MESOCLOUD TRACKER

2002JD002255
Title: Maps of Polar Mesospheric Clouds

Abstract: A middle ultraviolet imager (235-263 nm) on the Midcourse Space Experiment (MSX) has obtained the first large-scale, two- dimensional maps of polar mesospheric clouds (PMCs). The lower parts of individual images, which lie below the ozone horizon, are mapped onto an ellipsoidal shell at 83 km altitude and then combined to establish the transpolar PMC field in two spatial dimensions across the entire polar region. At all latitudes where they appear, the PMCs clearly evidence a "patchy" structure a s opposed to a uniform layer. Among the interesting features of these cloud patches are zonal alignments, arcs, and repetitive structures characteristic of waves. Whether random or repetitive, the cloud structures exhibit scales ranging from several hundred kilometers down to tens of kilometers.

Authors: James Carbary, Danny Morrison and Gerald Romick

2002JD002356

Title: The influence of planetary waves on noctilucent cloud occurrence over NW Europe

Abstract:
Observations of noctilucent clouds (NLC) from North West Europe have been collected by a network of observers for almost 40 years. Previous analyses of the observations have found an apparent increasing frequency of occurrence , a 10-11 year modulation and evidence for 5-day periodicity. Here we re- examine the observational data for NLC occurrence to test whether the observed variations can be explained by planetary wave activity in the middle atmosphere. Planetary wave amplitudes and phases in the lower mesosphere are derived from global meteorological assimilations from 1979-2000 and extrapolated to the mesopause. When the NLC observations are selected from a constant observing area, we find that there is no substantial trend in yearly NL C occurrence over the observation period, whereas the 10-11 year and 5-day modulations remain significant. We find a strong correlation between the probability of observing NLC and the combined effects of stationary, 16-day and 5-day planetary waves at the N LC location. The most reasonable explanation for the correlation is that that probability of observing NLC depends on the strength of the wind from the north, which in turn depends on the amplitude and phase of the planetary waves. The influence of planetary waves on NLC occurrence may to a certain extent explain the 10-11 year periodicity in NLC. This possibility is a consequence of a strong correlation between the phase of the stationary planetary waves and the 10-11 year cycle of solar activity during the period 1979-2000.

Authors: Sheila Kirkwood and Kerstin Stebel

2002JD002363

Title: Gravity Wave Influences on Arctic Mesospheric Clouds as Determined by the Sondrestrom, Greenland, Rayleigh Lidar Wave Influences on Mesospheric Clouds

Abstract
Since 1994, Rayleigh lidar measurements of the arctic middle atmosphere have been conducted at the Sondrestrom research facility near Kangerlussuaq, Greenland (67.0N,50.9W). The summer lidar observations typically cover the late-June through August period. From these observations, 220 hours of noctilucent clouds (NLC) have been detected by the lidar spanning 16 hours of local time. Organizing the cloud characteristics irrespective of local time reveals the most common cloud height as 82.5 km, the most common full-width-half-maximum (FWHM) as 0.7 km, and the most common peak volume backscatter coefficient (VBC) as 20.0x10-11 m-1sr-1. The FWHM is noticeably thinner than determined by other lidar observations of NLCs in Norway and the South Pole. We found the mean backscatter strength to increase and the FWHM to decrease with decreasing cloud height. In addition, the cloud slopes with time are greater for the thicker, weaker clouds at higher altitudes than the thinner, stronger clouds at lower altitudes. Gravity wave signatures are routinely observed in the cloud detections. Upon estimating stratospheric wave activity in the data, we observed stronger cloud backscatter during low gravity wave activity and weak cloud backscatter during high gravity wave activity. To help support these results, simulations from a microphysical cloud model were performed under summer mesospheric conditions with and without gravity wave activity. Upon including short-period (~2-3 hours) gravity wave activity, the model simulation reproduced the behavior observed in the ensemble cloud properties by producing a broader altitude distribution, weaker backscatter strength, and thinner clouds.

