the compressible and Boussinesq gravity wave spectra, and find that these wave sources must include compressibility for those waves which can propagate deeply into the mid to high thermosphere. We also show typical solutions for both of these examples (in terms of density and horizontal velocity perturbations, etc).

MLT-MLTG-04 Four Channel Airglow Photometer for Gravity Wave Observation (ALO, Chile) by Tony Mangognia, presented by Gary Swenson

Status of First Author: Student NOT in poster competition

Authors: Tony Mangognia, Gary Swenson, Alan Liu

Abstract: The four channel airglow photometer provides phase information for waves passing through three airglow layers (OH, O2, Greenline). Data resulting from the four channel photometer for waves observed simultaneously in imaging instruments provides additional information, such as direction of propagation, magnitude, and vertical wavelength. Results obtained from data collected at the Andes LIDAR facility from observations of waves obtained with the four channel photometer in conjunction with imagers will be discussed as well as data processing and background removal.

MLT-MLTG-05 Investigating Short-Period Gravity Wave Characteristics Over Rothera, Antarctica (68°S) - by Thomas Martin

Status of First Author: Student IN poster competition Undergraduate

Authors: T. Martin, J.R. Pugmire, M.J. Taylor, K. Nielsen, P.-D. Pautet, M.J. Jarvis

Abstract: As part of a collaborative program between British Antarctic Survey and Utah State University, we present an intra-annual study of short-period, mesospheric gravity wave events observed over Antarctica in the near infrared OH emission. The measurements were made using an all-sky airglow imager operated at Rothera Station (68°S, 68°W), situated on the Antarctic Peninsular. A total of 5 years of austral winter seasons have been analyzed (2002-2009). Distributions of their observed wave parameters were found to be similar to previous findings using imaging instrumentation at other latitudes in the Northern and Southern Hemispheres. However, the observed wave headings exhibited strong anisotropy that was also found to be remarkably consistent from year to year, establishing a predominance for westward wave propagation over the Antarctic peninsula. In this poster we present data from each year summarizing the seasonal wave properties focusing on wave anisotropy and the strong year to year consistency.

MLT-MLTG-06 Observation of Gravity Waves at Ferraz Station (62°S, 58°W) with an OH Airglow Imager: Overview of the Results for 2007 - by Jose Valentin Bageston

Status of First Author: Non-student PhD

Authors: Bageston, J.V.; Wrasse, C.M.; Gobbi, D.; Hibbins, R.E.; Batista, P.P.; Takahashi, H.; Fechine, J.; Fritts, D.
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Abstract: An observational airglow campaign was conducted at Comandante Ferraz Antarctica Station, EACF (62°S, 58°W), between April and October 2007, using an all-sky imager, in order to investigate the gravity wave characteristics.

During the campaign, it was possible to identify 241 gravity wave events observed in 43 nights. The main characteristics of the gravity waves are presented as following: horizontal wavelengths between 10 and 65 km; observed periods, between 5 and 35 minutes and observed phase speeds ranging from 5 to 120 m/s. The vertical wavelength was also determined, varying between 5 and 25 km, the intrinsic period showed a small range between 5 and 15 minutes while the intrinsic phase speed was distributed between 25 and 75 m/s. Ray tracing technique was applied to the gravity wave parameters observed at EACF. The results showed that 78% of the waves had its origin at the mesosphere region, indicating in situ generation or a typical ducted wave behavior. In 15% of the waves the ray path stopped in the stratosphere. Only 7% of the waves were traced down to the troposphere. The most likely tropospheric sources were related to convective instability, eight wave events were associated with orographic source, one case was related to a cold front and one event was associated with a cyclonic activity. Three case studies of mesospheric fronts were also performed and the vertical propagation characteristics of the events were compatible with ducted wave propagation. The first event was classified as a mesospheric bore propagating in a dual duct (Doppler and thermal). This case study also showed the contribution of the semidiurnal and terdiurnal tidal components in the duct configuration. The last two fronts were classified mesospheric wall and were supported by a thermal duct.

MLT-MLTG-07 Simultaneous SOFDI and CASI observations of gravity waves over Oneida, NY
by Dhvanit Mehta

Status of First Author: Student IN poster competition Masters

Authors: D. Mehta, Center for Solar-Terrestrial Research, New Jersey Institute of Technology, 323 Martin Luther King Jr. Boulevard, 101 Tiernan Hall, Newark, NJ 07102-1982, USA. (dm36@njit.edu); A. J. Gerrard, Center for Solar-Terrestrial Research, New Jersey Institute of Technology, 323 Martin Luther King Jr. Boulevard, 101 Tiernan Hall, Newark, NJ 07102-1982, USA. (andrew.j.gerrard@njit.edu); J. W. Meriwether, Department of Physics and Astronomy, Clemson University, Kinard Laboratory, Clemson, SC 29634-1911, USA. (meriwej@ces.clemson.edu); M. Nicolls, SRI International, 333 Ravenswood Avenue, Menlo Park, CA 94025-3493, USA. (michael.nicolls@sri.com); M. Kelley, Cornell University, 318 Rhodes Hall, Ithaca, NY 14853, USA. (mikek@ece.cornell.edu); Y. Bhattacharya, Center for Solar-Terrestrial Research, New Jersey Institute of Technology, 323 Martin Luther King Jr. Boulevard, 101 Tiernan Hall, Newark, NJ 07102-1982, USA. (yajnaval@gmail.com)

Abstract: Gravity wave observations from mesopause OI 557.7-nm all-sky data from the Cornell All-Sky Imager [CASI] in March and July 2005 over upstate NY are presented. When the measured horizontal wavelengths and observed periods are combined with background wind and temperature measurements from the co-located Second-generation, Optimized, Fabry-Perot Doppler Imager [SOFDI] instrument, the intrinsic gravity wave parameters are ascertained. These waves are then reverse ray-traced using the NJIT FOREGRATS gravity wave forecasting model to lower altitudes where the tropospheric sources of these waves are determined. We find tropospheric convective systems to be a strong generator of monochromatic gravity waves and speculate that such fronts are the sources of mesospheric fronts, like mesospheric bores.

MLT-MLTG-08 First 6 Month Investigation of Gravity Waves and Temperature Variability Over the Andes - by Jonathan R. Pugmire

Status of First Author: Student IN poster competition Undergraduate

Authors: J.R. Pugmire, N.R. Criddle, M.J. Taylor, P.-D. Pautet, Y. Zhao

Abstract: The Andes region is an excellent natural laboratory for investigating gravity wave influences on the Upper Mesospheric and Lower Thermospheric (MLT) dynamics: during the summer months the dominant gravity waves result from deep convection arising from severe thunderstorms over the continent to the east. In winter this convective activity is expected to be replaced by strong orographic forcing due to intense prevailing zonal winds blowing eastward from the Pacific Ocean and suddenly encountering the towering Andes mountain range (6000m). This creates large amplitude mountain waves that have been measured well into the stratosphere and most recently penetration occasionally into the mesosphere (Smith et al., 2009). The instrument suite that comprised the very successful Maui-MALT program was recently re-located to a new Andes Lidar Observatory (ALO) located at Cerro Pachon, Chile (30.25°S, 70.74°W) to obtain in-depth seasonal measurements of MLT dynamics over the Andes mountains. As part of the instrument set the Utah State University CEDAR Mesospheric Temperature Mapper (MTM) has operated continuously since August 2009 measuring the near infrared OH(6,2) band and the O2(0,1) Atmospheric band intensity and temperature perturbations. This poster focuses

on an analysis of nightly OH temperatures and the observed variability, as well as selected gravity wave events illustrating the high wave activity and its diversity.