Authors: Jeffrey Thayer , M Rapp , Andrew Gerrard , Timothy Kane , Eggert Gudmundsson

2002JD002364

Title: 40 years of Noctilucent Clouds observations near Moscow : database and simple statistics

Abstract
The observation procedure and relevant database of Moscow (56œ N, 37œ E) Noctilucent Clouds (NLCs) systematic observations (1962-2001)are described. The long-term series of Moscow NLCs data are analyzed and compared to the observations in Western Europe. Statistical analysis of seasonally averaged parameters of the NLCs is carried out. Characteristic periods in interannual variability of the integral NLCs brightness fluctuation are extracted. Particular attention is paid to decadal (~10 years) periodicity in the NLCs occurrence and their brightness. A distinct difference between decadal periodicity in NLCs parameters and solar activity is found and its possible origin is discussed.

Authors: Peter Dalin ,Vitrom Romejko , Nick Pertsev

2002JD002369

Title: Seasonal and long-term variations of PMSE from VHF radar observations at Andenes, Norway

Abstract:
The observation of polar mesosphere summer echoes (PMSE) with VHF radars is an important possibility for the investigation of the polar mesospheric region during summer. This region is characterized by the lowest temperatures in the Earth?s atmosphere and the existence of mesospheric ice clouds, observed visually or by lidars as noctilucent clouds (NLC). Using measurements at 53.5 MHz in Andenes, Norway, with the ALOMAR SOUSY radar between 1994-1997 and with the ALWIN radar between 1999-2001 mean seasonal, solar cycle and long-term variations of PMSE have been derived. The seasonal variation of PMSE is characterized by a strong increase during end of May/beginning of June, a rather high level in June and July, and a more gradual decrease during August. The occurrence rate of PMSE is positively correlated with the mesospheric ionization level mainly caused by solar cycle variations of the solar Lyman ? radiation and also by the flux of precipitating high energetic particles. Long-term trends of PMSE are only very small and not significant due to the limited data series.

Authors: Juergen Bremer ,Peter Hoffmann , Ralph Latteck , Werner Singer

2002JD002385

Title: The Response Time of PMSE to Ionospheric Heating&a???

Abstract:

During July of 1999, experiments were conducted in northern Norway to investigate the effects of ionospheric heating on polar mesosphere summer echoes (PMSE). The experiments were conducted using the European incoherent scatter (EISCAT) VHF radar and heating facility. It was shown that heating can dramatically reduce the backscattered echo power of PMSE. Here, we re-examine the high temporal resolution data of the PMSE backscattered power from three of the experiments as a function of ionospheric heat i ng. Particular attention is paid to the transitions from the heater off-to-on and on-to-off states. The transition times of the PMSE echo power from high to low and low to high, respectively, is estimated in both cases to be less than 30 ms. It is su gge sted that enhancement of the electron diffusivity during heating is unlikely to account for such a fast decrease of radar backscattered power when the heater is switched on. We consider that an increase of the electron Debye length up to a significant fraction of a radar wavelength due to electron heating will change scattering character that might explain the observed heating effect on PMSE.Bl

Authors: Evgenia Belova , Phillip B. Chilson , Sheila Kirkwood , Michael T. Rietveld

2002JD002392

Title: Mesospheric turbulence measurements from persistent Leonid meteor train observations

Abstract:

Long-duration meteor trains have fascinated observers for many years. The great Leonid meteor storms of 1866-1888 were the first to spark organized scientific study on the subject, but despite years of study, more than a century later, persistent trains remain for the most part a mystery.
Over the last few years, however, the heightened Leonid activity has fueled considerable research efforts, much of it dealing with persistent trains.
Some of the results of a comprehensive study of persistent trains conducted at the Starfire Optical Range (SOR) on Kirtland Air Force Base, New Mexico, during the 1998 and 1999 Leonid showers are reported here. For the first time, the time-evolution of persistent trains is used to determine the eddy diffusion coefficient at mesospheric heights. In three of the four trains studied, portions of the train exhibited molecular diffusion while the remainder of the train, as well as the entire fourth train exhibited eddy diffusion. The eddy diffusion coefficients were several hundred m^2 s^{-1}, two orders of magnitude higher than the molecular rates. The sodium density in the train was sufficient to use it as a passive scalar tracer of turbulent fluctuations. The spectra are well modeled by the Heisenberg turbulence model and the values found for the energy dissipation rate are in agreement with the eddy diffusion coefficient estimates. The gradient Richardson number and Brunt-V\"{a}is\"{a}ll\"{a} frequency were
determined from lidar measurements and indicated regions of convective and dynamic instability.

Authors: Michael C. Kelley , Craig A. Kruschwitz , C.S. Gardner , J. D. Drummond , Timothy Kane

2002JD002398

Title: SBUV Observations of PMCs Over Two Solar Cycles

Abstract:

Previous satellite measurements have provided nearly complete seasonal and geographic coverage of polar mesospheric clouds (PMC), but previous data sets have not been able to evaluate changes in PMC behavior on decadal time scales. The SBUV series of ozone measuring instruments have been flying continuously since 1978. While the instrument design is not optimized for PMC detection, the radiance data can be analyzed to examine the occurrence frequency and intensity of relatively bright PMCs. In this paper, we present PMC results from five SBUV and SBUV/2 instruments covering 23+ years (1978-2002), starting just before the maximum of solar cycle 21 and extending through

the maximum of solar cycle 23. The overlapping data sets from nearly identical instruments give an accurate picture of long-term variations. Multiple linear regression fits are used to examine solar and secular correlations. PMC occurrence frequency is anti-correlated with solar Lyman alpha irradiance, with an approximate 0.5-year phase lag in the Northern Hemisphere (Rsolar = –0.87) and no phase lag in the Southern Hemisphere (Rsolar = –0.65). The distribution of cloud brightness by season appears to be changing over time. When the PMC brightness for each season is characterized using an exponential cumulative distribution function, the exponent decreases in magnitude by a factor of 2 from 1978 to 2002 in the Southern Hemisphere (Rtime = +0.85). This implies an increase in the relative proportion of the brightest PMCs. The secular brightness trend is less significant in the Northern Hemisphere (Rtime = +0.58). We discuss possible origins for these changes.

Authors: Matthew DeLand, Eric Shettle , Gary Thomas , John Olivero

2002JD002406

Title: Layering Accompanying Turbulence Generation Due to Shear Instability and Gravity Wave Breaking

Abstract:

We describe and compare idealized, high-resolution simulations of turbulence arising due to Kelvin-Helmholtz shear instability and gravity wave breaking, believed to be the two major sources of turbulence generation near the mesopause. The two flows both share characteristics related to turbulence transition, evolution, and duration and exhibit a number of differences that have important implications for layering, layered structures, and atmospheric observations at mesopause altitudes. Common features related to layering include sharp, local gradients in turbulent kinetic energy production, dissipation, and magnitude and a clear spatial separation of the maxima of turbulent kinetic energy dissipation and thermal dissipation accompanying vigorous turbulence. Differences arise because shear instability causes turbulence and mixing confined by stratification to a narrow layer, whereas gravity wave breaking leads to a maximum of turbulence activity that moves with the phase of the wave. As a result, the effects of turbulence due to shear instability likely persist for much longer than those of turbulence due to gravity wave breaking. We also discuss the implications of these results for a number of atmospheric measurements employing radar.

Authors: Dave Fritts, Chris Bizon , Joe Werne , Christian Meyer

2002JD002409

Title: Freeze-drying at the summer polar mesopause: Its likely persistence and consequences. -- Or proposed new title -- Persistent ice cloud in the mid-summer upper mesosphere at high latitudes: 3-D modeling and its interactions with the ambient water vapor

Abstract:

We infer from the observed occurrence frequency of polar mesosphere summer echoes and from the 3-D modeling of conditions in the high latitude mesopause region that a persistent layer of icy particles exists in mid-summer at all latitudes poleward of about 60°N at and a few kilometers below the mesopause. All of these icy particles are transported equatorward by the climatological mean winds. At the same time, many of the larger icy particles possess a high enough sedimentation velocity to induce a net downward transport of water vapor. Both types of particle motions cause the mesopause region to become substantially dryer than without these transports of icy particles. We follow the interactions between water vapor and icy particles by means of a 3-D dynamical and chemical model which includes a module for the formation, growth and sublimation of icy particles.
For mid-summer conditions and poleward of 67°N latitude, the model predicts (a) a strongly dehydrated region, typically near 88 km, in which the water vapor mixing ratio falls below 0.2 ppmv and (b) atmospheric regions with enhanced water vapor abundance near both the lower and the equatorward borders of the icy particle layer.