MLT-MLTG-09 Influence of an Inertia-Gravity Wave on Mesospheric Dynamics: A Case Study with the Poker Flat Incoherent Scatter Radar - by Michael Nicolls

Status of First Author: Non-student

Authors: M. J. Nicolls, R. H. Varney, S. L. Vadas, P. A. Stamus, C. J. Heinselman, R. B. Cosgrove, and M. C. Kelley

Abstract: A case study of mesospheric winds and waves observed by the Poker Flat Incoherent Scatter Radar (PFISR) on 23 April 2008 is presented. Active auroral precipitation created sufficient ionization for nearly 12 hours of continuous incoherent scatter measurements of the D-region ionosphere from ~60-90 km altitude.

PFISR utilized a multi-look-direction mode which permitted measurements of vector winds, in addition to high precision vertical velocities, at high temporal resolution. A large-amplitude coherent wave packet (appearing superficially to be a single wave) with a downward phase velocity and a long period (tau~10.5 hours) was observed. Vertical wavelengths were measured directly to be lz~4-10 km, increasing with altitude. The proximity of tau to the local inertial period in addition to its large horizontal wavelength are suggestive of a coherent inertia-gravity wave (IGW) packet. Using polarization analyses, we find that the IGWs are propagating mainly southward. The waves were observed to saturate at z~70-85 km, and have their largest amplitudes in the first 8 hours of the measurements (before 20 UT). A stability analysis confirms that the waves were likely dynamically unstable at these altitudes and times. In conjunction with this observation, the background wind is found to be southward of HWM winds by 10-20 m/s until ~20 UT, consistent with the horizontal background wind acceleration created by the saturation of these IGWs. After 20 UT, the background wind relaxes to the north by 10-20 m/s, consistent with a significant decrease of the IGW amplitudes. The IGWs may have originated from a jet stream adjustment at z~10 km in northern Russia about 5 days prior to the observation in Alaska.

MLT-MLTG-10 Gravity Wave Propagation and Momentum Flux in the Mesopause Region by Deepak B. Simkhada

Status of First Author: Student IN poster competition PhD

Authors: Deepak B. Simkhada, dbsimkhada@aggiemail.usu.edu, Michael J. Taylor, mike.taylor@usu.edu, Center for Atmospheric and Space Sciences, Utah State University; Steven J. Franke, Department of Electrical and Computer Engineering, University of Illinois at Urbana-Champaign

Abstract: Airglow imaging observations using Utah State University Mesospheric Temperature Mapper (MTM) have been analyzed to investigate short-period gravity waves and their propagation characteristics in the low-latitude mesopause region from Maui, Hawaii (20.70 N, 156.30 W). A total of the 168 gravity wave events were recorded during 2004 period, exhibiting typical horizontal wavelengths of ~15-40 km, apparent phase speeds of ~30-65 m/s, and apparent periods of ~6-16 min. Gravity waves identified in the OH and O2 airglow emissions were propagating preferentially towards the northeast during the summer months. In contrast, during the winter months the preferential propagation direction was bimodal in form, with well-defined central wave azimuths towards the southwest and the northwest. Here we present the examples of momentum fluxes carried by vertically propagating waves. Utilizing measurements of the local background wind field provided by the collocated University of Illinois meteor radar, the ground-relative and intrinsic wave parameters and hence the propagation nature of the waves were derived.

MLT-MLTG-11 Gravity Wave Variations and Sources in Arctic during the 2009 SSW by Chihoko Yamashita

Status of First Author: Student IN poster competition PhD

Authors: Chihoko Yamashita (University of Colorado at Boulder/NCAR), Han-Li Liu (NCAR), and Xinzhao Chu (University of Colorado at Boulder/CIRES)

Abstract: Gravity wave is one of the key elements that affects the atmospheric variability and determines the circulation pattern of the middle and upper atmosphere. However, the gravity wave source distributions and their variations are not fully understood due to observational and modeling difficulty in tracing gravity waves from source to impact region. Recent ECMWF T799 simulation results with horizontal resolutions of ~25km have the potential of resolving gravity waves down to the mesoscale. In this study, we first validate these resolved gravity waves in ECMWF T799 by comparing them to lidar and COSMIC/GPS observations. The seasonal variations of gravity waves in ECMWF T799 show good agreements with lidar observations, and the short-term variations (daily) variations are comparable with COSMIC/GPS observation. We then investigate gravity wave variations as related to the rapid change of the wind during the 2009 Stratospheric Sudden Warming from the troposphere to the upper stratosphere. The causes of these gravity wave variations related to wave propagation and sources will be addressed.

MLT-MLTG-12 Airglow signatures of stationary gravity waves - by Jonathan Snively

Status of First Author: Non-student PhD

Authors: Jonathan B. Snively (Utah State University, Center for Atmospheric and Space Sciences, jonathan.snively@usu.edu); Michael J. Taylor (Utah State University, Center for Atmospheric and Space Sciences, mike.taylor@usu.edu)

Abstract: Recent airglow image measurements have captured apparently stationary gravity wave structures in the mesosphere, with horizontal scales of 36 km [Smith et al., 2009, GRL, 36, L08807], exhibiting minimal progression of phase during the nights of observation. Due to the close proximity of the Andes mountain range, and strong flow observed in the troposphere, it was concluded that the waves were most likely orographically forced. Although mountain waves are likely to reach the mesosphere only under certain conditions, model wind data [Hedin et al., 1991, JGR, 96, 7657-7688] combined with radiosonde data [Smith et al., 2009] suggest that wind flow was sufficient to facilitate upward propagation. Here we examine idealized cases of stationary wave generation and upward propagation using a two-dimensional nonlinear dynamics model, coupled with airglow photochemistry models. Airglow signatures associated with stationary waves are investigated. Results reveal significant dependence on vertical wavelength in the airglow layer region, and thus strong dependence on variable background winds. Amplitudes of emission intensity perturbations are strongly dependent on these ambient conditions, particularly where critical levels may confine the altitude of propagation, and where evolving tidal structure is present. Implications for future MLT-region observational studies are discussed, such as those at the new atmospheric observatory at Cerro Pachon, Chile.

MLT-MLTG-13 Numerical modeling of lower stratospheric Doppler ducted gravity waves within stationary gravity wave wind fields over Jicamarca, Peru - by Zhaozhao Li

Status of First Author: Student NOT in poster competition

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Abstract: The appearance of stationary gravity waves are seen in Jicamarca MST wind data of the troposphere and lower stratosphere in February 1999. On one of the days, signatures of a Doppler ducted gravity wave in the lower stratosphere were observed. Herein we present numerical simulations of such Doppler ducting utilizing the stationary wind fields observed over Jicamarca. We find a close replication of the observed ducted structure in the numerical model. Such observations allow for study of Doppler ducts at high spatial and temporal resolution that can be applied to studies of mesospheric ducts and, potentially, bores.

MLT-MLTG-14 Observations of high-frequency mesospheric gravity waves using the Super Dual Auroral Radar Network - by Elizabeth Ann McCubbin

Status of First Author: Student IN poster competition Undergraduate

Authors: Elizabeth McCubbin, Elizabeth.McCubbin@jhuapl.edu; Elsayed Talaat, Elsayed.Talaat@jhuapl.edu,
The Johns Hopkins University Applied Physics Laboratory

Abstract: The Super Dual Auroral Radar Network (SuperDARN), originally conceived to measure ionosphere convection, is also detecting backscattering from meteor trails in the mesosphere. Records of these trails have been used to characterize mesospheric winds at higher latitudes. Previous studies have examined hourly fitted meteor wind data for planetary waves and tides. Recently we have produced high-time resolution fits for both the meridional and zonal winds (down to 6-minute intervals). Using this new dataset we present analysis of high frequency waves from multiple SuperDARN sites.

MLT-MLTG-15 Characteristics of gravity waves and plasma bubbles observed during the COPEX campaign - by Igo Paulino

Status of First Author: Student NOT in poster competition PhD

Authors: I. Paulino; H. Takahashi; A.F. Medeiros; C.M. Wrasse; R.A. Buriti; D. Gobbi

Abstract: Using an all sky airglow imager, gravity waves and plasma bubbles were observed at Boa Vista (2.80°N; 60.70°W, dip angle 21.70°N) from October to December 2002 during the Conjugated Point Experiment (COPEX) campaign. A Keogram methodology was used to estimate some wave parameters of 18 medium-scale gravity waves observed in the mesospheric OHNIR images. The results (horizontal wavelengths, periods, and phase speed) were similar to the previous observations carried out in Brazilian sites. With respect to direction of propagation, the waves presented an anisotropy to Northeast, i.e. their main sources were likely in Southwest of Boa Vista. Eight plasma bubbles were observed from the OI630 nm images and the distances between the depletions had a strong linear relationship with the wavelengths of gravity waves observed in the mesosphere, which suggests a direct contribution of the mesospheric medium-scale gravity waves in seeding the equatorial plasma bubbles.

MLT - Mesosphere and Lower Thermosphere Lidar Studies

MLT-MLTL-01 Progress in MRI Fe-Resonance/Rayleigh/Mie Doppler Lidar - by Xinzhao Chu

Status of First Author: Non-student

Authors: Xinzhao Chu, Wentao Huang, Jeffrey P. Thayer, Zhangjun Wang, and John A. Smith
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Abstract: Ambitiously aiming to achieve bias-free resonance Doppler lidar for advancing the middle and upper atmosphere physics and chemistry, we started the development of a Major Research Instrumentation (MRI) mobile Fe-resonance/Rayleigh/Mie Doppler lidar about two years ago at the University of Colorado at Boulder. We report the significant progress made in the last two years, especially on the revolutionary ideas of pulsed alexandrite ring laser, Fe Doppler-free spectroscopy, and optical heterodyne detection for accurate frequency control and spectral analysis of the lidar pulse. Substantial efforts have also been spent to construct large-aperture receiver, state-of-the-art data acquisition and control system, and mobile lidar laboratory. We introduce the overall lidar architecture and some initial results to inspire future lidar advancement and atmospheric science endeavor worldwide.

MLT-MLTL-02 Development of STAR LiDAR in Boulder - by Ian Dahlke

Status of First Author: Student IN poster competition Masters

Authors: Ian Dahlke, Weichun Fong, Brendan Roberts, John Smith, Wentao Huang, Zhibin Yu, Xinzhao Chu, Zhangjun Wang

Abstract: Student Atmospheric Resonance (STAR) LiDAR, a narrow-band Na resonance fluorescence Doppler LiDAR, is being constructed and deployed to the Table Mountain LiDAR observatory. There are two main goals of the LiDAR system: One is to study the temperature and wind structure of the mesosphere and lower thermosphere region near Boulder. The other is to become the base of LiDAR education in Boulder, providing students with hands-on experience constructing and operating the system. We will be presenting the system design along with initial sodium density and temperature data.

MLT-MLTL-03 Feasibility analysis of a novel system for automatic beam alignment and spatial mode analysis in atmospheric Rayleigh and resonance Doppler LIDARs - by John A. Smith

Status of First Author: Student IN poster competition Masters

Authors: John Smith, Xinzhao Chu, Jonathan Friedman

Abstract: The feasibility of a dither-type transmitter-receiver beam alignment and optimization system is investigated. Hardware and theoretical descriptions of the system and algorithm are presented. A signal-to-noise ratio of 5.87*t^1/2 is estimated for the Arecibo potassium lidar assuming 10% loss of signal due to dither action.

MLT-MLTL-04 The Development of Na-DEMOF Doppler Lidar Technique: A New Step towards "Whole" Atmosphere Lidar - by Wentao Huang

Status of First Author: Non-student

Authors: Wentao Huang, W. Fong, Z. Wang, B. Roberts, B. Tan, C. Yamashita and X. Chu; University of Colorado at Boulder, Boulder, CO 80309; E-mail: Wentao.Huang@Colorado.edu, *Xinzhao.Chu@Colorado.edu; T. Yuan, S. D. Harrell, and C.-Y. She, Colorado State University, Fort Collins, CO 80523; B. P. Williams,
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Abstract: Our efforts on developing new lidar techniques have successfully demonstrated a noval Doppler lidar technique for simultaneous profiling of wind and temperature from near ground to stratosphere. It is based on the idea of implementing a sodium (Na) double-edge magneto-optical filter (Na-DEMOF) into the receiver of a 3-frequency Na Doppler lidar. We have finished multiple field tests in collaborating with the lidar group at Colorado Sate University. Reliable wind and temperature measurements from 10 to 45 km have been obtained with the prototype. We also achieved continuous measurements covering several whole nights using the second generation of Na-DEMOF, new optical setup, and improved experimental procedure with new data retrieval algorithm. In combination with the wind and temperature measurements in the mesopause region enabled by the classical Na Doppler lidar, we expect to measure wind and temperature covering near ground to 50 km and from 80-105 km with a practical Na lidar setup using this new technique. It is an important step towards achieving a "whole" atmosphere lidar by upgrading powerful existing lidar with novel receivers, which provide unique measurements of scientific significant. We have proposed on full development of this technique, and conduct field campaigns at several Na lidar sites. With additional measurements generally available at these sites from the Radiosonde, Rocket, Imagers, and/or Radars, new information will be gathered to characterize, trace and model some of the gravity waves from the lower altitude sources region all the way to the upper atmosphere. This will enhance infrastructure for research by complementing the existing major research instruments, and provide new insights with unique measurements.

MLT-MLTL-05 Fe Boltzmann and Rayleigh temperature lidar for McMurdo campaign: refurbishment, upgrade and initial results at Boulder - by Zhangjun Wang

Status of First Author: Student IN poster competition PhD

Authors: Zhangjun Wang1,2, Wentao Huang1, Weichun Fong1, John Smith1, Zhibin Yu1, Brendan Roberts1, Bo Tan1, and Xinzhao Chu1
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Abstract: Aiming to study atmospheric gravity waves, thermal structure, chemistry and composition, we plan to deploy an Fe Boltzmann temperature lidar to McMurdo (78^0S, 167^0E), Antarctica to make year-round measurements of atmospheric temperature and mesospheric Fe density with full-diurnal coverage for 3 years starting from Nov. 2010. The Fe Boltzmann temperature lidar was originally developed at the University of Illionis and now it is being refurbished and upgraded to restore and enhance its specifications. These include the refurbishment of two linear pulsed alexandrite lasers and two receiver channels. The electronic and cooling system of the pulse alexandrite laser have been restored and refurbished. The original seed lasers were replaced with two new External Cavity Diode Lasers (ECDLs) from Toptica to improve the stability and spectral purity of the alexandrite lasers. Newly developed DAQ and seed laser locking program based on LabVIEW makes the temperature lidar much user friendly. This lidar can measure atmospheric temperature profiles (30-110 km) and mesospheric Fe layers (75-115 km) coverage for both day and night. Initial results from the Table Mountain Lidar Observatory in Boulder will be presented.

MLT-MLTL-06 A new Lidar facility in the subtropics at 35° South, Buckland Park, Australia by Jens Lautenbach

Status of First Author: Non-student

Authors: J. Lautenbach, I. M. Reid, D. J. Ottaway, A. D. MacKinnon, D. J. Hosken

Abstract: Investigating the middle atmosphere by lidar is a well established experimental method and utilised at many sites around the world. However, these sites are predominately in the northern hemisphere and there are very few lidar stations in the southern hemisphere. The southern subtropics is in particularly important as there is significant demand for measurement with high spatial and temporal resolution.

This poster reports the ongoing development of the lidar facility at Buckland Park (35°S, 138°E), the second in the world at this latitude and the first in Australia. Within The University of Adelaide, the Atmospheric Physics Group, in collaboration with the Optics and Photonics Group, is setting up a facility to host three lidar systems. The aim of this facility is to measure atmospheric temperature and dynamical processes with high spatial and temporal resolution from 15 to 110 km altitude. The current work focuses on the development of a Rayleigh/Mie/Raman (RMR) backscatter lidar for measurements in the altitude range from 15 to 80 km. The derived temperature profiles will be used to study dynamical processes and to establish a climatology at this unique latitude.