Authors: Ulf von Zahn and Uwe Berger

2002JD002413

Title: Influences of ice particles on the ion chemistry of the polar summer mesosphere

Abstract:

In the polar summer mesosphere, charge is distributed over a wide range of constituents closely connected to phenomena like noctilucent clouds and polar mesosphere summer echoes. In this paper we study how the presence of ice particles influences mesospheric ion chemistry, and how this may feed back on the particle population. To this end, we present an ion-chemical model that for the first time features close coupling with cluster growth and ice particle charging. Starting out from molecular ion reactions, the H⁺(H₂O)_n proton hydrate chain is described using the Thomson model and Natanson's recombination scheme. Under most mesospheric conditions electron capture by particles is expected to enhance the lifetimes and concentrations of positive ions and clusters. This has important consequences for the total charge density and mobility in the environment of particle layers. Extending the proton hydrate chain to large cluster sizes, we also quantify the efficiency of ionic nucleation of mesospheric ice particles. While ionic nucleation is not feasible as the major mesospheric nucleation process, it can become efficient given moderate atmospheric variations as induced by gravity waves. This leads to a scenario of rapid generation of populations with many small particles in local temperature minima. We show that electron capture to existing particles can significantly enhance the ionic nucleation of new

particles. In summary, there are many potential connections between ion chemistry and layered phenomena in the mesosphere that should be included in comprehensive models of NLC/PMSE. Unfortunately, uncertainties in ionic reaction rates are a persistent problem and in great need of laboratory measurements representative for cold summer mesopause conditions.

Authors: Joerg Gumbel, David Siskind , Georg Witt , Klaus M. Torkar , M. Friedrich

2002JD002414

Title: First in-situ temperature measurements in the summer mesosphere at very high latitudes (78$^\\circ$N)

Abstract:

A total of 24 temperature profiles from $\sim$92--55~km were obtained from falling sphere flights in Longyearbyen (Svalbard, 78$^\\circ$N) from July 16 to September 14, 2001. The thermal structure of the upper mesosphere during the summer season (here from mid-July until August 23) is characterized by very low temperatures and little variability. The mesopause temperature decreases slightly from $\sim$130$^\\circ$K in mid-July to 126-128$^\\circ$K in late July/beginning of August. The mesopause altitude in summer is $\sim$89~km. Compared to 10 degrees further south (69$^\\circ$N, And\o ya) the mesopause temperature is very similar in mid-July but is significantly colder by 6--8$^\\circ$K in the second half of July and in August. Part of this difference (especially in late August) is due to the later transition from summer to winter in Longyearbyen. The mesopause altitude is higher by approximately 1~km at Longyearbyen compared to And\o ya. At 82~km the temperature in summer is very close to 150$^\\circ$~K, very similar to other Arctic and Antarctic stations (`equithermal submesopause'). The temperatures in the upper mesosphere are significantly lower compared to CIRA-1986 by up to 20$^\\circ$K. Assuming model water vapor concentrations we derived the degree of saturation of water vapor (S). In summer there is an extended altitude range (82--92~km) with super-saturation (S$>$1). Occasionally very high super-saturation was derived (S$>$100). Our temperature measurements are in general agreement with the occurrence morphology of polar mesosphere summer echoes (PMSE). However, double layered structures frequently observed in PMSEs are not a prominent feature of the temperatures in the upper mesosphere.

Authors: Franz-Josef Luebken and Arno Muellemann

2002JD002419

Title: Noctilucent Clouds above ALOMAR between 1997 and 2001: Occurrence and Properties

Abstract:

We report on observations of noctilucent clouds (NLCs) by a groundbased lidar located in Northern Norway at 69N, 16E. The ALOMAR Rayleigh/Mie/Raman (RMR) lidar conducted measurements of the Arctic middle atmosphere from June 1 to August 15 during each year from 1997 to 2001. This dataset contains 1122 hours of lidar observations whereof 408 hours include NLC signatures. The interannual variation of the NLC occurrence frequency shows a decrease of strong NLCs, while weak NLCs occur more frequent. The seasonal variation of the NLC occurrence shows a well pronounced core period where NLCs appeared during 43% of the time. The basic properties of NLCs are characterized by three parameters: maximum value of the volume backscatter coefficient beta_max (=brightness), centroid altitude z_c, and half width delta_z (=thickness).
A typical NLC above ALOMAR during the 5-year period reported here owns a brightness of beta_max=3.5x10^-10 m^-1 sr^-1, an altitude of z_c=83.4km, and a thickness of delta_z=0.7km. The interannual variation of the parameters shows a decrease of the brightness, an increase of the altitude, and a nearly constant thickness while seasonal variability is higher than these interannual changes. During the core period the NLCs are noticeable brighter than at the beginning as well as the end of the season. Altitude and thickness of NLCs decrease during the season.