The BP lidar facility completes the Buckland Park site as a unique atmospheric research location as a number of co-location radars and passive optical instruments are in operation since decades. The co-located Stratospheric-Tropospheric (ST) and Medium-Frequency (MF) radars can measure winds and dynamical processes up to 20 km and upwards of 60 km, respectively. The lidar will close this observational gap between 20 and 60 km and provide various parameters for the investigation of dynamical processes. The scientific outcomes of this project will greatly enhance our understanding of the middle atmosphere and will contribute to the evaluation of meteorological satellites and models in this southern subtropical region.

MLT - Mesosphere or Lower Thermosphere General Studies

MLT-MLTS-01 Seasonal Variations of the Mesospheric Temperature Estimated from the VHF Meteor Radar Observation at King Sejong Station (62.2°S, 58.8°W), Antarctica
by Jeong-Han Kim

Status of First Author: Non-student

Authors: Jeong-Han Kim, Yong Ha Kim, Chang-Sup Lee, Geonhwa Jee; jhkim@kopri.re.kr

Abstract: A VHF meteor radar and Spectral Airglow Temperature Imager (SATI) have been operated at King Sejong Station (62.2°S, 58.8°W), Antarctica, to study the characteristics of the mesosphere in the southern high latitude region since March 2007 and February 2002, respectively. We estimated the mesospheric temperatures from the observations of meteor decay time by using Hocking (1999)'s method, which requires the slope of logarithmic inverse meteor decay time vs. height and the temperature gradient at meteor peak altitude, during March 2007 through July 2009 and compared the estimated temperatures with the SATI measurements. The temperature estimated from the observed meteor decay times seems to be consistent with the SATI rotational temperatures obtained from OH(6-2) and O2(0-1) emission lines during March through October in 2007. The annual variation of the mesospheric temperatures with a minimum in southern summer is in good agreement with observations at other locations. The mean temperature during summer was colder than the CIRA86 model values by about 30 K, which is similar to the results of Lübken et al. (1999). We also discussed the relationship between the estimated temperature and the meridional component of neutral winds obtained from the same meteor radar.

MLT-MLTS-02 The Turbopause Experiment: Observations of turbulence structure in sounding rocket chemical tracer trails associated with high-shear regions - by Tyler Scott

Status of First Author: Student IN poster competition PhD

Authors: G. Lehmacher and M. F. Larsen

Abstract: Although a number of ground-based and in situ techniques have been applied to the observation of turbulence in the mesosphere and lower thermosphere, one of the most direct is the observation of the structure in neutral chemical tracer trails. The Turbopause Experiment was carried out in February 2009 at the Poker Flat Research Range in Alaska to study turbulent structure in the neutral atmosphere across the turbopause transition. The measurements included a variety of in situ and ground-based measurements during an event characterized by strong gravity wave activity and large vertical shears in the horizontal winds. A total of four rockets were launched over a period of approximately two hours, providing a unique time history of the variations in turbulent diffusion as the event evolved. This poster focuses specifically on the chemical tracer measurements and the interpretation of the turbulent structure that is evident in the trail images, as it relates to the wind profiles obtained from the trails by triangulation.

MLT-MLTS-03 Observations of Nitric Oxide by the Remote Atmospheric Ionospheric Detection System (RAIDS) - by Ying-tsen Lin

Status of First Author: Student NOT in poster competition

Authors: Lin, S M Bailey, J Yonker, K Minschwaner, S Budzien, A Stephan, R K Bishop, J H Hecht, P R Straus, A B Christensen, Rebecca

Abstract: Nitric oxide (NO) is a minor constituent of the lower thermosphere which plays numerous key roles there. Its production is very sensitive to those energy sources able to break the strong molecular nitrogen bond; thus NO concentrations are indicative of energy deposition. Cooling through infrared NO emission is a crucial part of the thermospheric energy balance. NO is also the terminal ion in the E-region of the ionosphere. If NO is transported to lower altitudes, it is a catalytic destroyer of ozone.

The Remote Atmospheric and Ionospheric Detection System (RAIDS) is a suite of limb viewing radiance monitors observing the lower thermosphere at wavelengths from the EUV through the NIR. An inverse technique is applied to radiance profiles near 237 nm measurements so that the vertical profile of NO density can be determined. One of the key advantages of RAIDS NO observations compared to previous experiments is that RAIDS is attached to the International Space Station and thus not in a sun-synchronous orbit. RAIDS has been making observations of NO concentrations across all sunlit local times.

To validate the RAIDS NO observations, we present comparisons of with pervious NO measurements from SNOE and HALOE. We will also show our first results regarding local time variation of NO.

MLT-MLTS-04 IRI Storm-time correction using TIMED/SABER NO+(v) VER and its comparisons with ISR at E-region altitudes - by Jose R. Fernandez

Status of First Author: Non-student PhD

Authors: J.R. Fernandez , C. J. Mertens, D. Bilitza, X. Xu, J. M. Russell III, M. G. Mlynczak

Abstract: The arrival of new products derived from the TIMED/SABER radiance measurements have provide new insights on ionosphere studies. In particular, the capability of NO(+) Volume Emission Rate (VER) to be used as a proxy to monitor electron densities during magnetic storm nighttime periods at E-region altitudes has been demonstrated by comparisons of Incoherent Scatter Radar (ISR) measurements. Subsequently, NO(+) VER has been used in the correction of the International Reference Ionosphere (IRI) for the storm disturbed ionospheric E-region during nighttime. In this work, we present results of such applications and discuss the underestimation of IRI compared to ISR data during storm and quiet conditions.

MLT-MLTS-05 Synchronized Imagery of Noctilucent Clouds at the Day-Night Terminator using Airborne and Spaceborne Platforms - by Jason David Reimuller

Status of First Author: Student IN poster competition Masters

Authors: Reimuller, J.D1;Thayer, J.P1; Baumgarten, G3.;Chandran, A,1,2; Hulley, B4; Rusch, D.2; Nielsen K.5; Lumpe, J.5
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Abstract: A synchronized observation of a noctilucent cloud (NLC) using an airborne camera and a polar mesospheric cloud (PMC) using spaceborne cameras was obtained on 6 July 2009. Two Canon EOS-30D cameras were integrated to a Mooney M20K research aircraft and flown to a location of 58.32ON, 112.30OW in Northern Alberta, Canada to coordinate with the overpass of the Aeronomy of Ice in the Mesosphere (AIM) satellite at 06:48 GMT. The aircraft was positioned so that imagery would be taken while the sun was at a solar depression angle (SDA) of 8.5 degrees and then oriented so that the imager would be pointed along the AIM groundtrack. The common-volume imagery obtained from both the Cloud Imaging and Particle Size (CIPS) experiment and the aircraft at the time of the AIM overpass concurrently detected clouds identified by congruent band structures. The imagery from the aircraft also shows definite billow structures, implying that the greater spatial resolution achievable in airborne imagery was able to discriminate the finer structures of the billows smaller than the resolution of CIPS. Subsequent analysis of the CIPS imagery from the AIM satellite at this location shows a correlation in orientation of the prominent structures in both sets of imagery, showing overlay of prominent features and coincidence of band orientation.

MLT-MLTS-06 Observations of Lower Thermospheric Nitric Oxide from SOFIE and HALOE and Comparision of their response to the Current and Previous Solar Minimum
by Padma L. Thirukoveluri

Status of First Author: Student NOT in poster competition PhD

Authors: Padma Thirukovelori(a), Scott M. Bailey(a), Larry L. Gordley(b), Mark E. Hervig(b), James M. Russell(c)
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Abstract: Nitric oxide (NO) is a key minor constituent in the lower thermosphere. Of particular importance is its role in the energy balance in that altitude region. NO is produced through the reaction of excited atomic nitrogen with molecular oxygen. Thus its production is very sensitive to those energy sources able to break the strong molecular nitrogen bond. These include solar soft X-rays and precipitating energetic particles. Nitric oxide emits efficiently in the infrared and is an important cooling mechanism in the lower thermosphere. The abundance of NO is thus both a direct response to recent energy deposition as well as a key mechanism by which the upper atmosphere releases that energy.
The current extended solar minimum is an interesting case study for NO and its role in the upper atmosphere. Reduction in energy deposition to the thermosphere leads to cooler temperatures. But the production of NO is also reduced and thus the cooling efficiency of the atmosphere is reduced as well. Thus NO may in some way controls the minimum temperatures reached. For this reason, understanding the response of NO to this unique extended solar minimum is of significant importance.