Authors: Jens Fiedler, Gerd Baumgarten , G. von Cossart

202JD002425

Title: Measurement of positively and negatively charged particles inside PMSE during MIDAS SOLSTICE 2001

Abstract:

A magnetically shielded, charge collecting rocket probe was used on two flights in the MIDAS (MIddle Atmosphere Dynamics and Structure) SOLSTICE (Studies of Layered STructures and ICE) 2001 rocket campaign over And??ya, Norway. The probe was a graphite collection surface with a permanent magnet underneath to deflect electrons. The first MIDAS was launched June 17, 2001 into a strong, multiply layered PMSE. The probe measured negative particles inside an electron biteout within the PMSE, having a peak charge number density of -1500 charges per cubic centimeter. The second MIDAS was launched June 24, 2001 into another strong, multiply layered PMSE. The probe saw a band of positive particles centered in the lowest radar echo maximum, and a negative particle layer accompanied by a positive ion excess. The charge number densities for the positive and negative PMSE particles were several thousand charges per cubic centimeter. Unexpectedly, 2 km beneath the PMSE, the probe also found a very pronounced negative layer which was probably an NLC. Computer simulations of incoming, negatively charged ice grains were performed using a rarefied flow field representative of the MIDAS payload at zero angle of attack. Ice grains !A1 nm in radius were diverted by the leading shock front, indicating the smallest detectable ice particle by this probe.

Authors: Byron Smiley, Scott Robertson , Mihaly Horanyi , Tom-Arild Blix , M Rapp , Ralph Latteck , Joerg Gumbel

2002JD002427

Title: Simultaneous Lidar Observations of an Noctilucent Cloud and an Internal Wave in the Polar MesosphereP2

Abstract:
Lidar and radar observations of the upper mesosphere and lower thermosphere were conducted in interior Alaska (65? N, 147? W) during the summer of 2001. Lidar observations of a noctilucent cloud (NLC) were made on the night of 20-21 August 2001 during a visible noctilucent cloud display when the midnight solar depression angle was 12?. These nighttime lidar observations in late August have yielded measurements of both the NLC at 82.7 km and the mesospheric temperature profile below the cloud (~40-80 km). Analysis of the temperature profile indicates the presence of a wave with a vertical wavelength of 7.9 km. The altitude of the NLC coincides with the negative temperature phase of the wave. Located approximately 50 km from the lidar, the radar observations yielded measurements of Polar Mesosphere Summer Echoes (PMSEs) during daytime
on 21 August 2001. The PMSE layer occurs just above the NLC layer and also shows structural characteristics associated with the passage of gravity waves through the layer. The presence of NLCs in late August supports recent reports that the late summer Arctic mesosphere is colder and wetter than represented in ?standard? models. These NLC observations are discussed in terms of earlier lidar observati ons over Alaska, observations at other sites, and current models.

Authors: Richard Collins, Michael C. Kelley , Michael Nicolls , Camilo Ramos , Tao Hou , Timothy Stern , Kohei Mizutani , Itabe Toshikazu

2002JD002430

Title: Relations between small scale electron number density fluctuations, radar backscatter and charged aerosol particles

Abstract

During several campaigns during the last 10 years, detailed in situ studies of electrons, positive ions and charged aerosols have been performed by means of rocket borne instruments in the presence of Polar Mesophere Summer Echoes (PMSE) and Noctilucent Clouds (NLC). We have studied the correlation between the amount of charged aerosols present in the mesopause region and the PMSE echo power. We have also correlated the PMSE echo strength with the small scale structure of electrons at the radar Bragg scale that are responsible for the echoes. We find that PMSE occur for rather small amounts of charged aerosols, with the number of electrons exceeding the number of charged aerosols. This is in contradiction with previous, mainly theoretical, studies predicting that

PMSE only occur when the ratio between the aerosol charge number density and the number density of electrons is larger than about 1. We also find that there is a high degree of correlation between the PMSE echo power and the fluctuation intensity of electrons at scales comparable to half the radar wavelength. This confirms that variations in electron number density are responsible for the echoes, but does not explain the mechanism that creates the fluctuations.