The Solar Occultation for Ice Experiment (SOFIE) instrument was launched on-board the Aeronomy of Ice in the Mesosphere (AIM) satellite on April 25, 2007. It is currently in its third year of operation. SOFIE is a 16 channel differential absorption radiometer using the solar occultation technique to measure ice and environmental properties at a range of altitudes, and in particular the mesopause region. One of the constituents measured by SOFIE is NO in the mesosphere and lower thermosphere to about 130 km. The AIM orbit and the solar occultation technique confine observations to latitudes of 65 to 85 degrees in each hemisphere and varying with season. In this talk we overview the SOFIE and HALOE observations of NO in the southern hemisphere lower thermosphere and provide a preliminary description of its behavior during this curious extended solar minimum. The comparison of SOFIE and HALOE during the current and previous solar minimum will also help us to understand the response of lower thermospheric NO to the solar minimum.

MLT-MLTS-07 A Study of Polar Mesospheric Cloud Structures (Ice Voids) as seen by the AIM satellite - by Brentha Thurairajah

Status of First Author: Non-student

Authors: Brentha Thurairajah, Scott M Bailey, David E Siskind, Cora E Randall, , Justin N Carstens, Jerry D Lumpe, Kim Nielson, Michael J. Taylor, James M Russell III

Abstract: The Cloud Imaging and Particle Size (CIPS) experiment on the Aeronomy of Ice in the Mesosphere (AIM) spacecraft images Polar Mesospheric Clouds (PMCs) using four cameras operating with a 15 nm passband centered at 265 nm. A curious and interesting feature observed by CIPS is PMC ice voids - cloud free circular regions that are sometimes surrounded by rings of bright clouds, and are structurally similar to features observed in tropospheric clouds. In this poster we report the occurrence frequency and latitude/longitudinal variability of these ice voids and investigate the meteorological conditions which may support their formation.

MLT - Mesosphere and Lower Thermosphere Other Tidal or Planetary Waves

MLT-MLTT-01 On the sensitivity of infrasonic signals to the atmospheric tides - by Jelle Daniel Assink

Status of First Author: Student IN poster competition PhD

Authors: J.D. Assink 1), R. Waxler 1), D. Drob 2)
1) National Center for Physical Acoustics, University of Mississippi, MS, USA
2) Naval Research Laboratory, Washington, DC, USA

Abstract: Initial analysis of long term monitoring of infrasonic signals from the Tungurahua volcano in Ecuador will be reported. Tungurahua is monitored by two infrasound arrays, one, RIOE, is 37 km south of the volcano, another, LITE, is 250 km north of the volcano. Tungurahua goes through long periods during which it emits high amplitude impulsive infrasound signals. By comparing the signals received at RIOE with those received at LITE the travel times of the various arrivals can be determined. It is found that the travel times of the thermospheric arrivals have strong but systematic variability with periods equal to those of the tidal harmonics. It is hoped that this will eventually develop into a tool for remote monitoring of the tides and serve to improve and constrain the tidal models.

MLT-MLTT-02 Comparative study of migrating diurnal tidal variability induced by nonlinear interaction with propagating planetary waves - by Loren C. Chang

Status of First Author: Student IN poster competition PhD

Authors: Loren C. Chang, Scott E. Palo, Department of Aerospace Engineering Sciences, University of Colorado; Han-Li Liu, High Altitude Observatory, National Center for Atmospheric Research

Abstract: The migrating diurnal tide is one of the dominant dynamical features in the low latitudes of the Earth's Mesosphere and Lower Thermosphere (MLT) region, representing the atmospheric response to the largest component of solar forcing, propagating upwards from excitation regions in the lower atmosphere. Ground-based observations of the tide have resolved short term variations attributed to nonlinear interactions between the tide and planetary waves also in the region. However, the conditions, effects, and mechanisms of a planetary wave - tidal interaction are still unclear. Using the NCAR Thermosphere Ionosphere Mesosphere Electrodynamics General Circulation Model (TIME-GCM), we simulate a quasi-two day wave (QTDW) event, known to attain large amplitudes in the post solstice periods. In this case, sideband sum and difference child waves are resolved, indicating that a nonlinear interaction is occurring between the QTDW and the tide. The migrating diurnal tide displays a general amplitude decrease of 20 - 40%, as well as a shortening of vertical wavelength by roughly 4 km.

Examining the physical mechanisms driving the interaction, nonlinear advection is found to result in energy transfer to and from the tide, manifesting as tidal damping in the tropics. Additionally, the QTDW also produces significant changes to the mean zonal winds in the equator and at summer mid to high latitudes that can also account for changes in tidal amplitude and vertical wavelength. Comparing the QTDW case study to the case of an Ultra Fast Kelvin (UFK) wave, we conclude that the QTDW produces much greater tidal variability due to its broader horizontal and vertical structure compared to the UFK wave, resulting in greater nonlinear advection, and broader background wind changes. We also find that planetary wave induced background atmosphere changes can drive tidal variability at levels equal to or greater than nonlinear advection - a possibility not previously considered.

MLT-MLTT-03 Aura MLS observations of the 16-day planetary wave in the middle atmosphere – climatology and cross-equatorial propagation - by Kerry Day

Status of First Author: Student IN poster competition PhD

Authors: K. A. Day, R. Hibbins, N. J. Mitchell

Abstract: The microwave limb sounder (MLS) on the Aura satellite has been used to measure temperatures in the stratosphere and mesosphere, from July 2004 – December 2009, at latitudes from 75S to 75N. The temperature data reveal

the presence of the 16-day planetary wave. The wave maximizes in winter in the mesosphere and lower thermosphere at middle to high latitudes, where amplitudes can be as large as 4 K. Significant wave activity is also observed in the stratosphere. A strong seasonal variability is observed, with largest amplitudes being reached in winter and early spring. However, wave activity is observed in the mesosphere throughout the year. This summer-time wave activity in the mesosphere cannot be the result from the wave propagating from below (Charney and Drazin theorem). This wave activity must therefore arise from either i) in situ excitation by modulated gravity wave fluxes, or ii) ducting of the wave across the equator from the winter hemisphere. Further, recent work has suggested that the Quasi-Biennial Oscillation (QBO) can modulate the ducting of the wave. Here we examine the summer-time wave activity and QBO phase to investigate the possible role of the QBO in controlling the 16-day wave in the summer mesosphere.

MLT-MLTT-04 Seasonal-latitudinal Variation of the Eastward-Propagating Diurnal Tide with Wavenumber 3 in the MLT Region - by Xiaoli Zhang

Status of First Author: Student IN poster competition PhD

Authors: Xiaoli Zhang and Jeffrey M. Forbes, Department of Aerospace Engineering Sciences, University of Colorado, Boulder, CO, USA and Maura E. Hagan, High Altitude Observatory, NCAR, Boulder, CO

Abstract: This study demonstrates how the zonal mean zonal wind affects the propagation of tidal energy from the troposphere to the mesosphere lower thermosphere (MLT) region (c.a., 80-120 km) by examining the seasonal latitudinal variation of the eastward-propagating diurnal tide with zonal wavenumber 3 (DE3), which agree well between theory and observation. It is shown here how the seasonal-latitudinal variation of mean zonal wind modulates and filters the total (radiative and latent heating) DE3 energy propagating upwards from the troposphere during the course of the year. Our results are based upon numerical simulations using the Global-Scale Wave Model (GSWM) forced by new tidal heating rates derived from ISCCP radiative fluxes and TRMM (Tropical Rainfall Measuring Mission) latent heating profiles together with TRMM rainfall rates. The zonal winds employed are the zonal mean 19 gradient winds derived from TIMED/SABER geopotentials, and the observed tidal signatures are determined from temperature measurements made by the SABER instrument on the TIMED satellite.

MLT-MLTT-05 Error analysis of tidal/planetary waves for data containing regular large gaps by Yun Gong

Status of First Author: Student IN poster competition Masters

Authors: Yun Gong, Matthew Brenneman, Qihou Zhou, Y.T. Morton

Abstract: Normally, ISR data have a large data gap because the ion density is very low at night time. Therefore, the radar cannot obtain reliable data. In this case, using a traditional least square fitting cannot fit ISR data well. Sometimes, it will even give you a wrong fitting result at data missing part (nighttime part). In this poster, the least square fitting errors are analyzed.

MLT-MLTT-06 A study of the 3-4-day Kelvin waves effects over the Brazilian ionospheric equatorial region - by Amelia Naomi Onohara

Status of First Author: Student IN poster competition Masters

Authors: Amelia N Onohara, Hisao Takahashi, Inez S Batista, Paulo P Batista, Barclay R Clemesha, Lourivaldo M Lima

Abstract: We investigate the 3-4-day Kelvin wave effects on the ionospheric parameters, h´F and foF2, obtained by a digisonde installed at Fortaleza (3.9 S, 38.4 W), Brazil. In order to find out these wave oscillations in the mesopause region, temporal variations of the mesospheric wind structure measured by meteor radar at São João do Cariri (7.4 S, 36.5 W) were used. The wavelet analysis was used to identify the 3-4-day Kelvin wave oscillations in the observational data, and some coincidence between the parameters was analyzed. The effect of winds induced by the planetary waves in the ionospheric parameters was tested using the ionospheric model named "CODB2005" (Código de Batista 2005). Some relevant results in comparison of the model calculation and observed oscillation amplitude will be presented.

MLT-MLTT-07 SABER OH Mesospheric Airglow Emissions - by Bryant Svedin

Status of First Author: Student IN poster competition Undergraduate

Author: Bryant Svedin

Abstract: Mesospheric nighttime hydroxyl-airglow volume emission rates were derived from the NASA LaRC/USU SABER instrument, aboard the TIMED satellite. Results at the spring equinox are presented for the 2002 through 2010 period of the current solar cycle. The SABER 1.6 μm and 2.0 μm radiometric channels provide measurements of the OH (5-3), (4-2) and (9- 7), (8- 6) emission bands, respectively. The equinoxes exhibit variation by year, apparently related to the solar cycle.

MLT - Polar Aeronomy

MLT-POLA-01 The Electron Density Dependence of Polar Mesospheric Summer Echoes by Roger Hale Varney

Status of First Author: Student IN poster competition

Authors: Roger H. Varney, Michael C. Kelley, Michael J. Nicolls, Craig J. Heinselman, and Richard L. Collins

Abstract: Many of the expressions for the reflectivity of polar mesospheric summer echoes (PMSE) predict that the echo strength is a strong function of the electron density. This paper presents several observations made using the Poker Flat Incoherent Scatter Radar (PFISR) which are difficult to explain based on those expressions. PMSE has been observed at night with no detectable incoherent scatter from free electrons below 90 km, meaning that the D-region electron densities are at most 2 x 10^9 m^-3. Furthermore, PMSEs observed during particle precipitation only occasionally exhibit large changes in reflectivity in response to dramatic changes in the ionization. We study one example of PMSE during extremely strong particle precipitation in detail and demonstrate a new method for deriving absolute electron densities inside the PMSE layer. Nonetheless, we are still able to explain all of these observations as scatter from free electrons. We derive a new expression for the radar reflectivity based on the rigorous treatment of turbulence in weakly ionized gases by Hill et al. [1999, Turbulence induced fluctuations in ionization and application to PMSE, Earth Planets Space, 51, 499-513] which predicts a much more complicated dependence on electron density than previous theories. When the electron density is much smaller than the ice density the reflectivity is a strong function of electron density, but for 30-50 nm particles the minimum required electron density for detectable PMSE is well below the detection limit for incoherent scatter. In the opposite limit the reflectivity is solely controlled by the ice density because only a fraction of the electron density variance generated at the largest scales can be convected out to the small scales responsible for PMSE.

MLT-POLA-02 Relative airglow emission rates in the vicinity of the polar vortex - by Y. Bhattacharya

Status of First Author: Non-student

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Abstract: Relative, column integrated volume emission rates of the Meinel band hydroxyl airglow (upper mesosphere - lower thermosphere, MLT) observed by a Michelson Interferometer in the vicinity of a winter polar vortex are presented. Although the instrument did not directly measure absolute volume emssion rates [since the primary aim was to measure wind velocities using Doppler shift of the airglow line center], useful information can be extracted from time series analysis of the airglow relative emission rate data. An attempt is made to interpret the observations in the context of the state of the vortex at that time using assimilated data. The study is in preparation for a planned network of photometers to be deployed at three or four locations in the Antarctic to continuosly monitor MLT temperatures during the polar vortex season, spanning the approximate extent of the polar cap - at the PENGUIn-Automatic Geophysical Observatories (AGOs).

MLT-POLA-03 Vertical mesopause winds in the Arctic Polar Vortex season - by Yaj Bhattacharya

Status of First Author: Non-student PhD

Authors: Yaj Bhattacharya and Andrew J. Gerrard

Abstract: Vertical neutral winds in the upper mesosphere - lower thermosphere, measured by observing the hydroxyl (OH) airglow using a wide-angle Michelson Interferometer from Resolute Bay (74 deg N), over the course of three Arctic winters, are presented. The measurement of vertical winds, which span three to four months during the 1995-96, 1996-97, and 2000-01 winters, are unique and allow for a variety of studies on the mechanisms associated with vertical winds in the mesosphere - notably the influence of both geomagnetic activity and the polar vortex. These results should help enhance our understanding of the mechanisms that determine the magnitude and variability of vertical neutral winds at high latitudes

MLT-POLA-04 Antarctic Mesosphere Warming During Wintertime Planetary Wave Surges in 2007 by Irfan Azeem

Status of First Author: Non-student PhD

Author: Irfan Azeem

Abstract: Continuous (24-hrs a day) observations of OH airglow have been made at South Pole, Antarctica during the austral winter since 1992 using a Michelson Interferometer. In this paper we show mesospheric temperatures at high Southern latitudes during the 2006-2008 period. OH rotational temperatures observed at the South Pole and mesospheric temperatures measured from the NASA Thermosphere-Ionosphere-Mesosphere Energetics and Dynamics (TIMED) satellite have been used here to highlight unusually high temperatures during the 207 Austral winter. OH temperatures have been shown, in general, to follow the F10.7 solar flux cycle. However, both the airglow and satellite measurements show 2007 temperatures to be aberrantly higher than the average wintertime temperatures from 2006 and 2008. These temperature enhancements are not limited to the middle atmosphere as the NCEP/NCAR Reanalysis data also reveals the 2007 temperature anomaly at stratospheric heights. In this paper we investigate the role of wave drag in temperature anomalies in the stratosphere and mesosphere. We also compare NCAR's Whole Atmosphere Community Climate Model (WACCM) prediction of 2007 temperatures with Antarctic observations of mesosphere temperatures. Observed temperature anomalies in 2007 are not captured by the model and highlight the need to better understand the dynamical and energetic processes in the Antarctic mesosphere region.