Authors: Tom Blix, M Rapp , F. J. Lubken

2002JD002442

Title:Properties of mid-latitude mesosphere summer echoes after three seasons of VHF radar observations at 54?N

Abstract:

During the three summer seasons of the years 1998, 2000 and 2001 mid-latitude me\-so\-sphere summer echoes (MSE) were observed with the OSWIN VHF radar. The radar is located at K\"uhlungsborn (54.1\deg N, 11.8\deg E). Based on nearly continuous operation of the radar a large data set with altogether more than 200~hours of MSE observations with signal-to-noise ratios greater than 0~dB has been obtained. We present and discuss the results of the three years observation. Mid-latitude me\-so\-sphere summer echoes occur much more seldom than their corresponding polar mesosphere summer echoes (PMSE) in polar regions. Both phenomena are characterized by very strong radar returns with a high aspect sensitivity and a restriction to the summer mesosphere. But beside these analogies their main differences will be discussed also. MSE occur in a shorter time interval in the summer months and normally only during daytime. They are still observable although the low temperatures and the sufficient degree of saturation necessary for the existence of ice particles cannot be reached at all times. Furthermore we show MSE distribution, scattering characteristics, aspect sensitivity, and turbulence characteristics as functions of height.

Authors: Marius Zecha , Juergen Bremer , Ralph Latteck , Werner Singer , Peter Hoffmann

2002JD002524

Title:Lidar Studies of Interannual, Seasonal and Diurnal Variations of Polar Mesospheric Clouds at the South Pole

Abstract:

Polar Mesospheric Clouds (PMC) were observed by an Fe Boltzmann temperature lidar at the South Pole in the 1999-2000 and 2000-2001 austral summer seasons. We report the study of interannual, seasonal and diurnal variations of PMC using more than 430 h PMC data. The most significant differences between the two seasons are that in the 2000-2001

season the PMC mean total backscatter coefficient is 82% larger and mean centroid altitude is 0.83 km lower than PMC in the 1999-2000 season. The mean PMC altitude in two seasons is 85.03 km, which is 2-3 km higher than PMC observed in the northern hemisphere. Clear seasonal trends in PMC altitudes were observed at the South Pole where maximum altitudes occurred around 13 days after summer solstice. Seasonal variations of PMC backscatter coefficient and occurrence probability show maxima around 25-40 days after summer solstice. Strong diurnal and semidiurnal variations in PMC backscatter coefficient and centroid altitude were observed at the South Pole with both in-phase and out-of-phase correlations during different years. A PMC altitude model presented in this paper suggests that the seasonal variations of PMC altitudes are caused by the seasonal variations of upwelling vertical wind at the summer pole.
The hemispheric difference in PMC altitude is attributed to the hemispheric differences in the altitudes of the super-saturation region mainly caused by the solar flux in January being 6% greater than the solar flux in July because of the Earth's orbital eccentricity. Possible PMC latitudinal variations are also discussed.