MLT - Sprites

MLT-SPRT-01 Effects of Ambient Field and Altitude Variation on Exponential Growth Rate of a Model Positive Sprite Streamer - by Burcu Kosar

Status of First Author: Student IN poster competition

Authors: Burcu Kosar (bkosar@fit.edu), Ningyu Liu (nliu@fit.edu), Hamid K. Rassoul (rassoul@fit.edu)

Abstract: Sprites are electrical discharges of air usually produced by an intense positive cloud-to-ground lightning stroke. The filamentary plasma channels observed in sprites are known as streamers. Recently, streamer models [e.g., Liu and Pasko, JGR, 109, A04301, 2004; Liu et al., JGR, 114, A00E03, 2009; Luque and Ebert, Nat. Geosci., 757, 2009; Celestin and Pasko, GRL, 37, L07804, 2010] are employed to explain many observed features of sprite events. Exploring the relation between sprite streamer characteristics (e.g., speed, radius, brightness) and ambient field and/or altitude is very important for theoretical and observational study of sprites. Previous studies [e.g., Liu and Pasko, 2004; Liu et al., 2009] showed that the speed and radius of sprite streamers exhibit an exponential increase in time. Recent high speed observations [e.g.,Cummer et al., GRL, 33, L04104, 2006; McHarg et al., GRL, L06804, 2007; Stenbaek-Nielsen et al., GRL, L11105, 2007] provided very detailed information about structural features and advancement of sprite streamers. Comparisons between streamer models and high speed observations suggest that the brightness of sprite streamer head also exponentially grows in time. The growth rates are highly dependent on the magnitude of ambient field. This can be a very useful tool for remote sensing of ambient fields above thunderstorms that give rise to sprite events [Liu et al., 2009]. In addition, a recent

study [Naidis, Phys. Rev. E 79, 057401, 2009] explores the velocity-diameter relation of streamers from an analytical point of view for analyzing the magnitude of electric field in the streamer head.

In this study, we will examine the variation of the exponential growth rate of streamer parameters with ambient field and/or altitude. The modeling results of streamer propagation in several different ambient fields at various altitudes will be reported. The results obtained from streamer simulation will be discussed in relation to analytical approach by Naidis [2009] as well as those from high speed observations.

MLT-SPRT-02 **Study of the conditions for the emergence of sprite streamers from halo events with different polarities** - by Jianqi Qin

Status of First Author: Student IN poster competition PhD

Authors: Jianqi Qin, Sebastien Celestin, and Victor P. Pasko
Communications and Space Science Laboratory, Department of Electrical Engineering, Penn State University, University Park, Pennsylvania, USA

Abstract: The removal of thundercloud charges by cloud-to-ground (CG) lightning discharges can trigger sprite streamers that occur above thunderstorms at altitudes typically ranging from 40-90 km, although only luminous diffuse glows called 'halo' are often observed. In the literature, sprite streamers can be observed emerging from a halo in numerical simulations for charge moment (LQ) change above 1300 C km [e.g., Luque and Ebert, Nat. Geosci., 2, 757, 2009]. However, previous reported data provided by Hu and Cummer [GRL, 29, 1279, 2002] and [Barrington-Leigh, PhD thesis, Stanford University, Chapter 5, 2000] indicate that LQ changes in the cloud during lightning flash as low as 120 C km can initiate sprite streamers. Up to now, no numerical modeling provides enough information about how the sprite streamers can be triggered by such low LQ changes. In the present work, we develop a more accurate description of image charges in the lower ionosphere in comparison with previously published models, and investigate the formation of halo events for different LQ changes in the framework of a quasi-electrostatic model. Meanwhile, we improve the avalanche-to-streamer transition criterion to investigate the possible initiation of sprite streamers with different polarities from halo events, especially in the cases of low LQ changes. Our preliminary results expose the significance of particular features of ambient electron density profiles for the initiation of sprite streamers with low LQ changes. We also investigate the role of the polarity (+CG and -CG) of the lightning discharges on the formation of sprite streamers. By fixing the lightning discharge duration, we show the relations between the ambient electron density profiles and LQ changes leading to formation of sprite streamers.

MLT-SPRT-03 **Fluid Model to Evaluate the Penetration of LIghtning Electric Fields in the Mesophere/Lower Ionosphere Generating Sprites** - by Caitano Luiz da Silva

Status of First Author: Student IN poster competition Masters

Authors: Caitano Luiz da Silva - INPE - Brazil - caitano@dae.inpe.br; Fernanda T. São Sabbas, INPE - Brazil - saosabbas@dae.inpe.br

Abstract: Sprites are streamer-like discharges above thunderclouds, which occur between 40 and 90 km height and are usually generated by positive cloud-to-ground lightning flashes. Several efforts in the literature try to model sprite inception and streamer propagation on atmosphere. The most accepted sprite onset mechanism is the penetration of quasi-static electric fields from lightning discharges in mesosphere/lower ionosphere, leading to ambient electron heating and ionization of neutral species. Here we present a fluid model to describe the atmospheric response to lightning quasi-electrostatic fields building up on previous works, combining different techniques and input parameters. We consider four species of particles: neutrals, electrons and positive/negative ions. Distribution of neutral particles is assumed to do not change in time. The model consists in continuity equations for the three species of charged particles (including advective transport of electrons and ions) coupled with Poisson's equation to evaluate the electric field. We consider the processes of ionization, attachment and recombination to create and aniquilate charged particles. The attachment/ionization frequencies and the electron mobility are strongly dependent of the reduced electric field strength, what implies in a highly non-linear set of equations. We solve the equations in a cylindrically symmetric coordinate system. The particle densities are updated using an explicit (two-step) trapezoidal rule, which is second-order accurate. The electric potential is evaluated with the successive over-relaxation method (SOR). Preliminary results show that the gross electric field characteristic is a downward screening-ionization wave, which can creates the scenario for sprite streamers inception in agreement with previous works.

MLT-SPRT-04 **Modeling of Sprite Streamer Chemistry** - by Ningyu Liu

Status of First Author: Non-student

Authors: Ningyu Liu (nliu@fit.edu), Department of Physics and Space Sciences, Florida Institute of Technology, Melbourne, FL, USA; Davis Sentman (dsentman@gi.alaska.edu), Geophysical Institute, University of Alaska, Fairbanks, Alaska, USA.

Abstract: Transient luminous events (TLEs) are large electrical discharges of air in the upper atmosphere, which are driven by underlying thunderstorm/lightning activities [Pasko, PSST, 16, S13, 2007]. They deposit electromagnetic energy from tropospheric altitudes into the mesosphere and lower ionosphere. Because relatively energetic electrons are produced in such discharges, the potential chemical effects of TLEs on this region of the atmosphere have been recognized as an important research subject since the discovery of those phenomena in 1990s. Those electrons can obtain sufficient energies to excite, dissociate and ionize neutral molecules in air, which can trigger a chain of chemical reactions leading to production of many minor but important neutral and charged constituents in the upper atmosphere.

Several recent outstanding papers report detailed modeling results of the chemistry introduced by sprite streamer discharges in the mesosphere [e.g., Sentman et al., JGR, 113, D11112, 2008; Gordillo-Vázquez, J. Phys. D: Appl. Phys., 41, 234016, 2008; Enell et al., Ann. Geophys., 26, 13, 2008; Sentman and Stenbaek-Nielsen, PSST, 18, 034012, 2009]. On the other hand, possible signatures of chemical perturbations caused by sprites have been observed by MIPAS/GMTR satellite [Arnone et al., GRL, 35, L05807, 2008]. The satellite data show that the enhancement of NO2 density by sprite activities could be significant on a regional scale.

A zero dimensional chemistry model is recently developed at Florida Tech to investigate the chemical kinetics accompanying with sprite streamer discharges. In this talk, we will compare the simulation results from this model with those reported by Sentman et al. [2008]. It is known that the modeling results are very sensitive to the electric field pulse driving the streamer chemistry. We will further report the simulation results obtained by using an electric field pulse extracted from the sprite streamer modeling. Our discussion of the results will indicate the density change of atmospheric species caused by sprite streamers and what chemical processes might be important for the dynamics of sprite streamers.