Authors: XINZHAO CHU, C.S. Gardner , Ray Roble

2002JD002650

Title: PMSE dependence on aerosol charge number density and aerosol size

Abstract:
It is commonly accepted that the existence of polar mesosphere summer echoes (PMSE) depends on the presence of charged aerosols since these are comparatively heavy and reduce the diffusion of free electrons due to ambipolar forces. Simple micro-physical modeling suggests that this diffusivity reduction is proportional to r$_A^2$ (r$_A$= aerosol radius) but only if a significant amount of charges is bound on the aerosols such that $N_A|Z_A|/n_e >$ 1.2 (N$_A$ = number of aerosols, Z$_A$ = aerosol charge, n$_e$ = number of free electrons). The fact that the background electron profile frequently shows large depletions (`bite-outs') at PMSE altitudes is taken as a support for this idea since within bite-outs a major fraction of free electrons is missing, i.\ e., bound on aerosols. In this paper we show from in-situ measurements of electron densities and from radar and lidar observations that PMSE can also exist in regions where only a minor fraction of free electrons is bound on aerosols, i.\ e., with no bite-out and with $N_A|Z_A|/n_e \ll$1. We show strong experimental evidence that it is instead the product $N_A|Z_A|\cdot r_A^2$ which is crucial for the existence of PMSE. For example, small aerosol charge can be compensated by large aerosol radius. We show that this product replicates the main features of PMSE, in particular the mean altitude distribution and the altitude of PMSE in the presence of noctilucent clouds (NLC). We therefore take this product as a `proxy' for PMSE. The agreement between this proxy and the main characteristics of PMSE implies that simple micro-physical models do not satisfactorily describe PMSE physics and need to be improved. The proxy can easily be used in models of the upper atmosphere to better understand seasonal and geographical variations of PMSE, for example the long debated difference between northern and southern hemisphere PMSE.

Authors: Markus Rapp, Franz-Josef Luebken , Peter Hoffmann , Ralph Latteck , Gerd Baumgarten , Tom Bllix

2002JD002753

Title: Modelling the plasma response to small-scale aerosol particle perturbations in the mesopause region

Abstract:
We have developed a numerical model that solves the time-dependent, one-dimensional, coupled continuity and momentum equations for an arbitrary number of charged and neutral particle species. The model includes production and loss of particles due to ionization, recombination, and attachment of ions and electrons by heavy aerosol particles, and transport due to gravity and multipolar diffusion. The model is used to study the response of the mesopause plasma to small-scale aerosol particle density perturbations. We find that for aerosol structures of order a few meters, electron attachment and ambipolar diffusion are the dominant processes, leading to small-scale electron perturbations that can cause PMSE.
Moreover, for small aerosol particles, with radii of order 10 nm or less, ambipolar diffusion leads to an anticorrelation between electron and ion densities, which is in agreement with most rocket observations. These small-scale structures persist as long as the aerosol layer persists, which will be limited by aerosol particle diffusion. For 10 nm particles this diffusive lifetime will be of order hours. The few instances where rocket observations find instead a correlation between electron and ion densities can be explained either if the aerosol particles become large, of order 50 nm or more, in which case ion attachment becomes important, or by rapid evaporation of aerosol particles. In the latter case evaporation must be sufficiently fast to overcome ambipolar diffusion.

Authors: Oystein Lie-Svendsen, Tom Blix , Ulf-Peter Hoppe , Eivind Thrane

2002JD002857

Title: On the nature of PMSE: Electron diffusion in the vicinity of charged particles revisited

Abstract:

Triggered by recent experimental evidence showing that some parts of the Cho et al [1992]-theory describing electron diffusion in the vicinity of charged aerosol particles cannot be correct we reconsider the process of electron diffusion under the conditions of the polar summer mesopause region. The key idea is that perturbations in the distribution of charged aerosol particles created for example by neutral air turbulence almost immediately lead to (anticorrelated) perturbations in the electron number density due to simple charge neutrality and zero net current arguments. We obtain analytical solutions of the coupled diffusion equations for electrons, charged aerosol particles and positive ions subject to the initial condition of anticorrelated perturbations in the charged aerosol

and electron distribution. The main signatures of these solutions are in line with available in situ evidence of small scale plasma structures in the vicinity of PMSE. I.e., electron perturbations are anticorrelated to both perturbations in the distributions of negatively charged aerosol particles and positive ions. The lifetime of these perturbations is proportional to the square of the aerosol particle radius such that the presence of particles with radii larger than $\sim$10~nm allows for the existence of electron number density perturbations up to several hours after the initial creation mechanism has stopped. These results are almost independent of the ratio between the aerosol charge number density and the number density of free electrons. These electron perturbations potentially give rise to a radar reflectivity comparable to values observed with 50~MHz VHF radars. Our model results can readily explain why in situ measurements of neutral air turbulence have repeatedly shown active turbulence only in the upper part of the PMSE layer whereas turbulence was basically absent in the lower part.
Furthermore, our model concept qualitatively yields the correct altitude profile of the mean PMSE occurrence frequency based on the measured altitude profile of the turbulence occurrence frequency.

Authors: Markus Rapp, Franz-Josef Luebken