MLT-SPRT-05 **Finite-difference time-domain modeling of infrasound from sprites and comparison with recent observations** - by Sebastien de Larquier

Status of First Author: Student NOT in poster competition

Authors: Sebastien de Larquier and Victor P. Pasko, CSSL, The Pennsylvania State University, University Park, Pennsylvania 16802, USA

Abstract: Atmospheric infrasonic waves are acoustic waves with frequencies ranging from 0.02 to 10 Hz [e.g., Blanc et al., Ann. Geophys., 3, 673, 1985]. The attenuation of acoustic waves in the atmosphere is approximately proportional to the frequency squared, so unlike audible frequencies, infrasound can propagate thousands of kilometers through the tropospheric, stratospheric, mesospheric and lower thermospheric regions, exhibiting global propagation characteristics [Drob et al., JGR, 108, D21, 4680, 2003].

A number of natural events have been identified as generating atmospheric infrasound. Transient Luminous Events (TLEs) termed sprites have recently been identified as generating infrasound [e.g., Farges et al., GRL, 32(1), L01813, 2005; Farges and Blanc, JGR, 115, doi:10.1029/2009JA014700, 2010; Liszka and Hobara, JASTP, 68(11), 1179, 2006]. Sprite-attributed infrasonic signals are observed from 50 km to more than 400 km horizontal distances from the source. Close observations reveal an inverted chirp signal with high frequency infrasonic waves leading low frequency components, while long range observations show chirp signatures (i.e., with leading low frequencies), both exhibiting long time scales (~1-2 min) relatively to sprites time scales (<100 ms).

A two-dimensional finite-difference time-domain (FDTD) model of infrasound propagation in a realistic atmosphere has been developed. The model is based on linearized equations of acoustics employing the realistic atmospheric structure and infrasound absorption algorithms advanced by Sutherland and Bass [J. Acoust. Soc. Am., 115 (10/2), 2004]. The absorption

is implemented using a decomposition technique recently introduced by de Groot-Hedlin [J. Acoust. Soc. Am., 123 (3), 2008]. The model has been recently applied for studies of infrasound from pulsating auroras [de Larquier et al., GRL, 37, L12808, 2010] In this presentation the FDTD model is used to provide qualitative explanations of close range ground observations of infrasonic radiation from sprites. Results suggest that the vertical extents of sprites combined with the altitude dependency of the transverse extent of filamentary structures in sprites are responsible for the inverted chirp signal observed on the ground.

MLT-SPRT-06 Corrections on Spectroscopic Diagnostics of Peak Electric Fields in Transient Luminous Events - by Sebastien Celestin

Status of First Author: Non-student

Authors: Sebastien Celestin, and Victor P. Pasko, Communications and Space Sciences Laboratory, Pennsylvania State University

Abstract: Spectroscopic diagnostics of Transient Luminous Events (TLEs) occurring in the upper-atmosphere and related to electrical activity of underlying thunderstorms allow for obtaining information on the electric field associated with these events. Indeed, the ratio of volume emission rates with different energy excitation thresholds, such as the second positive system of N2 (2PN2) and the first negative system of N2+ (1NN2+), is a sensitive function of the electric field. The related diagnostic techniques have been extensively developed for laboratory discharges [e.g., Gallimberti, J. Phys. D: Appl. Phys., 7, 880, 1974; Kozlov et al., J. Phys. D: Appl. Phys., 34, 3164, 2001; 38, 518, 2005]. Essentially the same approaches have been used to utilize the data recorded by the ISUAL instrument on FORMOSAT-2 satellite for studies of sprites [Kuo et al., GRL, 32, L19103, 2005; Adachi et al., GRL, 33, L17803, 2006; J. Phys. D: Appl. Phys., 41, 234010, 2008], and gigantic jets [Kuo et al., JGR, 114, A04314, 2009]. Liu et al., [GRL, 33, L01101, 2006] compared streamer modeling results with the ISUAL measurements and concluded that in order to agree with observations during initial stage of sprite development the maximum field driving emissions of a sprite event must be greater than 3 Ek, where Ek is the breakdown field. Adachi et al. [2006] analyzed twenty sprite events captured by ISUAL and inferred that electric fields in the streamer region do not exceed 1-2 Ek, which is lower than those predicted by streamer head theory [Liu et al., 2006].

In a streamer, the head is responsible for the most part of ionization and excitation of species, and therefore is responsible for the most part of emission. However, the spatial non-uniformity of streamer discharges are such that the maximum excitation rates are not exactly located at the maximum electric field. Naidis [Phys. Rev. E, 79, 057401, 2009] has recently emphasized that the evaluation of the electric field through the ratios of integrated emissions would lead to substantial deviations from the peak electric field in the streamer head.

We have recently shown that the corrective factors to apply on electric fields obtained from ratios of spatially integrated emissions of N2 (2PN2) and N2+ (1NN2+) are close to 1.4 for positive streamers and >1.5 for negative streamers, propagating at altitudes from ground to 80 km [Celestin and Pasko, GRL, 37, L07804, 2010]. In this work, we will show that these corrective factors have two main origins. First, the spatial non-uniformity of electric field and electron density in streamers produces a spatial shift between the maximum excitation rates and the peak electric field. And second, due to the cylindrical geometry of the streamer the highest contribution to the total number of excited species does not come from the axis of symmetry, where the field is maximum, but from the peripheral regions of streamer head away from the axis.

MLT - Stratosphere Studies and Below

MLT-STRB-01 Diurnal tide in the troposphere and stratosphere as observed with reanalysis Data by Takatoshi Sakazaki

Status of First Author: Student IN poster competition PhD

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Abstract: Tides are mainly excited in the troposphere and stratosphere so that the understanding of tides in this height region is essential. In previous studies, the characteristics of tides in the troposphere and stratosphere were examined

mainly using atmospheric radar data. Analysis that fully investigate the global structures (latitudinal structure for each wavenumber) are particularly valuable.

In this study, we use 6-hourly reanalysis data (JRA25/JCDAS, ERA-Interim, NCEP1, NCEP2) to examine the diurnal tide in the troposphere and stratosphere including its vertical strucutures, latitudinal structures, and seasonal variations.

It is found that the migrating component is basically dominant at most height levels. As a classical tidal theory predicts, the principal upward propagating diurnal Hough mode is dominant in the troposphere and stratosphere. Also, a marked seasonal variation is observed. Details will be presented in a poster.

MLT-STRB-02 **Variability of the spring-time transition date and planetary waves in the boreal stratosphere** - by Elena Savenkova

Status of First Author: Student IN poster competition Masters

Authors: Savenkova E.N., Pogoreltsev A.I., Merzlyakov E.G.

Abstract: The analysis of observations shows that there exists a strong interannual variability of the spring-time transition date of the stratospheric circulation. In the present study the year-to-year variability of the polar vortex breakup date and planetary waves in the Northern Hemisphere is examined on the base of data assimilated in the UK Met Office model. As a characteristic of the zonal mean flow the geostrophic wind calculated at 67.5N using the geopotential heights of the 10 hPa pressure level has been used. The results obtained show a significant correlation of the spring-time transition date with the observed planetary-wave activity in the lower stratosphere. There is a positive tendency (secular trend) in the spring-time transition date (of about 9 days per decade) during 1992-2009 years.

MLT-STRB-03 **The NJIT-UACNJ-PSU Collaborative: A spatially scanning middle atmospheric lidar system in northwest New Jersey** - by Anthony Teti

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Abstract: We present an overview of a new middle and upper atmospheric observatory located in northwest New Jersey; focusing specifically on the 355-nm molecular-aerosol lidar system deployed in summer 2009. The lidar system currently uses a 1.2-W 355-nm laser system with a 4" Meade optical telescope to collect molecular and aerosol return from the troposphere and lower stratosphere. We are currently installing a 1.2-meter, fully steerable optical telescope to expand our measurements in host of lower and middle atmospheric fields, including a) lower and middle atmospheric gravity wave structures, b) lower atmospheric cloud/aerosol formations, and c) frontal systems as progenitors of gravity waves. These topics of interest will be studied using 4D volume visualization methods often used in tropospheric Doppler radar systems.